CENTRE NATIONAL D'ÉTUDES SPATIALES

Improving the long-term stability of the GDR orbit solutions

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POD Splinter Session

Status of the POD standards applied in GDR orbits

- **Current POD models are applied in GDR orbits since July 2008 and are referred to as GDR-C standards**
  - **Sometimes the *GDR-C'* naming convention is used, because final orbits were reprocessed removing the GRACE-derived drifts in the EIGEN-GL04S-Annual model (estimated over only two years of data at that time)**
- **GDR-C orbits are dynamic solutions consistent with ITRF2005 and are the first GDR solutions that attempt to model the non-tidal periodic component of the time varying gravity field**
  - **Annual and semi-annual component from Grace/Lageos EIGEN-GL04S-Annual**
  - **Atmospheric gravity from the AGRA service at GSFC (NCEP pressure fields)**

Error budget of GDR-C orbits

Radial error budget for Jason GDR orbit. When the errors in this table are assumed to be uncorrelated, the RSS value is 10.3 mm.

	Typical RMS	Systematic	Rationale
Orbit determination noise	<7 mm	1/rev with varying amplitude and phase, no significant geographical correlation	Inter-comparison of orbits using same or similar models or with low dependency from models
Static gravity field	<1 mm	static order-1 pattern	Comparison between EIGEN-GL04S and the following generation of mean field
Tide model	<2 mm	1–2 mm varying order-1 pattern	Comparison of FES2004 Vs GOT4.7 and of FES2004 Vs CSR3.0
Atmosphere/Ocean/ Hydrology	<6 mm	varying order-1 pattern	Comparison with orbits using the most complete TVG models
Solar radiation pressure	<3 mm	120-day variable pattern stronger at high and low latitudes, amplitude <3 mm	Comparison of orbits with UCL and GDR-C box models
Reference frame (long term)	2 mm	<1 mm/year drift along Z	Comparison of N/S centering of Jason-1 and Jason-2 ITRF2005 based orbits and analysis of drift of LAGEOS 1 and 2 geocenter series
Geocenter motion	2 mm	<5 mm annual variation along the N/S direction. Depends on the relative weight between SLR, DORIS and GPS tracking	Relative centering of orbits obtained by displacing the reference network of 5 mm along Z

Table extracted from 2010 MG paper "POD standards for the Jason series of altimeter missions"

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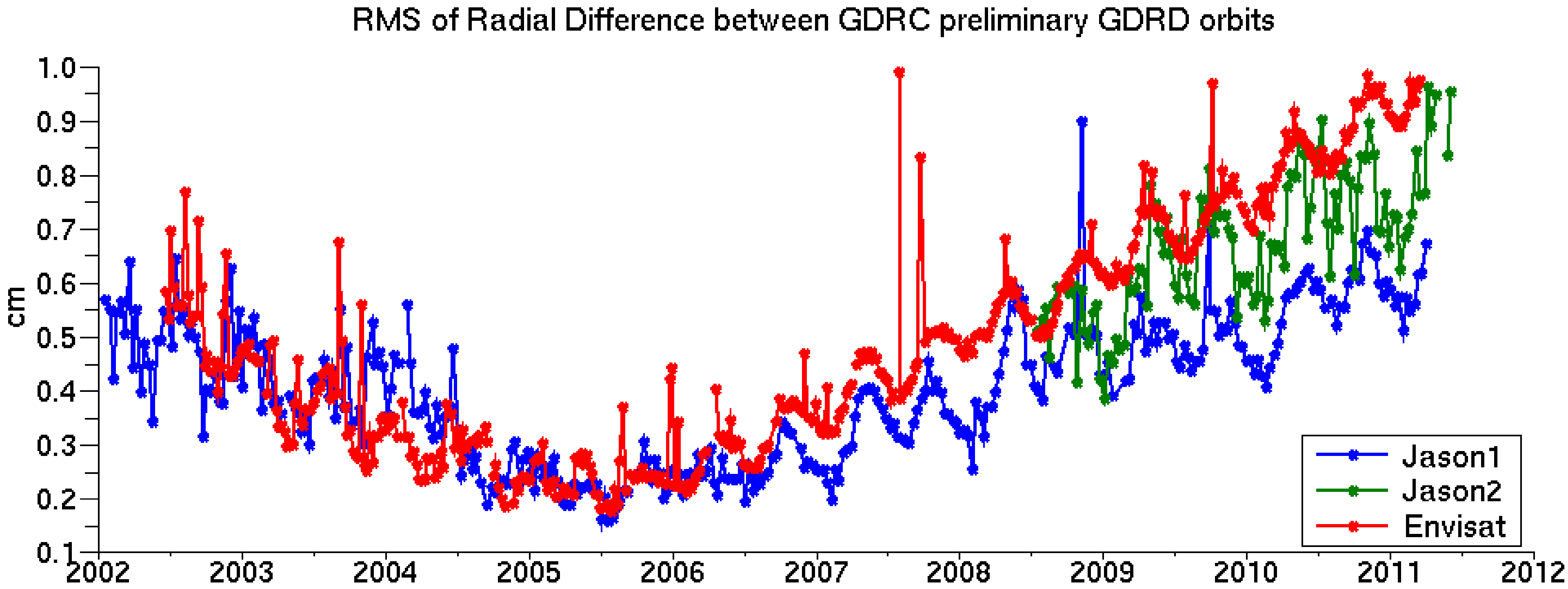
Availability of improved models makes current standard obsolete

