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

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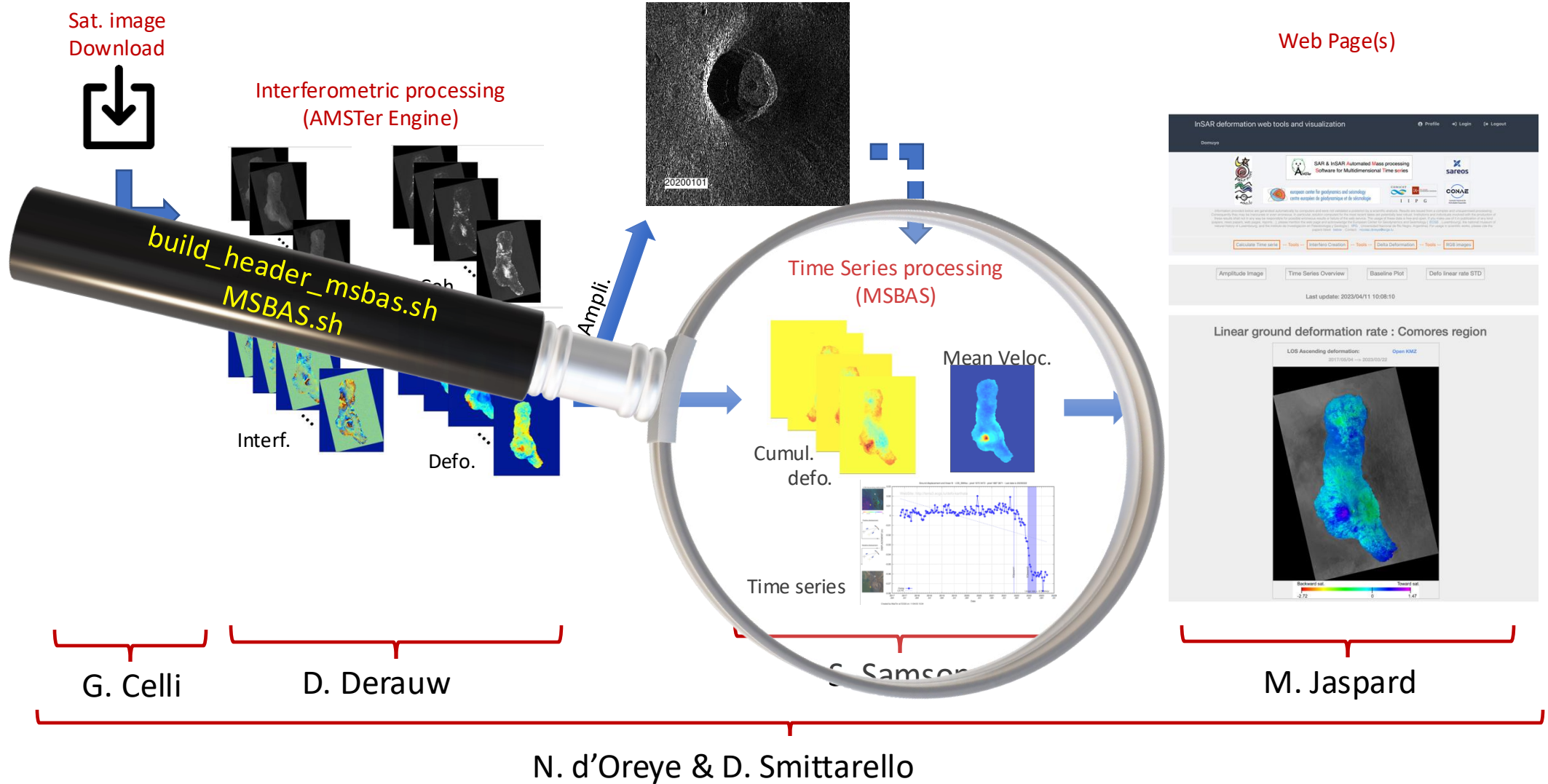
Plan:

Preparing the msbas inversion:

- build_header_msbas_criteria.sh
- The header.txt

Running the msbas inversion:

- MSBAS.sh
- SBAS, MSBAS 2D, MSBAS 3D

Selecting the best inversion parameters:

- test_lcurve.sh

Additional pairs selection:

- Coherence threshold
- Start – stop dates
- Optimisation (cfr Delphine) or Max 3 times
- Phase closure

Hands-on exercice 3 with data on
Domuyo - Laguna del Maule

Preparing the msbas inversion:

- **build_header_msbas_criteria.sh**

  ➢ First step consist in preparing the required files for MSBAS, that is

  - A directory where to run the inversion, e.g. *$3602*/MSBAS/*YourRegion_and_Some_Info*

  - A directory containing the (links to the) deformation maps for each mode to invert, e.g.
    $3602/MSBAS/*YourRegion_and_Some_Info*/DefoInterpolx2Detrend*i*

  - A file listing the deformation maps for each mode to invert along with some info, e.g.
    $3602/MSBAS/*YourRegion_and_Some_Info*/DefoInterpolx2Detrend*i.txt*

