New orbits of ERS-1, ERS-2, TOPEX/Poseidon, Envisat, Jason-1 and Jason-2 for altimetry applications and their validation

Sergei Rudenko[1], Karl-Hans Neumayer[1], Denise Dettmering[2], Saskia Esselborn[1] and Tilo Schöne[1]

1) GFZ German Research Centre for Geosciences, Telegrafenberg, D-14473, Potsdam, Germany
2) Deutsches Geodaetisches Forschungsinstitut der Technischen Universitaet Muenchen (DGFI-TUM), Arcisstrasse 21, Munich, Germany
(e-mail: rudenko@gfz-potsdam.de, fax: +49 8153 281735)

Introduction

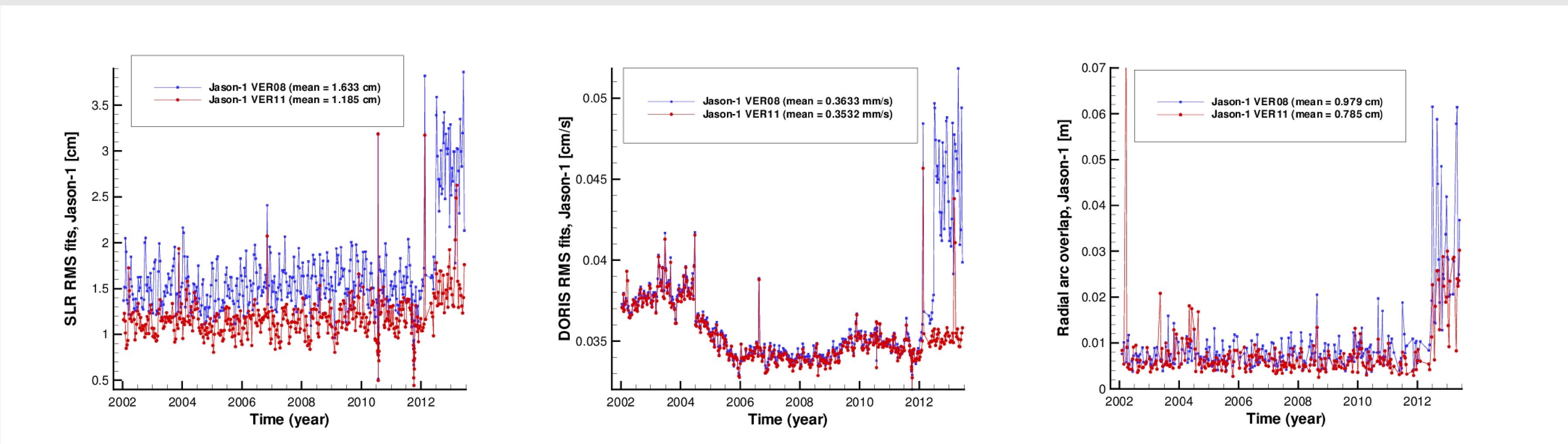
New (GFZ VER11) precise orbits of altimetry satellites Envisat (Environmental Satellite, from April 2002 to April 2012), European Remote Sensing Satellites ERS-1 (from August 1991 till July 1996), ERS-2 (from May 1995 till July 2003), TOPEX/Poseidon (from September 1992 till October 2005), Jason-1 (from January 2002 till July 2013) and Jason-2 (from July 2008 till April 2015) have been derived at GFZ in the same for all six satellites ITRF2008 terrestrial reference frame using consistent models based mainly on the IERS Conventions (2010), but using also some new updated and improved models. Homogeneous, precise orbits of altimetry satellites derived in the same reference frame using consistent precise models are very important to avoid possible inconsistencies in the derived sea level products caused by using different reference frames and models.

The orbits are computed using the Earth Parameter and Orbit System - Orbit Computation (EPOS-OC) software for precise orbit determination and the Altimeter Database and Processing System (ADS) both developed at GFZ for altimetry crossover data computation and altimetry analysis of the orbits. Satellite laser ranging (SLR) and altimeter crossover data were used for ERS-1, additionally Precise Range And Range-rate Equipment (PRARE) measurements were utilized for ERS-2 and SLR and Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) observations were applied for Envisat, TOPEX/Poseidon, Jason-1 and Jason-2.

