A short guide on the use of Earth2012 topopotential models

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1 Introduction

Two topographic potential models have been created using the Earth2012.RET2012.SHCto2160 rock-equivalent topography model as input. These are:

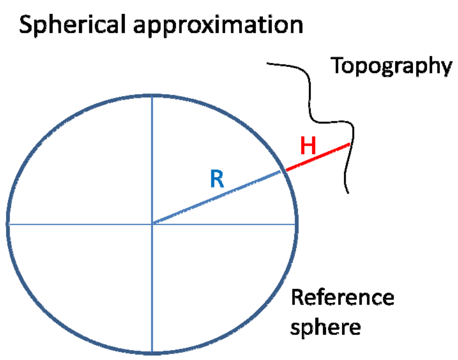
- Spherical topographic potential model dV_SPH_RET2012, constructed in fully-spherical approximation as described in Hirt and Kuhn (2012).
- Ellipsoidal topographic potential model dV_ELL_RET2012, constructed in fully-ellipsoidal approximation, as described in Claessens and Hirt (2013, submitted)

The spherical-harmonic coefficients of both topographic potential models and of the input RET2012 topography are available via http://geodesy.curtin.edu.au/research/models/Earth2012/.

The topographic potential represented in these models is the gravitational potential generated by the topographic masses with respect to the **geoid**, i.e., the combined effect of masses above the geoid (where orthometric terrain height is positive) and the lack of topographic mass under the geoid (where orthometric terrain height is negative).

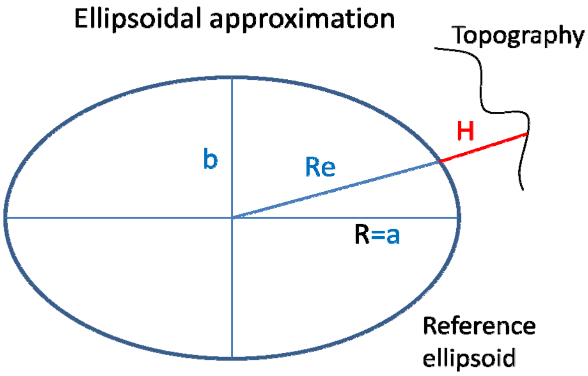
2 Explanation of the approximations applied

2.1 Spherical topographic potential model dV_SPH_RET2012



- Use of RET2012 heights H to represent topographic masses
- H is orthometric height of topography (distance between geoid and topography) over land, and rock-equivalent height over sea and ice sheets (see Hirt and Kuhn 2012)
- “Mapping” of H onto surface of reference sphere of constant radius R (see e.g. Balmino et al. 2012)
- Modelling principle used e.g. by Rummel et al. 1988, Novak 2010, Balmino et al. 2012, Hirt and Kuhn 2012 and the World Gravity Map project by UNESCO (Bonvalot et al. 2012)

2.2 Ellipsoidal topographic potential model dV_ELL_RET2012



- Use of RET2012 heights H to represent topographic masses
- H is orthometric height of topography (distance between geoid and topography) and rock-equivalent height over sea and ice sheets (see Hirt and Kuhn 2012)
- Mapping of H onto surface of the reference ellipsoid represented through semi-major axis a and semi-minor axis b of the GRS80 reference system
- New method, based on Claessens (2005), Claessens (2006), used by Claessens and Hirt (2013, submitted).

Note that the geoid-ellipsoid separation is disregarded in these approximations for the same reasons as those outlined in Balmino et al. (2012).

3 Modelling constants used

For both models (dV_SPH_RET2012 and dV_ELL_RET2012), the modelling constants are:

- R = 6,378,137 m (model reference axis) and
- GM = 3.986005E14 $m^3\ s^{-2}$ (product Earth's mass M with Universal Gravitational Constant G).

The mass-density assumption is 2670 kg m^{-3} for the topographic masses in both models.

4. Recommended use of the models

4.1 Spherical topographic potential model dV_SPH_RET2012

- We recommend this model be used for synthesis of topographic gravity effects on the surface of the reference sphere with radius R, or at the Earth's topography represented by R + topographic height, or at any other point exterior to the reference sphere.
- Topographic gravity effects shall not be synthesized on the GRS80 ellipsoid (located deep inside the reference sphere).
- Because of the underlying *spherical approximation*, this model shall not be used for spectral analysis of geopotential models (e.g. EGM2008) that rely on *ellipsoidal approximation.* This would yield degree correlation coefficients to be underestimated at high degrees (see appendix)

