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InSAR Time Series analysis of the Eyjafjallajökull eruptions using TerraSAR-X data

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After a period of quiescence since a sill intrusion in 1999-2000, a subtle deformation signal was again detected at Eyjafjallajökull, beginning in the summer of 2009, at a continuous GPS station on the southern flank. At our request the German Space Centre (DLR) immediately began tasking the TerraSAR-X satellite to acquire three SAR images every 11 days, giving a time series of SAR images prior to the eruption with unprecedented temporal sampling (although interrupted by snow during the winter). Here we present the results of InSAR time series analysis of this data set. After correcting for DEM errors and reduction of atmospheric signal, we find a number of signals that we interpret in terms of magma movement.

The displacement time series from June 2009 to 4 February 2010 (pre-eruptive-phase) shows line-of-sight shortening on the south-west flank of about 2 cm. The signal shows a largely linear behaviour and is smooth in time, implying that it is not due to atmospheric contamination. The signal seems consistent with the nearby continuous GPS station THEY. We therefore interpret it as due to the intrusion of magma to shallow depths. Superimposed on this uplift signal are two periods of subsidence, in August and November 2009, perhaps representing redistribution of the intrusion.

Between 4 February and 20 March 2010 there is a large uplift signal which we model as a series of sills and a dike, with a total volume of $\sim$0.05 km3 During the flank eruption, beginning on 20 March, no significant deformation is detected, but coinciding with the start of the explosive eruption on April 14, we detect subsidence centred on the caldera. The subsidence proceeds in an approximately steady-state fashion until the end of the eruption. In preliminary modelling we fit this with a pressure decrease of an ellipsoidal source, equivalent to a volume reduction of $\sim$0.03 km3.