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Plate-Boundary-Scale Deformation from InSAR Time-Series Analysis: Examples from southwest Iceland

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Measuring interseismic strain accumulation and the effects of several other slow plate-boundary processes with InSAR is challenging, due to the low deformation rates and large spatial extent of the deformation, which sometimes exceeds the typical size of a single radar frame. Therefore, it is important to use time-series analysis to separate the deformation signal from atmospheric and orbital contributions. In this study I use multiple InSAR images to gather information about the plate-boundary deformation in southwest Iceland, both on Reykjanes peninsula and within the South Iceland seismic zone.

The main problems of using InSAR in Iceland are winter snow cover and limited data acquisition. In addition, part of the study area is an agricultural region, so there InSAR data become decorrelated within several months. Due to the low density of man-made structures in this area, I focus on using a network of multi-looked and spatially-unwrapped small-baseline interferograms to derive information about the deformation. In the time-series analysis I first reference all the unwrapped interferograms to a single location near the middle of the imaged area where coherence is high in all interferograms. I then use a subset of the data to estimate both orbital and deformation ramps, and correct the input interferograms for orbital biases. After this correction, I analyze one pixel location at a time and estimate the unwrapped displacement value for each acquisition date using all the interferograms, but without using a reference date to avoid that reference-date noise contaminates the solution. However, this leads to an under-determined problem, which I therefore solve by calculating the minimum-norm solution using singular-value decomposition. Then the mean line-of-sight velocity for each pixel is calculated and removed from the solution to estimate atmospheric-phase screens for the acquisition dates based on spatial low pass filtering and temporal high-pass filtering. I then remove the atmospheric-phase screen from each interferogram and re-estimate the minimum-norm solution to derive the spatio-temporal evolution of the plate-boundary deformation within the imaged area.

In the South Iceland seismic zone I use the time-series analysis to extract information about the interseismic deformation during 1995-2000 and about the postseismic transient deformation following the two magnitude 6.5 earthquakes that occurred in June 2000. The derived interseismic rates agree with results from campaign GPS measurements, although such comparison provides limited information due to the poor vertical accuracy of the campaign GPS measurements. The derived postseismic deformation has provided unique insights into what postseismic mechanisms were at work during the years following the earthquakes. On Reykjanes peninsula, I use data from 1992-1999 to derive information about both the steady plate-boundary deformation and about other deformation sources. The most prominent signals on Reykjanes are uplift east of Hengill volcano in 1994-1998 and subsidence around a geothermal power-plant, which both varies in space and time during the measurement period.