- The focus is on the long term stability of the orbit solutions
- ITRF2008
  - DPOD2008 (dedicated presentation from P. Willis)
  - IGS08 (JPL solution at IGS)
- Gravity:
  - EIGEN-GRGS_RL02bis_MEAN-FIELD: a new mean model from CNES/GRGS spanning 8 years of Grace data
- Other modeling improvements (negligible impact on the GDR orbits)
  - GPT/GMF tropospheric correction
  - IERS2010 mean pole model
  - New atmospheric tide model (Biancale/Bode)
- Preliminary set of orbits (Jason1, Jason2, Envisat) has been produced with this new standards
  - Cryosat-2 results will not be presented here but are in line with what is presented for other satellites

Radial orbit difference between GDR-C and GDR-D

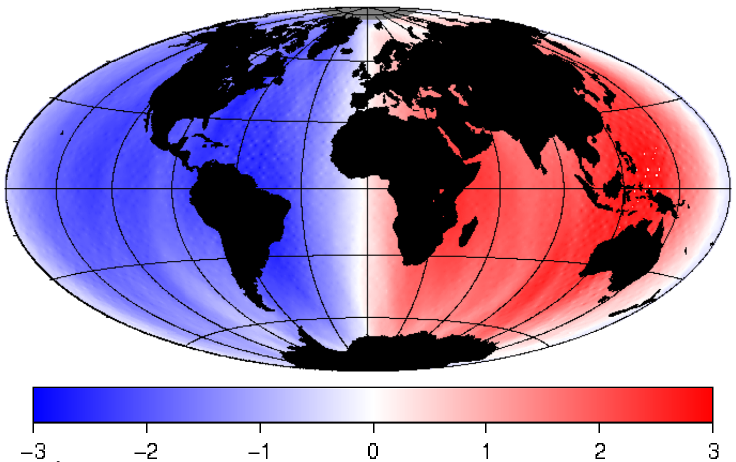
- RMS of radial differences is mostly driven by the new variable terms in the gravity field
- Below 1 cm RMS for Jason, reaches 1 cm on Envisat



Radial difference between GDR-C and preliminary GDR-D orbits

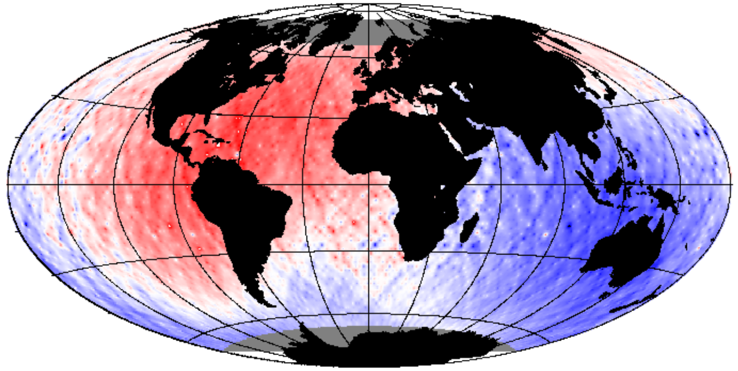
- For MSL applications, the most significant difference between GDR-C and GDR-D orbits is a geographically correlated radial drift with opposite sign between Envisat and Jason

Envisat GDRD-GDRC (2002-2011.5)

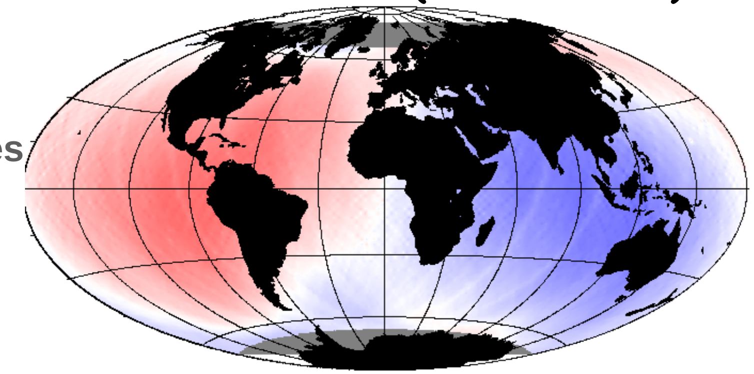


-3 mm/year +3 mm/year

Jason2 GDRD-GDRC (2008.5-2011.5)



