

A Review of IDS Processing for ITRF2008 and Avenues for Future Improvements

F.G. Lemoine¹, J.J. Valette², G. Moreaux², P. Willis^{3,4},
L. Soudarin², P. Stepanek⁵, M. Otten⁶

- ¹ NASA Goddard Space Flight Center, Greenbelt, Maryland, U.S.A.
- ² Collecte Localisation Satellites, Ramonville Saint-Agne, FRANCE
- ³ Institut de Physique du Globe de Paris, Paris, FRANCE
- ⁴ Institut Géographique National, FRANCE
- ⁵ Geodetic Observatory Pecny, Ondrejov, CZECH REPUBLIC
- ⁶ European Space Operations Centre, Darmstadt, GERMANY



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Outline

- I. Introduction
- II. Overview of AC's.
- III. Significant improvements for ITRF2008
 - SRP; • Grace gravity models; • Drag parameterization.
- IV. Processing Standards
- V. Orbit comparisons
- VI. Design of Combinations.
- VII. Results.
- VIII. Lessons learned & Issues
 - SPOT-5 SAA; DORIS Time-bias;
- IX. Future work. Analysis campaigns.



DORIS Ground Network



Colocations: GPS (~37); SLR(9); VLBI(7); Tide gauges (~23)

Ground ties (< 3 mm): GPS-DORIS, ~25; DORIS-DORIS; ~45

IDS Analysis Centers Participating in ITRF2008

Analysis Center	Acron.	Contact & Reference	Software
ESA/ESOC , Germany European Space Agency/European Space Operations Center	ESA	<i>Michiel Otten Otten et al. (2010)</i>	NAPEOS
Geoscience Australia Canberra, Australia	GAU	<i>Ramesh Govind Govind et al. (2010)</i>	GEODYN
Geodetic Observatory Pecny , Czech Republic	GOP	<i>Petr Stepanek Stepanek et al. (2010)</i>	BERNESE 5.0
NASA Goddard Space Flight Center , (GSFC), USA	GSC	<i>Karine Le Bail Douglas Chinn Frank Lemoine Le Bail et al. (2010)</i>	GEODYN
IGN/IPGP , France Institut Géographique National (IGN)/ Institut de Physique du Globe de Paris (IPGP)	IGN	<i>Pascal Willis Marie-Line Gobinddass Gobinddass et al. (2009a;2009b)</i>	GIPSY/OASIS 5.0
INASAN , Institute of Astronomy, Russian Academy of Sciences, Russia	INA	<i>Sergey Kuzin Suriya Tatevian Kuzin et al. (2010)</i>	GIPSY/OASIS 4.03
CLS/CNES , France Centre National d'Etudes Spatiales Laboratoire d'Etudes en Géophysique et Océanographie Spatiale Collecte Localisation Satellites	LCA	<i>Laurent Soudarin</i>	GINS/DYNAMO

IDS AC's Included in ITRF2005



Preparations and Improvements Implemented for IDS ITRF2008 Processing (1)

Needed new a priori for ITRF2008 processing

DPOD2005 (*Willis et al., Adv. Space Res., 44, 535-544, 2009*)

- Extend ITRF2005 for POD/Altimetry applications.
- Fix anomalies: e.g. Arequipa.
- Specify periods when data should be deleted (station anomalies).
- Test on TOPEX/Poseidon & Jason 1.
- Verify with available GPS & DORIS data.

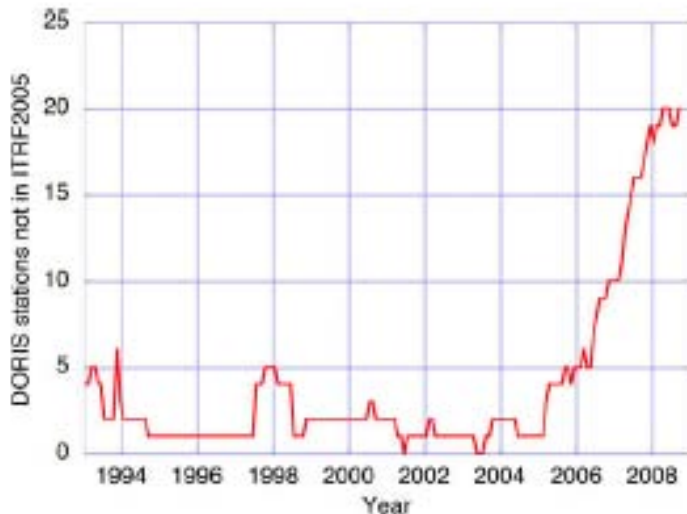


Fig. 2. Number of DORIS observing tracking stations not in the original ITRF2005 solution (per month).

