

Interactive comment on “Anomalous frequency characteristics of groundwater levels before major earthquakes in Taiwan” by C.-H. Chen et al.

Anonymous Referee #1

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It has long been documented that there are hydrological responses to earthquakes. Water level changes in wells are examples. Responses range from oscillations at seismic frequencies to near-permanent changes in water level. These are responses to changes in stress, so it is not unreasonable to hope to see hydrological signals associated with stress changes prior to earthquakes. This hope has not yet materialized in the observational record.

The present paper claims to have identified widespread precursors to large earthquakes in Taiwan. They make use of a great dataset of water levels from monitoring wells. I do not think their analysis in either the time or frequency domain supports their conclusions, however.

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1) Time domain “Unusual” decreases in water level are reported during the year before the Chi Chi earthquake. This was a drier-than-average year, so decreased water levels over the preceding year make sense. The authors dismiss a climatic origin by noting that similar decreases are not seen in other drought years. However, Figure 5 shows that, in fact, the year before the Chi Chi event is not unusual. Indeed, when discussing figure 5 the authors note that in the time domain there is nothing obvious prior to earthquakes (hence the reason for looking in the frequency-domain, which I evaluate next). The analysis in Figure 2 should be based on many more years of data before the earthquake.

2) Frequency domain One common flaw in studies reporting precursors is that the response to the earthquake (which is well documented, both in Taiwan and globally) is not separated from the behavior prior to the earthquake. If the earthquake changes hydrogeological properties, the time series of water level variations afterwards should be different from that before the earthquake. Elkhoury et al. (Nature 2006), for example, used phase lags of tidal responses to document changes in permeability and their recovery after earthquakes. The amplitude ratio changes in Figure 5 could similarly be a response to the earthquake because they change after the earthquake, with the exception of event M.

There is a second problem with the spectral analysis. Figure 4 shows that the spectral amplitude changes at many frequencies, not just in the 0.02 – 0.04 1/day range. In fact the biggest changes occur at 0.06 1/day, 600 days before the earthquake. The chosen range for the analysis has no physical meaning that I could discern. The changes at other frequencies need to be addressed, especially when they have no obvious connection to earthquakes.

Why was hourly data down-sampled to a daily record?

The authors are making a remarkable claim – that they have identified precursory signals (though they acknowledge that they are not understood and need further study).

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A remarkable and important claim requires strong support. I think the analysis in the present paper is not adequate to support their claims.

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