

Installation of MasTer

(FOR Linux DISTROS)

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Preliminary information

MasTer tool is a set of mostly shell scripts aiming at processing automatically a large number of interferometric pairs and feeding and running the **MSBAS** processor [Samsonov and d'Oreye, 2012, 2017; Samsonov et al., 2017, 2020] in order to obtain the desired deformation maps and time series in vertical and horizontal components. Geocoded amplitude, coherence, interferometric phase and deformation maps are computed using the **MasTer Engine**, a command line InSAR processor derived from the Centre Spatial de Liege (CSL) InSAR Suite (CIS) [Derauw, 1999; Derauw et al, 2019].

This guide explains the installation procedure for **MasTer (MasTer tool, MasTer Engine, MSBAS)**, on a Mac computer. It does not replace the [manual](#) file provided with the software distribution ([MasTer_Manual_x.x.docx](#)), but rather provide much more details to allow any user with less-advanced knowledge of the Mac environment to properly install the software suite.

The installation procedure has been last tested with the **MasTerEngine_v20230828** package, msbasv3 (20190121), msbasv4 (20201009) and shell scripts dated from Aug 2023.

Sources and codes are available from Github at repositories by ndoreye.

If you are not granted the access to the repositories, please send an email to ndo@ecgs.lu.

Download:

Either from the **distribution repository** (all in one package):

- https://github.com/ndoreye/MasTerToolbox_Distribution

Or from the **development repositories**:

- the documentation and manuals from [ndoreye/DOCS](#)
- the scripts from [ndoreye/SCRIPTS_MT](#)
- the MSBAS sources tuned for MasTer Toolbox from [ndoreye/MSBAS](#) (also available directly from S. Samsonov; see manual)
- the MasTerEngine sources from [ndoreye/_Sources_ME](#) (also available directly from D. Derauw; see manual)

Note: Gitkraken is a convenient interface for Github but is not mandatory.

This installation procedure as been tested on:

- **Ubuntu 22.0.4 LTS**

though former installations were operational.

It is assumed that the user has the administrator rights on the computer and can provide the root privilege when the “sudo” command is executed in the terminal.

In this installation guide, each command line that has to be written and executed in a terminal is written in *italic blue*. Files names are in *blue*. Paths are given in *green*.

Note:

A script exists to assist you making the installation (at least for Debian OS). See [.../SAR/MasTerToolbox/SCRIPTS_MT/zz_Uilities_MT/MasTer_install.sh](#) (in distribution repository), or [.../SAR/MasTerToolbox/SCRIPTS_MT/zz_Uilities_MT/MasTer_install.sh](#) (in development repository).

Read carefully all the text and questions displayed by the script.

For other type of Linux OS, you may need to adapt the script or proceed manually by adapting the procedure below.

Note that the **MasTer_install.sh** installation script may be run several times (either to correct a problem during the installation or to perform an update of any element at any time). However, if some elements were installed manually (eg Gitkraken, Fiji or QGIS...), the script may not properly detect them as they may have been installed in an expected. This must not be a problem though.

Kind reminder: The software is provided for free. To help us carrying on with the development of the tool, we kindly ask you to cite the **MasTer Toolbox** in publications that contains results produced by the toolbox thanks to at least the most recent references from below:

For MasTer Engine

- Derauw, D., (1999). Phasimétrie par Radar à Synthèse d'Ouverture; théorie et applications. PhD Dissertation, University of Liège, 141 pages.
- Libert, L., Derauw, D., d'Oreye, N., Barbier, C., Orban, A., (2017). Split-band interferometry-assisted phase unwrapping for the phase ambiguities correction. *Remote Sensing*, 9(9), 879.

For MSBAS

- Samsonov, S., d'Oreye, N., (2012). Multidimensional time-series analysis of ground deformation from multiple InSAR data sets applied to Virunga Volcanic Province. *Geophysical Journal International* 191(3), 1095–1108. doi: 10.1111/j.1365-246X.2012.05669.x.
- Samsonov, S., d'Oreye, N., (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
- Samsonov S., W. Feng, A. Peltier, H. Geirsson, N. d'Oreye, KK. F.Tiampo (2017). Multidimensional Small Baseline Subset (MSBAS) for volcano monitoring in two dimensions: opportunities and challenges. Case study Piton de la Fournaise volcano. *Journal of Volcanology and Geothermal Research*, Vol 344, 121-138, <https://doi.org/10.1016/j.jvolgeores.2017.04.017>
- Samsonov, S., A. Dille, O. Dewitte, F. Kervyn, and N. d'Oreye (2020). Satellite interferometry for mapping surface deformation time series in one, two and three dimensions: A new method illustrated on a slow-moving landslide. *Engineering Geology*, (266), 105471, doi:10.1016/j.enggeo.2019.105471.items

For MasTer toolbox

- Derauw, D., N. d'Oreye, M. Jaspard, A. Caselli, and S. Samsonov (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., *Journal of South American Earth Sciences*, 104, 102850, doi:10.1016/j.jsames.2020.102850.
- 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.
- d'Oreye N., Derauw, D., S. Samsonov, M. Jaspard, D. Smittarello, G. Celli (2022), MasTer: InSAR automated Mass processing Toolbox for Multidimensional time series. *Instruction manual V4.0*, Oct. 2022. 191 pp.
- 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.

