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Evaluating Simulation-Based Earthquake Forecasts

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Probabilistic earthquake forecasts are key ingredients for probabilistic seismic hazard assessments (PSHA) and for short-term operational earthquake forecasting (OEF). To build confidence in the utility of PSHA and OEF products, these forecasts need to be evaluated, ideally independently and prospectively. The Collaboratory for the Study of Earthquake Predictability (CSEP) supports an international effort to conduct and rigorously evaluate such earthquake forecasting experiments. In the past, most earthquake forecasts have been specified as synoptic probability maps over some region and time period. These maps are simple to interpret and help visualise and communicate the probabilities. The drawback is that potential spatio-temporal correlations within the space-time volume are no longer captured. Recent forecasting models, including OEF candidates, provide substantially more information than synoptic maps (although maps can always be constructed, too). Here, we focus on the problem of designing appropriate evaluation metrics for models that generate hundreds to thousands of synthetic earthquake catalogs as forecasts. Specifically, using forecasts and seismicity data from CSEP regions, we compare and contrast several proposed methods and tests. These include visual/qualitative techniques, statistical hypothesis tests of features of the simulated and observed catalogs, as well as modern Bayesian methods. We aim to provide guidance for CSEP in its quest to evaluate the next generation of earthquake forecast models, including the recent spatio-temporal clustering model UCERF3-ETAS (the Uniform California Earthquake Rupture Forecast version 3 - Epidemic Type Aftershock Sequence model).