New precise orbits of Envisat, ERS-1 and ERS-2 in the ITRF2008 computed at GFZ

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Overview

- Introduction
- The main models and input data used for precise orbit determination
- The results of determination and evaluation of precise orbits of Envisat (2002-2010), ERS-1 (1991-1996) and ERS-2 (1995-2003) computed recently at GFZ within the Sea Level project of the ESA Climate Change Initiative (SLCCI)
- The next DORIS-related activities planned at GFZ as a preparation for becoming an IDS Analysis Centre
- Conclusions

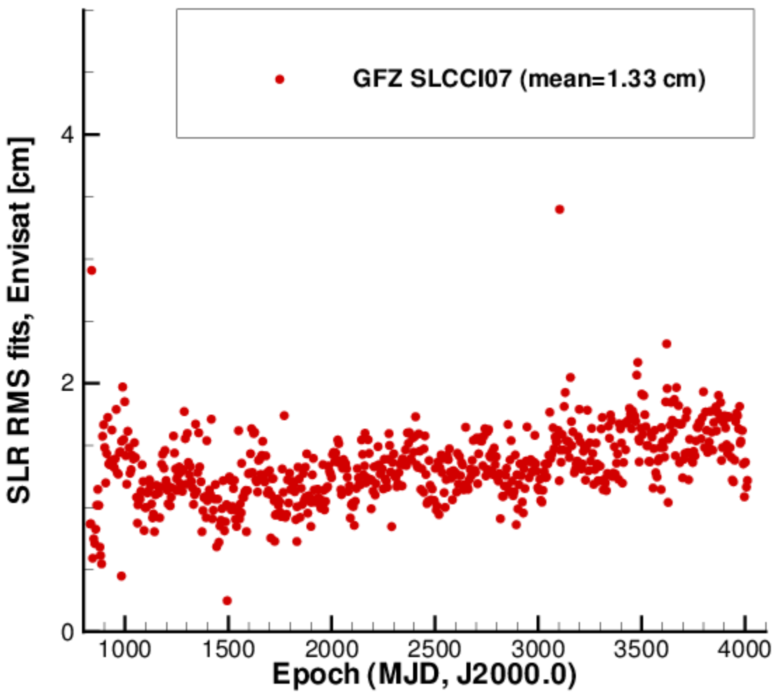
Introduction

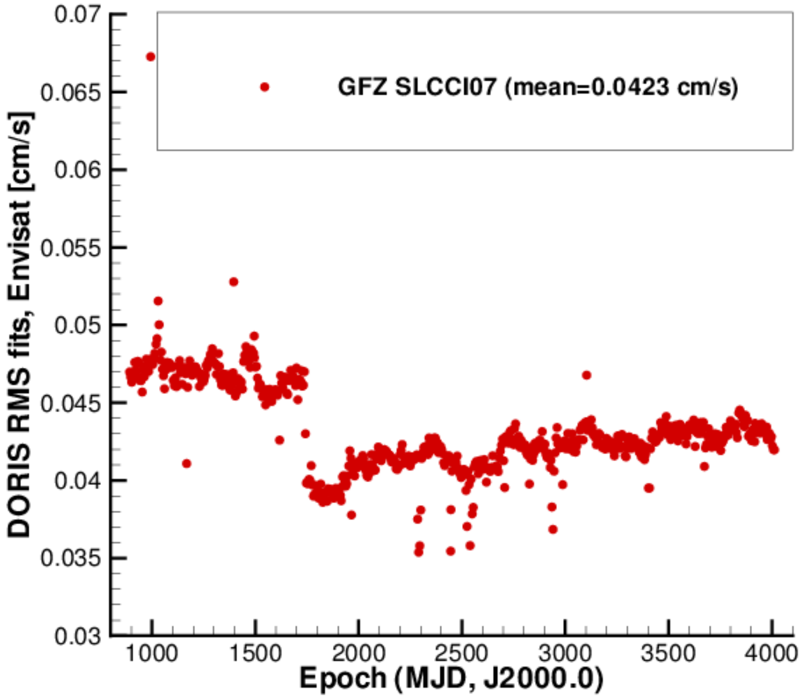
- New precise orbits of Envisat (from April 2002 to December 2010) and the European Remote Sensing Satellites ERS-1 (from August 1991 till July 1996) and ERS-2 (from May 1995 till July 2003) have been computed at GFZ in the same for all satellites ITRF2008 terrestrial reference frame using consistent models based mainly on the IERS Conventions (2010) within the Sea Level project of the European Space Agency (ESA) Climate Change Initiative. The purpose of the project is to develop and validate products for sea level investigations.
- 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.
- The quality of these new orbit solutions is presented in the comparison with the quality of the previous orbit solutions

