Can InSAR contribute to volcano early warning systems?

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InSAR is known to be efficient to produce high-resolution ground deformation maps. Providing that a SAR sensor acquires enough data in a given geometry, the displacement of each coherent pixel can be monitored over an extended period of time. However these InSAR time series methods often do not permit contributing to an early warning system as they rely on the revisiting period of the satellite, which typically ranges from week to month. Namely, if InSAR detects a possible pre-eruptive signal, the eruption might come too soon before a second acquisition may confirm it and discriminate it from an atmospheric artifact.

Perspective offered by these time series methods can be improved if enough data acquired under different geometries can be combined in a common time series. This is hardly achievable with only one satellite. We present here a novel Multidimensional Small Baseline Subset (MSBAS) methodology for integration of multiple InSAR data sets for computation of 2D or 3D time series of deformation (Samsonov and d Oreye, GJI2012). The approach combines all possible SAR data acquired with different acquisition parameters, temporal and spatial sampling and resolution, wave-band and polarization. The method has 4 main advantages:

1) It achieves combined temporal coverage over an extended period of time when data from many different sensors with different temporal coverages are available;

2) Temporal resolution increases since it includes the combined sampling from all data sets, which helps to observe signal in more details and improves the quality of post-processing (i.e. filtering);

3) 2 or 3 components of ground deformation vector are computed, which helps in interpretation of observed ground deformation and further modeling and inversion;

4) Various sources of noise (i.e. atmospheric, topographic, orbital, thermal...) are averaged out during the processing improving S/N ratio.

The technique was successfully applied to study ground deformation in Virunga Volcanic Province (VVP, DRCongo). Using ERS, ENVISAT, Radarsat2, ALOS and TerraSarX SAR data, we identify long-term deformation of Mt. Nyamulagira and deformations associated to its most recent eruptions. The method also reveals the first unambiguous pre-eruptive deformations in the VVP. They are detected about 15 days prior the onset of the 2010 eruption by 3 successive images acquired by 3 different sensors in different geometries while the seismic precursors only started less than 1 hour before the lava outburst. These pre-eruptive signals are of about the same amplitude and spatial extent as the atmospheric noise and therefore cannot be identified on individual differential interferograms.

Providing that enough SAR data is available with a short latency, and with the help of automated processing and trend change detection algorithms, MSBAS method opens new opportunities for very high-resolution ground deformations studies and possibly for contributing to early warning systems.