Sea Level CCI project

Phase II
1st annual review
Activities on altimetry satellite precise orbit determination at GFZ in the 2nd phase of the SL_cci project

Sergei Rudenko and Tilo Schöne
(Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences)
Outline

- New developments on precise orbit determination of altimetry satellites at GFZ
- New results of precise orbit determination of Envisat, TOPEX/Poseidon, and Jason-1
- New publications and presentations in 2014
- Next planned and possible additional activities on precise orbit determination at GFZ within the 2nd phase of the SLCCI project
Altimeter Satellite Orbit Modelling and Determination

• Detailed tests on using seven tropospheric refraction models (Yionoulis and Hopfield, Saastamoinen, Davis, Niell, Glob Mapping Function (GMF), Vienna Mapping Function 1) for the correction of DORIS observations for Envisat (2002-2012), TOPEX/Poseidon (1992-2005) and Jason-1 (2002-2013) precise orbit determination were performed.

• Detailed tests on using GFZ Atmosphere and Ocean De-aliasing Level 1B (AOD1B) RL05 product (maximum degree and order 100) instead of RL04 one (maximum degree and order 50) and no atmospheric gravity data at all for ERS-1 (1991-1996), ERS-2 (1995-2006), TOPEX/Poseidon (1992-2005), Envisat (2002-2012) and Jason-1 (2002-2012) precise orbit determination were done.

• A new orbit solution was computed for Envisat by using, additionally to SLR, also DORIS data and denser parameterization from 12.04.2012 till 12.06.2012.

• A new geopotential model EIGEN-6S2.extended.v2 was tested for Envisat and Jason-1.
Precise orbits of Jason-1 (2002-2013) computed at GFZ

- CCI01 and CCI02 orbits using EIGEN-GL04S and EIGEN-6S2 geopotential model
- Seven CCI02_DOR01-DOR07 orbits derived using seven tropospheric refraction models
- CCI06 orbit derived using DORIS data corrected for the South Atlantic Anomaly
- CCI09 orbit derived using AOD1B RL05 product instead of RL04 one
- CCI10 orbit computed using
  - EIGEN-6S2.extended.v2 geopotential model,
  - DORIS data corrected for the South Atlantic Anomaly,
  - Vienna Mapping Function 1 as a tropospheric refraction model
for the correction of DORIS observations,
- AOD1B RL05 product,
- improved parameterization at some orbital arcs.
## The main models used for precise orbit determination

<table>
<thead>
<tr>
<th>Parameter</th>
<th>SLCCI project 2 phase (VER08 orbits)</th>
<th>SLCCI project 1 phase (VER06 orbits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrestrial Reference Frame</td>
<td>ITRF2008</td>
<td>ITRF2008</td>
</tr>
<tr>
<td>Polar motion and UT1</td>
<td>IERS EOP 08 C04 (IAU2000A)</td>
<td>IERS EOP 08 C04 (IAU2000A)</td>
</tr>
<tr>
<td>Precession and nutation model</td>
<td>IERS Conventions 2010</td>
<td>IERS Conventions 2010</td>
</tr>
<tr>
<td>Gravity field model (static)</td>
<td>EIGEN-6S2.extended.v2</td>
<td>EIGEN-6S2</td>
</tr>
<tr>
<td>Gravity field model (time varying)</td>
<td>EIGEN-6S2.extended.v2</td>
<td>EIGEN-6S2</td>
</tr>
<tr>
<td>Tropospheric correction for DORIS observations</td>
<td>Vienna Mapping Function 1</td>
<td>Hopfield model</td>
</tr>
<tr>
<td>Solid Earth and pole tide</td>
<td>IERS Conventions 2010</td>
<td>IERS Conventions 2010</td>
</tr>
<tr>
<td>Ocean tides</td>
<td>EOT10A</td>
<td>EOT10A</td>
</tr>
<tr>
<td>Atmospheric gravity</td>
<td>GFZ AOD1B RL05 based on ECMWF 6-hourly fields up to degree and order 100</td>
<td>GFZ AOD1B RL04 based on ECMWF 6-hourly fields up to degree and order 50</td>
</tr>
<tr>
<td>Third bodies</td>
<td>Sun, Moon, all 8 major planets (DE-421)</td>
<td>Sun, Moon, all 8 major planets (DE-421)</td>
</tr>
</tbody>
</table>
### The main differences of the VER08 orbits w.r.t. VER06 orbits

