EGU2020-59, updated on 04 Jul 2022
https://doi.org/10.5194/egusphere-egu2020-59
EGU General Assembly 2020

Subtleties in spherical harmonic synthesis of the gravity field

Ropesh Goyal[1,2], Sten Claessens[2], Will Featherstone[2,1], and Onkar Dikshit[1]
[1]Department of Civil Engineering, Indian Institute of Technology Kanpur, Kanpur 208016, India (rupeshg@iitk.ac.in, onkar@iitk.ac.in)
[2]School of Earth and Planetary Sciences, Curtin University of Technology, GPO Box U1987, Perth WA 6845, Australia (S.Claessens@curtin.edu.au, W.Featherstone@curtin.edu.au)

Spherical harmonic synthesis (SHS) can be used to compute various gravity functions (e.g., geoid undulations, height anomalies, deflections of vertical, gravity disturbances, gravity anomalies, etc.) using the 4pi fully normalised Stokes coefficients from the many freely available Global Geopotential Models (GGMs). This requires a normal ellipsoid and its gravity field, which are defined by four parameters comprising (i) the second-degree even zonal Stokes coefficient (J2) (aka dynamic form factor), (ii) the product of the mass of the Earth and universal gravitational constant (GM) (aka geocentric gravitational constant), (iii) the Earth's angular rate of rotation (ω), and (iv) the length of the semi-major axis (a). GGMs are also accompanied by numerical values for GM and a, which are not necessarily identical to those of the normal ellipsoid. In addition, the value of W_0, the potential of the geoid from a GGM, needs to be defined for the SHS of many gravity functions. W_0 may not be identical to U_0, the potential on the surface of the normal ellipsoid, which follows from the four defining parameters of the normal ellipsoid. If W_0 and U_0 are equal and if the normal ellipsoid and GGM use the same value for GM, then some terms cancel when computing the disturbing gravity potential. However, this is not always the case, which results in a zero-degree term (bias) when the masses and potentials are different. There is also a latitude-dependent term when the geometries of the GGM and normal ellipsoids differ. We demonstrate these effects for some GGMs, some values of W_0, and the GRS80, WGS84 and TOPEX/Poseidon ellipsoids and comment on its omission from some public domain codes and services (isGraflab.m, harmonic_synth.f and ICGEM). In terms of geoid heights, the effect of neglecting these parameters can reach nearly one metre, which is significant when one goal of modern physical geodesy is to compute the geoid with centimetric accuracy. It is also important to clarify these effects for all (non-specialist) users of GGMs.