  /Volumes/hp-D3602-Data_RAID5/MSBAS/_Domuyo_S1_Auto_20m_450days/DefoInterpolx2Detrend1.txt ▾

  ```
  1   DefoInterpolx2Detrend1/deformationMap.interpolated.flattened.UTM.50x50.bil.interpolated_S1_ARG_DOMU_LAGUNA_A_18-36.2deg_20170429_20170517_Bp-11.2m_HA1247.m_BT18days_Head106.3deg -11.24840315551214 20170429 20170517
  2   DefoInterpolx2Detrend1/deformationMap.interpolated.flattened.UTM.50x50.bil.interpolated_S1_ARG_DOMU_LAGUNA_A_18-36.2deg_20170429_20171113_Bp-14.2m_HA986.6m_BT198days_Head106.3deg -14.21692611793151 20170429 20171113
  3   DefoInterpolx2Detrend1/deformationMap.interpolated.flattened.UTM.50x50.bil.interpolated_S1_ARG_DOMU_LAGUNA_A_18-36.2deg_20170429_20171125_Bp-7.15m_HA1960.m_BT210days_Head106.3deg -7.157866784961501 20170429 20171125
  4   DefoInterpolx2Detrend1/deformationMap.interpolated.flattened.UTM.50x50.bil.interpolated_S1_ARG_DOMU_LAGUNA_A_18-36.2deg_20170429_20171207_Bp-8.19m_HA1711.m_BT222days_Head106.3deg -8.197533034650927 20170429 20171207
  5   DefoInterpolx2Detrend1/deformationMap.interpolated.flattened.UTM.50x50.bil.interpolated_S1_ARG_DOMU_LAGUNA_A_18-36.2deg_20170429_20180205_Bp-6.20m_HA2259.m_BT282days_Head106.3deg -6.206981104693649 20170429 20180205
  6   DefoInterpolx2Detrend1/deformationMap.interpolated.flattened.UTM.50x50.bil.interpolated_S1_ARG_DOMU_LAGUNA_A_18-36.2deg_20170429_20180313_Bp-2.82m_HA4967.m_BT318days_Head106.3deg -2.823428235143036 20170429 20180313
  7   DefoInterpolx2Detrend1/deformationMap.interpolated.flattened.UTM.50x50.bil.interpolated_S1_ARG_DOMU_LAGUNA_A_18-36.2deg_20170429_20180406_Bp10.02m_HA-1398m_BT342days_Head106.3deg 10.02870116689994 20170429 20180406
      DefoInterpolx2Detrend1/deformationMap.interpolated.flattened.UTM.50x50.bil.interpolated_S1_ARG_DOMU_LAGUNA_A_18-36.2deg_20170429_20180524_Bp14.57m_HA-961.m_BT390days_Head106.3deg 14.57809257251186 20170429 20180524
  ```

  - A header file containing the description of the
    data sets and the chosen parameters for the inversion

  ```
  FORMAT = 0
  FILE_SIZE = 5361, 4801
  WINDOW_SIZE = 0, 5360, 0, 4800
  R_FLAG = 3, 0.04
  T_FLAG = 0
  C_FLAG = 0
  V_FLAG=0
  I_FLAG = 0
  SET = 0, 232707, 344, 36.4002, DefoInterpolx2Detrend1.txt
  SET = 0, 095628, -162.711, 36.2386, DefoInterpolx2Detrend2.txt
  ```

Preparing the msbas inversion:

- **build_header_msbas_criteria.sh**

  ➢ To prepare these required files for MSBAS:

    1. Create and go into a directory where to run the msbas *$3602*/MSBAS/*YourRegion_and_Some_Info*
       <u>Here, do e.g.:</u>
       mkdir *$3602*/MSBAS/*_Argentina_S1_20m_450days_NoOptim*
       cd *$3602*/MSBAS/*_Argentina_S1_20m_450days_NoOptim*

    1. Run the ***build_header_msbas_criteria.sh*** script with the followng parameters:
       - the name of the mode (eg. DefoInterpolx2Detrend) and the number of modes
       - Max Bp and Bt to select the pairs to invert
       - the path to where the mass processed are stored for each mode (e.g. where the Geocoded/ directory is), e.g.
         …$PATH_3601/SAR_MASSPROCESS/*SAT*/*TRK*/SM*Crop_SM_ZOOM_ML*/
       <u>Here, do e.g.:</u>
       build_header_msbas_criteria.sh DefoInterpolx2Detrend 2 20 450
         PATH_3601/SAR_MASSPROCESS/S1/ARG_DOMU_LAGUNA_A_18_SAMPLE/SMNoCrop_SM_20180512_Zoom1_ML4/
          PATH_3601/SAR_MASSPROCESS/S1/ARG_DOMU_LAGUNA_D_83_SAMPLE/SMNoCrop_SM_20180222_Zoom1_ML4

  ➢ Note that it must be run in the directory where msbas will be run.

Preparing the msbas inversion:

- **build_header_msbas_criteria.sh**

  ➢ Warning: it will need to access the deformation maps which are stored in the provided path, that is e.g.

    …$PATH_3601/SAR_MASSPROCESS/*SAT/TRK*/SM*Crop_SM_ZOOM_ML*/Geocoded/*DefoInterpolx2Detrend*

    but also access to some info (baselines, acquisition time, azimuth, look angle…) that are in the pair directories, eg.