<table>
<thead>
<tr>
<th>The differences (improvements)</th>
<th>ERS-1</th>
<th>ERS-2</th>
<th>Envisat</th>
<th>TOPEX</th>
<th>Jason-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOD1B RL04 → RL05</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>AOD1B truncation level: 50 → 100</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Improvement of parametrization at some orbital arcs</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Use of VMF1 instead of Hopfield model for DORIS troposp. correction</td>
<td>–</td>
<td>–</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Use of the EIGEN-6S2.extended.V2 geopotential model (after 2012.0)</td>
<td>–</td>
<td>–</td>
<td>Yes</td>
<td>–</td>
<td>Yes</td>
</tr>
<tr>
<td>Use additionally DORIS data at some time spans (Envisat, Apr.-Jun. 2002)</td>
<td>–</td>
<td>–</td>
<td>Yes</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Correction of DORIS data for the South Atlantic Anomaly</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Improvement of RMS fits of observations for Envisat (2002 – 2012): CCI33 (VER08) orbit versus CCI14 (VER06) orbit

Reduction of the mean values of the observation RMS fits of Envisat VER08 orbit, as compared to VER06 orbit:
SLR - from 1.302 to 1.262 cm, i.e. by 0.04 cm (about 3.1%),
DORIS - from 0.4314 mm/s to 0.4209 mm/s, i.e. by 0.0105 mm/s (about 2.4%)
Two-day arc overlaps for Envisat: VER08 orbit versus VER06 orbit

Reduction of the mean values of the arc overlap of VER08 orbit, as compared to VER06 orbit:
Radial – from 0.518 to 0.515 cm, i.e. by 0.003 cm (about 0.6%),
Cross-track – from 2.092 to 1.934 cm, i.e. by
Along-track – from 2.158 to 1.830 cm, i.e. by
Reduction of the mean values of the observation RMS fits of TOPEX/Poseidon VER08:
SLR - from 2.022 to 2.009 cm, i.e. by 0.013 cm (about 0.6%),
DORIS - from 0.4797 mm/s to 0.4780 mm/s, i.e. by 0.0017 mm/s (about 0.4%)
Two-day arc overlaps for TOPEX: VER08 orbit versus VER06 orbit

Reduction of the mean values of the arc overlap of VER08 orbit, as compared to VER06 orbit:

Radial – from 1.023 to 1.017 cm, i.e. by 0.006 cm (about 0.6%),
Cross-track – from 6.535 to 6.520 cm, i.e. by
Along-track – from 3.593 to 3.559 cm, i.e. by
Improvement of RMS fits of observations for Jason-1 (2002 – 2012): CCI10 (VER08) orbit versus CCI02 orbit

Reduction of the mean values of the observation RMS fits of TOPEX/Poseidon VER08:
SLR - from 1.575 to 1.505 cm, i.e. by 0.070 cm (about 4.4%),
DORIS - from 0.3827 mm/s to 0.3545 mm/s, i.e. by 0.0282 mm/s (about 7.4%).
Reduction of the mean values of the arc overlap of CCI10 orbit, as compared to CCI02 orbit:
Radial – from 0.906 to 0.755 cm, i.e. by 0.151 cm (about 16.7%),
Cross-track – from 4.709 to 4.337 cm, i.e. by 0.372 cm (about 7.9%),
Along-track – from 2.463 to 2.118 cm, i.e. by 0.345 cm (about 14.0%).
Peer-reviewed publications published within the work on the SLCCI project


Publications in preparation


• Fagiolini, E., Rudenko, S., Esselborn, S., Schöne, T., Dobslaw, H., and Flechtner, F. ...
Presentation of the results at the international conferences

• Rudenko, S., Dettmering, D., Esselborn, S., Schöne, T., Förste, C., Lemoine, J.M., Ab…

Rudenko, S., Esselborn, S., Schöne, T., Gruber, Ch., Neumayer, K.-H. Investigation of long-term...

Fagiolini, E., Dobslaw, H., Rudenko, S., Flechtner, F. Backward extension to 1976 of RL05 G...
Next planned activities on the POD of altimetry satellites

- Computation of Jason-2 orbit (2008-2014)
- Improvements of attitude computations for Jason-1 and Jason-2 by using quaternions instead of nominal attitude laws
- Tests and use of some other background models for precise orbit determination that will become available by June 2015
- New orbits of TOPEX/Poseidon (1993-2005), Jason-1 (2002 - 2013) and Jason-2 (2008-2014) are to be provided to CLS by the end of June 2015
Suggestions for additional activities (CCN)
on the POD of altimetry satellites

• Task 1: Impact of a new ITRF realization (ITRF2014, to be released in July-August 2015) on precise orbits of altimetry satellites (ERS-1, ERS-2, TOPEX/Poseidon, Envisat, Jason-1 and Jason-2 over 1991-2014 time span), global and regional sea level trends, as compared to those computed using ITRF2008.

• Task 2: Impact of new ocean tide models (EOT11a, FES2012, FES2014) on precise orbits of altimetry satellites, global and regional sea level trends.

• These activities should start from October 1, 2015.
Acknowledgements

SLR and DORIS data available from the ILRS and IDS were used in this research.

These activities were partly supported by the European Space Agency (ESA) within...