California Earthquakes

A researcher in geology was interested in predicting earthquakes by the level of water in nearby wells. She had a large ($8192 = 2^{13}$ measurements) data set of water levels taken every hour (time increments: 1/24= 0.0417 julian days) in a period of time of about one year in a California well. Here is the description of the problem.

> The ability of water wells to act as strain meters has been observed for centuries. The Chinese, for example, have records of water flowing from wells prior to earthquakes. Lab studies indicate that a seismic slip occurs along a fault prior to rupture. Recent work has attempted to quantify this response, in an effort to use water wells as sensitive indicators of volumetric strain. If this is possible, water wells could aid in earthquake prediction by sensing precursory earthquake strain.
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> We have water level records from six wells in southern California, collected over a six year time span. At least 13 moderate size earthquakes (Magnitude 4.0 - 6.0) occurred in close proximity to the wells during this time interval.
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> There is a a significant amount of noise in the water level record which must first be filtered out. Environmental factors such as earth tides and atmospheric pressure create noise with frequencies ranging from seasonal to semidiurnal. The amount of rainfall also affects the water level, as do surface loading, pumping, recharge (such as an increase in water level due to irrigation), and sonic booms, to name a few. Once the noise is subtracted from the signal, the record can be analyzed for changes in water level, either an increase or a decrease depending upon whether the aquifer is experiencing a tensile or compressional volume strain, just prior to an earthquake.

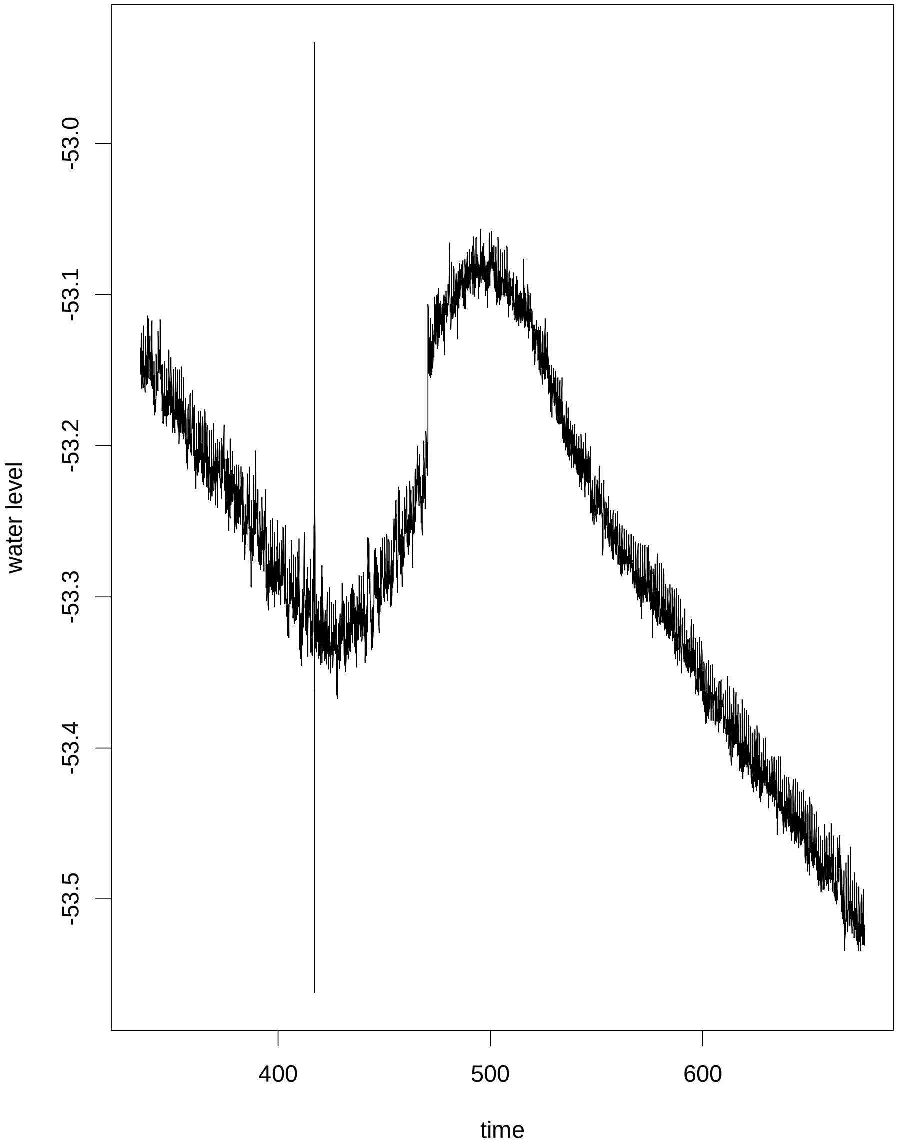

Figure 1: Earthquake