    …$PATH_3601/SAR_MASSPROCESS/*SAT/TRK*/SM*Crop_SM_ZOOM_ML/MAS_SLV/*i12/…

    However, if you have cleaned these pair directories to spare room on your disk, you can use the script
    build_header_msbas_criteria_From_nvi_name_WithoutAcqTime.sh
    It will get approximate information found in the deformation maps names. However, it will not find the acquisition time, which you will have to add manually in the header file (even a dummy time, that is OK).
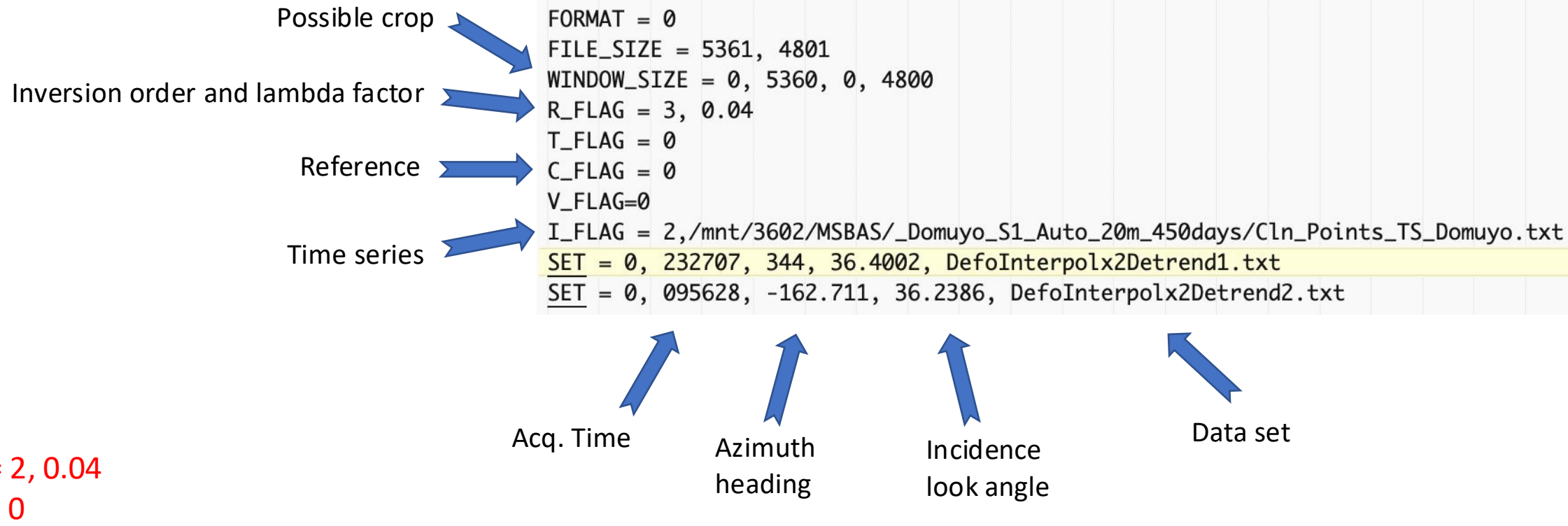   This script is however only for test purpose and may not be accurate !

  ➢ Incremental: slower the first time, faster the next one…

Preparing the msbas inversion:

- build_header_msbas_criteria.sh
- **The header.txt**

Edit and change according to your needs (example below may differ from your data):

Possible crop →

Inversion order and lambda factor →

Reference →

Time series →

```
FORMAT = 0
FILE_SIZE = 5361, 4801
WINDOW_SIZE = 0, 5360, 0, 4800
R_FLAG = 3, 0.04
T_FLAG = 0
C_FLAG = 0
V_FLAG=0
I_FLAG = 2,/mnt/3602/MSBAS/_Domuyo_S1_Auto_20m_450days/Cln_Points_TS_Domuyo.txt
SET = 0, 232707, 344, 36.4002, DefoInterpolx2Detrend1.txt
SET = 0, 095628, -162.711, 36.2386, DefoInterpolx2Detrend2.txt
```

Acq. Time

Azimuth heading

Incidence look angle

Data set

Set e.g.
R_FLAG= 2, 0.04
I_FLAG = 0

Preparing the msbas inversion

Running the msbas inversion:

- **MSBAS.sh**

  ➢ Run the **MSBAS.sh** script with the following parameters:
    - a description used for naming directories where results will be sorted (eg. *_Order_Lambda_Info*)
    - a list of pixels for which you want to extract simple time series (with error bar)
    Here, do e.g.:
      MSBAS.sh _2_0.04_NoCrop

  ➢ It will run in parallel with all the available CPUs

  In case of crash:

  ➢ Check DefoInterpolx2Detrend*i*.txt for bad links or duplicated lines: **_Check_bad_DefoInterpolx2Detrend.sh**

  ➢ Check the baseline plot: **PlotBaselineGeocMSBASmodeTXT.sh**

  ➢ Check non empty deformation in given zone: **Check_Interfero_Not_Empty_In_Zone.sh**

