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A combined multi-resolution multi-dimensional wavelet approach for the inversion of geodetic integrals

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An efficient computational scheme using the wavelet transform is employed for the numerical inversion of the integrals involved in geodetic inverse problems. The integrals are approximated in finite multiresolution analysis subspaces and the wavelet algorithm is built using an orthogonal wavelet base function. A set of linear equations is formed in the wavelet domain and solved using the conjugate gradient method. The full solution with all equations requires large computer memory; therefore the multiresolution properties of the wavelet transform are used to divide the full solution into parts. Each part represents a level of the wavelet detail coefficients or the approximation coefficients. Global hard thresholding is used for the compression of the wavelet coefficients of the kernel. Numerical examples are given to illustrate the use of this procedure for the numerical evaluation of the inversion of the Stokes and Poisson (downward continuation) integrals. The Stokes integral was inverted successfully using the full wavelet coefficients matrix. The solution achieved an RMS error of 4.03 mGal in comparison to the reference data. The solution with the conjugate gradient method converged after 101 iterations. The global thresholding approach achieved a 93.5% compression level with 0.12 mGal loss in accuracy in comparison to the full matrix solution. The Stokes inversion solution was repeated after the addition of stationary and non-stationary noise and soft thresholding was used as to de-noise the data. Efficient filtering of both types of noise was achieved with a 90% improvement in the inverse solutions accuracy. In the case of the Poisson integral, Tikhonov regularization was used. The conjugate gradient method converged after 28 iterations with an RMS accuracy of 5.5 mGal in comparison to the reference data.