



AMSTer:

SAR & InSAR Automated Mass processing Software for Multidimensional Time series

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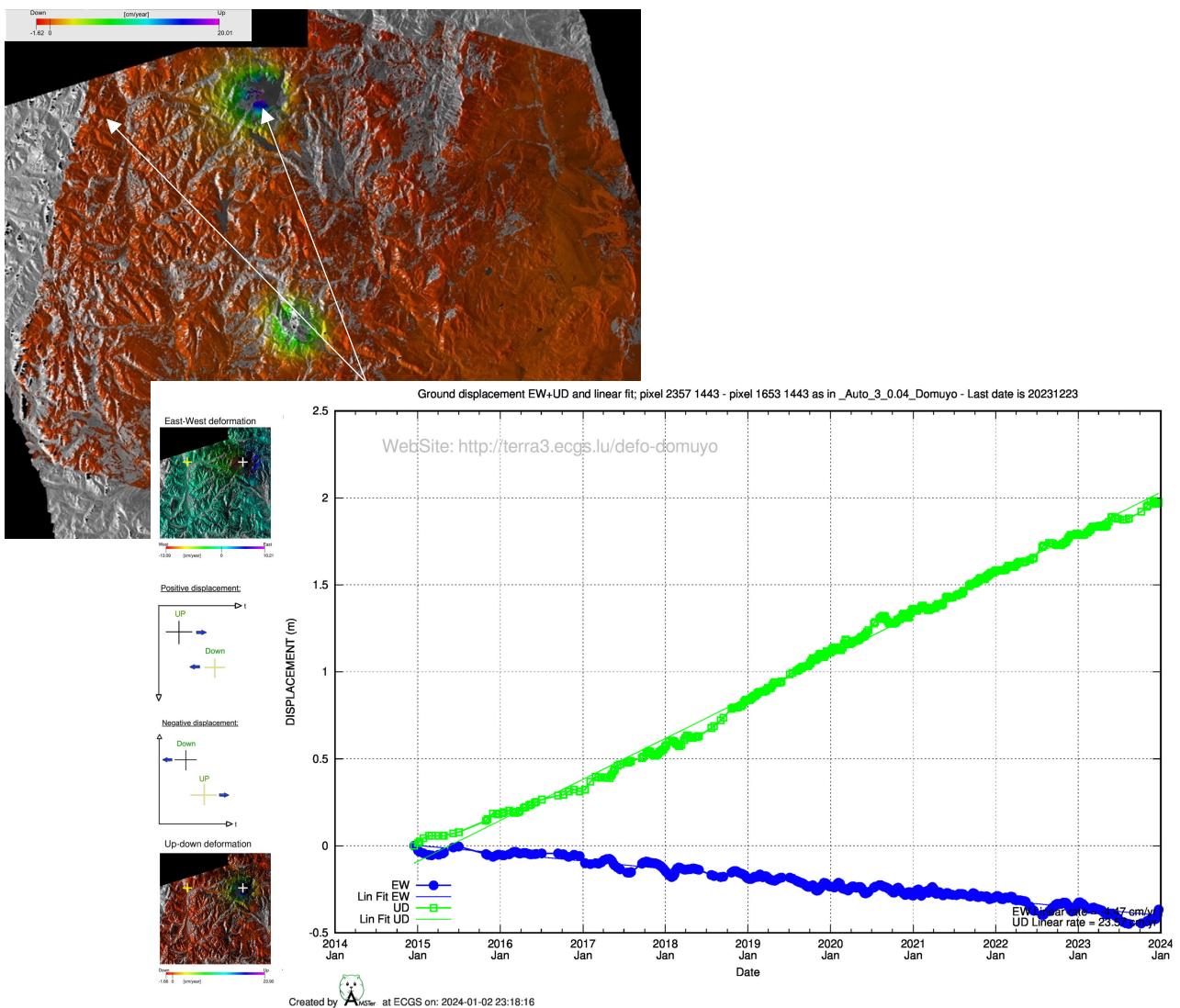
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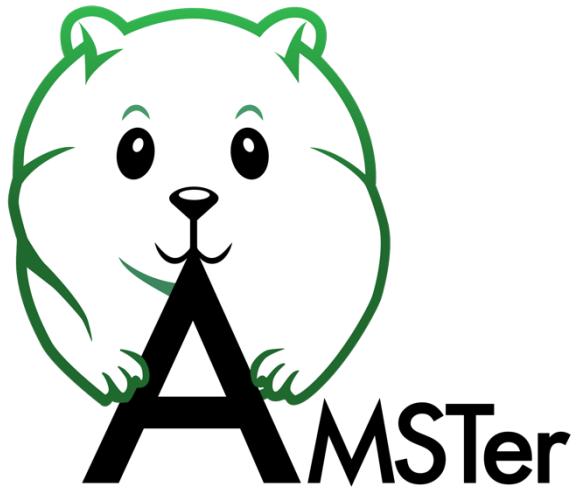
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Version 6.3.2 – April 2025





*AMSTer:
to crunch the SAR and InSAR mass processing*

https://github.com/AMSTerUsers/AMSTer_Distribution

Illustration on the front page is an example of double difference of vertical (green) and horizontal (East-West; blue) ground deformation observed with Sentinel-1 images in the Domuyo (Argentina) – Laguna del Maule (Chile) volcanic region between pixels pointed at by arrows on the vertical velocity map. The time series was fully automatically computed using 250 images acquired in ascending orbit and 319 images acquired in descending orbit spanning October 2014 – Jan 2024. More than 6000 interferograms were computed and 4600 were used for MSBAS inversion considering a coherence threshold.

For more information, see

- Derauw D., d’Oreye N., Jaspard M., Caselli A. and Samsonov S. (2020) Ongoing automated Ground Deformation monitoring of Domuyo – Laguna del Maule area (Argentina) using Sentinel-1 MSBAS time series: Methodology description and first observations for the period 2015 – 2020. *J. South Am. Earth Sc.*, Vol. 104, 102850. <https://doi.org/10.1016/j.jsames.2020.102850>
Open Access here: <https://www.sciencedirect.com/science/article/pii/S089598112030393X?via%3Dihub>
- d’Oreye N., Derauw, D., S. Samsonov, M. Jaspard, and D. Smittarello (2021), MasTer: a full automatic multi-satellite InSAR mass processing tool for rapid incremental 2D ground deformation time series. Proc. IEEE IGARSS21, Brussels, July 2021.

See also:

- Smittarello, D., d’Oreye, N., Jaspard, M., Derauw, D. & Samsonov, S. Pair Selection Optimization for InSAR Time Series Processing. *J Geophys Res Solid Earth* 127, (2022).
Open Access here: <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021JB022825?af=R>

The every-day updated version of these results can be freely accessed at the following web page:
<https://terra4.ecgs.lu/defo-domuyo/index.php>

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0. Introduction

0.1) What is AMSTer ?

AMSTer stands for Automated SAR & InSAR Mass processing Software for Multidimensional Time series.

AMSTer software is a tool dedicated to the processing of Synthetic Aperture Radar (SAR) images. It is mostly designed to allow optimized **mass processing of SAR interferometry** (InSAR) and the production of **2/3D ground deformation time series**. However, AMSTer can also be used for the production of **Digital Elevation Models** (DEM), coherence maps and amplitude images time series e.g. for **land cover or geomorphological changes, flood mapping etc...**

AMSTer software is made of three components:

1. an InSAR command line processor (the **AMSTerEngine**),
2. the **MSBAS** processor (for the computation of 2/3D time series of ground deformation)
3. and a bunch of **shell scripts** automatizing all tasks, from data downloading to updated displacement maps and time series and possible automatic display on a dedicated webpage (**AMSTer Toolbox**).

AMSTer was initially named MasTer. Some publications refer to that former name.

The **AMSTerEngine** (formerly named MasTerEngine) is a command line InSAR processor written in C derived from the Centre Spatial de Liege (CSL, Belgium) InSAR Suite (CIS) [Derauw, 1999]. It is able to process nearly all the SAR sensor currently available (ERS1 & 2, EnviSAT, ALOS, ALOS2, RadarSAT 1& 2, CosmoSkyMed, TerraSAR-X, TanDEM-X (incl. bistatic and pursuit mode), Sentinel1 A & B, Kompsat5, PAZ, SAOCOM, ICEYE? NISAR...)).

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The Multidimensional Small BAseline Subset (**MSBAS**) time series software [Samsonov and d'Oreye, 2012, 2017; Samsonov et al. 2020] allows inverting simultaneously several interferometric SAR time series acquired along different acquisition modes, including different sensors, SAR wavelengths, incidence angles, polarization etc., to solve for horizontal and vertical component of the ground displacement. MSBAS is maintained at NRCan/RNCan, Canada.

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The **AMSTer toolbox** explained here (see specificities hereafter) is mostly based on bash scripts and Python and is maintained at ECGS, Luxembourg [Derauw et al. 2020; d'Oreye et al. 2021].

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Kind reminder: The software is licensed under CC BY-NC-SA 4.0 (Attribution-NonCommercial-ShareAlike 4.0 International) and freely available for noncommercial use from GitHub¹. To help us carrying on with the development of the tool, we kindly ask you to cite the **AMSTer** in publications that contains results produced by the software thanks to at least the most recent references (see **References** at the end of the present manual).

You can also drop us a line on the discussion group of the GitHub¹ repository to let us know your usage. It is encouraging for us.

¹ https://github.com/AMSTerUsers/AMSTer_Distribution

0.2) License

"AMSTer: Automated SAR & InSAR Mass processing Software for Multidimensional Time series" © 2023 by Nicolas d'Oreye, Dominique Derauw, Sergey Samsonov, Delphine Smittarello, Maxime Jaspard and Gilles Celli is licensed under CC BY-NC-SA 4.0 (Attribution-NonCommercial-ShareAlike 4.0 International).

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Moreover, MSBAS is licensed to the <https://open.canada.ca/en/open-government-licence-canada>

Because AMSTer software is licensed free of charge, there is no warranty for the program.

0.3) AMSTer specificities

- Multiplatform:

AMSTer is fully Mac OSX and Linux (at least Ubuntu 20.04, 22.04, 24.04) compliant

- Automatization:

AMSTer performs all its tasks thanks to a series of scripts launched by few command lines which are easily integrated in cron jobs to become a fully automated tool. The whole processing chain makes use of single files containing all the parameters required for the mass processing of each satellite mode. Examples of cron jobs for making a fully automatic processing & monitoring tool are provided.

- Optimization:

The processing chain is designed to split the work in several tasks, some of which can be run in parallel. These tasks are optimized e.g. by sharing intermediate results that are common between some steps. Masking of decorrelated regions allows faster unwrapping. AMSTer also benefits from an optional unwrapping accelerator (DetPhun, [\[Derauw and d'Oreye, in prep.\]](#)). When updated Sentinel1 orbits are made available, AMSTer automatically downloads only the orbits (not the image) and recompute automatically each step (and only those) impacted with that update up to the production of the ground deformation time series.

- Self-evaluation:

It is self-evaluating and able to automatically tune some parameters and recompute some steps that would be unsatisfactory.

- Incremental:

Computation of time series is incremental, that is, when a new image is available, AMSTer downloads it automatically, then computes the new interferometric pairs formed using this new image along with all the images already acquired that satisfy the pre-defined spatial and temporal baselines criteria. The new differential deformation maps are then added to the existing database to be inverted by MSBAS. To compute the 2D or 3D linear rates and the cumulative deformation maps and time series, the MSBAS inversion itself only takes few tens of minutes to hours depending on the size of the area and the number of pairs.

- Security:

The processing architecture is designed in order to minimize the loss of data in case of hardware failure by storing the data and the intermediate and final results in a directories structure that is easily shared between several dedicated hard disks or servers.

- Flexibility:

AMSTer contains several tools for testing and fine-tuning the processing, for selecting the most appropriate MSBAS inversion parameters, or for cleaning or reprocessing only some steps after a possible crash, for preparing, extracting results, making time series and double difference time series plots, creating maps and kmz for display with Google Earth etc.... If an image presents some problem, it can be quarantined from the automated processing chain.

- User oriented tools:

Specific scripts exist to select the appropriate InSAR pairs based on temporal and spatial thresholds or Delaunay triangulation etc. Further selection can be performed based on the mean coherence computed over a user-defined footprint (kml). There are also tools to test the installation, to create masks based on mean coherence or to generate sequence of amplitude gif animation (to monitor the ground cover changes or the geomorphologic changes over time)

etc... If you need a tool, there are high chances that you are not the first one to need it and it must exist... If not, let us know.

- Interactive web page:

Optional scripts allow displaying the results in a dedicated web page as linear rate of deformation maps (wrapped either on SAR amplitude images, Google Maps or Google Earth), amplitude maps, differential cumulated deformation maps, coherence maps, RGB amplitude-coherence maps, baselines plots as well as time series of ground displacement double difference between pairs of pre-selected pixels.

An interactive tool also allows extracting time series for any other pair of points. The results are then sent by email to the user within a minute [Derauw et al., 2020]. The module to create the web page was developed by M. Jaspard (ECGS) and is described in a separate manual named [Web_tool_Vx.x.pdf](#) (where **x.x** is the number of the latest version of that manual).

The methodology and succession of steps are described below in the main text. Architecture of main scripts are described in annexes.

Idea: Why not a virtual assistant?



You can try to install tools like [GPT4ll](#) on your computer (<https://www.nomic.ai/gpt4all>), or use online AI tools (like <https://notebooklm.google>) to assist you in searching information in the present manual... Feed these AI tools with the present manual (and maybe the installation manuals) and ask them your questions (often in any language). Sometimes it helps. Note that ChatGPT knows AMSTer as it is openly available on GitHub but the answers do not seem reliable.

0.4) Conventions (hopefully) used in the present document:

- Paths are in **green** (“`../`” at the beginning of a path means “whatever your path starts with”)
- Parameters are in ***italic green***
- External commands or files are in ***italic blue***, as well as AMSTer python scripts
- AMSTer Toolbox scripts and functions are in ***bold italic***
- AMSTerEngine commands are in ***bold***
- Some warnings or important remarks are in **red**
- YYYY MM DD stands obviously for year, month and day
- **Yellow highlight** is coming soon (hopefully) or to be revised after main changes in AMSTer toolbox
- Parameters with square brackets (i.e. `[..]`) show in command lines are optional
- Names of AMSTer Toolbox scripts usually start with a capital letter. Names starting with a small letter are usually an AMSTer Engine command or an external command.

Some names start by one or more “`_`” or “`zz_`”. This is only to get them at the top of the list when searching a directory...

In addition, lines of text displayed at the terminal (or logged in log files) starting with a double slash (i.e. “`//`”) are output by AMSTer Toolbox scripts. Lines starting without these double slashes are usually output by AMSTer Engine or external commands. It can also be errors or warnings, though this must be obvious from the message itself.

MT stands for Main Toolbox (see for instance the directory **SCRIPTS_MT** or the file **FUCNTIONS_FOR_MT.sh**).

Among the InSAR community, images used to perform an interferogram were commonly named **Master (MAS)** and **Slave (SLV)**. Given the inappropriate connotations of this terminology, the InSAR scientific community recommended using a different nomenclature in the early 2020s (see for instance the [Open Statement on Terminology in InSAR by COMET centre](#)). In the present manual, the images used to compute an interferogram are called **Primary (PRM)** and **Secondary (SCD)**. When all the images are coregistered on a single reference image, this image, formerly commonly named **Super Master, is named here the Global Primary image (GLOBPRM)**. Despite our efforts, some traces of the old terminology used for ~30 years are still present e.g. in the naming of some scripts, files and directories (e.g. using Super Master, sometimes dubbed SM) or in the naming of variables within the scripts. Because AMSTer is aiming at computing automatic and incremental time series, changing these remaining names would require recomputing or renaming millions (literally) of files, directories and parameters within files in the complex architecture currently running in several scientific institutions or they would be rendered inoperative.

0.5) Installation:

All the resources are available from https://github.com/AMSTerUsers/AMSTer_Distribution.

Installation can be performed using the script **AMSTer_Install.sh**. That script can also be used to update AMSTer and can be run several times. It is stored in **SAR/AMSTer/SCRIPTS_MT/zz_Utilities_MT**.

The script **AMSTer_Install.sh** will guide you through the whole process of installation, through a set of questions and actions. **Please read carefully all the messages and questions.** It will download the required libraries, apt or ports, gnu tools, ancillary software etc. It will also update your **.bashrc** and **.bash_profile** with the required (mandatory) state variable and update the **\$PATH**.

In a nutshell, it will

- Recommend to delete from your **.bashrc** former information that would result from an old installation, that is old enough for not having been performed by the present installer script.
- After confirming the former step, it will ask you to confirm your **\$HOME** directory.
- It will then ask you if you want a [f]ull installation or an [u]pdate of only the main components (i.e. only AMSTer Engine, msbas or Toolbox scripts).
- It will then offer you to install / check or skip (if you are sure that it is already installed) mandatory elements (*apts or ports, libraries, gmt and gdal, clang14, gnu utilities, Java, Fiji (imageJ), snaphu, gnuplot, python3...*)
- Follow the instructions if it asks you to download external software and copy them where it asks you (**/SAR/EXEC/**).
- In addition, it will offer you to install / check or skip some useful tools (and often highly recommend) such as *GitKraken, QGIS, GIMP, gnu fortran, cpxfiddle*)
- It will then update the PATH and state variables in your **bashrc**.

Note about the PATH state variable: you need to have a line in your **.bashrc** like:
export PATH=\$PATH

It will look for it but may find another **export PATH=(something you need)** in your **.bashrc** that comes from another installation on your computer. In that case, it will ask you if you are satisfied with that other line. If you say no, it will offer you to enter another variable. Enter **export PATH=\$PATH**. The existing one can be deleted or kept after having entered your own new variable. Follow the questions and everything should be fine. At the worst, you can have several exports of **export PATH=\$PATH** if you mess up. It is not harmful, and you can always remove them manually after by editing your **bashrc** after the installation.

- It will then ask you to assign state variables to some mandatory disks (or directories) where it will expect to find and/or store several products, intermediate results or final results, that is at least **\$PATH_DataSAR, \$PATH_1650, \$PATH_3600, \$PATH_3601, \$PATH_3602**. For each of these variables, enter a path to a disk or a directory. More disks (or directories) are suggested (**\$SynoData** or **\$HOMEDATA**) though they are not mandatory and can be ignored. You can do it or add more later manually in your **bashrc** if needed.

Note that if the disk (or directory) that you entered as state variable is not reachable (or does not exist yet), it will offer you to enter again the name (in case it would result from a typo), or define it anyway and it will be your responsibility to mount the disk later. (If it is a directory, it will offer you to create it for you).

On Linux, mounting points of external disks are supposed to be in **/mnt/** while on Mac, they are in **/Volumes/**.

- Then it offers to download the geoid data that are mandatory for building DEMs

- Then it offers you to download S1 orbits (providing that the AMSTer Engine is already installed and that you have a file named `.netrc` in your home directory (see chapter 0.8) with the login and password to ESA dataspace server. Downloading the orbits can either be done from the first orbit (**beware, it takes a lot of time !**), or from a given date.
- If your `.bashrc` and/or `.bash_profile` have been modified, a backup is created and renamed by appending the date and time of the modification. In that case it will also offer you to reboot the computer for making these changes active.
- **Note** : in case of problem, ensure that **you have the rights to create/change** the `.bashrc` and `.bash_profile`
- **Note**: it is mandatory that the path to where some of the tools will be stored (`/opt/local/bin`) appears first in your `.bashrc`. If AMSTer does not act as expected, ensure that the `$PATH` with `/opt/local/bin` is declared first.

Note that the installation can also be performed manually (see documents [Install_AMSTer_Mac_Vx.x.pdf](#) or [Install_AMSTer_Linux_Vx.x.pdf](#) where `x.x` is the number of the latest version of that manual).

When installed, all the AMSTer Toolbox scripts are stored in a directory that must be named `/SAR/AMSTer/SCRIPTS_MT`, and which contains a.o. a subdirectory named `zz_Utils_MT`.

Also, several scripts are tools that were used at ECGS for our own needs. They are stored in a sub directory named `SCRIPTS_MT/zz_Utils_MT_Ndo` left in the package as they may be of some use for other users, providing (most probably) that the user performs necessary adjustments.

After the installation, you can check it using the script **`Check_Installation.sh`** that is in `zz_Utils_MT`. It will try to check mains components (AMSTerEngine, MSBAS and AMSTer shell scripts compilation and access, as well as third party software, libraries, state variables etc...). Watch the displayed messages. Note that, given the diversity of computer configurations, some displayed messages may be inaccurate (eg. complaining about wrong version and offering instead... the same version). Just ignore these warnings.

The script **`TEST_ALL_TYPE_OF_PROCESS.sh`** that is in `zz_Utils_MT_Ndo` may also help you to run several processings using data from several sensors in order to check that the tools run smoothly. It can also be useful to run this again after major updates. Of course, it was designed for our own needs at ECGS but with a bit of work, you can change the several hard-coded lines in order to tune it to your own needs.

0.6) Current status:

- Because AMSTer is in constant evolution and involves several types of satellite data, it may happen that some old functionalities (or some rarely used functionalities) do not survive the most recent updates. If you observe some problem with some scripts (especially for non S1 data for instance), feel free to let us know asap (amster@ecgs.lu).
- Geocoding of (too) large images leads to crash while allocating too big memory blocs. This requires in depth modification of the geocoding function. If you do not have enough RAM, consider either processing smaller images, or increase the multilooking.
- Lat/Long geocoding is not implemented. Results are only given in UTM although AMSTerEngine allows lat/long results. Nevertheless, transforming UTM in Lat/Long is straight forward e.g. with **gdal** (see e.g. the script **UTM2LL.sh**) or any GIS software.
Note that geocoding of amplitude files is however possible after computation of all the amplitudes using **ALL2GIF.sh** (see paragraph about **ALL2GIF.sh**).
- Mass re-processing from unwrapping or geocoding was only tested for S1 in WS mode.
- The function used to make raster figures uses **cpxfiddle**. This could be improved e.g. by using **Python** or **convert** (from **ImageMagick**). Currently there is a function in **FUNCTIONS_FOR_MT.sh** named **MakeFigFiji** that uses **ImageJ** to create a jpg figure instead of raster files. However, **this function is NOT used** in the scripts because 1) it is much slower than the functions that uses **cpxfiddle**, and 2) because several scripts expect raster files instead of jpg files. Nevertheless, if the user wants to avoid using **cpxfiddle**, and use **ImageJ** instead, he/she can adapt and replace the several **MakeFig** functions and then adapt the scripts that would search for raster files.
- Radarsat-1 can be read and processed, though only in slant range. Hence, DInSAR can be performed in 3 passes mode but results can't be geocoded because external DEM can't be taken into account. This is related to the fact that the orbits of RS1 are provided in a different reference frame.

Note about the **MakeFig** functions:

In “**FUNCTIONS_FOR_MT.sh**” several functions (named resp. **MakeFig**, **MakeFigR**, **MakeFigR2**, **MakeFigR3**, **MakeFigNoNorm**, **MakeFigRflip**, **MakeFigNoNormFlip**, **MakeFigflip**) create one-line scripts that are stored in the processing directories and that use **cpxfiddle** to create raster files. They can be edited to change the way to display the data and re-run from the same directory to re-create the figure.

0.7) What is new in the manual:

New in manual V6.4:

- Now reads and process NISAR data
- New tools to check S1 RAW and CSL images (***Check_RAW_S1.sh*** and ***Check_CSL_Data_Size.sh***)
- A new tool to create kml based on a list of coordinates (***Make_kml.sh***)
- A new tool to transform a list of geographical coordinates into a list of Col(X) and Lines(Y) positions with respect to a geographic zone define in an Envi hdr file (***Transform_UTM_List_In_XY.sh***).
- A new tool to extract, for each point from a list of Col(X) and Lines(Y) positions, the time series of defo from all the defo maps in the present dir; It reads the first hdr file to extract the required informations about the images. (***Extract_TimeSeries_InDir_From_List.sh***)
- A new tool to compare a kml to several ***map-overlay.kml*** (from raw S1 images) (***Check_kml_coverage_kml.py***)
- Some remarks about cropping images from satellites other than S1

New in manual V6.3.2:

- Note for Linux users running AMSTer on computer with more than 64 cores
- Usage of ZOOM is improved (can be asymmetric in Range and Azimuth as ***NAzMRg*** or ***MRgNAz*** in ***SinglePair.sh*** or ***SinglePairNoUnwrap.sh***). Only cropped images can be zoomed. Use with care though...
- Add new toolbox for diagnostic (in ***SCRIPTS_MT/diagtoolbox/***). See scripts ***Run_Diagnostic_TARGET.sh*** and dependencies (by Delphine Smittarello)
- Clarify RAM needs and possible issue with MSBAS in the trouble shooting section.
- scripts to assist in creating list of pixels' coordinates for plotting:
Get_pix_name_And_Coord_from_kml.py,
Create_Point_TS_File_From_NameLatLong_file.sh, ***UTM2EnviPosition.py***,
Points_TS_2_List_DoubleDiff.py
- Script to check if bursts in image overlap a provided kml (***Check_burst_coverage_kml.py***) and to sort raw S1 images (by orbit and mode) based on their ***manifest.safe*** (***Sort_UNZIP_S1.sh***)
- Explains old option in ***__SplitSession.sh*** for computing only a list of pairs (provided as DATE_DATE) or only the new pairs.
- Also reads new ERS archive format (ENVISAT-like format)
- New tool to convert a list of pixel's coordinates from one grid to another in order to pinpoint the same point location (***Convert_DoubleDiff.sh*** and ***Convert_PointDiff.sh***).
- New tool to re-wrap image (***ReWrap_Image.py***)
- Information about AMSTer Engine function for downloading Sentinel 1 and 2 data (***SentinelDataDownloader***)

New in manual V6.3.1:

- New multi-level masks and state variables for DEM, MASKS (and MODELS).
- Explanation about MSBAS with coherence threshold: the manual was reading that the pairs with a mean coherence above the coherence threshold were rejected. Obviously, it was the other way around.
- Updated description of the ***LaunchMTparam.txt***
- New tool ***Check_MasSlv_SlvMas_Pairs.sh*** to check that there are no pairs processed twice in the current directory as Primary_Secondary and Secondary_Primary.
- New tools ***Trim_Bt_In_Defomodei.txt.sh*** and ***Trim_Bt_In_restrictPairsSelection.txt.sh*** to remove all pairs with Bt larger than a provided value from ***DefolInterpolx2Detrendi.txt*** and ***restrictedPairSelection(_DefolInterpolx2Detrendi).txt*** respectively.
- New tool to compute semi-variograms: ***Variogram.py***.

- New tools to change values in file: [Change_Val255_0_in_0_1.py](#) and [Swap_0_1_in_BytFile.py](#)
- Suggest virtual assistant like [GPT4All](#)

New in manual V6.3.0:

- Change creation of SRTM DEM using **getSRTMDEM** instead of **aggregateSRTMTiles**. The same new function is also used to change the geoidal height correction of DEM if needed.
- New tool to search for all products made with AMSTer Engine version > given date ([Search_All_Made_With_AE_Version_After.sh](#)) and to check that there is a *deg.hdr for each *deg file and there is no orphan *deg.hdr in directory ([Check_deg_hdr_in_dir.sh](#)).

New in manual V6.2.1:

- New procedure to split MSBAS inversion: when very long time series must be updated as soon as a new image is provided, computing the MSBAS inversion with the whole data set will take more and more time. Because the beginning of the time series is not affected by the new data, the new procedure allows to freeze the first part of the time series, compute only the most recent part, then merge both parts to be displayed as if it would have been inverted in one run. It may spare a lot of time and computer resources (See chapter 6.3).
Example of cron script for Domuyo was updated accordingly. See [Domuyo_S1_Step3_MSBAS_DEMGeoid_Split.sh](#) and chapter 8.4.
- New tools for splitting MSBAS: see [Add_DefoMap_ToAllMapsInDir.py](#), [Compute_Velocity_Stdv_R2_maps_From_AllDefoMaps.py](#) and [Compare_Full_And_Parts_msbas_TS.py](#)
- Prepare for multi-level masks: It will be possible to automatically combine several masks in a single one. Each binary mask must be given in Lat-Lon on WGS84. They can each have their own resolution and extend. They will be combined to cope with external DEM projected in slant range. For each binary mask given in entry, masking value must be given. First mask is a purely geographical one that will always be taken into account when requested (like water bodies, borders, ...). The other masks are conditional ones. Second mask is the coherence mask that will be considered at phase unwrapping step and stay activated only if coherence is below a given threshold. Third mask is a fixed geographical mask that will be taken into account for automatic best plane removal at end of phase unwrapping.
Note: from this version, the reading of S1 IW data from a kml selects the exact number of bursts overlapping the kml instead of the circumscriptive rectangle. As a result, less bursts might be present in the images in CSL format. Hence, former images must be re-read. Without that it will be impossible to compute pairs between new and old read data.

Minor changes:

- New tool to check NaN's in maps (see [Check_NaN_Pix_In_All_Maps.sh](#))
- New tool to create a .ras figure from an Envi maps (see [Envi2ras.sh](#))
- New tool to list all products (CSL images read, resampled images or processed pairs) computed with an AMSTerEngine version after a given date (see [Search_All_Made_With_AE_Version_After.sh](#))
- Indicate that the **_DEMGeoid** string in the name of cron scripts examples for the Domuyo simply reminds that the processing was performed with the DEM corrected from the ellipsoidal height
- Troubleshooting: info about possible problem in launching cron jobs with Mac OSX from Sonoma (i.e. V 14.6 and after). It may requires to use LaunchAgent instead.

New in manual V6.2.0:

- Procedure to perform 3D MSBAS inversion and related figures

- **Read_All_Img.sh** can now read zip S1 images
- Some new tools:
 - To analyse ([Analyse_AIPairsListing_data.py](#) and [Analyse_BaselineCoh_data.py](#)) and compare baseline plots ([Compare_BSplot.sh](#)), by D. Smittarello
 - To check if a kml is included in another one ([_Check_kml_in_kml.py](#))
 - To replot results from a cron step 3 processing ([Replot_EW_UD_DoubleDiff_TS_From_Cron_Step3.sh](#) and [Replot_LoS_DoubleDiff_TS_From_Cron_Step3.sh](#))
 - A script to assist sorting ALOS2 data acquired in several geometries. This was written for a specific case at ECGS but can be used as an example for similar cases ([ALOS2_UNZIP_Check_Sort.sh](#)).
 - A script to remove files in subdirectories named with twice the same date separate by an underscore ([Delete_All_bil_files_with_twice_same_date.sh](#))
 - Scripts to compute Earth to satellite unit vectors and rank of the unit vectors' matrix (see [Earth2Sat_UnitVectors.py](#) and [Rank_and_SVD_Matrix.py](#))
- Update info about S1 orbits since Nov 2023 and ASF S1 orbits
- Update info about downloading the S1 data from Copernicus' dataspace instead of scihub
- Add a table listing the mandatory satellite naming throughout the AMSTer workflow
- Update cron scripts provided as example for Domuyo

Minor changes:

- Remove script **MSBASV3_results_plots.sh** because obsolete and managed from [Add_hdr_Files_Less_Ras.sh](#)
- Correct a non-harmful bug in **plotTS_template_multi_fit.gnu**
- Remind that files to re-geocode with **ReGeocode_AmpliSeries.sh** MUST start with **REGEOC.** (note the dot).
- Add trouble shooting info :
 - if cron stays hanging while not having proper definition of `/usr/sbin` in `$PATH` in `.bashrc`
 - when **PlotTS_all_comp.sh** with coh option
- Specify that script **RemovePairsFromFlist_WithImagesBefore.sh** and **RemovePairsFromFlist_WithImagesAfter.sh** also create 4 col tables as input table.
- Add info about new option of date from which to test results of mass processing with **Verify_MassProcess_results.sh**
- Add info warning to compile AMSTer Engine without parallel option when performing **__SplitSession.sh** or **__SplitCoreg.sh** scripts
- Add info about compiling [opencv](#) on Ubuntu if not installed properly by [apt install](#)
- In installer docs, update zip msbas source code to 1.2 to avoid compilation error with most recent Mac OSX version
- New email address amster@ecgs.lu
- Some cosmetic changes

0.8) Notes about Sentinel-1 orbits:

Processing Sentinel-1 data requires orbits files, either the Near Real Time predicted (PRE) orbits available 180 minutes after the acquisition, or the Non Time Critical Precises (POE) orbits available typically 20 days after the acquisition.

These can be downloaded automatically using the AMSTer Engine function **updateS1Orbits** as a transparent step in the processing, either from ESA or from ASF (Alaska SAR Facility).

In both cases, it requires to have **at least AMSTerEngine V20231213** and a login and a password to be obtained from ESA or ASF, which must be stored in a file named **.netrc** in your home directory. That file must contain one line for either ESA and/or ASF login as follow:

```
machine identity.dataspace.copernicus.eu login <YourLogin> password <YourPassword>
machine urs.earthdata.nasa.gov login <YourLogin> password <YourPassword>
```

The first line is dedicated to the access the ESA server <https://dataspace.copernicus.eu> (this dataspace server replaces the <https://scihub.copernicus.eu> server that was closed in November 2023), while the second line is dedicated to the access the ASF server.

Of course, **<YourLogin>** and **<YourPassword>** must be replaced (without the **< >** symbols) with the login and password obtained from the provider:

- For ESA, visit <https://dataspace.copernicus.eu> and proceed to the registration by following the instructions provided on the web site;
- For ASF, visit urs.earthdata.nasa.gov and proceed to the registration by following the instructions provided on the web site. When registered and logged in, you must also:
 - click on “My Profile”, then menu “Applications > Authorized Apps”.
 - At the bottom, click on button “APPROVE MORE APPLICATIONS”
 - In the “Search” bar, type “Sentinel”
 - Click on “AUTHORIZE” button next to each application named with Sentinel 1.

Then in a terminal on your computer type:

```
> cd ~
> touch .netrc
> echo "machine urs.earthdata.nasa.gov login <YourLogin> password <YourPassword>" > .netrc
> chmod 0600 .netrc
```

Then

```
> cd ~
> touch .urs_cookies
```

For more information, see:

<https://wiki.earthdata.nasa.gov/display/EL/How+To+Access+Data+With+cURL+And+Wget>.

With such a **.netrc** file, providing that your destination directory **S1_ORBITS_DIR** is set up and defined as state variable in your **.bashrc** (see chapter 0.13), you can download the orbits from ESA or ASF by launching either **updateS1Orbits** or **updateS1Orbits -ASF** respectively. This is usually done from the scripts and you do not have to worry about it.

Remarks:

1. A start date can be used to verify the orbit data base from a given date (see **updateS1Orbits** help). In particular, **Read_All_Img.sh** now performs update of local S1 orbit data base only since last available precise orbit date. To force update of older orbits, either add option **from=YYYYMMDD** either
 - in **Read_All_Img.sh** script where it calls the function **updateS1Orbits**, or
 - performed manually using command **updateS1Orbits** (see **updateS1Orbits -help**), or
 - when using **Read_All_Img.sh** script with **ForceAllYears** option.

2. Before November 2023, the procedure was slightly different depending on the evolution of the services offered by the space agencies. For the sake of completeness, these old procedures are listed here below. However, they are obsolete and must be ignored.

From February 2021 to March 2022:

Since Feb 2021, ESA changed the way the rapid orbits are dealt with. The orbits delivered within the original images are now not accurate enough to provide with satisfying coregistration. One need Restituted orbits, provided since February 2021 through 3h long segments. Downloading these Precises (POE) and Restituted (RES) orbits can be performed from Alaska SAR Facility (ASF). It requires:

- AMSTerEngine at least from 20210519 (with function **updateS1Orbits**) to cope with new ESA orbits.
 - Procedure to download orbits from ASF as explained here:
<https://wiki.earthdata.nasa.gov/display/EL/How+To+Access+Data+With+cURL+And+Wget>
that is (see web page for details):
 - Make an account to urs.earthdata.nasa.gov and get a *login* and *pwd*
 - While logged in,
 - click on "My Profile", then menu "Applications > Authorized Apps".
 - At the bottom, click on button "APPROVE MORE APPLICATIONS"
 - In the "Search" bar, type "Sentinel"
 - Click on "AUTHORIZE" button next to each application named with Sentinel 1.
 - In a terminal on your computer type:
> cd ~
> touch .netrc
> echo "machine urs.earthdata.nasa.gov login *login* password *pwd*" > .netrc
> chmod 0600 .netrc
 - Then
 - > cd ~
 - > touch .urs_cookies
 - When access is granted to ASF facility, use **updateS1Orbits -ASF** the same way.
- Ensure that you have *S1_ORBITS_DIR* as state variable in *.bashrc* for path to directory where orbits are stored (*./AUX_POEORB* and *./AUX_RESORB*). Old versions of AMSTer had *S1_PRECISES_ORBITS_DIR* but it is not used anymore.
 - Note that since March 2021 images may be distributed with original orbits (i.e. not Restituted nor Precise) which are of very poor quality. Because it is useless for interferometry, **S1DataReader** is now used with option -p to prevent reading images that only have these orbits. When these orbits will be automatically updated at the occasion of another reading (with Restituted or Precise orbits), the images will be read normally. This is hence a transparent process for the user.
 - **Later**, ESA changed the way they make the S1 orbits available (see below). The ASF procedure here above is not needed anymore but can still be used as a backup.

From March 2022 to November 2023:

Since March 16 2022, AMSTer takes again the orbits from ESA scihub server using default user and password (i.e. *gnssguest/gnssguest*). This is transparent to the user as long as he/she has a AMSTerEngine more recent than March 2022.

Note however that AMSTerEngine is still able to use ASF orbits using -ASF option at call of **updateS1Orbits** function. Nevertheless, AMSTer toolbox (and especially **Read_All_Img.sh**) is tuned to use the easiest and fastest solution, that is ESA orbits.

0.9) RECOMMENDATIONS:

Unsorted advices:

- Even if you do not have 4 hard disks where you will store the data, the processing results and the final results, it will spare you a lot of time and troubles to keep the same architecture by defining 4 paths in your PATH state variable to identify 4 places (or disks) where the scripts expect to find some specific directories. The names of these 4 places (or disks) used by AMSTer are based after servers' name at ECGS: [1650](#), [3600](#), [3601](#) and [3602](#). It might be the easiest solution for you to keep this naming as it is used nearly everywhere. Also, even if you do not work with 4 separate disks, it is required to have these 4 state variables (see below "Expected architecture of disks"): [\\$PATH_1650](#), [\\$PATH_3600](#), [\\$PATH_3601](#) and [\\$PATH_3602](#). These state variables are created at installation if it is performed with the installer script (see above).
- Avoid naming directories with dash or blank characters. This is always a good practice anyway...
- **Do not use hard drives formatted in FAT format because it does not support symbolic links, which are widely used by AMSTer**
- Keep the same directories structure as what is proposed here (including for instance "[/NoCrop](#)") for storing the data and results. This is mandatory...
- In case of crash or problem, start by reading the header of the script(s). It may contain useful information about dependencies, hard coded information etc. After a crash, do not forget to check/clean directories where results are supposed to be stored.
- When raster figures are not processed as expected, before concluding that the processing was wrong, check the original file e.g. with [cpxfiddle](#), [Fiji](#) or [QGis](#).... If file is ok, then either
 - the name of the processing directory contains some string that conflicts with one of the functions (such as a star), or
 - as it was observed on some Linux computer, scripts launched through cron jobs can't be run with the user's profile defined in the [bashrc](#). State variables must be copied in the crontab.
 - If images look like noise when opened with [Fiji](#), check that you have correctly ticked the endianness box in the [Fiji](#) dialog box asking for image path, size etc...

In the first case, try the reprocessing with another processing path. In the second case, just relaunch manually the script generating the figure.

- If you stitch your DEM tiles with the appropriate AMSTerEngine tool (i.e. **aggregateSRTMTiles** if produced with AMSTerEngine version < October 2024, or **getSRTMDEM** if produced with AMSTerEngine version > October 2024), it will create a [.txt](#) file that will be used by the **SlantRangeDEM** function to extract the necessary values. Be careful because with this technique, the DEM is in mathematical order and referred to the ellipsoid.
If you create a DEM with a GIS tool in Envi format, it must contain a [.hdr](#) file instead of a [.txt](#) file. Be aware that in such a case the DEM will be inverted compared to mathematical logic and may not be referred to the ellipsoid. In order for the AMSTerEngine to cope properly with that difference, ensure that the [.hdr](#) file contains the proper "description" fields with all the appropriate information about reference frame, datum etc... !! **If there is a [.hdr](#) and [.txt](#) in the directory, AMSTerEngine will consider only the [.txt](#). Beware of possible conflict.**

- Ensure that your DEM is referred to ellipsoid and not the geoid !
- As for the DEM, if a mask is provided with .txt description file, AMSTerEngine will expect it to be in mathematical order. If provided with .hdr it will expect it to be in GIS order.
- If you intend to do mass processing using S1, ensure that the kml you will use to crop the interferometric products overlaps the same bursts that the kml used for the bulk reading. The reason of the care required here is just a matter of disk space and processing time: if the kml file used for cropping the interferogram has a footprint that covers less bursts than what has been read (and hence assembled in the primary image (*PRM*) directory as *.../SAR_CSR/SAT/TRK/NoCrop/PRM.csl/Data/SLCData.pol*), AMSTerEngine will assemble again the required bursts in a new *SLCData.pol* but saved this time in your *PRM_SCD/i12* directory (where *SCD* stands for the secondary image name). Hence it will make a new copy of the primary image in **EACH** processing pair, **which would be a huge waste of time and disk space**. There is of course no problem if you set no kml as a crop region for interferometric computation.
- You can run the script *zz_Utilities_MT/Check_Installation.sh* which will test some of the required components and configuration. This might be useful at first setup, but also after some upgrades of the OS or whatever you upgrade on your computer(s)...

0.10) Hard coded lines in scripts:

Although it was attempted to avoid it as much as possible, some specific information (e.g. related to the user's computer infrastructure) are sometimes hard coded in some scripts. We can observe the following type of scripts using hard coded lines:

1. Those related e.g. to the computer infrastructure, or some parameters related to the satellite and/or track and/or target. These parameters needed by these scripts are as much as possible stored in a single file named ***HardCodedLines.sh*** (see below);
2. Those where some parameter(s) or plot style(s) are defined and which are usually OK, thought the user may want/need to change the default value (see below);
3. Scripts to be launched from a terminal without profile definition, hence needing to source the *.bashrc* (see below);
4. Those that are really specific to the target(s), e.g. containing names, coordinates, positions, dates etc... This is typically the case for the cron scripts (see below);
5. And some specific cases that need short explanations (see below).

When hard coded lines are required, it is mentioned in the header of the script. In addition, the hard coded lines are usually located at the beginning of the script in a dedicated section that looks like:

```
# vvv ----- Hard coded lines to check --- vvv
# Explanation about parameter to define
    Parameter=...
# ^^^ ----- Hard coded lines to check --- ^^^
```

Let's briefly discuss these 5 types of scripts using hard coded lines.

0.10.1 Hard coded lines in `__HardCodedLines.sh`:

Whenever possible, the hard coded lines are gathered in a dedicated file named `__HardCodedLines.sh`, which is stored in `/SCRIPTS_MT`. That file is sourced by the scripts requiring these parameters definitions. Parameters are called in the script as functions.

These functions are arranged in sections entitled by the name of the script(s) calling them. Comments with some explanations about the parameter(s) are provided for each function.

Review carefully that file and tune it to your own needs. Ensure to get a backup that will not be overwritten when you update the scripts of your AMSTer toolbox e.g. from the GitHub² repository.

The scripts using the `__HardCodedLines.sh` file are the following:

- `__SplitCoreg.sh`
- `__SplitSession.sh`
- `ALL2GIF.sh`
- `FUNCTIONS_FOR_MT.sh`
- `Geocode_from_ALL2GIF.sh`
- `Plot_All_EW_UP_ts_inDir.sh`
- `Plot_All_LOS_ts_inDir.sh`
- `Plot_Diff_TS.sh`
- `plot_Icurve.sh`
- `PlotBaselineGeocMSBAS.sh`
- `PlotBaselineGeocMSBASmodeTXT.sh`
- `PlotBaselineGeocRaster.sh`
- `plotBaselines.sh`
- `PlotTS_all_comp.sh`
- `RenamePath_Volumes_MNTtoVOL.sh`
- `RenamePath_Volumes_VARtoMNT.sh`
- `RenamePath_Volumes_VARtoVol.sh`
- `RenamePath_Volumes.sh`
- `RenamePathAfterMove_in_SAR_MASSPROC.sh`
- `RenamePathAfterMove_in_SAR_SM_AMPLITUDES.sh`
- `RenamePathInPlace_Volumes_VOLtoMNT.sh`
- `SinglePairNoUnwrap.sh`
- `TimeSeriesInfo_HP.sh`
- `UpdateAMSTerEngine.sh`

² https://github.com/AMSTerUsers/AMSTer_Distribution

0.10.2 Hard coded lines in scripts that should be OK:

Some other scripts have hard coded lines for defining some parameter(s) or plot style(s), which are usually OK. However, the user may want/need to change these default value.

See e.g.:

- **_Check_S1_SizeAndCoord.sh** (Tolerance in position of the corners of the Area of Interest)
- **_Remove_All_Files_With_PairDate_Bp.sh** (Path to base directory where to operate)
- **AmpAmpAmp.sh** (Plot style in Fiji commands)
- **AmpAmpCoh.sh** (Plot style in Fiji commands)
- **AmpDefo_map.sh** (Plot style in Fiji commands)
- **CronLaunch2Term.sh** (path to /SCRIPTS_MT/)
- **Fiji_Amp_Defo_Coh.sh** (Plot style in Fiji commands)
- **Fiji_DEM_Defo_Coh.sh** (Plot style in Fiji commands)
- **Fiji_Open_Envi2tif.sh** (Plot style in Fiji commands)
- **Plot_All_EW_UP_ts_inDir.sh** (Plot style)
- **Plot_All_LOS_ts_inDir.sh** (Plot style)
- **Plot_Diff_TS.sh** (Plot style)
- **plot_Icurve.sh** (Plot style)
- **PlotBaselineGeocMSBAS.sh** (Plot style)
- **PlotBaselineGeocMSBASmodeTXT.sh** (Plot style)
- **PlotBaselineGeocRaster.sh** (Plot style)
- **plotBaselines.sh** (Plot style)
- **PlotTS_all_comp.sh** (Plot style)
- **Read_All_Img_Rebuild.sh** (Expected polarization)
- **ReGeocode_fromList.sh** (Which products to re-geocode & recompute rasters)
- **ReGeocode_ManuallyUnwrapped_SinglePair.sh** (Which products to re-geocode & sat def)
- **ReGeocode_SinglePair.sh** (Which products to re-geocode)
- **RerunFromGeoc.sh** (Which products to re-geocode)
- **SinglePairNoUnwrap.sh** (Max. Sigma considered for successful Coreg & Crop fct)
- **TSmap2moviegif.sh** (Plot style in Fiji commands)

See also the gnu templates for plots in /SCRIPTS_MT/TemplatesForPlots

Sometimes, hard coded parameters are not listed at the beginning of the script. However, this happens when changing them is not expected, though it remains possible. For instance:

- **Envi2ColorKmz.sh:** may want to change path to the colour table to get a better one
- **Filter_Interpolate_DefoMaps.sh:** extension of the files to filter and width of the median filter
- **Filter_Interpolate_SingleMap.sh:** width of the median filter
- **_Remove_All_Files_With_PairDate_Bp.sh:** Path to dir where pairs are stored
- **Check_S1_SLCLimageInfo.sh:** Preferred polarization for S1 images

0.10.3 Hard coded lines specific to targets:

Some scripts have **hard coded lines that are specific to the target of interest**. Each user will probably define its own set of script such as those for the cron jobs.

At ECGS we have for instance the following ones, which can be an inspiration to build your own processing chain (see also section 8):

- ***Domuyo_S1_Step1_Read_SMCoreg_Pairs_DEMGeoid.sh*** (specific for processing Domuyo region)
- ***Domuyo_S1_Step2_MassProc_DEMGeoid.sh*** (specific for processing Domuyo region)
- ***Domuyo_S1_Step3_MSBAS_DEMGeoid.sh*** (specific for processing Domuyo region)
- ***Domuyo_S1_Step3_MSBAS_DEMGeoid_Split.sh*** (specific for processing Domuyo region)
- ***Lazy_prepas_msbas_all_sets_andPlotBaselines_VVP.sh*** (batch of commands for a specific region)
- ***Nyigo_Nyam_Crater_S1_Read_AMPLI.sh*** (specific for processing amplitude in DRC craters)
- ***Shadows_S1_Nyam_Desc.sh*** (specific for processing amplitude in DRC craters)

Etc...

Also, some small tools are sometimes designed for specific manual tasks.

- ***CompareTimeSeries.sh*** (Path to time series and where to store the results)
- ***Del_All_dir_from_list.sh*** (String to search)
- ***Del_All_files_in_Dirs_Named_With.sh*** (String to search and path to dir to clean)
- ***r4togif.sh*** (Date tag & crop size)
-

Etc...

0.10.4 Hard coded lines for script launched from a terminal without profile definition:

Some scripts must be launched from cron jobs or from a terminal open from a command line in another terminal. In these cases, there is no profile definition yet. Hence the script MUST start by sourcing the `.bashrc` to get the state variables and the AMSTer environment variables.

Ensure that a `.bashrc` is present in your `$HOME` directory, which is done automatically if you installed AMSTer with the installation script. Hence, **in principle, there is nothing to change.**

The following scripts start by sourcing the `.bashrc`:

- `ALL2GIF.sh`
- `AllProd2GIF.sh`
- `AmpAmpAmp.sh`
- `AmpAmpCoh.sh`
- `AmpDefo_map.sh`
- `build_header_msbas_criteria_From_nvi_name_WithoutAcqTime.sh`
- `build_header_msbas_criteria.sh`
- `Check_Installation.sh`
- `FUNCTIONS_FOR_MT.sh`
- `MultiLaunch_Ampli_Coh.sh`
- `MultiLaunch_ForMask.sh`
- `MultiLaunch.sh`
- `plot_Multi_BaselinePlot.sh`
- `Read_All_Img_Rebuild.sh`
- `Read_All_Img.sh`
- `Remove_BrokenLinks_and_Clean_txt_file.sh`
- `SinglePair.sh`
- `TimeSeriesInfo_HP.sh`
- `TS_AddLegend_EW_UD.sh`
- `TS_AddLegend_LOS.sh`

and all the cron jobs of course.

0.10.5 Some specific cases:

The script `00_RasterPixelCoord.py` contains the hard coded path to where the deformation maps are stored and where the `PlotTS.sh` script is located. Unlike in nearly all the other scripts, this cannot be set as a parameter here because that script is used from the python console in QGIS (see e.g. section 6.5, which cannot source the `.bashrc` etc).

Also, `00_RasterPixelCoord.py` uses `PlotTS.sh`. In general, when used from the terminal, `PlotTS.sh` would get the paths to AMSTerEngine, `SCRIPTS_MT` and the gnu utilities from the state variables defined in the `.bashrc`. However, when used from `00_RasterPixelCoord.py`, that is from the python console in QGIS, these paths cannot not be interpreted from the state variable. For that reason, they are set as hard coded parameters in these scripts.

The script `CronLaunch2Term.sh` aims at launching a script in a new terminal from a cron job. It requires the path to the `SCRIPTS_MT` because it can't be read from the `.bashrc`.

The script `__Tune_your_AMSTer.sh` aims at changing hard coded lines in script. Each change, for each script, must be hard coded (See section 10.17).

The script `__TEST_ALL_TYPE_OF_PROCESS.sh` aims at running several processings using data from several sensors in order to check that the AMSTer runs smoothly, e.g. after updates. Of course, it was designed for our own needs at ECGS (sensors and images available at ECGS). Corresponding hard-coded lines must be adapted depending on your data.

The scripts `_Check_Cron_MassProcessed.sh`, `_Check_Cron_Ampli.sh`, `I3.sh` and `psn` aim at testing the status of the last processes run from the cron jobs at ECGS. It requires an in-depth revision to be adapted to another automated set of processes.

The scripts `ChgeAll_LaunchParamFiles.sh` aims at changing a given parameter in all the `LaunchMTparam.txt`. while `Chge_Several_Criteria_LaunchParamFiles.sh` runs several occurrences of `ChgeAll_LaunchParamFiles.sh`. This must be tuned to your own needs (See Section 10.15).

And of course, although this is not a script, all your `LaunchMTparam.txt` files must be tuned to your targets.

0.11) Python scripts:

AMSTer toolbox contains some *python* script. They were written for *python3* and are called in scripts with `#!/opt/local/bin/python`. Hence you must ensure that your *python3* can be launched as *python* from that directory. This may require that you create an alias for that from your *python3* installation to `/opt/local/bin/python`. This will allow you to avoid modifying your python scripts again and again after each synchronization with the GitHub repository when you will update your AMSTer Toolbox. If AMSTer was installed by the installer script, this should be done by default for you. Here are some python scripts used in AMSTer Toolbox :

- *00_RasterPixelCoord.py*
- *checkOnlyNaN.py*
- ***FLIPproducts.py.sh*** and ***FLOPproducts.py.sh***
- *MeanCoh.py* and *MeanAmpl.py*
- *Norm.py*
- *NaN2zero.py* and *zero2NaN.py*
- *byte2float.py* and *float2byte.py*
- *Mask_Builder.py*
- *FiltMedian.py*
- *flip_raster.py*
- etc...

Note: *python2* might not be compatible because it had several differences with *python3*, e.g. (see web for more info):

	Python V2	Python V3
print	print "your text"	print ("your text")
xrange	xrange	range

Note for Linux users:

It may happen that *opencv* does not install properly with Ubuntu. The following page explains how to manually compile it:

https://docs.opencv.org/4.x/d2/de6/tutorial_py_setup_in_ubuntu.html

0.12) Dependencies:

AMSTer needs at least the following:

- AMSTerEngine (ensure to get the latest version).
- MSBAS at least V2: cfr Sergey's web page, in "Research Interest": <http://www.insar.ca>
- *Fiji* ([ImageJ](#))
- ***sed, awk, grep, seq, find, date, uniq, stat, readlink, xargs...***: these commands are usually provided by default on most of the Linux and Mac computers. However, some version (e.g. on Mac computers) are not fully compatible with gnu version and syntax may slightly vary. For the sake of portability, scripts are developed for gnu version of these functions.

They are expected:

- to be stored in a specific directory ***\$(PATHGNU)*** (see description of the state variables below).
- to be named with a "g" (e.g. ***gsed*** instead of ***sed***), at least for ***sed, awk, grep, date, stat***.

These functions are called in the scripts with their path, e.g. ***\$(PATHGNU)gsed*** (see description of the state variables below).

As a consequence, it is **MANDATORY** to have these functions installed (or copied or linked) in a directory that will be defined as the ***\$(PATHGNU)*** state variable in your ***.bashrc*** (avoid using ***.bash_profile*** because all scripts that needs your state variable call ***.bashrc***; if needed, link them). Just in case one of these functions would be called without its g-name in a script, it is **recommended** to have them in ***\$(PATHGNU)*** with **both names**, that is with and without heading g (that is ***sed*** and ***gsed***, ***awk*** and ***gawk***, ***grep*** and ***ggrep***, ***date*** and ***gdate***, ***stat*** and ***gstat***).

This can be simply done with a link.

If you installed AMSTer with the installer, this should have been done for you.

- ***convert*** (from [ImageMagick](#))
- ***bc***
- ***gmt***, ***gdal***
- ***snaphu***.
- ***cpxfiddle***: see https://github.com/TUDelftGeodesy/Doris/tree/master/sar_tools.
- ***Python3***
- ***gnuplot***
- ***osascript*** (Mac) or ***x-terminal-emulator*** (Linux)
- ***XnView*** or ***GIMP*** (or equivalent, to open sun raster files)
- If you process ENVISAT and/or S1 data, you will of course require their orbits and they will have to be stored in the appropriate directory (see state variables below).

0.13) Environmental (state) variables:

To operate, your `.bashrc` (if you use `.bash_profile` link it to `.bashrc` because all scripts that need you state variables etc call `.bashrc`) must be updated with the following state variables. If you installed AMSTer with the installer, this should have been done for you.

Beware of the spelling!:

- **\$PATH_SCRIPTS:**

Define the path to the folder containing the AMSTer *scripts* (named `SCRIPTS_MT`), i.e. add the following line to your profile:

```
export PATH_SCRIPTS=${HOME}/SAR/AMSTer
```

Note: the scripts MUST be stored in a directory named `SCRIPTS_MT`. Hence, they will be located in: `/${HOME}/SAR/AMSTer/SCRIPTS_MT`

- **\$PATHGNU:**

Define the path to the gnu version of executable `gsed`, `gawk`, `grep`, `gnuplot`, `gseq`, `find` and `gdate`, i.e. add a line like this to your profile:

```
export PATHGNU=/opt/local/bin
```

Note: ensure that `/opt/local/bin` is in your path before the `/usr/bin` to ensure that it would in priority take into account your GNU commands in case of doubt.

- **\$PATHFIJI:**

Define the path to the executable `Fiji` (which is `ImageJ`), i.e. add a line like this to your profile (for Mac):

```
export PATHFIJI=/Applications/Fiji.app/Contents/MacOS
```

- **\$PATHCONV:**

Define the path to the executable `convert` (which is a function of `ImageMagick`), i.e. add a line like this to your profile:

```
export PATHCONV=/opt/local/bin
```

- **\$PATHTOCPXFIDDLE:**

Define the path to the executable `cpxfiddle`, i.e. add a line like this to your profile:

```
export PATHTOCPXFIDDLE=/usr/local/bin
```

- **\$PATH_1650, \$PATH_3600, \$PATH_3601 and \$PATH_3602:**

Define the path to 4 disks where the scripts are supposed to find some directories. Although naming `1650`, `3600`, `3601` and `3602` is associated to servers at ECGS, it might be the easiest solution for you to keep this naming as it is used nearly everywhere. Also, even if you do not work with 4 separate disks, it is required to have these 4 variables (see below “Expected architecture of disks”). E.g (for Mac):

```
export PATH_1650=/Volumes/hp-1650-Data_Share1
export PATH_3600=/Volumes/hp-D3600-Data_Share1
export PATH_3601=/Volumes/hp-D3601-Data_RAID6
export PATH_3602=/Volumes/hp-D3602-Data_RAID5
```

- **\$PATH_DataSAR:**

Define the path to a disk where mandatory data will be stored, e.g in a directory named `SAR_AUX_FILES` that will contain:

- **DEM**: directory that contains the digital elevation model(s)
- **EGM**: directory that contains the geoid information
- **MASKS**: directory that contains the mask(s) if required
- **ORBITS**: directory that contains the ENVISAT and/or Sentinel1 orbits

- **\$ENVISAT_PRECISES_ORBITS_DIR:**

Define the path to the folder containing the Envisat orbits, i.e. add the following line to your profile:

```
ENVISAT_PRECISES_ORBITS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/ORBITS/ENV_ORB
```

- **\$S1_ORBITS_DIR:**

Define the path to the folders containing the Restituted (i.e. fast) and Precise Sentinel 1 orbits, i.e. add the following line to your profile:

```
export S1_ORBITS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/ORBITS/S1_ORB
```

Note that the function ***updateS1Orbits*** will automatically create in that directory the following 2 directories to store respectively the Precise and Restituted orbits: **/AUX_POEORB** and **/AUX_RESORB**

- **\$EXTERNAL_MASKS_DIR:**

Define the path to the folder where AMSTer Engine will create the masks. (See notes below in 0.15).

- **\$EXTERNAL_DEMS_DIR:**

Define the path to the folder where **getSRTMDEM** function will create the DEMs. (See notes below in 0.14).

- **\$EXTERNAL_MODELS_DIR:**

Not used yet: Define the path to the folder where AMSTer Engine will images with deformation models to be removed from observed deformation.

- **\$EARTH_GRAVITATIONAL_MODELS_DIR:**

Define the path to the folders containing a directory named **EGM**. This must contain the geoid file **WW15MGH.DAC** in a sub directory **EGM96**. The geoid will be mandatory to correct the DEM heights from the geoid heights.

For this, Earth Gravity Model EGM96 **WW15MGH.DAC** must be downloaded from site below and stored in that **\$EARTH_GRAVITATIONAL_MODELS_DIR/EGM96** (link checked 05 10 2022):

<https://web.archive.org/web/20130314064801/http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm96/binary/WW15MGH.DAC>

```
export EARTH_GRAVITATIONAL_MODELS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/EGM
```

- **\$PATH**

Add to your \$PATH the path to the folders containing respectively the **AMSTerEngine** and **msbas** software and to folder containing AMSTer Toolbox scripts (**SCRIPTS_MT**), utilities scripts (**zz_Utilities_MT**), EXEC (used during installation by the installer script)... i.e. add lines like this to your profile:

```
PATH=$PATH:/Users/nicolas/SAR/EXEC
PATH=$PATH:/Users/nicolas/SAR/AMSTer/MSBAS
PATH=$PATH:/Users/nicolas/SAR/AMSTer/AMSTerEngine
PATH=$PATH:/Users/nicolas/SAR/AMSTer/SCRIPTS_MT/zz_Utilities_MT_Ndo
PATH=$PATH:/Users/nicolas/SAR/AMSTer/SCRIPTS_MT/zz_Utilities_MT
PATH=$PATH:/Users/nicolas/SAR/AMSTer/SCRIPTS_MT/_cron_scripts
PATH=$PATH:/Users/nicolas/SAR/AMSTer/SCRIPTS_MT/AMSTerOrganizer
PATH=$PATH:/Users/nicolas/SAR/AMSTer/SCRIPTS_MT/optimtoolbox
PATH=$PATH:/Users/nicolas/SAR/AMSTer/SCRIPTS_MT/diagtoolbox
PATH=$PATH:/Users/nicolas/SAR/AMSTer/SCRIPTS_MT
```

Hence you should have something in your **.bashrc** such as :

For a Mac installation:

```
[...]
PATH="$PATH:/opt/local/bin:/usr/local/bin:/usr/bin:/bin:/usr/sbin:/sbin"

# AMSTer PATHS
#####
PATH=$PATH:/Users/YourAccount/SAR/EXEC
PATH=$PATH:/Users/YourAccount/SAR/AMSTer/MSBAS
PATH=$PATH:/Users/YourAccount/SAR/AMSTer/AMSTerEngine
PATH=$PATH:/Users/YourAccount/SAR/AMSTer/SCRIPTS_MT
PATH=$PATH:/YourAccount/doris/SAR/AMSTer/SCRIPTS_MT/AMSTerOrganizer
PATH=$PATH:/Users/YourAccount/SAR/AMSTer/SCRIPTS_MT/zz_Utils_MTNdo
PATH=$PATH:/Users/YourAccount/SAR/AMSTer/SCRIPTS_MT/zz_Utils_MT
PATH=$PATH:/Users/YourAccount/SAR/AMSTer/SCRIPTS_MT/_cron_scripts
PATH=$PATH:/Users/YourAccount/SAR/AMSTer/SCRIPTS_MT/optimtoolbox
PATH=$PATH:/Users/YourAccount/SAR/AMSTer/SCRIPTS_MT/diagtoolbox

# AMSTer VARIABLES
#####
export PATH_HOMEData=/Users/YourAccount/
export PATH_3602=/Volumes/hp-D3602-Data_RAID5/
export PATH_3601=/Volumes/hp-D3601-Data_RAID6/
export PATH_3600=/Volumes/hp-D3600-Data_Share1/
export PATH_1650=/Volumes/hp-1650-Data_Share1/
export PATH_DataSAR=/Volumes/DataSAR/

export EARTH_GRAVITATIONAL_MODELS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/EGM
export ENVISAT_PRECISES_ORBITS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/ORBITS/ENV_ORB
export S1_ORBITS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/ORBITS/S1_ORB

export EXTERNAL_MASKS_DIR=/Users/YourAccount/YourPath/MASKS/
export EXTERNAL_DEMS_DIR=/Users/YourAccount/YourPath/DEMS/

export PATH_SCRIPTS=/Users/YourAccount/SAR/AMSTer
export PATHCONV=/opt/local/bin
export PATHFiji=/Applications/Fiji.app/Contents/MacOS/
export PATHGNU=/opt/local/bin
export PATHTOCPXFIDDLE=/Users/YourAccount/SAR/EXEC/
export PATH=$PATH
```

Attention: PATH_SCRIPTS should **not** be PATH_SCRIPTS=\${HOME}/SAR/AMSTer/SCRIPTS_MT

For a Linux installation:

```
[...]

# If not running interactively, don't do anything
#case $- in
#      *i*) ;;
#      *) return;;
#esac

[...]

PATH="/usr/local/bin/:/opt/local/bin:/usr/bin:/bin:/usr/sbin:/sbin"

# AMSTer PATHS
#####
PATH=$PATH:/usr/local/tigervnc/bin/
PATH=$PATH:/home/YourAccount/SAR/EXEC
PATH=$PATH:/home/YourAccount/SAR/AMSTer/MSBAS
PATH=$PATH:/home/YourAccount/SAR/AMSTer/AMSTerEngine
PATH=$PATH:/home/YourAccount/SAR/AMSTer/SCRIPTS_MT
PATH=$PATH:/home/YourAccount/SAR/AMSTer/SCRIPTS_MT/AMSTerOrganizer
PATH=$PATH:/home/YourAccount/SAR/AMSTer/SCRIPTS_MT/zz_Utils_MT_Ndo
PATH=$PATH:/home/YourAccount/SAR/AMSTer/SCRIPTS_MT/zz_Utils_MT
PATH=$PATH:/home/YourAccount/SAR/AMSTer/SCRIPTS_MT/_cron_scripts
PATH=$PATH:/home/YourAccount/SAR/AMSTer/SCRIPTS_MT/optimtoolbox

# AMSTer VARIABLES
#####
export OPENBLAS_NUM_THREADS=1
export JAVA_HOME="/usr/lib/jvm/java-11-openjdk-amd64"
export PATH_3602=/mnt/3602/
export PATH_3601=/mnt/3601/
export PATH_3600=/mnt/3600/
export PATH_1650=/mnt/1650/
export PATH_DataSAR=/mnt/syno_sar/

export EARTH_GRAVITATIONAL_MODELS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/EGM
export ENVISAT_PRECISES_ORBITS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/ORBITS/ENV_ORB
export S1_ORBITS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/ORBITS/S1_ORB

export EXTERNAL_MASKS_DIR=/Users/YourAccount/YourPath/MASKS/
export EXTERNAL_DEMS_DIR=/Users/YourAccount/YourPath/DEMS/

export PATH_SCRIPTS=/home/YourAccount/SAR/AMSTer
export PATHCONV=/usr/bin
export PATHFiji=/home/YourAccount/SAR/EXEC/Fiji.app/
export PATHGNU=/usr/bin
export PATHTOCPXFIDDLE=/home/nicolas/SAR/EXEC/
export PATH=$PATH
```

Attention: PATH_SCRIPTS should **not** be PATH_SCRIPTS=\${HOME}/SAR/AMSTer/SCRIPTS_MT

See also installation notes:

[Install_AMSTer_Mac_Vx.x.pdf](#), or
[Install_AMSTer_Linux_Vx.x.pdf](#)

where **x.x** is the number of the latest version of that manual.

0.14) The external DEM:

To perform differential interferometry, AMSTerEngine requires an external DEM operates (unless you need to create a DEM based on interferometric pairs; see usage of **SinglePair.sh** in TOPO mode).

That DEM must have the following specificities:

- As most -if not all- the InSAR processors, AMSTerEngine requires a DEM with reference to ellipsoidal heights, not to the geoid. If this is not the case, altitudes being wrongly interpreted, small offsets will be visible at geocoding.
- The DEM is expected to be in the mathematical order (i.e. not the GIS order)

AMSTerEngine format will be composed of a binary matrix and a header file named with a .txt extension.

With version of AMSTerEngine < October 2024:

If you do have SRTM tiles, the DEM can be created using **aggregateSRTMTiles** function from AMSTerEngine to stitch them and transform them in the appropriate format (see procedure below).

Since May 2022, the function **aggregateSRTMTiles** also correct the heights from the difference between ellipsoidal and geoidal heights.

Older version did not correct the SRTM from the geoidal height. However, **aggregateSRTMTiles** can also be used to apply a posteriori that geoidal height correction to DEM in AMSTerEngine format by launching the following command:

aggregateSRTMTiles \$PATH_DataSAR/SAR_AUX_FILES/DEM/DEM_REGION/dem_name_to_correct

It will then modify the DEM accordingly and change the .txt file by adding a line confirming that the DEM is related to the ellipsoid.

With version of AMSTerEngine > October 2024:

The DEM can be created using **getSRTMDEM** function from AMSTerEngine. It will download the SRTM tiles from NASA web site and create a DEM directly in the appropriate format. The DEM is corrected from the difference between ellipsoidal and geoidal heights (see procedure below).

The function downloads only the SRTM tiles encompassing a given *kml* from NASA servers, aggregate them and save the DEM within the DEM directory given as a second parameter. The DEM will have the same name than the given kml.

SRTM tiles are fetched from:

https://e4ftl01.cr.usgs.gov/MEASURES/NASADEM_HGT.001/2000.02.11/

Your credentials must be saved in a *.netrc* file.

Note: if **EXTERNAL_MASKS_DIR** environmental variable is defined, a waterBody mask will also be saved there.

getSRTMDEM can also be used to apply a posteriori the geoidal height correction to DEM in AMSTerEngine format by launching the following command:

getSRTMDEM \$PATH_DataSAR/SAR_AUX_FILES/DEM/DEM_REGION/dem_name_to_correct

It will then modify the DEM accordingly and change the .txt file by adding a line confirming that the DEM is related to the ellipsoid.

Note: If you run several times the command to correct a DEM from the geoidal height, it will not change the reference of the DEM several times (as long as the .txt file contains the line saying that the correction has already been applied).

Note: to apply the geoid correction, an Earth Gravity Model (e.g. EGM96 geoid) must be stored in **\$PATH_DataSAR/SAR_AUX_FILES/DEMS** (see below).

The EGM96 file named **WW15MGH.DAC** can be downloaded from (link checked 05 10 2022):

<https://web.archive.org/web/20130314064801/http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm96/binary/WW15MGH.DAC>

To create a DEM from srtm tiles:

With **AMSTerEngine** version from October 2024, you can directly download the SRTM tiles and stitch them as follow:

Launch the AMSTerEngine function **getSRTMDEM** as follow

getSRTMDEM /Path/To/your.kml [/Path/WhereTo/Store/yourDEM/]

where

- **/Path/To/your.kml** is the path to the kml encompassing the region for which you need a DEM
- **/Path/WhereTo/Store/yourDEM/** (optional) is the optional path to the directory where to store the DEM.

If no path to a directory where to store the DEM is provided, it will create the DEM in the directory defined by the **EXTERNAL_DEMS_DIR** state variable defined in your **.bashrc** (.e.g.: `export EXTERNAL_DEMS_DIR=/YourPath/DEMS`).

In that case, it is **strongly advised to move (and rename if needed)** the created DEM to a directory from where you will call it in the **ParametersFile.txt** files. By default, the DEM will have the same name than the given kml.

If you move the DEM, **remember to change the path** indicated in the **DEM.txt** file accordingly to the new place where the DEM is stored.

Note:

if an **EXTERNAL_MASKS_DIR** environmental variable is defined in your **.bashrc** (.e.g.: `export EXTERNAL_MASKS_DIR=/YourPath/MASKS`), a waterBody mask will also be saved in that **EXTERNAL_MASKS_DIR**. In that case, it is also **strongly advised to move (and rename if needed)** the created mask to a directory from where you will call it in the **ParametersFile.txt** files. If you move the mask, **remember to change the path** indicated in the **MaskWB.txt** file accordingly to the new place where the mask is stored.

The function **getSRTMDEM** downloads only the SRTM tiles encompassing the given **kml** from NASA servers https://e4ftl01.cr.usgs.gov/MEASURES/NASADEM_HGT.001/2000.02.11/.

Your credentials must be saved in a **.netrc** file that contains a line such as:

`machine e4ftl01.cr.usgs.gov login yourlogin password yourpwd`

If you already have srtm1 tiles in **BIL format**:

- Move the srtm1 tiles in a dedicated dir (e.g. **\$PATH_DataSAR/SAR_AUX_FILES/DEM/DEM_REGION**).
- Decompress the files and delete the zip files. You stay with several subdirs where .bil, .blw, .hdr and .prj files are stored for each tile.

- Ensure you have in your `.bashrc` a state variable named:
`EARTH_GRAVITATIONAL_MODELS_DIR=$PATH_DataSAR/SAR_AUX_FILES`
and that it contains a directory named `/EGM96` that contains the Geoid file named
`WW15MGH.DAC` (downloaded from web).
- Launch the command:
`aggregateSRTMTiles $PATH_DataSAR/SAR_AUX_FILES/DEM/DEM_REGION`
with AMSTerEngine version < October 2024, or
`getSRTMDEM $PATH_DataSAR/SAR_AUX_FILES/DEM/DEM_REGION`
with AMSTerEngine version from October 2024
- After a while you will find two files named by the same way as the directory with and without `.txt` extension. The one without extension is the DEM and the one with the `.txt` extension is the one that contains the details about the DEM and which is used for filling the `slantRange.txt` file during the AMSTer processing.
- If you move the DEM, it is advised to change the path indicated in the `DEM.txt` file accordingly to the new place where the DEM is stored.

To create a DEM from another source:

If you have an external DEM created from any other source than srtm, you can convert it in the appropriate format using the script `DEM_Envi_hdr2AMSTer_txt.sh`. That script allows to convert tif or ENVI DEM in format expected by AMSTerEngine, that is in mathematical order, and referred to the ellipsoid (see below).

For instance, if you need to transform a `Copernicus DEM` into AMSTer format `DEM`, you will need to:

- Download the tif tiles
- Merge them with QGIS for instance
(Processing toolbox -> GDAL/OGR -> Miscellaneous -> Merge as Float32, BIL or tif)
- run the following command:
`DEM_Envi_hdr2AMSTer_txt.sh YOUR_PATH_TO/Your_COPERNICUS_DEM.tif`

And because, following the Copernicus documentation³,

- o the horizontal reference datum is WGS84-G1150; EPSG 4326
- o the vertical reference datum is the Earth Gravitational Model 2008 (EGM2008; EPSG 3855), that is EGM2008 geoid undulation values with respect to WGS84,

when the script will ask you if “*your DEM referred to the Ellipsoid (E), Geoid (G) or you do not know (Q)*”, you will have to answer `G` (for Geoid). It will then refer your Copernicus DEM in AMSTer format to the Ellipsoid as expected by AMSTer.

Attention: there are two types of ENVI formats, both made of a binary matrix and a text header with a `.hdr` extension, but with different coordinate reference:

- the ESRI ArcGis: the coordinate of a pixel is the coordinate of its centre (as geotiff format or as for AMSTerEngine format when provided with a `.txt` DEM)
- the ENVI HARRIS: the coordinate of a pixel is the coordinate of its top left corner.

AMSTer expects files in ENVI HARRIS format when provided with a ENVI DEM.

AMSTer creates geocoded files in ENVI HARRIS format.

³ https://spacedata.copernicus.eu/documents/20126/0/GEO1988-CopernicusDEM-SPE-002_ProductHandbook_I1.00.pdf

One can distinguish them by their hdr file (see below).

Although these two ENVI formats are very similar, that small difference in the way they referred the coordinate of a pixel may introduce geocoging error if not properly taken into account.

The script **DEM_Envi_hdr2AMSTer_txt.sh** (which uses a python script [flip_raster.py](#) by Warmerdam & Perry) can manage geotif and both types of ENVI format and will take care of that difference of reference. Just beware that if you create artificially your ENVI format, you must ensure that you create the header in the form that corresponds to your reference.

Example of ESRI ArcGis header file:

(see <https://desktop.arcgis.com/en/arcmap/10.3/manage-data/raster-and-images/bil-bip-and-bsq-raster-files.htm>):

For instance, it uses *nrows* and *ncols* for image size.

```
Sample BIL header file
Lines that don't begin with a keyword are treated as comments.
nrows 1024  Comments can be placed here as well.
ncols 1024
nbands 3
nbits 8
layout bil
skipbytes 128
```

Example of ENVI HARRIS header file

(see <https://www.l3harrisgeospatial.com/docs/enviheaderfiles.html>):

For instance, it uses *lines* and *samples* for image size.

```
description = {
    Registration Result. Method1st degree Polynomial w/ nearest neighbor [Wed Dec 20
23:59:19 1995] }
samples = 709
lines = 946
bands = 7
header offset = 0
file type = ENVI Standard
data type = 1
interleave = bsq
sensor type = Landsat TM
byte order = 0
map info = {UTM, 1, 1, 295380.000, 4763640.000, 30.000000, 30.000000, 13, North}
z plot range = {0.00, 255.00}
z plot titles = {Wavelength, Reflectance}
pixel size = {30.000000, 30.000000}
default stretch = 5.0% linear
band names = {
    Warp (Band 1:rs_tm.img), Warp (Band 2:rs_tm.img), Warp (Band 3:rs_tm.img), Warp
(Band 4:rs_tm.img), Warp (Band 5:rs_tm.img), Warp (Band 6:rs_tm.img), Warp (Band
7:rs_tm.img)}
wavelength = {
    0.485000, 0.560000, 0.660000, 0.830000, 1.650000, 11.400000, 2.215000}
fwhm = {
    0.070000, 0.080000, 0.060000, 0.140000, 0.200000, 2.100000, 0.270000}
```

0.15) The masks:

Since November 2024, AMSTer can incorporate multiple masks with different resolutions and footprints for use at various processing stages, e.g.:

- always masking pixels over certain areas e.g., for water bodies (named water bodies or geographical mask),
- and/or masking pixels during unwrapping if coherence remains below a specified threshold (named coherence threshold mask),
- and/or masking pixels during residual phase ramp computation (detrending), e.g. excluding deforming areas from detrend calculation (named detrend masks). These masks for detrending must be stored in a dedicated directory and named as:

eventMask YYYYMMDDThhmmss_YYYYMMDDThhmmss_Whatever_You_Want.raw
eventMask YYYYMMDDThhmmss_YYYYMMDDThhmmss_Whatever_You_Want.hdr

where **YYYYMMDDThhmmss**'s are date&time of beginning and end of expected deformation to be masked.

All these 3 types of masks (coded with different values, e.g. 1, 2 and 3 to mask respectively and with 0 = to keep) will be combined and projected in the geometry of the Primary image at the occasion of the coregistration step:

- Water bodies and coherence threshold mask (if applicable) will be combined and projected in slant range geometry of the Primary image. They will be stored in a file named **externalSlantRange** in the **/SAR_CSR/SAT/TRK/YYYYMMDD.csl/Data** directory of the Primary image.

Note: To avoid recomputing the same mask multiple times, the **externalSlantRange** file (default name required by the AMSTer Engine) will be implemented as a symbolic link. This link will point to the combined mask file, which is automatically named with additional details indicating the name of the specific masks that were combined, e.g. something like: **externalSlantRange_NameOfWaterBodiesMask_NameOfCohMask**

Similarly, default **/SAR_CSR/SAT/TRK/YYYYMMDD.csl/Info/externalSlantRangeDEM.txt** is copied as **externalSlantRangeDEM_NameOfWaterBodiesMask_NameOfCohMask.txt** for backup and re-use if needed.

- All the detrend masks used during the detrending step, located in the designated directory, will also be projected and stored in the **/SAR_CSR/SAT/TRK/YYYYMMDD.csl/Data** directory of the Primary image.

However, these masks are not combined within the **externalSlantRange** file. This is because the combination of detrend masks depends on the dates of the Primary and the Secondary images. Consequently, the final detrend mask (created by combining all detrend masks whose dates fall within the Primary-Secondary date range) will only be generated in the pair directory during the interferometric computation process.

Water bodies masks can be created automatically by the function **getSRTMDEM** at the same time as creating the DEM using srtm tiles, providing that the state variable **\$EXTERNAL_DEMS_DIR** is defined in the **.bashrc**.

Coherence mask is used during the unwrapping process in conjunction with a parameter named **COHCLNTHRESH** (defined in **LaunchMTparam.txt**), which tells **snaphu** to give no weight to pixels where the coherence is below that value (see also the paragraph 3.4 about **MultiLaunch_ForMask.sh**). This can influence the masking process as follows: pixels with mask = 0 will always be kept. However, pixels with mask = 2 will normally be masked UNLESS their coherence is above that threshold. Hence, during a mass processing, you can recover some good quality pixels for some pairs while they are usually of bad coherence and hence masked for all the other ones.

The 3 types of masks can also be created with whatever method you want, keeping in mind that:

- they must be in Bytes, filled with
 - 0 (to keep),
 - 1 (to always mask), and/or
 - 2 (to mask at unwrapping if coherence is below a provided threshold), and/or
 - 3 (to mask at detrending)
- they must be ENVI Harris (not ESRI) format (!)
- they must be in Lat Long (not UTM !)
- the mask can NOT contain NaN !!
- they can be of any resolution and footprint.

These masks must be defined for usage in [LaunchMTparam.txt](#) version >20241015 with their path/name and masking value.

Note that a same mask that would contain two different masking values, can be used for water bodies and coherence threshold. One just must define in the [LaunchMTparam.txt](#) the appropriate masking value for each of the type of masking (see e.g. A.1).

Former versions of AMSTer had a slightly different mask usage, used at the unwrapping step only:

AMSTerEngine < V20230928:

A weight 0 is given to masked pixels during the unwrapping process (1 = to keep). If the unwrapping is performed with [snaphu](#), the deformation maps are then multiplied by the mask in order to only display the trusted pixels.

The expects a mask must have the following characteristics:

- the mask must be in Bytes, filled with 1 (to keep) or 0 (to mask)
- the mask must be ENVI Harris (not ESRI) format (!)
- the name of the mask **must have no extension** compared to its header, e.g.
[name_of_your_mask.what_ever_your_want](#)
[name_of_your_mask.what_ever_your_want.hdr](#)
- the zone must be GREATER than image,
- the mask must be in Lat Long (not UTM !)
- the mask can NOT contain NaN !!

Note : The mask is used during the unwrapping process in conjunction with a parameter named **COHCLNTHRESH** (defined in [LaunchMTparam.txt](#)), which tells [snaphu](#) to give no weigh to pixels where the coherence is below that value (see also the paragraph 3.4 about [MultiLaunch_ForMask.sh](#)). This can influence the masking process as follow: pixels with mask = 1 will always be kept. However, pixels with mask = 0 will normally be masked UNLESS their coherence is above that threshold. Hence, during a mass processing, you can recover some good quality pixels for some pairs while they are usually of bad coherence and hence masked for all the other ones.

Having said so, if your mask is aiming at filtering out pixels where you NEVER want any information (e.g. on water bodies), then you must set the **COHCLNTHRESH** = 1, so that it will never use pixels where mask = 0.

Unfortunately, if you mask combines regions where you never want any information (e.g. water bodies) and regions where coherence is usually bad except at some occasions (e.g. vegetated areas, created by computing a mean coherence and keeping only the pixels with a value above a given threshold), by setting the **COHCLNTHRESH** = 1, you will never recover the information when

coherence is good enough. And if you set the **COHCLNTHRESH** to a value between 0 and 1, you will recover some pixels located where you never want to (e.g. the water bodies).

To solve this issue, the masking method was inverted since **AMSTerEngine V20230928**. From that version the **mask was inverted (0 = keep) and could contain two masking values**, that is:

- 0 is to keep (no mask applied)
- 1 is always masked (e.g. water bodies area)
- 2 is masked during unwrapping except if coherence is above a given threshold (see parameter **COHCLNTHRESH** in *LaunchMTparam.txt*)

You can find several scripts to create and/or transform files to such a kind of mask characteristics (see annexes).

Example to create masks for AMSTerEngine from 20241015:

1. **Mask for water bodies:** can be created automatically at the time of stitching strm tiles using **getSRTMDEM**. They can also be produced with any other method as long as it is Lat, Long, in bytes, and with 0 = keep and 1 = mask.
2. **Mask for coherence:** They can be produced with any method as long as it is Lat, Long, in bytes, and with 0 = keep and 2 (or another chosen value) = mask when coherence is below a given threshold (defined as parameter **COHCLNTHRESH** in *LaunchMTparam.txt*).
3. **Mask for detrending:** They can be produced with any method as long as it is Lat, Long, in bytes, and with 0 = keep and 3 (or another chosen value) = mask only when estimating the ramp at detrending step.

The “any method” mentioned here can be for instance like the method described below for the older versions of AMSTer Engine, based on shape files, providing that the masking values are adjusted to your needs.

Example to create mask for AMSTerEngine before V20230928:

Rough procedure to create a mask based on water bodies shape file.

1. Download a shape file
2. Process a **SinglePair.sh** with a **Forced** geocoding (no need to unwrap) on an area larger than the images you will need to mask
3. In **QGIS** import the shape file and a copy (because original file will be changed) of the coherence computed here above
4. RASTERIZE from GDAL toolbox:
 - Input layer = shape
 - Input raster = coherence
 - Fixed value to burn = 2
5. Raster Calculator:
 - If (coherence < 2 , 0 ,1)
 - Save as “mask”
 - Output format = ENVI.hdr (not ESRI !)
 - As Lat Long
(if needed, use the script **UTM2LL.sh**, which uses the gdal command **gdalwarp -of ENVI -t_srs EPSG:4326 UTMfileName LLfileName**)
6. Replace NaN with zeros in mask (e.g. using **Nan2zero.py**)
7. Transform floats to bytes (e.g. using **float2byte.py**)
8. Copy the **mask.hdr** as **mask.zeroBytes.hdr**
9. Edit **mask.zeroBytes.hdr** and change “data type = 4” with “data type = 1”

Example to create a 2-levels mask for AMSTerEngine from V20230928 to 20241015:

1. Invert your old water bodies mask using [*Change_Val.py*](#) (see script for usage) in order to change pixels with value = 1 as value = 2, then do it again to change the 0 in 1 and again to finally change the 2 in 0. Your new water bodies mask is now made of 0 (for pixels to keep) and 1 (for pixels to always mask). This can also be done in one step using [*InvertWaterMask.sh*](#) (see script).
2. Invert your mean coherence mask using [*Change_Val.py*](#) to change the 0 in 2, then the 1 in 0. Your new mean coherence mask is now made of 0 (pixels to keep) and 2 (pixels to mask if coherence is below [*COHCLNTHRESH*](#)). This can also be done in one step using [*InvertCohMask.sh*](#) (see script).
3. Combine (sum) the two masks in QGIS (because they probably do not have the same size) or with [*Combine_mask_Water_Coh.py*](#) (if they have the same size). The combined mask has now values 0, 1, 2 or 3.
4. Transform the combined mask (which is in float) into bytes using e.g. [*float2byte.py*](#)
5. Change the pixels with values 3 in 1 using [*Change_Val.py*](#). Your final product is now as expected: 0 means always keep, 1 means never keep, and 2 means pixels not to keep unless the coherence is above [*COHCLNTHRESH*](#).
6. Save your new mask e.g. as [*WaterBodies_CohAboveThresh_012*](#) in ENVI format (_012 is to remind that it is made of these 3 values).

0.16) Notes for Linux:

- See the document [Install_AMSTer_Linux_Vx.x.pdf](#) (where **x.x** is the number of the latest version of that manual).
 - Because in Linux `sed` is `gsed` anyway, copy or better, link `sed` as `gsed` in the same directory as where `gawk` is.
 - If you are running AMSTer on a **computer with more than 64 cores**, MSBAS inversion may crash because it is compiled to run with all the available cores. If more than 64 cores are available, it will use more than 128 threads. However, default Lapack library available for Ubuntu are compiled for max 128 threads. To circumvent that problem, either
 - compile manually Lapack (which contains CBLAS lib)⁴ and change the MSBAS make file to use these new compiled libraries⁵, or
 - launch the **`MSBAS.sh`** script with a limited number of threads(≤ 128), e.g.
`OMP_NUM_THREADS=128 MSBAS.sh`

⁴ E.g. install LAPACK from source:

```
 wget https://github.com/Reference-LAPACK/lapack/archive/refs/tags/v3.12.1.tar.gz mv v3.12.1.tar.gz lapack-v3.12.1.tar.gz tar -xvf lapack-v3.12.1.tar.gz
```

Compile LAPACK - use cmake with SHARED LIBS:

```
Compile LAPACK - use cmake with SHARED LIBS.  
cd ~/Downloads/Lapack/lapack-3.12.1/  
cmake -S . -B build -DBUILD_SHARED_LIBS=ON -DCMAKE_INSTALL_PREFIX=/$HOME/SAR/EXEC/LAPACK/ cmake --build build cd build make
```

> LAPACK libe will be installed into /\$HOME/SAP/EVNC/LAPACK/1.1.1/

⁵ E.g., `makefile` for `mabcsy4` for Linux with LAPACK compiled above.

- If you want to use some of the scripts with a cron, Linux may require defining the **PATH** state variables in a system-wide environment.

- Create a file in /etc/profile.d/, such as : /etc/profile.d/yourname_sar.sh
- Add your state variables in that file, e.g:

```

export PATH_1650="/mnt/1650"
export PATH_3600="/mnt/3600"
export PATH_3601="/mnt/3601"
export PATH_3602="/mnt/3602"

export PATH_SynoData="/mnt/syno_data"
export PATH_SCRIPTS="/home/nicolas/SAR"
export PATHGNU=/bin
export PATHFiji=$HOME/SAR/EXEC/Fiji.app/
export PATHCONV=/bin

export EARTH_GRAVITATIONAL_MODELS_DIR=$PATH_DataSAR/SAR_AUX_FILES
export S1_ORBITS_DIR="/mnt/3600/ORBITS/S1_ORB/AUX_POEORB"
export ENVISAT_PRECISES_ORBITS_DIR="/mnt/3600/ORBITS/ENV_ORB/vor_gdr_d"

alias gsed='sed'

PATH=$PATH:/home/nicolas/SAR:/home/nicolas/SAR/AMSTer/AMSTerEngine:/home/nicolas/SAR/AMSTer/SCRIPTS_MT
PATH=$PATH:/home/nicolas/SAR/AMSTer/MSBAS/

etc...

```

- In your crontab, launch your scripts as follow (at 12h00 in example):

00 12 * * * cd /full_path_to_the_dir_where_your_scripts_are/; bash -l -c './your_script.sh'

Another option (preferred) is to start your cron tab by defining the path, eg:

```

# m h dom mon dow command
SHELL=/bin/bash
BASH_ENV=~/bashrc

PATH_1650=/mnt/1650
PATH_3600=/mnt/3600
PATH_3601=/mnt/3601
PATH_3602=/mnt/3602
PATH_SynoData=/mnt/syno_data
PATH_DataSAR="/mnt/syno_sar"
PATH_HOMEDATA="/mnt/dell3/raid5"
PATH_SCRIPTS=/home/nicolas/SAR/AMSTer

S1_ORBITS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/ORBITS/S1_ORB
ENVISAT_PRECISES_ORBITS_DIR=/mnt/syno_sar/SAR_AUX_FILES/ORBITS/ENV_ORB
EARTH_GRAVITATIONAL_MODELS_DIR=$PATH_DataSAR/SAR_AUX_FILES/EGM
EXTERNAL_MASKS_DIR=/mnt/3600/SAR_TMP/MASKS/
EXTERNAL_DEMS_DIR=/mnt/3600/SAR_TMP/DEMS/

PATHGNU=/usr/bin
PATHCONV=/usr/bin
PATHFiji=$HOME/SAR/EXEC/Fiji.app/
PATHTOCPXFIDDLE=${HOME}/SAR/EXEC

# # # # Domuyo
15 00 * * * /home/nicolas/SAR/AMSTer/SCRIPTS_MT/_cron_scripts/Domuyo_S1_Step1_Read_SMCoreg_Pairs_DEMGoid.sh >
/dev/null 2>&1
45 02 * * * /home/nicolas/SAR/AMSTer/SCRIPTS_MT/_cron_scripts/Domuyo_S1_Step2_MassProc_DEMGoid.sh > /dev/null 2>&1
02 15 * * * /home/nicolas/SAR/AMSTer/SCRIPTS_MT/_cron_scripts/Domuyo_S1_Step3_MSBAS_DEMGoid.sh > /dev/null 2>&1

```

0.17) Expected architecture of disks:

For safety reasons, it is advised to store raw data and data in CSL format (i.e. from AMSTerEngine) on different hard drives. For the same reason, it is advised to store mass processing results and msbas times series on different hard drives.

AMSTer Toolbox expects the directory structure as below (**in red = mandatory**). Most of the directories where the intermediate and final results are stored will be created by the scripts. For those which must be created by the user, it is required to follow the following architecture and directories naming (again only the green must be adapted to your satellite(s), orbital mode(s) and region(s)) :

Disk 1 (i.e. PATH_1650):

PATH_1650/kml	: where to store kml for cropping, or for coherence check
PATH_1650/Param_files	: where to store your LaunchMTparam.tx file by <i>/SAT/TRK....</i>
PATH_1650/ SAR_CSR/SAT/TRK/NoCrop	: where data in csl format are stored (incl. crops)
PATH_1650/SAR_SM/AMPLITUDES/ SAT/TRK/Region	: where amplitudes gif will be computed
PATH_1650/ SAR_SM/MSBAS/Region	: where compatible pairs for msbas are computed
PATH_1650/ SAR_SM/RESAMPLED/SAT/TRK	: where data resampled on Global Primary are saved

Disk 2 (i.e. PATH_3600):

PATH_3600/ SAR_DATA/SAT/...	: where raw data are stored (safer to keep them on a different hard drive than 1650)
------------------------------------	--

Disk 3 (i.e. PATH_3601):

PATH_3601/ SAR_MASSPROCESS/SAT/TRK/Crop	: where directories with each pair computation details and results are stored
PATH_3601/ SAR_MASSPROCESS/SAT/TRK/Crop/Geocoded	: where geocoded maps are stored in sub dir by type (Amp, Coh, Defo...)
PATH_3601/ SAR_MASSPROCESS/SAT/TRK/Crop/GeocodedRasters	: where rasters of geocoded maps (for quick look) are stored

Disk 4 (i.e. PATH_3602):

PATH_3602/ MSBAS_RESULTS/Region	: where msbas series are computed
--	-----------------------------------

Maybe in one of these disks, or somewhere else where enough storage room is available:

PATH_DataSAR/ SAR_AUX_FILES/DEM	: where DEMs are stored
PATH_DataSAR/ SAR_AUX_FILES/EGM	: where geoid is stored
PATH_DataSAR/ SAR_AUX_FILES/MASKS/SAT/TRK	: where coherence masks are computed
PATH_DataSAR/ SAR_AUX_FILES/ORBITS/SAT	: where orbits are stored

You can of course decide to change the location of these mandatory directories. Ensure consistency with paths defined in the *LaunchMTparam.txt*.

Remember: **Do not use hard drives formatted in FAT format because it does not support symbolic links, which are widely used by AMSTer**

0.18) Organizing the work:

When properly installed, AMSTer should be easy to operate. The largest “difficulty” might be to remember where are stored the data, the auxiliary data, the configuration files, the scripts, the intermediate results etc..

To assist the user to figure out where all the files and results are, a small interface was developed using **pyqt6**. Note that **pyqt6 requires recent operating system (at least Mac OSX 12.6 Monterey or Ubuntu 22.04)**.

It can be opened by launching at the Terminal (which can be closed after it was launched) the script **AMSTerOrganizer.sh** (located in **SCRIPTS_MT/AMSTerOrganizer/**).

It will open a window organized in 5 sections as follow (see figure Figure 1):

1. Three (or more) rows of buttons are displayed at the top (separated by light grey line). Their name and function (i.e. the directory to which they refer) are defined in a config file names **SCRIPTS_MT/AMSTerOrganizer/config.txt**.

A good practice would be to define in the first row the buttons corresponding to the logical progression of data progressing:

- where the RAW data are stored,
- where the data transformed in CSL format are stored,
- where the data coregistered and RESAMPLED on a Global Primary are stored,
- where the lists of compatible pairs are computed,
- where the AMPLI images (coregistered on a Global Primary image, in radar geometry) are stored,
- where the results of the MASSPROCESS are stored,
- where the results of the MSBAS are stored.

If more than one target are considered (e.g. several regions, satellites or tracks) and files of each steps must be stored on different hard drives, one can have another layer of these buttons (see buttons RAW_DATA_Other_Zones Figure 1)

The second row of buttons could help locating:

- the mains SCRIPTS,
- the scripts used to launch CRON jobs,
- the directory where the **LaunchMTparam.txt** files are stored,
- the directory where the DEMs are stored,
- the directory where the MASKS are stored,
- the directory where the KML (e.g. for reading the data) are stored,
- the directory where the EVENTS (e.g. for plotting on the time series) are stored,
- the directory where the list of POINTS_TS are stored (for automatic plot at during MSBAS inversion).

The third row of buttons could be the disks where processing's are operated, that is a list of available disks or directories.

2. Below, a main window displays the content of the directory selected by a button above. One can navigate in that directory and its subdirectories (displayed in columns).
3. Further below, a line labelled “**Go To Dir Where To Run**” followed by two buttons labelled **GOTO** and **HOME**
4. Further below, a line labelled “**Select Command/Param To Run**” followed by a button labelled **ADD**

5. Finally, a window like a Terminal, with a “>” displayed as a prompt, and two buttons labelled **EXEC** and **CLEAR**.

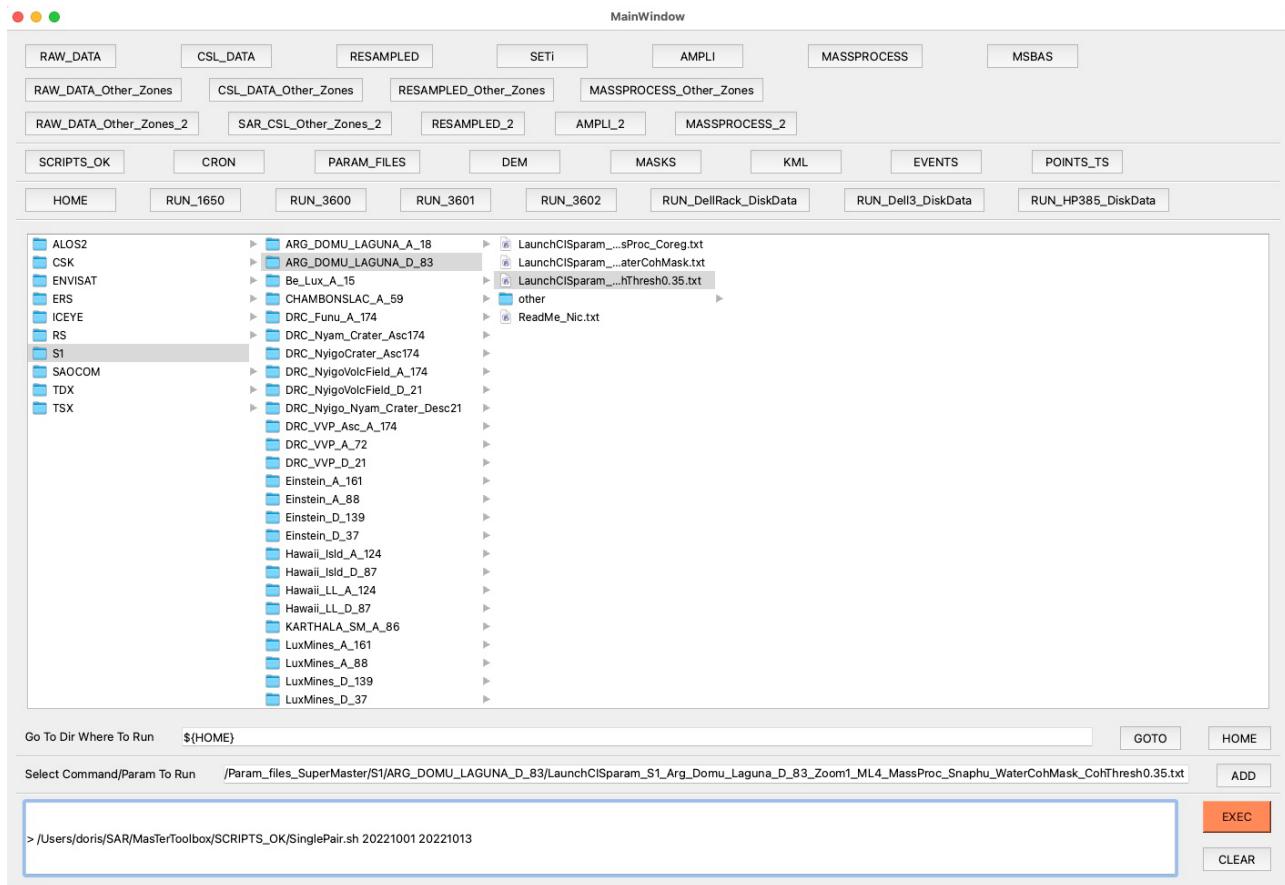


Figure 1: example of AMSTer Organizer window

The goal is to allow the user to find where the files are and to launch commands from the prompt in last section (at the bottom).

Suppose the user wants to launch the processing of a pair of Sentinel 1 data that are already read (i.e. transformed in CSL format).

To do so, the user must

- click on the button **SCRIPTS_MT** (first button of second layer of buttons) and locate for instance the script ***SinglePair.sh***. The path and name of that script will appear in the section 4 “**Select Command/Param To Run**”. By clicking on the button **ADD**, that path and name will appear in the Terminal in section 5.
- The user can then type in that section 5 after the name of the script, the date of the Primary and Secondary image he/she wants to compute. The user can check the date of these images by navigating for instance in the subdirs obtained by clicking on the 2nd button of first layer of buttons (**CSL_DATA**)
- Then the user must provide the script with the third expected parameter, which is the file containing all the parameters for the processing. That file can be located by pressing the button **PARAM_FILES** (3rd button of second layer of buttons). Again, by clicking **ADD**, that path and name will appear in the Terminal in section 5.
- The user can add an optional remark as 4th parameter by entering a string in the Terminal window.

- If the user press **EXEC**, the command will be executed in a Terminal window that will pop up and from the path that is visible in the 3rd section. In the example, that is **\$HOME**. If the user wants to run the command from another directory, he/she must simply navigate in the directories by pressing e.g. the buttons from the 3rd layer of buttons. When the location is found, the user must press the button **GOTO**. If the user press **HOME**, the script will be launched obviously back in **\$HOME**.

So far, the **AMSTerOrganizer.sh** does not allow to drag and drop files, delete files from the main windows, launch bash commands outside of a script etc..

The script requires **PyQT6** and the following python scripts: *main_window.py*, *start_app.py* and *Ui_main_window_man.py* (located in .../AMSTer/SCRIPTS_MT/AMSTerOrganizer).

0.19) Contributions:

DD wrote the AMSTerEngine software.

SS wrote the MSBAS software.

NdO wrote most of the AMSTer Toolbox scripts.

DS wrote the pair selection optimization module, the recursive unwrapping module and some other tools.

MJ wrote the web interface and the AMSTer Organizer module.

GC helped to debug, improve, compile several codes and hardware installation

The development of AMSTer commenced in the early 2010s and leveraged the capabilities of various pre-existing tools, including the CSL InSAR suite, which was fully remastered to be the MaSTerEngine, renamed later as AMSTerEngine (end of 2023).

Over time, the AMSTer underwent incremental enhancements, both independently and within the context of numerous projects, notably (unsorted) RESIST, MUZUBI, GEORISCA, SMMIP, TIGRES, ECTIC, MODUS, VERSUS, advInSAR, Vi-X... These projects were primarily funded by the Belgian Scientific Policy (BelSPo) and the Luxembourgish Fond National de la Recherche (FNR).

0.20) Acknowledgements:

The authors wish to address special thanks to:

- Benoît Smets, research scientist at the Royal Museum for Central Africa, who contributed as an efficient beta tester and provided the first version of the Linux installation manual.
- Antoine Dille, PhD at the Royal Museum for Central Africa and the Vrije Univ. Brussels, who contributed as an efficient beta tester and suggested several useful features such as the Python script to extract time series from QGIS.
- Ludivine Libert, who developed the initial tools required for preparing the baseline plots during her thesis at the Centre Spatial de Liège (Belgium).

0.21) General remarks:

- We can't repeat enough the importance of directory structure (and naming).
- The use of multiple disks is recommended both for safety (e.g. keep raw and CSL data on separate disks) and for speed (e.g. split processing on several disks). See directory structure).
- Sometimes **TRACK** is written **TRK** and **SATDIR** is written **SAT** in path in the present manual for the sake of brevity.
- Classical processing(s) will involve several main steps (Figure 2):
 - o Downloading the images and reading them in csl format
 - o Process interferograms from single pairs of images either for testing and selecting the best parameters before a mass processing, or for producing DEM, or simply because you may need only one interferogram...
 - o Selecting a Global Primary image (also named Super Master and dubbed SM in file or directory naming) and computing the list of all the pairs that would fit a spatial and temporal baseline threshold.
 - o The coregistration of all the images to the Global Primary
 - o The mass processing of all the interferograms
 - o The production of the time series
 - o The selection of the best parameters for the msbas processing
 - o The production of figures and graphs either for display on a web page or for processing in GIS software.



Figure 2: Work flow and corresponding directories infrastructure.

1. Download the SAR data

AMSTer is able to process automatically data that would be made available automatically and incrementally as the time passes. This is for instance possible for Sentinel 1 data that are put online as they are recorded. But of course, you can process any type of image and archives.

If you want to set up your own automated procedure, you will need a script to get the data automatically. An example is provided for the Sentinel 1 data, but you can develop your own scripts for other satellite.

If you are not interested by the incremental and continuous automatic processing, you can simply manually store your data.

In any case, if you manually deal with the archiving of satellite images in their native format or if you set up new scripts for that, it is important that the raw images are stored in directories with the same naming and/or structure. This is especially important for the S1 data that must be stored in a **S1-DATA-TARGET-SLC.UNZIP** directory where **TARGET** is the name of the region under concern, at least if you want to operate an automatic processing.

Of course, store only the same sort of data (region/footprint, track, mode, frequency, incidence...) in a given directory and name it in a smart way.

The following steps provide with some help to sort and store the data, depending on the satellites. **Attention, the naming of the satellite is important throughout the workflow.** It is mandatory to keep the same naming as provided here below and listed in Table 1 (e.g. use CSK instead of CosmoSkyMed).

Satellite	Name used by AMSTer
ALOS 1	ALOS
ALOS 2	ALOS2
CosmoSkyMed	CSK
ENVISAT	ENVISAT
ERS	ERS
ICEYE	ICEYE
KOMPSAT	KS or KOMPSAT
NISAR	NISAR
PAZ	PAZ
RADARSAT1	RS1 or RADARSAT1 ⁶
RADARSAT2	RS or RADARSAT ⁴
SAOCOM	SAOCOM
Sentinel-1	S1
TandDEM-X	TDX
TerraSAR-X	TSX

Table 1: List of satellite names to be used in AMSTer's workflow

1.1. CSK:

- download manually the images from ASI in .../SAR_DATA/CSK/Original/info (e.g. .../SAR_DATA/CSK/OriginalZip/Download_Jan2018).
The parameter **info** is chosen to help identifying the data and remembering where they come from or when they were downloaded. This is helpful because ASI usually does not provide meaningful naming in the data structure.
- change dir in .../SAR_DATA/CSK/Original/info
- run “**ReadDateCSK.sh**” in directory without any parameters (the script is in **zz_Utilitys_MT/**). For each image, it will read the date from the xml file located in the directory of the image and rename

⁶ If you choose the short or the long name, you should use the same throughout the whole workflow.

it by that date. The original name of the directory is kept as a file.txt within the image directory.

(For old images, as they came zipped, use [zz_Utilities_MT/Prepa_CSK.sh](#) that will first unzip the files and store them in a directory named by the date. Attention it will delete the gz files.).

(For images obtained from SuperSite, use [zz_Utilities_MT/Prepa_CSK_SuperSite.sh](#))

1.2. Sentinel 1:

Use a script (see example in [zz_Download_Sentinel/](#)) to download them e.g. in
[.../SAR_DATA/S1/S1-DATA-TARGET-SLC](#)
where [TARGET](#) depends on your area of interest.

It is recommended that your script unzip and move the images in an appropriate directory named
[.../SAR_DATA/S1/S1-DATA-TARGET-SLC.UNZIP](#)

(If need, see for instance the script [zz_Utilities_MT_Ndo/Unzip_S1.sh](#) aiming at decompressing all the S1 images from a directory provided as parameter and store them in a directory with the same name, though terminated by [.UNZIP](#). Note that the script tests if the files were already unzipped and if their size is as expected; if not, it unzips them again).

Note that at the step of reading the images, to avoid scanning increasing data base of images, the scripts will archive images older than 6 months in

[.../SAR_DATA/S1/S1-DATA-TARGET-SLC.UNZIP_FORMER/_YYYY](#)

Note also that the download of Sentinel 1 (and Sentinel 2 by the way) can also be achieved using AMSTer Engine function **SentinelDataDownloader**. You can build your own script for downloading S1 data with it. See usage by simply typing **SentinelDataDownloader** at the prompt.

Remember that these Sentinel 1 data require Restituted or Precise Orbit. Downloading these Precises (POE) and Restituted (RES) orbits is now performed from ESA or Alaska SAR Facility (ASF).

It requires:

- AMSTerEngine at least from [20231213](#) (with function **updateS1Orbits**)
- Orbit from ESA are available using a login and password obtained from <https://dataspace.copernicus.eu> (see chapter 0.8). With these credentials in your [.netrc](#) file, AMSTerEngine from [20231213](#) will download them for you without requiring further procedure.
- If you still want to use ASF orbits, procedure to download them is explained here:
<https://wiki.earthdata.nasa.gov/display/EL/How+To+Access+Data+With+cURL+And+Wget>
that is (see web page for details) :
 - Make an account to urs.earthdata.nasa.gov and get a [login](#) and [pwd](#)
 - While logged in,
 - click on "My Profile", then menu "Applications > Authorized Apps"
 - At the bottom, click on button "APPROVE MORE APPLICATIONS"
 - In the "Search" bar, type "Sentinel"
 - Click on "AUTHORIZE" button next to each application named with Sentinel 1.
 - In a terminal on your computer type :
> cd ~
> touch .netrc
> echo "machine urs.earthdata.nasa.gov login [login](#) password [pwd](#)" > .netrc
> chmod 0600 .netrc

Then

- ```
> cd ~
> touch .urs_cookies
```
- When access is granted to ASF facility, use **updateS1Orbits -ASF** the same way.

- Ensure that you have **S1\_ORBITS\_DIR** as state variable in **.bashrc** for path to directory where orbits are stored (**./AUX\_POEORB** and **./AUX\_RESORB**).

### 1.3. Radarsat 2:

Download images manually and store them in  
**.../SAR\_DATA/RADARSAT/MODE**

### 1.4. TSX-TDX:

These images are acquired in several modes and footprints. Store them appropriately in directories named after their characteristics, e.g.:

**.../SAR\_DATA/TSX/MODE**

or

**.../SAR\_DATA/TDX/MODE**

You may want to use the script **Prepa\_TSX.sh** to change the name of the raw image directories and check their acquisition modes and/or footprints.

### 1.5. ENVISAT and ERS:

Download images manually and store them in  
**.../SAR\_DATA/ENVISAT/MODE**

Note: data downloaded on ESA web site after termination of the ERS and ENVISAT missions might be stored in a different manner compared to when data were delivered after each acquisition during the operational phase of the mission. Each image must be stored in a subdirectory named by its orbit number. If it is not the case, run **MoveBulkEnvusat\_InSubDirs.sh** or **MoveBulkERS\_InSubDirs.sh** (in **zz\_Utilities\_MT\_Ndo**) prior reading the data.

### 1.6. KOMSAT:

Works mostly like CSK

### 1.7. PAZ:

Works mostly like TSX

### 1.8. RS1:

Radarsat-1 can be read and processed, though only in slant range. Hence, DInSAR can be performed in 3 passes mode but results can't be geocoded because external DEM can't be taken into account. This is related to the fact that the orbits of RS1 are provided in a different reference frame.

**1.9. SAOCOM:**

SAOCOM data made available by CONAE might mix several production dates for the same image. Each might be due to a re-focusing or a focusing along a new frame (different start/stop time). Because the file naming does not tell the user which image is what, one can download everything, and the reader will later take care of this.

**1.10. ICEYE:**

ICEYE data can be acquired along Ascending and Descending orbits, with a Right or Left looking direction, and with several different incidence angles. All the data can be stored in the same directory. They will be read and sorted automatically by the scripts here after.

Download images and store them in  
[.../SAR\\_DATA/ICEYE/MODE](#)

**1.11. NISAR:**

NISAR data can be acquired along Ascending and Descending orbits, with a Right or Left looking direction. All the data can be stored in the same directory. They will be read and sorted automatically by the scripts here after.

Download images and store them in  
[.../SAR\\_DATA/NISAR/MODE](#)

## 2. Reading all available images for each mode: *Read\_All\_Img.sh*

This step is aiming at reading all the SAR images available in a given directory for a given satellite in a given mode or track and store them in CSL format where they can be read by AMSTerEngine and used for further processing.

