Submitted Bulletin IGeS, Feb 98

3831

Evaluation of the EGM96, the EGG97 and the GEONZ97 (gravimetric) Geoids in the North Sea Area.

by

C.C.Tscherning
Department of Geophysics
Juliane Maries Vej 30,
DK-2100 Copenhagen Ø, Denmark.

Abstract: ERS-1, Topex altimeter heights as well as OSU95 Mean Sea Surface Heights have been compared to the EGM96 geoid, the EGG97 geoid and the GEONZ97 gravimetric geoid in the North Sea area. The altimeter and MSS data were converted from the Topex reference system to WGS84. The comparison showed mean absolute differences of the order of 0.2 m and standard deviations of 0.35 m for the differences with respect to EGM96 and 0.23 - 0.26 m for differences with respect to EGG97 and GEONZ97. This shows that the EGG97 geoid and the GEONZ97 gravimetric geoid both are significant improvements as compared to EGM96 in this area.

1. Introduction.

The EGG97 geoid has been calculated using local data to improve the EGM96 geoid. The geoid has been evaluated for the European land areas, see Denker et al. (1997, Table 1). Furthermore a North Sea Geoid Model, GEONZ97, (Bruijne et al., 1997) has been computed having as an intermediate result a gravimetric geoid computed from local gravity data and the EGM96 spherical harmonic model. The GEONZ97 model covers "only" the North Sea and the Netherlands, while the EGG97 model covers all of Europe. Obviously the EGM96 model is global.

In this brief report an evaluation of the three geoids in two rectangles using altimeter data and mean sea surface heights will be described. The comparison is for all three geoids made in the lat.-long.-rectangle corresponding to the area of the GEONZ97, and for the EGM96 and the EGG97 geoids as well in a larger rectangle covering the North Sea.

2. Altimeter Data for the evaluation.

NASA has published a CD-ROM with so called pathfinder data. ERS-1 (repeat 1 - 18) and Topex (repeat 1 - 154) altimeter heights are interpolated into normal points, and the residuals with respect to the OSU 95 Mean Sea Surface (Yi , 1996) are stored for each track together with the height of this surface so that the original height with respect to the Topex reference ellipsoid (a = 6378136.3 m, 1/f = 298.257) can be restored.

ERS-1, Topex and OSU95 MSS data in the area 50° < latitude < 60° and -5 ° < longitude < 15° was selected. This gave 2143 ERS-1 values, 229227 Topex values and 168+1692 OSU95 MSS "normal point heights".

The EGG97 geoid is given with respect to the GRS80 reference ellipsoide, so the altimeter heights were transformed to this ellipsoid by first converting all positions to (X,Y,Z), and then converting the positions to latitude, longitude and ellipsoidal height with respect to GRS80. The GEONZ97 gravimetric geoid is in a system similar to the Topex system, since its evaluation is based on the use of EGM96.

3. Geoid heights.

Geoid heights were obtained by evaluating the EGM96 spherical harmonic model complete to degree 360 (Lemoine et al., 1996) using the GRAVSOFT program GEOCOL12 (Tscherning et al.,1993). The EGG97 grid was evaluated using the program EGGPRO provided with the EGG97 CD-ROM. The GEONZ97 gravimetric geoid was also given as a grid, and was evaluated using the GRAVSOFT program geoip.

The EGG97 geoid is shown in Figure 1, and the differences with respect to the EGM96 geoid are shown in Figure 2.

