CHAMP Gravity Field Models using Precise Orbits

C. C. Tscherning, E. Howe, L. Stenseng

Department of Geophysics, University of Copenhagen, E-mail: cct@gfy.ku.dk

Abstract

The German CHAlleging Minisatellite Payload (CHAMP) was launched in July 2000. It carries a GPS receiver and a three-axes accelerometer.
From GPS measurements a precise orbit of the satellite in August 2001 has been determined by DEOS at TU Delft. With these orbits and pre-processed accelerometer data it has been possible to determine two global gravity field models to degree and order 90, UCPH2003_02 and UCPH2003_03. The gravity field models have been determined using least squares collocation and by considering energy conservation.
Comparisons have been made with Arctic gravity data, EIGEN-2 and between the two models.

Energy conservation

For the determination of the gravity potential at satellite altitude, the kinetic energy of the satellite must be computed, and external forces must be taken into account. The external forces are tidal potential of the Sun, V_s, Moon, V_m, and friction F. In UCPH2003_02 we have taken the complete acceleration vector into account when calculating friction. In UCPH2003_03 only the along-track component is considered.
The rotation of the earth's potential in the inertial frame must also be taken into account. By subtracting the Earths normal potential U and an integration constant E_0, we find the potential difference;

$$T_{sat} = \frac{1}{2}v^2 - V_s - V_m - \omega(xv_y - yv_x) - F - U - E_0$$

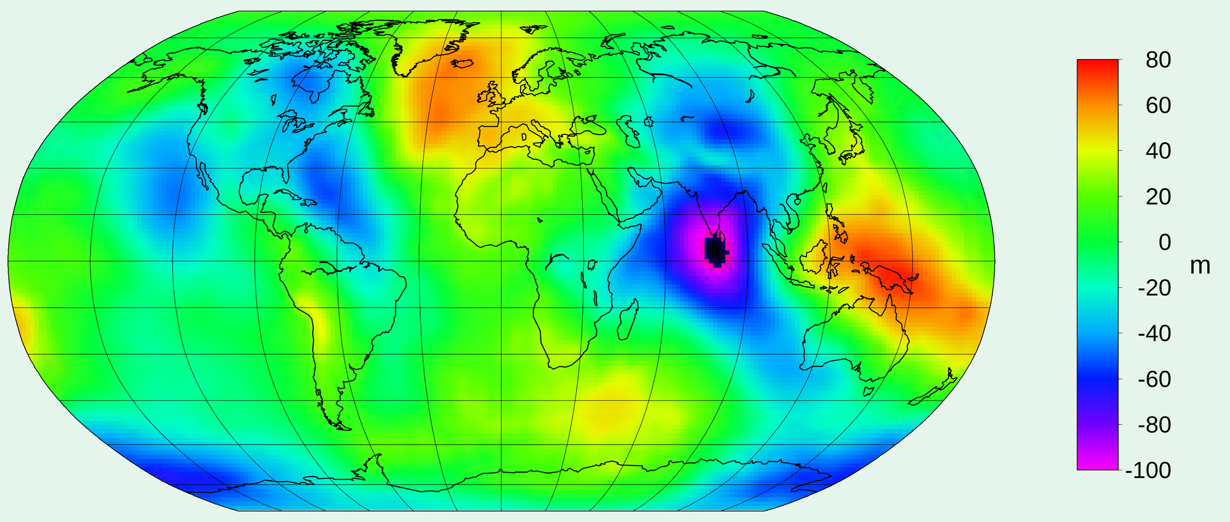

Figure 1: UCPH2003_03 Geoid heights in metre.

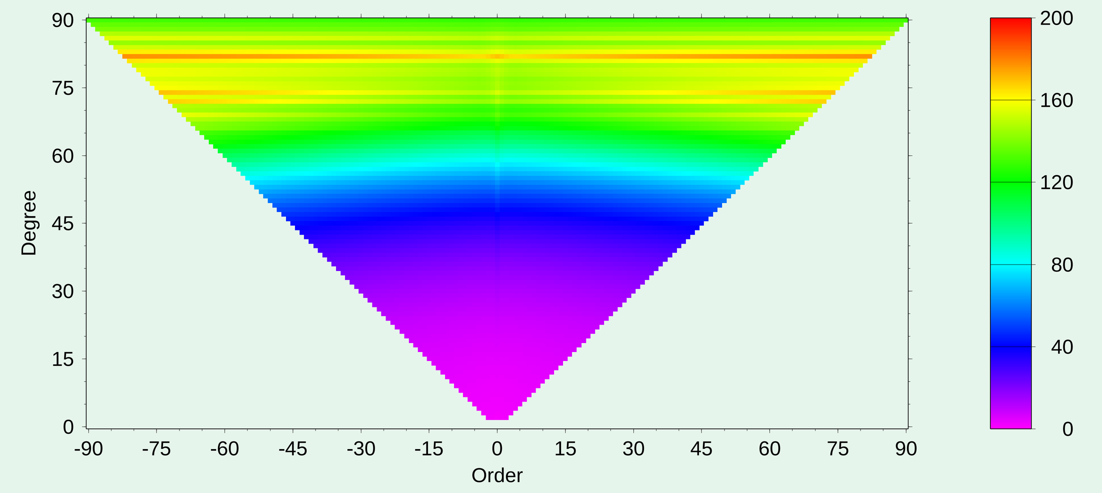

Figure 2: Error estimate for UCPH2003_03. Scale is in units of 10^{-11}.

