



# Welcome to the 2<sup>nd</sup>



## Summer School in InSAR, time series processing and deformation modelling

***“If you need InSAR... MasTer it !”.***

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Remotely: Sergey Samsonov

Assisted by:  
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## Summer School in InSAR, time series processing and deformation modelling

- Module 1 (3 days) -

### MasTer Toolbox: InSAR Mass Processing chain for ground deformation time series

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## Summer School in InSAR, time series processing and deformation modelling

- Module 2 (1 day) -

### DefVolc: tools for 3D inverse modelling of deformation data

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with: Y. Fukushima, F. Dabaghi, O. Bodart, M. Tridon, D. Smittarello, Q. Dumont,  
J.-L. Froger, C. Wauthier, C. Cattelain, C. Gouinaux

## Why MasTer toolbox ?

Ever growing SAR database:

- Need automation
- Need optimization
- Need incremental

+ Opportunities from archives (several old satellites)





# Introduction to MasTer Toolbox



## What is MasTer toolbox for ?

- Processing single pair interferograms (any satellite) for
  - Ground deformation
  - DEM
- Mass processing of InSAR pairs (any satellite) for
  - Ground deformation
  - Amplitude time series (geomorphological changes, flood or fire mapping...)
  - Coherence time series (land cover changes, flood or fire mapping...)
- MSBAS inversion (combination of any satellites) for
  - Ground deformation time series in LoS and/or 2D (3D)



# Other processing chains

| Process. chain                      | (InSAR processor) | All sat. inc. S1 SM | Combine sat. | Atmo corr | S1 WS stitching automatic | Parallelized | Pair selec. optim. | Ampli-Coh TS | Incremental | Auto-eval. | Free  | Web - GIS | PS | SBAS  | 2/3 D | Enh. Spect. D. | Coh Threshold | Gap proof | Coh. Proxy | Ref  |
|-------------------------------------|-------------------|---------------------|--------------|-----------|---------------------------|--------------|--------------------|--------------|-------------|------------|-------|-----------|----|-------|-------|----------------|---------------|-----------|------------|--|
| <b>MasTer (MasTer Engine)</b>       | V                 | V                   | X            | V         | V                         | V            | V                  | V            | V           | V          | V     | V         | X  | V     | V     | X              | V             | V         | V          | (Derauw et al. 2020)<br>(d'Oreye et al. 2021)          |
| <b>LiCSBAS (Gamma)</b>              | ?                 | X                   | V            | ?         | V                         | ?            | 3                  | X            | V           | V          | V (X) | V         | X  | V     | X     | V              | V             | Lin       | X          | (Morishita et al. 2020)<br>(lazecky et al. in prep.)   |
| <b>MOUNTS (SNAP)</b>                | X                 | X                   | X            | X         | V                         | X            | X                  | V            | V           | V          | V     | V         | X  | X     | X     | ?              | X             | X         | X          | (Valade et al. 2019)                                   |
| <b>SARVIEWS (Gamma)</b>             | X (V)             | X                   | V            | V         | V                         | ?            | 1                  | V            | X           | ?          | ?     | (X)       | V  | X     | X     | ?              | X             | X         | X          | (Meyer et al. 2019)                                    |
| <b>OSARIS (GMTSAR)</b>              | X (V)             | X                   | V            | V         | V                         | V            | 1                  | V            | V           | V          | V     | V         | X  | X (V) | X     | V              | V             | X         | X          | (Loibl et al. 2019)<br>(Sandwell et al. 2016)          |
| <b>MTInSAR (PSIG @ CTTC)</b>        | X (V)             | X                   | Filt         | ?         | V                         | ?            | V                  | ?            | X           | ?          | X     | ?         | X  | V     | V     | ?              | ?             | ?         | X          | (Palama et al. 2022)<br>(Devanthery et al. 2014)       |
| <b>SNAP-StaMPS (SNAP)</b>           | X                 | X                   | V            | V         | V                         | ?            | X                  | X            | X           | ?          | V     | ?         | V  | X     | 1D    | V              | X             | X         | X          | (Delgado Blasco et al. 2019)<br>(Foumelos et al. 2018) |
| <b>P-SBAS / GEP</b>                 | X                 | X                   | V            | X         | V                         | V            | 3                  | X            | X           | ?          | ?     | V         | X  | V     | V     | V              | X             | ?         | X          | (Cigna & tapete, 2021)<br>(De Luca et al. 2018)        |
| <b>FLATSIM-NSBAS (ROI_PAC)</b>      | X(V)              | X                   | V            | X         | V                         | V            | V                  | C            | ?           | V          | ?     | V         | X  | V     | X     | V              | X             | ?         | X          | (Thollard et al., 2021)<br>(Doin et al. 2012)          |
| <b>MintPy (ROI_PAC, ISCE, GAM.)</b> | V                 | X                   | V            | V         | ?                         | V            | V                  | X            | ?           | V          | V     | X         | X  | V     | X     | ?              | V             | ?         | X          | (Yunjun et al. 2019)                                   |
| <b>SqueeSAR® (ALTAMIRA)</b>         | X                 | X                   | ?            | ?         | V                         | V            | ?                  | ?            | V           | ?          | X     | ?         | V  | X     | V     | ?              | ?             | ?         | ?          | (Raspini et al. 2018)<br>(Bischoff et al. 2020)        |

