# The Global Earthquake Activity Rate (GEAR) forecast test

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We present a global seismicity reference model based on uniform global datasets, transparently merging the best features of competing approaches and resulting in a testable product. In the past, two approaches to forecasting shallow seismicity have had comparable success. The tectonic method is based on maps of deforming regions and/or active faults, with some empirical calibration of seismic coupling. This captures the distribution of energy sources and may provide good forecasts for very long time windows. The smoothed seismicity approach applies optimized smoothing to cataloged earthquakes. This captures triggering, including ongoing aftershock sequences, and may work best on short to intermediate timescales. Here we combine a leading global forecast of each type using several kinds of combination: linear, log-linear, and an envelope method. We test the success of each parent and hybrid forecast in an 8-year retrospective test by information score, area skill score, and spatial-likelihood metrics that are all roughly independent of total earthquake rate. In this 2005-2012 test, the most successful hybrid model is the log-linear mixture of 60% seismicity with 40% tectonics. This hybrid outperforms both parent forecasts. The chance that this improvement results from a temporary random fluctuation is much less than 1%. We also test all models against the analog-instrumental catalog years 1918-1976; the same patterns of hybrid improvement are found. Likelihood scores are generally less than for the more recent catalog, possibly because of limitations in the older data. We compute an update of the preferred hybrid model using all modern catalog years 1977-2013, for future prospective testing. This hybrid model is named Global Earthquake Activity Rate model 1 (GEAR1) and is provided on a 0.1° ×0.1° global grid, for hypocentroid depths up to 70 km, with magnitude bins whose centers range from 6.0 to 9.0 in steps of 0.10. Comparing our GEAR1 forecast to the recent fault-based UCERF3 long-term forecast in California, we find that both predict the same total earthquake rates (within 4%) at each of two thresholds, but that the map patterns of the GEAR1 forecast most strongly resemble the maps of UCERF3 after spatial smoothing with characteristic distances of 25~30 km has been applied to UCERF3.

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