4.2 Ellipsoidal topographic potential model dV_ELL_RET2012

- We recommend this model be used for synthesis of topographic gravity effects on the surface of the GRS80 reference ellipsoid (represented by the ellipsoidal radius Re), at the Earth's topography represented by Re + topographic height, or at any other point exterior to the GRS80 ellipsoid.
- Because of the underlying *ellipsoidal approximation*, this model is suitable for spectral analysis of geopotential models (e.g. EGM2008) that rely on *ellipsoidal approximation* as well. Our dV_ELL_RET2012 can also be used for computation of EGM2008 Bouguer gravity maps in fully-ellipsoidal approximation.
- Akin to EGM2008, dV_ELL_RET2012 features additional spherical harmonic coefficients in spectral band 2161-2190. We recommend that all coefficients be used when the dV_ELL_RET2012 model is evaluated.

Appendix:

Correlation coefficients with EGM2008, visualisation of topographic gravity effects from both models and their differences

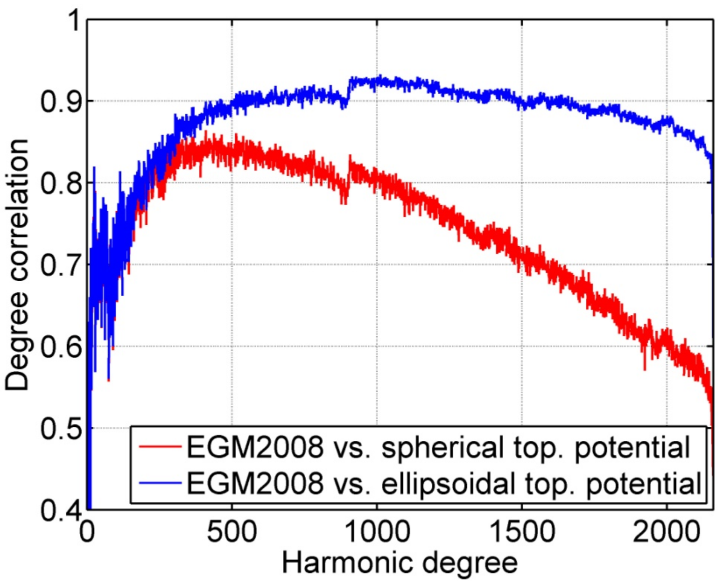


Fig.1 Degree correlation coefficients between EGM2008 and dV_SPH_RET2012 as well as EGM2008 and dV_ELL_RET2012. The ellipsoidal topographic potential offers higher correlation with EGM2008 at high degrees because the underlying approximation level (ellipsoidal approximation) is the same for EGM2008 and dV_ELL_RET2012.