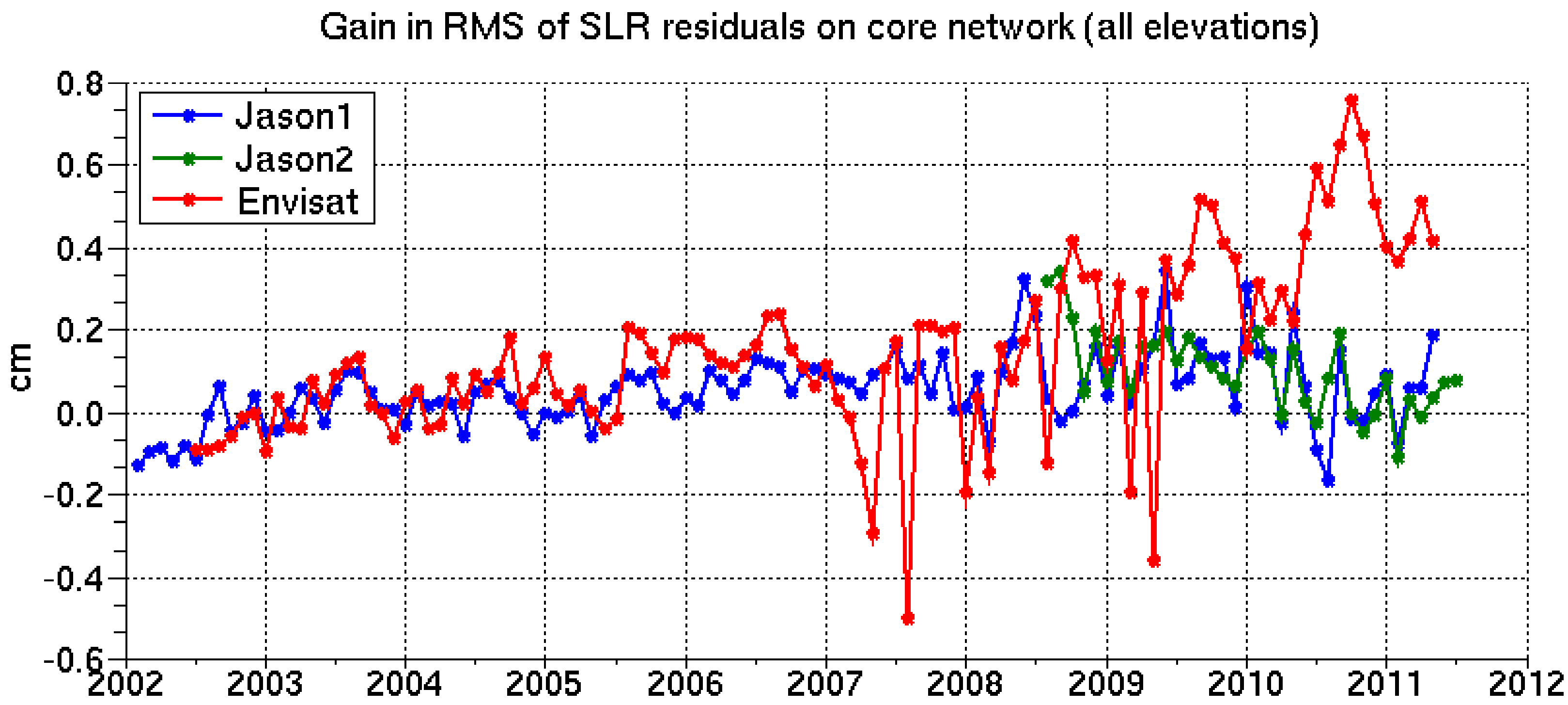
Jason1 GDRD-GDRC (2002-2011.5)



- New orbits correct the E/W hemispheric differences between Envisat and Jason SSH
- Cryosat-2 orbits behave similarly as those of Envisat (Proceedings of the 2011 CS-2 Validation Workshops)

SLR residuals on reference stations

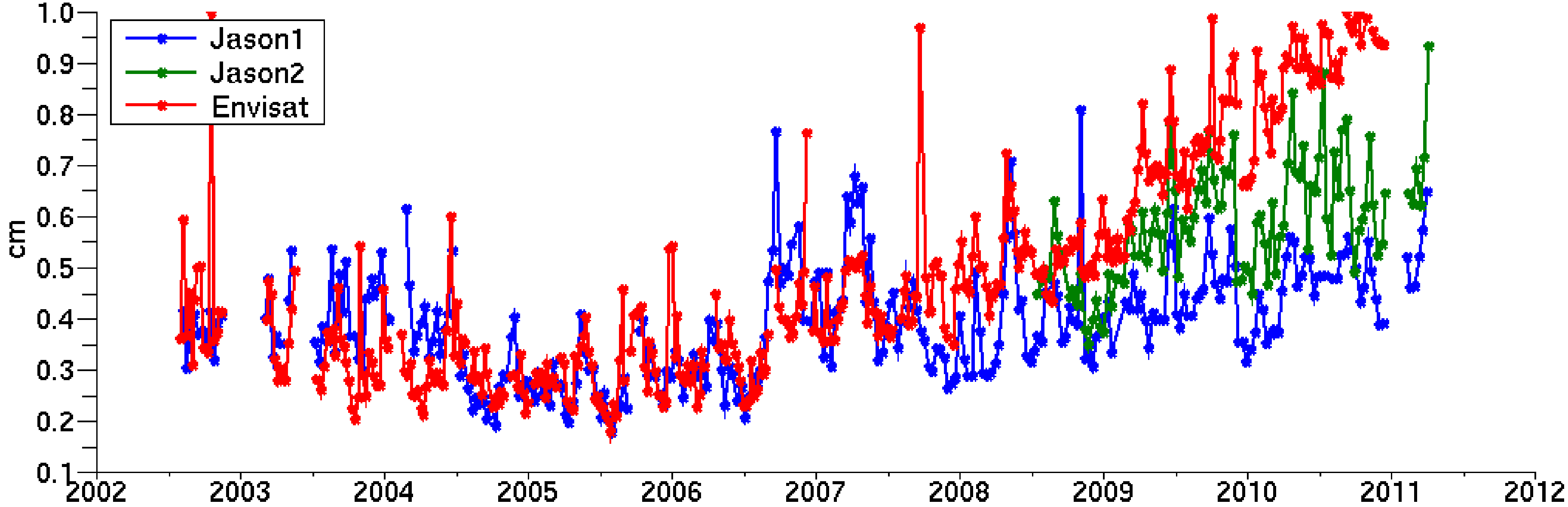
- **Orbit accuracy is noticeably improved when using the GDRD preliminary orbit standard**
  - **Core SLR Network (7080,7090,7105,7839,7840,7810) , all elevations**



