

A New Optimisation Tool for Automatic InSAR Time Series Processing with MasTer

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1 - European Center for Geodynamics and Seismology, 19 rue Josy Welter, L-7256 Walferdange, Gd Duchy of Luxembourg

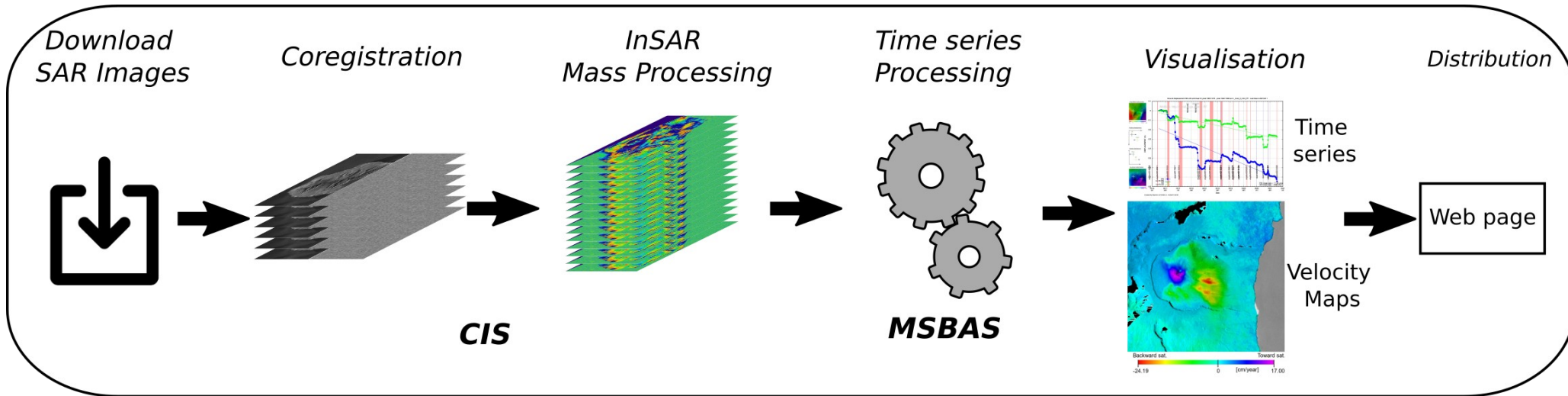
2 - National Museum of Natural History, Department of Geophysics/Astrophysics, Rue Josy Welter 19, L-7256 Walferdange, Grand-Duchy of Luxembourg

3 - Laboratorio de Estudio y Seguimiento de Volcanes Activos (LESVA), IIPG-Universidad Nacional de Río Negro - CONICET, 1242 Av. General Roca, 8332, General Roca, Argentina

4 - Centre Spatial de Liège (CSL), Avenue du Pré Aily, B-4031 Angleur, Belgium

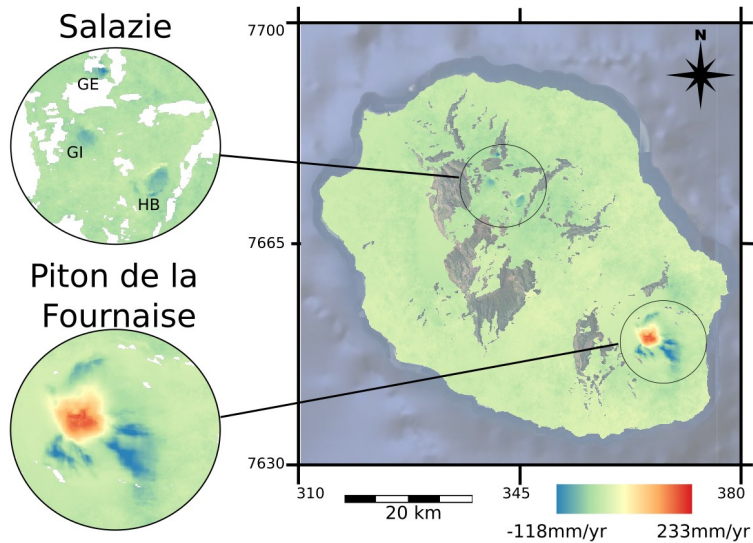
5 - Canada Center for Mapping and Earth Observation, Natural Resources Canada (NRCAN), 560 Rochester Street, Ottawa, ON K1A 0E4, Canada