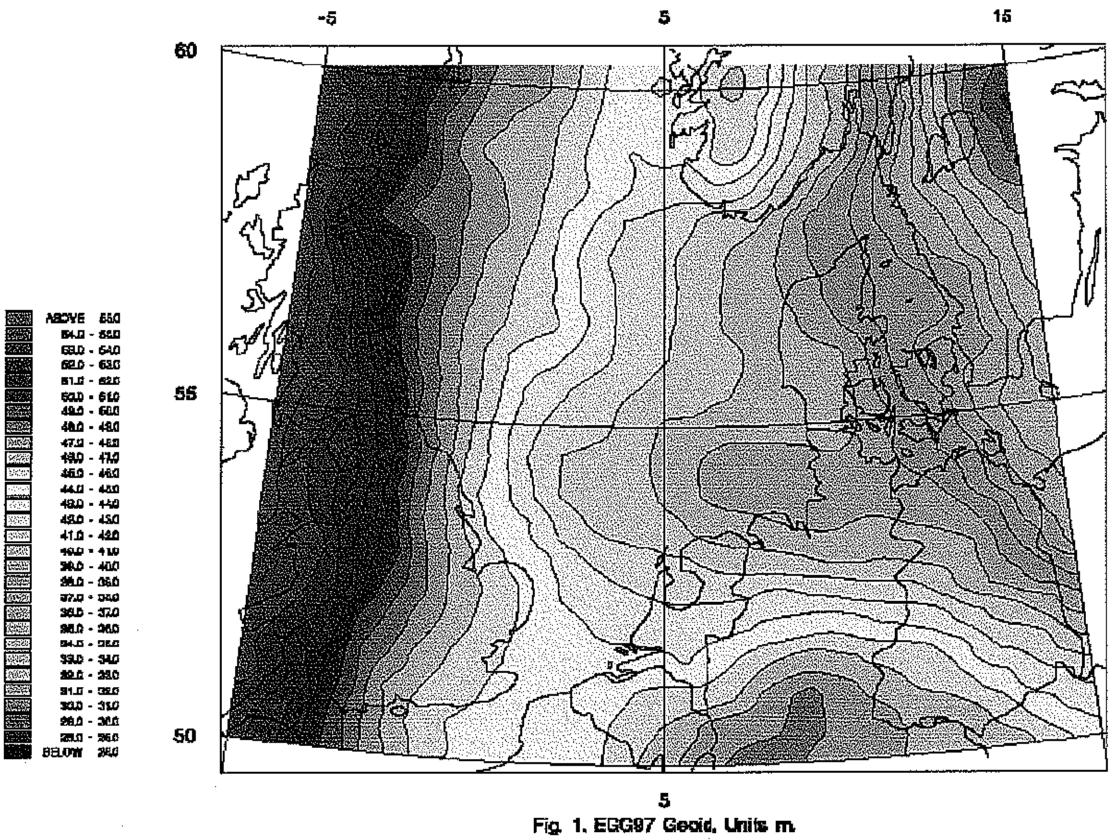

Fig. 1. EGG97 Geoid. Units m.

