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Geodynamics of Afar: 3D crustal velocities and strain rates from multiple InSAR tracks and GPS

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Since onset of the Dabbahu rifting episode in 2005, an extensive geodetic data set has been acquired over Afar. Here we combine InSAR data from different tracks and the available GPS data to obtain the large scale 3D velocity field and strain information over a ∼500x500 km area in Afar.
We obtain the line-of-sight (LOS) deformation rates and the associated uncertainties for each InSAR track using a network approach to mitigate planar orbital and linear topographically correlated atmospheric delay errors in the interferograms. Pixels with deformation rates larger (within 2*sigma) than the mean deformation rate of the entire pixel network were removed. Thus our rate maps only preserve the linear deformation rates while sudden deformations, ie. due to dyke intrusions or eruptions, are not analyzed. Furthermore, unreliable pixels are not included in the rate maps by removing pixels with uncertainties of deformation larger than an a priori value, about 3-4 mm/yr. We combine the LOS rate maps with the GPS data and invert for the three-dimensional velocity field based on Tikhonov regularization, following the method of England and Molnar (1), as adapted by Wang and Wright (2) to incorporate InSAR data. A triangular mesh is constructed over the Afar area and then we solve for the best-fit horizontal and vertical velocities on each node. The final RMS misfit is 5 mm/yr for the InSAR rate maps and 7 mm/yr for the GPS velocities. These values are comparable to the uncertainties of the GPS and InSAR velocities used as input in the inversion.
Our analysis shows that strain in Afar is accumulated not only around the Dabbahu segment. A high strain rate is also observed towards the north in the Erta ‘Ale and Tat Ale segment but not to the south. This corresponds to several geologic features, a cluster of earthquakes occur at the Tat Ale segment and two eruptions occurred in Erta Ale since 2008. The strain map highlights the area affected by post-rifting deformation around Dabbahu, with high strain rates observed over a 400 km wide area centred at the Dabbahu segment.

References

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