The AMSTerEngine image reader ingests unzipped images. For safety reason, it is recommended to save original (raw) data in native format and data read in .csl format on separate disks.

All images must be SLC (level 1). **AMSTer does not work with level 0 data.**

The process is done by launching the script ***Read\_All\_Img.sh*** with at least 3 parameters:

- the path to the folder where unzipped **raw** data are stored
- the path to the folder where **CSL** data will be stored
- the **satellite** (beware of the naming that must fit the directory naming, that is also the naming expected in the script – see Table 1 page 53)

More parameters might be necessary for some specific cases (there is no specific order in providing these options):

- for S1 and SAOCOM data: the path to a **kml** file delimiting the footprint of the area of interest. It will be used by the bulk reader to select all and only the S1 bursts that overlap that area of interest, or will be used by the bulk reader to crop the SAOCOM data during the reading.
- **ForceAllYears**: for S1 data, it will force the reader to read not only the last 6 months data that are stored in **/SAR\_DATA/S1-DATA\_YourPlace-SLC.UNZIP**, but also those stored in **/SAR\_DATA/S1-DATA\_YourPlace-SLC.UNZIP\_FORMER/\_yyyy** (where **yyyy** stands for each year of data already read and older than 6 months). Note that when **ForceAllYears** is used, it will also update all the S1 orbits (and not only those since the last update).
- **-n**: for S1 data, it will skip updating the S1 orbits (precise S1 orbits are made available about 3 weeks after the image acquisition).
- **RESAMPLED\_DIR**: for S1 data, the path to the directory that contains the data already resampled (**/SAR\_SM/RESAMPLED/**). The script will check over there which resampled data were computed with old orbits (or with FAST24 images) and move them to **/SAR\_SM/RESAMPLED/S1\_CLN**. Hence, at the next run of coregistering the data, AMSTer will recompute the resampling with the most accurate orbits.

Notes:

- The path **MUST** end with the **/RESAMPLED/** string (as expected anyway in the usual architecture)
- If no path is provided, it will NOT update the results, obviously
- The script will **flush that S1\_CLN directory** for files older than 180 days, which is a hard coded value in the script. If you need to save place on your hard disk, decrease that value or do it manually on a regular basis.
- **MASSPROCESS\_DIR**: for S1 data, the path to the directory that contains the InSAR pairs already computed (**/SAR\_MASSPROCESS/**). The script will check over there which pairs were computed with old orbits (or FAST24 images) and move them to **/SAR\_MASSPROCESS /S1\_CLN**. Hence, at the next run of mass processing the InSAR pairs, AMSTer will recompute them with the most accurate orbits.

Notes:

- The path **MUST** end with the **/SAR\_MASSPROCESS/** string (as expected anyway in the usual architecture)
- If no path is provided, it will NOT update the results, obviously
- The script will **flush that S1\_CLN directory** for files older than 180 days, which is a hard coded value in the script. If you need to save place on your hard disk, decrease that value or do it manually on a regular basis.
- **POL**: for S1 or SAOCOM data (**mandatory**), the preferred polarization (**VV**, **HH**, **VH**, **VV** or **ALLPOL**) in order to read only that polarity and spare room on disk. For S1, if a VV (or HH) polarization is requested but does not exist, it will try read HH (or VV) to avoid gaps in time series. Cross polarization for interferometry (e.g. VV-HH) may however be of a lesser quality.  
To force reading all the polarizations, use the parameter **ALLPOL**. Reading all the polarizations is however NOT RECOMMENDED for data used for mass processing for time series as it will take a lot of time and resources!



The script makes use of ***FUNCTIONS\_FOR\_MT.sh***, ***Check\_All\_S1\_ImgReadSize.sh***, ***List\_All\_S1\_ImgSize.sh*** and ***List\_S1\_Frames\_Swaths\_Bursts.sh***.

In order to keep track of the version of AMSTerEngine used to read the data, the script will store a small text file named ***Read\_w\_AMSTerEngine\_V.txt*** in ***.../SAR\_CS/MT/REGION/NoCrop/date.CSL/***. It contains a single line indicating the date of the last version of the software present in the ***/\$HOME/SAR/AMSTer/AMSTerEngine/\_Sources\_AE/Older***. It is supposed to be the last one that was compiles and hence the one currently used.

#### NOTES:

In principle, if the script is launched several times while some images may be added in the **raw** directory, it will only process the new data and ignore the images already read. At least, this should be the case

- For the data read using the bulk reader, that is Sentinel-1, SAOCOM, ICEYE and TDX
- For all the other satellites, which are read one by one, as long as the date of the images are included as *yyyymmdd* somewhere in the name of the raw image directory (or, for ALOS2, at least as *ymmd* in the name).

When raw images do not contain the date in their name, (e.g. for ALOS, TSX or CSK), it is strongly advised to run a preparatory script that will rename the raw image directories by their dates (and maybe check if / sort all the images that would be acquired in different modes or on different targets). See for instance ***Prepa\_CS.sh*** or ***Prepa\_TS.sh***. Depending on your needs, you may want/need to adapt these scripts.

Note that reading with bulk reader or one by one is defined in the script and is not an option. Bulk reader has the advantage of taking care of image that would be already read etc. but has the inconvenient to stop when it encounters a bad image. Reading one by one requires to check the data that would be already read. If it is not performed correctly, it will ask the user if one wants to overwrite the existing data each time the scripts encounter an image already processed with the same acquisition date.

Note: you can always check the characteristics of all the images in your directory [.../SAR\\_CSR/SAT/REGION](#) by running the script [\\_Check\\_CSR\\_Corners\\_Trk\\_etc.sh](#), which will log the main characteristics of all the images in a file named [List\\_Img\\_Characteristics.txt](#). That file logs the following characteristics read in the [/Info/SLCImageInfo.txt](#) of each image:

|                  |                                                                       |
|------------------|-----------------------------------------------------------------------|
| Date:            | The acquisition date of the image                                     |
| Time:            | The acquisition time                                                  |
| Mode:            | The Orbit geometry (Asc or Desc)                                      |
| LookDir:         | Right or Left                                                         |
| LookAngl[deg]:   | The incidence angle                                                   |
| Xsize[pix]:      | The size of image in range direction (in pixels)                      |
| Ysize[pix]:      | The size of image in azimuth direction (in pixels)                    |
| Xsampl[m]:       | The pixel size in range direction (in m)                              |
| Ysampl[m]:       | The pixel size in azimuth direction (in m)                            |
| Center/Ext-Lon:  | The longitude of the center (or the min-max UTM Y value) of the scene |
| Center/Ext-Lat : | The latitude of the center (or the min-max UTM X value) of the scene  |

**Note:** For images read with bulk reader (i.e. S1, SAOCOM, ICEYE...), do not run at the same time several occurrences of [Read\\_All\\_img.sh](#) that would be pointing toward the same destination directory [.../SAR\\_CSR/SAT/REGION/NoCrop](#). Indeed, the first [Read\\_All\\_img.sh](#) that would have finished to read its data would start sorting them, that is moving the images in directories by mode and orbit number and create links back in the [.../SAR\\_CSR/SAT/REGION/NoCrop](#). This may cause crashes at other processes that would be reading images in [.../SAR\\_CSR/SAT/REGION/NoCrop](#) (moving the directory where they would be writing etc...).

## 2.1. Sentinel 1 (Wide Swath or Strip Map):

Sentinel-1 Strip Map (SM) or Wide Swath (IW) data are usually downloaded as .zip files<sup>7</sup>. After unzip, each image is stored in a directory named e.g.

`S1A_IW_SLC_1SDV_20220801T232721_20220801T232748_044365_054B6D_01E8.SAFE`

AMSTer will read Sentinel-1 images from that expected format.

For Sentinel-1 data, the script `Read_All_Img.sh` will select all and only the swath(s) and burst(s) of interest to cover the desired footprint (these can be from separate images if the area of interest is larger than a regular S1 frame or if the area of interest is located across two S1 frames). The footprint is defined by providing a `KML` file as the 4<sup>th</sup> parameter (e.g. produced in Google Earth). The script will also sort the S1 images (Ascending or Descending).

The optional 5<sup>th</sup> parameter is a text string. If that string is `ForceAllYears`, the script will force the reading of all the images available. If that parameter is left empty (or contains another string than `ForceAllYears`, the script will read only the images that are less than 6 months old (or that were not read yet). See below for explanations about the archiving of raw images after reading.

Note that using the parameter `ForceAllYears` will also force the script to update the whole orbit database instead of updating it only since last available precise orbit date.

The optional 6<sup>th</sup> parameter is a text string “-n” (without quotes). This option allows skipping the orbits update process.

After having selected the required swaths and bursts and sorted the images, it will assemble the bursts into a single image in each `.../SAR CSL/S1/REGION/NoCrop/IMAGE.slc` directory (where `IMAGE` is the date of the image), then check that the size in bytes of that file is consistent with the expected number of lines and columns. If not, it will re-read (re-stitch actually) the image. This is sometimes needed for unknown reason. Do not remove the separated bursts after stitching as it will need them for coregistration when the image will be used as Secondary image.

Because all Ascending and Descending raw Sentinel-1 images that are stored in `.../SAR DATA/S1/S1_info_UNZIP` will be read at the same time by the AMSTerEngine reader, the script will sort and store the CSL images in directories named after their geometry (ascending or descending) and their orbit number. However, because the mass reading compares the folder with raw data (`.../SAR DATA/S1/S1_info_UNZIP`) with the target folder where the CSL data are (`.../SAR CSL/S1/REGION/NoCrop`), one cannot move the CSL data in sub-directories (these images would be read again at the next execution of the reader). For this reason, the script keeps all the images (whatever their geometry or orbit) as links in the target directory (`.../SAR CSL/S1/REGION/NoCrop`) while CSL images (to which links point at) are stored in other directories (Figure 3) such as

`.../SAR CSL/S1/REGION_GEOM_ORB/NoCrop`

where

- `GEOM` is `A` or `D` (for ascending or descending orbit)
- `ORB` is the orbit number

Images in CSL format are named as:

`S1A(orB)_ORB_DATE_A(orD).csl` where

- `A` or `B` depends on the Sentinel 1A or 1B
- `A` or `D` depends on ascending or descending orbit
- `ORB` is the orbit number

Note that the stitched image file

---

<sup>7</sup> `Read_All_Img.sh` can also read images from the zip files, though it might be slower. See note at the end of the present chapter 2.1

`.../SAR_CS/S1/REGION_GEO_ORB/NoCrop/IMAGE.slc/Data/SLCData.POL` (where `POL` is the polarization and which is usually `VV`; see the preferred polarization chosen in `Read_All_Img.sh`) is used during the (mass)processing at coregistration step. If it is missing, it will be recomputed at **S1Coregistration**, but it will not be overwritten if present and of expected size.

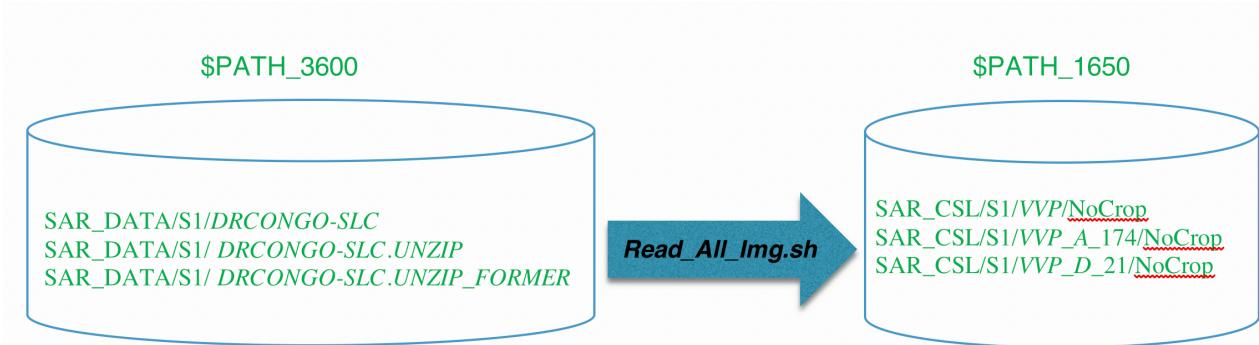


Figure 3: Example of input and output directories associated with the usage of `Read_All_Img.sh` in the case of S1 data acquired for DR Congo and reading for the Virunga Volcanic Province (VVP)

Attention, if a `kml` is provided at mass processing for cropping, and if that `kml` does not overlaps the same bursts as those assembled at reading (Figure 4), it will stitch again the bursts in the `i12` directory during the InSAR processing. This would take time and disk space! To spare time and space, better adjust your `kml`'s properly from beginning, i.e. at reading step.

This was planned for mass processing using S1. The reason is a matter of disk space and processing time: if the `kml` used to crop the interferogram has a footprint that cover less bursts than what has been read (and hence assembled as

`.../SAR_CS/SAT/TRK/NoCrop/IMAGE.slc/Data/SLCData.pol`), AMSTEREngine will assemble again the required bursts in a new `SLCData.pol` but saved this time in your `PRM_SCD/i12` directory. Hence it will make a new copy of the primary image in **EACH** processing pair, **which would be a huge waste**. There is of course no problem if you set no `kml` as a crop region for interferometric computation.

### Example:

- Black: S1 bursts footprints as selected with KML used for reading (blue)
- Blue: KML used for reading.
- Green: Example of good KML's used for cropping interferograms.
- Red: Examples of bad KML's used for cropping interferograms.

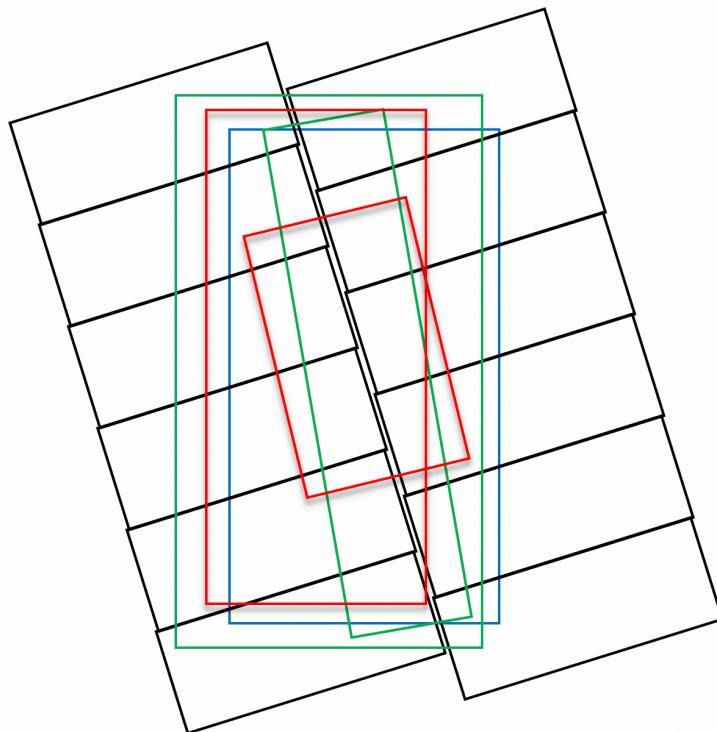


Figure 4: Example of S1 bursts footprint (black), kml footprint used for reading (blue) and for cropping at processing (Greens are good, Reds would require wasted time and disk space).

#### Notes:

- Remember that the script ***Read\_All\_Img.sh*** will also restrict the reading to a chosen polarization. If you want all the polarizations, use the option **ALLPOL** in ***Read\_All\_Img.sh*** at each use of **S1DataReader**. Same applies for SAOCOM.
- If precise orbits are not present in the **S1\_ORBITS\_DIR** folder yet, the script will attempt to download them if available (i.e. for image at least ~31 days old). If no Precise orbits are available, Restituted orbits will be used.
- To gain time, the script attempts to update the S1 orbits only since last available precise orbit date (i.e. it supposes that all the former orbits were already correctly updated). If for any reason you need to update older orbits, you can either change the script to manually hard code the date from when to begin the update (***Read\_All\_Img.sh*** where it calls the function **updateS1Orbits**), or launch manually the function **updateS1Orbits** with appropriate **from=YYYYMMDD** parameter, (see **updateS1Orbits -help**) before launching ***Read\_All\_Img.sh***, or more simply, you can launch ***Read\_All\_Img.sh*** with the **ForceAllYears** parameter. In that case, it will indeed update the whole S1 orbit database since the beginning of S1.
- Note that the path to the folder with the sentinel orbits must be defined in the **/\$HOME/.bashrc** as a state variable **S1\_ORBITS\_DIR**.
- **Note: Do not** name two S1 **REGION** with the same beginning of name followed by an underscore (e.g. do NOT use **LUX** and **LUX\_TEST**; you can, however, use for instance **LUX** and **LUXTEST**) because it would result in some problems at sorting the orbit modes after reading **LUX** images.
- You can use the python tool **Check\_kml\_coverage\_kml.py** to compare a kml of your area of interest with several **map-overlay.kml** (from raw S1 images in /preview subdirectory) in order to check that the desired footprint is fully covered by your Sentinel1 raw data. For this, simply copy all the **.../SAR\_DATA/S1/S1\_info\_UNZIP/YourImage.SAFE/preview/map-overlay.kml** files into a directory and launch the script in that directory. See script for usage.

**Attention:** when an updated precise orbit is found (or when a FAST24 image is updated with a normal one), the script will update the `SLCImageInfo.txt` with the new orbit in  
`.../SAR_CSR/S1/REGION/NoCrop/S1AorB_track_date_AorD.csl/Data/Framei.csl/Info`  
where *i* of `Frame` stands for each of the frame used in your footprint. The former `SLCImageInfo.txt` will be renamed `SLCImageInfo.txt.old`

Because this update impacts the results, the script will search for all the processes already performed with the outdated orbits and move them to specific directories. In that case, the products impacted by that updated will be automatically re-processed at the next mass processing runs. Specifically, the script will move the `RESAMPLED` images and the `MASS_PROCESSED` pairs involving the updated images resp. in:

- `.../SAR_SM/RESAMPLED/S1_CLN/CLEANED_FAST24` (both Asc and Desc in same dir) or  
`.../SAR_SM/RESAMPLED/S1_CLN/CLEANED_ORB` (both Asc and Desc in same dir)
- `.../SAR_MASSPROCESS/S1_CLN/CLEANED_FAST24` (both Asc and Desc in same dir) or  
`.../SAR_MASSPROCESS/S1_CLN/CLEANED_ORB` (both Asc and Desc in same dir)

Of course, one must run again the scripts `SuperMasterCoreg.sh` and `SuperMaster_MassProc.sh` to get the products involving the updated images back into the database. Note that updating the orbits does not require to recompute the slant Range DEM nor the Slant Range Mask (unless your DEM is precise at few cm.. which is unlikely).

The amplitude products computed with `ALL2GIF.sh` (see below) are not updated! This however shouldn't be a problem.

If you do not want to have the images removed from your `RESAMPLED` and/or `MASSPROCESS` databases, simply do not provide corresponding paths during `Read_All_Img.sh` execution. If you want to remove instead of moving these files, or if you want to update also the amplitude products computed with `ALL2GIF.sh` (I don't see why you would like that form amplitudes though), see and change script `Read_All_Img.sh`.

## EXECUTION:

For a Sentinel 1 processing, run “`Read_All_Img.sh`” with the following 4 or more parameters:

|                                               |                                                                                                                              |
|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| <code>.../SAR_DATA/S1/S1_info_UNZIP</code>    | (that is where unzipped raw data are)                                                                                        |
| <code>.../SAR_CSR/S1/REGION/NoCrop</code>     | (that is the target folder where CSL images must be stored)                                                                  |
| <code>S1</code>                               | (that is the satellite name; must be consistent with dir naming,<br>see Table 1 page 53)                                     |
| <code>.../SAR_CSR/S1/REGION/region.kml</code> | (a kml file spanning the area of interest)                                                                                   |
| <code>ForceAllYears</code>                    | (an option to force reading of images older than roughly 6 months)                                                           |
| <code>-n</code>                               | (an option to skip updating the orbits)                                                                                      |
| <code>.../SAR_SM/RESAMPLED/</code>            | (a path to the resampled data to recompute them later with updated<br>orbits)                                                |
| <code>.../SAR_MASSPROCESS/</code>             | (a path to the InSAR pairs to recompute them later with updated<br>orbits)                                                   |
| <code>POL</code>                              | (preferred polarization, i.e. <code>VV</code> , <code>HH</code> , <code>VH</code> , <code>VV</code> or <code>ALLPOL</code> ) |

The name `info` is chosen to help identifying the data (e.g. name of a country).

The name `REGION` describes the area of interest; chose it carefully as it will also be part of the `TRK` parameter. It differs from the `info` because from the same set of S1 image, you may want to process InSAR over different regions (e.g. name of a volcano).

The `region.kml` is a polygon e.g. created with Google Earth contouring the footprint of the area of interest.

**Do not forget** `/NoCrop` at the end of dir path where data in csl format must be stored.

To avoid time consuming re-check of former S1 images during the next execution of **Read\_All\_Img.sh**, the script will move images older than 6 months in YYYY directories in **.../SAR\_DATA/S1/S1\_info\_UNZIP\_FORMER/\_YYYY**.

Next time **Read\_All\_Img.sh** is executed, it will hence only check and read the last 6 months of data. If you want to check and read (again) images older than 6 months, run the script with the 5<sup>th</sup> parameter **ForceAllYears**. If you want to re-read only some of the FORMER images, you can put them back in **.../SAR\_DATA/S1/S1\_info\_UNZIP**.

When run again, the script will ensure that every link in **.../SAR CSL/S1/REGION/NoCrop** points toward an image in the corresponding directory and that every image in the **.../SAR CSL/S1/REGION\_Geom\_ORB/NoCrop** directories have a link in **.../SAR CSL/S1/REGION/NoCrop**. If not, it will read again what is missing and/or clean up the directories.

**Note:** to read only S1 images from ONLY a given year, you can try to launch **Read\_All\_Img.sh** with the first parameter as **.../SAR\_DATA/S1/S1\_info\_UNZIP\_FORMER/\_YYYY** without **ForceAllYears**.

**Note:** after reading S1 images, it will make a file listing the size of all the images, saved in **.../SAR CSL/S1/REGION/NoCrop/List\_Master\_Sizes.txt**. It might be a good idea to check it and check that all your images have the same kind of size. If one image is too small, it will most likely be due to missing bursts. That area, if missing in one pair used in your mass processing for msbas, will be lost for the whole msbas series! Reminder: a S1 burst is about 1.200-1.500 lines by 22.000-25.000 columns.

It will also list the bursts in **.../SAR CSL/S1/REGION/NoCrop/FramesSwathBurst\_DATE\_xx\_bursts.txt** for each primary image (where **xx** is the number of bursts). It allows a quick look to identify wrong images.

If some of your images are incomplete (i.e. if not all the bursts are available for some images) or corrupted for any reason, you can move your images from **.../SAR CSL/S1/REGION/NoCrop** into **.../SAR CSL/S1/REGION/Quarantained**. Images set in **Quarantined** will be ignored when re-running the **Read\_All\_Img.sh**. Deleting rather than moving these images in **Quarantined** would result in re-reading them every time you run a **Read\_All\_Img.sh**, which is not what you want unless you have corrected the problem leading to a corrupted image or incomplete image.

Scripts **\_Check\_S1\_SizeAndCoord.sh** and **\_Check\_ALL\_S1\_SizeAndCoord\_InDir.sh** can also be used to check if image(s) are as expected, that is

- 1) the image has the expected number of bursts and
- 2) corner's coordinates are within a range of 0.05 degree (hard coded tolerance) of expected coordinates from kml corners, or are within the provided min/max coordinates of an Area of interest, or a kml. (For more info see chapter 10.1.)

Example:

```
Read_All_Img.sh .../SAR_DATA/S1/S1-DATA-DRCONGO-SLC.UNZIP .../SAR CSL/S1/DRC_Funu/NoCrop S1
.../Share1/SAR CSL/S1/DRC_Funu/Funu.kml ForceAllYears .../SAR SM/RESAMPLED/ .../SAR MASSPROCESS/ VV
```

**Note** since **AMSTerEngine V20231110**, **S1DataReader** can read S1 images directly from zip file. The script **Read\_All\_Img.sh** can then also read directly the zip files and files older than 6 months will be stored in **\_FORMER/yyy** directories as in the regular case. However, not decompressing the images might make the reading slower as it will have to check if each image is already read. For that it starts by checking all the images already read. Nevertheless, this is an interesting option when being short on storage room.

Note: do not read images from a directory where zipped and de-zipped images are mixed.

The syntax in that case of reading zipped data is rather something like:

```
Read_All_Img.sh .../SAR_DATA/S1/S1-DATA-DRCONGO-SLC .../SAR CSL/S1/DRC_Funu/NoCrop S1
.../Share1/SAR CSL/S1/DRC_Funu/Funu.kml ForceAllYears .../SAR_SM/RESAMPLED/ .../SAR_MASSPROCESS/ VV
```

In that example, the images (in zip format) of more than 6 months will be stored in  
.../SAR\_DATA/S1/S1-DATA-DRCONGO-SLC\_FORMER/yyyy

## 2.2. CSK:

CSK data are usually provided in directories named with codes that are not explanatory such as [525071-400979](#) or [EL20161213\\_1412143\\_4408467.6.2](#) for instance. **Read\_All\_Img.sh** will however expect these CSK images to be renamed by the date to avoid possible confusion. CSK images must hence be prepared with preliminary processing (**ReadDateCSK.sh** and **PrepaCSK.sh**; see § 1.).

Then, because ASI's CSK data naming doesn't allow to assess which image is in Asc and which is Desc orbit, one must proceed with a two steps procedure:

- read all the images in a temporary directory named **MassRead** with **Read\_All\_Img.sh**
- then move the corresponding Asc and Desc images toward appropriate respective directories with an additional script **ReadModeCSK.sh**, while keeping links in the original directory. This is mandatory to allow incremental reading without having to read again images.

Note: if links from [.../SAR CSL/CSK/REGION\\_Mode/NoCrop](#) to [.../SAR CSL/CSK/REGION](#) need to be rebuilt, you can use the script **Rebuild\_Ins\_CSK.sh**.

### EXECUTION:

- a) run "**Read\_All\_Img.sh**" with the following 3 parameters:

... /SAR\_DATA/CSK/OriginalZip/info (that is where **zipped** data are stored)  
... /SAR CSL/CSK/MassRead (that is a temporary folder where Asc and Desc CSK images in csl format will be stored before sorting)  
CSK (satellite name; must be consistent with dir naming, see [Table 1 page 53](#))

Example:

**Read\_All\_Img.sh** .../SAR\_DATA/CSK/OriginalZip/Dec2017 /SAR CSL/CSK/UnZipNoRename\_AndMassRead CSK

- b) go to the temporary directory [.../SAR CSL/CSK/MassRead](#)

- c) run "**ReadModeCSK.sh**" with the following parameter:

**REGION** (that is the region name used to identify the data)

Attention, [.../SAR CSL/CSK/REGION\\_Asc/NoCrop](#) and  
[.../SAR CSL/CSK/REGION\\_Desc/NoCrop](#) must exist.

Example:

**ReadModeCSK.sh** **Bukavu**

### 2.3. TDX (Bistatic or Pursuit mode):

Usually, TDX data are provided as .zip files. After unzip, each image is stored in a directory named e.g. `dims_op_oc_dfd2_369957642_11`, which is fine like that for the script ***Read\_All\_Img.sh*** if you are sure to have only one mode and footprint.

However, that naming will be of little help if you have several modes or footprints (hence incompatible for InSAR) and maybe several images acquired on the same days.

In that case, the script ***Read\_All\_Img.sh*** can't unfortunately sort automatically the images by footprint because coordinates vary. Hence the user must sort them manually or ensure that all the images in `.../SAR_DATA/TDX/REGION` have the same footprint.

If your data contains several footprints, it is advised to sort the raw data prior to read the data. This can be eased by using the script ***SORT\_TDX.sh***. That script will:

- copy in specific directories created on purpose (`_Check_common_images` and `_Check_single_images`), a quick look of all the images that are stored in all the subdirectories from the current directory (i.e. TSX or TDX amplitude images)
- list the path and date of each image in each of these directories in a file named `List.tif.txt`.

See script for more information about usage.

By looking at these quick looks and files list, you can move the images in appropriate directories such as `.../SAR_DATA/TDX/REGION`.

To further assist the user for sorting the footprints, the script ***Read\_All\_Img.sh*** can also create a text file `.../SAR CSL/ TDX/REGION/Center_Of_Scene.txt` with the list of the Latitude and Longitude of each scene coordinates. This allows to quickly check if images have similar footprint.

Note that if the images are incorrectly sorted by footprint or mode, there are some chances that two images would be acquired at the same date. Nevertheless, the script ***Read\_All\_Img.sh*** can cope with that and avoid missing or overwriting images. Images read will be stored in directories `.../SAR CSL/ TDX/REGION_BWZ_BIS_MODE_ORB_TX(orRX)_ii/NoCrop`, where `ii` is an integer index.

In any case, each of the image directory must contain somewhere two subdirectories which names contain the date coded as `yyyymmddThhmmss`, eg.:

`TDX1_SAR_SSC_BRX2_SM_S_SRA_20120905T035616_20120905T035621`  
`TSX1_SAR_SSC_BTX1_SM_S_SRA_20120905T035616_20120905T035621`

***"Read\_All\_Img.sh"*** works with the same 3 parameters, the third being **TDX**:

`.../SAR_DATA/TDX/TRK_MODE` (that is where unzipped raw data are)  
`.../SAR CSL/TDX/REGION/NoCrop` (that is the target folder where CSL images must be stored)  
`TDX` (that is the satellite name; must be consistent with dir naming)

Remember that TSX and TDX are two satellites operating in tandem and TDX can acquire images in two modes: as emitting (TX) or reception (RX). If you need the tandem specificity (i.e. 2 images at the nearly same time) to perform DEM computation for instance, then you need to read both type of image which are provided in the same directory. Note however that these two images can be labelled TDX and/or TSX. No matter the label, it is indeed the **TDX** option you should use here as third parameter while using the script ***Read\_All\_Img.sh***.

***Read\_All\_Img.sh*** will read all the images that are stored in the sub directories of the `.../SAR DATA/TDX/REGION` and read them and store them in CSL format in the `.../SAR CSL/TDX/REGION/NoCrop`. Because TDX tandem data contains TX (transmit) and RX (receive) images,

the script will then move these two data in directories named

`.../SAR_CS/ TDX/REGION_BWZ_BIS_MODE_ORB_TX(orRX)/NoCrop` where

**BWZ** is the bandwidth [in Mhz]

**BIS** is the type of TDX acquisition: BS for Bistatic, PM for Pursuit Mode

**MODE** is A or D for Ascending or Descending

**ORB** is the orbit number

**TX or RX** stands for the Transmit or Receive image,

and keep links to these data in `.../SAR_CS/ TDX/REGION`. The directory is named with useful information related to the images acquisition mode.

#### Notes:

- When using TDX for InSAR, the primary image must always be TX. If it needs a Secondary image of the same date (eg for making a DEM from bistatic data), the Secondary will be obviously RX, that is it will be actually stored in another directory. However, the processing scripts always expect the primary and secondary images to be stored in the same `.../SAR_CS/` directory. To allow the processing, the InSAR scripts will hence link the data from RX dir to TX dir. But to avoid clash in naming with the same date, the first digit of the secondary image's date (i.e. the millennia) will be replaced by 9 (e.g. 9019 instead of 2019). The script ***Read\_All\_Img.sh*** is able to cope with data too.

## 2.4. TSX:

Usually, TSX data are provided as .zip files. After unzip, each image is stored in a directory named e.g. `dims_op_oc_dfd2_371205443_1`, which is fine like that for the script ***Read\_All\_Img.sh*** if you are sure to have only one mode and footprint.

However, that naming will be of little help if you have several modes or footprints (hence incompatible for InSAR) and maybe several images acquired on the same days.

In that case, the script ***Read\_All\_Img.sh*** can't unfortunately sort automatically the images by footprint because coordinates vary. Hence the user must sort them manually or ensure that all the images in `.../SAR_DATA/TSX/REGION` have the same footprint.

If your data contains several footprints, it is advised to sort the raw data prior to read the data. This can be eased by using the script ***SORT\_TDX.sh***. That script will:

- copy in specific directories created on purpose (`_Check_common_images` and `_Check_single_images`), a quick look of all the images that are stored in all the subdirectories from the current directory (i.e. TSX or TDX amplitude images)
- list the path and date of each image in each of these directories in a file named `List_tif.txt`.

See script for more information about usage.

By looking at these quick looks and files list, you can move the images in appropriate directories such as `.../SAR_DATA/TSX/REGION`.

To further assist you in sorting out your images if you have images acquired by several modes ad/or footprints, and possibly facing the risk of having two images acquired on the same date, you can run the script ***Prepa\_TSX.sh***, which will rename all your images directories by their acquisition dates. If two or more images are acquired on the same date, the script will rename the data to read by their date and add an index in case of redundancy. The script ***Read\_All\_Img.sh*** will cope with that index and you will have the possibility to further sort your images.

In any case, each of the image directory must contain somewhere a subdirectory which name contains the date coded as `yyyymmddThhmmss`, eg.:

`TSX1_SAR_EEC_SE__SL_D_SRA_20080503T162043_20080503T162044`

“***Read\_All\_Img.sh***” works with the same 3 parameters, the third being **TSX**:

`.../SAR_DATA/TSX/TRK_MODE` (that is where unzipped raw data are)  
`.../SAR CSL/TSX/REGION/NoCrop` (that is the target folder where CSL images must be stored)  
`TSX` (that is the satellite name; must be consistent with dir naming)

Remember that TSX and TDX are two satellites operating in tandem. TDX can however acquire simple images as TSX. That is why DLR may provide TSX images labelled TDX, but in any case, images can be read the same way using ***Read\_All\_Img.sh*** using the third parameter as **TSX**.

Note: if you have TDX data in tandem mode (i.e. with a pair of TX and RX images) and want to use only the TX data to perform a differential interferogram between two dates, just read the TDX data in TDX mode with ***Read\_All\_Img.sh*** (see 2.3), and then perform your interferograms using the `_TX` data as input.

## 2.5. ENVISAT:

**Read\_All\_Img.sh** expects ENVISAT data to be provided in directories named by their orbit number (e.g. [33069](#)). That directory must contain a file with N1 extension, e.g.

[ASA\\_IMS\\_1PNIPA20120227\\_075954\\_00000163112\\_00107\\_52276\\_0144.N1](#)

However, data downloaded on ESA web site after termination of ENVISAT mission might be stored in a different manner compared to when data were delivered after each acquisition. If each image is not stored in a directory named by its orbit number, run **MoveBulkEnvisat\_InSubDirs.sh** (in [zz\\_Utils\\_MT\\_Ndo](#)) prior reading the data.

Note that **Read\_All\_Img.sh** expects the acquisition date to be written in the third position of the .N1 file name (underscore-separated string).

The path to the folder with the Envisat DORIS precise orbits must be present in the [\\$HOME/.bashrc](#) as a state variable **ENVISAT\_PRECISES\_ORBITS\_DIR**.

## EXECUTION:

Run “**Read\_All\_Img.sh**” with the following 3 parameters:

[.../SAR\\_DATA/ENVISAT/TRK\\_MODE](#) (that is where unzipped raw data are)  
[.../SAR CSL/ENVISAT/REGION/NoCrop](#) (that is the target folder where CSL images must be stored)  
ENVISAT  
(that is the satellite name; must be consistent with dir naming,  
see [Table 1 page 53](#))

## 2.6. ERS:

**Read\_All\_Img.sh** expects ERS data in CEOS format to be provided in directories named by their orbit number (e.g. [22712](#)). That directory must contain a file which name start with the string [LEA\\_](#) and where **Read\_All\_Img.sh** will be able to dig out the acquisition date.

However, data downloaded on ESA web site after termination of ERS mission might be stored in a different manner compared to when data were delivered after each acquisition. If each image is not stored in a directory named by its orbit number, run **MoveBulkERS\_InSubDirs.sh** (in [zz\\_Utils\\_MT\\_Ndo](#)) prior reading the data.

Note that **Read\_All\_Img.sh** expects the acquisition date to be written in the third position of the .E1 or .E2 file name (underscore-separated string).

## EXECUTION:

Run “**Read\_All\_Img.sh**” with the following 3 parameters:

[.../SAR\\_DATA/ERS/TRK\\_MODE](#) (that is where unzipped raw data are)  
[.../SAR CSL/ERS/REGION/NoCrop](#) (that is the target folder where CSL images must be stored)  
ERS  
(that is the satellite name; must be consistent with dir naming,  
see [Table 1 page 53](#))

## 2.7. RADARSAT-2 (Fine, Ultra Fine,...) :

***Read\_All\_Img.sh*** expects RADARSAT-2 data to be provided in directories where the acquisition date is provided in 6<sup>th</sup> position (from underscore-separated string) as *yyyymmdd*, whatever the mode of acquisition, e.g. for Fine or Ultra Fine acquisitions respectively:

**RS2\_OK73287\_PK656053\_DK586304\_F2F\_20101217\_034132\_HH\_HV\_SLC**

**RS2\_OK58499\_PK545801\_DK482829\_U9W2\_20140925\_162413\_HH\_SLC.**

### EXECUTION:

Run “***Read\_All\_Img.sh***” with the following 3 parameters:

.../SAR\_DATA/RADARSAT/TRK\_MODE (that is where unzipped raw data are)  
.../SAR CSL/RADARSAT/REGION/NoCrop (that is the target folder where CSL images must be stored)  
RADARSAT (that is the satellite name; must be consistent with dir naming,  
see [Table 1 page 53](#))

## 2.8. RADARSAT-1:

***Read\_All\_Img.sh*** expects RADARSAT-1 data in CEOS format to be provided in directories named by a code (e.g. **M0272711**).

### EXECUTION:

Run “***Read\_All\_Img.sh***” with the following 3 parameters:

.../SAR\_DATA/RS1/TRK\_MODE (that is where unzipped raw data are)  
.../SAR CSL/RS1/REGION/NoCrop (that is the target folder where CSL images must be stored)  
RS1 (that is the satellite name; must be consistent with dir naming  
see [Table 1 page 53](#))

### Notes:

- The third parameter can be **RADARSAT1** or more simply **RS1**.
- Because of Radarsat-1 orbital information format incompatible (yet) with AMSTer Toolbox, it is not possible to take into account an external DEM. As a consequence, DInSAR can be performed in 3 passes mode but **results can't be geocoded**.
- For the same reason, RS1 images can be read and amplitude images can be computed (e.g. with **MakeAmpliPlotSingleImg.sh**) though it **can't be cropped based on a kml file**.

## 2.9. PAZ:

PAZ data are pretty much like TSX data. They are provided as .zip files. After unzip, each image is stored in a directory with a name that contains the date coded as *yyyymmddThhmmss*, e.g. **PAZ1\_SAR\_SSC\_SL\_S\_SRA\_20220614T002135\_20220614T002137**, which is fine like that for the script ***Read\_All\_Img.sh***.

“***Read\_All\_Img.sh***” works with the same 3 parameters, the third being **PAZ**:

.../SAR\_DATA/PAZ/TRK\_MODE (that is where unzipped raw data are)  
.../SAR CSL/PAZ/REGION/NoCrop (that is the target folder where CSL images must be stored)  
PAZ (that is the satellite name; must be consistent with dir naming,  
see [Table 1 page 53](#))

## 2.10. KOMPSAT:

KOPMPSAT data are pretty much like CSK data. They are provided as .zip files. After unzip, each image is stored in a directory with a name that contains the date coded as `yyyymmddhhmmss`, e.g. `K5_20170717094902_004042_21423_D_ES06_HH_SCS_A_L1A`, which is fine like that for the script ***Read\_All\_Img.sh***.

“***Read\_All\_Img.sh***” works with the same 3 parameters, the third being **PAZ**:

`.../SAR_DATA/PAZ/TRK_MODE` (that is where unzipped raw data are)  
`.../SAR CSL/PAZ/REGION/NoCrop` (that is the target folder where CSL images must be stored)  
`PAZ` (that is the satellite name; must be consistent with dir naming,  
see [Table 1 page 53](#))

## 2.11. ALOS:

ALOS (i.e. ALOS-1) data are provided as .zip files. After unzip, each image is stored in a directory that contains a file named `workreport` where ***Read\_All\_Img.sh*** will be able to dig out the acquisition date.

“***Read\_All\_Img.sh***” works with the same 3 parameters, the third being **ALOS**:

`.../SAR_DATA/ALOS/TRK_MODE` (that is where unzipped raw data are)  
`.../SAR CSL/ALOS/REGION/NoCrop` (that is the target folder where CSL images must be stored)  
`ALOS` (that is the satellite name; must be consistent with dir naming,  
see [Table 1 page 53](#))

## 2.12. ALOS-2 (Wide Swath or Strip Map):

ALOS-2 Strip Map (SM) or Wide Swath (WS) data are provided as .zip files. After unzip, each image is stored in a directory named by a string ending with the date coded as `yyymmdd` which will be interpreted by ***Read\_All\_Img.sh***.

“***Read\_All\_Img.sh***” works with the same 3 parameters, the third being **ALOS2**:

`.../SAR_DATA/ALOS2/TRK_MODE` (that is where unzipped raw data are)  
`.../SAR CSL/ALOS2/REGION/NoCrop` (that is the target folder where CSL images must be stored)  
`ALOS2` (that is the satellite name; must be consistent with dir naming,  
see [Table 1 page 53](#))

### Notes:

- Note the difference in third parameter: do not mix ALOS2 with ALOS used for reading ALOS1 data.
- Beware, ALOS2 images may be affected by strong long wavelength residuals. You may need some tricks such as [`Deramp\_Spotlight.py`](#) to attempt removing long wavelength artefacts (or attempt some cleaning with Split Band interferometry).
- A script named ***ALOS2\_UNZIP\_Check\_Sort.sh*** is designed to assist sorting ALOS2 data acquired in several geometries for a specific case at ECGS. It may serve as an example if you face that kind of situation. See script in [`zz\_Utils\_MTNdo`](#).

- ALOS2 images produced before March 2021 are affected by a bug and every second line must be multiplied by -1. Note that images acquired before March 2021 thought reprocessed after March 2021 are not affected. In any case, AMSTer will take care of that for you in a totally transparent way.

## 2.13. SAOCOM:

SAOCOM data are provided in directories named e.g. [112878-EOL1ASARSAO1A695905](#) which contain a zip file and a .xemt file. All the data are read using a bulk reader (transparent to the user) which will sort out which data are already read and read only the new ones. Note however that it will stop reading all the images in the input directory if it encounters a bad image.

Because Ascending and Descending raw images can be stored in [.../SAR\\_DATA/SAOCOM/REGION](#), the script will read them all, then sort them and store the CSL images in directories named after their orbit number and geometry (ascending or descending). However, because the bulk reader compares the folder with raw data ([.../SAR\\_DATA/AOCOM/REGION](#)) with the target folder where the CSL data are ([.../SAR CSL/SAOCOM/REGION/NoCrop](#)), one cannot move the CSL data in sub-directories (these images would be read again at the next execution of the reader). For this reason, the script keeps all the images (whatever their geometry) as links in the target directory ([.../SAR CSL/SAOCOM/REGION/NoCrop](#)), while CSL images (to which links point at) are stored in other directories such as

[.../SAR CSL/SAOCOM/REGION\\_ORB\\_GEOM/NoCrop](#)

where *ORB* is the orbit number and *GEOM* is A or D (for ascending or descending orbit).

Moreover, because the SAOCOM data made available by CONAE might mix several production dates for the same image. Each might be due to a re-focusing or a focusing along a new frame (different start/stop time). To cope with that, the reader will check if the data contains the area of interest (provided as a mandatory *kml* file). If it does not, the image is skipped. If several images include the *kml*, the reader will select the one which has its centre closer to the centre of the *kml*.

If an image is re-focused and updated, at the next reading, the reader will compare. If the new image is more favourable (better overlap with the *kml*), it will take it instead of the existing one. If they are similar, it will take the most recent one.

Note that if a path to the Coregistered and/or Mass Processed products is provided to the script, it will move all the products computed with the former image in [/SAR\\_SM/RESAMPLED/SAOCOM\\_CLN](#) and these will be recomputed with the updated image at the next run of the scripts dedicated to the coregistration on a Global Primary and/or Mass Processing.

Finally, to spare time at reading, the images of more than 6 months are moved in [SAR\\_DATA/SAOCOM-DATA\\_YourPlace-SLC.UNZIP\\_FORMER/\\_yyyy](#) (where *yyyy* stands for each year of data already read and older than 6 months) after being read.

To force the re-reading of the images of more than 6 months, either add the parameter *ForceAllYears* or move the images to re-read from [/SAR\\_DATA/SAOCOM-DATA\\_YourPlace-SLC.UNZIP\\_FORMER/\\_yyyy](#) back in [/SAR\\_DATA/SAOCOM-DATA\\_YourPlace-SLC.UNZIP](#).

## EXECUTION:

For a SAOCOM processing, run “***Read\_All\_Img.sh***” with the following 4 or more parameters:

|                                              |                                                                                                |
|----------------------------------------------|------------------------------------------------------------------------------------------------|
| .../SAR_DATA/SAOCOM/REGION                   | (that is where unzipped raw data are)                                                          |
| .../SAR CSL/SAOCOM/REGION/NoCrop             | (that is the target folder where CSL images must be stored)                                    |
| SAOCOM                                       | (that is the sat. name; must be consistent with dir naming, see <a href="#">Table 1</a> )      |
| .../SAR CSL/SAOCOM/REGION/ <i>region.kml</i> | (a kml file spanning the area of interest for optional cropping)                               |
| <i>ForceAllYears</i>                         | (an option to force reading of images older than > 6 months)                                   |
| .../SAR_SM/RESAMPLED/                        | (a path to the resampled data to recompute them later with updated orbits)                     |
| .../SAR_MASSPROCESS/                         | (a path to the InSAR pairs to recompute them later with updated orbits)                        |
| <i>POL</i>                                   | (preferred polarization, i.e. <i>VV</i> , <i>HH</i> , <i>VH</i> , <i>VV</i> or <i>ALLPOL</i> ) |

**Note:** the kml file is mandatory.

## 2.14. ICEYE:

ICEYE data are provided as files named with a .h5 extension, e.g.

*ICEYE\_SLC\_SM\_5415\_20190518T211319.h5*.

All the data are read using a bulk reader (transparent to the user) which will sort out which data are already read and read only the new ones. Note however that it will stop reading all the images in the input directory if it encounters a bad image.

Because ICEYE is a constellation of agile satellites, able to acquire data on several geometries (Asc or Desc, Right or Left looking, with several look angles), the images stored in the raw images directory (i.e. .../SAR\_DATA/ICEYE/REGION) may be of a high variety.

The script will read them all, then sort them and store the CSL images in directories named after their geometry: *REGION\_GEOM\_MODE\_RL\_INCIDdeg*, where *GEOM*, *MODE*, *RL* and *INCID* are respectively the orbit geometry (A for Ascending, or D for Descending), the acquisition mode (e.g. Spotlight or Stripmap), the looking direction (*RL* for Right Looking or *LL* for Left Looking) and the incidence angle.

However, because the bulk reader compares the folder with raw data (.../SAR\_DATA/ICEYE/REGION) with the target folder where the CSL data are (.../SAR CSL/ICEYE/NoCrop), one cannot move the CSL data in sub-directories (these images would be read again at the next execution of the reader). For this reason, the script keeps all the images (whatever their geometry) as links in the target directory (.../SAR CSL/ICEYE/REGION/NoCrop), while CSL images (to which links point at) are stored in other directories such as .../SAR CSL/ICEYE/REGION\_*GEOM\_MODE\_RL\_INCIDdeg* *NoCrop*.

## EXECUTION:

For a ICEYE processing, run “***Read\_All\_Img.sh***” with the following 4 or more parameters:

|                                 |                                                                                                                                                              |
|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| .../SAR_DATA/ICEYE/REGION       | (that is where unzipped raw data are)                                                                                                                        |
| .../SAR CSL/ICEYE/REGION/NoCrop | (that is the target folder where CSL images must be stored)                                                                                                  |
| ICEYE                           | (that is the satellite name; must be consistent with dir naming, see <a href="#">Table 1 page 53</a> )                                                       |
| <i>ForceAllYears</i>            | (an option to force reading of images all the images in .../SAR DATA/ICEYE/REGION instead of only those that are not yet in .../SAR CSL/ICEYE/REGION/NoCrop) |

**Note:** ICEYE has a very large orbital tube, which provides most of the time perpendicular baselines too large for a proper interferometric processing. It may only work if you are very lucky !...

## 2.15. NISAR:

NISAR data are provided as files named with a `.h5` extension.

All the data are read using a bulk reader (transparent to the user) which will sort out which data are already read and read only the new ones. Note however that it will stop reading all the images in the input directory if it encounters a bad image.

Because NISAR can acquire data on several geometries (Asc or Desc, Right or Left looking), the images stored in the raw images directory (i.e `.../SAR_DATA/NISAR/REGION`) may be of a high variety.

The script will read them all, then sort them and store the CSL images in directories named after their geometry: `REGION_GEOM_RL`, where `GEOM` and `RL` are respectively the orbit geometry (A for Ascending, or D for Descending), and the looking direction (`RL` for Right Looking or `LL` for Left Looking).

However, because the bulk reader compares the folder with raw data (`.../SAR_DATA/NISAR/REGION`) with the target folder where the CSL data are (`.../SAR CSL/NISAR/NoCrop`), one cannot move the CSL data in sub-directories (these images would be read again at the next execution of the reader). For this reason, the script keeps all the images (whatever their geometry) as links in the target directory (`.../SAR CSL/NISAR/REGION/NoCrop`), while CSL images (to which links point at) are stored in other directories such as `.../SAR CSL/NISAR/REGION_MODE_RL/NoCrop`.

## EXECUTION:

For a NISAR processing, run “***Read\_All\_Img.sh***” with the following 4 or more parameters:

|                                              |                                                                                                                                                                                               |
|----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>.../SAR_DATA/NISAR/REGION</code>       | (that is where unzipped raw data are)                                                                                                                                                         |
| <code>.../SAR CSL/NISAR/REGION/NoCrop</code> | (that is the target folder where CSL images must be stored)                                                                                                                                   |
| <code>NISAR</code>                           | (that is the satellite name; must be consistent with dir naming,<br>see <a href="#">Table 1 page 53</a> )                                                                                     |
| <code>ForceAllYears</code>                   | (an option to force reading of images all the images in<br><code>.../SAR_DATA/NISAR/REGION</code> instead of only those that are not<br>yet in <code>.../SAR CSL/NISAR/REGION/NoCrop</code> ) |

### 3. Single Pair processing

Before running a mass processing, it is advised to test the required processing parameters (saved in a [LaunchMTparam.txt](#)) on a given pair. Better do that for each satellite, in each mode, for each type of footprint. For that purpose, or maybe because you only need one pair, you can use the automatic processing script named **SinglePair.sh**. Its architecture is presented in detail in Annexes. **SinglePair.sh** may also be used to create (geocoded) DEM if option **PROCESSMODE** is set to **TOPO** in the [LaunchMTparam.txt](#) (see below).

**SinglePair.sh** will read the text file ([LaunchMTparam.txt](#), or any other name you would have given it) containing all the parameters for the processing and some options you can tune (such as computing figures or skipping the time-consuming unwrapping process) and lead you (hopefully) up to the final products in a single run. **SinglePair.sh** also allows the processing of a given pair for which the primary image would be first coregistered on a Global Primary. However, this requires first to launch **SuperMasterCoreg.sh** which is the first step of the mass processing - see chapter 5 and annexes.

Even if you do not want to coregister all your products on a Global Primary, but if each of the images from your pair were already coregistered to a common image, the script will offer you the possibility to gain time by benefitting from these former processing. It will indeed benefit from former amplitude and coarse coregistration computations. The script will speak out the offer and be waiting for you to agree on that trick. He will also show you the list of all available Global Primary coregistrations and wait for you to select one. If you do not want that trick and do not want to have the script waiting for your answer, you can simply run it with the following syntax:

**Echo "n" | SinglePair.sh**

**Note** that for TSX, TDX or Envisat, orbits should be good enough to skip the coarse coregistration and hence spare time. If you want to do that, you can set **CCOHWIN** to 0 in the [LaunchMTparam.txt](#).

A version named **SinglePairNoUnwrap.sh** stops before unwrapping and then does not allow to geocode the products. But this version also has some adds to be used e.g. when one need accurate coregistered amplitude maps (in radar geometry) e.g. for estimating heights using shadow casted by sub-vertical structures. It will also output amplitude figures in JPEG with the date stamped on the corner. (Note that the style and font size of the date are hard coded; look for **DATECELL** parameter in script and in [HardCodedLines.sh](#)). For the specific need of computing a series of amplitude images (and output a gif animation for instance), see also the script **ALL2GIF.sh**.

You can also use **MultiLaunch.sh** to run a set of **SinglePairNoUnwrap.sh** processing using the provided Global Primary as Primary image and all the images present in a provided directory as Secondary image. This could be useful for instance to compute a set of geocoded coherence maps that you would combine (and combine with average geocoded coherence maps computed from the other sat/track modes you plan to use e.g. for a (m)sbas processing). That set of coherence maps can be averaged, weighted, complemented with water bodies maps etc... to create a mask to be used before unwrapping all the interferograms in a full mass processing procedure. This will spare you a lot of computing time! Note that **MultiLaunch.sh** is so far tuned for launching **SinglePairNoUnwrap.sh** but adaptation would be quick for launching other scripts.

Actually, there are slightly different versions named **MultiLaunch\_ForMask.sh** and **MultiLaunch\_Ampli\_Coh.sh** which run a set of **SinglePair.sh** and which have additional features:

- **MultiLaunch\_ForMask.sh** will only compute the pairs that satisfy the criteria of max Bperp and max Btemp baseline from the provided list of pairs. It will also create a mask based on a chosen coherence threshold.

- ***MultiLaunch\_Ampli\_Coh.sh*** will compute amplitude and coherence maps aligned on the same grid (in slant range and geocoded). This is useful e.g. to track land cover changes. It will also allow masking the coherence in slant range etc.

See below for more information.

Note that these scripts, as the other mass processing scripts described in chapter 5 and maybe some utilities, requires the **mandatory *FUNCTIONS\_FOR\_MT.sh*** file which is the compilation of several functions called by the scripts.

The processing also outsources the processing of the DEM. Hence it requires ***MasterDEM.sh***

In order to keep track of the version of AMSTerEngine used to process the data, the script will store a small text file named ***Processing\_Pair\_w\_AMSTerEngine\_V.txt*** in the directory where the pair was processed. It contains a single line indicating the date of the last version of the software present in the ***/\$HOME/SAR/AMSTer/AMSTerEngine/\_Sources\_AE/Older***. It is supposed to be the last one that was compiled and hence the one currently used.

### 3.1. Single pair automated processing: ***SinglePair.sh***



Launch ***SinglePair.sh*** with the following 3 mandatory parameters and optionally a 4<sup>th</sup> and/or 5<sup>th</sup> parameter:

|                                 |                                                                    |
|---------------------------------|--------------------------------------------------------------------|
| <b>PRM</b>                      | (date of the Primary image)                                        |
| <b>SCD</b>                      | (date of the Secondary image)                                      |
| <b><i>LaunchMTparam.txt</i></b> | (text file with all the parameters and options chosen for the run) |
| <b>REMARK</b>                   | (Info used in naming the dir where computation will occur)         |
| <b>SuperMaster</b>              | (date of the Global Primary image - optional)                      |

where

- **PRM** and **SCD** are the dates of the images in format YYYYMMDD
- ***LaunchMTparam.txt*** is a text file (and path) with all the parameters and options chosen for the run. It is a good practice to store parameters files in separate subdirectories sorted by satellite and track for instance. Name them appropriately to easily figure out what is that configuration for.

**Attention:** the ***LaunchMTparam.txt*** parameters file must respect some syntax:

- Parameters in file must be followed by a # and its variable name **must be followed by a coma**. Description is optional.
- As reading this file is made using the first occurrence of a search criteria, do not add text with the variable name followed by a coma elsewhere in the text.
- Always keep the main paths at the end of the file.
- See the description of the parameters from ***LaunchMTparam.txt*** in annex 1.
- **REMARK** is usually optional. But it is very convenient, and it is advised to use it with a bit of attention. The **REMARK** is only used to be added at the end of name of the folder where the results are computed. It is convenient to use it to remember what are the specificities of the test performed with that pair (e.g. “\_Increased\_Coh\_threshold”), especially if you run several tests. Usually, the significance of names such as Test1, Test2... are only remembered for a short time... For the sake of readability, it is a good practice to start that parameter with an underscore.

Note that this ***REMARK*** is mandatory if one makes uses of ***SuperMaster*** option (date of Global Primary) here after as a 5<sup>th</sup> parameter. It will still be used to name the output directory but, as we will coregistrate the processed pair on a Global Primary, it is advised to put as ***REMARK*** something like “***\_SMSuperMaster\_***” where ***SuperMaster*** is the date of the Global Primary image in the form of YYYYMMDD. This helps to keep track of the Global Primary used.

- ***SuperMaster*** is the date of an optional Global Primary image for a common coregistration on that image. Obviously if one uses that option, the 4<sup>th</sup> parameter (i.e. ***REMARK***) is mandatory as explained here above.

Even if you do not work with a Global Primary, you can spare time. If each of the images from your pair were already coregistered to a common image, the script will offer you the possibility to gain time by benefitting from these former processing. The script will speak out the offer and be waiting for you to agree on that trick. If a Global Primary date is provided in the ***LaunchMTparam.txt*** it will use it. If not, the script will show you the list of all available Global Primary used for former coregistrations and wait for you to select one. If specific images of the pair to process are however not yet registered, the script will perform a simple processing without trying to benefit from the coregistration to a Global Primary.

You can also spare time by skipping the unwrapping if not needed (it will still geocode the results). This requires setting parameter ***SKIPUW*** as ***SKIPYes*** in ***LaunchMTparam.txt***.

At the end of this processing, a folder will be created where all the conventional results will be stored (e.g. ***.../PROCESS/MT/PRM\_SCD\_CROP\_ZOOM\_ML\_REMARK***) as in a normal manual AMSTerEngine processing.

To use ***SinglePair.sh*** for computing DEM, ensure that parameter ***PROCESSMODE*** is set to ***TOPO***. It is highly recommended to set also ***SNAPHU\_MODE*** to ***TOPO***. In that case, interpolation before geocoding is not allowed. Note that detrending is not advised when computing DEM. Masking is allowed but probably only make sense for masking water bodies. Remember that AMSTerEngine takes care and **masks the layover regions by default**. Remember that it **also expects an external DEM** to compute the topography from the interferometric pair. Indeed, it will unwrap the « residual » phase, then add the “differential phase to the computed topography. By doing so, it strongly reduces the gradients and ease the unwrapping. External DEM will also allow to geocode the final products, including the obtained new DEM.

#### Notes:

- 1) It is possible to perform recursive ***saphu*** unwrapping (see also ***Launch\_RecurUnwr.sh*** called from ***FUNCTIONS\_FOR\_MT.sh*** and which needs ***recur\_unwr.sh***, ***add\_unwrphase.py***, ***CropLastCol\_float.py***, ***findshift\_bytes.py*** or ***findshift\_float.py***, ***smoothbyconv\_bytes.py*** or ***smoothbyconv\_floats.py***, ***init\_interf\_ref.py*** or ***init\_interf\_float.py***, ***smoothbyconv\_bytes.py*** or ***smoothbyconv\_floats.py***, ***subtract\_interf\_bytes.py*** or ***subtract\_interf\_float.py***, ***filtercut.py***, ***Maskwithseuilcoh.py***, ***write\_unwr\_defo.py*** and ***CropLastLine\_float.py***). This might be useful for high gradient or complex interferogram that can't be properly unwrapped. The method is based on the procedure proposed by J-L Froger and Yo Fukushima. That procedure creates a saphu unwrapping configuration file named ***recur\_unwr.brief***.

To operate that recursive unwrapping, set variable ***MULTIUWP*** to ***MultiSnapuYes*** and select the following variables in your ***LaunchMTparam.txt*** as in the example below:

```

MultiSnapuYes # MULTIUWP, MultiSnapuYes performs recursive saphu unwrapping
 # (need 4 params bellow). MultiUnwrapNo (or any other string)
 # will perform single saphu unwrapping
ResidInterfFilt # WHICHINTERF, which interferogram to unwrap, ResidInterf (residual
 # interfero) or ResidInterfFilt (residual interfero filtered)
0.9 # COEFREQ, Coefficient of increase of cut-off frequency
12.5 # CUTINI, Initial cut-off frequency (e.g. 12.5 for a 400x400 image,

```

```

10 #10 for a 2200x1500 img)
0.0627 # NITMAX, Max total nr of iterations
 # COHMUWPTHRESH, coh threshold (between 0 and 1) below which it replaces
 # the phase by white noise (corresponding mask will be produced).
 # If set to 0, do not mask with white noise

```

It is also possible to do that during the mass processing. However, **beware that this will be time consuming of course (for a single interferogram and a fortiori on a mass processing) !**

- 2) It is possible to crop the images to a region of interest and hence gain computer time and resources. This is performed by adjusting the **CROP** parameters in [LaunchMTparam.txt](#), *that is :*

```

CROPyes # CROP, CROPyes or CROPno, or for S1, path to kml that will be used to define area of interest.
SRA # COORDSYST, type of coordinates used to define crop: SRA (lines and pixels) or GEO
10000 # FIRSTP, Crop limits: first point (row) to use
8000 # FIRSTL, Crop limits: first line to use
24000 # LASTP, Crop limits: last point (row) to use
12000 # LASTL, Crop limits: last line to use
1 # ZOOM, factor during crop (either a single real value,
 # or NAzMRg, where N and M are reals values if want an asymmetric zoom)
aName # REGION, Text description of area for dir naming

```

#### Attention :

- **CROP:** If option is set to ***CROPyes***, images from **all satellites** (including Sentinel1 in Strip Map mode) **but Sentinel1 in Wide Swath mode** will be cropped based on the coordinates of the corners provided below (in LINES/PIXELS numbers, i.e. SRA coordinates system, or with LAT/LONG coordinates, i.e. GEO coordinates system).

**Sentinel1 TOPSAR Wide Swath images**, when a ZOOM factor of ***1*** is chosen, must be cropped by providing a ***path\_to\_kml***. The interferometric products and all subsequent products will be cropped at that footprint. Steps up to the S1coregistration will be performed on the whole set of tracks/swaths/bursts that span the area of interest defined at reading.

However, if a **ZOOM factor other than *1*** is wanted, **Sentinel1 TOPSAR Wide Swath images** must be cropped by providing LINES/PIXELS numbers (a bug in AMSTerEngine prevents so far defining crop zone using LAT/LONG coordinates). (See Annex A.1).

**Beware:** if you intend to perform small crops on images acquired with satellites with poor footprint reproducibility from one acquisition to another (e.g. like ERS or ENVISAT), define your crop using GEO coordinates instead of SRA. It will avoid having poor overlap between your cropped region.

- **ZOOM:** image oversampling (zoom) is possible for images from **all satellites** (including Sentinel1 in Strip Map mode) **but Sentinel1 in Wide Swath mode** by setting the CROP parameter as ***CROPyes***, by providing the corners of the CROP region as LINES/PIXELS numbers or LAT/LONG coordinates, and by providing the ZOOM factor. Zooming **Sentinel1 TOPSAR Wide Swath images** can only be performed by providing LINES/PIXELS numbers (a bug in AMSTerEngine prevents so far defining crop zone using LAT/LONG coordinates). (See Annex A.1).

Note that ML factor of zoomed processing will then be ML of Zoomed pixels.

You can also provide an asymmetric value of ZOOM, i.e. a different zoom factor in Range and Pixel. For that, simply enter the ZOOM factor in the form of ***NAzMRg*** or ***MRgNAz*** in the [LaunchMTparam.txt](#) file.

- You can crop an image and keep pixels as **SQUARE** or **ORIGINALFORM** (see **PIXSHAPE** parameter in [LaunchMTparam.txt](#)), that is with or without the same ratio between Range and Azimuth sides of the pixels. The original form will be kept in

geocoded products only for the **Closest** and **Forced** options (see **GEOCMETHOD** parameter in [LaunchMTparam.txt](#)).

Note that for **Forced** option, the **FORCEGEOPIXSIZE** must be provided as **xAzyRg** or **yRgxAz** in [LaunchMTparam.txt](#)

- 3) There is a **hard-coded parameter** at the beginning of the script that may be useful to check: **MAXSIGMARGAZ** (set by default to 5) is the maximum value of Sigma (in Range and Azimuth) admitted for successful Fine Coregistration. If Sigma obtained during the processing is larger, it attempts to restart a fine coregistration with larger window size (maximum 3 times) until it ends up with an acceptable value of Sigma (that is below **MAXSIGMARGAZ**).
- 4) For TDX in Tandem (i.e. Primary date = Secondary date) or for S1, no coregistration on a Global Primary is possible. Hence it will not offer you that possibility. For all the other cases, it will ask you to answer *Yes* or *No* at the prompt.  
If you want to answer this question at the launch of the script rather than answering at the prompt, launch the command preceded by echo followed by the answer then pipe followed by the script. E.g.

```
echo "n" | SinglePair.sh prm scd LaunchMTparam.txt...
```

- 5) For TDX in Tandem, when the secondary image is used as RX, its image in SLC format is linked in the TX directory although with a dummy date where millennia is changed in 9000 (e.g. 90190730 instead of 20190730). This is mandatory to preserve the integrity of the processing chain and directory naming conventions.
- 6) If you processed a pair with **SinglePair.sh** and want to add these results to your mass processing directories as if it was computed by a normal **SuperMaster\_MassProcess.sh**, you can do that with  
**zz\_Utils\_MT\_Ndo/Move\_SinglePair\_Results\_To\_MAASSPROCESS.sh** which will rename and move the geocoded results in the appropriate directories and subdirectories in  
.../SAR\_MAASSPROCESS/SAT/REGION/SMCrop\_Zoom\_ML/Geocoded/...,  
.../SAR\_MAASSPROCESS/SAT/REGION/SMCrop\_Zoom\_ML/GeocodedRasters/... and move the directory with the rest of the processing in  
.../SAR\_MAASSPROCESS/SAT/REGION/SMCrop\_Zoom\_ML/

Of course, **SinglePair.sh** must have been performed with geocoding on the **SAME Global Primary** as what already exists in the mass processing.

See the description of **SinglePair.sh** script in annexes.

### 3.2. Single pair automated processing without unwrapping and geocoding: **SinglePairNoUnwrap.sh**

This is processing is the same as **SinglePair.sh** except that it will:

- stop before the unwrapping; It will not do the geocoding neither
- If run with 7 parameters, it means you want to output amplitude images in radar geometry with date label. In such a case the **SuperMaster** parameter will be set to **NOSM**. If you want to run several **SinglePairNoUnwrap.sh** for shadows measurements or for producing gif animation for instance, see **ALL2GIF.sh**.

- if run with 7 parameters, it will tag the amplitude images in radar geometry with the date. Position of that tag in the image is adjusted with the parameters `LabelX` and `LabelY` from the command line. Note that the font style and size of that date tag can be adjusted by changing the `DATECELL` hard coded parameter in the script. Some are already pre-defined depending on the satellite.

- Trim the cropped amplitude image in radar geometry.

Explanation: during the InSAR processing, images are cropped according to the parameters `FIRSTP`, `FIRSTL`, `LASTP`, `LASTL` that are set in the `LaunchMTparam.txt` file. However, if several pairs of images are processed in the intend of producing a stack of amplitude image of exactly the same dimensions (e.g. for shadows measurements or for producing animation gifs using `ALL2GIF.sh`), it might be useful to trim a little more the cropped images. This might be necessary e.g when the target region is close to the border of the raw image causing the size of the image to vary from one acquisition to another if the satellite does not start/stop exactly on the same footprint.

To perform that trimming, the script `SinglePairNoUnwrap.sh` uses the parameters `LLRGCO` (i.e. the Lower Left Range Coordinate Offset for final interferometric products generation) and `LLAZCO` (i.e. the Lower Left Azimuth Coordinate Offset for final interferometric products generation) that are set in the `LaunchMTparam.txt` file. The same offsets will be assigned to the upper right corner. The final cropped output amplitude images in radar geometry will hence be (`LASTP-FIRSTP`)-(2x`LLRGCO`) wide and (`LASTL-FIRSTL`)-(2x`LLAZCO`) high (Figure 5).

If all the amplitude images in radar geometry do not have the same size and footprint as expected, adjust your trimming offsets.

If no `LLRGCO` and `LLAZCO` are provided in the `LaunchMTparam.txt` file, it will use 50 pixels for both by default.

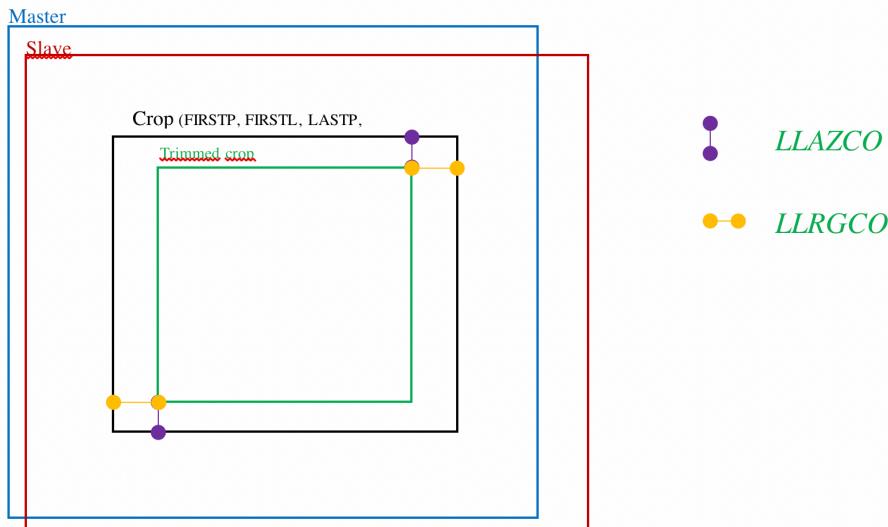


Figure 5: Crop and Trim convention

`SinglePair_NoUnwrap.sh`

PRM

SCD

ParametersFile

Comment

SUPERMASTER

[ Label X ]

[ Label Y ]

Launch ***SinglePairNoUnwrap.sh*** with the following 4 - 7 parameters:

|                                 |                                                                                                                            |
|---------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| <b><i>PRM</i></b>               | (date of the Primary image)                                                                                                |
| <b><i>SCD</i></b>               | (date of the Secondary image)                                                                                              |
| <b><i>LaunchMTparam.txt</i></b> | (text file with all the parameters and options chosen for the run)                                                         |
| <b><i>REMARK</i></b>            | (Info used in naming the dir where computation will occur)                                                                 |
| <b><i>SuperMaster</i></b>       | (date of the Global Primary image, only if used with 5 parameters.<br>If run with 7 parameters, it will be forced to NOSM) |
| <b><i>Label X</i></b>           | (Position (in pixels) of the date label added on amplitude images)                                                         |
| <b><i>Label Y</i></b>           | (Position (in pixels) of the date label added on amplitude images)                                                         |

where

- ***PRM*** and ***SCD*** are the dates of the images in format YYYYMMDD
- ***LaunchMTparam.txt*** is a text file (and path) with all the parameters and options chosen for the run. It is a good practice to store parameters files in separate subdirectories sorted by satellite and track for instance.

**Attention:** the ***LaunchMTparam.txt*** parameters file must respect some syntax:

- Parameters in file must be followed by a # and its variable name **must be followed by a coma**. Description is optional.
- As reading this file is made using the first occurrence of a search criteria, do not add text with the variable name followed by a coma elsewhere in the text.
- Always keep the paths at the end of the file.
- See the description of the parameters from ***ParametersFile.txt*** in annex 1.

- ***REMARK*** is mandatory here, though it is only used to be added at the end of name of the folder where the results are computed. It is convenient to use it to remember what are the specificities of the test performed with that pair (e.g. “\_Increased\_Coh\_threshold”), especially if you run several tests. Usually, the significance of names such as Test1, Test2... are only remembered for a short time... For the sake of readability, it is a good practice to start that parameter with an underscore.
- ***SuperMaster*** here is either the date of the Global Primary if run with only 5 parameters (similar usage as ***SinglePair.sh*** though without unwrapping), or set to **NOSM** if used with 7 parameters for generating amplitude images with a date tag e.g. for a gif animation (see for instance ***MultiLaunch.sh*** in 3.3 below or ***ALL2GIF.sh*** in 3.5).
- ***Label X*** and ***Label Y*** are the X and Y coordinates of the date tag to be overlaid to the amplitude image.

Notes:

- There is a **hard-coded parameter** at the beginning of the script that may be useful to check: **MAXSIGMARGAZ** (set by default to 5) is the maximum value of Sigma (in Range and Azimuth) admitted for successful Fine Coregistration. If Sigma obtained during the processing is larger, it attempts to restart a fine coregistration with larger window size (maximum 3 times) until it ends up with an acceptable value of Sigma (that is below **MAXSIGMARGAZ**).
- The script uses a function to crop the data to a desired zone based on the ***cutAndZoom*** function from ***AMSTEREngine***. However, before June 2022, that function cropped the zone based on the provided coordinates while considering a default zero mean altitude, which could of course result in an offset cropped zone when the area of interest is at high altitude. From June 2022, the ***cutAndZoom*** function crops the region based on the altitude computed from the provided DEM. The script ***SinglePairNoUnwrap.sh*** can use both type of cropping (of course the most recent one is the best, but older version might still be used for compatibility if a long time series already exists). The selection of new or old cropping method is performed by hard coded **CROPFCT** parameter at the beginning of the script, which can be set as ***Crop*** (to crop at mean altitude computed from provided DEM) or ***CropAtZeroAlt***. Both these functions are defined ***FUNCTIONS\_FOR\_MT.sh***.



### 3.3. Batch run of Single pair automated processing: *MultiLaunch.sh*

This script is aiming at launching multiple occurrences of a ***SinglePairNoUnwrap.sh*** processing using a Global Primary image as Primary image, and all other existing images in the input directory as Secondary images in order to obtain a set of amplitude images in radar geometry all cropped and trimmed the same way. It can be run incrementally i.e. it will only compute the new pairs. It can also be used by providing as a 7<sup>th</sup> parameter to process only a list of Secondary images.

So far it is tuned for using ***SinglePairNoUnwrap.sh*** but it should be straight forward to adapt that to ***SinglePair.sh*** as already done in ***MultiLaunch\_ForMask.sh*** (see below 3.4).



Launch ***MultiLaunch.sh*** with the following 4 (or 6 or 7) parameters:

|                          |                                                                                                                        |
|--------------------------|------------------------------------------------------------------------------------------------------------------------|
| <i>SuperMaster</i>       | (date of the Global Primary image)                                                                                     |
| <i>INPUTDATA</i>         | (path to dir where original data are stored in csl format)                                                             |
| <i>OUTPUTDATA</i>        | (path to dir where results will be stored)                                                                             |
| <i>LaunchMTparam.txt</i> | (text file with all the parameters and options chosen for the run)                                                     |
| <i>Label X</i>           | (Position (in pixels) of the date label added on amplitude images)                                                     |
| <i>Label Y</i>           | (Position (in pixels) of the date label added on amplitude images)                                                     |
| <i>PairsList.txt</i>     | (text file with a list of images to process instead of all possible ones.<br>Images are given as YYYYMMDD or S1 names) |

where

- *SuperMaster*: date of the Global Primary image in format YYYYMMDD,
- *INPUTDATA*: Usually something like ... /SAR\_CS/SAT/TRK/NoCrop
- *OUTPUTDATA*: If it is for amplitude stacking purpose e.g. for shadows measurements, it might be something like ... /SAR\_SM/AMPLITUDES/SAT/TRK/REGION
- *LaunchMTparam.txt* is a text file (and path) with all the parameters and options chosen for the run.
- *Label X* and *Label Y* are the X and Y coordinates of the date tag to be overlaid to the amplitude image
- *PairsList.txt* is a text file with a list of images to process instead of all possible ones.  
Images are given as YYYYMMDD or S1 names

### 3.4. Batch run of Single pair automated processing: *MultiLaunch\_ForMask.sh*

This script is aiming at launching multiple occurrences of a ***SinglePair.sh*** processing using either:

- a Global Primary image as Primary (taken from the *ParametersFile.txt*) and all other existing images in the input directory as Secondary in order to compute the geocoded coherence maps of every image with the Global Primary, as far as Bp and Bt are smaller than what is input as parameters.
- A list of pairs you can choose manually  
(in the form of .../SAR\_SM/MSBAS/REGION/seti/SM\_Approx\_baselines.txt or .../SAR\_SM/MSBAS/REGION/seti/table\_BpMin\_BpMax\_BtMin\_BtMax.txt, that is 4 columns with Primary and Secondary dates followed by Bp and Bt, with or without header).

It will then create a mask based on a chosen coherence threshold and save it as 8 bits as required by AMSTerEngine. It must however be transformed in LatLong before being used by AMSTerEngine as a mask. Thanks to a line suggested by A. Dille, the script now does it for you but it requires [gdal](#) installed on your computer.

Check that the created mask in LatLong (name ending with \_LL) has a header with consistent name. **If you use AMSTerEngine version from V20230928**, you will need to invert your mask (see below of chapter 0.15).

***MultiLaunch\_ForMask.sh*** can be run incrementally i.e. it will only compute the new pairs.

To spare time, it is advised:

- to disable in the [\*LaunchMTparam.txt\*](#) the unwrapping by selecting option [\*SKIPUW\*](#) as [\*SKIPyes\*](#) or even as [\*Mask\*](#). Option [\*Mask\*](#) geocodes only the coherence and, for check purpose, the amplitudes and residual interferogram.
- to disable in the [\*LaunchMTparam.txt\*](#) the masking by selecting option [\*APPLYMASK\*](#) as [\*APPLYMASKno\*](#).

Do not forget to set these options back after if you intend to use the same [\*LaunchMTparam.txt\*](#) for mass processing.



Launch ***MultiLaunch\_ForMask.sh*** with either 5 or 7 parameters:

If you want to run it with criteria of Bt and Bp and a Global Primary:

|                                          |                                                                    |
|------------------------------------------|--------------------------------------------------------------------|
| <a href="#"><i>INPUTDATA</i></a>         | (path to dir where original data are stored in csl format)         |
| <a href="#"><i>OUTPUTDATA</i></a>        | (path to dir where results will be stored)                         |
| <a href="#"><i>LaunchMTparam.txt</i></a> | (text file with all the parameters and options chosen for the run) |
| <a href="#"><i>MaxBt</i></a>             | (Maximum temporal baseline to compute pair)                        |
| <a href="#"><i>MaxBp</i></a>             | (Maximum spatial baseline to compute pair)                         |
| <a href="#"><i>Set_i_dir</i></a>         | (Path to <a href="#"><i>file</i></a> where baselines are computed) |
| <a href="#"><i>Coh_threshold</i></a>     | (Coherence threshold)                                              |

If you want to run it with a table where you manually selected a list of pairs to process:

|                                          |                                                                    |
|------------------------------------------|--------------------------------------------------------------------|
| <a href="#"><i>INPUTDATA</i></a>         | (path to dir where original data are stored in csl format)         |
| <a href="#"><i>OUTPUTDATA</i></a>        | (path to dir where results will be stored)                         |
| <a href="#"><i>LaunchMTparam.txt</i></a> | (text file with all the parameters and options chosen for the run) |
| <a href="#"><i>PairsFile.txt</i></a>     | (list of pairs to process, it can have any name)                   |
| <a href="#"><i>Coh_threshold</i></a>     | (Coherence threshold)                                              |

where

- [\*INPUTDATA\*](#): Usually something like [\*.../SAR\\_CSR/SAT/TRK/NoCrop\*](#)
- [\*OUTPUTDATA\*](#): path to where processed pairs will be stored, it might be something like [\*.../SAR\\_SM/MASKS/SAT/TRK/REGION\*](#) or [\*.../SAR\\_SM/AMPLITUDE/SAT/TRK/REGION\*](#)
- [\*LaunchMTparam.txt\*](#) is a text file (and path) with all the parameters and options chosen for the run. If run with 7 parameters (i.e. with criteria of Bt and Bp), it MUST contains the date of the Global Primary ([\*SuperMaster\*](#)) used to coregister all the Secondary images.
- [\*MaxBt\*](#) and [\*MaxBp\*](#) are the maximum temporal and perpendicular baselines under which the pairs will be computed.

OR

A table [\*PairsFile.txt\*](#) with a list of pairs in the form of

[\*... /SAR\\_SM/MSBAS/REGION/seti/SM\\_Approx\\_baselines.txt\*](#) or  
[\*... /SAR\\_SM/MSBAS/REGION/seti/table\\_BpMin\\_BpMax\\_BtMin\\_BtMax.txt\*](#).

- *Set\_i\_dir* is the path **and name of file** containing baselines computed using ***Prepa\_MSBAS.sh*** (see chapter 4 below), i.e. a file named like **... /SAR\_SM/MSBAS/REGION/seti/SM\_Approx\_baselines.txt**.  
Note: if there is no satisfying pair using the Global Primary (GLOBPRM\_SCD or SCD\_GLOBPRM) in **SM\_Approx\_baselines.txt**, the script will offer to work with **table\_MinBp\_MaxBp\_MinBt\_MaxBt.txt** instead, which contains all pairs satisfying criteria. But that might be too much. It will hence take only into account the first 10 pairs. It is the operator's responsibility to verify that it is significant. If needed, either change your **table\_MinBp\_MaxBp\_MinBt\_MaxBt.txt** or change the script to change the number of pairs to keep.
- *Coh\_threshold* is the coherence threshold used to compute the mask. The script will actually compute the mean of all the coherence maps, then apply the threshold and save the mask as **coherence\_above\_Coh\_threshold.mean** and create a gif figure of it. Launching the script for the first time takes time because it must compute the mean of all the coherence maps. However, when this is already computed, relaunching the script with only a different coherence threshold is way much faster.

The script ***MultiLaunch\_ForMask.sh*** requires **python**, **numpy** and **OpenCV**. If one prefers to compute the median rather than the mean of coherence maps, see the script ***MeanCoh.py***.

**Note:** With **AMSTerEngine version before September 2023**, the mask can be combined with coherence when unwrapping is performed with ***snaphu***. See parameter **COHCLNTHRESH**. Pixels with coherence above threshold OR where mask = 1 will be unwrapped. If **COHCLNTHRESH** is set to 0, it will only use the mask provided without taking into account the coherence:

| Mask | Coh > <b>COHCLNTHRESH</b> | unwrapping |
|------|---------------------------|------------|
| 1    | Yes                       | Yes        |
| 1    | No                        | Yes        |
| 0    | Yes                       | Yes        |
| 0    | No                        | No         |

**Warning:** since **AMSTerEngine V20230921**, masks are inverted and multi-layers, that is:

- o 0 is to keep (no mask applied)
- o 1 is always masked (e.g. water bodies area)
- o 2 is masked during unwrapping except if coherence is above a given threshold (see parameter **COHCLNTHRESH** in ***LaunchMTparam.txt***)

That is:

| Mask | Coh > <b>COHCLNTHRESH</b> | unwrapping |
|------|---------------------------|------------|
| 0    | yes                       | Yes        |
| 0    | no                        | Yes        |
| 1    | yes                       | No         |
| 1    | no                        | No         |
| 2    | yes                       | Yes        |
| 2    | no                        | No         |

Since **AMSTerEngine V20241129**, several masks are usable, whatever the resolution and footprint, with the following characteristics:

- o 0 is to keep (no mask applied)

- 1 is always masked (e.g. water bodies area)
- 2 is masked during unwrapping except if coherence is above a given threshold (see parameter **COHCLNTHRESH** in *LaunchMTparam.txt*)
- 3 is masked for computing the residual ramp at detrending step

That is:

| Mask | Coh ><br><b>COHCLNTHRESH</b>                                       | unwrapping |
|------|--------------------------------------------------------------------|------------|
| 0    | yes                                                                | Yes        |
| 0    | no                                                                 | Yes        |
| 1    | yes                                                                | No         |
| 1    | no                                                                 | No         |
| 2    | yes                                                                | Yes        |
| 2    | no                                                                 | No         |
| 3    | Only mask for computing phase ramps,<br>i.e. no mask at unwrapping |            |

### 3.5. Batch run of Single pair automated processing: *MultiLaunch\_Ampli\_Coh.sh*

This script is aiming at launching multiple occurrences of a ***SinglePair.sh*** processing using either a list of pairs you can choose manually in the form of a list of dates separated by a space, or in the form of `.../SAR_SM/MSBAS/REGION/seti/SM_Approx_baselines.txt` or even `.../SAR_SM/MSBAS/REGION/seti/table_BpMin_BpMax_BtMin_BtMax.txt`, that is 4 columns with Primary and Secondary dates followed by Bp and Bt, with or without header.

It will compute each pair from the provided list and that was not processed yet in order to :

- create slant range amplitudes and coherence images aligned on the same grid for all the pairs
- geocode Ampli and coh only
- create a fake hdr file for coherence in slant range (to allow reading them with a GIS software)
- mask the coherence in slant range (can be opened with a GIS with the same hdr as unmasked coherence)
- move all the geocoded coherence and amplitude images in dedicated directories:
  - o `_ALL_COH_GEOC`
  - o `_ALL_COH_SLANTRG`
  - o `_ALL_AMPLI_SLANTRG` (or `_ALL_AMPLI_SIGMA_SLANTRG` for S1 data if Sigma Nought calibration is requested in the `LaunchMTparam.txt`)
  - o `_ALL_AMPLI_GEOC` (or `_ALL_AMPLI_SIGMA_GEOC` for S1 data if Sigma Nought calibration is requested in the `LaunchMTparam.txt`)

These features are useful for checking land cover changes, or track landslides etc...

To spare time, it is advised to disable in the `LaunchMTparam.txt` the unwrapping by selecting option `SKIPUW` as `SKIPyes`.

**Do not crop S1 Wide Swath images with a kml. It would prevent the size of slant range products to remain the same for all pairs.**

Launch ***MultiLaunch\_Ampli\_Coh.sh*** with the 4 parameters:

|                                |                                                                    |
|--------------------------------|--------------------------------------------------------------------|
| <code>INPUTDATA</code>         | (path to dir where original data are stored in csl format)         |
| <code>OUTPUTDATA</code>        | (path to dir where results will be stored)                         |
| <code>LaunchMTparam.txt</code> | (text file with all the parameters and options chosen for the run) |
| <code>PairsFile.txt</code>     | (list of pairs to process, it can have any name)                   |

where

- `INPUTDATA`: Usually something like `.../SAR CSL/SAT/TRK/NoCrop`
- `OUTPUTDATA`: Path to where processed pairs will be stored. It will automatically add `/SAT/TRK/REGION` to that path
- `LaunchMTparam.txt`: A text file (and path) with all the parameters and options chosen for the run.
- `PairsFile.txt`: A table with a list of pairs in the form of `PrimaryDate SecondaryDate` or  
`... /SAR_SM/MSBAS/REGION/seti/SM_Approx_baselines.txt` or  
`... /SAR_SM/MSBAS/REGION/seti/table_BpMin_BpMax_BtMin_BtMax.txt`

Note that it created a file named `SizeOfCroppedAreaOfInterest.txt` where it stores the limits of the common slant range area (as it does with ***MultiLaunch.sh***).

### 3.6. Batch run of automated processing for amplitude images: ***ALL2GIF.sh***

This script is an additional layer of automation to launch ***MultiLaunch.sh*** (i.e a set of ***SinglePairNoUnwrap.sh***) using a Global Primary image as Primary and all other existing images as Secondary, then other scripts (namely ***Cp\_Ampli.sh***, ***CheckAreOfInterest.sh*** and ***jpg2movie\_gif.sh***) in order to output an animated gif of amplitude images and figures for shadow tracking for instance. It can be run incrementally i.e. it will only compute the new pairs.

At the end of this processing, amplitude images in radar geometry (flipped or flopped if required) will be stored in Envi format (binary + header txt file) in  
**.../SAR\_SM/AMPLITUDES/SAT/TRK/REGION/AMPLI\_**

A copy of these files in jpg and an animated gif will be stored in the same directory. Attention, resulting gif file can become huge; opening big ones (e.g. > 2.5 Gb) may crash on some computers.

You can further use **Fiji** to equalise the amplitude gif (and math>log processed) for a better contrast, and/or to crop the gif etc...

In the **.../SAR\_SM/AMPLITUDES/SAT/TRK/REGION/** directory, there will be also a set of sub-directories containing the intermediate data from computation for each pair.



Launch ***ALL2GIF.sh*** with the following 4 parameters:

|                                 |                                                                    |
|---------------------------------|--------------------------------------------------------------------|
| <b><i>SuperMaster</i></b>       | (date of the Global Primary image)                                 |
| <b><i>LaunchMTparam.txt</i></b> | (text file with all the parameters and options chosen for the run) |
| <b><i>Label X</i></b>           | (Position (in pixels) of the date label added on amplitude images) |
| <b><i>Label Y</i></b>           | (Position (in pixels) of the date label added on amplitude images) |

where

- ***SuperMaster***: date of the Global Primary image in format YYYYMMDD,
- ***LaunchMTparam.txt*** is a text file (and path) with all the parameters and options chosen for the run.
- ***Label X*** and ***Label Y*** are the X and Y coordinates of the date tag to be overlaid to the amplitude image.

Notes:

- If images "jumps" in the gif file, check ***List\_Az\_Rg\_UpperLeft\_coord.txt*** (created by ***CheckAreaOfInterest\_InAmplitudesDir.sh*** launched within ***ALL2GIF.sh***) for pairs whose Upper right range and azimuth coordinate are not as expected (that is not the same as in ***\_SizeOfCroppedAreaOfInterest.txt***). Either discard these wrong images or try to adjust the parameters ***LLRGCO*** and ***LLAZCO*** in ***LaunchMTparam.txt*** (see ***SinglePairNoUnwrap.sh*** in 3.2).
- ***ALL2GIF.sh*** makes use of ***jpg2movie\_gif.sh***
- There is a version that should produce a gif animation with any other type of geocoded products from all pair directories in the current directory. See ***AllProd2GIF.sh*** (in ***SCRIPTS\_MT/zz\_Utils\_My\_Ndo***)
- During the conversion to jpeg, ***convert*** uses a ratio to make the image square. Check that its output resolution fits your expectation.
- After completion of ***ALL2GIF.sh*** you can geocode the amplitudes. This is done by running the script ***Geocode\_from\_ALL2GIF.sh*** in the **.../SAR\_SM/AMPLITUDES/SAT/TRK/REGION/**

directory with a parameter file containing the desired details of the geocoding. This parameter file has a structure similar to the [LaunchMTparam.txt](#) files and must contains the following lines (see for instance [\\_\\_V20200812\\_LaunchParamReGeocAmpli.txt](#)):

```
PARAMETERS TO RUN SCRIPT Geocode_from_ALL2GIF.sh.
PARAMETERS MUST BE FOLLOWED BY A # AND ITS VAR NAME FOLLOWED BY COMA.
(DESCRIPTION, THOUGH THIS IS OPTIONAL)
AS READING THIS FILE IS MADE USING FIRST OCCURENCE OF SEARCH CRITERIA,
DO NOT ADD TEXT WTH VARIABLE NAME FOLLOWED BY COMA.
#
VERSION August 12 2020

GEOCODING
#####
UTM # PROJ, Chosen projection (UTM or GEOC - both are ok here)
TRI # RESAMPMETHOD, TRI = Triangulation; AV = weighted average; NN = nearest neighbour
LORENTZ # WEIGHTMETHOD, Weighting method : ID = inverse distance; LORENTZ = lorentzian
1.0 # IDSMOOTH, ID smoothing factor
1.0 # IDWEIGHT, ID weighting exponent
0.1 # FWHM, Lorentzian Full Width at Half Maximum
15 # XPIX, Easting sampling [m] if UTM or Longitude sampling [dd] if LatLong
15 # YPIX, Northing sampling [m] if UTM or Latitude sampling [dd] if LatLong
pathToKmlFile # AREAOFINT, Forced footprint of geocoded product : Path_to_a_kml_file or pathToKmlFile to ignore forcing
```

Geocoded products will be stored in [.../SAR\\_SM/AMPLITUDES/SAT/TRK/REGION/\\_GEOCAMPLI](#)

### Remark:

A script names ***MakeAmpliPlotSingleImg.sh*** also creates amplitude (module) images, though for only one image at a time. This is convenient

- 1) if only one image is available (no pair possible),
- 2) if no coregistration on a Global Primary is required or
- 3) if speed is important (as it skips all processes other than what is needed to just compute the module image).

See script in [\\$PATH\\_SCRIPTS/SCRIPTS\\_MT/zz\\_Utils\\_MT](#).

Note that the script ***MakeAmpliPlotSingleImg.sh*** requires a parameter file as the one named [\\_\\_V20220719\\_LaunchParamAmpli.txt](#) and provided as a template in [\\$PATH\\_SCRIPTS/SCRIPTS\\_MT](#). That file contains information about desired multilooking and zoom factors, output pixel shape (**SQUARE** or **ORIGINAL**), crop region (provided either as pixels coordinates in lines and columns or geographic coordinates or kml<sup>8</sup>) and a path to an external DEM.

Note that unlike in the case of the interferometric processing, the **SQUARE** option will compute the ratio between azimuth and range pixel size without taking into account the incidence angle in order to display squared pixels in Slant Range. Considering the incidence angle would square the pixel in Ground Range. If needed, uncomment the lines in the script to square the pixels taking into account the incidence angle.

The script is launched by providing it with two parameters: the path to the image (which MUST be in a directory named [.../SAR\\_CSL/SAT/TRK/NoCrop/IMAGE.csl](#) because the name of the satellite, track and date are extracted from that path) and the parameter file [\\_\\_V20220719\\_LaunchParamAmpli.txt](#).

---

<sup>8</sup> Attention, cropping using geographic coordinates or kml may be a problem for very small area located e.g. in high relief area as the crop region is defined based on the mean altitude of the whole image in order to define the crop in slant range-azimuth. If altitude of the small cropped region differs significantly from the mean altitude of the scene, the cropped region might be offset significantly. Providing the cutAndZoom parameter file with the path to the DEM may improve. Avoid also locating margins of the crop in lay over region.

## 4. Preparation for Mass Processing

A series of scripts aims at preparing directories and parameter files that will be used in the mass processing procedure.

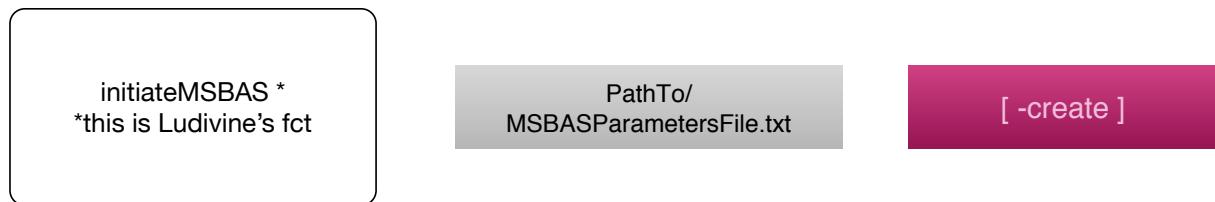
### 4.1. Prepare the directories used in the mass processing: *initiateMSBAS*

This is a function from AMSTerEngine (**not a script**) prepared by Ludivine Libert and is aiming at preparing a list of set/directories where links to each **SAT/TRK** images in *csl* format will be stored to compute the compatible pairs, as well as creating parameters files that will be needed later (for the MSBAS pair selection etc.).

Example of set for the VVP:

|                 |                      |
|-----------------|----------------------|
| set1 = CSK Asc  | set4 = R2 F21N       |
| set2 = CSK Desc | set5 = R2 UF         |
| set3 = R2 F2F   | set6 = S1 Asc 174    |
|                 | Set7 = S1 Desc 21... |

Remark: It is advised to keep a track somewhere in a file of the images (sensor, track, region) present in the different *set i*.



To operate this,

- First create an *MSBASParametersFile.txt* in the `../SAR_SM/MSBAS/REGION` directory as follows:
  - Launch the command  
***initiateMSBAS* .../SAR\_SM/MSBAS/REGION/MSBASParametersFile.txt -create**
  - Modify the *MSBASParametersFile.txt* according to your data. e.g.:

```
/* MSBAS Initialization parameter file */
/* ***** */
....SAR_SM/MSBAS/Bukavu/ /* Path to MSBAS directory */
4 /* Number of sets for MSBAS processing */
40 /* Total number of CSL images in all sets */
/* The total number of CSL images can be replaced by a maximum number of images */
```

- The Path to MSBAS directory is the path where your *MSBASParametersFile.txt* is, as well as your different set*i* e.g. `../SAR_SM/MSBAS/REGION`

- Re-run ***initiateMSBAS*** to create the desired number of set using this newly created and just modified *MSBASParametersFile.txt*:

***initiateMSBAS*** *.../SAR\_SM/MSBAS/REGION/MSBASParametersFile.txt*

(**Note** that the option *-create* is not anymore at the end of the command line).

When done, all the *seti* are in *.../SAR\_SM/MSBAS/REGION/MSBAS/seti* directory. This is not necessary. You can move then one level of directory up and delete the empty **MSBAS** dir. You should end up with a path like *.../SAR\_SM/MSBAS/REGION/seti*.

#### 4.2. Create links to the original *cs/* images in their respective *set* directory: *Ins\_All\_Img.sh*

The *Ins\_All\_Img.sh* script is aiming at creating a symbolic link for the *cs/* data in the respective *set*i** directories where they will be used by the AMSTerEngine automated scripts (e.g. *Prepa\_MSBAS.sh*).



In each *set*i**, run *Ins\_All\_Img.sh* with following 3 parameters:

.../SAR\_CS/SET/TRKDIR/NoCrop (where the data are stored in *cs/* format)  
.../SAR\_SM/MSBAS/REGION/*set*i** (where links will be stored in *i*th set)  
*SAT* (name of the satellite; must be compatible with dir naming)

where

- *SAT* is the name of the satellite (must be compatible with dir naming, see [Table 1 page 53](#)),
- *TRKDIR* is the track of the satellite (must be compatible with dir naming),
- *REGION* is the region
- *set*i** is the series of directories names *set1*, *set2*.... *setn* where links to each *SAT/TRK* images in *cs/* format will be stored to compute the compatible pairs.

Note that the order of the different *set*i** is arbitrary and does not matter but you need to remember which *SAT/TRACK* is in each *set* directory.

Make one run like that for each *set*i**.

### 4.3. Compute the compatible pairs and make the baseline plots: ***Prepa\_MSBAS.sh***

This script is aiming at preparing the MSBAS data sets and computing baselines table and baselines plot. Data must have already been linked in cs/format in the different directory (see chapter 4.2). One can force the date of the Global Primary if you do not want to compute a new one. This is mandatory when adding image(s) to a large existing data base.

The script is able to create tables and plots using former tools made by Ludivine Libert (using functions ***approximateBaselines***, ***selectInterferometricPairs***, ***globalMaster*** and using for instance the script ***build\_bperp\_file.sh***, or with more recent tools (after May 2022) by Dominique Derauw (using AMSTerEngine function ***baselinePlot***).

The script ***Prepa\_MSBAS.sh*** checks if the AMSTerEngine function ***baselinePlot*** exists, which would mean that the most recent tools by D Derauw are available. Using the former or the most recent tools should be transparent to the user as the scripts will generate all the necessary files. However, the old tool might be slower and may consider the criteria for the baselines search as exclusive, that is if you search for a max Bp of 120m, 120 will not be taken into account.

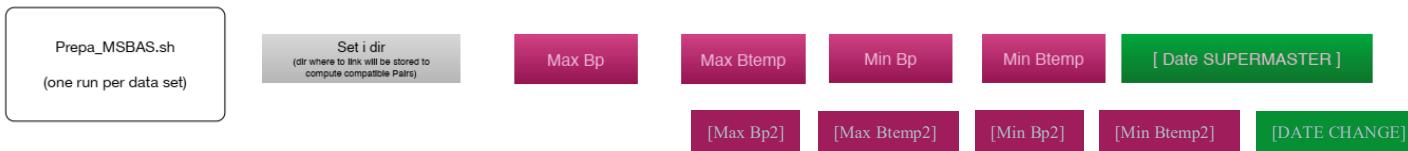
Note that the tools by L. Libert allows selecting a minimum Btemp or Bp, while the tool by D. Derauw considers that the ***MinBtemp*** and ***MinBp*** are ***zero***. As a consequence, ***Prepa\_MSBAS.sh*** may be launched with either 2 or 4 baselines criteria as parameters. The script will automatically check, given the number of baselines criteria, what to do. If you provide it with 4 criteria including ***MinBtemp*** and ***MinBp*** different from ***zero***, it will launch the old tools. If you provide him with 4 criteria including ***MinBtemp*** and ***MinBp*** equal ***zero***, it will try to launch the new tool if available, or the old tools if not.

Note that since its version 4.0 (January 2023), the scripts ***Prepa\_MSBAS.sh*** is **able to cope with two different sets of criteria**. This was developed to assist the continuation of long Sentinel-1 time series that were using short Bp and/or Btemp thanks to the narrow orbital tube maintained by ESA. However, since the failure of Sentinel-1B in December 2021, and to spare the Sentinel-1A satellite's fuel, ESA increased the size of the orbital tube. The time series started experiencing gaps in the baseline plots. To overcome the problem, one can launch ***Prepa\_MSBAS.sh*** with two sets of baselines criteria and a date from which the second set of criteria must be applied. Hence, one can keep the existing short-baselines baseline plots until e.g. mid 2022, then use larger baseline criteria after. This requires launching the script with 3 or 5 more parameters (depending if one wants to use the old or the new tools). See below.

The script ***Prepa\_MSBAS.sh*** must be run for each set. It will calculate a baseline plot and the optimal Global Primary image for each set, based on the selected baseline parameters.

#### Note:

- With the new tools to compute the baseline plots, the date of the Global Primary from the dataset satisfying the baseline criteria (***BP*** and ***BT***) can be found in the ***baselinePlot\_BpMax=BP\_BTMax=BT.png***. The Global Primary that is mentioned in the ***allPairsListing.txt*** file is the Global Primary from the whole dataset.
- When using the old tools to compute the baseline plots, the date of the Global Primary can be found in ***setParametersFile.txt***.



In each set, run “***Prepa\_MSBAS.sh***” with 5 or 6 parameters:

|                                           |                                                                                                                                                                                                            |
|-------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>.../SAR_SM/MSBAS/REGION/seti</code> | (dir containing links to data)                                                                                                                                                                             |
| <code>MaxBp</code>                        | (Max perpendicular baseline criteria for pair selection)                                                                                                                                                   |
| <code>MaxBtemp</code>                     | (Max temporal baseline criteria for pair selection)                                                                                                                                                        |
| <code>[MinBp]</code>                      | (Min perpendicular baseline criteria for pair selection)                                                                                                                                                   |
| <code>[MinBtemp]</code>                   | (Min temporal baseline criteria for pair selection)                                                                                                                                                        |
| <code>DateOfSuperMaster</code>            | (date of Global Primary if it has to be forced)                                                                                                                                                            |
| <code>MaxBp2</code>                       | (Max perpendicular baseline criteria for pair selection, to be applied after a given date, i.e. <code>DateChangeCriteria</code> )                                                                          |
| <code>MaxBtemp2</code>                    | (Max temporal baseline criteria for pair selection, to be applied after a given date, i.e. <code>DateChangeCriteria</code> )                                                                               |
| <code>[MinBp2]</code>                     | (Min perpendicular baseline criteria for pair selection, to be applied after a given date, i.e. <code>DateChangeCriteria</code> )                                                                          |
| <code>[MinBtemp2]</code>                  | (Min temporal baseline criteria for pair selection, to be applied after a given date, i.e. <code>DateChangeCriteria</code> )                                                                               |
| <code>[DateChangeCriteria]</code>         | (date before which the pair selection is made based on <code>MaxBp</code> and <code>MaxBtemp</code> , and after which the pair selection is made based on <code>MaxBp2</code> and <code>MaxBtemp2</code> ) |

`MinBp` and `MinBtemp` (and `MinBp2` and `MinBtemp2`) are not mandatory if you operate with the AMSTerEngine tools by D. Derauw after May 2022. They would then be set automatically to zero.

Usually, `MinBp` and `MinBtemp` (and `MinBp2` and `MinBtemp2`) are 0 unless you want to select only a new bunch of pairs with new criteria. For instance, suppose you processed images with Bp comprise between 0-100 meters and you want later to add pairs with Bp comprised between 100 and 150 meters. Running again the script with Bp criteria set to 0-150m would compute all the pairs satisfying that range. Running the script with Bp criteria set to 100-150m would only compute the new pairs, hence you can know exactly how many pairs you add. Note that it would not make a difference at the mass processing step because the mass processing ignores pairs that were already computed.

`DateOfSuperMaster` is required if one do not want to recompute a new Global Primary image. For instance, when you assess the best Global Primary, then compute the mass processing of all the compatible pairs, then add a new image, you do not want to evaluate a new Global Primary. Indeed, selecting a new Global Primary would result in reprocessing the whole bunch of pairs rather than only the new compatible pairs (i.e. containing only the new image).

During the processing of ***Prepa\_MSBAS.sh***, the script will (vocally) ask you if you want to select a new Global Primary. The former Global Primary used can be found in `setParametersFile.txt`.

After that run, a table with all the pairs to be used in the ***SuperMaster\_MassProc.sh*** is written in each set (e.g. `Table_0_100_0_100.txt`). It contains something like:

| Master   | Slave    | Bperp | Delay |
|----------|----------|-------|-------|
| 20180306 | 20180318 | -43   | -12   |
| 20180306 | 20180330 | -55   | -24   |
| 20180318 | 20180330 | -12   | -12   |
| 20180306 | 20180411 | -52   | -36   |
| 20180318 | 20180411 | -8    | -24   |
| 20180330 | 20180411 | 3     | -12   |
| 20180306 | 20180423 | -11   | -48   |
| 20180318 | 20180423 | 31    | -36   |
| 20180330 | 20180423 | 44    | -24   |
| 20180411 | 20180423 | 40    | -12   |

Make one run like that for each *seti*. See section 4.4 for doing them all in one run.

Check the baselines plot in: .../SAR\_SM/MSBAS/REGION/seti/span\_Bmin\_Bmax\_Tmin\_Tmax.jpg (old tools) or .../SAR\_SM/MSBAS/REGION/seti/baselinePlot\_BpMax=Bmax\_BTMax=Tmax.txt.jpg (tools after May 2022). Note that these recent tools also provide figure with the spatial localization within the orbital tube, that is: *imageSpatialLocalization\_BpMax=Bmax\_BTMax=Tmax.txt.jpg*.

**Note:** Before running the script, ensure that there are links to *cs*/images in the *seti* directory and that *setParametersFile.txt* is present as well! The *setParametersFile.txt* is created using the *initiateMSBAS* script (see 4.1).

**Note:** If, for any reason, you need to add some pairs that do not fit the *MinBp*, *MaxBp*, *MinBt* and *MaxBt* baseline criteria (e.g. to ensure phase closure, or have as much usage of an image as Primary than as Secondary image, or want to have a continuous baseline plot), you can create a file named *table\_MinBp\_MaxBp\_MinBt\_MaxBt\_AdditionalPairs.txt* (with the same values for *MinBp*, *MaxBp*, *MinBt* and *MaxBt* as those already used !) that contains the list of additional pairs you would like to process. These pairs must be stored in the file in the form of (without header):

| <i>DatePrimary</i> | <i>DateSecondary</i> | <i>Bp</i> | <i>Bt</i> |
|--------------------|----------------------|-----------|-----------|
|--------------------|----------------------|-----------|-----------|

**Prepa\_MSBAS.sh** will paste these new pairs to *table\_MinBp\_MaxBp\_MinBt\_MaxBt.txt*. The file *table\_MinBp\_MaxBp\_MinBt\_MaxBt\_AdditionalPairs.txt* will further be copied automatically in *SAR\_MASSPROCESS/SAT/REGION\_TRK/SM\_ZOOM\_ML* directory, where it might be used later.

**Note:** If one need to add/remove some pairs and plot again the baseline plot:

- add/remove lines in the *Table\_Bmin\_Bmax\_Tmin\_Tmax.txt* file
- Launch the script “**plotBaselines.sh**” with 5 parameters:  
.../SAR\_SM/MSBAS/REGION/seti      (dir containing links to data and baselines tables)  
*MinBp*                                (Min perpendicular baseline criteria for pair selection)  
*MaxBp*                                (Max perpendicular baseline criteria for pair selection)  
*MinBtemp*                            (Min temporal baseline criteria for pair selection)  
*MaxBtemp*                            (Max temporal baseline criteria for pair selection)

Results in plots may differ from one script to another because of X axis units. You may want to force the Y axis limits: see **plotspan.sh**.

**Note:** If you run the script on a Linux computer without sound card, it may display an error message as below while attempting to read aloud the question whether or not you want “to search for a new Global Primary image”:

```
ALSA lib confmisc.c:767:(parse_card) cannot find card '0'
ALSA lib conf.c:4732:(_snd_config_evaluate) function snd_func_card_driver returned error: No such file or directory
ALSA lib confmisc.c:392:(snd_func_concat) error evaluating strings
ALSA lib conf.c:4732:(_snd_config_evaluate) function snd_func_concat returned error: No such file or directory
ALSA lib confmisc.c:1246:(snd_func_refer) error evaluating name
ALSA lib conf.c:4732:(_snd_config_evaluate) function snd_func_refer returned error: No such file or directory
ALSA lib conf.c:5220:(snd_config_expand) Evaluate error: No such file or directory
ALSA lib pcm.c:2642:(snd_pcm_open_noupdate) Unknown PCM default
error: No such file or directory
ALSA lib confmisc.c:767:(parse_card) cannot find card '0'
ALSA lib conf.c:4732:(_snd_config_evaluate) function snd_func_card_driver returned error: No such file or directory
ALSA lib confmisc.c:392:(snd_func_concat) error evaluating strings
ALSA lib conf.c:4732:(_snd_config_evaluate) function snd_func_concat returned error: No such file or directory
ALSA lib confmisc.c:1246:(snd_func_refer) error evaluating name
ALSA lib conf.c:4732:(_snd_config_evaluate) function snd_func_refer returned error: No such file or directory
ALSA lib conf.c:5220:(snd_config_expand) Evaluate error: No such file or directory
ALSA lib pcm.c:2642:(snd_pcm_open_noupdate) Unknown PCM default
error: No such file or directory
```

These messages can be ignored... Or google them if you want to fix the issue.

**Remark:**

If a new processing is carried out using the same crop (name), Global Primary image, ML factor and Zoom but with some parameters being different, ensure that you change former directories naming accordingly

- [.../SAR\\_SM/SAR\\_RESAMPLED/SAT/REGION\\_TRACK/SMCrop\\_SM\\_DATESM\\_CROPNAME\\_\(Used during the mass coregistration\)](#)
- [.../SAR\\_MASSPROCESS/SAT/REGION\\_TRACK/SMCrop\\_SM\\_DATESM\\_CROPNAME\\_\(Used during the InSAR mass processing\)](#)

**Warnings:**

- In **AMSTerEngine** version prior **20210217**, the **AMSTerEngine** tool **selectInterferometricPairs** had a bug preventing to take into account the pairs with **Bp=0**, although they would be the best ones one can imagine...
- Baseline selection may have a strong influence on the MSBAS inversion.

**Note:** if you prefer to have a list of pairs computed with other criteria rather than Max **Bp** and **Bt**, see scripts

- **Extract\_x\_Shortest\_Connections.sh**, which prepares a similar table [table\\_0\\_0\\_MaxShortest\\_x.txt](#) with all the pairs with the **x** shortest connections in the baseline plot. It computes this from the file [allPairsListing.txt](#) (created with **Prepa\_MSBAS.sh**) from the current directory.

It will also create a table [allPairsListing\\_Maxx\\_ForPlot.txt](#) (that is all the pairs for being plotted using **baselinePlot**), and a baseline plot named [baselinePlot\\_table\\_max\\_x.txt.png](#).

- **DelaunayTable.sh**, which uses [DelaunayTable.py](#) to prepares a table named [table\\_0\\_0\\_DelaunayPARAM\\_0.txt](#) (where **PARAM** is **RatioxxxMaxBtxxxMaxBpxxx** ; see below) with all the pairs in the baseline plot satisfying a Delaunay triangulation, and a possible filtering of the baselines larger than a maximum temporal and/or spatial baseline provided as parameters. The script computes this selection thanks to the file [allPairsListing.txt](#) (created with **Prepa\_MSBAS.sh**) from the current directory. It takes 3 optional parameters (in any order):

- -Ratio=**float**: where **float** is a number (as float format) representing the ratio between X axis (time; in years) and Y axis (Bp in meters) in the Delaunay plot. For instance, a ratio of **x** will make the 1m baseline orthogonal to 1 day/**x**. Adjusting that ration allows avoiding elongated triangles;
- -BpMax=**integer**: the Max Bp (as integer format) allowed for the segments of the triangles in y direction;
- -BtMax=**integer**: the Max Bt (as integer format) allowed for the segments of the triangles in x direction.

