Geophysical fluid models for atmosphere, ocean and hydrology and their impact on SLR analysis

Ole Roggenbuck, Maria Mareyen, Daniela Thaller

Federal Agency for Cartography and Geodesy
<table>
<thead>
<tr>
<th></th>
<th>Deformation</th>
<th>Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>GGFC</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NASA</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>TU Vienna</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Uni Strasburg</td>
<td>X / X</td>
<td>-</td>
</tr>
<tr>
<td>GFZ</td>
<td>(X)</td>
<td>(X)</td>
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# Geophysical Models – Compilation 1

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<td>-</td>
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<td>(X)</td>
<td>(X)</td>
</tr>
</tbody>
</table>
Hydrology loading

GGFC Hydrology Loading UP

Station names (sorted by latitude)

Years

[mm]
Data used in this analysis

- Normal points from Lageos 1 + 2 and Etalon 1 + 2
- Time span: 2001 – 2011
- Tidal loading models:
  - FES2004
  - Ray and Ponte 2003
- Gravity effect from GFZ (AOD 1B (RL5))
- 1. Run: Non tidal models from GGFC
- 2. Run: Non tidal models from NASA

- Software: Bernese Software
  - Software used in daily ILRS analysis at BKG AC
  - Needs gridded models
Earth rotation parameters
External comparison

Reference: IERS C04 series

<table>
<thead>
<tr>
<th></th>
<th>X-pol Mean</th>
<th>RMS</th>
<th>Y-pol Mean</th>
<th>RMS</th>
<th>UT1 Mean</th>
<th>RMS</th>
<th>LOD Mean</th>
<th>RMS</th>
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<tr>
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<td>[µas]</td>
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<td>[µs]</td>
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<td>[µs]</td>
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<td>10</td>
<td>227</td>
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<td>56.8</td>
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</tbody>
</table>
Earth rotation parameters
Internal comparison

Model impact on X-pol

Difference to ref. solution (no models) [marsec]

Years


0.15
0.1
0.05
0
-0.05
-0.1

all models
atmosphere
ocean
hydrology
no models
Earth rotation parameters
Internal comparison

Model impact on LOD

Difference to ref. solution (no models) [ms/d]

Years


-0.02 -0.015 -0.01 -0.005 0 0.005 0.01 0.015 0.02

all models
atmosphere
ocean
hydrology
no models
Geocenter coordinates

 GCC Z [m]

0.02
0.01
0.00
-0.01
-0.02


Geocenter Z: with / without NASA models

Amplitude [m]

0 1 2 3 4 5 6 7 8 9 10

cycles/year

Geocenter Z: improvement

Amplitude [m]

0 0.5 1 1.5 2 2.5 3 3.5 4

cycles/year

1330.00 days

221.67 days

362.73 days
Geocenter coordinates
Impact of individual models

NASA: GCC Z

NASA: GCC X
Conclusions

- Many different models available
  - Validation is necessary
- With SLR hard to say which model performs best
  - Sparse network
  - Gaps in time series of station positions

- Seasonal variations in geocenter can be explained by the sum of atmosphere + ocean + hydrology

Further investigations:
  - multi-year solution
  - model tests with GNSS and VLBI, combined
This work was funded by the DFG as a part of the Research Project (FOR1503): „Space-Time Reference Systems for Monitoring Global Change and for Precise Navigation in Space“

Visit our website: www.referenzsysteme.de
Station coordinates

FFT Yarragadee UP

Amplitude [m]

cycles/year

1330.00 days

362.78 days

x 10^{-3}

no models

all NASA models
## Geophysical Models – Compilation 2

<table>
<thead>
<tr>
<th>Atmosphere</th>
<th>Temp. Res.</th>
<th>Spatial Res.</th>
<th>Timespan</th>
<th>Model</th>
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<td>2.5 °</td>
<td>1980 – now</td>
<td>NCEP</td>
</tr>
<tr>
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<td>2.5 °</td>
<td>1976 – now</td>
<td>NCEP</td>
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<td>TU Wien</td>
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<td>1 °</td>
<td>1997 – 2013</td>
<td>ECMWF</td>
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<tr>
<td>Strasburg</td>
<td>3 h</td>
<td>0.5 °</td>
<td>2001 – 2013</td>
<td>ECMWF Operational ECMWF + MOG2D</td>
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</table>

<table>
<thead>
<tr>
<th>Ocean</th>
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<tbody>
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<td>1993 – 2012</td>
<td>ECCO1</td>
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<tr>
<td>NASA</td>
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<td>1 °</td>
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<td>ECCO1</td>
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</table>

<table>
<thead>
<tr>
<th>Hydrology</th>
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</thead>
<tbody>
<tr>
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<td>2.5 °</td>
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<td>GLDAS (NOAH)</td>
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<td>1 °</td>
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<td>0.5 °</td>
<td>2001 – 2013</td>
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</tr>
</tbody>
</table>

Ocean and Hydrology models includes trend and offset!
Earth rotation parameters
Internal comparison

Model impact on X-pol

Model impact on Y-pol

Model impact on UT1

Model impact on LOD
Hydrology loading

1999: Sep  Difference UP component (GGFC - NASA)
Hydrology models

GGFC Hydrology Loading UP

Difference GGFC - NASA Hydrology

Station names (sorted by latitude)

Years


Station names (sorted by latitude)

Years

1999: Sep  Difference UP component (GGFC - NASA)
Ocean non tidal loading

GGFC Ocean Loading UP

Station names (sorted by latitude)

Years

-6 -4 -2 0 2 4 6

1884 7841 7811 1879 7840 1868 1824 1831 8634 7839 7810 1873 7237 7835 7845 7848 7941 7249 7130 7105 1864 7824 7328 7838 7110 7837 7821 7080 7358 7820 7832 7119 7403 7124 7501 7090 7405 7825 7405

50° 40° 30° 20° 0° -30°
Ocean non tidal loading

Difference GGFC - NASA Ocean UP

Station names (sorted by latitude)

Years

-2 -1.5 -1 -0.5 0 0.5 1 1.5 2
RMS comparison (eventuell weg)

- Better modelling → smaller RMS
- Difference between RMS
  - RMS (all models) - RMS (no models)
  - Mean difference = -0.06 mm
- Histogram of RMS median values
  - Small improvement visible if models are used
  - Biggest impact → atmosphere
Station coordinates

Station: 7090 Yarragadee, Australia

Station: 7839 Graz, Austria

FTT Yarragadee UP

FTT Graz UP
Station coordinates

Station: 7090

Station: 7839