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Spatial and temporal distribution of volcano-induced seismicity at Nyiragongo and Nyamulagira volcanoes (Democratic Republic of Congo) using cross-correlation based techniques

Julien Barrière (1,2), Adrien Oth (1), Nicolas d'Oreye (1,2), and François Kervyn (3)

(1) European Center for Geodynamics and Seismology, Luxembourg (julien.barriere@ecgs.lu), (2) National Museum of Natural History, Luxembourg, (3) Royal Museum for Central Africa, Belgium

The Virunga Volcanic Province (VVP) in the Democratic Republic of the Congo hosts two of the most active and hazardous volcanoes in Africa, Nyiragongo and Nyamulagira. Monitoring of volcanic seismicity is a key component in order to improve the understanding of the processes driving the volcanic activity and to identify potential precursory phenomena for the purpose of eruption forecasting. To this end, the development of a telemetered seismic network with continuous recording abilities is an indispensable tool, yet remains a difficult task for most of World's volcanoes, and especially in the aforementioned area. The recent deployment of the KivuSnet has led to a significant increase in the number of broadband seismic stations in the Kivu region (from two in January 2014 to thirteen in October 2015).

In the domain of volcano seismology, seismic noise interferometry designed for Green's function retrieval has been applied for seismic imaging or monitoring of temporal velocity changes. As pointed out by Ballmer et al. (2013, GJI), noise-derived Green's functions should however be carefully used in volcanic environments where the ambient noise may be dominated by strongly localized sources such as volcanic tremors. However some recent studies have shown that interferometry based data processing could also be employed for studying stable, continuous tremors sources and may provide new research opportunities in the study of volcanic tremors with a sparse seismic network (Ballmer et al., 2013, GJI; Droznin et al., 2015, GJI).

In the VVP, daily cross-correlations of continuous seismic records exhibit strong one-sided coherent signals dominated by volcanic tremor sources well localized in space. This procedure is thus applied each day in order to locate the dominant tremor sources. Their intensity is determined as well using the level of the correlation coefficient. Eleven stations transmitting data in real-time from October-November 2015 are used (nine stations are located in the VVP with inter-station distance < 50km). Moreover, applying the processing among different sub-frequency bands allows highlighting different sources from the two volcanoes and identifying their strong temporal changes.

In addition to tremor signals, we also developed a dedicated location routine for seismic events occurring in the VVP. This method also relies on the inter-station cross-correlation technique and is based on multi-frequency bands envelope functions. A source scanning algorithm is then performed through a 3D travel-time grid to find the source region that maximizes the stacked inter-station cross-correlation. As the current stage of development, the method appears equally applicable to the full range of volcanic seismicity with impulsive or emergent onsets (i.e. volcano-tectonic, hybrid or long period). First results exhibit a strong occurrence of low-frequency earthquakes around the pit crater at Nyamulagira volcano with depth ranging from 0 to 30 km while a dominant source of short-period, volcano-tectonic events at 15-20 km depth is highlighted at the south-east flank of Nyiragongo volcano.