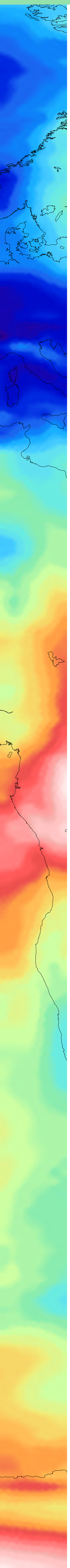
CHAMP Gravity Field Model UCPH2002_01

Eva Howe, Lars Stenseng, C. C. Tscherning



Introduction

On the 15. of Juli 2000 the German CHAMP (CHAllending Minisatellite Payload) satellite was launched. The satellite is in a near polar orbit about 450 km over the surface of the Earth.

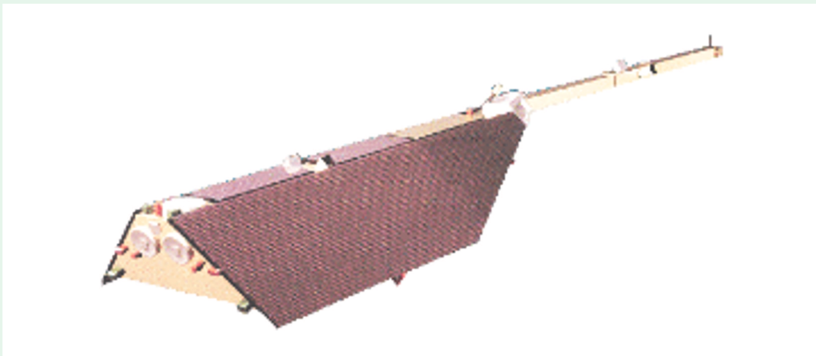


Figure 1: CHAMP satellite.

The scientific objectives include the mapping of the earths gravity field. For this purpose CHAMP carries an accelerometer, which measures the non-conservative forces, which acts on the satellite.

Determination of height anomalies

An energy conservation method has been applied to data from august 2001, where the solaractivity was nearly constant. We have used 'Rapid Science Orbit' data, which include position and velocity of the satellite, as well as accelerometer measurements.

In order to use energy conservation for the determination of the gravitypotential at satellite altitude, the kinetic energy of the satellite $T = \frac{1}{2}v^2$ must be computed, and external forces must be taken into account. The satellite is affected by the Sun, V_s, and Moon, V_m, and the Earth rotation must also be taken into account $\omega(xv_y - yv_x)$. The largest external forces is the friction from the atmosphere. This may be estimated using the accelerometer measurements in the flight direction, $F = \int |\vec{v}| a_y dt$. By subtracting the Earths normal potential U and integration constants E_0, we find the potential difference;

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

Using Bruns formula, $\zeta = T_{sat}/\gamma$, the height anomaly at satellite altitude is determined. γ is the normal gravity.

Orbit errors

The orbit errors were estimated using Fourier analysis. The largest orbit error is associated with a frequency of 14 as seen in figure 2. This corresponce to a twice per revolution signal. The mean amplitude was found to be 8 cm.