For DORIS

- Kampes, B.M., Hanssen, R.F., Perski, Z., (2003). Radar interferometry with public domain tools. In: *Third International Workshop on ERS SAR Interferometry, FRINGE03*, Frascati, Italy, 1-5 Dec. 2003, 6 pages.

0) Prepare the work

The tools will need the following directories:

- /opt/local/bin
- \$HOME/SAR/EXEC
- \$HOME/SAR/MasTerToolbox/DOC
- \$HOME/SAR/MasTerToolbox/MasTerEngine/_Sources_ME/Older
- \$HOME/SAR/MasTerToolbox/MSBAS
- \$HOME/SAR/MasTerToolbox/SCRIPTS_MT

Where \$HOME/ is obviously your home directory.

It is also advised to source your **.barshrc** in your **.bash_profile** as all the config will be set in **.bashrc**.

If you do not have these files, create them and ensure you can write and execute them.

If you have old MasTer installation parameters in your **.bashrc**, it is advised to remove them and write new ones based on the instructions below.

1) Installing some external components

The following tools and apps are not all mandatory but experience shows that it may greatly help the user.

Note: if apt name or lib has changed, you can search by keyword the new name by typing at the Terminal:

- `sudo apt-cache search <keyword>`

Update installation:

- If not done yet:
 - `sudo apt install make`
 - `sudo apt install gzip`
- To ensure update version of OS, type at terminal:
 - `sudo apt update`
 - `sudo apt upgrade`
- For old version of Ubuntu (<18):
 - `sudo apt install snapd`

GitKraken :

Although not mandatory, Gitkraken is a useful tool to sync with the last versions of MasTer Toolbox. It requires credentials to access MasTer private repositories on Github (contact ndo@ecgs.lu). GitKraken used to access private repositories requires a license though.

- Command line download (`gitkraken-amd64.deb`), and install by typing
 - `wget -c https://release.gitkraken.com/linux/gitkraken-amd64.deb`
 - `sudo apt install ./gitkraken-amd64.deb`
- In case of manual download (`gitkraken-amd64.deb` from web site), install by typing
 - `sudo dpkg -i gitkraken-amd64.deb`
- may also be done using snap:
 - `sudo snap install gitkraken --classic`
- Connect e.g. via [Github](#)
- Create profile in GitKraken (may need pay version for accessing private repositories)
- Launch GitKraken
- Clone Repo > Github.com:
 - Where to Clone: `$HOME/SAR/MasTerToolbox`
 - Repo to clone: DOC, MSBAS, SCRIPTS_MT
- Clone Repo > Github.com:
 - Where to Clone: `$HOME/SAR/MasTerToolbox/MasTerEngine`
 - Repo to clone: `_Sources_ME`
- New tab > Open a Repo > select in Finder `$HOME/SAR/MasTerToolbox/RepoYouWant`

To display raster figure: XnView, GIMP or Graphic Converter

For instance, see <https://www.gimp.org/downloads/>

Or at Terminal :

- `sudo add-apt-repository ppa:ubuntuhandbook1/gimp`
- `sudo apt update`
- `sudo apt install gimp`

Editor:

- Get a good text editor you like

FTP:

- Get a convenient ftp software that you like

gnu fortran (not mandatory):

- Get it from http://fortran-lang.org/learn/os_setup/install_gfortran
- install with:
 - `sudo apt-get install gfortran`

GMT and GDAL:

GMT, GDAL and some associated utilities are required for plots, images and GIS manipulations.

- At Terminal, type:
 - `sudo apt install gdal-bin`
 - `sudo apt install libgdal-dev`
 - `sudo apt install libgdal26`
 - check gdal by typing: `gdalinfo --version`
 - `sudo apt install libhdf5-dev`
 - `sudo apt install gmt`
 - `sudo apt install libnetcdf-dev`
 - `sudo apt install graphicsmagick ffmpeg`
 - `sudo apt install openjpeg` (optional I think)

To display geocoded products: QGIS

- Visit <https://qgis.org> and get it eg as follow:
- At Terminal type:
 - `sudo apt install gnupg software-properties-common`
 - `wget -qO - https://qgis.org/downloads/qgis-2021.gpg.key | sudo gpg --no-default-keyring --keyring gnupg-ring:/etc/apt/trusted.gpg.d/qgis-archive.gpg --import`
 - `sudo chmod a+r /etc/apt/trusted.gpg.d/qgis-archive.gpg`
 - `sudo add-apt-repository "deb https://qgis.org/ubuntu $(lsb_release -c -s) main"`
 - `sudo apt update`
 - `sudo apt install qgis qgis-plugin-grass`
- note some interesting plugins are:
 - point sampling tool
 - PointConnetor