The main models and input data used for precise orbit determination

Terrestrial Reference Frame	ITRF2008 (Altamimi et al., 2011), SLRF2008 (Pavlis, 2009) and DPOD2008 (Willis, 2011) are used for stations missing in ITRF2008
Polar motion and UT1	IERS EOP 08 C04 (IAU2000A) series with IERS daily and sub-daily corrections
Precession and Nutation model	IERS Conventions (2010)
Gravity field (static)	EIGEN-GL04S-ANNUAL (Lemoine et al., 2007)
Gravity field (time varying)	Annual and semi-annual variation up to degree and order 50 from EIGEN-GL04S-ANNUAL gravity field model (Lemoine et al., 2007)
Solid Earth tides	IERS Conventions (2010)
Pole tide	IERS Conventions (2010)
Ocean tides	EOT10A (Savcenko and Bosch, 2010), all constituents up to degree and order 50
Atmospheric tides	Biancale and Bode (2006)
Atmospheric gravity	ECMWF 6-hourly fields up to degree and order 50 (Flechtner, 2007)
Third bodies	Sun, Moon, Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto (DE-421) (Folkner et al., 2009)

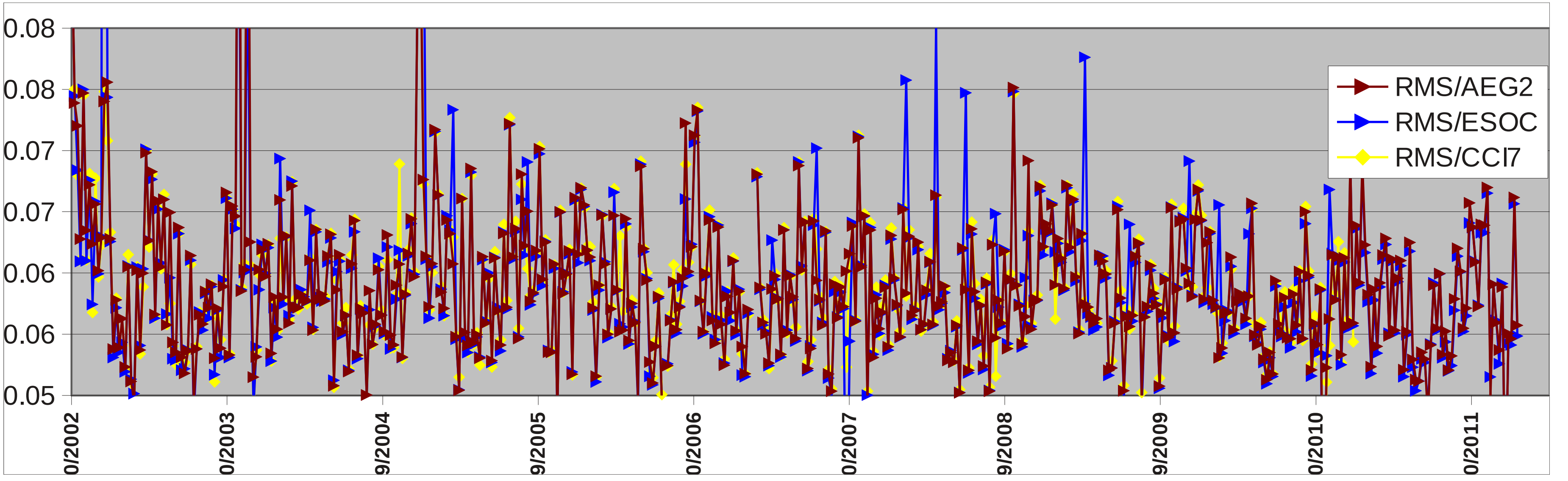
The results of Envisat precise orbit determination: April 2002 – December 2010