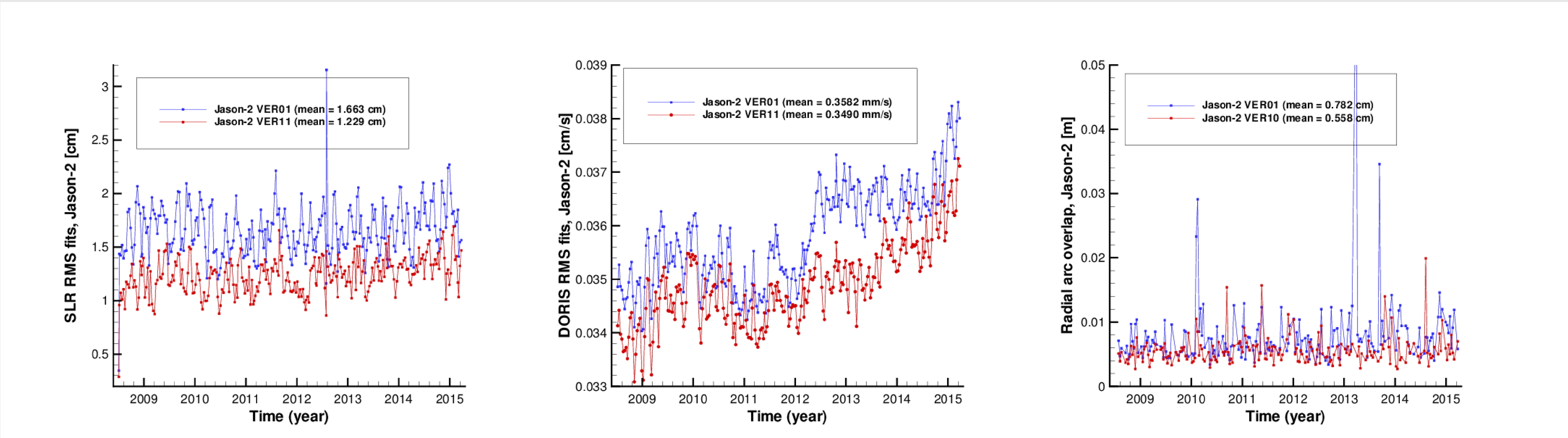
These orbits differ from GFZ VER06 orbits (2013) by using new models, such as EIGEN-GRGS.RL03-v2.MEAN-FIELD time variable geopotential model, reprocessed AOD1B RL05 product, EOT11a ocean tide model, Vienna Mapping Function 1 tropospheric refraction model for DORIS data, ERA-INTERIM atmospheric loading, improved satellite macro-models for TOPEX/Poseidon, Jason-1 and Jason-2, using true attitude in the quaternion form for Jason-1 and Jason-2, updated station file and ocean loading files, improved parameterization at some orbital arcs and other improvements.

The quality of GFZ VER11 solutions is presented in the comparison with the quality of the GFZ previous (VER06 and VER08) orbit solutions and some actual external orbit solutions.

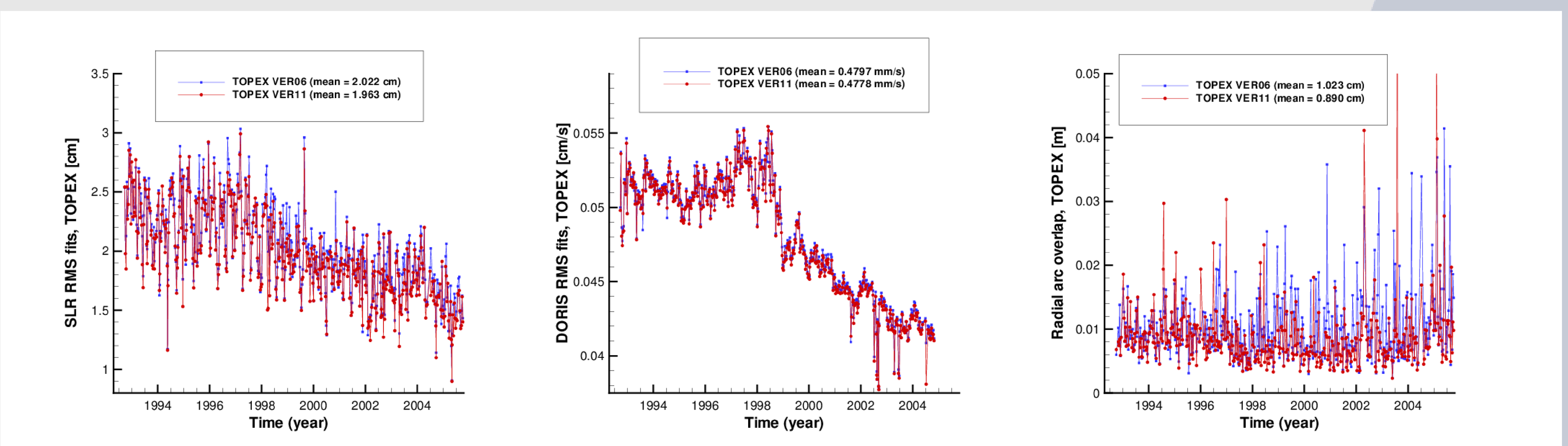
The results of precise orbit determination