Determination of spherical harmonic coefficients

To make the residual potential statistically more homogeneous EGM96 to degree and order 24 was subtracted. The residual potential values are then up-/downwards continued to a common height of 440 km above the ellipsoid.

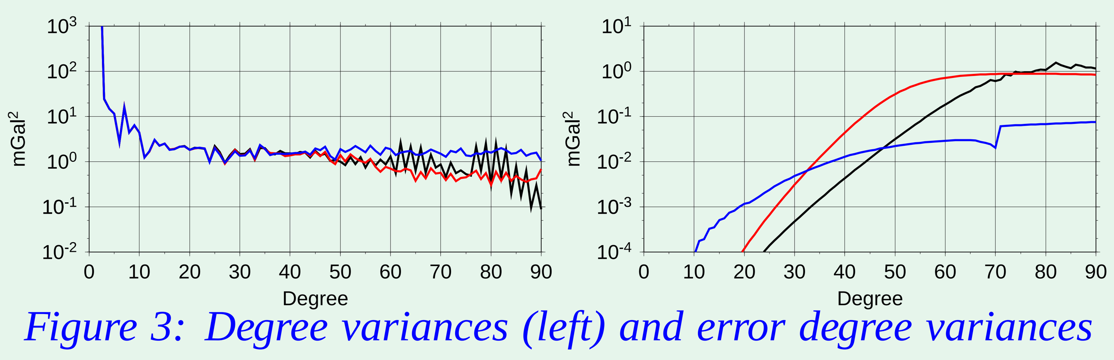

Figure 3: Degree variances (left) and error degree variances (right) for UCPH2003_03 (black), EGM96 (blue) and EIGEN-2 (red)

A grid with 0.5^{o} spacing was determined. The spherical harmonic coefficients and their associated errors were then determined by 'Fast Spherical Collocation'. EGM96 to degree and order 24 is then subsequently added to get a complete set of spherical harmonic coefficients.

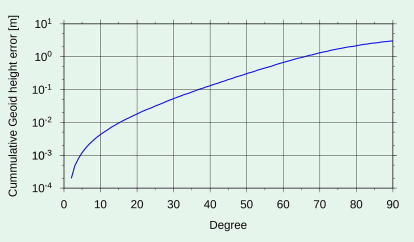

Figure 4: The accumulative geoid height error of our models

Degree variances and error degree variances of our model are compared with EGM96 and EIGEN-2, see Figure 3. It is seen by inspection of Figure 3 that above degree 60 there is no or little information left in UCPH2003_03 and EIGEN-2. Furthermore it is seen that below degree 40 UCPH2003_03 is expected to improve EGM96.
The accuracy of our models is seen in Figure 4. At degree 60 the accumulated geoid error is <u>66 cm</u>.

Comparison with Arctic gravity data

To verify our models they are both compared to Arctic gravity data. The same comparison has been made for EIGEN-2 and EGM96. The Arctic gravity data is derived from airborne, surface and submarine data.
An area in Northwest Greenland has been chosen, 75^{o}-78^{o}N and 43^{o}-53^{o}W. In this area the gravity models do not agree. The comparison has been made to degree and order 60. It can be seen in Table 1 that our models fits better to the Arctic data than EIGEN-2 and EGM96.

	UCPH2003_02	UCPH2003_03	EIGEN-2	EGM96
Mean	-1.2 mGal	-0.9 mGal	-6.6 mGal	-4.6 mGal
St. Dev.	13.6 mGal	13.8 mGal	15.8 mGal	17.8 mGal

Table 1: Comparison between Arctic gravity data and UCPH2003, EIGEN-2 and EGM96.

Evaluation of UCPH2003_03

The models UCPH2003_02 and UCPH2003_03 have been compared to degree 90, see Figure 5. The only difference between the two models is that UCPH2003_02 is determined using the full acceleration vector and for UCPH2003_03 we only used the along-track component. For UCPH2003_03 we determined a scale factor for the along-track accelerometer for each day.