MasTer : A Fully Automatic InSAR Time Series Processor



A toolbox designed for ground deformation monitoring in near real time

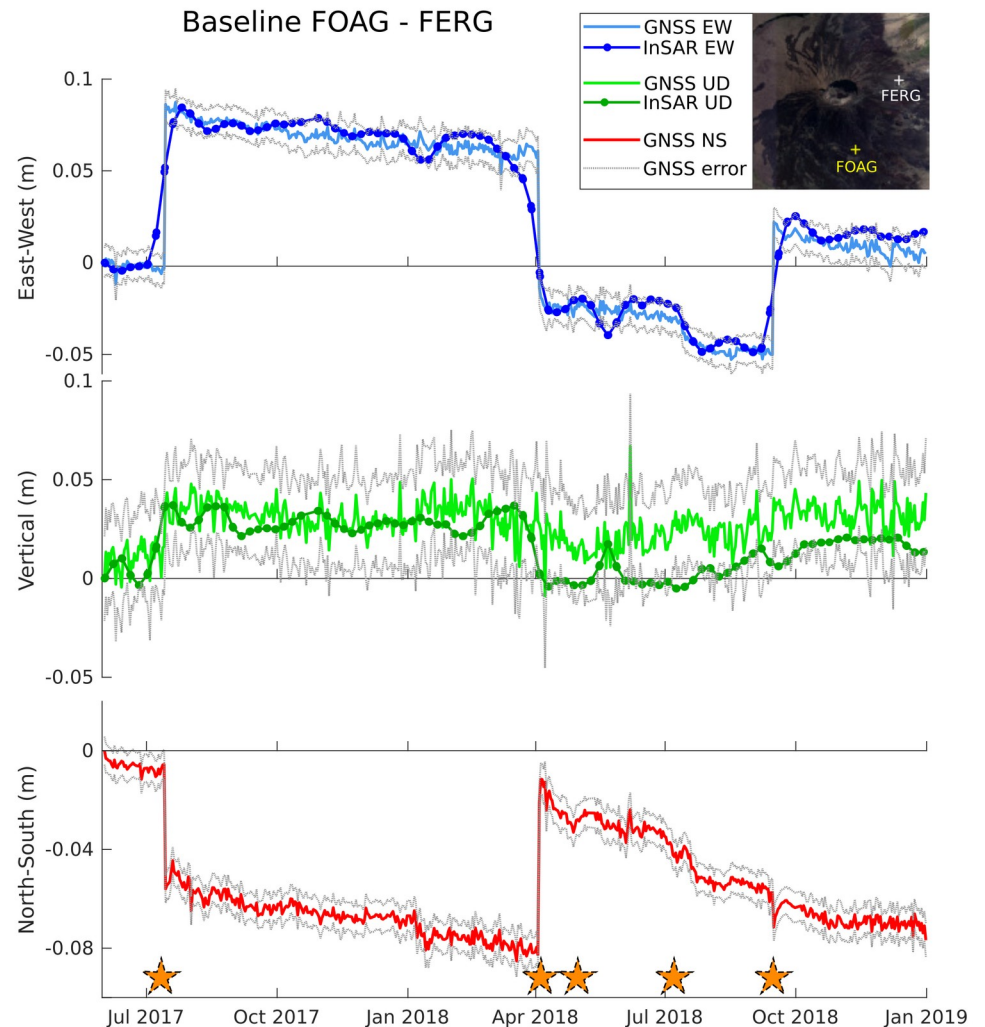
Velocity Maps



Detection of

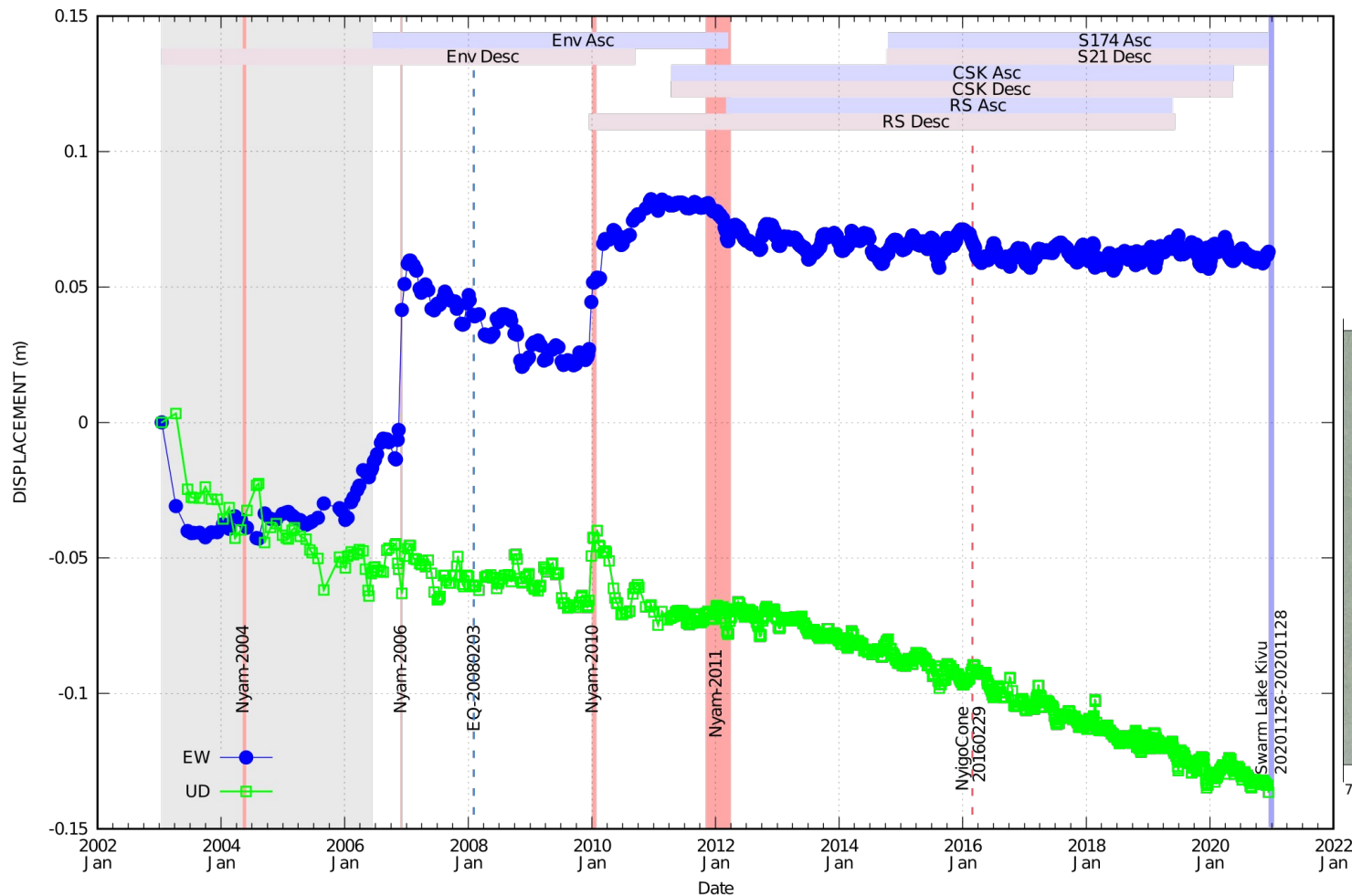
- Landslides
- Volcano deformation
- ...