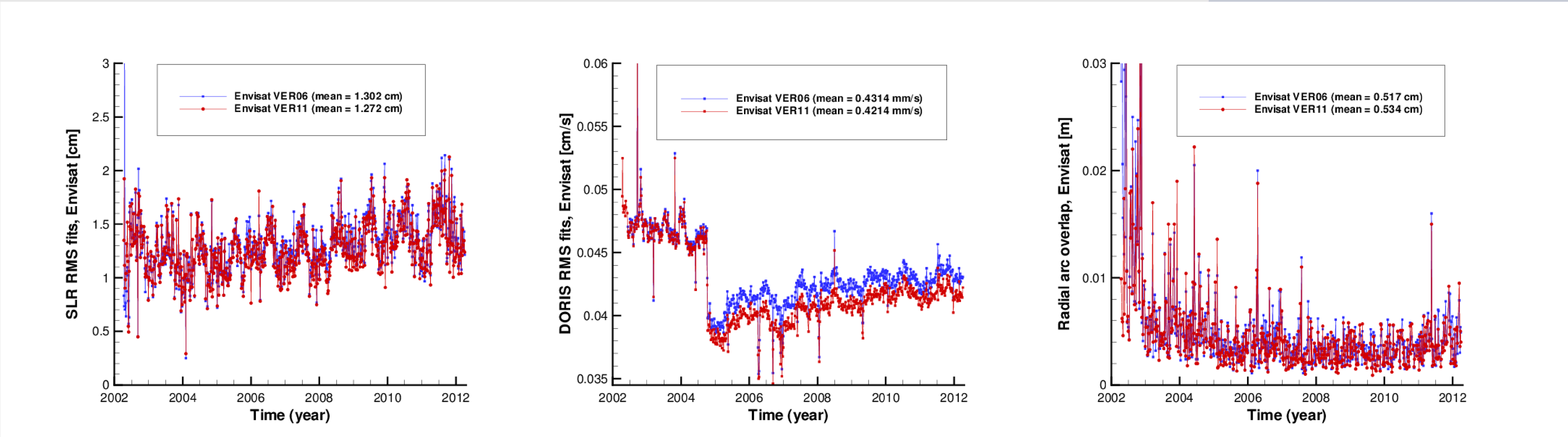
Figures 1-3. RMS fits of SLR [cm], DORIS [cm/s] observations and radial two-day arc overlap [m] of GFZ VER08 and VER11 orbits of Jason-1



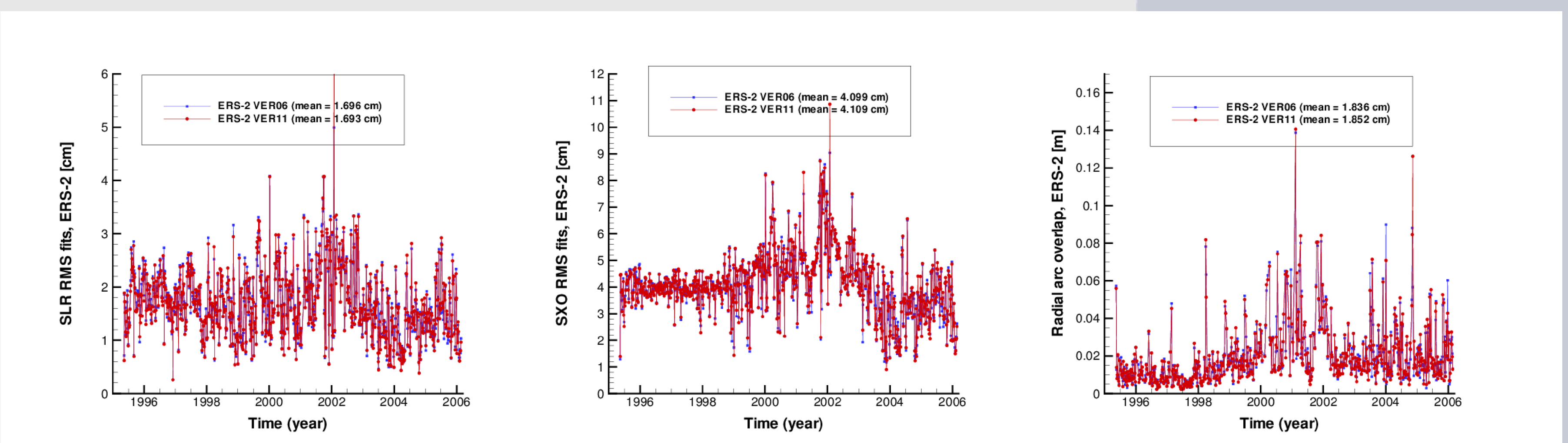
Figures 4-6. RMS fits of SLR [cm], DORIS [cm/s] observations and radial two-day arc overlap [m] of GFZ VER01 and VER11 orbits of Jason-2