In a first stage, the python script [DelaunayTable.py](#) creates:

- a file named [table\\_0\\_0\\_DelaunayRatioxxx\\_0.txt](#) that contains all the list of pairs for the mass processing (where **xxx** is defined by the parameter -Ratio.),
- a file named [Delaunay\\_Triangulation\\_xyRatioxxx\\_PairsforPlot.txt](#) that contains all the list of pairs for plotting with **baselinePlot** with the -r option,
- a figure (for a quick look) [Delaunay\\_Triangulation\\_Plot\\_xyRatioxxx.png](#) with the baseline plot without any baseline filtering.

Then the bash script **DelaunayTable.sh** performs the optional baseline filtering and creates the following files:

- a file named [table\\_0\\_0\\_DelaunayRatioxxxMaxBtxxxMaxBpxxx\\_0.txt](#) that contains all the list of pairs for the mass processing (where **xxx** is defined by the parameter -Ratio). It is the filtered version of [table\\_0\\_0\\_DelaunayRatioxxx\\_0.txt](#).

- a file that contains all the list of pairs for plotting with **baselinePlot** and named [Delaunay\\_Triangulation\\_xyRatioxxxMaxBtxxxMaxBpxxx\\_PairsforPlot.txt](#). It is the filtered version of [Delaunay\\_Triangulation\\_xyRatioxxx\\_PairsforPlot.txt](#).
- a figure named [baselinePlot\\_Delaunay\\_Triangulation\\_xyRatioxxxMaxBtxxxMaxBpxxx\\_PairsforPlot.txt.png](#) with the baseline plot with the baseline filtering. It is the filtered version of [Delaunay\\_Triangulation\\_Plot\\_xyRatioxxx.png](#).
- The usual files are also created by **baselinePlot -r**, e.g:  
[imageSpatialLocalization\\_Delaunay\\_Triangulation\\_RatioxxxMaxBtxxxMaxBpxxx\\_PairsforPlot.txt.png](#)  
[restrictedAcquisitionsRepartition.txt\\_Delaunay\\_Triangulation\\_xxxMaxBtxxxMaxBpxxx\\_PairsforPlot.txt](#)  
[restrictedPairSelection\\_Delaunay\\_Triangulation\\_xyRatio xxxMaxBtxxxMaxBpxxx \\_PairsforPlot.txt](#)

Note: if one or both MaxBt or MaxBp is/are not used, no corresponding filtering is performed and that/these parameter(s) do(es) not appear in the file naming.

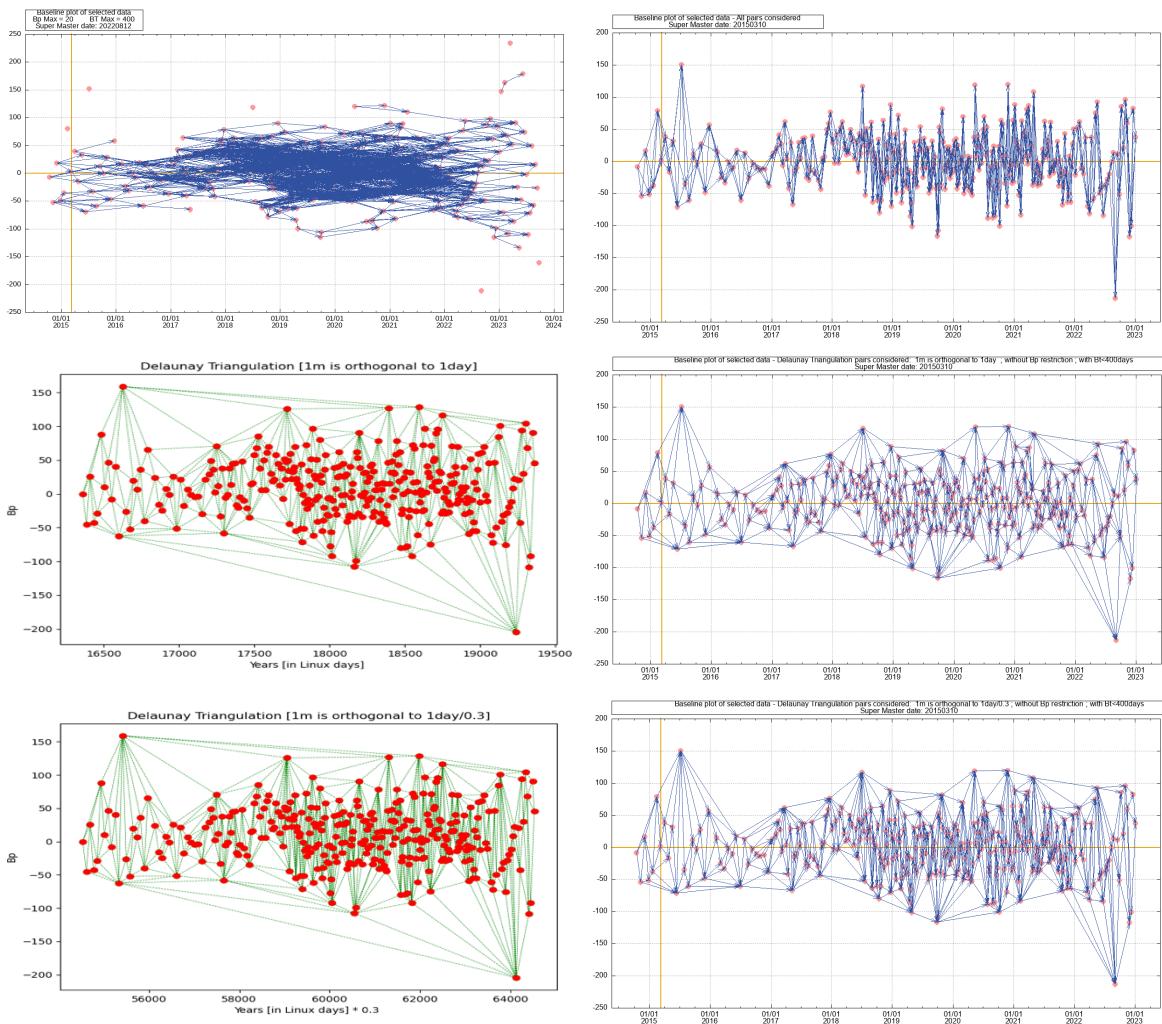


Figure 6: Example of baseline plot for Sentinel 1 images acquired in the Virunga (DRC) computed with several techniques:

Top Left: All pairs with  $Bp < 20m$  and  $Bt < 400$  days (obtained with [prepa\\_MSBAsh.sh](#)).

Top Right: Max 3 shortest connection (obtained with [Extract\\_x\\_Shortest\\_Connections.sh](#)).

Middle Left: Delaunay Triangulation without Ratio (i.e.  $1m$  is orthogonal to  $1$  day) and without maximum baseline filtering.

Middle right: Same as above with spatial baseline restricted to Max 400 days (both obtained with [DelaunaTable.sh](#)).

Bottom Left: Delaunay Triangulation with Ratio 0.3 (i.e.  $1m$  is orthogonal to  $1/3$  day) and without maximum baseline filtering.

Bottom right: Same as above with spatial baseline restricted to Max 400 days (both obtained with [DelaunaTable.sh](#)).

(Note: The top left baseline plot covers a slightly longer time span)

#### 4.4. Analyse the pairs to assist the creation of the baseline plot based on a Max Bp and Bt:

The python script [Analyse\\_AllPairslisting\\_data.py](#) provides some statistics on the pairs to be selected for a baseline plot. It takes as input parameters:

- the path to the file `allPairsListing.txt` file, which is created by `Prepa_MSBAS.sh` in `.../SAR_SM/MSBAS/REGION/set//`
- the maximum spatial and temporal baseline envisaged to create a baseline plot: `BPmax` (in m) and `BTmax` (in days)
- The largest gap in days allowed in the baseline plot: `GAPINDAYS`
- A multiplicative factor `NBR` (integer) to search for pairs with a spatial baseline = (`BPmax` x `NBR`) and a temporal baseline = (`BTmax` x `NBR`) to be listed. The pairs with these enlarged baselines would not be taken into account in a baseline plot based on only `BPmax` and `BTmax` but some of them could be interesting to add to avoid gaps instead. Increasing `BPmax` and `BTmax` would also fill the gaps of course, but it would certainly increase the number of pairs to compute where it would be not necessary.

The output of the script is twofold: a python figure made of 9 plots (Figure 7) and a list of information at the terminal (Figure 8).

The python figure displays from upper left to lower right (Figure 7):

- 1 All Bp versus Bt (in black) and those satisfying  $Bp < BPmax$  versus  $Bt < BTmax$  in blue.
- 2 The time between two consecutive images
- 3 The number of pairs using an image as Secondary image
- 4 All the possible temporal baselines for each image (in black) or satisfying  $Bt < BTmax$  in blue.
- 5 All the possible spatial baselines for each image (in black) or satisfying  $Bp < BPmax$  in blue.
- 6 The number of pairs using an image as Primary image
- 7 The temporal baselines of all the pairs using each image and satisfying the `BPmax` and `BTmax` criteria
- 8 The spatial baselines of all the pairs using each image and satisfying the `BPmax` and `BTmax` criteria
- 9 The number of pairs using an each image as Primary and Secondary image

The output at the terminal provides with the following information (Figure 8):

- The path to the `allPairsListing.txt` file that was analysed (from input),
- The `BPmax` and `BTmax` criteria envisaged to create the baseline plot (from input),
- The total number of images (“Number of nodes”)
- The total number of possible pairs (“Number of edges”)
- The number of images and pairs satisfying to the input criteria of `BPmax` and `BTmax`
- The list of images never used as a Secondary (“node IN degree =0”)
- The list of images never used as a Primary (“node OUT degree =0”)
- Some statistics about the number of time images are used as Secondary and Primary
- Some statistics about the spatial and temporal baselines for all the possible pairs
- The list of images that are not in the baseline plot because they cannot be used to form a pair satisfying to the input criteria of `BPmax` and `BTmax`
- The list of pairs that could be formed with the images that are not in the baseline plot (see above) but which satisfy one of the two criteria and less than `NBR` times the second criteria. These are pairs that could be added to the baseline plot to recover

the images that were not taken into the baseline plot satisfying to the input criteria of  $BP_{max}$  and  $BT_{max}$ .

- The largest gap between 2 consecutive images
- The list of gaps above  $GAPINDAYS$  days

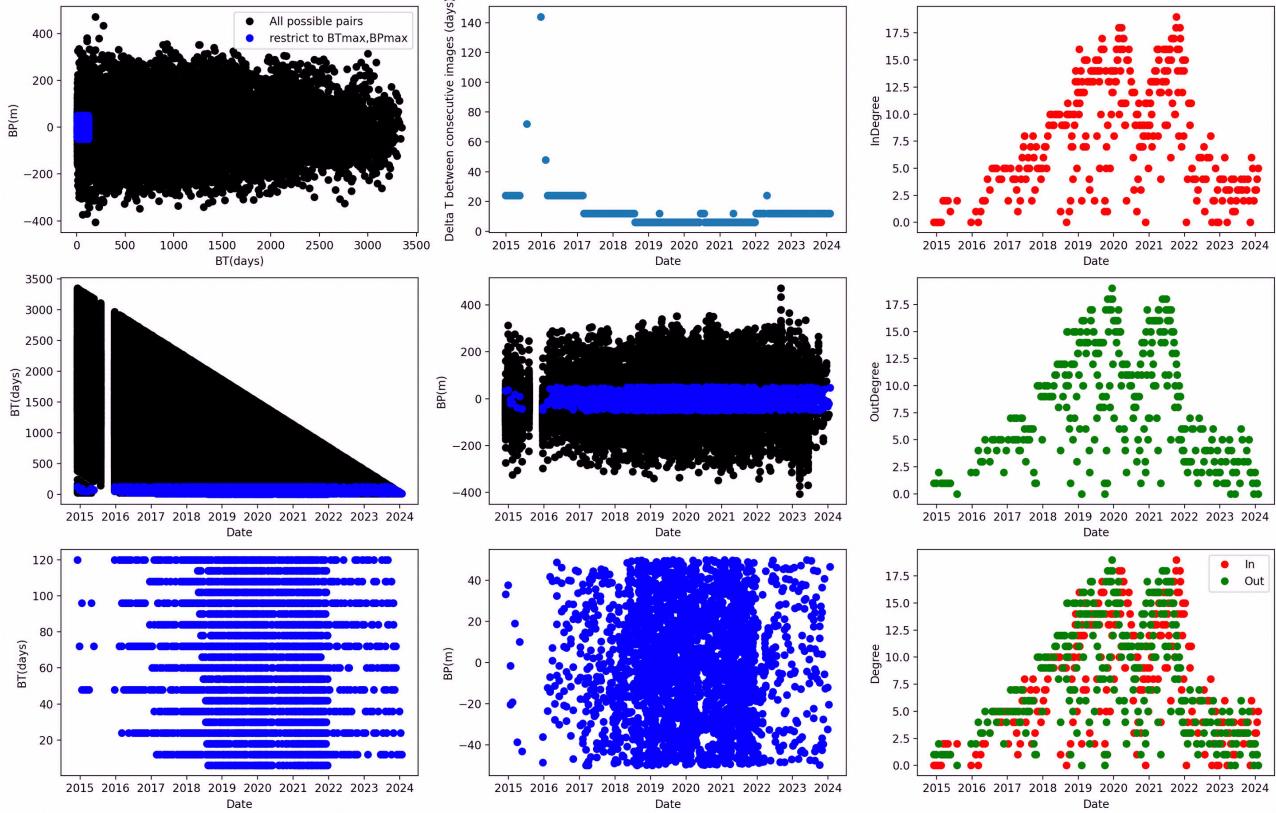


Figure 7: Example of figure output from a run of [Analyse\\_AllPairslisting\\_data.py](#) for a dataset of images acquired over the Guadeloupe region with a Max  $Bp$  and  $Bt$  criteria of respectively 50m and 120 days (pairs satisfying these criteria are displayed in blue). The script was launched with a  $GAPINDAYS$  of 140 days and multiplier  $NBR$  of 3 to search for additional pairs that could improve the baseline plot based on the 50m and 150 days criteria. These possible improvements are only displayed at the terminal (see Figure 8).

```

import pandas as pd
Distro V2.1 AMSTer script utilities
Delphine Smittarello (c)2016-2019, Last modified on Feb 14, 2024

Analyse /Volumes/hp-1650-Data_Share1/SAR_SM/MSBAS/GUADELOUPE/set1/allPairsListing.txt
BTmax = 120 days and BPmax = 50 meters

Graph of all pairs created
Number of nodes: 334
Number of edges: 55611
Graph satisfying both criteria created
Number of nodes: 332
Number of edges: 2831

node IN degree =0
[20141283, 20141227, 20150120, 20150213, 20151222, 20160303, 20180901, 20201125, 20220119, 20221010, 20221127, 20221221, 20230315, 20231110]
node OUT degree =0
[20150731, 20190204, 20191002, 20230420, 20230607, 20231216, 20240202]

Statistics
Indegree : Mean = 8.52710843373494 ; Min = 0 ; Max = 19
Outdegree: Mean = 8.52710843373494 ; Min = 0 ; Max = 19
BT : Mean = 62 ; Min = 6 ; Max = 120
BP : Mean = 23.71066760861886 ; Min = 0.03 ; Max = 49.98

2 images are discarded due to too restrictive baselines criteria: [20220904, 20230923]
Consider adding pairs satisfying one of both criteria and less than 3 times the second to a table of additional pairs to avoid discarding those images
Such possible pairs are :

Image 20220904
pair with 20221127 has BT= 84 < 120 days and BP= 105.39 meters

Image 20230923
pair with 20221127 has BT= 300 days and BP= -39.96 < 50 meters
pair with 20230514 has BT= 132 days and BP= -33.49 < 50 meters
pair with 20230713 has BT= 72 < 120 days and BP= -71.05 meters
pair with 20230725 has BT= 68 < 120 days and BP= -64.45 meters
pair with 20230806 has BT= 48 < 120 days and BP= -120.46 meters
pair with 20230818 has BT= 36 < 120 days and BP= -141.00 meters
pair with 20230911 has BT= 12 < 120 days and BP= -93.52 meters
pair with 20231005 has BT= 12 < 120 days and BP= 147.68 meters
pair with 20231017 has BT= 24 < 120 days and BP= 137.91 meters
pair with 20231204 has BT= 72 < 120 days and BP= 98.01 meters
pair with 20231216 has BT= 84 < 120 days and BP= 85.4 meters

Searching for the largest gap between consecutive images
Max BT between consecutive images is 144.0 between 2015-07-31 and 2015-12-22

Searching for gaps over 140 days between consecutive images
BT between consecutive images is 144.0 days between 2015-07-31 and 2015-12-22

```

Figure 8: Example of Terminal output from a run of [Analyse\\_AllPairslisting\\_data.py](#) for a dataset of images acquired over the Guadeloupe region with a Max Bp and Bt criteria of respectively 50m and 120 days and a GAPINDAYS of 140 days and multiplier NBR of 3 to search for additional pairs that could improve the baseline plot. It shows that a Bt criteria of 120 days is too restrictive to keep some images in the baseline plot. It shows also the pairs using these missing images and that satisfies the extra criteria of max NBR times Bp or Bt. To recover these images in the baseline plot, either increase BPmax and BTmax or add the suggested pairs in a file [table\\_BpMin\\_BpMax\\_Btmin\\_Btmax\\_AdditionalPairs.txt](#).

#### 4.5. Process more than one *Prepa\_MSBAS.sh* for several *seti* at a time:

You can prepare a script to make several *Prepa\_MSBAS.sh*. See for instance  
*Lazy\_prepas\_msbas\_all\_sets\_andPlotBaselines\_Funu.sh*  
or  
*Lazy\_prepas\_msbas\_all\_sets\_andPlotBaselines\_VVP.sh*

In these scripts, there is also a suggestion for plotting baseline plots with several sets on the same plot using *plot\_Multi\_span.sh*. See its syntax therein if you are interested by that option.

## 5. Mass Processing

Before performing a mass processing, it is advised to carefully check the [LaunchMTparam.txt](#) that will be used, then run some tests with [SinglePair.sh](#).

If some errors are encountered during a first run of mass processing, it is advised to carefully check the [.../SAR\\_MASSPROCESS](#) directory and clean pair directories and files in [/Geocoded](#) and [/GeocodedRasters](#) directories.

### 5.1. Coregistration of images pairs to the Global Primary image: [SuperMasterCoreg.sh](#)



This script is aiming at coregistering and resampling all the images from a given sat mode in the geometry of a Global Primary image using AMSTerEngine.

For each set of sat mode, launch “[SuperMasterCoreg.sh](#)” with following 1 or 2 parameters:

[LaunchMTparam.txt](#) (text file with all the parameters and options chosen for the run)

[FORCE](#) (optional; for S1 only, to force recomputing DEM for each image)

where

- o [LaunchMTparam.txt](#) is a text file (and path) with all the parameters and options chosen for the run.
- o [FORCE](#) is an option (for S1 use only) to force the script to compute DEM (and mask if required) in slant range for each S1 image.

- [SuperMasterCoreg.sh](#) will create a directory for each set where it will store the coregistration and resampling of each image to the Global Primary. Its naming is as follows:

[.../SAR\\_SM/SAR\\_RESAMPLED/SAT/REGION\\_TRACK/SMCrop\\_SM\\_DATESM\\_CROPNAME](#)

where [DATESM](#) is the date of the Global Primary image.

For Sentinel 1 images, orbits and geometries are good enough to bypass the coregistration step of each image to the Global Primary image. However, each image will need its DEM (and mask, if any) computed in slant range. This will be performed at the present step. If no [FORCE](#) parameter is used, it will only compute the slant range projection of the DEM (and mask) for the new images.

- Note that for specific use at ECGS, because computation is not performed on the same hard disk as the place where final RESAMPLED results are stored, the scripts will update each path in [OUTPUTDATA/i12/TextFiles](#) for each processed pair. This is done by calling the script [RenamePathAfterMove.sh](#) at the end of [SuperMasterCoreg.sh](#) script.

- Note that for specific use at ECGS, because computation is performed with a combination of Linux and Mac computers, which have their external disks mounted with different syntax, the scripts will update each path in [OUTPUTDATA/i12/TextFiles](#) for each processed pair, with its form as a state variable (e.g. change [/Volumes/hp-1650-Data\\_Share1](#) with [\\$PATH\\_1650](#)).

This is done by calling the script ***RenamePath\_Volumes.sh*** at the end of ***SuperMasterCoreg.sh*** script. If you do not need this, just comment that call at the end of the ***SuperMasterCoreg.sh*** script.

- In order to keep track of the version of AMSTerEngine used to coregister the data, the script will store a small text file named ***Coreg\_w\_AMSTerEngine\_V.txt*** in the directory where the pair was coregistered. It contains a single line indicating the date of the last version of the software present in the ***/\$HOME/SAR/AMSTer/AMSTerEngine/\_Sources\_AE/Older***. It is supposed to be the last one that was compiled and hence the one currently used.

## 5.2. Parallel run of Coregistration: `__SplitCoreg.sh`

You can speed up the coregistration processing by launching several `SuperMasterCoreg.sh` sessions at the same time using `__SplitCoreg.sh`. The script must be provided with:

- A list of images to coregister and to be split (must be in the form of image names if S1 (e.g. `S1x_Trk_DATE_AD.csl`) or `dates` if not S1, in 1 col)
- The `LaunchMTparameters.txt` file (with its path) to be used
- The number of parallel sessions to process the coregistration
- A 4<sup>th</sup> parameter (named `FORCES1DEM` in the script) may be provided for S1 images: if set to `FORCE`, it will recompute the DEM for each S1 wide swath image

Note that images already coregistered will be ignored (unless `FORCE` is set for S1 of course).

The user must select manually the hard disks where he wants to process each split session. To assist the user, the script will list all the drives (that are hard coded in `__HardCodedLines.sh`) and display the corresponding available disk space. To select a hard disk, the user must select the number provided next to the hard disk proposed by the script. When all the sessions are attributed to a hard drive, the user must confirm that each split session can be run in a separate Terminal. The script then opens as many additional Terminal windows as the required split session. It keeps the main Terminal windows open and wait there the confirmation to clean the processing directories. **Do not clean before all the split sessions are finished!**

**Note** that `__SplitCoreg.sh` only works if you are running it on your local computer, or if you are logged on another computer with a graphical interface such as `Microsoft Remote Desktop`. [It can't work if you are logged on a server by ssh !!!](#)

If you want to operate it from a `ssh` session, you must use `ssh -X` session instead of `ssh` and ensure that you have:

- on the client side, in the `~/.ssh/config` file:

```
Host *
 ForwardAgent yes
 ForwardX11 yes
 ForwardX11Trusted yes
```

If the client is a Mac, you must install `XQuartz`, which contains `Xterm`, because `Terminal.app` is not X11 compatible.

- on the server side, in the `/etc/ssh/sshd_config` file:

```
X11Forwarding yes
X11DisplayOffset 10
X11UseLocalhost no
```

You should also have `xauth` installed on the server side (most probably existing by default).

**Note:** it is advised to **compile AMSTer Engine without the parallel option** when you perform a `__SplitCoreg.sh` because projecting DEM in slant range step uses all the available CPUs. When you perform a `__SplitCoreg.sh`, it may run several of these steps at the same time and each would try to use all the CPUs, resulting in a crawling computer.

**Note for the Linux users:** in order to automatically open one or more new Terminal windows from a Terminal and run command(s) in these newly open Terminal(s), `x-terminal-emulator` needs to know in which `DISPLAY` it must open the new Terminal windows. This is normally automatically determined by the script using the “`who`” command from `coreutils`. If the scripts can't figure out which is your `DISPLAY`, it will ask you to enter it manually. For this it will show you all the `DISPLAY` that are currently used on your computer. Enter the `DISPLAY` value in the form e.g. `:0.0` or `:10.0...`

### 5.3. InSAR mass processing of the image pairs: ***SuperMaster\_MassProc.sh***



This script is aiming at processing all compatible pairs form a given sat/mode in the geometry of a given Global Primary image as selected by ***Prepa\_MSBAS.sh***.

All Secondary images must have been initially resampled at the Global Primary grid using ***SuperMasterCoreg.sh*** (see chapter 5.1).

For each set, launch “***SuperMaster\_MassProc.sh***” with the following 2 (or 3) parameters:

|                                    |                                                                                                                                 |
|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| <i>PairsFile.txt</i>               | (path to file with the list of compatible pairs)                                                                                |
| <i>LaunchMTparam.txt</i>           | (text file with all the parameters and options chosen for the run)                                                              |
| <b>-f</b> or <b>-list=filename</b> | (optional: resp. to force processing list of pairs based on files in Geocoded/DefolInterpolx2Detrend or based on provided list) |

where

- *PairsFile.txt* is a text file (and path) with the list of all compatible pairs. This file was created using ***Prepa\_MSBAS.sh*** and is stored in ***.../SAR\_SM/MSBAS/REGION/seti***. It is named ***table\_MinBp\_MaxBp\_MinBt\_MaxBt.txt***. The script then compares that list with the list of directories of pairs already computed in ***.../SAR\_MASSPROCESS/SAT/REGION\_TRACK/SMCrop\_SM\_DATESM\_CROPNAME*** and computes the missing pairs.
- *LaunchMTparam.txt* is a text file (and path) with all the parameters and options chosen for the run.
- The third parameter is optional. It can either be ***-f*** or ***-list=filename***.
  - o In the first case, it forces the script to build the list of existing pairs based on the files that are already present in  
***.../SAR\_MASSPROCESS/SAT/REGION\_TRACK/SMCrop\_SM\_DATESM\_CROPNAME/Geocoded/DefolInterpolx2Detrend***  
instead of based on the list of existing pair directories in  
***.../SAR\_MASSPROCESS/SAT/REGION\_TRACK/SMCrop\_SM\_DATESM\_CROPNAME***
  - o If ***-list=filename***, it forces to compute only pairs in provided in the ***filename*** list. Pairs in ***filename*** MUST be in the form of list of ***PRM\_SCD*** dates (i.e. dates of Primary and Secondary images separated by an underscore).

Note that the processing is performed on a hard drive and/or a directory that differs from the final storage place. Directories of processed pairs are kept during the processing in ***.../PROCESS/MT/SAT/*** (path defined in your ***LaunchMTparam.txt***) and copied to the final storage place ***.../SAR\_MASSPROCESS/SAT/REGION\_TRACK/SMCrop\_SM\_DATESM\_CROPNAME*** as soon as a pair is finished. The geocoded files of the processed pairs are moved directly in their final location as things progress, that is in ***.../SAR\_MASSPROCESS/SAT/REGION\_TRACK/SMCrop\_SM\_DATESM\_CROPNAME/Geocoded*** (Similarly, their raster versions are moved at the same place, though in ***/GeocodedRasters*** dir).

All the pair directories are removed from the ***PROCESS*** directory only when everything is finished. Therefore, if a problem occurs before the end of the process, the directories for each pair already processed remains available in ***.../PROCESS/MT/SAT/...*** for trouble shooting. In such a case, before relaunching ***SuperMaster\_MassProc.sh***, these directories could be checked and, if not OK, removed manually from ***SAR\_MASSPROCESS***. However, because geocoded products and their raster were moved as soon as they were computed, check that these geocoded and raster products are OK as well. If not, remove them before relaunching the script ***SuperMaster\_MassProc.sh***.

In order to keep track of the version of AMSTerEngine used to mass process the data, the script will store a small text file named *Processing\_Pair\_w\_AMSTerEngine\_V.txt* in the directory where each pair was processed. It contains a single line indicating the date of the last version of the software present in the */\$HOME/SAR/AMSTer/AMSTerEngine/\_Sources\_AE/Older*. It is supposed to be the last one that was compiles and hence the one currently used.

Note that because the geocoded products are moved right after production (without waiting for the end of the whole ***SuperMaster\_MassProc.sh*** process), they could be used in an MSBAS processing even if all the images have not been processed yet (see 6.1.b).

## 5.4. Parallel runs of *SuperMaster\_MassProc.sh*: \_\_*SplitSession.sh*



The script `__SplitSession.sh` (Attention: double underscore at the beginning of the name...) allows splitting the processing of `SuperMaster_MassProc.sh` in a series of processing, each running in a separate Terminal window. For the sake of efficiency (speed), it is advised to run the split sessions on separate disks. The available disks must be hardcoded in the script (see `__HardCodedLines.sh`). Check their availability and if sufficient space.

Note that `__SplitSession.sh` only works if you are running it on your local computer, or if you are logged on another computer with a graphical interface such as *Microsoft Remote Desktop*. [It can't work if you are logged on a server by ssh !!!](#)

If you want to operate it from a `ssh` session, you must use `ssh -X` session instead of `ssh` and ensure that you have:

- on the client side, in the `~/.ssh/config` file:

```
Host *
 ForwardAgent yes
 ForwardX11 yes
 ForwardX11Trusted yes
```

If the client is a Mac, you must install *XQuartz*, which contains *Xterm*, because *Terminal.app* is not X11 compatible.

- on the server side, in the `/etc/ssh/sshd_config` file:

```
X11Forwarding yes
X11DisplayOffset 10
X11UseLocalhost no
```

You should also have `xauth` installed on the server side (most probably existing by default).

`__SplitSession.sh` needs the following parameters:

|                                                |                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>PairsFile.txt</code>                     | (path to file with the list of compatible pairs)                                                                                                                                                                                                                                                                                                                                                                              |
| <code>LaunchMTparam.txt</code>                 | (text file with all the parameters and options chosen for the run)                                                                                                                                                                                                                                                                                                                                                            |
| <code>NumberOfSplit</code>                     | (Number of set of data to be run independently from the set).                                                                                                                                                                                                                                                                                                                                                                 |
| <code>-list=filename</code> or <code>-f</code> | (Optional: <code>filename</code> (with path) to force using a list of pairs to process provided in the format <code>DATE_DATE</code> , or<br>- <code>f</code> to force checking (and skipping) existing pairs already processed based on the files present in <code>Geocoded/DefoMode</code> where mode is either <code>Interpol2Detrend</code> , or <code>InterpolDetrend</code> , or... depending on previous computation). |

For the sake of efficiency, pairs using the same `PRIMARY` will not be split into different sessions. For that reason, each set (or batch) of pairs to be run in parallel may have a different number of pairs to process. That number is always at the **maximum** the total number of pairs divided by the number of sessions (`NumberOfSplit`). Hence often the last batch contains more pairs to process than the others. If that last set of pairs to process contains more than 10% of pairs than the maximum expected, the script offers to divide that last batch in two and hence add a parallel processing to the `NumberOfSplit` that were chosen. This is useful for having all the parallel processings ending at about the same time.

The user must then select manually the hard disks where he wants to process each split session. To assist the user, the script will list all the drives (that are hard coded in `_HardCodedLines.sh`) and display the corresponding available disk space. To select a hard disk, the user must select the number provided next to the hard disk proposed by the script. When all the sessions are attributed to a hard drive, the user must confirm that each split session can be run in a separate Terminal. The script then opens as many additional Terminal windows as the required split session. It keeps the main Terminal windows open and wait there the confirmation to clean the processing directories. **Do not clean before all the split sessions are finished!**

If `SuperMaster_MassProc.sh` processing crashes:

- Check which pair folder(s) do(es) not contain the complete set of expected final products in `PROCESS` directories (usually the pair that caused the process to stop; see Terminal) and check the results in `SAR_MASSPROCESS/....` Kill what was wrong or incomplete and remove the copy of these wrong directories that would already be copied in the corresponding `SAR_MASSPROCESS` folder.
- If the cause of crash is external (e.g. power failure, connection to disk lost or disk full), relaunch the processing. No need to change the list of pairs to process because it will only compute the ones that are not yet in `SAR_MASSPROCESS`.
- If the cause of crash is due to a faulty image, try to identify and solve the cause of failure (e.g. corrupted raw image due to problem at download), then relaunch the processing. If the cause can't be fixed, edit the list of pairs and remove it from the list (if it is related to a corrupted image, you may need to remove all pairs involving it and/or move that image in `.../SAR CSL/S1/REGION/Quarantined`), then relaunch the processing.

Note that this script needs the script `LaunchTerminal.sh` in order to be able to launch a new Terminal from a Terminal.

**Note:** it is advised to compile AMSTer Engine without the parallel option when you perform a `_SplitSession.sh` because projecting DEM in slant range step or geocoding step uses all the available CPUs. When you perform a `_SplitSession.sh`, it may run several of these steps at the same time and each would try to use all the CPUs, resulting in a crawling computer.

**Note for the Linux users:** in order to automatically open one or more new Terminal windows from a Terminal and run command(s) in these newly open Terminal(s), `x-terminal-emulator` needs to know in which `DISPLAY` it must open the new Terminal windows. This is normally automatically determined by the script using the “`who`” command from `coreutils`. If the scripts can't figure out which is your `DISPLAY`, it will ask you to enter it manually. For this it will show you all the `DISPLAY` that are currently used on your computer. Enter the `DISPLAY` value in the form e.g. `:0.0` or `:10.0...`

## 5.5. Combined Mass Processing (Mass Coregistration + InSAR processing): *SuperMaster.sh*

It is possible to launch both coregistration and mass processing with a single script: In each set, launch ***SuperMaster.sh*** with the following 2 parameters:

*PairsFile.txt* (path to file with the list of compatible pairs)

*LaunchMTparam.txt* (text file with all the parameters and options chosen for the run)

It will first compute the coregistration then the mass processing. As usual, these runs are incremental i.e. it will only compute the new pairs and ignore the pairs that are already processed.

## 5.6. Check results: *Verify\_MassProcess\_Results.sh*

Use ***Verify\_MassProcess\_Results.sh*** to check if all pairs are processed and each product is created correctly. Missing products will be listed in files. It will also offer to clean incoherent occurrence of files and pair directories. It might then be necessary to re-run a mass process to recompute the missing pairs/products. This is of course useless if the reason of the problem was not identified and sorted.

***Verify\_MassProcess\_Results.sh*** will read the list of pairs supposed to be processed, then

- check if data are stored in each .../SAR\_MASSPROCESS/.../Geocoded/*Modes*, (where *Modes* are respectively Ampli, Coh, Defo, DefolInterpol, DefolInterpolDetrend, DefolInterpolx2Detrend, InterfFilt, InterfResid, UnwrapPhase)
- check if each directory of processed pair is stored in corresponding SAR\_MASSPROCESS directory.

It will output a series of text files with the status of each of these checks. It will then check if Geocoded products exist but not the corresponding Pair directory.

Launch ***Verify\_MassProcess\_Results.sh*** with the following 2 or 3 parameters:

|                           |                                                                                                                                   |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| <i>PairsFile.txt</i>      | (path to file with the list of compatible pairs)                                                                                  |
| <i>MASSPROCESSINGPATH</i> | (path to where geocoded products are stored)                                                                                      |
| <i>[DATE]</i>             | (Optional: date from which test the pairs from the list. Both Primary and Secondary images must be after that date to be checked) |

where

- *PairsFile.txt*: is a text file (and path) with the list of compatible pairs created using ***Prepa\_MSBAS.sh***. This file is stored in .../SAR\_SM/MSBAS/REGION/set*i* and named *table\_MinBp\_MaxBp\_MinBt\_MaxBt.txt*
- *MASSPROCESSINGPATH* is the path to where all the geocoded products are stored (eg. .../SAR\_MASSPROCESS/SAT/TRACK/CROP\_SM\_DATE\_ZOOM\_ML/Geocoded).
- *DATE*: is a date in the form of YYYYMMDD from which test the pairs from the list. Both Primary and Secondary images must be after (or equal to) that date to be checked.

It might be advised to run ***Verify\_MassProcess\_Results.sh*** twice in case some corrections are performed on the first run.

It is also a good practice to have a quick look at the GeocodedRasters/*Modes*, (where *Modes* are respectively Ampli, Coh, Defo, DefolInterpol, DefolInterpolDetrend, DefolInterpolx2Detrend, InterfFilt, InterfResid, UnwrapPhase) to ensure that each image that you intend to use is ok.

Note: There is similar script named ***Verify\_Geocoded\_versus\_Rasters.sh*** which ensure that the results from the mass processing are successfully stored the same way as /Geocoded and /GeocodedRasters.

## 6. MSBAS Processing

(M)SBAS is a software developed by Sergey Samsonov (<https://doi.org/10.4095/313749>) that can be downloaded at <http://insar.ca>. It aims at performing multi-dimensional time series of ground deformation in EW and UD components [Samsonov and d'Oreye, 2012; 2017<sup>9</sup>] and in certain circumstances, in 3D (EW, NS and UD), either when the displacement is thought to occur along the steepest slopes [Samsonov et al. 2020<sup>10</sup>] (see chapter 6.1.f), or when enough diversity of looking geometries is available (see chapter 6.1.g). However, this last case is very rare. It requires acquisitions with some sensitivity along the NS direction, which can be achieved e.g. with airborne InSAR, or when several acquisitions are performed in both right and left looking directions along ascending and descending orbits.

Note that MSBAS can also perform 3D inversion if provided with horizontal time series from pixel tracking processing (see e.g. [Dille et al., 2021]<sup>11</sup>).

If only one look angle is provided (or if several sets are acquired in similar looking geometry), the software will perform a conventional SBAS processing [Berardino et al., 2002<sup>12</sup>] and results will be given in radar Line Of Sight (LOS).

In the following chapter, we will see how prepare the processing for a 2D or a 3D inversion, how to perform the inversion, chose the optimum inversion parameters, and how to plot the results.

### 6.1. Preparation

When the mass processing is finished, one can prepare the msbas processing by selecting the pairs to invert and preparing the required files. The selection can be performed using several scripts depending on your needs. Note that the pair selection made for the inversion may differ from the pair selection for mass processing. Indeed, you can prepare the mass processing based on a set of criteria and perform the msbas inversion based on another set of criteria. Of course, if the pair selection for the msbas inversion expects more pairs than what was prepared during the mass processing(s), it will not compute these missing pairs before performing the msbas inversion.

Basically, you can perform the pair selection for the msbas inversion using two types of scripts:

- ***build\_header\_msbas\_criteria.sh*** (and its variant ***build\_header\_msbas\_criteria\_From\_nvi\_name\_WithoutAcqTime.sh***), or
- ***build\_header\_msbas\_Tables.sh***

The first type of scripts prepares the msbas inversion based on baselines criteria (max *Bp* and *Bt*). It will check among all the processed pairs which ones satisfy the baselines criteria. **These criteria must be the same for all the modes to invert.**

<sup>9</sup> Samsonov, S., and N. d'Oreye (2012), Multidimensional time-series analysis of ground deformation from multiple InSAR data sets applied to Virunga Volcanic Province, *Geophysical Journal ...*, doi:10.1111/j.1365-246X.2012.05669.x.

Samsonov, S. V., and N. d'Oreye (2017), Multidimensional Small Baseline Subset (MSBAS) for two-dimensional deformation analysis: Case study Mexico City, *Canadian Journal of Remote Sensing*, 82(6), 1–12, doi:10.1080/07038992.2017.1344926.

<sup>10</sup> Samsonov S., Dille A., Dewitte O., Kervyn F., d'Oreye N. (2020)

Satellite interferometry for mapping surface deformation time series in one, two and three dimensions.

*Eng. Geol.*, 266, 105471. doi.org/10.1016/j.enggeo.2019.105471.

<sup>11</sup> Dille et al. 2021, “When image correlation is needed: Unravelling the complex dynamics of a slow-moving landslide in the tropics with dense radar and optical time series”, *Rem. Sensing of Env.*, 258, 112402

<sup>12</sup> Berardino, P., G. Fornaro, R. Lanari, and E. Sansosti (2002), A new algorithm for surface deformation monitoring based on small baseline differential SAR interferograms, *IEEE Transactions on Geoscience and Remote Sensing*, 40(11), 2375–2383, doi:10.1109/TGRS.2002.803792.

The second type of script prepares the msbas inversion based on provided tables (one for each mode to invert). These tables list the pairs that were selected based either on the `x` shortest connections (with ***Extract\_x\_Shortest\_Connections.sh***), or on a Delaunay triangulation (with ***DelaunayTable.sh***), or based on baselines criteria (with ***Prepa\_MSBAS.sh***). Note that unlike the version based on criteria only (***build\_header\_msbas\_criteria.sh***), the version based on Tables **can mix any type of criteria among the modes**. For instance, you may perform an msbas inversion with 4 modes where pairs for the mode 1 are selected based on a Delaunay table, the mode 2 with given values of BP and Bt, mode 3 with other values of Bp and/or Bt, and mode 4 with a 3 shortest connection table.

All these scripts prepare for a 2D inversion as it is the most common case.

To process a 3D inversion when the displacement is thought to occur along the steepest slopes, an additional script named ***Add\_NS\_comp\_msbas.sh*** is required to compute the necessary gradient of the topography in X and Y directions and adapt the ***header.txt*** file (see chapter 6.1.f).

To process a 3D inversion when enough diversity of looking geometries is available, see chapter 6.1.g).

The scripts for 2D or 3D MSBAS inversions are explained here after.

### 6.1.a) After completion of SuperMaster\_MassProc.sh: *build\_header\_msbas\_criteria.sh*

When the mass processing is finished, one can prepare the msbas processing by launching ***build\_header\_msbas\_criteria.sh***. This script must be launched in the directory where msbas will be run (e.g. `.../MSBAS_RESULTS/MSBAS_SAT_REGION`). It will create all the files needed by msbas. For this it will need to read information from files in `.../SAR_MASSPROCESS/SAT/TRACK/CROP_SM_DATE_ZOOM_ML/PRM_SCD` directories.

Note:

***build\_header\_msbas\_criteria.sh*** cannot operate if `PRM_SCD` directories (where it searches information in specific files) are not present (e.g. if these directories were removed or if ***SuperMaster\_MassProc.sh*** is not finished yet). In that case, one can still get approximate information from products file names rather than from parameters in files in `.../SAR_MASSPROCESS/.../PRM_SCD` directories by using ***build\_header\_msbas\_criteria\_From\_nvi\_name\_WithoutAcqTime.sh*** instead of ***build\_header\_msbas\_criteria.sh*** (see below).



The script ***build\_header\_msbas\_criteria.sh*** is aiming at:

- Copy only the deformation maps that fulfil criteria (Bperp and Btemp) in the given directories
- Creating the required `list_of_InSAR_files.txt` with path to the deformation files, Bperp, PrmDate, ScdDate
- Creating the `header.txt` required for the msbas processing
- Creating hdr files for results
- Check if files are OK or contains NaN
- It also outputs files with incidence angle, heading and acquisition time.

In the directory where the results of MSBAS will be stored,

(e.g. `/MSBAS_RESULTS/MSBAS_SAT_REGION`), launch “***build\_header\_msbas\_criteria.sh***” with the following 4+ parameters:

|                             |                                                                              |
|-----------------------------|------------------------------------------------------------------------------|
| <code>MODE</code>           | (which product do you want to use).                                          |
| <code>NrOfModes</code>      | (nr of modes)                                                                |
| <code>MaxBp</code>          | (Maximum perpendicular baseline to select pairs)                             |
| <code>MaxBtemp</code>       | (Maximum temporal baseline to select pairs)                                  |
| <code>PathToEachSeti</code> | (path to each mode= directory where the interferometric products are stored) |

where

- **`MODE`**: type of products to use such as `Defo`, `DefolInterpol`, `DefolInterpolDetrend` or `DefolInterpol2Detrend`; must be the name of the subdir where data are stored
- **`NrOfModes`** is the number of `seti` to be processed.
- **`MaxBp`** and **`MaxBtemp`** are obvious although they can be more restrictive than the amount of data mass processed. E.g. if one had prepared pairs with `MaxBp` and `MaxBtemp` say resp. < 100 meters and 100 days, one can still compute msbas with criteria such as `MaxBp` and `MaxBtemp` say resp. < 50 meters and 50 days.
- **`PathToEachSeti`**: path to the geocoded deformation files produced for the different pairs, for each mode (eg:

`.../SAR_MASSPROCESS/SAT/TRK/Resampled_YYYYMMDD_Crop_REGION_coord_ZOOM_ML`; where `YYYYMMDD` is the date of the Global Primary, `REGION` is the region corresponding to the `coord`, and `ZOOM` and `ML` are the zoom factor and multilooking used for processing that mode.

#### Notes:

- ⇒ To spare time, if you run several msbas, the system remembers which pairs in `.../SAR_MASSPROCESS/...` do not satisfy your baselines criteria. This allows to avoid checking them again if you perform a new msbas with the same criteria.  
For example, if a former **`MSBAS.sh`** was already performed with a max `20m` and `450days` Bp and Bt criteria respectively, a file named `Out_Of_Range_20m_450days.txt` will be created in `.../MSBAS_RESULTS/LOCATION/MODEi` directories. These files contain the list of pairs that were in  
`.../SAR_MASSPROCESS/SAT/TRK/SMCrop_SM_YYYYMMDD_Crop_REGION_coord_ZOOM_ML/MODEi` but that do not satisfy the baselines criteria. In order to avoid testing them again while selecting the pairs **with the same baseline criteria**, the script **`build_header_msbas_criteria.sh`**, when run a second time, will ignore these pairs.
- ⇒ Similarly, if a previous run of **`MSBAS.sh`** was performed with an additional criterion for pair selection based on the minimum coherence computed over a given area (defined by a provided kmz file; see script **`restrict_msbas_to_Coh.sh`** and paragraph 6.1.d), files named `List_All_img_For_Coh_THRESHOLD_Region.kml.txt` and `List_Checked_img_For_Coh_THRESHOLD_Region.kml.txt` and `Checked_For_CohThreshold_To_Be_Ignored_At_Next_Rebuild_msbas_Header.txt` will also be present in the `.../MSBAS_RESULTS/LOCATION/MODEi` directories (where `THRESHOLD` is the coherence threshold above which pairs are rejected for the msbas processing if the mean coherence computed for the `Region` is exceeded; the region footprint is provided by a kml file. See paragraph 6.1.d).  
These files contain the list of pairs that were already tested against the coherence criteria (satisfying it or not). In order to avoid testing them again while selecting the pairs with the same coherence criteria, the script **`build_header_msbas_criteria.sh`**, when run a second time, will ignore the unsatisfying pairs.
- ⇒ Because msbas version after October 2020 has new features, the header.txt file need other options. If you run such a version of msbas, ensure that it is named `msbasv4`.
- ⇒ **`build_header_msbas_criteria.sh`** will prepare corresponding info for msbas for each pair that satisfies the Bp and Bt criteria. However, one can **force** also the script to take **some more pairs** into account (i.e. that do not satisfy the baselines criteria but that are good enough to bring valuable information for the inversion). In that case, pairs must be listed in a specific file named `table_BpMin_BpMax_Btmin_Btmax_AdditionalPairs.txt` and located in the `SAR_MASSPROCESS/SAT/TRK/REGION/` directory.  
That file must have the same structure as `table_BpMin_BpMax_Btmin_Btmax.txt` though without header.  
It is advised to keep track of that list by keeping a copy maybe in your `.../SAR_SM/MSBAS/REGION/seti` directory.  
If only one `table_BpMin_BpMax_Btmin_Btmax_AdditionalPairs.txt` file exists, it will use it. If more than one `table_BpMin_BpMax_Btmin_Btmax_AdditionalPairs.txt` file exist, it will use the one with the same baselines criteria as `table_BpMin_BpMax_Btmin_Btmax.txt`.
- ⇒ Similarly, if one wants to process MSBAS with list of pairs from `table_BpMin_BpMax_Btmin_Btmax.txt` though **WITHOUT** some pairs, this must be done after the execution of **`build_header_msbas_criteria.sh`**.  
In that case, add in your `/MSBAS/.../MODEi` (where `MODEi` is e.g. `DefolInterpol2Detrendi`)

a file `_EXCLUDE_PAIRS_ALTHOUGH_CRITERIA_OK.txt` that contains pairs list as DATE\_DATE. Then run the script `/zz_Utilities_MT/Exclude_Pairs_From_Mode.txt.sh` with only one parameter, that is the path to `.../MSBAS/REGION/MODEi` where file `_EXCLUDE_PAIRS_ALTHOUGH_CRITERIA_OK.txt` is located.

It is advised to keep track of that list by keeping a copy maybe in your `.../SAR_SM/MSBAS/REGION/seti` directory.

⇒ **WARNING:** when preparing an inversion using several `seti`, the script `build_header_msbas_criteria.sh` looks in each `.../SAR_SM/MSBAS/REGION/seti` for the table `table_0_BpMax_0_Btmax.txt` based on the `BpMax Btmax` parameters provided to `build_header_msbas_criteria.sh`. However, it might happen (and it is highly probable e.g. when mixing satellites) that the most appropriate baseline plot for each `/seti` required a different set of `BpMax Btmax` parameters.

Because only one set of `BpMax Btmax` is provided to `build_header_msbas_criteria.sh`, all the `table_0_BpMax_0_Btmax.txt` must have the same name in each `/seti`. Hence it is required to copy (or better, link) each table that would have a name different from what the script will be searching for (`table_0_BpMax_0_Btmax.txt`) with a fake name.

Example: suppose `set1` has a table named `table_0_400_0_50.txt`, `set2` has a table named `table_0_400_0_70.txt`, `set3` has a table `table_0_50_0_50.txt`, then one need to run `build_header_msbas_criteria.sh` with only one set of values for Bt and Pb, e.g. 400m and 70days. If one does not copy tables from `set1` and `set3` as `table_0_400_0_70.txt`, `build_header_msbas_criteria.sh` will not prepare msbas data for these sets.

A more elegant solution is to use the script `build_header_msbas_Tables.sh` (see section 6.1.c). However, in that case, excluding pairs is done by adding a file with the same name as the pair files ending with `_ExcludePairs.txt`, e.g.

- `table_0_0_DelaunayRatioxxxMaxBtxxxMaxBpxxx_0_ExcludePairs.txt`, and/or
- `table_0_0_MaxShortest_x_ExcludePairs.txt`, and/or
- `table_MinBp_MaxBp_MinBt_MaxBt_ExcludePairs.txt` table

(see section 6.1.c).

⇒ The script needs `checkOnlyNaN.py`

### 6.1.b) Without all the pairs processed:

***build\_header\_msbas\_criteria\_From\_nvi\_name\_WithoutAcqTime.sh***

This script does the same as the original ***build\_header\_msbas\_criteria.sh***, although without reading information in each **PRM\_SCD** pair directory in **SAR\_MASSPROCESS**. It will gather the required info from the name of the geocoded files instead. The only missing info will be the acquisition time (**hhmmss**) of each mode. This will have to be added manually in the **header.txt** before running the msbas. The list of incidence angle is also provided with less accuracy but for most of the case, it will be of no influence.

Remark: there might be a bug which delivers the incidence angle with a wrong sign when picked from file names?! Need to be double checked.



***build\_header\_msbas\_criteria\_From\_nvi\_name\_WithoutAcqTime.sh*** is aiming at:

- Copy only the deformation maps that fulfils criteria (Bperp and Btemp) in the given directories
- Creating the required list\_of\_InSAR\_files.txt with path to the deformation files, Bperp, PrmDate, ScdDate
- Creating the **header.txt** required for the msbas processing
- Creating **hdr** files for results
- Check if files are OK or contains of NaN
- It also output files with incidence angle and heading

In the directory where the results of MSBAS will be stored

(e.g. .../MSBAS\_RESULTS/MSBAS\_SAT\_REGION), launch

“***build\_header\_msbas\_criteria\_From\_nvi\_name\_WithoutAcqTime.sh***” with the following 4+ parameters:

|                       |                                                                              |
|-----------------------|------------------------------------------------------------------------------|
| <b>MODE</b>           | (which product do you want to use).                                          |
| <b>NrOfModes</b>      | (nr of modes)                                                                |
| <b>MaxBp</b>          | (Maximum perpendicular baseline to select pairs)                             |
| <b>MaxBtemp</b>       | (Maximum temporal baseline to select pairs)                                  |
| <b>PathToEachSeti</b> | (path to each mode= directory where the interferometric products are stored) |

where

- **MODE**: type of products to use such as **Defo**, **DefolInterpol**, **DefolInterpolDetrend** or **DefolInterpolx2Detrend**; must be the name of the subdir where data are stored
- **NrOfModes** is the number of **seti** to be processed.
- **MaxBp** and **MaxBtemp** are obvious although they can be more restrictive than the amount of data mass processed. E.g if one had prepared pairs with **MaxBp** and **MaxBtemp** say resp. < 100 meters and 100 days, one can still compute msbas with criteria such as **MaxBp** and **MaxBtemp** say resp. < 50 meters and 50 days.
- **PathToEachSeti**: path to the geocoded deformation files produced for the different pairs, for each mode (eg:  
.../SAR\_MASSPROCESS/SAT/TRK/Resampled\_YYYYMMDD\_Crop\_REGION\_coord\_ZOOM \_ML; where **YYYYMMDD** is the date of the Global Primary, **REGION** is the region corresponding to the **coord**, and **ZOOM** and **ML** are the zoom factor and multilooking used for processing that mode.

This script must also be launched in the directory where msbas will be run. It will create all the files needed by msbas.

Attention, this script requires gnu grep (grep) V 3.3 or above!

### 6.1.c) Based on tables: *build\_header\_msbas\_Tables.sh*

Similarly, to *build\_header\_msbas\_criteria.sh*, when the mass processing is finished, one can prepare the msbas processing by launching *build\_header\_msbas\_Tables.sh*.

This script must be launched in the directory where msbas will be run (e.g. `.../MSBAS_RESULTS/MSBAS_SAT_REGION`). It will create all the files needed by msbas. For this it will need to read information from files in

`.../SAR_MASSPROCESS/SAT/TRACK/CROP_SM_DATE_ZOOM_ML/PRM_SCD` directories.

The script *build\_header\_msbas\_Tables.sh* is aiming at:

- Copy only the deformation maps from the pairs provided in the given Tables,
- Creating the required *list\_of\_InSAR\_files.txt* with path to the deformation files, Bperp, PrmDate, ScdDate
- Creating the *header.txt* required for the msbas processing
- Creating hdr files for results
- Check if files are OK or contains NaN
- It also output files with incidence angle, heading and acquisition time.



In the directory where the results of MSBAS will be stored,

(e.g. `/MSBAS_RESULTS/MSBAS_SAT_REGION`), launch “*build\_header\_msbas\_Tables.sh*” with the following 4+ parameters:

|                               |                                                                                                                                                                                   |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>MODE</code>             | (which product do you want to use).                                                                                                                                               |
| <code>NrOfModes</code>        | (nr of modes)                                                                                                                                                                     |
| <code>TableForEachMode</code> | (path to tables with list of pairs and their baselines, one for each mode)                                                                                                        |
| <code>PathToEachSeti</code>   | (path to each mode= directory where the interferometric products are stored)                                                                                                      |
| <code>[-msbasv]</code>        | (optional: version of the msbas for which one want to prepare the processing, e.g. msbasv4. If not provided, it will do it for the most recent version available on the computer) |

where:

- `MODE`: type of products to use such as `Defo`, `DefolInterpol`, `DefolInterpolDetrend` or `DefolInterpolx2Detrend`; must be the name of the subdir where data are stored
- `NrOfModes` is the number of `seti` to be processed.
- `TableForEachMode` are path to 4 columns tables (one for each mode), with the list of pairs and their baselines. These can be either (*types of tables can be mixed between the modes*):
  - o `table_0_0_DelaunayRatioxxxMaxBtxxxMaxBpxxx_0.txt` table  
(created with *DelaunayTable.sh*), and/or
  - o `table_0_0_MaxShortest_x.txt` table  
(created with *Extract\_x\_Shortest\_Connections.sh*), and/or
  - o `table_MinBp_MaxBp_MinBt_MaxBt.txt` table  
(created with *Prepa\_MSBAS.sh*)

Note: the tables must be entered in the same order as the path to each mode here after!

Obviously, the pairs listed in the tables must have been processed beforehand. If the criteria in these tables are less restrictive than those used for the mass processing, the script will not notice and pairs will be missing in the inversion.

- ***PathToEachSeti***: path to the geocoded deformation files produced for the different pairs, for each mode (eg:  
.../SAR\_MASSPROCESS/SAT/TRK/Resampled\_YYYYMMDD\_Crop\_REGION\_coord\_ZOOM\_ML; where **YYYYMMDD** is the date of the Global Primary, **REGION** is the region corresponding to the **coord**, and **ZOOM** and **ML** are the zoom factor and multilooking used for processing that mode.
- **--msbasvi**: optionally, one can force the creation of the header file for a given version of msbas. If no --msbasvi (either --msbas or --msbasvi where *i* is a number above 2) is provided, the script searches for the most recent version of msbas available on your computer.

#### Notes:

- ⇒ To spare time, if you run several msbas after each other, the system remembers which pairs were already checked. This allows to avoid checking them again if you perform a new msbas with the same criteria.
- ⇒ Msbas versions before (msbasv3 or before) and after October 2020 (msbasv4 or after) require specific features in the header.txt file. Hence you can force the script to prepare the msbas inversion for a given version by adding a last optional parameter --msbasvx. If no such a parameter is provided (as it is usually the case), the script checks the latest version of msbas available on your computer and prepares the files accordingly.  
Also, the **msbasv10** (provided in the **AMSTerSoftware\_Distribution/MSBAS\_sources** directory) also needs specific features, which are not fully implemented yet in AMSTer.
- ⇒ **build\_header\_msbas\_Tables.sh** will prepare corresponding info for msbas for each pair provided in the Tables. However, one can **force** also the script to take **some more pairs** into account.  
In that case, the additional pairs must simply be listed in a table file named like the original table, though with an extra string “**\_AdditionalPairs**” (beware of typos) before the “**.txt**” extension, that is e.g. :
  - **table\_0\_0\_DelaunayRatioxxxMaxBtxxxMaxBpxxx\_0\_AdditionalPairs.txt**, and/or
  - **table\_0\_0\_MaxShortest\_x\_AdditionalPairs.txt**, and/or
  - **table\_MinBp\_MaxBp\_MinBt\_MaxBt\_AdditionalPairs.txt** table
 These extra tables must be in the same directory as the main tables. They must also have the same structure (with or without the classical 2 lines of header), that is 4 columns as follow:

| PRMDATE | SCDDATE | BP | Bt |
|---------|---------|----|----|
|---------|---------|----|----|

- ⇒ Similarly, one can force the rejection of some pairs although they would be listed in the provided tables. To **remove (exclude)** some pairs listed in the tables, they must simply be listed in a table file named like the original table, though with an extra string “**\_ExcludePairs**” (beware of typos) before the “**.txt**” extension, that is e.g. :
  - **table\_0\_0\_DelaunayRatioxxxMaxBtxxxMaxBpxxx\_0\_ExcludePairs.txt**, and/or
  - **table\_0\_0\_MaxShortest\_x\_ExcludePairs.txt**, and/or
  - **table\_MinBp\_MaxBp\_MinBt\_MaxBt\_ExcludePairs.txt** table

These extra tables must be in the same directory as the main tables. They must also have the same structure (with or without the classical 2 lines of header, that is 4 columns as follow:

| PRMDATE | SCDDATE | BP | Bt |
|---------|---------|----|----|
|---------|---------|----|----|

#### Beware:

Remember that using **build\_header\_msbas\_criteria.sh**, pairs are excluded using a file named **\_EXCLUDE\_PAIRS\_ALTHOUGH\_CRITERIA\_OK.txt** and the script **/zz\_Utils\_MT/Exclude\_Pairs\_From\_Mode.txt.sh** instead (see section 6.1.a).

⇒ If a previous run of ***MSBAS.sh*** was performed with an additional criterion for pair selection based on the minimum coherence computed over a given area (defined by a provided *kmz* file; see script ***restrict\_msbas\_to\_Coh.sh*** and paragraph 6.1.d), files named *List\_All\_img\_For\_Coh\_THRESHOLD\_Region.kml.txt* and *List\_Checked\_img\_For\_Coh\_THRESHOLD\_Region.kml.txt* and *Checked\_For\_CohThreshold\_To\_Be\_Ignored\_At\_Next\_Rebuild\_msbas\_Header.txt* will be present in the .../MSBAS\_RESULTS/LOCATION/MODE/*i* directories (where *THRESHOLD* is the coherence threshold below which pairs are rejected for the msbas processing if the mean coherence computed for the *Region* is lower than the *THRESHOLD*; the region footprint is provided by a kml file. See 6.1.d).

These files contain the list of pairs that were already tested against the coherence criteria (satisfying it or not). In order to avoid testing them again while selecting the pairs with the same coherence criteria, the script ***build\_header\_msbas\_Tables.sh***, when run a second time, will ignore the unsatisfying pairs.

⇒ The script needs *checkOnlyNaN.py*

### 6.1.d) With additional restriction to coherence threshold: `restrict_msbas_to_Coh.sh`

In addition to restrict the pair selection to the spatial and temporal baseline criteria, further selection among the interferometric pairs can be performed based on the mean coherence computed over an area defined by a *kml* file. This for instance may be of interest for monitoring regions that are affected by strong seasonal variations causing decorrelation from the summer to winter transition while preserving coherence from summer to summer (e.g. free from snow cover).

This is performed by launching `restrict_msbas_to_Coh.sh`, which aiming at removing from a prepared msbas data set (eg DefolInterpolx2Detrend2) all the images that does not satisfy a minimum average coherence on a selected zone provided by a *kml*. It must be run after `build_header_msbas_Tables.sh`, `build_header_msbas_criteria.sh` or `build_header_msbas_criteria_From_nvi_name_WithoutAcqTime.sh` and before running `MSBAS.sh`, in the directory where msbas will be run and which contains all the *MODEi* directories and *Modei.txt*.

In the directory where the results of MSBAS will be stored  
(e.g. .../MSBAS\_RESULTS/MSBAS\_SAT\_REGION), launch

“`restrict_msbas_to_Coh.sh`” with the

following 4 parameters:

|                     |                                                                              |
|---------------------|------------------------------------------------------------------------------|
| <i>MODETOCLEANI</i> | (which product do you want to clean for unsatisfying coherence).             |
| <i>COHTHRESHOLD</i> | (coherence threshold)                                                        |
| <i>PathToKml</i>    | (path to kml file that defines the zone where to test for mean coherence)    |
| <i>PathToCoh</i>    | (path to coherence files:<br>SAR_MASSPROCESS/SAT/TRK/REGION_ML/Geocoded/Coh) |

where

- *MODETOCLEANI*: products to clean for unsatisfying coherence, such as *Defoi*, *DefolInterpol*, *DefolInterpolDetrendi* or *DefolInterpolx2Detrendi*, where *i* is the index of the data set. *MODETOCLEANI* must be the name of the subdir where data are stored.
- *COHTHRESHOLD* is the mean coherence value below which pairs will be discarded.
- *PathToKml* is the path to the kml file that defines the footprint of the area where to compute the mean coherence.
- *PathToCoh*: path to the directory that contains all the geocoded coherence files for the selected SAT/TRK, e.g. SAR\_MASSPROCESS/SAT/TRK/REGION\_ML/Geocoded/Coh.

Notes:

1. If a previous run of `restrict_msbas_to_Coh.sh` was performed, files named *List\_All\_img\_For\_Coh\_THRESHOLD\_Region.kml.txt* and *List\_Checked\_img\_For\_Coh\_THRESHOLD\_Region.kml.txt* and *Checked\_For\_CohThreshold\_To\_Be\_Ignored\_At\_Next\_Rebuild\_msbas\_Header.txt* are present in .../MSBAS\_RESULTS/LOCATION/MODE*i* directories (where *THRESHOLD* is the coherence threshold below which pairs are rejected for the msbas processing if the mean coherence computed for the *Region* is lower than the *THRESHOLD*). These files contain the list of pairs that were already tested against the coherence criteria (satisfying it or not). These files are used to avoid testing again the same pairs while using the same coherence criteria.

2. In some rare occurrence, some pairs are satisfying by accident the coherence threshold. Instead of increasing the threshold (which would result in rejecting most probably more pairs than only the one(s) that are problematic), one can force discarding them by listing these pairs in a file named *\_EXCLUDE\_PAIRS\_ALTHOUGH\_CRITERIA\_OK.txt* and located in .../MSBAS\_RESULTS/LOCATION/MODE*i*/

That file only contains the list of pairs in the form *PRM\_SCD* (i.e. the date of the Primary and Secondary images separated by an underscore).

When ***Exclude\_Pairs\_From\_Mode.txt.sh*** is run, these pairs will be excluded from the msbas inversion.

3. If one wants to process MSBAS with a list of pairs from *table\_BpMin\_BpMax\_Btmin\_Btmax.txt* though **WITHOUT** some pairs, add in your */MSBAS/.../MODEi* (where *MODEi* is e.g. *DefolInterpolx2Detrend*) a file *\_EXCLUDE\_PAIRSALTHOUGH\_CRITERIA\_OK.txt* that contains pairs list as *DATE\_DATE*. When ***Exclude\_Pairs\_From\_Mode.txt.sh*** is run, these pairs will be excluded from the msbas inversion.

### 6.1.e) Pair selection optimization based on coherence proxy

A procedure to optimize the pair selection during automated mass processing is explained in the following open access paper:

Smittarello, D., d'Oreye, N., Jaspard, M., Derauw, D., & Samsonov, S. (2022). **Pair selection optimization for InSAR time series processing**. Journal of Geophysical Research: Solid Earth, 127, e2021JB022825. <https://doi.org/10.1029/2021JB022825>

The proposed algorithm narrows the classical pair selection based on the shortest temporal and spatial baselines thanks to a coherence proxy and balances the use of each image as Primary and Secondary images thanks to graph theory methods. The method can help to drastically reduce the total number of computed differential InSAR interferograms, and hence, the computation time. The optimization also allows to reduce the influence of DEM errors and atmospheric phase screen, which increase the signal-to-noise ratio of the inverted displacement time series.

For this, you need:

- A kml file defining the region of interest where the coherence will be estimated to select the best pairs e.g. in: `$PATH_1650/kml/YourRegion/Your_ROI.kml`
- A table of pairs to optimize (created by `build_header_msbas_criteria.sh`, that is a `.../SAR_SM/MSBAS/YourRegion/seti/table_0_BpMax_0_BtMax.txt`)
- For each mode to optimize, a Coherence table calibration to prepare as follow:

In `.../SAR_MASSPROCESS/SAT/TRK/SMNoCrop_SM_Zoom_ML/Geocoded/Coh`

Launch the script `Baseline_Coh_Table.sh` with the kml file as parameter:

`$PATH_1650/kml/YourRegion/Your_ROI.kml`

It will create a table of coherence named `Baseline_Coh_Table_Your_ROI.kml.txt`  
in `.../SAR_MASSPROCESS/SAT/TRK/SMNoCrop_SM_Zoom_ML/Geocoded/Coh`

The optimization can be done either based on the known coherence or on a coherence proxy.

#### OPTION 1: optimization based on the coherence

- In each directory of the mode `.../SAR_SM/MSBAS/YourRegion/seti`, optimise the pair selection by running:  
`Run_optim_module.sh` with the following 4 parameters:  
`.../SAR_SM/MSBAS/YourRegion/seti/table_0_BpMax_0_BtMax.txt`  
`.../SAR_MASSPROCESS/SAT/TRK/SMNoCrop_SM_Zoom_ML/Geocoded/Coh/Baseline_Coh_Table_Your_ROI.kml.txt`  
`NrLinks`  
`CohThreshold`

Where `NrLinks` (or degree of optimisation) is the maximum number of times each image is used as a Primary or Secondary and `CohThreshold` is a coherence threshold below which pairs will be discarded anyway.

This will output 3 text files in `.../SAR_SM/MSBAS/YourRegion/seti/`  
`table_0_BpMax_0_BtMax_listPR2rm4optim_NrLinks_thCohThreshold.txt`  
`table_0_BpMax_0_BtMax_listPR2rm4optim_NrLinks_thCohThreshold_optimized.txt`  
`table_0_BpMax_0_BtMax_orig.txt`

## OPTION 2: optimization based on a coherence proxy

- In each directory of the mode `.../SAR_SM/MSBAS/YourRegion/seti`, optimise the pair selection by running:

***Run\_optim\_module.sh*** with the following 10 parameters:

```

.../SAR_SM/MSBAS/YourRegion/seti/table_0_BpMax_0_BtMax.txt
.../SAR_MASSPROCESS/SAT/TRK/SMNoCrop_SM_Zoom_ML/Geocoded/Coh/Baseline_Coh_Table_Your_ROI.kml.txt
NrLinks
DOYlow
 α
 β
 γ
Mxc
Mnc
CohThreshold

```

Where `NrLinks` (or degree of optimisation) is the maximum number of times each image is used as a Primary or Secondary, `DOYlow` [in days] is a calibration factor to be fixed by the user that represents the epoch of the year when coherence is the lowest,  $\alpha \in [1; 5]$  is a calibration factor to be fixed by the user that represents the width of this low coherence period,  $\beta$  and  $\gamma$  account for the temporal and spatial decorrelation rates in the studied area, `Mxc` and `Mnc` are the maximum and minimum expected values for the mean coherence on the ROI when acquisition dates vary, and `CohThreshold` is a coherence threshold below which pairs will be discarded anyway.

This will output 3 text files in `.../SAR_SM/MSBAS/YourRegion/seti/`

```

table_0_BpMax_0_BtMax_listPR2rm4optim_NrLinks_thCohThreshold.txt
table_0_BpMax_0_BtMax_listPR2rm4optim_NrLinks_thCohThreshold_optimized.txt
table_0_BpMax_0_BtMax_orig.txt

```

## Restricting pairs to optimized selection:

For each mode to optimize, run the script ***Remove\_Pairs\_From\_BaselinePlotOptimisation.sh*** with the following 2 parameters:

```

DefolInterpolx2Detrendi
.../SAR_SM/MSBAS/YourRegion/seti/table_0_BpMax_0_BtMax_listPR2rm4optim_NrLinks_thCohThreshold.txt

```

It outputs a text file `DefolInterpolx2Detrendi_Optimized_TABLE.txt_RUNTIME.txt`, which is to be used instead of `DefolInterpolx2Detrendi.txt` for the msbas inversion (see chapter 6).

The script requires the following scripts: `creategraphfromtable_realcoh.py`, `creategraphfromtable.py`, `optimFunctions.py` and ***RemovePairs\_fromtableforOptim\_V2.sh*** (located in `.../AMSTer/SCRIPTS_MT/optimtoolbox`).

### 6.1.f) Preparing the required elements for the 3D inversion: **Add\_NS\_comp\_msbas.sh**

Under certain circumstances, such as for landslides or glacier flows, one can assume that the displacement occurs along the steepest slope of the topography. Under this hypothesis, and providing that images are acquisition with a sufficient diversity of viewing geometries (e.g. one ascending and one descending), msbas can perform not only an EW and Vertical decomposition of the displacement, but it can also estimate the NS component.

Note that it is advised to **perform a 3D MSBAS inversion with a regularisation order 1 and high lambda factor** (e.g. 0.4). If results are satisfactory, you can decrease the lambda factor.

To perform such a 3D displacement, after having prepared the data with ***build\_header\_msbas\_criteria.sh*** or ***build\_header\_msbas\_Tables.sh***, and maybe proceed to additional pair selections, one must prepare the necessary gradient of the topography in X and Y directions and adapt the ***header.txt*** file. This is performed by launching in the directory where the msbas inversion will be run, the script ***Add\_NS\_comp\_msbas.sh*** with one or two parameters.

The first parameter is the width of the Gaussian kernel used for filtering the data (in meters) applied to the topography before computing the gradients. The script will then compute the first central derivative along both EW (X) and NS (Y) directions and store the results with appropriate names at the appropriate place and prepared the ***header.txt*** file accordingly. Note that if you want to change the computed gradients by changing the kernel size of the Gaussian filter, it is necessary to use "Force" as the second parameter (otherwise optional). Without that, it will not recompute the filtering and gradients! Note that filtering may severely affect the results. It is advised to compare the msbas inversion with external data (e.g. GPS) to calibrate the filtering.

The script ***Add\_NS\_comp\_msbas.sh*** requires the ***Filter\_and\_Gradient.py*** python script. It also provides a plot with the filtered gradients and DEM contours for check (***contour\_plot\_FiltKernSizeX.jpg*** where x = size of the kernel filter in pixels used as parameter).

To plot the results of the 3D inversion, you can use ***PlotTS\_all\_comp.sh*** as usual. It will cope by itself to add the third component on the time series plots, including with the fitting options etc... Vector plots are performed with ***Plot\_vectorDispl\_DEM.py*** (see script in ***zz\_Utils\_MT***).

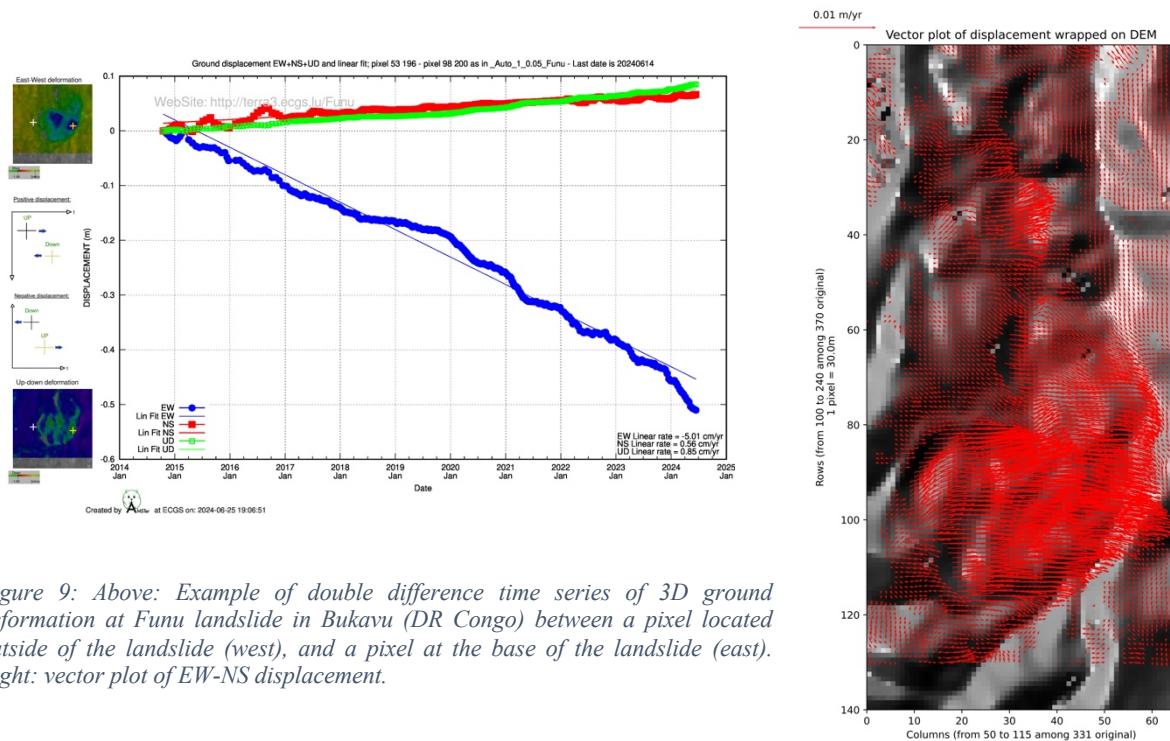


Figure 9: Above: Example of double difference time series of 3D ground deformation at Funu landslide in Bukavu (DR Congo) between a pixel located outside of the landslide (west), and a pixel at the base of the landslide (east). Right: vector plot of EW-NS displacement.

### 6.1.g) 3D inversion with sufficient diversity in viewing geometries

Under **very rare** circumstances, series of SAR acquisitions may be available not only with sensitivity in east-west and vertical directions, but also in the north-south direction. This can be achieved e.g. with airborne InSAR, or when several acquisitions are performed in both right and left looking directions along ascending and descending orbits, or when feeding msbas with displacements maps obtained with pixel tracking methods (see e.g. [Dille et al. 2021]).

To assess if the acquisitions offer enough diversity to be sensitive also in the NS direction, you can check the rank of the matrix formed with all the Earth to Satellite unit vectors ( $s_n$ ,  $s_e$ ,  $s_u$ ) for each dataset. These unit vectors can be computed e.g. with the script *Earth2Sat\_UnitVectors.py* based on the incidence angle and the azimuth heading of each data set. The **rank of that matrix must be 3** to hope being able to derive the 3 components.

Also, compute the SVD of this matrix (see e.g. the script *Rank\_and\_SVD\_Matrix.py*, which computes the rank and the SVD of a hard coded matrix). The conditioning number (the largest singular value divided by the smallest) must be small (e.g. less than 100).

In such a case, one can attempt to perform a 3D inversion without the assumption that the displacement occurs along the steepest slope of the topography. This requires preparing the deformation maps as usual using e.g. *SuperMaster\_MassProc.sh*.

Then you need to recompile the MSBAS software manually after having released the constraint of ignoring the NS component. This is achieved by changing the line in *carea.cpp* that contains “**DIM=2;**” into “**DIM=3;**”. This line must be near a line like “// no azimuth offsets, no DEM”.

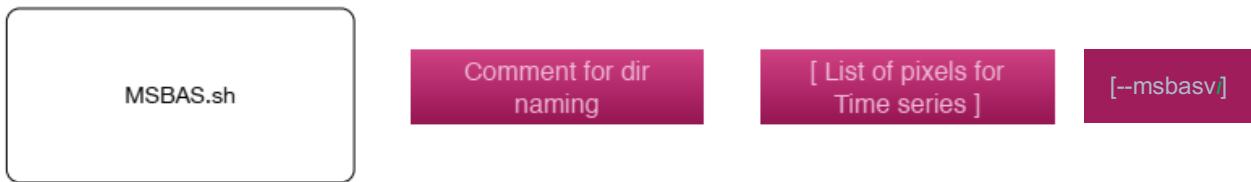
When the *msbasv4* is recompiled with that modification, do not forget to move (replace) that executable file in your .../SAR/AMSTer/MSBAS directory.

You can then execute the regular scripts, that is *build\_header\_msbas\_criteria.sh* or *build\_header\_msbas\_Tables.sh*, then *MSBAS.sh* as usual (see chapter 6.2) and it will take care of the 3 components. Note that in the case of left looking geometries, looking angles indicated in the *header.txt* must have a negative sign.

**Do not forget to get back to the regular compilation of *msbasv4* in your .../SAR/AMSTer/MSBAS directory.**

Remember however that this is highly prospective! Usually, this does not apply to common space-based acquisitions because the subpolar orbits of the satellites offer no sensitivity in the NS direction.

## 6.2. MSBAS processing: ***MSBAS.sh***



- Modify (if needed), the header file ([/MSBAS\\_RESULTS/MSBAS\\_SAT\\_REGION/header.txt](#)) according to your parameters. See [Samsonov and d'Oreye \(2017\)](#) for detailed description.

**Table 1.** MSBAS parameters and supported processing options must have only one uniquely named parameter in header file. Detailed description is provided in text.

| Parameter   | Type           | Value(s)                  | Description                            |
|-------------|----------------|---------------------------|----------------------------------------|
| FORMAT      | int            | 0                         | 4 bytes float, small endian            |
| FORMAT      | int            | 1                         | 4 bytes float, big endian              |
| FILE_SIZE   | int(s)         | x,y                       | For example, 1000, 1000                |
| WINDOW_SIZE | int(s)         | xa, xb, ya, yb            | Default: 0, x - 1, 0, y - 1            |
| C_FLAG      | int            | 0                         | No calibration                         |
| C_FLAG      | int(s)         | 1, xi, yi, Δx, Δy         | 1 reference region                     |
| C_FLAG      | int(s)         | 2, xi, y1, x2, y2, Δx, Δy | 2 reference regions                    |
| C_FLAG      | int            | 10                        | Average set to zero                    |
| R_FLAG      | int            | 0                         | No regularization                      |
| R_FLAG      | int, float     | 1, λ                      | Zero order regularization              |
| R_FLAG      | int, float     | 2, λ                      | First order regularization             |
| R_FLAG      | int, float     | 3, λ                      | Second order regularization            |
| T_FLAG      | int            | 0                         | No topographic correction              |
| T_FLAG      | int            | 1                         | Topographic correction                 |
| I_FLAG      | int            | 0                         | No interactive mode                    |
| I_FLAG      | int            | 1                         | Interactive mode                       |
| I_FLAG      | int, s         | 2, par.txt                | Process par.txt file                   |
| I_FLAG      | int            | 3                         | Save everything in text file           |
| SET         | s, int, int, s | hhmmss, θ, φ, set.txt     | For example, 122435, -189, 34, dsc.txt |
| #           |                |                           | Comment                                |

Note. Type s means string. x and y are width and length of interferograms.  $x_a, x_b, y_a$  and  $y_b$  are first and last columns and rows of sub-region to be processed.  $x_i$  and  $y_i$  are column number and row number of reference region(s), up to 9 regions are supported.  $\Delta x$  and  $\Delta y$  are half-width/length of reference region(s).  $\lambda$  is regularization parameter. hhmmss is acquisition time for each set (must be 6 symbols).  $\theta$  and  $\varphi$  are azimuth and incidence angles, measured in degrees. Lines can be commented with # symbol.

Note that msbas version from October 2020 (must be named **msbasv4** or later) have two additional features in the [header.txt](#) (prepared automatically by scripts with default as in green below):

- **V\_FLAG=0** to compute displacement time series as before or **V\_FLAG=1** to compute velocity time series, in this case linear rate is acceleration.
- An additional parameter as first element in defining sets:  
**SET=0**, ACQTIME, AZIMUTH, INCID, MODEi.txt for InSAR range measurements, or  
**SET=1**, ACQTIME, AZIMUTH, INCID, MODEi.txt for InSAR azimuth measurements

- Launch “***MSBAS.sh***” with the following 2 optional parameters:

[**COMMENT**] (optional, string used to add to dir names where results will be stored).  
[**ListOfPixels**] (optional, path and name of file containing a list of pixels)  
[**--msbasv*i***] (optional, version of msbas as msbasv*i* where *i* is the version nr.  
If it does not exist or not provided, it takes the most recent version)

where

- **COMMENT**: string used to be added at end of directories containing the results. This can help to remember e.g. some processing configs.
- **ListOfPixels** is a text file (with path) containing the list of pixels (as COL ROW RADIUS) for which one wants to output time series, eg ([pixlist.txt](#)):  
125 130 5 (i.e. pixels of coord 125/130 and radius 5)  
160 210 2 ... (i.e. pixels of coord 160/210 and radius 2)

- `--msbasvi` is the version of msbas to use (as `msbasvi` where *i* is the version nr, eg. `msbasv4`). If that version does not exist or if no `msbasvi` is provided, it takes the most recent version.

Note that all parameters are optional, but `COMMENT` is mandatory if one use the pixels list output or if one force the version of msbas.

Coordinates of the pixels are provided as X and Y. (See section 9.31) for some helpful tools to assist in creating these `ListOfPixels` files). Radius is the radius [in pixels] around the pixel where the value will be averaged and the stdev will be computed. Script `msbas_plot_ts.sh` made by Sergey Samsonov can be used to plot the time series with the error bars. This can be for instance launched for all the time series generated by MSBAS that are in the current directory using the script `Plot_All_EW_UP_ts_inDir.sh` as it is done for instance in `Add_hdr_Files.sh` in `MSBAS.sh`.

This will compute the desired processing (hopefully).

If `MSBAS.sh` is launched with only one data set (or several sets with similar looking angles), the scripts will compute msbas deformation times series in mean LOS direction (that is a SBAS-like processing). Results (cumulative deformation maps at each acquisition date/time + velocity map etc...in ENVI format) and corresponding rasters will be stored in a subdirectory named `zz_LOS_COMMENT`, with an additional directory `zz_LOS_TS_COMMENT` containing the ascii time series of displacements for each pixel that was provided in the `pixlist.txt` (if any) as well as the plot of each time series.

If `MSBAS.sh` is launched with several sets with distinct geometries, the scripts will compute msbas deformation times series in EW and UD directions. Results (cumulative deformation maps at each acquisition date/time + velocity map etc...in ENVI format) and corresponding rasters will be stored in subdirectories `zz_EW_COMMENT` and `zz_UP_COMMENT`. If a `pixlist.txt` was provided, an additional `zz_UD_EW_TS_COMMENT` will contain the ascii time series of displacements for each pixel that was provided in the `pixlist.txt` as well as the plot of each time series.

Each product resulting from msbas processing (deformation, velocity maps...) are given in ENVI format and is accompanied with a raster quick look thanks to the use of the script `Add_hdr_Files.sh` and the template file `HDR.hdr` called by `MSBAS.sh`. To spare time and space, another version (`Add_hdr_Files_Less_Ras.sh`) only creates the rasters for the velocity's maps. However, it also creates a script to generate these rasters if needed. It is during the execution of `Add_hdr_Files.sh` that time series are plotted (see `Plot_All_LOS_ts_inDir.sh` and `Plot_All_EW_UP_ts_inDir.sh`)

The `header.txt` file that was used to compute the time series will be copied in `zz_LOS_TS_COMMENT` or `zz_EW_COMMENT` in order to keep track of parameters used.

**Note:** MSBAS will crash if the computer has not enough RAM memory. If you can't increase the RAM, either increase the Multilooking (but this requires performing at the best a new geoprocessing of all the deformation pairs) or crop the area of interest (see msbas' `header.txt`).

You can also try to split the MSBAS inversion in two parts (see 6.3).

### **6.3. Splitting the MSBAS inversion in two parts to spare computing resources:**

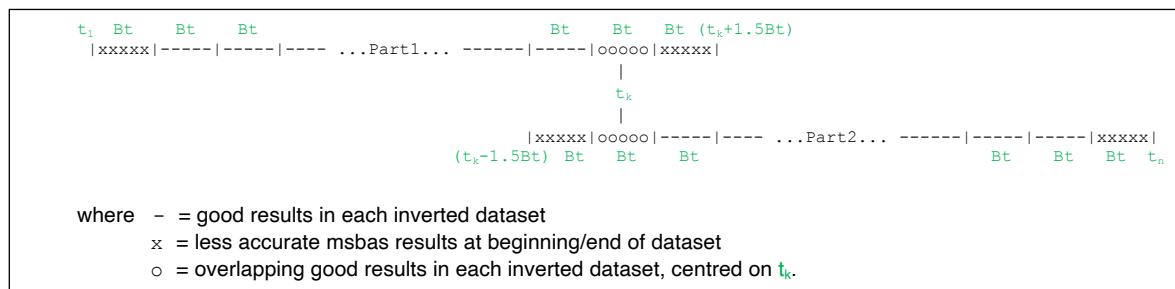
When very long deformation time series must be updated as soon as a new image is provided, computing the MSBAS inversion with the whole dataset will take more and more time. Because the beginning of the time series is not affected by the new data, one can invert the first part of the time series and keep these results to be added to the second part of the time series, which will be regularly updated. The most recent part can then be merged to the “frozen” first part as explained below, and merged results will be like those that would have been inverted in a single common run.

This procedure may spare a lot of time and computer resources. However, some care must be taken to ensure that the two parts are delimited in a safe way (i.e. there is enough overlap between the two parts) and that the junction is made appropriately (i.e. a proper offset is applied to the second part of the time series to smoothly continue the first part).

Suppose you have  $n$  images ( $i=1, \dots, k, \dots, n$ ) acquired from dates  $t_1$  to  $t_n$ . spanning e.g. more than 7 years. It is recommended to split the MSBAS inversions in two parts as follow:

- part 1 must start from beginning of the dataset ( $t_1$ ) up to a given date ( $t_k + 1.5 Bt$ ), where  $t_k$  is e.g. close to, or after the central epoch of the whole dataset, and  $Bt$  is the maximum temporal baseline used in the pair selection. Note that if  $Bt$  is small (e.g. few months or less), replace  $Bt$  e.g. with 400, that is a little more than a year. This value will be explained here after.  $t_k$  must be at least 3 times  $Bt$  (or 3 times 400) days after  $t_1$ .
  - part 2 must start from ( $t_k - 1.5 Bt$ ) and extend up to the end of the dataset, that is  $t_n$ .

See Figure 10.



*Figure 10: illustration of splitting the datasets for MSBAS inversion*

By selecting such a split, you will ensure that both parts overlap over at least 3 times the maximum temporal baseline (or 3 times 400 days if  $Bt$  is small), that is from  $(t_k - 1.5 Bt)$  up to  $(t_k + 1.5 Bt)$ . The results in these overlaps are potentially less accurate during the last  $Bt$  of the first dataset and during the first  $Bt$  of the second dataset (see xxxx in Figure 10). This is because the beginning and the end of each msbas inversion are performed with usually less pairs than the central part of the dataset.

The central part of the overlap, centred on  $t_k$ , is accurate in both dataset (see  $\circ\circ\circ\circ\circ$  in Figure 10).

Now, the results of an MSBAS inversion are such that the deformation is zero at the time of the first image ( $t_1$ ). When splitting the dataset in two, it will start the second time series of deformation maps at ( $t_k - 1.5 \text{ Bt}$ ) as zero instead of the value of the deformation at the same date ( $t_k - 1.5 \text{ Bt}$ ) obtained from the first part. To display the full time series of deformation continuously, one must apply an offset to the second part. This offset can't simply be the last deformation map of the first part ( $t_k + 1.5 \text{ Bt}$ ) for the reasons explained above. Instead, one can take the difference between the deformation maps at date  $t_k$ , that is in the middle of the unaffected overlap.

This operation can be performed using the Python script [\*Add\\_DefoMap\\_ToAllMapsInDir.py\*](#). It must be launched in the directory that contains all the deformation maps resulting from the MSBAS

inversion of the second dataset. It takes as input parameters the deformation map at  $t_k$  resulting from the MSBAS inversion of the first dataset and the one at  $t_k$  resulting from the MSBAS inversion of the second dataset. It adds that offset to each deformation map named **MSBAS\_YYYYMMDDhhmmss\_xx.bin** in the current directory of part 2 (where **xx** is **UD** or **EW** or **LOS**). **Beware**, it will overwrite the existing deformation maps with the offset ones.

**Note:** If **Bt** is small (i.e. equivalent of only a small number of orbit cycles or only a few months), then it is advised to consider e.g. **400** days instead of **Bt** to ensure that the solution of the inversion that will be taken hereafter to estimate the offset between both datasets are outside of the possible influence of the ends of the datasets.

When deformation maps obtained from MSBAS inversion of the part 1 and those obtained from the inversion of part 2 corrected from the computed offset are merged in a common directory, one can use the Python script **Compute\_Velocity\_Stdv\_R2\_maps\_From\_AllDefoMaps.py** (which takes no parameters) to recompute the linear deformation rate map and the stdv and R2 maps as they would have been produced by a single MSBAS inversion from the whole dataset. If **Bt** and **t<sub>k</sub>** are carefully chosen as suggested, combined results must be similar as results from a processing that would not have been split in two parts.

**Note:** it is advised, when performing such a split, to keep track of starts, stop and overlap dates of these parts in the .../EVENTS\_TABLES/TARGET (e.g. in **Other\_Events\_TARGET.txt** or in **EQ\_TARGET.txt**). That way, these dates can be plotted on the time series, which allows to visually check that there is no impact on the results.

An example of implementation of such a procedure to split a MSBAS inversion is available in the script **Domuyo\_S1\_Step3\_MSBAS\_DEMGeoid\_Split.sh**. See chapter 8.4

You can use the tool **Compare\_Full\_And\_Parts\_msbas\_TS.py** to check that the offset between Part1 and Part2 is ok. It takes as input parameters the date of the middle of the overlap, then files with double difference time series for a pair of pixels (computed with **PlotTS\_all\_comp.sh**) for Part 1 and Part 2, which may be wisely named e.g. like

**timeLine\_CMP\_Xpix1\_Ypix1\_Xpix2\_Ypix2\_YourProcessDetails\_PART1\_OVERLAPyyyymmdd.txt** and  
**timeLine\_CMP\_Xpix1\_Ypix1\_Xpix2\_Ypix2\_YourProcessDetails\_PART2\_OVERLAPyyyymmdd.txt**

where

- **CMP** is the component (i.e. EW, UD or LOS) ;
- **Xpix1**, **Ypix1**, **Xpix2** and **Ypix2** are the coordinates of the 2 pixels taken for the double difference ;
- **YourProcessDetails** is the description of your msbas characteristics (i.e. the parameters used while launching **MSBAS.sh** and used for naming the directories where the results were stored) ;
- **PART1\_OVERLAPyyyymmdd** and **PART2\_OVERLAPyyyymmdd** is a good choice for naming directories where the data from each processed parts are stored. This is for instance the convention used in the example of cron script performing the msbas inversion of the Domuyo data set (see script **Domuyo\_S1\_Step3\_MSBAS\_DEMGeoid\_Split.sh** and chapter 8.4) while splitting the msbas in two parts ;
- **yyyymmdd** is the date in the middle of the overlapping period at which the offset is computed.

One can also provide the script with a 3<sup>rd</sup> optional file, which is the double difference for the same pair of pixels, though obtained from a MSBAS inversion of the whole data set performed in a single block (if available), or obtained by the combination of part1 and 2 as performed from a processing like in the example **Domuyo\_S1\_Step3\_MSBAS\_DEMGeoid\_Split.sh**.

The [\*Compare\\_Full\\_And\\_Parts\\_msbas\\_TS.py\*](#) script will create and save a figure with these double difference time series in the current directory, which allows checking that the two parts are well aligned. See script in [\*/SCRIPTS\\_MT/zz\\_Utilities\\_Ndo\*](#) for details.

#### 6.4. Estimates optimal MSBAS regularization order and lambda factor: ***test\_Lcurve.sh***

This script aims to facilitate the choice of an optimal regularization order (1, 2 or 3) and lambda factor (0→1). The choice of regularization order depends on the signal characteristics and study objectives. In case of the zero-order regularization, the solution is found by the least squares fitting of data and by minimizing the solution norm (i.e., deformation rates between consecutive acquisitions VE and VU). This type of regularization should be used when the mean of the deformation rates is expected to be close to zero (e.g., oscillating motion). See [[Samsonov and d'Oreye 2017](#)].

Launch “***test\_Lcurve.sh***” without parameters in the directory with the MSBAS results. It requires however the presence of a file *Steps\_LCurve.txt* (in **SCRIPTS\_MT**) that contains the list of points where one wants to assess the curve such as:

```
0.0001
0.0005
0.0010
0.0025
0.005
0.010
0.015
0.020
0.030
0.040
0.055
0.070
0.090
0.110
0.140
0.170
0.210
0.300
0.400
0.600
0.950
```

It will run that for each of the 3 orders of regularization. It will produce a plot (Figure 11) for each regularization order using ***plot\_Lcurve.sh***. The most appropriate order of regularization will depend on the deformation encountered (e.g. if the deformation is close to zero over time, there is a relatively steady increase or a gap in the data set). The most appropriate lambda is usually where there is a kink in the curve. An increase in the lambda factor will lead to a smoothing of the time series of deformation.

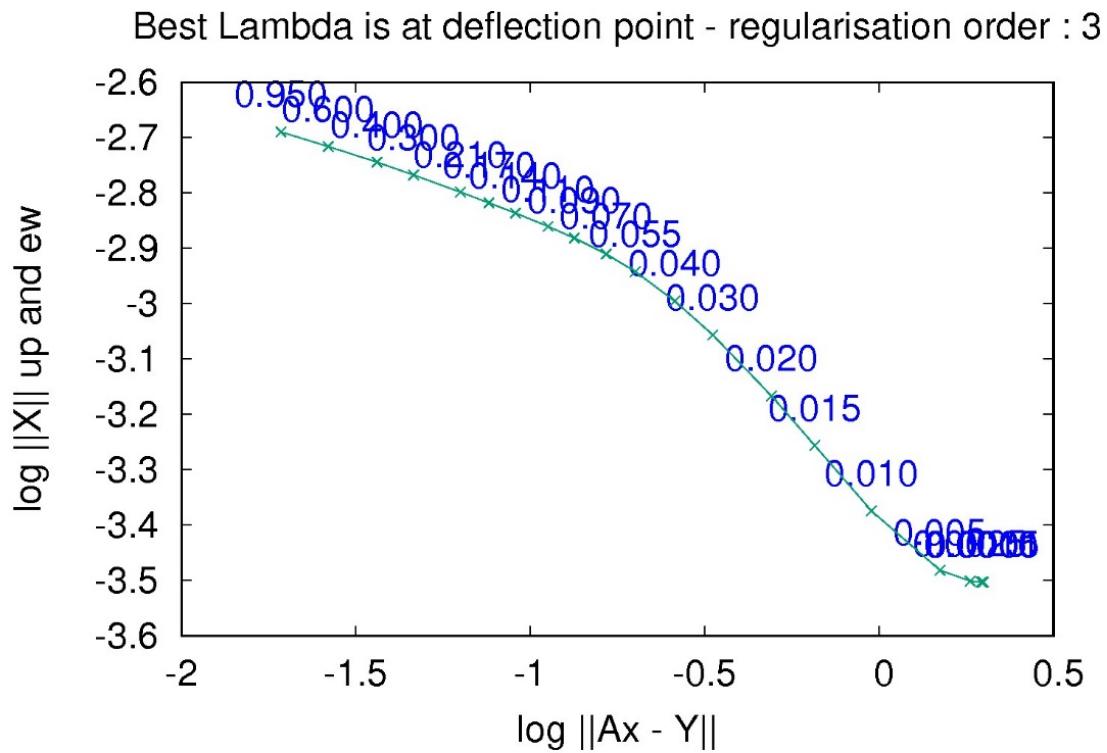


Figure 11: Example of l-curve to assist determination of the regularization. The most appropriate lambda factor is where there is a kink in the curve, that is about 0,02 in the present example.

Results might take a lot of disk space. Delete results that are not to be kept...

This script needs the python script [Norm.py](#).

## 6.5. Plot times series of displacement:

Several scripts allow plotting time series results of msbas. If ***MSBAS.sh*** was run with a ***pixlist.txt***, some time series are already provided in ***zz\_LOS\_TS\_COMMENT*** or ***zz\_EW\_TS\_COMMENT***.

However, if no ***pixlist.txt*** was provided, or if more points are required, or if double differences are wished, more scripts can be used here.

### 6.5.a) Plot times series of displacement (or double difference) for a pixel in a given direction: ***PlotTS.sh***

This script aims to plot a time series of single component displacement for a given pixel. If two pixels are provided, it will compute the time series of both pixels as well as the double difference (pixel 1 – pixel 2).

Several options exist to add on the plot a linear trend (and display the annual rate) or tags with explanation of direction of movement of one pixel with respect to the other in Double Difference.

It is also possible to add several types of events on the plot as lines or rectangles:

- Eruptions (as semi-transparent vertical red rectangles),
- Seismic swarms (as semi-transparent vertical blue rectangles),
- Possible asymmetric acquisition geometry - that is when Asc and Desc acquisitions are not well balanced - (as semi-transparent vertical grey rectangles),
- Satellite coverage by ascending or descending tracks (as semi-transparent horizontal red or blue rectangles respectively),
- Change of polarization scheme (as semi-transparent horizontal grey rectangles),
- Earthquakes (as vertical blue dashed lines), or
- Any other events (as vertical dark blue dashed lines).

Time span of the plot may also be adjusted. If a **-start=YYYYMMDD** and/or **-stop=YYYYMMDD** parameter(s) is/are provided, it takes respectively the first and/or the last date as the limit. If no such parameters are provided, it displays the time series for the whole duration.

**It must be launched in the subdirectory where data are stored i.e. *zz\_LOS\_COMMENT*, *zz\_EW\_COMMENT* or *zz\_UP\_COMMENT*.**



Launch ***PlotTS.sh*** with the following parameters:

- |                  |                                                                                                                 |
|------------------|-----------------------------------------------------------------------------------------------------------------|
| <b>XPixel1</b>   | (Position of pixel 1 in X direction, i.e. nr of col in raster map).                                             |
| <b>YPixel1</b>   | (Position of pixel 1 in Y direction, i.e. nr of lines in raster map).                                           |
| <b>[XPixel2]</b> | (Position of pixel 2 in X direction, i.e. nr of col in raster map).                                             |
| <b>[YPixel2]</b> | (Position of pixel 2 in Y direction, i.e. nr of lines in raster map).                                           |
| <b>[-f]</b>      | (for optional linear fit to be added on the plot).                                                              |
| <b>[-r]</b>      | (for optional linear annual rate displayed on the plot. Needs option -f).                                       |
| <b>[-t]</b>      | (for optional tag with direction of displacement and pixel's location).                                         |
| <b>[-d]</b>      | (for optional cleaning of both TS values text files after completion).                                          |
| <b>[-D]</b>      | (for optional cleaning of both Time Series values text files and double difference text file after completion). |

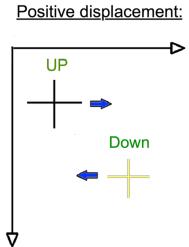
[-g] (for optional cleaning of gnuplot scripts after completion).  
 [-png] (for optional creation of png versions of some plot).  
 [-events= PATH] (to add optional events on figures as lines or rectangles,  
   where PATH is e.g. `./EVENTS_TABLES/NAME/` and NAME is the  
   name of area which is also in events table names – see below).  
 [-start=YYYYMMDD -stop=YYYYMMDD] (to optionally restricts the plot to corresponding time span).

### Notes:

1. **PlotTS.sh** requires gnu plot templates `plotTS_template.gnu` or `plotTS_template_fit.gnu` (in `SCRIPTS_MT/TemplatesForPlots/`)
2. Option `-t` add tags to locate the pixel(s) on the velocity map wrapped on amplitude. It allows add sketches that explains the direction of displacement (see Figure 12 below, although illustrated on figure combining EW and UD on the same plot).

Attention, this option requires the usage of several other tools and files:

- `TS_AddLegend_LOS.sh`, `TimeSeriesInfo_HP.sh`, `AmpDefo_map.sh`
- Python + Numpy + scripts: `CreateColorFrame.py`, `Mask_Builder.py`
- gnu function `stat (gstat)` e.g. from `coreutils`
- figures in `$PATH_SCRIPTS/SCRIPTS_MT/TSCombiFiles/` with the explanations:
  - `TS_Displ_LOS_Neg.png`
  - `TS_Displ_LOS_Pos.png`
  - `TS_Displ_Neg_EW.png`
  - `TS_Displ_Neg_UD.png`
  - `TS_Displ_Neg.png`
  - `TS_Displ_Pos_EW.png`
  - `TS_Displ_Pos_UD.png`
  - `TS_Displ_Pos.png`



- a figure named `satview.jpg` (see point 3 below and [Web\\_tool\\_Vxx.pdf](#))
- a parameters file named `TS_parameters.txt` that contains e.g. the following parameters (to be adjusted by the user):

```

Data related to HP server path

defo-domuyo # WebPage

Fiji_Amp_Defo_Coh script and ImageCreator.sh
Value used to build the legend of the deformation maps
1.3 # IJAMPMin (Minimum value for brightness to build amplitude image using ImageJ)
2.7 # IJAMPMax (Maximum value for brightness to build amplitude image using ImageJ)
40 # MarkUp (Legend vertical bar position Up)
90 # MarkDown (Legend vertical bar position Down)
125 # LegValPosH (Vertical Position of the value in the legend)
125 # LegUnitPosH (Vertical Position of the unity in the legend)
35 # LegTxtPosH (Vertical Position of the text info in the legend)
8 # LegAdjZero (Fine adjustment of the horizontal positionnement of Zero)
60 # LegAdjMin(Fine adjustment of the horizontal positionnement of Min Val)
10 # LegAdjMax (Fine adjustment of the horizontal positionnement of Max Val)
70 # LegAdjLOS (Fine adjustment of the horizontal positionnement of Max Val for LOS maps)
200 # LegAdjUnit (Fine adjustment of the horizontal positionnement of Unity related to the left)

CreateColorFrame script + Fiji_Amp_Defo_Coh script
100 # Margin
800 # LegendWidth
0.6 # ColorBackgrdLegnd (0 = white --> 1 = grey)
35 # LegendTxtSize (Size of the text in the legend)
140 # LegendHeight (Height of the legend in pixels margin include)
40 # FrameTop (distance between top of colour frame and top of the legend)
60 # FrameBott (distance between bottom of colour frame and top of the legend)

ImageCreator.sh and TimeSeriesInfo.sh
0 # Crop_X (Top left X coordinate of the cropped zone)
0 # Crop_Y (Top left Y coordinate of the cropped zone)
3361 # Crop_L (Horizontal size of the cropped zone)
2800 # Crop_H (Vertical size of the cropped zone)

TimeSeriesInfo.sh
100 # CrossTresh (Distance between 2 points (Vert or Horiz) which determine the size of the cross)
15 # CrossBig Size of the cross in defo map as thumbnail if spacement between 2 pts are > treshold)
15 # CrossSmall Size of the cross in defo map as thumbnail if spacement between 2 pts are < treshold)

```

**NOTES:**

- **Parameters**
  - o Crop\_X (Top left X coordinate of the cropped zone),
  - o Crop\_Y (Top left Y coordinate of the cropped zone),
  - o Crop\_L (Horizontal size of the cropped zone)
  - o Crop\_H (Vertical size of the cropped zone)

must be adapted to the size of the deformation maps
- if ***PlotTS.sh*** crashes while making the tags using the script, check the script ***AmpDefo\_map.sh***, see in that script the command line launching ***ImageJ*** and check the ***--headless*** option.

3. When plotting double difference time series in LOS with ***PlotTS.sh*** and option ***-t***, the scripts ***TS\_AddLegend\_LOS.sh*** and ***TimeSeriesInfo\_HP.sh*** add a small Google Earth map to locate the pixels with the same crosses as on the small images with the LOS velocity. This feature (set up by Maxime Jaspard) requires however that a referenced Google Earth image is prepared according to the area of interest (named ***satview.jpg*** in ***MSBAS\_DIR/\_CombiFiles***).

The procedure to prepare this file is explained in [Web\\_tool\\_Vxx.pdf](#).

If that ***satview.jpg*** image does not exist, it will proceed as usual, with only the velocity map to locate the pixels.

**Note:** when plotting time series of LOS only and using option ***-t***, the direction of the orbit (Asc or Desc) **MUST be in the name** of the directory where the msbas results are (i.e. in the **COMMENT** in the directory name ***zz\_LOS\_TS\_COMMENT***) to properly tag the direction of displacement.

4. Events can be added on the plot if a path to a directory where events tables are stored is provided. See example in Figure 13 below, although illustrated on a figure combining EW and UD on the same plot.

Events tables must be named as one or more of the following where **NAME** is the name of the area of interest (must be the name of the directory that contains all the event files, e.g.

**..*EVENTS\_TABLES/NAME***):

- ***Eruptions\_NAME.txt*** (displayed as vertical red rectangles)
- ***EQ\_Swarms\_NAME.txt*** (displayed as vertical blue rectangles)
- ***Asymmetric\_Acquisition\_NAME.txt*** (displayed as vertical light grey rectangles)
- ***EQ\_NAME.txt*** (displayed as vertical blue dashed lines)
- ***Other\_events\_NAME.txt*** (displayed as vertical grey dashed lines)

**Note** that these tables **MUST** be in the form of "**Name    StartDate    StopDate**" where dates are **YYYYMMDD** and fields are **separated by tab**.

Additional marks can be plotted horizontally based on additional tables i.e.:

- ***Sat\_Cover\_NAME.txt*** (displayed as horizontal red and blue rectangles for Asc and Desc respectively)
- ***Polarisation\_Change\_NAME.txt*** (displayed as horizontal grey rectangles)

**Note** that these tables **MUST** be in the form of "**Name    Date**" where date is **YYYYMMDD** and fields are **separated by tab**.

**Note** that for the specific case of ***Sat\_Cover\_NAME.txt*** the **Name** in the table **MUST** be **WHATEVER\_Asc** or **WHATEVER\_Desc**. Asc and Desc string is used by the script to be detected as sat geometry and colour code the rectangles accordingly. If these strings are not detected in second position delimited by underscores, the script will consider that it is not a satellite geometry and the rectangles will be grey, without vertical offsets in the plot.

5. if paths are properly hard coded, it can be used within a python script from QGIS (see [00\\_RasterPixelCoord.py](#)) in order to click on the velocity map on a pixel and get its coordinates and plot the time series at the same time. The hard coded paths in **PlotTS.sh** are mandatory because python console in QGIS can't read state variables in **.bashrc**. Attention, in python script, the path to the **MSBAS\_RESULTS** directory must be hardcoded as well.

Procedure to use the [00\\_RasterPixelCoord.py](#):

- Open QGIS and load a deformation or velocity map. Adjust colour if wanted
- In QGIS, add a background map and adjust transparency (if wanted)
- In QGIS: Plugin > Python Console
- In the column to the right-hand side, click on “open script” icon and load [00\\_RasterPixelCoord.py](#)
- Click on green arrow to start the script
- Click on the pixel on the map for which you want to see the time series. At the console, you will be prompted the coordinates of the pixel. Its time series will be plotted as usual in the **MSBAS\_RESULTS** directory
- Note: if you navigate in the map, it will interrupt the python script. You only have to click on the green arrow to start it again.

Special thanks to Antoine Dille for having provided with the backbone of that python script.

6. With Linux, **if an error occurs** while generating the eps file using [convert](#), change the permissions in /etc/ImageMagick/policy.xml and set:

```
</policy domain="coder" rights="none" pattern="PS" />
as
</policy domain="coder" rights="read/write" pattern="PS" />
(i.e. with pipe between read and write),
and
</policy domain="coder" rights="none" pattern="EPS" />
as
</policy domain="coder" rights="read/write" pattern="EPS" />
```

Also, change as follow:

```
</policy domain="resource" name="height" value="16KP" />
as
</policy domain="resource" name="height" value="32KP" />
```

and

```
</policy domain="resource" name="width" value="16KP" />
as
</policy domain="resource" name="width" value="32KP" />
```

and

```
</policy domain="resource" name="disk" value="1GiB" />
as
</policy domain="resource" name="disk" value="8GiB" />
```

**6.5.b) Plot times series of displacement for a pixel (or double difference) in all directions in the same plot: *PlotTS\_all\_comp.sh***

This script is only useful for 2D displacements. ***PlotTS\_all\_comp.sh*** aims to plot in the same figure both EW and UD time series of displacements for a given pixel. If two pixels are provided, it will compute the time series of both pixels as well as the double difference (pixel 1 – pixel 2).

Unlike the former script for single component, ***PlotTS\_all\_comp.sh*** must be launched in the directory that contains the subdirectories `zz_EW_COMMENT` and `zz_UP_COMMENT`.

Note: it also works for 3D displacements if MSBAS allowing that option is used (i.e. when NS displacement can be deduced from additional information coming from topography [Samsonov et al. 2020]).

Launch ***PlotTS\_all\_comp.sh*** with the following parameters:

|                                               |                                                                                                                                                                                                 |
|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>REMARKDIR</code>                        | (remark that was used at the time of running <b><i>MSBAS.sh</i></b> and that is used to name the UD and EW dirs e.g. <code>zz_UD_REMARKDIR</code> ).                                            |
| <code>XPixel1</code>                          | (Position of pixel 1 in X direction, i.e. nr of col in raster map).                                                                                                                             |
| <code>YPixel1</code>                          | (Position of pixel 1 in Y direction, i.e. nr of lines in raster map).                                                                                                                           |
| <code>[XPixel2]</code>                        | (Position of pixel 2 in X direction, i.e. nr of col in raster map).                                                                                                                             |
| <code>[YPixel2]</code>                        | (Position of pixel 2 in Y direction, i.e. nr of lines in raster map).                                                                                                                           |
| <code>[-f]</code>                             | (for optional linear fit to be added on the plot).                                                                                                                                              |
| <code>[-r]</code>                             | (for optional linear annual rate displayed on the plot. Needs option <code>-f</code> ).                                                                                                         |
| <code>[-t]</code>                             | (for optional tag with direction of displacement and pixel's location).                                                                                                                         |
| <code>[-d]</code>                             | (for optional cleaning of both TS values text files after completion).                                                                                                                          |
| <code>[-D]</code>                             | (for optional cleaning of both TS values text files and double difference text file after completion).                                                                                          |
| <code>[-g]</code>                             | (for optional cleaning of gnuplot scripts after completion).                                                                                                                                    |
| <code>[-png]</code>                           | (for optional creation of png versions of some plot).                                                                                                                                           |
| <code>[-events= PATH]</code>                  | (to add optional events on figures as lines or rectangles, where PATH is e.g. <code>./EVENTS_TABLES/NAME/</code> and NAME is the name of area which is also in events table names – see below). |
| <code>[-start=YYYYMMDD -stop=YYYYMMDD]</code> | (to optionally restricts the plot to corresponding time span).                                                                                                                                  |

See ***PlotTS.sh*** for explanations about the options above. ***PlotTS\_all\_comp.sh*** has however an additional option (rather for check, debug or development) that is to add boxes and error-bars-like features that are proportional to the coherence:

|                            |                                                                                                                                                                                                                                                                                                                         |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>[-coh=option]</code> | (to optionally add error bars-like info about coherence)<br>where option is either <code>avgavg</code> , <code>avgmin</code> , <code>avgminmax</code> or <code>avgavgminmax</code> to plot data +- Mean and/or Min and/or Max coherence. This is only plotted on single pixel eps plot (not on double difference plot). |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

In a nutshell, the coherence at the location of the pixel is extracted from all the interferometric pairs used to compute the displacement during the msbas inversion. The script then computes the mean coherence (avg), the min and max coherence, and the number of pair files used. Note that the values of the coherence are arbitrary divided by 100 for the sake of scaling in plot.