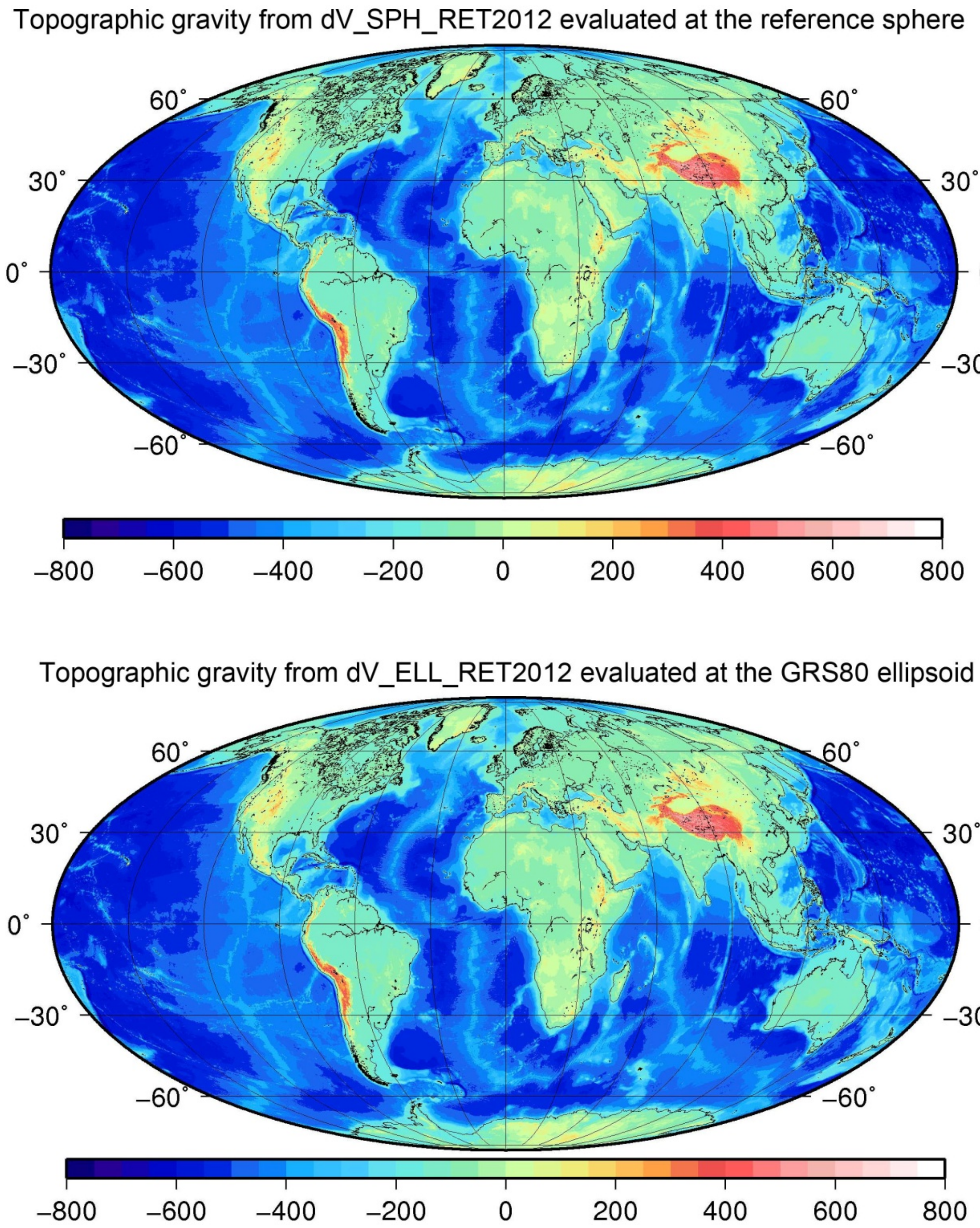


Fig.2. Top: Topographic gravity from the dV_SPH_RET2012 (evaluated at the reference sphere in band 0 to 2160), Bottom: Topographic gravity from the dV_ELL_RET2012 (evaluated at the GRS80 ellipsoid in band 0 to 2190), units in mGal.

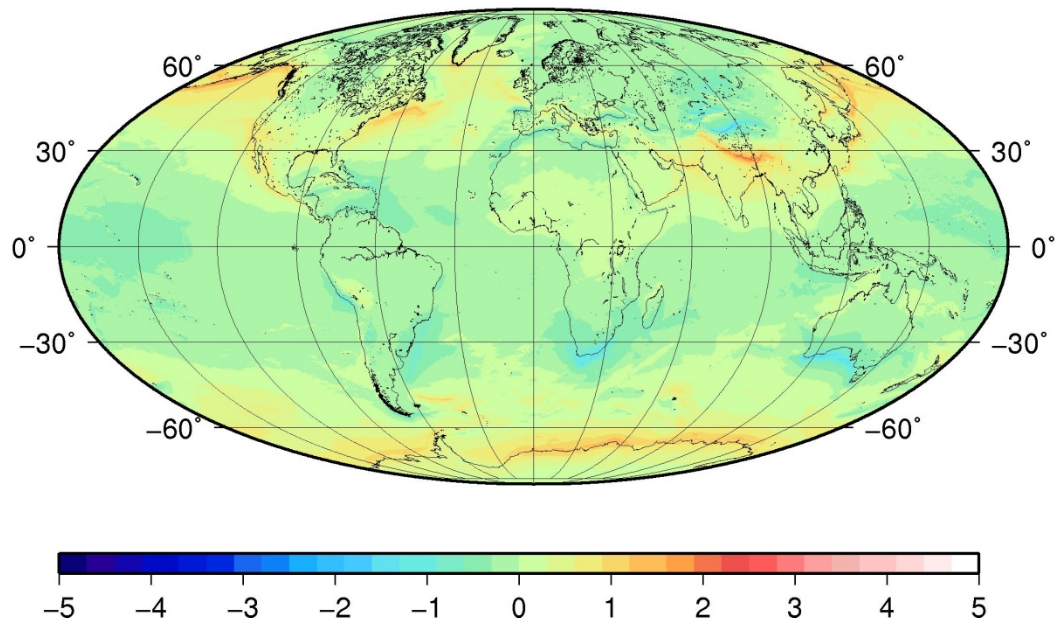


Fig.3. Differences in topographic gravity from the dV_SPH_RET2012 (evaluated at the reference sphere in band 0 to 2160), and dV_ELL_RET2012 (evaluated at the GRS80 ellipsoid in band 0 to 2190) models, units in mGal. The difference is the *ellipsoidal effect of topographic gravity modelling*, and at the mGal-level.

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