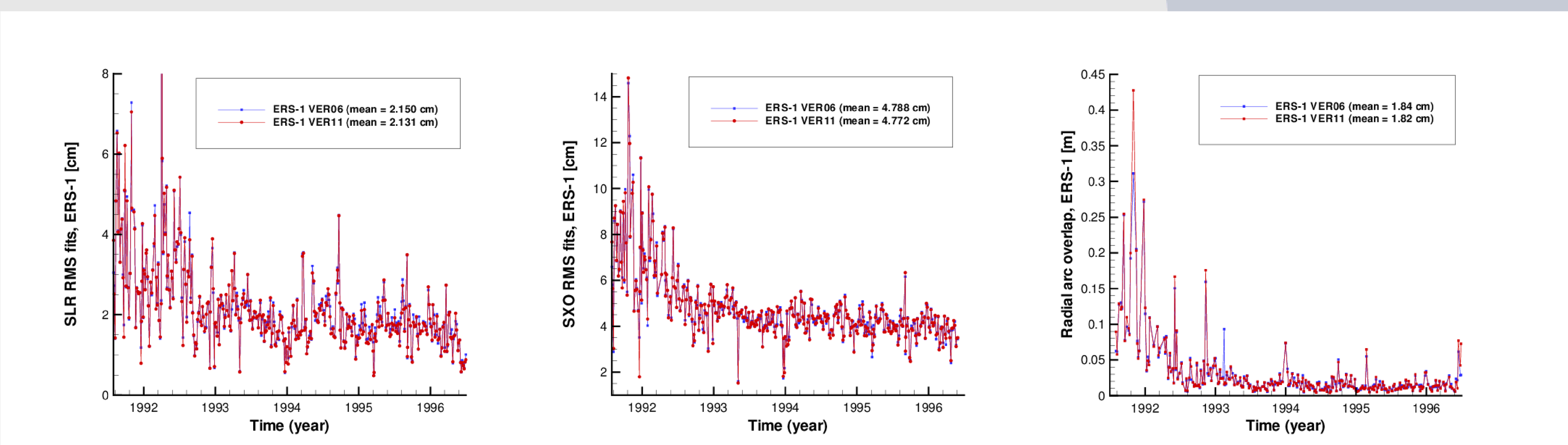
Figures 7-9. RMS fits of SLR [cm], DORIS [cm/s] observations and radial two-day arc overlap [m] of GFZ VER06 and VER11 orbits of TOPEX/Poseidon



Figures 10-12. RMS fits of SLR [cm], DORIS [cm/s] observations and radial two-day arc overlap [m] of GFZ VER06 and VER11 orbits of Envisat



Figures 13-15. RMS fits of SLR [cm], altimetry crossover (SXO, cm] observations and radial two-day arc overlap [m] of GFZ VER06 and VER11 orbits of ERS-2



Figures 16-18. RMS fits of SLR [cm], altimetry crossover (SXO, cm] observations and radial two-day arc overlap [m] of GFZ VER06 and VER11 orbits of ERS-1

