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地震時静的応力変化および地震活動予測のプロスペクティブ評価へ向けて

CoulombExpress: Near-realtime forecasts of earthquake-induced stress transfer and seismicity for prospective testing

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A principal tenet of the Coulomb hypothesis is that stress increases promote, and decreases inhibit, fault failure. In support of such a simple hypothesis, a growing number of studies have found that seismicity rates climb where the stress increases and fall where the stress drops. However, they are all evaluated retrospectively, which may permit unintentionial bias to enter into data interpretation. Further, retrospective tests do not contribute to earthquake disaster mitigation. In particular, the probability rate for triggered seismicity is highest immediately after a mainshock, as suggested by rate/state friction. Thus, to make the stress-based earthquake forecasting rapidly available and to permit objective prospective testing, we have developed CoulombExpress, an automatic stress calculation system, which uses near real-time information, such as earthquake magnitude, location, depth, and its rapid moment tensor solution. Two versions of CoulombExpress, CoulombExpress Global and CoulombExpress Regional are in progress.
1) CoulombExpress Global: The system quickly computes the Coulomb stress change caused by an M?6 around the globe. It automatically accesses the USGS National Earthquake Information Center parameters. In order of time, the system uses the NEIC W-phase, central, and body-wave moment tensor solutions, when available, to make the two-nodal-plane source fault models using the empirical scaling relations of Wells and Coppersmith [1994]. The stress changes are resolved on receiver faults parallel to the sources and also on both nodal planes of the nearby 1967-2005 Global CMT earthquakes, as stand-in's for active faults. The color-coded displays allow the viewer to grasp where and by how much the off-fault aftershocks might become active. Keeping long-term records of our results in an official archive will allow evaluators to examine rigorously the forecasting skills of our model.
2) CoulombExpress Regional: This is a forecasting system that computes not only Coulomb stresses but also the space-time seismicity rate evolution (Toda et al., JGR, 2005) for a particular region or country where high-quality local data are available. It has been implemented for M?4 in Japan first (with California to follow). Coseismic stress changes caused by large historical earthquakes since 1891 M=8.0 Nobi earthquake have been calculated to evolve regional state variables. Moderate earthquakes for the recent years are also implemented as point sources to generate local stress perturbations. Since the local catalog is available, we analyze the background rate of seismicity, aftershock durations, and regional G-R parameters needed to translate the calculated stress changes into expected seismicity rate changes. The estimation of the background (or reference) seismicity rate was done by declustering the earthquake catalog using the stochastic method proposed by Marsan and Lengline (Science, 2008). Alternatively, we have also

estimated a reference rate by smoothing the seismicity for some prescribed time windows, using the undeclustered earthquake catalog. We have built matrices of assumed receiver fault planes (strike, dip, and rake) based on focal mechanism data and structural controls. Since stress increase should immediately increase the seismicity rate, we select and use for further calculations the maximum stress changes throughout the various receiver planes and calculation depths. We submitted our first version of this regional model to CSEP (Collaboratory for the Study of Earthquake Predictability) Japan in October 2009.

キーワード:地震長期予測,クーロン応力変化,応力,地震活動,歴史地震,活断層

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