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Accelerated Multiscale Analysis on the Earth's Surface

Martin Gutting

University of Siegen, Fachgruppe Angewandte Analysis und Numerik, Mathematik, Germany
(gutting@mathematik.uni-siegen.de)

By the use of an underlying Runge sphere harmonic scaling functions and wavelets can be constructed on regular surfaces such as the surface of the Earth. They allow a space-frequency decomposition of geopotentials on the surface. Moreover, due to their localizing properties regional modeling or the improvement of a global model is possible.
The acceleration of the convolution by the fast multipole method is possible for certain types of harmonic scaling functions and wavelets. The main idea of the fast multipole algorithm consists of a hierarchical decomposition of the computational domain into cubes and a kernel approximation for the more distant points. The kernel evaluation is performed directly only for points in neighboring cubes on the finest level. The contributions of the other points are transferred into a set of coefficients. The kernel approximation is applied on the coarsest possible level using translations of these coefficients. This reduces the numerical effort of the convolution for a prescribed accuracy of the kernel approximation.
Multiscale methods are known to possess a tree algorithm that allows the computation of the lower frequency scales from a starting scale that contains the highest frequency parts of the signal. The application of the fast multipole method can accelerate the computation of this starting point as well as the tree algorithm itself. The presentation includes applications to gravitational field modeling.