Depending on the option chosen, one can plot boxes above (and below) the data, and/or error bar with min coh value below and max coh above data. Note that because these boxes and bars are

coherence-related information and not error bars, the **larger is the best!**.

Note that because the script must look for all the pairs containing each image and then compute the statistics, this may be very slow at first run. However, it is an incremental process: it only computes that statistic for dates that were not computed yet. Therefore, next runs will be much faster. Note however that pre-existing coherence values will not be estimated again, even if new pairs are added. If this is the case, the line in the data files corresponding to that date in `timeLine_EW_COH_LIN_PIX_REMARK.txt` and `coh_LIN_PIX_REMARK.txt` (in `MSBAS_DIR/zzz_coh_per_pixels`), where `LIN`, `PIX` and `REMARK` are respectively the coordinates of the pixel and the string used to name the directories where the MSBAS results are stored, must be removed.

Color-coded symbols are added along the  $y=0$  axis corresponding to the number of pairs used to compute the coherence statistics. See Figure 14 for illustration.

This script uses `TS_AddLegend_EW_UD.sh` to add the legends as for LOS with `PlotTS.sh`.

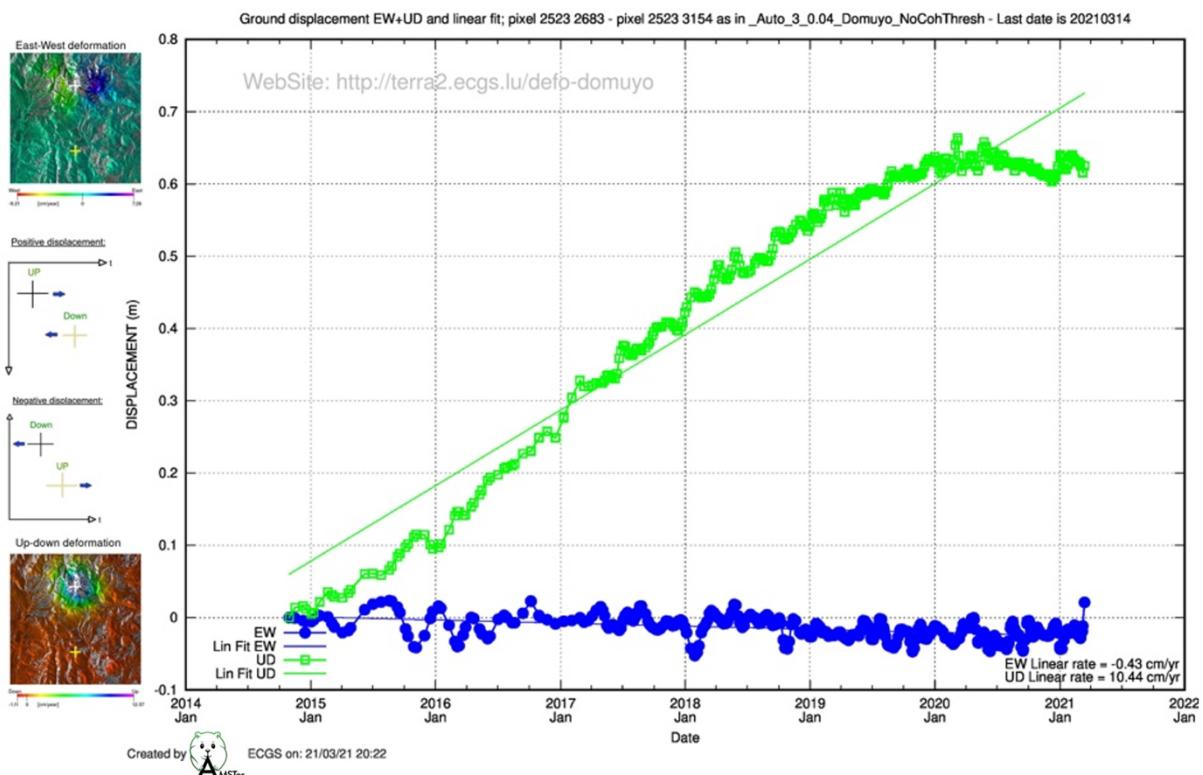


Figure 12: Example of plot (all comp) using options `-f -r -t`

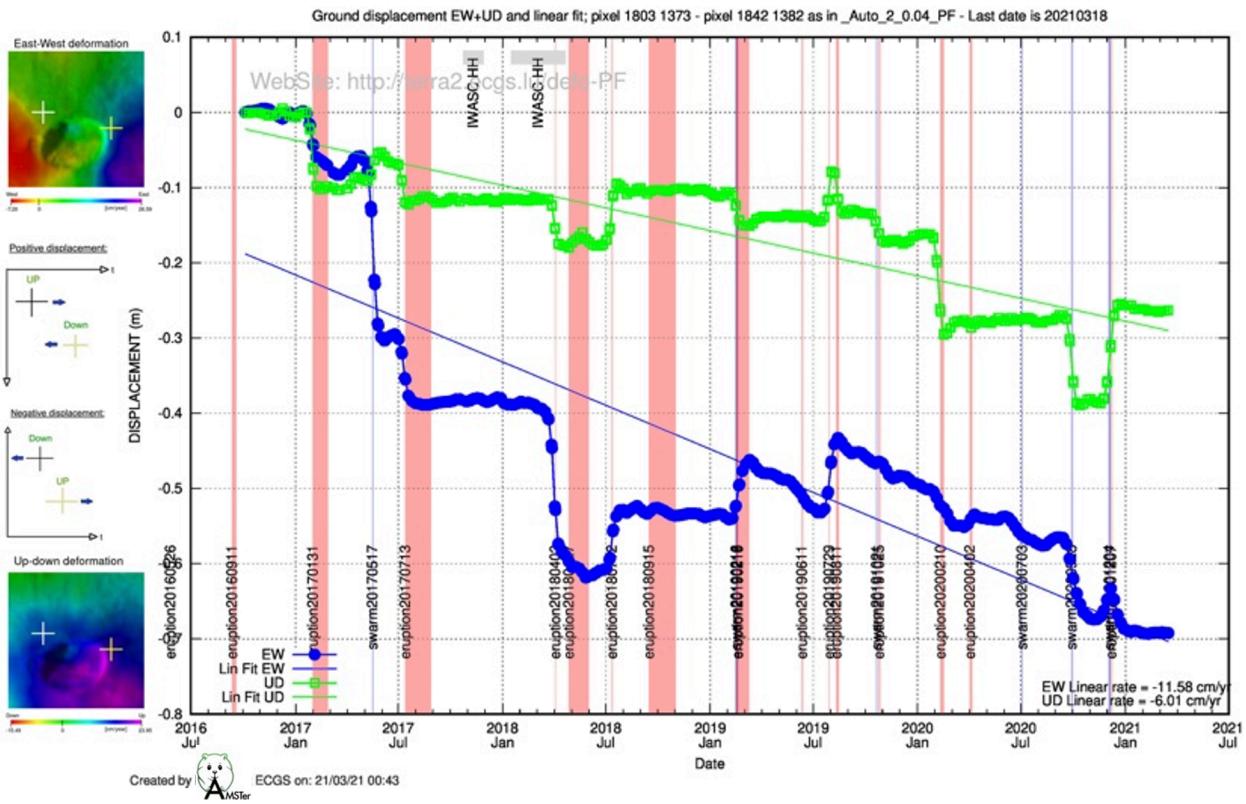


Figure 13: Example of plot (all comp) with option `-f-r-t -events=...`

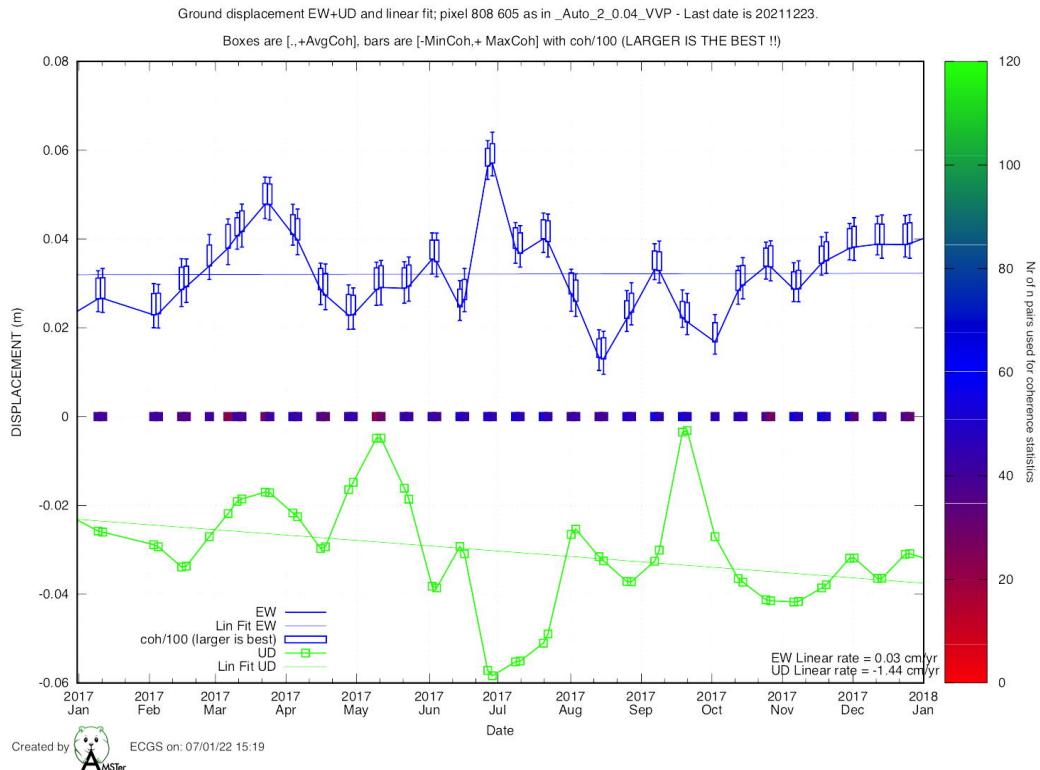


Figure 14: Example of plot (all comp) with option `-coh=avgminmax`. Bottom of the box is displacement, top of the box is the average coherence (/100), lower and upper bars are min and max coherence (/100) respectively. Color coded symbols is the number of pairs use for the coherence statistics.

## 6.6. Create customized baselines plot:

### 6.6.a) Create baselines plot with the images effectively used for msbas: *PlotBaselineGeocMSBAS.sh* and *PlotBaselineGeocMSBASmodeTXT.sh*

When preparing the msbas at step ***Prepa\_MSBAS.sh***, it creates a baseline plot. However, it might be required to add pairs from the default selection of pairs based on solely the Bt and Bp (e.g. when too long gaps are observed in the time series) or remove pairs (e.g. if some pairs can't be computed). This is done by adding/removing files in the directories prepared by ***build\_header\_msbas\_criteria.sh*** (i.e. `.../MSBAS_RESULTS/MSBAS_SAT_REGION/DefoModei`) and adding/removing the corresponding lines in `DefoModei.txt` (where `DefoMode` is the first option used in ***build\_header\_msbas\_criteria.sh***).

When pairs are added or removed, one can use ***PlotBaselineGeocMSBAS.sh*** to create new baselines plots based on the list of pairs that were effectively used by msbas i.e. that are in each `.../MSBAS_RESULTS/MSBAS_SAT_REGION/DefoModei`.

The script will take the characteristics of the images from the image names that are in `DefoModei`.

Launch ***PlotBaselineGeocMSBAS.sh*** with the following 3 parameters:

`PathToSeti` (path to dir where pair lists are i.e. `.../SAR_SM/SAT/TRK/REGION/seti`)  
where *i* is the first mode used in the msbas processing).

`DefoMode` (the mode used in msbas as selected at ***build\_header\_msbas\_criteria.sh***).  
`ith_mode` (*i*<sup>th</sup> mode of msbas processing for which one wants to create a plot).

The script must be launched from `.../MSBAS_RESULTS/MSBAS_SAT_REGION`

Probably better, a slightly different version of that script, which is named ***PlotBaselineGeocMSBASmodeTXT.sh***, uses the list of interferograms to draw the baseline plot, i.e. `.../MSBAS_RESULTS/MSBAS_SAT_REGION/DefoModei.txt`

Launch ***PlotBaselineGeocMSBASmodeTXT.sh*** with the following 2 parameters:

`PathToSeti` (path to dir where pair lists are i.e. `.../SAR_SM/SAT/TRK/REGION/seti`)  
where *i* is the first mode used in the msbas processing).

`PathToTxt` (path to `DefoModei.txt`).

### 6.6.b) Create baselines plot with the images contained in GeocodedRasters: *PlotBaselineGeocRaster.sh*

***PlotBaselineGeocRaster.sh*** allows to create a baselines plot based on the list of rasters contained in `.../SAR_MASSPROCESS` in subdirectories `/GeocodedRasters`.

The script will take the characteristics of the images from the image names that are in `/GeocodedRasters/Coh`.

The script MUST be launched from `/GeocodedRasters` and one must copy in that directory the `initBaselines.txt` file. Launch ***PlotBaselineGeocRaster.sh*** without parameters.

**6.6.c)** Create a combined baselines plot from several data sets: *plot\_Multi\_span.sh*

***plot\_Multi\_span.sh*** makes a common baselines plot for multiple data sets. The script must be launched from `.../MSBAS_RESULTS/MSBAS_SAT_REGION/` and data are expected to be in subdirectories `.../MSBAS_RESULTS/MSBAS_SAT_REGION/DefoModei`. It supposes that a first plot was already computed with ***Prepa\_MSBAS.sh*** for each mode in order to generate the `span(1).txt` files with the same MaxBp and MaxBt.

Launch ***plot\_Multi\_span.sh*** with the following 6 parameters:

|                   |                                                                                      |
|-------------------|--------------------------------------------------------------------------------------|
| <i>SETLIST</i>    | (file with the list of sets used in the order of <code>DefoMode<i>i</i></code> dir). |
| <i>MinBp</i>      | (minimum Bp)                                                                         |
| <i>MaxBp</i>      | (maximum Bp)                                                                         |
| <i>MinBt</i>      | (minimum Bt)                                                                         |
| <i>MaxBt</i>      | (maximum Bt)                                                                         |
| <i>ColorTable</i> | (file with colour table in hex)                                                      |

For table color, see for instance `SCRIPTS_MT/TemplatesForPlots/ColorTable_AD.txt`, or `SCRIPTS_MTT/TemplatesForPlots/ColorTable_ADDA.txt` (where A and D stands for Asc and Desc, and corresponds to the order of `DefoModei` sets) in.

It is advised to try keeping eg. blueish for Ascending and reddish for Descending orbits.

Blue like colors e.g. : #0000ff, #8a2be2, #6495ed, #00008b, #00ffff, #7ffd4

Red like colors e.g. : #dc143c, #a52a2a, #d2691e, #ff7f50, #ff1493, #ff00ff

see for instance <http://cloford.com/resources/colours/500col.htm>

**6.6.d)** Create a combined baselines plot from 2 data sets with different baselines criteria:  
*plot\_Multi\_span\_multi\_Baselines.sh*

***plot\_Multi\_span\_multi\_Baselines.sh*** makes a common baselines plot for 2 data sets of different baselines.

The script must be launched from `.../MSBAS_RESULTS/MSBAS_SAT_REGION/` and data are expected to be in subdirectories `.../MSBAS_RESULTS/MSBAS_SAT_REGION/DefoModei`.

It supposes that a first plot was already computed with ***Prepa\_MSBAS.sh*** for each mode in order to generate the `span(1).txt` files with the same MaxBp and MaxBt.

Launch ***plot\_Multi\_span\_multi\_Baselines.sh*** with the following 10 parameters:

|                   |                                                                                      |
|-------------------|--------------------------------------------------------------------------------------|
| <i>SETLIST</i>    | (file with the list of sets used in the order of <code>DefoMode<i>i</i></code> dir). |
| <i>MinBp1</i>     | (minimum Bp of first data set)                                                       |
| <i>MaxBp1</i>     | (maximum Bp of first data set)                                                       |
| <i>MinBt1</i>     | (minimum Bt of first data set)                                                       |
| <i>MaxBt1</i>     | (maximum Bt of first data set)                                                       |
| <i>ColorTable</i> | (file with colour table in hex)                                                      |
| <i>MinBp2</i>     | (minimum Bp of second data set)                                                      |
| <i>MaxBp2</i>     | (maximum Bp of second data set)                                                      |
| <i>MinBt2</i>     | (minimum Bt of second data set)                                                      |
| <i>MaxBt2</i>     | (maximum Bt of second data set)                                                      |

**6.6.e)** Create a combined baselines plot from several data sets with different baselines criteria (using AMSTerEngin version May 2022 or later): *plot\_Multi\_BaselinePlot.sh*

The script ***plot\_Multi\_BaselinePlot.sh*** makes a common Baseline plot for as much data set as wanted. It is sort of an updated version of ***plot\_Multi\_span\_multi\_Baselines.sh*** as it makes also a common imageSpatialLocalization plot for these multiple data sets.

**Notes :**

- It supposes that a first plot was already computed (see ***Prepa\_MSBAS.sh***) for each mode in order to generate the required data and gnuplot files
- It required AMSTerEngine version May 2022 or later as it needs [acquisitionsRepartition.txt](#) and gnuplot files prepared during run of ***Prepa\_MSBAS.sh***.
- Unlike ***plot\_Multi\_span\_multi\_Baselines.sh*** it searches by himself the Bp, Bt and the date of the Global Primary for each dataset
- If more than 5 different datasets are plotted, colours code in the imageSpatialLocalization figure will loop (i.e. set 1 and 6 will be plotted with the same colour). But more than 5 sets would be unreadable anyway... Above 10 sets, see yourself...

It must be launched with only one parameter, that is a text file listing the datasets as e.g. :

```
$PATH_1650/SAR_SM/MSBAS/REGION/set6
$PATH_1650/SAR_SM/MSBAS/REGION/set7
```

## 7. Checking the data and results: the diagtoolbox

In `/SCRIPTS_MT/diagtoolbox/`, some shell and python scripts allow the user to perform several automated diagnoses of the AMSTer processes, including

- listing and comparing of CSL and MSBAS data, and
- graphical tools to help defining the pair selection parameters.

### 7.1. Launching the diagnostic: `Run_Diagnostic_TARGET.sh`

The script `Run_Diagnostic_TARGET.sh`:

- creates directories to store the analysis results,
- looks for necessary files in processing directories and copy some of them locally, and
- run the diagnostic tools.

As with the cron scripts for Steps 1, 2, and 3 (see chapter 8), this **script must be edited and adapted to the processing performed on the study area** (see description of the hardcoded parameters below).

**Usage:**

`Run_Diagnostic_TARGET.sh STARTDATE ENDDATE`

Where:

|                        |                                                                                                |
|------------------------|------------------------------------------------------------------------------------------------|
| <code>TARGET</code>    | is the name of your region of interest                                                         |
| <code>STARTDATE</code> | is the start date of the analysis period in YYYY-MM-DD format (e.g. <code>2023-01-01</code> ). |
| <code>ENDDATE</code>   | is the end date of the analysis period in YYYY-MM-DD format (e.g. <code>2023-12-31</code> ).   |

It requires the following **Hardcoded Parameters** (paths to directories and variables):

|                                      |                                                                                                                                                                                                                 |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>REGION</code> :                | The label for the study area.                                                                                                                                                                                   |
| <code>PATH_CSLSAT</code> :           | Paths to the directories containing CSL data<br>(e.g. <code>.../SAR_CSLSAT/TRK/Crop</code> ).                                                                                                                   |
| <code>PATH_SM</code> :               | Paths to the <code>SAR_SM</code> directories containing the <code>seti</code> files<br>(e.g. <code>.../SAR_SM/MSBAS/Region/seti</code> ).                                                                       |
| <code>PATH_MASSPROCESS_MODE</code> : | Paths to the <code>SAR_MASSPROCESS</code> directories for each mode<br>(e.g. <code>.../SAR_MASSPROCESS/SAT/TRK/Crop</code> ).                                                                                   |
| <code>PATH_MS BAS_XXX</code> :       | Paths to the MSBAS product directories<br>(e.g. <code>.../MSBAS_RESULTS/Region</code> or <code>.../MSBAS/Region</code> ).                                                                                       |
| <code>Label_x</code> :               | Labels for the MSBAS directories (e.g. the <code>COMMENT</code> used at MSBAS processing, see chapter 6.2).                                                                                                     |
| <code>DEM_XX</code> :                | Path to the DEM file.                                                                                                                                                                                           |
| <code>ALL_MODESLIST</code> :         | File containing a list with all modes used for MSBAS inversion (see description of <code>All_modes_list.txt</code> below).                                                                                      |
| <code>REJECT_MODE</code> :           | File containing the number of the modes to be rejected (see description of <code>Reject_modes_list.txt</code> below).                                                                                           |
| <code>BTBP</code> :                  | File containing for information about Bp and Bt for each mode (see description of <code>BTBP_Infos.txt</code> below).                                                                                           |
| <code>KML_list</code> :              | File containing a list of kml to be plot regions of interest on the DEM (see description of <code>KML_list.txt</code> below).                                                                                   |
| <code>Coh_th_Info</code> :           | File containing the coherence thresholds to be used for computing the mean coherence over a provided kml (see description of <code>Coh_th_Infos_kmlname.txt</code> below).                                      |
| <code>PointList</code> :             | File containing names and pixel coordinates of points for which double difference time series of ground deformation can be plotted (see description of <code>List_DoubleDiff_YourDescription.txt</code> below). |
| <code>EVENTSDummy</code> :           | File containing a list of events to be plotted on graphs (see description of <code>Events_list.txt</code> below).                                                                                               |
| <code>RESULT_DIR</code> :            | Path to the directory for storing the outputs (e.g. <code>.../DIAG_RESULTS/</code> ).                                                                                                                           |

**WARNING :** All paths must be written in the script between double quotes ("").

**Features:**

1. Creation of result directories: The script creates several directories where the results of the diagnostics will be stored, including logfiles and figures.
2. Displaying DEM and Kml: The script calls [\*Plot\\_cslDEM\\_and\\_KMLs.py\*](#), which generates two plots: one for the entire DEM and another for a zoomed-in view of the maximum extension of the provided KMLs from the [\*KML\\_list.txt\*](#) file (see example below).
3. Listing CSL images: The script calls [\*List\\_All\\_Modes\\_and\\_All\\_Images.sh\*](#), which generates a list of images present in the [\*PATH\\_CSLSAT\*](#) directories for the specified period.
4. Updating MSBAS information: The script copies files containing MSBAS information ([\*restrictedPairSelection\\_\\*.txt\*](#); see example below) from the directories where MSBAS is performed to the diagnostic directory.
5. Comparing CSL and MSBAS databases: The script calls [\*Check\\_images.py\*](#), which compares images from the CSL and MSBAS databases.
6. Processing [\*SAR\\_SM\*](#) data: The script copies the [\*allPairsListing.txt\*](#) files for each set and analyzes them using the [\*Analyse\\_AllPairslisting\\_data.py\*](#) script.
7. Coherence analysis: The script calls [\*Baseline\\_Coh\\_Table.sh\*](#) for all modes and all provided KMLs to check the coherence behavior based on [\*Bp/Bt\*](#) criteria, seasonality, and to validate the coherence threshold choice using the [\*Analyse\\_BaselineCoh\\_data.py\*](#) script.
8. Statistical calculations on MSBAS pair selection: The script calls [\*Extract\\_Stats\\_All\\_Modes.py\*](#).
9. Comparison of Baseline Plots: The script calls [\*CompareBS\\_MSBAS.sh\*](#), which produces graphs showing common and unique pairs between two baseline plots.
10. Comparison on maps: The script calls [\*Compare\\_MSBAS\\_Maps\\_Interpolated.py\*](#), which compares EW, UD (and NS if available) maps from two different MSBAS processing.
11. Time series comparison: The script calls [\*CompareTS\\_EWUD.sh\*](#), which overlays the EW, UD (and NS if available) time series for each point pair listed in the [\*PointList\*](#) file (i.e. [\*List\\_DoubleDiff\\_YourDescription.txt\*](#)).

**Required text files :**

To operate, the script [\*Run\\_Diagnostic\\_TARGET.sh\*](#) needs the following text files located wherever you want, as they are called with their full path from within [\*Run\\_Diagnostic\\_TARGET.sh\*](#). All these names provided here are given as example, thought they can be changed as they are hardcoded with their full path in the script. Only the file [\*Coh\\_th\\_Infos\\_kmlname.txt\*](#) must keep the name structure.

- [\*All\\_modes\\_list.txt\*](#) :

This ascii text file contains, between curly brackets, one line for each mode used in the MSBAS inversion. These lines, separated by commas, contain :

- o the name of the directories where the interferometric pairs and geocoded maps are stored (i.e. [\*"YourRegion\\_YourTrack"\*](#) in [\*/SAR\\_MASSPROCESS/SAT/YourRegion\\_YourTrack\*](#)) between double quotes, followed by, and separated by a semicolon,
- o the number of the mode it is used for in the MSBAS inversion (see the [\*i\*](#) in e.g. [\*DefolInterpol2Detrend\*](#)).

```
{
 "ARG_DOMU_LAGUNA_DEMGeoid_A_18": 1,
 "ARG_DOMU_LAGUNA_DEMGeoid_D_83": 2
}
```

- [\*BTBP\\_Infos.txt\*](#) :

This ascii text file contains, after a one-line description header (see example below), a line for each mode used in the MSBAS inversion. These lines, contain the following elements separated by tabs:

- o The number of the mode it is used for in the MSBAS inversion (see the [\*i\*](#) in e.g. [\*DefolInterpol2Detrend\*](#))
- o The spatial and temporal baseline used for the first part of the baseline plot
- o The description of the mode in the form of [\*Sat\\_Orb\\_Trk\*](#)

- The spatial and temporal baseline for the second part of the baseline plot (see chapter 6.6.d). If no change of **Bp** and/or **Bt**, set **Bp2** and **Bt2** as **Bp** and **Bt** and set *none* in the **DateChange** column.
- The date at which the baselines are changed in the baseline plot
- The start and stop date of the period to be analyzed.

| Set | BP | BT  | Mode    | BP2 | BT2 | DateChange | Startdate  | Enddate    |
|-----|----|-----|---------|-----|-----|------------|------------|------------|
| 1   | 20 | 450 | S1_A_18 | 80  | 450 | 2022-05-01 | 2014-01-01 | 2025-05-31 |
| 2   | 20 | 450 | S1_D_83 | 80  | 450 | 2022-05-01 | 2014-01-01 | 2025-05-31 |

- [Reject\\_modes\\_list.txt](#) :

This ascii text file contains the number of the modes to be rejected, in one line separated by commas.

|     |
|-----|
| 1,2 |
|-----|

- [KML\\_list.txt](#) :

A list of kml's can be used to be plot on the DEM. It can be the kml used to select the data to be downloaded, and/or the one to read the raw data or crop the data in CSL format, and/or a kml used to compute the mean coherence on a given area of interest (see e.g. chapter 6.1.d). They are provided as ascii text files containing the full path to the kmls.

|                                                                                                                                                                                                                                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| /Volumes/hp-1650-Data_Share1/kml/ARGENTINA/Domuyo_Edifice.kml<br>/Volumes/hp-1650-Data_Share1/kml/ARGENTINA/Domuyo.kml<br>/Volumes/hp-1650-Data_Share1/kml/ARGENTINA/DomuyoYLagunaFea.kml<br>/Volumes/hp-1650-Data_Share1/kml/ARGENTINA/Laguna_Maule.kml<br>/Volumes/hp-1650-Data_Share1/kml/ARGENTINA/LagunaFea.kml |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

- [Events\\_list.txt](#) :

This ascii text file contains a list of events to be plotted by script (see chapter 1.7.1.d)

|                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| master slave other_column<br>09/10/2014 09/10/2014 Start_S1A<br>07/08/2018 07/08/2018 Start_S1B<br>23/12/2021 23/12/2021 Loss_S1B<br>15/04/2024 15/04/2024 Drift_S1A<br>04/01/2023 04/01/2023 EndPart1<br>25/05/2019 25/05/2019 StartPart2<br>26/03/2021 26/03/2021 MidOverlap<br>27/03/2021 27/03/2021 MidOverlap |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

- [Coh\\_th\\_Infos\\_kmlname.txt](#) :

This ascii text file contains the coherence thresholds to be used for computing the mean coherence over a provided kml (see e.g. chapter 6.1.d). It expects one file per kml.

|                                     |
|-------------------------------------|
| Set Threshold<br>1 0.235<br>2 0.235 |
|-------------------------------------|

- [List\\_DoubleDiff\\_YourDescription.txt](#) :

This ascii text file contains the coordinates of pairs of pixels followed by a text string describing that pair of pixels (see also chapter 8.4 where the plotting of Double Difference Time Series is automatized a cron job as well as the naming of the results based on the description string). It contains one line per pair of pixels to be plotted as Double Difference.

|                                                                                                       |
|-------------------------------------------------------------------------------------------------------|
| 2523 2680 1965 2682 _Domuyo_C_W<br>2523 2680 3055 2707 _Domuyo_C_E<br>2523 2680 2523 3157 _Domuyo_C_S |
|-------------------------------------------------------------------------------------------------------|

**Dependencies:**

The script ***Run\_Diagnostic\_TARGET.sh*** needs and call the following other scripts, which are explained here after:

*Plot\_csiDEM\_and\_KMLs.py*  
*List\_All\_Modes\_and\_All\_Images.sh*  
*List CSL\_Images\_In\_Mode.sh*  
*Check\_images.py*  
*Analyse\_AllPairslisting\_data.py*  
***Baseline\_Coh\_Table.sh***  
*Analyse\_BaselineCoh\_data.py*  
*Import\_RestrictedPairSelectionFiles\_as\_DF.py*  
*Compute\_Graphs\_From\_dfpkl.py*  
*Graph2StatsImagesDF.py*  
*Extract\_Stats\_All\_Modes.py*  
***CompareBS\_MSBAS.sh***  
*Compare\_MSBAS\_Maps\_Interpolated.py*  
***CompareTS\_EWUD.sh***

### 7.1.a) *Plot\_csiDEM\_and\_KMLs.py*

This script *Plot\_csiDEM\_and\_KMLs.py* allows to visualize a Digital Elevation Model (DEM) in AMSTer format (binary matrix and its .txt file) and overlays the contours of polygons contained in multiple KML files listed in a *KML\_list.txt* text file.

It outputs two files (Figure 15):

- The first PDF file named *DEM\_KML\_list.txt\_kmlplot.pdf* shows the full DEM with the contours of the KML polygons (where *DEM* is the name of the DEM file and *KML\_list.txt* is the name of the file with the list of KMLs).
- The second PDF file named *DEM\_KML\_list.txt\_kmlplot\_ZOOM.pdf* is a zoom of the DEM on the area(s) bounded by the polygons from the KML files.

#### Usage:

***Plot\_csiDEM\_and\_KMLs.py DEMfullpath KML\_list\_file RESULTDIR***

Where:

*DEMfullpath* is the path to the Digital Elevation Model (DEM) file (binary matrix, which must be accompanied by its .txt file in the same directory).

*KML\_list\_file* is the path to a *KML\_list.txt* text file, which contains a list of paths to KML files.

*RESULTDIR* is the path to a destination folder where the results (PDF plots) will be saved.

#### Dependencies:

*Python3* and the modules: *matplotlib*, *shapely*, *numpy* and *xml.etree.ElementTree*

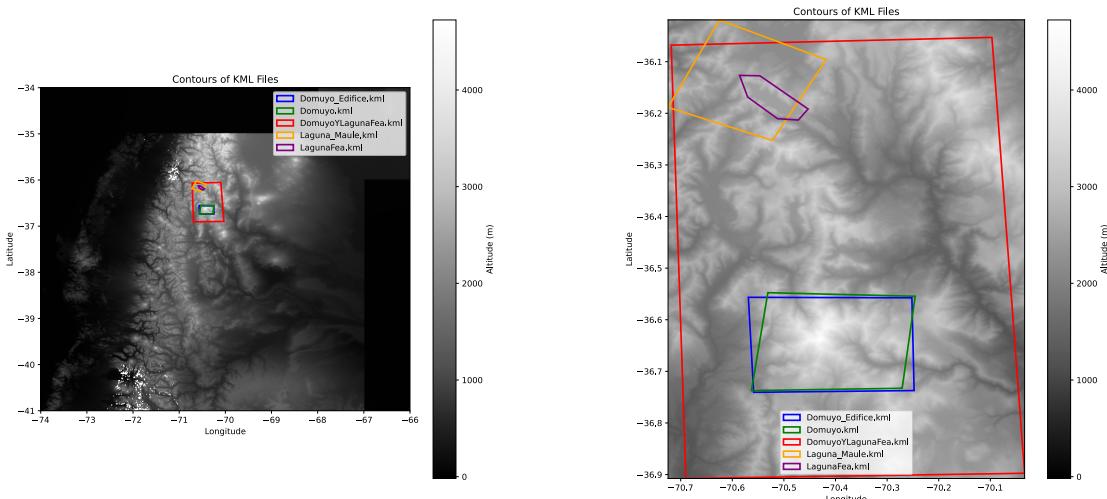


Figure 15: Example of *DEM\_KML\_list.txt\_kmlplot.pdf* (left) and *DEM\_KML\_list.txt\_kmlplot\_ZOOM.pdf* (right) displaying several KMLs on the DEM in the Domuyo/Laguna Del Maule area (Chile/Argentina border).

### 7.1.b) *List\_All\_Modes\_and\_All\_Images.sh*

The script *List\_All\_Modes\_and\_All\_Images.sh* lists all the modes corresponding to the *Region* in a *.../SAR CSL/SAT* directory, and if requested, uses the *List CSL\_Images\_In\_Mode.sh* script to list all the CSL images available for each mode.

Outputs are written in a text file named *SAT\_mode\_list.txt* (where *SAT* is the name of the satellite), that contains, after a description header, the name of each mode, the corresponding number of images present for that mode, and the date of the first and last image. It ends with the first and last image dates among all the modes. See example below obtained from the processing of Sentinel-1 images over the Domuyo region (Argentina; see e.g. chapter 8):

*S1\_mode\_list.txt* :

```
Directory: /$PATH_1650/SAR CSL/S1 From 2010-01-01 to 2026-01-01
Columns: Mode Name Number of Images First Image Date Last Image Date
ARG_DOMU_LAGUNA_DEMGeoid_A_18 285 20141030 20250222
ARG_DOMU_LAGUNA_DEMGeoid_D_83 353 20141023 20250227

Total images: 638
Overall first date: 20141023
Overall last date: 20250227
```

#### Usage

*List\_All\_Modes\_and\_All\_Images.sh* *Directory\_SAT\_full\_path REGION [STARTDATE] [ENDDATE]*

Where:

|                                |                                                                                                  |
|--------------------------------|--------------------------------------------------------------------------------------------------|
| <i>Directory_SAT_full_path</i> | Full path to the <i>SAT</i> directory in <i>SAR CSL</i> (e.g., <i>.../SAR CSL/SAT</i> )          |
| <i>REGION</i>                  | Region name to filter the directories<br>(e.g. <i>ARG_DOMU_LAGUNA_DEMGeoid</i> in example above) |
| <i>[STARTDATE]</i>             | Optional: Start date in format YYYYMMDD                                                          |
| <i>[ENDDATE]</i>               | Optional: End date in format YYYYMMDD                                                            |

#### Dependencies

*awk*

*List CSL\_Images\_In\_Mode.sh* (see chapter 7.1.c)

### 7.1.c) *List CSL\_Images\_In\_Mode.sh*

The script *List CSL\_Images\_In\_Mode.sh* lists all the images with a \*.csl extension that are stored in a *.../SAR CSL/SAT/Region\_TRK/NoCrop* directory and writes that in a text file (one file per mode, i.e. *Region\_TRK*) named *YourMode\_csl\_list.txt* (e.g. *ARG\_DOMU\_LAGUNA\_DEMGeoid\_A\_18\_csl\_list.txt*).

#### Usage

*List CSL\_Images\_In\_Mode.sh* *Directory\_Mode\_Full\_Path*

Where:

|                                 |                                                                                                                                       |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <i>Directory_Mode_Full_Path</i> | Full path to the <i>Region TRK</i> directory ( <b>do not provide the path up to NoCrop</b> , e.g. <i>.../SAR CSL/SAT/Region TRK</i> ) |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|

### 7.1.d) *Check\_images.py*

The script *Check\_images.py* compares:

- The list of all the images available for a given mode listed in the files *YourMode\_csl\_list.txt* (computed by *List\_All\_Modes\_and\_All\_Images.sh*; see chapter 7.1.b), and
- The list of images used for the MSBAS inversion listed in the files *../MSBAS/restrictedPairSelection\_Modei.txt*

From that comparison, it can identify which images are not used in the MSBAS inversion.

The results are provided as:

- two CSV files:
  - o one listing all the images used for the MSBAS inversion ([combined\\_subdirectories\\_with\\_modes\\_and\\_dates.csv](#)) and
  - o one to list the images skipped for the MSBAS inversion ([differences\\_dates\\_modes.csv](#)), and
- one plot [Plot\\_database\\_with\\_model\\_names.pdf](#) displaying the timeline with images in blue when used for MSBAS and grey when skipped. If an event file is provided, they will appear as vertical lines in the plot (see Figure 16),
- a text file logging the information about the processing: [logfile\\_checkimage.txt](#)

#### Usage :

```
Check_images.py DIR_INFO_CSL DIR_INFO_MSBAS STARTDATE ENDDATE RESULTDIR
MODELISTFILE [-event EVENTS] [-rejected REJECTEDMODESFILE]
```

Where:

|                            |                                                                                                                                                                                                                                        |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>DIR_INFO_CSL</i>        | Path to the directory containing the information about the data in CSL format (i.e. .../DIAG_RESULTS/Region/CSL, where .../DIAG_RESULTS/Region is hard coded in <a href="#">Run_Diagnostic_TARGET.sh</a> as param <i>RESULT_DIR</i> ). |
| <i>DIR_INFO_MSBAS</i>      | Path to the directory containing the MSBAS results.                                                                                                                                                                                    |
| <i>STARTDATE</i>           | Start date for the range to analyze (format: YYYYMMDD).                                                                                                                                                                                |
| <i>ENDDATE</i>             | End date for the range to analyze (format: YYYYMMDD).                                                                                                                                                                                  |
| <i>RESULTDIR</i>           | Path to the directory where to store the output results (e.g. .../DIAG_RESULTS/Region/MSBAS/SAT).                                                                                                                                      |
| <i>MODELISTFILE</i>        | Path to the <a href="#">All_modes_list.txt</a> file (see chapter 7.1) containing a list of modes to consider (mandatory).                                                                                                              |
| <i>[REJECTEDMODESFILE]</i> | Optional: Path to the file <a href="#">Reject_modes_list.txt</a> (see chapter 7.1) containing modes to reject from the analysis.                                                                                                       |
| <i>[EVENTS]</i>            | Optional: Path to the file <a href="#">Events_list.txt</a> (see chapter 7.1) containing the date of events to plot.                                                                                                                    |

#### Dependencies

[Python3](#)

[Check\\_images\\_functions.py](#)

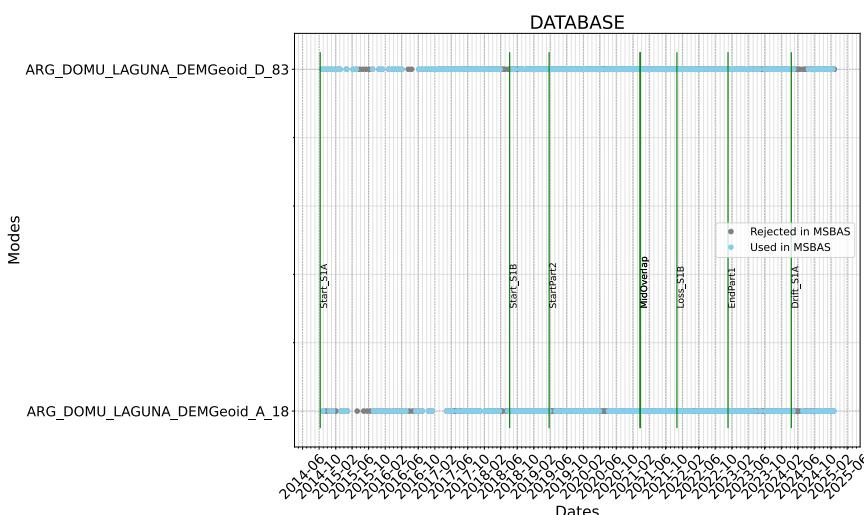


Figure 16: Example of [Plot\\_database\\_with\\_model\\_names.pdf](#) displaying the timeline with images used for MSBAS inversion (blue dots) and images skipped for MSBAS inversion (grey dots) of the processing of Domuyo area. Vertical green lines events provided from the [Events\\_list.txt](#).

### 7.1.e) Analyse\_AllPairslisting\_data.py

This script [Analyse\\_AllPairslisting\\_data.py](#) analyzes pairs of SAR images from the table `allPairsListing.txt` file computed by [Prepa\\_MSBAS.sh](#) (see paragraph 4).

It performs a date range selection (from `STARTDATE` to `ENDDATE`), gap analysis, and generates various statistics and plots to assist in the image pair selection for further processing. The script performs the following functions:

- Reads the `allPairsListing.txt` input file containing the details of all the possible pair combinations of images.
- Creates a plot (named `allPairsListing_i.pdf`, where *i* is the mode number) based on all the possible pairs of images in `allPairsListing.txt` (in black), those satisfying `STARTDATE` to `ENDDATE` time range (in Green), and those satisfying the maximum spatial (Bp) and temporal baseline (Bt) thresholds (in Blue).
- The same type of plot (named `restrictdatePairsListing_i.pdf`, where *i* is the mode number) with only those satisfying `STARTDATE` to `ENDDATE` time range (in Green), and those satisfying the maximum spatial (Bp) and temporal baseline (Bt) thresholds (in Blue) (See Figure 17).
- Generates statistical summaries (`logfile_i.pdf`; see example below) about the image pairs and their characteristics, e.g.:
  - o It checks for gaps larger than the specified threshold between consecutive image pairs (see rubric “*Searching for gaps over 12 days between consecutive images*” in `logfile_i.pdf`);
  - o When an image can’t be combined with other images because no pair would satisfy the `MaxBP` and/or `MaxBt` criteria, the script searches for other pair combinations satisfying a new `maxBp=NBRxBPmax` and `maxBt=NBRxBTmax` criteria (see rubric “*x images are discarded due to too restrictive baselines criteria.*” in `logfile_i.pdf`);
  - o List the images that are never used as a Primary or Secondary image (i.e. out-degree or in-degree = 0). (see rubric “*node IN degree =0*” and “*node OUT degree =0*” in `logfile_i.pdf`).

```
Analyse /Volumes/D3611/DIAG RESULTS/Domuyo/SM/allPairsListing_1.txt
BTmax = 450.0 days and BPmax = 20.0 meters
After 2022-05-01 BTmax = 450.0 days and BPmax = 80.0 meters

Graph of all pairs created
Number of nodes: 285
Number of edges: 40470

Graph satifying dates criteria created
Number of nodes: 285
Number of edges: 40470

Graph satifying both criteria created
Number of nodes: 282
Number of edges: 2567

node IN degree =0
[20141030, 20141217, 20150919, 20160703, 20170529, 20220509, 20220602, 20240603]
node OUT degree =0
[20150311, 20180418, 20180605, 20220202, 20211122, 20220415, 20220427, 20220310, 20241025, 20250117, 20250222, 20250210]

Statistics
Indegree : Mean = 9.102836879432624 ; Min = 0 ; Max = 24
Outdegree: Mean = 9.102836879432624 ; Min = 0 ; Max = 25
BT : Mean = 215 ; Min = 6 ;Max = 450
BP : Mean = 21.06046357615894 ; Min = 0.0 ; Max = 79.97

3 images are discarded due to too restrictive baselines criteria: [20141123, 20150709, 20150203]
Consider adding pairs satifying one of both criteria and less than 1.5 times the second to a table of additional pairs to avoid discarding thoses images
Such possible pairs are :

Image 20141123
Image 20150709
Image 20150203

Searching for the largest gap between consecutive images
Max BT between consecutive images is 120.0 between 2015-04-28 and 2015-08-26

Searching for gaps over 12 days between consecutive images
BT between consecutive images is 24.0 days between 2014-10-30 and 2014-11-23
BT between consecutive images is 24.0 days between 2014-11-23 and 2014-12-17
BT between consecutive images is 24.0 days between 2014-12-17 and 2015-01-10
BT between consecutive images is 24.0 days between 2015-01-10 and 2015-02-03
BT between consecutive images is 36.0 days between 2015-02-03 and 2015-03-11
BT between consecutive images is 24.0 days between 2015-03-11 and 2015-04-04
...
```

- A plot named `GapListing_i.pdf` displaying the gap length between 2 consecutive acquisitions (Figure 18).
- A plot named `NodesListing_i.pdf` of the node degree of each date in the pair selection, that is the sum of in and out degree (the sum of number of times an image is used as a Primary and Secondary image in an interferometric pair) (Figure 19).

**Usage:**

```
Analyse_AllPairslisting_data.py --input_file ..\MSBAS\Region\allPairsListing.txt --BPmax BPmax
--BTmax BTmax --startdate STARTDATE --enddate ENDDATE [--gap GAP] [--nbr NBR]
[--datechange DATECHANGE] [--BP2 BP2] [--BT2 BT2]
```

Where:

|                                                 |                                                                                                                                                                                                                                                                 |
|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>..MSBAS/Region/allPairsListing.txt</code> | Path to the input file containing the list of image pairs.                                                                                                                                                                                                      |
| <code>BPmax</code>                              | Maximum spatial baseline (Bp) in meters.                                                                                                                                                                                                                        |
| <code>BTmax</code>                              | Maximum temporal baseline (Bt) in days.                                                                                                                                                                                                                         |
| <code>STARTDATE</code>                          | Start date for analysis period (format: YYYY-MM-DD).                                                                                                                                                                                                            |
| <code>ENDDATE</code>                            | End date for analysis period (format: YYYY-MM-DD).                                                                                                                                                                                                              |
| <code>[GAP]</code>                              | Optional: Minimum gap (in days) between consecutive images to check for large gaps.                                                                                                                                                                             |
| <code>[NBR]</code>                              | Optional: When images can't be combined with other images because no pair satisfies the <code>MaxBp</code> and/or <code>MaxBt</code> criteria, searches for other pair satisfying a new <code>MaxBp=NBRxBPmax</code> and <code>MaxBt=NBRxBTmax</code> criteria. |
| <code>[DATECHANGE]</code>                       | Optional: Date after which different Bp and Bt values will be used (format: YYYY-MM-DD) (see chapter 4.3).                                                                                                                                                      |
| <code>[BP2]</code>                              | Optional: New baseline (Bp) value after the <code>DATECHANGE</code> .                                                                                                                                                                                           |
| <code>[BT2]</code>                              | Optional: New temporal baseline (Bt) value after the <code>DATECHANGE</code> .                                                                                                                                                                                  |

**Dependencies :**

`python3` and modules `pandas`, `matplotlib`, `networkx`, `statistics`, `numpy` and `argparse`

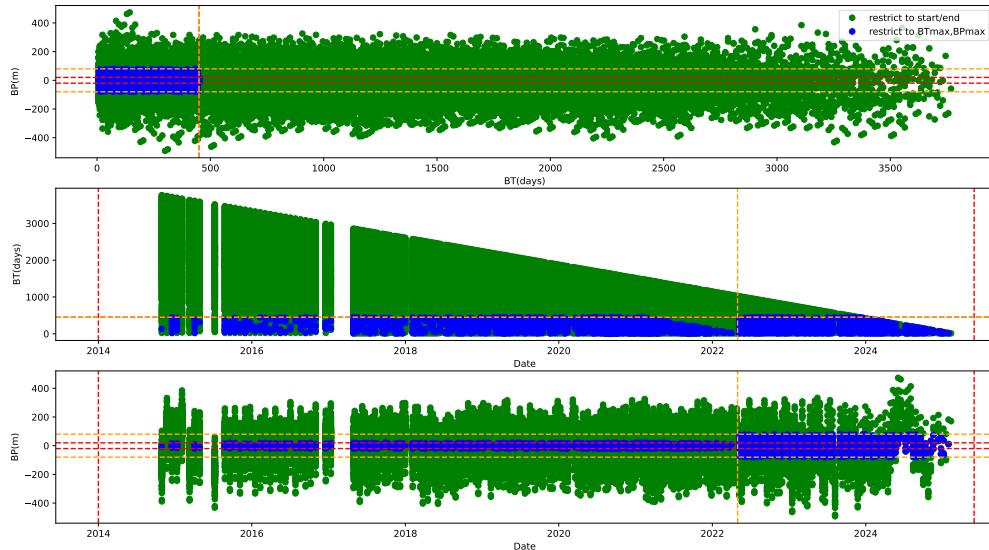


Figure 17: example of `restrictdatePairsListing_i.pdf` plot generated by `Analyse_AllPairslisting_data.py`. All possible pairs are in Green. Selected pairs based on maximum Bp and Bt criteria are in Bleu. Red lines are BTmax, BPmax, STARTDATE and ENDDATE. Orange lines are Bp and Bt criteria (i.e. Bt2 and Bp2) after DATECHANGE.

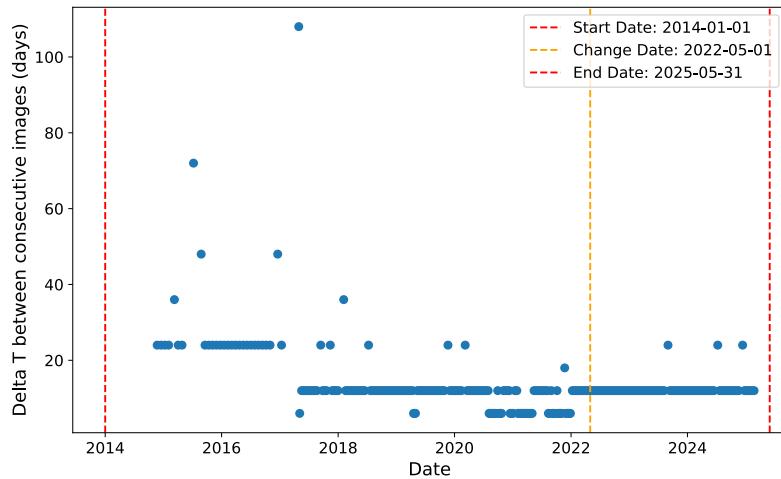


Figure 18: Example of `GapListing_i.pdf` plot generated by `Analyse_AllPairslisting_data.py` displaying the gap length between 2 consecutive acquisitions

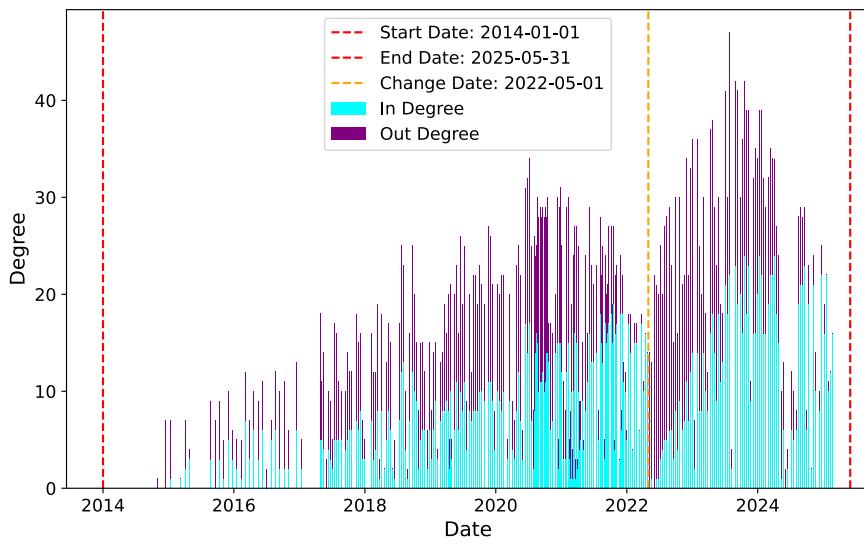


Figure 19: Example of `NodesListing_i.pdf` plot generated by `Analyse_AllPairslisting_data.py`. Representation of the node degree of each date in the pair selection, that is the sum of in and out degree, i.e. the sum of number of times an image is used as a Primary and Secondary image in an interferometric pair.

### 7.1.f) Analyse\_BaselineCoh\_data.py

This script `Analyse_BaselineCoh_data.py` analyzes and displays statistical information from a given tab-delimited text file named `BaselineCohTable_kml.txt` produced with `Baseline_Coh_Table.sh` (see chapter 9.9) and a provided `kml` file.

The script calculates statistical metrics, identifies outliers, and generates various plots showing how the coherence varies as a function of Bt, Bp and time as follow:

- Reads and processes coherence data from `BaselineCohTable_kml.txt` produced with `Baseline_Coh_Table.sh`.
- Computes statistical metrics: mean, median, standard deviation, quartiles, kurtosis, and outliers.
- Filters coherence values based on the specified threshold.
- Generates and saves plots, including scatter plots, box plots, and histograms:
  - `Baseline_Coh_Table_kml_i.boxplot.pdf` (where `kml` is the name of the kml file without its extension and `i` is the mode number): Boxplot visualization of coherence distribution (see Figure 20, left).
  - `Baseline_Coh_Table_kml_i_stats.pdf`: Histogram and statistical analysis of coherence values (see Figure 20, right).
  - `Baseline_Coh_Table_kml_i.pdf`: Various scatter plots showing relationships between coherence and other parameters (see Figure 21).
- Store the statistics and identifies image pairs with outlier coherence values (i.e. < 1.5 InterQuartile) in `logfile_kml_i.txt`

```
Distro V2.0 AMSTer script utilities
Delphine Smittarello (c)2016-2019, Last modified on Jan 30, 2025

Analyse /Volumes/D3611/DIAG_RESULTS/Domuyo/COH/Baseline_Coh_Table_Laguna_Maule_1.kml.txt
Coherence Threshold = 0.235
3824 pairs available for statistics
1800, pairs with coherence above 0.235 (47.07%)
2024, pairs with coherence below 0.235 (52.93%)
Mean: 0.275916390167364
Median: 0.2324305
Standard deviation: 0.09395502368442167
Q1 (1st quartile): 0.221934
Q3 (3rd quartile): 0.29251575
IQR: 0.07058175000000003
IQR Lower Bound: 0.11606137499999995
IQR upper Bound: 0.3983883750000001
Outliers number: 0
```

#### Usage:

`Analyse_BaselineCoh_data.py BaselineCohTable_kml.txt COH_TH`

Where:

`BaselineCohTable_kml.txt` Is a file containing coherence data (produced by the script `Baseline_Coh_Table.sh`, as a tab delimited text file) and where `kml` is the name of a file delimiting the area of interest on which the statistics are performed.

`COH_TH` Is a numerical threshold to filter coherence values.

#### Dependencies:

`Python3` with modules `numpy`, `pandas`, `matplotlib` and `scipy`

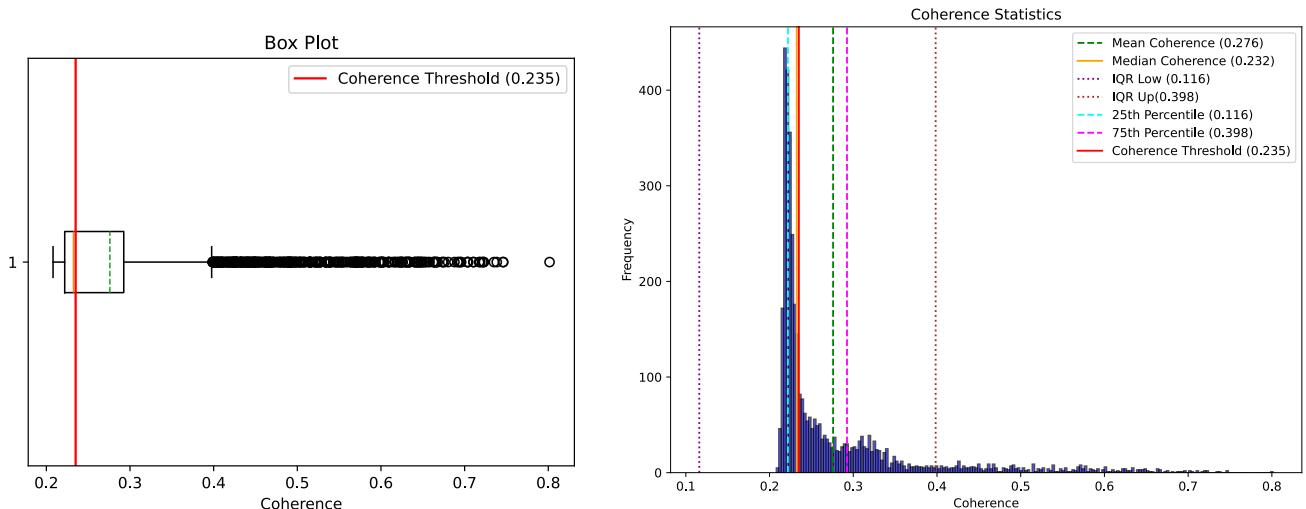


Figure 20: Example of [Baseline\\_Coh\\_Table\\_kml\\_i.boxplot.pdf](#) (left) showing the boxplot visualization of coherence distribution: Box = Q1 to Q3; Bars = InterQuartile, circles = outliers ; green dotted line = mean ; orange line = median ; red = coherence threshold. Example of [Baseline\\_Coh\\_Table\\_kml\\_i.stats.pdf](#) (right) showing the histogram and statistical analysis of coherence values.

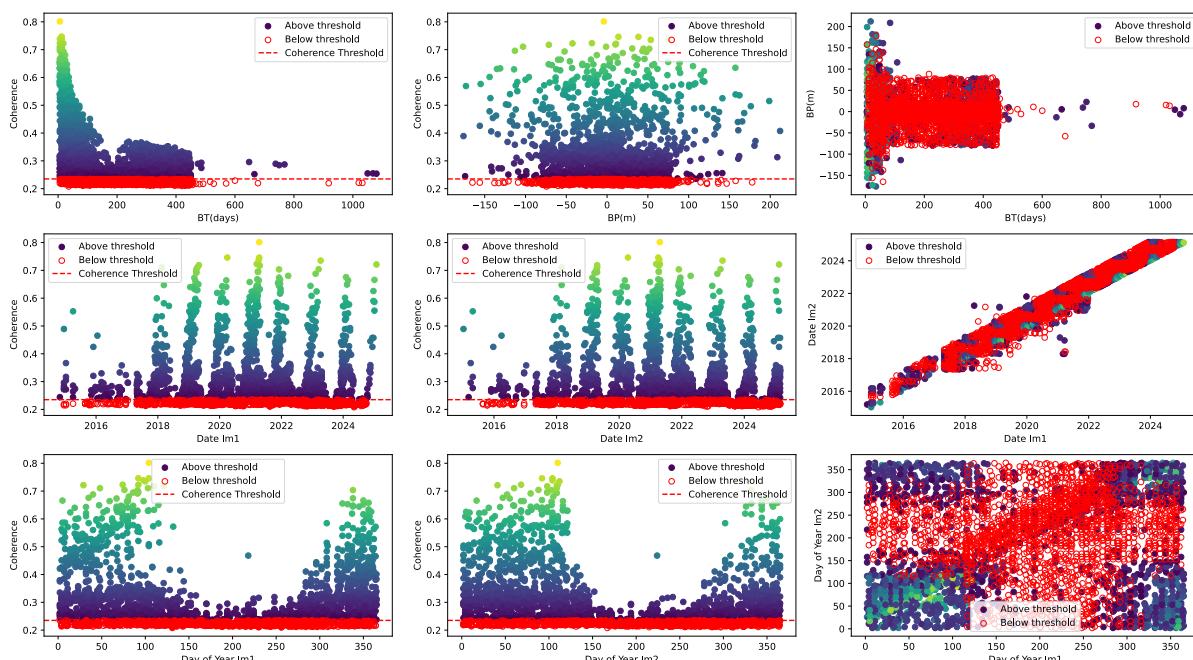


Figure 21: Example of [Baseline\\_Coh\\_Table\\_kml\\_i.pdf](#): Various scatter plots showing relationships between coherence (Y-axis) and several other parameters (X-axis).

### 7.1.g) Import\_RestrictedPairSelectionFiles\_as\_DF.py

This script [Import\\_RestrictedPairSelectionFiles\\_as\\_DF.py](#) scans a specified directory for all `restrictedPairSelection_YourCriteria.txt` files (i.e. `restrictedPairSelection_*.txt` from `.../MSBAS/Region/` directory), loads them as a `pandas "DataFrame"`, and saves the combined data as a python “pickle” file, which is an optimized object structure to ease its further use. To achieve this, the script:

- Searches for files matching the pattern `restrictedPairSelection_*.txt`.
- Extracts relevant data from each file and loads it into a `DataFrame`.

- Assigns a mode number *i* based on the filename (e.g., `DefoModei`).
- Converts date columns (Primary date, Secondary date) into datetime format.
- Saves the processed data as a *pickle* file for efficient storage and retrieval.

The output pickle file containing the combined *DataFrame* of all loaded pairs is named `pairs.pkl`.

**Usage:**

`Import_RestrictedPairSelectionFiles_as_DF.py INPUT_DIR OUTPUT_PKL_FILE`

Where:

|                              |                                                                                              |
|------------------------------|----------------------------------------------------------------------------------------------|
| <code>INPUT_DIR</code>       | The full path to the directory containing <code>restrictedPairSelection_* .txt</code> files. |
| <code>OUTPUT_PKL_FILE</code> | The full path where the combined <i>DataFrame</i> will be saved as a <i>pickle</i> file.     |

### 7.1.h) *Compute\_Graphs\_From\_dfpkl.py*

This script `Compute_Graphs_From_dfpkl.py` loads a *pickle* file containing a *DataFrame* of all pairs used for a given MSBAS processing. It then converts the data into directed graphs (*DiGraph*) for each mode based on Primary date and Secondary date using `python3 NetworkX` module. It then saves the graph structures as a *pickle* file for further processing or visualization. That *pickle* file, named `graphs.pkl`, contains a dictionary of `NetworkX` graphs (one per mode).

**Usage:**

`Compute_Graphs_From_dfpkl.py Input_pickle_file Output_pickle_file`

Where:

|                                 |                                                                            |
|---------------------------------|----------------------------------------------------------------------------|
| <code>Input_pickle_file</code>  | Full path to the <i>pickle</i> file containing the pair <i>DataFrame</i> . |
| <code>Output_pickle_file</code> | Full path where the graph objects will be saved as a <i>pickle</i> file.   |

**Dependencies:**

`Python3` and `pickle` and `network` modules

### 7.1.i) *Graph2StatsImagesDF.py*

This script `Graph2StatsImagesDF.py` loads a *pickle* file containing a dictionary of graphs (one per mode). It then computes various **node-level statistics** for all nodes in the graphs, that is :

- Degree (total, in-degree, out-degree, net-degree)
- Degree centrality (overall, in-degree, out-degree)
- Closeness centrality
- Betweenness centrality
- (*Eigenvector*, *Katz*, and *PageRank* centralities can be enabled if needed.)

It then saves results in a *pickle* file named `images.pkl` containing a *DataFrame* with node statistics for each image for all modes.

**Usage:**

`Graph2StatsImagesDF.py Input_pickle_file Output_pickle_file`

Where:

|                                 |                                                                                     |
|---------------------------------|-------------------------------------------------------------------------------------|
| <code>Input_pickle_file</code>  | Full path to the <i>pickle</i> file containing the graph dictionary.                |
| <code>Output_pickle_file</code> | Full path where the computed node statistics will be saved as a <i>pickle</i> file. |

**Dependencies:**

`Python3` and modules `pickle`, `networkx` and `pandas`

### 7.1.j) ***Extract\_Stats\_All\_Modes.py***

This script ***Extract\_Stats\_All\_Modes.py*** loads a *pickle* file containing a *DataFrame* of images grouped by mode. It then computes statistics on image acquisition dates, including time spans and intervals between consecutive images, that is :

- Oldest and newest image dates for each mode.
- Average time interval between consecutive images.
- Minimum and maximum time gaps between consecutive images.

Then it saves the results in a *pickle* file named ***result\_stats.pkl*** that contains a *DataFrame* of computed date statistics for each mode.

#### Usage:

***Extract\_Stats\_All\_Modes.py Input\_pickle\_file Output\_pickle\_file***

Where:

- Input\_pickle\_file* Full path to the *pickle* file containing the *DataFrame* with image dates.  
*Output\_pickle\_file* Full path where the computed statistics will be saved as a *pickle* file.

#### Dependencies:

**Python3** with modules ***pickle*** and ***pandas***

### 7.1.k) ***CompareBS\_MSBAS.sh***

This script ***CompareBS\_MSBAS.sh*** compares two baseline tables used for different MSBAS processings (e.g. ***restrictedPairSelection\_DefolInterpol2Detrendi.txt***). It finds common and unique pairs between the two tables and generates corresponding baseline plots. For this, it :

- Filters and extracts pairs from both tables.
- Computes min/max date and baseline values and store them in ***range\_date.txt*** (Min/Max dates for both tables) and ***range\_bs.txt*** (Min/Max baselines for both tables) text files.
- Generates multiple plots using ***BSplot.sh***:
  - Individual plots for Table 1 and Table 2: named ***BPLOT\_Name1.png*** and ***BPLOT\_Name2.png*** (see Figure 22)
  - Plot of common pairs between both tables: ***BPLOT\_bothName1andName2.png*** (see Figure 23)
  - Plot of unique pairs in each table: ***BPLOT\_Name1only.png*** and ***BPLOT\_Name2only.png*** (see Figure 24)
- Summarizes the number of pairs found at the Terminal (not logged in file).

#### Usage:

***Compare\_BSPlot.sh FullpathTableFile1 Name1 FullpathTableFile2 Name2 AllPairsListing OutputDir***

Where:

- FullpathTableFile1* Path to the first baseline table file  
(e.g. .../MSBAS/Region/restrictedPairSelection\_DefolInterpol2Detrendi.txt).
- Name1* Label to describe Table 1 in the plots (and name ***BPLOT\_Name1.png***).
- FullpathTableFile2* Path to the second baseline table file.
- Name2* Label to describe Table 2 in the plots (and name ***BPLOT\_Name2.png***).
- AllPairsListing* Path to a file listing all pairs (used for filtering).  
(e.g. .../MSBAS/seti/allPairsListing.txt).
- OutputDir* Path to a directory where results and plots will be saved.

#### Dependencies:

- ***gawk, gsed, bc***
- ***Find\_minmaxforBSplots.py***
- ***Find\_minmaxBSforBSplots.py***
- ***BSplot.sh***
- ***List\_simil\_in\_table.sh***

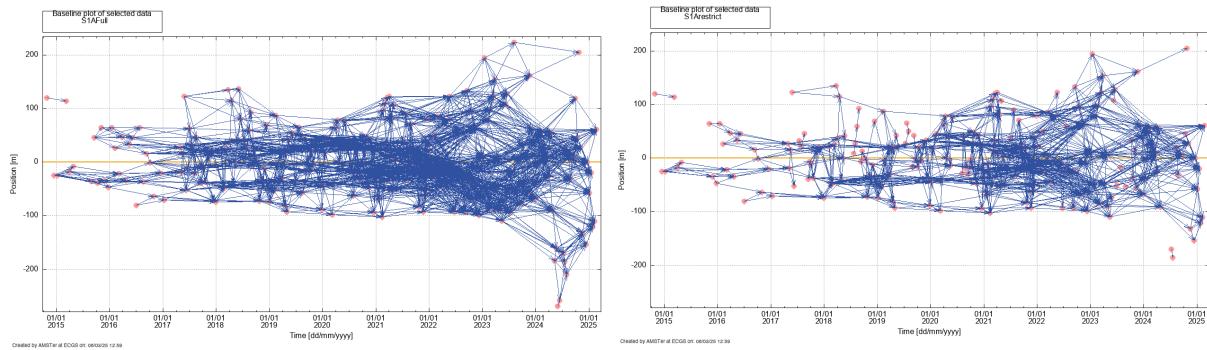


Figure 22: Example of [BPLOT\\_Name1.png](#) (left) and [BPLOT\\_Name2.png](#) (right), that is the Baseline plot for Table 1 and 2 respectively.

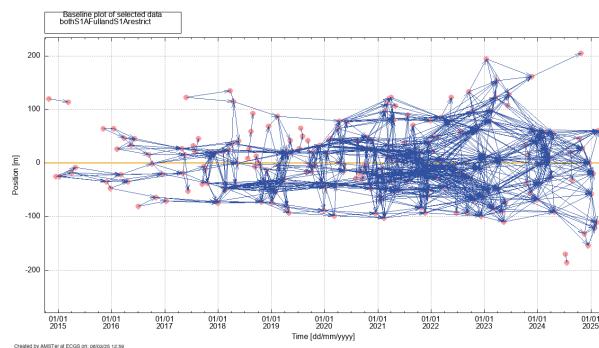


Figure 23: Example of [BPLOT\\_bothName1andName2.png](#), that is the Baseline plot of pairs in common to both Tables.

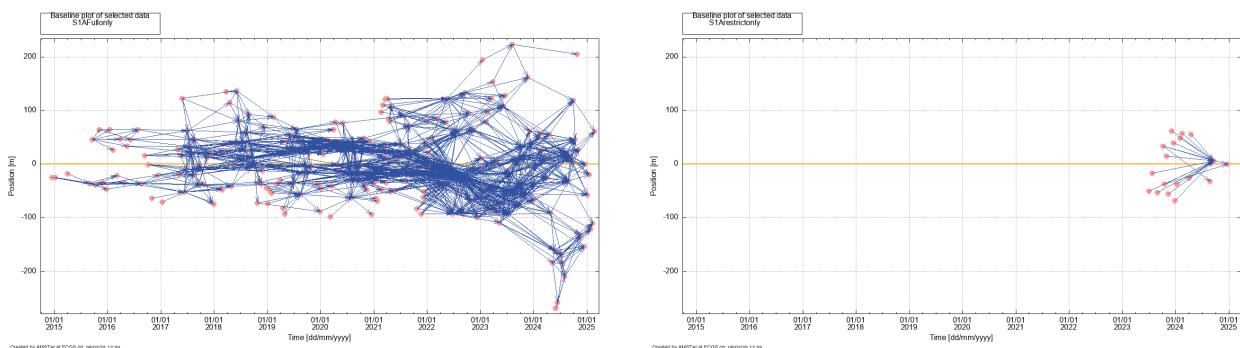


Figure 24: Example of : [BPLOT\\_Name1only.png](#) (left) and [BPLOT\\_Name2only.png](#) (right), that is the Baseline plot of pairs only in Table 1 and 2 respectively.

When comparing a processing with and without coherence threshold, right plot must be empty if no additional pairs are taken into account when performing the coherence threshold compared to the Full processing.

### 7.1.I) Compare\_MSBAS\_Maps\_Interpolated.py

This script `Compare_MSBAS_Maps_Interpolated.py` compares the EW (East-West) and UD (Vertical) (and NS if available) velocity maps from two MSBAS processing results, even if their resolutions and spatial extents are not the same. It aligns the images, crops the common intersection area, and visualizes the differences as maps. To perform this, it:

- Reads MSBAS files:
  - Loads the `ENVI` binary files containing the velocity maps `MSBAS_LINEAR_RATE_COMP.bin` where `COMP` stands for `EW` and `UD` (and `NS` if available).
  - Extracts their metadata from their associated `MSBAS_LINEAR_RATE_COMP.bin.hdr` files (resolution, coordinates).
- Aligns the Image:
  - Crops the velocity maps to retain only the common intersection area.
  - Applies interpolation if necessary to harmonize resolutions.
- Computes the difference between the two datasets for EW and UD (and NS if available) components.
- Visualizes and saves the results:
  - Generates six maps (or nine if NS component is available) in one file per `COMP` (that is EW, UD and NS if available) named `mapsCOMP.png` stored in `RESULTDIR` (see Figure 25 and Figure 26)
  - Uses a symmetric (i.e.  $\text{Max} = -\text{Min}$ ) color scale, centered on 0 displayed in white, to enhance the comparison.

#### Usage

`Compare_MSBAS_Maps_Interpolated.py RESULTDIR MSBAS_DIR_1 LABEL_1 MSBAS_DIR_2 LABEL_2`

Where:

|                          |                                                                                                                                             |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| <code>RESULTDIR</code>   | Path to the directory where the comparison results (map images) will be stored.                                                             |
| <code>MSBAS_DIR_1</code> | Path to the directory containing the first MSBAS processing results.                                                                        |
| <code>LABEL_1</code>     | Identifier associated with the first MSBAS results (that identifier is the <code>COMMENT</code> used at MSBAS processing, see chapter 6.2). |
| <code>MSBAS_DIR_2</code> | Path to the directory containing the second MSBAS processing results.                                                                       |
| <code>LABEL_2</code>     | Identifier associated with the second MSBAS results.                                                                                        |

#### Dependencies:

`Python3` with modules: `numpy`, `matplotlib`, `scipy`.

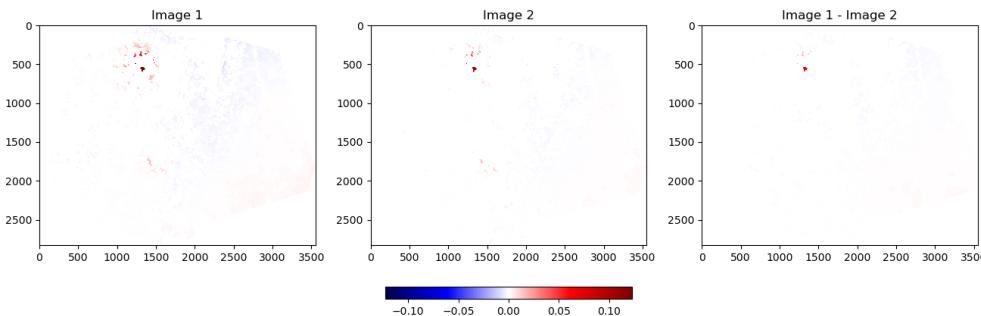


Image 1 = /Volumes/hp-D3602-Data\_RAID5/MSBAS/\_Domuyo\_S1\_Auto\_80m\_450days/zz\_UD\_Auto\_3\_0.04\_Domuyo  
 Image 2 = /Volumes/hp-D3602-Data\_RAID5/MSBAS/\_Domuyo\_S1\_Auto\_80m\_450days/zz\_UD\_Auto\_3\_0.04\_Domuyo\_NoCohThresh

Figure 25: Example of `mapsUD.png` showing the comparison between two vertical velocity maps obtained from two MSBAS inversions performed on the Domuyo area with and without coherence threshold (image 1 and image 2), and their difference (image1 – image 2)

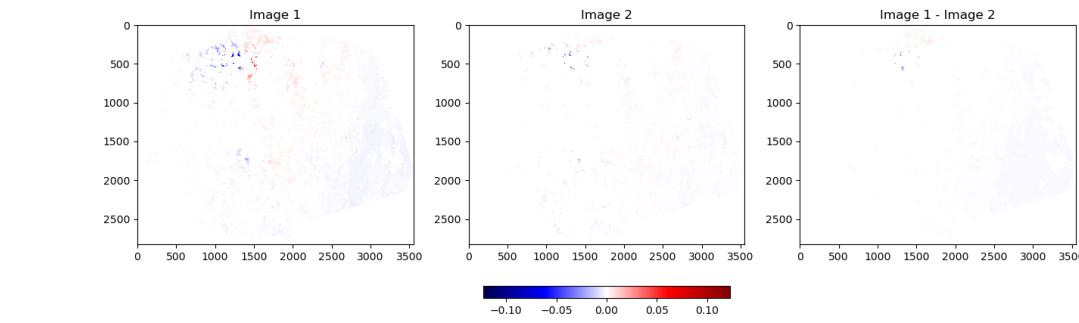


Figure 26: Example of [mapsEW.png](#) showing the comparison between two vertical velocity maps obtained from two MSBAS inversions performed on the Domuyo area with and without coherence threshold (image 1 and image 2), and their difference (image1 – image 2).

### 7.1.m) CompareTS\_EWUD.sh

This script **CompareTS\_EWUD.sh** executes several [Plot\\_compareTS.py](#) (see chapter 7.1.n) to compare double difference time series of points obtained by different MSBAS processings. It performs time-series comparisons for each pair of points specified in a [POINTS\\_LIST](#) input file (e.g. `$(PATH_1650)/Data_Points/List_DoubleDiff_EW_UD_YourDescription.txt`).

For this, it:

- Creates the Results Directory [RESULTS\\_DIR](#) where it will perform the analysis.
  - For each pair of point listed in the file [POINTS\\_LIST](#) (providing that the same pair of points were present in both MSBAS inversions), it executes the script [Plot\\_compareTS.py](#) (see chapter 7.1.n) with the specified parameters, which plots the EW and UD (and NS if available) time series obtained from both MSBAS inversions (see Figure 27).
- Each figure of time series comparison is saved as [DOUBLEDIFFPOINTS\\_timeLines\\_.png](#), where [DOUBLEDIFFPOINTS](#) is the text string in 5<sup>th</sup> column in [POINTS\\_LIST](#) that describes the pair of points.
- The file [logfile.txt](#) contains only the list of command lines launching each [Plot\\_compareTS.py](#).

### Usage

**CompareTS\_EWUD.sh** [RESULTS\\_DIR](#) [MSBASDIRFULLPATHlist](#) [MSBASIdentifierList](#) [POINTS\\_LIST](#) [[EVENTS](#)]

Where:

|                                      |                                                                                                                                                                                         |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">RESULTS_DIR</a>          | Path to a directory where the results will be stored.                                                                                                                                   |
| <a href="#">MSBASDIRFULLPATHlist</a> | List of full paths to each directory containing MSBAS results to be compared, e.g. ...MSBAS/Region/.                                                                                    |
|                                      | <i>The list of paths must be double quoted and separated by commas.</i>                                                                                                                 |
| <a href="#">MSBASIdentifierList</a>  | List of identifiers used for naming MSBAS processings (that is the <a href="#">COMMENT</a> used at each MSBAS processings), in the same order as <a href="#">MSBASDIRFULLPATHlist</a> . |
|                                      | <i>The list of identifiers must be double quoted and separated by commas.</i>                                                                                                           |
| <a href="#">POINTS_LIST</a>          | Path to the file containing the list of pairs of points to compare (e.g. <code>\$(PATH_1650)/Data_Points/List_DoubleDiff_EW_UD_YourDescription.txt</code> ).                            |
| [ <a href="#">EVENTS</a> ]           | Optional: Full path to <a href="#">Events_list.txt</a> file                                                                                                                             |

### Dependencies

[Plot\\_compareTS.py](#) (see chapter 7.1.n)

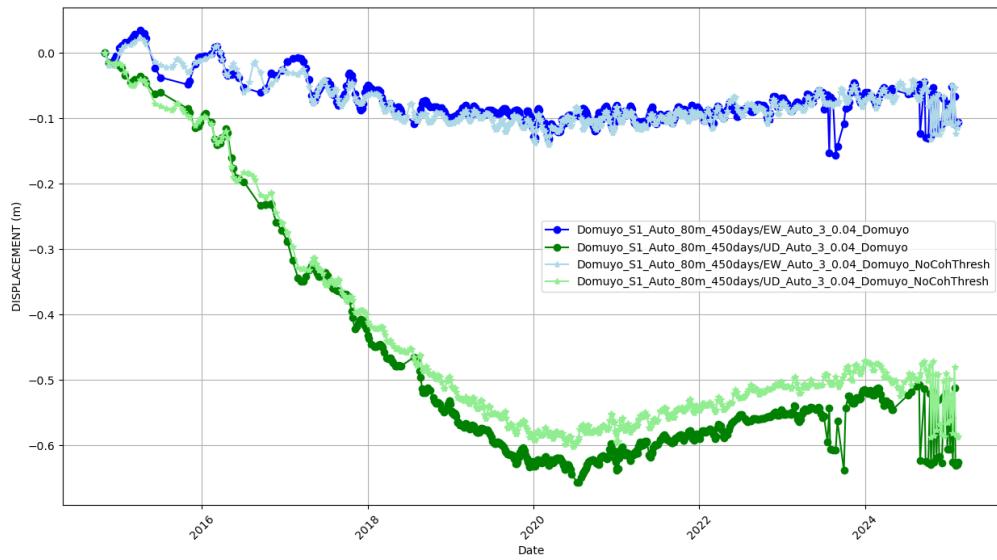


Figure 27: Example of comparison of differential UD (Green) and EW (Blue) ground deformation time series obtained from two MSBAS inversion performed with (dark color), and without (light color), coherence threshold. The coordinates of the pair of pixels used for the double differences are stored in two `List_DoubleDiff_EW_UD_YourDescription.txt` (one for each MSBAS inversion). These coordinates may differ if they result e.g. from processings performed with different ground resolution. That is why the script identifies the pair of pixels not on their coordinates, but based on the description string that is listed in the `List_DoubleDiff_EW_UD_YourDescription.txt` files. In the example above, the pixels were associated to the string `Domuyo_C_N` in the two `List_DoubleDiff_EW_UD_YourDescription.txt` files and the plot is hence named `Domuyo_C_N_timeLines.png`.

### 7.1.n) `Plot_compareTS.py`

This script `Plot_compareTS.py` aims at comparing double difference times series obtained from different MSBAS inversions, by creating a plot of all the components of these times series on the same graph.

Because the two MSBAS inversions may have been performed with **different ground resolution or footprint**, **one cannot identify the pair of pixels to be compared by their coordinates** (number of column and line in image). To circumvent that issue, we **rather use a string of text (`DOUBLEDIFFPOINTS`)** used in all MSBAS inversions to describe these points.

That string of text `DOUBLEDIFFPOINTS` is used to name the plots and text files created by the script `PlotTS_all_comp.sh` during the **cron step3** (see chapter 8.4).

Indeed, `PlotTS_all_comp.sh` makes among others (see chapter 6.5.b):

- 3 plots with respectively the time series of pixel 1, the time series of pixel 2 and the time series of the double difference (pixel 1 - pixel 2), and
- a text files named `timeLine_COMP_X1_Y1_X2_Y2_LABEL.txt` with the values used for these plots,

where `X1`, `X2`, `Y1` and `Y2` are X and Y coordinates of the pixel 1 and pixel 2, `COMP` is the component (EW or UD, or NS if available) and `LABEL` is the description of the MSBAS inversion parameters.

During the **cron step3** (see chapter 8.4), the list of pairs of pixels to be plotted is stored in a 5 columns text file in the form of `X1 Y1 X2 Y2 DOUBLEDIFFPOINTS` (where `X1`, `X2`, `Y1` and `Y2` are X and Y coordinates of the point 1 and point 2, and `DOUBLEDIFFPOINTS` is string of text allowing to identify the two points). That file is usually named `$(PATH_1650)/Data_Points/List_DoubleDiff_EW_UD_YourDescription.txt` (see also chapter 9.31), where `YourDescription` usually refers to the region on which the MSBAS inversion is performed.

At the end of **cron step3**, the results are moved in an appropriate directory:

*MSBASDIR/zz\_UD\_EW[\_NS]\_TSLABEL/\_Time\_Series/*

and renamed as

*DOUBLEDIFFPOINTS\_timeLines\_COMP\_X1\_Y1\_X2\_Y2\_LABEL.txt*

Hence, *Plot\_compareTS.py* will compare time series of pairs of pixels identified by the string *DOUBLEDIFFPOINTS* thanks to the information to be found in the files *DOUBLEDIFFPOINTS\_timeLines\_\*.txt* in each of the MSBAS subdirectory.

The comparison plot is saved in *DOUBLEDIFFPOINTS\_timeLines\_.png*

## Usage

*Plot\_compare\_TS.py MSBASDIRFULLPATHlist MSBASIdentifierList DOUBLEDIFFPOINTS [-events EVENTS]*

Where:

*MSBASDIRFULLPATHlist* List of full paths to each directory containing MSBAS results to be compared, e.g. ...*MSBAS/Region/*.

*The list of paths must be double quoted and separated by commas.*

*MSBASIdentifierList* List of identifiers used for naming MSBAS processings (that is the *COMMENT* used at each MSBAS processings), in the same order as *MSBASDIRFULLPATHlist*.

*The list of identifiers must be double quoted and separated by commas.*

*DOUBLEDIFFPOINTS [EVENTS]* String of text to identify the pair of points to plot  
Optional: Full path to *Events\_list.txt* file

## Dependencies

*Python3* with modules *matplotlib, glob, numpy*

## 7.2. Defo / DEM Correlation

The script `Launch_Defo_Dem_RegLin_Compute_and_Apply_Correction_YourRegion_YourSat.sh` (e.g. `Launch_Defo_Dem_RegLin_Compute_and_Apply_Correction_Guadeloupe_TSX.sh`) allows to test the possible correlation between deformation maps and DEM.

It must be edited and named according to your target. It is provided here as an example tuned for the specificities of the processing of TSX images over the Guadeloupe island. However, it should be straightforward to adapt it to your needs.

For each map in `.../SAR_MASSPROCESS/YourRegion/Geocoded/DefoMode` this script computes the linear regression between the deformation and the topography. The defo/dem model is then subtracted from the deformation map and residuals are stored in a directory named

`.../SAR_MASSPROCESS/YourRegion/Geocoded/DefoMode_Cor_Dem`.

For each `i` mode, statistic of the correlation with Bt, Bp and acquisition dates are also computed.

### Usage

`Launch_Defo_Dem_RegLin_Compute_and_Apply_Correction_YourRegion_YourSat.sh`

Where the following hardcoded parameters must be adapted:

`DEM` Full Path to the DEM, (beware, the DEM grid must be exactly the same as deformation).

`DEFODIR` Full path to the directory containing the geocoded deformation maps in ENVI format, i.e.  
`.../SAR_MASSPROCESS/.../Geocoded/DefolInterpolx2Detrend`

`PROCESSDIR` Full Path do the directory where correlation results will be stored

### Dependencies:

The script needs and call the following other scripts, which are explained here after:

- `RegLin_DEFo_all_Maps_In_Geocoded.sh`
- `RegLin_DEFo.py`
- `Load_and_Plot_Output_DEFoDEM.py`
- `Compute_and_Subtract_Defo_Dem_All_In_Dir.sh`
- `Compute_and_Subtract_Defo_Dem.py`

### 7.2.a) `RegLin_DEFo.py`

This script `RegLin_DEFo.py` computes the linear regression between a DEM and a DEFO map and save the plot named by the same name as the deformation file ending with `.png` (`DEFO.png`) in the current directory (see Figure 28). DEM and DEFO maps must have the same size. It also logs incrementally in `output.txt` file the deformation file name, the slope, intercept and r2 values of the linear regression.

### Usage

`RegLin_DEFo.py DEM DEFO`

Where:

`DEM` Full path to DEM file

`DEFO` Full path to deformation file

### Dependencies

`Python3` with modules `matplotlib` and `numpy`

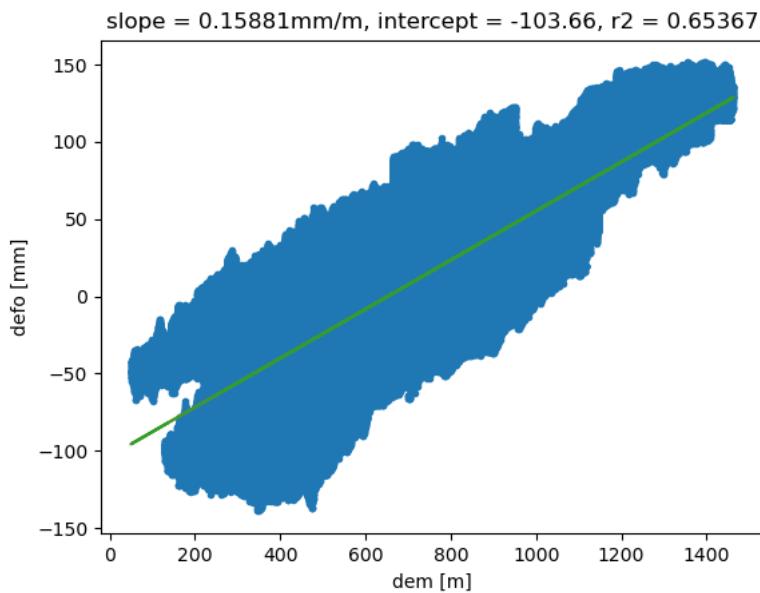


Figure 28: Example of linear regression between the DEM and a deformation map computed with [RegLin\\_DEM\\_Defo.py](#). Green line represents the best linear fit.

### 7.2.b) [\*\*RegLin\\_DEM\\_Defo\\_all\\_Maps\\_In\\_Geocoded.sh\*\*](#)

This script [\*\*RegLin\\_DEM\\_Defo\\_all\\_Maps\\_In\\_Geocoded.sh\*\*](#) calls and run the script [\*\*RegLin\\_DEM\\_Defo.py\*\*](#) to computes a linear regression between a **DEM** and each **DEFO** map from a provided directory (**DEFODIR**). It also creates an **output.txt** file that will be incrementally filled with the deformation file name, the slope, intercept and r2 values of each linear regression.

#### Usage

**RegLin\_DEM\_Defo\_all\_Maps\_In\_Geocoded.sh DEM DEFODIR**

Where:

|                |                                                                                                                             |
|----------------|-----------------------------------------------------------------------------------------------------------------------------|
| <b>DEM</b>     | Full path to DEM file                                                                                                       |
| <b>DEFODIR</b> | Full path to the directory where deformation files are stored<br>(i.e. <a href="#">../Geocoded/DefolInterpolx2Detrend</a> ) |

#### Dependencies

[RegLin\\_DEM\\_Defo.py](#)

### 7.2.c) Load\_and\_Plot\_Output\_DEMDefo.py

This script [Load\\_and\\_Plot\\_Output\\_DEMDefo.py](#) loads and plots stats about the linear regression between the DEM and all deformation files in a [.../SAR\\_MASSPROCESS/YourRegion/Geocoded/DefoMode](#) directory. It reads the [output.txt](#) file created with [RegLin\\_DEM\\_Defo\\_all\\_Maps\\_In\\_Geocoded.sh](#). It creates 9 plots with r2, slope and intercept vs Bt, Bp and acquisition dates (see Figure 29). It also converts the file [output.txt](#) in [resultats.csv](#).

#### Usage

[Load\\_and\\_Plot\\_Output\\_DEMDefo.py INPUTFILE](#)

Where:

[INPUTFILE](#)

Full path to the [output.txt](#) file containing the data to load and plot, created with [RegLin\\_DEM\\_Defo\\_all\\_Maps\\_In\\_Geocoded.sh](#).

#### Dependencies

[Python3](#) with modules [matplotlib](#) and [numpy](#)

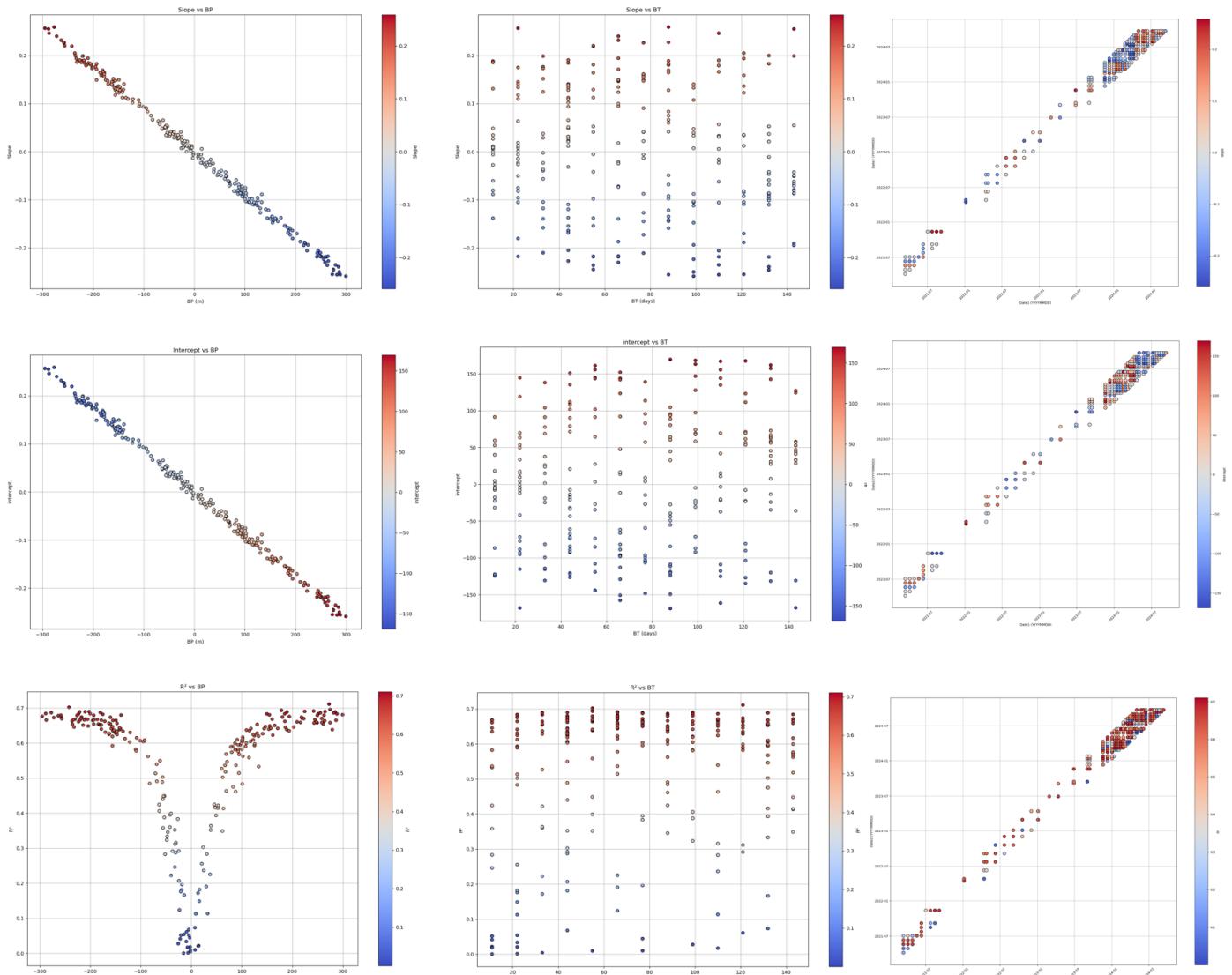


Figure 29: Example of slope (first line), intercept (second line) and r2 (third line) vs Bp (first column), Bt (second column) and acquisition date (third column)

### 7.2.d) ***Compute\_and\_Subtract\_Defo\_Dem.py***

This script [\*Compute\\_and\\_Subtract\\_Defo\\_Dem.py\*](#) computes the residual of the linear regression computed by [\*RegLin\\_DEM\\_Defo.py\*](#) between a deformation map in [\*../SAR\\_MASSPROCESS/YourRegion/Geocoded/DefoMode\*](#).

and the DEM. It stores the corrected deformation map (with its [.hdr](#) file) in a newly created directory named [\*../SAR\\_MASSPROCESS/YourRegion/Geocoded/DefoMode\\_Cor\\_Dem\*](#).

It also creates a [.png](#) figure with the DEM, the deformation map, the model and the residuals (see Figure 30) in [\*../SAR\\_MASSPROCESS/YourRegion/GeocodedRasters/DefoMode\\_Cor\\_Dem\*](#).

#### Usage

*Compute\_and\_Subtract\_Defo\_Dem.py DEM DEFOFILE INPUTFILE*

Where:

|                  |                                                                                                                     |
|------------------|---------------------------------------------------------------------------------------------------------------------|
| <i>DEM</i>       | Full path to DEM file.                                                                                              |
| <i>DEFOFILE</i>  | Full path to a deformation file (e.g. in <a href="#"><i>../Geocoded/DefoInterpolx2Detrend</i></a> ).                |
| <i>INPUTFILE</i> | Full path to <a href="#">resultats.csv</a> file created by <a href="#"><i>Load_and_Plot_Output_DEMDefo.py</i></a> . |

#### Dependencies

[Python3](#) with modules [matplotlib](#), [pandas](#), [rasterio](#) and [numpy](#)

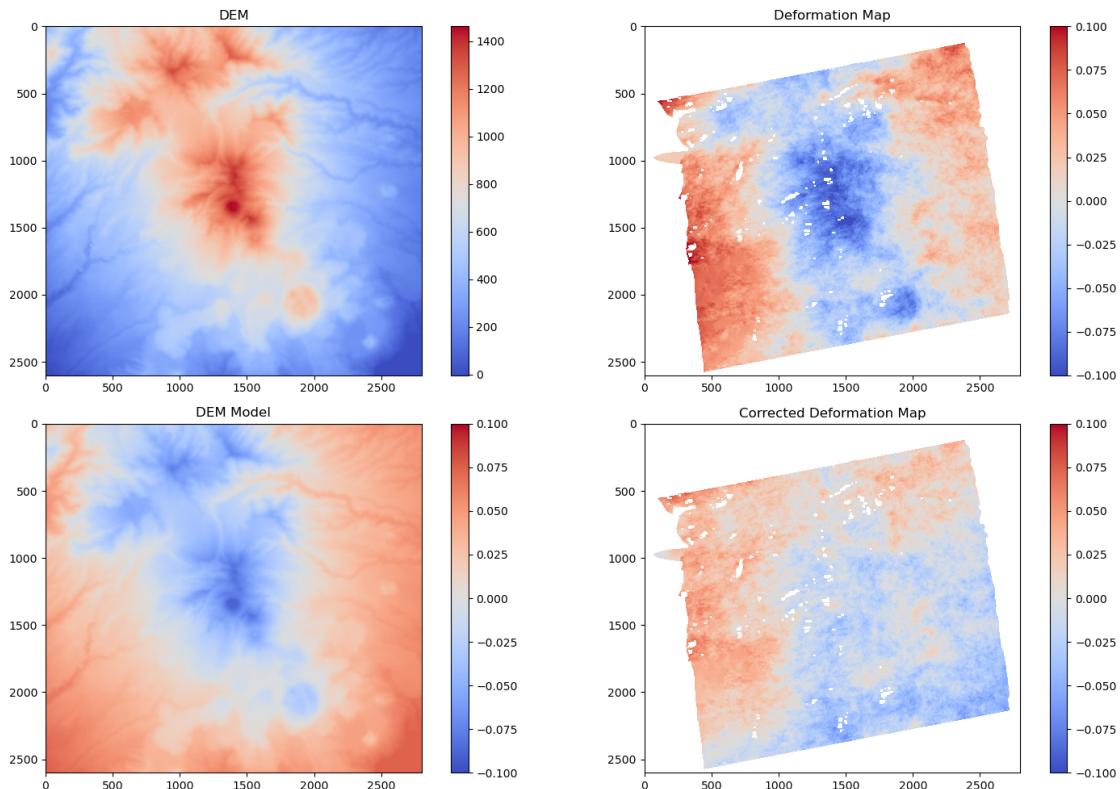


Figure 30: Example of DEM (Upper left), Deformation map (Upper right), modeled DEM (lower left) and residual (lower right).

### 7.2.e) ***Compute\_and\_Subtract\_Defo\_Dem\_All\_In\_Dir.sh***

This script ***Compute\_and\_Subtract\_Defo\_Dem\_All\_In\_Dir.sh*** calls for each deformation map in the input directory, the script [\*\*\*Compute\\_and\\_Subtract\\_Defo\\_Dem.py\*\*\*](#).

#### Usage

***Compute\_and\_Subtract\_Defo\_Dem\_All\_In\_Dir.sh DEM DEFODIR INPUTFILE***

Where:

|                         |                                                                                                                             |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| <b><i>DEM</i></b>       | Full path to the DEM                                                                                                        |
| <b><i>DEFODIR</i></b>   | Full path to the directory where all deformation files are stored (i.e.<br><code>../Geocoded/DefolInterpol2Detrend</code> ) |
| <b><i>INPUTFILE</i></b> | Full path to <code>resultats.csv</code> file created by <a href="#"><i>Load_and_Plot_Output_DEMDefo.py</i></a> .            |

#### Dependencies

[\*\*\*Compute\\_and\\_Subtract\\_Defo\\_Dem.py\*\*\*](#)

## 7.3. Other tools

### 7.3.a) ***Plot\_Quicklookcompar\_Geocoded.py***

This script ***Plot\_Quicklookcompar\_Geocoded.py*** displays interferogram, coherence and `DefolInterpol2Detrend` maps stored in a `.../SAR_MASSPROCESS/Geocoded` directory. It takes coordinates as an optional argument to crop the 3 output maps. It takes a coherence threshold as an optional argument and mask all pixels where coherence is below this threshold (See Figure 31).

#### Usage

***Plot\_Quicklookcompar\_Geocoded.py GEOCODEDFULLPATH DATE1 DATE2 [-coh\_threshold COTH] [-crop XMIN XMAX YMIN YMAX]***

Where:

|                                     |                                                                                    |
|-------------------------------------|------------------------------------------------------------------------------------|
| <b><i>GEOCODEDFULLPATH</i></b>      | Full path to <code>../SAR_MASSPROCESS/../Geocoded</code>                           |
| <b><i>DATE1</i></b>                 | Primary image date YYYYMMDD.                                                       |
| <b><i>DATE2</i></b>                 | Secondary image date YYYYMMDD.                                                     |
| <b><i>[COTH]</i></b>                | Optional: Coherence threshold applied to mask, interferogram and deformation maps. |
| <b><i>[XMIN XMAX YMIN YMAX]</i></b> | Optional: Crop coordinates in pixels                                               |

#### Dependencies

[\*\*\*Python3\*\*\*](#) with modules `matplotlib`, `argparse`, `rasterio` and `numpy`

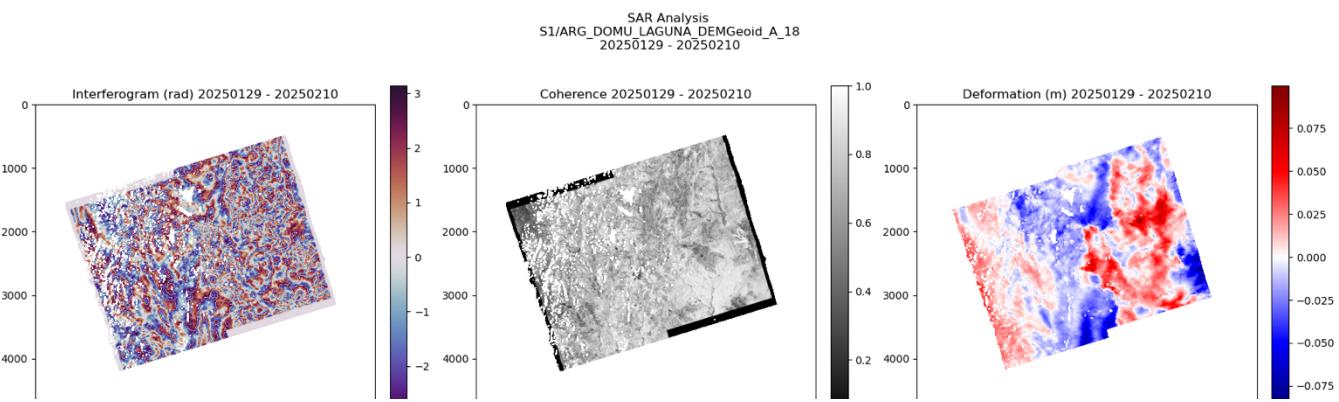


Figure 31: Example of geocoded interferogram, coherence map and deformation map plotted with [Plot\\_Quicklookcompar\\_Geocoded.py](#).

### 7.3.b) [Plot\\_Quicklookcompar\\_MSBAS.py](#)

This script [Plot\\_Quicklookcompar\\_MSBAS.py](#) displays EW, UD, and (if available) NS velocity maps stored in an [MSBAS](#) directory. It accepts crop coordinates as an optional argument and displays two or three maps based on these coordinates. An option is also available to plot a profile line on the velocity maps (see Figure 32). Both crop and profile coordinates can be provided in either pixels or UTM, but if both options are used, they must be in the same coordinate system.

#### Usage

```
Plot_Quicklookcompar_MSBAS.py MSBASDIRFULLPATH MSBASLABEL [--profile X1 Y1 X2 Y2]
[--crop XMIN XMAX YMIN YMAX] [--utm]
```

Where:

|                                       |                                                                                                                                                                                                               |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">MSBASDIRFULLPATH</a>      | Full path to .. <a href="#">MSBAS/MSBASDIR</a>                                                                                                                                                                |
| <a href="#">MSBASLABEL</a>            | Label used for naming <a href="#">MSBAS</a> processing (that identifier is the <a href="#">COMMENT</a> used at <a href="#">MSBAS</a> processing, e.g. <a href="#">_Auto_2_0.04_Domuyo</a> , see chapter 6.2). |
| <a href="#">[XMIN XMAX YMIN YMAX]</a> | Optional: Crop coordinates                                                                                                                                                                                    |
| <a href="#">[X1 Y1 X2 Y2]</a>         | Optional: Profile extremities coordinates                                                                                                                                                                     |
| <a href="#">[-utm]</a>                | Optional: Flag to add if crop and profiles coordinates are provided in utm. X and Y ticks will appear accordingly in utm coordinates in plots.                                                                |

#### Dependencies

[Python3](#) with modules [matplotlib](#), [argparse](#), [rasterio](#) and [numpy](#)

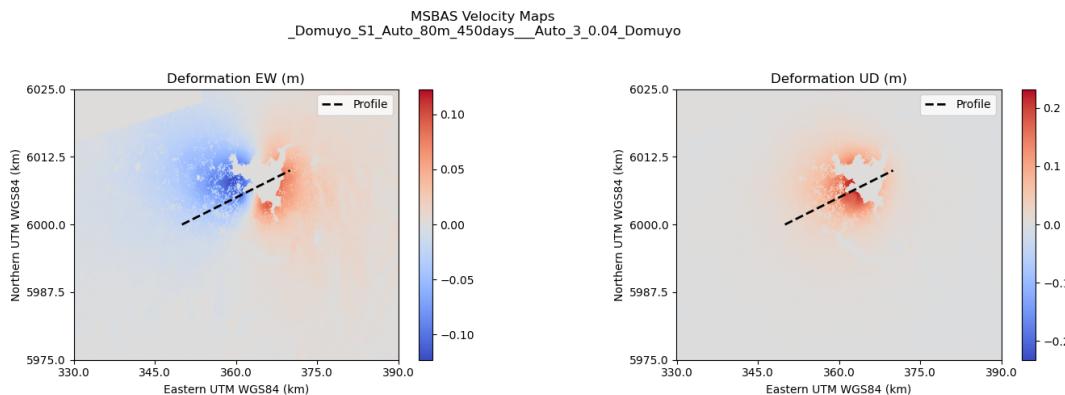


Figure 32: Example of EW and UD velocity maps along with a profile drawn by [Plot\\_Quicklookcompar\\_MSBAS.py](#).

### 7.3.c) ExtractMSBAS\_Profiles.py

This script [ExtractMSBAS\\_Profiles.py](#) displays all profiles for comparison (see Figure 33) from a list of MSBAS directories and associated identifier (that is the [COMMENT](#) associated with each MSBAS, see chapter 6.2).

#### Usage

```
ExtractMSBAS_Profiles.py MSBASDIRFULLPATHlist MSBASIdentifierList --profile X1 Y1 X2 Y2
 [--utm] --mode COMP --figname FIGNAME [--align] [-ylim YLIM]
```

Where:

|                                                                        |                                                                                                                                                                                                                                                                           |
|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">MSBASDIRFULLPATHlist</a>                                   | List of full paths to each directory containing MSBAS results to be compared, e.g. ... <a href="#">MSBAS/Region/</a> .<br><i>The list of paths must be double quoted and separated by commas.</i>                                                                         |
| <a href="#">MSBASIdentifierList</a>                                    | List of identifiers used for naming MSBAS processings (that is the <a href="#">COMMENT</a> used at each MSBAS processings), in the same order as <a href="#">MSBASDIRFULLPATHlist</a> .<br><i>The list of identifiers must be double quoted and separated by commas.</i>  |
| <a href="#">X1 Y1 X2 Y2</a><br>[-utm]                                  | Coordinates of the pixels between which the profile must be displayed.<br>Flag to add if crop and profiles coordinates are provided in utm.<br>If not, it expects values in pixel coordinates                                                                             |
| <a href="#">COMP</a><br><a href="#">FIGNAME</a><br>[YLIM]<br>[--align] | Component to consider, that is either “EW”, “UD” or “NS”.<br>String chain to describe the figure<br>Optional: to force the scale of output plot from - <a href="#">YLIM</a> to + <a href="#">YLIM</a> .<br>Optional: align all profiles using their respective mean value |

#### Dependencies

[Python3](#) with modules [matplotlib](#), [argparse](#), [scipy](#), [rasterio](#) and [numpy](#)

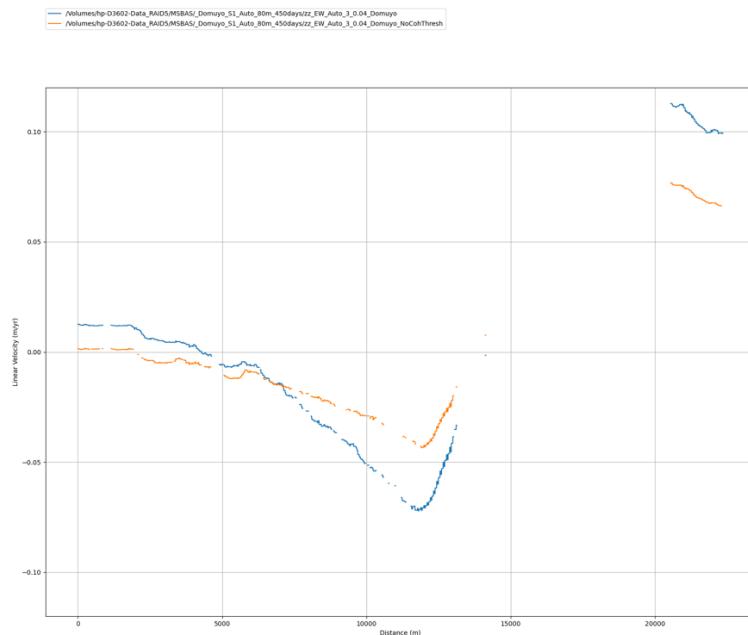


Figure 33: Example of EW profiles extracted from velocity maps on the Domuyo area computed by MSBAS inversion performed with (Blue) and without (Orange) coherence threshold.

## 8. Automation with cronjobs:

In [SCRIPTS\\_MT/\\_cron\\_scripts/](#) some scripts are suggested to make a fully automated system using Sentinel 1 data or CSK data.

First, the data must be downloaded. It is the responsibility of the user to set up such a procedure. ESA may provide some hints to set up scripts to automatically download S1 data from their web site for instance. We provide below some examples for S1 data.

From there, 3 main scripts will process the data up to the time series.

A final batch of scripts is used to create and update the web page. See [Web\\_tool\\_Vxx.pdf](#) manual by Maxime Jaspard for more information about that part.

The procedure and the AMSTer software is also illustrated and explained in the following paper (open access), although the software was still named MasTer at the time of its publication:

Derauw D., d'Oreye N., Jaspard M., Caselli A. and Samsonov S.

Ongoing automated Ground Deformation monitoring of Domuyo – Laguna del Maule area (Argentina) using Sentinel-1 MSBAS time series: Methodology description and first observations for the period 2015 – 2020. *J. South Am. Earth Sc.*, Vol. 104, 102850.  
<https://doi.org/10.1016/j.jsames.2020.102850>

**Open Access here:**

<https://www.sciencedirect.com/science/article/pii/S089598112030393X?via%3Dihub>

You will need to adapt the cron scripts explained below to your needs and prepare crontabs to launch them if required.

Some explanations are illustrated below with the processing of Sentinel 1 data for the Domuyo/Laguna del Maule region (Argentina/Chile) used for the above-mentioned paper. The corresponding scripts are provided in Annex A.6).

