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Analysis of tectonic and magmatic activity at Virunga volcanic Province (Congo) revealed by SBAS-DInSAR analysis

Eugenio Sansosti (1), Giovanni Zeni (1), Antonio Pepe (1), Giuseppe Solaro (1), Nicolas d'Oreye (2), Christelle Wauthier (3), Francois Kervyn (3), Sergey Samsonov (2), José Fernàndez (4), and Pietro Tizzani (1)

(1) IREA-CNR, National Research Council, Napoli, Italy (sansosti.e@irea.cnr.it, +390815705734), (2) National Museum of Natural History, Walferdange, Luxembourg, (3) Royal Museum for Central Africa, Tervuren, Belgium, (4) Instituto de Astronomía y Geodesia (CSIC-UCM), Madrid, Spain.

The Virunga Volcanic Province is located near the northern end of the western branch of the East African Rift System (EARS). Existing seismic data and tomographic models show hot astenosphere throughout the EARS length. In particular, the earthquakes focal depths over Virunga region and the mechanisms solutions suggest an EW extensional regime with a brittle-ductile transition located between 15-20 km of the depth.
Moreover, the Western branch of the EARS represents a low-volcanicity rift at the early stages of the extensional process, characterized by a marked along axis mechanical segmentation due to the presence of regional transfer zones, representing the complex structural elements that allow the extensional deformation to be transferred from one rift segment to the next.
Geochronologic analyses have also shown that magmatism takes place at the same time, or shortly before extension, suggesting that magmatic bodies have been present in the system since at least the early stages of extension, and have played an important role in the evolution of deformation. Indeed, a strong interaction between magmatism and deformation in transfer zones has been also hypothesized.
In this study, we investigate the regional tectonic and volcanic ground deformation induced by magmatic activity, as revealed by a Small Baseline Subset (SBAS) DInSAR analysis. In particular, we focus on two sets of SAR images related to the Nyiragongo and Nyiamuragira volcanic areas and collected by the ENVISAT/ASAR sensor between 2003 and 2010 on both descending (IS2, Track: 35) and ascending (IS7, Track: 314) orbits. Accordingly, we first generate the mean displacement velocity maps and the corresponding deformation time-series for both data-sets for pixels where coherence is preserved. Subsequently, we combine the two Line of Sights (LOS) deformation measurements to retrieve the temporal evolution of the East-West and vertical deformation components, thus investigating with deeper details the deformation signals in the 2006-2010 time interval, when both the ascending and descending data-sets have points in common.
The achieved results show that the 2006-2009 deformation trend is characterized by a radial-like deformation pattern around the Nyiamuragira volcano. In addition, in 2009-2010 time period a more articulate deformative pattern is observed. In particular, our analysis allows the identification of two main different signals: (i) a localized signal mostly related to the magma rising effect in the volcanic conduit and characterized by significant (temporal) high-frequency components, with a predominant horizontal component (of about 24 cm) at the Nyiamuragira summit area; (ii) a spatially-extended signal within a broad region inside the rift zone, due to the effect of the regional structural lineaments: such a signal is characterized by a predominant vertical displacement with a normal component, which is typical of extensional regimes. Accordingly, we argue that the deformation pattern associated with the 2010 eruption is related to the reactivation of pre-existing tectonic structures induced by magma rising.