- [Profile tool](#)
- [Qdraw](#)
- [QuickMapServices](#)
- [RasterDataPlotting](#) (may require to install python first)
- [Serval](#)
- [Temporal/Spectal Profile Tool](#)
- [Value Tool](#)

For special characters if you keyboard sometimes plays it funny:

- Install Ubuntu package [Character Map](#)

2) Installing required tools

MasTer needs some pre-existing software and libraries to work properly. This is what we call the “dependencies”. So, we first need to install them. These installations are explained here, sorted by type of installation procedure.

GNU functions and utilities:

Several commands might exist by default on Linux, but getting the gnu version again is wise.

To be sure to have the latest version of gnu tools, type at the Terminal:

- `sudo apt install sed`
- `sudo apt install gawk`
- `sudo apt install coreutils` (i.e. for `gdate`, `gstat`)
- `sudo apt install findutils` (i.e. for `find`)
- `sudo apt install grep` (i.e. for `ggrep`)
- `sudo apt install wget` (needed i.e. to download the S1 orbits)
- `sudo snap install curl` and add the path to `curl` (e.g. `/snap/bin`) in your `$PATH`

- Check that all these gnu functions are stored in the `/usr/bin` directory. If not, move them there. That directory MUST be defined as `${PATHGNU}` state variable in your `.bashrc`. At Terminal, type

- `which sed`
- `which gawk`
- `which date`
- `which stat`
- `which find`
- `which grep`

If answer to all these lines is not the same as `echo ${PATHGNU}`, edit your `.bashrc` and change `${PATHGNU}` state variable. It must be something like
`export PATHGNU=/usr/bin`

Don't forget that a reboot (or source `.bashrc`) is required for changes in `.bashrc` to be taken into account.

- 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. In Terminal, type:
 - `cd ${PATHGNU}`
 - `sudo ln -s sed gsed`
 - `sudo ln -s gawk awk` (beware if `awk` already exist and would be a link pointing toward another version of `awk`. Replace it with our `gawk`)
 - `sudo ln -s date gdate`
 - `sudo ln -s stat gstat`
 - `sudo ln -s find gfind`

And to be sure...(I know it is overkill, but one never know...):

- `sudo ln -s grep ggrep`
- `sudo ln -s seq gseq`
- `sudo ln -s uniq guniq`
- `sudo ln -s readlink greadlink`
- `sudo ln -s xargs gxargs`
- `sudo ln -s du gdu`

Check also that `wget` is `${PATHGNU}`

Libraries & modules:

- Install libraries and modules :
 - o `sudo apt install clang`
 - o `sudo apt install libfftw3-dev`
 - o `sudo apt install libfftw3-long3`
 - o `sudo apt install libfftw3-single3`
 - o `sudo apt install libgeotiff-dev`
 - o `sudo apt install libtiff-dev`
 - o `sudo apt install libxml2`
 - o `sudo apt install libxml2-dev`
 - o `sudo apt install liblapack-dev`
 - o `sudo apt install libomp-dev`
 - o `sudo apt install libopenblas-dev`
 - o `sudo apt install graphicsmagick-imagemagick-compat`
 - o `sudo apt install imagemagick-6-common`
 - o `sudo apt install imagemagick`
 - o `sudo apt install g++`
 - o `sudo apt-get espeak -y` (to make your computer talking during mass processing)
 - o `sudo apt install parallel`

Attention: for `convert` function to operate properly **ps** and **eps** files, change permissions in `/etc/ImageMagick/policy.xml` (or `/etc/ImageMagick-6/policy.xml`) and set (e.g. using nano as sudo):

```
</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" />
```

For some plotting applications: Java (preferably installed before Fiji)

Install it with :

- o `sudo apt install default-jdk`

or manually :

- o see <http://www.java.com>

- o follow instructions to install Java

Notes:

- if some scripts crash with the following message, re-install java and then re-install Fiji:
The operation couldn't be completed. Unable to locate a Java Runtime that supports (null).
- One may need to define **JAVA_HOME** state variable in the **.bashrc** for some application using it. Check where it is installed by typing:
 - o `java -XshowSettings:properties -version 2>&1 > /dev/null | grep 'java.home'`
 and update the **.bashrc** by adding a line with the answer of the line above:
 - o `export JAVA_HOME=PATH_FROM_LINE_ABOVE`

Fiji/ImageJ:

Do not install it with the terminal !!! You must use the stand-alone version.