Remember:

- Launch your scripts while redirecting the output to /dev/null to avoid unwanted messages filling up your mailbox or logs.
- If you run your scripts on recent Mac OSX, where bash is not the default shell, launch your scheduled scripts as follow

hh mm \* \* \* **/bin/bash YourScript.sh > /dev/null 2>&1**

- If you run your scripts on LINUX, it may not know/read your **.bashrc**. To overcome that, define your environmental variables within you crontab, eg.

```
PATH_1650=/mnt/1650
PATH_3600=/mnt/3600
PATH_3601=/mnt/3601
PATH_3602=/mnt/3602
PATH_DataSAR=/mnt/DataSAR
PATH_SynoData=/mnt/syno_data
PATH_SCRIPTS=/home/nicolas/SAR
ENVISAT_PRECISES_ORBITS_DIR=/mnt/DataSAR/SAR_AUX_FILES/ORBITS/ENV_ORB/vor_gdr_d
S1_ORBITS_DIR=/mnt/DataSAR/SAR_AUX_FILES/ORBITS/S1_ORB
EARTH_GRAVITATIONAL_MODELS_DIR=/mnt/DataSAR/SAR_AUX_FILES
PATHGNU=/usr/bin
PATHCONV=/usr/bin
```

```
PATHFIJI=/usr/bin
hh mm * * * /bin/bash YourScript.sh > /dev/null 2>&1
```

- If cron does not start (e.g. with recent Mac OSX), ensure that you have allowed cron and crontab to have “Full Disk Access” rights. For that:
  - o open the System Preferences > Security & Privacy > Full Disk Access.
  - o Unlock the dialog windows using the lock and your pwd,
  - o click on “+”, cmd + shift + g and enter /usr/bin, then select “crontab”
  - o click on “+”, cmd + shift + g and enter /usr/sbin, then select “cron”
- On Linux, ensure your `.bashrc` don't start with the following lines (as by default in at least Ubuntu 18.04 and later):
 

```
~/.bashrc: executed by bash(1) for non-login shells.
see /usr/share/doc/bash/examples/startup-files (in the package bash-doc)
for examples

If not running interactively, don't do anything
case $- in
 i) ;;
 *) return;;
esac
```

If this is the case, comment them of course.

## 8.1. Step 0: Download the images Sentinel 1 images (`sentinel1_download_all.sh` and `s1_downloader.sh`)

The script `sentinel1_download_all.sh` is launched on a Mac server 3 times per day (at midnight, 6am and 6pm). It runs several calls of the script `s1_downloader.sh`, each one being aimed at a different target we are monitoring at ECGS. In our case, as we are only interested in the Domuyo/Laguna del Maule region (or Domuyo in short), the only lines that are of interest in that script are:

```
Domuyo
/Users/doris/scripts/S1-Copernicus/s1_downloader.sh --domuyoA18 --slc --startdate=15-DAYS-AGO --enddate=TODAY
/Users/doris/scripts/ S1-Copernicus/s1_downloader.sh --domuyoD83 --slc --startdate=15-DAYS-AGO --enddate=TODAY
```

i.e. it calls the script `s1_downloader.sh` to check and download any new `slc` data available over the `domuyo` region between today and `15 days ago`. To operate, the script mainly needs (hard coded with several things in the script):

- a login and password to access ESA [dataspace.copernicus.eu](http://dataspace.copernicus.eu) web site
- the target directory where to store the new data  
(e.g. `.../SAR_DATA/S1/S1-DATA-DOMUYO-SLC/`)
- the corners of the footprint for the area of interest

After having compared local directory with data provider's directory and downloaded only the required files, it will unzip the data in `.../SAR_DATA/S1/S1-DATA-DOMUYO-SLC.UNZIP`. Finally, another script will delete the zip files older than a certain number of days (`delete_S1_ZIP_files_older_120days.sh`).

It will then send an email to dedicated addresses to provide feedback about the status of the operation. The details of the execution and results are stored in a log file.

See scripts for details (Annex A.6.1). Special thanks to Gilles Celli who wrote these scripts provide an example in `.../AMSTer/SCRIPTS_MT/_cron_scripts/_Download_Sentinel/`.

## 8.2. Step 1: Read and coregister images on a Global Primary (Super Master) (*Domuyo\_S1\_Step1\_Read\_SMCoreg\_Pairs\_DEMGeoid.sh*)

The script ***Domuyo\_S1\_Step1\_Read\_SMCoreg\_Pairs\_DEMGeoid.sh*** is launched once per day by a cronjob e.g. at 3 am. (Note: the string *\_DEMGeoid* in the name is there only to remind that the processing was performed with a DEM where heights are corrected from the Geoidal height, that is, the it is referred to the ellipsoid).

It will:

- Create a log file  
`$PATH_1650/SAR CSL/S1/ARG_DOMU_LAGUNA/Last_Run_Cron_Step1.txt` which contains the date of execution (start and stop), which can be useful for verification or debugging.
- Read all the images (and stitch the necessary swaths/bursts) with ***Read\_All\_Img.sh*** (see chapter 0) from `$PATH_3600/SAR_DATA/S1/S1-DATA-DOMUYO-SLC.UNZIP` and transform then in CSL format in  
`$PATH_1650/SAR CSL/S1/ARG_DOMU_LAGUNA/NoCrop`.

Because all orbit geometries are read at the same time, it will then sort each image depending on its geometry and store them respectively in

`$PATH_1650/SAR CSL/S1/ARG_DOMU_LAGUNA_A_18/NoCrop` and  
`$PATH_1650/SAR CSL/S1/ARG_DOMU_LAGUNA_A_18/NoCrop` while keeping links in the original `$PATH_1650/SAR CSL/S1/ARG_DOMU_LAGUNA/NoCrop` (to prevent re-downloading the data if they are missing in that directory).

The script ***Read\_All\_Img.sh*** will also store data older than 6 months in  
`$PATH_3600/SAR_DATA/S1/S1-DATA-DOMUYO-SLC.UNZIP_FORMER/_YYYY` in order to speeding up the processing of reading the data (because it reads all the data in the directory).

It will then check the orbits (or FAST24 data) and update the new ones (without downloading again the data). If no process is running using the updated products, it will delete all the products created with outdated orbits so that they can be rebuild. If a processing is running using these data, it stores the list of outdated products to be cleaned at next run.

- Check the nr of bursts and coordinates of corners of each image using the script ***\_Check\_ALL\_S1\_SizeAndCoord\_InDir.sh***. If these values are not as expected, it will move the images in a temporary quarantine directory (`__TMP_QUARANTINE`) and log the names of these files and the reason why, that is the unexpected values compared to the expected ones.

Note that the expected values of kml corners can be obtained by running

***\_Check\_S1\_SizeAndCoord.sh*** `$PATH_1650/SAR CSL/SAT/TRK/NoCrop/img.kml Dummy` where the path is the full path to a good image in SLC format for that region and `Dummy` only tells the script to read and output the values instead of checking them against known values (see 10.1).

Instead of providing ***\_Check\_ALL\_S1\_SizeAndCoord\_InDir.sh*** with these kml corners, one can provide the min longitude, max longitude, min latitude and max latitude of the area of interest measured eg. from Google Earth.

It is the responsibility of the user to check regularly the

`$PATH_1650/SAR CSL/SAT/TRK/NoCrop/__TMP_QUARANTINE` directory: images there are either not fully downloaded yet and hence it might be solved the day after, or the image has a problem and must be manually moved to the definitive  
`$PATH_1650/SAR CSL/SAT/TRK/quarantined` directory.

Note however that sometimes the S1 tasking may vary a little and the number of bursts required to cover the area of interest may vary if the zone is close to the limit of a burst (Murphy's law... it happens more often than one may think). In such a case, the checking script is run twice, one with each expected number of bursts and corner's coordinates. This is the case in our example for images acquired in orbit *D\_83*.

- Coregister all the new images on the Global Primary image (*20180512* in Asc and *20180222* in Desc orbits) using ***SuperMasterCoreg.sh***. However, because S1 orbits are good enough, coregistration on a Global Primary is not required here. Instead, the script will take that opportunity to compute the DEM (and mask if available) in the slant range geometry of each new image. Results are stored in  
`$PATH_1650/SAR_SM/RESAMPLED/S1/ARG_DOMU_LAGUNA_A_18/SMNoCrop_SM_20180512`  
and  
`$PATH_1650/SAR_SM/RESAMPLED/S1/ARG_DOMU_LAGUNA_D_83/SMNoCrop_SM_20180222`
- Search for new compatible interferometric pairs to be formed with the new data. For this it will first link the new Asc and Desc data respectively in  
`$PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1` and  
`$PATH_1650/SAR_SM/MSBAS/ARGENTINE/set2` thanks to the script ***Ins\_All\_Img.sh***. Then it will run ***Prepa\_MSBAS.sh*** in order to select the new pairs satisfying the spatial and temporal baseline criteria (respectively *20* meters and *450* days) and make the baseline plots.  
Note that the list of
  - ⇒ all interferometric combinations (for Asc and Desc geometries resp.),
  - ⇒ the list of pairs satisfying the baselines criteria (for Asc and Desc geometries resp.),
  - ⇒ the baselines plot (for Asc and Desc geometries resp.), and
are stored respectively in
  - ⇒ `$PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/approximateBaselinesTable.txt` and  
`$PATH_1650/SAR_SM/MSBAS/ARGENTINE/set2/approximateBaselinesTable.txt`,
  - ⇒ `$PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/table_0_20_0_450.txt` and  
`$PATH_1650/SAR_SM/MSBAS/ARGENTINE/set2/table_0_20_0_450.txt`,
  - ⇒ `$PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/span_0_20_0_450.jpg` and  
`$PATH_1650/SAR_SM/MSBAS/ARGENTINE/set2/span_0_20_0_450`.
- Create a combined baselines plot (Asc+Desc) and store it in  
`$PATH_1650/SAR_SM/MSBAS/ARGENTINE/BaselinePlots_S1_set_1_2/span_2sets_0_20_0_450.jpg`

See script for details (Annex A.6.2).

### **8.3. Step 2: Processing all pairs (*Domuyo\_S1\_Step2\_MassProc\_DEMGeoid.sh*)**

The script ***Domuyo\_S1\_Step2\_MassProc\_DEMGeoid.sh*** is launched once per day by a cronjob at 5h30 am.

It will:

- Check that no ***Domuyo\_S1\_Step1\_Read\_SMCoreg\_Pairs\_DEMGeoid.sh*** is running. If such a process is still running, it will stop and try again the day after.
- Check that no ***SuperMaster\_MassProc.sh*** is already running with the same parameters (i.e for Asc and Desc respectively)

`$PATH_1650/Param_files/S1/ARG_DOMU_LAGUNA_A_18/LaunchMTparam_S1_Arg_Domu_Laguna_A_18_Zoom1_ML4_MassProc_MaskCohWater.txt` and  
`$PATH_1650/Param_files/S1/ARG_DOMU_LAGUNA_D_83/LaunchMTparam_S1_Arg_Domu_Laguna_D_83_Zoom1_ML4_MassProc_Snaphu_WaterCohMask.txt`).

If such a process is still running, it will stop and try again the day after.

- Launch the script ***SuperMaster\_MassProc.sh*** for the Asc and Desc modes.

If it aborts, it logs the info in a corresponding text file.

See script for details (Annex A.6.3).

#### **8.4. Step 3: MSBAS processing and time series computation**

**(*Domuyo\_S1\_Step3\_MSBAS\_DEMGeoid.sh* or  
*Domuyo\_S1\_Step3\_MSBAS\_DEMGeoid\_Split.sh*)**

The script ***Domuyo\_S1\_Step3\_MSBAS\_DEMGeoid.sh*** is launched once per day by a cronjob at 5h30 pm.

It will:

- Check that no ***Domuyo\_S1\_Step3\_MSBAS\_DEMGeoid.sh*** is running. If such a process is still running, it will stop and try again the day after.
- Check that no ***SuperMaster\_MassProc.sh*** is already running with the same parameters (i.e for Asc and Desc respectively).
- Check that no ***Domuyo\_S1\_Step2\_MassProc\_DEMGeoid.sh*** is running. If such a process is still running, it will stop and try again the day after.

If it stops for any of the previous reasons, it will store the information in

**\$PATH\_3602/MSBAS/\_Domuyo\_S1\_Auto20m\_450days/\_last\_MSBAS\_process.txt**

- Look for duplicated products in all ***Mode*** directories based on pair of dates that is in the name. Duplicate products may happen in **/Geocoded/*Mode*** and **/GeocodedRasters/*Mode*** (where ***Mode*** is e.g. **DefoInterpolx2Detrend**) when a pair is reprocessed with updated orbit with resulting slightly different Bp. It then move them in each ***Mode*/\_\_Duplicated\_ToKill**. It **DOES NOT PROCESS GEOCODED AMPLITUDE IMAGES** because PRM and SCD can be geocoded within the same pair. All this is performed using a script located in **zz\_Utils\_MT\_Ndo** that is ***Remove\_Duplicate\_Pairs\_File\_All\_Modes\_But\_Ampl.sh***

- Check the date/time at which the last Asc and Desc pairs were computed and compare to the date/time at which the last Asc and Desc pairs were processed during the last run of this ***Domuyo\_S1\_Step3\_MSBAS\_DEMGeoid.sh***. This information was saved at the previous run in

**\$PATH\_3602/MSBAS/\_Domuyo\_S1\_Auto\_20m\_450days/\_Last\_MassProcessed\_Pairs\_Time.txt**

If no new pair were computed, it stops. (If it is the first run, the script will cope with the absence of the file with dates from a previous run).

- Remove possible broken links in **MSBAS/.../*Modei*** and clean files in corresponding lines in **MSBAS/.../*Modei*.txt**, i.e. clean files in **\$PATH\_3602/MSBAS/\_Domuyo\_S1\_Auto\_20m\_450days/DefoInterpolx2Detrend*i*** (where *i* is 1 for Asc and 2 for Desc). Links in **/DefoInterpolx2Detrend*i*** must points to existing deformation maps in

**\$PATH\_3601/SAR\_MASSPROCESS/S1/ARG\_DOMU\_LAGUNA\_A\_18/SMNoCrop\_SM\_20180512\_Zoom1\_ML4/Geocoded/DefoInterpolx2Detrend** and

**\$PATH\_3601/SAR\_MASSPROCESS/S1/ARG\_DOMU\_LAGUNA\_D\_83/SMNoCrop\_SM\_20180222\_Zoom1\_ML4/Geocoded/DefoInterpolx2Detrend**

This check is performed with the script ***Remove\_BrokenLinks\_and\_Clean\_txt\_file.sh***.

- It does it also in case of processing with coherence cleaning threshold in **MSBAS/.../*Modei*\_Full** with the script ***Remove\_BrokenLinks\_and\_Clean\_txt\_file.sh***.

- If not the first run,

- o Check that each **DefoInterpolx2Detrend*i*.txt** contains 4 columns and clean it if required (both for full processing and for coherence restricted processing if it exists).

- Remove lines in **MSBAS/ DefolInterpolx2Detrendi.txt** associated to possible broken links or duplicated lines (i.e. same pairs but name differs because of perpendicular baseline or altitude of ambiguity e.g. after S1 orbit update; in that case it only keeps the most recent file). This is performed using **\_Check\_bad\_DefolInterpolx2Detrend.sh**
- Same cleaning in **DefolInterpolx2Detrendi\_Full** if previous processing was performed with coherence cleaning threshold
- Prepare the required files for the msbas processing using **build\_header\_msbas\_criteria.sh** (see chapter 6.1.a)
- Update the msbas **\$PATH\_3602/MSBAS/\_Domuyo\_S1\_Auto\_20m\_450days/header.txt** file by setting up the appropriate inversion order and lambda factor (**3** and **0.04** in the present case).
- Update the msbas **\$PATH\_3602/MSBAS/\_Domuyo\_S1\_Auto\_20m\_450days/header.txt** file by **discarding the calibration**. Calibration is indeed not necessary because the deformation maps were detrended (i.e. averaged to zero).
- Check again (if first run or in case some pairs would have been added in the meantime...) that each **DefolInterpolx2Detrendi.txt** contains 4 columns.
- In case of processing with coherence threshold restriction, clean again (if first run, or just in case...) **MSBAS/ DefolInterpolx2Detrendi.txt** from possible lines associated to broken links or duplicated lines using **\_Check\_bad\_DefolInterpolx2Detrend.sh**.
- If not the first run, Remove again (just in case...) possible broken links and clean files in **\$PATH\_3602/MSBAS/\_Domuyo\_S1\_Auto\_20m\_450days/DefolInterpolx2Detrendi** using **Remove\_BrokenLinks\_and\_Clean\_txt\_file.sh**
- Run a first msbas processing with **MSBAS.sh** using all the available Asc and Desc deformation maps satisfying to the baselines criteria (i.e. **without coherence restriction**) and output the time series for all the reference points provided in list **\$PATH\_SCRIPTS/SCRIPTS\_MT/\_cron\_scripts/Cln\_Domuyo.txt**. These plots are simple time series (no double difference) **with error bars** (stdev computed in the radius around the pixel as provided in **Cln\_Domuyo.txt**, which contains 4 columns: **Xpix Ypix Xrad Yrad** where **X pix** and **Y pix** are coordinates of the pixel (position in file) and **rad** is radius (in pixel) around the pixel to estimate the stdev. Plots are named by the pixel coordinates.
- Make a baseline plot using **PlotBaselineGeocMSBASmodeTXT.sh** for the data set without coherence restriction
- Add description to pdf plots and txt time series of single points with their error bars. Description comes from point file **\$PATH\_SCRIPTS/SCRIPTS\_MT/\_cron\_scripts/Points\_TS\_Domuyo.txt** that contains (after a header “**name x y radiusX radiusY**”) the following fields : “**description\_as\_desired Xcoord Ycoord Xrad Yrad**”, where **rad** is the radius (in pixels) around the **X/Y** pixel where the stdev is computed. Beware that valid pixels must exist everywhere in that radius (if not, i.e. if **X/Y** pixel to plot is located at the border of a zone, set **rad** to zero; no stdev will be computed of course).
- Create plots of double difference between the time series of pixels provided in **\$PATH\_SCRIPTS/SCRIPTS\_MT/\_cron\_scripts/List\_DoubleDiff\_EW\_UD\_Domuyo.txt**, which contains 5 columns: **Xpix1 Ypix1 Xpix2 Ypix2 string** where **X** and **Y** are coordinates of the two pixels and **string** is a text to describe the area where are located the pixels. (See section 9.31) for some helpful tools to assist in creating these **List\_DoubleDiff\_EW\_UD\_xx.txt** files). Plots are named by the pixel coordinates and **string**. A small inset is added in the plot to help the reader figuring out where the pixels are located and interpreting the sense of deformation observed and displayed as a double difference (see description of **PlotTS\_all\_comp.sh** for explanations).

Plots are stored in  
`$PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/zz_UD_EW_TS_Auto_3_0.04_Domuyo_NoCohThresh/_Combi/` and text files with time series values are stored in  
`$PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/zz_UD_EW_TS_Auto_3_0.04_Domuyo_NoCohThresh/_Time_series/`.

- Apply the coherence restriction: Remove all the interferometric pairs for which the mean coherence computed in an area defined by a provided kml file (`$PATH_1650/kml/ARGENTINA/Laguna_Maule.kml` in the present case) is below a provided Coherence Threshold (`0.235` in the present case). This selection is performed using the script `restrict_msbas_to_Coh.sh`
- Offers the possibility to force exclusion of pairs that satisfies the baseline criteria and the threshold although they are obviously decorrelated on the area under concern. Instead of lowering the Coherence Threshold (which would result in removing probably much more pairs than only the faulty one), one can exclude here some pairs that are be provided in a list stored in  
`$PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/DefolInterpolx2Detrendi/_EXCLUDE_PAIRS_ALTHOUGH_CRITERIA_OK.txt`. This is performed with the script `Exclude_Pairs_From_Mode.txt.sh`
- Run a second msbas processing using Asc and Desc deformation maps satisfying to the baselines criteria and after coherence threshold restriction.
- Make a baseline plot using `PlotBaselineGeocMSBASmodeTXT.sh` for the data set with coherence restriction
- Add description to pdf plots and txt time series of single points with their error bars. Description comes from point file  
`$PATH_SCRIPTS/SCRIPTS_MT/_cron_scripts/Points_TS_Domuyo.txt`.
- Create again plots of double difference between the time series of pixels provided in  
`$PATH_SCRIPTS/SCRIPTS_MT/_cron_scripts/List_DoubleDiff_EW_UD_Domuyo.txt`. Results are stored in directories with names consistent with the processing.
- Run a third msbas processing using only Asc deformation maps satisfying to the baselines criteria though after removing all the interferometric pairs for which the mean coherence computed in `$PATH_1650/kml/ARGENTINA/Laguna_Maule.kml` is below the Coherence Threshold of `0.235` and make the corresponding plots.
- Create again plots of double difference in LOS Asc between the time series of pixels provided in  
`$PATH_SCRIPTS/SCRIPTS_MT/_cron_scripts/List_DoubleDiff_EW_UD_Domuyo.txt`. (Note that the list of pixels could have been specific to Asc orbit). Results are stored in directories with names consistent with the processing.
- Run a fourth msbas processing using only Desc deformation maps satisfying to the baselines criteria though after removing all the interferometric pairs for which the mean coherence computed in `$PATH_1650/kml/ARGENTINA/Laguna_Maule.kml` is below the Coherence Threshold of `0.235` and make the corresponding plots.
- Create again plots of double difference in LOS Desc between the time series of pixels provided in  
`$PATH_SCRIPTS/SCRIPTS_MT/_cron_scripts/List_DoubleDiff_EW_UD_Domuyo.txt`. (Note that the list of pixels could have been specific to Desc orbit). Results are stored in directories with names consistent with the processing.

#### Notes:

- 1) To spare time, the processing keeps track of pairs already tested against the baseline criteria as well as the Coherence Threshold. This information is stored in several files in  
`$PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days` or `DefolInterpolx2Detrendi/`.

See e.g. in

`/$PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/`:

- o `Checked_CohThreshold_To_Be_Ignored_At_Next_Rebuild_msbas_Header.txt`

See e.g. in

`/$PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/DefolInterpolx2Detrendi:`

- o `Checked_CohThreshold_To_Be_Ignored_At_Next_Rebuild_msbas_Header.txt`
- o `Checked_CohThreshold_To_Be_Ignored_At_Next_Rebuild_msbas_Header.txt_Including_Broken_Links.txt`
- o `List_Checked_img_For_Coh_0.235_Laguna_Maule.kml.txt`
- o `Out_Of_Range_20m_450days.txt`

See e.g. in

`/$PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/DefolInterpolx2Detrendi_Full:`

- o `Checked_CohThreshold_To_Be_Ignored_At_Next_Rebuild_msbas_Header.txt`
- o `Checked_CohThreshold_To_Be_Ignored_At_Next_Rebuild_msbas_Header.txt_Including_Broken_Links.txt`
- o `Checked_CohThreshold_To_Be_Ignored_At_Next_Rebuild_msbas_Header.txt_Including_Missing_Files.txt`
- o `List_All_img_For_Coh_0.235_Laguna_Maule.kml.txt`
- o `List_Checked_img_For_Coh_0.235_Laguna_Maule.kml.txt`
- o `List_Out_Of_Range_CohThreshold_0.235_in_Laguna_Maule.kml.txt`

In case of problem or doubts, it is advised to check these files and if needed remove them or start from scratch (that is erasing the whole directory

`$/PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days)`.

This will however require a much longer processing time at next run.

- 2) Remember that msbas **will crash if the computer has insufficient RAM**. In that case you may want to crop the area of interest by editing the `header.txt`. You can also try to split the processing (see ***Domuyo\_S1\_Step3\_MSBAS\_DEMGeoid\_Split.sh*** below)
- 3) Status of last MSBAS automatic processing (date and time in human readable format of last processing and info if finished without new pairs to process) is stored in a file `$/PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/_last_MSBAS_process.txt`
- 4) See some logs in  
`$/PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/_MSBAS_log.txt`

More details about the processing is stored e.g. in:

```
$PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/zz_LOS_TS_Asc_Auto_3_0.04_Domuyo/_Time_series/MSBAS_LOG.txt
$PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/zz_LOS_TS_Desc_Auto_3_0.04_Domuyo/_Time_series/MSBAS_LOG.txt
$PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/zz_UD_EW_TS_Asc_Auto_3_0.04_Domuyo/_Time_series/MSBAS_LOG.txt
$PATH_3602/MSBAS/_Domuyo_S1_Auto_20m_450days/zz_UD_EW_TS_Asc_Auto_3_0.04_Domuyo_NoCohThresh/_Time_series/
MSBAS_LOG.txt
```

**GENERAL NOTE:** If these cron scripts are launched with cron tabs, it is usually a good practice to end cron lines with `> /dev/null 2>&1` to mute output and avoid filling up internal mailbox. It is also required for those scripts that are launched with cronjobs and that must first check if another occurrence is already running. In that case, the scripts will search for that string (dev/null) to discard cron line from counting occurrence.

**Remark:** The version of that cron script named ***Domuyo\_S1\_Step3\_MSBAS\_DEMGeoid\_Split.sh*** is doing the same, although it offers the possibility to split the MSBAS inversion in two parts (see 6.3). See the following hard coded parameters to be adjusted at the beginning of the script:

- `SPLIT="YES"` If set to YES, it will perform the processing in two parts
- `PART1END=yyyymmdd` Date of the end of part 1
- `PART2START=yyyymmdd` Date of the beginning of part 2 (see 6.3 for selection procedure)
- `MIDOVERLAPASC=yyyymmdd` Date at which offset is computed between both parts for EW/UD time series as well as Asc LOS time series.
- `MIDOVERLAPDESC=yyyymmdd` Date at which offset is computed between both parts for Desc LOS time series.

## 8.5. Step 4: Web page

The code for this part was written by Maxime Jaspard ([Maxime@ecgs.lu](mailto:Maxime@ecgs.lu)) and is explained in the document entitled [Web\\_tool\\_Vx.x.pdf](#) (where *x.x* is the number of the latest version of that manual).

We briefly describe here the structure of the web page. See also the open access paper: [Derauw et al., J. South Am. Earth Sc. \(2020\)](#).

The web page of the automatic AMSTer processing of the Laguna del Maule – Domuyo region discussed here as an example is openly available at <http://terra2.ecgs.lu/defo-domuyo>.

Below and introductory header, the web page offers to use a tool to Calculate Time series on demand (see section 8.5.e), displays specific interferograms on demand by selecting the dates (see section 8.5.f), displays specific deformation maps between selected dates (it is not mandatory to combine images acquired in the same geometry because this is based on displacement maps resulting from MSBAS inversion; see section 8.5.g), or a RGB amplitude/coherence combination (see section 8.5.i) (Figure 34).

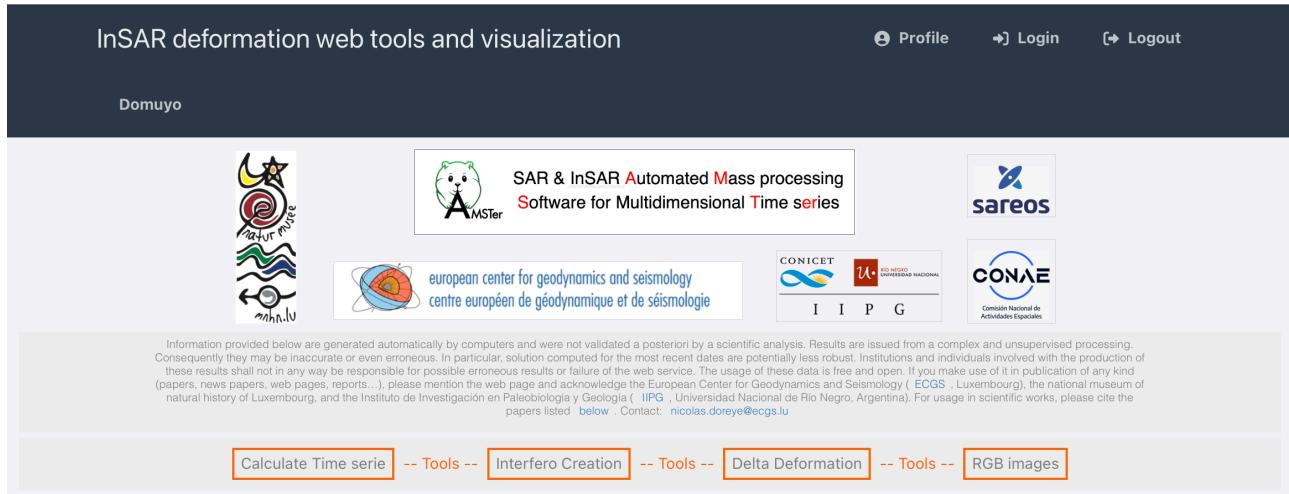


Figure 34: Header of the web page and buttons to switch to Time Series calculation on demand, display specific interferograms by selecting the dates, display specific deformation maps between selected dates (dates must not be from images acquired in the same geometry because this is based on displacement maps resulting from MSBAS inversion), or an RGB amplitude/coherence combination.

Then it offers to jump lower in the page directly to the panel showing either the Amplitude images (see section 8.5.b), the pre-defined time series (see section 8.5.d), the Baseline Plots (see section 8.5.h), or maps of Deformation linear rate Standard Deviation (see section 8.5.j), followed with the information about the date of the last synchronization between the web server and the processing server (Figure 35).

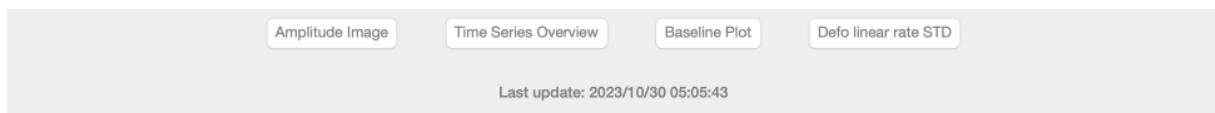


Figure 35: Button to jump directly to panel showing the Amplitude images, the pre-defined time series, the Baseline Plots, or Deformation Linear Rate Standard Deformation maps, followed with the date of the last synchronization between the web server and the processing server.

Further down, the results are displayed in five different main sections, accessible by scrolling down the page or by clicking on the buttons: the velocity maps (see section 8.5.a), the RGB maps

(see section 8.5.i), the amplitude maps (see section 8.5.b), the pixel location of pre-defined double difference time series (see section 8.5.c) and the pre-defined double difference time series (see section 8.5.d).

### 8.5.a) Velocity maps

The first panel (Figure 36) presents colour figures of linear deformation rates estimates along vertical (UD) and East-West (EW) axes (MSBAS processing) and along each LOS views (SBAS processing).

Clicking on the images allows to zoom in; clicking on the “Open KMZ” blue link allows downloading the kmz colour map to be displayed e.g. with *Google Earth*. Dates of the first and last images used are displayed above the maps.

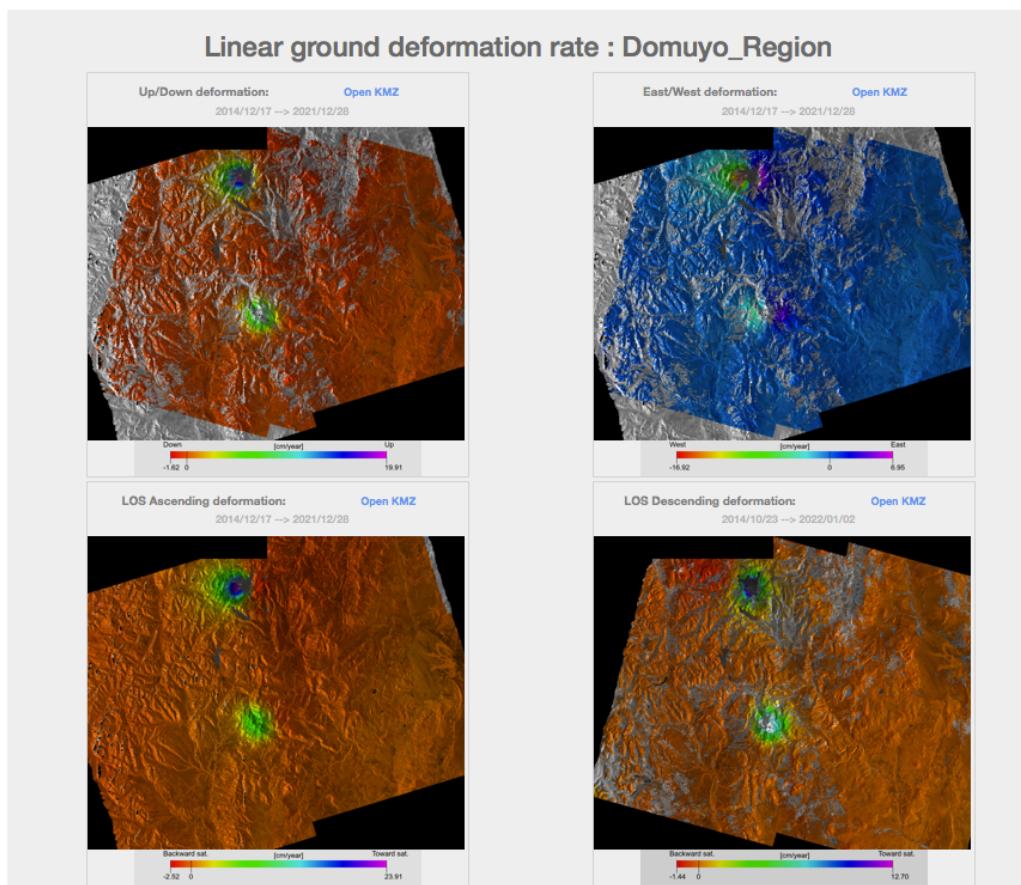


Figure 36: First panel of web page displaying the results of the AMSTer automated processing at Laguna del Maule – Domuyo region. Linear deformation rate maps computed using MSBAS processing along Up-Down (UD) and East-West (EW) directions (Above), and using SBAS processing along Ascending and Descending line of sight directions (below). Maps can be downloaded in kmz format and imported in Google Earth.

### 8.5.b) Amplitude maps

The section below (Figure 37) shows the last ascending and descending amplitude images of the area of interest and the averages of the last 10 amplitudes images in both modes. Dates of last images are displayed below the images.

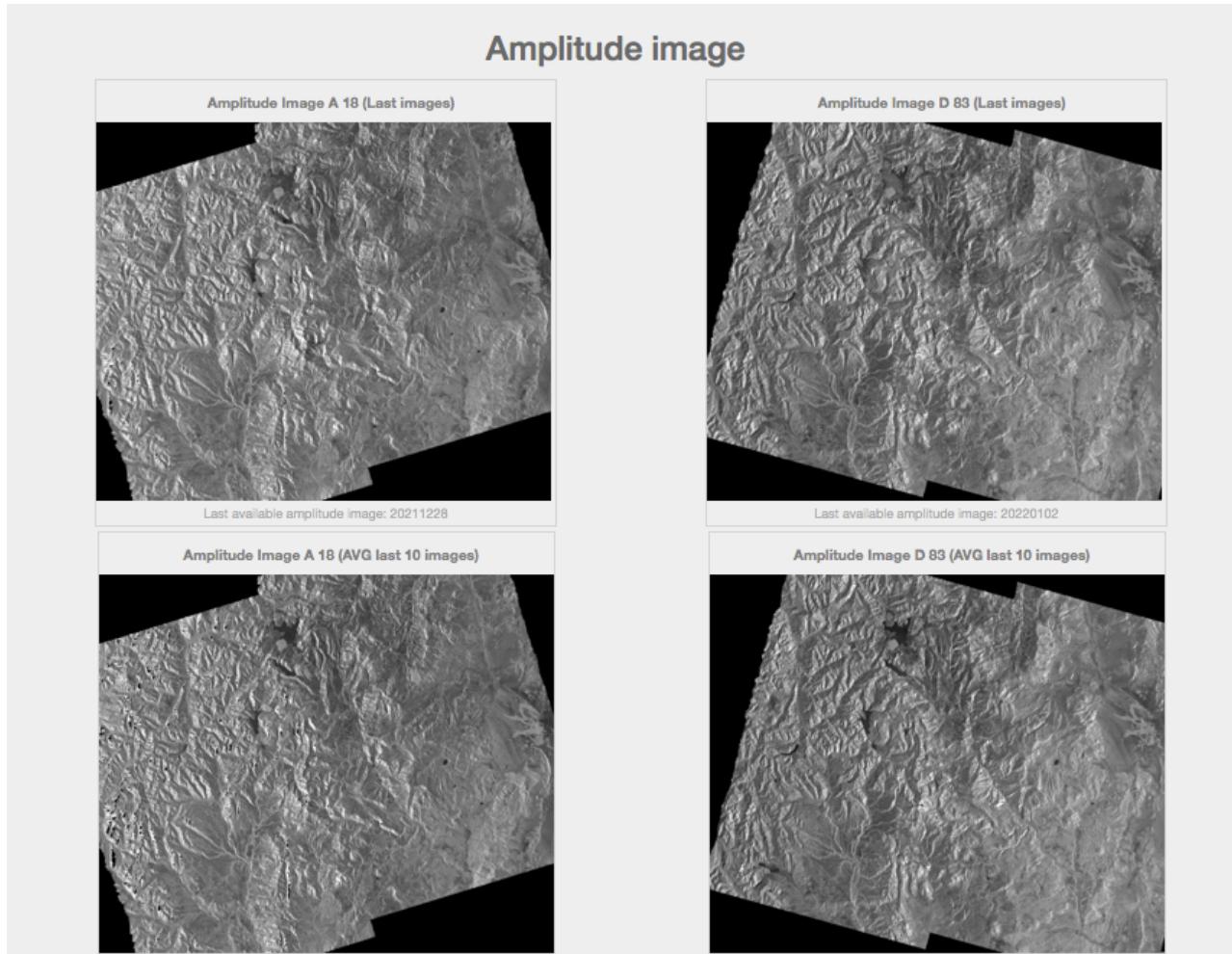
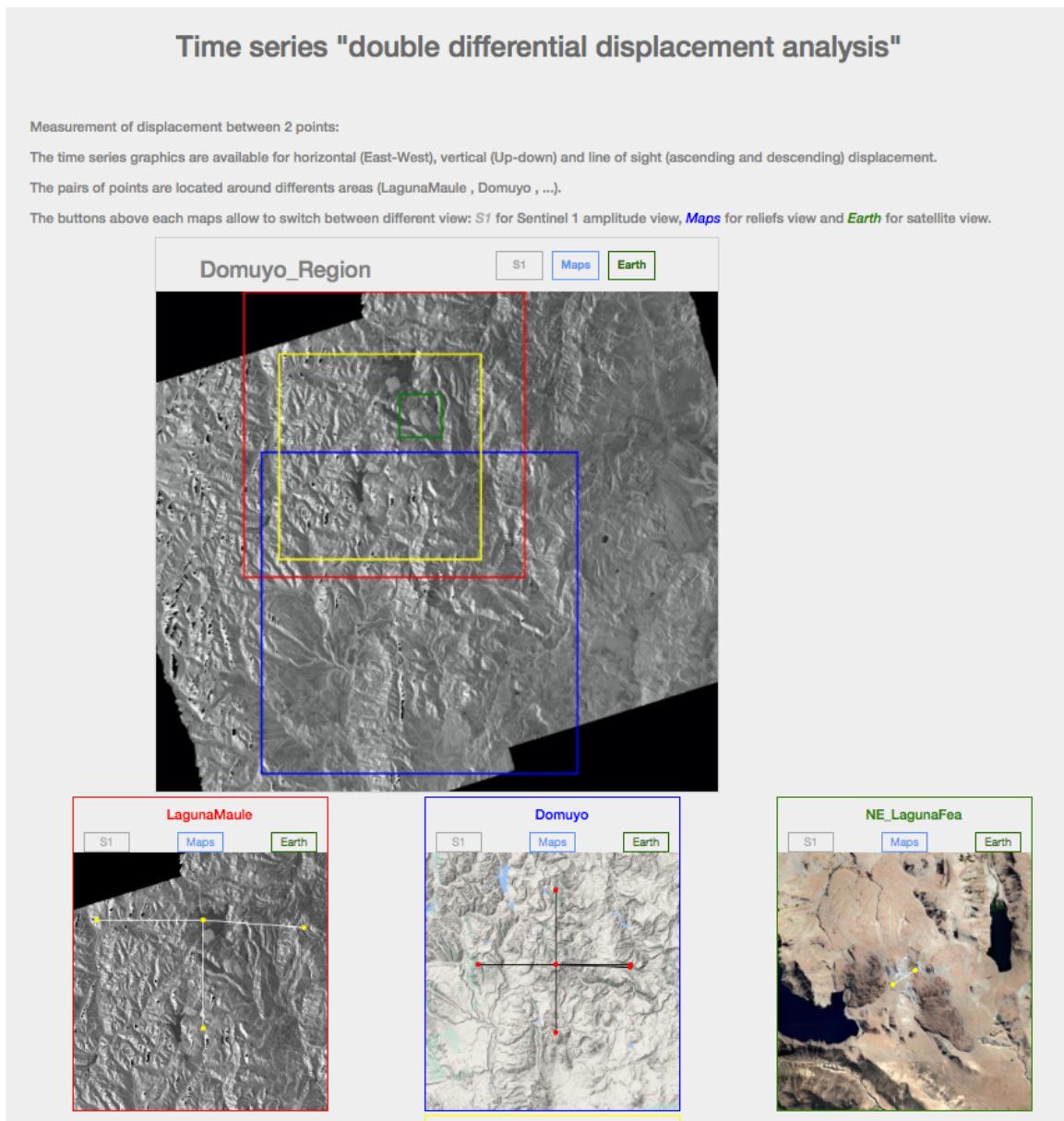


Figure 37: Amplitude maps of last Ascending and Descending images (Upper Left and Right resp.) and Amplitude average of the last 10 images acquired in Ascending and Descending orbits (Lower Left and Right resp.)

### 8.5.c Pixel localization maps

The next panel (Figure 38) shows a full-size SAR amplitude image with colour framed zooms indicating the location of some pairs of pre-defined points of interest. That map and the zooms can be displayed as SAR amplitude image or a Google map or a Google Earth view (see buttons at the upper right corner). Clicking on the small maps contoured in colour make the web page to jump directly to panel displaying the differential time series of corresponding pixels (see 8.5.d).



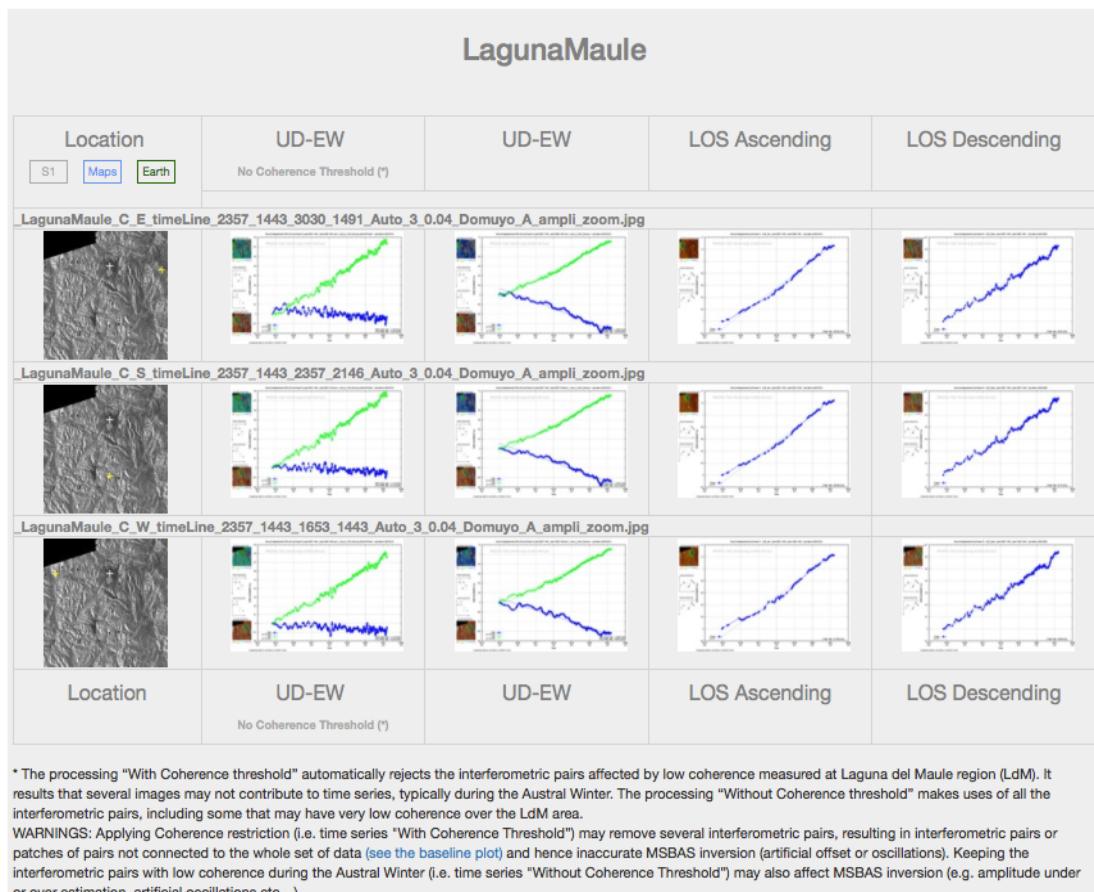
*Figure 38: Example of maps displaying the location of pairs of pre-defined points of interest at the Laguna del Maule Volcanic Complex. The user can choose to display the location on a SAR amplitude image (main map and lower left zoom), a Google map view (lower center) or Google Earth (Lower right).*

### 8.5.d) Differential time series of pre-defined pairs of pixels

Below are displayed the corresponding double difference time series of ground displacement at pre-defined pairs of points in UD & EW without coherence threshold, UD & EW with a coherence threshold (if applicable), and in both LOS (Figure 39).

To the left of the panel, pixels are located on an amplitude image (which can be changed to Google Map or Google Earth). For each pair, the point used as the reference is displayed in yellow and the “moving” point is displayed in white. The double difference is computed as the moving minus the reference point (i.e. values at the white point minus the values at the yellow point).

To help the reader to interpret the time series plot and understand the physical direction of the observed relative ground displacement, small explanatory sketches and location of points on the corresponding linear rate deformation maps are also plotted on the side of the time series graphs, best seen on the full-size plot obtained by clicking on the corresponding time series (Figure 40).



*Figure 39: Web page sample showing some automatically generated double difference time series of ground deformation spanning 2015 – 2021 for pairs of points at Laguna del Maule (above). For each pair of points, UD-EW graph shows Up-Down (green) and East-West (blue) displacement and Line of Sight (LOS) displacements for Ascending and Descending orbits. Clicking on these plots allows enlarged view with detailed information about direction of displacement. Note that in the present case the processing automatically rejects pairs of low coherence measured on Laguna del Maule region (see second column of graphs). It results that several images do not contribute to time series (compared to first column), such as those acquired during the Austral Winter.*

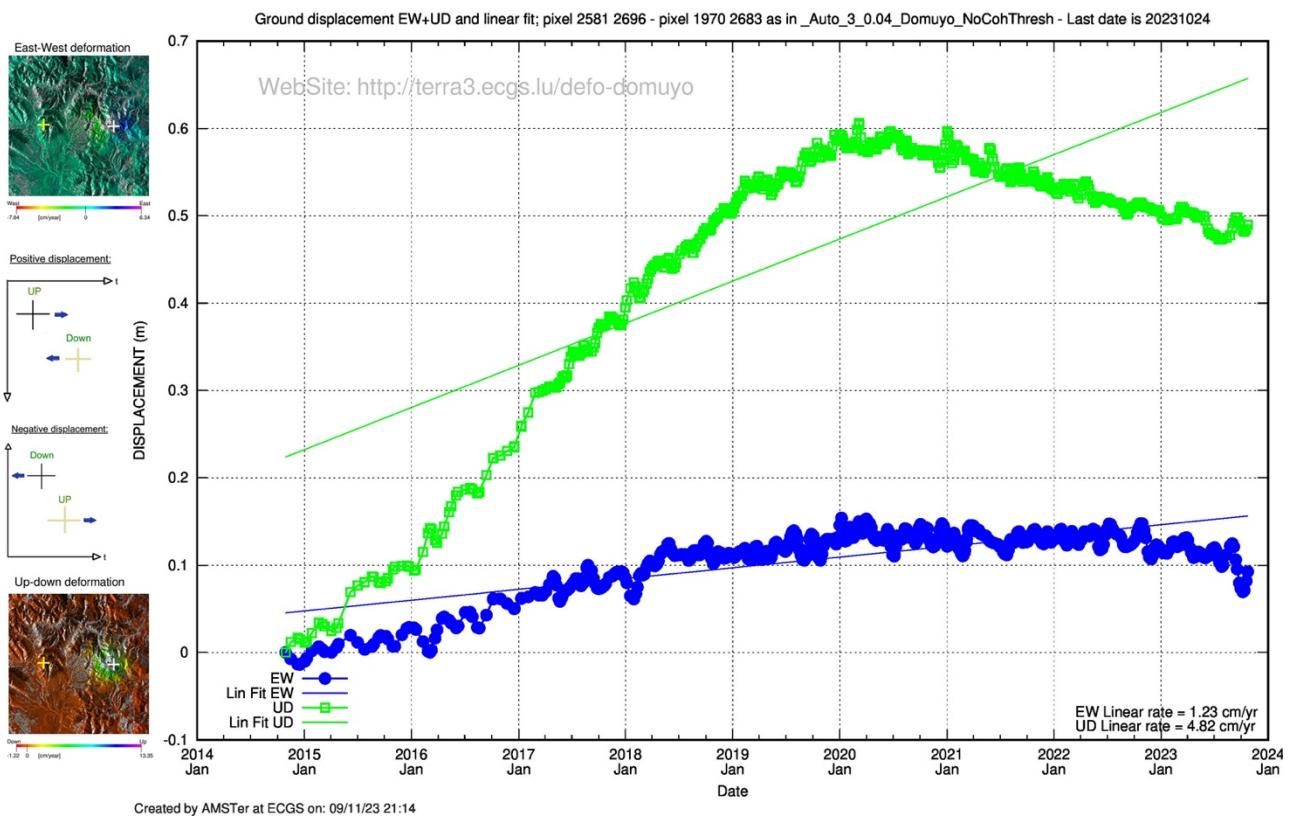


Figure 40: Zoom obtained by clicking on a graph from the web page. In the present case it shows the double difference of pixels located to the West and the summit of Domuyo volcano. See location on the insets to the left. Small sketch also explains the direction of displacement. A linear fit is displayed as a straight line and value of the mean annual rate is provided in the lower right of the picture (in cm/yr).

However, if the user wants to have a look at points that are not in the pre-defined list of points of interest, and hence displayed on the web page, see section 8.5.e).

### 8.5.e) Differential time series on demand

By clicking on the button “Calculate Time series” at the top of the page opens a new section that allows to select new points on a map and create its own time series plots (Figure 41).

The user can first select which layer to display by clicking on the small layers’ icon in the upper right corner (LOS Asc, LOS Desc, UP-DWN and/or EW). These layers can be displayed on the Google Earth image (terrain) or Google Map (relief). Amplitude Asc and Desc can also be displayed.

Note that the results of all the time series will be provided (LOS Asc, LOS Desc, UP-DWN and EW), whatever the layers were displayed (providing of course that the pixels are coherent for each mode).

One can zoom in and out in the map either by scrolling with the mouse or by clicking on the “+/-” icons in the upper left corner. To move laterally or vertically the map, click and grab the map while moving the mouse.

To select the points for the double difference, 3 options are possible:

- 1) Move the blue pins that are displayed on the map where you want your pixels. You can see **the position of the pixels in number of lines and columns in the light grey text lines below the map. Latitude and Longitude is also displayed there.**
- 2) If you know the position of the pixels in number of lines and columns, these coordinates can be manually entered in the small boxes below the map.
- 3) Similarly, the position of the pixels in decimal latitude and longitude can be manually entered in the small boxes below the map.

The user can move the points as much as wanted before submitting the time series request. Keeping the mouse inactive on a pin will display “Point A” or “Point B” for the user convenience in order to select the most appropriate order of double difference.

User can also change the time span of the desired time series.

To receive the figures with the selected differential time series, the user must provide a name for the request (to be chosen smartly at the user best convenience in order to conveniently remember what was requested) and must provide its e-mail address.

#### Notes:

- 1) To receive the double difference time series by email, the two pixels must be located in a coherent region.
- 2) It may happen that one of the pixels selected by the user is only coherent in Ascending or Descending orbit. In that case, the user will only receive the results in that coherent component.

Clicking on the orange button “Submit Time Series request” opens a new box summarizing the request while the server prepare the data and send the plots. **Check that box carefully!** If a pixel is located in a decorrelated region both in Asc and Desc, no time series will be computed and the user will receive no mail.

Plots are delivered by email within one or two minutes. If mail does not arrive, please check your spams.

Server will refuse another request while the first one is still processed.

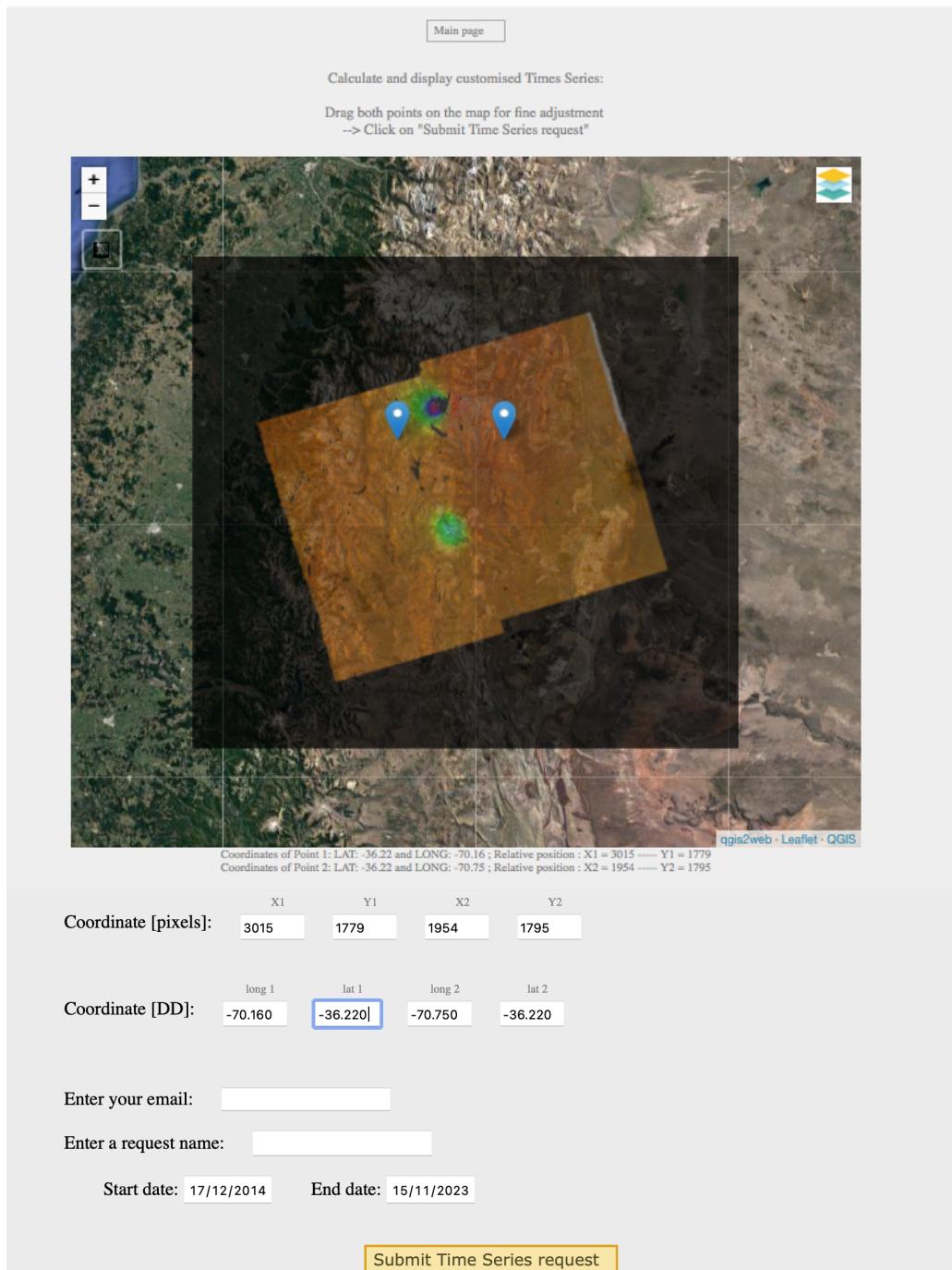


Figure 41: Example of time series request. User must select the 2 pixels (see procedure in main text), select the layers, select the time span, provide a name for the request (optional) and an email address where to receive the plots. Check the box that opens after submitting the request. It summarizes the request and warns the user if request is invalid (and hence no plot will be sent).

Note the small measurement tool in the upper left corner: it allows to click on the map and see the coordinates and distances between the points.

### 8.5.f) Display specific interferograms and coherence map on demand

By clicking on the button “Interfero Creation” at the top of the page opens a new section that allows to display specific wrapped interferograms in Line of Sight. This can be done by selecting first the Primary or Secondary image using dedicated grey buttons above the map (Figure 42).

The user must select first the satellite, then the orbit, then the dates using the menus. Note that to select the value that is displayed by default on the scrolling menu requires to click on Submit button. Selecting another a value form the scrolling menu directly jumps to the next thing to select (no need to click “Submit”).

When all parameters are selected, a last page summarizing the information is displayed. If satisfied, click “Submit”. If not, get back or cancel.

Displaying the wrapped interferogram may take one or two minutes (Figure 43). Note that coherence map is also available by clicking on the layer icon in the upper right corner.

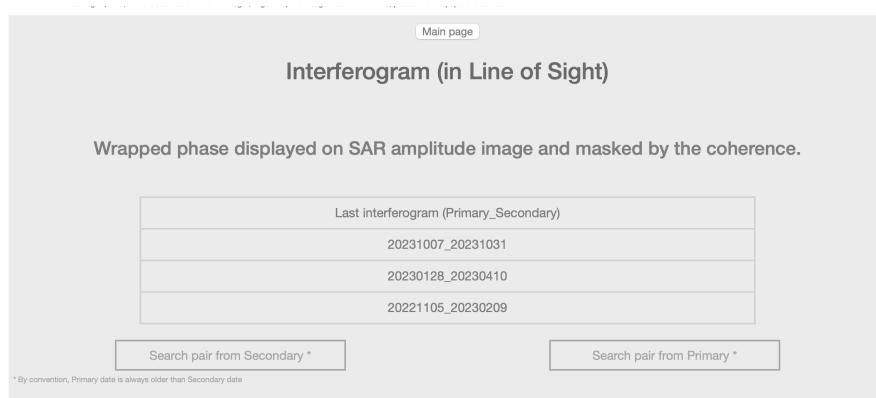


Figure 42: Web page displaying the beginning of the procedure for displaying wrapped interferogram on demand.



Figure 43: Example of wrapped interferogram on demand (left). Coherence map can also be displayed by clicking on the layer icon in the upper right corner (right).

### 8.5.g) Display specific deformation map on demand

By clicking on the button “Delta Deformation” at the top of the page opens a new section that allows to display specific deformation maps in EW, UD or LOS. This can be done by selecting first the deformation direction (EW, UD, Asc LOS or Desc LOS) using dedicated grey buttons above the map (Figure 44)

The user must first select the two dates. The most recent dates are already suggested by clicking on the layer icon in the upper right corner but any date can be otherwise chosen with the “Choose date” boxes. Note that it is not mandatory to combine images acquired in the same geometry because this is based on displacement maps resulting from MSBAS inversion, hence the user can combine any dates).

When satisfied with choices, click “Calculate differential deformation map (date 1 – date 2)”.

Displaying the deformation map may take one or two minutes (Figure 44)

Note again the small measurement tool in the upper left corner: it allows to click on the map and see the coordinates and distances between the points.

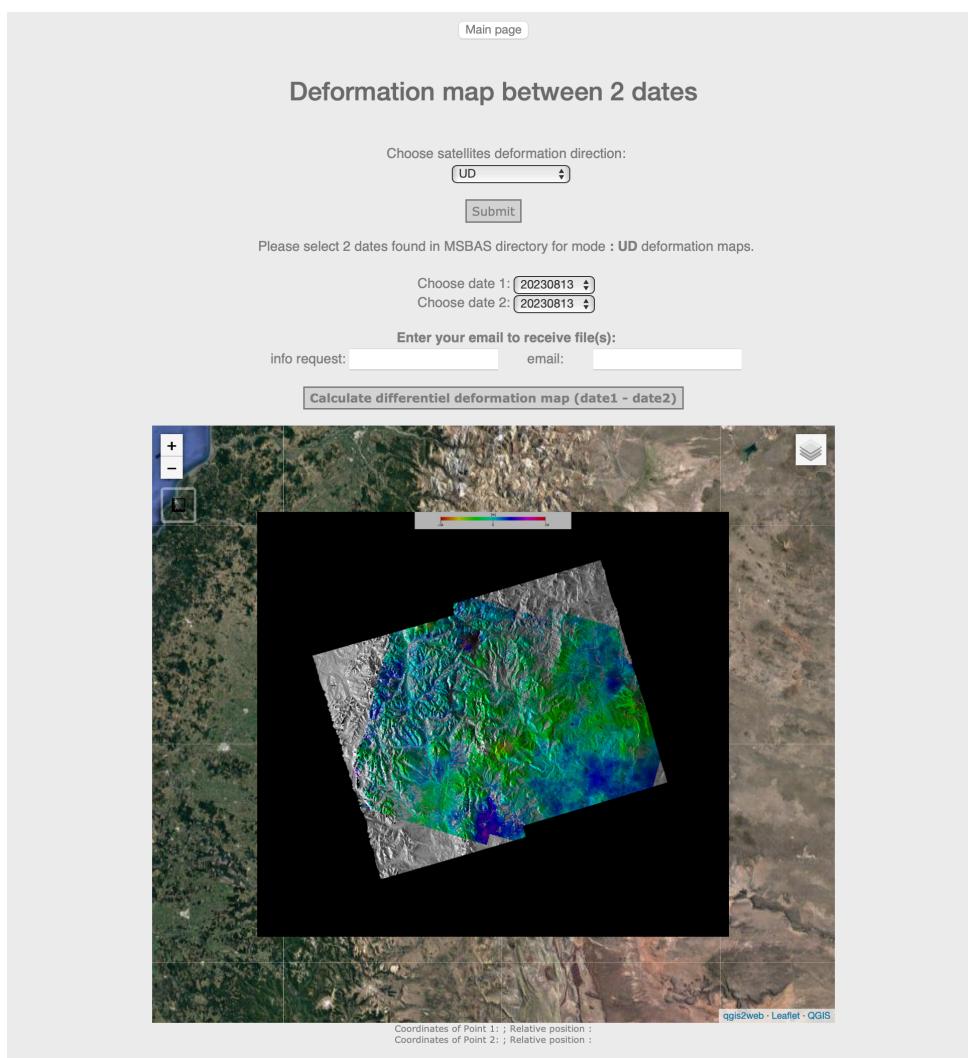


Figure 44: Deformation map on demand.

### 8.5.h) Display time-baselines plots

By clicking on the button “Baseline Plot” at the top of the page opens a new section that allows to display the baseline plots for each mode (Figure 45): Ascending and Descending orbits, with and without coherence threshold restriction (if applicable).

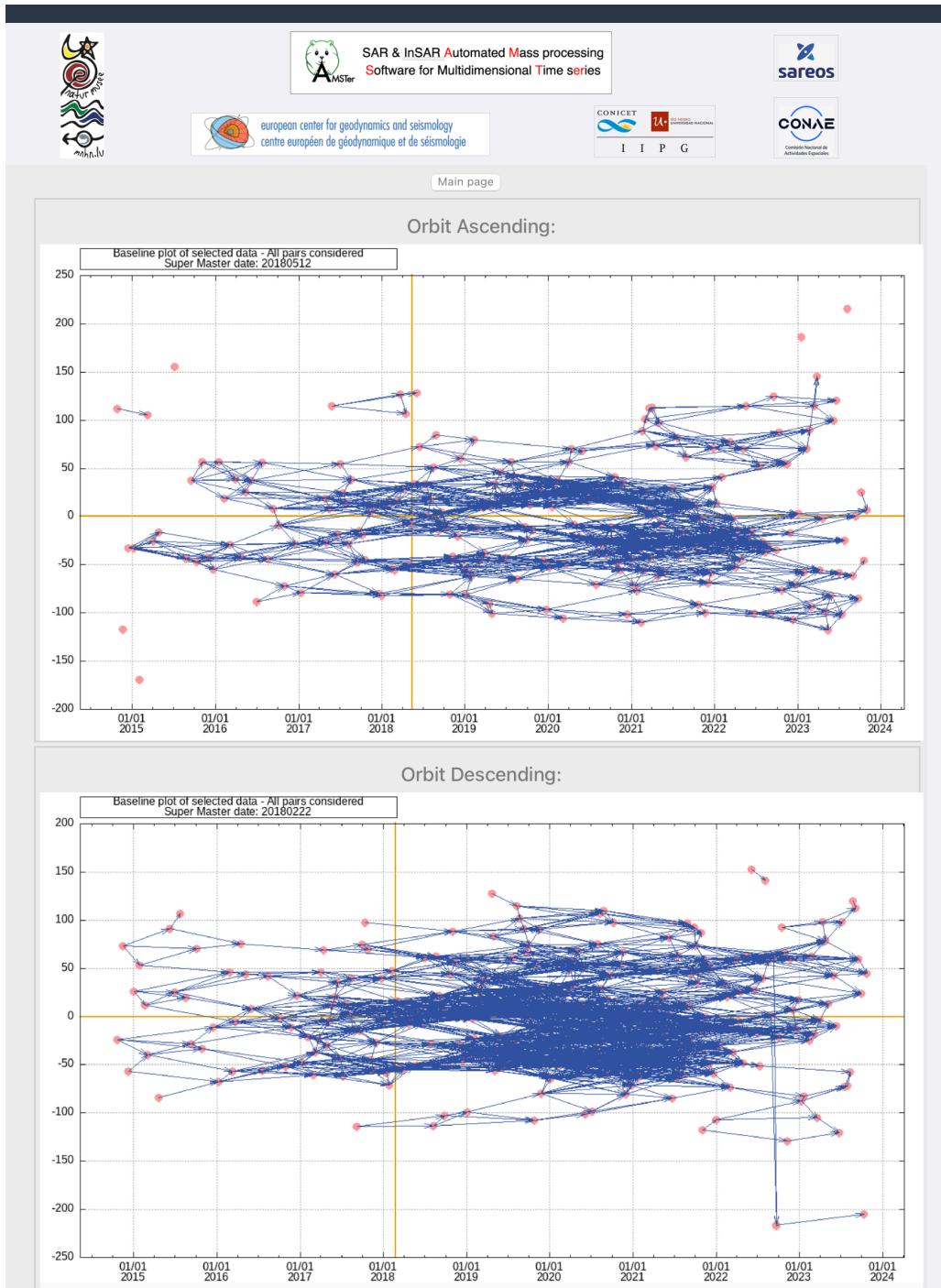


Figure 45: Example of baselines plot for Domuyo volcano region.

### 8.5.i Display RGB coded amplitude changes

By clicking on the button “RGB images” at the top of the page opens a new section that allows to create and visualize RGB composition with amplitude of Primary image as Green, amplitude of Secondary image as Red and coherence as Blue.

For details about RGB composition, see [Web\\_tool\\_Vxx.pdf](#) by Maxime Jaspard.

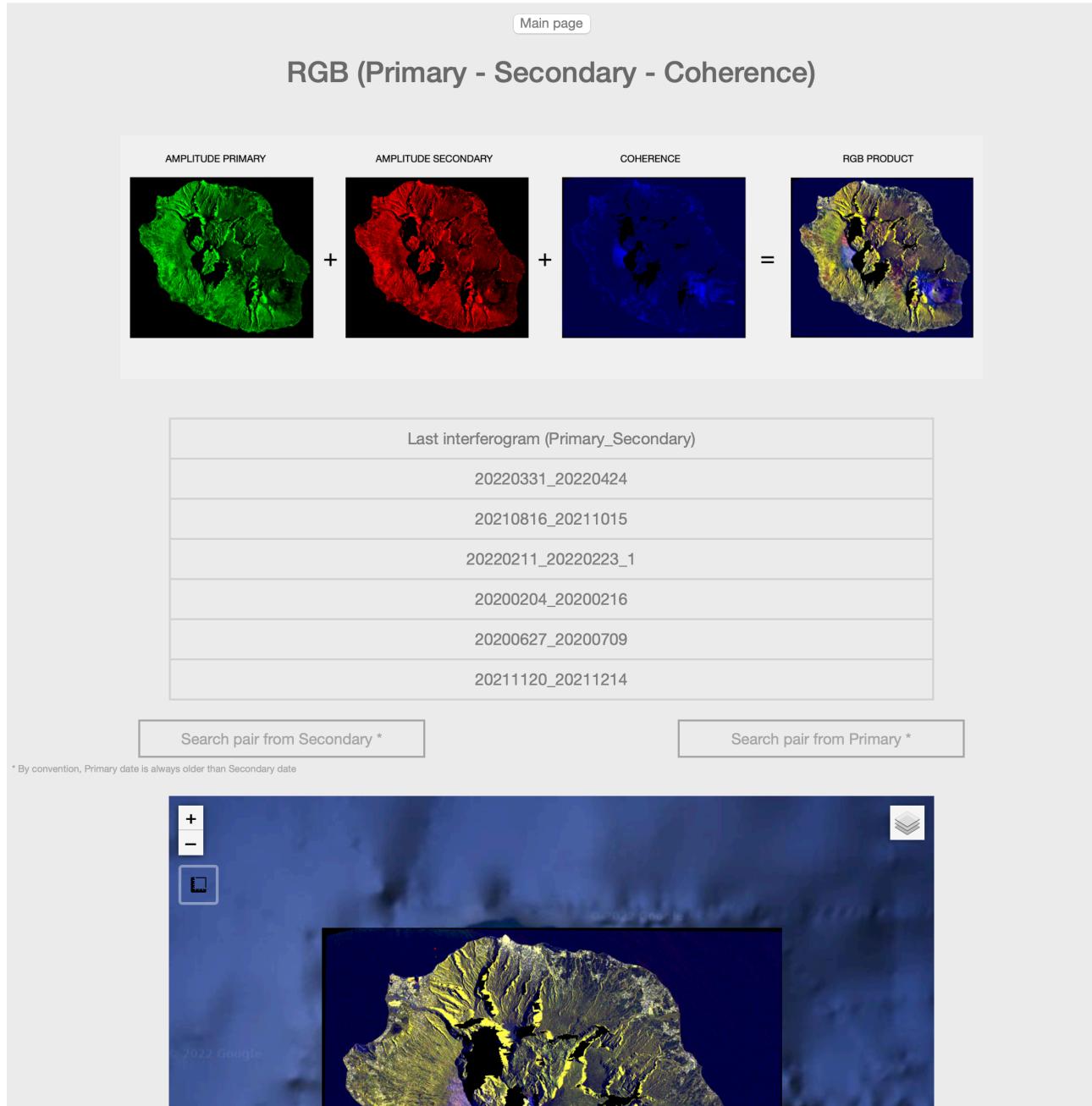


Figure 46: Example of RGB image for Réunion Island.

### 8.5.j) Display Deformation Linear Rate Standard Deviation

By clicking on the button “Defo linear rate STD” at the top of the page opens a new section that allows to create and visualize maps of Standard Deviation of the Deformation Linear Rate.

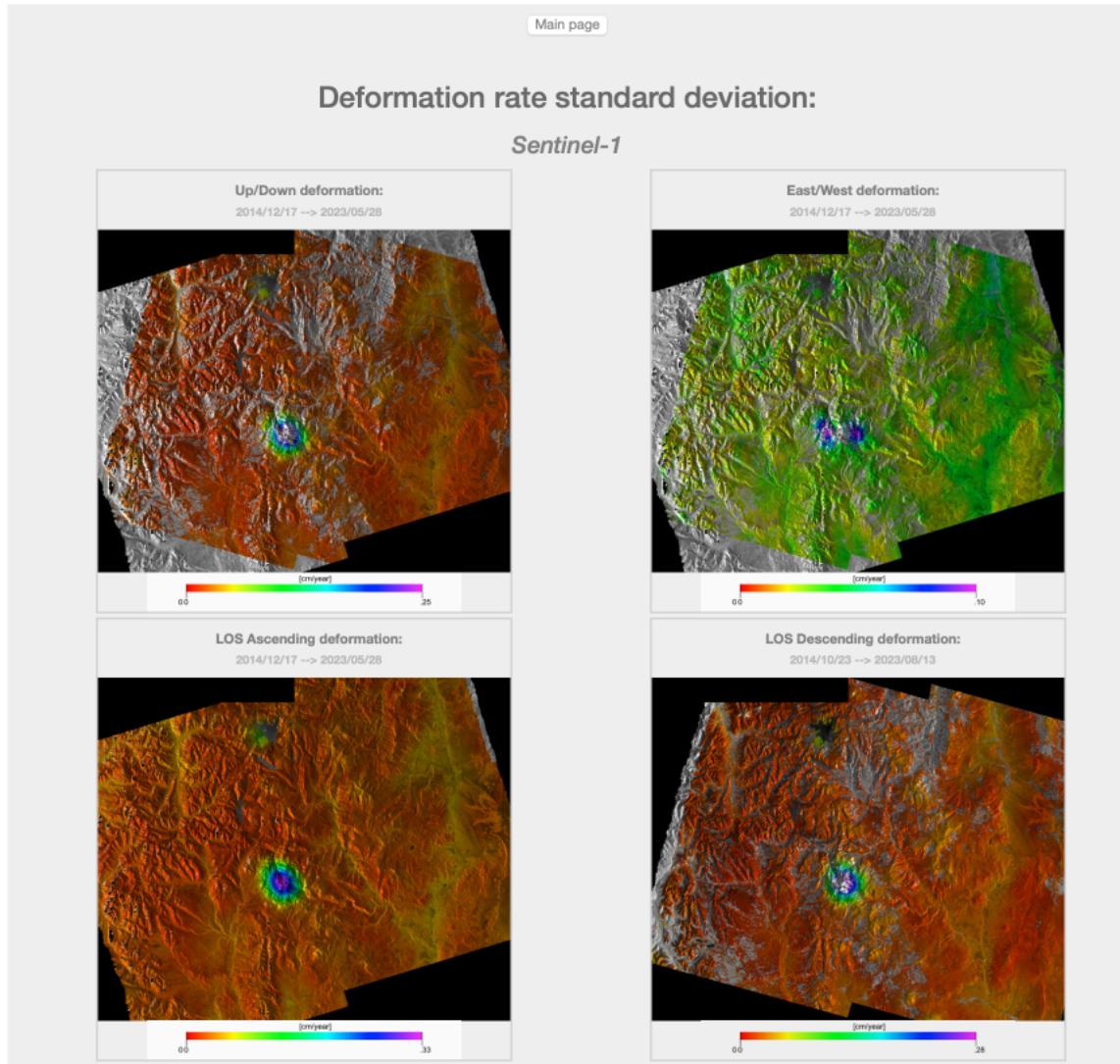


Figure 47: Example of maps of Standard Deviation of the Deformation Linear Rate (Domuyo – Laguna Del Maule region).

## 9. Useful additional scripts:

The following scripts are also stored in `SCRIPTS_MT` or `zz_Utilities_MT` or even `zz_Utilities_MT_Ndo`. Some haven't been used for a while. In any case, these scripts can be of interest at some point. Use with care. Read carefully at least the header of the scripts. It is strongly advised to check first these scripts before launching them.

### 9.1) Changing path in Parameters test files:

Because scripts are run on several computers, sometimes operated under different OS, it happens that the external hard drives are mounted differently. As a consequence, the results obtained from the processing performed on these different computers are accompanied by parameters files where path may not be understood by the other computers. The following scripts allow to rename these paths. Note that the details about the renaming is hard coded in `_HardCodedLines.sh`.

See scripts (in `SCRIPTS_MT/zz_Utilities_MT_Ndo`) for usage:

- **`RenamePath_Volumes_MNTtoVOL.sh`**,  
which transforms paths such as `/mnt/1650` in `/hp-1650-Data_Share1`
- **`RenamePath_Volumes_VARtoMNT.sh`**  
which transforms paths such as `$PATH_1650` in `/mnt/1650`
- **`RenamePath_Volumes_VARtoVOL.sh`**  
which transforms paths such as `$PATH_1650` in `/hp-1650-Data_Share1`
- **`RenamePathInPlace_Volumes_VOLtoMNT.sh`**  
which rename IN PLACE (in various parameters text files) external HD path such as `Volumes/hp-1650-Data_Share1` (from OSX) in `mnt/1650` (from Linux). This may have an interest when processing data prepared on a computer using another OS

See also (in `SCRIPTS_MT`):

- **`RenamePath_Volumes.sh`**  
which transforms paths such as `/mnt/1650` or `/hp-1650-Data_Share1` in `$PATH_1650`
- **`RenamePath_AfterMove.sh`**  
which renames path of files in `InSARParameters.txt` after moving them from where they were computed to where the mass processing wants them to be stored. Need to be run in dir where all `/PRM_SCD/i12/TextFiles/InSARParameters.txt` were moved, e.g. `.../SAR_SM/RESAMPLED/SAT/TRK/CROPDFIR/`
- **`RenamePathAfterMove_in_SAR_MASSPROC.sh`**  
which renames path of files in TextFiles in PAIR DIRS in `SAR_MASSPROCESS` after having moved them from where they were computed. Need to be run in dir where all `.../SAR_MASSPROCESS/.../i12/TextFiles/InSARParameters.txt` were moved, e.g. `.../SAR_MASSPROCESS/S1/DRC_VVP_A_174/SMNoCrop_SM_20150310_Zoom1_ML8`

See also (in `SCRIPTS_MT/zz_Utilities_MT`):

- **`RenamePathCropSM.sh`**  
which rename path of files in `InSARParameters.txt` that were computed with CSL images stored in dir named by SM instead of normal name (e.g `.../SAR CSL/CSK/Virunga_Desc/SMCrop_SM_20160105_NyigoCrater_-1.510--1.560_29.280-29.330_Zoom1_ML8` instead of `.../SAR CSL/CSK/Virunga_Desc/Crop_NyigoCrater_-1.510--1.560_29.280-29.330_Zoom1_ML8`). Attention, the input must contain enough info (SAT/TRK) to avoid confusion. Parameters are the beginning of existing dir name and the beginning of wished dir name

- ***UpdateLinkAfterMove.sh***  
Which updates link of S1 resampled files in INPUTDATA/ after moving them from where they were computed to where the mass processing wants them to be stored. Need to be run in dir where all `/PRM_SCD/i12/InSARProducts` were moved (i.e. OUTPUTDATA), e.g. `.../SAR_SM/RESAMPLED/SAT/TRK/CROPDIR/`
- ***UpdateLinksInMassProc.sh***  
which updates all path in all type of parameters file (including bestPlaneRemoval.txt) for a given pair. Need to be run in dir PRM\_SCD where `i12/InSARProducts` are stored.

See also (in `SCRIPTS_MT/zz_Utilities_MT_Ndo`):

- ***RenamePathAfterMove\_in\_SAR\_SM\_AMPLITUDES.sh***  
which renames (in parameters text files) the path of files in TextFiles in PAIR DIRS in `SAR_SM/AMPLITUDES` after having moved them from where they were computed. This may have an interest in case of geocoding in `SAR_SM/AMPLITUDES` directories.

## 9.2) Updating links if point toward disks mounted on Mac or Linux:

This script update links that are correct except for the two first directories levels (which are the external mounted disk that we want to change).

Example: suppose that we have links in `MSBAS/sat/crop/Defomode/` that points toward

`/Volumes/hp-D3601-Data_RAID6/SAR_MASSPROCESS/sat/crop/Geocoded/Defomode` (i.e. computed on Mac), but we need to run it from a computer where `$PATH_3601` is `/mnt/1650` instead of `/Volumes/hp-D3601-Data_RAID6`, that in a disk mounted from Linux.

The script will change all the links to that new mount point. It is used for instance in some versions

See script (in `SCRIPTS_MT/zz_Utilities_MT_Ndo`) for usage:

**Update\_links\_Mac\_vs\_Linux.sh**

## 9.3) Removing or repairing links:

The script ***Remove\_BrokenLinks\_and\_Clean\_txt\_file.sh*** will remove broken links from `.../MSBAS/Site/MODEi` and clear corresponding text file `.../MSBAS/Site/MODEi.txt`

The script ***Remove\_BrokenLinks.sh*** only removes broken links in a given directory.

The script ***Rebuild\_Ins.sh*** search for all files with a name containing a string (parameter 1) in the current directory. For each one, it checks that the file is a link and that it points toward an existing file in a target directory (parameter 2). If it fails but the file exists in that target directory, it will rebuild the link. If not, it will tell the user that the target file does not exist.

The script ***Rebuild\_Ins\_Ampli.sh*** aims at rebuilding links to amplitude files in all pairs directories in current directory (usually `SAR_SM/AMPLITUDES/SAT/TRK/REGION/`) after the original file were moved to `_AMPLI`. It also remove possible wrong .ras and .sh links resulting from usage of wrong ***Cp\_Ampli.sh*** V2.0.

The script ***Rebuild\_Ins\_CSK.sh*** recreates the links for CSK images from ***.../SAR\_CSR/CSK/Region\_Mode/NoCrop*** to ***.../SAR\_CSR/CSK/Region***. It takes into account the possible occurrence of multiple images acquired on the same day.

See scripts for usage:

- ***Remove\_BrokenLinks\_and\_Clean\_txt\_file.sh*** (in ***SCRIPTS\_MT***)
- ***Remove\_BrokenLinks.sh*** (in ***SCRIPTS\_MT/zz\_Utilities\_MT***)
- ***Rebuild\_Ins.sh*** (in ***SCRIPTS\_MT/zz\_Utilities\_MT***)
- ***Rebuild\_Ins\_Ampli.sh*** (in ***SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo***)
- ***Rebuild\_Ins\_CSK.sh*** (in ***SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo***)

#### 9.4) Moving results from SinglePair.sh into SAR\_MASSPROCESS or from MassProcess pairs to Geocoded

Use this script if you processed a pair with ***SinglePair.sh*** and want to add these results to your mass processing directories as if it was computed by a normal ***SuperMaster\_MassProcess.sh***, providing that the ***SinglePair.sh*** was performed with geocoding on the **SAME Global Primary (SuperMaster)** as what already exists.

The script ***Move\_SinglePair\_Results\_To\_MASSPROCESS.sh*** renames and moves the geocoded results from a ***SinglePair.sh*** processing in the appropriate directories and subdirectories of a mass processing, i.e. in

***.../SAR\_MASSPROCESS/SAT/REGION/SMCrop\_Zoom\_ML/Geocoded/...,***  
***.../SAR\_MASSPROCESS/SAT/REGION/SMCrop\_Zoom\_ML/GeocodedRasters/...***

and move the directory with the rest of the processing in

***.../SAR\_MASSPROCESS/SAT/REGION/SMCrop\_Zoom\_ML/***

The script ***Move\_MassProcessPair\_Results\_To\_Geocoded.sh*** aims at moving the geocoded results from a ***SuperMaster\_MassProc.sh*** and that would be still located in a pair directory, that is ***SAR\_MASSPROCESS/SAT/TRK/SMCrop.../PRM\_SCD/i12/GeoProjection*** to where it was supposed to be, that is

***SAR\_MASSPROCESS/SAT/TRK/SMCrop.../Geocoded/... directories.***  
It also copies the corresponding rasters in ***/GeocodedRasters***.

See script for usage:

- ***Move\_SinglePair\_Results\_To\_MASSPROCESS.sh***
- ***Move\_MassProcessPair\_Results\_To\_Geocoded.sh***  
(in ***SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo***)

## 9.5) Reprocessing unwrapping and/or geocoding and/or detrending after MassProcessing:

- For the unwrapping of all the given products from a list of pairs:  
See script for usage: **ReUnwrap\_fromList.sh** (in **SCRIPTS\_MT**)

Note: as for the other reprocessing scripts below, it is advised to run first **RenamePathAfterMove\_in\_SAR\_MASSPROC.sh** in order to update the path in the parameters file.).

Pair list must be in the form of

YYYYMMDD\_YYYYMMDD, or  
S1imageDateFormat\_S1imageDateFormat

After running **ReUnwrap\_fromList.sh** you can of course run the scripts below to re-process the next steps.

- For the geocoding of all the given products from a list of **PAIR DIRS** in **SAR\_MASSPROCESS** :  
See script for usage: **ReGeocode\_fromList.sh** (in **SCRIPTS\_MT**)
- For reprocessing all steps from Detrend (included) till geocoding and renaming:  
See script for usage: **ReRunFromDetrend.sh**  
(in **SCRIPTS\_MT/zz\_Utils\_MNdo/Need\_testing\_and\_update**)
- For reprocessing the interpolating of **SAR\_MASSPROCESS/Geocoded/DefolInterpolDetrend** images and store them in **SAR\_MASSPROCESS/Geocoded/DefolInterpolx2Detrend**:  
See script for usage: **Interpol\_From\_Geocoded\_DefolInterpolDetrend.sh**  
(in **SCRIPTS\_MT/zz\_Utils\_MNdo**)
- For reprocessing the detrending and interpolation of **SAR\_MASSPROCESS/Geocoded/Defo** images and store them in **SAR\_MASSPROCESS/Geocoded/DefolInterpolDetrend** and **/DefolInterpolx2Detrend** although they will be missing the first interpolation (i.e. before geocoding):  
See script for usage: **Detrend\_From\_Geocoded\_Defo.sh**  
(in **SCRIPTS\_MT/zz\_Utils\_MNdo**)
- For geocoding the snapuZoneMap (obtained with unwrapping the interferogram with the option ZONEMAP set to ZoneMapYes), one must use the script **GeocSnapuZoneMap.sh**. It tricks AMSTerEngine by asking to unwrap again the coherence while the coherence file is actually the snapuZoneMap, which was renamed and transformed into float (using **byte2float.py**).

There is another version named **GeocSnapuZM\_and\_corr.sh** which also geocodes the manually corrected unwrapped phase and deformation map (maybe detrended as well). These corrections must be so far performed using Matlab tool such as developed by Delphine Smittarello. Final geocoded products are renamed with long names as all the other geocoded products.

- See scripts for usage (in **SCRIPTS\_MT/zz\_Utils\_MNdo**):
- **GeocSnapuZoneMap.sh**
  - **GeocSnapuZM\_and\_corr.sh**

- For geocoding the slantRangemask, one must use the script ***GeocodeMask.sh***. It is supposed to tricks AMSTerEngine by asking to unwrap again the interferogram while it is actually the slantRangemask. Note however that this **version is old and MUST be revised** (see for instance errors in float to byte conversion), but it must be straight forward. See script in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**.
- For geocoding a series of files (e.g. time series of amplitudes to geocode after a pixel tracking processing), one must use the script ***ReGeocode\_AmpliSeries.sh***. The script must be launched from the pair directory where at least one of the original products was computed. It expects all the files to (re-)geocode to be in **/InSARProducts** and have the same size as the original products. The name of all the files to geocode **MUST** start by the string "**REGEOC.**" (**note the dot!**). It will geocode all and only the files with a name starting that string and store the results in **/GeoProjection** directory as usual and create raster quick looks. It will perform the geocoding based on the criteria provided in the **LaunchMTparam.txt** file as usual. See script for usage (in **SCRIPTS\_MT/zz\_Utilities\_MT**).

## 9.6) Reprocessing unwrapping and/or geocoding and/or detrending after **SinglePair.sh**:

- For unwrapping again an interferogram computed using the ***SinglePair.sh*** processing, and interpolate and detrend again the results if required, see script ***ReUnwrap\_SinglePair.sh***.

Former unwrapped phase is saved as **unwrappedPhase\_LongName.bak**.

If you have enough room on your disk, it might be wise to duplicate the directory where you will re-process the unwrapping(s).

From there, you can then run a ***ReGeocode\_SinglePair.sh*** if required (see below).

Because this script will need information from several text files containing the information about the processing, it requires to be run in the same directory and with the same type of computer (Mac or Linux) as the one where ***SinglePair.sh*** was performed.

Note that this procedure was only tested for S1 so far, and not in STRIPMAP !!!!

- For geocoding again the products computed using the ***SinglePair.sh*** processing, and interpolate again the deformation maps if required, see script ***ReGeocode\_SinglePair.sh***.

This script must be run in the directory where ***SinglePair.sh*** was run. It takes as parameter the type of interpolation: "BEFORE", "AFTER", "BOTH" or "NONE".

It contains a hard-coded list of products to geocode. Note that it skips the geocoding of **amplitude** if it exists. You can however force it again by editing the script (around lines 177-186).

Note that **Incidence** angle map is geocoded by default if present in **InSARProducts**. If you do not want to re-geocode it, it must be renamed temporarily. For this, let the script know by adding an additional **NO** at the hardcoded list of geocoded files.

Note: only verified for interpolation BOTH and with detrend !

The script was only tested for S1 so far and not in STRIPMAP !!!!

- For geocoding the unwrapped phase resulting from a ***SinglePair.sh*** processing that was unwrapped again manually e.g. by iterative procedure (such as proposed e.g. by J.L. Froger and Y. Fukushima), see script ***ReGeocode\_ManuallyUnwrapped\_SinglePair.sh***. It will also detrend and/or interpolate the deformation map if required. This script must be run in the directory where ***SinglePair.sh*** was run.

The script expects:

- in **/InSARProducts**, the Unwrapped phase (e.g. from MATLAB or python code) named as **unwrappedPhase** (without polarizations). **InSARParameters.txt** must be updated accordingly.
- the number of lines and columns of Unwrapped file issued by the MATLAB (or python) code IS ALWAYS even. If these numbers in the original file were not the even, **InSARParameters.txt** must be updated accordingly.

Note that before reprocessing the phase-to-height conversion and geocoding, the former results are moved in a directory one level above **/InSARProducts** and **/GeoProjection** named **/ORIGINAL**. The script reads again the **LaunchMTparam.txt** file to assess how to re-geocode. Size of pixel and/or method of geocoding can hence be changed. It can also geocode it forced on a **kml** file.

Note: only verified for interpolation BOTH and with detrend !  
The script was only tested for S1 so far and not in STRIPMAP !!!!

See scripts for usage (in **SCRIPTS\_MT**):

- ***ReUnwrap\_SinglePair.sh***
- ***ReGeocode\_SinglePair.sh***
- ***ReGeocode\_ManuallyUnwrapped\_SinglePair.sh***

## 9.7 Detecting and cleaning duplicate Geocoded and GeocodedRasters products:

Duplicate products may happen in **/Geocoded/Mode** and **/GeocodedRasters/Mode** (where **Mode** is e.g. DefolInterpolx2Detrend) when a pair is reprocessed with updated orbit with resulting slightly different Bp for instance.

**Remove\_Duplicate\_Pairs\_File.sh** looks for duplicated products in directories based on pair of dates that is in the name. It then offers to interactively delete the oldest version of duplicated files, or delete them without warning if you are brave enough (USE WITH CARE), or safer, to move them in **SAR\_MASSPROCESS/.../Geocoded/Mode/\_Duplicated\_ToKill/**.

The script must be launched in the Mode directory that need to be cleaned, i.e.

**SAR\_MASSPROCESS/.../Geocoded/Mode**

**Remove\_Duplicate\_Pairs\_File\_ras.sh** looks for duplicated raster products in directories based on pair of dates that is in the name. It then offers to interactively delete the oldest version of duplicated files, or delete them without warning if you are brave enough (USE WITH CARE), or safer, to move them in

**SAR\_MASSPROCESS/.../GeocodedRasters/Mode/\_Duplicated\_ToKill/**.

The script must be launched in the Mode directory that need to be cleaned, i.e.

**SAR\_MASSPROCESS/.../GeocodedRasters/Mode**

Note that **Remove\_Duplicate\_Pairs\_File.sh** and **Remove\_Duplicate\_Pairs\_File\_ras.sh** do not allow to clean **Ampli** mode because Primary and Secondary images can be geocoded within the same pair.

**`Remove_Duplicate_Pairs_File_All_Modes_But_Ampl.sh`** look for duplicated products in all `Mode` directories (but `Ampli`) based on pair of dates that is in the name (i.e. `/Geocoded/Mode` and `/GeocodedRasters/Mode`). It then moves them in `__Duplicated_ToKill` in each corresponding `Mode`.

**`_Remove_All_Files_With_PairDate_Bp.sh`** deletes all files (deg, deg.hdr and ras) in `MSBAS/region/DefolInterpolDetrendi(Full)` and its texts and in `/Geocoded/Mode` and `/GeocodedRasters/Mode` for given pairs of date and for a given Bp. DO NOT USE IT ON GEOCODED AMPLITUDE IMAGES because PRM and SCD images can be geocoded within the same pair.

See scripts for usage: **`Remove_Duplicate_Pairs_File.sh`**

**`Remove_Duplicate_Pairs_File_ras.sh`**

**`Remove_Duplicate_Pairs_File_All_Modes_But_Ampl.sh`**

**`_Remove_All_Files_With_PairDate_Bp.sh`**

(in `SCRIPTS_MT/zz_Utils_MT_Ndo`)

Note:

there are also old scripts **`Check_Duplicate_Geocoded.sh`** and **`CompareGeocodedDates.sh`** (in `SCRIPTS_MT/zz_Utils_MT_Ndo`).

Not sure what the first one is doing (must be verified...) but the second one checks in each Mode (but the Ampli) that files exist in `/Geocoded` and `/GeocodedRasters` with the same dates. It may not be with the same Bt, Bp, ha etc... though. Those two are **old stuffs and must be taken with care**.

See also **`Verify_MassProcess_Results.sh`** and **`Verify_Geocoded_versus_Rasters.sh`** (in `SCRIPTS_MT`) at chapter 5.6.

## 9.8) Checking DefolInterpolx2Detrend.txt:

The script **`_Check_bad_DefolInterpolx2Detrend.sh`** look for bad file names (pointing toward nonexistent files) in `DefolInterpolx2Detrend.txt` prepared for MSBAS processing. This may result from crashes in MSBAS preparation or cleaning from update of S1 orbits.

It also checks for duplicated lines in `DefolInterpolx2Detrend.txt`. Indeed, it may happen that after updating Primary and/or Secondary orbits of S1 data, file name might be the same but col 2 (Bp) might differ while it provides the value with more digits.

See script for usage (in `SCRIPTS_MT`): **`_Check_bad_DefolInterpolx2Detrend.sh`**

## 9.9) Creating a table with PRM SCD Bp Bt Coh from files in /Geocoded

The script **`Baseline_Coh_Table.sh`** is aiming at making a table PRM SCD Bp Bt Coh from all the files that are in `../SAR_MASSPROCESS/..Geocoded/Coh`

named **`Baseline_Coh_Table_KMLNAME.txt`** and where `KMLNAME` is the name of the kml file defining the footprint where to compute the average coherence (Coh). The first time this script is launched, it can be very slow if the number of images where to compute the mean coherence is large. However, the process is incremental and it is faster at next runs as it will only compute the coherence from the new pairs.

Note that there is a python script named [Analyse\\_BaselineCoh\\_data.py](#) that helps analysing the [Baseline\\_Coh\\_Table\\_KMLNAME.txt](#) (Figure 48):.

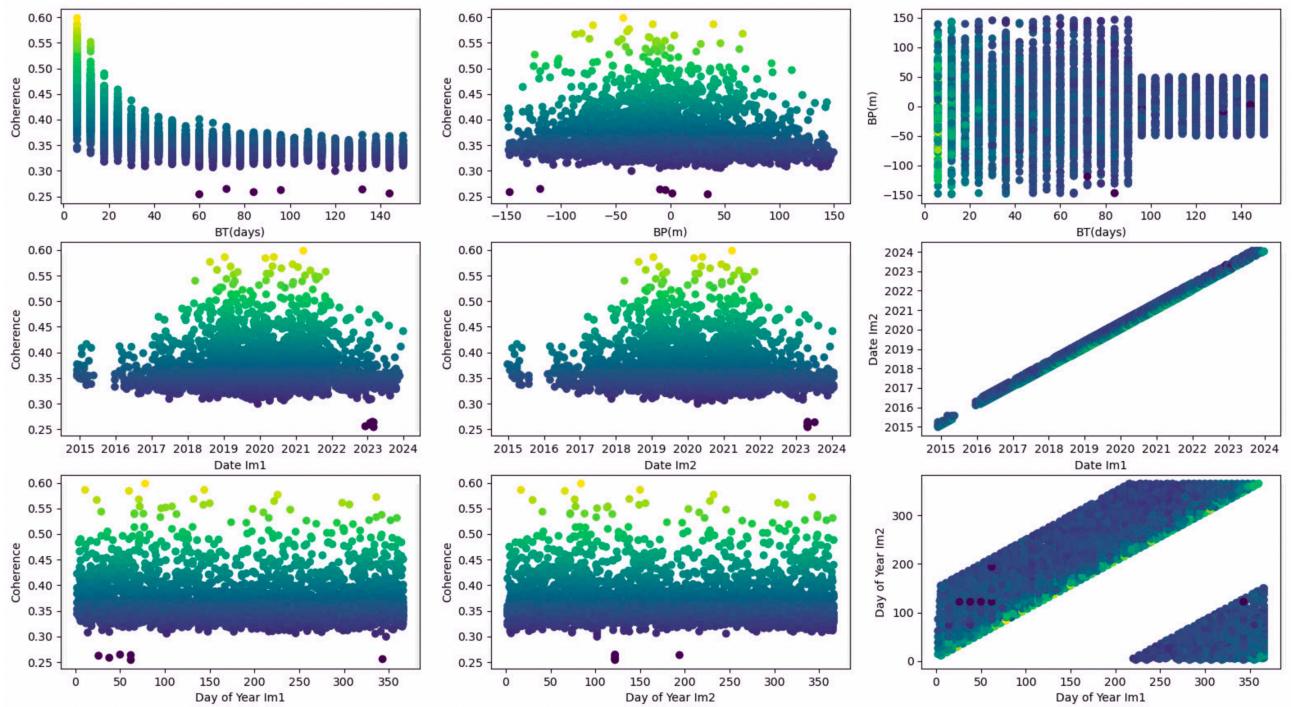


Figure 48: Example of output from [Analyse\\_BaselineCoh\\_data.py](#): The scripts, which only take as parameter the full path to [Baseline\\_Coh\\_Table\\_KMLNAME.txt](#), displays several plots with respectively:

1. The mean coherence computed in area defined by the file [KMLNAME](#) versus the temporal baseline,
2. The mean coherence computed in area defined by the file [KMLNAME](#) versus the spatial baseline,
3. The spatial baseline versus the temporal baseline and the colour coded mean coherence,
4. The mean coherence computed in area defined by the file [KMLNAME](#) versus the date of the Primary image,
5. The mean coherence computed in area defined by the file [KMLNAME](#) versus the date of the Secondary image,
6. The date of the Secondary image versus the date of the Primary image and the colour coded mean coherence,
7. The mean coherence computed in area defined by the file [KMLNAME](#) versus the DoY of the Primary image,
8. The mean coherence computed in area defined by the file [KMLNAME](#) versus the DoY of the Secondary image,
9. The DoY of the Secondary image versus the DoY of the Primary image and the colour coded mean coherence.

The colour code of the mean coherence is preserved through all the graphs. Note the poor quality pairs identified as black dots e.g. in the lowest parts of the left and central graphs. The images used for these pairs must be investigated.

See scripts for usage (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT](#)):

- **[Baseline\\_Coh\\_Table.sh](#)**
- [Analyse\\_BaselineCoh\\_data.py](#)

## 9.10) Selecting the pairs such as each image is used a maximum of 3 times as Primary and as a Secondary:

See also [Stat\\_Mas\\_Slv.sh](#) to assess how many times an image is taken as a Primary and as a Secondary.

When all pairs are selected to be taken max 3 times as Primary and Secondary, you can run [Keep\\_Pairs\\_From\\_Extract\\_Baseline\\_3.sh](#) to limit the pairs in [.../MASBAS/.../Modei.txt](#) to only those taken max 3 times.

See scripts for usage (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT](#)):

- **[Extract\\_Baselines\\_3.sh](#)**
- [Keep\\_Pairs\\_From\\_Extract\\_Baseline\\_3.sh](#)

### 9.11) Tools to assist in selecting Bt and Bp:

The python script [\*Analyse\\_BaselineCoh\\_data.py\*](#) takes as input a table of mean coherence computed on a kml (created with ***Baseline\_Coh\_Table.sh***) and plot several figures to show how coherence changes with respect Bt, Bp and acquisition dates.

The python script [\*Analyse\\_AllPairslisting\\_data.py\*](#) takes as input a table **AllPairslisting.txt** (created with ***Prepa\_MSBAS.sh***) as well as a **BpMax** and **Btmax**. It creates several figures showing the characteristics of the selected subgraph based on the given baselines. It also displays at the terminal:

- some information about the images that were not selected and the possible additional pairs with these images;
- some statistics.

See scripts for usage (in **SCRIPTS\_MT/zz\_Utilities\_MT**):

- [\*Analyse\\_BaselineCoh\\_data.py\*](#)
- [\*Analyse\\_AllPairslisting\\_data.py\*](#)

### 9.12) Tools to compute a semi-variogram:

The python script [\*Variogram.py\*](#) computes a variogram of a velocity map provided as an Envi Harris image. The semivairiance displayed in the plot is a measure of the average squared difference between points separated by a certain lag distance. It is calculated using the following formula:

$$Y(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(x_i) - Z(x_i+h)]^2$$

where  $Y(h)$  = the semivariance at lag distance h  
 $Z(x_i)$  = the value of the variable at location  $x_i$   
 $N(h)$  = the number of pairs of points separated by lag distance h

Units of the variogram are square of initial units. Normally, velocity maps from MSBAS inversions are in m/yr. Here we multiply the value time 100 for being in cm/yr.

If image is too big, it can crash for memory issues... Try to crop the image by providing 4 more parameters (First Line, First Col, Nr of lines and Nr of Columns).

Beware: processing a  $L \times C$  image in a float 32 format (4 bytes per pixel) requires the following amount of RAM:

$$\text{Total Memory} = L \times C \times 4 + \frac{(L \times C) \times (L \times C) \times 8}{2}$$

See script for usage (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**):

### 9.13) Testing phase closure:

The objective is to search for possible interferograms affected by unwrapping error. This is done by checking phase closure consistency between triangles of pairs: for each triplet of interferograms spanning 3 dates (says date1-date2, date2-date3 and date1-date3), the mean

unwrapped phase  $\phi_{ij}$  (where  $i$  and  $j$  are the index of the date) is computed over an area defined by a user-provided kml file.

If  $|\phi_{13} - (\phi_{12} + \phi_{23})|$  is larger than a chosen threshold, the triplet of interferograms are flagged as affected by possible unwrapping errors. Comparing all the flagged triplets allows identifying the faulty interferograms, which must be manually checked and/or removed from the database.

One must first run ***Extract\_Triangles.sh*** to list all the triangles from the list of pairs such as `$PATH_1650/SAR_SM/MSBAS/Region/seti/table_MinBp_MaxBp_MinBt_MaxBt.txt`, which is computed by ***Prepa\_MSBAS.sh***. That list is named `List_Triangels.txt`. The script also lists the pairs that are not used in triangles (`List_No_Triangels.txt`).

One should then run the script ***Check\_Closure\_All\_Triangles.sh*** which is aiming at checking unwrapping error in all triangles from `List_Triangels.txt`. It must be launched with 4 parameters:

- the file with list of triangles (`List_Triangels.txt`)
- the path to deformation files:  
(e.g. `.../SAR_MASSPROCESS/SAT/TRK/SMCrop_SM_DATE_Zoom_ML/Geocoded/Mode`)
- the path to a kml of zone where to check the mean phase
- a threshold above which one consider that there is a phase error

It will output 3 files: `_Good_Closure.txt`, `_Wrong_Closure.txt` and  
`_Pairs_To_Clean_From_WrongClosure_NotIn_GoodClosure.txt`

Wrong pairs in `_Pairs_To_Clean_From_WrongClosure_NotIn_GoodClosure.txt` can be rejected from MSBAS by running ***Remove\_Pairs\_From\_BaselineOptimisation.sh***.

Note that there is another script that checks the phase closure of only a single triangle (***Check\_Closure\_Triangle.sh***).

See scripts (in `SCRIPTS_MT/zz_Utils_MT`) for usage:

- ***Check\_Closure\_All\_Triangles.sh***,
- ***Extract\_Triangles.sh*** and
- ***Check\_Closure\_Triangle.sh***

## 9.14) Remove lines in `DefolInterpolDetrendi.txt` or in `table_0_Bp_0_Bt.txt` from a list of pairs:

The script ***Remove\_Pairs\_From\_BaselinePlotOptimisation.sh*** deletes all lines in `MSBAS/region/DefolInterpolDetrendi.txt` or in `table_0_Bp_0_Bt.txt` that contain pairs computed from baseline plot optimization (provided as list of `PRMdate_SCDdate`). It keeps the links in `MSBAS/region/DefolInterpolDetrendi`. It also saves uncleaned `DefolInterpolDetrendi.txt` as `DefolInterpolDetrendi_NotOptimized.txt`.

See scripts (in `SCRIPTS_MT/zz_Utils_MT_Ndo`) for usage:

***Remove\_Pairs\_From\_BaselinePlotOptimisation.sh***

## 9.15) Remove lines with Bt larger than a given value in `DefolInterpolx2Detrendi.txt` or `restrictedPairSelection(_DefolInterpolx2Detrendi).txt`:

- The scripts ***Trim\_Bt\_In\_Defomodei.txt.sh*** and ***Trim\_Bt\_In\_restrictPairsSelection.txt.sh*** remove all pairs with **Bt** larger than a provided value from ***DefoInterpolx2Detrendi.txt*** and ***restrictedPairSelection(\_DefoInterpolx2Detrendi).txt*** respectively.

See scripts (in **SCRIPTS\_MT/zz\_Utilitys\_MT\_Ndo**) for usage:

- ***Trim\_Bt\_In\_Defomodei.txt.sh***
- ***Trim\_Bt\_In\_restrictPairsSelection.txt.sh***

## 9.16) Testing if images have values at given places:

The script ***Check\_Bursts\_Results.sh*** is aiming at testing if a set of all the images from the current directory (e.g. from MSBAS results, that is list of cumulated deformation maps in the form of ***MSBAS\_YYYYMMDDThhmss...***), or list of other type of data such as amplitudes (and hence of other format or naming, thought they must be all of the same size, e.g. in geocoded envi format) have valid values at given places.

The places to be tested are provided as a list of coordinates in **LINES** and **PIXELS** in a file named ***BurstMap\_REGION\_TRK.txt*** (e.g. one point per burst if one wants to check if all the bursts are present – ensure that you select your points in coherent zones if you test deformation maps). **Note:** the file ***BurstMap\_REGION\_TRK.txt*** MUST end with one and only one carriage return.

Remember that you can use “Value Tool” plugin in QGIS to see the coordinate in LINES and PIXELS from a geocoded image. Remember also that **burst KMLs** can be found in each **SAR CSL/SAT/TRK/NoCrop/Img.csl/Info/PerBurstInfo** directory.

The script will then run a ***getLineThroughStack*** for each point and output a file with the values at each image:

- If the script is used for MSBAS results, the output files ***timeLine\${COLX}\_\${LINY}.txt*** will contain "***dates times values***" in columns.
- If the script is used for checking other type of data (such as amplitudes...), the output files ***timeLine\${COLX}\_\${LINY}.txt*** will contain "***name\_of\_the\_files values***" in columns.

If there is a **NaN** in the time series, or if all the values are null, the script outputs a notification.

The script must be launched in the directory where all envi files are, e.g.:

- **SAR\_MASSPROCESS/SAT/REGION\_TRK/SM\_ZOOM\_ML/Geocoded/Ampli**, or
- **SAR\_MASSPROCESS/SAT/REGION\_TRK/SM\_ZOOM\_ML/Geocoded/DefoInterpolx2Detrend**, or
- **MSBAS/REGION/DefoInterpolx2Detrend**

Parameters:

- path to ***BurstMap\_REGION\_TRK.txt***: i.e. to an ascii file that may contain a header "Lin(Y) Col(X) Swath,Burst" and contains the list of points stored as lines and columns separated by a space and followed by BurstPosition as Swath,Burst.

Notes:

- + regions that are overlapped by two bursts can be tested as well and can be noted by their Swath,Burst+Burst numbers
- + if some regions are depicted by the same burst but holding two different names, it can be noted as Swath,Burst-SwathBurst
- Path to the directory with envi files to check
- **KEEPFILES** if you want to keep the ***timeLine\${COLX}\_\${LINY}.txt*** files

## 9.17) Testing if interferograms are empty in given zone:

The script ***Check\_Interfero\_Not\_Empty\_In\_Zone.sh*** is aiming at removing from a prepared msbas data set (eg ***DefolInterpolx2Detrend2***) all the images that would be empty on a selected zone provided by a kml. It is intended to run after ***build\_header\_msbas\_criteria.sh*** or after ***build\_header\_msbas\_criteria\_From\_nvi\_name\_WithoutAcqTime.sh*** and before running ***MSBAS.sh***.

Run this for each mode that need to be cleaned.

Select the kml zone where you know signal must not be zero.

The script must be launched in the directory where msbas will be run, which contains all the ***Mode*i**** and ***Mode*i*.txt***.

Parameters are:

- mode to clean; beware of index at the end of name (eg ***DefolInterpolx2Detrend2***)
- kml of zone where to test the validity
- path to defo (from mode) files:

**SAR\_MASSPROCESS/SAT/TRK/REGION\_ML/Geocoded/DefolInterpolx2Detrend**

A version of the script does the same things although without deleting the files where the zone is empty. It only output at terminal the list of wrong images.

A simpler version also exists that only check the value at a given pixel coordinate of all the maps in the running directory. It then outputs the list of maps which contain NaN's at that place (if any). See script ***Check\_NaN\_Pix\_In\_All\_Maps.sh***.

See scripts for usage (in ***SCRIPTS\_MT/zz\_Utils\_MT***):

- ***Check\_Interfero\_Not\_Empty\_In\_Zone.sh***
- ***Check\_Interfero\_Not\_Empty\_In\_Zone\_TestWithoutDel.sh***
- ***Check\_NaN\_Pix\_In\_All\_Maps.sh*** (in ***SCRIPTS\_MT/zz\_Utils\_MT\_Ndo***)

## 9.18) Interpolating times series of deformation maps for msbas

This is not a script, but a function developed by Ludivine Libert named ***interpolateDataSet***. See sources and make your own script if needed. It is not used so far in the mass processing.

## 9.19) Computing Earth to satellite unit vectors

The script ***Earth2Sat\_UnitVectors.py*** computes the Earth to satellite unit vectors based on the incidence and heading angles taken from e.g. the header.txt file.

See scripts for usage (in ***SCRIPTS\_MT/zz\_Utils\_MT\_Ndo***).

## 9.20) Computing the rank and SVD of the unit vectors matrix

The script ***Rank\_and\_SVD\_Matrix.py*** computes the rank and the SVD of a hard coded matrix. This is useful e.g. to test if the diversity of looking angles is enough to perform a 3D MSBAS decomposition: rank must be 3 and conditioning number (the largest singular value divided by the smallest) must be small (e.g. less than 100). Usually, this does not apply to common space-based acquisitions because of the subpolar orbits of the satellites. However, the condition may

be fulfilled e.g. when mixing enough ascending and descending acquisitions, in right and left looking geometries.

See scripts for usage (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT\\_Ndo](#)).

## 9.21) Filtering deformation maps:

Additional filtering may be computed using GMT for instance  
(see scripts in [SCRIPTS\\_MT/zz\\_Utilities\\_MT](#)):

- [\*Filter\\_Interpolate\\_DefoMaps.sh\*](#)
- [\*Filter\\_Interpolate\\_SingleMap.sh\*](#)

or using python [\*FiltMedian.py\*](#)

## 9.22) Creating gif from all Geocoded Amplitudes or deformation or r4 files in a directory:

The script ***AmpliGeocRas2GIF.sh*** is aiming at creating a gif from all geocoded amplitude rasters that are in [SAR\\_MASSPROCESS/GeocodedRasters/Ampli](#). It must be launched from the directory where the amplitude files are stored.

Parameters:

- X and Y coord of date tag position
- font size for date tag
- output images resolution
- output directory where to store results

The script ***TSmap2moviegif.sh*** is aiming at converting binary deformation maps from MSBAS processing to jpg then combine all jpg into a gif movie.

Parameter: - path to directory where [\*MSBAS\\_????????T??????\\_\\*\*.bin](#) and [\*.hdr\*](#) are.

The script ***r4togif.sh*** is aiming at converting all r4 (float32; eg from MATLAB post processing) files from the current directory to jpg (cropped to dimensions hard coded in script) and tagged with date (in position hard coded in script), then combine all jpg into a gif movie.

Parameter: - width of r4 files (in pixels)

See scripts for usage:

|                                   |                                                      |
|-----------------------------------|------------------------------------------------------|
| <b><i>AmpliGeocRas2GIF.sh</i></b> | (in <a href="#">SCRIPTS_MT/zz_Utilities_MT</a> )     |
| <b><i>TSmap2moviegif.sh</i></b>   | (in <a href="#">SCRIPTS_MT/zz_Utilities_MT</a> )     |
| <b><i>r4togif.sh</i></b>          | (in <a href="#">SCRIPTS_MT/zz_Utilities_MT_Ndo</a> ) |

## 9.23) Creating kmz file from Geotiff or Envi files:

The script ***Geotif2kmz.sh*** creates a kmz from a Geotiff file.