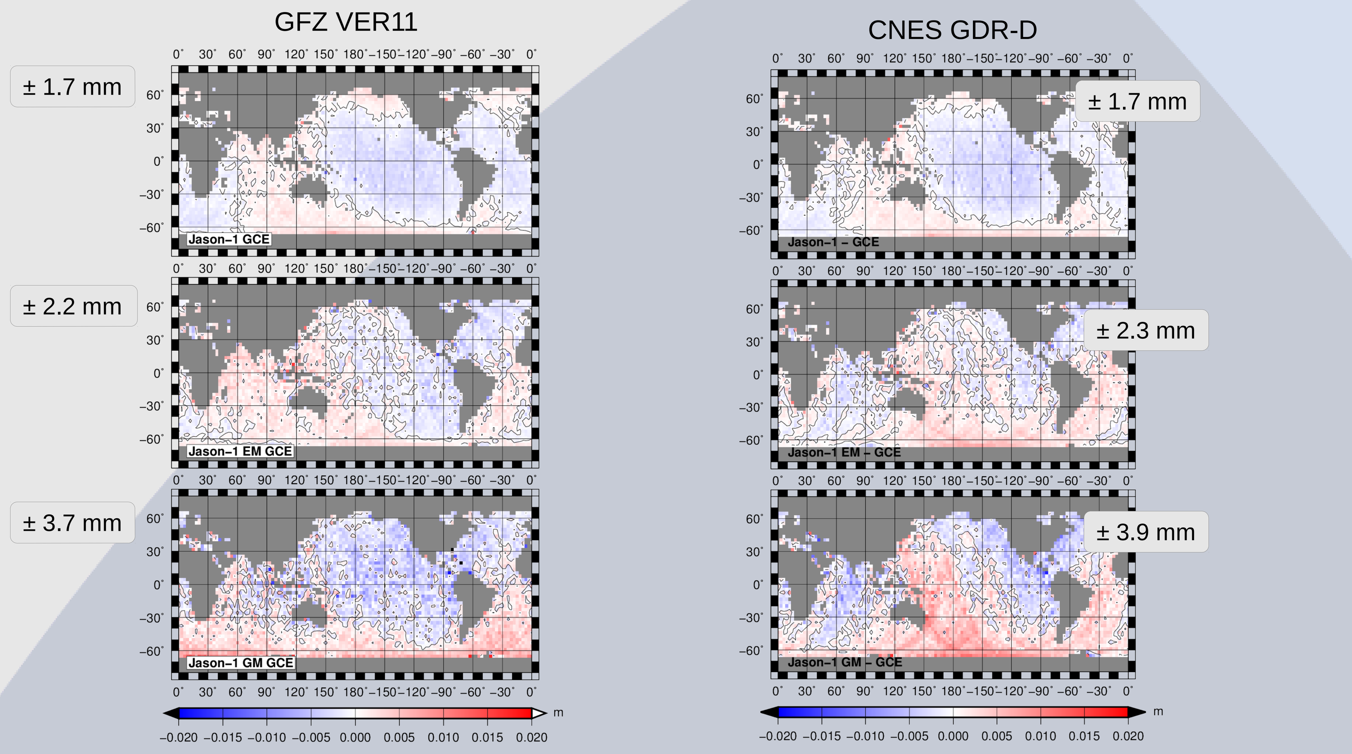
Conclusions

1. The analysis of these orbits performed at GFZ shows improved orbit quality of the new (VER11) orbits, as compared to the previous (VER06) orbits derived within the phase 1 of the SLCCI project.
2. The major improvement of the orbit quality was obtained for Jason-1, Jason-2, TOPEX/Poseidon due to using improved satellite macro-model and true attitude for Jason-1/2. Envisat orbit also improved.
3. Thus, the mean value of RMS fits of SLR observations reduced from 1.63 to 1.19 cm (27.4%), that one of DORIS observations reduced from 0.363 to 0.353 mm/s (2.8%), and radial arc overlaps reduced from 0.98 to 0.79 cm (19.8%) for GFZ Jason-1 VER11 orbit, as compared to VER08 orbit.
4. The mean value of RMS fits of SLR observations reduced from 1.66 to 1.23 cm (26.1%), that one of DORIS observations reduced from 0.358 to 0.349 mm/s (2.6%), and radial arc overlaps reduced from 0.78 to 0.56 cm (28.6%) for GFZ Jason-2 VER11 orbit, as compared to VER01 orbit.
5. The mean value of RMS fits of SLR observations reduced from 2.02 to 2.01 cm (2.9%) and radial arc overlaps reduced from 1.023 to 0.890 cm (13.0%) for GFZ TOPEX/Poseidon VER11 orbit, as compared to VER06 orbit.
6. The mean value of RMS fits of SLR observations reduced from 1.30 to 1.27 cm (2.3%), that one of DORIS observations reduced from 0.431 to 0.4214 mm/s (2.3%) for GFZ Envisat VER11 orbit, as compared to VER06 orbit.
7. Multi-mission crossover analysis shows reduced or comparable values of geographically correlated errors of GFZ VER11 orbits, as compared to recent external orbits (Figures 19-28).