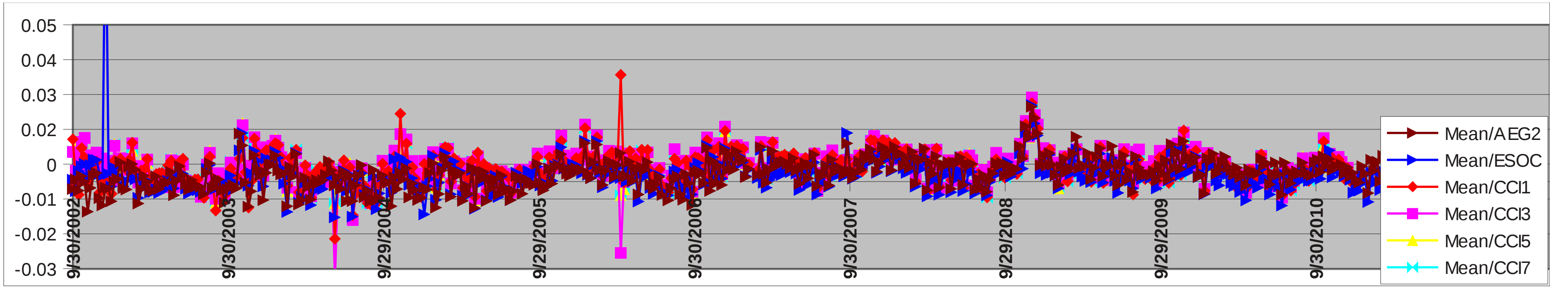




RMS fits of SLR and DORIS observations

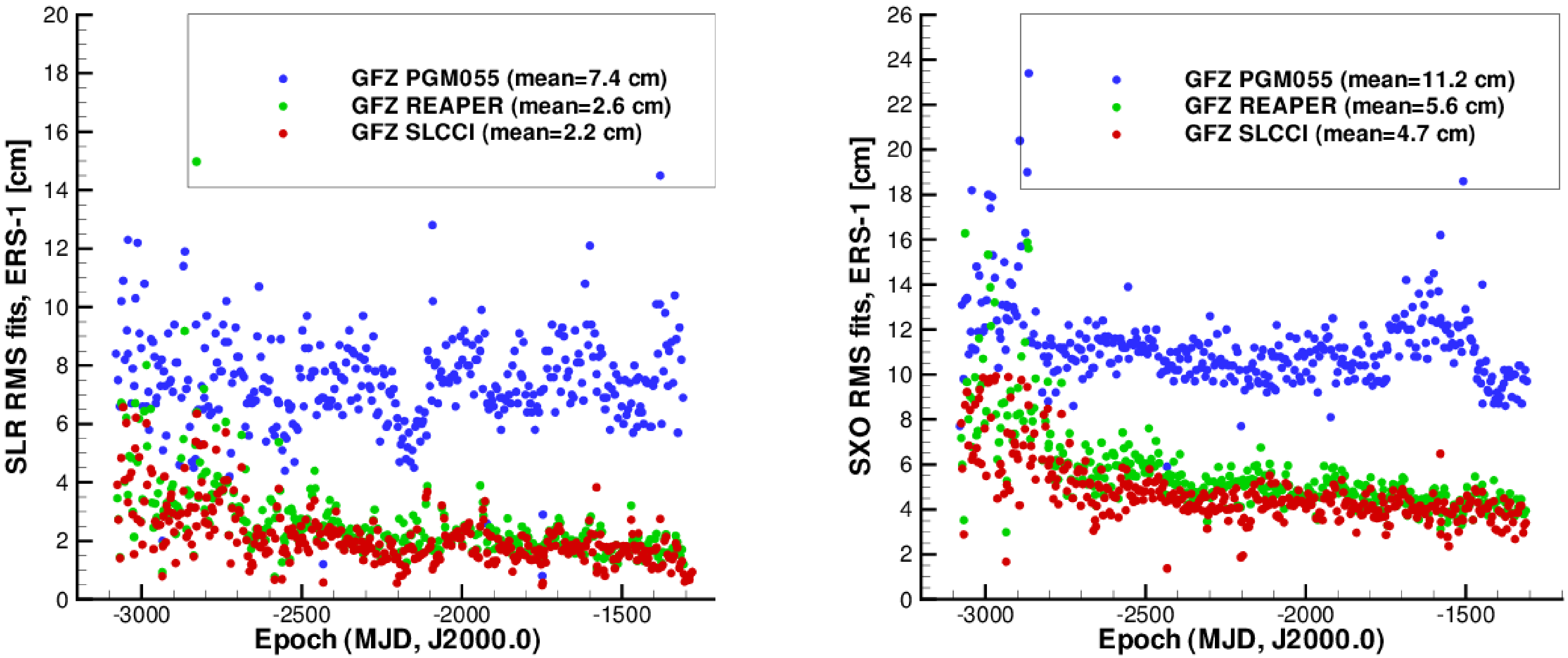
The results of Envisat orbit evaluation





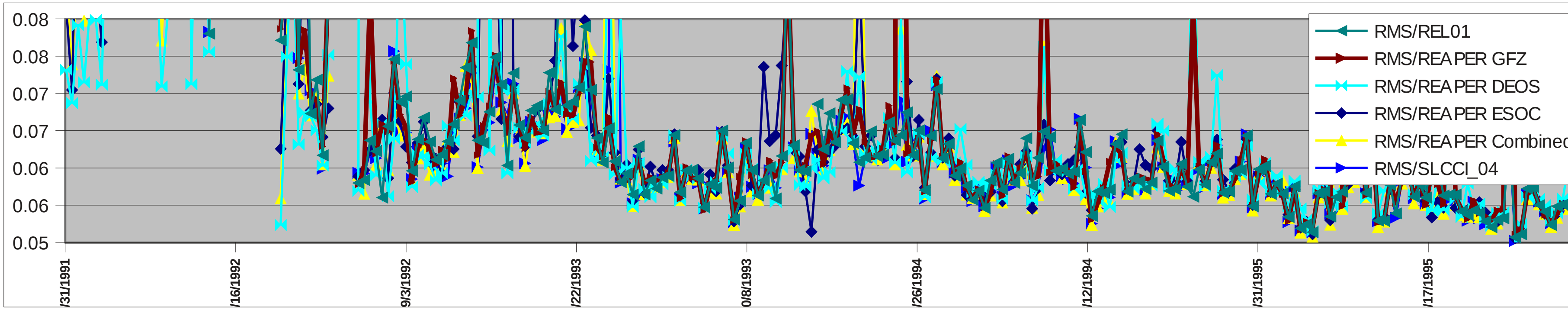
RMS and mean of crossover differences [m] of CNES GDR-C (AEG2), ESOC (version 8) and GFZ SLCCI orbits of Envisat. GFZ SLCCI07 