EGU2020-6144, updated on 15 May 2020
https://doi.org/10.5194/egusphere-egu2020-6144
EGU General Assembly 2020

Converting InSAR- and GNSS-derived strain rate maps into earthquake hazard models for Anatolia

Chris Rollins[1,2], Tim Wright[1,2], Jonathan Weiss[1,2,3], Andrew Hooper[1,2], and Richard Walters[2,4]
[1]University of Leeds, School of Earth and Environment, Leeds, United Kingdom (j.c.rollins@leeds.ac.uk)
[2]Centre for the Observation and Modeling of Earthquakes, Volcanoes and Tectonics (COMET)
[3]University of Potsdam, Institut für Geowissenschaften, Potsdam, Germany
[4]Durham University, Durham, United Kingdom

Geodetic measurements of crustal deformation rates can provide important constraints on a region's earthquake hazard that purely seismicity-based hazard models may miss. For example, geodesy might show that strain (or a deficit of seismic moment) is accumulating faster than the total rate at which known earthquakes have released it, implying that the long-term hazard may include larger earthquakes with long recurrence intervals (and/or temporal increases in seismicity rates). Conversely, the moment release rate in recent earthquakes might surpass the geodetic moment buildup rate, suggesting that the long-term-average earthquake activity and hazard may in fact may be more quiescent than might be estimated using the earthquake history alone. Such geodetic constraints, however, have traditionally been limited by poor spatial and/or temporal sampling, resulting in ambiguities about how the lithosphere accommodates strain in space and time that can bias estimates of the resulting hazard. High-resolution deformation maps address this limitation by imaging (rather than presuming and/or modelling) where and how deformation takes place. These maps are now within reach for the Alpine-Himalayan Belt – one of the most populous and seismically hazardous regions on Earth – thanks to the COMET-LiCSAR InSAR processing system, which performs large-scale automated processing and timeseries analysis of Sentinel-1 data provided by the EU's Copernicus programme. We are pairing LiCSAR products with GNSS data to generate high-resolution maps of interseismic surface motion (velocity) and strain rate for the Anatolia region. Here we quantitively investigate what these strain rate distributions imply for seismic hazard in this region, using two approaches in parallel.

First, building on previous work, we develop a fully probability-based method to pair geodesy and seismic catalogs to estimate the recurrence times of large, moderate and small earthquakes in a given region. We assume that earthquakes 1) obey a power-law magnitude-frequency distribution up to a maximum magnitude and 2) collectively release seismic moment at the same rate that we estimate it is accumulating from the strain rate maps. Iterating over various magnitude-frequency distributions and their governing parameters, and formally incorporating uncertainties in moment buildup rate and the magnitudes of recorded earthquakes, we build a probabilistic long-term-average earthquake model for Anatolia as a whole, including the most likely maximum earthquake magnitude. Second, we estimate how seismic hazard may vary from place to place within Anatolia.

Using insights from dislocation models, we identify two key signatures of a locked fault in a strain rate field, allowing us to convert the newly developed strain maps to “effective fault maps.” Additionally, we explore how characteristics of earthquake magnitude-frequency distributions may scale with the rate of strain (or moment) buildup, and what these scaling relations imply for the distribution of hazard in Anatolia, using the seismic catalog to evaluate these hypotheses. We also explore the implications of our findings for seismic hazard and address how to expand these approaches to the Alpine-Himalaya Belt as a whole.