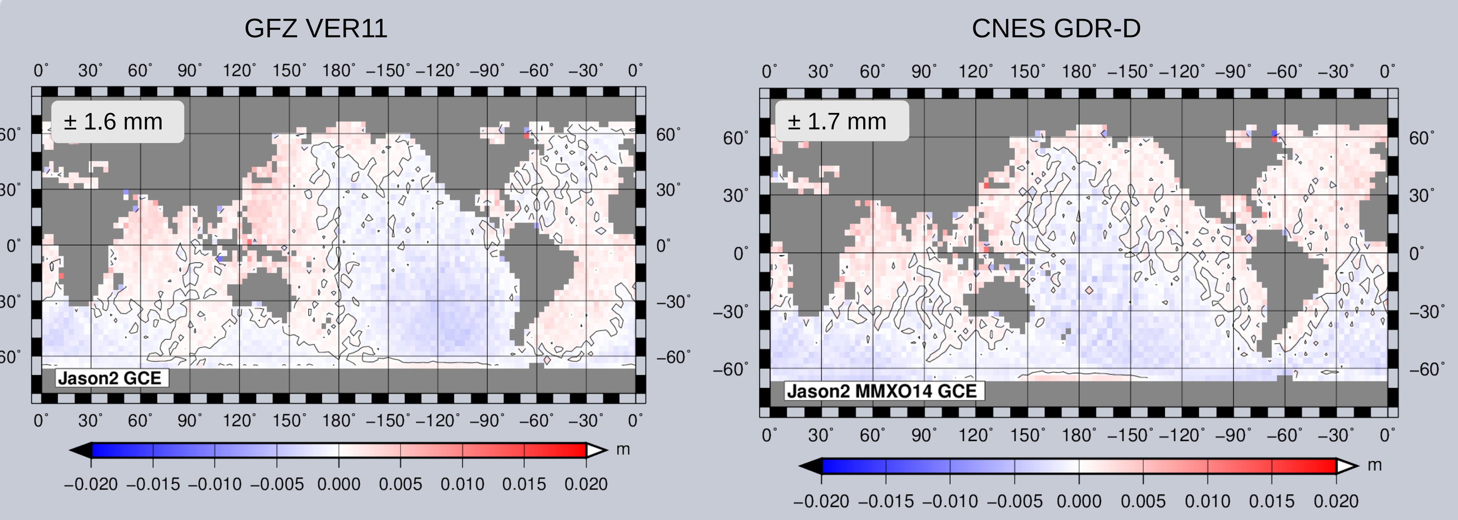
Acknowledgements

SLR, DORIS and PRARE data available from ILRS, IDS and ESA accordingly were used in this research that was funded by the European Space Agency within the Sea Level Climate Change Initiative project and by the German Research Foundation (DFG) within the UHR-GravDat project that is greatly acknowledged.

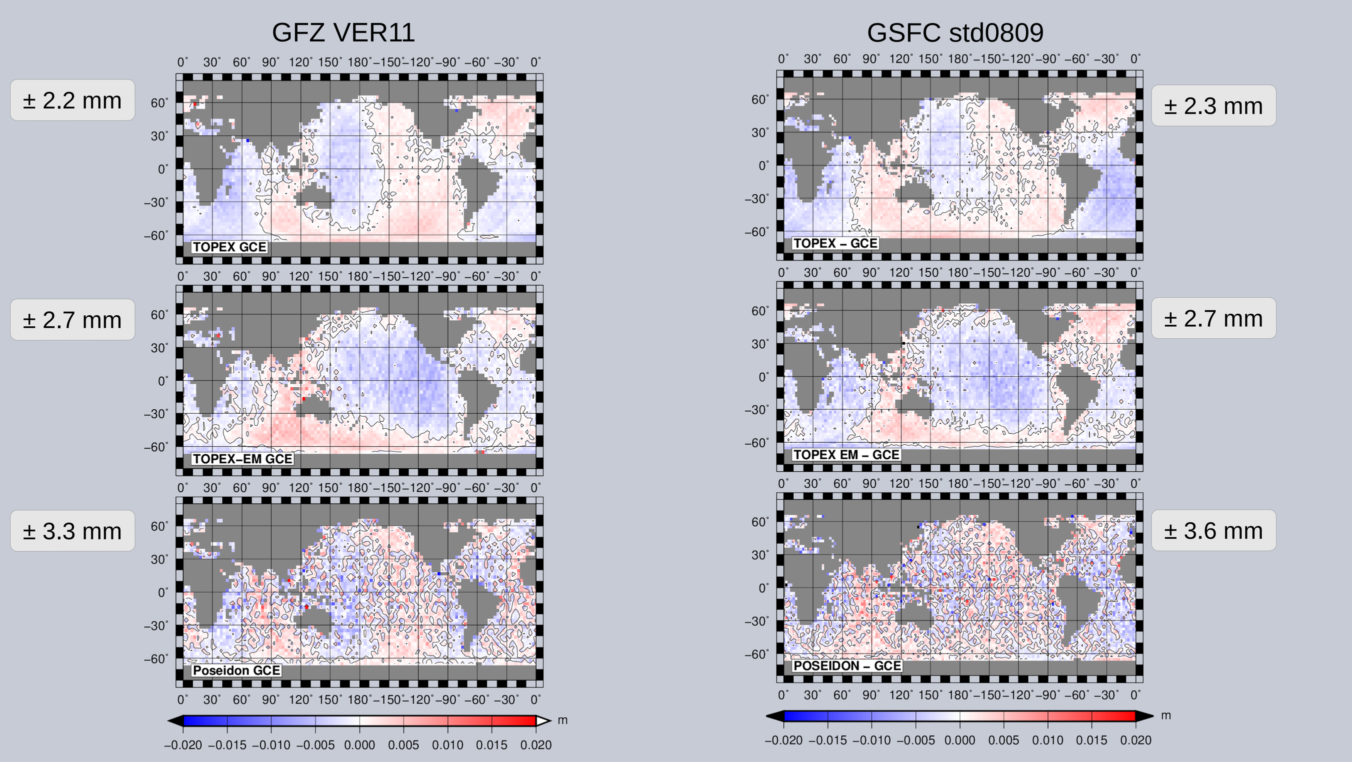
Geographically correlated errors (GCE) of GFZ VER11 and external orbits



