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Evaluating the role of large earthquakes on aquifer dynamics using data fusion and knowledge discovery techniques

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Artificial adaptive systems are evaluated for their usefulness in modeling earthquake hydrology of the Canterbury region, NZ. For example, an unsupervised machine-learning technique, self-organizing map, is used to fuse about 200 disparate and sparse data variables (such as, well pressure response, ground acceleration, intensity, shaking, stress and strain; aquifer and well characteristics) associated with the M7.1 Darfield earthquake in 2010 and the M6.3 Christchurch earthquake in 2011. The strength of correlations, determined using cross-component plots, varied between earthquakes with pressure changes more strongly related to dynamic- than static stress-related variables during the M7.1 earthquake, and vice versa during the M6.3. The method highlights the importance of data distribution and that driving mechanisms of earthquake-induced pressure change in the aquifers are not straight forward to interpret. In many cases, data mining revealed that confusion and reduction in correlations are associated with multiple trends in the same plot: one for confined and one for unconfined earthquake response. The autocontractive map and minimum spanning tree techniques are used for grouping variables of similar influence on earthquake hydrology. K-means clustering of neural information identified 5 primary regions influenced by the two earthquakes. The application of genetic doping to a genetic algorithm is used for identifying optimal subsets of variables in formulating predictions of well pressures. Predictions of well pressure changes are compared and contrasted using machine-learning network and symbolic regression models with prediction uncertainty quantified using a leave-one-out cross-validation strategy. These preliminary results provide impetus for subsequent analysis with information from another 100 earthquakes that occurred across the South Island.