Geodetic hydrological excitation functions by different atmosphere and ocean models and comparison with hydrological excitation functions and GRACE solutions

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Objectives

Here, we compare the results of several geodetic hydrological excitation functions (GAM) that are calculated by removing modeled-atmospheric w/AAM and oceanic (OAM) effects from precise observations of full polar motion excitation (GAM). These geodetic residuals are compared to each other and with hydrological excitation functions determined from hydrological model and Gravity Recovery and Climate Experiment (GRACE) satellite mission. We analyze the polar motion budget at seasonal, and short-term oscillations for a most often used models of atmosphere and ocean considered the global mass balance inside AAM, OAM, and HAM excitation functions using following approach:

\[
GAM = \text{AAM} - \text{OAM} + \text{HAM} + \text{SLAM} - \text{GRACE} \tag{1}
\]

Models and data description

The following materials were required to complete the research:

1. **GRACE observed polar motion excitations**
   - obtained from International Earth Rotation and Reference System Service (IERS) CM series of polar motion;

2. **Atmospheric Angular Momentum (AAM) models**
   - National Center for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) models (with 1 day resolution, 36 grid points in longitude and 19 grid points in latitude) with the North American Geodetic System (NAD83) for the whole period of measurements.

3. **Oceanic Angular Momentum (OAM) models**
   - The Jet Propulsion Laboratory (JPL) ocean models, ECCO-I (ECCO ocean model without data assimilation) and ECCO-II (ECCO ocean model include altimetric and in situ observations of sea surface height and expendable bathythermographs (XBT) data), assimilation, product of the ISSS program for the Ocean.

4. **Effective Atmospheric Angular Momentum (EAM)** of the ocean were calculated from 6-hourly NCEP/NCAR Model (FNMOC) and was obtained from the GFZ Research Center.

5. **GRACE solutions and HAM excitations**
   - GRACE-GMCSR, total gravity variability due to land surface hydrology, cryospheric processes, and motion terms, obtained from the Geophysical Fluids Centre with corrections.

Table 1: Amplitudes and phases of annual prograde and retrograde oscillations of different geodetic residuals GAM and HAM and GRACE excitation functions.

<table>
<thead>
<tr>
<th>GAM</th>
<th>HAM LSDM + HAM</th>
<th>GRACE CSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Res1 (NCEP/NCAR, ECCO-I)</td>
<td>0.68 ± 0.10</td>
<td>0.87 ± 0.18</td>
</tr>
<tr>
<td>Res2 (NCEP/NCAR, ECCO-II)</td>
<td>0.71 ± 0.10</td>
<td>0.85 ± 0.20</td>
</tr>
<tr>
<td>Res3 (AAM GFZ, OAM GFZ)</td>
<td>0.65 ± 0.10</td>
<td>0.90 ± 0.20</td>
</tr>
<tr>
<td>Res4 (ECHMWF TV, OAM GFZ)</td>
<td>0.60 ± 0.10</td>
<td>0.84 ± 0.20</td>
</tr>
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Table 2: Comparison of variance explained of polar motion excitation function of motion and geodetic residuals from different models of AAM and OAM and GRACE excitation function.

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Acknowledgements

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Conclusion

We detected that \( \chi_1 \) and \( \chi_2 \) components of geodetic residuals and HAM excitation (from model and GRACE observation), in seasonal and non-seasonal oscillations, are considerably different. For seasonal oscillations the agreement between geodetic residuals and HAM LSDM + SLAM and GRACE observations is better than for non-seasonal oscillations.

The major conclusion of this study is that the hydrological signals in polar motion, studied here as different components of geodetic residual motion and a sum of atmospheric and oceanic residual and hydrological residual components, as well, especially in non-seasonal part of oscillations.

Methodology

The study contains the following analyses of geodetic residuals, HAM GAM, and GRACE time series:

1. The comparison of seasonal and non-seasonal oscillations of all considered functions,
2. The study of seasonal components of geodetic residuals and hydrological excitation functions in terms of their annual amplitude and phase (prograde and retrograde oscillations),
3. The study of non-seasonal components of geodetic residuals and hydrological excitation functions in terms of their annual amplitude and phase (prograde and retrograde oscillations),
4. The correlation coefficients between HAM LSDM + SLAM excitation function of polar motion and geodetic residuals and GRACE excitation functions.