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Using Arrays to Characterize and Locate Sources of Short Period Seismic Noise

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With the recognition that ambient seismic noise can be used to image Earth structure there has been renewed interest in locating and characterizing sources of seismic noise. In addition to the fundamental physical question of precisely how the ocean and atmosphere interact with the solid Earth to create seismic energy, the structure of the noise is relevant because it can profoundly influence images of Earth structure. For instance, anisotropic noise fields can lead to biased Green's functions that in turn lead to biased Earth models, and non-stationary noise fields can lead to the appearance of time-varying Earth structure.

The two most common approaches to characterizing the structure of seismic noise are polarization analysis and array processing. The former is effective over a wide range of frequencies, but provides only indirect evidence of mode-type. Array processing gives a much stronger constraint on mode-type via direct estimation of phase velocity, however the aperture of the array restricts its effectiveness to a relatively narrow range in frequency. Here I present results from several recent studies of seismic noise recorded on a variety of small- and medium-aperture arrays deployed around the world:

(1) A study of 10 years of ambient noise recorded by a 10-km aperture array in Thailand (CMAR) found evidence for Lg waves generated along nearby coasts (Koper and de Foy, 2008). The Lg noise showed strong seasonality, however the phase depended on the direction of arrival: Lg energy from the east (Pacific Ocean) peaked in the northern hemisphere winter while Lg energy from the west (Indian Ocean) peaked in southern hemisphere winter.

(2) A study of 17 years of noise recorded on a 23-km aperture array in Canada (YKA) showed evidence for a wide range of phases including teleseismic P from oceanic interiors, Lg from the Atlantic coastline of North America, and Rg from the nearby Great Slave Lake (Koper et al, 2009). The freezing of the Great Slave Lake was apparent in the sharp decline of Rg energy in November of each year.

(3) A third study recently examined noise at 18 arrays of the International Monitoring System, varying in aperture from 2 to 28 km, for the year of 2007 (Koper et al, 2010). The most commonly observed phase was Lg (49%), followed by Rg (23%), teleseismic P (14%), PKP (8%), and regional Pn/Pg (6%). A persistent source of P energy in the North Pacific was simultaneously observable from three nearby arrays (PET, YKA, and ILAR).

I also present initial results from an analysis of short-period (1-3 s), vertical component noise recorded across USArray in 2009. The array consists of over 400 stations deployed with an aperture over 2000 km. Owing to the large size, standard plane-wave FK analysis cannot be applied; instead energy is backprojected through a radial Earth model assuming teleseismic P-wave propagation. Issues of statics and focusing for this continental-scale array will be discussed.