How does the mean model compare to the 10-day series

- Comparison of GDRC orbit with a GDRD-like test orbit in which the 50x50 part of the mean model is replaced by the 10-day series of Grace-derived gravity fields (not available for operational orbit production)
- GDR-C: mean model derived over 2003-2005

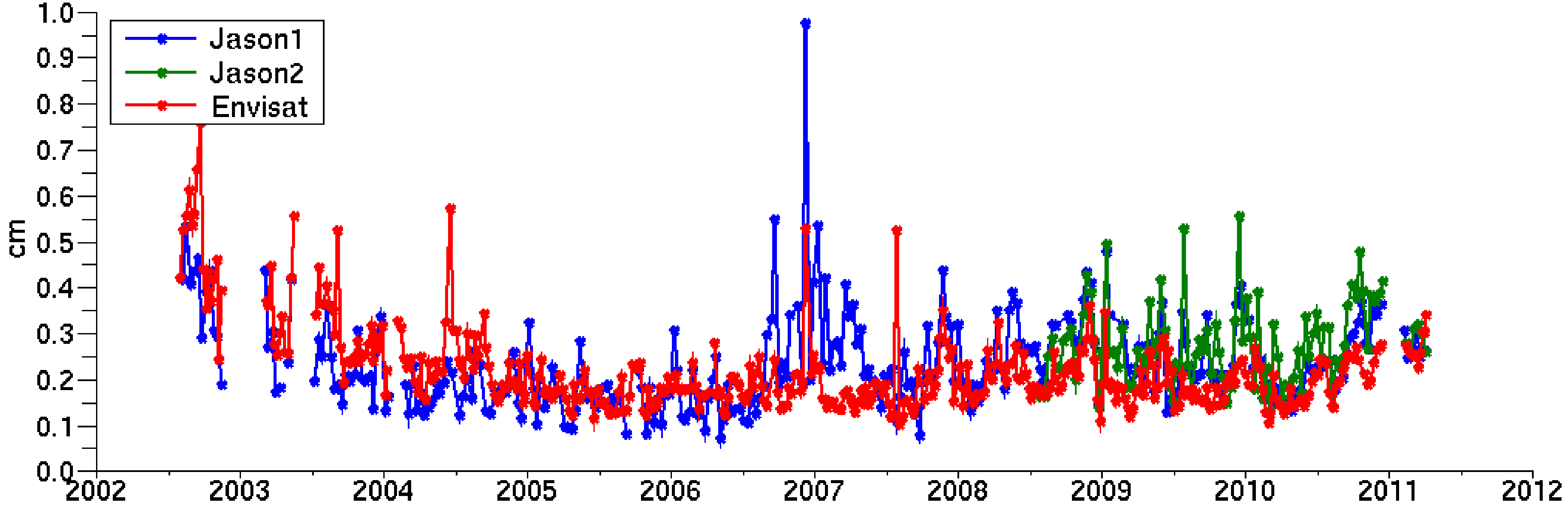
RMS of Radial Difference between GDRC orbits (using the old mean field w/o drifts) and GDRD orbits using the 10-day series



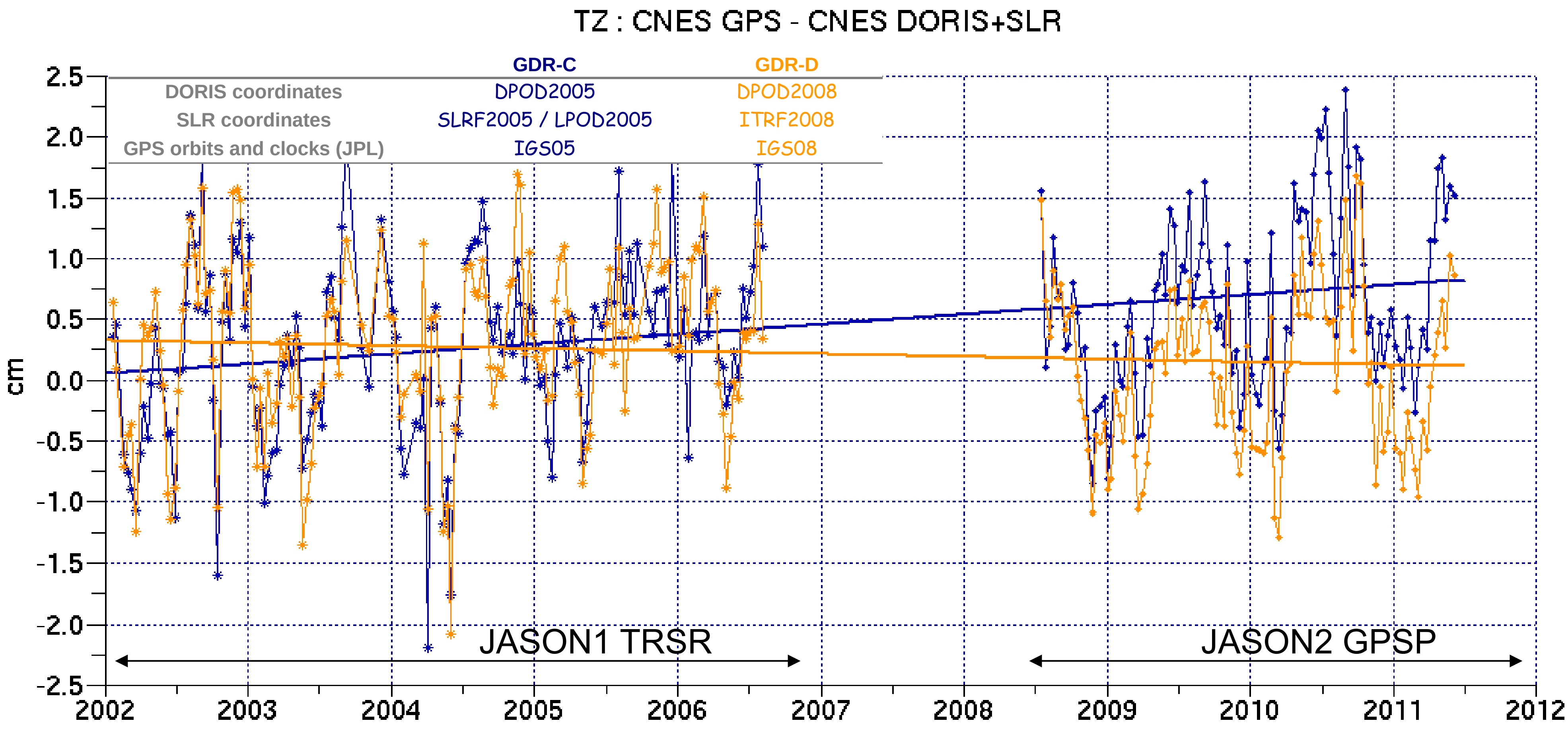
How does the mean model compare to the 10-day series