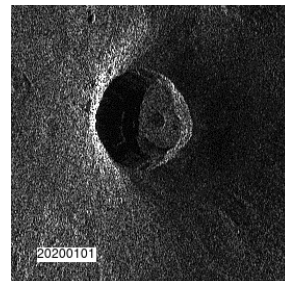
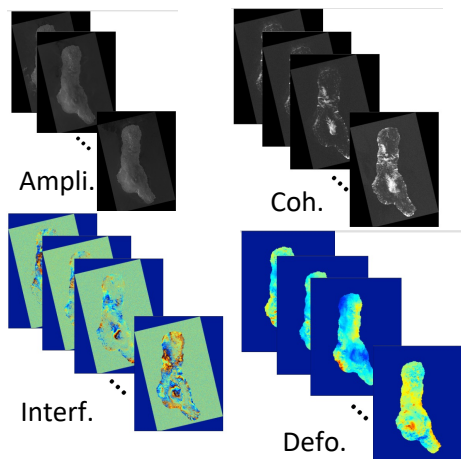
Also: RapidSAR, InSAR Viewer (ISCE/MindPy), INSARMAPS, ARIA – JPL, GIANt, StaMPS/MTI (DORIS), SARPROZ....

# MasTer Toolbox

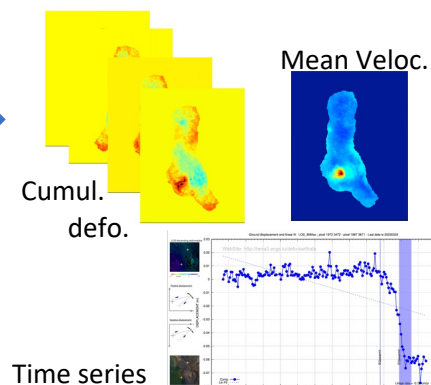
Sat. image  
Download



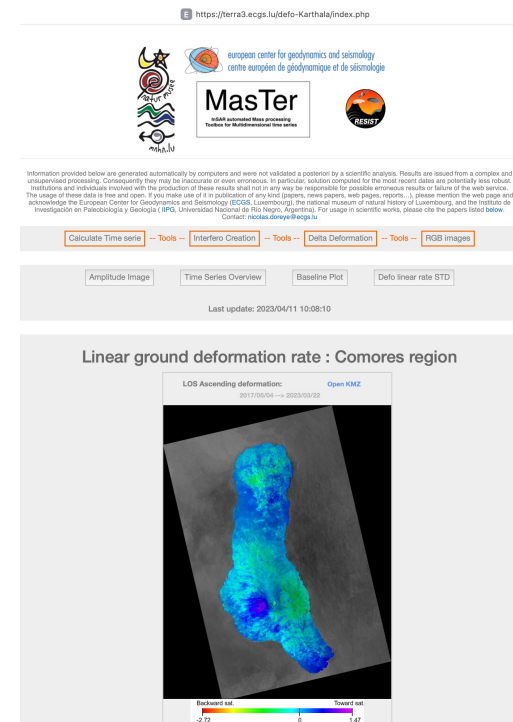
Interferometric processing  
(MasTer Engine)



