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Publication date: 2009

Document Version
Publisher's PDF, also known as Version of record

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Citation (APA):

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Full Resolution Geoid from GOCE Gradients for Ocean Modeling

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Introduction
The main objective of the study is to improve the methodology for combining GOCE gravity field models with satellite altimetry to derive optimal dynamic ocean topography models for oceanography. Here a method for full resolution geoid determination using simulated GOCE gradients is presented.

Background
Preliminary results by Knudsen and Tscherning have indicated that compared to a spherical harmonic expansion truncated at degree 200 a full resolution determination of the geoid may reduce the omission error from about 30 cm to 15 cm. Combining GOCE geoid models with satellite altimetric observations of the sea surface height might lead to substantial improvements in the modeling of the ocean transport and circulation.

The primary requirement for oceanographers is to have access to a geoid and its error covariance at the highest spatial resolution and accuracy possible. For that purpose a point mass program is developed for processing GOCE gradients in order to determine the geoid.

Point mass method
The masses for each point are calculated using the first order derivatives of gravitational potential (from GOCINA gravity anomaly values, EGM96 to degree 200 has been subtracted to obtain residual gravity anomaly values). Then the Earth anomalous gravity field is modelled by the set of base functions, each obtained as the anomalous gravity potential from each point masses. From the anomalous gravity field, the geoid is then calculated using Bruns formula. Gradients are then computed using second order derivatives of the gravity potential.

Evaluation of the geoid is carried out in the part of the GOCINA region in the North Atlantic (figure 1).

Results
Using GOCINA gravity anomaly (figure 3) both Gravsoft (figure 5) and point mass geoid (figure 6) are calculated. Residuals are presented on figure 7. Vertical gradient from simulated GOCE gradient in GOCINA region can be seen on figure 4.

Conclusions
Applying this method on GOCE gradient data, it is possible to make independent validation of already accepted methods for geoid determination. The presented point mass method shows that it is possible to acquire a full resolution geoid from GOCE gradients. Results of the method can be used in future geoid modeling. New detailed geoid surface will serve as a homogeneous and accurate reference surface for satellite altimetry and in that way it will provide important improvements in the ocean circulation modeling.

References
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R. Forsberg, C.C. Tscherning: GRAVSOFT, Geodetic Gravity Field Modelling Programs (overview manual), 2008
P. Knudsen and The GOCINA team: Integration of Altimetry and GOCE geoid for Ocean Modeling

Fig. 1. GOCINA region

For evaluation of the calculated geoids, Gravsoft Geofour is used as a reference. Geofour program is used for gravity field modeling using fast Fourier transform. Gradients (used as simulated GOCE gradients) are processed in point mass program to obtain the geoid. From that, geoid determination using point mass and GOCE gradients is demonstrated.

Fig. 2. GOCE tensor elements

Fig. 3. GOCINA gravity anomaly

Fig. 4. Vzz tensor component over GOCINA region

Fig. 5. Geoid from Gravsoft

Fig. 6. Geoid from Pointmass

Fig. 7. Difference between Gravsoft and point mass geoid