Evaluation of the RL05 GRACE atmosphere and ocean de-aliasing level 1B (AOD1B) product with precise orbit and altimetry analysis

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Poster EGU2015-9982

Introduction

GRACE Atmospheric and Oceanic De-aliasing Level-1B (AOD1B) product is intended to serve as a background model for a wide range of satellite missions [1]. The main usage of the AOD1B is the removal of high-frequency non-tidal mass variations due to short-term (daily and sub-daily) mass transport in the atmosphere and oceans. AOD1 shall avoid aliasing of these high frequency signals into monthly gravity models derived from modern gravimetric missions (CHAMP, GRACE, GRACE-F0) and shall help to derive consistent orbit solutions for altimetry and SLR satellites. Recently, the latest release 05 has been extended backwards to 1979, based on ERA-Interim (ECMWF Re-Analysis) input data. Some results of the implementation of the new and previous releases of the AOD1B product on precise orbit determination (POD) of altimetry satellites are presented.

Extended AOD1B RL05 product

So far, the latest model version RL05 of AOD1B was available until recently for the period January 2001 until present [2]. The new release presents an improved Ocean Model for Circulation and Tides (OMCT) with higher spatial resolution (1° regular grid in RL05 instead of 1.875° in RL04) and improved parameterization (e.g. reduced horizontal eddy viscosity and bottom friction). Additionally, we generated a consistent AOD1B RL05 product back to 1979 based on ERA-Interim. The discontinuity due to the changing of the input model in 2001 has been taken into account following the same method used for the extended RL04 [3]. The bias correction applied to the atmospheric solution (Fig.1) depicts inhomogeneities localized, as expected, mostly over land and at high altitudes in mountainous regions.

In order to check the consistency of the AOD1B products, following plots have been generated: time series of the statistical values of geoid height variability for all data types (e.g. for the global combination of atmosphere and ocean, shown in Fig. 2); 6-hourly time series of spherical harmonics 0, 1, 2 degree coefficients (C(0,0) for atmosphere shown in Fig. 3 and C(2,0) for the global combination of atmosphere and ocean shown in Fig. 4). More plots will be available at www.gfz-potsdam.de/aod1b.

Application of the AOD1B products to precise orbit determination of altimetry satellites

Precise orbits of altimetry satellites ERS-1 (1991-1996), ERS-2 (1995-2006), TOPEX/Posidon (1992-2005), Envisat (2002-2012) and Jason-1 (2002-2012) were computed at the time intervals given using the same background model, but with different releases of AOD1B product (see Table 1) [4], but applying two different releases of AOD1B product (RL04 and RL05) and no AOD1B data at all. The orbit tests definitely show, that the mean values of RMS fits of observations and two-day arc overlaps improve for all five satellites, when AOD1B product (either RL04 or RL05) is used, as compared to the case, when no AOD product is used at all. Thus, the mean values of RMS fits of SLR observations reduce by 2.1%, 3.4%, 6.9%, 9.9% and 1.0% for ERS-1, ERS-2, Envisat, TOPEX/Posidon and Jason-1, accordingly (Tables 1-5), for the case, when AOD1B RL05 product is used, as compared to the case, when no AOD product is used at all.

Using AOD1B RL05 product instead of AOD1B RL04 product reduces the mean values of RMS fits of SLR observations by 0.6%, 0.6%, 0.7%, 0.5% and 0.1% for ERS-1, ERS-2, Envisat, TOPEX/Posidon and Jason-1, accordingly (Tables 1-5).

Impact of the AOD1B corrections on the radial orbit components

Large-scale changes in the radial orbit components are found, when applying the AOD1B correction. The RMS values of the radial orbit differences rise for ERS-1, rapidly to 0.6% and 0.1% for ERS-1 and TOPEX, respectively, when RL04 is used, and they are comparable for the two missions. The annual signal for ERS-1 is similar for RL04. The annual signal for Envisat is rather similar to one for ERS-1, the annual signal for the Jason-1 mission resembles the one from TOPEX. The radial orbit differences of the orbits derived using the AOD1B product can be as large as a few millimeters. However, for the ERS-1 and the TOPEX there are mean changes of the radial orbit component, which is not negligible. The mean range differences of the AOD1B product range from 0.1% to 0.2%.

Conclusions

We successfully extended backwards to 1979 the last release 05 of the AOD1B model. The new time series are stable and free from discontinuities caused by the changes in the input model. The implication of the AOD1B RL04 and RL05 models on precise orbit determination of five different altimetry satellites has been investigated. We found, that using AOD1B product reduces RMS fits of SLR observations by about 1.0-6.4%, two-day arc overlaps in radial, cross-track and along-track directions by about 1.3-12.0%, 0.3-10.0% and 2.0-10.0%, accordingly, for various satellites tested, as compared to the case, when no AOD1B product is used at all. Using AOD1B RL04 product instead of RL05 one reduces SLR RMS fits by 0.1-0.7%, two-day arc overlaps in radial, cross-track and along-track directions by 0.1-0.6%, 0.1-1.3%, 0.2-1.2%, accordingly, for the satellite orbits tested.

Acknowledgements

This study was performed within the ESA Climate Change Initiative Sea Level Phase 2 project, EHR-GravDat project funded by the German Research Foundation (DFG) and under grant 03F0544A of the German Ministry for Education and Research (BMBF). SLR and DORIS data available from IRLS and IDS were used in this research.

References


Impact of the AOD1B corrections on the radial orbit components. Note the range of the radial orbit differences of ERS-1 (blue) and TOPEX (red) obtained using AOD1B RL04 and RL05 products.

Figure 7: Mean values of the RMS fits of observations and two-day arc overlaps for ERS-1, Envisat, TOPEX/Posidon and Jason-1 orbits derived using AOD1B products, RL04 and RL05 products.

Table 1: The mean values of RMS fits of observations and two-day arc overlaps with various AOD1B products for ERS-1, Envisat, TOPEX/Posidon and Jason-1 estimated using RL04, AOD1B RL05 and AOD1B RL06 products.

Figure 6: Annual amplitude (top) and phase (bottom) of the radial orbit differences of ERS-1 (right) and TOPEX (left) obtained using AOD1B RL04 and NO-AOD product. The annual amplitude difference is 7 mm.