- Download latest version from <https://imagej.net/software/fiji/downloads>
- Unzip the compressed file in `$HOME/SAR/EXEC`.
- Locate `ImageJ-linux64` in your `$HOME/SAR/EXEC/Fiji.app` directory.
- Update `$PATHFIJI` in your `.bashrc`. It must be something like
`export PATHFIJI=$HOME/SAR/EXEC/Fiji.app/`
- Store the installed source e.g. in `$HOME/SAR/EXEC/Sources_Installed`.

snaphu:

- Download latest version (e.g. `snaphu-v2.0.5.tar`) from
<https://web.stanford.edu/group/radar/softwareandlinks/sw/snaphu/>
and store it in in `$HOME/SAR/EXEC`.
- unzip it e.g. using `tar -zxvf`
- edit the Makefile in the `/src` directory to specify your compiler and the optimization flags.
Ensure that makefile has no static option in following line
`CFLAGS = -O3 # -D NO_CS2`
- compile: at Terminal in `/src` dir, type `make`
(it seems that you can ignore warnings; most recent compilers are more sensitive)
- Move compiled `snaphu` from `/bin` into `$HOME/SAR/EXEC`
- Download also the `snaphu_man1.txt` if you need more info about snaphu and its configurations.
- Store the installed source e.g. in `$HOME/SAR/EXEC/Sources_Installed`.

Note: this installation can also be made using install, but it might not be the latest version and path must be checked...

- o `sudo apt install snaphu`

cpxfiddle:

Not mandatory, but pretty convenient for creating raster files for quick looking at results.

- Download source from https://github.com/TUDELFTGeodesy/Doris/tree/master/sar_tools
- Cut/paste source in new document with your favorite editor
- Save the file in `$HOME/SAR/EXEC/cpxfiddle.cc`
- Edit `$HOME/SAR/EXEC/cpxfiddle.cc` and replace line 1857:
`if (argv[optind]=='\0')`
by
`if (argv[optind]==0 || argv[optind][0]=='\0')`
- In Terminal:
 - o `cd $HOME/SAR/EXEC`
 - o `make -n cpxfiddle`

- `g++ -O -c -ocpxfiddle.o cpxfiddle.cc`
- `g++ -O cpxfiddle.o -o cpxfiddle`
- Clean sources in `$HOME/SAR/EXEC/cpxfiddle.o`
- Store the installed source `cpxfiddle.cc` e.g. in `$HOME/SAR/EXEC/Sources_Installed`
- Update `$PATHTOCPXFIDDLE` in your `.bashrc`. It must be something like
`export PATHTOCPXFIDDLE=${HOME}/SAR/EXEC/`

gnuplot: gnuplot is used e.g. to create time series figures or baseline plots.

- At Terminal:
 - `sudo apt install gnuplot-x11`
 - `which gnuplot`
- Ensure that the path provided by the former command displays the same path as `$PATHGNU` in your `.bashrc`, that is `/usr/bin`

python:

- At Terminal:
 - `sudo apt install python3`
 - `sudo apt install python3-opencv`
 - `sudo apt install python3-numpy`
 - `sudo apt install python3-scipy`
 - `sudo apt install python3-matplotlib`
 - `sudo apt install python3-gdal`
- Check which version is used:
 - at Terminal, type: `python -c 'import sys ; print(sys.path)'`
 - It must answer something like:

```
["", '/usr/bin/python3.8.zip', '/usr/lib/python3.8', '/usr/lib/python3.8/lib-dynload', '/usr/local/lib/python3.8/dist-packages',
'/usr/lib/python3/dist-packages']"
```
 - If a package such as numpy does not load, search where it is stored and check that it is in the same version as your python.

If versions differ, change the default python version with same command as above or try to install an appropriate version of the package.

- Link python to appropriate directory: **It MUST be in `/opt/local/bin/` as it is from there that it will be called by all the scripts:**
 - `sudo mkdir -p /opt/local/bin`
 - `which python3` (To know where it is installed, e.g. `/usr/bin`)
 - `sudo ln -s /usr/bin/python3 /opt/local/bin/python3`
(To make this the default Python, providing that the path is indeed `/usr/bin`)
 - `sudo ln -s /usr/bin/python3 /opt/local/bin/python`
(Just in case... i.e. to be sure that it will be called either as python or python3)
- Install `utm` package, which is used eg. in `_LatLong2UTM.py` script:
 - `pip install --upgrade pip`
 - `sudo apt install python3-pip`
 - `pip install utm`
- Install `pyqt6` package, which is used eg. in `MasterOrganizer.sh` script:
 - `/opt/local/bin/python -m pip install pyqt6`
- Add the path to python (`/opt/local/bin/`) in the `$PATH` in your `bashrc`. To avoid any risk of using another version of python if badly called, **add it in the beginning** of the `$PATH`.

x-terminal-emulator: A terminal emulator is required to open terminal from command line (e.g. when splitting mass processing).

