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Length scales and Stokes' integral

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This paper describes a new rationale for geoid computation that depends on identifying and treating separately components of the gravity field with different scales. Gravimetric geoid solutions depend essentially on converting observations of the force of gravity into its potential. For components where the gravity information is in the form of an analytical model – for example a spherical harmonic description of the gravity potential or the geometrical form of topographic masses with a constant density – computation can give exactly equivalent values of the force and the potential, so evaluating an integral transform numerically is unnecessary. Other components need some version of Stokes integral to compute the equivalent potential from residual gravity anomalies. In an appropriate coordinate system, Stokes' kernel is smooth, slowly varying and not peaked near the origin, so limiting the range of integration to a local region cannot be justified by any property of the kernel: it requires the gravity field to have a short correlation length. The power spectrum derived from a global gravity model resolves four stochastic gravity field components, characterised by coherence lengths of about 10 000 km, 2200 km, 480 km and 75 km. This means that, in practice, Stokes' integral cannot be localised unless the first three components are removed and dealt with separately. They are adequately contained within a spherical harmonic model up to about degree 60, which is now well determined with a satellite-only gravity model. After its removal, the residual anomalies have a short coherence length and Stokes' integral over a 1.24˚ spherical cap captures 95% of the residual geoid signal, while 99% is captured by a 2.15˚ cap. With such a small domain, many complexities in Stokes-like integrals can be simplified (for example, a version using a planar FFT may be adequate). Also, the computational effort needed to represent locally irregular topography becomes tractable when the region is small.