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Surface Deformation Prior to and During the 2010 Eyjafjallajökull Eruptions from Spatial and Temporal Variations in GPS Time Series

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We summarize the temporal changes in GPS time series to elucidate the possible magma source depths and pathways prior to and during the March-May 2010 Eyjafjallajökull flank and summit eruptions. Deep earthquake swarm activity started in March 2009 and continued until August. Simultaneously, southward motion of 10-12 mm were observed at the continuous GPS station THEY, located on the south flank of Eyjafjallajökull. The seismic activity and deformation were interpreted to indicate renewed magmatic activity, continuing two decades of intermittent intrusive episodes at the volcano. To better monitor the activity, two semi-continuous stations were deployed on the north and south flanks of the volcano. In December 2009, seismic activity resumed and the cGPS station THEY started moving southward, indicating inflation of the volcano. Modelling data from GPS stations near the volcano suggests intrusive magmatic activity at ∼5-6 km depth from early January 2010 until mid-February. Time series from more distant cGPS stations show small but distinct changes in the deformation pattern in February that may indicate deep pressure changes, and could correlate with deep seismic activity. More rapid changes in the rate of deformation and bursts of earthquake activity observed from mid-February until the onset of the basaltic Fimmvörduháls flank eruption on March 20 are interpreted as northward and upward migration of the intrusive activity. As earthquake and deformation activity intensified, two more semi-continuous GPS stations were installed two days before the start of the flank eruption. In contrast, very little deformation was observed during the flank eruption, which lasted until April 12. The pattern of deformation changed at the start of the second, more explosive summit eruption on April 14. The GPS station motions indicate contraction of a shallow source at 3-4 km depth below the summit. Two more semi-continuous stations were installed after the start of the summit eruption. The time series of the stations closest to the summit show rapid motion toward the summit and subsidence during the first week of the eruption, with the rate gradually decreasing, although continuing at a very slow rate even after continuous eruptive activity stopped in late May. Irregularities and indications of pressure increase in time series at stations closest to the summit in the first week of May correlate with the occurrence of deep earthquakes, suggesting inflow of magma from great depth (> 20 km).