- When the same series of 10-day gravity field test orbit is compared with the GDRD orbits, the comparison is quite stable through the 2002-2011 time span
- This indicates that the new mean model captures most of the variability

RMS of Radial Difference between GDRD orbits (using the new mean field) and GDRD orbits using the 10-day series



N/S consistency of Jason 1 and 2 DORIS/SLR vs GPS-based orbits (internal CNES orbits)



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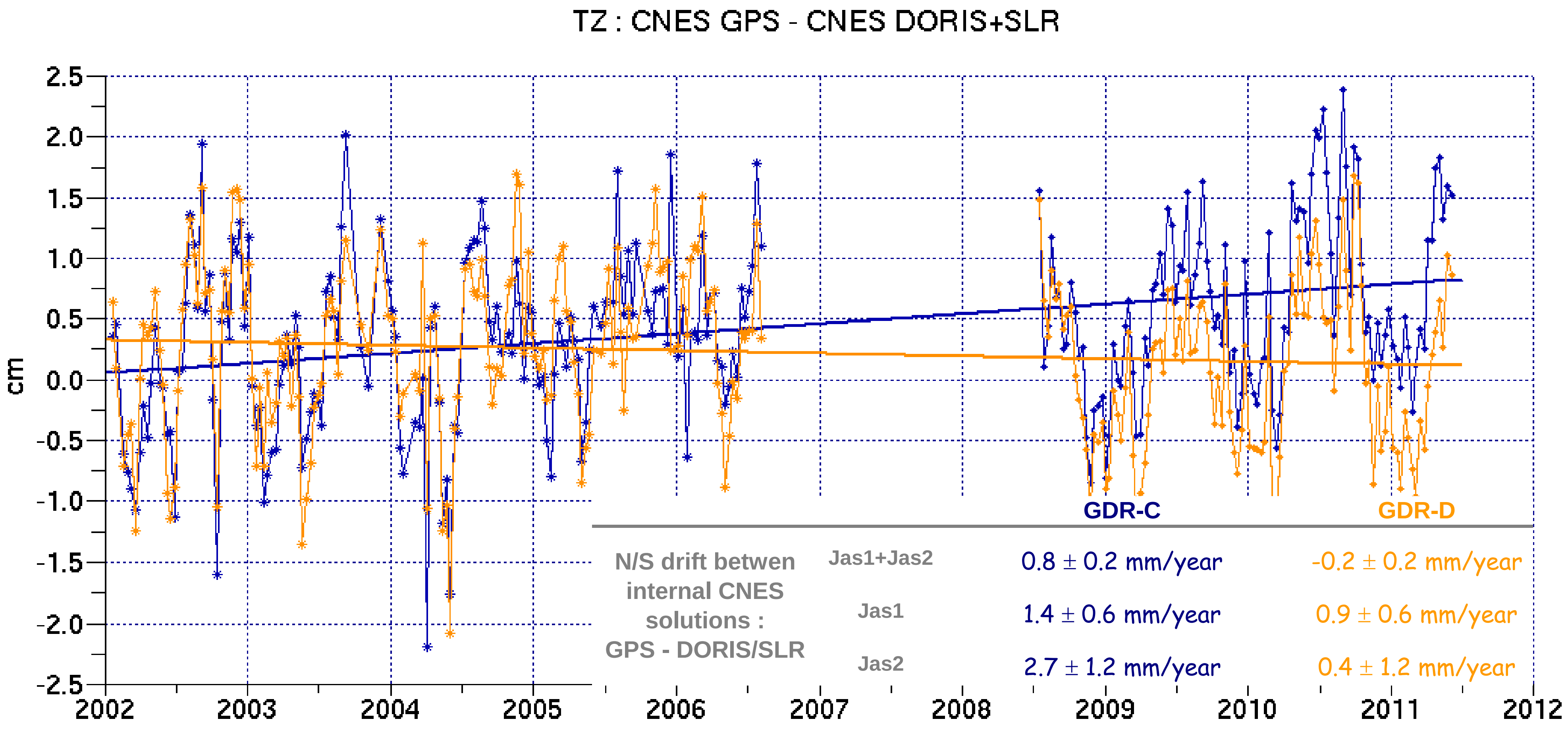

