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Convergence in spectral forward modelling: Binominal series solutions vs. direct integral solutions at high degrees – spherical and ellipsoidal case

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The number of relevant terms of binominal series expansions used in spectral forward modelling of the gravitational potential is known to rise substantially as the resolution of the models increases. Here, we investigate and compare the binominal series expansions in forward modelling w.r.t. a sphere and w.r.t. an ellipsoid (Claessens and Hirt, 2013) in view of high degree forward modelling (d/o 10800). The series in each case depend on different parameters - such as elevation of the topographic function or ellipsoidal radius/co-latitude – and reveal different maximum orders of truncation for a 1% convergence level (=relative error). The results are verified in a real data scenario up to d/o 5400 by spot-checks using direct integral solutions that do not depend on binomial series expansions.
As a conclusion, our study demonstrates that for d/o 10800 modelling up to 30 terms of the binominal series accounting for the radial integral are needed within the spherical and the ellipsoidal case, while up to 60 terms are needed for the binominal series accounting for the oblateness of Earth in the ellipsoidal case for a convergence at the 1% level.

References: Claessens, S.J.; Hirt, C.: Ellipsoidal topographic potential - new solutions for spectral forward gravity modelling of topography with respect to a reference ellipsoid; Journal of Geophysical Research (JGR) - Solid Earth, Vol. 118, DOI: 10.1002/2013JB010457, 2013.