The RESIST Project: a Study of Geohazards in the Kivu Basin Region using ground- and spaceborne Techniques

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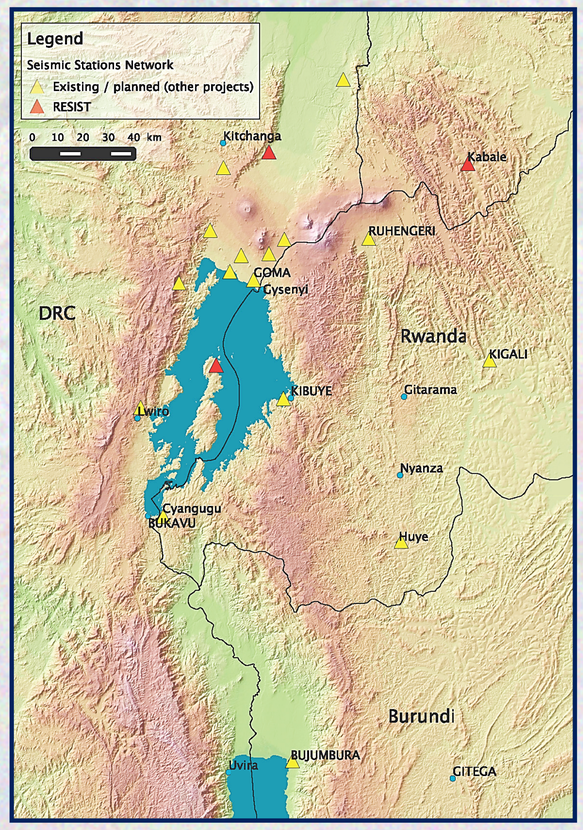
I. Introduction : RESIST

The RESIST project focuses on the study of geohazards in the Kivu Basin region, in Central Africa. The Kivu lake, at the border between the Democratic Republic of Congo (DRC), Rwanda, Burundi and Uganda, is the center of a densely populated region exposed to multiple kinds of high-level geohazards : seismicity, landslides and volcanism. The potential human impact and the variable frequency of these natural disasters make this region particularly threatened.

The Nyiragongo and Nyamulagira volcanoes located in the Virunga Volcanic Province in DRC are part of the most active volcanoes in Africa. Both have undergone eruptions in the 2000s and the proximity of the Nyiragongo with the city of Goma reinforces the importance of ***understanding the processes*** leading to eruptions, ***monitoring the volcanic activity*** and the ***detection of precursory signals***.

In this region like in many others in Equatorial Africa, rains seem to be the main triggering factor for landslides. Knowledge of the triggering rainfall levels according to the type of landslide is therefore a key element in the anticipation of occurrence of such events, as well as the rainfall distribution across the region.

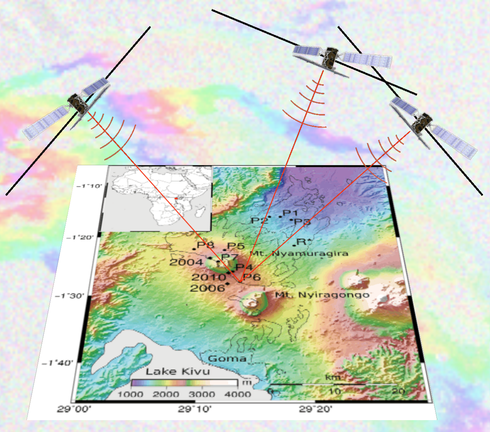


II. InSAR techniques for ground deformations: combination of MSBAS and SBInSAR

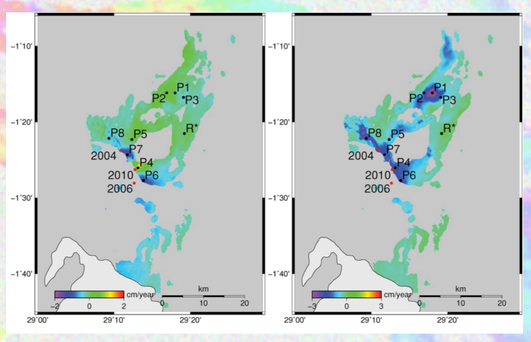
The objectives regarding volcanoes and landslides require to ***measure*** and ***monitor*** the ***ground deformations***. To this end, RESIST propose a combination between well-known GPS measurements and new InSAR techniques such as Multidimensional Small BAseline Subset (MSBAS) and Split-Band interferometry (SBInSAR), which is expected to highly improve the accuracy of the measurements.

