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Is Coulomb stress the best choice for aftershock forecasting?

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The Coulomb failure stress (CFS) criterion is the most commonly used method for predicting spatial distributions of aftershocks following large earthquakes. However, large uncertainties are always associated with the calculation of Coulomb stress change. The uncertainties arise due to non-unique slip inversions and unknown receiver fault mechanism. Especially for the latter, uncertainties are highly dependent on the choice of the assumed receiver mechanism. There are two ways of defining the receiver faults, either by predefining fault kinematics by geological constraints, or by calculating optimally oriented planes, both ways are pretty unrealistic as real aftershocks show variable rupture mechanisms. Recent studies have proposed an alternative method based on deep learning to forecast aftershocks. Using a binary test (aftershocks yes/no), it has been shown that their method as well as alternative stress values, such as maximum shear or the von-Mises criteria, are more accurate and reliable than the classical CFS criterion with predefined receiver mechanism.

Here we use 351 slip inversions from SRCMOD database to calculate Coulomb failure stress on a layered-half space using variable receiver mechanisms as well as proposed alternative stress metrics. We also perform tests for different magnitude cut-offs, grid size variation, and aftershock duration to verify the use of ROC analysis for ranking of stress metrics. The observations suggest that introducing a layered-half space does not improve the stress maps and ROC curves. However, magnitude cut-off and aftershock duration does effect the efficiency of stress metric in a way that larger magnitudes and shorter aftershock durations are forecasted efficiently. Two alternative statistics based tests i.e. log-likelihood and information gain tests using rate-based forecasts (non-binary) are also performed to compare the ability of metrics to discriminate the regions with and without aftershocks. The results suggest that simple methods of stress calculations perform better than the classic Coulomb failure stress calculations.