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Land-Atmosphere Interaction in the low-frequency seismic band (0.001-0.05 Hz)

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For frequencies below about 0.05 Hz, except for the hum signals generated by ocean waves, the atmosphere is the main source of seismic noise. Some characteristics of such noise, generated by the land-atmosphere interaction, have been reported (e.g., Zu¨rn et al., 2007; Zu¨rn and Wielandt, 2007) but recent data from co-located pressure and seismic sensors allow us to further improve our understanding of this interaction. We report on our analysis of the EarthScope Transportable Array (TA) and some global permanent stations that are equipped with pressure and seismic sensors.

We first point out that coherence between pressure data and vertical seismic data shows two broad peaks, one that rises below about 0.002 Hz and the other that peaks about 0.02 Hz. There is a minimum of coherence between them at about 0.003-0.004 Hz.

We have noted that there is basically no phase-shift between pressure and vertical seismic displacement for the lower frequency peak while there is a 180-degree phase shift between pressure and vertical displacement for the higher frequency peak at about 0.02 Hz. The zero phase-shift for the lower frequency peak is consistent with the predominant mass-attraction effect due to density perturbations in the atmosphere and the 180-degree phase shift for the peak about 0.02 Hz is consistent with elastic deformation by atmospheric pressure on the surface.

They suggest that there are two competing forces generated by the atmosphere, one that tends to attract the ground upward by density perturbations in the atmosphere and the other that tends to push down the ground due to high pressure. The former wins in the lower frequency below 0.002 Hz and the latter wins for frequencies above 0.01 Hz. The existence of the minimum between the two peaks indicates that relative size of these forces switches at about 0.003-0.004 Hz (also noted by Zu¨rn and Wielandt, 2007).

The size of the higher frequency peak (at about 0.02 Hz) is strongly influenced by the elasticity of near-surface materials; at many sites with STS-1 sensors, this high frequency peak is often hard to identify as the sites are mostly at (truly) hard-rock sites, meaning there is little deformation due to atmospheric pressure. On the other hand, some EarthScope TA sites are at soft sediment sites and show a large (and dominant) peak at about 0.02 Hz.

We will discuss how the competition of two effects (mass attraction vs. pressure on the surface) and the elasticity of the medium determine the main characteristics of coherence between pressure and vertical seismic data.