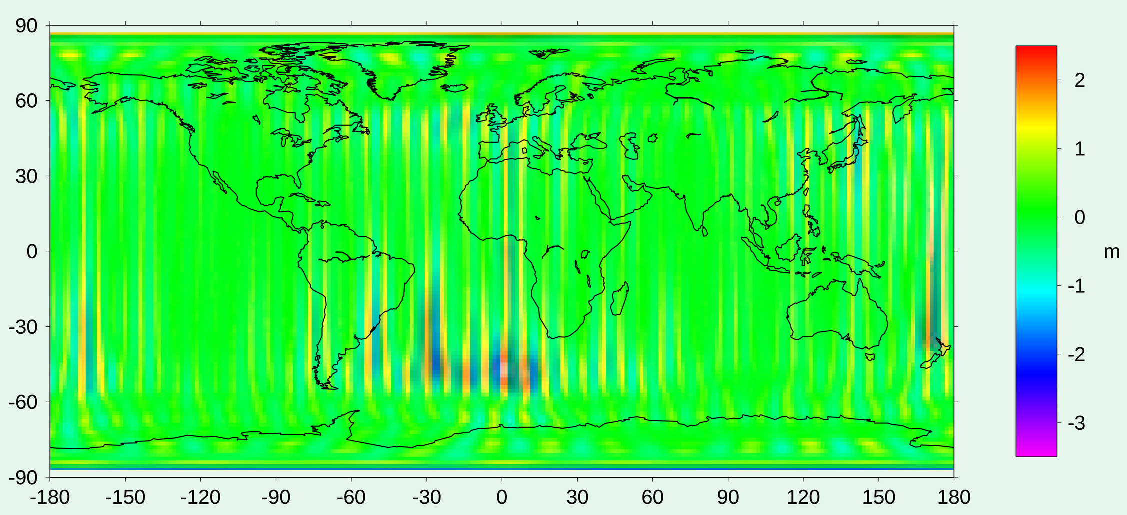

Figure 5: Differences between UCPH2003_02 and UCPH2003_03.

The mean difference between the two models is 0.2 cm and the standard deviation is 59.5 cm at zero level.

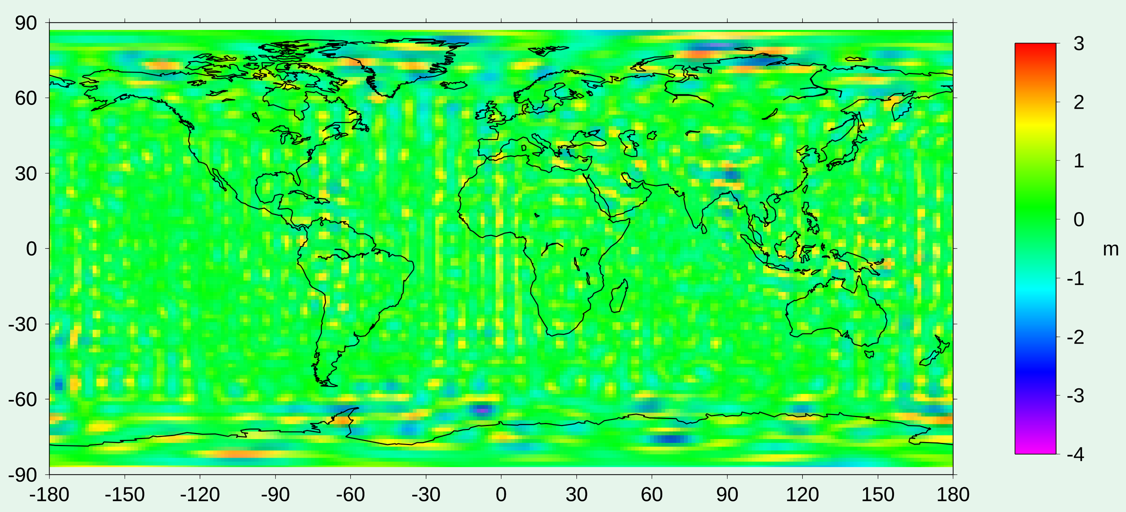

Figure 6: Differences between EIGEN-2 and UCPH2003_03.

The model UCPH2003_03 has also been compared to EIGEN-2 to degree 60. The difference between geoid heights computed from EIGEN-2 and UCPH2003_03 respectively are shown in figure 6. The mean difference between the two models is -0.46 cm and the standard deviation is 73.8 cm.
Since the accuracy of our model is 66 cm, the difference between the models is within the models accuracy. It is therefore not possible to say that the models are significantly different.

Acknowledgment:

Thanks to J. Van den IJssel DEOS for Precise Orbits and quaternion files. Thanks to the national survey and cadastre (KMS) of Denmark for Arctic gravity data. They are available at NIMA's homepage: www.nima.mil/GandG. This poster is a contribution to the SAGRADA project sponsored by The Danish Science Research Council.

The Gravity Fields:

The spherical harmonic coefficients of the Gravity Field Models UCPH2003_02 and UCPH2003_03 are available at http://www.gfy.ku.dk/~eva/en/sagrada.php

Contacts:

C. C. Tscherning or E. Howe
Department of Geophysics
Juliane Maries Vej 30
Dk-2100 Copenhagen Oe
E-mail: cct@gfy.ku.dk or eva@gfy.ku.dk