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Detection of Gravity Waves and Infrasound Signals at the USArray

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The USArray Transportable Array (TA) is a 400-station network that has been deployed in the continental United States since 2004. The network, which at its height spanned 2,000,000 km^2, has gradually moved east across the country via station re-deployments. Although originally conceived as a seismic-only network, a suite of atmospheric pressure sensors added to each station starting in early 2010 allows for enhanced observations of pressure variations at the Earth's surface associated with infrasound and other atmospheric phenomena. We present novel techniques that make use of the close spacing of stations within the TA to detect and track the progress of pressure disturbances across the network. The method has been applied to the detection of both atmospheric gravity waves having periods from 40 minutes to 8 hours, and 1-3 Hz infrasound energy generated by meteoroids. The TA is sufficiently dense that gravity waves with wavelengths from tens to hundreds of kilometers are coherent between neighboring stations, but is too large for coherence across the entire network. To examine the characteristics of gravity waves propagating across the network, the TA is divided into a large number of elemental, triangular, sub-arrays consisting of three neighboring stations. Coherent analysis of the data at each triad provides a robust estimate of the signal's direction and speed. The results from all triads are combined to follow the progress of a gravity wave as it propagates across the TA. This method allows for observation of fine-scale variations in the speed, direction and amplitude of long period signals across the TA, as well as the statistics of these waves.
The method has been applied to TA data collected over the eastern half of the continental United States over a 5-year timespan beginning on January 1, 2010. The network has detected particularly large and long-lived gravity waves such as from a tornadic storm system in the American south in April, 2011. In addition to studying the characteristics of singular events, we have used the data to study the statistics of gravity wave activity across the study area. We observe clear variations across the study region – most notably a persistent and active region in the vicinity of the Great Lakes. This high coincides with elevated activity seen in images of gravity wave activity in the stratosphere observed with satellite data.
The method described above has been modified to detect pressure disturbances with wavelengths much less than the inter-station spacing. In this case, the waveform data is appropriately bandpassed and an STA/LTA filter is applied to form envelopes of the data. Coherent analysis is performed on the data envelopes at each triad rather than the waveforms; in other respects the analysis is similar to that described above. This method has been applied to infrasound generated by the terminal burst of meteors in order to infer the trajectory of several small bolides, and the location of their terminal burst.