  ➢ Check and remove broken links: **Remove_BrokenLinks_and_Clean_txt_file.sh**

  ➢ Check that you have enough RAM; crop if needed

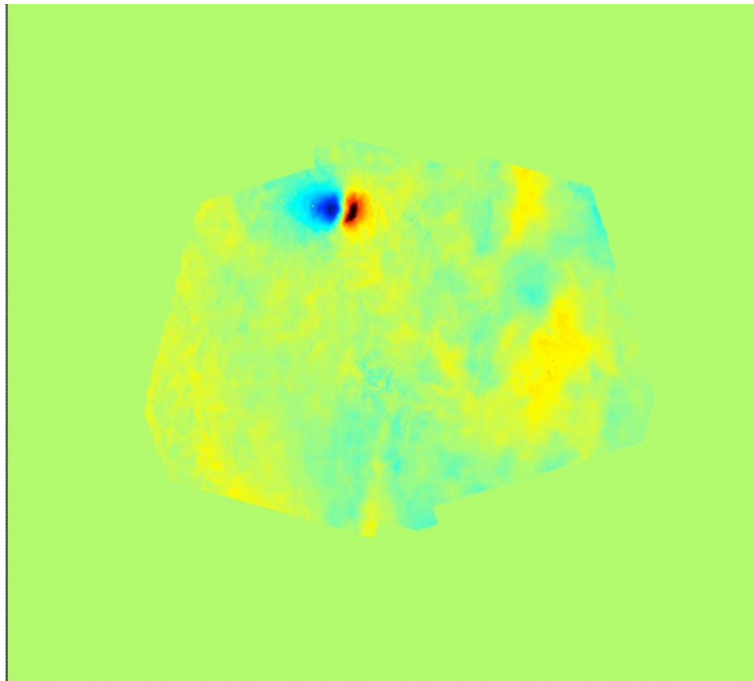 ➢ If complains about KMLSUPEROVERLAY (only needed to create kml file), check gdal

  ➢ …

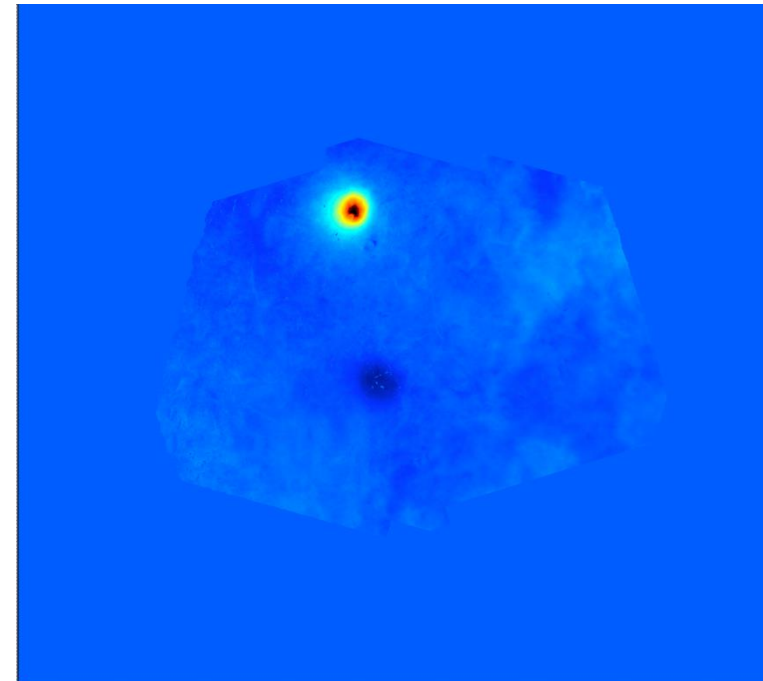**Preparing the msbas inversion**

Running the msbas inversion:

- **MSBAS.sh**

Results:

EW linear rate

UD linear rate

…/3602/MSBAS/_Argentina_S1_20m_450days_NoOptim/zz_*Comp*_2_0.04_NoCrop

Preparing the msbas inversion

Running the msbas inversion:

- MSBAS.sh

- **SBAS, MSBAS 2D, MSBAS 3D**

➢ If enough looking angle diversity is provided, msbas will perform a 2D decomposition.

➢ If only one mode is provided, or if similar incidence angles, it will perform a (mean) SBAS inversion

➢ To perform 3D inversion when movement is supposed to take place of the steepest slope, one needs additional constrains (i.e. gradient).
See MSBASv10_notheory_processing_manual_Sergey.pdf

