Local elastic effects in low-frequency spectra of Earth's free oscillations

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Observed Earth tide tilts and strains are known to be strongly affected by local distortions of the large scale deformation field by local heterogeneities (cavities, topography, and geology). It was predicted that these distorsions will also occur in other phenomena, like seismic free oscillations and/or long period surface waves.

The megaquakes near Sumatra 2004 and Japan 2011 excited the normal modes of the Earth to unprecedented levels since 1964 and high-quality spectra could be obtained. Two observations at the Black Forest Observatory provided more or less direct evidence for the effects of local distortions which will be described.

Firstly, spectra from the seismograms of the Sumatra quake from three different accelerometers with two components each showed significantly different spectral line shapes for several low-frequency modes, especially in the NS-components. Secondly, taking a local (probably topographic) effect into account in synthetic seismograms improved their fit in spectra of the observed strains for a wire strainmeter significantly for both quakes. This local effect was incorporated into the synthetics using coupling coefficients derived from comparison of Earth tide records of the same instrument with synthetic tides.

These local effects could well be one of the reasons why synthetic seismograms for current heterogeneous Earth models provide excellent fits for vertical but not for horizontal records.