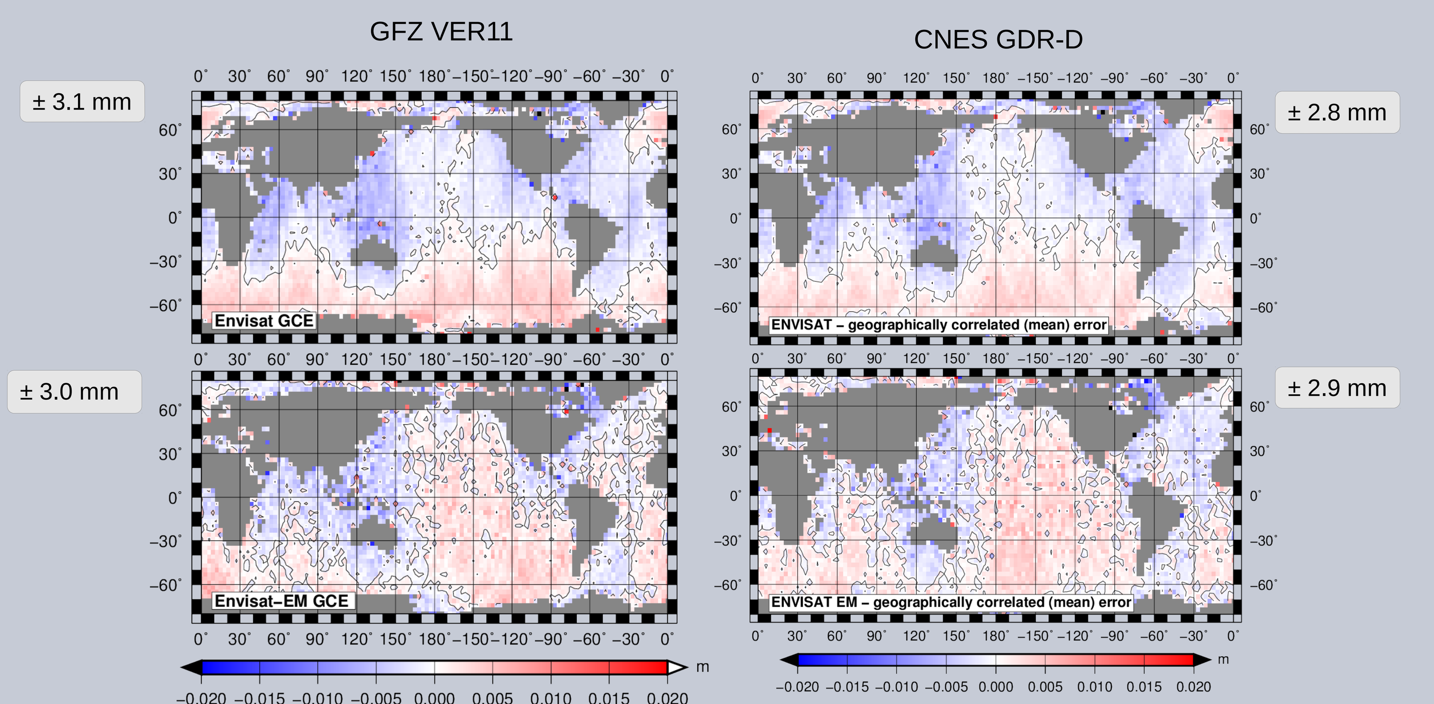
Figures 19-20. GCE of GFZ VER11 (left) and CNES GDR-D orbits for Jason-1 (top), Jason-1 EM (middle) and Jason-1 GM (bottom)



