Active Kinematics of Lithospheric Extension Along the East African Rift

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Summary

Geodetic observations have been identified by the GeoPRISMS Community as an essential component for future research on the kinematics and dynamics of rift initiation and evolution in general, and in East Africa in particular (Figure 1). GPS has the capability to measure very small relative velocities over large distances and well enough to resolve the lowest rates of total deformation seen along the entire East African Rift (EAR) given 5–10 years of observations with optimal site stability and noise sources. InSAR has the advantage of dense spatial coverage but requires larger displacements over a smaller distance to be resolvable, and may therefore be used to supplement the GPS coverage in areas of episodic, rapid rifting events. The cost- and time-effective approach to constraining the kinematics of rifting along the EAR, given that distance along strike is a proxy for maturity of rifting, is to build upon earlier GPS observations. This allows useful observations to be obtained quickly and a full set of geodetic constraints to be developed during the proposed life of the GeoPRISMS program. Figure 2 shows the locations of current survey and continuous sites for which data is available along the EAR. These include data from the authors of the accompanying White Paper, and others available through a range of datasharing agreements. Integrating, necessarily expanding, and uniformly processing and analyzing these data for accurate and precise evaluation of the extension across the rift will help to constrain and differentiate models of stages of rifting: incipient rifting (e.g. proposed transects 1 and 7); early continental rifting (e.g. transects 4, 5 and 6); well developed continental rifting (e.g. transect 3) and ocean-like rifting (e.g. transect 2).

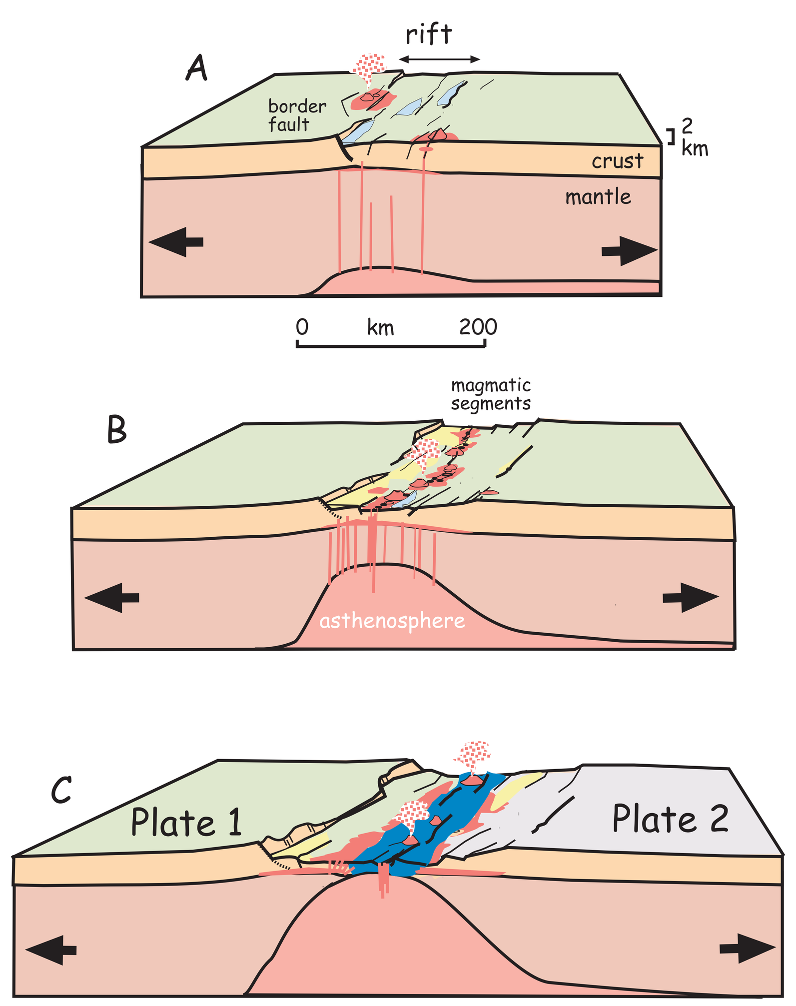

Figure 1 ⇧ *Schematic representation of a three-stage progressive strain localization model for rifting of a continental plate. From Ebinger (2005), Astronomy & Geophysics.*

