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Spatio-temporal stress changes caused by rifting episodes in the southern Red Sea region

Renier Viltres (1), Sigurjón Jósson (1), Joël Ruch (1), Cecile Doubre (2), Robert Reilinger (3), Michael Floyd (3), and Ghebrebrhan Ogubazghi (4)

(1) King Abdullah University of Science and Technology, Saudi Arabia, (2) EOST – IPGS, University of Strasbourg, France, (3) Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, USA, (4) Eritrea Institute of Technology, Mai Nefhi, Eritrea

Extensional stresses at divergent plate boundaries are released by rifting episodes that are characterized by multiple dyke intrusions, volcanic eruptions and faulting. Rifting episodes cause large stress changes in the surrounding media, both instantaneously and in the years following the episodes, and can significantly influence the occurrence of future seismic and magmatic activity.
An exceptional opportunity to study rifting episodes and their effects was provided by the recent occurrence of three rifting episodes in the southern Red Sea (2007-2013), Afar (Dabbahu 2005-2010) and Gulf of Aden (2010) region. The region comprises several subaerial magmatic segments (Danakil depression) and narrow oceanic ridges (southern Red Sea and Gulf of Aden), allowing for instrumental monitoring. In addition to the three rifting episodes, several volcanic eruptions and intense seismic swarms were documented by seismic, geodetic and remote sensing data during the last decade.
Stress changes generated by dyke intrusions and faulting have already been related to some seismo-magmatic activity in the region. For example, the location of successive dyke intrusions (a total of 14) during the Dabbahu 2005-2010 rifting episode appears to have been controlled by the stress change induced by the immediate previous intrusion. Moreover, strong post-rifting deformation signals have been measured in Afar several years after rifting episodes, indicative of transient anelastic processes within the subsurface. While coupling between seismic and magmatic activity has been detected over distances of about 50-100 Km, the influence of rifting episodes on the notable increase in regional seismic and magmatic activity remains poorly studied and understood.
Here we combine new geodetic observations (GPS) with the implementation of stress transfer models in order to constrain the spatiotemporal scale of the stress changes produced by recent rifting episodes in the southern Red Sea region. We use the changes in GPS rates caused by the recent seismo-magmatic activity at stations located in Eritrea, Djibouti and Ethiopia in order to assess temporal changes in crustal strain and motions. This result, together with published studies, is used to parameterize each rifting event (length, width, timing of diking), which we use as sources in the stress change calculations. We then perform both elastic and viscoelastic stress transfer calculations to quantify the instantaneous co-rifting stress changes as well as time-varying post-rifting stress changes at different locations of interest. Finally, we constrain the spatio-temporal extent at which subsequent volcanic eruptions, dyke intrusions and/or significant seismicity can be associated to induced stress changes by the rifting episodes in the region.