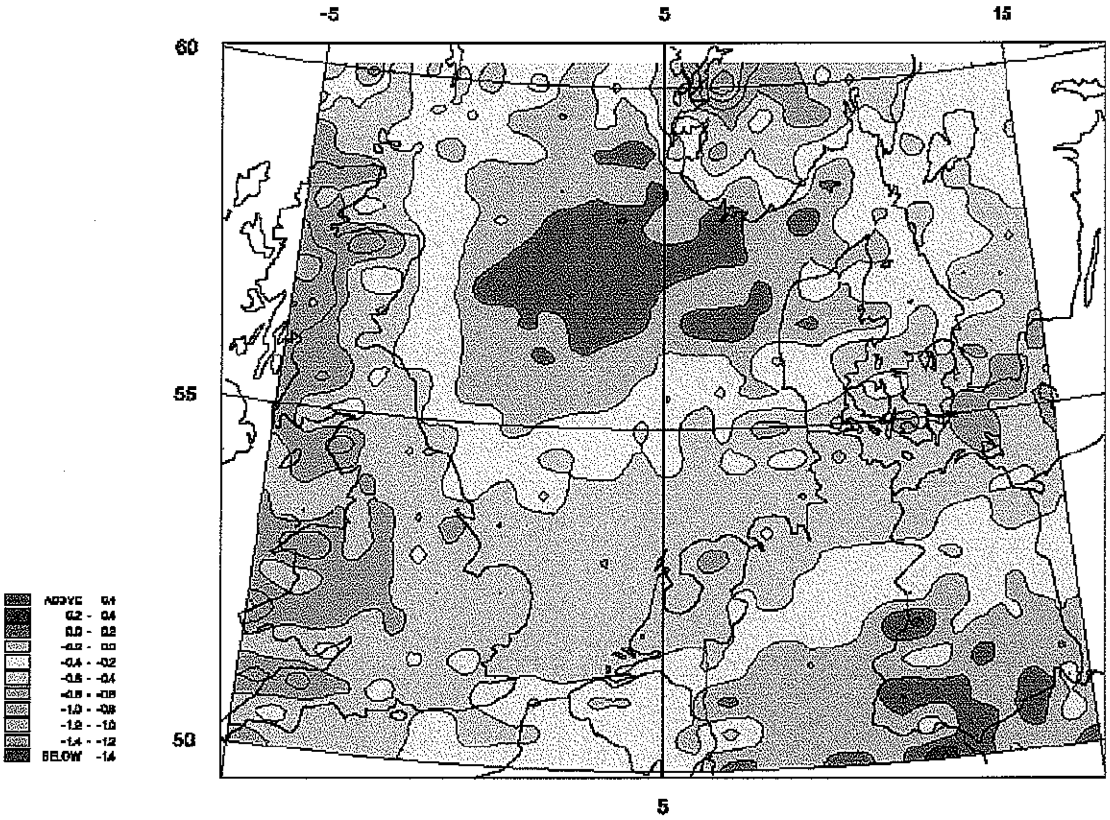

Fig. 2. Differences EGM96 and EGG97 Geoids. Units m.

The mean value of the differences is -0.35 m, the standard deviation of the differences is 0.25 m, the minimum difference is -1.33 m and the maximal difference is 0.45 m. This is a regular grid of 861 points spaced 0.5° in latitude and longitude.

The differences between EGG97 and GEONZ97 which have a 0.10 m mean value (after conversion to GRS80) and a standard deviation of 0.14 m are shown in Fig. 4.

4. **Result of Comparison.**

The differences between the altimeter heights and the MSS heights and their standard deviations are given in Table 1 for the larger rectangle.

Table 1	EGM96		EGG97	
Units: m	Mean	Stan.dev.	Mean	Stan.dev
Topex	-0.29	0.42	-0.31	0.34
ERS-1	0.06	0.33	0.10	0.25
OSU95/ERS	-0.20	0.30	-0.19	0.15
OSU95/Topex	-0.16	0.31	-0.19	0.18

Table 2 shows the result of the comparison for all 3 geoids in the smaller rectangle.

Table 2	EGM96		EGG97		GEONZ97	
Units: m	Mean	Stan.dev.	Mean	Stan-dev.	Mean	Stan.dev.
Topex	-0.29	0.35	-0.29	0.26	-0.20	0.25
ERS-1	0.09	0.32	0.13	0.24	0.22	0.23
OSU95/ERS	-0.18	0.28	-0.16	0.12	-0.07	0.11
OSU95/Topex	-0.16	0.26	-0.17	0.14	-0.07	0.13

The histogram of the differences showed that the Topex data contained relatively many outliers. In fact land data (on lakes) had not been removed completely. Also data in areas with a large tidal signal showed large residuals. Figure 3 shows the location of the differences for

