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Report of the section for the computation of the Nordic Geoid 1986-1990.

by

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Abstract: The report summarizes the data collection and computational work done by the section for the computation of the Nordic Geoid 1986-90. A new geoid has been computed for the Nordic Area east of longitude 3° using FFT and residual terrain modelling. It is recommended to continue the data collection and computational effect in order to enable the computation of a geoid for the sea territories, of the Nordic Countries, Iceland and Greenland.

1. Introduction.

At the meeting of the Nordic Geodetic Commission in Helsingfors, 1986, it was decided to establish a section for the computation of the Nordic Geoid. The work started formally in 1988, where members were appointed as follows:

DK: R. Forsberg, P. Knudsen, C.C. Tscherning (president)
IS: G. Thorbergsson
SF: M. Vermeer
N: D. Solheim
S: M. Ekmann, L.A. Haller, L.E. Sjøberg

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The task of the section has been the following:

(1) The production of a precise quasi-geoid for the Nordic area, including ocean areas in the North Atlantic above latitude 54°. When permitted by the data distribution, geoid height differences should be computed with a standard deviation of 0.5 ppm for distances below 100 km.

The geoid should be provided in the form of values given in a grid which permits the interpolation of the values without a significant loss of precision.

(2) The evaluation of methods for geoid computation, including the evaluation of spherical harmonic expansions of the gravity potential.

(3) Evaluation of the computed geoid by comparison with data not used in the computation or with geoids computed by different methods.

The members of the group who were actively engaged in the computational effect met in Charlottenlund April 19, 1989. All other business has been conducted by correspondance. Fortunally two members of the group (M. Vermeer, D. Solheim) have stayed for longer periods in Denmark, where the computation have taken place. This has very much facilitated the work of the section.

In this brief report the result of the data collection effort will be described in section 2, and the fulfilment of the tasks (1)-(3) in section 3. Recommendations for future work are given in section 4.

2. Data collection.

In order to achive the goals of the section new data were needed. Here large amounts of new, high quality, gravity data has been received from GECO A/S and later Amarok A/S (Norway), the Geological Surveys of Denmark and of Greenland, the Finnish Geodetic Institute and the National Survey of Sweden. Further data has been reguested from Oliedirektoratet (Norway). These data have been released with the restriction that they must only be used for scientific purpose, and no product must be published which enable the recovery of the gravity information to a precision better than 3 mgal.

The gravity data has been used for the computation of new ½° mean gravity anomalies for the Fenno-Scandian area. The values were supplied to the University of Hannover and to the Ohio State University, when they were used in the computation of the spherical harmonic expansions complete to degree 360, called IFE88E2 and OSU89A,B, respectively. This has contributed to the high quality of these expansions in the Fenno-Scandian Area, (Basic et al., 1989).

There is still a lack of gravity data in the polar regions, and especially on the Greenland Ice Cap. Negotiations with U.S. authorities are in progress, which may result in a new gravity collection effort in Greenland using airborn gravimetry. On the long term a dedicated satellite gravity mission (GRADIO, GRAVSAT, ARISTOTELES) would be of great benefit for the determination of the global geoid, the Nordic Geoid and thereby for the geoid in Greenland.

Also new satellite altimeter data has been aquired (GEOSAT). The analysis of this data is still in progress. It covers the same area as the SEASAT mission. The fortcomming ERS-1 mission, however, will cover the area up to latitude 81°, and we will thereby get a large amount of new data.

GPS-derived ellipsoidal heights have been collected in 1.-order levelling stations by the University of Hannover. This information has been converted to precise geoid undulation differences, which have had great value in the evaluation of recent geoid computations, see Torge et al. (1989), Forsberg and Kearsley (1989). New supplementary height information has also been collected, see the following section.

3. Computation of the geoid.

The need for a precise geoid was emphasized when Statens Kortverk (N) in the spring of 1989 requested that the section provided as soon as possible a geoid with 0.5 relative precision. Earlier computed geoids (Tscherning and Forsberg, 1986) do have this mean error, but a large 1 m error in the middle of the area (cf. Torge et al. (1989)) makes this result unsatisfactory. On the other hand, it would take a long time to recompute the geoid using the same method as used in 1986 (blockwise collocation).

At the meeting of the persons directly engaged in the geoid computation April 19, 1989 in Charlottenlund, it was decided to use the fast FFT method with residual terrain modelling. Besides being fast it has the advantage that a large area may be covered by one solution, and it is therefore not so sensitive to longwavelength errors in the underlying spherical harmonic reference model.

After the April meeting, the work started immediately, with the hope of finishing the task within a few months. But several problems occured caused by lack of height data or inconsisteney of the height data close to the border between Norway and Sweden. The height data were also given in several different UTM-zones, as well as in the Swedish national Ganss-Krüger system. This caused considerable problems during the computation of terrain effects.

The computations were completed ultimo 1989 due to a tremendons effort by R. Forsberg, see Forsberg (1990). The geoid covers the Nordic Area east of 3° longitude. As mentioned in the definition of task (1), the geoid is provided in the form of a grid, which may be used for interpolation. It should be pointed out, that the zero level of the geoid still is uncertain, and has to be fixed by convention. However, this must be done so that the conversion of GPS-ellipsoidal heights given in WGS84 to orthometric or normal heights gives results which agree with the national systems of heights above sea-level.

Geoid heights have been computed for the area around the Faroe Island, see Knudsen et al. (1988). Also for other areas are geoid heights computed on a routine basis see e.g. Madsen and Tscherning (1990).

4. Future work.

Task (1) has only been partially completed. Only the eastern part of the Nordic Area has been covered by a reasonably precise geoid. The task must therefore be continued. A strategy must be found to take full advantage of both gravity and satellite altimeter data.

A systematic evaluation of methods for geoid computation (Task (2)) has not been made. However, various comparisons of different methods have been made by members of the section (Barzaghi et al., 1988). Evaluation of spherical harmonic expansions of the gravity potential are now done one a routine basis through a comparison with GPS-derived geoid heights and point gravity anomalies (Basic et al., 1989).

An evaluation of geoids using GPS-derived geoid heights is also a very good method. However, it would be important to have more GPS-derived geoid heights close to unsurveyed or inaccessible areas. These data may be used both for control, and as additional data in a local geoid determination using collocation.

A continued joint effort by the Nordic Countries is needed. S + SF would benefit for an improved geoid in the Baltic Sea area. N, DK, IS would benefit very much by an proved geoid in the Norwegian and Greenland Seas, Island and Greenland.

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