final orbit has least outliers in the RMS of crossover differences as compared to other orbit solutions

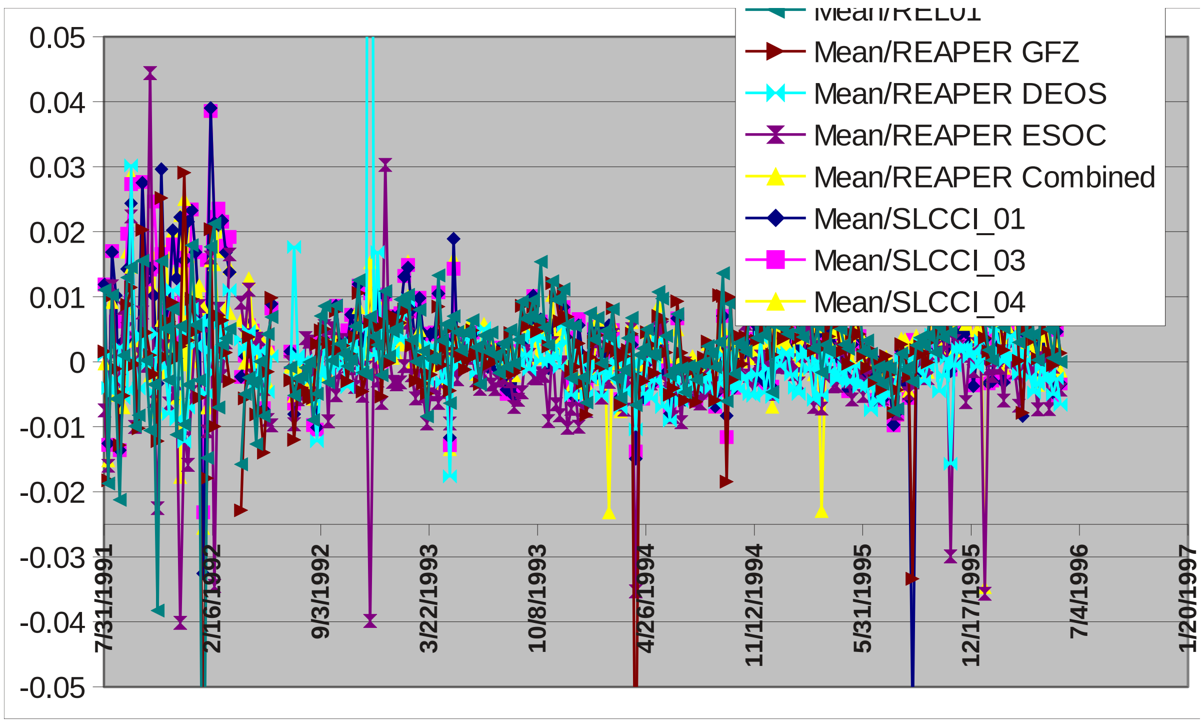
The results of ERS-1 precise orbit determination: August 1991 – July 1996



RMS fits of SLR and altimetry crossover (SXO) data of GFZ PGM-055, REAPER (ITRF2005) and SLCCI (ITRF2008) orbits