2D Time Series



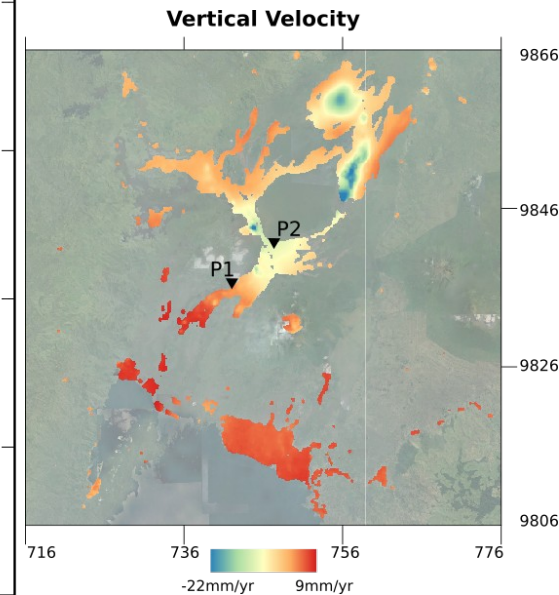
Validation obtained by comparing to GNSS ground deformation measurements

Ability to use multiple sensors allows to produce long time series



Created by MasTer at ECGS on: 14/01/21 09:05

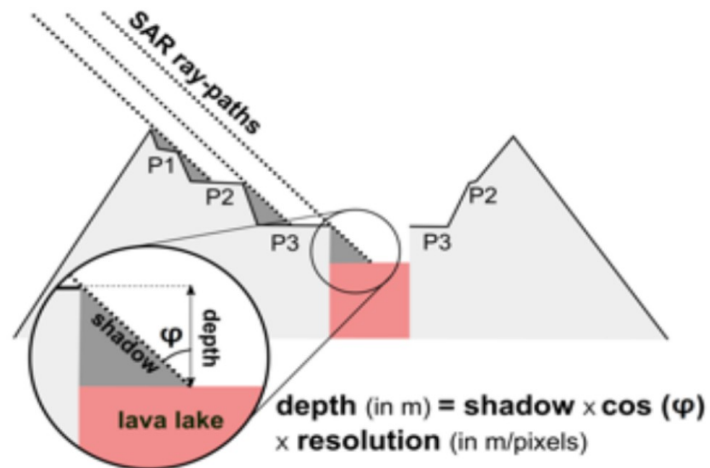
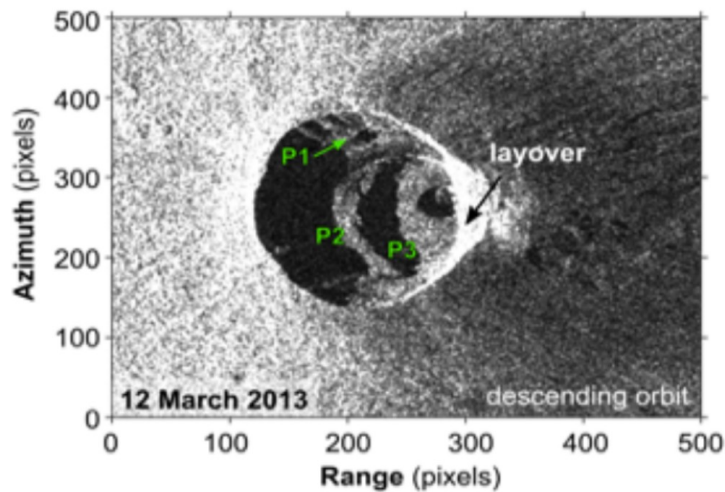
- ENVISAT
- RADARSAT
- CosmoSkyMed
- Sentinel-1



~18 years of deformation monitoring in the Virunga

Lava lake level monitoring

Make use of
crater rim
shadow in
amplitude
image



Nyiragongo monitoring using SAR shadows (S1) | Last day : 20-Dec-2020

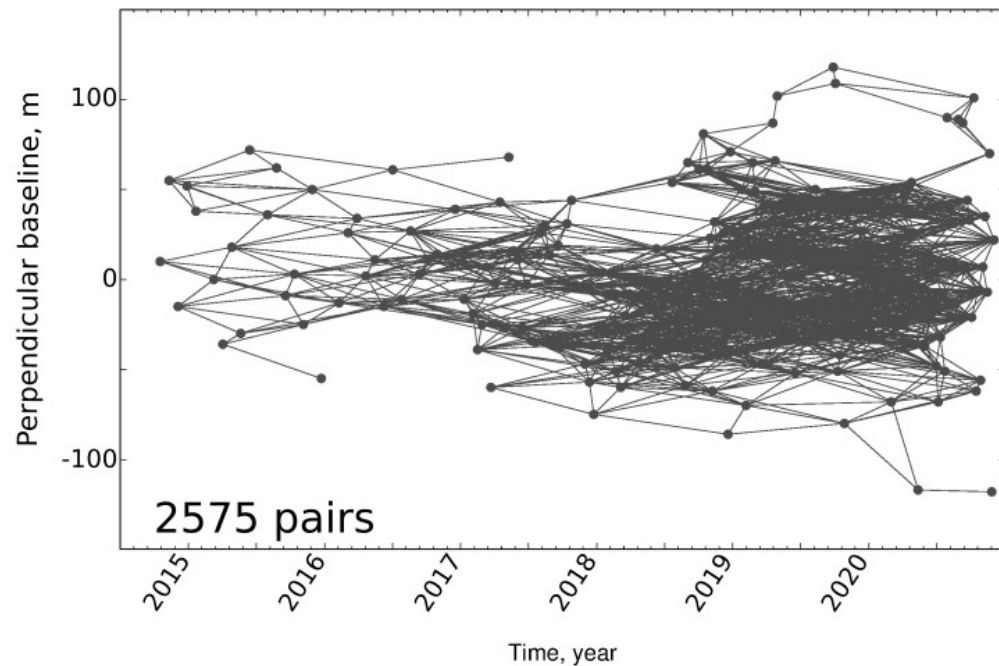


- How to deal with very large and size increasing databases ?
- Time consuming
- Computer resources consuming
- Large data storage requirement

