Towards a new best estimate for the conventional value of W_0

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Working Group on Vertical Datum Standardisation

A global vertical reference system in agreement with the GGOS objectives

GGOS promotes the establishment of a global gravity field-related vertical reference system to

1) provide a global frame of reference for measuring and consistently interpreting global change processes;
2) guarantee vertical coordinates with global consistency (the same accuracy everywhere) and long-term stability (the same order of accuracy at any time);
3) support a highly-precise (at cm-level) combination of physical and geometric heights worldwide; and
4) allow the reliable unification of all existing local height datums.

The global vertical reference level

The reference level of the proposed global vertical reference system is

1) defined by a conventional W_0 value
2) realised by the geometric representation of the corresponding equipotential surface with respect to a reference ellipsoid (i.e. the geoid modelling).

To ensure consistency between definition and realisation, the adopted W_0 value must be commensurate with measurements, models and standards used for the geoid computation. At present, the commonly accepted W_0 value is 62 636 856 m^2s^{-2}. Recent W_0 computations show discrepancies of about -2 m^2s^{-2} and make evident the need of a new better W_0 estimate.

Working Group on Vertical Datum Standardisation

In order to make a new best estimate for the W_0 value available, the Working Group on Vertical Datum Standardisation was established for the term 2011-2015 with the following main objectives

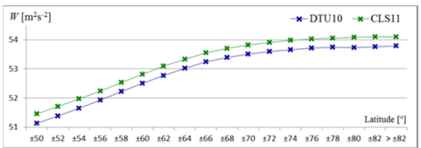
1) to identify the basic conventions needed to guarantee uniqueness, reliability and repeatability of the W_0 estimate;
2) to release a recommendation about the W_0 value to be introduced as the reference level in the GGOS vertical reference system;
3) to outline a strategy for the local/regional realisation of the reference level defined by the new W_0.

Conventions for a new W_0

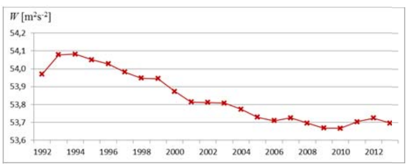
1) Underlying convention: the geoid is the equipotential surface coinciding with the mean sea level;
2) Empirical estimation based on the combination of global models of the Earth's gravity field and the sea surface;
3) Known effect of the secular sea level change to facilitate the integration of the existing height systems;
4) Satellite-only gravity data to avoid uncertainties caused by the terrestrial gravity data referring to the local height datums;
5) Evaluation over ocean areas only because
   - geometry of the sea surface is known with more accuracy than continental surfaces;
   - geoid and quasi-geoid are the same over oceans (identical reference level for normal and orthometric heights)
   - gravity effects of topographical features not scanned by satellite gravity are minimized (disregard of the omission error).

Dependence of the W_0 estimate on the mean sea surface model

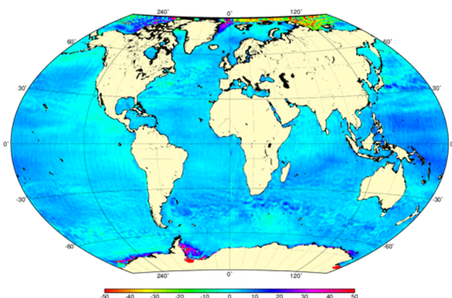
1) When the latitude coverage is reduced, features of the sea surface topography are excluded and W_0 decreases, i.e. it is not global.
2) By using the models MSS-CNES-CLS11 and DTU10 there is a difference of 0,31 m^2s^{-2}, which reflects the mean discrepancy of ~ 3 cm between both models. Possible causes:
   - Different strategies to process the altimetry data;
   - Different reductions taken into account in each model;
   - Different periods (inter-annual ocean variability).
3) Alternative: use of yearly mean sea surface models
   - the W_0 estimates reflect (with opposite sign) the sea level rise measured by satellite altimetry;
   - a reference epoch shall be adopted.



W_0 *estimates varying the latitude coverage of the sea surface model (models: MSS-CNES-CLS11, DTU10 and EIGEN-6C3).*



W_0 *estimates using yearly mean sea surface models derived from the OpenADB cross-calibrated sea surface heights (GGM: EIGEN-6C3).*



Potential differences (divided by the normal gravity) between the estimations derived from the models MSS-CNES-CLS11 and DTU10 (GGM: EIGEN-6C3).

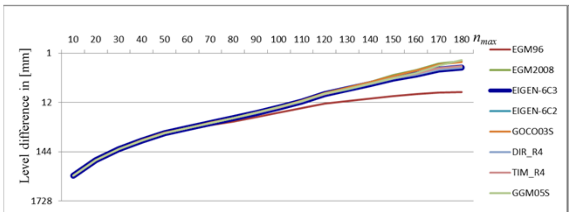
Strategy for the computation of W_0

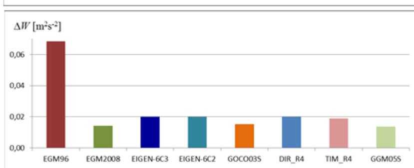
1) Determination of the potential value of the sea surface by introducing the vanishing gravitational potential at infinity as main constraint;
2) The sea surface is given by a mean sea surface model: a set of discrete points with known coordinates derived from satellite altimetry;
3) Due to the sea surface topography (Ξ), the points describing the sea surface are not on the same equipotential surface and a further constraint is necessary:

$$\int_{\Omega} \Xi^2 d\Omega = \min; \Xi_j = \frac{W_0 - W_j}{\gamma_j}; \Omega: \text{ocean surface}$$

4) The sea surface must be globally sampled to include all features of the sea surface topography, on the contrary, W_0 is not representative;
5) Since the mean sea level coincides with a different equipotential surface depending on the time span used for averaging sea surface heights, a certain epoch shall be selected.

Dependence of the W_0 estimate on the choice of the gravity model





W_0 *estimates using different global gravity models (GGM) and the MSS-CNES-CLS11 sea surface model .*

1) Models including GRACE, GOCE and Satellite Laser Ranging data are preferred. Recent models provide differences < 0,01 m^2s^{-2}.
2) The use of a satellite-only gravity model is suitable. After n = 200 the largest differences are 0,001 m^2s^{-2}, which are negligible.

3rd International Gravity Field Service (IGFS) General Assembly, June 30-July 6, 2014, Shanghai, China