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Response of the San Jacinto Fault Zone to static stress changes from the 1992 Landers earthquake

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Transfer of static stress has been proposed as a mechanism for interaction of earthquakes, by Coulomb stress triggering. The ability of this model retrospectively to explain the qualitative spatial characteristics of many aftershock distributions suggests that it has the potential to become an important tool not only in short-term aftershock forecasting, but also in longer term regional seismicity forecasts. The model also has implications for hazard assessment in the context of induced seimicity. However, in practice, its suitability as part of any prospective forecast will rely on determining a quantitative relationship between static stress changes and aftershock probability. In order to make progress in validating such a relationship, we perform an analysis of the seismicity response of the San Jacinto Fault Zone to static Coulomb stress changes from the 1992 Landers earthquake sequence. Results show that, in general, stress changes forecast rate changes well: we find a statistically significant positive correlation between the change in rate and the magnitude of the Coulomb stress change, with a correlation coefficient of 0.76 (equivalent to 5.6σ, when compared to a $\rho = 0$ null hypothesis). This result is an important step in the validation of Coulomb stress based methods for quantitative seismicity forecasting. Comparison of the data with the predictions of the Coulomb rate-and-state model, yield parameter estimates of $A\sigma = 0.4$ bars and $t_a \sim 8$ years. These estimates are likely to be sensitive to the choice of reference seismicity model. With regard to the input parameters of the Coulomb stress model, we find that, although there seems to be a trade-off between the orientation and effective co-efficient of friction μ' of the target faults, in general structually constrained target fault orientations and values of $\mu' = 0.4$ to 0.8 explain the data best, particularly for longer term aftershock rates. We conclude that the correspondence between the predictions of Coulomb stress models for aftershock seismicity and observed rate changes may be sensitive to strong heterogeneity in aftershock locations and orientations associated with the presence of large-scale structure in aftershock study areas. In these cases, we suggest that, where the regional structure is mapped, incorporating it explicitly into Coulomb stress models may improve the performance of quantitative Coulomb stress based forecasts.