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Using multi-scale methods for sensitivity analysis in potential field interpretation

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It is a common practise to use spherical harmonic coefficients and the associated global spectrum to analyse the sensitivity of time-variable potential field data, e.g. those provided by the GRACE satellite mission. When studying a signals detectability by a satellite mission with known error characteristics, the conventional method has disadvantages. While delivering meaningful comparisons for global signals, the global nature of the spherical harmonic functions makes it unsuitable for strongly localised signals. In such cases, the global spectrum will compare the energy of locally concentrated signal to the globally distributed energy of the measurement errors, strongly underestimating the signal-to-noise ratios.

We study alternative methods for sensitivity analysis. Since we want to maintain the spectral nature of the spherical harmonics, to be able to distinguish between signals of different scales [a pointwise comparison is meaningless, instead...] we concentrate on methods offering a spatio-spectral compromise. After a brief foray into the optimally concentrated band-limited Slepian's functions, the main effort goes into investigating wavelets on the sphere. Using Monte Carlo methods, we propagate the errror characteristics of the GFZ-RL04 GRACE solution from the original spherical harmonic coefficients onto a wavelet basis. Using these, we study the detectability of locally concentrated events in Earth's gravity field, using the great Sumatra-Andaman earthquake of 2004 as a test-case.