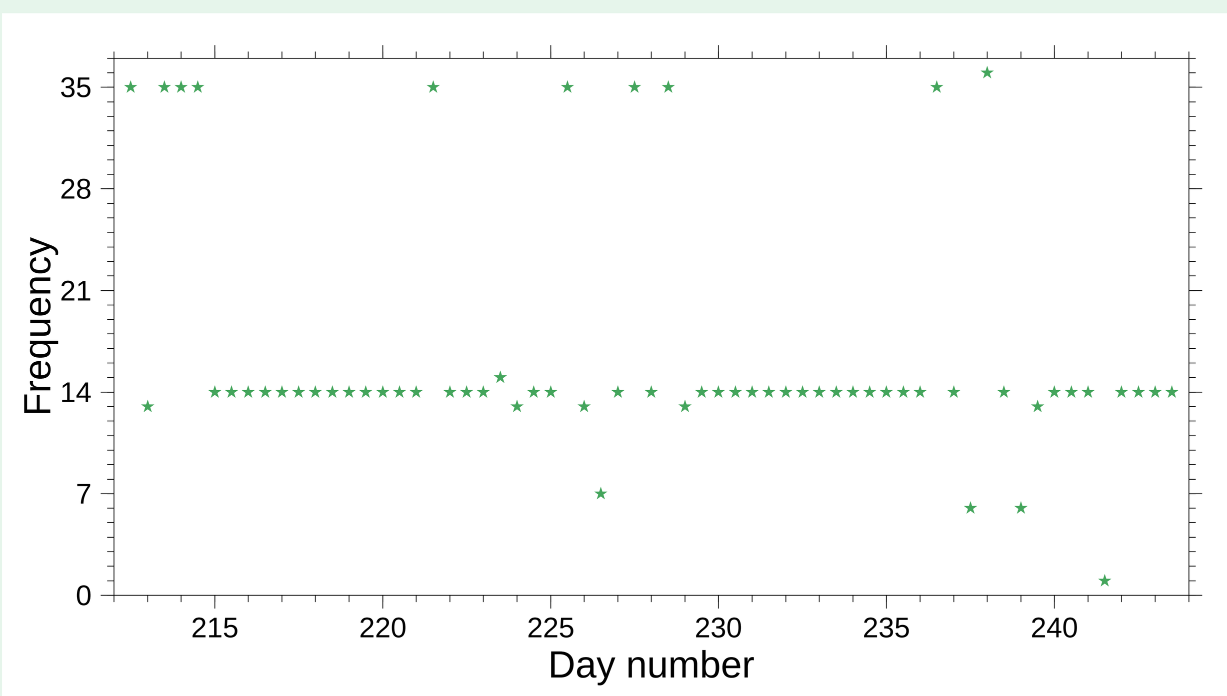


Figure 2: Frequency of the largest amplitude for each 12 hour period.

The collocation method used to grid the data filtes away some of this error which is expected to be insignificant when 'Precise Orbits' becomes available.

Determination of spherical harmonic coefficients

The values of the anomalous potential are up-/downwards continued to a mean altitude 440 km above the WGS84 ellipsoid and gridded with 1.5 degree spacing. The EGM96 to degree 24 is subtracted in order to achieve a reasonable statistical homogeneity.

'Fast Spherical Collocation' is used to estimate the spherical harmonic coefficients to degree 90 and the corresponding errors. The solution is denoted UCPH2002_01. The Fast Spherical Collocation method does not require data in the polar region.

Evaluation of UCPH2002_01

Above degree 70 the error of the solution exceeds the standard deviation of the signal, see figure 3.

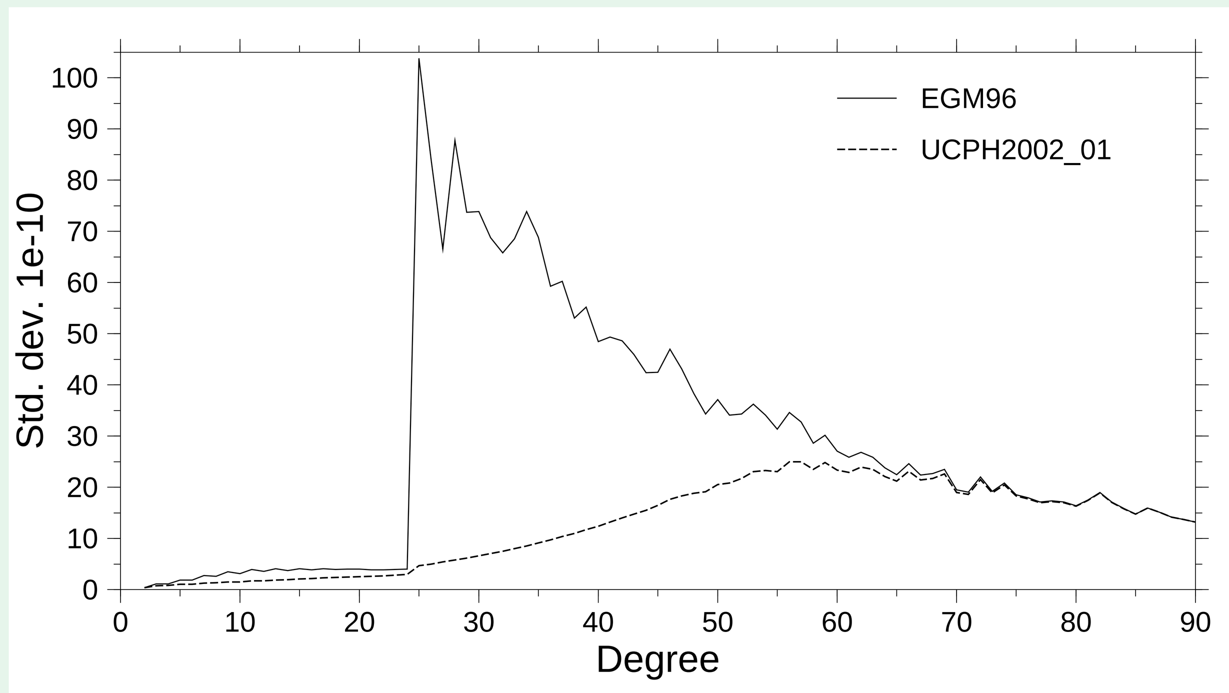


Figure 3: Error degree standard deviations from degree 2 to 90 for UCPH2002_01 and from 2 to 24 for EGM96. Degree standard deviations from 25 to 90.

