EGU2020-6700
https://doi.org/10.5194/egusphere-egu2020-6700
EGU General Assembly 2020

Negentropy anomaly analysis of the borehole strain data associated with the Ms 7.0 Lushan earthquake

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Several YRY-4 borehole strainmeters have been installed in Sichuan province, China, aiming at monitoring the crustal activities associated with earthquakes. In order to verify the existence of strain precursors preceding the Lushan earthquake, we investigate the negentropy of the borehole strain data during 2011-2013.

First, some local factors that could affect the strain are ruled out, such as environmental disturbances, we analyze the strain responses to air pressure as well as solid tides and water level which were recorded on one YRY-4 strainmeter. Based on a state-space model according to the observations of the strainmeter, we remove the strain response to air pressure, in addition to those due to water level changes and the solid tides by Kalman filter. To investigate whether the remained strain changes are related to the Lushan earthquake, we introduce the approximate negentropy as an easily computable non-randomness measure to give evidence of strain changes and illustrate the instability of the underground of the earthquake zone. Generally, the appearance of a pre-catastrophic state can be characterized by significant higher non-randomness in terms of approximate negentropy.

Negentropy analysis of 3 stations of the southwest end of the Longmenshan fault zone have been performed. The nearest GZ station is 77 km away from the epicenter, and the epicenter distances of XM and RH are respectively 270 and 436 km. The statistical results at GZ station of cumulative counts of negentropy anomaly show acceleration about 6 to 4 months and 10 days prior to the earthquake, implying there are non-random changes in the borehole strain data, which is similar to the previous results. In addition, after the earthquake, the anomalies increase briefly and recover to a quiet state. Besides, XM station appears a significant surge from October 2012 to 2013, which is consistent with the first period anomaly extracted from the GZ station. However, RH station doesn't show anomaly acceleration, probably due to the distance.

Furthermore, we compare the anomaly acceleration rate of each station. The results indicate that as the epicenter distance increases, the acceleration rate becomes less significant, suggesting the negentropy anomalies are more sensitive near the Lushan earthquake epicenter. In other words, the anomalies of the borehole strain data dependent on the epicenter distance. Therefore, we conclude that there may be strain precursors before the Lushan earthquake and the negentropy analysis have potential capability in the study of earthquake precursors.