Development of an Interferometric Mass Processing Chain for Multitemporal Ground Deformation Measurements

L. Libert¹, D. Derauw¹, N. d’Oreye²,³

¹Centre Spatial de Liège, Université de Liège, Belgium
²European Center for Geodynamics and Seismology, Luxembourg
³National Museum of Natural History, Luxembourg
The main goal of RESIST is to understand the mechanisms driving volcanic eruptions and landslides in the Kivu region.
The Differential SAR Interferometry Approach

**Interferometry** measures the optical path difference related to two coherent wavefronts.

The Synthetic Aperture Radar (SAR) interferometry is used to map the **topography** and **ground deformations**.
**The Differential SAR Interferometry Approach**

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The Differential SAR Interferometry Approach

Differential SAR Interferometry offers **large spatial coverage** and temporal sampling of the order of **one to several days**.

Contrary to PSI, MSBAS considers **distributed scatterers** and computes deformations along **two axes**.

http://www.e-geos.it
Multidimensional Small BAseLine Subset (MSBAS)

Integration of DInSAR data sets
- From different sensors
- With different spatial and temporal sampling and resolution
- With different incidence angles, wavelengths, pass directions, etc.

Computation of 2D time series of ground deformations, along:
- The East-West direction
- The vertical direction

MSBAS code available on: www.insar.ca
MSBAS Mass processing chain

S. Samsonov and N. d’Oreye, Canadian Journal of Remote Sensing, 2017
Mass Processing Chain
A three-step approach:

- Interferometric pairs selection
- Coregistration on super master
- Interferometric processing and geopropjection on a common grid

Integration of the *CSL InSAR Suite* (CIS) routines by a shell script for an automatic processing of the selected interferometric pairs
Interferometric Mass Processing Chain

Interferometric pairs selection

- Small perpendicular baselines to prevent geometric decorrelation
- Small temporal baselines to prevent temporal decorrelation

Reading data set images and conversion in CSL format

Computation of perpendicular and temporal baselines for all possible pairs in data set

Select pairs such as

\[ B_{\perp, \text{min}} < B_{\perp} < B_{\perp, \text{max}} \]
\[ \Delta t_{\text{min}} < \Delta t < \Delta t_{\text{max}} \]

Selection of a super master minimizing the average perpendicular baseline
Interferometric Mass Processing Chain

Coregistration on super master

Let us consider a data set composed of $N + 1$ SAR images acquired at times $t_0, t_1, \ldots, t_N$.

Super master image is acquired at time $t_{SM}$.
What is the CIS added-value?

- Fully adaptable and flexible
- A user/developer co-construction
- Saving memory and time in the long-term

What is now possible with CIS?

- Supporting ERS, Envisat, Radarsat, TerraSAR-X/TanDEM-X, ALOS, Cosmo-SkyMed and Sentinel-1 data
- Adaptive filtering
- Phase unwrapping: branch-cut or snaphu
- Image/data set interpolation
- Sentinel-1 interferometry
What is now possible with CIS?

Adaptive filtering

Residual Interferogram - Before filtering - 13/05/2017 - 03/04/2017

Residual Interferogram - After filtering - 13/05/2017 - 03/04/2017
What is now possible with CIS?

Phase unwrapping: snaphu or branch-cut algorithm
What is now possible with CIS?

Interpolation

1st CASE

Image interpolation based on a simple bilinear/linear interpolation of nearest neighbours value

2nd CASE

3rd CASE
What is now possible with CIS?

Interpolation
What is now possible with CIS?

Sentinel-1 interferometry
MSBAS preliminary results on Bukavu
Test site: Funu landslide, Bukavu
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Two data sets spanning 2016 - 2017:

- Cosmo-SkyMed ascending pass: 77 acquisitions / 188 interferograms
- Cosmo-SkyMed descending pass: 75 acquisitions / 193 interferograms

Funu landslide: data sets

\[ B_{\perp} < 300 \text{ m} \]
\[ \Delta t < 56 \text{ days} \]
Two data sets spanning 2016 - 2017:

- Cosmo-SkyMed ascending pass: 77 acquisitions / 188 interferograms
- Cosmo-SkyMed descending pass: 75 acquisitions / 193 interferograms

### Computing performances?

**Crop centered on Bukavu + ML 10x10**
- Adpative filtering
- Snaphu + mask

**Coregistration on super master:**
- ~ 1h40 (two processes in parallel)
- 14 Go + 16 Go

**Interferometric processing and geoprojection:**
- ~ 6h40 (two processes in parallel)
- 60 Go + 66 Go
Funu landslide : SBAS

Cosmo-SkyMed – Ascending pass

Cosmo-SkyMed – Descending pass

Linear rate
~ max -7 cm/yr

Linear rate
~ max 4 cm/yr
Funu landslide: MSBAS

**Vertical deformation**
Linear rate

~ -4 cm/yr

**West-East deformation**
Linear rate

~ max 8 cm/yr towards East
Funu landslide: MSBAS

Order 1: $\lambda = 0.0015$
Order 2: $\lambda = 0.0010$
Funu landslide : MSBAS

Deformation time series - CSK Bukavu (2015-2016) - Order 2

E-W Deformation
U-D Deformation
LOS Deformation - Asc
LOS Deformation - Desc

E-W Deformations - CSK Bukavu (2016-2017) - Lambda 0.001 - Order 2

Northing, m
Easting, m
Deformations, m

RESIST
Funu landslide: MSBAS

Comparison of deformations for regularization orders 1 and 2

- E-W Deformation - order 1
- U-D Deformation - order 1
- E-W Deformation - order 2
- U-D Deformation - order 2

Deformations, m

Date, Year

2016 2016.2 2016.4 2016.6 2016.8 2017 2017.2 2017.4 2017.6 2017.8
Conclusions

- Numerous improvements made and options integrated in CIS
- An end-to-end working interferometric processing chain
- Preliminary results on Bukavu, for the 2016 – 2017 period, consistent with previous analysis
Thank you for your attention