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Hydrologically-Induced Crustal Stress Changes and Their Association with Seismicity Rates in Taiwan

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Studying crustal stress changes associated with hydrological cycles and their influence on seismicity rate illuminate the complex interplay between crustal stress conditions, faulting types, and earthquake nucleation. By analyzing GNSS position time series in 2006-2021 across Taiwan, we unveil a prevailing NW-SE trending contraction and expansion of the Earth's crust in response to hydrological loading and unloading in western Taiwan. The largest annual crustal strain variation in SW Taiwan is consistent with the maximum annual water storage change inferred from independent studies. During the wet season, we observe increased hydrologically-induced contraction, aligning with the tectonic compressive stress axis, accompanied by a decrease in seismicity rates in SW Taiwan. The alignment of hydrologically-induced and tectonic stress axes does not lead to frequent earthquakes during the wet season; rather, seismicity peaks in the dry months, coinciding with maximum uplift and water unloading. This pattern suggests that hydrologically-induced vertical stress primarily influences earthquake triggering, evidenced by stress amplitudes 3~5 times greater than horizontal stress. The statistical correlation evaluating the timing of earthquakes and hydrologically-induced stress further affirms the seismicity rate increases with reduced tectonic compression and enhanced crustal extension in SW Taiwan.

Keywords: GNSS, seismicity rate, hydrological loading, earthquake triggering