Project: **499**

Project title: **Numerical Simulation of High-Frequency Ocean Bottom Pressure Variability**

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Report period: **2018-01-01 to 2018-12-31**

A central focus of the scientific discipline Geodesy is the precise measurement of the Earth's external gravity field and its time-variable rotation. Beside the large-scale dynamics of atmosphere and terrestrial hydrosphere, the spatially and temporally highly variable ocean bottom pressure plays a major part in determining gravity and rotational variability. Therefore, the processing of global geodetic measurements - including the satellite gravimetry missions GRACE (2002 - 2017) and GRACE-FO (launched May 22nd, 2018); Very Long Baseline Interferometry based on a network of globally distributed radio telescopes; and station positions of a permanent network of stations receiving Global Navigational Satellite System (GNSS) signals - requires prior information from numerical ocean models in order to separate signals caused by ocean bottom pressure variability from other geophysical relevant signal sources.

For two peer-reviewed projects

- **ASPIRE** ("Atmosphere-Induced Short Period Variations of Earth Rotation", founded by Deutsche Forschungsgemeinschaft und Fonds zur Förderung der Wissenschaft (Austria)
- **GRACE-FO** ("Realisierung der Deutschen Projektanteile der GRACE-Follow On Satellitenmission", funded by the German Ministry for Education and Research

we performed new simulations of the time-evolution of the global ocean bottom pressure field. Both projects made use of the same numerical experiments with the current ocean component of the MPI Earth System Model, MPIOM (Jungclaus et al., 2013). The projects **ASPIRE** and **GRACE-FO** are in particular concerned with short-term mass variability, and thus required simulations that are additionally forced with atmospheric surface pressure (usually turned off in standard MPIOM experiments), the incorporation of oceanic self-attraction and loading parametrizations (initially coded, but not yet fully tested and tuned in MPIOM), and the consideration of 3-hourly sampled atmospheric forcing (standard MPIOM re-analysis experiments use 6 hourly forcing only) in order to fully resolve atmospheric pressure tides and their corresponding oceanic response.

In particular, the project focussed in 2018 on the following activities:

Earth rotation predictions:

The rotational speed of the Earth and the position of the rotational pole vary slowly in time caused by angular momentum changes due to mass re-distributions in atmosphere, oceans, and the terrestrial hydrosphere. Short-term forecasts from ECMWF and DWD were used to force both MPIOM and a land surface scheme and discharge model (LSDM) to predict the Earth's rotation. Numerous hindcast experiments over 2 years (2016 and 2017) have been performed to identify the best prediction settings for forecast horizons between 1 and 90 days.

Ensemble Simulations:

To arrive at a realistic estimate of uncertainties in the simulated ocean bottom pressure fields, an ensemble of experiments under different forcing and with perturbed physics conditions over a time period of 10 years has been performed. Atmospheric reanalyses used as forcing of MPIOM include MERRA, CFSR, and ERA-5. In addition, we also tested operational NWP data from ECMWF and the German Weather Service (ICON-GLOBAL). For the perturbed physics, we modified the vertical momentum transfer of wind stress, which is known to be the major driver of bottom pressure variability on short periods relevant for de-aliasing of GRACE satellite data. The ensemble spread was benchmarked against in situ ocean bottom pressure observations for different frequency bands.

Self Attraction and Loading:

In its standard configuration, MPIOM does not consider dynamic feedback effects of self-attraction of the water masses and corresponding deformation of the ocean sea-floor, which is in particular important for wind-driven variability at periods from hours to days. Since those high-frequency mass variations are highly relevant sources of aliased signals that are responsible for a considerable fraction of the overall GRACE error budget, we attempt to incorporate this dynamic process into MPIOM as well. Development work will be done with the TOY and GR30 configurations of MPIOM. Due to a change in project personnel, this work has not yet been completed and will be continued in 2019.

References

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Dobslaw, H., Dill, R. (2018): Predicting Earth orientation changes from global forecasts of atmosphere-hydrosphere dynamics. - Advances in Space Research, 61, 4, pp. 1047-1057. doi:10.1016/j.asr.2017.11.044.

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