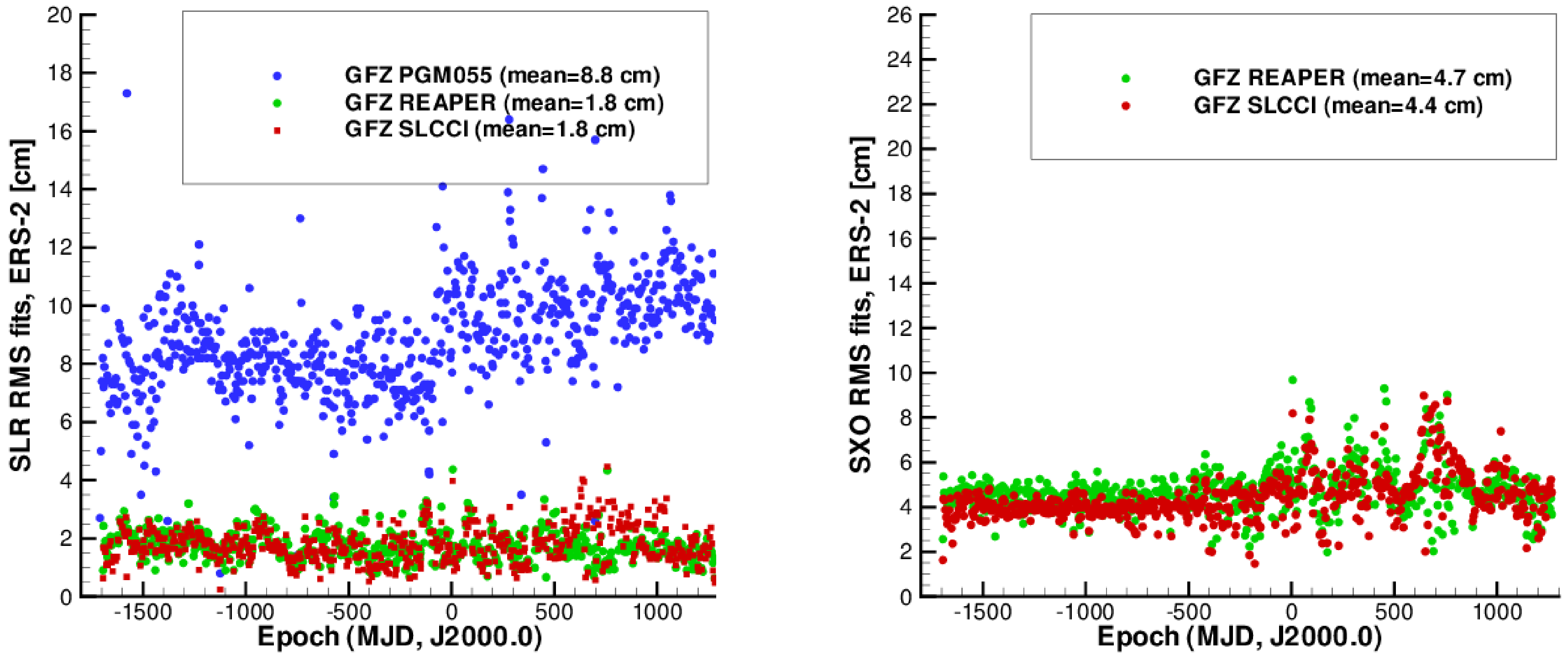
The results of ERS-1 orbit evaluation





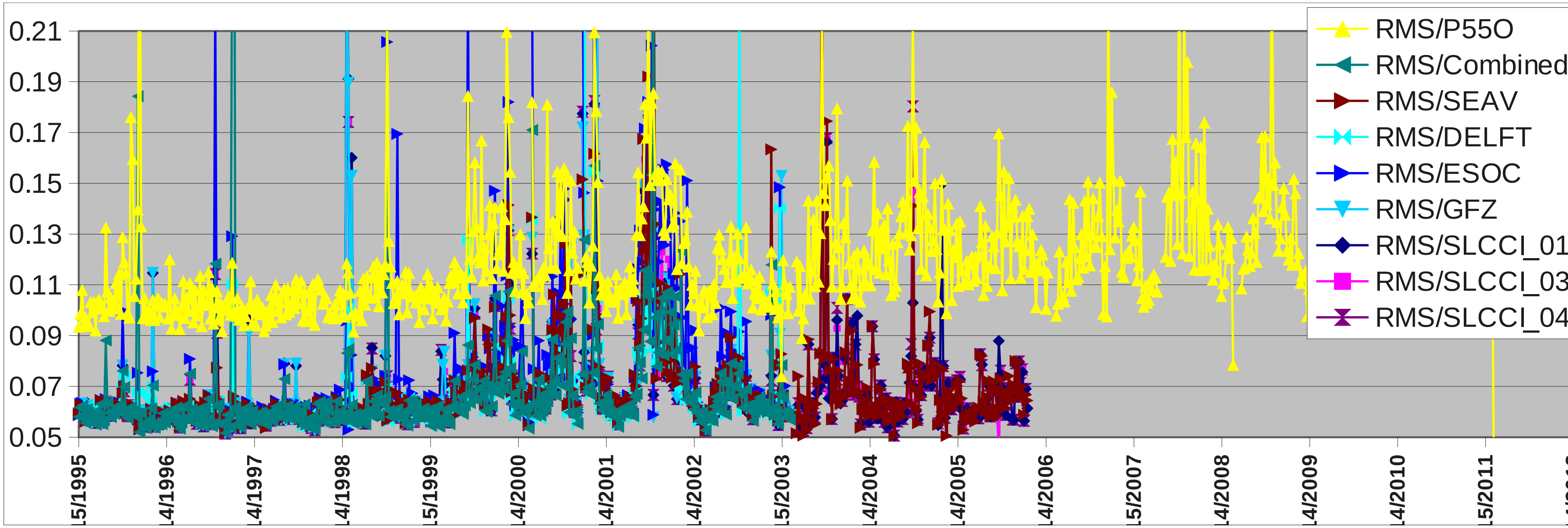
RMS and mean of crossover differences [m] of SEAVAR, REAPER and SLCCI orbits of ERS-1. GFZ SLCCI04 orbit has less outliers than GFZ REAPER orbit

