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Constraints on deformation of Hekla volcano, Iceland, 2011-2014, from time-series interferometric analysis of COSMO-SkyMed SAR data and Singular Spectrum Analysis (SSA)

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Hekla volcano is one of the most active volcanoes in Iceland with 18 summit eruptions during the last 1100 years. Since 1970, the volcano has erupted approximatively every 10 years: in 1980–1981, 1991 and 2000. A special feature of Hekla volcano is its aseismic behavior except within 2 hours before these eruptions. However, in 2013 and 2014, some seismic swarms were detected within a 5km radius centered on the volcano, which is unusual for any time period between eruptions. No change in the ground deformation (continuous borehole strainmeter and ground-based GPS), was observed during these events. This year, will be the fifteenth year without an eruption at Hekla, the extended period (since the last eruption) raises the following question: Has the magma plumbing system or the rate of melt supply changed since the last eruption? What is the state of the volcano? What does it imply for its eruptive cycle?

To address these questions, we study ground deformation around Hekla volcano using time-series analysis. We analyzed COSMO-SkyMed SAR data acquired between 2011 and 2014 using the Persistent Scatterer Interferometric Synthetic Aperture Radar (PS-InSAR) approach for both ascending and descending configurations. As highlighted by previous studies of ground deformation around Hekla, the small deformation rate distributed over a large area increases the importance of the noise reduction process. Once the signal to noise ratio is improved, both time-series display a dominant subsidence signal. The subsiding areas correlate with lava flows extruded during the 2000 eruption.

A small inflation signal is more difficult to substantiate from the SAR data alone. For this reason further investigation of source characteristics using a Singular Spectrum Analysis (SSA) is required. SSA is an empirical based decomposition of the signal. This decomposition is applied on a trajectory matrix, called a Hankel matrix (similar to a cross-lag correlation matrix). This method enables the extraction of different patterns included in the original signal. We apply the SSA algorithm to velocity maps derived from PS-InSAR processing. Using this approach, we are able to compare the 2011-2014 deformation signal to the inflation detected prior to the 2000 eruption.