Change header file and add required files accordingly
Scripts are under development for that 3D application
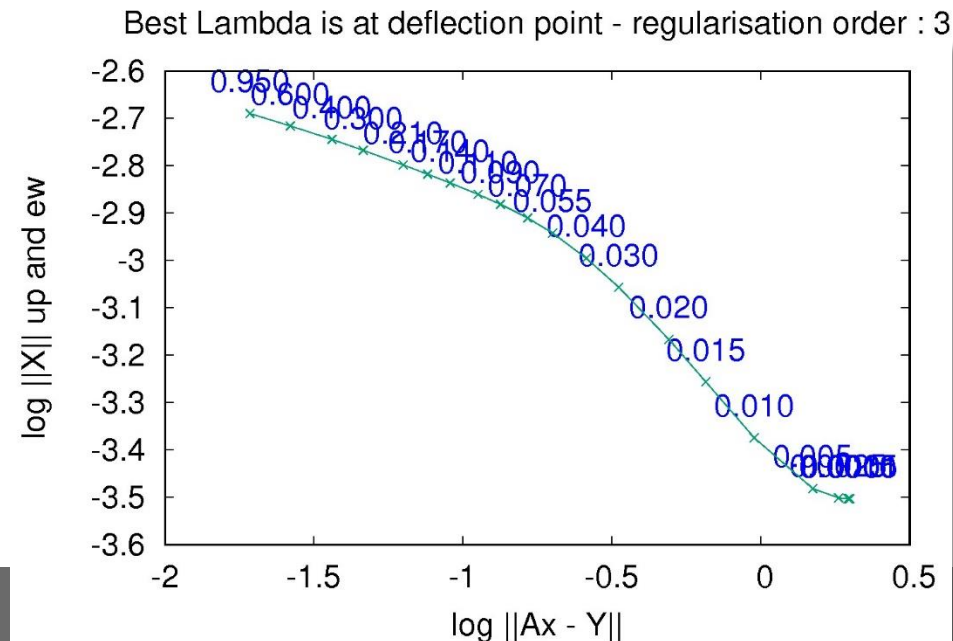(filtering of DEM must be fine tuned; See ***Add_NS_comp_msbas.sh***).
➔ commin soon…

Preparing the msbas inversion
Running the msbas inversion

Selecting the best inversion parameters:

- **test_lcurve.sh**

  ➤ Search for best lambda factor for each regularisation order.

  ➤ Based on a table of steps of lambda *Steps_LCurve.txt*
    (in SCRIPTS_MT) for which it will run each time an
    msbas inversion (➜ time consuming !)

  ➤ Output l-curves where the kink in the curve points to
    the best lambda factor.
    Larger value will lead to stronger smoothing.

```
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
```


Best Lambda is at deflection point - regularisation order : 3
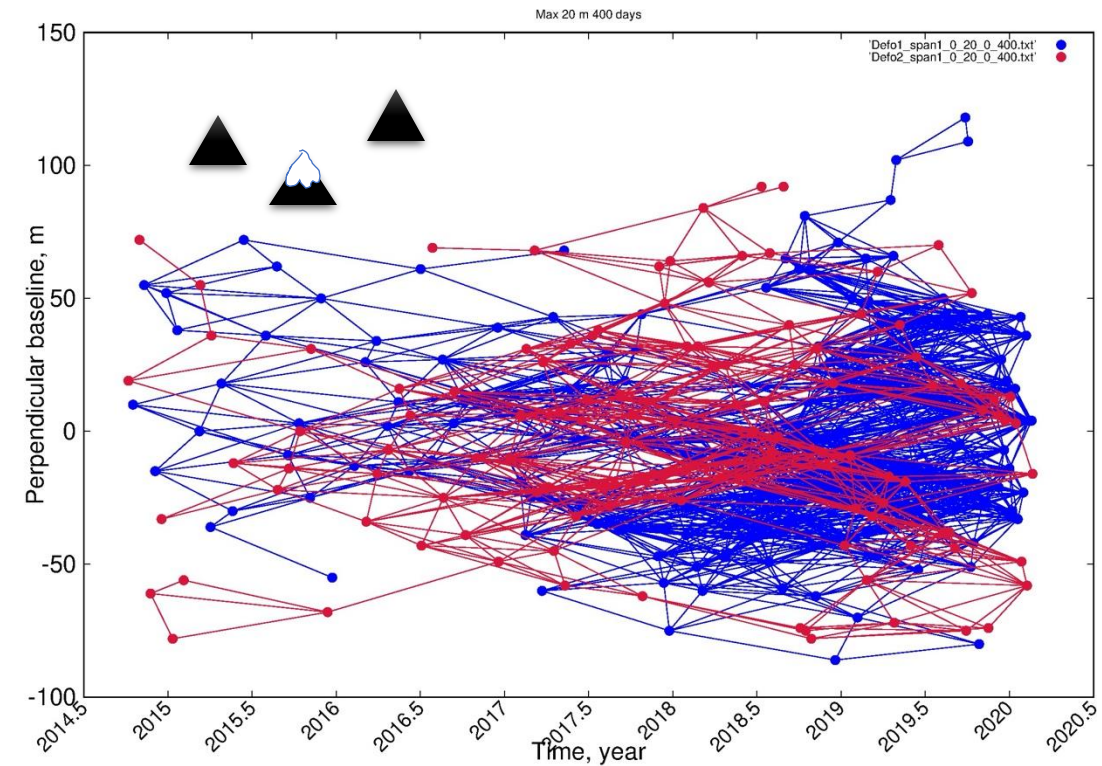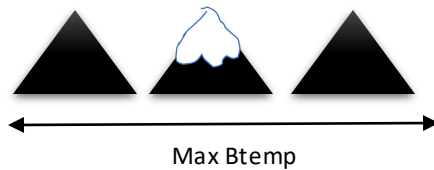
Preparing the msbas inversion
Running the msbas inversion
Selecting the best inversion parameters