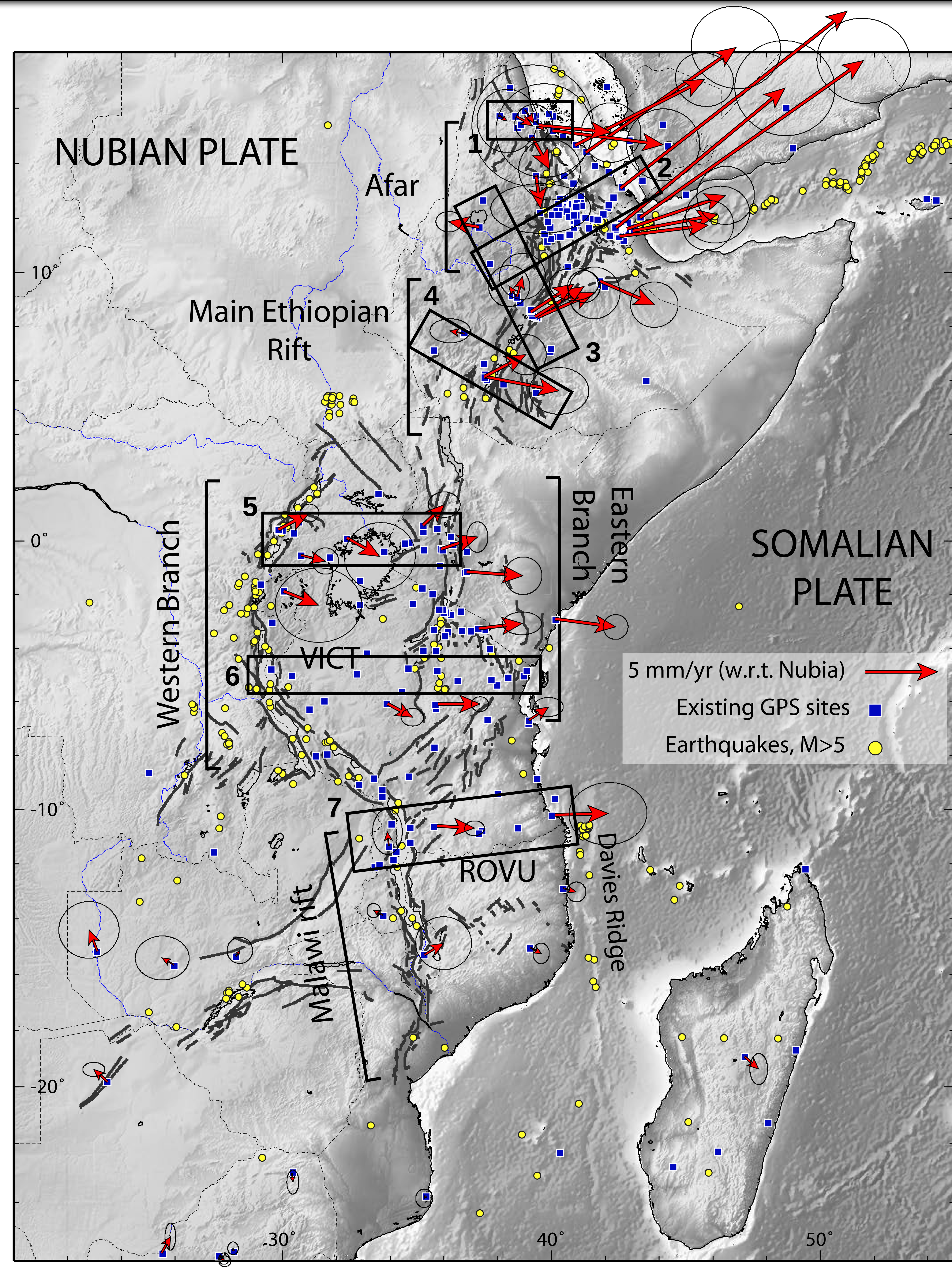

Figure 2 ⇨ *Overview of the East African Rift and current GPS coverage. In the main figure, existing GPS sites with reliable velocities from two or more occupations are shown by red vectors relative to Nubia; all other GPS sites are shown by blue squares. Black lines show major faults. Earthquakes are from the NEIC catalog. Further to the major bounding plates, micro-plates are Victoria (VICT) and Rovuma (ROVU), according to Stamps et al. (2008), GRL. Proposed transects to study various stages of rifting are outlined by black rectangles and discussed in the Summary, above.*

