Geophysical Research Abstracts
Vol. 14, EGU2012-9650, 2012
EGU General Assembly 2012

The systematic study of the stability of forecasts in the rate- and state-dependent model.

D. De Gaetano (1), J. McCloskey (2), and S. Nalbant (2)

(1) School of Environmental Sciences, University of Ulster, Northern Ireland, UK (de_gaetano-d@email.ulster.ac.uk), (2) School of Environmental Sciences, University of Ulster, Northern Ireland, UK

Numerous observations have shown a general spatial correlation between positive Coulomb failure stress changes due to an earthquake and the locations of aftershocks. However this correlation does not give any indication of the rate from which we can infer the magnitude using the Gutenberg-Richter law.

Dieterich's rate- and state-dependent model can be used to obtain a forecast of the observed aftershock rate for the space and time evolution of seismicity caused by stress changes applied to an infinite population of nucleating patches. The seismicity rate changes on this model depend on eight parameters: the stressing rate, the amplitude of the stress perturbation, the physical constitutive properties of faults, the spatial parameters (location and radii of the cells), the start and duration of each of the temporal windows as well as the background seismicity rate. The background seismicity is obtained from the epidemic type aftershock sequence model. We use the 1992 Landers earthquake as a case study, using the Southern California Earthquake Data Centre (SCEDC) catalogue, to examine if Dieterich's rate- and state-dependent model can forecast the aftershock seismicity rate. A systematic study is performed on a range of values on all the parameters to test the forecasting ability of this model. The results obtained suggest variable success in forecasting, when varying the values for the parameters, with the spatial and temporal parameters being the most sensitive.

Dieterich's rate- and state-dependent model is compared with a well studied null hypothesis, the Omori-Utsu law. This law describes the aftershock rate as a power law in time following the main shock and depends on only three parameters: the aftershock productivity, the elapsed time since the main shock and the constant time shift, all of which can be estimated in the early part of the aftershock sequence and then extrapolated to give a long term rate forecast. All parameters are estimated using maximum likelihood methods. We compare the Dieterich and the Omori-Utsu forecasts using the Akaike information criterion which appropriately penalises each model for the number of free parameters used in the fit and explore the full spatial distribution of parameters, forecasts and forecast skill. We find that the Omori-Utsu law consistently out-performs the Dieterich model. The method described is then applied to other earthquake sequences and we assess its usefulness as a real time aftershock forecasting protocol.

Finally, we produce a synthetic catalogue. The spatial seismicity of this catalogue is governed by the structural fractal complexity of the region, while the rate of the earthquakes (the temporal seismicity) follows the rate- and state-dependent model. This enables us to examine if we are able to recover the rate- and state-dependent model parameters and help us understand if the variable success in forecasting is due to the physics in the model differing from the real world or else due to the lack of enough data in the catalogue.