Additional pairs selection:

- **Coherence threshold**

If the selectedd temporal baseline is long enough to keep coherent pairs from summer to summer, it may happen that, in the mean time, the winter would cause decorrelation between summer and winter time:
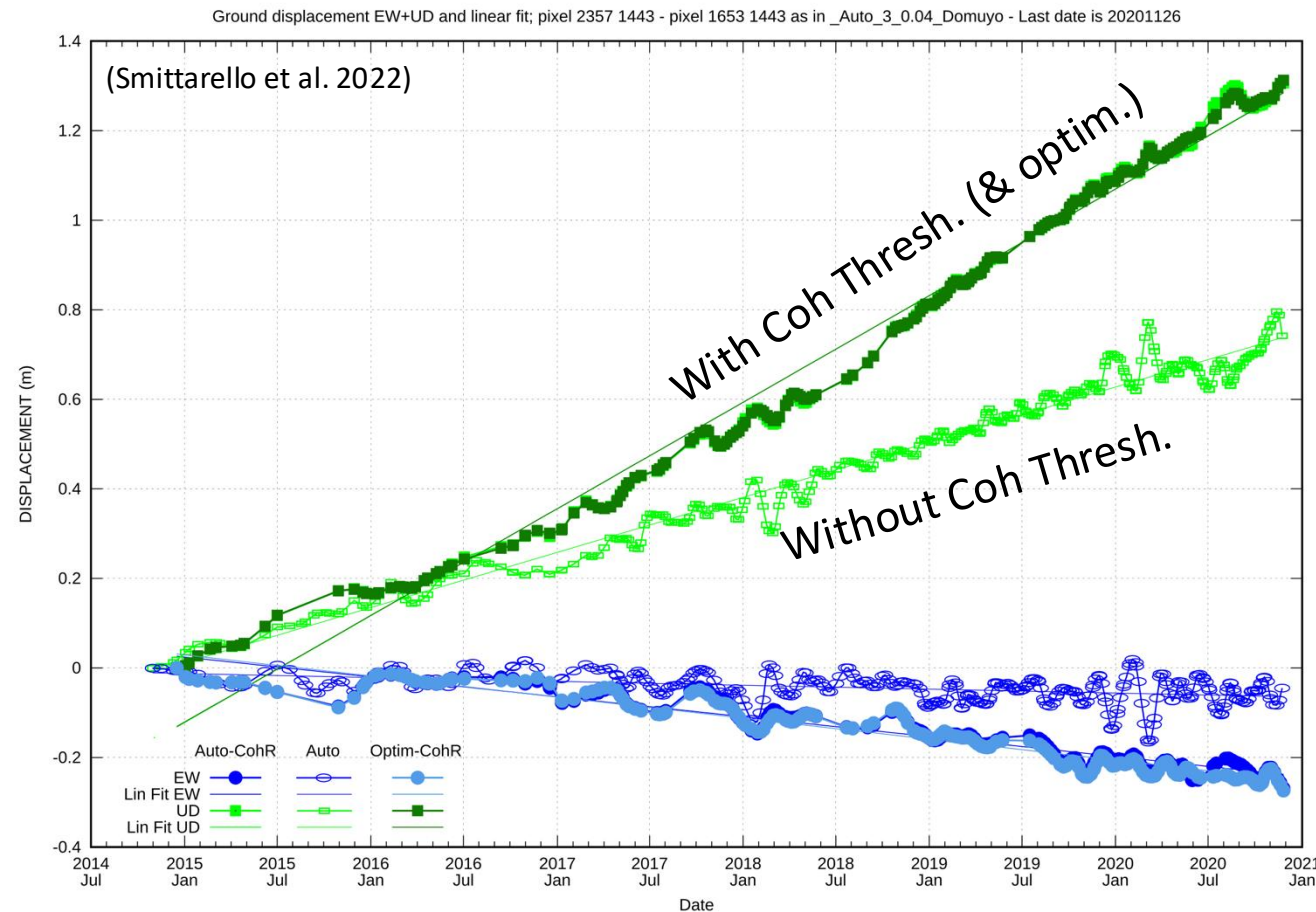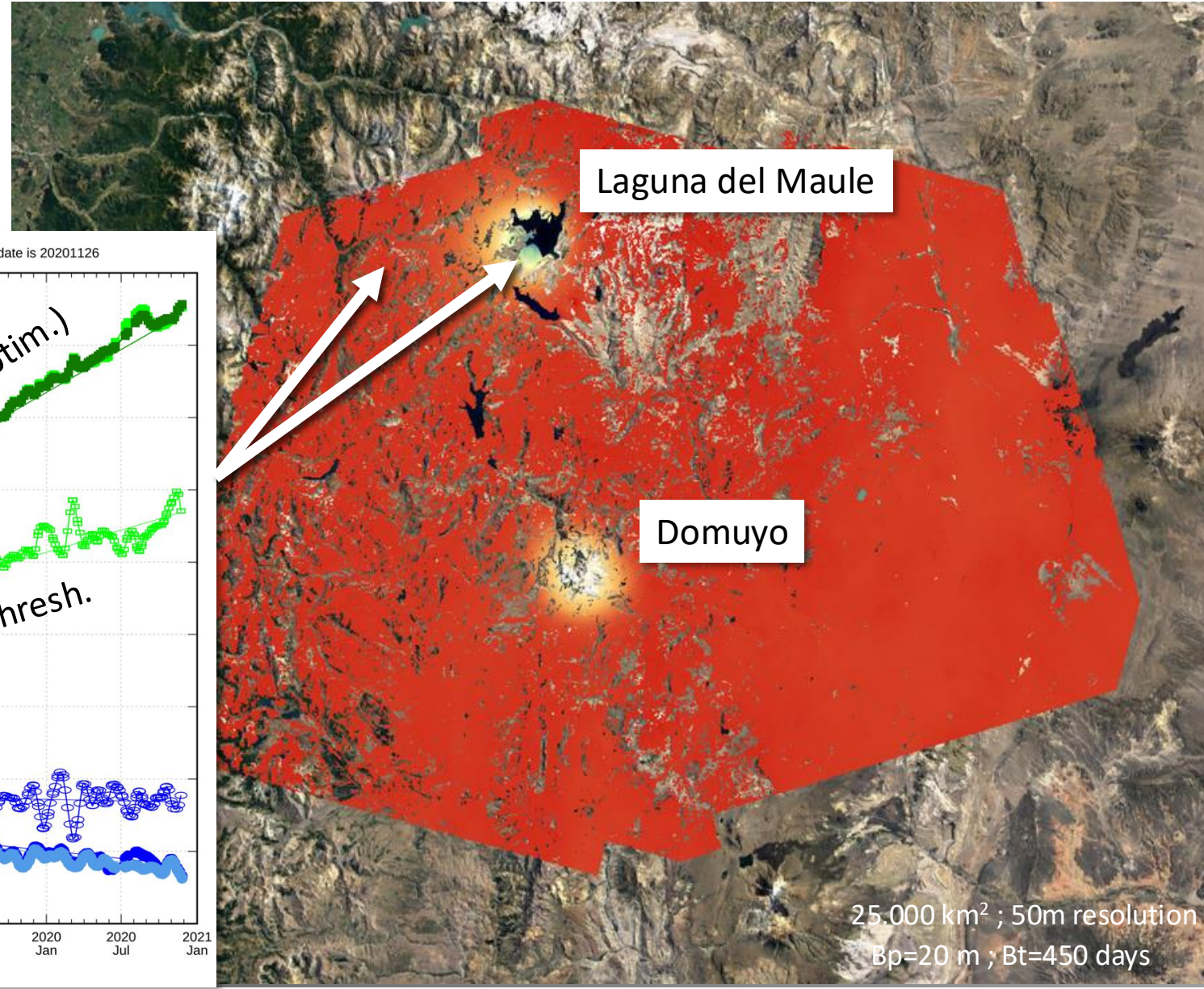
Max Btemp

