INTRODUCTION

Our investigations are focused on the influence of Terrestrial Water Storage (TWS) variations obtained from Gravity Recovery and Climate Experiment (GRACE) mission on polar motion excitation functions. The global and regional trend as well as annual, semi-annual and 120-day oscillations of TWS variations are considered.

We have obtained TWS from the monthly mass grids (top panel) GRACE Telus data. As a comparative database, we also used TWS estimates determined from the World Climate Research Programme’s Coupled Model Intercomparison Project Phase 5 (CMIP5) as well as from Global Land Data Assimilation System models (GLDAS).

Our studies include two stages:

1. The determination and comparisons of global and regional patterns of TWS obtained from GRACE data, GLDAS and CMIP5 climate models.
2. Comparison of the global hydrological excitation functions of polar motion with a hydrological signal in the geodetic excitation functions of polar motion.

DATA

- **GRACE data**: We used monthly grids of terrestrial water storage anomalies obtained from the Jet Propulsion Laboratory’s website (https://grace.jpl.nasa.gov/) CSR RL05, JPL RL05 and GFZ RL05 The dataset, with grid resolution of 1° and a time resolution of one month, contains the current surface mass change in units of equivalent water height.
- **GLDAS global hydrological models**: The Global Land Data Assimilation System models contain state variables (soil moisture content, snow water equivalent, canopy surface water) and flux variables (net radiation, evapotranspiration, runoff) which can be used for the calculation of terrestrial water storage and terrestrial water storage change. In our analysis we used four GLDAS models: Noah, VIC, Mosaic (MOS) and GLM from https://mirrordata.goddard.nasa.gov/ Each model has a spatial resolution of 1° and a time resolution of one month (Fang et al., 2018).
- **CMIP5 climate models**: The fifth phase of the Climate Model Intercomparison Project model contains a complete database for providing information about climate variability and climate change (Taylor et al., 2012). The state and flux variables, which are necessary to determine the TWS values, have also been included. We used four CMIP5 models: MPI and MPI with a grid resolution of 1°32” and 1°87” respectively. The time resolution for both MPI and MPI is one month. The models are available at http://cmip-pcmdi.ll.</a>

- **Geodetic, atmospheric and oceanic polar motion excitation functions (GAM, AAM, OAM)**: The hydrological part of the polar motion excitation - geodetic residual GAD has been determined as a difference of observed geodetic excitation functions (Geodetic Angular Momentum - GAM derived from International Earth Rotation and Reference Systems Service (IERS) with the sum of Atmospheric Angular Momentum (AAM - ICDP/NCAR model - from Global Geophysical Fluid Center GGFC) and Oceanic Angular Momentum (OAM - model ECEC - from Global Geophysical Fluid Center GGFC) according to the formula: GAD=GAM-AAM-OAM.

METODOLOGY

The Terrestrial Water Storage from GLDAS and CMIP5 climate models has been computed using state variables according to the following formulas:

\[ \Delta \text{TWS} = \Delta \text{SM} + \Delta \text{SWE} + \Delta \text{CAN} \]

where \( \Delta \text{TWS} \) is TWS change, \( \Delta \text{SM} \) is soil moisture change, \( \Delta \text{SWE} \) is snow water equivalent change and \( \Delta \text{CAN} \) is canopy water storage change. The excitation of polar motion both for GRACE and for GLDAS and CMIP5 models has been computed according to the following formulas (Eubanks, 1993):

\[ \chi_1 = \frac{\text{SN}}{2\pi} \left[ \int \text{g} \left( \Delta \text{TWS} \right) \sin \phi \, \text{d}S \right] \]

\[ \chi_2 = \frac{\text{SN}}{2\pi} \left[ \int \text{g} \left( \Delta \text{TWS} \right) \cos \phi \, \text{d}S \right] \]

where SN is the number of epoch, \( \text{g} \) is the gravity field parameter, and \( \phi \) is the Earth’s mean radius, dS is the surface element area, C and A are the Earth’s principal moments of inertia.

RESULTS

- Global changes of Terrestrial Water Storage
- Regional patterns of Terrestrial Water Storage
- Polar motion excitation spectra

CONCLUSIONS

- In our study we have analyzed different models of land hydrology and we have compared them with GRACE data in terms of global and regional TWS changes as well as their impact on polar motion excitation.
- Time series of TWS obtained from GRACE data show a strong linear trend which cannot be observed for GLDAS and CMIP5 models. This might be caused by the fact that only observations from GRACE include the area of Antarctica. Then TWS observations from GRACE are the only ones which do not saturate and the trend component is the result of the actual terrestrial water storage change.
- The spectra for polar motion excitation functions derived from GRACE, GLDAS, CMIP5 as well as for hydrological part of the polar motion HAM (fig. 7) show that the excitation functions have been filtered with the Butterworth filter in order to remove long period oscillations (with periods longer than 500 days). The plots in fig. 7 show the oscillations both in the prograde and retrograde band.

REFERENCES


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