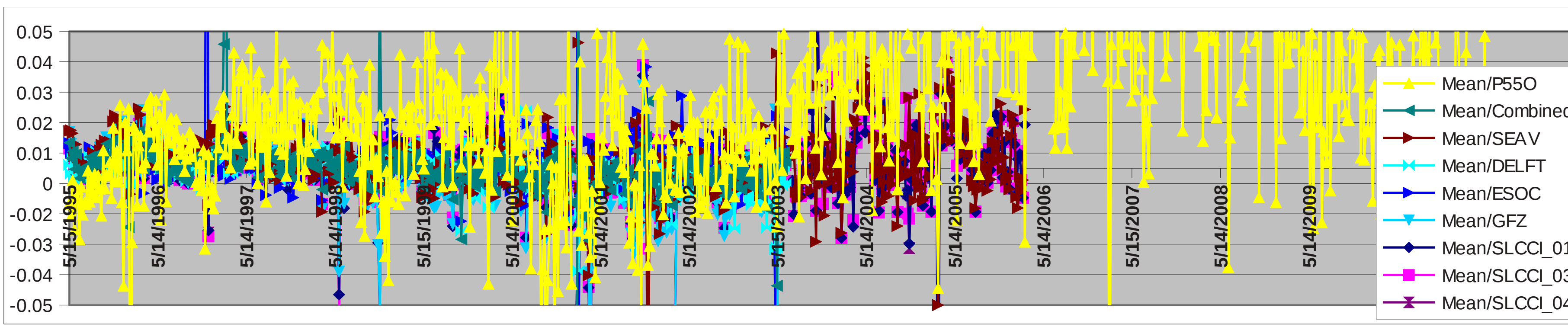
The results of ERS-2 precise orbit determination: May 1995 – July 2003



RMS fits of SLR and altimetry crossover (SXO) data of GFZ PGM-055, REAPER (ITRF2005) and SLCCI (ITRF2008) orbits

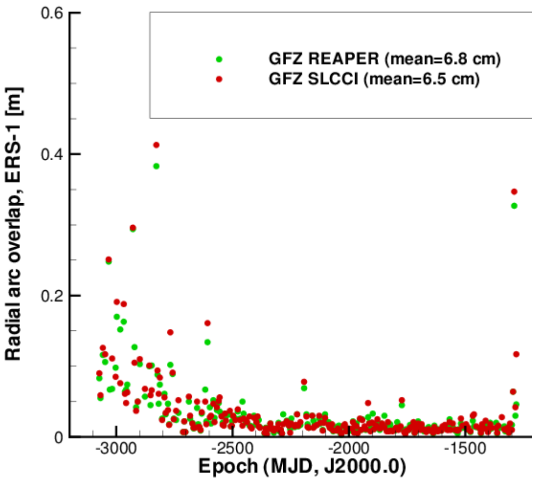
The results of ERS-2 orbit evaluation



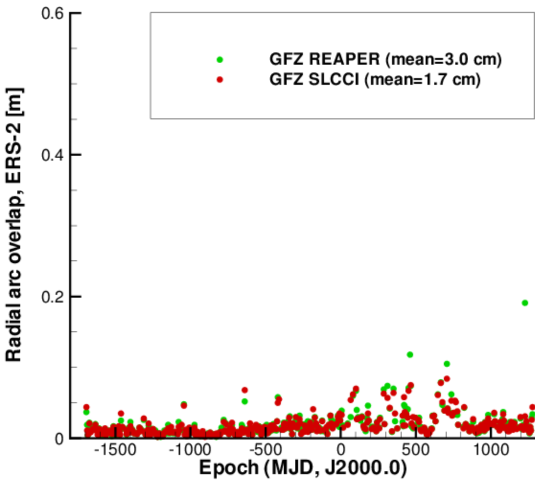


RMS and mean of crossover differences [m] of PGM-055, SEAVAR, REAPER and SLCCI orbits of ERS-2. GFZ SLCCI04 orbit indicates better quality than GFZ REAPER orbit

