Excitation of Earth's Incessant Free Oscillations by Atmosphere-Ocean-Seafloor Coupling

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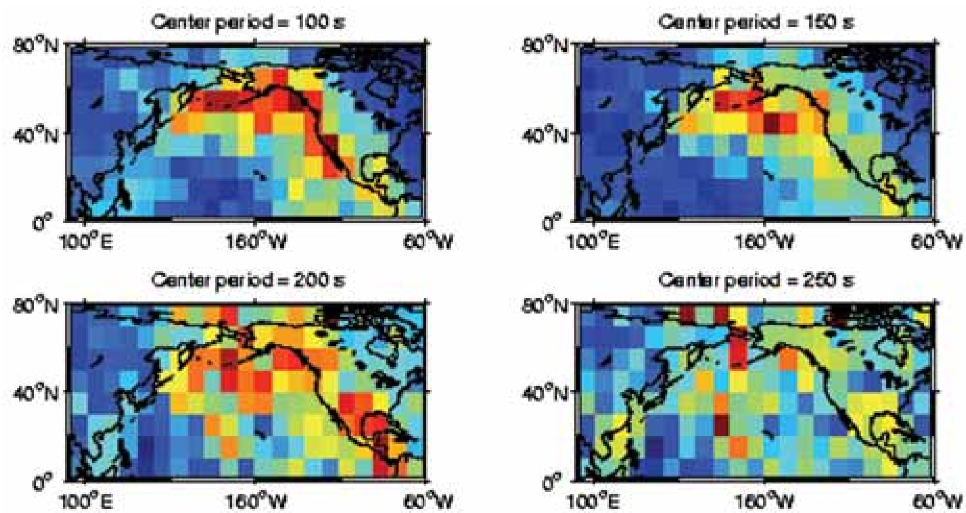
The observation on long period seismograms of continuously excited free oscillations of the Earth was first made by japanese scientists in 1998, during intervals free of significant earthquakes. Since then, attention has focused on elucidating the physical mechanism responsible for them. The sum of all small earthquakes remaining in the records cannot explain the observed level of excitation. The mechanism must be shallow, as fundamental modes appear to be preferentially excited. It shows seasonal variability, with peaks in the northern and southern hemisphere winters. Stochastic mechanisms involving turbulent motion in the atmosphere have been proposed as well as random distribution of sources around the world. An alternative potential source of excitation of the continuous oscillations is in the oceans, but so far the observations, based on the computation of spectra or correlations of signals across long time series, do not have the spacial and temporal resolution to locate these sources.



Results of application of a grid search method to locate the source of the low frequency hum using 6 hours of data from the BDSN array, F-NET and 10 additional quiet GSN stations, on a day without earthquakes (January 31, 2000). In each panel, the data have been narrow bandpass filtered with a different center period. Dark red areas indicate 5 x 5 degrees areas which yield maximum amplitudes of the corresponding network stacks. Resolution is lost at periods greater than 200 sec.

We have developed an array-based method to detect and locate sources of very long period surface wave energy, utilizing the dispersive properties of Rayleigh waves. Our basic approach uses data from two large aperture arrays of very long period seismometers (BDSN in California and F-NET in Japan). We stack the data after projection to the center of each array, and look for directions of arrival of maximum amplitude in the stacks as a function of back-azimuth, taking into account the array response. We show that, for each array, there is a well defined preferential direction, which is stable over one season but changes significantly from winter to summer. The fluctuation as a function of time of the maximum stack amplitudes are correlated across the two arrays and point to the northern Pacific ocean in the northern hemisphere winter and the southern Oceans in the summer, correlating with changes in the global distribution of maximum wave height. The addition of other stations equipped with STS-1 seismometers (GSN and GEOSCOPE) allows us to apply a grid search method to more precisely determine the loci of the multiple sources during a particularly stormy day in the north Pacific ocean.

We infer that the background oscillations originate primarily in the oceans, and are caused by a non-linear coupling mechanism involving the atmosphere (winds), the oceans (transfer of energy from ocean waves to infragravity waves) and the seafloor (transfer of energy to elastic waves).

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