II.A. MSBAS

The ***Multidimensional Small BAseline Subset (MSBAS)*** methodology computes multidimensional pixel-by-pixel time series of the ground deformations from several InSAR data sets. These data sets can be acquired by different sensors and have various orbital parameters.



Solving the SBAS problem simultaneously through Tikhonov regularization along different lines of sight enables resolving 2D displacements (Est-West and Up). Due to the polar orbit of all SAR sensors, North-South components remain difficult to resolve.



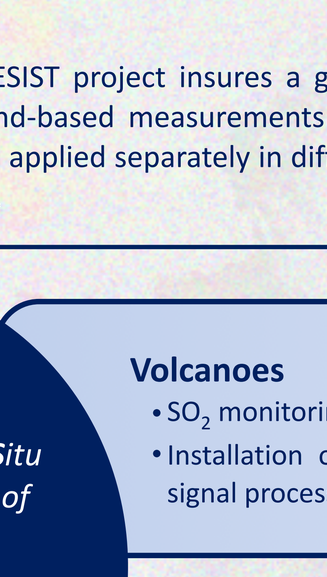
2006 - 2010 East-west and vertical linear deformation rates of the Nyiragongo area

[1] S. Samsonov and N. d'Oreye (2012), Multidimensional time-series analysis of ground deformation from multiple InSAR data sets applied to Virunga Volcanic Province, *Geophys. J. Int.*, 191, pp 1095-1108.

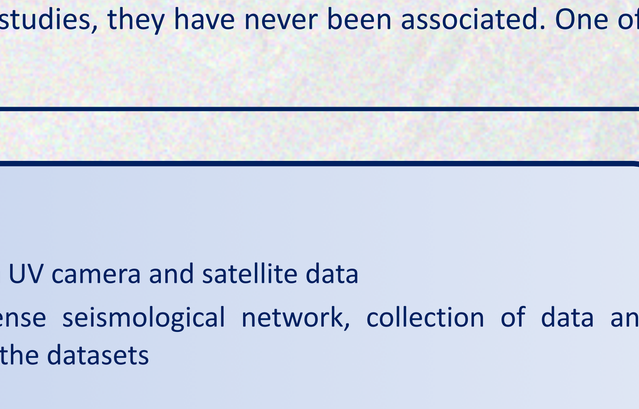
II.B. SBInSAR

Split-Band is based on the generation of several lower resolution images from a single acquisition by dividing the bandwidth into sub-bands, each having a slightly different carrier frequency.

The computation of several interferograms from sub-bands images of slave and master acquisitions similarly split is called the ***Split-Band Interferometry (SBInSAR)***.



$$\Delta\varphi_i = 4\pi\frac{\nu_i}{c}(r_s - r_m)$$



Having a linearly-variable phase across the so-generated interferogram stack allows solving the phase unwrapping problem on a point-wise basis. This approach makes the connection of displacements observed in separated areas possible.

[2] D. De Rauw et al., *Split-Band Interferometric SAR Processing Using TanDEM-X Data*, Fringe 2015, Frascati, March 2015.

III. Conclusion

By using at the same time well-established processing methods and innovative approaches, the RESIST project insures a good balance between risk and reward. These various methodologies combined with the great amount of spaceborne data collected for years and ground-based measurements should enable improvement in the understanding of geohazards processes in the Kivu region. In particular, although MSBAS and SBInSAR have already been applied separately in different studies, they have never been associated. One of RESIST's goals is to merge both in order to improve the accuracy of ground deformation measurements.

Ground deformations
- Remote sensing : VHSR optical data analysis and SAR interferometry (MSBAS time series and Split-Band interferometry)
- GPS measurements
- Field observations

Landslides
- Inventory of landslides
- Study of spatial occurrence and environmental factors
- Identification of triggering rainfall thresholds for different types of landslides
- TRMM measurements

RESIST

***RE**mote **S**ensing and **I**n **S**itu detection and **T**racking of geohazards*

Collaboration between RMCA, ECGS/MNHN, CSL, BIRA-IASB, NASA-Landslides

Volcanoes
- SO_2 monitoring with UV camera and satellite data
- Installation of a dense seismological network, collection of data and signal processing of the datasets

Processes modelling
- Pre-eruptive physical processes assessment (forecasting ?)
- Characterization of dyke-intrusions and volcanic eruptions mechanisms
- Anticipation of the landslides occurrence according to the rainfall distribution

resist.africamuseum.be

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