Optimization of Pair Selection - Result

BT/BP criteria

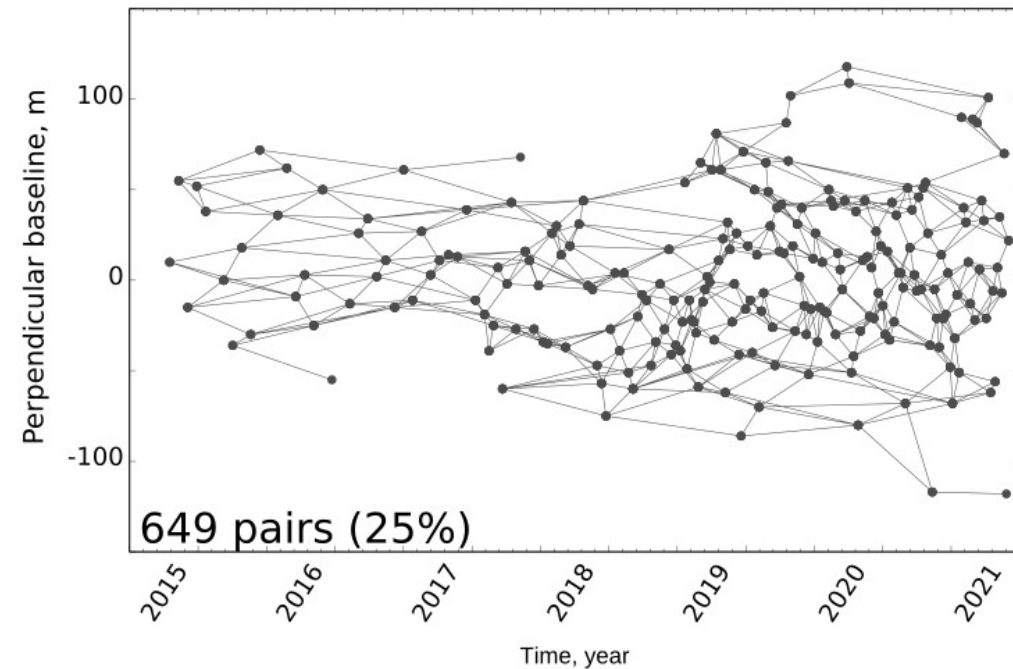
Max 20 m 400 days



***Time Baseline plot of Sentinel-1 Ascending
InSAR data on the Virunga***

BT/BP criteria + Graph Optimization

Max 20 m 400 days



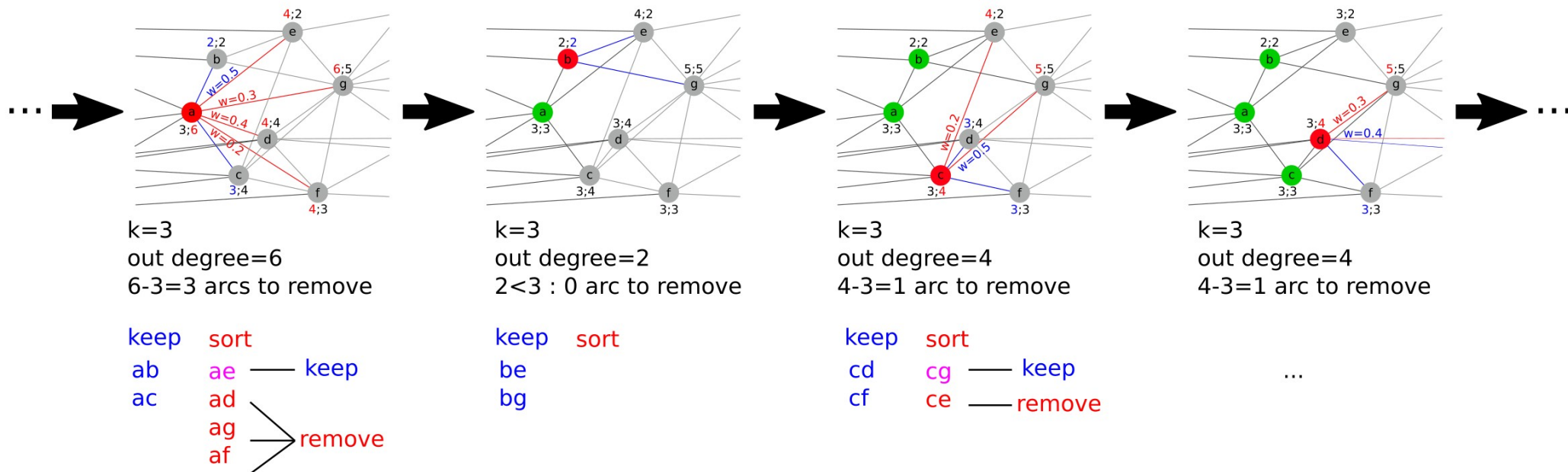
- ***Symmetric use of each image***
- ***Keep best quality pairs***

