Strong Land-Atmosphere Coupling in Low Frequency Band below 0.05 Hz

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There are now many arrays that have co-located seismometers and barometers. They provide new opportunities to examine the nature of coupling between the atmosphere and the solid Earth. We will discuss some basic characteristics of the coupling that we learned from the Earthscope Array when we analyzed hurricane data.

In our recent paper (GRL, 43, Geophys. Res. Lett., 43, 2016, doi:10.1002/2016GL070858), we showed that there is a threshold pressure for the coupling between atmospheric pressure and vertical seismic motions; below this threshold pressure vertical amplitudes are flat and are irrespective of local atmospheric pressure. Above this pressure the local atmosphere pressure directly controls vertical amplitudes. This applies only to a low frequency range, below about 0.05 Hz, but for such a low frequency band, correlation between vertical displacement and pressure becomes very high. The correlation coefficients (with zero time shifts) are about 0.8-0.9. In a higher frequency range than 0.05 Hz, such a high correlation does not occur; for example, for 0.1-0.4 Hz which is a secondary microseismic frequency band, amplitudes (noise) are generated in the ocean and are irrelevant to the local atmospheric pressure.

As an interesting display of this characteristics, we will show an example from a hurricane. When Hurricane Isaac (2012) moved over some stations in the Earthscope Transportable Array, pressure and seismic data showed clear effects of vanishing amplitudes near the center of this hurricane for a frequency band below 0.05 Hz. Both pressure and seismic time series showed vanishing amplitudes, appearing like data gaps, if the hurricane center moved over a station almost exactly (within less than 10km). But for stations away from the hurricane track by more than 50 km, such gap-like features were not seen. This may not be surprising for barometer data as pressure is known to be small near the hurricane center but vertical seismic amplitudes also showed similar small amplitudes. This is of course related to a high correlation between pressure and vertical displacement in a low frequency band. Such gap-like features were not found for higher frequency bands.

This feature is somewhat counter-intuitive for a seismologist as we tend to think that the generated low-frequency seismic waves should propagate from a high atmospheric pressure region. Such waves should reach the center of a hurricane and cause some seismic signals. There may be some such signals but the data show that they are quite small; what we observe are highly correlated vertical seismic motion with the local pressure, an almost perfect phase-to-phase match.

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