Geophysical Research Abstracts
Vol. 14, EGU2012-13577-1, 2012
EGU General Assembly 2012

The 2010 Eyjafjallajökull and 2011 Grímsvötn eruptions: Insights from GPS geodesy

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Both the Eyjafjallajökull summit eruption in 2010 and Grímsvötn eruption in 2011 resulted in significant disruption of aviation. Three historic (last 1100 years) eruptions are known in Eyjafjallajökull volcano prior to 2010 (in 920, 1612, and 1821-23). In contrast Grímsvötn volcano is Icelands most active volcano with the last three eruptions in 1983, 1998, and 2004. Both volcanoes have been monitored with continuous GPS measurements in the last few years, revealing different style of deformation leading up to and during the eruption.
On March 20 2010 a 300 m long fissure opened up on the east flank of Eyjafjallajökull volcano. The eruption was preceded by three months of unrest with increased seismic activity and surface deformation. The deformation pattern leading up to the eruption was both spatially and temporally variable. In January and February 2010 inflation was observed at GPS sites on the flanks of the volcano indicating formations of sills. From February 20 more distant GPS stations showed a small but distinct change in horizontal velocity. Sites started moving in toward the volcano, suggesting deep pressure changes. In early March seismic activity intensified and rapid deformation leading up to the eruption suggested the upward migration of magma. During the flank eruption deformation almost ceased and the volcano remained at an inflated state. On April 14 2010, a more explosive eruption began at the ice-caped summit of the volcano. Rapid deformation toward the summit and subsidence was observed at GPS sites around the volcano during this eruption. In early May a small but significant inflation signal was observed at the GPS sites closest to the summit suggesting a renewed flux of magma from depth but was followed by a continued deformation toward the summit for a few weeks.
Around 19 UTC on May 21, 2011 a phreatomagmatic eruption started at Grímsvötn volcano lasting until the May 28. The Grímsvötn volcano lies beneath the Vatnajökul icecap, limiting the near field monitoring efforts to a single nunatak, Mt. Grímsvötn. A high rate GPS station and electronic tilt meter are collocated at the nunatak. The GPS station had registered inflation of the volcano since the 2004 when it last erupted. Rapid deformation, starting about an hour prior to the onset of the eruption, suggested a pressure drop in a magma chamber located at a shallow depth ($\sim$1.8 km). The GPS station recorded a total displacement of 57 cm with over 20% of the deformation taking place prior to the eruption and majority of the displacement (95%) taking place within the first 24 hours of the eruption. Rapid inflation signal was observed following the eruption suggesting refilling of the magma chamber.