The script ***Envi2kmz.sh*** creates a kmz from an Envi format file. Note however that colour table is not set automatically yet; rather, it uses

[SCRIPTS\\_MT/TemplatesForPlots/ColorTableGDAL.txt](#). Must be done when time... or see ***Envi2ColorKmz.sh***, which uses [SCRIPTS\\_MT/TemplatesForPlots/ColorTableKMZ.txt](#) or [SCRIPTS\\_MT/TemplatesForPlots/ColorTableKMZ\\_2.txt](#).

See scripts for usage:

- **Geotif2kmz.sh** (in `SCRIPTS_MT/zz_Utilities_MT`)
- **Envi2kmz.sh** (in `SCRIPTS_MT/zz_Utilities_MT`)
- **Envi2ColorKmz.sh** (in `SCRIPTS_MT`)

#### 9.24) Creating black and white kmz figure from amplitude (or other) file in Envi format:

Script to create figures of amplitude (or what you want) in black and white kmz, based on Envi image: **Envi2BIAAndWhKmz.sh**

Pretty useful to see image in Google Earth for instance.

See script for usage (in `SCRIPTS_MT`): **Envi2BIAAndWhKmz.sh**

#### 9.25) Creating a X/Y scatter plot between DEM and deformation map (or linear rate map) and compute linear regression:

Python script to create a scatter plot between a DEM and a deformation (or a linear rate map) and compute linear regression e.g. to detect possible atmospheric artefacts or topographic residuals: **RegLin\_DEM\_Defo.py**

DEM (in meters) and deformation map (in meters) must be of the same size and may contain NaN. The plot reads the deformation in “mm” and the slope of the linear regression between the DEM and the deformation in “mm/m” because input deformation map is multiplied by 1000 in the scripts. Note that if a linear velocity is provided instead of a deformation, you should change in the script the label of the Y axe and the units of the slope in the title.

See script for usage (in `SCRIPTS_MT/zz_Utilities_MT`): **RegLin\_DEM\_Defo.py**

#### 9.26) Creating figures:

Using ImageJ (Fiji), the script **Fiji\_Amp\_Defo\_Coh.sh** creates RGB figures of deformation wrapped on amplitude and damped with coherence, based on Envi images and using Fiji.

The script **Fiji\_DEM\_Defo\_Coh.sh** creates RGB figures of deformation wrapped on DEM amplitude and damped with coherence, based on Envi images and using Fiji.

All these files are from any pair processing.

Another version exists also as **AmpDefo\_map.sh**. This uses the deformation maps from the MSBAS inversion.

Similarly, **AmpAmpAmp.sh** and **AmpAmpCoh.sh** allow to create RGB composition using respectively 3 amplitude images and 2 amplitudes and one coherence image. They will highlight changes that occurred during the dates of the amplitude files. These are basic scripts that can be improved. See scripts.

Using GMT, scripts such as **plotall\_gmt5\_funuML4.sh** call **plot\_gmt5.sh** to create eps figures. These scripts are based on Sergey Samsonov's scripts.

The script **Rebuild\_ras\_and\_jpg\_ampli\_figs\_in\_all\_dirs.sh** aims at rebuilding amplitude ras and jpg figures from envi files in all pairs directories in current directory (usually

[SAR\\_SM/AMPLITUDES/SAT/TRK/REGION/](#)). It also adds the date as label in the jpg figure at provided position. See script.

The script ***Envi2ras.sh*** aims at creating an Sun raster figure (.ras) from an envi file. It takes as parameters: the path to the envi image, the type of figure, that is defo, amp, coh or interf (which will allow selecting the type of color scale) and the multilooking factor. See script.

See scripts for usage:

- ***Fiji\_Amp\_Defo\_Coh.sh*** (in [SCRIPTS\\_MT](#))
- ***Fiji\_DEM\_Defo\_Coh.sh*** (in [SCRIPTS\\_MT](#))
- ***AmpDefo\_map.sh*** (in [SCRIPTS\\_MT](#))
- ***AmpAmpAmp.sh*** (in [SCRIPTS\\_MT](#))
- ***AmpAmpCoh.sh*** (in [SCRIPTS\\_MT](#))
- ***plotall\_gmt5\_funuML4.sh*** (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT](#))
- ***plot\_gmt5.sh*** (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT](#))
- ***Envi2ras.sh*** (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT\\_Ndo](#))
- ***Rebuild\_ras\_and\_jpg\_ampli\_figs\_in\_all\_dirs.sh***  
(in [SCRIPTS\\_MT/zz\\_Utilities\\_MT\\_Ndo](#))

## 9.27) Re-wrap deformation map

The script [\*ReWrap\\_Image.py\*](#) re-wrap a deformation image (provided as input param 1, float) and save the rewrapped image as jpg if the width of the image is provided as a 2nd parameter. Re-wrapped image is named after the input file with an additional string before the extension, that is \_rewrapped\_{mod\_value}. Image is re-wrapped at 10 cm (0.1 m in script). Change hardcoded line in script if needed.

Parameters :  
- path to image to re-wrap  
- optional: width of image to create jpg plot

See scripts for usage:

- [\*ReWrap\\_Image.py\*](#) (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT\\_Ndo](#))

## 9.28) Transform all sun raster files from directory in png

The script ***Ras2Png.sh*** transforms all the sun raster files (\*.ras) from the current directory into png files. It is parallelized and incremental. Size of png file is smaller than ras.

See scripts for usage (in [SCRIPTS\\_MT\\_Ndo](#)):

- ***Ras2Png.sh***

## 9.29) Opening Envi image with Fiji and save it as tif format:

Script to open Envi image (i.e. with its hdr) with Fiji and save it in tif format:

***Fiji\_Open\_Envi2tif.sh***

See script for usage (in [SCRIPTS\\_MT](#)): ***Fiji\_Open\_Envi2tif.sh***

### 9.30) Plotting time series and times series with GPS data

Sergey Samsonov suggested gnuplot scripts to combine msbas time series and GPS data. See for instance something like ***PlotEW\_UP\_ts\_GPS\_BUK.sh*** (in **SCRIPTS\_MT/zz\_Utilities\_MT**).

### 9.31) Some tools to assist in creating list of pixels' coordinates for plotting time series and Double difference times series

Processing a msbas inversion can be done with a list of point provided as parameter (e.g. [\\$/PATH\\_1650/Data\\_Points/Points\\_TS\\_YourRegion.txt](#)). In that case, a time series will be extracted for each of the points provided in that list. The following scripts aim at assisting to build that kind of point list files.

The script ***Get\_pix\_name\_And\_Coord\_from\_kml.py*** aims at extracting pixels' name and coordinates from a kml file, providing that the kml file contains the fields "layer" and "coordinates". Such a kml can be produced e.g. by adding points (using XY drawing tool from QGIS) while looking at a mean linear velocity map or a displacement map. The script reads name of the point (further used in the naming of the time series plots) from the "layer" field and the coordinates of the points from the "coordinates" field. The output list is saved in a text file with the same name as the kml file with **.txt** extension instead. This is however not the format expected by ***MSBAS.sh*** for extracting and plotting the time series of these points. To reshape that list into the appropriate format, one must run the script ***Create\_Point\_TS\_File\_From\_NameLatLong\_file.sh***.

The script ***Create\_Point\_TS\_File\_From\_NameLatLong\_file.sh*** aims at reading a list of Lat Long coordinates provided as a 3 col file, e.g. "NAME Lat Long" (tab separated) such as what is produced with ***Get\_pix\_Name\_and\_Coord\_from\_kml.py***.

It outputs a file with the list of points that will be used to produce time series at ***MSBAS.sh*** step (e.g. [\\$/PATH\\_1650/Data\\_Points/Points\\_TS\\_YourRegion.txt](#)). That file must have a one-line header "name x y radiusX raduisY" followed by 5 columns with pixels names, X, Y, radiusX and raduisY. Note that the script forces the radius to 3. Change that hard coded value in the script if needed.

Because the position of the pixels in the input list are given in geographic coordinates, the script calls the other script ***UTM2EnviPosition.py*** in order to transform these coordinates into a X and Y format.

The script ***UTM2EnviPosition.py*** aims at converting geographical coordinates (decimal Latitude and Longitude or UTM) into pixel positions (in X and Y, that is number of columns and rows) from an ENVI file. It reads geographical information provided in the **.hdr** file.

Also, it is often convenient to plot double difference time series between pairs of points (e.g. with ***PlotTS.sh*** or ***PlotTS\_all\_comp.sh***). Such a list (usually named like e.g. [\\$/PATH\\_1650/Data\\_Points/List\\_DoubleDiff\\_EW\\_UD\\_YourRegion.txt](#)) can be created manually as it only contains 5 columns, that is: the X and Y coordinates of the point 1, the X and Y coordinates of the point 2, and the name to be given to the plot, preferably allowing to identify which are the two points. The following script ***Points\_TS\_2\_List\_DoubleDiff.py*** aims at creating such a list for double difference plotting, based on a list of points provided as a file in the form of **Points\_TS\_YourRegion.txt**.

The script ***Points\_TS\_2\_List\_DoubleDiff.py*** takes as input a list of points in the form of a file such as [\\$/PATH\\_1650/Data\\_Points/Points\\_TS\\_YourRegion.txt](#) and aims at creating a list of coordinates and names for double difference time series computation, such as

`/$PATH_1650/Data_Points/List_DoubleDiff_EW_UD_YourRegion.txt`. The script copes with the expected name when performing **MSBAS.sh**

Sometimes you will need to convert the coordinates of a point (in lines and pixels) from one grid to another in order to pinpoint the same location in these two grids. This can be achieved with the scripts **Convert\_DoubleDiff.sh** and **Convert\_PointDiff.sh**.

The script **Convert\_DoubleDiff.sh** is dedicated to convert the coordinates of a double difference list of pairs of pixels (i.e. `List_DoubleDiff_EW_UD_Region.txt`) from one reference system (original) to another (target).

Usage:

**Convert\_DoubleDiff.sh** `X0_ori Y0_ori DX_ori DY_ori X0_tar Y0_tar DX_tar DY_tar`  
`inputfullpath outputfullpath`

where:

- `X0_ori Y0_ori UTM` Coordinates of the original image corner
- `DX_ori DY_ori` Resolution of the original image
- `X0_tar Y0_tar` Coordinates of the target image corner
- `DX_tar DY_tar` Resolution of the target image
- `inputfullpath` (e.g. `FullPathto/List_DoubleDiff_EW_UD_Region.txt`)
- `outputfullpath` (e.g. `FullPathto/List_DoubleDiff_EW_UD_Region_newcoordinates.txt`)

The script **Convert\_PointDiff.sh** is dedicated to convert the coordinates of a list of pixels (i.e. `Points_TS_Region.txt`) from one reference system (original) to another (target).

Usage:

**Convert\_PointDiff.sh** `X0_ori Y0_ori DX_ori DY_ori X0_tar Y0_tar DX_tar DY_tar`  
`inputfullpath outputfullpath`

Where:

- `X0_ori Y0_ori UTM` Coordinates of the original image corner
- `DX_ori DY_ori` Resolution of the original image
- `X0_tar Y0_tar` Coordinates of the target image corner
- `DX_tar DY_tar` Resolution of the target image
- `inputfullpath` (e.g. `FullPathto/Points_TS_Region.txt`)
- `outputfullpath` (e.g. `FullPathto/Points_TS_Region_newcoordinates.txt`)

Also, if you have a list of UTM coordinates, you can transform it into a list of X and Y column to be used for these time series plots. For that, use the script **Transform\_UTM\_List\_In\_XY.sh**, which will read the details of the geographical coordinates vs X-Y position from an Envi header file provided as a parameter. You can input UTM or Lat Long coordinates as input. See script for details.

Finally, the script **Extract\_TimeSeries\_InDir\_From\_List.sh** will extract, for each point from a list of Col(X) and Lines(Y) positions, the time series of defo from all the defo maps in the present dir. It will read the first hdr file to extract the required informations about the images. See script for details.

See scripts for usage (in `SCRIPTS_MT/zz_Utils_My_Ndo`):

- **Get\_pix\_name\_And\_Coord\_from\_kml.py**
- **Create\_Point\_TS\_File\_From\_NameLatLong\_file.sh**

- [\*UTM2EnviPosition.py\*](#)
- [\*Points\\_TS\\_2\\_List\\_DoubleDiff.py\*](#)
- [\*Convert\\_PointDiff.sh\*](#)
- [\*Convert\\_Doublediff.sh\*](#)
- [\*Transform\\_UTM\\_List\\_In\\_XY.sh\*](#)
- [\*Extraxct\\_TimeSeries\\_InDir\\_From\\_List.sh\*](#)

### **9.32) Extracting time series values of several pixels from a stack of ground deformation maps**

The script ***Extract\_Pixels\_TimeSeries\_Values.sh*** aims at running a series of ***PlotTS.sh*** to extract the values of time series from a list of pixels. The list, provided as a parameter, is in the form of ***LINE COL*** nr. The script may run several processes in parallel on a fixed number of CPU's (***MAXCPU***; hard coded in script), or max CPU-1 if less than ***MAXCPU*** are available. However, experience showed that it might actually be slower while run in parallel. Keep ***MAXCPU***=1 or test on your computer and target first if you have intensive computation to run.

The script also removes the eps figure. If you want to keep it, comment the line in script below. It will then store all the time series values ***timeLineLINE\_COL.txt*** in a dir ***SVD***. Ensure that there is no unwanted ***timeLineLINE\_COL.txt*** list already present in the directory.

NOTE: Must be run where all the deformation maps are located, i.e.

***/MSBAS/REGION/zz\_LOSorUDorEW\_...***

See script for usage:

***Extract\_Pixels\_TimeSeries\_Values.sh*** (in ***SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo***)

### **9.33) Plotting difference between two time series e.g. computed with different msbas inversion parameters:**

If you process the same data set with different tuning of your parameters (either at the ***SuperMaster\_MassProc.sh*** or the ***MSBAS.sh***), you may want to look at the difference between the results. The difference between the deformation or velocity maps are easy with ***Fiji*** or any GIS tool.

***Plot\_Diff\_TS.sh*** allows to make the difference between the time series of two pixels.

- First, compute the time series of a given pixel in your first MSBAS process directory (using ***PlotTS.sh*** for instance).
- Second, do the same for the same pixel in the second MSBAS process directory.
- Then, preferably in a third directory dedicated to the comparison of the two data processings, launch ***Plot\_Diff\_TS.sh*** with the path to the two timeseries as parameters to get the plot of the difference.

See also ***CompareTimeSeries.sh*** which calls ***Plot\_Diff\_TS.sh*** with the coordinates of a pixel to automatically create the plot. Some hard-coded lines are required though for locating the directories.

You can also use this for making a double difference between two pixels from the same processing, but then it is the same as using ***PlotTS.sh*** with two pixels as input...

See scripts for usage:

- ***Plot\_Diff\_TS.sh*** (in **SCRIPTS\_MT**)
- ***CompareTimeSeries.sh*** (in **SCRIPTS\_MT/zz\_Utilities\_MT**)

See the gnu templates (in **SCRIPTS\_MT/TemplatesForPlots/**) used by ***Plot\_Diff\_TS.sh***, ***PlotTS.sh*** or ***PlotTS\_all\_comp.sh***, that is:

- *plotTS\_template\_fit.gnu*,
- *plotTS\_template\_multi\_fit.gnu*,
- *plotTS\_template\_multi.gnu* and
- *plotTS\_template.gnu*.

Modify these templates e.g. if you want add tags, change the colour or fonts etc...

You may also want to have a look at the template in **SCRIPTS\_MT/TemplatesForPlots/**:  
*plotTS\_808\_605\_830\_605\_multi\_Auto\_2\_0.04\_VVP\_WithInset.gnu*  
which contains some features for inserting vertical bars or rectangles.

### 9.34) Removing all pairs names from a list of images pairs when the Primary or the Secondary is before or after a given date, or if they are between or outside a date interval:

The scripts ***RemovePairsFromFlist\_WithImagesBefore.sh*** and ***RemovePairsFromFlist\_WithImagesAfter.sh*** aim at removing from a list of interferometric pairs those which have the Primary or the Secondary acquired before/after a given date.

The list of pairs must be like those created using ***Prepa\_MSBAS.sh***, that is with a 2 lines header followed by lines containing 4 columns: ***yyyymmdd yyyymmdd (-)val (-)val***. It must be provided with its full path.

The script will output a list of cleaned pairs named as follow

***PAIRFILE\_AboveMAXDATE\_NoBaselines\_RNDM.txt*** or  
***PAIRFILE\_BelowMAXDATE\_NoBaselines\_PROCDATE.txt***

and

***PAIRFILE\_AboveMAXDATE\_WithBaselines\_RNDM.txt*** or  
***PAIRFILE\_BelowMAXDATE\_WithBaselines\_PROCDATE.txt***

Where ***PAIRFILE*** is the original file (with path) containing the list of pairs, ***MAXDATE*** is the threshold date and ***PROCDATE*** is the date of processing (to avoid possible clash in naming). The version “WithBaselines” has the same format as the original 4 columns table with header. The version “NoBaselines” has only 1 column with ***yyyymmdd\_yyyymmdd*** without header.

The script ***RemovePairsFromModeList\_WithImagesAfter.sh*** does the same although the provided list is the text file with the list of images to be inverted by msbas, that is ***.../MSBAS/Region/Modei.txt*** (e.g. ***DefolInterpolx2Detrendi.txt***) which contains 4 columns (***Modei/PairName.xdeg Bp yyyymmdd yyyymmdd***) without header. ***RemovePairsFromModeList\_WithImagesBefore.sh*** obviously do the same for pairs before the given date.

The script ***RemovePairsFromTableList\_Between\_dates.sh*** aims at removing all pairs of images that contains at least one image between two dates provided as parameters. It will then store the results in a file named ***\$(PAIRFILE)\_Without\_\${MINDATE}\_\${MAXDATE}.txt*** that contains all pairs from the input file except those with at least one images in the interval ***[\$(MINDATE),\$(MAXDATE)]***. This file is a 4 columns file with header, as the input file.

Similarly, the script ***RemovePairsFromTableList\_Outside\_dates.sh*** aims at removing all pairs of images that does not contains at least one image between two dates provided as parameters. It will then store the results in a file named

`$(PAIRFILE)_Between_${MINDATE}_${MAXDATE}.txt`

that contains all pairs with at least one images in the interval `[$(MINDATE),$(MAXDATE)]`. This file is a 4 columns file with header, as the input file. It also output the results in a file named

`_EXCLUDE_PAIRS_ALTHOUGH_CRITERIA_OK.txt`

that contains only one column without header in the form of `datePRM_dateSCD`.

Remember that file `_EXCLUDE_PAIRS_ALTHOUGH_CRITERIA_OK.txt` must be put in the `MSBAS/REGION/Modei` directory, then when ***Exclude\_Pairs\_From\_Mode.txt.sh*** is run, these pairs will be excluded from the msbas inversion.

See scripts for usage (in `SCRIPTS_MT`):

- ***RemovePairsFromList\_WithImagesBefore.sh*** and
- ***RemovePairsFromList\_WithImagesAfter.sh*** or
- ***RemovePairsFromModeList\_WithImagesAfter.sh***
- ***RemovePairsFromTableList\_Between\_dates.sh***
- ***RemovePairsFromTableList\_Outside\_dates.sh***

### 9.35) Check pairs that would be computed twice, as Primary\_Secondary and Secondary\_Primary:

The script ***Check\_MasSlv\_SlvMas\_Pairs.sh*** check that there are no pairs processed twice in the current directory as `Primary_Secondary` and `Secondary_Primary`. If it happen, it removes the `Secondary_Primary`.

See scripts for usage (in `SCRIPTS_MT/zz_Utils_MT_Ndo`).

### 9.36) Deleting directories of interferometric pairs:

The following scripts delete directories named by Primary\_Secondary dates:

- ***Del\_All\_dir\_from\_list.sh***: remove from the current directory (or move them to `../Prblm`; see code) all the directories that are listed in a provided file and that contains only the date name of the Primary and Secondary images separated by an underscore (PRM\_SCD)
- ***Del\_All\_dir\_Named\_With.sh*** remove from the current directory (or move them to `../Prblm`; see code) all the directories (detected with “ls”) that contains a certain string in their name. That string is provided as a parameter in the form of two elements separated by an underscore, that is `string1_string2` (i.e. usually PRM\_SCD)

See scripts for usage (in `SCRIPTS_MT/zz_Utils_MT`):

- ***Del\_All\_dir\_from\_list.sh***
- ***Del\_All\_dir\_Named\_With.sh***

### 9.37) Searching all products (SLC, RESMAPLED, MASSPROCESSED) computed with a AMSTer Engine version after a given date

The script ***Search\_All\_Made\_With\_AE\_Version\_After.sh*** aims at searching in the working directory (and subdirectories) for all the products computed with a AMSTer Engine version after a given date (provided as a parameter).

It takes as parameters:

- the date to which compare the version used to produce the products in the form of **yyyymmdd**,
- the type of product:
  - o **SLC** to search for images read (incl. DEM and mask projection in slant range),
  - o **COREG** to search for resampled images, and
  - o **PAIRS** to search for processed pairs.

If the version of AMSTer Engine used to compute the products is (strictly) after the provided date, the script will list the path to that product and the date of AMSTer Engine version used. Usually these dates are stored in text files named respectively [Read\\_w\\_AMSTerEngine\\_V.txt](#), [Projecting\\_DEM\\_w\\_AMSTerEngine\\_V.txt](#), [Coreg\\_w\\_AMSTerEngine\\_V.txt](#) and [Processing\\_Pairs\\_w\\_AMSTerEngine\\_V.txt](#).

See script for usage (in [SCRIPTS\\_MT/zz\\_Utilsities\\_MT\\_Ndo](#)):

### 9.38) Deleting files based on their naming:

The following scripts delete files:

- **Del\_All\_files\_in\_Dirs\_Named\_With.sh** remove all files containing a given string (parameter 1) in a given directory (parameter 2).
- **Del\_Geocoded\_and\_GeocodedRasters\_from\_DateList.sh** remove in [/Geocoded](#) and [/GeocodedRasters](#) all the files that contains strings contained in a list provided as parameter. These strings are usually pairs of dates such as PRM\_SCD.
- **Del\_Geocoded\_and\_GeocodedRasters\_from\_FileName.sh** remove all files in [/Geocoded](#) and [/GeocodedRasters](#) if their name contains a provided string as parameter. The criteria to search for the files to delete is usually something such as:  
S1\_DRC\_VVP\_A\_174-37.0deg\_20190717\_20191108\_Bp-27.3m\_HA518.9m\_BT114days\_Head102.1deg
- **Del\_Geocoded\_Files\_Wrong\_Bt.sh** remove all files in [/Geocoded](#) and [/GeocodedRasters](#) that have a Bt larger than a value provided in parameter. This was needed after a bug was detected in AMSTerEngine computation of Bt. The script must be launched in the [SAR\\_MASSPROCESS](#) directory where [/Geocoded](#) and [/GeocodedRasters](#) are.
- **Delete\_All\_bil\_files\_with\_twice\_same\_date.sh** remove all files in all subdirectories that are named with twice the same date separated by an underscore
- 

See scripts for usage (in [SCRIPTS\\_MT/zz\\_Utilsities\\_MT](#)):

- **Del\_All\_files\_in\_Dirs\_Named\_With.sh**
- **Del\_Geocoded\_and\_GeocodedRasters\_from\_DateList.sh**
- **Del\_Geocoded\_and\_GeocodedRasters\_from\_FileName.sh**
- **Del\_Geocoded\_Files\_Wrong\_Bt.sh**

See script for usage (in [SCRIPTS\\_MT/zz\\_Utilsities\\_MT\\_Ndo](#)):

- **Delete\_All\_bil\_files\_with\_twice\_same\_date.sh**

### 9.39) FLIP or FLOP products:

These are python tools used for instance in **SinglePair.sh**, **SinglePairNoUnwrap.sh**, **Envi2CISdem.sh**, **GeocodeMask.sh**... and aiming at inverting the lines or columns in binary files.

The script ***Envi2CISdem.sh*** uses these two tools to transform an Envi format DEM computed by AMSTerEngine into a pseudo Envi file usable by AMSTerEngine using CIS format. This is however very old and was developed before some changes in the way AMSTerEngine outputs its products. It must hence be tested. Most probably you would prefer ***DEM\_Envi\_hdr2AMSTer\_txt.sh*** to transform an Envi or GEOTIFF format DEM into DEM file usable by AMSTerEngine.

See scripts for usage (in **SCRIPTS\_MT**):

- ***FLIPproducts.py.sh*** (in **SCRIPTS\_MT**)
- ***FLOPproducts.py.sh*** (in **SCRIPTS\_MT**)
- ***FLIPFLOPproducts.py.sh*** (in **SCRIPTS\_MT/zz\_Utils\_Mt\_Ndo**)

and (in **SCRIPTS\_MT/zz\_Utils\_Mt**):

- ***Envi2CISdem.sh***
- ***DEM\_Envi\_hdr2AMSTer\_txt.sh***

## 9.40) Transforming NaN to zero and inversely or change value:

Python scripts ***Nan2zero.py*** or ***zero2NaN.py*** transform NaN into zero and inversely.

Parameters are file to transform and input file format (byte or float32).

Note that setting NaN in byte file is not appropriate. Hence, if byte file is passed to ***zero2NaN.py***, the output file will not be in byte anymore but in float32.

Note that there is a script ***Check\_All\_Nan.sh*** which checks all the Envi files in the current directory and checks if they contain at least one NaN or if they are full of NaN.

Parameters are:

- ALL or ANY if want to search resp. for files filled with only NaN or files with at least one NaN. For that it will either use ***checkNaN.py*** or ***checkOnlyNaN.py***
- input file format (byte or float32)

Python script ***Change\_Val.py*** replaces a value by another in a file.

Parameters are file to transform, value to search, value to replace with and input file format (byte or float32).

Parameters are file to transform, value to search, value to replace with and input file format (byte or float32).

Python script ***Change\_Val255\_0\_in\_0\_1.py*** replaces all 255 by 0 and all 0 in 1 in an Envi file (in bytes). The output files is named after the input file with a trailing \_255and0\_to\_0and1 string. It also copies the input file header to get an output file header. In can ingest an Envi file with or named with or without an extension.

Python script ***Swap\_0\_1\_in\_ByteFile.py*** swaps 0 and 1 in a mask file (in bytes). The output files is named after the input file with a trailing \_Swap\_01 string.

See script (in **SCRIPTS\_MT/zz\_Utils\_Mt**):

- ***Nan2zero.py***
- ***zero2NaN.py***
- ***Change\_Val.py***
- ***Change\_Val255\_0\_in\_0\_1.py***
- ***Swap\_0\_1\_in\_ByteFile.py***
- ***Check\_All\_Nan.sh***

## 9.41) Transforming bytes to float and inversely:

See script (in `SCRIPTS_MT/zz_Utils_MTNdo`):

- `float2byte.py`
- `byte2float.py`

## 9.42) Cropping last col or line from binary files:

See script (in `SCRIPTS_MT/zz_Utils_MT`):

- `CropLastCol.py` or `CropLastCol_float.py`
- `CropLastLine.py` or `CropLastLine_float.py`

## 9.43) Check if an area defined by a kml file is included within a larger area defined by another kml:

If provided with two kml (smaller first), it will answer [True] or [False]

See script (in `SCRIPTS_MT/zz_Utils_MTNdo`):

- `_Check_kml_in_kml.py`

## 9.44) Check if all the bursts of a S1 image overlaps a provided kml:

The script `Check_burst_coverage_kml.py` reads a target KML provided as first parameter and all the KMLs of a S1 image bursts that are stored in a directory provided as a second parameter.

Then it checks that the combined geometries of all bursts KMLs fully cover the target area, meaning that the union of all small areas should be at least as large as the target area.

If the coverage is OK, it answers:

```
" Total small KML polygons detected: N" (with N = number of bursts)
"The target KML is fully covered by the bursts KMLs."
```

If the coverage is NOT OK, it answers:

```
" Total small KML polygons detected: N" (with N = number of bursts)
"The target KML is NOT fully covered. Saving coverage plot for review..."
"Coverage plot saved at:
.../CSLImgPath/NoCrop/S1?_Trk_DATE_?.cs1/Info/PerBurstInfo/Coverage_YourKmlName.png"
"The target KML is NOT fully covered by the bursts KMLs."
```

Optional: add option `-p` to save the coverage plot even if cover is OK. This might be useful when you suspect more bursts than needed.

The plot displays - the target kml in red (its file name is reminded in the title of the plot)  
- each burst (with its name) in blue (total number of bursts is also in legend)

**Note:** if you have a list of Lat Long coordinates, you can make a kml out of it thanks to the tool `Make_kml.sh`. See script for usage.

The script is used in `_Check_ALL_S1_SizeAndCoord_InDir.sh`.

See script for usage (in `SCRIPTS_MT/zz_Utils_MT`)

#### 9.45) Check if S1 RAW data are correctly unzipped:

The script ***Check\_RAW\_S1.sh*** lists all the image directories (in CSL format) that do not contain at least the following 4 sub-directories:

- `annotation`
- `measurement`
- `preview`
- `support`

and/or where the `measurement` directory does not contain `x` tiff files, (where `x` is an integer provided as parameter) in order to detect possible bad Sentinel 1 raw unzipped data.

See script (in `SCRIPTS_MT/zz_Utilities_MT_Ndo`).

#### 9.46) Check the size of the SAR CSL/SAT/.../Data/SLCData.xx :

The script ***Check CSL Data Size.sh*** list all CSL images where the size of the `./Data/SLCData.xx` (where `xx` is the polarisation scheme, e.g. VV) is not in a provided range.

The script must be run in the directory containing all the images in the CSL format. The range is provided as parameters as the min and max file size in MB (SI units).

See script (in `SCRIPTS_MT/zz_Utilities_MT_Ndo`).

#### 9.47) Compare the baseline plots prepared with different methods:

Several tools can be used to compare the pairs selected and compare the baseline plots obtained with different methods, that is either Max Bp and Bt, Delaunay or maximum `x` shortest connections.

See script (in `SCRIPTS_MT/zz_Utilities_MT_Ndo`):

- ***Compare\_BSplot.sh***, which needs:
  - o `BSplot.sh`
  - o `Find_minmaxBSforBSplots.py`
  - o `Find_minmaxforBSplots.py`
  - o `List_simil_in_table.sh`
- ***Funu\_comparebaselineplot.sh*** as example

## 10. Utilities for repair or development:

There are several scripts stored in `SCRIPTS_MT/zz_Utilities_MT` or `/zz_Utilities_MT_Ndo`. They were required at some points for repairing problems I had during faulty processing or during developments, or just small utilities that were useful to me at some point. Some are explained here below though more are present in these directories. If not explained here, it may mean that they haven't been used for a while or were never finished... **Use with care; Read carefully at least the header of the scripts. It is strongly advised to check first these scripts before launching them.**

### 10.1. Checking S1 images:

The script ***CheckS1Pol.sh*** aims at checking the polarization for each burst and ensure it is the same everywhere. It must be launched in the directory where all the S1 images are stored in cs1 format. There is a similar version of the script that also clean those for which the polarisation is not the same as the one provided in parameter: see

***Remove\_S1Pol\_Not\_as\_in\_LaunchParamFile.sh***

The script ***Check\_S1\_Mas\_Slv\_sizes.sh*** checks the size (in lines and columns) of the Primary and interpolated Secondary SLCs and compare them with the file sizes (in bytes). It must be launched in the pair directory where interferogram was computed.

The script ***Check\_S1\_SLCImageInfo.sh*** checks that there is a `SLCImageInfo.txt` in each S1.CSL directory and that polarisation is ok. Note that the polarization is hard coded in the script.

The script ***ReCreateLink\_S1\_Read.sh*** re-creating the link of S1 images in REGION after reading in cs1 format and stored in REGION\_MODE where they will be used by the AMSTerEngine automated scripts. The script will do this from S1 images in Asc and Desc specific directory. This script is based on ***Read\_All\_Img.sh***, which can explain some useless stuffs here and there...

The script ***Check\_S1\_Before\_MSBAS.sh*** checks that S1 data are OK in `SAR_MASSPROCESS/Geocoded` (except Ampl) and in `MSBAS/region/MODES/` i.e. from a previous MSBAS processing and for next preparation for a MSBAS.

The script ***Check\_S1\_RawImageSize.sh*** checks the size of the UNZIP S1 image files; that is the size of directory is at least ***6 Gb*** (must be integer) and contains ***57*** files & subdir (these numbers are hard-coded as parameters at the beginning of the script).

When performing a manual data download with another method as the daily automatic download, raw S1 images might be unzipped in a specific directory. The script ***CheckS1unzip.sh*** checks if directories with S1 unzipped images in that unconventional directory would already exist in `S1-DATA-TARGET-SLC.UNZIP` or `S1-DATA-TARGET-SLC.UNZIP_FORMER/_YYYY` directories and have the same size. If not, it displays the nr of files and the total size for comparison.

The script ***Check\_S1\_SizeAndCoord.sh*** checks the number of bursts and coordinates of corners of S1 images. It compares them to expected values provided as input parameters. These can either be the 4 corners of a kml (obtained e.g. by running ***Check\_S1\_SizeAndCoord.sh \$PATH\_1650/SAR\_CSL/SAT/TRK/NoCrop/img.cs1 Dummy*** where the path is the full path to a good image in SLC format for that region), or the min longitude, max longitude, min latitude and max latitude of the area of interest measured eg. from Google Earth.

If the number of bursts is not as expected, or if the corner's coordinates are not in a given range, it echoes an error message with the explanations about the difference. It also attributes to a parameter named **STATUS** a value (OK or FAIL) that can be used in other scripts such as **\_Check\_ALL\_S1\_SizeAndCoord\_InDir.sh**, which used to perform the check for all images in a directory (see below).

If you only want to read the nr of bursts and coordinates of an image, provide the script with the **PATH** to the image and a **Dummy** parameter.

The script **\_Check\_ALL\_S1\_SizeAndCoord\_InDir.sh** checks the size (in bursts) and coordinates of corners of **all** S1 images in a **\$PATH\_1650/SAR CSL/S1/TARGET/NoCrop** directory. Images that are not compliant are moved in a temporary quarantine directory **\_TMP\_QUARANTINE**. Result of each checked image is stored in a text log file depending on the status, that is either

**\_Unverifiable\_Images\_date.txt**  
**\_Wrong\_Images\_Images\_date.txt**  
**\_Good\_Images\_Images\_date.txt**

These log files are removed after 15 days. It is the responsibility of the user to check regularly the **\$PATH\_1650/SAR CSL/S1/ TARGET /NoCrop/\_TMP\_QUARANTINE** directory: images there are either not fully downloaded yet and hence it might be solved the day after, or the image has a problem and must be manually moved to the definitive **\$PATH\_1650/SAR CSL/S1/ TARGET /quarantined** directory.

The script **\_Check\_S1orbits\_InSubDirs.sh** checks the S1 orbits in all the subdirectories from current directory and list in a file named **\_List\_Orbits\_DATE\_TIME\_RND.txt** the name of each S1 image and the **SLCImageInfo.txt** versions that are present in the image directory, that is the .txt and possibly the .ori if the S1 orbit was updated. See script.

The script **\_Check\_S1\_annotation.sh** checks that the annotation directory is present in each image directory from the current directory. See script for usage.

The script **\_Which\_S1\_Is\_Missing.sh** lists the expected S1 images since provided dates (one for a first expected S1A image, and one for a first expected S1B image) until today. It compares these dates to what is existing in directories where raw and read images are expected (based on provided paths, e.g. **\$PATH\_3600/SAR DATA/S1/S1-DATA-REGION-SLC.UNZIP** and **\$PATH\_1650/SAR CSL/S1/REGION/NoCrop** respectively). Note that it will also check if RAW files are in **.../S1-DATA-REGION-SLC.UNZIP\_FORMER** and if CSL files are in **/Quarantined** or **\_TMP\_QUARANTINE**).

Missing RAW images are listed in **\_Missing\_Raw\_S1A/B.txt** in the directory where you have run the script and missing CSL images (only if RAW exists) are listed in **\_Missing CSL\_S1A/B.txt**.

See scripts for usage (in **SCRIPTS\_MT/zz\_Utilities\_MT**):

- **CheckS1Pol.sh**
- **Remove\_S1Pol\_Not\_as\_in\_LaunchParamFile.sh**
- **Check\_S1\_Mas\_Slv\_sizes.sh**
- **Check\_S1\_SLCImageInfo.sh**
- **ReCreateLink\_S1\_Read.sh** (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**)
- **Check\_S1\_Before\_MSBAS.sh** (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**)
- **Check\_S1\_RawImageSize.sh**
- **CheckS1unzip.sh** (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**)
- **\_Check\_S1\_SizeAndCoord.sh** (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**)
- **\_Check\_ALL\_S1\_SizeAndCoord\_InDir.sh** (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**)
- **\_Check\_S1orbits\_InSubDirs.sh** (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**)
- **\_Check\_S1\_annotation.sh** (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**)
- **\_Which\_S1\_Is\_Missing.sh** (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**)

## 10.2. Checking the characteristics of all images.scl from current directory:

The script **\_Check CSL Corners\_Trk\_etc.sh**, is aiming at logging the main characteristics of all the images stored in your `.../SAR CSL/SAT/REGION/NoCrop` directory in a file named `List_Img_Characteristics.txt`.

That file logs the following characteristics read in the `/Info/SLCImageInfo.txt` of each image:

|                  |                                                                       |
|------------------|-----------------------------------------------------------------------|
| Date:            | The acquisition date of the image                                     |
| Time:            | The acquisition time                                                  |
| Mode:            | The Orbit geometry (Asc or Desc)                                      |
| LookDir:         | Right or Left                                                         |
| LookAngl[deg]:   | The incidence angle                                                   |
| Xsize[pix]:      | The size of image in range direction (in pixels)                      |
| Ysize[pix]:      | The size of image in azimuth direction (in pixels)                    |
| Xsampl[m]:       | The pixel size in range direction (in m)                              |
| Ysampl[m]:       | The pixel size in azimuth direction (in m)                            |
| Center/Ext-Lon:  | The longitude of the center (or the min-max UTM Y value) of the scene |
| Center/Ext-Lat : | The latitude of the center (or the min-max UTM X value) of the scene  |

It must be launched from the directory where the images.scl are stored, that is `.../SAR CSL/SAT/REGION/NoCrop`. It does not expect parameter to run.

See script for usage (in `SCRIPTS_MT/zz_Utils_MTNdo`):

- `_Check CSL Corners_Trk_etc.sh`

## 10.3. Removing unnecessary data from slave.interpolated.csl in pair directory:

In the former versions of *AMSTerEngine*, the interpolated Secondary (slave) data was stored in full in the interferometric pair directory (`i12/InSARProducts/slave.interpolated.csl`).

However, this took a lot of space and was useless. Now it only keeps the `i12/InSARProducts/slaves.interpolated.csl/Info` directory with the required information if some reprocessing is necessary.

The script ***Del\_All\_Slave.csl\_But\_TextFile.sh*** removes all the unnecessary data resulting from usage of an old version of *AMSTerEngine* in each `slave.interpolated.csl` subdirectory from a mass processing directory. It is hence only needed to clean directories to spare room on hard disk. It will also tell you how much disk space you gained after performing that cleaning. Use with care though, as usual when it deals with deleting stuffs...

Note that there is a simpler version of that cleaning, that is ***Clean\_Slave.csl.sh***. It only clean `/SLCData` sub folder, not the `/Headers` subfolder. It requires `Crop_interf.py`.

See script for usage (in `SCRIPTS_MT/zz_Utils_MTNdo`):

- `Del_All_Slave.csl_But_TextFile.sh`
- `Clean_Slave.csl.sh`

#### 10.4. Removing files from PAIR directories in SAR\_MASSPROCESS:

In order to spare room on your disks, you may want to delete some files from *PAIR* directories located in *SAR\_MASSPROCESS/SAT/REGION\_TRKISM\_ZOOM\_ML/*.

You can do that using script ***Clean\_MassProcessedPairs.sh***. Note that a parameter allows you to choose the degree of cleaning:

- *All* :  
remove all files and subdirectories in each *PAIR* but */i12/TextFiles/InSARParameters.txt* and *masterSCLImageInfo.txt*, which are required by the script ***build\_header\_msbas\_criteria.sh*** when preparing the MSBAS inversion. You can of course delete these text files as well, but then you will need to prepare you msbas inversion using (for more info, see 6.1.a):  
***build\_header\_msbas\_criteria\_From\_nvi\_name\_WithoutAcqTime.sh..***
- *Moderate* :  
remove all but keeps what is needed if you want to be able to re-run a geocoding later on.
- *Light* :  
remove all but keeps what is needed if you want to be able to re-run an unwrapping and a geocoding later on.

Remember that if you need to update your time series, it is recommended to keep all the *PAIR* directories (at least empty) for ***SuperMaster\_MassProc.sh*** to identify which pairs were already processed.

See script for usage (in *SCRIPTS\_MT/zz\_Utils\_MT*):

- ***Clean\_MassProcessedPairs.sh***

#### 10.5. Deleting a large number of files:

The script ***\_\_\_\_Kill\_All.sh*** delete as quickly as possible the whole content of a directory (provided as parameter to the script). It uses *rsync* for the highest efficiency when dealing with a very large number of files.

Use it with a LOT OF CARE because there is no undo!

The name contains 3 leading underscores. Does it prevent accidental use? Who knows...

See script for usage (in *SCRIPTS\_MT/zz\_Utils\_MT*):

- ***\_\_\_\_Kill\_All.sh***

#### 10.6. Checking or creating links from each \*.csl in a source directory to another directory:

The basic script ***MakeHardLink.sh*** creates a hard link (if it does not exist yet) from each subdirectory \*.csl located in a source directory (path given as parameter 1) into a target directory (path given as parameter 2).

The script ***Remove\_Broken\_links.sh*** check in the directory provided as parameter if each \*.csl subdirectory is a directory or a link pointing toward a valid target. If no, it deletes the \*.csl.

There is also a script named ***Remove\_Links\_In\_Dir.sh*** which removes possible erroneous links in *image.csv* directories. See

See script for usage:

- ***MakeHardLink.sh*** (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT](#))
- ***Remove\_Broken\_links.sh*** (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT](#))
- ***Remove\_Links\_In\_Dir.sh*** (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT\\_Ndo](#))

## 10.7. Linking or copying Geocoded files to msbas directory

The script ***Ins\_msbas.sh*** is aiming at creating a symbolic link (or copying ; see code) from Envi geocoded files to where they will be used by MSBAS.

See script for usage (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT](#)):

- ***Ins\_msbas.sh***

## 10.8. Swapping columns in files

The scripts ***Swap\_Col3and4.sh*** makes use of [awk](#) to swap the 3<sup>rd</sup> and the 4<sup>th</sup> columns of an ascii file.

The version ***Swap\_Col3and4\_IfNeeded.sh*** does the same but only if the value of the 4th column is larger than the value of the 3rd column.

***Search\_Mas\_After\_Slv.sh*** list the lines of a file that contains 4 columns and where date in col1 is after date in col2.

See script for usage (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT](#)):

- ***Swap\_Col3and4.sh***
- ***Swap\_Col3and4\_IfNeeded.sh***
- ***Search\_Mas\_After\_Slv.sh***

## 10.9. Searching and removing files or directories if size is smaller than a given threshold

The script ***RemoveDEM\_SmallerThan.sh*** searches for the [externalSlantRangeDEM](#) files in the current directory and all its subdirectories and delete them if their size is smaller than a threshold value provided as parameter.

The script ***Move\_All\_Dir\_SmallerThan.sh*** searches in the current directory for all the directories that are smaller than a certain amount (in Mb) and move them in a provided path.

The script ***Move\_All\_Files\_SmallerThan.sh*** searches in the current directory for all the files named “\*deg” (and its hdr) that are not of the given size (in Bytes) and move them in a provided path.

See script for usage (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT](#)):

- ***RemoveDEM\_SmallerThan.sh***
- ***Move\_All\_Dir\_SmallerThan.sh*** (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT\\_Ndo](#))
- ***Move\_All\_Files\_SmallerThan.sh*** (in [SCRIPTS\\_MT/zz\\_Utilities\\_MT\\_Ndo](#))

## 10.10. Renaming, searching or copying files (or dir) based on string(s) in name

The very basic script ***Rename.sh*** search for all files in the current directory containing a given string in the name and rename these files by replacing that string with something else. (String to search and to replace with are hard-coded).

The script ***CP\_All\_files\_as.sh*** copies all files from current directory (incl. subdirs) that contains a certain string (parameter 1) in their name into a given dir. (parameter 2).

The script ***echo\_missing\_files\_as.sh*** searches in the current directory each subdirectory which name contains a given string, then check in that directory for the presence of a ***/i12/InSARproducts/\*.jpg*** file. If not, it echoes the name of the problematic pair directory.

The script ***ren.sh*** add a .bin string between the basename and the extension of all the .hdr files in dir.

The script ***Rename\_CSK\_From\_MassReader.sh*** renames the CSK directories obtained from CSK mass reading by only keeping ***DATE.cs/*** instead of ***CSKx\_DATE\_TIME.cs/***

The script ***Find\_Dir\_Name\_With\_Date\_Twice.sh*** looks for all files in current directory that are named with duplicated date (e.g. search for pairs that would have been accidentally processed with twice the same date as Primary and Secondary image. The script can be easily adapted to search for files instead of dir and in subdirs... and/or do something with results (see script in ***SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo***). It must obviously be launched in dir to search in.

The script ***Check\_deg\_hdr\_in\_dir.sh*** checks that all files ending with \**deg* in the current directory has another file ending with .*hdr* extension. It also checks that there is no .*hdr* file without \**deg* file.

See script for usage (in ***SCRIPTS\_MT/zz\_Utilities\_MT***):

- ***Rename.sh***
- ***CP\_All\_files\_as.sh***
- ***echo\_missing\_files\_as.sh***
- ***ren.sh***
- ***Rename\_CSK\_From\_MassReader.sh***
- ***Find\_Dir\_Name\_With\_Date\_Twice.sh*** (in ***SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo***)
- ***Check\_deg\_hdr\_in\_dir.sh*** (in ***SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo***)

## 10.11. Check value of the Ellipsoid in Geocode Parameters file

The script ***Check\_Ellipsoid\_in\_GeocParam.sh*** checks the size of the ellipsoid in all the ***i12/TextFiles/geoProjectionParameters.txt*** from the ***SAR\_MASSPROCESS***. If zero, it updates the value and store the pair name in file named ***\_Updated\_GeoProjParamFiles.txt***. The script must be launched in ***SAR\_MASSPROCESS/sat/trk/crop/***, i.e. where all pair directories are.

See script for usage (in ***SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo***):

- ***Check\_Ellipsoid\_in\_GeocParam.sh***

### 10.12. Check coordinates of corners from all geocoded products in SAR\_MASSPROCESS pair dirs.

The script ***Check\_GeocCropCoord\_GeocParam.sh*** checks the coordinates of corners from all geocoded products in the [i12/TextFiles/geoProjectionParameters.txt](#) from the [SAR\\_MASSPROCESS](#) pair directories. Coordinates are logged into [\\_GeoProjCoord.txt](#).

Size can be compared to expected values (hard coded); if not as expected, the script lists the pairs names in [\\_GeoProjCoord\\_WrongPairs.txt](#), where it will also log the creation date

See script for usage (in [SCRIPTS\\_MT/zz\\_Utilsities\\_MT\\_Ndo](#)):

- [\*\*\*Check\\_GeocCropCoord\\_GeocParam.sh\*\*\*](#)

### 10.13. Changing the endianness of a binary file

Using gdal, ***Change\_Bin\_Order.sh*** changes the byte ordering of all ENVI .bin files in the current directory.

See script for usage (in [SCRIPTS\\_MT/zz\\_Utilsities\\_MT](#)):

- [\*\*\*Change\\_Bin\\_Order.sh\*\*\*](#)

### 10.14. Changing date format

The script ***dat2sec.sh*** transforms the first column of a file (except the first header line) from [YYYYMMDD](#) into [Linux seconds](#).

The script ***date2decimalyr.sh*** transforms the first column of a file from [YYYYMMDD](#) into [decimal year](#).

The script ***decimalyr2date.sh*** transforms the first column of [decimal year](#) into [YYYYMMDD](#).

The script ***sec2date.sh*** transforms the first column of [Linux seconds](#) into [YYYYMMDD](#).

See script for usage (in [SCRIPTS\\_MT/zz\\_Utilsities\\_MT](#)):

- [\*\*\*dat2sec.sh\*\*\*](#)
- [\*\*\*date2decimalyr.sh\*\*\*](#)
- [\*\*\*decimalyr2date.sh\*\*\*](#)
- [\*\*\*sec2date.sh\*\*\*](#)

### 10.15. Update all LaunchMTparameters.txt files

The script ***ChgeAll\_LaunchParamFiles.sh*** is dedicated to change all lines containing a given string with another one from all param files (such as [\\_\\_V20231026\\_LaunchMTparam.txt](#)) in sub dirs. This might be useful if a new feature is added to AMSTer that requires for instance to change all the ***LaunchMTparameters.txt*** files.

It was also sometimes used in a script ***Chge\_Several\_Criteria\_LaunchParamFiles.sh*** dedicated to operate multiple occurrences of parameters changes.

The script ***RemoveFromAll\_LaunchParamFiles.sh*** removes all lines containing a given string from all parameters files in sub directories.

These scripts haven't been used for a while though. Not sure they still work properly.

See script for usage (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**):

- ***ChgeAll\_LaunchParamFiles.sh***
- ***Chge\_Several\_Criteria\_LaunchParamFiles.sh***
- ***RemoveFromAll\_LaunchParamFiles.sh***

### 10.16. Compile and store files when updating AMSTerEngine

The script ***UpdateAMSTerEngine.sh*** is aiming at updating AMSTerEngine by compiling the sources and sorting them in appropriate place and clean compilation directories. It compiles the main software and the tools. It expects the following parameters:

- path to zipper source of AMSTerEngine to update
- Date of version to update (YYYYMMDD)

See script for usage (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**):

- ***UpdateAMSTerEngine.sh***

### 10.17. Update hard coded lines after update of AMSTer toolbox

Script ***Tune\_your\_AMSTer.sh*** is aiming at updating all hard coded lines in AMSTer scripts used in your installation, i.e. that would differ from the scripts downloaded or synchronized e.g. from GitHub.

It helps to keep the updated scripts consistent with your own installation. It is hence recommended to run it after each synchronization with the GitHub repository for instance.

The script contains (among others) a function named ***UpdateLineInScript*** dedicated to replace a given line in a given script with a new line.

Hence you must first build your own set of calls of the function ***UpdateLineInScript*** for each hard coded line to change. Everything is then hardcoded in that script and there is no parameter for this script.

Because special characters (such as \*, \$, \ etc...) are interpreted by the shell scripts, finding and replacing them in the scripts requires a little trick. They are replaced by a chosen string (which one must be sure is not already used in the scripts) beforehand. After the replacement of the line, all these strings are replaced back with the special character. In principle,

***Tune\_your\_AMSTer.sh*** is able to cope with most of the special characters. However, if a new special character would mess up in the line to change during update, you may need to:

- Choose a replacement string
- add that special character in the functions ***RemoveSpecChar*** and ***RestoreSpecChar***
- add the replacement string in the test array LISTOFSSTRINGS

### ATTENTION:

- It is mandatory that your initial line (the one you search for) and the new line (the one that will be used to replace the initial one) **MUST** be clean of
  - double quotes (single are ok)
  - \$
  - @ because we use it as sed separator...
 If some of these are present, they **MUST** be preceded by a backslash.
- Be aware that if your line appears multiple time, it will change it multiple time
- Each script to be updated **MUST** be provided to ***UpdateLineInScript*** with its full path.

It is advised to test the script for instance by creating a file named **Test\_Syntax.txt** and copy the following 3 lines in it:

```
This line will be unchanged, but the following
abc ${a var}, == [why] {not} (brackets) "and quotes" && 'double quotes' || /a/PATH/${here} and 1 ; 2 : 3 , 4 . 5 - 6 -- 7 _ 8 __ "seems 'ok' though" hopefully
should be capitalized
```

then run ***Tune\_your\_AMSTer.sh*** with the 3 following lines hard coded in the body of the present script, i.e. below the functions definition

```
DEFAULTLINE="abc \${a var}, == [why] {not} (brackets) \"and quotes\" && 'double quotes' || /a/PATH/\${here} and 1 ; 2 : 3 , 4 . 5 - 6 -- 7 _ 8 __ \"seems 'ok' though\" hopefully"
PERSOLINE="ABC \${A Var}, == [Why] {Not} (Brackets) \"And Quotes\" && 'Double Quotes' || /A/path/\${Here} And 1 ; 2 : 3 , 4 . 5 - 6 -- 7 _ 8 __ \"Seems 'OK' Though\" Hopefully"
UpdateLineInScript /PATH_TO_YOUR/Test_Syntax.txt "\${DEFAULTLINE}" "\${PERSOLINE}"
```

After successful run of the script, the second line of **Test\_Syntax.txt** must have been updated and the file should now look like:

```
This line will be unchanged, but the following
ABC \${A Var}, == [Why] {Not} (Brackets) "And Quotes" && 'Double Quotes' || /A/path/\${Here} And 1 ; 2 : 3 , 4 . 5 - 6 -- 7 _ 8 __ "Seems 'OK' Though" Hopefully will be capitalized
```

**NOTE THAT A \ (back slash sign) MUST BE ADDED MANUALLY BEFORE EACH OCCURRENCE OF A \$ (dollar sign) OR A " (double quote sign) IN THE DEFINITION OF THE LINES TO SEARCH (DEFAULTLINE) AND REPLACE (PERSOLINE) IN THE PRESENT SCRIPT.**  
**YOU DO NOT HAVE TO ADD THESE \ IN THE ORIGINAL FILE TO CHANGE OF COURSE.**

For security reason, the script will back up your original scripts (e.g. **Test\_Syntax.txt** in the case of the test) with an **.original.perso** extension (e.g. **Test\_Syntax.txt.original.perso**). If you are satisfied with your updated script, you can delete that backup because it will not be overwritten at next run of the script.

See script for usage (in **SCRIPTS\_MT/zz\_Utilities\_MT**).

### 10.18. Check the version of AMSTer Engine used to compute products

The script ***Search\_All\_Made\_With\_AE\_Version\_After.sh*** aims at searching in the current directory (and subdirectories) for all the products (images in SLC format, RESMAPLED products, MASSPROCESSED products) computed with a AMSTer Engine version after a given date (provided as a parameter).

It expects the following parameters:

- date from which AMSTer Engine version must be searched for
- type of products to search for:
  - CSL will search for image reading and DEM projection
  - COREG will search for coregistration on SM
  - PAIRS will search for processed pairs

See script for usage (in [SCRIPTS\\_MT/zz\\_Utilsities\\_MT\\_Ndo](#)).

### 10.19. Small maintenance or check tools

Script ***I3.sh*** lists

- the 3 last S1 images read from VVP; Lux and Domuyo in Asc and Desc modes,
- then the 3 last resampled,
- then the last 3 mass processed (from [Geocoded](#), i.e. maybe not finished yet)
- then the last 3 finished directories in [MASSPROCESSED](#)
- then the last 3 images included in msbas processing in Asc and Desc LOS and in UD-EW combi (incl. with and w/o Coh threshold when appropriate).

Then it sorts the results in a table that helps to see quickly if the automated processes are up to date. See script for usage (in [SCRIPTS\\_MT/zz\\_Utilsities\\_MT\\_Ndo](#)).

Script ***psn*** uses the Linux command `ps -eaf` to make a summary of all the running processes using AMSTer tools. It will provide with valuable information such as on which hard disk some computations are running, how many pairs were already processed (on a total of how many) and when were these processes launched. See script for usage (in [SCRIPTS\\_MT](#)).

The script ***\_Check\_Cron\_MassProcessed.sh*** (in [SCRIPTS\\_MT/zz\\_Utilsities\\_MT\\_Ndo](#)) is specific to our cron jobs at ECGS. It lists the last [5](#) (hard-coded parameter) scheduled S1 and CSK mass processes and checks what was effectively performed. Knowing the revisiting time of S1, it will warn in case of missing image. However, because there is no pre-defined revisiting time for CSK, it only looks for the [5](#) last existing raw images. The script outputs a table summarizing the status of the processings at the different stages and offers comments to help the user sorting out what could have happened in case of problem.

Similarly, the script ***\_Check\_Cron\_Ampli.sh*** (in [SCRIPTS\\_MT/zz\\_Utilsities\\_MT\\_Ndo](#)) is specific to our cron jobs at ECGS. It lists the last [5](#) (hard-coded parameter) scheduled S1 and CSK AMPLITUDE processes and check what was effectively performed. Knowing the revisiting time of S1, it will warn in case of missing amplitude image. However, because there is no pre-defined revisiting time for CSK, it only looks for the [5](#) last existing amplitude images. These amplitude images are computed from automatic ***ALL2GIF.sh*** processes used to track geomorphological changes in the crater of some volcanoes.

The script outputs a table summarizing the status of the processings at the different stages and offers comments to help the user sorting out what could have happened in case of problem.

The script ***Get\_DateFromFileName\_And\_CreationDate.sh*** aims at getting the date from the name of all the image files (or directories) in the current directory as well as their creation date. It also displays the difference in days between name and creation, as well as some statistics related to latency with former images etc. It must be launched from directory where all the images are stored. See script in [SCRIPTS\\_MT/zz\\_Utils\\_MTNdo](#).

This script is used to check e.g. the latency of CSK images provided by the Virunga Supersite and outputs a message like:

```
Get_DateFromFileName_And_CreationDate.sh Distro V1.0.2 AMSTer script utilities, Nicolas d'Oreye, (c)2016-2019, Last modified on Mar 15, 2022
Processing launched on Fri Jun 10 10:48:17 CEST 2022

[...]
Image 20220127 was created on 20220203, i.e. nr of days between acquisition and delivered: 7 ; Nr of days between two last images: 2 ; Nr of days without info: 9
Image 20220210 was created on 20220216, i.e. nr of days between acquisition and delivered: 6 ; Nr of days between two last images: 14 ; Nr of days without info: 20
Image 20220212 was created on 20220214, i.e. nr of days between acquisition and delivered: 4 ; Nr of days between two last images: 2 ; Nr of days without info: 6
Image 20220228 was created on 20220305, i.e. nr of days between acquisition and delivered: 5 ; Nr of days between two last images: 16 ; Nr of days without info: 21
Image 20220305 was created on 20220311, i.e. nr of days between acquisition and delivered: 6 ; Nr of days between two last images: 5 ; Nr of days without info: 11
Image 20220307 was created on 20220311, i.e. nr of days between acquisition and delivered: 4 ; Nr of days between two last images: 2 ; Nr of days without info: 6
Image 20220316 was created on 20220415, i.e. nr of days between acquisition and delivered: 29 ; Nr of days between two last images: 9 ; Nr of days without info: 38
Image 20220321 was created on 20220415, i.e. nr of days between acquisition and delivered: 24 ; Nr of days between two last images: 5 ; Nr of days without info: 38
Image 20220323 was created on 20220415, i.e. nr of days between acquisition and delivered: 22 ; Nr of days between two last images: 2 ; Nr of days without info: 29
Image 20220324 was created on 20220415, i.e. nr of days between acquisition and delivered: 21 ; Nr of days between two last images: 1 ; Nr of days without info: 22
Image 20220330 was created on 20220415, i.e. nr of days between acquisition and delivered: 16 ; Nr of days between two last images: 5 ; Nr of days without info: 21
Image 20220401 was created on 20220423, i.e. nr of days between acquisition and delivered: 22 ; Nr of days between two last images: 2 ; Nr of days without info: 24
Image 20220409 was created on 20220429, i.e. nr of days between acquisition and delivered: 20 ; Nr of days between two last images: 8 ; Nr of days without info: 28
Image 20220422 was created on 20220429, i.e. nr of days between acquisition and delivered: 7 ; Nr of days between two last images: 13 ; Nr of days without info: 20
Image 20220423 was created on 20220429, i.e. nr of days between acquisition and delivered: 6 ; Nr of days between two last images: 1 ; Nr of days without info: 7
Image 20220424 was created on 20220429, i.e. nr of days between acquisition and delivered: 5 ; Nr of days between two last images: 1 ; Nr of days without info: 6
Image 20220425 was created on 20220513, i.e. nr of days between acquisition and delivered: 18 ; Nr of days between two last images: 1 ; Nr of days without info: 19
Image 20220503 was created on 20220513, i.e. nr of days between acquisition and delivered: 10 ; Nr of days between two last images: 8 ; Nr of days without info: 18
Image 20220509 was created on 20220526, i.e. nr of days between acquisition and delivered: 17 ; Nr of days between two last images: 6 ; Nr of days without info: 23
Image 20220510 was created on 20220526, i.e. nr of days between acquisition and delivered: 16 ; Nr of days between two last images: 1 ; Nr of days without info: 17
Image 20220511 was created on 20220526, i.e. nr of days between acquisition and delivered: 15 ; Nr of days between two last images: 1 ; Nr of days without info: 16
Image 20220519 was created on 20220526, i.e. nr of days between acquisition and delivered: 7 ; Nr of days between two last images: 8 ; Nr of days without info: 15
Image 20220524 was created on 20220526, i.e. nr of days between acquisition and delivered: 2 ; Nr of days between two last images: 5 ; Nr of days without info: 7
Today, 20220610, nr of days without info since last image was acquired is: 17

Statistics over last 60 images:
Average delay between acquisition and delivered: 9.31 days ; Average delay between two images: 4.20 days ; Average nr of days without info: 13.51
```

Because samba sometimes mess up with hidden temporary files that prevent deleting directories, the script ***KillGhost.sh*** aims at attempting circumventing the problem by moving these hidden unclosed files in a directory named [ToKill](#). See script for usage (in [SCRIPTS\\_MT/zz\\_Utils\\_MTNdo](#)).

In some cases, raster files created by a processing run on Linux computer were empty. The script ***Recreate\_Empty\_GeocodedRasters.sh*** will recreate all empty raster files from [/GeocodedRasters/DefolInterpol2Detrend](#).

It must be launched in SAR\_MASSPROCESS/region where [/Geocoded](#) and [/GeocodedRasters](#) are.

The script ***Which\_S1\_Is\_Missing.sh*** lists the expected S1 images since provided date until today and compare to raw and read images. It performs the check first for S1A then S1B images. Missing RAW images are listed in [\\_Missing\\_Raw\\_S1A/B.txt](#) in the current directory. Missing CSL images (when RAW exists) are listed in [\\_Missing CSL\\_S1A/B.txt](#) in the current directory. See script for usage (in [SCRIPTS\\_MT/zz\\_Utils\\_MTNdo](#))

The script ***Check\_All\_DEMs\_in CSL.sh*** checks the name and the size of the *slantRangeDEM* in each image directory (e.g. [SAR CSL/Sat/Region/NoCrop/image.csl](#) directories). It also displays the version of AMSTer used to create the *slantRangeDEM*. See script for usage (in [SCRIPTS\\_MT/zz\\_Utils\\_MTNdo](#))

## 10.20. Manually unzip and store S1 data

When downloading a new batch of S1 data, it might be useful to use ***Unzip\_S1.sh*** to decompress all .zip file in a directory provided as parameter (including in sub dir) and store them in a new directory with the same named, though with tailed with **.UNZIP**. The script also check that each image hasn't been unzipped yet. If so, it checks its size and redo the unzip if size is not as expected.

See script for usage (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**):

- ***Unzip\_S1.sh***

## 10.21. Sort unzip S1 data by mode and orbit

Although the sorting of S1 images by mode (Ascending or Descending) and orbit number is usually performed at reading with the automatic procedure included in the script ***Read\_All\_img.sh*** while being transformed from raw **UNZIP** to **SAR\_CSL**, it may happen that one needs to sort them already at the level of the raw data.

This can be achieved with the script ***Sort\_UNZIP\_S1.sh***. It will read the info from the **manifest.safe** of each raw image and sort them accordingly.

See script for usage (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**):

- ***Unzip\_S1.sh***

## 10.22. Mac only features: Add colour bullets to dir names or de-quarantine files

The script ***MacColorFile.sh*** aims at tagging a directory with a colour (**This is a Mac only feature!**):

- 0 No color
- 1 Orange
- 2 Red
- 3 Yellow
- 4 Blue
- 5 Purple
- 6 Green
- 7 Gray

This script is called e.g. by the script ***CheckJpg.sh***, which aims at checking all PAIR sub-directories and tag them with a green or red colour bullet if they do or do not contain a jpg file in **/i12/InSARProducts**.

See scripts for usage (in **SCRIPTS\_MT/zz\_Utilities\_MT\_Ndo**):

- ***MacColorFile.sh***
- ***CheckJpg.sh***

Because for unknown reason, some scripts are set in quarantine by recent Mac OSX, it happens sometimes that they can't be executed (e.g. sometimes after modifications). To solve this, the script ***MacOSX\_DeQuarantine\_File.sh*** removes either one file (provided as

parameter) or all the files in the current directory (if param : **-d**) and sub-dirs (if param : **-dd**) from security quarantine. (**This is a Mac only feature!**).  
See script in [SCRIPTS\\_MT/zz\\_Utils\\_MTNdo](#).

Similarly, ***Unlock\_all\_in\_dir.sh*** unlocks all Mac locked files from a directory and its sub-directories.

### 10.23. Single coordinates transformation:

The scripts [\\_UTM2LatLong.py](#) and [\\_LatLong2UTM.py](#) transform UTM coordinates to LatLong and inversely (single values).

See scripts for usage (in [SCRIPTS\\_MT/zz\\_Utils\\_MTNdo](#)):

- [\\_UTM2LatLong.py](#)
- [\\_LatLong2UTM.py](#)

### 10.24. Set up script:

The scripts ***Build\_Geocoded\_and\_GeocodedRasters\_Dirs.sh*** do nothing else than manually creating [Geocoded](#) and [GeocodedRasters](#) directories and subdirectories normally created during the mass processing.

## 11. Troubleshooting:

What could possibly go wrong? Well... here are some ideas.

Also:

- think about reading the manual (e.g. search for keywords or look in the index);
- consult the discussion group in the GitHub repository.

### 11.1. Can't find ...

One of the most classical errors is a **file or a directory that can't be found**. It can result from a typo in your parameters file or in your command line. It can also be due to missing data or results of course.

You can try to list at the terminal the directory where the missing file or directory is supposed to exist. If it does not exist, remove step by step the sub-directories from the path to see from where there is a failure.

You can also compare in a text editor the path of the missing file or directory as copied from the error message and the path from your file manager: see if there is a typo somewhere.

### 11.2. Problem with mask:

Check that the mask has the proper name and format.

In particular, in some old versions of AMSTer the **name of the mask must have no extension** compared to its header, e.g.

`name_of_your_mask.what_ever_your_want`  
`name_of_your_mask.what_ever_your_want.hdr`

and **not** something like

`name_of_your_mask.what_ever_your_want.envi`  
`name_of_your_mask.what_ever_your_want.hdr`

(See more about the format in section 0.15)

### 11.3. /bin/bash: bad interpreter

If you encounter the following message:

**`ScriptName.sh: /bin/bash: bad interpreter: Operation not permitted`**

means that the shebang (first line of your script containing the string “`#!/bin/bash`” is corrupted. Usually erasing and rewriting it will not solve the issue. By experience, the most efficient way to solve it is

- create a new empty file
- copy in it all the script but the first line with the shebang
- add manually that first line `#!/bin/bash`
- delete the initial corrupted script
- save your new file with the name of the script to be replaced
- you may need to make that new script executable by typing  
`chmod +x ScriptName.sh`

## 11.4. Problem with cron

With Linux, if your script launched by a cron does not behave as when launched from the terminal, check:

- that your state variables are all defined in your cron tab as they are in your `.bashrc`
- that no scripts related to the mass processing are open in a text editor. Indeed, the scripts for cron are usually checking that no other crons are running (same of previous steps), nor manual run of the same step for the same target. However, one of these scripts open with a text editor would be detected by the “`ps`” command. To be sure, close all the scripts open in text editor.
- The several logs that may give you a hint about the reason of the crash...
- Paths to where basic commands are stored (such as `/usr/sbin...`) are defined early in your `$PATH`. For instance, if a Mac does not execute a cron and stay hanging while attempting to perform a parallel computing (e.g. at `Read_all_Img.sh`), it might be because it does not know “`sysctl`” which is supposed to be in `/usr/sbin`.

With Mac, if your script does not launch from cron, check that cron is allowed to have full disk access:

- open the **System Settings**
- Select **Privacy & Security** menu
- Select **Full Disk Access** menu
- Add `/usr/bin/crontab`, `/usr/bin/cron` and `/usr/bin/bash`  
(this may differ depending on the Mac OSX version though).

**Note that from Sonoma (i.e. version 14.6), cron jobs may not work properly.**

It is then advised to use [LaunchAgents](#) instead.

You will need to create an xml file `~/Library/LaunchAgents/user.YourDescription.launch.plist` describing the task to launch and when to launch it. See for instance the example below launching every day at 20h45 the script `/FullPath/To/YourScript.sh`.

The agent will then be loaded by typing the following command at the terminal:

```
launchctl load ~/Library/LaunchAgents/user.YourDescription.launch.plist
```

To disable the agent, type

```
launchctl unload ~/Library/LaunchAgents/user.YourDescription.launch.plist
```

To list the planned tasks:

```
launchctl list | grep user
```

Ensure that `/usr/bin/bash` is granted full disk access in the **System Settings**.

To operate these automated tasks when the user is not logged in, you must use [LaunchDaemons](#) instead of [LaunchAgents](#). See Mac documentation for more details about [LaunchDaemons](#) and [LaunchAgents](#).

**Another solution** is to disable the **System Integrity Protection (SIP)**. **WARNING: The SIP aims at protecting Mac OS X from malicious code or accidental manoeuvres. Only do this if you know what you are doing and if your computer is in a safe environment:**

- Reboot the computer in safe mode
- Open a Terminal
- Type “`csrutil disable`”, then “`reboot`”

You can check the status of the SIP at any time by typing in a Terminal “`csrutil status`”.

Example of `~/Library/LaunchAgents/user.YourDescription.launch.plist`:

```
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE plist PUBLIC "-//Apple//DTD PLIST 1.0//EN" "http://www.apple.com/DTDs/PropertyList-1.0.dtd">
<plist version="1.0">
<dict>
 <key>Label</key>
 <string>user.YourDescription</string>
 <key>Program</key>
 <string>/FullPath/To/YourScript.sh</string>
 <key>ProgramArguments</key>
 <array>
 <string>/FullPath/To/YourScript.sh </string>
 </array>
 <key>StartCalendarInterval</key>
 <!-- Weekdays are 1 - 5; Sunday is 0 and 7 -->
 <array>
 <dict>
 <key>Weekday</key>
 <integer>1</integer>
 <key>Hour</key>
 <integer>20</integer>
 <key>Minute</key>
 <integer>45</integer>
 </dict>
 <dict>
 <key>Weekday</key>
 <integer>2</integer>
 <key>Hour</key>
 <integer>20</integer>
 <key>Minute</key>
 <integer>45</integer>
 </dict>
 <dict>
 <key>Weekday</key>
 <integer>3</integer>
 <key>Hour</key>
 <integer>20</integer>
 <key>Minute</key>
 <integer>45</integer>
 </dict>
 <dict>
 <key>Weekday</key>
 <integer>4</integer>
 <key>Hour</key>
 <integer>20</integer>
 <key>Minute</key>
 <integer>45</integer>
 </dict>
 <dict>
 <key>Weekday</key>
 <integer>5</integer>
 <key>Hour</key>
 <integer>20</integer>
 <key>Minute</key>
 <integer>45</integer>
 </dict>
 <dict>
 <key>Weekday</key>
 <integer>6</integer>
 <key>Hour</key>
 <integer>20</integer>
 <key>Minute</key>
 <integer>45</integer>
 </dict>
 <dict>
 <key>Weekday</key>
 <integer>7</integer>
 <key>Hour</key>
 <integer>20</integer>
 <key>Minute</key>
 <integer>45</integer>
 </dict>
 </array>
</dict>
</plist>
```

## 11.5. Problem with msbas

In case of problem, start by checking:

- The size of each `DefolInterpolx2Detrendi/*deg` file. Search for files that would be significantly smaller or bigger than the majority.
- The links are not broken or pointing toward empty images
- The `header.txt`
- The `DefolInterpolx2Detrendi/Out_Of_Range_Bpm_Btdays.txt` file. It must contain only a list of images already tested against your criteria of `Bp` and `Bt` (if using `build_header_msbas_criteria.sh`). Check that it is not corrupted, i.e. it contains nothing other than a list of pairs like e.g.  
`/.../SAR_MASSPROCESS/SAT/TRACK/SMNoCrop_SM_date_Zoom_ML/Geocoded/DefolInterpolx2Detrend/deformationMap.interpolated.flattened.UTM.....characteristics_of_pair....deg`
- If during the SVD inversion, it outputs a line mentioning “`xxx Killed`” where `xxx` is a number, or something like “Bus error”, it means that you ran out of RAM. Decrease the amount of data to invert either:
  - restricting the number of pairs to invert by optimizing the baseline plot (see `Run_optim_module.sh`) – preferred solution;
  - by cropping the zone to invert (see `WINDOW_SIZE` in `header.txt`);
  - restricting the number of pairs to invert by selecting pairs with each image taken max 3 times as Primary and Secondary (see `Extract_Baselines_3.sh`);
  - restricting the number of pairs to invert by selecting a coherence threshold (see `restrict_msbas_to_Coh.sh`);
  - restricting the number of pairs to invert by checking the phase closure (see `Extract_Triangles.sh` and `Check_Closure_All_Triangles.sh`);

Or add more RAM.

Note: MSBAS needs to load at least the whole data set to invert into the RAM. If there is not enough RAM for that, it can't work. Increasing the swap memory (see technical note [Create\\_Swap\\_Linux.pdf](#) for Linux) only helps for the additional memory it requires during the processing.

## 11.6. Problem with jpg time series plots

With Linux, if your jpg figure merging the eps time series plot and the tags (position of the pixels on the velocity maps and direction of deformation) is not as expected, check:

- The `/etc/ImageMagick/policy.xml` or `/etc/ImageMagick-6/policy.xml` file, which must contain the following values:
  - `<policy domain="coder" rights="read|write" pattern="PS" />`
  - `<policy domain="coder" rights="read|write" pattern="EPS" />`
  - `<policy domain="resource" name="width" value="32KP"/>`
  - `<policy domain="resource" name="height" value="32KP"/>`
  - `<policy domain="resource" name="disk" value="8GiB"/>`
- The scripts `AmpDefo_map.sh`, `TimeSeriesInfo_HP.sh` etc... use the right font, that is
  - `Font="FreeSans"`

With Mac or Linux, in case of problem, also check that:

- The necessary files from `SCRIPTS_MT/TSCombiFiles` were correctly copied in the directory `.../MSBAS/YourTarget/_CombiFiles`

- The `.../MSBAS/YourTarget/_CombiFiles/TS_parameters.txt` file has been correctly updated (see Section 6.5.a)
- The `.../MSBAS/YourTarget/_CombiFiles/satview.jpg` file has been correctly created (see Section 6.5.a)

If you had tables in `EVENTS_TABLES/YourTarget` with events to plot and they do not display, check the format of your table(s). It must be 2 or 3 columns (depending on the type of table) separated by tabs. Also, the **last line of the table must be followed by a carriage return**. Without that, the last line of the table will not be displayed.

### 11.7. Problem with eps time series Y scale when using -coh option

If your time series plot created with `PlotTS_all_comp.sh` using `-coh` option displays an abnormal Y scale, you can try the following:

- Create the same plot without the `-coh` option and without `-d`, `-D` and `-g` option (that is keeping the files to replot the figure). Check that the time series displays as expected and take note of the min/max Y scale.
- Plot again the time series with option `-coh`
- Edit the gnu plot file and uncomment the definition of the Y scale (see the line with something like `# set yrang [-0.12, 0.04]`)
- Change that `yrang` variable to the scale you noted at first step
- At the terminal, in the directory where you computed the time series, relaunch the plot by executing `gnuplot` followed with the name of your gnuplot file you just modified.

### 11.8. Problem with getLineThroughStack (e.g. in `PlotTS_all_comp.sh`)

If `getLineThroughStack` (i.e. the AMSTerEngine function used e.g. in `PlotTS_all_comp.sh`) does not properly extract the list of value for the given pixel, check that each of the deformation map has its proper `.hdr` file and no other `.hdr` file are present in the running directory without a proper file (e.g. no lonely `HDR.hdr` file). The `.hdr` files from velocity, stdv maps etc... are OK of course.

### 11.9. Problem with Java

If a script crashes with the following message, re-install java and then Fiji (e.g. using `AMSTer_Install.sh`)  
`<< The operation couldn't be completed. Unable to locate Java Runtime that supports (null). >>`

### 11.10. Problem reading h5 format data (like CSK data)

Check hdf5 library version with the command:

- `h5dump --version` (Mac)
- `pkg-config --modversion hdf5` (Linux)

On Mac, versions before 1.14.2 seems to have problems.

Note that the compiler checks the version before compiling and takes into account the major changes from v 1.12.

### 11.11. Problem while reading S1 images

If an image can't be read or is not read as expected (e.g. do not contains all the bursts etc...), check the following:

- Can the raw image(s) be unzipped without error? If not, re-download the data.
- Does the de-zipped data have the same size and number of files as other images that are OK ? If not, the acquisition of the raw image might be faulty. You can store the bad image.slc in [.../SAR CSL/S1/REGION\\_Mode/Quarantained](#)
- Is an image with the same name in  
[.../SAR CSL/S1/REGION\\_Mode/Quarantained](#)  
or  
[.../SAR CSL/S1/REGION\\_Mode/NoCrop/\\_TMP\\_QUARANTINE](#)  
If yes, try to remove them as well as the link in  
[.../SAR CSL/S1/REGION/NoCrop/](#)  
and try to read them again.

In any case, read carefully the output of the **Read\_All\_img.sh** script as it might tell you where the problem is.

If the script **Read\_All\_img.sh** does not read all the S1 images in the **SAR\_DATA** directory, check the output at the terminal. If it complains that one of the images can't be read, it will stop reading all the following images and carry on with the scripts to stitch the bursts of the images it had successfully read. Hence, you will miss all the images to read after the one that failed. To overcome that problem, remove the wrong image from **SAR\_DATA** directory and relaunch the **Read\_All\_img.sh** script. You can also try to re-download the image from the space agency and read it again.

### 11.12. Empty deformation maps when performing re-geocoding

Performing the re-geocoding of some products using e.g. **ReGeocode\_fromList.sh** may results in empty deformation maps if the original products were obtained with an old format mask (i.e. 0 was masking and 1 was keeping) and if you attempt to run the re-geocoding with a version of AMSTer after 20230921, that is dealing with (or expecting) new mask format (i.e. a 3 stages mask where 0=keep, 1=always mask, 2=mask only if coh < threshold; see e.g. chapter 0.15) or 3.4).

To overcome that problem, perform the re-geocoding without masking, that is setting parameter **APPLYMASK** from [LaunchMTparam.txt](#) as **APPLYMASKno**.

### 11.13. Problem with x-terminal-emulator

If, e.g. after an update, the function *x-terminal-emulator* used by [\\_\\_SplitSession.sh](#) or [\\_\\_SplitCoreg.sh](#), crashes with an error like

```
Error constructing proxy for org.gnome.Terminal:/org/gnome/Terminal/Factory0:
StartServiceByName for org.gnome.Terminal: Timeout was reached
```

try reinstalling the Terminal by typing the following commands:

```
Reinstalling terminal
dconf reset -f /org/gnome/terminal
sudo apt-get remove gnome-terminal
sudo apt-get install gnome-terminal

Reconfiguring locale
sudo locale-gen --purge
```

```
sudo dpkg-reconfigure locales
```

### 11.14. Problem with Libraries

If, after an update, some executables show messages such as

```
Library not loaded: 'opt/local/liblibtiff.5.dylib'
```

try to recompile the sources. It may happen e.g. after the update of some libraries...

## Annexes:

### A.1) Description of the *LaunchMTparam.txt* file

#### ATTENTION:

- options are case sensitive!
- Parameter value must be followed by a # and its variable name followed by coma.
- The description that follows the coma is optional though.
- As reading this file is made by searching for the first occurrence of the parameter's name followed by a coma, do not add text with the variable name followed by coma in the description.
- Do not put several lines with different values of the same variable. Scripts will only read the first occurrence.
- Always keep the path parameters at the bottom.

**Example ( [V20250513\\_LaunchMTparam.txt ; see former version below](#) ):**

```
PARAMETERS TO RUN SCRIPT LAUNCHING AMSTer Engine.
PARAMETERS MUST BE FOLLOWED BY A # AND ITS VAR NAME FOLLOWED BY COMA.
(DESCRIPTION, THOUGH THIS IS OPTIONAL)
AS READING THIS FILE IS MADE USING FIRST OCCURRENCE OF SEARCH CRITERIA,
DO NOT ADD TEXT WTH VARIABLE NAME FOLLOWED BY COMA.
ALWAYS KEEP THE PATH PARAMETERS AT THE BOTTOM
#
VERSION MAY 13 2025

AUTOMATIC FIGURES DISPLAY
#####
FIGyes # FIG, option to compute or not the quick look using cpxfiddle
POPno # POP, option to pop up figs created with cpxfiddle, or POPno

DATA
#####
S1 # SATDIR, Satellite system (must be the same as dirname structure: RADARSAT, TSX, TDX, CSK, S1, ENVISAT)
LUX_A_15 # TRKDIR, Processing directory and dir where data are stored E.g. SM/Asc160 (must be the same as dirname structure)

For mass processing only
#####
20170429 # SUPERMASTER, date of the Global Primary as selected by Prepa_MSBAS.sh in
 # e.g. /Volumes/hp-1650-Data_Share1/SAR_SM/MSBAS/Bukavu/seti/setParametersFile.txt

DEM
#####
GreaterRegion # DEMNAME, name of DEM (in mathematical order). Need txt file in same dir
SIMAMPno # SIMAMP, compute Simulated Amplitude during Ext Dem Generation - usually not needed (maybe ERS). SIMAMPno or SIMAMPyes
KEEP # RECOMPDEM, recompute DEM or mask in slant range even if already there (FORCE), or check the one that would exist (KEEP).
 # DO NOT RUN TWO "FORCE" OR A "FORCE" AND A "KEEP" PROCESS AT THE SAME TIME USING SAME PRIMARY
 # It may cause prblm if externalSlantRangeDEM and maybe slantRangeMask are being modified by the first FORCE run.

CROP
#####
/$PATH_1650/SAR_CSL/S1/LUX/Lux.kml # CROP, CROPyes or CROPno, or for S1, path to kml that will be used to define area of interest.
SRA # COORDSYST, type of coordinates used to define crop: SRA (lines and pixels) or GEO (geo coord) ; used only when CROP=CROPyes
10000 # FIRSTP, Crop limits: first point (row) to use
8000 # FIRSTL, Crop limits: first line to use
24000 # LASTP, Crop limits: last point (row) to use
12000 # LASTL, Crop limits: last line to use
1 # ZOOM, factor during crop (either a single real value or NAzMrg, where N and M are reals values if want an asymmetric zoom)
LUX # REGION, Text description of area for dir naming

AMPLITUDE
#####
4 # MLAMPLI, Multilooking factor for amplitude images reduction (used for coregistration - 4-6 is appropriate).
 # If rectangular pixel, it will be multiplied by corresponding ratio.
SQUARE # PIXSHAPE, pix shape for product : SQUARE, ORIGINALFORM, SQUAREUNITY or ORIGINALFORMUNITY
SIGMANO # CALIBSIGMA, if SIGMAYES it will output sigma nought calibrated amplitude file (for S1 only)

COARSE COREG
#####
64 # CCOHWIN, Coarse coreg window size (64 by default but may want less for very small crop). Can be set to 0 to skip coarse coreg
 # when using god orbit sat such as TSX, TDX and Envisat
0.4 # COH, Coarse Coherence threshold coregistration
24 # CCDISTANCHOR, Coarse registration range & az distance between anchor points [pix] (eg 24 for large img, 16 for medium and 2-8 for very small crops)

FINE COREG
#####
7 # FCOHWIN, Fine coreg window size (eg 3 for ERS/ENV or 7 for CSK, TSX and RS; must have win of eg 50 pixels; computed on full resol img)
0.5 # FCOH, Fine Coherence threshold coregistration
24 # FCDISTANCHOR, Fine registration range & az distance between anchor points [pix] (eg 24 for large img, 16 for medium and 2-8 for very small crops)
```

```

INSAR
#####
DEFO # PROCESSMODE, DEFO to produce DInSAR or TOPO to produce DEM (used only in SinglePair.sh)
VV # INITPOL, For multi pol images; force polarisation at initInSAR for InSAR processing. If it does not exists it will find the first compatible PRM-SCD pol.
50 # LLRGCO, Lower Left Range coord offset for final interferometric products generation. Used in SinglePairNoUnwrap only for Shadow measurements
50 # LLAZCO, Lower Left Azimuth coord offset for final interferometric products generation. Used in SinglePairNoUnwrap only for Shadow measurements

4 # INTERFML, multilook factor for final interferometric products generation (to multiply to the LARGEST side of the pixel); when used with zoom,
it is ML to apply zoomed pixels
1 # FILTFACTOR, filtering factor for interfero (2 might be too strong when used with POWSPECSMOOTHFACT filtering)
1 # POWSPECSMOOTHFACT, Power spectrum filtering factor (for adaptative filtering) (0 = no filtering; 1 or less is possible though stronger)
2 # COHESТИMFАCT, in pixels. Must be similar to INTERFML as far as it is not a ML higher than 5 or 7 non ML for instance. For ML1, if -le 1, will be forced to 2.
If INTERFML is larger than 5 or 7, limit anyway COHESТИMFАCT to 5 or 7 (Remember: computations load goes as square of win size)

MASK
#####
APPLYMASKyes # APPLYMASK, Apply mask (bytes, LatLong, Envi Harris, larger than img) before unwrapping (APPLYMASKyes or APPLYMASKno);
Mask for AMSTer Engine < 20230928: 1 = keep, 0 = mask. However, at unwrapping, 0-masked pixels are kept if their coh > COHCLNTHRESH
Mask for AMSTer Engine > 20230928:
0 = keep, 1 = always mask, 2 = mask. However, at unwrapping, 2-masked pixels are kept if their coh > COHCLNTHRESH
If a mask is requested but no Snaphu, one can also mask manually files with ffa (eg ffa residualInterferogram.HH-HH.f x slantRangeMask)
/YourPath/YourMask_always_Byt # PATHTOMASKGEOC, geocoded "Geographical mask" file name and path (water body etc..)
1 # DATAMASKGEOC, value for masking in PATHTOMASKGEOC
/ YourPath/YourMask_unwrapping # PATHTOMASKCOH, geocoded "Thresholded coherence mask" file name and path (mask at unwrapping below threshold)
2 # DATAMASKCOH, value for masking in PATHTOMASKCOH

/YourPath/YourDir2_DetrendMasks # PATHTODIREVENTSMASKS, path to dir that contains event mask(s) named
eventMaskYYYYMMDDThhmmss_YYYYMMDDThhmmss(.hdr) for masking at Detrend with all masks having dates in
Primary-Secondary range of dates
3 # DATAMASKEVENTS, value for masking in PATHTODIREVENTSMASKS

UNWRAPPING
#####
SKIPno # SKIPno unwraps and geocode all products, SKIPyes skips unwrapping and geocode only available products,
Mask geocode only ampli and coh (for mask generation)
SNAPHU # UW_METHOD, Select phase unwrapping method (SNAPHU, CIS, DETPHUN1ONLY, DETPHUN2ONLY,
DETPHUN1SNAPHU, DETPHUN2SNAPHU, DETPHUN1CIS, DETPHUN2CIS)

if snaphu unwrapping:
1.2 # DEFOTHRESHFACTOR, Snaphu : Factor applied to rho0 to get threshold for whether or not phase discontinuity is possible. rho0 is
the expected, biased correlation measure if true correlation is 0. Increase if not good.
0.9 # DEFOCONST, Snaphu : Ratio of phase discontinuity probability density to peak probability density expected for discontinuity-possible pixel
differences. Value of 1 means zero cost for discontinuity, 0 means infinite cost. Decrease if prblm.
0.2 # DEFOMAX_CYCLE, Snaphu : Max nr of expected phase cycle discontinuity. For topo where no phase jump is expected, it can be set to zero.
DEFO # SNAPHUMODE, Snaphu : TOPO, DEFO, SMOOTH, or NOSTATCOSTS.
ZoneMapYes # ZONEMAP, if ZoneMapYes, it will create a map with the unwrapped zones named snaphuZoneMap. Each continuously unwrapped zone
is numbered (from 1 to...)
0.00001 # ZONEMAPSIZE, Minimum size of unwrapped zone to map (in fraction of total nr of pixels)
300 # ZONEMAPCOST, Cost threshold for connected components (zones). Higher threshold will give smaller connected zones
50 # ZONEMAPTOTAL, Maximum number of mapped zones

MultiSnaphuNo # MULTIUPW, MultiSnaphuYes performs recursive snaphu unwrapping (need 4 params below). MultiUnwrapNo (or any other string)
will perform single snaphu unwrapping
ResidInterfFilt # WHICHINTERF, which interferogram to unwrap, ResidInterf (residual interfero) or ResidInterfFilt (residual interfero filtered)
0.9 # COEFREQ, Coefficient of increase of cut-off frequency
12.5 # CUTINI, Initial cut-off frequency (e.g. 12.5 for a 400x400 image, 10 for a 2200x1500 img)
10 # NITMAX, Max total nr of iterations
0.0627 # COHMUWPTHRESH, coh threshold (between 0 and 1) below which it replaces the phase by white noise
(corresponding mask will be produced). If set to 0, do not mask with white noise

if snaphu or CIS unwrapping:
0.25 # COHCLNTHRESH, Coherence cleaning threshold. Snaphu gives 0 weight at pixels below that threshold.
Moreover, if a mask is used, snaphu (or CIS) also unwraps 0-masked pixels (for AMSTer Engine < 20230928)
or 2-masked pixels (for AMSTer Engine > 20230928) if their coherence is above COHCLNTHRESH.

if CIS unwrapping:
0.1 # FALSERESOCOHTHR, False Residue Coherence Threshold: higher is much slower. Use max 0.15 e.g. in crater
3 # CONNEXION_MODE, nr of times that connexion search radius is augmented when stable connections are found ; 0 search along all coh zone
3 # BIASCOHESТИM, Biased coherence estimator range & Az window size (do not apply pix ratio)
3 # BIASCOHSPIR, Biased coherence square spiral size (if residual fringes are not unwrapped decrease it; must be odd)

if DETPHUN unwrapping:
3 # DETITERR, Number of iterations for detPhUn (Integer: 1, 2 or 3 is generally OK)
0.3 # DETCOHTHRESH, Coherence threshold

BOTH # INTERPOL, interpolate the unwrapped interfero BEFORE or AFTER geocoding or BOTH.
DETREND # REMOVEPLANE, if DETREND it will remove a best plane after unwrapping. Anything else will ignore the detrending.

GEOCODING
#####
UTM # PROJ, Chosen projection (UTM or GEOC – GEOC OPTION IS NOT READY YET)
Forced # GEOCMETHD, Resampling Size of Geocoded product: Forced (at FORCEGEOPIXSIZE - mandatory for further MSBAS),
Auto (closest multiple of 10), Closest (closest to ML az sampling), ClosestMassProc (Closest even for a Mass Process),

LetCIS # RADIUSMETHD, LetCIS (CIS will compute best radius) or forced to a given radius
TRI # RESAMPMETHD, TRI = Triangulation; AV = weighted average; NN = nearest neighbour
LORENTZ # WEIGHTMETHD, Weighting method : ID = inverse distance; LORENTZ = lorentzian
1.0 # IDSMOOTH, ID smoothing factor
1.0 # IDWEIGHT, ID weighting exponent
1.0 # FWHM, Lorentzian Full Width at Half Maximum

```

```

1 # ZONEINDEX, Zone index

100 # FORCEGEOPIXSIZE, Pix size wanted eg as you want for your final MSBAS database FORCEGEOPIXSIZE, Pix size wanted eg as you want
for your final MSBAS database (either a single real value or NAzMRg, where N and M are reals values if want an asymmetric pix shape)
UTMZONE, letter of row and nr of col of the zone where coordinates below are computed (e.g. U32)

225000 # XMIN, minimum X UTM coord of final geocoded product
426000 # XMAX, maximum X UTM coord of final geocoded product
5417000 # YMIN, minimum Y UTM coord of final geocoded product
5593000 # YMAX, maximum Y coord of final geocoded product
$PATH_1650/kml/ # GEOCKML, a kml file to define final geocoded product. If not found, it will use the coordinates above

#####
PATHS
#####
/$PATH_3601/PROCESS/AS # PROROOTPATH, path to dir where data will be processed in sub dir named by the sat name (SATDIR).
/$PATH_1650/SAR_CSR/ # DATAPATH, path to dir where data are stored
/$PATH_DataSAR/SAR_AUX_FILES/DEM/SRTM30/ALL # DEMDIR, path to dir where DEM is stored
/$PATH_SCRIPTS/SCRIPTS_MT/FUNCTIONS_FOR_MT.sh # FCTFILE, path to file where all functions are stored

for coregistration mass processing (required if coregistration on a Global Primary i.e. SuperMaster)
/$PATH_1650/SAR_SM/RESAMPLED # RESAMPDATPATH, path to dir where resampled data will be stored

for insar mass processing
/$PATH_3601/SAR_MASSPROCESS/ # MASSPROCESSPATH, path to dir where all processed pairs will be stored in sub dir named by
the sat/trk name (SATDIR/TRKDIR)

```

### Example ([V20241015\\_LaunchMTparam.txt ; see former version below](#)):

```

PARAMETERS TO RUN SCRIPT LAUNCHING AMSTer Engine.
PARAMETERS MUST BE FOLLOWED BY A # AND ITS VAR NAME FOLLOWED BY COMA.
(DESCRIPTION, THOUGH THIS IS OPTIONAL)
AS READING THIS FILE IS MADE USING FIRST OCCURENCE OF SEARCH CRITERIA,
DO NOT ADD TEXT WTH VARIABLE NAME FOLLOWED BY COMA.
ALWAYS KEEP THE PATH PARAMETERS AT THE BOTTOM
#
VERSION Oct 15 2024

AUTOMATIC FIGURES DISPLAY
#####
FIGyes # FIG, option to compute or not the quick look using cpxfiddle
POPno # POP, option to pop up figs created with cpxfiddle, or POPno

DATA
#####
S1 # SATDIR, Satellite system (must be the same as dirname structure: RADARSAT, TSX, TDX, CSK, S1, ENVISAT)
LUX_A_15 # TRKDIR, Processing directory and dir where data are stored E.g. SM/Asc160 (must be the same as dirname structure)

For mass processing only
#####
20170429 # SUPERMASTER, date of the Global Primary as selected by Prepa_MSBAS.sh in
e.g. /Volumes/hp-1650-Data_Share1/SAR_SM/MSBAS/Bukavu/seti/setParametersFile.txt

DEM
#####
GreaterRegion # DEMNAME, name of DEM (in mathematical order). Need txt file in same dir
SIMAMPno # SIMAMP, compute Simulated Amplitude during Ext Dem Generation - usually not needed (maybe ERS). SIMAMPno or SIMAMPyes
KEEP # RECOMPDEM, recompute DEM or mask in slant range even if already there (FORCE), or check the one that would exist (KEEP).
DO NOT RUN TWO "FORCE" OR A "FORCE" AND A "KEEP" PROCESS AT THE SAME TIME USING SAME PRIMARY
It may cause prblm if externalSlantRangeDEM and maybe slantRangeMask are being modified by the first FORCE run.

CROP
#####
$PATH_1650/SAR_CSR/S1/LUX/Lux.kml # CROP, CROPyes or CROPno, or for S1, path to kml that will be used to define area of interest.
10000 # FIRSTP, Crop limits: first point (row) to use
8000 # FIRSTL, Crop limits: first line to use
24000 # LASTP, Crop limits: last point (row) to use
12000 # LASTL, Crop limits: last line to use
1 # ZOOM, factor during crop
LUX # REGION, Text description of area for dir naming

AMPLITUDE
#####
4 # MLAMPLI, Multilooking factor for amplitude images reduction (used for coregistration - 4-6 is appropriate).
If rectangular pixel, it will be multiplied by corresponding ratio.
SQUARE # PIXSHAPE, pix shape for product : SQUARE, ORIGINALFORM, SQUAREUNITY or ORIGINALFORMUNITY
SIGMANO # CALIBSIGMA, if SIGMAYES it will output sigma nought calibrated amplitude file (for S1 only)

COARSE COREG
#####
64 # CCOHWIN, Coarse coreg window size (64 by default but may want less for very small crop). Can be set to 0 to skip coarse coreg
when using god orbit sat such as TSX, TDX and Envisat
0.4 # COH, Coarse Coherence threshold coregistration
24 # CCDISTANCHOR, Coarse registration range & az distance between anchor points [pix] (eg 24 for large img, 16 for medium and 2-8 for very small crops)

FINE COREG
#####
7 # FCOHWIN, Fine coreg window size (eg 3 for ERS/ENV or 7 for CSK, TSX and RS; must have win of eg 50 pixels; computed on full resol img)

```

```

0.5 # FCOH, Fine Coherence threshold coregistration
24 # FCDISTANCHOR, Fine registration range & az distance between anchor points [pix] (eg 24 for large img, 16 for medium and 2-8 for very small crops)

INSAR
#####
DEFO # PROCESSMODE, DEFO to produce DInSAR or TOPO to produce DEM (used only in SinglePair.sh)
VV # INITPOL, For multi pol images; force polarisation at initInSAR for InSAR processing. If it does not exists it will find the first compatible PRM-SCD pol.
50 # LLRGCO, Lower Left Range coord offset for final interferometric products generation. Used in SinglePairNoUnwrap only for Shadow measurements
50 # LLAZCO, Lower Left Azimuth coord offset for final interferometric products generation. Used in SinglePairNoUnwrap only for Shadow measurements

4 # INTERFML, multilook factor for final interferometric products generation (to multiply to the LARGEST side of the pixel); when used with zoom,
it is ML to apply to zoomed pixels
1 # FILTFACTOR, filtering factor for interfero (2 might be too strong when used with POWSPECSMOOTHFACT filtering)
1 # POWSPECSMOOTHFACT, Power spectrum filtering factor (for adaptative filtering) (0 = no filtering; 1 or less is possible though stronger)
2 # COHESTIMFACT, in pixels. Must be similar to INTERFML as far as it is not a ML higher than 5 or 7 non ML for instance. For ML1, if -le 1, will be forced to 2.
If INTERFML is larger than 5 or 7, limit anyway COHESTIMFACT to 5 or 7 (Remember: computations load goes as square of win size)

MASK
#####
APPLYMASKyes # APPLYMASK, Apply mask (bytes, LatLong, Envi Harris, larger than img) before unwrapping (APPLYMASKyes or APPLYMASKno);
Mask for AMSTer Engine < 20230928: 1 = keep, 0 = mask. However, at unwrapping, 0-masked pixels are kept if their coh > COHCLNTHRESH
Mask for AMSTer Engine > 20230928:
0 = keep, 1 = always mask, 2 = mask. However, at unwrapping, 2-masked pixels are kept if their coh > COHCLNTHRESH
If a mask is requested but no Snaphu, one can also mask manually files with ffa (eg ffa residualInterferogram.HH-HH.f.x slantRangeMask)
/YourPath/YourMask_always_Byt # PATHTOMASKGEOC, geocoded "Geographical mask" file name and path (water body etc.)
1 # DATAMASKGEOC, value for masking in PATHTOMASKGEOC
/ YourPath/YourMask_unwrapping # PATHTOMASKCOH, geocoded "Thresholded coherence mask" file name and path (mask at unwrapping below threshold)
2 # DATAMASKCOH, value for masking in PATHTOMASKCOH
/ YourPath/YourMask_detrend # PATHTOMASKDETREND, geocoded "Detrend masked areas" file name and path (mask when detrending)
3 # DATAMASKDETREND, value for masking in PATHTOMASKDETREND

UNWRAPPING
#####
SKIPno # SKIPUW, SKIPno unwraps and geocode all products, SKIPyes skips unwrapping and geocode only available products,
Mask geocode only ampli and coh (for mask generation)
SNAPHU # UW_METHOD, Select phase unwrapping method (SNAPHU, CIS, DETPHUN1ONLY, DETPHUN2ONLY,
DETPHUN1SNAPHU, DETPHUN2SNAPHU, DETPHUN1CIS, DETPHUN2CIS)

if snaphu unwrapping:
1.2 # DEFOTHRESHFACTOR, Snaphu : Factor applied to rho0 to get threshold for whether or not phase discontinuity is possible. rho0 is
the expected, biased correlation measure if true correlation is 0. Increase if not good.
0.9 # DEFOCONST, Snaphu : Ratio of phase discontinuity probability density to peak probability density expected for discontinuity-possible pixel
differences. Value of 1 means zero cost for discontinuity, 0 means infinite cost. Decrease if prblm.
0.2 # DEFOMAX_CYCLE, Snaphu : Max nr of expected phase cycle discontinuity. For topo where no phase jump is expected, it can be set to zero.
DEFO # SNAPHUMODE, Snaphu : TOPO, DEFO, SMOOTH, or NOSTATCOSTS.
ZoneMapYes # ZONEMAP, if ZoneMapYes, it will create a map with the unwrapped zones named snaphuZoneMap. Each continuously unwrapped zone
is numbered (from 1 to...)
0.00001 # ZONEMAPSIZE, Minimum size of unwrapped zone to map (in fraction of total nr of pixels)
300 # ZONEMAPCOST, Cost threshold for connected components (zones). Higher threshold will give smaller connected zones
50 # ZONEMAPTOTAL, Maximum number of mapped zones

MultiSnaphuNo # MULTIUWP, MultiSnaphuYes performs recursive snaphu unwrapping (need 4 params below). MultiUnwrapNo (or any other string)
will perform single snaphu unwrapping
ResidInterfFilt # WHICHINTERF, which interferogram to unwrap, ResidInterf (residual interfero) or ResidInterfFilt (residual interfero filtered)
0.9 # COEFREQ, Coefficient of increase of cut-off frequency
12.5 # CUTINI, Initial cut-off frequency (e.g. 12.5 for a 400x400 image, 10 for a 2200x1500 img)
10 # NITMAX, Max total nr of iterations
0.0627 # COHMUWPTHRESH, coh threshold (between 0 and 1) below which it replaces the phase by white noise
(corresponding mask will be produced). If set to 0, do not mask with white noise

if snaphu or CIS unwrapping:
0.25 # COHCLNTHRESH, Coherence cleaning threshold. Snaphu gives 0 weight at pixels below that threshold.
Moreover, if a mask is used, snaphu (or CIS) also unwraps 0-masked pixels (for AMSTer Engine < 20230928)
or 2-masked pixels (for AMSTer Engine > 20230928) if their coherence is above COHCLNTHRESH.

if CIS unwrapping:
0.1 # FALSERESCOHTHR, False Residue Coherence Threshold: higher is much slower. Use max 0.15 e.g. in crater
3 # CONNEXION_MODE, nr of times that connexion search radius is augmented when stable connections are found ; 0 search along all coh zone
3 # BIASCOHESTIM, Biased coherence estimator range & Az window size (do not apply pix ratio)
3 # BIASCOHSPIR, Biased coherence square spiral size (if residual fringes are not unwrapped decrease it; must be odd)

if DETPHUN unwrapping:
3 # DETITERR, Number of iterations for detPhUn (Integer: 1, 2 or 3 is generally OK)
0.3 # DETCOHTHRESH, Coherence threshold

BOTH # INTERPOL, interpolate the unwrapped interfero BEFORE or AFTER geocoding or BOTH.
DETREND # REMOVEPLANE, if DETREND it will remove a best plane after unwrapping. Anything else will ignore the detrending.

GEOCODING
#####
UTM # PROJ, Chosen projection (UTM or GEOC – GEOC OPTION IS NOT READY YET)
Forced # GEOCMETHD, Resampling Size of Geocoded product: Forced (at FORCEGEOPIXSIZE - mandatory for further MSBAS),
Auto (closest multiple of 10), Closest (closest to ML az sampling), ClosestMassProc (Closest even for a Mass Process),

LetCIS # RADIUSBMETHD, LetCIS (CIS will compute best radius) or forced to a given radius
TRI # RESAMPMETHD, TRI = Triangulation; AV = weighted average; NN = nearest neighbour
LORENTZ # WEIGHTMETHD, Weighting method : ID = inverse distance; LORENTZ = lorentzian
1.0 # IDSMOOTH, ID smoothing factor
1.0 # IDWEIGHT, ID weighting exponent
1.0 # FWHM, Lorentzian Full Width at Half Maximum
1 # ZONEINDEX, Zone index

```

```

100 # FORCEGEOPIXSIZE, Pix size wanted eg as you want for your final MSBAS database
 # UTMZONE, letter of row and nr of col of the zone where coordinates below are computed (e.g. U32)
225000 # XMIN, minimum X UTM coord of final geocoded product
426000 # XMAX, maximum X UTM coord of final geocoded product
5417000 # YMIN, minimum Y UTM coord of final geocoded product
5593000 # YMAX, maximum Y coord of final geocoded product
/$PATH_1650/kml/ # GEOCKML, a kml file to define final geocoded product. If not found, it will use the coordinates above

#####
PATHS
#####
/$PATH_3601/PROCESS/AS # PROROOTPATH, path to dir where data will be processed in sub dir named by the sat name (SATDIR).
/$PATH_1650/SAR_CSR/ # DATAPATH, path to dir where data are stored
/$PATH_DataSAR/SAR_AUX_FILES/DEM/SRTM30/ALL # DEMDIR, path to dir where DEM is stored
/$PATH_SCRIPTS/SCRIPTS_MT/FUNCTIONS_FOR_MT.sh # FCTFILE, path to file where all functions are stored

for coregistration mass processing (required if coregistration on a Global Primary i.e. SuperMaster)
/$PATH_1650/SAR_SM/RESAMPLED # RESAMPDATPATH, path to dir where resampled data will be stored

for insar mass processing
/$PATH_3601/SAR_MASSPROCESS/ # MASSPROCESSPATH, path to dir where all processed pairs will be stored in sub dir named by
 # the sat/trk name (SATDIR/TRKDIR)

```

### Example ([V20231026\\_LaunchMTparam.txt](#)):

```

PARAMETERS TO RUN SCRIPT LAUNCHING AMSTerEngine.
PARAMETERS MUST BE FOLLOWED BY A # AND ITS VAR NAME FOLLOWED BY COMA.
(DESCRIPTION, THOUGH THIS IS OPTIONAL)
AS READING THIS FILE IS MADE USING FIRST OCCURENCE OF SEARCH CRITERIA,
DO NOT ADD TEXT WTH VARIABLE NAME FOLLOWED BY COMA.
ALWAYS KEEP THE PATH PARAMETERS AT THE BOTTOM
#
VERSION Oct 26 2023

AUTOMATIC FIGURES DISPLAY
#####
FIGyes # FIG, option to compute or not the quick look using cpxfiddle
POPno # POP, option to pop up figs created with cpxfiddle, or POPno

DATA
#####
S1 # SATDIR, Satellite system (must be the same as dirname structure: RADARSAT, TSX, TDX, CSK, S1, ENVISAT)
LUX_A_15 # TRKDIR, Processing directory and dir where data are stored E.g. SM/Asc160 (must be the same as dirname structure)

For mass processing only
#####
20170429 # SUPERMASTER, date of the Global Primary as selected by Prepa_MSBAS.sh in
 # e.g. /Volumes/hp-1650-Data_Share1/SAR_SM/MSBAS/Bukavu/seti/setParametersFile.txt

DEM
#####
GreaterRegion # DEMNAME, name of DEM (in mathematical order). Need txt file in same dir
SIMAMPno # SIMAMP, compute Simulated Amplitude during Ext Dem Generation - usually not needed (maybe ERS). SIMAMPno or SIMAMPyes
KEEP # RECOMPDEM, recompute DEM or mask in slant range even if already there (FORCE), or check the one that would exist (KEEP).
 # DO NOT RUN TWO "FORCE" OR A "FORCE" AND A "KEEP" PROCESS AT THE SAME TIME USING SAME PRIMARY
 # It may cause prblm if externalSlantRangeDEM and maybe slantRangeMask are being modified by the first FORCE run.

CROP
#####
/$PATH_1650/SAR_CSR/S1/LUX/Lux.kml # CROP, CROPyes or CROPno, or for S1, path to kml that will be used to define area of interest.
10000 # FIRSTP, Crop limits: first point (row) to use
8000 # FIRSTL, Crop limits: first line to use
24000 # LASTP, Crop limits: last point (row) to use
12000 # LASTL, Crop limits: last line to use
1 # ZOOM, factor during crop
LUX # REGION, Text description of area for dir naming

AMPLITUDE
#####
4 # MLAMPLI, Multilooking factor for amplitude images reduction (used for coregistration - 4-6 is appropriate).
 # If rectangular pixel, it will be multiplied by corresponding ratio.
SQUARE # PIXSHAPE, pix shape for product : SQUARE, ORIGINALFORM, SQUAREUNITY or ORIGINALFORMUNITY
SIGMANO # CALIBSIGMA, if SIGMAYES it will output sigma nought calibrated amplitude file (for S1 only)

COARSE COREG
#####
64 # CCOHWIN, Coarse coreg window size (64 by default but may want less for very small crop).
 # Can be set to 0 to skip coarse coreg when using god orbit sat such as TSX, TDX and Envisat
0.4 # COH, Coarse Coherence threshold coregistration
24 # CCDISTANCHOR, Coarse registration range & az distance between anchor points [pix] (eg 24 for large img, 16 for medium and 2-8 for very small crops)

FINE COREG
#####
7 # FCOHWIN, Fine coreg window size (eg 3 for ERS/ENV or 7 for CSK, TSX and RS; must have win of eg 50 pixels; computed on full resol img)
0.5 # FCOH, Fine Coherence threshold coregistration
24 # FCDISTANCHOR, Fine registration range & az distance between anchor points [pix] (eg 24 for large img, 16 for medium and 2-8 for very small crops)

```

```

INSAR
#####
DEF0 # PROCESSMODE, DEF0 to produce DInSAR or TOPO to produce DEM (bytes, 1/0, UTM, Envi Harris format, larger than img) used only in SinglePair.sh
VV # INITPOL, For multi pol images; force polarisation at initInSAR for InSAR processing. If it does not exists it will find the first compatible PRM-SCD pol.
50 # LLRGCO, Lower Left Range coord offset for final interferometric products generation. Used in SinglePairNoUnwrap only for Shadow measurements
50 # LLAZCO, Lower Left Azimuth coord offset for final interferometric products generation. Used in SinglePairNoUnwrap only for Shadow measurements

4 # INTERFML, multilook factor for final interferometric products generation (to multiply to the LARGEST
 # side of the pixel); when used with zoom, it is ML to apply to zommed pixels
1 # FILTFACTOR, filtering factor for interfero (2 might be too strong when used with POWSPECSMOOTFACT filtering)
1 # POWSPECSMOOTFACT, Power spectrum filtering factor (for adaptative filtering) (0 = no filtering; 1 or less is possible though stronger)
2 # COHESTIMFACT, in pixels. Must be similar to INTERFML as far as it is not a ML higher than 5 or 7 non ML for instance. For ML1, if -le 1, will be forced to 2.
 # If INTERFML is larger than 5 or 7, limit anyway COHESTIMFACT to 5 or 7 (Remember: computations load goes as square of win size)

MASK
#####
APPLYMASKyes # APPLYMASK, Apply mask before unwrapping (APPLYMASKyes or APPLYMASKno);
 # Mask for AMSTer Engine <2 0230928: 1 = keep, 0 = mask. However, at unwrapping, 0-masked pixels are kept if their coh > COHCLNTHRESH
 # Mask for AMSTer Engine>20230928: 0 = keep, 1 = always mask, 2 = mask. However, at unwrapping, 2-masked pixels are kept
 # if their coh > COHCLNTHRESH
 # If a mask is requested but no Snaphu, one can also mask manually files with ffa (eg ffa residualInterferogram.HH-HH.f x slantRangeMask)
/$PATH_DataSAR/SAR_AUX_FILES/MASKS/WaterBodies/DR Congo/LakeKivu_LatLong_0keep # PATHMASK, geocoded mask file name and path

UNWRAPPING
#####
SKIPno # SKIPUW, SKIPno unwraps and geocode all products, SKIPyes skips unwrapping and geocode only available products, Mask geocode
 # only ampli and coh (for mask generation)
SNAPHU # UW_METHOD, Select phase unwrapping method (SNAPHU, CIS, DETPHUN1ONLY, DETPHUN2ONLY, DETPHUN1SNAPHU,
 # DETPHUN2SNAPHU, DETPHUN1CIS, DETPHUN2CIS)

if snaphu unwrapping:
1.2 # DEFOTHRESHFACTOR, Snaphu : Factor applied to rho0 to get threshold for whether or not phase discontinuity is possible. rho0 is the expected,
 # biased correlation measure if true correlation is 0. Increase if not good.
0.9 # DEFOCONST, Snaphu : Ratio of phase discontinuity probability density to peak probability density expected for discontinuity-possible pixel differences. #
 # Value of 1 means zero cost for discontinuity, 0 means infinite cost. Decrease if prblm.
0.2 # DEFOMAX_CYCLE, Snaphu : Max nr of expected phase cycle discontinuity. For topo where no phase jump is expected, it can be set to zero.
DEFO # SNAPHUMODE, Snaphu : TOPO, DEFO, SMOOTH, or NOSTATCOSTS.
ZoneMapYes # ZONEMAP, if ZoneMapYes, it will create a map with the unwrapped zones named snaphuZoneMap.
 # Each continuously unwrapped zone is numbered (from 1 to...)
0.0001 # ZONEMAPSIZE, Minimum size of unwrapped zone to map (in fraction of total nr of pixels)
300 # ZONEMAPCOST, Cost threshold for connected components (zones). Higher threshold will give smaller connected zones
50 # ZONEMAPTOTAL, Maximum number of mapped zones

MultiSnaphuNo # MULTIUWP, MultiSnaphuYes performs recursive snaphu unwrapping (need 4 params bellow).
 # MultiUnwrapNo (or any other string) will perform single snaphu unwrapping
ResidInterfFilt # WHICHINTERF, which interferogram to unwrap, ResidInterf (residual interfero) or ResidInterfFilt (residual interfero filtered)
0.9 # COEFREQ, Coefficient of increase of cut-off frequency
12.5 # CUTINI, Initial cut-off frequency (e.g. 12.5 for a 400x400 image, 10 for a 2200x1500 img)
10 # NITMAX, Max total nr of iterations
0.0627 # COHMUWPTHRESH, coh threshold (between 0 and 1) below which it replaces the phase by white noise
 # (corresponding mask will be produced). If set to 0, do not mask with white noise

if snaphu or CIS unwrapping:
0.25 # COHCLNTHRESH, Coherence cleaning threshold. Snaphu gives 0 weight at pixels below that threshold.
 # Moreover, if a mask is used, snaphu (or CIS) also unwraps 0-masked pixels (for AMSTerEngine < 20230928)
 # or 2-masked pixels (for AMSTerEngine > 20230928)
 # if their coherence is above COHCLNTHRESH.

if CIS unwrapping:
0.1 # FALSERESCOHTHR, False Residue Coherence Threshold: higher is much slower. Use max 0.15 e.g. in crater
3 # CONNEXION_MODE, number of times that connexion search radius is augmented when stable connections are found ; 0 search along all coh zone
3 # BIASCOHESTIM, Biased coherence estimator range & Az window size (do not apply pix ratio)
3 # BIASCOHSPIR, Biased coherence square spiral size (if residual fringes are not unwrapped decrease it; must be odd)

if DETPHUN unwrapping:
3 # DETITERR, Number of iteration for detPhUn (Integer: 1, 2 or 3 is generally OK)
0.3 # DETCOHTHRESH, Coherence threshold

BOTH # INTERPOL, interpolate the unwrapped interfero BEFORE or AFTER geocoding or BOTH.
DETREND # REMOVEPLANE, if DETREND it will remove a best plane after unwrapping. Anything else will ignore the detrending.

GEOCODING
#####
UTM # PROJ, Chosen projection (UTM or GEOC – GEOC OPTION IS NOT READY YET)
Forced # GEOCMETHD, Resampling Size of Geocoded product. Forced (at FORCEGEOPIXSIZE - mandatory for further MSBAS),
 # Auto (closest multiple of 10), Closest (closest to ML az sampling), ClosestMassProc (Closest even for a Mass Process),

LetCIS # RADIUSBMETHD, LetCIS (CIS will compute best radius) or forced to a given radius
TRI # RESAMPMETHD, TRI = Triangulation; AV = weighted average; NN = nearest neighbour
LORENTZ # WEIGHTMETHD, Weighting method : ID = inverse distance; LORENTZ = lorentzian
1.0 # IDSMOOTH, ID smoothing factor
1.0 # IDWEIGHT, ID weighting exponent
1.0 # FWHM, Lorentzian Full Width at Half Maximum
1 # ZONEINDEX, Zone index

100 # FORCEGEOPIXSIZE, Pix size wanted eg as you want for your final MSBAS database
 # UTMZONE, letter of row and nr of col of the zone where coordinates below are computed (e.g. U32)
225000 # XMIN, minimum X UTM coord of final geocoded product
426000 # XMAX, maximum X UTM coord of final geocoded product
5417000 # YMIN, minimum Y UTM coord of final geocoded product
5593000 # YMAX, maximum Y coord of final geocoded product
/$PATH_1650/kml/ # GEOCKML, a kml file to define final geocoded product. If not found, it will use the coordinates above

```

```
#####
PATHS
#####
/$PATH_3601/PROCESS/AS # PROROOTPATH, path to dir where data will be processed in sub dir named by the sat name (SATDIR).
/$PATH_1650/SAR_CSR/ # DATAPATH, path to dir where data are stored
/$PATH_DataSAR/SAR_AUX_FILES/DEM/SRTM30/ALL # DEMDIR, path to dir where DEM is stored
/$PATH_SCRIPTS/SCRIPTS_MT/FUNCTIONS_FOR_MT.sh # FCTFILE, path to file where all functions are stored

for coregistration mass processing (required if coresitration on a Global Primary i.e. SuperMaster)
/$PATH_1650/SAR_SM/RESAMPLED # RESAMPDATPATH, path to dir where resampled data will be stored

for insar mass processing
/$PATH_3601/SAR_MASSPROCESS/ # MASSPROCESSPATH, path to dir where all processed pairs will be stored in sub dir named by the sat/trk name
```

## Explanations:

# AUTOMATIC FIGURES DISPLAY

#####

- **# FIG,**

- (*FIGyes* or *FIGno*). Option to compute or not the quick look using *cpxfiddle*. If option is set to *FIGyes*, it will use *cpxfiddle* to create sunrasters figures that allow a quick look in the data. Note that some of these figures can be computed with a degraded resolution or can be displayed with distortion if multilooking in range and azimuth is not appropriate. The script created by AMSTer to generate these figures is usually stored in the directory where the file and its figure are. You can edit it (e.g. to change the multilooking, the resolution or the contrasts) and re-run it manually. Setting the option to *FIGno* will of course ignore the creation of these figures.