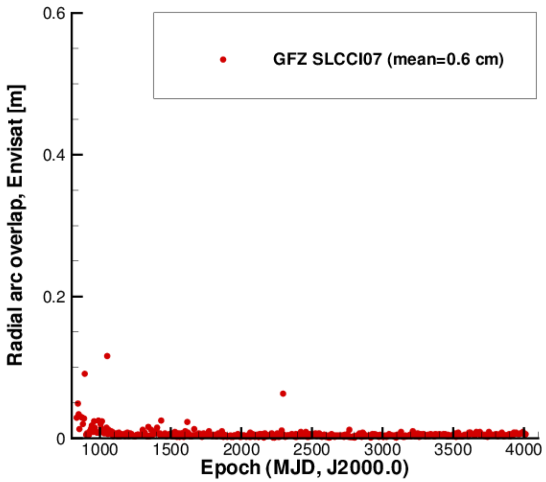
The internal consistency of ERS-1, ERS-2 and Envisat orbits



Radial two-day arc overlap [m] of GFZ REAPER and SLCCI orbits of ERS-1



Radial two-day arc overlap [m] of GFZ REAPER and SLCCI orbits of ERS-2



Radial two-day arc overlap [m] of GFZ SLCCI orbit of Envisat

The summary of altimetry crossover analysis of GFZ SLCCI orbits as compared to other orbits

RMS and mean of crossover differences determined over crossovers with the time differences of less than 5 days for latest GFZ SLCCI orbit solutions as compared to other orbits solutions

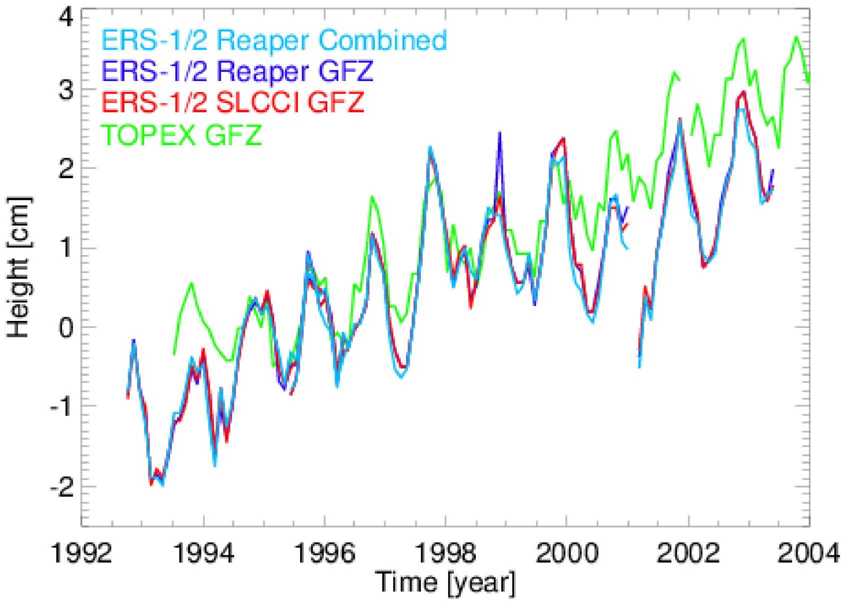
ERS-1 orbit (reference frame)	RMS of crossover differences [cm]	Mean of crossover differences [cm]
GFZ REAPER (ITRF2005)	7.35	0.18
Combined REAPER (ITRF2005)	7.01	0.16
GFZ SLCCI01 (ITRF2008)	7.26	0.26
GFZ SLCCI04 (ITRF2008)	7.12	0.28

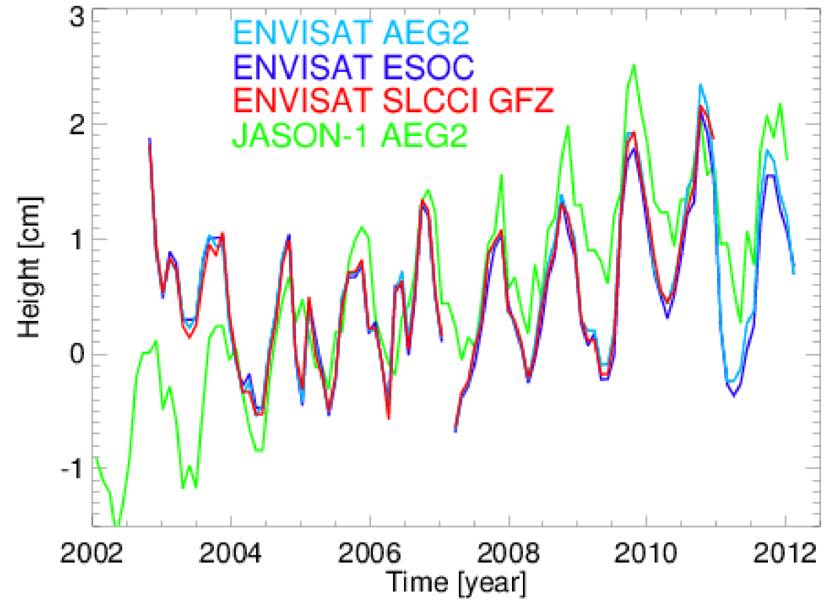
ERS-2 orbit (reference frame)	RMS of crossover differences [cm]	Mean of crossover differences [cm]
GFZ REAPER (ITRF2005)	6.79	-0.24
Combined REAPER (ITRF2005)	6.58	0.05
GFZ SLCCI01 (ITRF2008)	6.72	-0.01
GFZ SLCCI04 (ITRF2008)	6.51	0.04