N/S drift betwen internal CNES solutions : GPS - DORIS/SLR		GDR-C	GDR-D
	Jas1+Jas2	0.8 ± 0.2 mm/year	-0.2 ± 0.2 mm/year
	Jas1	1.4 ± 0.6 mm/year	0.9 ± 0.6 mm/year
	Jas2	2.7 ± 1.2 mm/year	0.4 ± 1.2 mm/year

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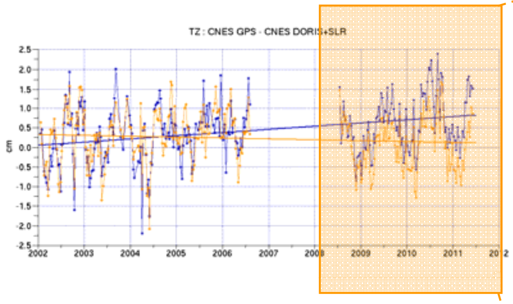
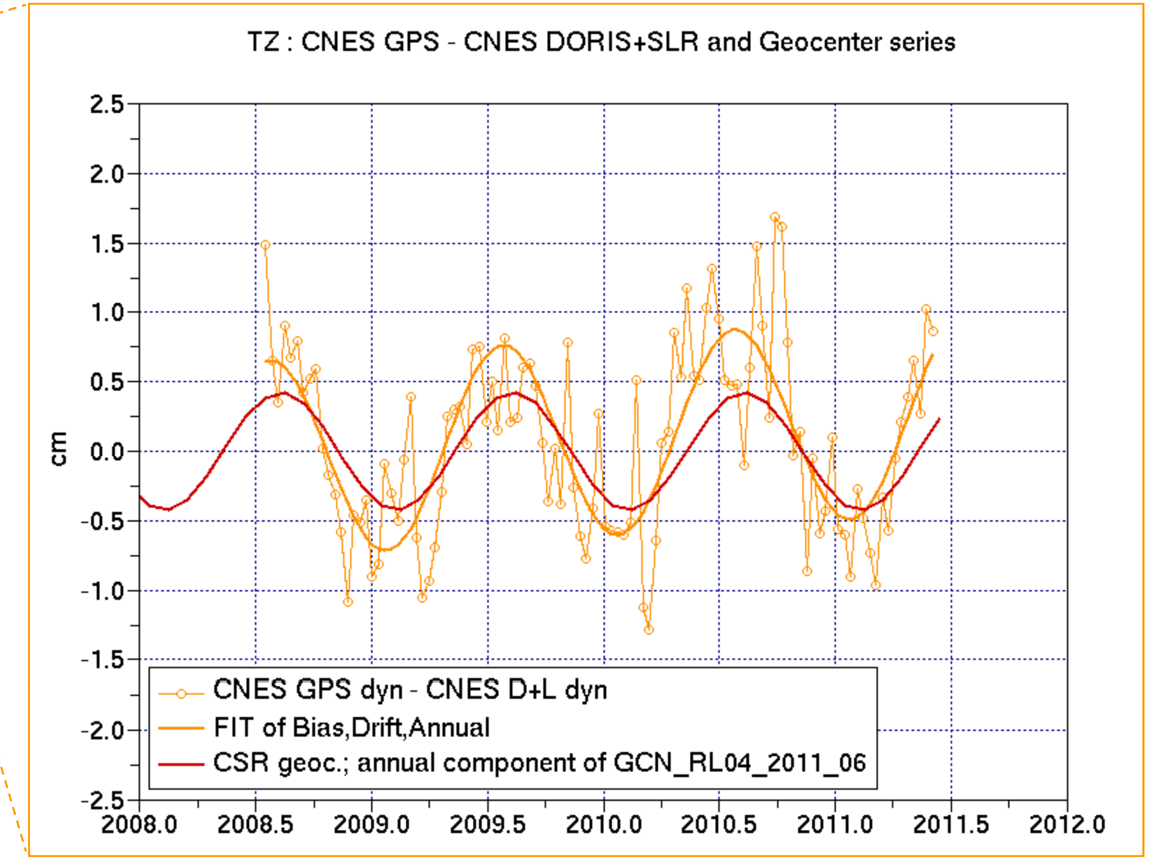
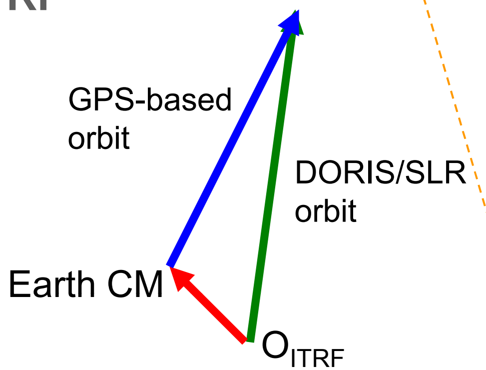




- GPS-based orbits appear to be more closely centered to the Earth CoM, while Doris+SLR orbits are tied to the ITRF

