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Inversion of a spatially and temporally dense InSAR data set for the current rifting episode in Afar (Ethiopia)

R. Grandin (1), E. Jacques (1), A. Socquet (1), A. Nercessian (1), G. King (1), S. Tait (2), A. Delorme (1), and A. Lemarchand (3)

(1) Institut de Physique du Globe de Paris, Laboratoire de Tectonique et Mécanique de la Lithosphère (grandin@ipgp.jussieu.fr), (2) Institut de Physique du Globe de Paris, Laboratoire de Dynamique des Fluides Géologiques, (3) Institut de Physique du Globe de Paris, Laboratoire de Volcanologie

At mid-oceanic ridges, the accommodation of far-field plate divergence occurs along narrow magmatic rift segments (often $<$ 10 km wide), and follows a magmato-tectonic cycle, with discrete periods of intense magmatic and seismic activity separated by long periods of quiescence. However, rifting events are scarcely detected by the sensors commonly used for the study of large "onland" earthquakes (e.g. seismometers, geodetic devices), and, due to the remote setting, little information can be retrieved from this data. Furthermore, a large amount of the deformation involved during a rifting event occurs aseismically.

The current Wal'is-Dabbahu rifting episode in Afar (Ethiopia) constitutes an unprecedented opportunity to study the interplay between tectonic and magmatic processes during such episodes of rapid strain accommodation. The main rifting event took place in September 2005, and more than 10 smaller rifting events repeatedly occurred from late 2005 to late 2008 with a recurrence time of the order of a few months. The centimetric to metric surface displacements associated with dike intrusions make them easily detectable with InSAR. Approximately 100 radar acquisitions have been achieved by the ENVISAT satellite since the beginning of the rifting episode, allowing for the computation of hundreds of interferograms. By using the data acquired on one individual satellite track, and selecting the most relevant InSAR pairs, it is possible to calculate a time-series of surface deformation with a theoretical temporal sampling of 35 days.

We have achieved this task for 4 different tracks (2 ascending, 2 descending), yielding a dense - yet irregular - temporal sampling. Individual rifting events are clearly identified in the time series. Dike intrusions occurred at various locations along the rift, and at different depths, producing distinct fringe patterns at the surface. Transient deformations, probably associated with vertical movements of magma, also occur between and during rifting events. For each rifting event, inversion of geodetic data is performed using elastic modeling, and a geometry taking into account dikes, simplified faults, and magma chambers. The complex dike geometry is first determined using a non-linear inversion scheme. Then, using a single model geometry, we produce a slip-inversion model for each sub-event, allowing for determination of the volume and shape of each dike, as well as the amount of slip on overlying faults. These models are compared to the solution for the main September 2005 event. The spatial and temporal distribution of incremental opening along the dike during the whole rifting episode is discussed. The interaction between dikes and faults is also investigated. Finally, a comparison with seismicity data acquired during two individual rifting events is presented.