Optimization of Pair Selection - Algorithm

A Graph Point of View

Images = Nodes

Interferograms = Arcs



An iterative procedure

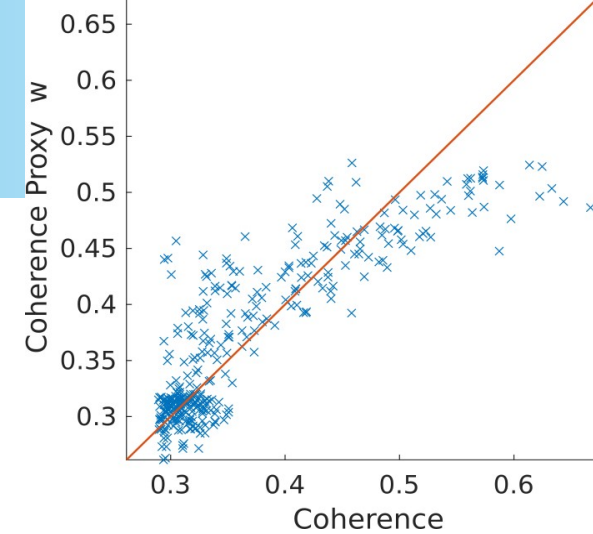
k-selection = extraction of a subgraph respecting maximum in-degree and out-degree of each node $< k$

Selection based on a coherence proxy

Weighted sum of 3 components

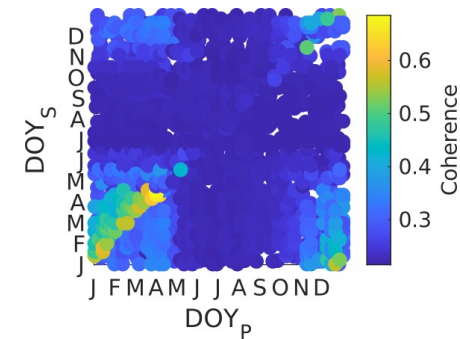
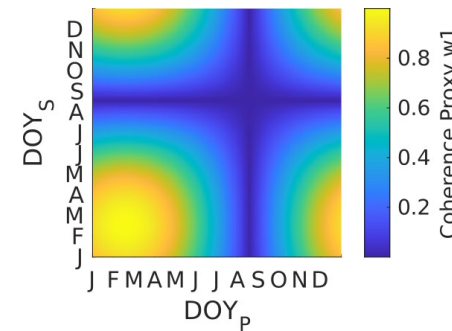
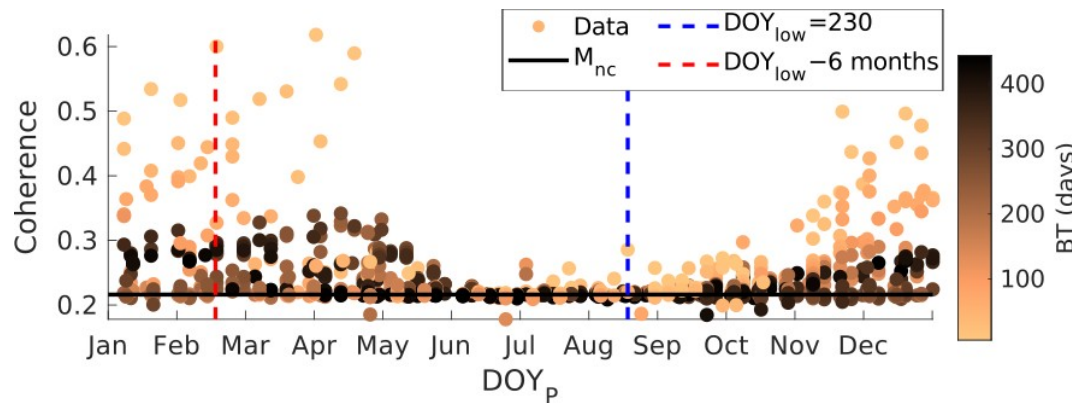
a, b, c : inverted weighting coefficient

$$w = aw_1 + bw_2 + cw_3$$



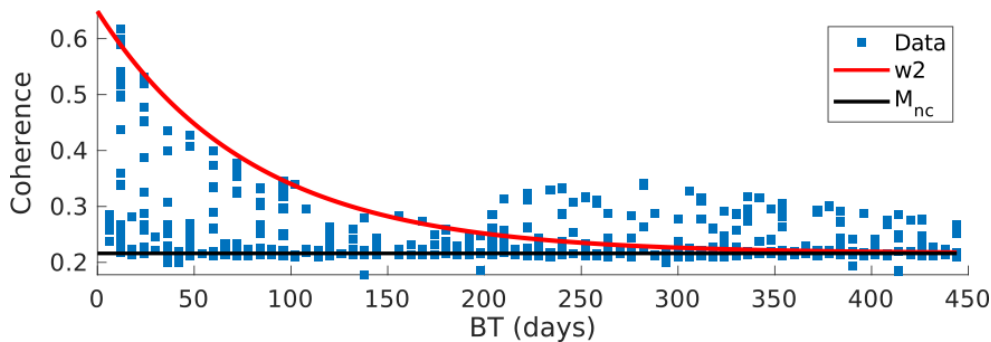
1. Seasonal

$$w_1 = \left| \sin\left(\frac{DOY_P + (365 - DOY_{low})}{365} \pi\right) \times \sin\left(\frac{DOY_S + (365 - DOY_{low})}{365} \pi\right) \right|^\alpha$$



