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The application of geodetic observations for near-real time monitoring of Icelandic volcanoes

Michelle Parks[1], Benedikt Ófeigsson[1], Halldór Geirsson[2], Vincent Drouin[3], Freysteinn Sigmundsson[2], Andrew Hooper[4], Sigrún Hreinsdóttir[5], Siqi Li[2], Cécile Ducrocq[2], Erik Sturkell[6], Kristín Vogfjord[1], Ásta Rut Hjartardóttir[2], Hildur María Fridriksdóttir[1], Ragnar Þrastarson[1], Sara Barsotti[1], Melissa Pfeffer[1], and Matthew Roberts[1]

[1]Icelandic Meteorological Office, Reykjavík, Iceland (michelle@vedur.is)
[2]University of Iceland, Reykjavík, Iceland
[3]Iceland Geosurvey, Reykjavík, Iceland
[4]University of Leeds, Leeds, United Kingdom
[5]GNS Science, Lower Hutt, New Zealand
[6]University of Gothenburg, Gothenburg, Sweden

Ground deformation is frequently one of the first detectable precursors alerting scientists to changes in behavior or the onset of unrest at active volcanoes. GNSS, InSAR, strain and tilt measurements are routinely used by volcano observatories for monitoring pre-eruptive, co-eruptive and post-eruptive deformation. In addition to monitoring signals related to magma migration, deformation observations are used as an input into geodetic modeling to determine the location and rate of magma accumulation and help define the structure of magma plumbing systems beneath active volcanoes.

This presentation will provide an update of how geodetic observations are being used in conjunction with seismicity and gas measurements, for the near-real time monitoring of key Icelandic volcanoes; to determine their current status, identify the onset and likely cause of unrest, locate magmatic intrusions, determine magma volumes and supply rates and assess the likelihood of eruption. An overview of the current status of the following active volcanoes will be provided: Hekla, Bárðarbunga and Grímsvötn, along with an update of the recent volcano-tectonic unrest on the Reykjanes Peninsula.

Hekla is one of the most active and dangerous volcanoes in Iceland with approximately 18 eruptions since 1104. Over the past few decades, Hekla erupted at almost regular ~10 year intervals, with the last four eruptions occurring in 1970, 1980–1981, 1991 and 2000. Previous geodetic studies have suggested magma storage at depths of 12-25 km directly beneath the volcanic edifice. However, recent InSAR analysis has detected a localized inflation signal to the west of the volcano. A regional borehole strain meter network has proven instrumental for real-time eruption forecasting at Hekla.

In the Bárðarbunga volcanic system, the six-month long effusive 2014-2015 Holuhraun eruption

was accompanied by gradual caldera collapse of up to 65 m and was preceded by a two-week period of 48 km long lateral dyke propagation with extensive seismicity and deformation. Geodetic observations indicate that Bárðarbunga began to slowly inflate in July 2015. This may be explained by a combination of renewed magma inflow and viscoelastic readjustment of the volcano.

The Grímsvötn subglacial volcano is the most frequently erupting volcano in Iceland, with eruptions in 1998, 2004 and 2011. A GPS station shows a prominent inflation cycle prior to eruptions. Observations during the 2011 eruption suggest a pressure drop at a surprisingly shallow level (about 2 km depth) during the eruption, in a similar location as in previous eruptions. Deformation at this volcano has now surpassed that observed prior to historic eruptions and its aviation color code is currently elevated to yellow.

In December 2019, the Reykjanes Peninsula entered a phase of volcano-tectonic unrest characterized by seismic swarms, followed in late January 2020 by inflation detected in near-real time by GNSS and InSAR observations. At the time of writing (mid-January 2021) there have been three magmatic intrusions in the vicinity of Svartsengi, an intrusion beneath Krýsuvík and indications of magma migration at depth along the entirety of the Peninsula.