Simulation of near-surface dynamics for the interpretation of geodetic observations


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Introduction

Modern geodetic observations have greatly improved in accuracy and global coverage during the last decades, primarily due to advances in space-based techniques. Besides time-mean estimates of station positions, sea surface heights or local gravity, reliable observations of temporal variations of these quantities have become available. In addition to tidal signals which can be easily identified by their characteristic frequencies, variability in geodetic observations is also caused by transient mass re-distributions of geophysical fluids in the Earth system, i.e., the solid Earth, atmosphere, ocean, cryosphere, and continental hydrology. In order to properly interpret and successfully correct for these signals, numerical models are required that describe the individual underlying physical processes and their interactions.

ECMWF atmospheric data

Global 1° fields with 6h temporal resolution from three atmospheric data-sets (1) ERA-40 re-analysis, 1958 – 2001; (2) ERA Interim re-analysis, 1989 – 2011; (3) operational ECMWF analyses, from 2001 onwards.

LSDM terrestrial hydrosphere model

Continental water storage variations and discharge are simulated with the Land Surface Discharge Model (LSDM, Dill, 2008) on a 0.1° grid every 24h.

SICOPOLIS land ice model

Ice accumulation, melting, and calving for Greenland and Antarctica is simulated with a dynamic polythermal ice-sheet model (SICOPOLIS) on a 20km x 20km grid on monthly time steps.

OMCT ocean model

Ocean dynamics are simulated with the Ocean Model for Circulation and Tides (OMCT; Thomas, 2002), discretized on a regular 1°x1° grid. Ocean state variables are obtained every 6h concurrent with ECMWF analysis times.

Ocean mass anomalies

Ocean mass anomalies from GRACE can be validated both against in-situ ocean bottom pressure gauges and spatially and temporally corrected satellite altimetry (Dobslaw and Thomas, 2010). Since regional mass anomalies are related to changes in barotropic currents, GRACE has been demonstrated to provide transport variations of the Antarctic Circumpolar Current (ACC). Today, improved time-variable gravity field products from GRACE additionally allow the assessment of high-frequency variations (Bergmann and Dobslaw, 2012).

Greenland Ice sheet (GIS) surface mass balance

The results of transient simulations of the Greenland Ice Sheet (GIS) with the thermomechanical ice sheet model SICOPOLIS (Elbern [1997], Rogozhina et al. [2011, 2012]) driven by the ECMWF climate datasets in the period of 1958 to 2010 are validated against high-resolution regional model results RACMO/GR (Ettema et al., 2009). Figures left and middle) and ice mass trends estimated from the GRACE and ICESat satellite data (Rogozhina et al., 2012). Figure right) within seven major drainage basins of the GIS (A-G).

Short-term Earth rotation prediction

<table>
<thead>
<tr>
<th>Standard deviation of MAE</th>
<th>bulletin A</th>
<th>model forecast</th>
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<tbody>
<tr>
<td>polar motion</td>
<td>UT1-UTC</td>
<td>UT1-UTC</td>
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<tr>
<td>Day 10</td>
<td>± 2.95mas</td>
<td>± 0.40mas</td>
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<tr>
<td>Day 30</td>
<td>± 7.41mas</td>
<td>± 2.26mas</td>
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<tr>
<td>Day 90</td>
<td>± 16.02mas</td>
<td>± 3.74ms</td>
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EOP predictions based modeled ESM forecasts have been demonstrated to provide superior skill when compared to the current state-of-the-art forecasts published in IERS Bulletin A (Dill and Dobslaw, 2010).

Together with observed ocean induced variations in Earth’s rotation, GRACE-based ocean bottom pressure estimates are subsequently assimilated into OMCT within an Ensemble Kalman Filter framework (Saynisch and Thomas, 2012).

Since ACC transport variations are closely related to coastal sea-level variations at the Antarctic Coast via the Southern Mode, transport anomalies from GRACE have been contrasted with data from various tide-gauges augmented with permanent GPS stations.