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Statistical quantification of time-dependence in the static Coulomb model

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Statistical tests of the consistency of observed aftershock sequences with the change in Coulomb Failure Function are based on evaluation of the Coulomb index for the aftershock sequence given the calculated spatial distribution of the change in CFF. Tests of the statistical significance of the results require a choice of null hypothesis, which involves estimating the number of aftershocks that would be expected to occur on regions where dCFF>0 by chance (in general it is assumed that this quantity is static). A null hypothesis of this nature will predict a number of "successes" (i.e. events on CFF>0) that is binomially distributed with parameter p, where p is the probability of an event to occur on CFF>0. Here, p depends on the distribution of seismicity that we assume would have occurred in the aftershock period had there been no mainshock. Using the normal approximation to the binomial, the observation can then be expressed as the number of standard deviations from the expected number of successes, z (a transformation to the standard normal distribution), given the chosen null hypothesis. It is also convenient to apply this method to the investigation of suppression of seismicity in regions where CFF<0. In this case we expect to see z<0, signifying an observation of fewer events than expected on areas where CFF<0. In this study we have corrected the statistic for errors in hypocentre locations. A number of considerations should influence the choice of null hypothesis. The spatial distribution of background seismicity with respect to the dCFF field, which is difficult to estimate with confidence, is strongly dependent on the location of structure and is therefore heterogeneous over the region of interest. Aftershock distributions from other events preceding the mainshock of interest contribute to the observed seismicity in the aftershock period. This introduces spatial heterogeneity (which is not static in time) into the aftershock distribution, which is again unrelated to the dCFF field from the mainshock. Finally, aftershocks in the distribution have their own aftershock sequences. Particularly for large events, this could have the effect of amplifying contributions to either positive or negative dCFF, causing the statistical significance of the observation to be misrepresented. A statistical study of the consistency of the spatial distribution of the observed aftershocks of the 1992 M7.3 Landers earthquake with the change in CFF is presented, which evaluates the significance of the observations within this framework. Temporal decay of the statistical significance in the months after the mainshock is demonstrated. Quantification of this time-dependence may give some insight into the influence of secondary effects on the observed aftershock distribution. The result is analysed with reference to a range of null hypotheses based on sets of explicit assumptions about the expected seismicity in the region. We find that the value of the test statistic z is strongly dependent on the nature of these assumptions.