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PS-InSAR measurements at the most active volcanoes in Iceland: role of the GEO supersite initiative in deformation monitoring at Bárðarbunga, Askja, Hekla, Katla and Eyjafjallajökull volcanoes

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Analysis of a time series of ground deformation measurements at active volcanoes can provide an improved understanding of sub-volcanic and sub-aerial processes; including those related to magmatic, hydrothermal and structural development. Interpreting a long time series may also help determine background behavior, and identify any deviations from this, including the migration of new melt. We use Persistent Scatterer Interferometric Synthetic Aperture Radar (PS-InSAR) techniques to generate a time series of high-resolution deformation measurements, in the vicinity of the most active volcanoes in Iceland: Bárðarbunga, Askja, Hekla, Katla and Eyjafjallajökull and compare these to other geodetic measurements. A comprehensive network of continuous GPS stations is already deployed at these volcanoes and a series of campaign GPS measurements are routinely undertaken each summer. InSAR observations are complementary to these field based measurements and their high spatial resolution assists in resolving the geometry of the deformation field hence gaining improved constraints on the inferred source.

The Committee on Earth Observation Satellites has recently declared Iceland a Permanent Geohazard Supersite, based on its propensity for relatively frequent eruptions and their potentially hazardous, long ranging effects. The recent Supersite award ensures a considerable amount of SAR data is made available for both past and future satellite acquisitions, including new X-band images (acquired by TerraSAR-X and Cosmo-SkyMed satellites), and historic C-band images from ERS and ENVISAT. We present a series of long-term deformation measurements for Hekla, Katla, Eyjafjallajökull and Askja volcanoes, derived using PS-InSAR techniques, and include recent interferograms spanning the 2014 unrest and eruption within the Bárðarbunga volcanic system.

InSAR and tilt measurements at Hekla indicate renewed melt supply to a sub-volcanic reservoir after the last eruption in 2000. Recent deformation studies utilising data spanning this eruption, have provided insight into the shallow plumbing system, which may explain the large reduction in eruption repose interval following the 1970 eruption. InSAR and GPS observations at Katla volcano prior to 2010 suggest no magma induced deformation. However, deformation associated with a small flood at Mýrdalsjökull in July 2011, followed by an increase in micro-seismic earthquakes, could be interpreted in relation to magma movements. Post-eruption deformation observations reveal inflation at Eyjafjallajökull possibly related to the influx of new melt or readjustment of crustal stresses following the 2010 eruption. Continued deflation at Askja caldera since 1983 may have led to crustal weakening and the triggering of a mega rockslide and subsequent tsunami occurring on the 21 July 2014. Interferograms spanning the recent unrest and eruption within the Bárðarbunga volcanic system display both pre-eruptive and co-eruptive deformation associated with the initial dyke emplacement and ongoing magma withdrawal from beneath the Bárðarbunga central volcano.

Continued high-resolution geodetic observations at these volcanoes are essential for assessing changes in their behaviour and the associated hazards. Rapid analysis of interferograms combined with GPS and earthquake seismicity measurements assists in tracking the evolution of magmatic activity during volcanic unrest/eruption, and may facilitate the assessment of associated hazards.