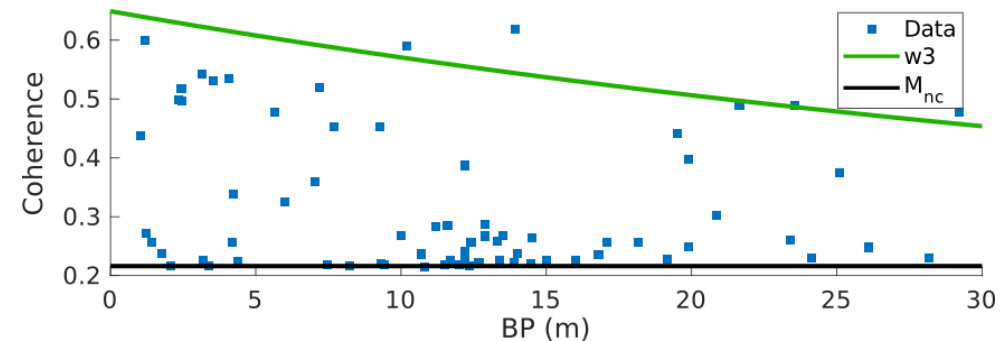
2. Temporal

$$w_2 = (M_{xc} - M_{nc}) e^{-\beta |BT|} + M_{nc}$$



3. Spatial

$$w_3 = (M_{xc} - M_{nc}) e^{-\gamma |BP|} + M_{nc}$$



DOYP : Primary image Day of Year

DOYS : Secondary image Day of Year

DOYlow : Day of Year with lowest coherence

Mxc : Max expected coherence

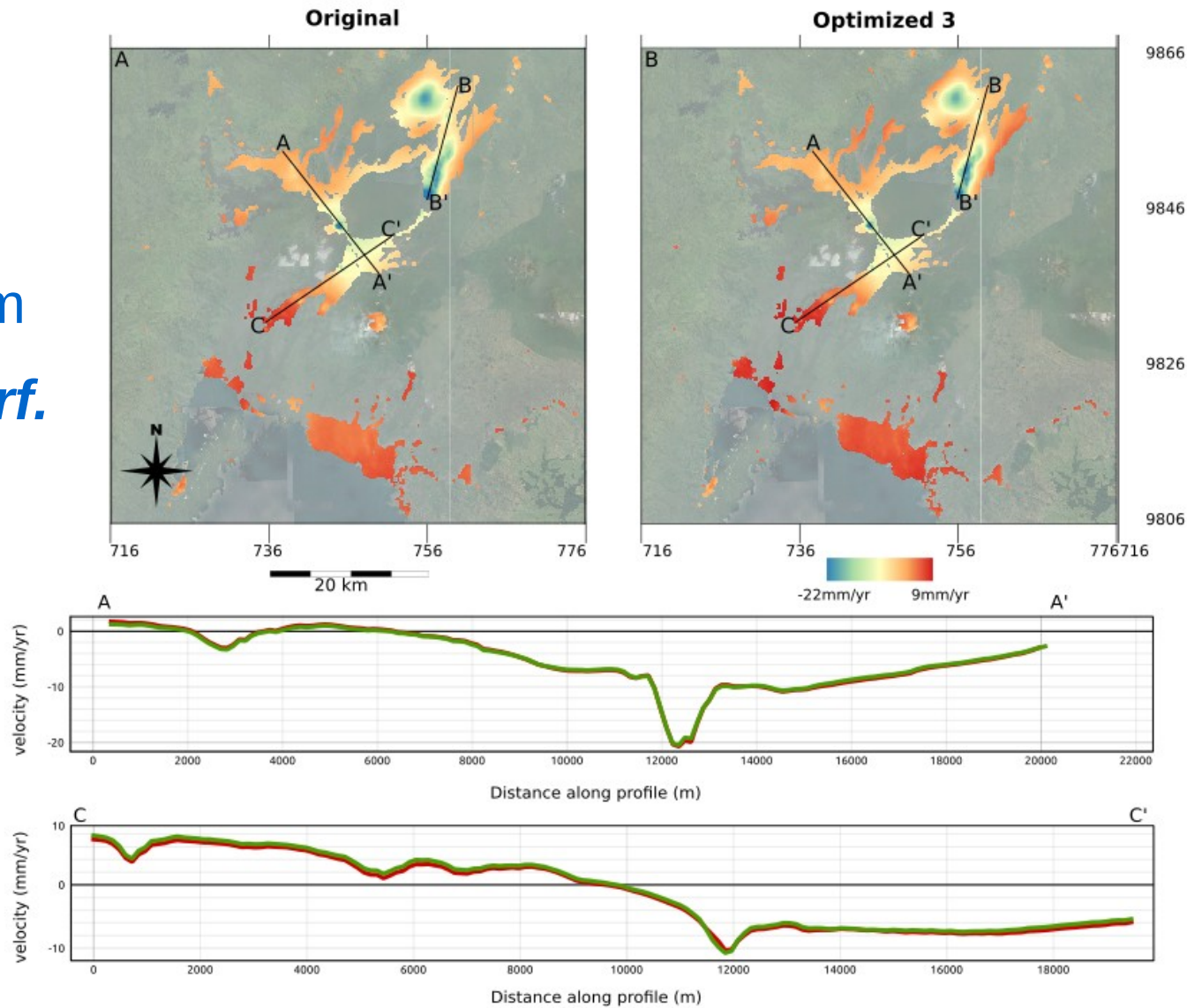
Mnc : Min expected coherence

BT and BP : Temporal and Spatial Baselines

β and γ : calibration parameters

Similar velocity maps, much less interferogram needed

Original
BT/BP
400d/20m
3401 interf.

