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Mapping Tectonic Strain on a Global Scale with InSAR

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With the launch of the first operational InSAR satellite, Sentinel-1A, in 2013 we will soon have SAR acquisitions guaranteed for the whole planet every 12 days, with a mission lifetime of 20 years. These data have the potential to be used to map time-varying tectonic strain over continental scales at high spatial resolution. A key problem, however, is how to combine all these data to form a useful product, particularly on the scale of tectonic faults, which often span multiple radar tracks. We present a method for determining continental scale velocity fields using a combination of GPS data with SAR data from multiple acquisition tracks and viewing geometries. Results from Western Tibet show significant strain occurs in regions away from the major tectonic faults. In Afar, the velocity field reveals a wide-spread transient deformation signature associated with the steady response to the 14 dyke intrusions (to date) of the ongoing Dabbahu rifting episode.

To be useful for earthquake hazard assessment, we show that measuring velocity gradients of 1.2 mm/yr over length scales of 100 km is an appropriate target: Earthquakes in areas straining at this level or higher, according to the global strain rate model of Kreemer et al. (2003), are responsible for 90% of earthquake deaths on the continents. We show that Sentinel-1A is capable of measuring 70% of this high-risk area with 5 years of observation. This rises to 80% if ascending and descending data are acquired, and will increase further with longer observation intervals and the launch of the twin satellite Sentinel-1B. The main limitations on the accuracy of long-term strain measurements remain atmospheric noise and interferometric coherence. Our calculations assume that atmospheric noise is reduced by combining large numbers of interferograms in network-based algorithms, but further research on using the predictions of numerical weather models is likely to yield improvements during the lifetime of Sentinel-1. Densely vegetated areas will be incoherent over 12 days at the short C-band wavelength of Sentinel-1. Only a dedicated L-band mission would be capable of mapping tectonic strain in such areas. We show that an optimised InSAR satellite could measure strain over 97% of the land surface with a 5 year mission.