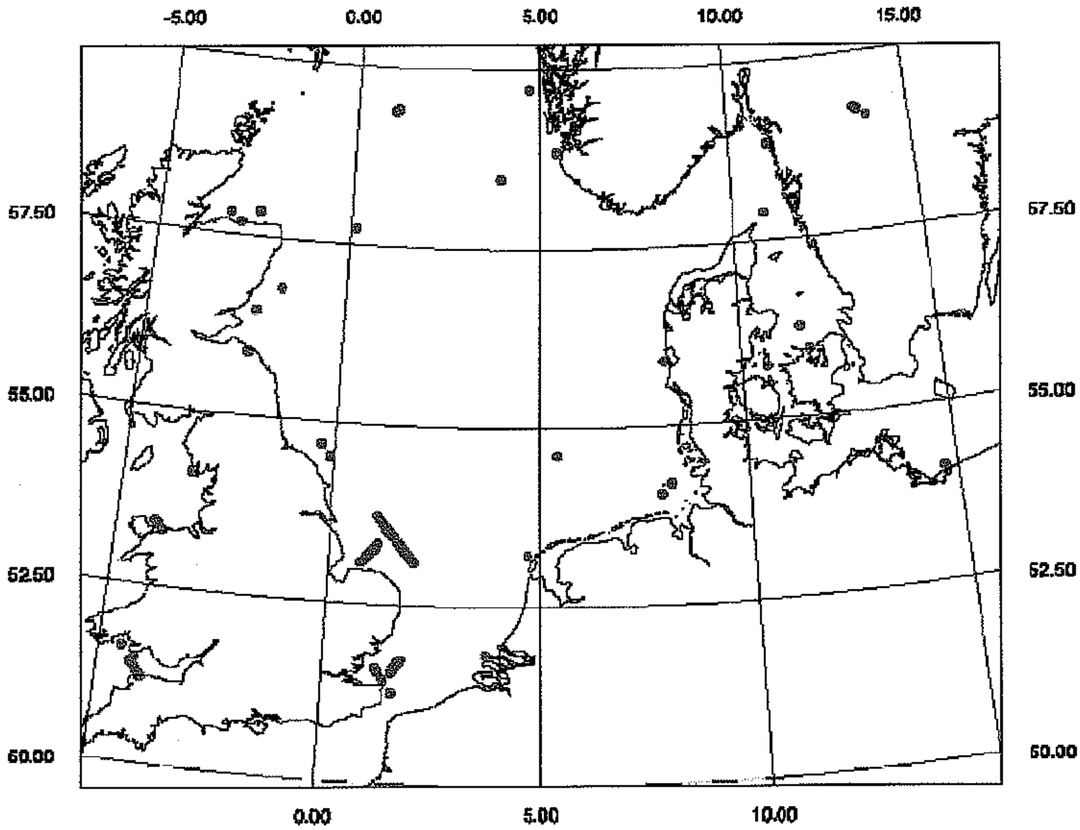

Figure 3. Topex data outliers.

which the numerical value is larger than 1.5 m.