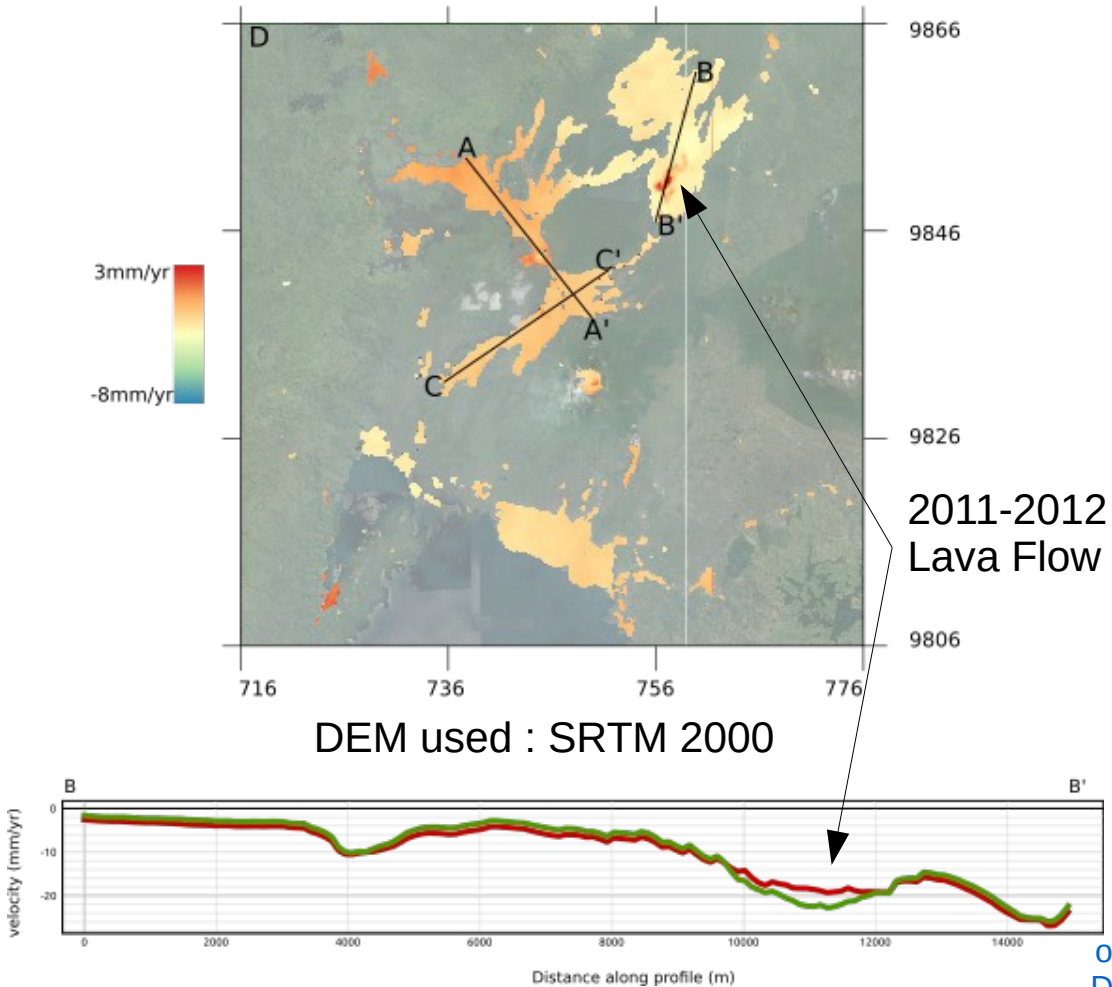


After
Optimization
1032 interf.

Reduction of atmospheric noise and DEM errors influence

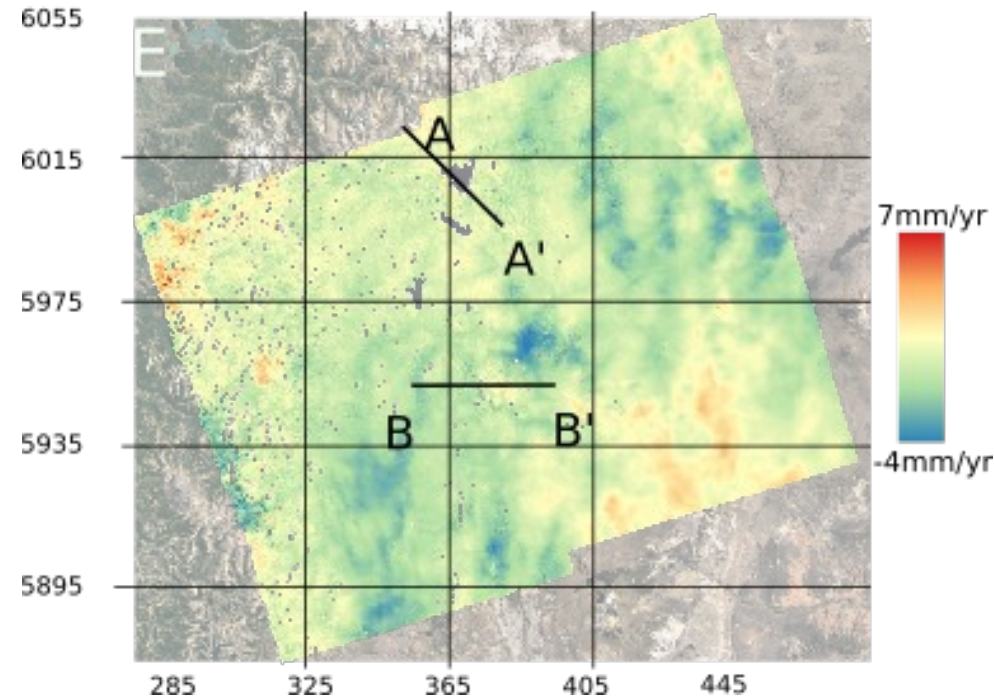
Virunga

Original - Optimized 3



Domuyo and Laguna Del Maule

Original - Optimized 3



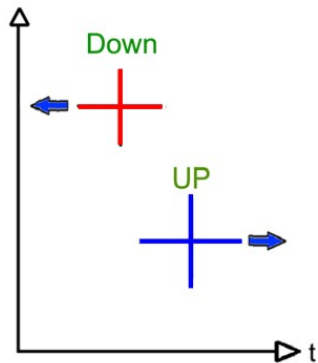
Differences between original and
optimized processing correlate with
DEM errors due to recent lava flows

