Precise geoid determination for geo-referencing and oceanography

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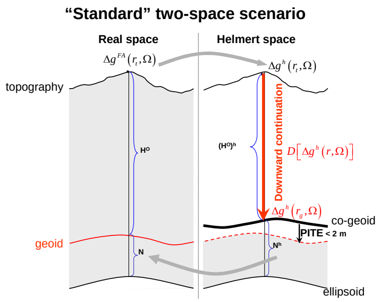
Introduction

The **geoid** as an equipotential surface of the Earth's gravity field more or less coincides with the **mean sea level** over the oceans and extends hypothetically into the continental regions. The geoid plays an essential role in the **national geodetic infrastructure**, as the topographic heights and the depths of water bodies are reckoned from it. Thus, many applications in geodesy, geophysics, oceanography and engineering require heights referred to the geoid.

During the last two decades, the increased need for refined geoid models has been driven by users of the **Global Positioning System** (GPS) **for height determination**. More specifically, GPS-derived geodetic heights (reckoned from a global reference ellipsoid) must be transformed into **orthometric heights**, in order to make them compatible with the local vertical datum. For the conversion between and combination of these fundamentally different height systems, the geoid model must be known to an accuracy comparable to the accuracy of GPS and traditional levelling, i.e., that of a few centimetres.

Stokes-Helmert method for geoid computation



In the past 12 years, the Stokes-Helmert method for geoid computation has been used at the University of New Brunswick. The present contribution reviews recent theoretical developments and the practical validation of the geoid computation results.

The gravity anomalies to be used for the geoid solution by Stokes's method are measured at the topographical surface of the earth. To prescribe the boundary condition the anomalies need be continued downward to the sea level. This procedure requires harmonic gravity anomalies, implying thus the topographical and atmospherical effects must be removed from the anomaly field.

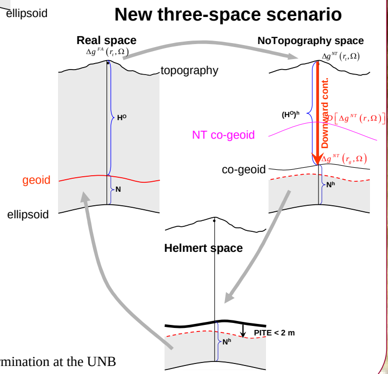
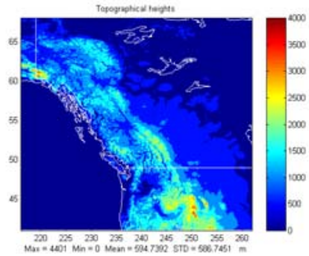


Figure 1: Two principal schemes for the geoid determination at the UNB

Test area in West-Canada



The evaluation of topographical effects and downward continuation are the most challenging task in the Rocky Mountains, chosen here as a geoid determination test area.

- ➢ Spherical approximation of topographical effects adopted (instead of widely used "flat earth" approximations)
- ➢ Modified Stokes's formula used
- ➢ Data from a new gravimetric satellite mission (GRACE)

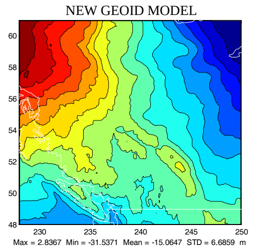
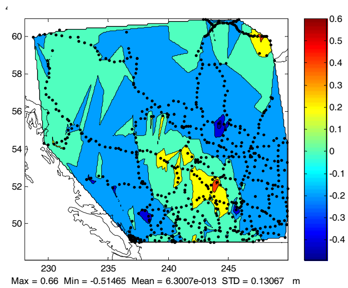


Figure 2: Topographical heights (**a**) and the resulting geoid model (**b**) over the test area in West – Canada

Comparisons with GPS – leveling data



Geoid determination results are validated with 726 GPS-leveling points (provided by the *Geodetic Survey Division of Canada*)

Post-fit residuals
Low-land - STD < 5…10 cm,
Mountains - STD >13 cm

Figure 3: Distribution of the GPS-leveling control points and the post-fit residuals (between the "geometric" and gravimetric geoid models)

Conclusions

The accuracy of the present regional geoid models is suitable for implementing alternative and cost-effective methods in many applications, such as geodetic positioning, geophysical and geological explorations.

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