Time Series processing  
(MSBAS)



Web Page(s)



G. Celli

D. Derauw

S. Samsonov

M. Jaspard

N. d'Oreye & D. Smittarello



## MasTer Engine ?

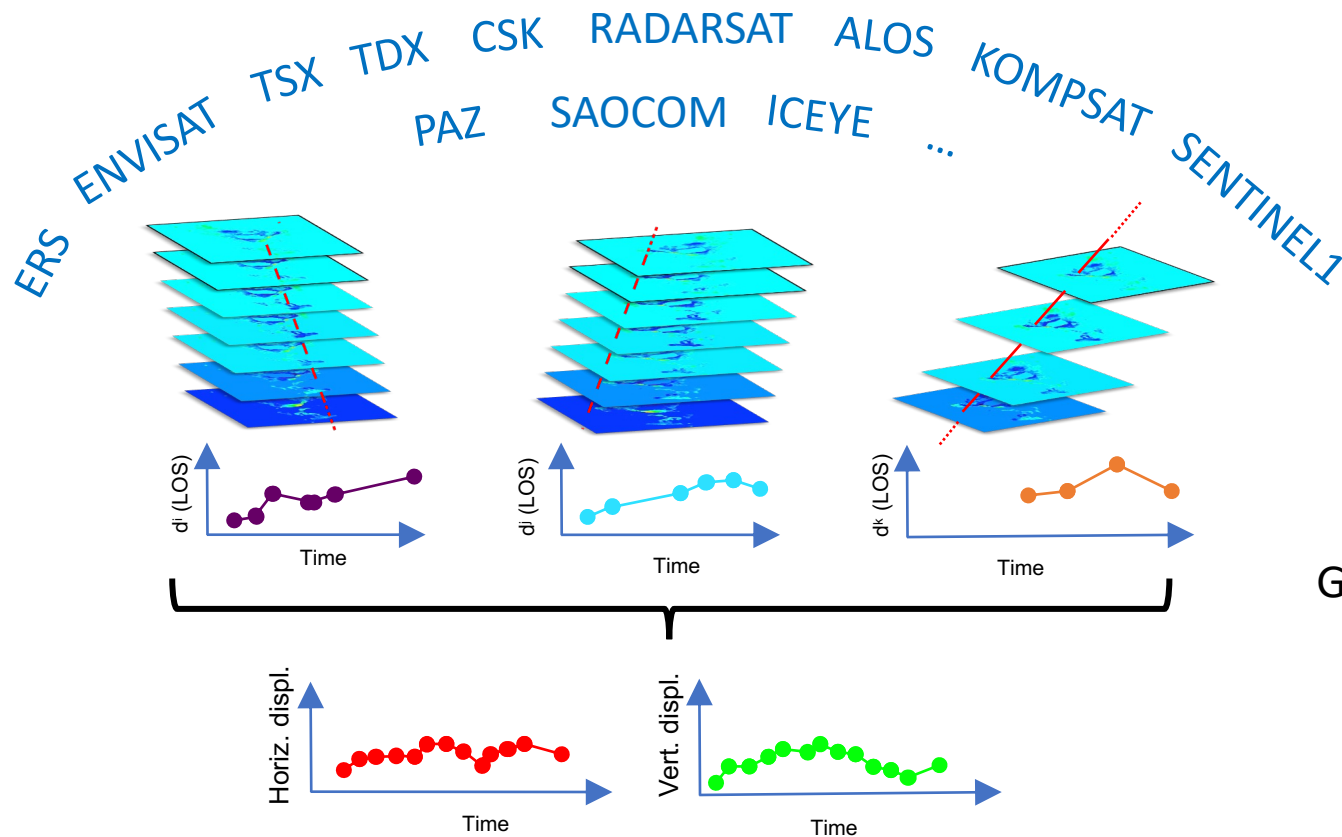
- Based on CSL InSAR Suite (CIS) (D. Derauw, 1999)
- Compatible with nearly all satellites
- Only command line
- Innovative functions
  - Eg. Split Band Interf., Sigma Nough calibration, Zoom, S1 Burst stitching...
- Several unwrapping methods
  - SNAPHU, Branch Cut, DetPhUn





