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Study of strong interaction between atmosphere and solid Earth by using hurricane data

Toshiro Tanimoto
UC Santa Barbara, Santa Barbara, United States (toshiro@geol.ucsb.edu)

The original energy of seismic noise is in the atmosphere although the most well-known seismic noise (microseism) gets excited through the ocean, i.e. the atmosphere (winds) excites ocean waves that in turn generate seismic noise in the solid earth. The oceans work as an intermediary in this case. But there is some seismic noise that is directly caused by the atmosphere-solid earth interactions.

An extreme example for such a direct interaction can be found in the case of hurricanes (tropical cyclones) when they landfall and move on land. If we had such data, we could study the process of atmosphere-solid earth interactions directly. The Earthscope TA (Transportable Array) provided a few examples of such landfallen hurricanes which moved through the TA that had both seismometers and barometers. This data set allows us to study how ground motions changed as surface pressure (i.e. the source strength) varied over time.

Because effects of surface pressure show up at short distances more clearly, we first examine the correlation between pressure and ground motion for the same stations. Plots of vertical ground velocity PSD (Power Spectral Density) vs. surface pressure PSD show that there are no significant ground motions unless pressure PSD becomes larger than 10 (Pâ2/s). Above this threshold, ground motion increases as P**1.69 (P is pressure and 1.69 is close to 5/3).

Horizontal ground motions are larger than vertical ground motions (in seismic data), approximately by a factor of 10-30. But we note that the variations of horizontal motions with pressure show a linear relationship. Considering the instrumental design of TA stations, this is more likely due to the tilt of the whole recording system as (lateral) strong winds apply horizontal force on it. This linear trend exists for the whole range of the observed pressure PSD data, extending to small pressure values. We interpret that tilt signals overwhelmed other seismic signals in horizontal seismograms for hurricane data. On the other hand, vertical-component signals that are excited by high surface pressure are most likely to be excited ground motions by surface pressure. We will discuss how this vertical amplitude vs. pressure plot with the power-law relationship of exponent 1.69 can be explained by invoking the random forcing theory.