- Install it by typing at the terminal:
 - o *sudo apt install deepin-terminal*

3) Installing MasTer

MasTer consists of several packages that need to be obtained or downloaded from different sources:

- **MasTerEngine** (core parts: InSAR and MSBASTools):
 - See **Preliminary information/Sources and codes** above for Github instructions, or
 - To request the executables, contact: dderauw@ecgs.lu
 - **MasTer Tool (SCRIPTS_MT: mass processing scripts)**:
 - See **Preliminary information/Sources and codes** above for Github instructions, or
 - To request the code, contact ndo@ecgs.lu
 - **MSBAS (2D or 3D inversion time series)**:
 - See **Preliminary information/Sources and codes** above for Github instructions, or
 - Download original version from: <https://doi.org/10.4095/313749>, or
 - Request code tuned for MasTer with a make file adapted to Mac and Linux, contact ndo@ecgs.lu
- In case of problem, contact sergey.samsonov@canada.ca

3.1 Compile **MasTerEngine**:

If executable files were provided (zip file),

- simply unzip it and copy the binaries in `$HOME/SAR/MasTerToolbox/MasTerEngine`
- then store the zipped file in `$HOME/SAR/MasTerToolbox/MasTerEngine/_Sources_ME/Older/Vmostrecent_MasterEngine` where *mostrecent* is the date of the last version, which is in the name of the zip file. This date must be as YYYYMMDD and will be used by some scripts to track (and log) the version used during processing.
- Update `$PATH` in your `.bashrc`. It must be something like `PATH=$PATH:$HOME/SAR/MasTerToolbox/MasTerEngine`

If you were provided with the source code (zip file), simply unzip it in

`$HOME/SAR/MasTerToolbox/MasTerEngine/_Sources_ME/Older/Vmostrecent_MasterEngine`

where *mostrecent* is the date of the last version, which is in the name of the zip file. This date must be as YYYYMMDD and will be used by some scripts to track (and log) the version used during processing. Then,

- In Terminal, in `$HOME/SAR/MasTerToolbox/MasTerEngine/_Sources_ME/Older/Vmostrecent_MasterEngine/MasterEngineYYYYMMDD/InSAR/sources`
type: `make`
- Move all files from `$HOME/SAR/MasTerToolbox/MasTerEngine/_Sources_ME/Older/Vmostrecent_MasterEngine/MasterEngineYYYYMMDD/InSAR/bin`
in `$HOME/SAR/MasTerToolbox/MasTerEngine`
- In Terminal, in `$HOME/SAR/MasTerToolbox/MasTerEngine/_Sources_ME/Older/Vmostrecent_MasterEngine/MasterEngineYYYYMMDD/MSBASTools/sources`
type: `make`
- Move all files from `$HOME/SAR/MasTerToolbox/MasTerEngine/_Sources_ME/Older/Vmostrecent_MasterEngine/MasterEngineYYYYMMDD/MSBASTools/bin`
in `$HOME/SAR/MasTerToolbox/MasTerEngine`

- Clean (delete) the decompressed directories; keep only the zip file in:
`$HOME/SAR/MasTerToolbox/MasTerEngine/_Sources_ME/Older/Vmostrecent_MasterEngine`
- Update `$PATH` in your `.bashrc`. It must be something like
`PATH=$PATH:$HOME/SAR/MasTerToolbox/MasTerEngine`

Note that if you are provided with an updated version of MasTer Engine (source code), you can simply update it by copying the zipped file it in `$HOME/SAR/EXEC` and run the script `/$HOME/SAR/MasTerToolbox/SCRIPTS_MT/zz_Uutilities_MT_Ndo/UpdateMasterEngine.sh` with 2 parameters: the path to the zipped sources file and the date of the version.

3.2 Compile **MSBAS**:

- In Terminal, in `$HOME/SAR/MasTerToolbox/MSBAS/3Dsbas_Archives/msbasv4` decompress `msbas_20201009_wExtract_Unified_20220919_Optimized_v1.1_Gilles.zip`
- In `$HOME/SAR/MasTerToolbox/MSBAS/3Dsbas_Archives/msbasv4/msbas_20201009_wExtract_Unified_20220919_Optimized_v1.1_Gilles`
type: `make all`
(it seems that you can ignore warnings; most recent compilers are more sensitive)
- Move `msbasv4` in: `$HOME/SAR/MasTerToolbox/MSBAS`
- In `$HOME/SAR/MasTerToolbox/MSBAS/3Dsbas_Archives/msbasv4/msbas_20201009_wExtract_Unified_20220919_Optimized_v1.1_Gilles/msbas_extract`
type: `make all`
- Move `msbas_extract` in: `$HOME/SAR/MasTerToolbox/MSBAS`
- Clean (delete) the decompressed directories; keep the sources in `$HOME/SAR/MasTerToolbox/EXEC/Sources_Installed`
- Update `$PATH` in your `.bashrc`. It must be something like
`PATH=$PATH:$HOME/SAR/MasTerToolbox/MSBAS`

