Climate- and Weather-Driven Solid-Earth Deformation and Seismicity

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There is long-standing interest in the interactions between atmospheric and hydrological processes and solid Earth deformation, including the occurrence of earthquakes. There is evidence for the effects of climatic processes and weather on deformation and seismicity in the lithosphere over a wide range of time scales, ranging from load cycles associated with the ice ages to the effects of short-term weather events. Space- and ground-based geophysical observations allow us to capture the redistribution of surface loads in the form of water, ice, and sediments, as well as near-surface pressure and temperature changes in the atmosphere and varying fluid pressure in the shallow subsurface. While earthquakes are generally the result of tectonic activity, the climatic forcings induce stress changes on faults that in some cases can be shown to significantly encourage or retard the occurrence of earthquakes. Climate-earthquake interactions are mostly subtle and proving the interaction between climate and earthquakes requires careful mechanical modeling and statistical analysis. While investigations of these interactions are not likely to be relevant for the characterization and mitigation of earthquake hazard, they provide important insights into the physical processes associated with lithospheric deformation, the earthquake cycle and frictional faulting in the Earth. By analyzing GNSS position time series across Taiwan, we reveal a prevailing NW-SE trending seasonal contraction and expansion of the Earth's crust in response to hydrological loading and unloading. Inspection of seismicity rate in in SW Taiwan indicates a positive correlation between excess seismicity rate and reduced NW-SE compression and/or decreasing vertical compression. Though hydrologically induced contraction aligns with the tectonic compressive stress axis in the wet season, this alignment does not lead to more frequent earthquakes. Instead, seismicity peaks during the dry months, coinciding with maximum uplift and water unloading. This feature suggests hydrologically induced vertical stress or pressure changes plays the dominant role in triggering earthquakes.