- **# POP,**

- (*POPyes* or *POPno*). Option to pop up figures created with *cpxfiddle*. If option is set to *POPyes*, it will open each figure as soon as it is created. It is NOT advised to do this during a mass processing because it would overload the RAM.

# DATA

#####

- **# SATDIR,**

- Satellite system. It must be the same as the directory naming structure where the data are stored in CSL format (e.g. *CSK*, *ENVISAT*, *ERS*, *RADARSAT*, *S1*, *TDX*, *TSX*,...). See [Table 1 page 53](#).

- **# TRKDIR,**

- Track (or orbit) number/mode. This name must correspond to the subdir where data are stored in CSL format. (e.g. *DRC\_Bukavu\_A\_174*)

# For mass processing only

#####

- **# SUPERMASTER,**

- Date of the Global Primary image (selected by *Prepa\_MSBAS.sh* and to be found in the *.../SAR\_SM/MSBAS/REGION/seti/setParametersFile.txt* created) → Only needed for mass processing with a Global Primary (SuperMaster). Needed also for *Prepa\_MSBAS.sh* when this script is used to compute new pairs to add to an existing mass processing and when one does not want to compute a new Global Primary.

# DEM

#####

- **# DEMNAME,**

- Name of the Digital Elevation Model [in Lat-Long](#). If computed using GIS software (e.g. Envi), it must be inverted by lines and columns because math and GIS order differs... If DEM is created using *aggregateSRTMTiles* or *getSRTMDEM* from AMSTerEngine, it

needs its `.txt` file in same directory. Do not put a `.txt` and a `.hdr` in the same dir.  
Do not put the path to DEM here; only the name (see below).

- **# SIMAMP,**
  - (`SIMAMPno` or `SIMAMPyes`). Option to compute Simulated Amplitude during External Dem Generation - usually not needed (maybe to assist ERS coregistration).
- **# RECOMPDEM,**
  - (`KEEP` or `FORCE`). Option to force recomputing the DEM in radar geometry (Slant Range DEM) and the projection of the mask in Slant Range if mask is required. `FORCE` obviously force to recompute the DEM (and mask if required) even if it/they already exist(s). If `KEEP` is selected, it will only compute the DEM and mask if it is not present yet.
  - **Note:** For obvious reasons, do not run two " `FORCE` " or a " `FORCE` " and a " `KEEP` " processes at the same time using same Primary image.

`# CROP`

#####

- **# CROP,**  
(`CROPyes`, `CROPno` or `path_to_kml`). Option to crop images to area of interest.  
If option is set to `CROPyes`, images from **all satellites** (including Sentinel1 in Strip Map mode) **but Sentinel1 in Wide Swath mode** will be cropped based on the coordinates of the corners provided below as LINES/PIXELS numbers, or as LAT/LONG coordinates.  
To crop a **Sentinel1 TOPSAR Wide Swath images**, with a ZOOM factor of `1`, one must provide here a `path_to_kml`. The interferometric products and all subsequent products will be cropped at that footprint. Steps up to the S1coregistration will be performed on the whole set of tracks/swaths/bursts that span the area of interest defined at reading.  
To crop a **Sentinel1 TOPSAR Wide Swath images**, with a ZOOM factor other than `1`, one must provide the coordinates of the crop zone corners as LINES and PIXELS numbers (a bug in AMSTerEngine prevents so far defining crop zone using LAT/LONG coordinates).
- **# COORDSYST,**  
Type of coordinates used to define crop: SRA (when crop limits is provided as lines and pixels) or GEO (when crop limits is provided as geographic coordinates). This parameter is only used when CROP=CROPyes.
- **# FIRSTP,**
- **# FIRSTL,**
- **# LASTP,**
- **# LASTL,**
  - Coordinates of the desired crop. Must be given as `Lat-Long`.
- **# ZOOM,**
  - Oversampling factor used during reading and cropping the image. This factor can be **any number** (not only integer). **ZOOM is only taken into account if images are cropped!** Combined with a multilooking factor, it can help to reduce noise (eg. ZOOM=2 and ML=3 → final resolution at 1.5)
  - Image oversampling (ZOOM) is possible for images from **all satellites** (including Sentinel1 in Strip Map mode) **but Sentinel1 in Wide Swath mode** by setting the CROP parameter as `CROPyes`, by providing the corners of the CROP region as LINES/PIXELS numbers or LAT/LONG coordinates, and by defining the ZOOM factor.  
Zooming **Sentinel1 TOPSAR Wide Swath images** can only be performed by providing the corners of the CROP region as LINES/PIXELS numbers (a bug in AMSTerEngine prevents so far defining crop zone using LAT/LONG coordinates).
  - ML factor of zoomed processing will then be ML of Zoomed pixels.
  - Keep `1` if no zoom is necessary.
  -

- **# REGION,**
  - *Text* description of the area. Will be used for dir naming.

## # AMPLITUDE

#####

- **# MLAMPLI,**
  - Multilooking factor (*Integer number*) for amplitude images reduction during the coregistration (usually, a factor of 4 to 6 is appropriate).  
This is not the same as the Multilooking factor used for the computation of the interferometric product (see **INTERFML** below).  
If pixels are rectangular, MLAMPLI will be multiplied by corresponding ratio in Range or Azimuth.  
**Convention:** multilooking factor provided is always considered to be used to multiply the longest side of the pixel if the pixel is rectangular. Then, if the shape of the final pixel (see **PIXSHAPE** below) is requested to be square, the scripts will compute the multilooking ratio to use for the shortest side of the pixel taking into account the incidence angle.  
**Example:** For an Envisat images acquired in mode i7 (i.e. slant range sampling = 7.8m; Azimuth sampling = 3.2m; incidence angle =43°), a ML of 9 means 9 in range and 31 in Az.  
Note that Sentinel1 pixels have larger Azimuth side than Range pixel side.
- **# PIXSHAPE,**
  - (**SQUARE**, **ORIGINALFORM**, **SQUAREUNITY** or **ORIGINALFORMUNITY**). Shape of the pixels for the final products.  
If option is set to **SQUARE**, scripts will select a ratio between range and azimuth pixels size (taking also into account the looking angle) to multilook the pixels in order to have square-like pixels in the final products. If set to **ORIGINALFORM**, the **INTERFML** multilooking factor will be applied both in range and azimuth and the shape of the pixels in the final products will be similar to the original shape. **ORIGINALFORM** is useful for instance when looking at shadows in amplitude images to estimate height of objects. **SQUAREUNITY** and **ORIGINALFORMUNITY** are experimental options to force pixels at ML factor 1. Do not use it.
- **# CALIBSIGMA**
  - For calibrating images (**S1 files only**): **SIGMANO** or **SIGMAYES**. **SIGMAYES** will output sigma nought calibrated amplitude file.

## # COARSE COREG

#####

- **# CCOHWIN,**
  - (*Integer number*). Window size (in pixels) for the computation of the Coarse Coregistration (64 by default but may want less for very small crop).  
This parameter can be set to **0** to **skip coarse coregistration** when using good orbit satellites such as TSX, TDX and Envisat
- **# COH,**
  - (*Real number*). Coherence threshold for the computation of the Coarse coregistration
- **# CCDISTANCHOR,**
  - (*Integer number*). Distance (in pixels) in range and azimuth between anchor points for the computation of the Coarse coregistration (eg 24 for large images, 16 for medium and 2-8 for very small crops)

## # FINE COREG

#####

- **# FCOHWIN,**

- (*Integer number*). Window size (in pixels) for the computation of the Fine Coregistration (eg 3 for ERS/ENVISAT, or 7 for CSK, TSX and RS; must have windows of -say- 50 pixels computed on full resolution images).
- **# FCOH,**
  - (*Real number*). Coherence threshold for the computation of the Fine coregistration
- **# FCDISTANCHOR,**
  - (*Integer number*). Distance (in pixels) in range and azimuth between anchor points for the computation of the Fine coregistration (eg 24 for large images, 16 for medium and 2-8 for very small crops)

```
INSAR
```

```
#####
```

- **# PROCESSMODE,**
  - (*DEFO* or *TOPO*). Option to produce defo or topo interferograms (used for *SinglePair.sh*)
- **# INITPOL,**
  - (*VV, HH, VH* or *HV*). For multi pol images; force selection of only the chosen polarisation at initInSAR for InSAR processing. If that polarization does not exist, it will find the first compatible PRM-SCD polarisation.
- **# LLRGCO,**
  - (*Integer number*). Lower Left Range coordinate offset (in pixels) for final interferometric products generation. It forces to crop the final products with this additional offset from the corner. **Used only in *SinglePairNoUnwrap.sh* only for Shadow measurements**
- **# LLAZCO,**
  - (*Integer number*). Lower Left Azimuth coordinate offset (in pixels) for final interferometric products generation. **Used only in *SinglePairNoUnwrap.sh* only for Shadow measurements**
- **# INTERFML,**
  - (*Integer number*). MultiLooking factor (ML) for interferometric products.  
**Convention (see MLAMPLI): select the INTERFML multilooking factor with respect to the largest side of your pixel.** For instance, if you want a squared pixel of 50x50m, - with Envisat i2 (supposing that the original ground range pixel size is 2m in azimuth and 10m in range, i.e. a pixel ratio of 1/5), you would need an INTERFML factor of 5 and it will multiply the pixels in range by 5 and in azimuth by a factor 25.  
- in Sentinel (supposing that the original ground range pixel size is 14m in azimuth and 2m in range, i.e. a pixel ratio of 7), you would need a INTERFML factor of 4 and it will multiply the pixels in range by 28 and in azimuth by a factor 4. Of course, if you select a pixel in ORIGINALFORM, it will multiply the pixels in range and in azimuth by the factor INTERFML factor provided.
  - if ML=1, # COHESTIMFACT will be forced to 2
  - When used with zoom, it is ML to apply to zoomed pixels
- **# FILTFACTOR**
  - (*Integer number*, usually 1). Filtering factor for filtering the interferogram. Factor 2 might be too strong when used with **POWSPECSSMOOTFACT** filtering.
- **# POWSPECSSMOOTFACT,**
  - (*Integer number*). Power spectrum filtering factor (for adaptive filtering) (*0* = no filtering; *1* or *<1* for filtering, smaller is stronger)
- **# COHESTIMFACT**
  - (*Integer number* in pixels). Number of pixels used to estimate the coherence. Must be similar to **INTERFML** as far as it is not a ML higher than 5 or 7 for instance. If INTERFML is larger than 5 or 7, limit anyway COHESTIMFACT to 5 or 7.

# MASK – version from November 28, 2024 (see former version below)

#####

- **# MASK**
  - (*APPLYMASKyes* or *APPLYMASKno*). The mask(s) provided in Lat-Long will be projected in SlantRange.
  - The mask(s) must be in Envi HARRIS format: a header text file (.hdr) and a binary 8-bit file.
- **# PATHTOMASKGEOC**
  - (*file path*). Path and file name of geocoded "Geographical mask" to be used to always mask the results (e.g. water bodies).
- **# DATAMASKGEOC**
  - (*value*). Value in PATHTOMASKGEOC file that will be used as mask (**usually 1**)
- **# PATHTOMASKCOH**
  - (*file path*). Path and file name of geocoded "Thresholded coherence mask" to be used to mask at unwrapping when coherence is below the **COHCLNTHRESH** threshold.
- **# DATAMASKCOH**
  - (*value*). Value in PATHTOMASKCOH file that will be used as mask (**usually 2**)
- **# PATHTODIREVENTSMASKS**
  - (*path to directory*). Path to the directory that contains all the event mask(s) named eventMaskYYYYMMDDThhmmss\_YYYYMMDDThhmmss(.hdr) for masking at Detrend step with all masks having dates in Primary-Secondary range of dates.
- **# DATAMASKEVENTS**
  - (*value*). Value for masking in PATHTODIREVENTSMASKS (**usually 3**)

# MASK – version October 15 2024 (see former version below)

#####

- **# MASK**
  - (*APPLYMASKyes* or *APPLYMASKno*). The mask(s) provided in Lat-Long will be projected in SlantRange.
  - The mask(s) must be in Envi HARRIS format: a header text file (.hdr) and a binary 8-bit file.
- **# PATHTOMASKGEOC**
  - (*file path*). Path and file name of geocoded "Geographical mask" to be used to always mask the results (e.g. water bodies).
- **# DATAMASKGEOC**
  - (*value*). Value in PATHTOMASKGEOC file that will be used as mask (**usually 1**)
- **# PATHTOMASKCOH**
  - (*file path*). Path and file name of geocoded "Thresholded coherence mask" to be used to mask at unwrapping when coherence is below the **COHCLNTHRESH** threshold.
- **# DATAMASKCOH**
  - (*value*). Value in PATHTOMASKCOH file that will be used as mask (**usually 2**)
- **# PATHTOMASKDETREND**
  - (*file path*). Path and file name of geocoded "Detrend masked areas" to be used to mask the deformation when computing the residual ramp at detrending step.
- **# DATAMASKDETREND**
  - (*value*). Value in PATHTOMASKDETREND file that will be used as mask (**usually 3**)

# MASK – version prior October 15 2024

#####

- # MASK

- (*APPLYMASKyes* or *APPLYMASKno*). The mask provided in Lat-Long will be projected in SlantRange.
- The mask must be in Envi HARRIS format: a header text file (.hdr) and a binary 8-bit file.
- If a mask is provided, snaphu (or CIS) also unwraps 0-masked pixels (for AMSTerEngine < 20230928), or 2-masked pixels (for AMSTerEngine > 20230928) if their coherence is above the **COHCLNTRESH** (see below).
- If computed manually, do not add extension at mask name. It must be something like *mask* and *mask.hdr*, not *mask.ext* and *mask.hdr*
- Masks of coherence can be created using the script **MultiLaunch\_ForMask.sh**
- If a mask requested but you do not use Snaphu, results will not be masked. One can however also mask manually files with *ffa* (eg *ffa residualInterferogram.HH-HH.f x slantRangeMask*)

- # PATHTOMASK

- (*file path*). Path and file name of mask to be used to mask the coherence before unwrapping (when using snaphu).
- Mask will be projected in slant range and hence can be used to mask the results of the interferometric computation, eg using the AMSTerEngine command *ffa*:

*ffa residualInterferogram.HH-HH.f x slantRangeMask*

# UNWRAPPING

#####

- # SKIPUW,

- (*SKIPyes*, *SKIPno* or *MASK*).  
*SKIPyes* will skip the time-consuming unwrapping step but will still geocode all the available and requested products. *SKIPno* will unwrap and geocode all available and requested products. *MASK* option is used to geocode only amplitude and coherence files; this is used for creating masks based on the coherence.

- # UW\_METHOD,

- (*SNAPHU*, *CIS*, *DETPHUN1ONLY*, *DETPHUN2ONLY*, *DETPHUN1SNAPHU*, *DETPHUN2SNAPHU*, *DETPHUN1CIS* or *DETPHUN2CIS*). Method used for the unwrapping. Snaphu is probably the most used method in the InSAR community. DETPHUN methods are fast but usually to be considered as preliminary step.

# if snaphu unwrapping:

- # DEFOTHRESHFACTOR,

- (*Real number*). Snaphu : Factor applied to rho0 to get threshold for whether or not phase discontinuity is possible. rho0 is the expected, biased correlation measure if true correlation is 0. Increase if results are not good. See snaphu literature for more information.

- # DEFCONST,

- (*Real number*). Snaphu : Ratio of phase discontinuity probability density to peak probability density expected for discontinuity-possible pixel differences. Value of 1 means zero cost for discontinuity, 0 means infinite cost. Decrease if results are not good. See snaphu literature for more information.

- # DEFOMAX\_CYCLE,

- (*Real number*). Snaphu : Maximum number of expected phase cycle discontinuity. For topo where no phase jump is expected, it can be set to zero. See snaphu literature for more information.

- **# SNAPHUMODE,**
  - (*TOPO, DEFO, SMOOTH, or NOSTATCOSTS*). Snaphu : pre-defined configuration for snaphu depending of the type of interferogram expected. See snaphu literature for more information.
- **# ZONEMAP,**
  - *ZoneMapYes* or *ZoneMapNo*. if ZoneMapYes, it will create a map with the unwrapped zones named snaphuZoneMap. Each continuously unwrapped zone is numbered (from 1 to...)
- **# ZONEMAPSIZE,**
  - (*Real number*) Minimum size of snaphu unwrapped zone to map (in fraction of total nr of pixels)
- **# ZONEMAPCOST,**
  - (*Integer number*) Cost threshold for connected components (zones) obtained with snaphu. Higher threshold will give smaller connected zones
- **# ZONEMAPTOTAL,**
  - (*integer number*) Maximum number of mapped zones unwrapped with snaphu.
  
- **# MULTIUWP,**
  - *MultiSnaphuYes* or *MultiSnaphuNo*. If MultiSnaphuYes, it performs recursive ***snaphu*** unwrapping (need 4 params below). MultiUnwrapNo (or any other string) will perform single snaphu unwrapping
- **# WHICHINTERF,**
  - (*ResidInterf* or *ResidInterfFilt*). Which interferogram to unwrap: residual interferogram or Filtered Residual interferogram
- **# COEFREQ,**
  - (*Real number*). Coefficient of increase of cut-off frequency (e.g 0.9)
- **# CUTINI,**
  - (*Real number*). Initial cut-off frequency (e.g. 12.5 for a 400x400 image, 10 for a 2200x1500 img)
- **# NITMAX,**
  - (*Integer number*). Maximum total number of iterations
- **# COHMUWPTHRESH,**
  - (*Real number*). Coherence threshold (between 0 and 1) below which it replaces the phase by white noise (corresponding mask will be produced). If set to 0, do not mask with white noise

# if snaphu or CIS unwrapping:

- **# COHCLNTHRESH,**
  - (*Real number*). Will use the coherence in conjunction with the mask at unwrapping. Pixels where coherence mask (see **PATHTOMASKCOH**) values are 2 will be masked at unwrapping, except if coherence is above the **COHCLNTHRESH** threshold. Combined with the other masks, it gives the following rules for masking:

Mask	Coh > <b>COHCLNTHRESH</b>	unwrapping
0	yes	Yes
0	no	Yes
1	yes	No
1	no	No
2	yes	Yes
2	no	No
3	Only mask for computing phase ramps, i.e. no mask at unwrapping	

**Note:** former versions or AMSTer had a different way of using the masks:

In the oldest versions, pixels with coherence above threshold OR where mask = 1 were unwrapped. If **COHCLNTHRESH** is set to 1, it would only use the mask provided without taking into account the coherence:

Mask	Coh > <b>COHCLNTHRESH</b>	unwrapping
1	1	Yes
1	0	Yes
0	1	Yes
0	0	No

**Note:** Do not set coherence threshold to 1 when using CIS unwrapping method !

From AMSTerEngine V20230921, masks were inverted and multi-layers, that is:

- 0 is to keep (no mask applied)
- 1 is always masked (e.g. water bodies area)
- 2 is masked during unwrapping except is coherence is above a given threshold (see parameter **COHCLNTHRESH** in *LaunchMTparam.txt*)

That is:

Mask	Coh > <b>COHCLNTHRESH</b>	unwrapping
0	yes	Yes
0	no	Yes
1	yes	No
1	no	No
2	yes	Yes
2	no	No

# if CSL unwrapping:

- **# FALSERESOHTHR,**
  - (*Real number*). False Residue Coherence Threshold: higher is much slower. Use max 0.15 e.g. in crater.
- **# CONNEXION\_MODE,**
  - (*Integer number*). Number of times that connection search radius is augmented when stable connections are found ; 0 search along all coherent zone.
- **# BIASCOHESTIM,**
  - (*Integer number*). Biased coherence estimator range and Az window size
- **# BIASCOHSPIR,**
  - (*Integer number*). Biased coherence square spiral size (if residual fringes are not unwrapped, decrease it; must be odd)

# if DETPHUN unwrapping:

- **# DETITERR,**
  - (*Integer number*). Number of iterations for detPhUn (1, 2 or 3 is generally OK).
- **# DETCOHTHRESH,**
  - (*Real number*). Coherence threshold.
- **# INTERPOL,**

- (*BOTH*, *BEFORE* or *AFTER*). Interpolate the unwrapped interferogram *BEFORE* or *AFTER* geocoding or *BOTH*. It allows to reduce very small gaps in the data. In principle the function developed by Ludivine Libert could be applied several times repeatedly, but the scripts only apply it once.
- # REMOVEPLANE,
  - (*DETREND* or *???*). If option set to *DETREND*, it will remove a best plane (phase ramp) after unwrapping. Anything else will ignore the detrending.
  - Note: selecting DETREND is equivalent to the calibration in MSBAS with C\_FLAG= 10. In such a case, you can set C\_FLAG at zero when processing msbas, which should speed up the msbas processing, but also would allow you to split the data in smaller batches in case of insufficient RAM. You can for instance run 4 msbas with the WINDOW\_SIZE set to each quarter of your footprint then assemble the results. Reminder : using C\_FLAG = 10 or DETREND means setting the interferogram averages to zero. If you prefer to calibrate the interferograms with another method (one or more points or region), then splitting the msbas will not be possible. Note that when computing a 3D inversion, keeping C\_FLAG = 10 may be relevant to remove possible trend in DEM gradients.
  - You can mask regions that you do not want to take into account for computing the phase ramp (e.g. when affected by deformation). See [PATHTODIREVENTSMASKS](#).

## # GEOCODING

#####

- # PROJ,
  - (*UTM* or *LATLONG*). Projection for geocoded products. Although AMSTerEngine is able to handle both UTM and Lat-Long, only UTM is implemented in the scripts. Whatever you set up here, it will be processed as *UTM* anyway... The only exception is the geocoding of amplitude images using [Geocode\\_from\\_ALL2GIF.sh](#) after usage of [ALL2GIF.sh](#).
- # GEOCMETHD,
  - (*Forced*, *Auto*, *Closest* or *ClosestMassProc*).
    - Resampling Size of Geocoded pixels:
      - *Forced*: will force pixels at size **FORCEGEOPIXSIZE** (see below) and along a grid at fixed size and position (see **XMIN**, **XMAX**, **YMIN**, **YMAX** below). This is the mandatory selection for MSBAS because it requires the crop of the geocoded interferometric product to be similar for all images acquired by all type of sensors, in all geometries. In that case, **FORCEGEOPIXSIZE** (in meters) must be chosen the closest as possible to the size of the multilooked pixel size. If used with **ORIGINALFORM** value for param **PIXSHAPE**, it must be provided in the form of **xAzyRg** or **yRgxAz**, where **x** and **y** a size in meters.
      - *Auto*: Will force the size of the geocoded pixels to be the closest multiple of 10m to the size of the multilooked pixel size.
      - *Closest*: Will force the size of the geocoded pixels to be the closest to the size of the multilooked pixel size.
      - *ClosestMassProc*: Will force the size of the geocoded pixels to be the closest to the size of the multilooked pixel size, even for a Mass Processing. Usually for a mass processing, which aims at performing MSBAS after, it is mandatory to have all the pixels forced at the same size, for all the sensors and geometries. Hence a security would prevent you to make a mass processing (using [SuperMaster\\_MassProc.sh](#)) without *Forced* option. *ClosestMassProc* allowed to override this security.

- **# RADIUSBMTHD,**
  - (*LetCIS* or *Integer*).  
*LetCIS* let AMSTerEngine chose the best (adaptive) interpolation radius (default and preferred option). If you set an *Integer* number, it forces the use of the same radius throughout the whole image. Note however than if chosen too small, it will be fast but will create gaps in slopy terrain. If too large, it will avoid the gaps but may become very slow. Usually, prefer the adaptive automatic solution.
- **# RESAMPBMTHD,**
  - (*TRI*, *AV* or *NN*). Triangulation, weighted average or nearest neighbour.
- **# WEIGHTBMTHD,**
  - (*ID* or *LORENTZ*). Weighting method: inverse distance or = Lorentzian
- **# IDSMOOTH,**
  - (*Real*). ID smoothing factor
- **# IDWEIGHT,**
  - (*Real*). ID weighting exponent
- **# FWHM,**
  - (*Real*). Lorentzian Full Width at Half Maximum. Having less than one (eg. 0.5 or 0.1) may provide less blurred geocoded images
- **# ZONEINDEX,**
  - (*Integer*). Zone index
- **#FORCEGEOPIXSIZE,**
  - (*Integer*). Pixel size (in meters) for geocoded products.
- **#UTMZONE,**
  - (*letter* followed by *Integer*). Letter of row and nr of col of the zone where coordinates below are computed (e.g. U32). **This is not mandatory unless** your area of interest intersect two UTM zones and the middle of the image is not in the same UTM zone depending on the track/mode used. If not set, the software will compute by itself the UTM zone. If provided, when using GEOCMETHOD *Forced*, the provided UTM coordinates will be computed from the provided UTM zone. In most of the case, you will not need that parameter and it can be left empty. Only use it if your Forced option does not provide you with the expected results. Another way to securely Force the geocoding on an area spanning different UTM zones is to force cropping based on a kml file, which does not suffer from a possible UTM zone confusion.
- **# XMIN,**
- **# XMAX,**
- **# YMIN,**
- **# YMAX,**
  - (*Integer*). Minimum/maximum X and Y UTM coordinates of final geocoded product
- **# GEOCKML,**
  - (*path\_to\_kml\_file*). A kml file to define final forced geocoded product. If file is not found, it will use the coordinates above.

```

PATHS #
#####
```

- **# PROROOTPATH,**
  - (*Path*). Path to directory where data will be processed in sub directories named by the SAT/TRACK/Crop etc... name. If you run several processes at the same time (either the same SAT/TRK/REGION split in several session using \_\_*SplitSession.sh* or running several different SAT/TRK/REGION), it is advised to process them on separate disks. Read and Write accesses are indeed often the bottleneck for a fast parallel processing.  
(example: \${HOME}/PROCESS/MT and/or \$PATH\_3600/PROCESS/MT)
- **# DATAPATH,**
  - (*Path*). Path to directory where data are stored in CSL format  
(example: /\$PATH\_1650/SAR CSL/)
- **# DEMDIR,**
  - (*Path*). Path to directory where DEM is stored.  
(example: /\$PATH\_DataSAR/SAR\_AUX\_FILES/DEM/SRTM30/ALL)
- **# FCTFILE,**
  - (*Path to file*). Path to shell script file where all functions are defined.  
(example: /\$PATH\_SCRIPTS/SCRIPTS\_MT/FUNCTIONS\_FOR\_MT.sh)

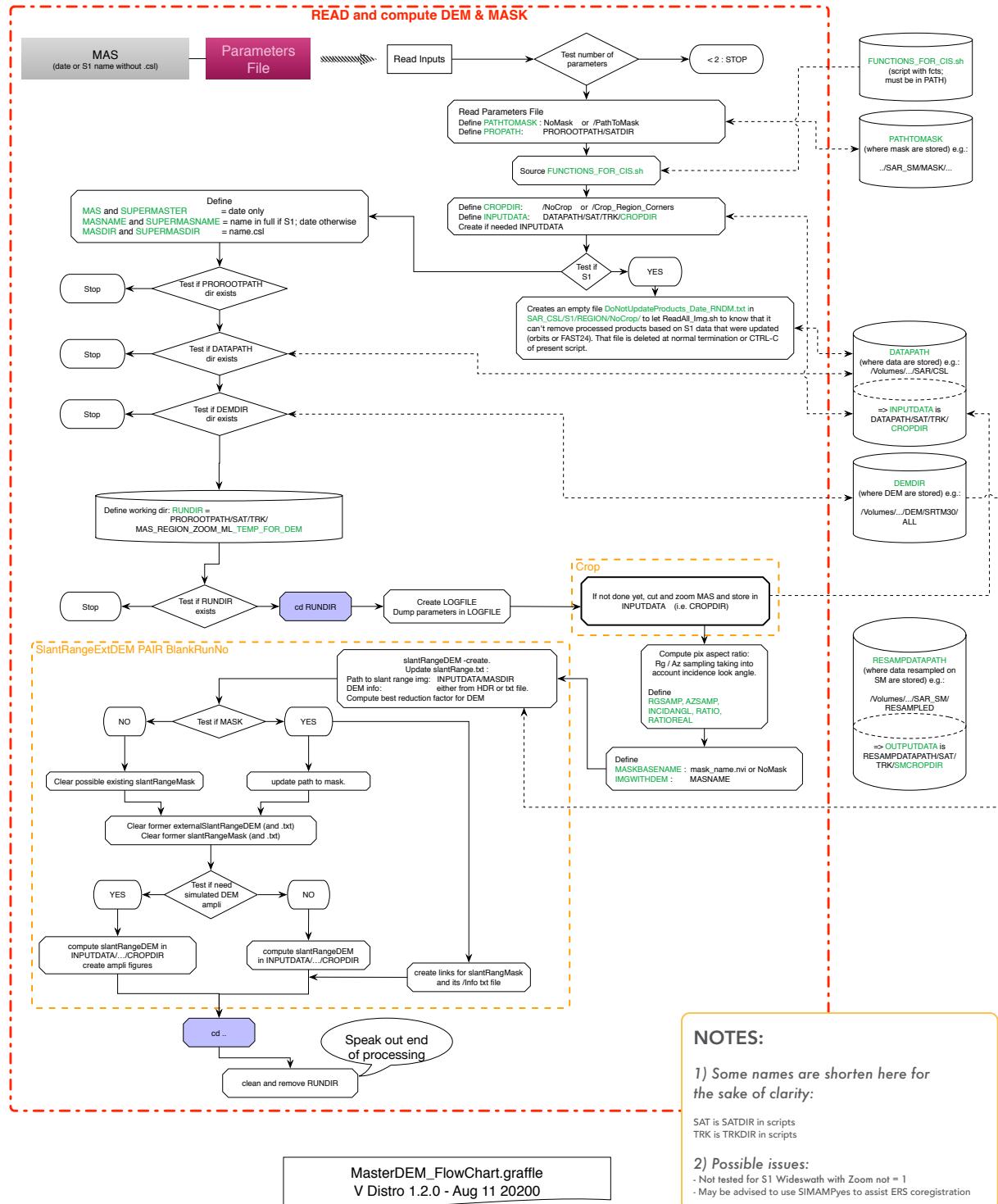
# for coregistration mass processing (required if coregistration on a Global Primary i.e. SuperMaster)

- **# RESAMPDATPATH,**
  - (*Path*). path to directory where resampled data will be stored.  
(example: /\$PATH\_1650/SAR\_SM/RESAMPLED)

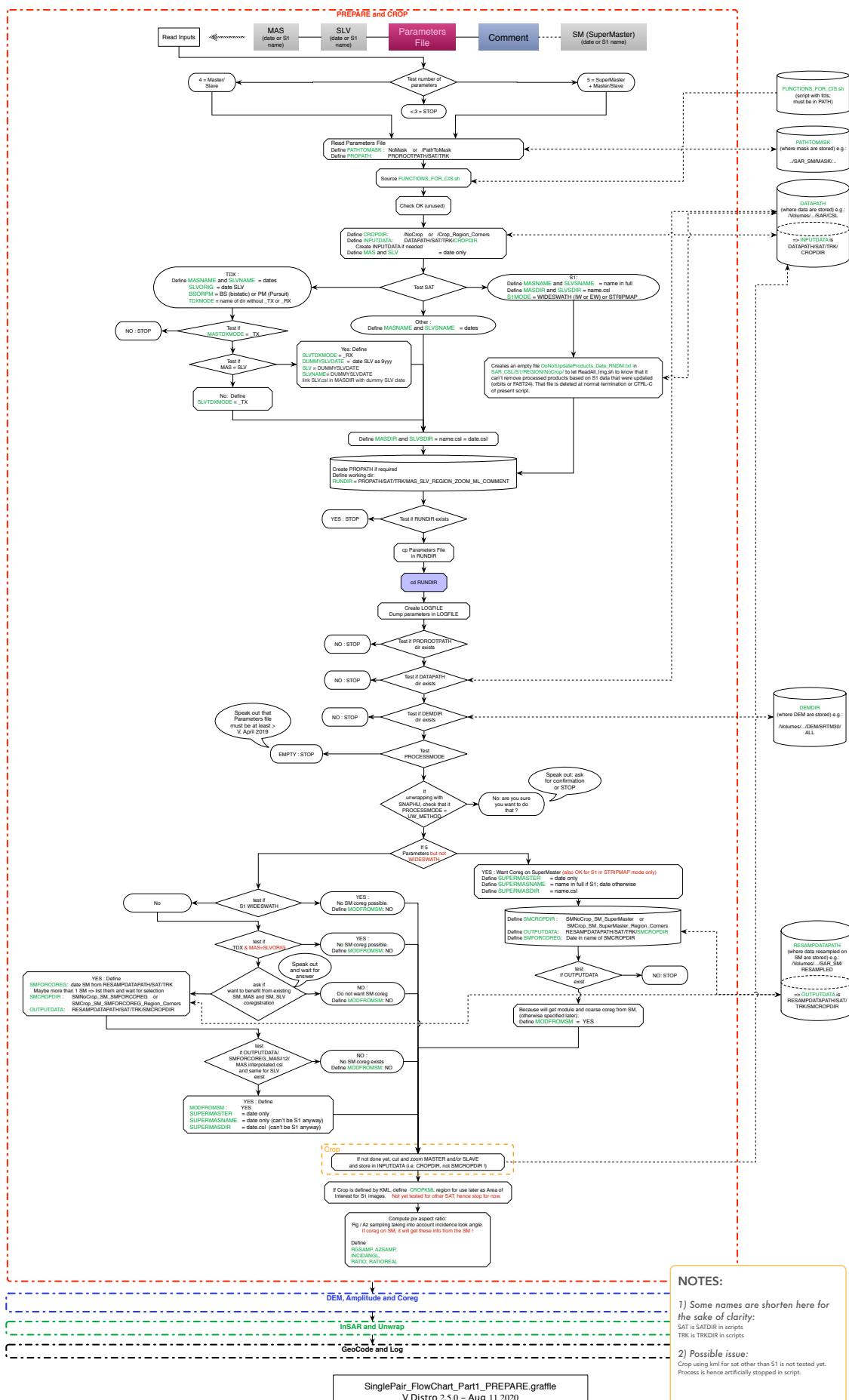
# for InSAR mass processing

- **# MASSPROCESSPATH,**
  - (*Path*). Path to directory where all processed pairs will be stored in sub directory named by the SAT/TRACK name (SATDIR/TRKDIR).  
(example: /\$PATH\_3601/SAR\_MASSPROCESS/)

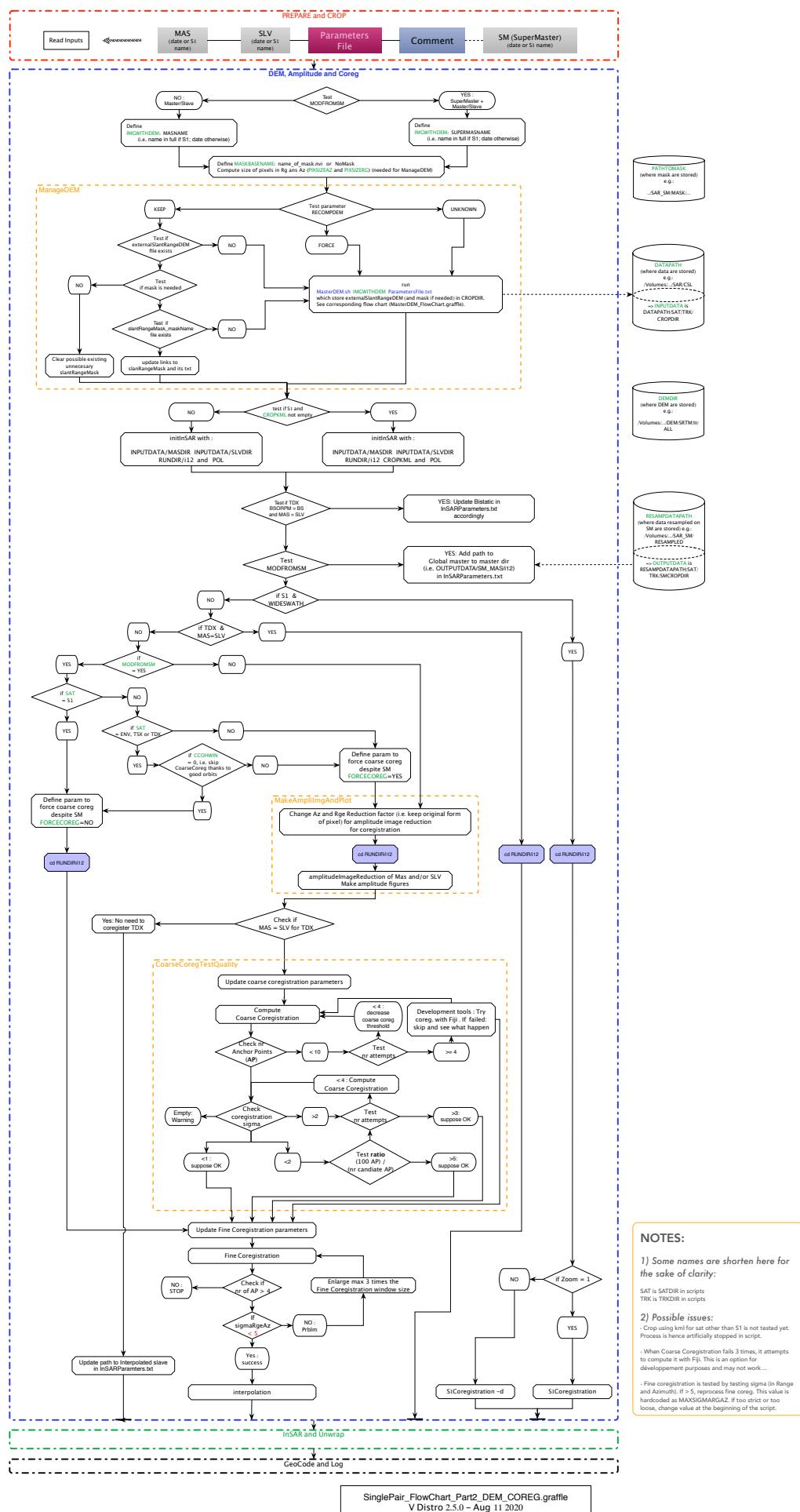
## A.2) Flow chart of *MasterDEM.sh*

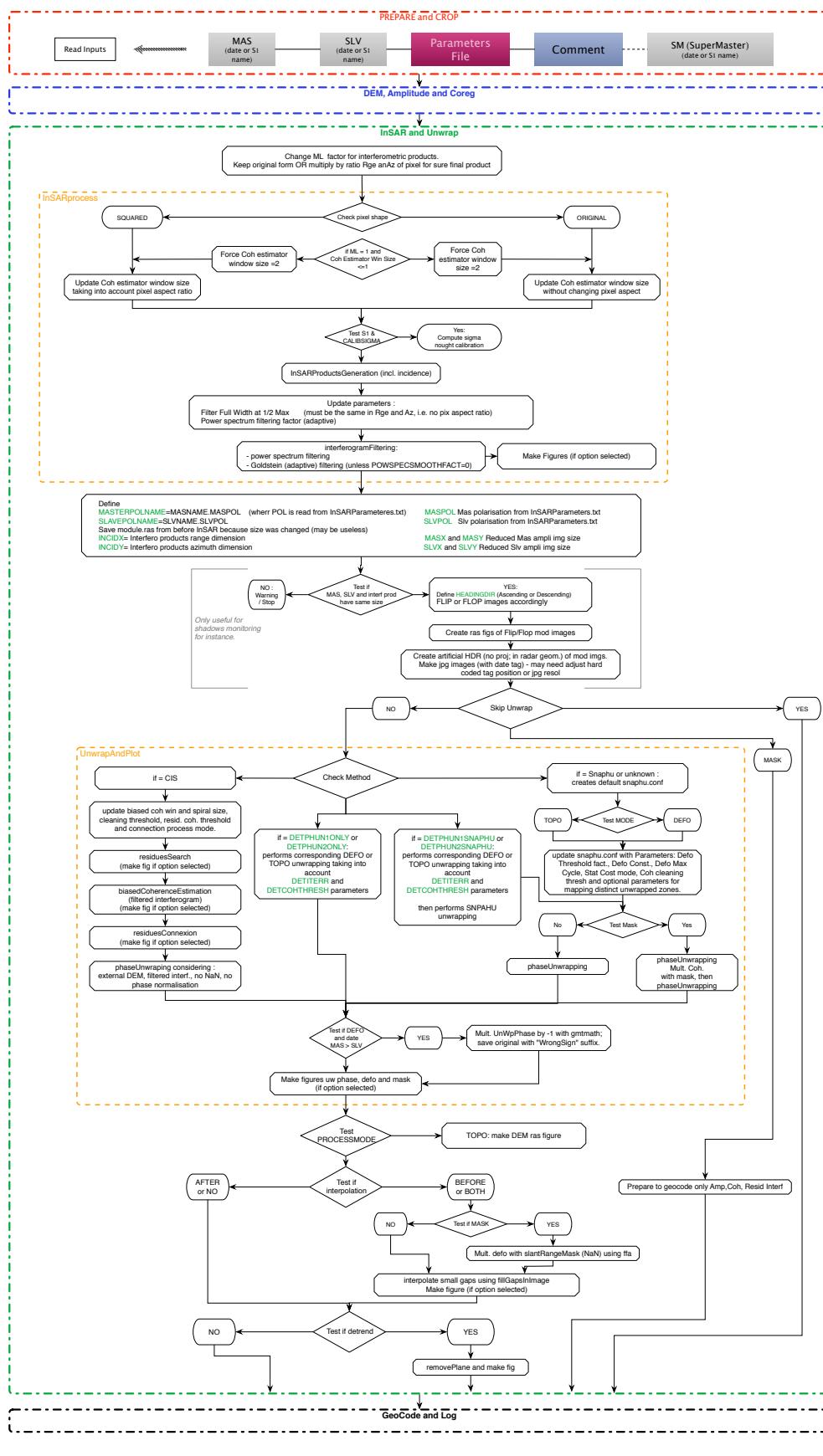


### A.3) Flow chart of SinglePair.sh

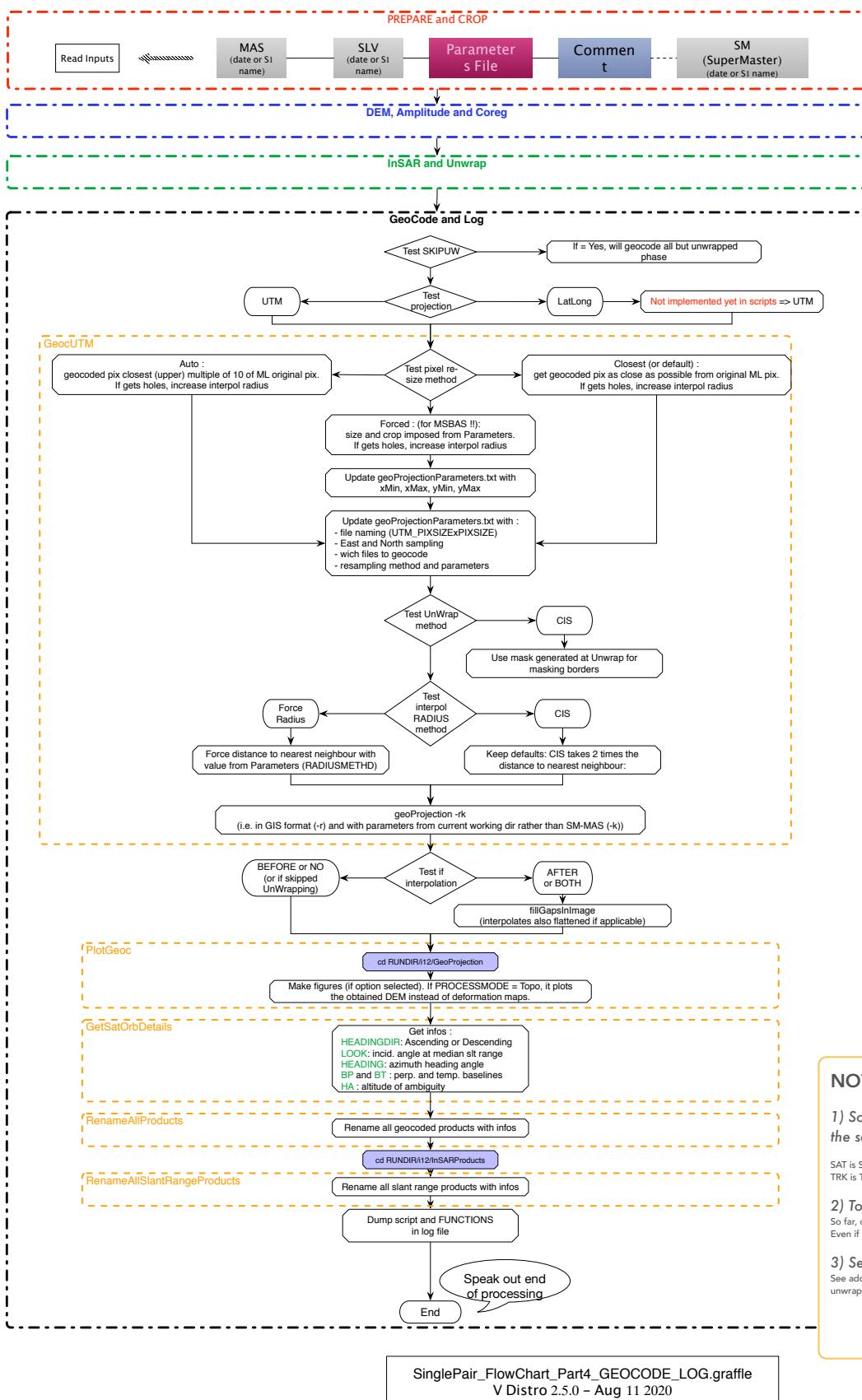


SinglePair\_FlowChart\_Part1\_PREPARE.graffle  
V Distro 2.5.0 - Aug 11 2020

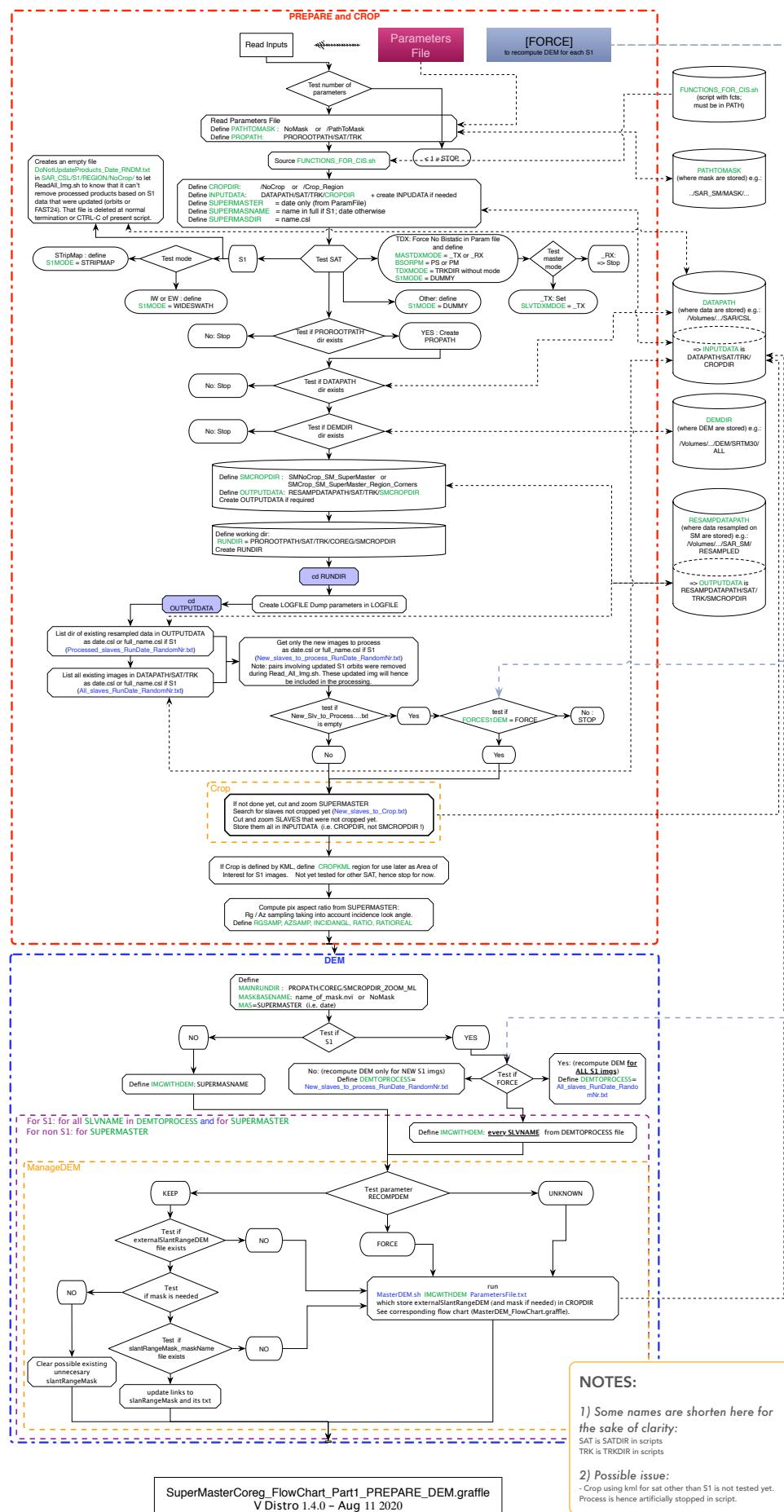




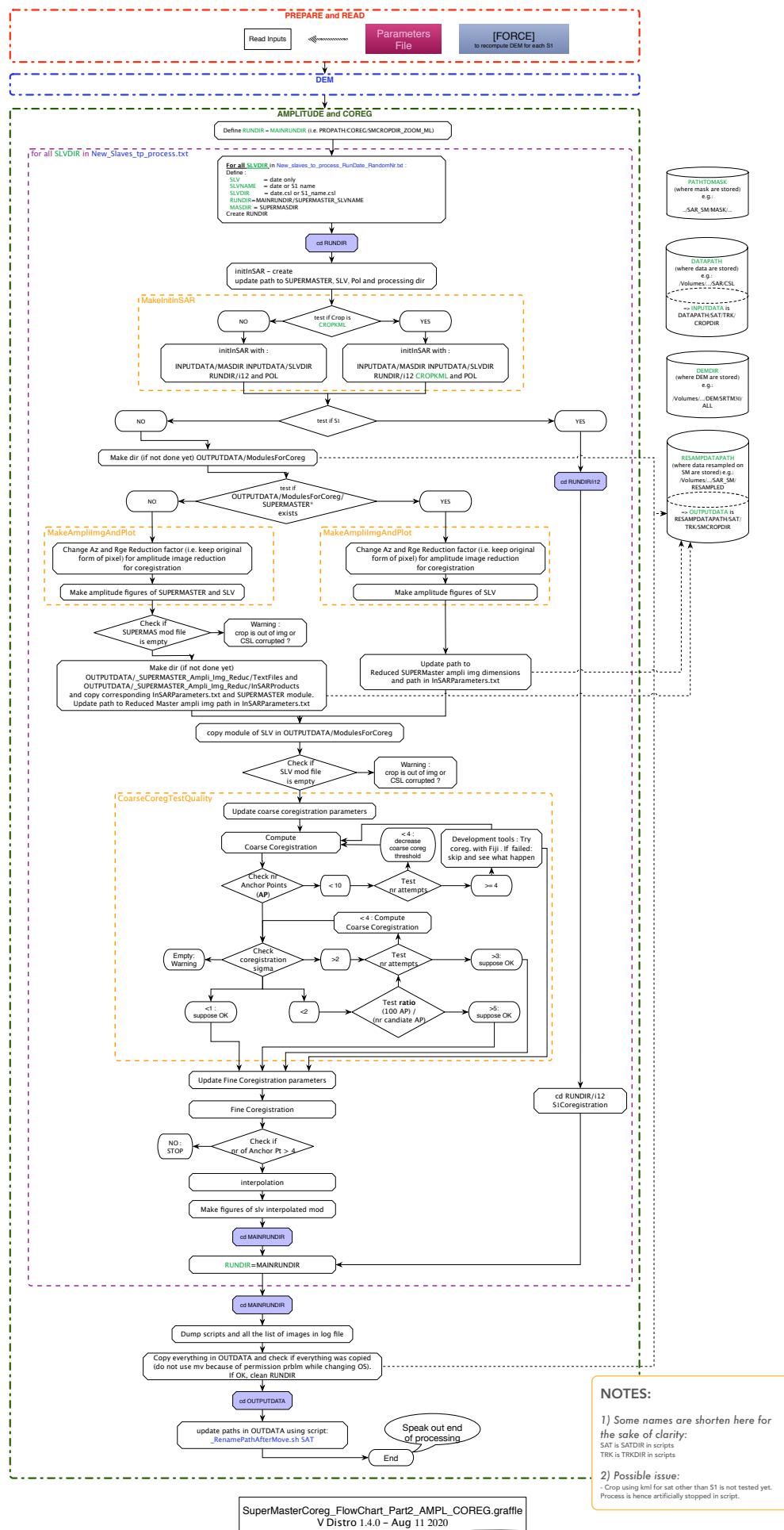
SinglePair\_FlowChart\_Part3\_INSAR.graffle  
V Distro 2.5.0 – Aug 11 2020



#### A.4) Flow chart of SuperMasterCoreg.sh

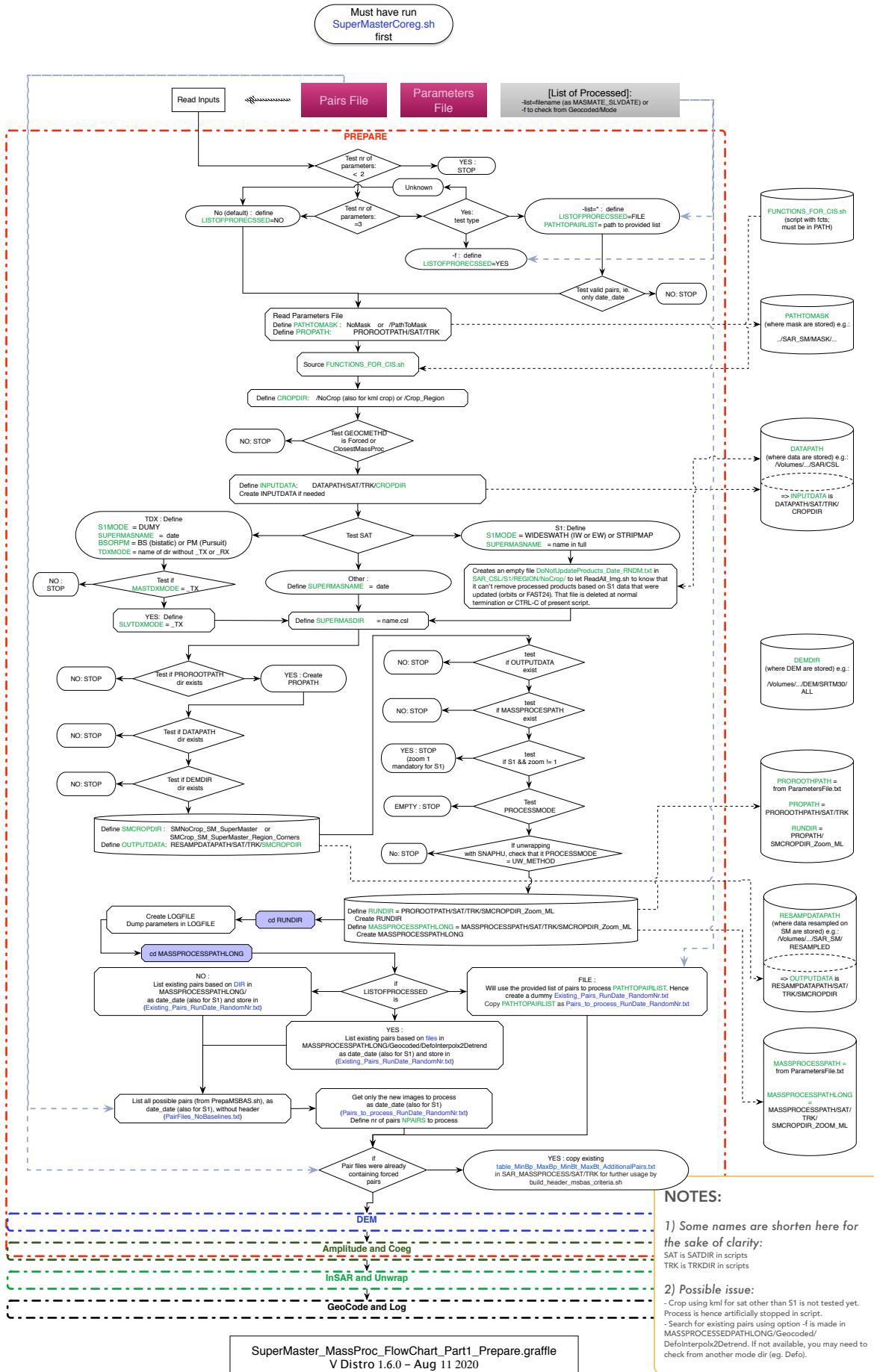


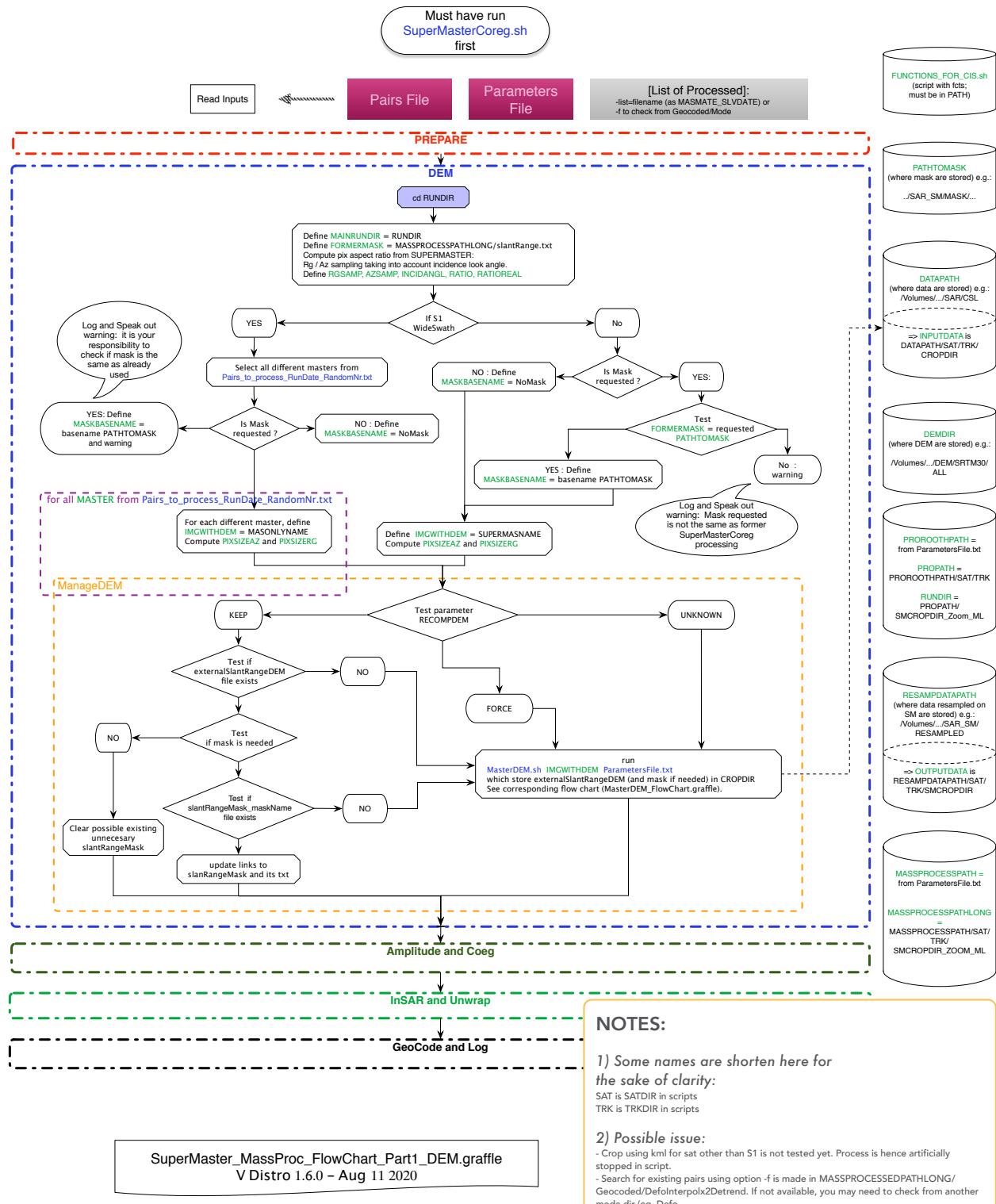
SuperMasterCoreg\_FlowChart\_Part1\_PREPARE\_DEM.graffle  
V Distro 1.4.0 - Aug 11 2020

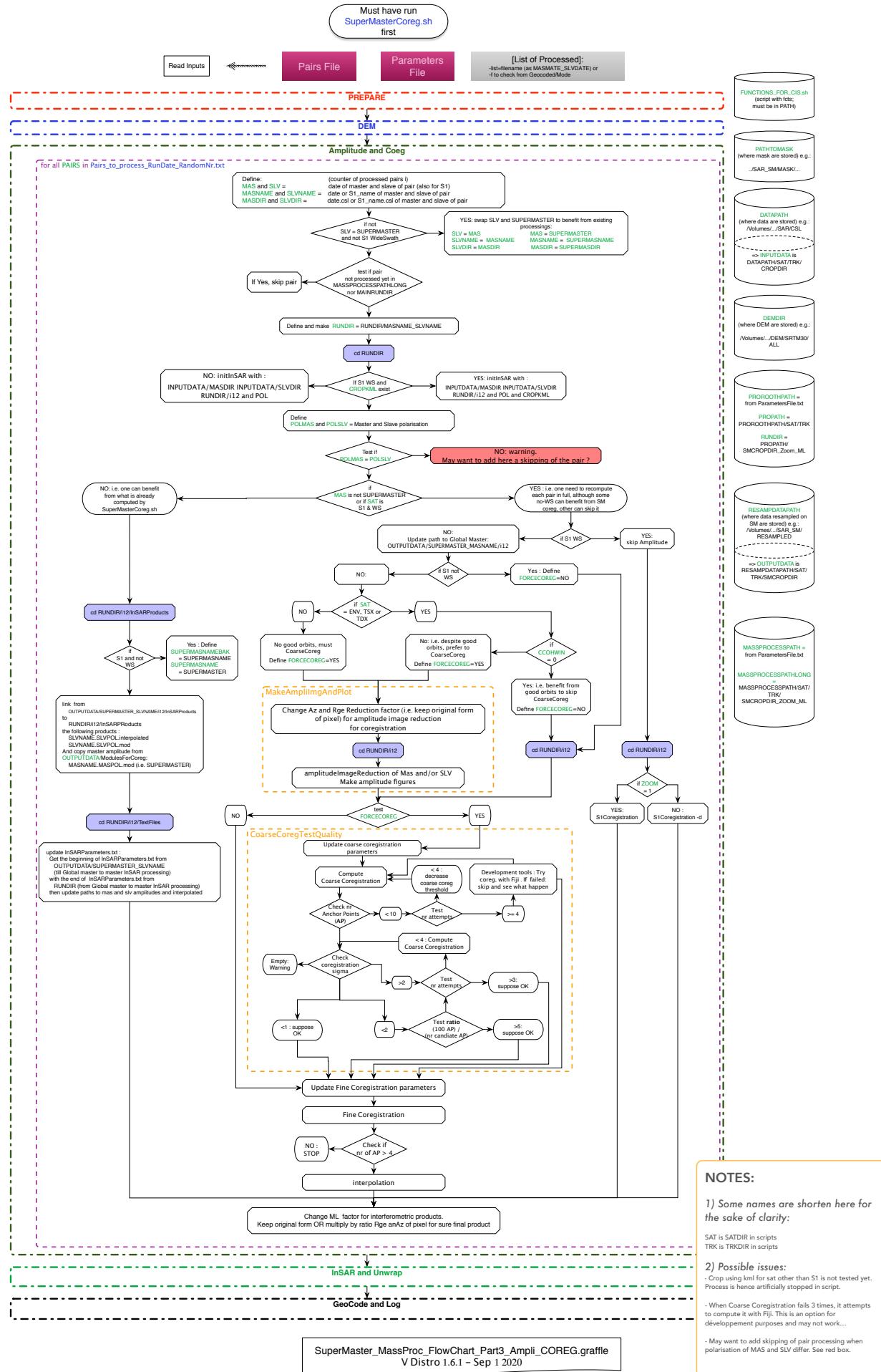


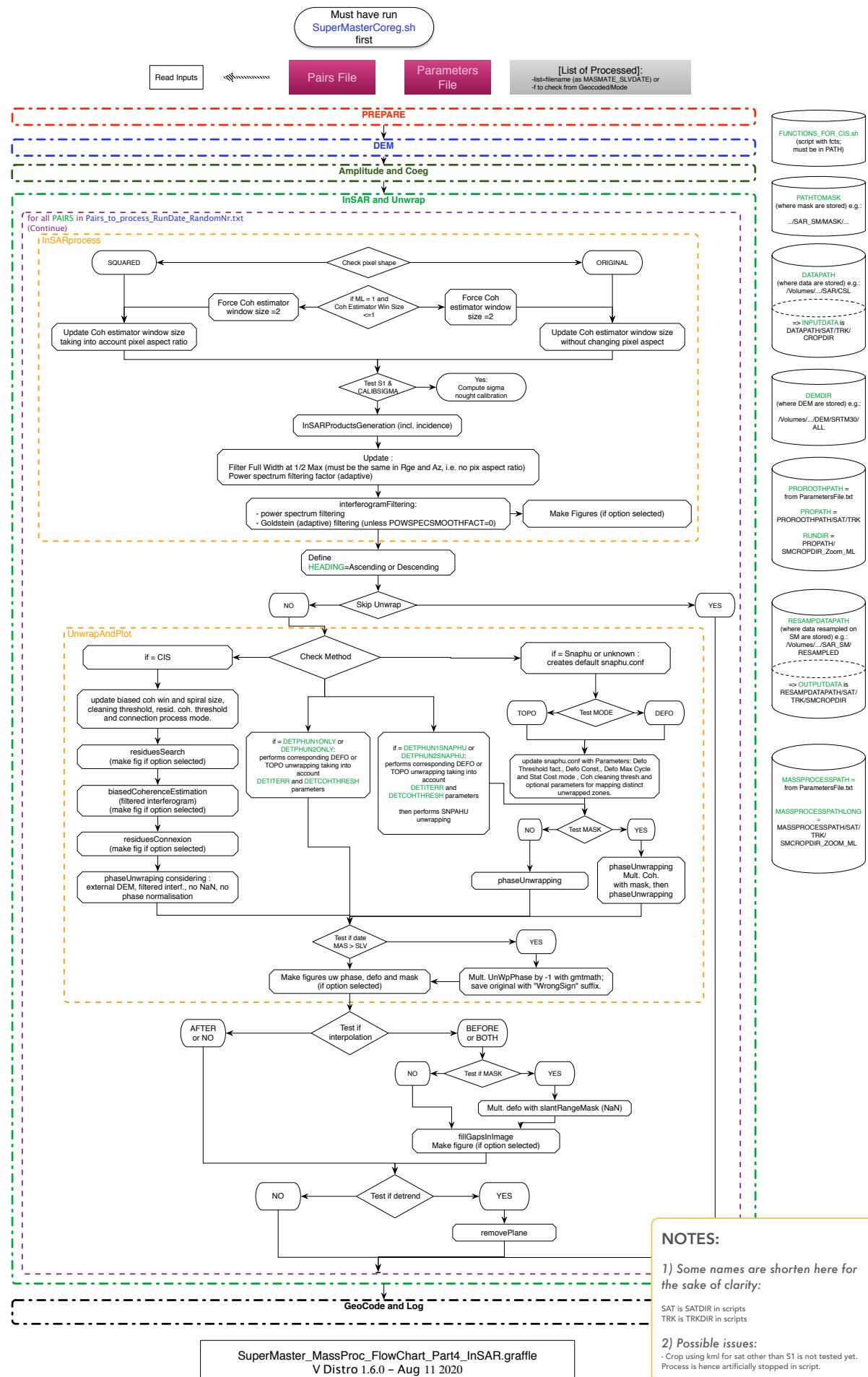
SuperMasterCoreg\_FlowChart\_Part2\_AMPL\_COREG.graffle  
V Distro 1.4.0 - Aug 11 2020

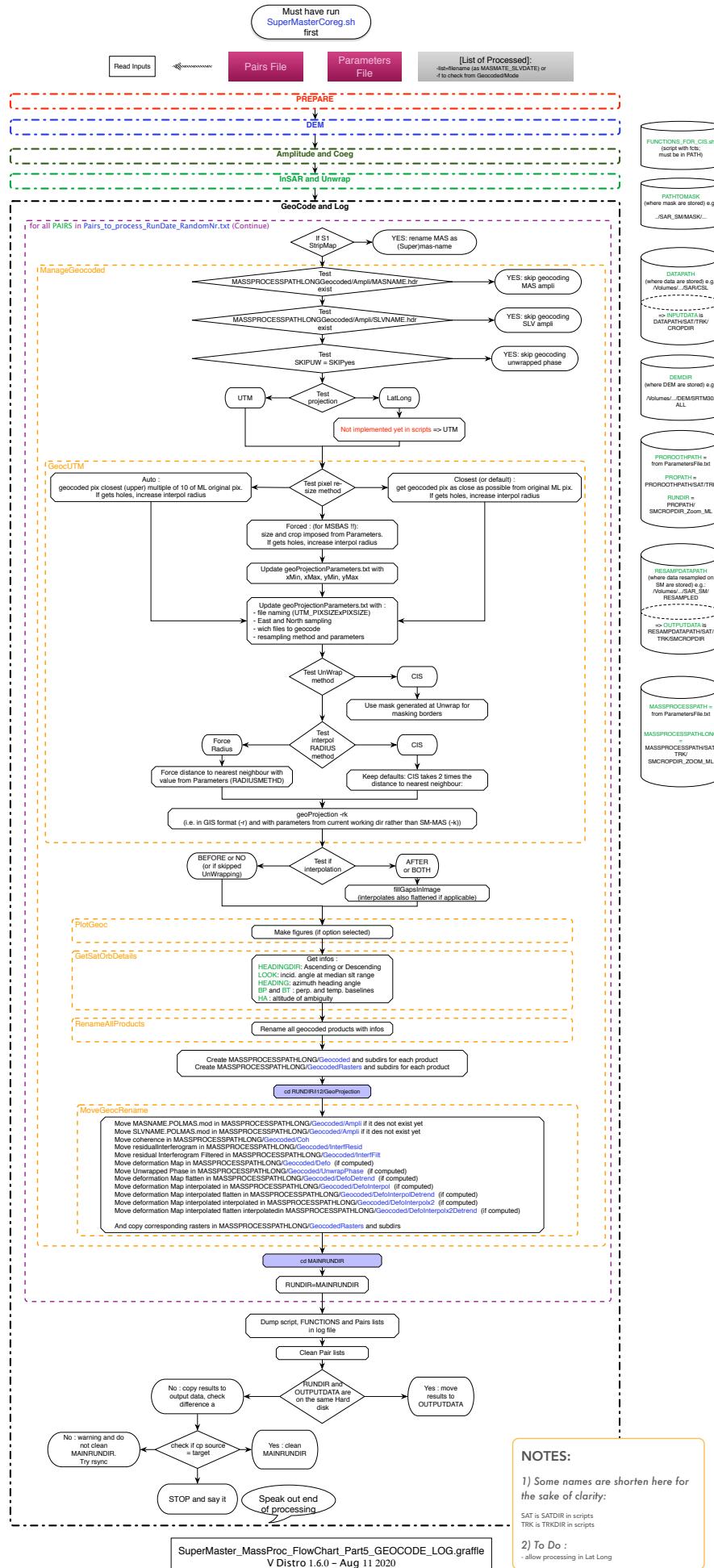
## A.5) Flow chart of SuperMaster\_MassProc.sh











## A.6) Example of full automation

### A.6.1) Automatic data download

Special thanks to Gilles Celli who wrote the following two scripts to automatically download data from several regions ([Gilles@ecgs.lu](mailto:Gilles@ecgs.lu)). Adapt the red lines and green parameters to your needs. Remember that you can also use AMSTer Engine function **SentinelDataDownloader**.

#### *sentinel1\_download\_all.sh:*

```
#!/bin/sh
#
This script downloads the satellite image files from ESA-Sentinel 1
for several pre-defined targets. These targets are defined in the
main script s1_downloader.sh
#
Dependencies:
- /opt/local/bin/xmlstarlet and curl (install with macports)
- the main script: /YourPath/S1-Copernicus/s1_downloader.sh
#
This script was made for Mac computer.
It is provided as an example and must be tuned to your needs:
- the path to s1_downloader.sh script on your computer
- your targets (footprints/orbits) as defined in s1_downloader.sh
- your options (which type of data, how far backward would you like to check data availability...)
#
Written by G. Celli for AMSTer software at ECGS

#####
Domuyo
/Users/doris/scripts/S1-Copernicus/s1_downloader.sh --domuyoA18 --slc --startdate=15-DAYS-AGO --enddate=TODAY
/bin/sleep 60

/Users/doris/scripts/S1-Copernicus/s1_downloader.sh --domuyoD83 --slc --startdate=15-DAYS-AGO --enddate=TODAY
/bin/sleep 60

RD of Congo
/Users/doris/scripts/S1-Copernicus/s1_downloader.sh --congoA174 --slc --startdate=15-DAYS-AGO --enddate=TODAY
/bin/sleep 60

/Users/doris/scripts/S1-Copernicus/s1_downloader.sh --congoD21 --slc --startdate=15-DAYS-AGO --enddate=TODAY
/bin/sleep 60

Hawaii
/Users/doris/scripts/S1-Copernicus/s1_downloader.sh --hawaiiA124 --slc --startdate=15-DAYS-AGO --enddate=TODAY
/bin/sleep 60

/Users/doris/scripts/S1-Copernicus/s1_downloader.sh --hawaiid87 --slc --startdate=15-DAYS-AGO --enddate=TODAY
/bin/sleep 60

[...]
```

#### *s1\_downloader.sh:* (the script downloads data from several targets in 2 different storage places)

```
#!/opt/local/bin/bash
#
Script to download SENTINEL-1 productFiles based on AOI (Area of Interest)
SENTINEL APIs documentation (replace SciHub interfaces):
https://documentation.dataspace.copernicus.eu/APIs/OData.html
#
It will send an e-mail summarising the results.
#
It also unzip the downloaded images
#
This script is provided as an example and must be tuned to your needs:
- Mounting of the disks is performed for Mac computer; change the method if needed
- sending the mail is performed with Mac app; change the method if needed
- your e-mail address
- your login and password to esa web site
- your path where to save the data
- and of course, your targets (footprints, orbits etc...)
#
Dependencies:
- curl, wget
- 7zip
- app to send mail
...
#
Written by G. Celli for AMSTer software at ECGS
VERSION="1.0.0-2024.06.18"
```

```

Default values
Start and End Date - obsolete
START_DATE=$1
END_DATE=$2

FULLHOSTNAME=$(/bin/hostname)
HOSTNAME=$(/bin/hostname -s)
LOG_DATE=$(/bin/date +"%Y%m%d%H%M")
SCRIPT_EXEC_STARTDATE=$(/bin/date +"%A, %d %B %Y @ %H:%M")

List the Catalogue only - when passing "--list-only" it will not try to download product files, but
LIST_CATALOGUE_ONLY=false

Set the email recipients, separate with comma for multiple recipients
EMAIL_RECIPIENTS="YourEmail@Address.com"

#EMAIL SUBJECT="[${HOSTNAME}] Sentinel emergency download for "
EMAIL_SUBJECT="SENTINEL-1 downloads for "

#####
Use macOS automount feature to mount smb network discs
Whole SMB_URL=/Users/doris/NAS-Discs/hp-D3600-Data_Share1/SAR_DATA/S1/
SMB_SHARE_NAME="hp-D3600-Data_Share1" # do not use a slash at beginning and end
SMB_SHARE_MOUNTED_ON_LOCAL_DIR="${HOME}/NAS-Discs/${SMB_SHARE_NAME}"
S1_WORKDIR="${SMB_SHARE_MOUNTED_ON_LOCAL_DIR}/SAR_DATA/S1"
echo "Working Dir: S1_WORKDIR= ${S1_WORKDIR}"

new since inclusion of Piton de la Fournaise (Sept 30 2020)
SMB_SHARE_NAME_OTHER="hp-D3601-Data_RAID6" # do not use a slash at beginning and end
SMB_SHARE_MOUNTED_ON_LOCAL_DIR_OTHER="${HOME}/NAS-Discs/${SMB_SHARE_NAME_OTHER}"
S1_WORKDIR_OTHER="${SMB_SHARE_MOUNTED_ON_LOCAL_DIR_OTHER}/SAR_DATA_Other_Zones/S1"
echo "And Working Dir: S1_WORKDIR_OTHER= ${S1_WORKDIR_OTHER}"

#####
Third-party applications, provide the correct path for curl, jq and others

GNU stat command
CMD_CURL="/opt/local/bin/curl"
CMD_GNU_STAT="/opt/local/bin/gstat"
CMD_JQ="/opt/local/bin/jq"

Use wget to download quicklook-file, handles way better URLs with dollar "$" signs
CMD_WGET="/opt/local/bin/wget"
CMD_TEE="/opt/local/libexec/gnubin/tee"

For unzipping, we're using 7zip with options:
-aos: Skip extracting of existing files
x: for extracting files with its directory content
CMD_UNZIP="/opt/local/bin/7zz x -bb0 -bd -aos"

#####
ESA-Site login details
USERNAME="YourLogin"
PASSWORD="YourPassword"
#####

Display help
function show_help
{
 echo "USAGE: sentinel_downloader.sh [COUNTRY] --startdate=YYYY-MM-DD --enddate=YYYY-MM-DD [OPTION_3] ... "
 echo "This script downloads Sentinel data of a given country using the ESA's COPERNICUS OData interface."
 echo " -h, --help display this help message"
 echo ""
 echo "Choose Country, only one can be selected:"
 echo ""
 echo " -1, --belgium download Sentinel data of Belgium"
 echo " -2, --capvert download Sentinel data of Capvert"
 echo " -3a, --congo download Sentinel data of Congo A174"
 echo " -3d, --congo download Sentinel data of Congo D21"
 echo " -4, --cameroon download Sentinel data of Cameroon"
 echo " -5a, --luxembourg download Sentinel data of Luxembourg A88"
 echo " -5d, --luxembourg download Sentinel data of Luxembourg D139"
 echo " -6, --tanzania download Sentinel data of Tanzania"
 echo " -7, --erta_ale download Sentinel data of Ethiopia (Erta Ale)"
 echo " -8a, --hawaii download Sentinel data of Hawaii A124"
 echo " -8d, --hawaii download Sentinel data of Hawaii D87"
 echo " -9, --tristan download Sentinel data of Tristan de Cuna"
 echo " -10, --domuyo18 download Sentinel data of Domuyo - ASCENDING 18"
 echo " -11, --domuyo83 download Sentinel data of Domuyo - DESCENDING 83"
 echo " -12, --PFascSM download Sentinel data of Piton de la Fournaise - ASCENDING 144 Strip Map mode"
 echo " -13, --PFdescSM download Sentinel data of Piton de la Fournaise - DESCNDING 151 Strip Map mode"
 echo " -14, --PFascSM download Sentinel data of Piton de la Fournaise - ASCENDING 144 IW mode"
 echo " -15, --PFdescSM download Sentinel data of Piton de la Fournaise - DESCNDING 151 IW mode"
 echo " -16, --karthala86 download Sentinel data of Karthala - ASCENDING 86 Strip Map mode"
 echo " -17, --guadeloupeD54 download Sentinel data of Guadeloupe - DESCENDING 54 IW mode"
 echo " -18, --guadeloupeA164 download Sentinel data of Guadeloupe - ASCENDING 164 IW mode"
 echo ""
 echo "Set product type (default: SLC)"
 echo " -g, --grd set product type to GRD"
 echo " -o, --ocn set product type to OCN"
 echo " -r, --raw set prodType to RAW"
 echo " -s, --slc set prodType to SLC"
 echo ""
 echo "Set Start date:"
 echo " --last-48hours :try to download last files 48h ago (when available)"
 echo " or:"
 echo " --startdate=YYYY-MM-DD"
 echo " or:"
 echo " --startdate=TODAY"
 echo " --startdate=YESTERDAY"
}

```

```

echo " --startdate=xx-DAYS-AGO"
echo " --startdate=xx-WEEK-AGO"
echo " --startdate=xx-MONTH-AGO"
echo ""
echo "Set End date:"
echo " --enddate=YYYY-MM-DD"
echo " or"
echo " --enddate=TODAY"
echo ""
echo "Skip md5 checksum:"
echo " --skipmd5check"
echo ""
echo "Delete Zip-File older than 30 days:"
echo " --deletezip30days"
echo ""
echo "Force download Zip-File.Caution: use only if you really want to (re)download the Zip-File(s)."
echo " This will not delete Zip-File older than 30 days"
echo " --force"
echo ""
echo " -v, --verbose display curl command lines and results"
echo " -V, --version display the current version of the script"
echo ""
echo " -l, --list-only: don't download anything just list the queries"
echo ""

}

Set default values
relativeOrbitNumber by default to empty
relOrbitNumber=""
productType to SLC
prodType="SLC"

Parse command line arguments
for arg in "$@"
do
 case "$arg" in
 -h | --help)
 show_help;
 exit 0
 ;;

 -1 | --belgium) COUNTRY="BELGIUM"
 polygon="POLYGON((2.2759179687511 49.39733675067,6.5825585937511
51.523048670724,2.2759179687511 51.523048670724,2.2759179687511 49.39733675067))"*
 sensormode="IW"
 orbitDirection="DESCENDING"
 relOrbitNumber=""
 ;;

 -2 | --capvert) COUNTRY="CAPVERT"
 polygon="POLYGON((-24.805380859375 14.770554001959,-24.212119140625
15.083713334744,-24.805380859375 15.083713334744,-24.805380859375 14.770554001959))"*
 sensormode="IW"
 orbitDirection="DESCENDING"
 relOrbitNumber=""
 ;;

 -3a | --congoA174) COUNTRY="DRCONGO"
 polygon="POLYGON((28.877000477879644 -1.771099490525117,29.510581143494434
1.771099490525117,29.510581143494434 -1.1466480690884282,28.877000477879644
1.771099490525117))"*
 sensormode="IW"
 orbitDirection="ASCENDING"
 relOrbitNumber="174"
 ;;

 -3d | --congoD21) COUNTRY="DRCONGO"
 polygon="POLYGON((28.877000477879644 -1.771099490525117,29.510581143494434
1.771099490525117,29.510581143494434 -1.1466480690884282,28.877000477879644
1.771099490525117))"*
 sensormode="IW"
 orbitDirection="DESCENDING"
 relOrbitNumber="21"
 ;;

 -4 | --cameroon) COUNTRY="CAMEROON"
 polygon="POLYGON((8.9940576171883 3.9091132063575,9.460976562501
4.4788700707381,8.9940576171883 4.4788700707381,8.9940576171883 3.9091132063575))"*
 sensormode="IW"
 orbitDirection="DESCENDING"
 relOrbitNumber=""
 ;;

 -5a | --luxembourgA88) COUNTRY="LUXEMBOURG"
 # incl. Belgium
 polygon="POLYGON((2.4495477846656244 51.09857384337633,3.404380618761151
51.555813466481226,5.198038559445268 51.51140532353608,7.134475241676382
50.06165685491578,6.679368002995337 49.618519748347836,8.169621117892092
48.76711197844659,6.715062688382086 48.82589534889004,6.31349747781164
49.34022139167058,5.474672371192572 49.34022139167058,5.028488803858213
49.80893300681208,4.153969011882872 49.906733443756224,3.9219535568690054
50.19894786989019,3.591777170415803 50.26744571831401,3.0474337648936642
50.78368908203797,2.4495477846656244 51.09857384337633,2.4495477846656244 51.09857384337633))"*
 sensormode="IW"
 orbitDirection="ASCENDING"
 relOrbitNumber="88"
 ;;

 -5d | --luxembourgD139) COUNTRY="LUXEMBOURG"
 # incl. Belgium
 polygon="POLYGON((2.4495477846656244 51.09857384337633,3.404380618761151
51.555813466481226,5.198038559445268 51.51140532353608,7.134475241676382
50.06165685491578,6.679368002995337 49.618519748347836,8.169621117892092
48.76711197844659,6.715062688382086 48.82589534889004,6.31349747781164
49.34022139167058,5.474672371192572 49.34022139167058,5.028488803858213
49.80893300681208,4.153969011882872 49.906733443756224,3.9219535568690054
50.19894786989019,3.591777170415803 50.26744571831401,3.0474337648936642
50.78368908203797,2.4495477846656244 51.09857384337633,2.4495477846656244 51.09857384337633))"*
 sensormode="IW"
 orbitDirection="DESCENDING"
 relOrbitNumber="139"
 ;;
 esac
done

```

```

49.80893300681208,4.153969011882872 49.906733443756224,3.9219535568690054 50.07311281836337,3.984419256295816
50.19894786989019,3.5917777170415803 50.26744571831401,3.0474337648936642 50.60279667420565,2.556631840825871
50.78368908203797,2.4495477846656244 51.09857384337633,2.4495477846656244 51.09857384337633)"
 sensormode="IW"
 orbitDirection="DESCENDING"
 relOrbitNumber="139"
 ;;

-6 | --tanzania) COUNTRY="TANZANIA"
 polygon="POLYGON((35.674355468752 -3.1120759839556,36.959755859378 -3.1120759839556,36.959755859378 -
1.3337017191793,35.674355468752 -1.3337017191793,35.674355468752 -3.1120759839556))"
 sensormode="IW"
 orbitDirection="DESCENDING"
 relOrbitNumber=""
 ;;

-7 | --erta_ale) COUNTRY="ERTA_ALE"
 polygon="POLYGON((40.47309769928795 13.38637299084182,40.937128609315685 13.38637299084182,40.937128609315685
13.885019945672866,40.47309769928795 13.885019945672866,40.47309769928795 13.38637299084182))"
 sensormode="IW"
 orbitDirection="DESCENDING"
 relOrbitNumber=""
 ;;

-8a | --hawaiiA124) COUNTRY="HAWAII"
 polygon="POLYGON((-155.43700607299937 19.195655095731155,-154.99082250566502 19.195655095731155,-
154.99082250566502 19.44828597828061,-155.43700607299937 19.44828597828061,-155.43700607299937 19.195655095731155))"
 sensormode="IW"
 orbitDirection="ASCENDING"
 relOrbitNumber="124"
 SMB_SHARE_NAME=${SMB_SHARE_NAME_OTHER}/
 SMB_SHARE_MOUNTED_ON_LOCAL_DIR=${SMB_SHARE_MOUNTED_ON_LOCAL_DIR_OTHER}/
 S1_WORKDIR=${S1_WORKDIR_OTHER}/
 ;;

-8d | --hawaiid87) COUNTRY="HAWAII-DESC87"
 polygon="POLYGON((-155.43700607299937 19.195655095731155,-154.99082250566502 19.195655095731155,-
154.99082250566502 19.44828597828061,-155.43700607299937 19.44828597828061,-155.43700607299937 19.195655095731155))"
 sensormode="IW"
 orbitDirection="DESCENDING"
 relOrbitNumber="87"
 SMB_SHARE_NAME=${SMB_SHARE_NAME_OTHER}/
 SMB_SHARE_MOUNTED_ON_LOCAL_DIR=${SMB_SHARE_MOUNTED_ON_LOCAL_DIR_OTHER}/
 S1_WORKDIR=${S1_WORKDIR_OTHER}/
 ;;

-9 | --tristan) COUNTRY="TRISTAN"
 polygon="POLYGON((-12.437366939445228 -37.19301009606267,-12.437366939445228 -37.032896613954165,-
12.437366939445228 -37.032896613954165,-12.437366939445228 -37.19301009606267))"
 sensormode="SM"
 orbitDirection="DESCENDING"
 relOrbitNumber=""
 SMB_SHARE_NAME=${SMB_SHARE_NAME_OTHER}/
 SMB_SHARE_MOUNTED_ON_LOCAL_DIR=${SMB_SHARE_MOUNTED_ON_LOCAL_DIR_OTHER}/
 S1_WORKDIR=${S1_WORKDIR_OTHER}/
 ;;

-10 | --domuyoA18) COUNTRY="DOMUYO"
 polygon="POLYGON((-70.6898267839218 -36.90762895618818,-70.03362627002683 -36.89749957901811,-
70.09693399654567 -36.05291395012518,-70.71831691721114 -36.06796170586554,-70.6898267839218 -36.90762895618818))"
 sensormode="IW"
 orbitDirection="ASCENDING"
 relOrbitNumber="18"
 ;;

-11 | --domuyoD83) COUNTRY="DOMUYO"
 polygon="POLYGON((-70.6898267839218 -36.90762895618818,-70.03362627002683 -36.89749957901811,-
70.09693399654567 -36.05291395012518,-70.71831691721114 -36.06796170586554,-70.6898267839218 -36.90762895618818))"
 sensormode="IW"
 orbitDirection="DESCENDING"
 relOrbitNumber="83"
 ;;

-12 | --PFascSM) COUNTRY="REUNION_SM"
 polygon="POLYGON((55.1977713794396 -21.40237876278574, 55.87579310257687 -21.40252330702253, 55.86371241079386
-20.87304877303437, 55.19472552487835 -20.87433374588863, 55.1977713794396 -21.40237876278574))"
 sensormode="SM"
 orbitDirection="ASCENDING"
 relOrbitNumber="144"
 # Will be stored on a different HD
 SMB_SHARE_NAME=${SMB_SHARE_NAME_OTHER}/
 SMB_SHARE_MOUNTED_ON_LOCAL_DIR=${SMB_SHARE_MOUNTED_ON_LOCAL_DIR_OTHER}/
 S1_WORKDIR=${S1_WORKDIR_OTHER}/
 CHANGEOLOGDIR="SM"
 ;;

-13 | --PFdescSM) COUNTRY="REUNION_SM"
 polygon="POLYGON((55.1977713794396 -21.40237876278574, 55.87579310257687 -21.40252330702253, 55.86371241079386
-20.87304877303437, 55.19472552487835 -20.87433374588863, 55.1977713794396 -21.40237876278574))"
 sensormode="SM"
 orbitDirection="DESCENDING"
 relOrbitNumber="151"
 # Will be stored on a different HD
 SMB_SHARE_NAME=${SMB_SHARE_NAME_OTHER}/
 SMB_SHARE_MOUNTED_ON_LOCAL_DIR=${SMB_SHARE_MOUNTED_ON_LOCAL_DIR_OTHER}/
 S1_WORKDIR=${S1_WORKDIR_OTHER}/
 CHANGEOLOGDIR="SM"
 ;;

-14 | --PFascIW) COUNTRY="REUNION"
 polygon="POLYGON((55.1977713794396 -21.40237876278574, 55.87579310257687 -21.40252330702253, 55.86371241079386
-20.87304877303437, 55.19472552487835 -20.87433374588863, 55.1977713794396 -21.40237876278574))"
 sensormode="IW"
 orbitDirection="ASCENDING"
 relOrbitNumber="144"
 # Will be stored on a different HD

```

```

SMB_SHARE_NAME=${SMB_SHARE_NAME_OTHER}/
SMB_SHARE_MOUNTED_ON_LOCAL_DIR=${SMB_SHARE_MOUNTED_ON_LOCAL_DIR_OTHER}/
S1_WORKDIR=${S1_WORKDIR_OTHER}/
CHANGELOGDIR="IW"
;;

-15 | --PFdescIW) COUNTRY="REUNION"
polygon="POLYGON((55.1977713794396 -21.40237876278574, 55.87579310257687 -21.40252330702253, 55.86371241079386
-20.87304877303437, 55.19472552487835 -20.87433374588863, 55.1977713794396 -21.40237876278574))"
sensormode="IW"
orbitDirection="DESCENDING"
relOrbitNumber="151"
Will be stored on a different HD
SMB_SHARE_NAME=${SMB_SHARE_NAME_OTHER}/
SMB_SHARE_MOUNTED_ON_LOCAL_DIR=${SMB_SHARE_MOUNTED_ON_LOCAL_DIR_OTHER}/
S1_WORKDIR=${S1_WORKDIR_OTHER}/
CHANGELOGDIR="IW"
;;
;

-16 | --karthala86) COUNTRY="KARTHALA_SM"
polygon="POLYGON((43.2069351946721 -11.3434508578491, 43.5403432377049 -11.3458995003596, 43.5403432377049 -
11.9512819903538, 43.2044377561476 -11.9512819903538, 43.2069351946721 -11.3434508578491))"
sensormode="SM"
orbitDirection="ASCENDING"
relOrbitNumber="86"
Will be stored on a different HD
SMB_SHARE_NAME=${SMB_SHARE_NAME}/
SMB_SHARE_MOUNTED_ON_LOCAL_DIR=${SMB_SHARE_MOUNTED_ON_LOCAL_DIR}/
S1_WORKDIR=${S1_WORKDIR}/
CHANGELOGDIR="SM"
;;
;

-17 | --guadeloupeD54) COUNTRY="GUADELOUPE"
polygon="POLYGON((-60.97642182170839 16.51471201845488,-61.82468479885705 16.52432647142963,
61.81692856642155 15.86193868727157, -60.98425058771025 15.8650629729729, -60.97642182170839 16.51471201845488))"
sensormode="IW"
orbitDirection="DESCENDING"
relOrbitNumber="54"
Will be stored on a different HD
;;
;

-18 | --guadeloupeA164) COUNTRY="GUADELOUPE"
polygon="POLYGON((-60.97642182170839 16.51471201845488,-61.826997 16.49533, -61.81692856642155
15.86193868727157, -60.98425058771025 15.8650629729729, -60.97642182170839 16.51471201845488))"
sensormode="IW"
orbitDirection="ASCENDING"
relOrbitNumber="164"
Will be stored on a different HD
;;
;

-g | --grd) prodType="GRD";;
-o | --ocn) prodType="OCN";;
-r | --raw) prodType="RAW";;
-s | --slc) prodType="SLC";;

taken from: http://mywiki.wooleedge.org/BashFAQ/035
-sd | --startdate)
Takes an option argument, ensuring it has been specified.
if [-n "$3"]; then
START_DATE=$3
echo "1. Start Date: ${START_DATE}"
shift
else
printf 'ERROR: "--startdate" requires a non-empty option argument, e.g 2017-12-31 (YYYY-MM-DD).\n' >&2
exit 1
fi
;;
--startdate=?*)
START_DATE=${3#*=} # Delete everything up to "=" and assign the remainder.
echo "2. Start Date: ${START_DATE}"
;;
;

--startdate=) # Handle the case of an empty --startdate=
printf 'ERROR: "--startdate" requires a non-empty option argument, e.g 2017-12-31 (YYYY-MM-DD) \n' >&2
exit 1
;;
;

-ed | --enddate) # Takes an option argument, ensuring it has been specified.
if [-n "$4"]; then
END_DATE=$4
echo "1. End Date: ${END_DATE}"
shift
else
printf 'ERROR: "--enddate" requires a non-empty option argument, e.g 2017-12-31 (YYYY-MM-DD) .\n' >&2
exit 1
fi
;;
;;
--enddate=?*)
END_DATE=${4#*=} # Delete everything up to "=" and assign the remainder.
echo "2. End Date: ${END_DATE}"
;;
;

--enddate=) # Handle the case of an empty --enddate=
printf 'ERROR: "--enddate" requires a non-empty option argument, e.g 2017-12-31 (YYYY-MM-DD) \n' >&2
exit 1
;;
;

--skipmd5check) SKIPMD5CHECK=true
;;
;

Delete the ZIPFILE older than 30days
--deletezip30days) DELETE_ZIPFILE_30DAYS=true
;;
;

Force download priority
--force) FORCE_DOWNLOAD=true
;;
;
-v | --verbose) VERBOSE=true
;;
;
```

```

-v | --version) show_version;
exit 0
;;
--list-only) LIST_CATALOGUE_ONLY=true
;;
--last-48hours) LAST_48HOURS_DOWNLOAD=true
;;
*)
echo "Invalid option: $arg" >&2;
show_help;
exit 1
;;
esac
done

Check 2 arguments are given
if [$# -lt 3]
then
echo "Usage: $0 <COUNTRY> [<COUNTRY> can be: --belgium, --capvert, --congo, --cameroon, --domuyo18, --domuyo83, --erta_ale,
--hawaii, --luxembourg, --tanzania, etc...]"
echo "<productType>:[can be: --slc, --raw, --grd, --ocn] --last-48hours OR --startdate=YYYY-MM-DD --enddate=YYYY-MM-DD"
echo "NOTE: when using --last-48hours don't use --startdate and --enddate"
echo "Check with --help to get full list of countrynames"
echo ""
echo ""
exit
fi

#####
if [[${START_DATE} == *"-DAY"]]; then
We cut the string at first '-' e.g: 12-DAYS-AGO > result: 12
DAYS_AGO=$(echo "${START_DATE}" | /usr/bin/cut -f 1 -d '-')
START_DATE=${(/bin/date -v "-${DAYS_AGO}d +'%Y-%m-%d')}

echo "${DAYS_AGO} days ago choosen > calculated Start date: ${START_DATE}"

elif [[${START_DATE} == *"-WEEK"]]; then
We cut the string at first '-' e.g: 12-WEEK-AGO > result: 12
WEEKS_AGO=$(echo "${START_DATE}" | /usr/bin/cut -f 1 -d '-')
START_DATE=${(/bin/date -v "-${WEEKS_AGO}w +'%Y-%m-%d')}

echo "${WEEKS_AGO} weeks ago choosen > calculated Start date: ${START_DATE}"

elif [[${START_DATE} == *"-MONTH"]]; then
We cut the string at first '-' e.g: 12-MONTHS-AGO > result: 12
MONTHS_AGO=$(echo "${START_DATE}" | /usr/bin/cut -f 1 -d '-')
START_DATE=${(/bin/date -v "-${MONTHS_AGO}m +'%Y-%m-%d')}

echo "${MONTHS_AGO} months ago choosen > calculated Start date: ${START_DATE}"

elif ["${START_DATE}" == "YESTERDAY"]; then
START_DATE=${(/bin/date -v -1d '+%Y-%m-%d')}
echo "YESTERDAY ago choosen > calculated Start date: ${START_DATE}"

elif ["${START_DATE}" == "TODAY"]; then
START_DATE=${(/bin/date "+%Y-%m-%d")}
echo "Start Date: TODAY > calculated start date: ${START_DATE}"
fi

if ["${END_DATE}" == "TODAY"]; then
END_DATE=${(/bin/date "+%Y-%m-%d")}
echo "End Date: TODAY > calculated end date: ${END_DATE}"
fi

#####
Create the local log directory (if not present) to save the log-file locally if Network Disc can't be mounted
if [! -e "${HOME}/scripts/logs/"]
then
/bin/mkdir -p "${HOME}/scripts/logs/"
/bin/mkdir -p "${HOME}/scripts/logs/sentinel1_disc-mount_error_logs/"
fi

Check if directory exists
if [-e "${S1_WORKDIR}"] && [-e "${S1_WORKDIR_OTHER}"] ; then
echo "${SMB_SHARE_MOUNTED_ON_LOCAL_DIR} mounted and"
echo "${SMB_SHARE_MOUNTED_ON_LOCAL_DIR_OTHER} mounted and , continuing ..."
else
ERROR_LOG="${HOME}/scripts/logs/sentinel1_disc-mount_error_logs/disc-mount_error-$LOG_DATE.log"
EMAIL SUBJECT="[$(HOSTNAME)] ALERT! Network Disc Mount error ! No Sentinel Downloads"

echo "ALERT! This is script: $0 running on $FULLHOSTNAME" > "${ERROR_LOG}"

if [! -e "${S1_WORKDIR}"] ; then
echo "Error: ${SMB_SHARE_MOUNTED_ON_LOCAL_DIR} not mounted! Check the network disc with share-name: ${SMB_SHARE_NAME} !" >> "${ERROR_LOG}"
else
echo "Error: ${SMB_SHARE_MOUNTED_ON_LOCAL_DIR_OTHER} not mounted! Check the network disc with share-name: ${SMB_SHARE_NAME_OTHER}" >> "${ERROR_LOG}"
fi

echo " There was an error mounting this disc." >> "${ERROR_LOG}"

send an email using /usr/bin/mail
/usr/bin/mail -s "${EMAIL_SUBJECT}" "${EMAIL_RECIPIENTS}" < "${ERROR_LOG}"
exit 1;
fi

#####
Set the Working-Dir (were zipped files are downloaded) and the Unzip-Dir
ZIP_DOWNLOAD_DIR="${S1_WORKDIR}/S1-DATA-${COUNTRY}-${prodType}"
UNZIP_DIR="${ZIP_DOWNLOAD_DIR}.UNZIP/"

#####

```

```

Adapt log dir to avoid clash while running several requests for PF - NDO Oct 12 2020
case ${CHANGELOGDIR} in
 "SM")
 LOG_PATH="${S1_WORKDIR}/S1_COHERNICUS_DOWNLOAD_SM_LOGS/"
 mkdir -p "${LOG_PATH}" ;;
 "IW")
 LOG_PATH="${S1_WORKDIR}/S1_COHERNICUS_DOWNLOAD_IW_LOGS/"
 mkdir -p "${LOG_PATH}" ;;
 *)
 LOG_PATH="${S1_WORKDIR}/S1_COHERNICUS_DOWNLOAD_LOGS/"
 mkdir -p "${LOG_PATH}" ;;
esac
#####
LOG_FILE=${LOG_PATH}"S1-${COUNTRY}-$(prodType)_$(START_DATE)-to-$(END_DATE)_$(LOG_DATE)-LOG.txt"
LOG_SUMMARY=${LOG_PATH}"S1-${COUNTRY}-$(prodType)_$(START_DATE)-to-$(END_DATE)_$(LOG_DATE)-SUMMARY.txt"
LOG_SUMMARY_HEADER=${LOG_PATH}"S1-COHERNICUS_summary-header.txt"
LOG_SUMMARY=${LOG_PATH}"S1-COHERNICUS_summary.txt"

LOG_ALL=${LOG_PATH}"S1-${COUNTRY}-$(prodType)_$(START_DATE)-to-$(END_DATE)_$(LOG_DATE)-ALL.txt"
CATALOGUE_LOG_PATH=${LOG_PATH}"S1-CATALOGUE-RESULT/"
mkdir -p "${CATALOGUE_LOG_PATH}"

LOG_CATALOGUE_RESULT=${LOG_PATH}"S1-${COUNTRY}-$(prodType)_$(START_DATE)-to-$(END_DATE)_$(LOG_DATE)_CATALOGUE.json"
QUICKLOOK_FILE_URL=${LOG_PATH}"quicklookURL.txt"
#####

Create the directories if not present
if [! -e "${ZIP_DOWNLOAD_DIR}"]
 then
 /bin/mkdir -p "${ZIP_DOWNLOAD_DIR}"
fi

if [! -e "$UNZIP_DIR"]
 then
 /bin/mkdir -p "$UNZIP_DIR"
fi

if [! -e "${LOG_PATH}"]
 then
 /bin/mkdir -p "${LOG_PATH}"
fi

#####
echo "" | ${CMD_TEE} -a "${LOG_FILE}"
echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
echo " DETAILED LOG" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
echo "" | ${CMD_TEE} -a "${LOG_FILE}"

echo "This is script: $0 v$VERSION running on $FULLHOSTNAME" | ${CMD_TEE} -a "${LOG_FILE}"
echo "Script execution start date: ${SCRIPT_EXEC_STARTDATE}" | ${CMD_TEE} -a "${LOG_FILE}"
echo ""
 | ${CMD_TEE} -a "${LOG_FILE}"

echo "Command used:" | ${CMD_TEE} -a "${LOG_FILE}"
echo "$0 $" | ${CMD_TEE} -a "${LOG_FILE}"
echo ""
 | ${CMD_TEE} -a "${LOG_FILE}"

echo "Working Dir:" | ${CMD_TEE} -a "${LOG_FILE}"
echo "${ZIP_DOWNLOAD_DIR}" | ${CMD_TEE} -a "${LOG_FILE}"
echo ""
 | ${CMD_TEE} -a "${LOG_FILE}"

echo "Unzip Dir:" | ${CMD_TEE} -a "${LOG_FILE}"
echo "$UNZIP_DIR" | ${CMD_TEE} -a "${LOG_FILE}"
echo ""
 | ${CMD_TEE} -a "${LOG_FILE}"

echo "Log saved to:" | ${CMD_TEE} -a "${LOG_FILE}"
echo "${LOG_FILE}" | ${CMD_TEE} -a "${LOG_FILE}"
echo ""
 | ${CMD_TEE} -a "${LOG_FILE}"

#echo "COHERNICUS Query Result List saved to:" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "${LOG_CATALOGUE_RESULT}" | ${CMD_TEE} -a "${LOG_FILE}"
#echo ""
 | ${CMD_TEE} -a "${LOG_FILE}"
#####

EMAIL
#####

Redefine Email Subject
if ["${LAST_48HOURS_DOWNLOAD}" = true]; then
 EMAIL SUBJECT=${EMAIL_SUBJECT}"${COUNTRY} product=${prodType} - 48hours ago"
else
 EMAIL SUBJECT=${EMAIL_SUBJECT}"${COUNTRY} product=${prodType} - from: ${START_DATE} to: ${END_DATE}"
fi

#####
catalogueItems=100
catalogueListOrder="desc"

platformname="SENTINEL-1"

Generate string with sensormode_prodType_1S e.g: IW_SLC__1S
SENSORMODE_PRODTYPE="${sensormode}_$(prodType)_1S"
#####

function get_curl_catalogue_with_orbitnumber() {
local CURL_CAT_OPT=""
To get all attributes (e.g to get relativeOrbitNumber) - example from ESA Copernicus Support Team - Friday 2023.11.24:
https://catalogue.dataspace.copernicus.eu/odata/v1/Products?&$filter=(startswith(Name,'S1') and (contains(Name,'SLC')) and ((Online eq false or Online eq true) and Attributes/OData.CSC.IntegerAttribute/any(att:att/Name eq 'relativeOrbitNumber'