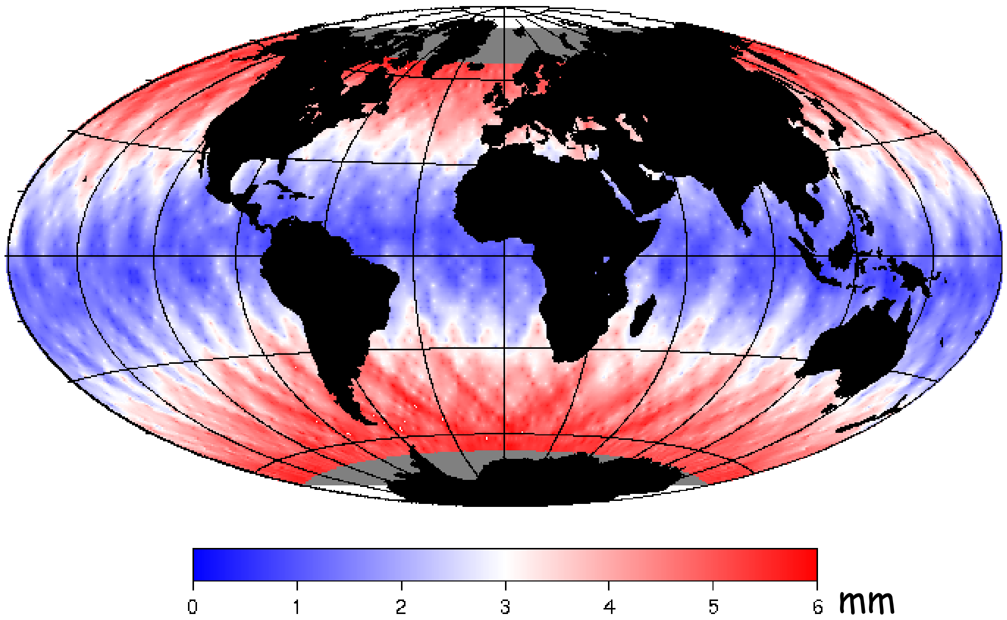


N/S consistency of Jason 1 and 2 DORIS/SLR vs GPS-based orbits

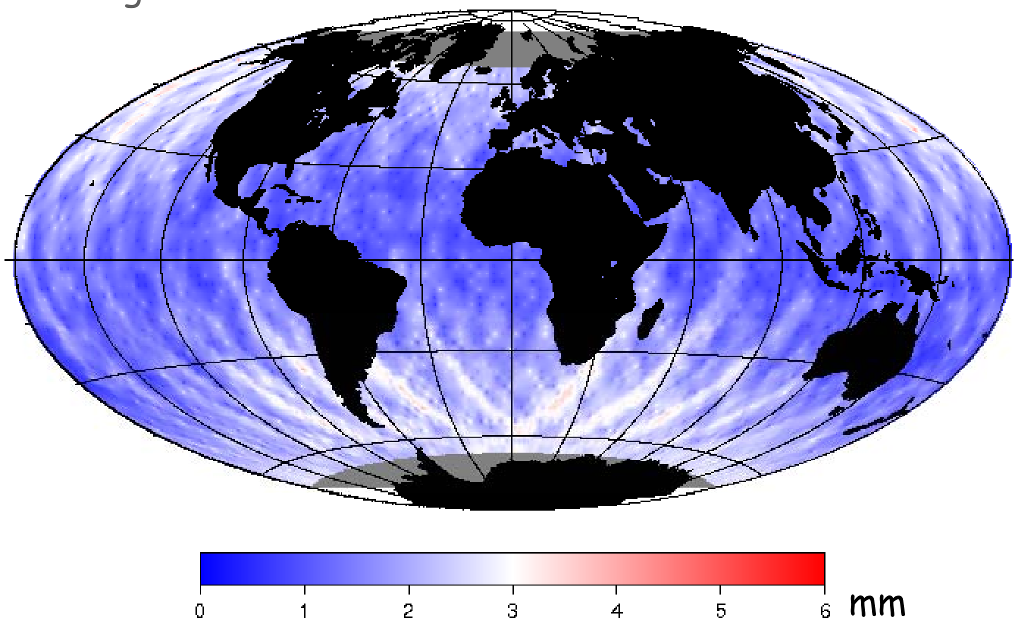
- As expected, TZ geocenter correction maps directly into significant radial orbit difference at high and low latitudes

Amplitude of annual signal in Jason-2 radial orbit difference

CNES GPS – CNES DORIS/SLR (GDRD)