The model has been compared to EGM96 to degree 60. The difference between geoide heights computed from EGM96 and UCPH2002_01 respectively are shown in figure 4. The mean difference between the two models is -0.82 cm and the standard deviation is 71,5 cm corresponding to the orbit error of 8 cm.

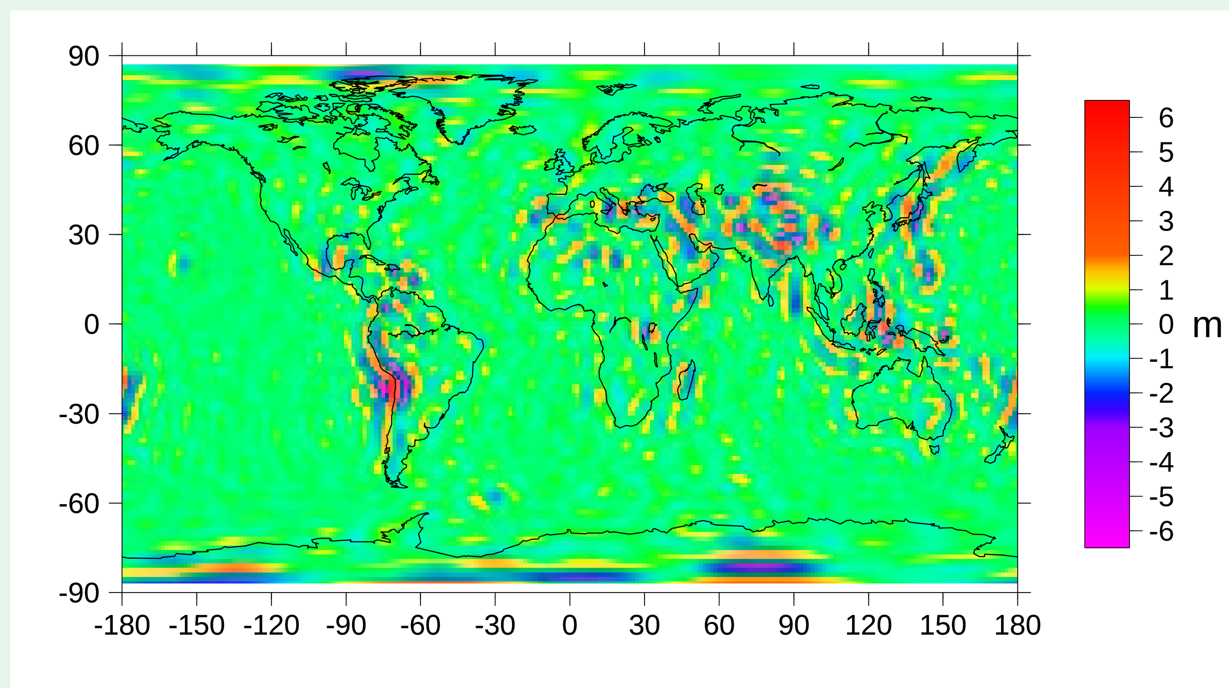


Figure 4: Differences between EGM96 and UCPH2002_01.

The largest differences between EGM96 and UCPH2002_01 is found at places where little data were available in 1996.

References:

1. Jekeli, C. (1999), *The determination of gravity potential differences from satellite-to-satellite tracking*, Celestial Mechanics and Geodynamical Astronomy, Vol. 75, s. 58-101.
2. Wessel, P. and Smith, W. H. F. (1998), *New, improved version of Generic Mapping Tools released*, EOS Trans. Amer. Geophys. U., vol. 79 (47), s. 579.

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Contact:

Eva Howe, Lars Stenseng, C. C. Tscherning
Department of Geophysics
NBIfAFG, University of Copehagen
E-mail: eva@gfy.ku.dk,
stenseng@gfy.ku.dk, cct@gfy.ku.dk