Envisat orbit (reference frame)	RMS of crossover differences [cm]	Mean of crossover differences [cm]
CNES GDR-C (ITRF2005)	5.92	0.24
ESOC version 8 (ITRF2008)	5.97	0.20
GFZ SLCCI (ITRF2008)	5.91	0.41

The latest GFZ SLCCI orbit solutions, at least of ERS-2 and Envisat, provide improvements in the comparison with other orbit solutions for these satellites

The global mean sea level height computed different orbits





The latitude area between -67 degrees and +67 degrees used, the GIA effect included

Courtesy of S. Esselborn (GFZ)

The checklist of the activities in updating EPOS-OC software planned in May 2011

Implementation and tests of the following models and input data:

- “IERS Conventions (2010)” - DONE!
- SLRF2008 and DPOD2008 - DONE!
- Envisat, Jason-1 and Jason-2 macro- and attitude models, manoeuvre acceleration files - DONE for Envisat, in progress for Jason-1/2
- Jason-1 South Atlantic Anomaly corrective model – in progress
- Update of input information on DORIS stations for 2006-2011 - DONE
- Preparations for processing Envisat, Jason-1 and Jason-2 observations - DONE for Envisat, in progress for Jason-1/2
- New ocean tide models (EOT10A and EOT11A) - DONE!
- New planetary ephemerides (DE-421) - DONE!
- NIC09 model for ionosphere correction for altimeter data - DONE!
- IERS EOP 08 C04 (IAU2000A) series - DONE!
- Tests of new gravity field models - in progress
- Other models and input data

The future DORIS-related activities at GFZ

- To complete reprocessing precise orbit of TOPEX/Poseidon in ITRF2008
- To complete implementing models for Jason-1 and Jason-2 precise orbit determination: macromodels, attitude models, manoeuvre information, South Atlantic Anomaly for Jason-1
- To compute Jason-1 and Jason-2 precise orbits in ITRF2008 using SLCCI project POD Standards
- To adopt and test EPOS-OC software for estimating Earth rotation parameters using DORIS observations
- To implement and test procedures for estimating weekly positions of DORIS stations and providing the results in SINEX format
- To elaborate further models for precise orbit determination of DORIS satellites and processing DORIS data
- To provide IDS some products (ephemerides of DORIS satellites, coordinates and velocities of the IDS tracking stations, Earth rotation parameters) for evaluation

Conclusions

- New precise orbits of Envisat (from April 2002 to December 2010), ERS-1 (from August 1991 till July 1996) and ERS-2 (from May 1995 till July 2003) have been derived at GFZ in ITRF2008 terrestrial reference frame using consistent models based mainly on the IERS Conventions (2010) within the ESA Climate Change Initiative Sea Level project.
- New (SLCCI) orbits of ERS-1 and ERS-2 show improved quality as compared to the orbits of these satellites computed at GFZ in ITRF2000 in the SEAVAR project and in ITRF2005 in the REAPER project. Thus, ERS-1 and ERS-2 SLCCI orbits show 2.3 and 2.8 mm smaller RMS of crossover differences than GFZ REAPER orbits.
- GFZ SLCCI orbit of Envisat indicates 0.1 and 0.6 mm smaller value of RMS of crossover differences than CNES GDR-C (AEG2) and ESOC (version 8) orbits, accordingly, and has less outliers in the RMS of crossover differences than two other orbits.
- Global mean sea level height changes have been computed using new orbits of ERS-1, ERS-2 and Envisat and compared with those from some other orbits.

References

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GFZ SLCCI orbits of ERS-1, ERS-2 and Envisat in the SP3c format are available at

ftp://slcci:slcci@ftp.esa-sealevel-cci.org/Data/WP2200/GFZ_SLCCI_ER1_V2/ for ERS-1,
ftp://slcci:slcci@ftp.esa-sealevel-cci.org/Data/WP2200/GFZ_SLCCI_ER2_V2/ for ERS-2,
ftp://slcci:slcci@ftp.esa-sealevel-cci.org/Data/WP2200/GFZ_SLCCI_ENV/ for Envisat

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