## MSBAS : Multidimensional Small Baseline Subset

(S. Samsonov & N. d'Oreye, 2012, 2017)



$$\text{SBAS : } A^k V_{\text{los}}^k = \Phi_{\text{obs}}^k \quad \rightarrow \quad V_{\text{los}} = A^+ \Phi_{\text{obs}}$$

$$\rightarrow \quad d_{\text{los}}^{i+1} = d_{\text{los}}^i + V_{\text{los}}^{i+1} \Delta t^{i+1}$$

$$\text{Generalization : } V_{\text{los}} = \mathbf{VS} = S_N V_N + S_E V_E + S_U V_U$$

$$\begin{bmatrix} S_N^k A, S_E^k A, S_U^k A \end{bmatrix} \cdot \begin{bmatrix} V_N, V_E, V_U \end{bmatrix}^T = \Phi_{\text{obs}}^k$$

## MasTer toolbox: a set of scripts

- Make all automatic (images downloads → Web Page w/ 2D time series)
- Optimized (parallel computing; share results between processings)
- Incremental (new image/new orbit)
- Secure (storage on separate disks)
- Self evaluating
- Output ready for work (in satellite coord. or GIS)
- Various tools for installation, organize, evaluate, tests, repair, display...
- Multiplatform (Linux & Mac)

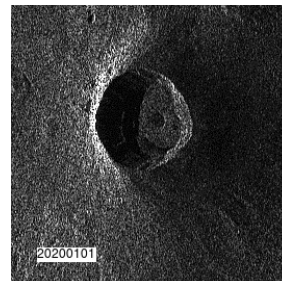
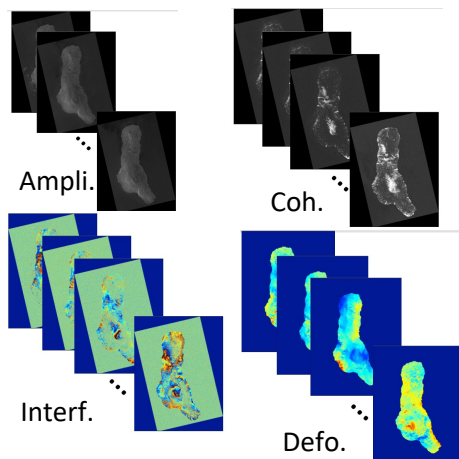


# MasTer Toolbox

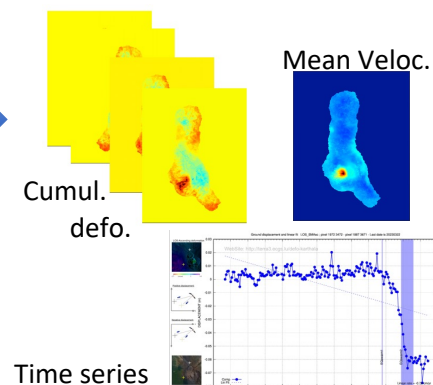
Sat. image  
Download



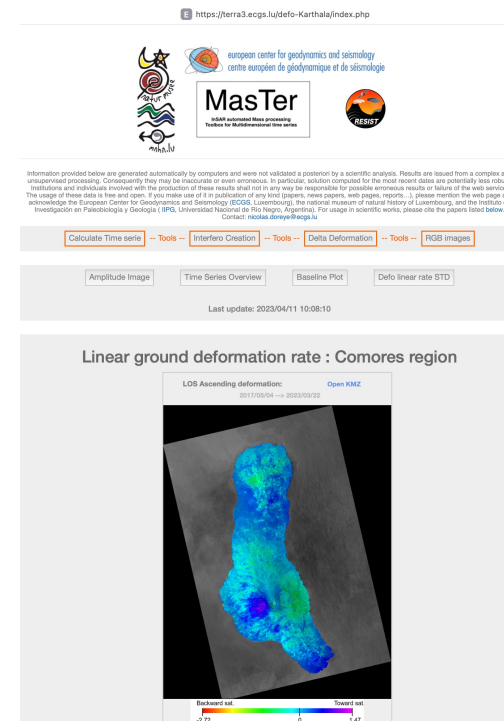
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