3.3 Get the **MasTer Toolbox** scripts at the right place:

- Ensure that the scripts (obtained from Github or from unzipped file) are stored at the right place:
`$HOME/SAR/MasTerToolbox/SCRIPTS_MT`
- Update `$PATH` in your `.bashrc`. It must be something like
`PATH=$PATH:$HOME/SAR/MasTerToolbox/SCRIPTS_MT`
`PATH=$PATH:$HOME/SAR/MasTerToolbox/SCRIPTS_MT/zz_Uutilities_MT`
`PATH=$PATH:$HOME/SAR/MasTerToolbox/SCRIPTS_MT/zz_Uutilities_MT_NdO`
`PATH=$PATH:$HOME/SAR/MasTerToolbox/SCRIPTS_MT/_cron_scripts`
`PATH=$PATH:$HOME/SAR/MasTerToolbox/SCRIPTS_MT/MasterOrganizer`
- If scripts were receiver from a zipped file, it can be stored in `$HOME/SAR/MasTerToolbox/EXEC/Sources_Installed`

3.4 Define the environmental variables:

MasTerEngine, MSBAS and MasTer Toolbox requires environmental variables that will be called from the scripts. These are:

`PATH_SCRIPTS=${HOME}/SAR/MasTerToolbox` : path to **SCRIPTS_MT**
(i.e. the directory containing all the scripts)

`PATHGNU=/usr/bin` : path to where the **gnu utilities** are stored
(**Note:** in case you have several versions of the gnu utilities, it is highly recommended to have the path to **/usr/bin** defined first in your **\$PATH**)

`PATHFIJI=/Applications/Fiji.app/Contents/MacOS/` : path to where **Fiji** application is

`PATHCONV=/usr/bin` : path to where the **convert** command is (from **ImageMagick**)

`PATHTOCPXFIDDLE=${HOME}/SAR/EXEC/` : path to where the **cpxfiddle** command is (from TU Delft)

The path to some disks where data, intermediate results and final results will be stored must also be defined by state variable. At least 5 variables **must be defined**, that is:

`PATH_1650`, `PATH_3600`, `PATH_3601`, `PATH_3602` and `PATH_DataSAR`.

Names are inherited from architecture at ECGS and will be called throughout the processing. For security reason, it is a good practice to have them pointing to different physical drives, if possible, but this is not mandatory; they can also point toward directories instead of disks, e.g.:

<code>PATH_1650=/mnt/hp-1650-Data_Share1</code>	(disk or dir where data or results will be stored)
<code>PATH_3600=/mnt/hp-D3600-Data_Share1</code>	(disk or dir where data or results will be stored)
<code>PATH_3601=/mnt/hp-D3601-Data_RAID6</code>	(disk or dir where data or results will be stored)
<code>PATH_3602=/mnt/hp-D3602-Data_RAID5</code>	(disk or dir where data or results will be stored)
<code>PATH_DataSAR=/mnt/DataSAR/</code>	(disk or dir where auxiliary data will be automatically stored such as orbits, geoid etc... in a dir named SAR_AUX_FILES)

Note also that more disks can be defined and used e.g. for sharing the computation through several disks when intensive computation is required.

When processing ENVISAT or Sentinel 1 data, MasTerEngine will require orbital information. It will usually pick them for you and store them automatically in dedicated directories where it will get them when required. These directories **must be defined** by the following state variable names:

`S1_ORBITS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/ORBITS/S1_ORB`
`ENVISAT_PRECISES_ORBITS_DIR=${PATH_DataSAR}/SAR_AUX_FILES/ORBITS/ENV_ORB/vor_gdr_d`

To create DEM corrected from geoid height, the following state variable must be defined:

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

A directory named **EGM96** must exist in that directory and it must contain the geoid file **WW15MGH.DAC**. It 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>

4) Directory structure for data, auxiliary data and results

In addition to the structure of the installation directories, it is important to store your data, auxiliary data (DEM, masks, kml, orbits, geoid, parameters files...), intermediate results and final results in a structure as described below.

MasTer toolbox expects a directory structure similar as what is shown below. Most of the directories where the intermediate and final results are stored will be created by the scripts based on the information provided in the [LaunchMTparameters.txt](#) file.

For those which must be created by the user (in full or based on name provided in the [LaunchMTparameters.txt](#) file), it is required to follow the following architecture and directories naming.

In *italic green* is the information that must be adapted to your satellite(s), orbital mode(s) and region(s). These directories can be located in the disk(s) you want.

Note that, for safety reasons, it is advised to store e.g. raw data and data in csl format (i.e. from MasTerEngine) on different hard drives, or the mass processed results and the msbas results on different hard drives etc....

Names in **red** are **mandatory**.

Disk 1 (i.e. **PATH_1650**):

PATH_1650/kml	: where to store kml for cropping, or for coherence check
PATH_1650/Param_files_SuperMaster	: where to store your LaunchMTparameters.txt file by /SAT/TRK...
PATH_1650/ SAR_CSL/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 Super Master 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 Amp, Coh, Defo etc...
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/EGM96	: 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

Note that **\$PATH_DataSAR** is the state variable defined in .bashrc !!

