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Gravity and magnetic data analysis based on Poisson wavelet-transforms

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Studies of the Earth's interior structure are one of the most complex topics in modern science. Integration of different geophysical methods plays a key role in effectively tackling the problem. In the last decade capabilities of potential field geophysical methods have been increasing due to development of advanced digital technologies. Improved resolution and accuracy of gravity and magnetic fields measurements made by modern equipment makes it possible to build more detailed geological models. Different tectonic and structural elements being interpreted in such models produce potential field signals with different spectral characteristics. Like any geophysical signals, potential fields can be described as a spatially non-stationary signal. This means its frequency content may change depending on a given signal sample, in particular with different spatial location of a sample. In this case, approaches of gravity and magnetic fields analysis based on Fourier transform or signal decomposition into a number of harmonic functions can lead to incorrect results. One of the ways to solve this challenge involves using wavelet transform based algorithms, since these transforms do not assume stationary signals and each function of a wavelet-based basis is localized in space domain.

In gravity and magnetic data analysis it is beneficial to use wavelets based on partial derivatives of the Poisson kernel, which correspond to derivatives of a point source gravity potential. Application of Poisson wavelets in potential field data analysis has begun in the 1990's and is predominantly aimed at studying gravity and magnetic fields singularity points during data interpretation.

Similar to Fourier-based potential field techniques, it is possible to construct a number of data filtering algorithms based on Poisson wavelets. Current work demonstrates that it is possible to construct algorithms based on Poisson wavelets for transforming profile and spatially gridded gravity and magnetic data, e.g. for calculation of equivalent density and magnetization distributions, upward and downward continuations, reduction to pole and many other filters that take into account spatial distribution of the signal.

Wavelet-transforms allow to account for spatially non-stationary nature of geophysical signals. Use of wavelet based techniques allows to effectively carry out potential field data interpretation in a variety of different geologic and tectonic settings in a consistent fashion.