Studies have shown that it could lead to severe signal underestimation (Smittarello et al. 2022) !

2014-2020: Sentinel 1:
- Full: 2666 interferograms
- With Coh Threshold: 1013
- Optimized => -75 %

(Smittarello et al. 2022)

Ground displacement EW+UD and linear fit; pixel 2357 1443 - pixel 1653 1443 as in _Auto_3_0.04_Domuyo - Last date is 20201126

Laguna del Maule

Domuyo

25.000 km^2 ; 50m resolution
Bp=20 m ; Bt=450 days

Preparing the msbas inversion
Running the msbas inversion
Selecting the best inversion parameters

Additional pairs selection:

- **Coherence threshold**

  ➢ Use the script ***restrict_msbas_to_Coh.sh*** with the following parameters:
    - Mode to clean, eg. DefoInterpolx2Detrend*i*
    - a coherence threshold
    - the path to a kml where mean coherence must be computed
    - the path to the directory where the geocoded coherence maps are stored, e.g
      SAR_MASSPROCESS/*SAT*/*TRK*/*REGION_ML*/Geocoded/Coh

    => it creates the necessary files in …/MSBAS_RESULTS/LOCATION/MODE*i*

  ➢ Use the script ***Exclude_Pairs_From_Mode.txt.sh*** with the following parameter:
      $3602/MSBAS/*YourRegion_and_Some_Info*/DefoInterpolx2Detrend*i*

  ➢ Execute ***MSBAS.sh*** as before (provides a meaningful text string for directory naming)

  ➢ Note: Coherence threshold selection is incremental ➔ slower the first time, faster the next ones…

Preparing the msbas inversion

Running the msbas inversion

Selecting the best inversion parameters

Additional pairs selection:

- Coherence threshold

- **Start – stop dates**

  ➤ To restrict the computation of MSBAS to images acquired before or after a given date, use the scripts:

    - *RemovePairsFromFlist_WithImagesAfter.sh*

    - *RemovePairsFromFlist_WithImagesBefore.sh*

  ➤ Similarily, to restrict the computation of MSBAS to images acquired between or without images acquired between a given pair of dates, use the scripts:

    - *RemovePairsFromTableList_Between_dates.sh*

    - *RemovePairsFromTableList_Outside_dates.sh*

  ➤ We will see later how we can plot ground deformation times series (from msbas results) for given pixels. These plots of time series can also be restricted to given dates, but that is not the same ! Here we restrict the inversion.