Note: In Linux, to mount external drive, you must

- 1) Define the mounting point of your disks, e.g for a disk named "syno_sar":

```
sudo mkdir /mnt/syno_sar
sudo chown yourlogin /mnt/syno_sar
```

- 2) Add them in the [/etc/fstab](#). Example below shows the mounting of a Windows server and a Synology server:

```
# EG FOR A WINDOWS STORAGE SERVER
# IMPORTANT: Leave "cache=none" to avoid issues with 10Gbit Ethernet-Network on eno1
//hp-storeeasy.ecgs.welter/hp-1650-Data_Share1 /mnt/1650 cifs
comment=systemd.automount,username=YOURUSERNAME,password=YOURPWD,uid=YOURID,gid=users,noatime,iochar
set=utf8,rw,mfsymlinks,cache=strict,vers=3.1.1,soft,noserverino,nobrl,nounix 0 0

# EG FOR SYNOLOGY STORAGE
```

```
//syno-sar.ecgs.welter/DataSAR /mnt/syno_sar cifs
comment=systemd.automount,username=YOURUSERNAME,password=YOURPWD,uid=YOURID,gid=1001,ioccharset=utf8,
file_mode=0777,dir_mode=0777,noatime,rw,mfsymlinks,soft,nounix 0 0
```

5) Check installation

5.1 The directory structure

At the end, you should have MasTer installed in a folder named “SAR” as shown in **Fig. 1**.

```
/$HOME/SAR/EXEC
|--Executables...
|--Sources_Installed

/$HOME/SAR/MasTerToolbox
|--DOC
|   |--Biblio
|   |--MasTerEngine
|   |--MasTer_Toolbox
|   |--MSBAS
|
|--MasTerEngine
|   |--_Sources_ME/Older
|   |   |--[several sources of old versions]
|   |   |--V20230828_MasTerEngine
|   |--Executables...
|
|--MSBAS
|   |--3Dsbas_Archives
|   |   |--msbasv4
|   |--Executables...
|
|--SCRIPTS_MT
|   |--_cron_scripts
|   |--MasTerOrganizer
|   |--optimtoolbox
|   |--TemplatesForPlots
|   |--TSCombiFiles
|   |--zz_Uilities_MT
|   |--zz_Uilities_MT_Ndo
|   |--A lot of scripts...
```

Figure 1 – Directory structure required for the proper usage of MasTer Toolbox.

Notes:

- 1) The folders `/$HOME/SAR/MasTerToolbox/MasTerEngine/_Sources_ME/Older` is used to store the archives and the most recent sources of both components of MasTerEngine, that is **InSAR** and **MSBASTools**.

Their latest executable version, when compiled, must be moved to `/$HOME/SAR/MasTerToolbox/MasTerEngine/`.

Hence, when a new version of these packages is available, no need to change the paths of the environmental variables.

- 2) Similarly, the folders `/$HOME/SAR/MasTerToolbox/MSBAS/_3Dsbas_Archives` is used to store the archives and the most recent sources of both components of MSBAS, that is **MSBAS_EXTRACT** and **MSBAS*i*** (where *i* stands for the version). Their latest

executable version, when compiled, must be moved to [/HOME/SAR/MasTerToolbox/MSBAS/](#).

Hence, when a new version of these packages is available, no need to change the paths of the environmental variables.

- 3) You can use the script **Check_Installation.sh** to check your installation. See script and manual.

You should also have auxiliary files stored in a folder named "SAR_AUX_FILES" in [DataSAR](#) as shown in **Fig. 2**.

```
$PATH_DataSAR/SAR_AUX_FILES/
|--DEM
|--EGM96
|   |--WW15MGH.DAC
|--Masks
|--ORBITS
|   |--ENV_ORB
|   |--S1_ORB
```

Figure 2 – Directory structure required for the storage of auxiliary files required by MasTer Toolbox.

Notes:

- 1) The folders [/PATH_DataSAR/SAR_AUX_FILES/DEM/](#) is used to store the DEM. It may be associated to a state variable [\\$EXTERNAL_DEMS_DIR](#) used automatically by MasTer Engine. However, for the automation with MasTer Toolbox, to avoid possible confusion, the path to the DEM for each run is rather given in the [LaunchMTparameters.txt](#) file.
- 2) The folders [/PATH_DataSAR/SAR_AUX_FILES/EGM](#) **must** contain the geoid file in [EGM96/WW15MGH.DAC](#).
- 3) The folders [/PATH_DataSAR/SAR_AUX_FILES/MASK](#) is not mandatory, but it is a convenient place to store the mask you would build and used during your processing.
- 3) The folders [/PATH_DataSAR/SAR_AUX_FILES/ORBITS](#) **must** contain the orbits for ENVISAT (if required) or Sentinel 1 (if required). These directories must be associated to the state variable [\\$ENVISAT_PRECISES_ORBITS_DIR](#) and [\\$S1_ORBITS_DIR](#) respectively.