```

```

and att/OData.CSC.IntegerAttribute/Value eq 122))) and ContentDate/Start ge 2022-01-01T00:00:00.000Z
and ContentDate/Start lt 2022-01-25T23:59:59.999Z&$orderby=ContentDate/Start
https://catalogue.dataspace.copernicus.eu/odata/v1/Products?&$filter=
(startswith(Name,'S1') and (contains(Name,'SLC'))) and ((Online eq false or Online eq true)
and Attributes/OData.CSC.IntegerAttribute/any(att:att/Name eq 'relativeOrbitNumber'
and att/OData.CSC.IntegerAttribute/Value eq 122)))
and ContentDate/Start ge 2022-01-01T00:00:00.000Z
and ContentDate/Start lt 2022-01-25T23:59:59.999Z
&$orderby=ContentDate/Start

With relativeOrbitNumber - expand assets to get the quicklook-file URL-address
CURL_CAT_OPT="https://catalogue.dataspace.copernicus.eu/odata/v1/Products?&$filter="
CURL_CAT_OPT+="OData.CSC.Intersects(area=geography'SRID=4326;$polygon')"
CURL_CAT_OPT+=" and (startswith(Name,'S1') and (contains(Name,'$(prodType)')))"
CURL_CAT_OPT+=" and ((Online eq true)"
CURL_CAT_OPT+=" and Attributes/OData.CSC.IntegerAttribute/any(att:att/Name eq 'relativeOrbitNumber'"
CURL_CAT_OPT+=" and att/OData.CSC.IntegerAttribute/Value eq $(relorbitNumber)))"
CURL_CAT_OPT+=" and Attributes/OData.CSC.StringAttribute/any(att:att/Name eq 'orbitDirection' and
att/OData.CSC.StringAttribute/Value eq '$(orbitDirection)')
CURL_CAT_OPT+=" and Attributes/OData.CSC.StringAttribute/any(att:att/Name eq 'operationalMode' and
att/OData.CSC.StringAttribute/Value eq '$(sensormode)')"
CURL_CAT_OPT+=" and PublicationDate gt ${START_DATE}T00:00:00.000Z"
CURL_CAT_OPT+=" and PublicationDate lt ${END_DATE}T23:59:59.999Z"
CURL_CAT_OPT+="&&$orderby=ContentDate/Start ${catalogueListOrder}"
CURL_CAT_OPT+="&&$count=false"
#CURL_CAT_OPT+="&&$expand=Attributes"
CURL_CAT_OPT+="&&$expand=Assets"
CURL_CAT_OPT+="&&$top=${catalogueItems}"

Replace SPACE with char %20
CURL_CAT_OPT="${CURL_CAT_OPT// /%20}"
Replace ' with char %27
CURL_CAT_OPT="${CURL_CAT_OPT//'/%27}"
Return type for this function
echo "${CURL_CAT_OPT}"

}

function get_curl_catalogue_without_orbitnumber() {
local CURL_CAT_OPT=""

2023.12.14 - reply from ESA request ID 1885 - https://helpcenter.dataspace.copernicus.eu/hc/en-gb/requests/1885
https://catalogue.dataspace.copernicus.eu/odata/v1/Products?&$filter=(startswith(Name,'S1') and (contains(Name,'SLC'))
and ((Online eq false or Online eq true))) and ContentDate/Start ge 2022-01-01T00:00.000Z and ContentDate/Start
lt 2022-01-25T23:59.999Z&$orderby=ContentDate/Start
https://catalogue.dataspace.copernicus.eu/odata/v1/Products?&$filter=(startswith(Name,'S1') and (contains(Name,'SLC'))
and ((Online eq false or Online eq true)))
and ContentDate/Start ge 2022-01-01T00:00:00.000Z and ContentDate/Start lt 2022-01-25T23:59.999Z&$orderby=ContentDate/Start

2023.12.05 - To get Catalogue without (knowing) relativeOrbitNumer (from ESA Copernicus support team 2023.12.05) - e.g
Luxembourg
https://catalogue.dataspace.copernicus.eu/odata/v1/Products?$filter=Collection/Name eq 'SENTINEL-1' and
Attributes/OData.CSC.StringAttribute/any(att:att/Name eq 'productType' and att/OData.CSC.StringAttribute/Value eq 'IW_SLC__1S')
and Attributes/OData.CSC.StringAttribute/any(att:att/Name eq 'orbitDirection' and att/OData.CSC.StringAttribute/Value eq
'ASCENDING') and (OData.CSC.Intersects(area=geography'SRID=4326;POLYGON((2.4495477846656244 51.09857384337633,3.404380618761151
51.42802325283006,4.555534222483794 51.555813466481226,5.198038559445268 51.51140532353608,7.134475241676382
50.91890083858132,6.313497477781164 50.06165685491578,6.679368002995337 49.618519748347836,8.169621117892092
49.1362978376153,7.812674264024606 48.76711197844659,6.715062688382086 48.82589534889004,6.313497477781164
49.0895684890138,6.099329365460672 49.34022139167058,5.474672371192572 49.34022139167058,5.028488803858213
49.68207378905507,4.716160306724163 49.80893300681208,4.153969011882872 49.906733443756224,3.9219535568690054
0.07311281836337,3.984419256295816 50.19894786989019,3.591777170415803 50.26744571831401,3.0474337648936642
50.60279667420565,2.556631840825871 50.78368908203797,2.4495477846656244 51.09857384337633,2.4495477846656244
51.09857384337633)) and ContentDate/Start gt 2022-05-14T00:00:00.000Z) and ContentDate/Start
lt 2022-05-21T00:00:00.000Z&$orderby=ContentDate/Start&$count=True&$expand=Attributes
https://catalogue.dataspace.copernicus.eu/odata/v1/Products?$filter=
Collection/Name eq 'SENTINEL-1'
and Attributes/OData.CSC.StringAttribute/any(att:att/Name eq 'productType' and att/OData.CSC.StringAttribute/Value
eq 'IW_SLC__1S')
and Attributes/OData.CSC.StringAttribute/any(att:att/Name eq 'orbitDirection' and att/OData.CSC.StringAttribute/Value
eq 'ASCENDING')
and (OData.CSC.Intersects(area=geography'SRID=4326;POLYGON((2.4495477846656244 51.09857384337633,3.404380618761151
51.42802325283006,4.555534222483794 51.555813466481226,5.198038559445268 51.51140532353608,7.134475241676382
50.91890083858132,6.313497477781164 50.06165685491578,6.679368002995337
49.618519748347836,8.16962111789209249.1362978376153,7.812674264024606 48.76711197844659,6.715062688382086
48.82589534889004,6.313497477781164 49.0895684890138,6.099329365460672 49.34022139167058,5.474672371192572
49.34022139167058,5.028488803858213 49.68207378905507,4.716160306724163 49.80893300681208,4.153969011882872
49.906733443756224,3.9219535568690054 50.07311281836337,3.984419256295816 50.19894786989019,3.591777170415803
50.26744571831401,3.0474337648936642 50.60279667420565,2.556631840825871 50.78368908203797,2.4495477846656244
51.09857384337633,2.4495477846656244 51.09857384337633)) and ContentDate/Start gt 2022-05-14T00:00:00.000Z
and ContentDate/Start lt 2022-05-21T00:00:00.000Z
&$orderby=ContentDate/Start
&$count=True&$expand=Attributes

Without knowing or setting the orbitNumber - Expand assets to get the quicklook-file URL-address

CURL_CAT_OPT="https://catalogue.dataspace.copernicus.eu/odata/v1/Products?&$filter="
CURL_CAT_OPT+="Collection/Name eq 'SENTINEL-1'"
CURL_CAT_OPT+=" and Attributes/OData.CSC.StringAttribute/any(att:att/Name eq 'productType' and
att/OData.CSC.StringAttribute/Value eq '$(SENSORMODE_PRODTYPE)'"
CURL_CAT_OPT+=" and Attributes/OData.CSC.StringAttribute/any(att:att/Name eq 'orbitDirection' and
att/OData.CSC.StringAttribute/Value eq '$(orbitDirection)'"
CURL_CAT_OPT+=" and (OData.CSC.Intersects(area=geography'SRID=4326;$polygon))"
CURL_CAT_OPT+=" and ContentDate/Start gt ${START_DATE}T00:00:00.000Z"
CURL_CAT_OPT+=" and ContentDate/Start lt ${END_DATE}T23:59:59.999Z"
CURL_CAT_OPT+="&&$orderby=ContentDate/Start ${catalogueListOrder}"
CURL_CAT_OPT+="&&$count=false"
#CURL_CAT_OPT+="&&$expand=Attributes"
CURL_CAT_OPT+="&&$expand=Assets"
CURL_CAT_OPT+="&&$top=${catalogueItems}"

Replace SPACE with char %20
CURL_CAT_OPT="${CURL_CAT_OPT// /%20}"

Replace ' with char %27
CURL_CAT_OPT="${CURL_CAT_OPT//'/%27}"

```

```

Return type for this function
echo "${CURL_CAT_OPT}"
}

#echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "" | ${CMD_TEE} -a "${LOG_FILE}"
echo "Getting catalogue of Product-IDs...." | ${CMD_TEE} -a "${LOG_FILE}"
#echo "" | ${CMD_TEE} -a "${LOG_FILE}"

if [[-z $relOrbitNumber]]; then
 #echo "Orbit Number not provided" | ${CMD_TEE} -a "${LOG_FILE}"
 CURL_CAT_OPT=${get_curl_catalogue_without_orbitnumber}
 #echo "CURL CATALOGUE OPTION: ${CURL_CAT_OPT}"
else
 #echo "relativeOrbitNumber provided: ${relOrbitNumber}" | ${CMD_TEE} -a "${LOG_FILE}"
 CURL_CAT_OPT=${get_curl_catalogue_with_orbitnumber}
 #echo "CURL CATALOGUE OPTION: ${CURL_CAT_OPT}"
fi

#echo "Generated catalogue URL - can be copy/pasted to a Web-Browser:" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "${CURL_CAT_OPT}" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "" | ${CMD_TEE} -a "${LOG_FILE}"

#${CMD_CURL} "${CURL_CAT_OPT}" -H "Accept: application/json" > "${LOG_CATALOGUE_RESULT}"

#CATALOG_QUERY_OUTPUT=$(${CMD_CURL} "${CURL_CAT_OPT}" -H "Accept: application/json" > "${LOG_CATALOGUE_RESULT}")

#echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "CATALOG_QUERY_OUTPUT: ${CATALOG_QUERY_OUTPUT}" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "" | ${CMD_TEE} -a "${LOG_FILE}"

Print all found ProductIDs

${CMD_CURL} "${CURL_CAT_OPT}" -H "Accept: application/json" > "${LOG_CATALOGUE_RESULT}"

Create an array with ($command) and filter JSON by .value.[].Id
try JSON extraction with 'jq' with https://jqplay.org/
declare -a productIDArray
declare -a productNameArray
declare -a remoteZipFileSizeArray
declare -a productFilePublicationDateArray
declare -a quicklookFilesArray

Bash - prefer mapfile to fill array - see: https://www.shellcheck.net/wiki/SC2207
mapfile -t productIDArray < <($CMD_JQ --raw-output '.value.[].Id' "${LOG_CATALOGUE_RESULT}")
mapfile -t productNameArray < <($CMD_JQ --raw-output '.value.[].Name' "${LOG_CATALOGUE_RESULT}")
mapfile -t remoteZipFileSizeArray < <($CMD_JQ --raw-output '.value.[].ContentLength' "${LOG_CATALOGUE_RESULT}")
mapfile -t productFilePublicationDateArray < <($CMD_JQ --raw-output '.value.[].PublicationDate' "${LOG_CATALOGUE_RESULT}")
mapfile -t quicklookFilesArray < <($CMD_JQ --raw-output '.value.[].Assets.[].DownloadLink' "${LOG_CATALOGUE_RESULT}")

echo "" | ${CMD_TEE} -a "${LOG_FILE}"

echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
echo "List of Products found from ${START_DATE} to ${END_DATE}" | ${CMD_TEE} -a "${LOG_FILE}"
echo "" | ${CMD_TEE} -a "${LOG_FILE}"

numberOfProducts=${#productIDArray[@]}

echo "-Nr - | -- Product-ID ----- | -- ProductName ----- | -- Publishing Date ----- | | - Size"
for ((i=0; i < numberOfProducts; i++)); do
 printf "[%03d]: ${productIDArray[$i]} | ${productNameArray[$i]} | ${remoteZipFileSizeArray[$i]} | "
 ${productFilePublicationDateArray[$i]} | ${quicklookFilesArray[$i]}\n" $(i) | ${CMD_TEE} -a "${LOG_FILE}"
 printf "%03d | ${productIDArray[$i]} | ${productNameArray[$i]} | ${remoteZipFileSizeArray[$i]} | "
 ${productFilePublicationDateArray[$i]}\n" $((i+1)) | ${CMD_TEE} -a "${LOG_FILE}"
done

#echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"

echo "" | ${CMD_TEE} -a "${LOG_FILE}"

#####
DOWNLOAD
#####

if [["$LIST_CATALOGUE_ONLY" = false]]; then
 echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
 echo "PROCESSING DOWNLOADS" | ${CMD_TEE} -a "${LOG_FILE}"
 # Prepare productFile download by generating the required ACCESS_TOKEN
 echo "Getting new access token..." | ${CMD_TEE} -a "${LOG_FILE}"

 # See: https://documentation.dataspace.copernicus.eu/APIs/OData.html#product-download
 RAW_ACCESS_TOKEN=$(${CMD_CURL} -d 'client_id=cde-public' \
 -d "username=${USERNAMR}" -d "password=${PASSWORD}" \
 -d "grant_type=password" \
 'https://identity.dataspace.copernicus.eu/auth/realmms/CDSE/protocol/openid-connect/token') > access_token.txt
 # We use the simpler "jq" command (Copernicus website uses 'Python3' and 'awk' to extract "access_token")
 access_token_with_quotes=$(echo "$(RAW_ACCESS_TOKEN)" | ${CMD_JQ} '.access_token')

 # Remove double-quotes
 ACCESS_TOKEN="${access_token_with_quotes//\"/\"}"

 REFRESH_TOKEN_WITH_QUOTES=$(echo "$(RAW_ACCESS_TOKEN)" | ${CMD_JQ} '.refresh_token')
 # Remove double-quotes
 REFRESH_TOKEN="${REFRESH_TOKEN_WITH_QUOTES//\"/\"}"

 echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
 echo "Access Token: ${ACCESS_TOKEN}" | ${CMD_TEE} -a "${LOG_FILE}"
 echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
 echo "Refresh Token: ${REFRESH_TOKEN}" | ${CMD_TEE} -a "${LOG_FILE}"

```

```
#echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"

Reset bash built-n "SECONDS"
SECONDS=0

Acces time limit in seconds (10 minutes)
After this time limit continue to download with the refreshed ACCESS TOKEN
ACCESS_TOKEN_TIME_LIMIT_IN_SECONDS=600

#TOKEN_REFRESHED=false
download_required=false

declare -a downloadedFilesArray # succesfully downloaded product files
declare -a downloadedFileSizeArray
declare -a failedDownloadsArray
declare -a unzippedFilesArray
declare -a failedUnzippedFilesArray

echo "" | ${CMD_TEE} -a "${LOG_FILE}"

for ((i=0; i < number_of_products; i++)); do
 prodID="${productIDArray[$i]}" # e.g: 7d96670d-8229-4041-ab36-f43163bb6f38
 prodName="${productNameArray[$i]}" # e.g: SIA_IW_SLC_1SDV_20231211T095725_20231211T095752_051605_063B0A_B6F1.SAFE
 zippedProdName="${prodName}.zip" # e.g: SIA_IW_SLC_1SDV_20231211T095725_20231211T095752_051605_063B0A_B6F1.SAFE.zip
 prodSize="${remoteZipFileSizeArray[$i]}" # e.g.: 81437597724

 printf "+-[%03d]:${prodID} | ${prodName} | ${prodSize}\n" $((i+1)) | ${CMD_TEE} -a "${LOG_FILE}"

 echo "+--Checking local presence of zipped product file..." | ${CMD_TEE} -a "${LOG_FILE}"

 if [-e "${ZIP_DOWNLOAD_DIR}/${zippedProdName}"]; then
 echo "+--Local file exists!" | ${CMD_TEE} -a "${LOG_FILE}"
 localZipFileSize=${CMD_GNU_STAT} -C %s "${ZIP_DOWNLOAD_DIR}/${zippedProdName}"
 echo "+--Local file size = ${localZipFileSize} | Remote file size: ${prodSize}" | ${CMD_TEE} -a "${LOG_FILE}"

 if ["${localZipFileSize}" -ne "${prodSize}"]; then
 echo "+--Local file: ${zippedProdName} not correctly downloaded!" | ${CMD_TEE} -a "${LOG_FILE}"
 echo "+--Deleting local file: ${zippedProdName} (server doesn't support resume download)." | ${CMD_TEE} -a "${LOG_FILE}"
 echo "+--Will be downloaded next." | ${CMD_TEE} -a "${LOG_FILE}"
 /bin/rm "${ZIP_DOWNLOAD_DIR}/${zippedProdName}"
 download_required=true
 else
 echo "+--No download required: Local and remote file sizes matches." | ${CMD_TEE} -a "${LOG_FILE}"
 echo "" | ${CMD_TEE} -a "${LOG_FILE}"
 download_required=false
 fi
 else
 echo "+--Remote product file not downloaded yet." | ${CMD_TEE} -a "${LOG_FILE}"
 download_required=true
 fi

 if [[${download_required} = true]]; then
 echo "+--Trying to download remote product file..." | ${CMD_TEE} -a "${LOG_FILE}"

 if [[${SECONDS} -ge ${ACCESS_TOKEN_TIME_LIMIT_IN_SECONDS}]]; then
 echo "+->${SECONDS} seconds since last download(s) passed, refeshing access token..." | ${CMD_TEE} -a "${LOG_FILE}"

 # Generate a new refresh token with previous REFRESH_TOKEN
 RAW_REFRESHED_TOKEN=$(curl --location --request POST \
 'https://identity.dataspace.copernicus.eu/auth/realms/CDSE/protocol/openid-connect/token' \
 -H 'Content-Type: application/x-www-form-urlencoded' \
 -d 'grant_type=refresh_token' \
 -d "refresh_token=${REFRESH_TOKEN}" \
 -d 'client_id=cdse-public')

 # Extract the new refreshed token, remove double-quotes and set ACCESS_TOKEN with refreshed token
 # We use the simpler "jq" command (Copernicus website uses 'Python3' and 'awk' to extract "access_token")
 REFRESHED_TOKEN_WITH_QUOTES=$(echo ${RAW_REFRESHED_TOKEN} | jq '.refresh_token')
 REFRESHED_ACCESS_TOKEN_WITH_QUOTES=$(echo "${RAW_REFRESHED_TOKEN}" | ${CMD_JQ} '.access_token')

 # Remove double-quotes and set ACCESS_TOKEN with REFRESHED_TOKEN
 ACCESS_TOKEN="${REFRESHED_ACCESS_TOKEN_WITH_QUOTES//\"/\"}"

 # RESET time & token since we have to refresh the token after 3600s
 # set SECONDS to Zero and ACCESS_TOKEN_TIME_LIMIT_IN_SECONDS to 1h (3600s)
 #SECONDS=0
 ACCESS_TOKEN_TIME_LIMIT_IN_SECONDS=3600
 fi

 curl_prod_opts=(-H "Authorization: Bearer ${ACCESS_TOKEN}" \
 "https://catalogue.dataspace.copernicus.eu/odata/v1/Products(\"${prodID}\")/\$value" \
 "--location-trusted --output ${ZIP_DOWNLOAD_DIR}/${zippedProdName}")

 echo "curl_prod_opts: => ${curl_prod_opts[*]} <="
 eval "${CMD_CURL}" --fail "${curl_prod_opts[*]}"

 if eval "${CMD_CURL}" --fail "${curl_prod_opts[*]}"; then
 echo "+--SUCCESS! Download done." | ${CMD_TEE} -a "${LOG_FILE}"
 downloadedFilesArray+=("${zippedProdName}")
 downloadedFileSizeArray+=("${prodSize}")

 # Quicklook file URL: curl and wget have problems to read dollar signs (need tp convert /$value to /\$value)
 # get Quicklook file URL - if we store the URL to a file we can read it with 'wget -i'
 # https://catalogue.dataspace.copernicus.eu/odata/v1/Assets(6fe22346-965c-41e2-9ac4-e2b604e40a4c)/$value
 quicklookURL=${quicklookFilesArray[$i]}
 echo "${quicklookURL}" > "${QUICKLOOK_FILE_URL}"

 quicklookFileName="${prodName}.png"
 echo "+--DEBUG: Downloading Quicklook file from URL: ${quicklookURL}" | ${CMD_TEE} -a "${LOG_FILE}"
 fi
 fi
done
```

```

echo "---Downloading Quicklook file: ${quicklookFileName}" | ${CMD_TEE} -a "${LOG_FILE}"

Since the URL contains a dollar sign at the end with "$value" read the file with '-i'
${CMD_WGET} -O "${ZIP_DOWNLOAD_DIR}/${quicklookFileName}" -i "${QUICKLOOK_FILE_URL}"
Remove the quicklook file
/bin/rm "${QUICKLOOK_FILE_URL}"

else
 echo "!--FAIL! Download failed for ${zippedProdName}" | ${CMD_TEE} -a "${LOG_FILE}"
 echo "!--Deleting failed downloaded Zip-file." | ${CMD_TEE} -a "${LOG_FILE}"
 /bin/rm "${ZIP_DOWNLOAD_DIR}/${zippedProdName}"
 failedDownloadsArray+=("${zippedProdName}")

fi
done

#echo "" | ${CMD_TEE} -a "${LOG_FILE}"
#echo " END PROCESSING DOWNLOADS" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
echo "" | ${CMD_TEE} -a "${LOG_FILE}"

#####
Unzip files
#####

numberOfDownloadedFiles=${#downloadedFilesArray[@]}

if [[$numberOfDownloadedFiles -gt 0]]; then

echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
echo "UNZIPPING FILES" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
echo "" | ${CMD_TEE} -a "${LOG_FILE}"

echo "+-Trying to unzip ${numberOfDownloadedFiles} files to ${UNZIP_DIR}" | ${CMD_TEE} -a "${LOG_FILE}"

for ((i=0; i < numberOfDownloadedFiles; i++)); do
 #echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
 prodFileToUnzip="${downloadedFilesArray[$i]}"
 remoteZipFileSize="${downloadedFileSizeArray[$i]}"

 printf "+-[%03d]: ${prodFileToUnzip} with size: ${remoteZipFileSize} bytes \n" $((i+1)) | ${CMD_TEE} -a "${LOG_FILE}"

 # Check if unzipped directory exists - we need to remove .zip from prodFileToUnzip
 # e.g prodFileToUnzip: SIA_IW_SLC_1SDV_20231211T095659_20231211T095727_051605_063B0A_4A67.SAFE.zip
 # after: unzippedProdName: SIA_IW_SLC_1SDV_20231211T095659_20231211T095727_051605_063B0A_4A67.SAFE
 unzippedProdName="${prodFileToUnzip//.zip/}"

 unzippedProdNameDirectory="${UNZIP_DIR}${unzippedProdName}"

 if [[-d "${unzippedProdNameDirectory}"]]; then
 echo "+-Unzip-Dir: ${unzippedProdNameDirectory} exists !" | ${CMD_TEE} -a "${LOG_FILE}"

 localDirSize=$((${CMD_DU} "${unzippedProdNameDirectory}" | cut -f1)
 echo "+-UnZip-Dir size in bytes: ${localDirSize}" | ${CMD_TEE} -a "${LOG_FILE}"

 if [["${localDirSize}" -ge "${remoteZipFileSize}"]]; then
 echo "+-Unzip-Dir size is bigger or equal to remote Zip-File, seems OK." | ${CMD_TEE} -a "${LOG_FILE}"
 echo "+-Unzipping product file not required." | ${CMD_TEE} -a "${LOG_FILE}"

 elif [["${localDirSize}" -lt "${remoteZipFileSize}"]]; then
 echo "+-Unzip-Dir is smaller than size of ${prodFileToUnzip}" | ${CMD_TEE} -a "${LOG_FILE}"
 echo "+-Unzip-Dir size ${localDirSize} | Zip-File size: ${remoteZipFileSize}"
 hrs=$((${secs}/3600)); mins=$((${secs-hrs*3600}/60)); secs=$((${secs-hrs*3600-mins*60 })
 unzipRatio=$((${localDirSize} / ${remoteZipFileSize}))
 #echo "+-Unzip-Dir is probably OK. Please check its content manually." | ${CMD_TEE} -a "${LOG_FILE}"

 echo "+-Unzip Ratio: ${unzipRatio}"
 # In Bash - decimals are not supported. Either use integers only, or use bc or awk to compare.
 # https://www.shellcheck.net/wiki/SC2072
 if [[$(echo "${unzipRatio} <= 0.90" | bc) == 1]]; then
 echo "+-Unzip-Ratio is <= 0.90: Unzip-Dir seems to have missing or corrupted files, please check content." | ${CMD_TEE} -a "${LOG_FILE}"
 else
 echo "+-Unzip-Dir is probably OK, please check manually." | ${CMD_TEE} -a "${LOG_FILE}"
 fi
 fi
 else
 echo "+-Trying to unzip file: ${prodFileToUnzip} to ${UNZIP_DIR}/* | ${CMD_TEE} -a "${LOG_FILE}"
 ${CMD_UNZIP} "${ZIP_DOWNLOAD_DIR}/${prodFileToUnzip}" -o"${UNZIP_DIR}"
 unzipReturnVal=$?
 if ["${unzipReturnVal}" -eq 0]; then
 echo "+-Unzipping done for Zip-File: ${prodFileToUnzip}" | ${CMD_TEE} -a "${LOG_FILE}"
 unzippedFilesArray+=("${prodFileToUnzip}")
 else
 printf "+-Fatal Error unzipping file ${prodFileToUnzip}. Skipping!" | ${CMD_TEE} -a "${LOG_FILE}"
 echo "+-Zipped file ${prodFileToUnzip} will be deleted and redownloaded by next launch."
 failedUnzippedFilesArray+=("${prodFileToUnzip}")
 fi # END -- if [${unzipReturnVal} -eq 0];
 fi
 echo "" | ${CMD_TEE} -a "${LOG_FILE}"
done

#echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "END UNZIPPING FILES" | ${CMD_TEE} -a "${LOG_FILE}"
#echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"

fi # unzipping files

```

```

#echo "" | ${CMD_TEE} -a "${LOG_FILE}"
echo "-----" | ${CMD_TEE} -a "${LOG_FILE}"
echo " Done for ${platformname} ${COUNTRY} ${prodType} $sensormode $relOrbitNumber $orbitDirection" | ${CMD_TEE} -a "${LOG_FILE}"
echo " in dir: ${ZIP_DOWNLOAD_DIR}" | ${CMD_TEE} -a "${LOG_FILE}"
echo "" | ${CMD_TEE} -a "${LOG_FILE}"

#####
SUMMARY Header
#####

Create LOG Summary - use a redirect to file - do not append to file with 'tee' command
for the first line since it can generate null character
echo "${platformname} download process done for ${COUNTRY} | productType:${prodType}" > "${LOG_SUMMARY_HEADER}"
echo "sensormode=$sensormode | relativeOrbitNumber:$relOrbitNumber | orbitDirection:$orbitDirection" | ${CMD_TEE} -a "${LOG_SUMMARY_HEADER}"
echo "" | ${CMD_TEE} -a "${LOG_SUMMARY_HEADER}"
echo "Catalog query Start Date:${START_DATE} to End Date:${END_DATE}" | ${CMD_TEE} -a "${LOG_SUMMARY_HEADER}"
echo "" | ${CMD_TEE} -a "${LOG_SUMMARY_HEADER}"
echo "Elapsed time: ${SECONDS / 60} minutes and ${SECONDS % 60} seconds." | ${CMD_TEE} -a "${LOG_SUMMARY_HEADER}"
echo "Working dir: ${ZIP_DOWNLOAD_DIR}" | ${CMD_TEE} -a "${LOG_SUMMARY_HEADER}"
echo "Log file written to: ${LOG_ALL}"
echo "" | ${CMD_TEE} -a "${LOG_SUMMARY_HEADER}"

#####
SUMMARY various infos
#####
echo "-----" | ${CMD_TEE} "${LOG_SUMMARY}" # note not -a for appending
echo "SUMMARY" | ${CMD_TEE} -a "${LOG_SUMMARY}"
echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"

numberOfDownloadedFiles=${#downloadedFilesArray[@]}

if [[numberOfDownloadedFiles -gt 0]]; then
 # For the first echo don't append to the summary log or else it will append to previous summary file.
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "+-Total of downloaded files: ${numberOfDownloadedFiles}" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "+--Successfully downloaded the following files in ${ZIP_DOWNLOAD_DIR}" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"

 for ((i=0; i < numberOfDownloadedFiles; i++)); do
 printf "+->[%03d]: ${downloadedFilesArray[$i]} \n" $((i+1)) | ${CMD_TEE} -a "${LOG_SUMMARY}"
 done
else
 # For the first echo don't append to the summary log or else it will append to previous summary file.
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "* No product file(s) downloaded." | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
fi

numberOfFailedDownloads=${#failedDownloadsArray[@]}
if [[numberOfFailedDownloads -gt 0]]; then
 # For the first echo don't append to the summary log or else it will append to previous summary file.
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "+-Total of failed downloads: ${numberOfFailedDownloads}" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "+--Failed downloads of the following files in: ${ZIP_DOWNLOAD_DIR}" | ${CMD_TEE} -a "${LOG_SUMMARY}"

 for ((i=0; i < numberOfFailedDownloads; i++)); do
 printf "+->[%03d]: ${failedDownloadsArray[$i]} \n" $((i+1)) | ${CMD_TEE} -a "${LOG_SUMMARY}"
 done
else
 # For the first echo don't append to the summary log or else it will append to previous summary file.
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "* No failed downloads reported." | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
fi

numberOfUnzippedFiles=${#unzippedFilesArray[@]}
if [[numberOfUnzippedFiles -gt 0]]; then
 # For the first echo don't append to the summary log or else it will append to previous summary file.
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "+-Total of unzipped files: ${numberOfUnzippedFiles}." | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"

 echo "+--Unzipped the following product files in ${UNZIP_DIR}" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 for ((i=0; i < numberOfUnzippedFiles; i++)); do
 printf "+->[%03d]: ${unzippedFilesArray[$i]} \n" $((i+1)) | ${CMD_TEE} -a "${LOG_SUMMARY}"
 done
else
 # For the first echo don't append to the summary log or else it will append to previous summary file.
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "* No product files unzipped." | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
fi

```

```
numberOfFailedUnzippedFiles=${#failedUnzippedFilesArray[@]}

if [[numberOfFailedUnzippedFiles -gt 0]]; then
 # For the first echo don't append to the summary log or else it will append to previous summary file.
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "+-Failed unzipped files: " | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "+-Total of failed unzipped files: ${numberOfFailedUnzippedFiles}." | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "+-Failed to unzip these files in ${UNZIP_DIR}" | ${CMD_TEE} -a "${LOG_SUMMARY}"

 for ((i=0; i < numberOfFailedUnzippedFiles; i++)); do
 printf "+->[%03d]:${failedUnzippedFilesArray[$i]} \n" ${((i+1))} | ${CMD_TEE} -a "${LOG_SUMMARY}"
 done
else
 # For the first echo don't append to the summary log or else it will append to previous summary file.
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"
 echo "* No failed unzipped files reported." | ${CMD_TEE} -a "${LOG_SUMMARY}"
 #echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
fi

echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"
echo "Processing done in: ${ZIP_DOWNLOAD_DIR}" | ${CMD_TEE} -a "${LOG_SUMMARY}"
echo "Log file written to: ${LOG_ALL}"

#echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
#echo "END SUMMARY" | ${CMD_TEE} -a "${LOG_SUMMARY}"
#echo "-----" | ${CMD_TEE} -a "${LOG_SUMMARY}"
#echo "" | ${CMD_TEE} -a "${LOG_SUMMARY}"

Combine the summary header and summary log and the log file together into LOG_ALL
/bin/cat "${LOG_SUMMARY_HEADER}" "${LOG_SUMMARY}" "${LOG_FILE}" > "${LOG_ALL}"
Remove the logs - just leave the LOG_ALL
/bin/rm "${LOG_SUMMARY_HEADER}"
/bin/rm "${LOG_SUMMARY}"
/bin/rm "${LOG_FILE}"
/bin/rm "${LOG_CATALOGUE_RESULT}"

if [[$numberOfDownloadedfiles -gt 0]]; then
 /usr/bin/mail -s "${EMAIL_SUBJECT}" "${EMAIL_RECIPIENTS}" < "${LOG_ALL}"
fi

fi # END - if [[LIST_QUERY_ONLY = false]]
```

## A.6.2) Domuyo\_S1\_Step1\_Read\_SMCoreg\_Pairs\_DEMGeoid.sh

```
#!/bin/bash
Script to run in cronjob for processing DOMUYO images:
Read images, check if nr of bursts and corners coordinates are OK,
corigister them on a Global Primary (super master) and compute the compatible pairs.
It also creates a common baseline plot for ascending and descending modes.
#
BEWARE, if it is the first run, you must compute the baseline plot (to get the Global Primary) before starting the coregistration
#
New in Distro V 2.0.0 20220602 : - use new Prepa_MSBAS.sh compatible with D Derauw and L. Libert tools for Baseline Plotting
New in Distro V 3.0.0 20230104 : - Use ReadAll_Img.sh V3 which requires 3 more parameters (POL + paths to RESAMPLED and to SAR_MASSPROCESS)
New in Distro V 3.1.0 20230626 : - Color tables are now in TemplatesForPlots
New in Distro V 4.0.0 20230830: - Rename SCRIPTS_OK directory as SCRIPTS_MT
- Replace CIS by MT in names
- Renamed FUNCTIONS FOR MT.sh
New in Distro V 5.0.0 20231030: - Rename Master and Slave as Primary and Secondary (though not possible in some variables and files)
New in Distro V 5.1.0 20231116: - Reshape with variables
- double criteria to compute baseline plot in order to account for the loss of S1B
- run_Check_All_S1_SizeAndCoord_InDir.sh in parallel
New in Distro V 6.0.0 20240530: - reprocesing with DEM referred to Geoid
New in Distro V 6.1.0 20240624: - enlarge BP2 (from back to 20220501) to cope with new S1 orbital tube from 05 2024
#

AMSTer: SAR & InSAR Automated Mass processing Software for Multidimensional Time series
Ndo (c) 2016/03/25 - could make better... when time.

source $HOME/.bashrc

Some variables
#####
Max baseline (for building msbas files)
BP=20
BP2=80
BT=450
DATECHG=20220501

Global Primaries (SuperMasters)
SMASC=20180512 # Asc 18
SMDESC=20180222 # Desc 83

POL=VV

some files and PATH
#####
#SAR DATA
DIRSARDATA=${PATH}_1650/SAR_DATA/S1/S1-DATA-DOMUYO-SLC.UNZIP
#SAR CSL
DIRSARCSL=${PATH}_1650/SAR CSL/S1/ARG_DOMU_LAGUNA_DEMGeoid

#kml file
KMLFILE=${DIRSARCSL}/DomuyoYLagunaFea.kml # also in ${PATH}_1650/kml/ARGENTINA/DomuyoYLagunaFea.kml

#Launch param files
PARAMCOREGASC=${PATH}_1650/Param_files/S1/ARG_DOMU_LAGUNA_A_18/LaunchMTparam_S1_Arg_Domu_Laguna_A_18_Zoom1_ML4_MassProc_Coreg_DEMGeoid.txt
PARAMCOREGDESC=${PATH}_1650/Param_files/S1/ARG_DOMU_LAGUNA_D_83/LaunchMTparam_S1_Arg_Domu_Laguna_D_83_Zoom1_ML4_MassProc_Coreg_DEMGeoid.txt

#SETI DIR
DIRSET=${PATH}_1650/SAR_SM/MSBAS/ARGENTINE

Tracks (end of dir name where S1 images.csv are stored)
TRKASC=A_18
TRKDESC=D_83

Where data will be resampled (on the Global Primary)
NEWASCPATH=${PATH}_1650/SAR_SM/RESAMPLED/S1/ARG_DOMU_LAGUNA_DEMGeoid_A_18/SMNoCrop_SM_${SMASC}
NEWDESCPATH=${PATH}_1650/SAR_SM/RESAMPLED/S1/ARG_DOMU_LAGUNA_D_83/SMNoCrop_SM_${SMDESC}

Dir to clean when orbits are updated
RESAMDIR=${PATH}_1650/SAR_SM/RESAMPLED/
MASSPRODIR=${PATH}_3602/SAR_MASSPROCESS_2

#Color table
#COLORTABLE=${PATH}_SCRIPTS/SCRIPTS_MT/TemplatesForPlots/ColorTable_AAADD.txt # for 6 data sets
COLORTABLE=${PATH}_SCRIPTS/SCRIPTS_MT/TemplatesForPlots/ColorTable_AD.txt # for 2 data sets

Let's Go
#####
echo "Starting S0" > ${DIRSARCSL}/Last_Run_Cron_Step1.txt
date > ${DIRSARCSL}/Last_Run_Cron_Step1.txt

Read all S1 images for that footprint
#####
${PATH}_SCRIPTS/SCRIPTS_MT/Read_All_Img.sh ${DIRSARDATA} ${DIRSARCSL}/NoCrop S1 ${KMLFILE} ${POL} ${RESAMDIR} ${MASSPRODIR} > /dev/null 2>&1

Check nr of bursts and coordinates of corners. If not as expected, move img in temp quarantine and log that.
Check regularly: if not updated after few days, it means that image is bad or zip file not correctly downloaded
#####
Asc ; bursts size and coordinates are obtained by running e.g.:
_Check_S1_SizeAndCoord.sh /Volumes/hp-1650-Data_Share1/SAR_CS1/ARG_DOMU_LAGUNA_A_18/NoCrop/S1B_18_20211210_A.csv Dummy
_Check_All_S1_SizeAndCoord_InDir.sh ${DIRSARCSL}_A_18/NoCrop 14 -71.1264 -37.3038 -69.1902 -36.8461 -71.5447 -36.0797 -69.6394 -35.6292 &

Desc ; bursts size and coordinates are obtained by running
e.g.: _Check_S1_SizeAndCoord.sh /Volumes/hp-1650-Data_Share1/SAR_CS1/ARG_DOMU_D_83/NoCrop/S1B_83_20211109_D.csv Dummy
Beware D83 with S1B after Jan 2020 are shorter on the Western side, hence check first with large coordinate, then check the images in
TMP QUARANTINE with smaller coordinates.
If OK, put them back in NoCrop dir. If not, keep them in original __TMP_QUARANTINE

consistent with S1B before Jan 2020
_Check_All_S1_SizeAndCoord_InDir.sh ${DIRSARCSL}_D_83/NoCrop 14 -69.0318 -36.1361 -70.9962 -35.6524 -69.4497 -37.3619 -71.4464 -36.8704 &
wait

consistent with S1B after Jan 2020
_Check_All_S1_SizeAndCoord_InDir.sh ${DIRSARCSL} ${TRKDESC}/NoCrop/_TMP_QUARANTINE 14 -68.9461 -36.1361 -70.9962 -35.6524 -69.3630 -37.3619 -71.4464 -36.8704
mv ${DIRSARCSL}_D_83/NoCrop/_TMP_QUARANTINE/*.* ${DIRSARCSL}_D_83/NoCrop/ 2>/dev/null
mv ${DIRSARCSL}_D_83/NoCrop/_TMP_QUARANTINE/_TMP_QUARANTINE/*.* ${DIRSARCSL}_D_83/NoCrop/_TMP_QUARANTINE/ 2>/dev/null
mv ${DIRSARCSL}_D_83/NoCrop/_TMP_QUARANTINE/*.* ${DIRSARCSL}_D_83/NoCrop/_TMP_QUARANTINE/ 2>/dev/null
rm -R ${DIRSARCSL}_D_83/NoCrop/_TMP_QUARANTINE/_TMP_QUARANTINE 2>/dev/null
```

... .

```
Coregister all images on the Global Primary (Super Master)
#####
in Ascending mode
SPATH_SCRIPTS/SCRIPTS_MT/SuperMasterCoreg.sh ${PARAMCOREGASC} &
in Descending mode
SPATH_SCRIPTS/SCRIPTS_MT/SuperMasterCoreg.sh ${PARAMCOREGDESC} &

Search for pairs
#####
Link all images to corresponding set dir
SPATH_SCRIPTS/SCRIPTS_MT/lns_All_Img.sh "${DIRSARSL}/NoCrop" ${DIRSET}/set1 $1 > /dev/null 2>&1 &
SPATH_SCRIPTS/SCRIPTS_MT/lns_All_Img.sh "${DIRSARSL}/NoCrop" ${DIRSET}/set2 $1 > /dev/null 2>&1 &
wait

Compute pairs
Compute pairs only if new data is identified
if [! -s ${NEWASCPATH}/_No_New_Data_Today.txt] ; then
 #echo "n" | Prepa_MSBAS.sh ${DIRSET}/set1 ${BP} 450 20180512 > /dev/null 2>&1 &
 echo "n" | Prepa_MSBAS.sh ${DIRSET}/set1 ${BP} ${BT} ${SMASC} ${BP2} ${BT} ${DATECHG} > /dev/null 2>&1 &
fi
if [! -s ${NEWDESCPATH}/_No_New_Data_Today.txt] ; then
 #echo "n" | Prepa_MSBAS.sh ${DIRSET}/set2 ${BP} 450 20180222 > /dev/null 2>&1 &
 echo "n" | Prepa_MSBAS.sh ${DIRSET}/set2 ${BP} ${BT} ${SMDESC} ${BP2} ${BT} ${DATECHG} > /dev/null 2>&1 &
fi
wait

Plot baseline plot with both modes - TAKING ONLY INTO ACCOUNT THE FIRST OF THE TWO BASELINE CRITERIA, THAT IS THE ONE USED BEFORE DATECHG
if [! -s ${NEWDESCPATH}/_No_New_Data_Today.txt] || [! -s ${NEWDESCPATH}/_No_New_Data_Today.txt] ; then
 if [`baselinePlot | wc -l` -eq 0]
 then
 # use AMSTer Engine before May 2022
 mkdir -p ${DIRSET}/BaselinePlots_S1_set_1_2
 cd ${DIRSET}/BaselinePlots_S1_set_1_2

 echo "${DIRSET}/set1" > ModelList.txt
 echo "${DIRSET}/set2" >> ModelList.txt

 SPATH_SCRIPTS/SCRIPTS_MT/plot_Multi_span.sh ModelList.txt 0 ${BP} 0 ${BT} ${COLORTABLE}

 else
 # use AMSTer Engine > May 2022
 mkdir -p ${DIRSET}/BaselinePlots_set1_set2
 cd ${DIRSET}/BaselinePlots_set1_set2

 echo "${DIRSET}/set1" > ModelList.txt
 echo "${DIRSET}/set2" >> ModelList.txt

 plot_Multi_BaselinePlot.sh ${DIRSET}/BaselinePlots_set1_set2/ModelList.txt
 fi
fi
echo "Ending $0" >> ${DIRSARSL}/Last_Run_Cron_Step1.txt
date >> ${DIRSARSL}/Last_Run_Cron_Step1.txt
```

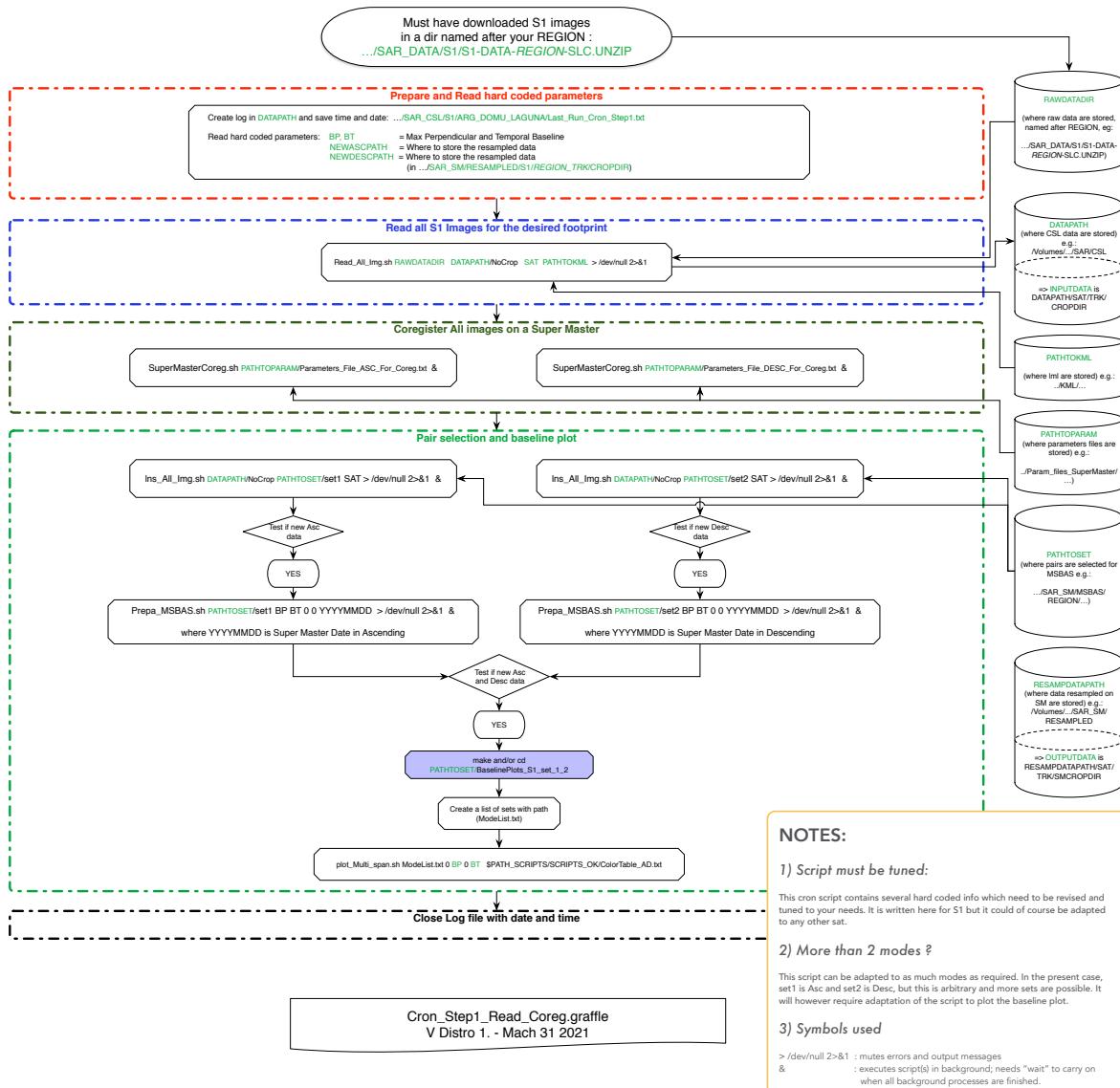


Figure 49: Flow chart of cron job step 1 (read and coregister images) – Beware, this corresponds to an old version, though it must give enough hints to understand the flow.

### A.6.3) Domuyo\_S1\_Step2\_MassProc\_DEMGeoid.sh

```
#!/bin/bash
Script to run in cronjob for processing Domuyo images:
Runs a mass processing after having checked that no other process is using the same param file (on this computer).
#
NOTE: usually by running the reading and coregistration at 1 am, it is finished around 1am30
hence this script should be safely launched around 2 am for instance
Nevertheless because VVP_S1_Step1_Read_SMCoreg_Pairs.sh uses RadAll_Img.sh, which also move updated prelim orbit images at all levels in _CLN dir,
and coregister images on Global Primary (super masters), one check that it is not running anymore before starting.
#
New in Distro V 2.0 20230830: - Rename SCRIPTS_OK directory as SCRIPTS_MT
- Replace CIS by MT in names
- Renamed FUNCTIONS_FOR_MT.sh
New in Distro V 3.0 20231030: - Rename Master Toolbox as AMSTer Software
- rename Master and Slave as Primary and Secondary (though not possible in some variables and files)
New in Distro V 3.1 20231116: - Reshape with variables
- double criteria to compute baseline plot in order to account for the loss of S1B
New in Distro V 4.0.0 20240530: - reprocessing with DEM referred to Geoid
New in Distro V 4.1.0 20240624: - enlarge BP2 (from back to 20220501) to cope with new S1 orbital tube from 05 2024
#
AMSTER: SAR & InSAR Automated Mass processing Software for Multidimensional Time series
NdO (c) 2016/03/25 - could make better... when time.

#
source $HOME/.bashrc
echo "Starting $0"
cd

Some variables
#####
Max baseline (for buliding msbas files)
BP=20
BP2=80
BT=450
BT2=450
DATECHG=20220501

Global Primaries (SuperMasters)
SMASC=20180512 # Asc 18
SMDESC=20180222 # Desc 83

some files and PATH
#####

table files
TABLEASC=$PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/table_0_${BP}_0_${BT}_Till_${DATECHG}_0_${BP2}_0_${BT2}_After_WITHH HEADER.txt
TABLEDESC=$PATH_1650/SAR_SM/MSBAS/ARGENTINE/set2/table_0_${BP}_0_${BT}_Till_${DATECHG}_0_${BP2}_0_${BT2}_After_WITHH HEADER.txt

#Launch param files
PARAMPROCESSASC=$PATH_1650/Param_files/S1/ARG_DOMU_LAGUNA_A_18/LaunchMTparam_S1_Arg_Domu_Laguna_A_18_Zoom1_ML4_MassProc_MaskCohWater_DEMGeoid.txt
PARAMPROCESSDESC=$PATH_1650/Param_files/S1/ARG_DOMU_LAGUNA_D_83/LaunchMTparam_S1_Arg_Domu_Laguna_D_83_Zoom1_ML4_MassProc_Snaphu_WaterCohMask_DEMGeoid.txt

PARAMASCNAMES='basename ${PARAMPROCESSASC}'
PARAMDESCNAME='basename ${PARAMPROCESSDESC}'

#mass Process dir
MASSPROCESSASCDIR=$PATH_3602/SAR_MASSPROCESS_2/S1/ARG_DOMU_LAGUNA_DEMGeoid_A_18/SMNoCrop_SM_20180512_Zoom1_ML4
MASSPROCESSDESCDIR=$PATH_3602/SAR_MASSPROCESS_2/S1/ARG_DOMU_LAGUNA_DEMGeoid_D_83/SMNoCrop_SM_20180222_Zoom1_ML4

Name of step 1 cron script
CRONSTEP1="Domuyo_S1_Step1_Read_SMCoreg_Pairs_DEMGeoid.sh"

#
Let's Go
#####

TODAY=`date`

first restric pair table to last data
#RemovePairsFromList_WithImagesBefore.sh $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/table_0_20_0_450.txt 20190425
#RemovePairsFromList_WithImagesBefore.sh $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set2/table_0_20_0_450.txt 20190430

Check that Domuyo_S1_Step1_Read_SMCoreg_Pairs.sh is finished
#CHECKREAD='ps -eaf | $(PATHGNU)/grep Domuyo_S1_Step1_Read_SMCoreg_Pairs.sh | $(PATHGNU)/grep -v "grep" | wc -l'
below will be 0 if no run and 2 if script is running (3 if two runs are in progress etc...)
#CHECKREAD='ps -eaf | $(PATHGNU)/grep ${CRONSTEP1} | $(PATHGNU)/grep -v "grep" | $(PATHGNU)/grep -v "dev/null" | wc -l'
if [${CHECKREAD} -eq 0]
then
 # OK, no more Domuyo_S1_Step1_Read_SMCoreg_Pairs.sh is running:
 # Check that no other Global Primary (SuperMaster) automatic Ascending and Desc mass processing uses the LaunchMTparam_.txt yet
 CHECKASC='ps -eaf | $(PATHGNU)/grep SuperMaster_MassProc.sh | $(PATHGNU)/grep -v "grep" | $(PATHGNU)/grep ${PARAMASCNAMES} | wc -l'
 CHECKDESC='ps -eaf | $(PATHGNU)/grep SuperMaster_MassProc.sh | $(PATHGNU)/grep -v "grep" | $(PATHGNU)/grep ${PARAMDESCNAME} | wc -l'
 if [${CHECKASC} -lt 1]
 then
 # No process running yet
 echo "Asc run on ${TODAY}" >> ${MASSPROCESSASCDIR}/_Asc_last_MassRun.txt
 $PATH_SCRIPTS/SCRIPTS_MT/SuperMaster_MassProc.sh ${TABLEASC} ${PARAMPROCESSASC} >/dev/null 2>&1 &
 else
 echo "Asc attempt aborted on ${TODAY} because other Mass Process in progress" >> ${MASSPROCESSASCDIR}/_Asc_last_aborted.txt
 fi
 # if running yet we will try again tomorrow
 if [${CHECKDESC} -lt 1]
 then
 # No process running yet
 echo "Desc run on ${TODAY}" >> ${MASSPROCESSDESCDIR}/_Desc_last_Mass.txt
 $PATH_SCRIPTS/SCRIPTS_MT/SuperMaster_MassProc.sh ${TABLEDESC} ${PARAMPROCESSDESC} >/dev/null 2>&1 &
 else
 echo "Desc attempt aborted on ${TODAY} because other Mass Process in progress" >> ${MASSPROCESSDESCDIR}/_Desc_last_aborted.txt
 fi
else
 # VVP_S1_Step1_Read_SMCoreg_Pairs.sh is still running: abort and wait for tomorrow
 echo "Step2 aborted on ${TODAY} because DOMUYO_S1_Step1_Read_SMCoreg_Pairs.sh is still running: wait for tomorrow" >> ${MASSPROCESSASCDIR}/_aborted_because_Read_inProgress.txt
 echo "Step2 aborted on ${TODAY} because DOMUYO_S1_Step1_Read_SMCoreg_Pairs.sh is still running: wait for tomorrow" >> ${MASSPROCESSDESCDIR}/_aborted_because_Read_inProgress.txt
fi
exit 0
fi
```

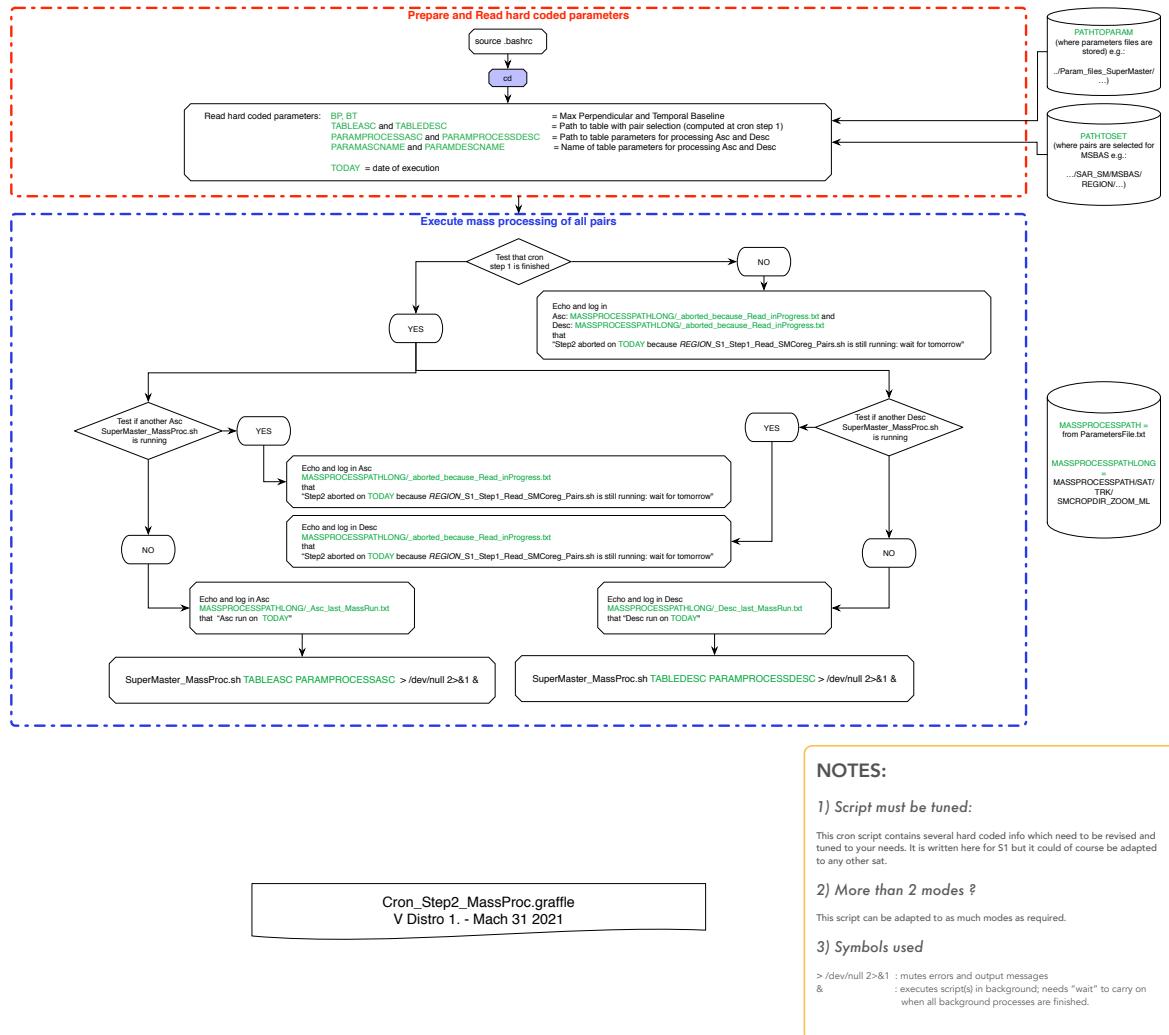


Figure 50: Flow chart of cron job step 2 (mass processing of all pairs) – Beware, this corresponds to an old version, though it must give enough hints to understand the flow.

### A.6.4) Domuyo\_S1\_Step3\_MSBAS\_DEMGeoid.sh

```

#!/bin/bash
Script intends to run in a cronjob an automatic systematic (re)processing of msbas time
series when new images were made available. If orbits were updated, corresponding products
will be taken into account at the time of processing with new images.
#
It will prepare and run MSBAS only if no other mass process is in progress.
It also plots several time series and double differences based on provided list of points.
#
Optional : perform a selection of pairs based on a mean coh computed on a provided footprint.
This might be useful for regions known to be affected by strong seasonal decorrelation.
For instance, ensuring a mean coh of at least 0.235 on the Laguna_Maule area (Chile)
ensured a proper estimation of the deformation. Not performing that selection based
on the coh underestimated the defo up to 60%.
#
NOTE: - MSBAS Calibration is disabled because deformation maps are detrended at processing.
#
Parameters: - none
#
Hardcoded: - a lot... see below paragraph named HARD CODED but also adapt below depending on the number of modes
- suppose everywhere that modes are Defointerpolx2Detrend
#
Dependencies: - awk
- several scripts from SCRIPTS_MT
#
New in Distro V 2.0: - based on beta version used for VVP, Domuyo, Lux and PF processing at ECGS
New in Distro V 2.1: - updated to use new PlotTS all_comps.sh that computes as well the location and explanation tags etc...
New in Distro V 2.2: - correct syntax bug in testing EXCLUDBi
New in Distro V 2.3: - rm jpg images before moving to __Combi
New in Distro V 2.4: - change all_combi as __Combi for uniformisation
New in Distro V 2.5: - search for latest deg file using find instead of ls, which crashes when too many files
New in Distro V 2.6: - correct bug in searching for latest deg file
New in Distro V 2.7: - replace if -s as -f & -f to be compatible with mac os if
New in Distro V 3.0 20230830: - Rename SCRIPTS_OK directory as SCRIPTS_MT
- Replace CIS by MT in names
- Renamed FUNCTIONS_FOR_MT.sh
New in Distro V 4.0 20231030: - Rename Master Toolbox as AMSTer Software
- rename Master and Slave as Primary and Secondary (though not possible in some variables and files)
New in Distro V 4.1 20231116: - Reshape with variables
- double criteria to compute baseline plot in order to account for the loss of S1B
New in Distro V 5.0.0 20240530: - reprocessing with DEM corrected from Geoidal height
New in Distro V 5.1.0 20240624: - enlarge BP2 (from back to 20220501) to cope with new S1 orbital tube from 05 2024
#
AMSTer: SAR & InSAR Automated Mass processing Software for Multidimensional Time series
Ndo (c) 2016/03/07 - could make better with more functions... when time.

PRG=`basename "$0"`
VER="Distro V5.1 AMSTer script utilities"
AUT="Nicolas d'Orsay, (c)2016-2019, Last modified on June 24, 2024"
echo " "
echo "${PRG} ${VER}, ${AUT}"
echo " "

source $HOME/.bashrc
cd
TODAY=`date`

vvvvvvvv Hard coded lines vvvvvvvvvvvvvv
some parameters
#####
Global Primaries (SuperMasters)
SMASC=20180512 # Asc 18
SMDESC=20180222 # Desc 83

Max baselines (used for all the mode in present case but you can change)
SET1BP1=20
SET1BP2=80
SET1BT1=450
SET1BT2=450
DATECHG1=20220501

SET2BP1=20
SET2BP2=80
SET2BT1=450
SET2BT2=450
DATECHG2=20220501

To take into account the whole set of data with both sets
of baseline criteria, one must take here the largest of each Bp and Bt
See warning below
BP=$(echo "$SET1BP1 $SET1BP2 $SET2BP1 $SET2BP2" | awk '{BP=$1; for(i=2;i<=NF;i++) if($i>BP) BP=$i; print BP}') # max perpendicular baseline
BT=$(echo "$SET1BT1 $SET1BT2 $SET2BT1 $SET2BT2" | awk '{BT=$1; for(i=2;i<=NF;i++) if($i>BT) BT=$i; print BT}') # max temporal baseline

LABEL=Domuyo # Label for file naming (used for naming zz_dirs with results and figs etc)

#R_FLAG
Order
ORDER=3
Lambda
LAMBDMA=0.04

some files and PATH for each mode
#####
Path to Pair Dirs and Geocoded files to use (need one for each mode)
S1ASC=${PATH}_3602)/SAR_MASSPROCESS_2/S1/ARG_DOMU_LAGUNA_DEMGeoid_A_18/SMNoCrop_SM_20180512_Zoom1_ML4
S1DESC=${PATH}_3602)/SAR_MASSPROCESS_2/S1/ARG_DOMU_LAGUNA_DEMGeoid_D_83/SMNoCrop_SM_20180222_Zoom1_ML4

Path to dir where list of compatible pairs files are computed (need one for each mode)
SET1=${PATH}_1650)/SAR_SM/MSBAS/ARGENTINE/set1
SET2=${PATH}_1650)/SAR_SM/MSBAS/ARGENTINE/set2

Path to LaunchParameters.txt files for each mode (need one for each mode)
LAUNCHPARAMASC=LaunchMTparam_S1_Arg_Domu_Laguna_A_18_Zoom1_ML4_MassProc_MaskCohWater_DEMGeoid.txt
LAUNCHPARAMDESC=LaunchMTparam_S1_Arg_Domu_Laguna_D_83_Zoom1_ML4_MassProc_Snapu_WaterCohMask_DEMGeoid.txt

WARNING: build header_msbas_criteria.sh requires all table files with the same Bp and Bt names, hence one MUST link
SM tables as `tables` named with max baselines ;
if they exist yet, rename them first as _Real and then link the final table to new name with max baselines

This can be improved by using e.g. build_header_msbas_Tables.sh to cope with several criteria...
So far, we change all the tables with the same name

TABLESET1=${SET1}/table_0_${SET1BP1}_0_${SET1BT1}_Till_${DATECHG1}_0_${SET1BP2}_0_${SET1BT2}_After.txt
TABLESET2=${SET2}/table_0_${SET2BP1}_0_${SET2BT1}_Till_${DATECHG2}_0_${SET2BP2}_0_${SET2BT2}_After.txt

```

```

Just in case a table would exist with the same values as the max Bp and Bt among all the modes,
let's keep it with the name table_0_${BP}_0_${BT}_RealBaselinesVal.txt
then link the dual table as a table with the common name table_0_${BP}_0_${BT}.txt for each mode
if [-f ${SET1}/table_0_${BP}_0_${BT}.txt] && [`diff ${SET1}/table_0_${BP}_0_${BT}.txt ${TABLESET1} | wc -l ` -gt 0]
then
 mv ${SET1}/table_0_${BP}_0_${BT}.txt ${SET1}/table_0_${BP}_0_${BT}_RealBaselinesVal.txt
 ln -s ${TABLESET1} ${SET1}/table_0_${BP}_0_${BT}.txt 2>/dev/null
fi

if [-f ${SET2}/table_0_${BP}_0_${BT}.txt] && [`diff ${SET2}/table_0_${BP}_0_${BT}.txt ${TABLESET2} | wc -l ` -gt 0]
then
 mv ${SET2}/table_0_${BP}_0_${BT}.txt ${SET2}/table_0_${BP}_0_${BT}_RealBaselinesVal.txt
 ln -s ${TABLESET2} ${SET2}/table_0_${BP}_0_${BT}.txt 2>/dev/null
fi

Events tables
#####
#EVENTS=${PATH_1650}/EVENTS_TABLES/${LABEL}

Path to dir where MSBAS will be computed
#####
MSBASDIR=${PATH_3602}/MSBAS_${LABEL}_S1_Auto_${BP}m_${BT}days

Coherence restriction
#####
IFCOH="YES" # YES or NO
if [${IFCOH} == "YES"]
then
 # Path to kml zone used to check coherence
 KMLCOH=${PATH_1650}/kml/ARGENTINA/Laguna_Maule.kml
 # Coherence restriction threshold (to be compared to mean coh computed on KMLCOH)
 COHRESTRICT=0.235

 # Exclude pairs from modes: If pairs are incidentally above Coh Threshold,
 # they can be excluded if they are stored as DATE_DATE in a list named
 # ${MSBASDIR}/DefoInterpolx2Detrendi/_EXCLUDE_PAIRS_ALTHOUGH_CRITERIA_OK.txt
 # and parameter below set to YES
 EXCLUDE1="NO" # YES or NO
 EXCLUDE2="NO" # YES or NO

 if [! -s ${KMLCOH}] ; then echo "Missing kml for coherence estimation. Please Check" ; exit ; fi
else
 EXCLUDE1="NO" # always NO of course
 EXCLUDE2="NO" # always NO of course
fi

Path to list of points for plotting time series
#####
List of SINGLE points for plotting time series with error bars
TIMESERIESPTSDESCR=${PATH_SCRIPTS}/SCRIPTS_MT/_cron_scripts/Points_TS_${LABEL}.txt

List of PAIRS of points for plotting double difference (i.e. without error bar) in EW and UD, ASC and Desc...
Note: if pixels are coherent in all modes, these can be the same list
DOUBLEDIFFPAIRSWUD=${PATH_SCRIPTS}/SCRIPTS_MT/_cron_scripts/List_DoubleDiff_EW_UD_S${LABEL}.txt
DOUBLEDIFFPAIRSASC=${PATH_SCRIPTS}/SCRIPTS_MT/_cron_scripts/List_DoubleDiff_EW_UD_${LABEL}.txt
DOUBLEDIFFPAIRSDesc=${PATH_SCRIPTS}/SCRIPTS_MT/_cron_scripts/List_DoubleDiff_EW_UD_${LABEL}.txt

Name of previous cron jobs for the automatic processing of that target (used to check that no other process is running)
#####
CRONJOBS2=Domuyo_S1_Step2_MassProc_DEMsecid.sh

^^^^^^^^^^ Hard coded lines ^^^^^^^^^^

Prepare directories
#####
mkdir -p ${MSBASDIR}

mkdir -p ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}
mkdir -p ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}/Time_series
mkdir -p ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}/_Combi/

mkdir -p ${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_${LAMBDA}_${LABEL}
mkdir -p ${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_${LAMBDA}_${LABEL}/_Combi/
mkdir -p ${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_${LAMBDA}_${LABEL}
mkdir -p ${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_${LAMBDA}_${LABEL}/_Combi/

in Coh threshold restriction
if [${IFCOH} == "YES"]
then
 mkdir -p ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/
 mkdir -p ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/_Combi/
 mkdir -p ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/_Time_series
fi

cd ${MSBASDIR}

prepare points lists
#####
TIMESERIESPTNAME=${(basename "${TIMESERIESPTSDESCR}")}

cp -f ${TIMESERIESPTSDESCR} ${MSBASDIR}/$(TIMESERIESPTNAME)
TIMESERIESPTSDESCR=${MSBASDIR}/$(TIMESERIESPTNAME)
#cp -f ${TIMESERIESPTSDESCR} ${MSBASDIR}/$(TIMESERIESPTNAME).tmp #.tmp is now as the original, the original will be cut from first line (title)
Remove header and naming in 1st col from Pts list
${PATHGNU}/gsed '1d' "${TIMESERIESPTSDESCR}" > ${MSBASDIR}/Cln_${TIMESERIESPTNAME}
${PATHGNU}/gsed -i -r 's/^(s+)?\$+/1' ${MSBASDIR}/Cln_${TIMESERIESPTNAME}
remove 3rd col
#${PATHGNU}/gsed -i -r 's/(\s+)?\$+//3' /Users/doris/PROCESS/SCRIPTS_MT/_cron_scripts/Cln_${LABEL}.txt
TIMESERIESPTS=${MSBASDIR}/Cln_${TIMESERIESPTNAME}
```

.../..

```

functions
#####
function PlotAll()
{
unset X1 Y1 X2 Y2 DESCRIPTION
local X1=$1
local Y1=$2
local X2=$3
local Y2=$4
local DESCRIPTION=$5

if ["$EVENTS" == ""]
then
$PATH_SCRIPTS/SCRIPTS_MT/PlotTS_all_comp.sh _Auto_${ORDER}_$(LAMBDA)_$(LABEL) ${X1} ${Y1} ${X2} ${Y2} -f -r -t -g
remove -f if does not want the linear fit etc.
else
$PATH_SCRIPTS/SCRIPTS_MT/PlotTS_all_comp.sh _Auto_${ORDER}_$(LAMBDA)_$(LABEL) ${X1} ${Y1} ${X2} ${Y2} -f -r -t -g -events=$EVENTS
remove -f if does not want the linear fit etc.
fi
mv ${MSBASDIR}/timeLines_${X1}_${Y1}_Auto_${ORDER}_$(LAMBDA)_$(LABEL).eps
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/$(DESCRIPTION)_timeLines_${X1}_${Y1}_Auto_${ORDER}_$(LAMBDA)_$(LABEL).eps
mv ${MSBASDIR}/timeLines_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL).eps
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/$(DESCRIPTION)_timeLines_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL).eps

mv ${MSBASDIR}/timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL).eps
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/$(DESCRIPTION)_timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL).eps

add map tag in fig
rm -f
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/$(DESCRIPTION)_timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_Combi.jpg
mv ${MSBASDIR}/timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_Combi.jpg
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/$(DESCRIPTION)_timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_Combi.jpg

mv ${MSBASDIR}/timeLine_UD_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL).txt
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/$(DESCRIPTION)_timeLines_UD_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL).txt
mv ${MSBASDIR}/timeLine_EW_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL).txt
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/$(DESCRIPTION)_timeLines_EW_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL).txt
}

function PlotAllNoCoh()
{
unset X1 Y1 X2 Y2 DESCRIPTION
local X1=$1
local Y1=$2
local X2=$3
local Y2=$4
local DESCRIPTION=$5

if ["$EVENTS" == ""]
then
$PATH_SCRIPTS/SCRIPTS_MT/PlotTS_all_comp.sh _Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh ${X1} ${Y1} ${X2} ${Y2} -f -r -t -g
remove -f if does not want the linear fit etc..
else
$PATH_SCRIPTS/SCRIPTS_MT/PlotTS_all_comp.sh _Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh ${X1} ${Y1} ${X2} ${Y2} -f -r -t -g -events=$EVENTS
remove -f if does not want the linear fit etc..
fi

if [-f ${MSBASDIR}/timeLines_${X1}_${Y1}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps"] && [-s
"${MSBASDIR}/timeLines_${X1}_${Y1}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps"]; then
mv ${MSBASDIR}/timeLines_${X1}_${Y1}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh/$(DESCRIPTION)_timeLines_${X1}_${Y1}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps
fi
if [-f ${MSBASDIR}/timeLines_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps"] && [-s
"${MSBASDIR}/timeLines_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps"]; then
mv ${MSBASDIR}/timeLines_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh/$(DESCRIPTION)_timeLines_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps
fi
if [-f ${MSBASDIR}/timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps"] && [-s
"${MSBASDIR}/timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps"]; then
mv ${MSBASDIR}/timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh/$(DESCRIPTION)_timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.eps

add map tag in fig
rm -f
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh/$(DESCRIPTION)_timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh_Combi.jpg
mv ${MSBASDIR}/timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh_Combi.jpg
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh/$(DESCRIPTION)_timeLines_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh_Combi.jpg

mv ${MSBASDIR}/timeLine_UD_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.txt
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh/$(DESCRIPTION)_timeLines_UD_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.txt
mv ${MSBASDIR}/timeLine_EW_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.txt
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh/$(DESCRIPTION)_timeLines_EW_${X1}_${Y1}_${X2}_${Y2}_Auto_${ORDER}_$(LAMBDA)_$(LABEL)_NoCohThresh.txt
fi
}

```

.../..

```

function PlotAllLOSasc()
{
unset X1 Y1 X2 Y2 DESCRIPTION
local X1=$1
local Y1=$2
local X2=$3
local Y2=$4
local DESCRIPTION=$5

cd ${MSBASDIR}/zz_LOS_Asc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/*
mkdir -p ${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/_Time_series

if ["${EVENTS}" == ""]
then
${PATH_SCRIPTS}/SCRIPTS_MT/PlotTS.sh $X1 $Y1 $X2 $Y2 -f -r -t -g # remove -f if does not want the linear fit
else
${PATH_SCRIPTS}/SCRIPTS_MT/PlotTS.sh $X1 $Y1 $X2 $Y2 -f -r -t -g -events=${EVENTS} # remove -f if does not want the linear fit etc..
fi

mv timeLine$X1_$Y1.eps
${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/$(DESCRIPTION)_timeLine_$X1_$Y1_Auto_${ORDER}_$(LAMBDA)_${LABEL}.eps
mv timeLine$X2_$Y2.eps
${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/$(DESCRIPTION)_timeLine_$X2_$Y2_Auto_${ORDER}_$(LAMBDA)_${LABEL}.eps
mv timeLine$X1_$Y1_$X2_$Y2.eps
${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/$(DESCRIPTION)_timeLine_$X1_$Y1_$X2_$Y2_Auto_${ORDER}_$(LAMBDA)_${LABEL}.eps

mv timeLine$X1_$Y1.txt ${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/_Time_series/
mv timeLine$X2_$Y2.txt ${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/_Time_series/
mv timeLine$X1_$Y1_$X2_$Y2.txt ${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/_Time_series/

add map tag in fig
rm -f
${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/$(DESCRIPTION)_timeLine_$X1_$Y1_$X2_$Y2_Auto_${ORDER}_$(LAMBDA)_${LABEL}_Combi_Asc.jpg
mv ${MSBASDIR}/zz_LOS_Asc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/timeLine$X1_$Y1_$X2_$Y2_Combi.jpg
${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/$(DESCRIPTION)_timeLine_$X1_$Y1_$X2_$Y2_Auto_${ORDER}_$(LAMBDA)_${LABEL}_Combi_Asc.jpg
}

}

function PlotAllLOSDesc()
{
unset X1 Y1 X2 Y2 DESCRIPTION
local X1=$1
local Y1=$2
local X2=$3
local Y2=$4
local DESCRIPTION=$5

cd ${MSBASDIR}/zz_LOS_Desc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/*
mkdir -p ${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/_Time_series

if ["${EVENTS}" == ""]
then
${PATH_SCRIPTS}/SCRIPTS_MT/PlotTS.sh $X1 $Y1 $X2 $Y2 -f -r -t -g # remove -f if does not want the linear fit
else
${PATH_SCRIPTS}/SCRIPTS_MT/PlotTS.sh $X1 $Y1 $X2 $Y2 -f -r -t -g -events=${EVENTS} # remove -f if does not want the linear fit etc..
fi

mv timeLine$X1_$Y1.eps
${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/$(DESCRIPTION)_timeLine_$X1_$Y1_Auto_${ORDER}_$(LAMBDA)_${LABEL}.eps
mv timeLine$X2_$Y2.eps
${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/$(DESCRIPTION)_timeLine_$X2_$Y2_Auto_${ORDER}_$(LAMBDA)_${LABEL}.eps
mv timeLine$X1_$Y1_$X2_$Y2.eps
${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/$(DESCRIPTION)_timeLine_$X1_$Y1_$X2_$Y2_Auto_${ORDER}_$(LAMBDA)_${LABEL}.eps

mv timeLine$X1_$Y1.txt ${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/_Time_series/
mv timeLine$X2_$Y2.txt ${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/_Time_series/
mv timeLine$X1_$Y1_$X2_$Y2.txt ${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/_Time_series/

add map tag in fig
rm -f
${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/$(DESCRIPTION)_timeLine_$X1_$Y1_$X2_$Y2_Auto_${ORDER}_$(LAMBDA)_${LABEL}_Combi_Desc.jpg
mv ${MSBASDIR}/zz_LOS_Desc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/timeLine$X1_$Y1_$X2_$Y2_Combi.jpg
${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_${LABEL}/$(DESCRIPTION)_timeLine_$X1_$Y1_$X2_$Y2_Auto_${ORDER}_$(LAMBDA)_${LABEL}_Combi_Desc.jpg
}

}

Check that there is no other cron (Step 2 or 3) or manual SuperMaster MassProc.sh running
#####
Check that no other cron job step 3 (MSBAS) or manual SuperMaster_MassProc.sh is running
CHECKKMB='ps -Af | ${PATHGNU}/grep ${PRG} | ${PATHGNU}/grep -v "grep" | ${PATHGNU}/grep -v "/dev/null" | wc -l'
if [${CHECKKMB} -gt 3]
then
 # Use ${PATHGNU}/grep -v "grep" instead of ${PATHGNU}/grep -v "grep ${PRG}" because depending on environment, it may miss the second version
 REASON=" another ${PRG} is running"
 STOPRUN="YES"
else
 # Check that no other SuperMaster_MassProc.sh automatic Ascending and Desc mass processing uses the LaunchMTparam_.txt yet
 CHECKKASC='ps -eaf | ${PATHGNU}/grep SuperMaster_MassProc.sh | ${PATHGNU}/grep -v "grep" | ${PATHGNU}/grep ${LAUNCHPARAMASC} | ${PATHGNU}/grep -v "/dev/null" | wc -l'
 CHECKDESC='ps -eaf | ${PATHGNU}/grep SuperMaster_MassProc.sh | ${PATHGNU}/grep -v "grep" | ${PATHGNU}/grep ${LAUNCHPARAMDESC} | ${PATHGNU}/grep -v "/dev/null" | wc -l'
 # For unknown reason it counts 1 even when no process is running
 if [${CHECKKASC} -ne 0] || [${CHECKDESC} -ne 0]
 then
 REASON=" SuperMaster_MassProc.sh in progress (probably manual)" ; STOPRUN="YES" ; else STOPRUN="NO"
 fi
fi

Check that no other cron job step 2 (SuperMaster_MassProc.sh) is running
CHECKKMP='ps -eaf | ${PATHGNU}/grep ${CRONJOB2} | ${PATHGNU}/grep -v "grep" | ${PATHGNU}/grep -v "/dev/null" | wc -l'
if [${CHECKKMP} -ne 0] ; then REASON=" SuperMaster_MassProc.sh in progress (from ${CRONJOB2})" ; STOPRUN="YES" ; else STOPRUN="NO" ; fi

if ["$STOPRUN" == "YES"]
then
echo "MSBAS attempt aborted on ${TODAY} because ${REASON}" >> ${MSBASDIR}/_last_MSBAS_process.txt
echo "MSBAS attempt aborted on ${TODAY} because ${REASON}"
#mv -f ${MSBASDIR}/$(TIMESERIESPTSDESCR).tmp ${MSBASDIR}/$(TIMESERIESPTSDESCR)
exit
fi

```

.../..

```

Check defo maps in SAR_MASSPROCESS
#####
Remove possible duplicate geocoded products in SAR_MASSPROCESS/.../Geocoded/...
i.e. remove in each MODE (but Am1) possible products from same pair of dates but with different Bp, Ha etc.. that would results from
reprocessing with updated orbits. If duplicated product detected, it keeps only the most recent product.

cd ${S1ASC}
Remove_Duplicate_Pairs_File_All_Modes_But_Ampl.sh &
cd ${S1DESC}
Remove_Duplicate_Pairs_File_All_Modes_But_Ampl.sh &
wait

Get date (in sec) of last available processed pairs in each MODE
#####
get the name of last available processed pair in each MODE

ls crashes when too many files
LASTASC= find ${MSBASDIR}/Geocoded/DefoInterpolx2Detrend/ -maxdepth 1 -type f -name "*deg" -printf "%T+ %p\n" | sort -r | head -1 | ${PATHGNU}/gawk '{print $2}'
LASTDESC= find ${S1DESC}/Geocoded/DefoInterpolx2Detrend/ -maxdepth 1 -type f -name "*deg" -printf "%T+ %p\n" | sort -r | head -1 | ${PATHGNU}/gawk '{print $2}'
get date in sec of last available processed pairs in each MODE
LASTASCTIME=`stat -c %Y ${LASTASC}`
LASTDESCTIME=`stat -c %Y ${LASTDESC}`

Check if first run and if appropriate, get time of last images in time series
#####
if [-f "${MSBASDIR}/_Last_MassProcessed_Pairs_Time.txt"] && [-s "${MSBASDIR}/_Last_MassProcessed_Pairs_Time.txt"]
then
 echo "Existing ${MSBASDIR}/_Last_MassProcessed_Pairs_Time.txt, hence not the first run"
 FIRSTRUN=NO
 FORMERLASTASCTIME=`head -1 ${MSBASDIR}/_Last_MassProcessed_Pairs_Time.txt`'`FORMERLASTDESCTIME=`head -2 ${MSBASDIR}/_Last_MassProcessed_Pairs_Time.txt` | tail -1`'`# tail -1 ok also but this is ready for case where more than 2 lines are present in _Last_MassProcessed_Pairs_Time.txt

 if [${FORMERLASTASCTIME} -eq ${LASTASC}] && [${FORMERLASTDESCTIME} -eq ${LASTDESCTIME}]
 # if no more recent file is available since the last cron processing
 then
 echo "MSBAS finished on ${TODAY} without new pairs to process" >> ${MSBASDIR}/_last_MSBAS_process.txt
 echo "MSBAS finished on ${TODAY} without new pairs to process"
 #mv -f ${MSBASDIR}/${TIMESERIESPTSDSCR}.tmp ${MSBASDIR}/${TIMESERIESPTSDSCR}
 exit
 fi
else
 echo "No ${MSBASDIR}/_Last_MassProcessed_Pairs_Time.txt, hence first run"
 FIRSTRUN=YES
fi

Remove possible broken links in MSBAS/.../MODEi and clean corresponding files
#####
(clean if required MODEi.txt and Checked_For_CohThreshold_To_Be_Ignored_At_Next_Rebuild_msbas_Header.txt if any)
if ["${FIRSTRUN}" == "NO"] ; then
 echo "Remove Broken Links and Clean txt file in existing ${MSBASDIR}/DefoInterpolx2Detrend"
 Remove_BrokenLinks_and_Clean_txt_file.sh ${MSBASDIR}/DefoInterpolx2Detrend1 &
 Remove_BrokenLinks_and_Clean_txt_file.sh ${MSBASDIR}/DefoInterpolx2Detrend2 &
 wait
 echo "Possible broken links in former existing MODEi dir are cleaned"
 echo ""

#Need also for the _Full ones (that is without coh threshold)
if [${IFCOH} == "YES"] ; then
 Remove_BrokenLinks_and_Clean_txt_file.sh ${MSBASDIR}/DefoInterpolx2Detrend1_Full &
 Remove_BrokenLinks_and_Clean_txt_file.sh ${MSBASDIR}/DefoInterpolx2Detrend2_Full &
 wait
 echo "Possible broken links in former existing MODEi_Full dir are cleaned"
 echo ""
fi

Check MSBAS/.../MODEi.txt file
#####
cd ${MSBASDIR}

Remove possible lines with less than 4 columns
if ["${FIRSTRUN}" == "NO"] ; then
 mv DefoInterpolx2Detrend1.txt DefoInterpolx2Detrend1_all4col.txt
 mv DefoInterpolx2Detrend2.txt DefoInterpolx2Detrend2_all4col.txt
 ${PATHGNU}/gawk 'NF<4' DefoInterpolx2Detrend1_all4col.txt > DefoInterpolx2Detrend1.txt
 ${PATHGNU}/gawk 'NF<4' DefoInterpolx2Detrend2_all4col.txt > DefoInterpolx2Detrend2.txt
 rm -f DefoInterpolx2Detrend1_all4col.txt DefoInterpolx2Detrend2_all4col.txt
 echo "All lines in former existing MODEi.txt have 4 columns"
 echo ""

#Need also for the _Full ones (that is without coh threshold)
if [${IFCOH} == "YES"] ; then
 mv ${MSBASDIR}/DefoInterpolx2Detrend1_Full/DefoInterpolx2Detrend1_Full.txt ${MSBASDIR}/DefoInterpolx2Detrend1_Full/DefoInterpolx2Detrend1_Full_all4col.txt
 mv ${MSBASDIR}/DefoInterpolx2Detrend2_Full/DefoInterpolx2Detrend2_Full.txt ${MSBASDIR}/DefoInterpolx2Detrend2_Full/DefoInterpolx2Detrend2_Full_all4col.txt
 ${PATHGNU}/gawk 'NF<4' ${MSBASDIR}/DefoInterpolx2Detrend1_Full/DefoInterpolx2Detrend1_Full_all4col.txt >
 ${MSBASDIR}/DefoInterpolx2Detrend1_Full/DefoInterpolx2Detrend1_Full.txt
 ${PATHGNU}/gawk 'NF<4' ${MSBASDIR}/DefoInterpolx2Detrend2_Full/DefoInterpolx2Detrend2_Full_all4col.txt >
 ${MSBASDIR}/DefoInterpolx2Detrend2_Full/DefoInterpolx2Detrend2_Full.txt
 rm -f ${MSBASDIR}/DefoInterpolx2Detrend1_Full/DefoInterpolx2Detrend1_Full_all4col.txt
 ${MSBASDIR}/DefoInterpolx2Detrend2_Full/DefoInterpolx2Detrend2_Full_all4col.txt
 echo "All lines in former existing MODEi_Full.txt have 4 columns"
 echo ""
fi

Remove lines in MSBAS/MODEi.txt file associated to possible broken links or duplicated lines with same name though wrong BP (e.g. after S1 orb update)
cd ${MSBASDIR}
echo "Remove lines in existing MSBAS/MODEi.txt file associated to possible broken links or duplicated lines"
_Check_bad_DefoInterpolx2Detrend.sh DefoInterpolx2Detrend1 ${PATH_3602}/SAR_MASSPROCESS_2 &
_Check_bad_DefoInterpolx2Detrend.sh DefoInterpolx2Detrend2 ${PATH_3602}/SAR_MASSPROCESS_2 &
wait
echo "All lines in former existing MODEi.txt are ok"
echo ""

#Need also for the _Full ones (that is without coh threshold)
if [${IFCOH} == "YES"] ; then
 _Check_bad_DefoInterpolx2Detrend.sh DefoInterpolx2Detrend1_Full ${PATH_3602}/SAR_MASSPROCESS_2 &
 _Check_bad_DefoInterpolx2Detrend.sh DefoInterpolx2Detrend2_Full ${PATH_3602}/SAR_MASSPROCESS_2 &
 wait
 echo "All lines in former existing MODEi_Full.txt are ok"
 echo ""
fi

```

```

Prepare MSBAS
#####
${PATH_SCRIPTS}/SCRIPTS_MT/build_header_msbas_criteria.sh DefoInterpolx2Detrend 2 ${BP} ${BT} ${S1ASC} ${S1DESC}

update here the R_FLAG if needed
${PATH_GNU}/gsed -i "s/R_FLAG = 2, 0.02/R_FLAG = ${ORDER}, ${LAMBDA}/* ${MSBASDIR}/header.txt
because interferos are detrened, i.e. averaged to zero, there is no need to calibrate again
${PATH_GNU}/gsed -i 's/C_FLAG = 10/C_FLAG = 0/' ${MSBASDIR}/header.txt

Check again that files are OK
ensure that format is ok, that is with 4 columns
mv DefoInterpolx2Detrend1.txt DefoInterpolx2Detrend1_all4col.txt
mv DefoInterpolx2Detrend2.txt DefoInterpolx2Detrend2_all4col.txt
${PATH_GNU}/gawk 'NF=4' DefoInterpolx2Detrend1_all4col.txt > DefoInterpolx2Detrend1.txt
${PATH_GNU}/gawk 'NF=4' DefoInterpolx2Detrend2_all4col.txt > DefoInterpolx2Detrend2.txt
keep track of prblems
${PATH_GNU}/gawk 'NF<4' DefoInterpolx2Detrend1_all4col.txt > DefoInterpolx2Detrend1_MissingCol.txt
${PATH_GNU}/gawk 'NF<4' DefoInterpolx2Detrend2_all4col.txt > DefoInterpolx2Detrend2_MissingCol.txt
rm -f DefoInterpolx2Detrend1_all4col.txt DefoInterpolx2Detrend2_all4col.txt

Need again to check for duplicated lines with different Bp in Col 2 resulting from orbit update
if [${IFCOH} == "YES"] ; then
 echo "Remove lines in newly created MSBAS/MODEi.txt file associated to possible broken links or duplicated lines"
 _Check_bad_DefoInterpolx2Detrend.sh DefoInterpolx2Detrend1 ${PATH_3602}/SAR_MASSPROCESS_2 &
 _Check_bad_DefoInterpolx2Detrend.sh DefoInterpolx2Detrend2 ${PATH_3602}/SAR_MASSPROCESS_2 &
 wait
 echo "All lines in new MODEi.txt should be ok"
 echo ""
fi

Let's go
#####
cd ${MSBASDIR}
cp -f header.txt header_back.txt

EW-UD without coh threshold restriction

case ${FIRSTRUN} in
 "YES")
 # one have only the newly created MODEi dir and MODEi.txt
 mkdir -p ${MSBASDIR}/DefoInterpolx2Detrend1_Full
 cp -R ${MSBASDIR}/DefoInterpolx2Detrend1/* ${MSBASDIR}/DefoInterpolx2Detrend1_Full/
 cp -f ${MSBASDIR}/DefoInterpolx2Detrend1.txt ${MSBASDIR}/DefoInterpolx2Detrend1_Full/DefoInterpolx2Detrend1_Full.txt
 cp -f ${MSBASDIR}/DefoInterpolx2Detrend1.txt ${MSBASDIR}/DefoInterpolx2Detrend1_Full.txt

 mkdir -p ${MSBASDIR}/DefoInterpolx2Detrend2_Full
 cp -R ${MSBASDIR}/DefoInterpolx2Detrend2/* ${MSBASDIR}/DefoInterpolx2Detrend2_Full/
 cp -f ${MSBASDIR}/DefoInterpolx2Detrend2.txt ${MSBASDIR}/DefoInterpolx2Detrend2_Full/DefoInterpolx2Detrend2_Full.txt
 cp -f ${MSBASDIR}/DefoInterpolx2Detrend2.txt ${MSBASDIR}/DefoInterpolx2Detrend2_Full.txt
 ;;
 "NO")
 # one must merge the newly created MODEi dir and MODEi.txt with former _Full ones
 sort ${MSBASDIR}/DefoInterpolx2Detrend1.txt | uniq > ${MSBASDIR}/DefoInterpolx2Detrend1_tmp.txt
 sort ${MSBASDIR}/DefoInterpolx2Detrend2.txt | uniq > ${MSBASDIR}/DefoInterpolx2Detrend2_tmp.txt

 sort ${MSBASDIR}/DefoInterpolx2Detrend1_Full/DefoInterpolx2Detrend1_Full.txt | uniq > ${MSBASDIR}/DefoInterpolx2Detrend1_Full_tmp.txt
 sort ${MSBASDIR}/DefoInterpolx2Detrend2_Full/DefoInterpolx2Detrend2_Full.txt | uniq > ${MSBASDIR}/DefoInterpolx2Detrend2_Full_tmp.txt

 cat ${MSBASDIR}/DefoInterpolx2Detrend1_tmp.txt ${MSBASDIR}/DefoInterpolx2Detrend1_Full_tmp.txt | sort | uniq >
 ${MSBASDIR}/DefoInterpolx2Detrend1_Full.txt
 cat ${MSBASDIR}/DefoInterpolx2Detrend2_tmp.txt ${MSBASDIR}/DefoInterpolx2Detrend2_Full_tmp.txt | sort | uniq >
 ${MSBASDIR}/DefoInterpolx2Detrend2_Full.txt

 cp -R -n ${MSBASDIR}/DefoInterpolx2Detrend1/* ${MSBASDIR}/DefoInterpolx2Detrend1_Full/
 cp -R -n ${MSBASDIR}/DefoInterpolx2Detrend2/* ${MSBASDIR}/DefoInterpolx2Detrend2_Full/
 cp -f ${MSBASDIR}/DefoInterpolx2Detrend1_Full.txt ${MSBASDIR}/DefoInterpolx2Detrend1_Full/DefoInterpolx2Detrend1_Full.txt
 cp -f ${MSBASDIR}/DefoInterpolx2Detrend2_Full.txt ${MSBASDIR}/DefoInterpolx2Detrend2_Full/DefoInterpolx2Detrend2_Full.txt

 rm -f ${MSBASDIR}/DefoInterpolx2Detrend1_tmp.txt ${MSBASDIR}/DefoInterpolx2Detrend1_Full_tmp.txt
 rm -f ${MSBASDIR}/DefoInterpolx2Detrend2_tmp.txt ${MSBASDIR}/DefoInterpolx2Detrend2_Full_tmp.txt

 # because ${MSBASDIR}/DefoInterpolx2Detrendi_Full.txt was built with uncleaned ${MSBASDIR}/DefoInterpolx2Detrend2_Full/DefoInterpolx2Detrend2_Full.txt,
 # let's clean it again
 echo "Remove again lines in MSBAS/MODEi_Full.txt file associated to possible broken links or duplicated lines"
 _Check_bad_DefoInterpolx2Detrend.sh DefoInterpolx2Detrend1_Full ${PATH_3602}/SAR_MASSPROCESS_2 &
 _Check_bad_DefoInterpolx2Detrend.sh DefoInterpolx2Detrend2_Full ${PATH_3602}/SAR_MASSPROCESS_2 &
 wait
 echo "All lines in new MODEi_Full.txt should be ok"
 ;;
esac
trick the header file
${PATH_GNU}/gsed -i 's/DefoInterpolx2Detrend1.txt/DefoInterpolx2Detrend1_Full.txt/' ${MSBASDIR}/header.txt
${PATH_GNU}/gsed -i 's/DefoInterpolx2Detrend2.txt/DefoInterpolx2Detrend2_Full.txt/' ${MSBASDIR}/header.txt

${PATH_SCRIPTS}/SCRIPTS_MT/MSBAS.sh _Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh ${TIMESERIESPTS}

Make baseline plot
PlotBaselineGeocMSBASmodeTXT.sh ${SET1} ${MSBASDIR}/DefoInterpolx2Detrend1_Full.txt
PlotBaselineGeocMSBASmodeTXT.sh ${SET2} ${MSBASDIR}/DefoInterpolx2Detrend2_Full.txt

Now msbas single points (with error bars) times series and plots are in dir. Let's add the description to the naming
cp ${TIMESERIESPTSDESCR} ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/
remove header line to avoid error message
#TIMESERIESPTSDSCRNHEADER="tail -n +2 ${TIMESERIESPTSDESCR}"
while read -r DESCER X Y RX RY
do
 echo "Rename time series of ${X} ${Y} as ${X} ${Y} ${RX} ${RY} ${DESCR}"
 mv ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/MSBAS_${X}_${Y}_${RX}_${RY}.txt
 mv ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/MSBAS_${X}_${Y}_${RX}_${RY}_${DESCR}.txt
 mv ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/MSBAS_${X}_${Y}_${RX}_${RY}.pdf
 mv ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/MSBAS_${X}_${Y}_${RX}_${RY}_${DESCR}.pdf
done < ${TIMESERIESPTSDESCR} | tail -n +2 # ignore header

Why not some double difference plotting
while read -r X1 Y1 X2 Y2 DESCER
do
 PlotAllNoCoh $X1 $Y1 $X2 $Y2 ${DESCR}
done < ${DOUBLEDIFFPAIRSEWDU}

move all plots in same dir
rm -f ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/_Combi/*.jpg
mv ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/*_NoCohThresh_Combi.jpg
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/_Combi/_Time_series/

move all time series in dir
mv ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/*.txt
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_${LAMBDA}_${LABEL}_NoCohThresh/_Time_series/

```

.../..

```

EW-UD with coh threshold restriction

cd ${MSBASDIR}
cp -f header_back.txt header.txt

run restrict_msbas_to_Coh.sh
restrict_msbas_to_Coh.sh DefoInterpolx2Detrend1 ${COHRESTRICT} ${KMLCOH} ${S1ASC}/Geocoded/Coh
restrict_msbas_to_Coh.sh DefoInterpolx2Detrend2 ${COHRESTRICT} ${KMLCOH} ${S1DESC}/Geocoded/Coh

Force pair exclusion
if [${EXCLUDE1} == "YES"] ; then
 ${PATH_SCRIPTS}/SCRIPTS_MT/zz_Utils_Exclude_Pairs_From_Mode.txt.sh ${MSBASDIR}/DefoInterpolx2Detrend1
fi
if [${EXCLUDE2} == "YES"] ; then
 ${PATH_SCRIPTS}/SCRIPTS_MT/zz_Utils_Exclude_Pairs_From_Mode.txt.sh ${MSBASDIR}/DefoInterpolx2Detrend2
fi

cd ${MSBASDIR}
${PATH_SCRIPTS}/SCRIPTS_MT/MSBAS.sh _Auto_${ORDER}_$(LAMBDA)_$(LABEL) ${TIMESERIESPTS}

test if MSBAS log.txt contains "completed 100%"; if not log error
if ${PATHGNU}/grep -q "writing results to a disk" ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/MSBAS_LOG.txt
then
 echo "MSBAS ok"
else
 # try again after cleaning DefoInterpolx2Detrend1.txt
 _Check_bad_DefoInterpolx2Detrend1.sh DefoInterpolx2Detrend1 ${PATH_3601}/SAR_MASSPROCESS &
 _Check_bad_DefoInterpolx2Detrend2.sh DefoInterpolx2Detrend2 ${PATH_3601}/SAR_MASSPROCESS &
 wait
#
${PATH_SCRIPTS}/SCRIPTS_MT/MSBAS.sh _Auto_${ORDER}_$(LAMBDA)_$(LABEL) ${TIMESERIESPTS}
if ${PATHGNU}/grep -q "writing results to a disk" ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/MSBAS_LOG.txt ; then echo "Solved after
cleaning DefoInterpolx2Detrend's txt"; else echo "!! MSBAS crashed on ${TODAY}" >> ${MSBASDIR}/_last_MSBAS_process.txt ; fi
fi

Make baseline plot
PlotBaselineGeocMSBASmodeTXT.sh ${SET1} ${MSBASDIR}/DefoInterpolx2Detrend1.txt
PlotBaselineGeocMSBASmodeTXT.sh ${SET2} ${MSBASDIR}/DefoInterpolx2Detrend2.txt

Now msbas single points (with error bars) times series and plots are in dir. Let's add the description to the naming
cp ${TIMESERIESPTSDESCR} ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/

while read -r DESCX X Y RX RY
do
 echo "Rename time series of ${X} ${Y} as ${X} ${Y} ${RX} ${RY} ${DESCR}"
 mv ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/MSBAS_${X} ${Y} ${RX} ${RY} ${DESCR}.txt
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/MSBAS_${X} ${Y} ${RX} ${RY} ${DESCR}.txt
 mv ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/MSBAS_${X} ${Y} ${RX} ${RY} ${DESCR}.pdf
${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/MSBAS_${X} ${Y} ${RX} ${RY} ${DESCR}.pdf
done < ${TIMESERIESPTSDESCR} | tail -n +2 # ignore header

Why not some double difference plotting
#WhichPlots
while read -r X1 Y1 X2 Y2 DESCX
do
 PlotAll ${X1} ${Y1} ${X2} ${Y2} ${DESCR}
done < ${DOUBLEDIFFPAIRSEWUD}

move all plots in same dir
rm -f ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/__Combi*.jpg
mv ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/__Combi.jpg ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/__Combi/

move all time series in dir
mv ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/*.* ${MSBASDIR}/zz_UD_EW_TS_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/_Time_series/

Asc and Desc (with coh threshold restriction)

Prepare header files
Change second occurrence of "SET = " with "#SET =
${PATHGNU}/gsed '0,/SET = /! {0,SET = / s/SET = /#SET = /}' ${MSBASDIR}/header.txt > ${MSBASDIR}/header_Asc.txt
Change first occurrence of "SET = " with "#SET =
${PATHGNU}/gsed '0,/SET =/(s/SET =/#SET =/' ${MSBASDIR}/header.txt > ${MSBASDIR}/header_Desc.txt

ASCENDING
cd ${MSBASDIR}
cp -f header_Asc.txt header.txt

${PATH_SCRIPTS}/SCRIPTS_MT/MSBAS.sh _Asc_Auto_${ORDER}_$(LAMBDA)_$(LABEL) ${TIMESERIESPTS}

cp ${TIMESERIESPTSDESCR} ${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/
while read -r DESCX X Y RX RY
do
 echo "Rename time series of ${X} ${Y} as ${X} ${Y} ${RX} ${RY} ${DESCR}"
 mv ${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/MSBAS_${X} ${Y} ${RX} ${RY} ${DESCR}.txt
${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/MSBAS_${X} ${Y} ${RX} ${RY} ${DESCR}.txt
 # there is no automatic plotting by msbas when only in LOS
done < ${TIMESERIESPTSDESCR} | tail -n +2 # ignore header

Why not some double difference plotting
while read -r X1 Y1 X2 Y2 DESCX
do
 PlotAllLOSasc ${X1} ${Y1} ${X2} ${Y2} ${DESCR}
done < ${DOUBLEDIFFPAIRSASC}

move all plots in same dir
rm -f ${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/__Combi*.jpg
mv ${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/__Combi*.jpg ${MSBASDIR}/zz_LOS_TS_Asc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/__Combi/

DESCENDING
cd ${MSBASDIR}
cp -f header_Desc.txt header.txt

${PATH_SCRIPTS}/SCRIPTS_MT/MSBAS.sh _Desc_Auto_${ORDER}_$(LAMBDA)_$(LABEL) ${TIMESERIESPTS}

cp ${TIMESERIESPTSDESCR} ${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/
while read -r DESCX X Y RX RY
do
 echo "Rename time series of ${X} ${Y} as ${X} ${Y} ${RX} ${RY} ${DESCR}"
 mv ${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/MSBAS_${X} ${Y} ${RX} ${RY} ${DESCR}.txt
${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/MSBAS_${X} ${Y} ${RX} ${RY} ${DESCR}.txt
 # there is no automatic plotting by msbas when only in LOS
done < ${TIMESERIESPTSDESCR} | tail -n +2 # ignore header

Why not some double difference plotting
while read -r X1 Y1 X2 Y2 DESCX
do
 PlotAllLOSdesc ${X1} ${Y1} ${X2} ${Y2} ${DESCR}
done < ${DOUBLEDIFFPAIRSDESC}

move all plots in same dir
rm -f ${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/__Combi*.jpg
mv ${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/__Combi*.jpg ${MSBASDIR}/zz_LOS_TS_Desc_Auto_${ORDER}_$(LAMBDA)_$(LABEL)/__Combi/

```

```
Back to normal for next run and get out
cp -f ${MSBASDIR}/header_back.txt ${MSBASDIR}/header.txt

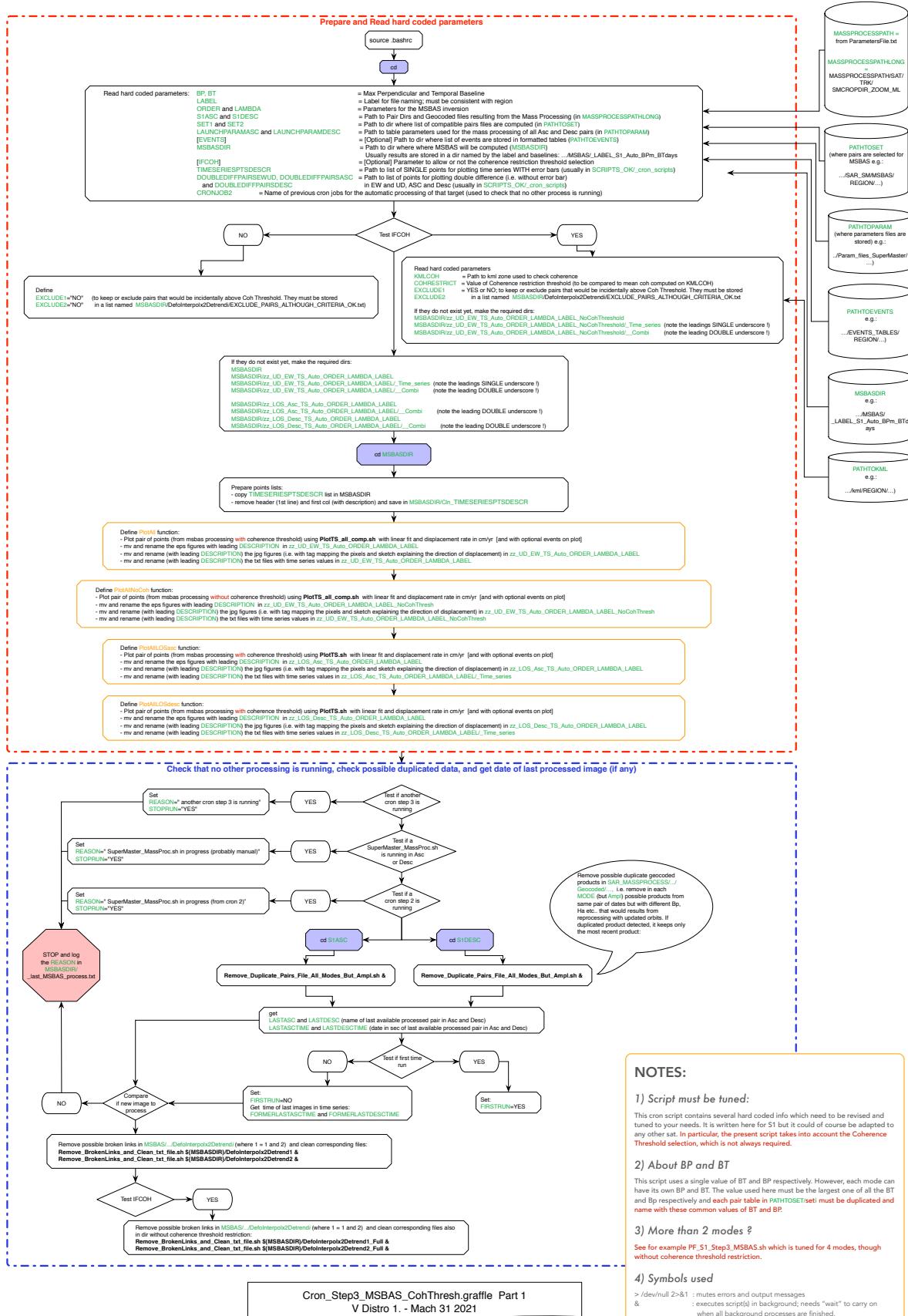
TODAY=`date`
echo "MSBAS finished on ${TODAY}" >> ${MSBASDIR}/_last_MS BAS_process.txt

echo "${LASTASCTIME}" > ${MSBASDIR}/_Last_MassProcessed_Pairs_Time.txt
echo "${LASTDESCTIME}" >> ${MSBASDIR}/_Last_MassProcessed_Pairs_Time.txt

#mv -f ${MSBASDIR}/${TIMESERIESPTSDSCR}.tmp ${MSBASDIR}/${TIMESERIESPTSDSCR}

All done...
```

See also script ***Domuyo\_S1\_Step3\_MSBAS\_DEMGoid\_Split.sh***, which is doing the same things, although it offers the possibility to split the MSBAS inversion in two parts (see 6.3).

**NOTES:****1) Script must be tuned:**

This cron script contains several hard coded info which need to be revised and tuned to your needs. It is written here for S1 but it could of course be adapted to any other sat. In particular, the present script takes into account the Coherence Threshold selection, which is not always required.

**2) About BP and BT**

This script uses a single value of BT and BP respectively. However, each mode can have its own BP and BT. The value used here must be the largest one of all the BT and BP respectively and each pair table in PATHTOSET/set must be duplicated and with these common values of BT and BP.

**3) More than 2 modes ?**

See for example PE\_S1\_Step3\_MSBAS.sh which is tuned for 4 modes, though without coherence threshold restriction.

**4) Symbols used**

>/dev/null 2>&1 : mutes errors and output messages  
& : executes script(s) in background; needs "wait" to carry on when all background processes are finished.

Figure 51: Flow chart of cron job step 3 - part 1/2 (msbas inversion and plot time series) – Beware, this corresponds to an old version, though it must give enough hints to understand the flow.

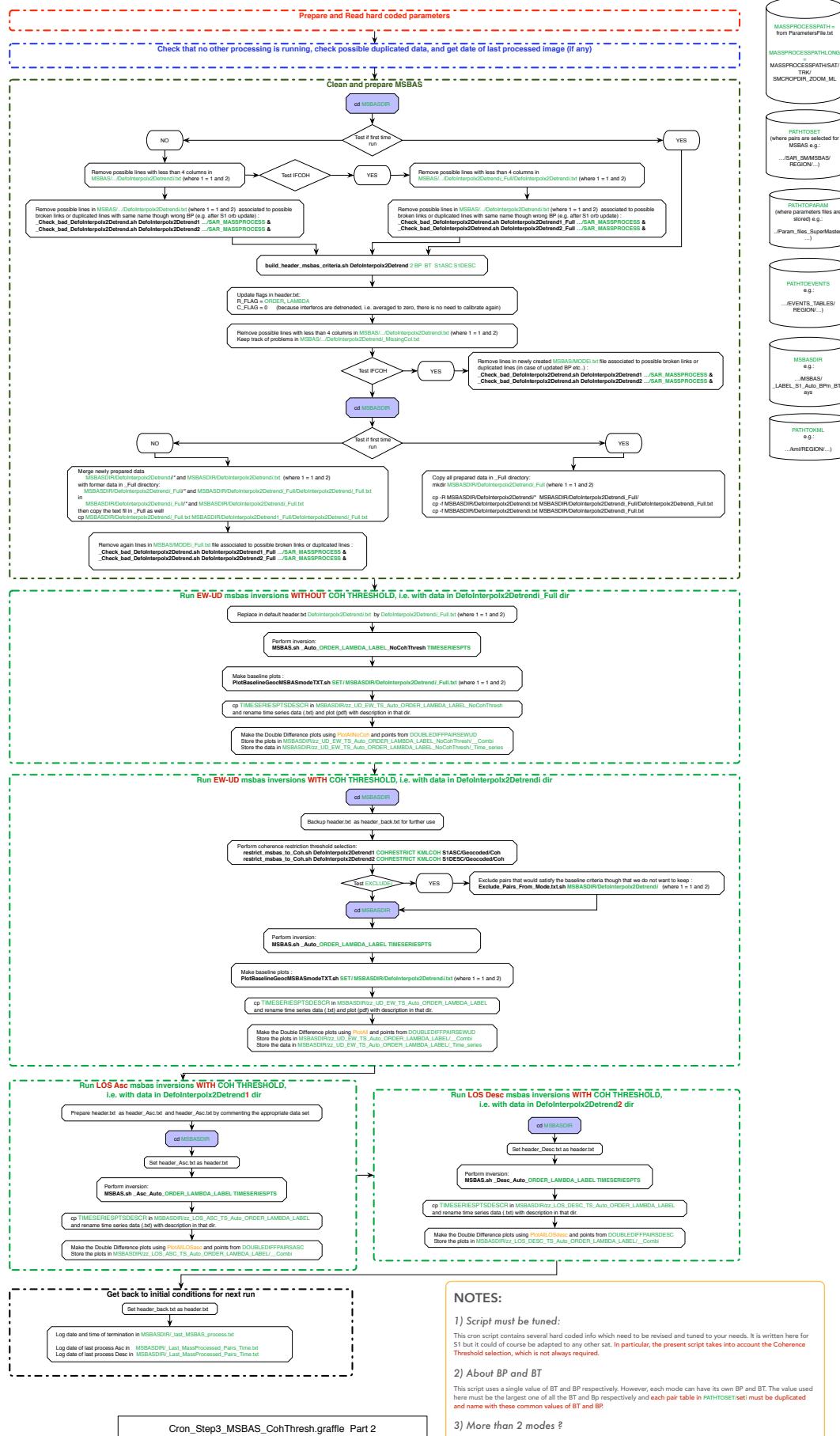


Figure 52: Flow chart of cron job step 3 - part 2/2 (msbas inversion and plot time series) – Beware, this corresponds to an old version, though it must give enough hints to understand the flow.

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