Geophysical Research Abstracts, Vol. 9, 07448, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-07448
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Improved Source Imaging of the Kleifarvatn Earthquake, Iceland, through a combined Use of ascending and descending InSAR Data

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We re-investigated the surface deformation on Reykjanes Peninsula, south-west Iceland, caused by the dynamically triggered earthquakes of the June 17 2000 mainshock in the South Icelandic Seismic Zone. Two ERS-2 interferograms from descending and ascending tracks were formed and used in combination with campaign GPS measurements. We inverted the derived deformation signal for the source parameters of two adjacent events, the Kleifarvatn and the Nupshlidarhals earthquakes.
As these events were dynamically triggered and happened while secondary waves of the main shock were still arriving at the local seismological network, computations of the earthquake source parameters based on seismic waveforms are difficult. The Kleifarvatn earthquake in particular, was initially not reported and actually later discovered by InSAR. The assigned moment magnitude of only $\sim$5, based on the seismological observations, contradicts the intensities inferred from surface cracks and rock fall in the epicentral region. Also, previous studies using descending InSAR and campaign GPS data indicate that the moment of the Kleifarvatn event corresponds to a magnitude larger than 5.8.
But still the fault geometry of these earlier geodetic studies, in particular a relative shallow dip of the fault plane, is not supported by the established understanding of the regional faulting in Southwest Iceland. The left-lateral shear at the oblique transform zone on Reykjanes Peninsula is mostly accommodated by north-south orientated and steeply dipping strike-slip faults with right-lateral slip (book-shelf faulting). The reason for the estimated shallow dip in earlier studies is likely to be a trade-off between fault dip and fault slip direction (rake) when using radar data from only one look direction in fault parameter inversions.
We have complemented the dataset used in previous studies with ERS-2 data from

an ascending track and we therefore have good data coverage in the epicentral region from two different viewing directions. In our inversions we are accounting for the noise level and the correlation of InSAR data points by incorporating the full covariance matrix to give meaningful weights not only to the independent sets but also to balance the subsampled InSAR data with respect to each other.

Our optimal solution for the fault parameters of the Kleifarvatn event supports earlier geodetic magnitude estimations while the geometry of fault plane now agrees with the regional style of faulting. Furthermore, it coincides with a plane that is sharply outlined by recently relocated aftershocks of the Kleifarvatn event. So the use of InSAR data with multiple look directions suppresses model parameter trade-offs effectively while careful weighting of extended data sets is needed.

The discrepancy of seismological and geodetic magnitude estimates, on the other hand, poses the question whether some slip took place aseismically, which could influence seismic hazard assessments in the vicinity of Reykjavik. With our new results we hope we can contribute to a solution to this problem.