Identification of Mass Variations from a Series of Global Gravity Field Models – A Simulation Study

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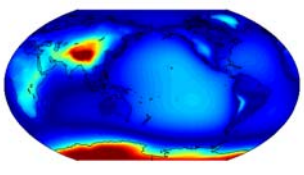
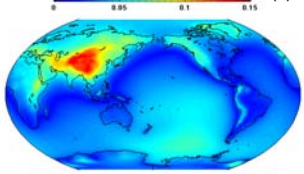
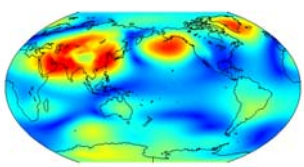
Abstract:

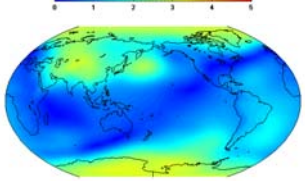
The GRACE mission is designed to provide monthly gravity field models up to degree and order 100. It is expected that the sequence of these models after 5 years nominal mission lifetime will represent a unique data set for the analysis of mass variations within the system Earth. Because GRACE will solely determine the integrated effect of mass variations, what means the combination of all sources of mass changes within a specific period, methods have to be developed to identify individual contribution sources to the overall effect of the variations (e.g. atmosphere, ocean, hydrology, post-glacial rebound). For this we started a simulation study. In the forward computation monthly gravity field models are computed for several years, each perturbed by mass variations based on ECMWF atmospheric pressure fields and ocean bottom pressure fields from the MIT ocean model (hydrology will be taken into account in the next phase). This set of simulated gravity field models can then be used in an analysis step to re-estimate the individual effects. The paper presents the simulation step with the combination of atmospheric and oceanic mass variations. Specifically the ECMWF atmospheric fields are investigated more detailed in the space and spectral domains in order to prepare a simulated time series of gravity field models, which represents as much as possible reality (or what we can expect from the GRACE models).

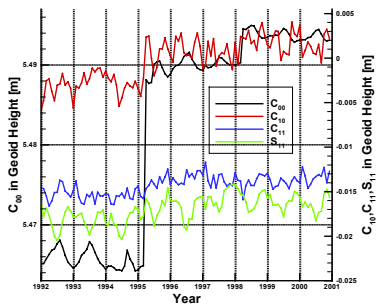
Analysis of ECMWF Residual Atmospheric Surface Pressure Fields:



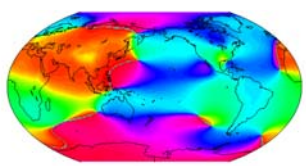


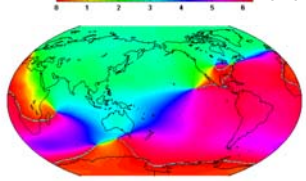






Above: Time series of very low coefficients from ECMWF atmosphere in terms of geoid heights.
Left: Amplitudes of different frequencies from FFT analysis of ECMWF fields in geoid heights.
Below: Phases of different frequencies from FFT analysis of ECMWF fields in geoid heights.



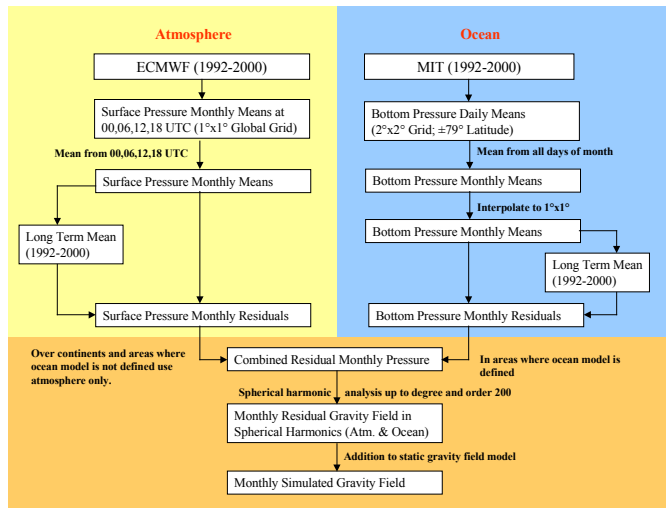


Results and Conclusions:

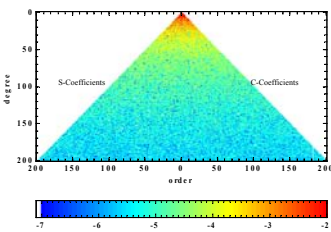
- ECMWF fields show a significant change in its monthly mean values (C_{00}) in April 1995 and a smaller change in April 1998. It was identified that these variations are related to model changes of the ECMWF forecast model. April 1995: New version of the forecast model was implemented; April 1998: Increase of model spatial resolution from T213 to T319. There are several other model changes, which are not reflected in a mean value variation.
- Atmospheric model changes are fully contained in the long term mean. This implies that the model mean should only be computed and used for periods with consistent model parameters.
- After removal of the C_{00} term from the series there remains a zero frequency signal in the ECMWF fields especially in the Himalaya region and Antarctica.
- Annual and semi-annual amplitudes and phases for combined atmosphere-ocean analysis show impact of deviation of IB-assumption. Semi-annual phases show clear North-South structure (seasonal effects).
- Current CHAMP gravity field models are not able to resolve temporal gravity field variations (see degree variances of TUM-1S with respect to monthly signal).

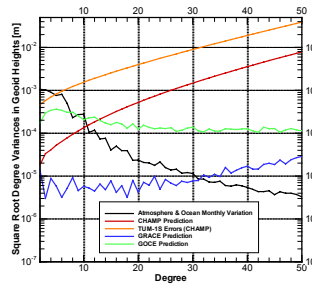
Processing Strategy (Simulation) - See Flow Chart Below

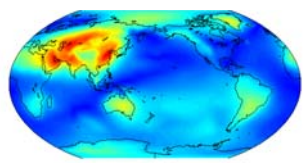
From ECMWF, monthly surface pressure mean fields for the years 1992 to 2000 at 00,06,12 and 18 hours UTC have been downloaded and averaged for each month and for the full period as well. Residual monthly surface pressure fields are computed by subtraction of the long term mean from the monthly means. This should represent the deviation of monthly atmospheric mass anomalies from the static gravity field. Similar, the ocean bottom pressure fields have been prepared for the investigated time period. Note the MIT ocean bottom pressure contains only oceanic mass variations without the atmospheric contribution. From daily means monthly means and the long term mean as well as residual monthly ocean bottom pressure variations have been computed. Atmospheric and oceanic residual fields finally are combined before monthly residual gravity field coefficients are computed.

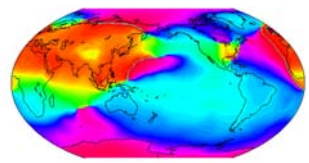


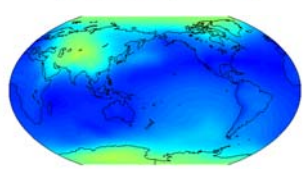
Analysis of Combined ECMWF Residual Atmospheric Surface Pressure Fields and MIT Residual Ocean Bottom Pressure Fields:

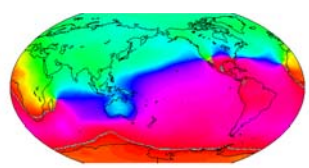












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