Impact of Atmospheric & Oceanic Uncertainties on GRACE De-Aliasing Products

Lieselotte Zenner , Thomas Gruber

Institut für Astronomische und Physikalische Geodäsie, Technische Universität München, Germany, ***e-mail: zenner@bv.tum.de***

Introduction

High-frequency, time varying mass redistributions in the ocean and atmosphere have a significant impact on GRACE and are therefore eliminated in the standard GRACE de-aliasing process.
Until now the atmosphere and ocean model used in the de-aliasing process are regarded as error free, although it is well known from various studies that data from atmospheric and oceanic models have large uncertainties.
In order to get insight into the importance of uncertainties in these models, we perform a full error propagation of the atmospheric and oceanic parameters up to the gravity field.

Computation of the atmospheric de-aliasing coefficients

$$T_v = (1+0.608S)T \quad ; \quad P_{k+1/2} = a_{k+1/2} + b_{k+1/2}P_S$$

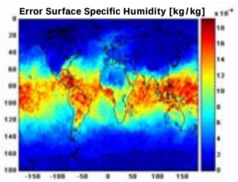
$$\Phi_{k+1/2} = \Phi_S + \frac{1}{g}\sum_{j=k+1}^{N_{lev}} R_{dry} T_v \ln\frac{P_{j+1/2}}{P_{j-1/2}}$$

$$C_{nm} = -\frac{a^2(1+k_n)}{(2n+1)Mg}\iint_{Earth}\left[\int_{P_S}^{0}\left(\frac{a}{a-\Phi}+\frac{\xi}{a}\right)^{n+4} dP\right] P_{nm}(\cos\theta)\cos m\lambda \sin\theta d\theta d\lambda$$

$$S_{nm} = -\frac{a^2(1+k_n)}{(2n+1)Mg}\iint_{Earth}\left[\int_{P_S}^{0}\left(\frac{a}{a-\Phi}+\frac{\xi}{a}\right)^{n+4} dP\right] P_{nm}(\cos\theta)\sin m\lambda \sin\theta d\theta d\lambda$$

Up to now the input parameters temperature (T), specific humidity (S), surface pressure (P_s) and surface geopotential height (Φ_s) are regarded as error-free, although it is well known that there are large uncertainties in the atmospheric input parameters.

One of our goals within the DFG "IDEAL-GRACE" Project is to determine the effect of uncertainties in T, S, P_s and Φ_s on the resulting De-Aliasing coefficients C_{nm}, S_{nm}. Therefore we developed a mathematical model to propagate the atmospheric field errors (Figure 1) to pressure errors at the centre of mass of the atmospheric column (inner integral of the two integral formulas). The propagated errors of the input parameters on the inner integral are shown in Figure 2. By a least squares adjustment these uncertainties are further propagated on the atmospheric de-aliasing coefficients (shown in Figure 3).



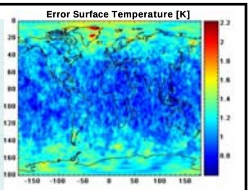
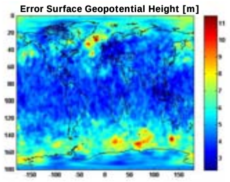
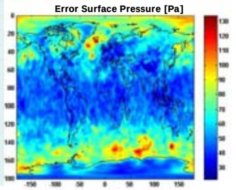


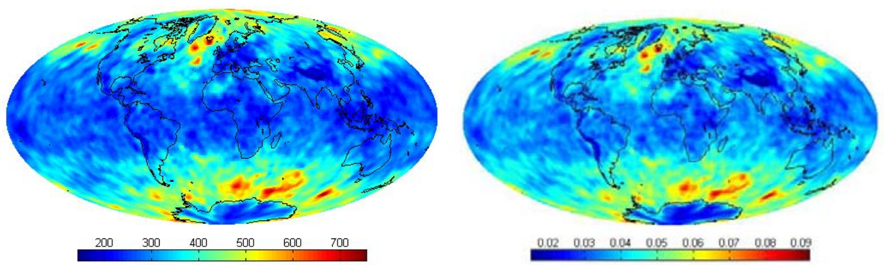
Fig.1: Errors of the atmospheric input parameters. ECMWF, Operational Archive, Errrors in Analysis, 30.11.06 21h.

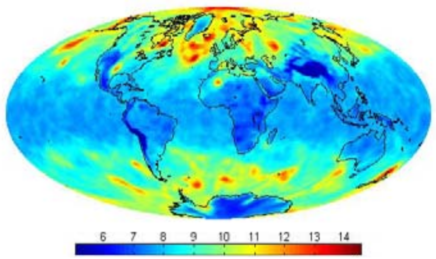
top: surface specific humidity (left) and surface temperature (right)

bottom: surface geopotential height (left) and surface pressure (right)









◄Fig.2: Error of the vertical integral in [Pa] due to uncertainties in the input parameters (November, 30 2006 21:00, n=0).

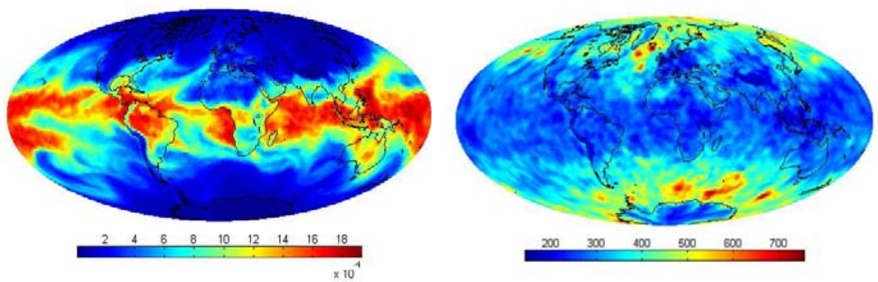
top left: surface pressure

top right: geopotential height

middle: temperature

bottom left: specific humidity

bottom right: all atmospheric input parameters



The Error of the vertical integral due to uncertainties in all atmospheric parameters (shown in Fig.2, bottom right) is propagated by a least squares adjustment on the potential coefficients C_{nm}, S_{nm}.

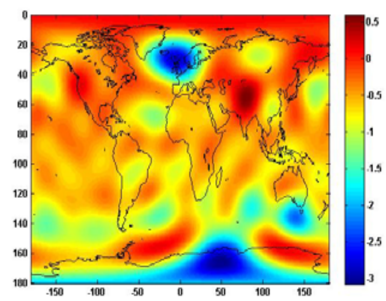
Figure 3 shows the difference in terms of geoid heights between two spherical harmonic series:

Two "error-scenarios" are simulated:

a) all atmospheric input parameters are regarded as error-free ("error-free")

b) the uncertainties of all atmospheric parameters are taken into account ("full error").

Fig.3: Geoid height differences in terms of [mm] between the "error-free" and "full error" case for December 1, 2006 00:00 (w.r.t. a March 1, 2006 00:00 mean, n_{max}=10) ▼.



Conclusion

Uncertainties of the atmospheric input parameters will affect the geoid in the mm-domain, which is already above the GRACE sensitivity.
Error propagation model should be applied to standard GRACE data processing.