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Statistical Analysis of the Wenchuan Aftershock Sequence

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An exploratory statistical analysis was performed on the Wenchuan aftershock sequence. The goals of the analysis were:

1. to assess the fit of common aftershock models;
2. to cluster the sequence spatially, and subsequently analyze spatial patterns;
3. to ascertain if forward prediction of magnitude was possible.

The models applied in the analysis included Omori-Utsu, ETAS, Mixture Models, Hidden Markov Models, Logistic Regression, Classification Trees, and ARIMA models.

The Omori-Utsu and ETAS models fit the aftershock sequence well if the entire sequence was used to create the model. However, if the model was trained on a smaller period of the sequence, the forward predictive performance of the model deteriorated (see Figure 1).

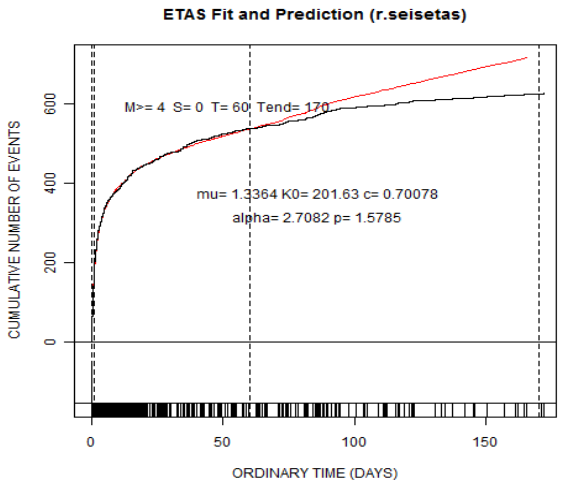

Figure 1. ETAS Model

Mixture models found eight spatial clusters. However, the hidden Markov model was unable to successfully predict the cluster location of the next earthquake based on the current location alone.

The logistic regression and classification tree showed no reliable forward prediction of magnitude. Therefore, an ensemble approach was taken. Ensembles combine many models in order to improve performance. The ensemble approach was Adaboost applied to classification trees. Here, Adaboost built many classification trees on subsamples of the data. Poorly predicted observational units (earthquakes) were increasingly included in the subsamples. The results of Adaboost with classification trees on this dataset were unsurprising. A training set with equal instances of greater than and less than four magnitude earthquakes could be almost perfectly predicted. Note the magnitude threshold had to be reduced so that the groups had equal numbers. However, applied to a test set the model lost substantial amounts of predictability. Further tuning of the model would be required to improve the test results and applicability to a larger magnitude threshold.

The ARIMA models showed similar results. Further refining and investigation of these models is warranted to assess the optimal level of the parameters necessary for reliable forward prediction.