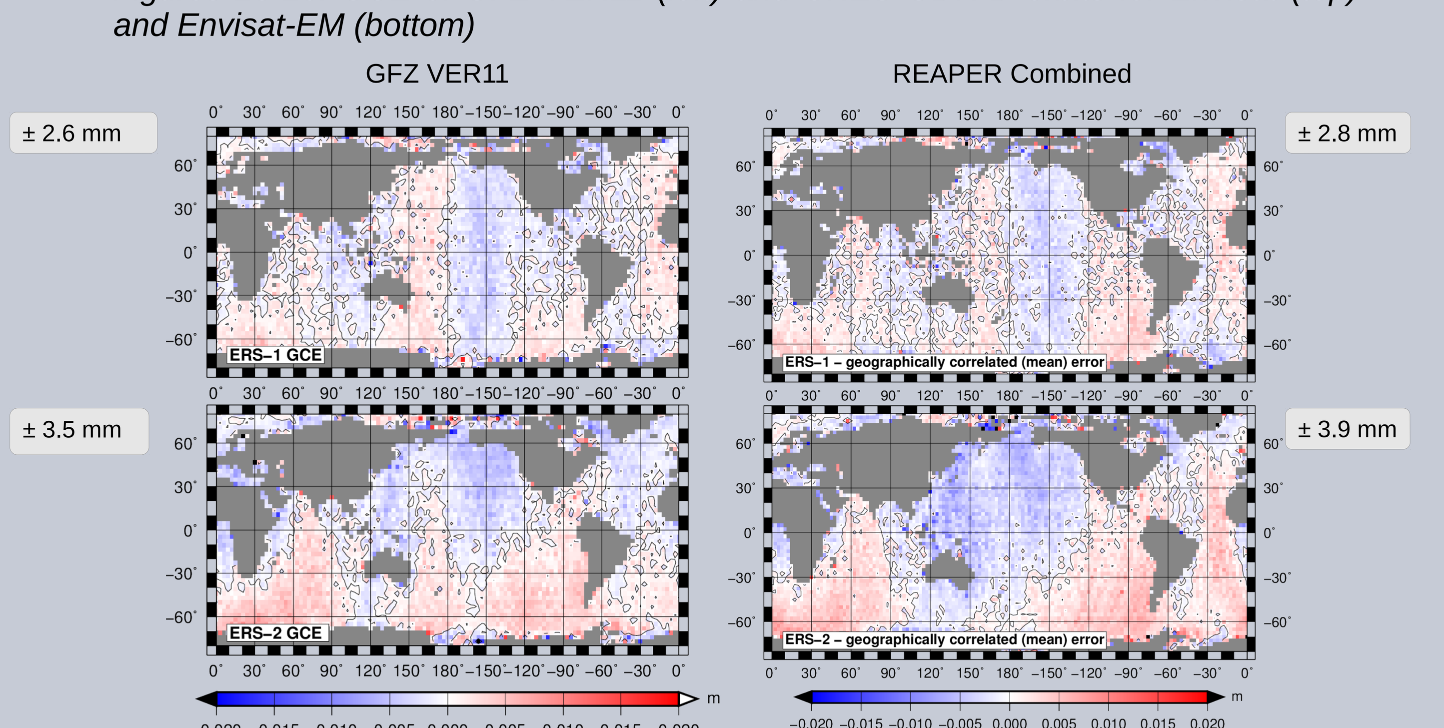
Figures 21-22. GCE of GFZ VER11 (left) and CNES GDR-D orbits for Jason-2



Figures 23-24. GCE of GFZ VER11 (left) and GSFC std0809 orbits for TOPEX (top), TOPEX-EM (middle) and Poseidon (bottom)



Figures 25-26. GCE of GFZ VER11 (left) and CNES GDR-D orbits for Envisat (top) and Envisat-EM (bottom)



Figures 27-28. GCE of GFZ VER11 (left) and REAPER combined orbits for ERS-1 (top) and ERS-2 (bottom)