5.2 The environmental variables in .bashrc

At the end, your `./bashrc` must look like:

```
# ~/.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

[...]

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

# trick to avoid error at usage of say function
alias say='echo | espeak -s 120 2>/dev/null'

# MasTer PATHS
#####

PATH=$PATH:/home/YourAccount/SAR/MasTerToolbox/MasTerEngine/_Sources_ME
PATH=$PATH:/home/YourAccount/SAR/MasTerToolbox/SCRIPTS_MT/MasTerOrganizer
PATH=$PATH:/usr/local/tigervnc/bin/
PATH=$PATH:/home/YourAccount/SAR/EXEC
PATH=$PATH:/home/YourAccount/SAR/MasTerToolbox/MSBAS
PATH=$PATH:/home/YourAccount/SAR/MasTerToolbox/MasTerEngine
PATH=$PATH:/home/YourAccount/SAR/MasTerToolbox/SCRIPTS_MT/zz_Uutilities_MT_Ndo
PATH=$PATH:/home/YourAccount/SAR/MasTerToolbox/SCRIPTS_MT/zz_Uutilities_MT
PATH=$PATH:/home/YourAccount/SAR/MasTerToolbox/SCRIPTS_MT/_cron_scripts
PATH=$PATH:/home/YourAccount/SAR/MasTerToolbox/SCRIPTS_MT
PATH=$PATH:/home/YourAccount/SAR/MasTerToolbox/SCRIPTS_MT/optimtoolbox

# MasTer VARIABLES
#####

export OPENBLAS_NUM_THREADS=1
export JAVA_HOME="/usr/lib/jvm/java-11-openjdk-amd64"
export PATH_HOMEDATA=/mnt/dell3raid5/
export PATH_SynoData=/mnt/syno_data/
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=${PATH_DataSAR}/SAR_AUX_FILES/ORBITS/S1_ORB
export PATH_SCRIPTS=/home/YourAccount/SAR/MasTerToolbox
export PATHCONV=/usr/bin
export PATHFIJI=/home/YourAccount/SAR/EXEC/Fiji.app/
export PATHGNU=/usr/bin
export PATHTOCPXFIDDLE=/home/YourAccount/SAR/EXEC/
export PATH=$PATH

#export OMP_NUM_THREADS=10,8,4
#export OMP_NUM_THREADS=4,3,2

# Trick to avoid error at usage of say function
alias say='echo | espeak -s 120 2>/dev/null'
```

6) Operating with cron jobs

If you want to operate **MasTer** toolbox from cron jobs, pay attention to the following:

- All variable environments are defined here in the **.bashrc** which is designed for interactive shell. Whatever you do, it won't be sources from scripts if it starts 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
```
- It is advised to source the **.bashrc** from the **.bash_profile**
- It is advised to define all your state variables at the beginning of your bashrc
- It is advised to launch scripts by redirecting the messages to /dev/null to avoid filling up the mailbox by ending the command line with:

```
> /dev/null 2>&1
```
- You can launch your commands in the crontab as follow (supposing that the path to your bash in /bin):

```
mm hh *** exec /bin/bash -l /path/to/script arg1 arg2 ... > /dev/null 2>&1
```

Example of crontab:

```
# Edit this file to introduce tasks to be run by cron.
# 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/dell3raid5"
PATH_SCRIPTS=/home/nicolas/SAR/MasTerToolbox
```

```
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
```

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

```
## ## Domuyo 03h05; 5h35; 17h30
05 03 *** cd /home/nicolas/SAR/MasTerToolbox/SCRIPTS_MT/_cron_scripts/; bash -l -c './Domuyo_S1_Step1_Read_SMCReg_Pairs.sh'
35 05 *** cd /home/nicolas/SAR/MasTerToolbox/SCRIPTS_MT/_cron_scripts/; bash -l -c './Domuyo_S1_Step2_MassProc.sh'
30 17 *** cd /home/nicolas/SAR/MasTerToolbox/SCRIPTS_MT/_cron_scripts/; bash -l -c './Domuyo_S1_Step3_MSBAS.sh'
```

7) In case of insufficient RAM

It may happen that your Linux computer runs out of RAM and MSBAS inversion can't be completed. See the document "[Create_Swap_Linux.pdf](#)" which explains how to create a swap file on a Linux computer.

8) Updates in this manual

V 4.1 (October 26 2022):

- add installation of gnu parallel
- add chapter “7) Updates in this manual”

V 4.3 (April 20 2023):

- Refer to last versions of software and scripts
- Check against installer script

V 4.4 (June 27 2023):

- Add reference to technical note on how create swap file

V 5.0 (Aug 30 2023):

- Major changes in dirs and files naming
- Take into account new MasTer Engine V20230828 which is mandatory