Preparing the msbas inversion
Running the msbas inversion
Selecting the best inversion parameters

Additional pairs selection:

- Coherence threshold
- Start – stop dates
- **Optimisation (cfr Delphine Smitarello's ppt) or restrict pair selection to Max 3 times**

  ➢ See 6_AMSTer_Optimisation.pptx for optimisation based on Coherence or Coherence proxy etc..

  ➢ To restrict the computation of MSBAS to images taken max 3 times as Master and 3 times as Slave, run these scripts (see manual or scripts):

    - *Extract_Baselines_3.sh*

    - *Keep_Pairs_From_Extract_Baseline_3.sh*

Preparing the msbas inversion
Running the msbas inversion
Selecting the best inversion parameters

Additional pairs selection:

- Coherence threshold
- Start – stop dates
- Optimisation (cfr Delphine Smitarello's ppt) or Max 3 times
- **Phase closure**

    To search for possible interferograms affected by unwrapping error by checking phase closure consistency between triangles of pairs, run the following scripts:

    ➢ ***Extract_Triangles.sh*** to list all the triangles from the list of pairs
       (eg $PATH_1650/SAR_SM/MSBAS/*Region*/set*i*/table_*0_MaxBp_0_MaxBt*.txt)
       saved in a file _Triangles/*List_Triangels.txt*.

    ➢ ***Check_Closure_All_Triangles.sh*** to check unwrapping error in all triangles. It computes the mean phase based on a kml provided as parameter and consider that there is or there is no phase closure error based on an offset provided also as a parameter. It outputs 3 files in …/SAR_MASSPROCESS/*SAT/TRK/REGION_ML*/Geocoded/_CheckTriangles.txt/:
    _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***

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To test phase closure with Argentine dataset (beware: need ***Check_Closure_All_Triangles.sh*** > V1.4):

➢ ***Extract_Triangles.sh*** $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/table_0_20_0_450.tx

    lists all triangles in $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/_Triangles/*List_Triangles.txt* i.e. including those for which you do not
    have pair directories in SAR_MASSPROCESS ➔ make artificial list with only 2022 and 2023 pairs, eg.
        grep 2022 *List_Triangles.txt* > *List_Triangles_2022-2023.txt*
        grep 2023 *List_Triangles.txt* >> *List_Triangles_2022-2023.txt*
        grep –v 2021 *List_Triangles_2022-2023.txt* > *List_Triangles_2022-2023-no2020.txt* (maybe also without 2020..)

➢ ***Check_Closure_All_Triangles.sh*** $PATH_1650/SAR_SM/MSBAS/ARGENTINE/set1/_Triangles/*List_Triangles_2022-2023-no2020.txt*
    $PATH_3601/SAR_MASSPROCESS/S1/ARG_DOMU_LAGUNA_A_18_SAMPLE/SMNoCrop_SM20180512_Zoom1_ML4/Geocoded/DefoInterpolx2Detrend
    $PATH_1650/kml/ARGENTINA/LagunaDelMaule_TestPhaseClosure.kml 0.9

    lists $PATH_3601/SAR_MASSPROCESS/*SAT*/*TRK*/*REGION_ML*/Geocoded/_CheckTriangles.txt/*_Good_Closure.txt*
    and $PATH_3601/SAR_MASSPROCESS/*SAT*/*TRK*/*REGION_ML*/Geocoded/_CheckTriangles.txt/*_Wrong_Closure.txt*
    and $PATH_3601/SAR_MASSPROCESS/*SAT*/*TRK*/*REGION_ML*/Geocoded/_CheckTriangles.txt/_Pairs_To_Clean_From_WrongClosure_NotIn_GoodClosure.txt
    (and ignore the triangles for which there is no pair directories in SAR_MASSPROCESS)

➢ Wrong pairs in _Pairs_To_Clean_From_WrongClosure_NotIn_GoodClosure.txt can be rejected from MSBAS by running
    Remove_Pairs_From_BaselineOptimisation.sh $PATH_3602/MSBAS/_Argentina_S1_20m_450days/DefoInterpolx2Detrend1
    $PATH_3601/SAR_MASSPROCESS/*SAT*/*TRK*/*REGION_ML*/Geocoded/_CheckTriangles.txt/_Pairs_To_Clean_From_WrongClosure_NotIn_GoodClosure.txt

➢ Do the same for DefoInterpolx2Detrend2 if required

➢ Run again ***MSBAS.sh*** after having renamed the DefoInterpolx2Detrend*i*_Optimized__Pairs_To_*CleanPFrom*…..txt as DefoInterpolx2Derend*i*.txt

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Selecting the best inversion parameters:

- test_lcurve.sh

Additional pairs selection:

- Coherence threshold
- Start – stop dates
- Optimisation (cfr Delphine Smitarello's ppt) or Max 3 times
- Phase closure

- DONE ! -

MasTer Toolbox

To crunch the SAR and InSAR mass processing

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