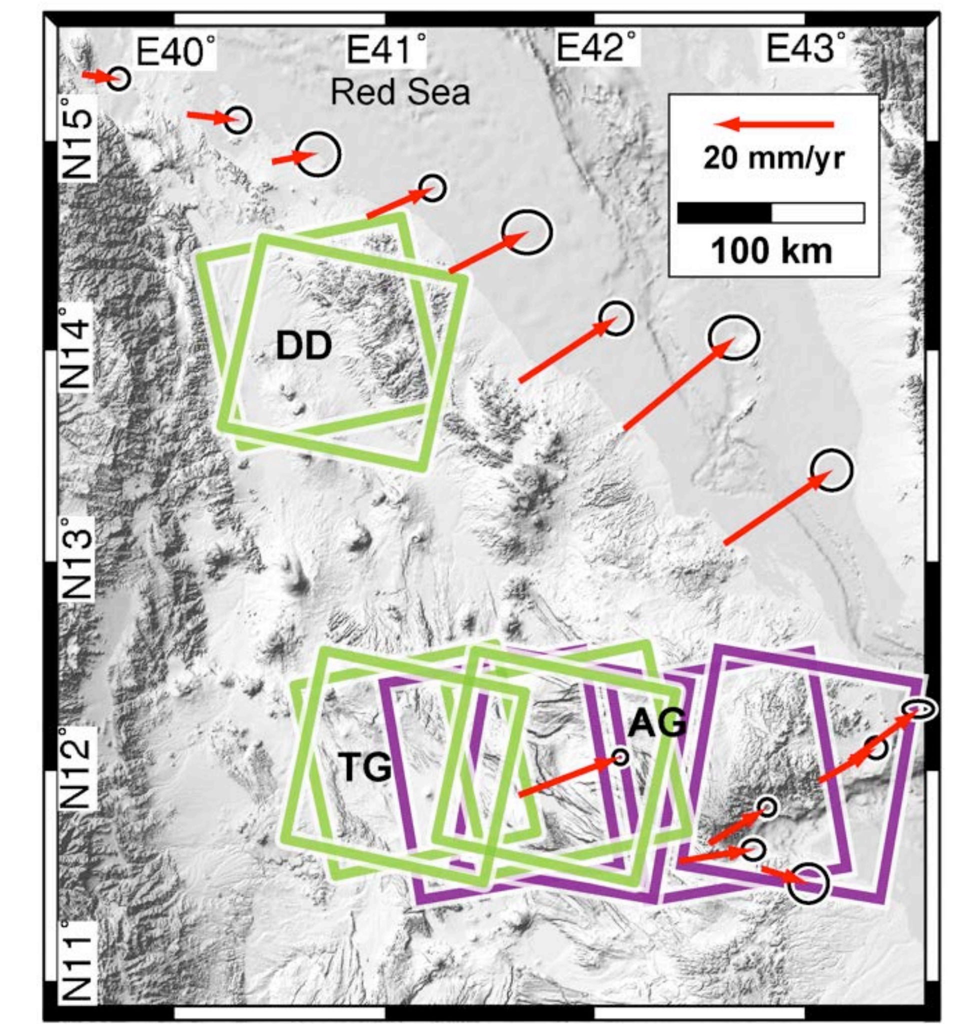

Figure 3 Map of the Afar region showing SAR image frames (green Envisat in green, Radarsat-1 in purple) available for use with time series methods for spatial density in focus areas. Also shown are GPS velocities relative to Nubia from McClusky et al. (2010) (other GPS velocities are removed for clarity). Axial rifts are the Danakil depression (DD), Tendaho graben (TG) and Asal graben (AG). Amagmatic extension occurs between TG and AG.

Discussion points and questions

1. Using GPS to monitor trans-rift deformation at a spatial scale of < 10km to accuracies of < 0.5 mm/yr along a series of transects at different stages of rift evolution is necessary to address the influence of a range of factors on the “initiation and evolution of rifting”.
2. Small rates of total extension across the EAR require building on available geodetic assets to develop sufficient time series to characterize the distribution of strain as a function of the degree of total extension.
3. cGPS stations should be constructed to the highest standards to assure stability, particularly where bedrock is not exposed at or sufficiently near the surface.
4. InSAR in conjunction with GPS will continue to be most useful in areas of rapid, or short-term (volcanic or earthquake activity) deformation, particularly in the rapidly extending Afar-Danakil Depression to identify localized strain anomalies.
5. What is the most effect combination of GPS survey and continuously recording station measurements to meet GeoPRISMS fundamental objectives of comparing and contrasting the distribution of crustal strain along the EAR?
6. How will GPS studies associated with the GeoPRISMS RIE Initiative be coordinated to avoid unnecessary redundancy and to assure uniform standards?
7. Considering the likely contributions from both NSF, host-country, and international partners to GPS monitoring of the EAR, should strategies for data archiving, processing, analysis, and distribution be established and coordinated by a “GeoPRISMS GPS Data Group” working with the NSFsupported University Navstar Consortium (UNAVCO) and the GeoPRISMS Data Portal?

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