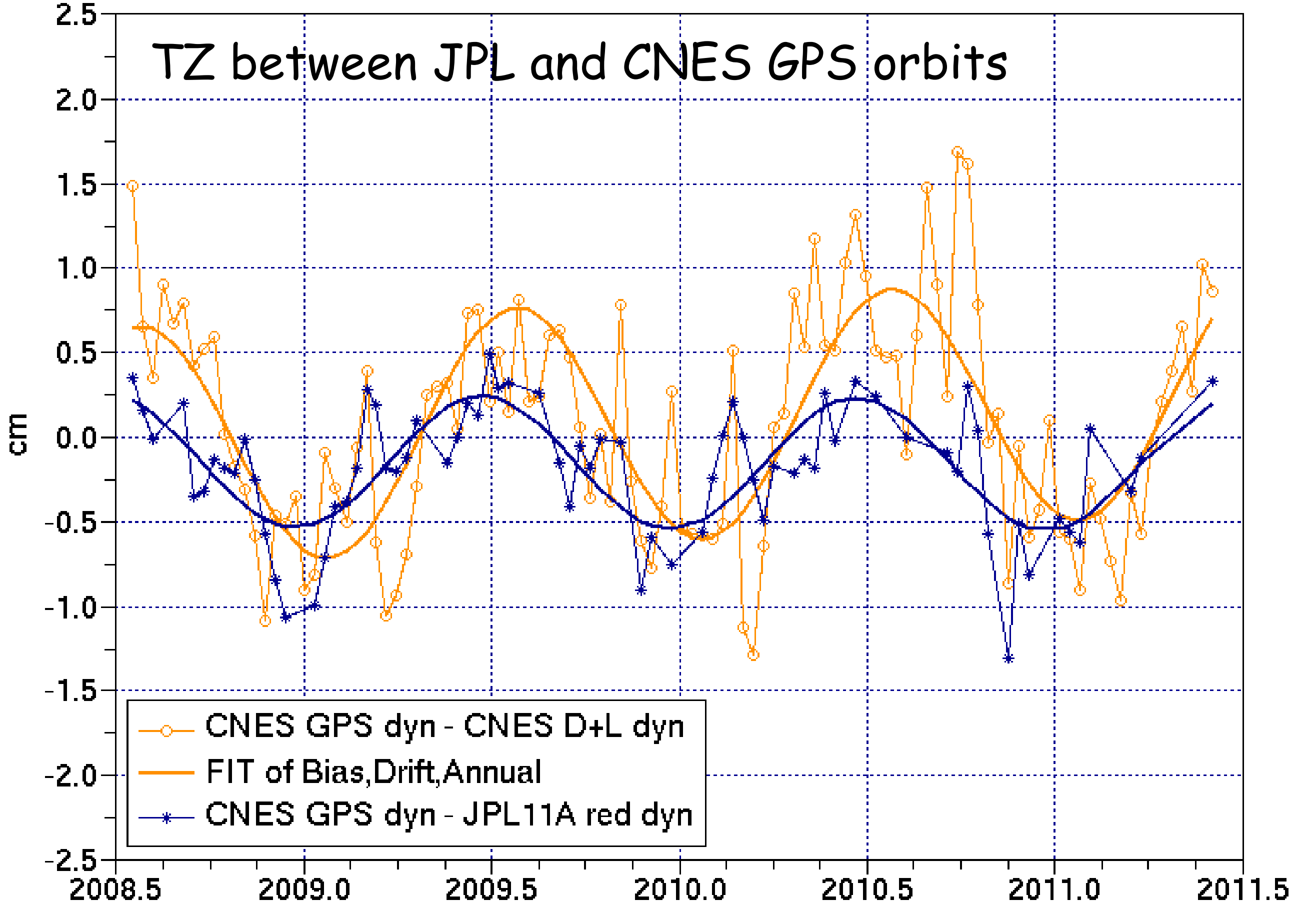


CNES GPS– CNES DORIS/SLR (GDRD) including geocenter correction on station coordinates



Centering of GPS-based solutions depends on parameterization

- The centering of JPL solution is closer to DORIS/SLR orbits, with respect to CNES gps-only dynamic orbit
  - Stronger tie of reduced dynamic orbits to the ITRF ?



Annual geocenter model ?

- Current standards only include the tidal (ocean loading) contribution to geocenter motion
- An annual geocenter correction applied in the next POD standards would
  - make DORIS/SLR based orbits centered at the instantaneous center of mass
  - clearly improve internal consistency with GPS-based orbits (whose centering in general depends on parameterization and solution strategy)
- Even though agreement between different geocenter models has improved (*)
  - A consensus model is not yet available in IERS conventions
  - Do all altimeter analysts need an orbit centered at the instantaneous center of mass? Needs to be clarified

(*) *Seasonal Geocenter Motion from Space Geodesy and Models* Ries, J.C. at GGOS Unified Analysis Workshop

Open points and proposed schedule

- **To be done before the end of the year**
  - **Test if any improvement in using EIGEN6S versus EIGEN-GRGS_RL02bis_MEAN-FIELD**
  - **Include JPL receiver phase maps consistent with JPL IGS08 orbits/clocks and IGS08 antex file**
  - **Revisit the relative weight of DORIS/SLR/GPS and carefully check the weight of SLR stations**
- **Proposed schedule**
  - **Switch to new GDR orbit standards in January 2012**
  - **Make final reprocessed orbits for all missions (Jason-1, Jason-2, Envisat, Cryosat-2, HY2A) available at the same time**

Conclusions

- Long term variations of the gravity field must be taken into account for multi-mission regional MSL analysis
- CNES POD team suggests to adopt the new orbit standards, which have proven to give accurate results over the 2002-2011 time span
- We cannot predict how the gravity field will evolve, but
  - we will carefully monitor the difference between dynamic (operational) orbits vs reduced dynamic orbits (internal solutions, jpl-gps solutions, gsfc dl solutions)
  - as long as they are available, compare orbits using the mean field with orbits using the 10-day series of Grace derived fields
  - Time-varying gravity field solutions inferred from Grace data remain a fundamental input for the analysis of mean-sea level, especially on a regional scale – without these time series, we wouldn't know that gravity is still the major source of error in orbit solutions
- Neglected annual geocenter motion is likely provoking the discrepancies observed along the N/S direction between solutions using different tracking techniques. A geocenter model could be introduced in POD computation at a later stage, once a consensus model is made available in the IERS conventions
  - Will require full reprocessing
- Orbit reprocessing tasks can now run in parallel on CNES linux cluster, computing time is no more an issue (all missions can be reprocessed in few hours)