Improve signal to noise ratio in time series

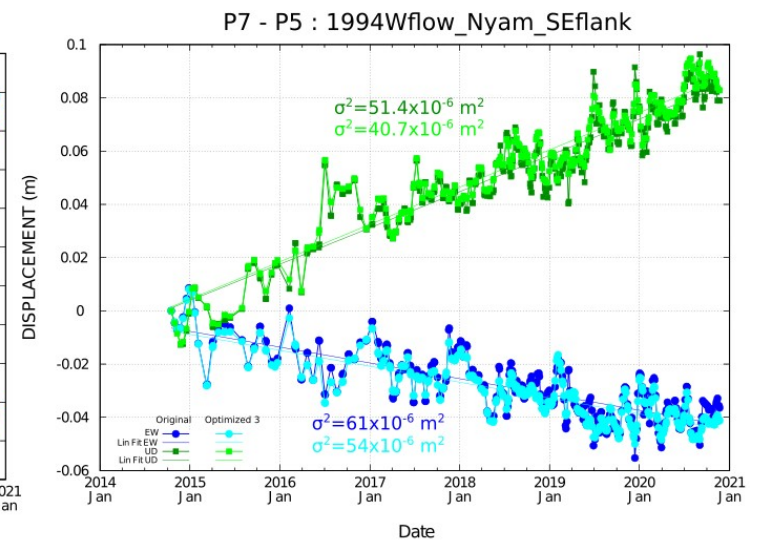
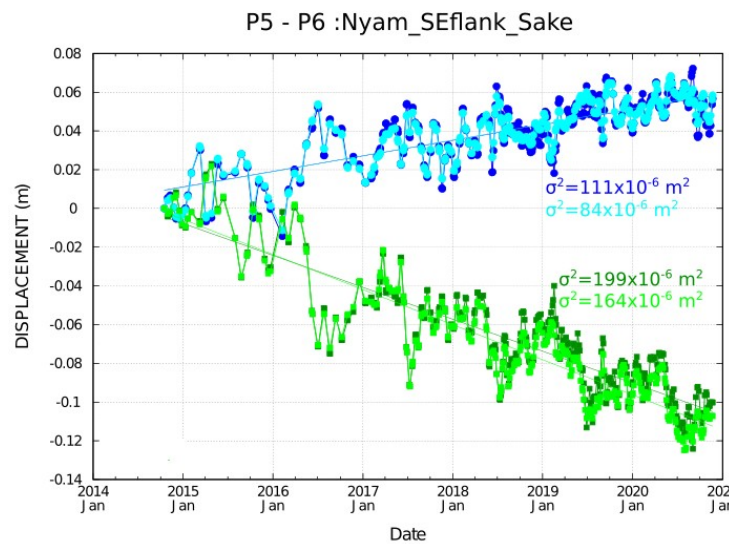
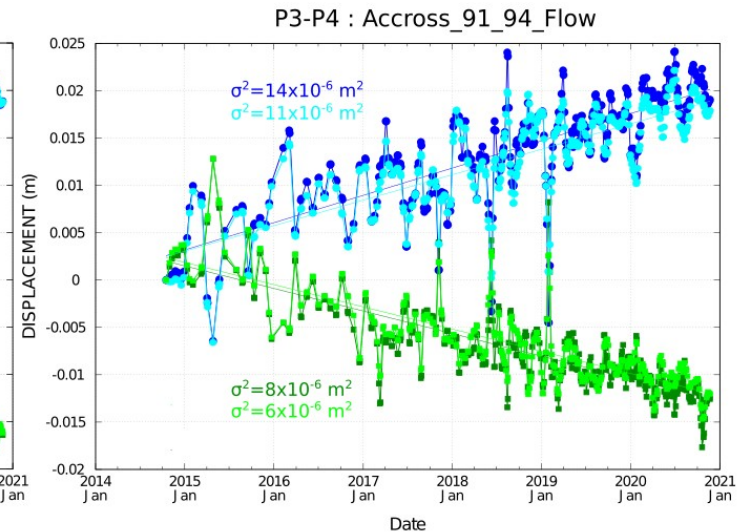
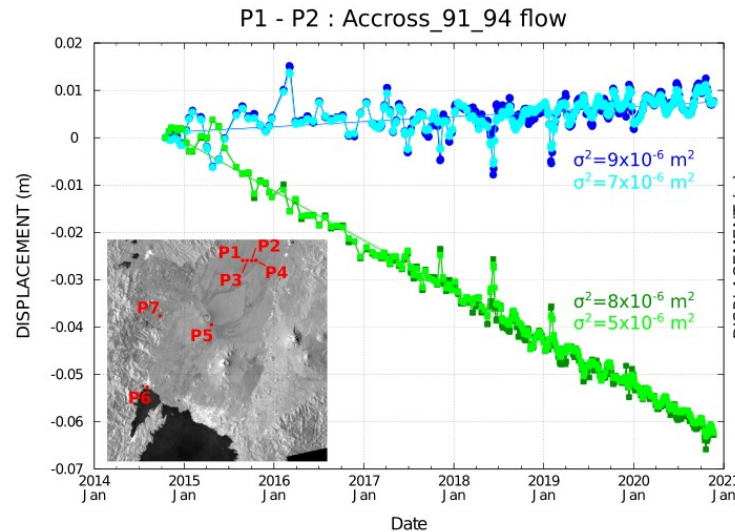
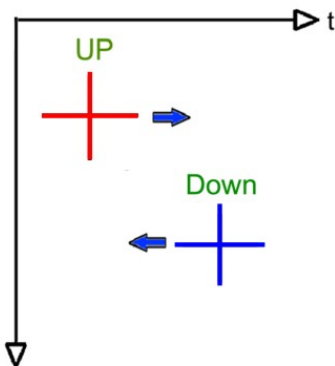
Differential displacement time series of four pairs of pixels in the Virunga

$Px - Py$

Negative displacement:



Positive displacement:



Take home messages

- MasTer is a fully automatic multi sensor InSAR time series processor designed for ground deformation monitoring in near real-time
- New optimization aims to deal with large and increasing database
 - Pair selection is done a priori to limit the number of interferograms computed with each image
 - After a calibration phase, selection is based on an easy to compute coherence proxy
 - Selection algorithm force a symmetric use of each image
- Reduction of atmospheric noise and DEM errors influence
- Improve the time series signal to noise ratio