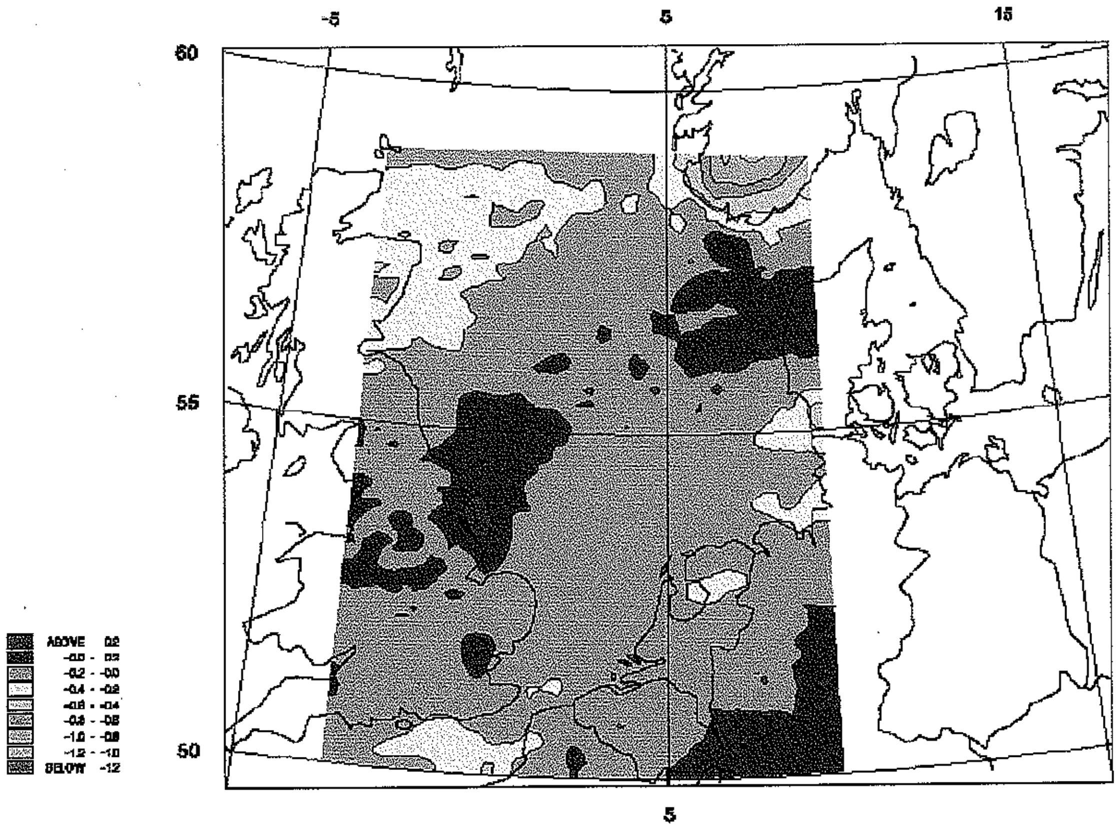

Fig. 4. Differences GEONZ97 Gravimetric and EGG97 Geoids, Units m.

5. **Conclusion**.

First of all is remarkable how small the biases are. This is probably due to the good progress made both in orbit improvement and tidal analysis. There is however a difference between ERS-1 and Topex which probably is due to that no joint cross-over analysis was made like when creating the OSU95 MSS (see Yi, 1995, section 2.11)..

The agreement with the OSU95 MSS is also very good, with standard deviation of differences of 0.15 - 0.18 m.

Most important is the fact that EGG97 and GEONZ97 (gravimetric geoid) represent real improvements as compared to EGM96. Whether the biases are due to stationary sea-surface topography, system inconsistencies or long wavelength errors in the gravity field models need to be explained. A future space borne gravity field mission should be able to help in solving this problem.

Finally it should be mentioned that GEONZ97 gravimetric geoid has been modified as to agree with Topex data in order to create a precise reference surface for oceanographic studies. For details see (Bruijne et al., 1997).

Acknowledgement: Thanks to Institut für Erdmessung, Hannover and IAG for providing the

CD-ROM with the EGG97 model, and thanks to NASA for providing the Pathfinderdata. The access to the ERS-1 data is within the framework of the ESA AO ERS-1 Project AFRICAR, and ESA is thanked for making the data available. The digital grid representing the GEONZ97 geoid was provided by the colleagues at DUT and at Rijkswaterstaat.

References.

Bruijne, A.J.T. de., R.H.N.Haagmans E.J. de Min: A preliminary North Sea Geoid model GEONZ97. MD-rap. MDGAP-9735. Rijkswaterstat, Delft, July 1997.

Denker, H., D.Behrend & W.Torge: The European Gravimetric Quasigeoid EGG96. IAG Symp., Proc. GraGeoMar96, Springer Verlag, 1997.

Koblinsky,C J, B D Beckley, R D Ray, Y M Wang, L Tsaoussi, A C Brenner, R G Williamson, NASA Ocean Altimeter Pathfinder Project Report 1: Data Processing Handbook, NASA Technical Memo., Goddard Space Flight Center, Greenbelt, 1998.

Lemoine, F.G., D.Smith, R.Smith, L.Kunz, E.Pavlis, N.Pavlis, S.Klosko, D.Chinn, M.Torrence, R.Williamson, C.Cox, K.Rachlin, Y.Wang, S.Kenyon, R.Salman, R.Trimmer, R.Rapp and S.Nerem: The development of the NASA GSFC and DMA joint geopotential model. Proc. Symp. on Gravity, Geoid and Marine Geodesy, Tokyo, 1996.

Tscherning, C.C., R.Forsberg and P.Knudsen: The GRAVSOFT package for geoid determination. Proc. 1. Continental Workshop on the Geoid in Europe, Prague, May 1992, pp. 327-334, Prague, 1992.

Yi, Yuchan: Determination of Gridded mean Sea Surface from TOPEX, ERS-1 and GEOSAT Altimeter data. Dep. Geodetic Sci. & Surveying, Rep. no. 434, Columbus, Ohio, 1995.