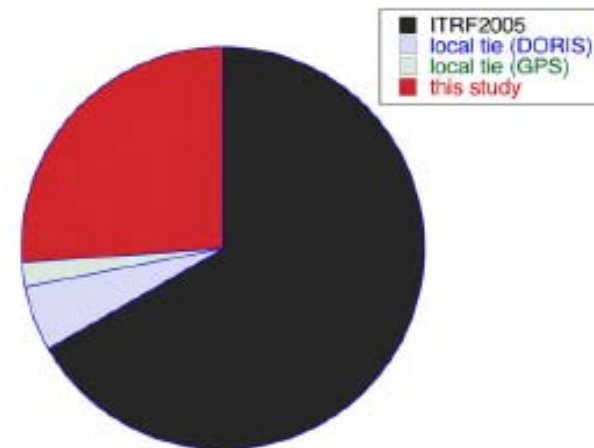


Fig. 6. Origin of DPOD2005 coordinates (statistics).

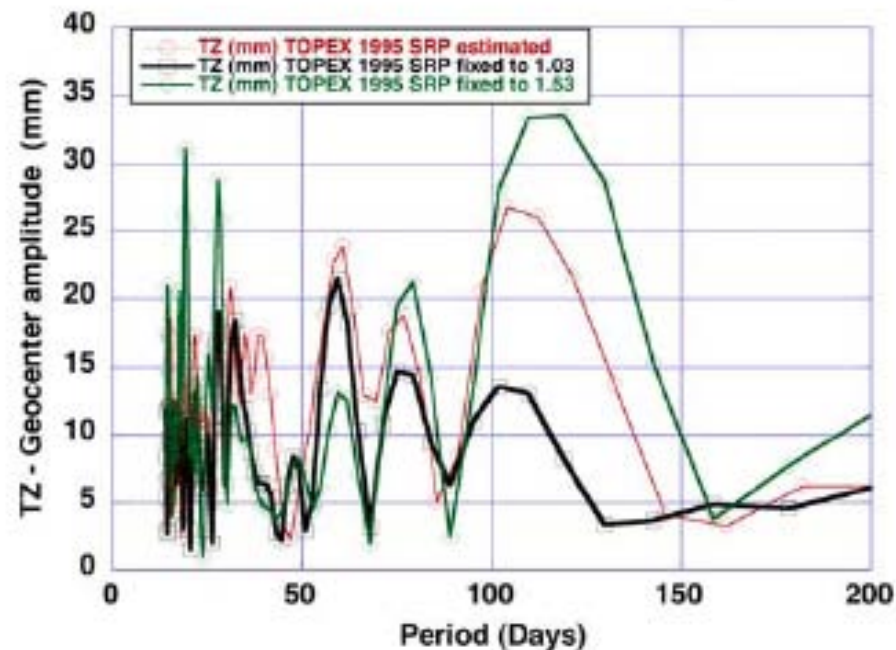
Preparations and Improvements Implemented for IDS ITRF2008 Processing (2)

Solar Radiation Pressure Modelling Improvements

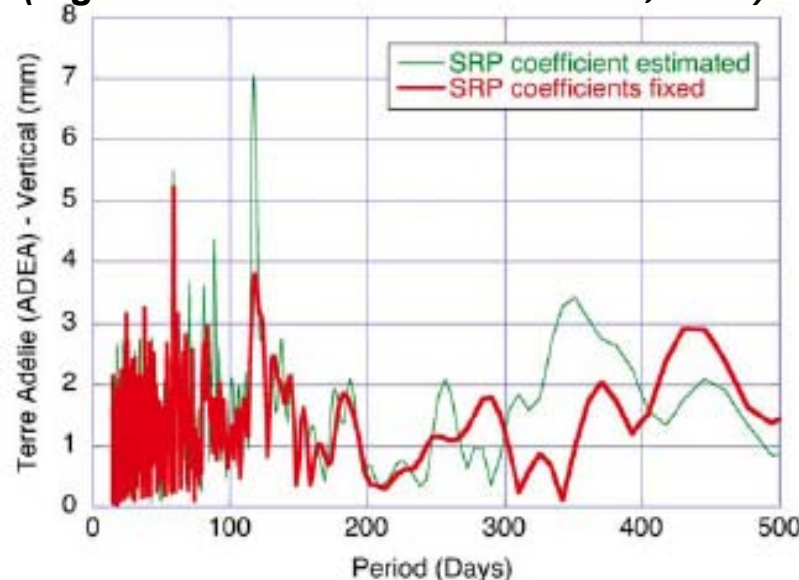
(Gobinddass et al., *J. Geodesy*, 83, 849-855, 2009)

- SRP Mismodelling impacts particularly TZ geocenter at beta-prime (draconitic) period (~120 days TP; ~annual for SPOT/Envisat).
- Mismodelling generates “extraneous” signal in station coordinates at those frequencies.
- Solution: Tune Cr (Reflectivity Coefficient) & Hold Fixed.

- Alternate solution: (Le Bail et al., *Adv. Space Res.*, 2010). Tune specific parameters of macromodel.



(Fig 5 & 8 from Gobinddass et al., 2009)



Preparations and Improvements Implemented for IDS ITRF2008 Processing (3)

Drag Modelling Parameterization

(Gobinddass *et al.*, *Adv. Space Res.*, *in press*, 2010)

- Low-altitude DORIS satellite affected by atmospheric drag (esp. SPOT, Envisat, ~800 km).
- Drag errors can bias pole determination and worsen station coordinate estimation.
- DORIS data density are sufficient to adjust C_d more frequently (1/hr or 1/2hr) ... & this reduces error.

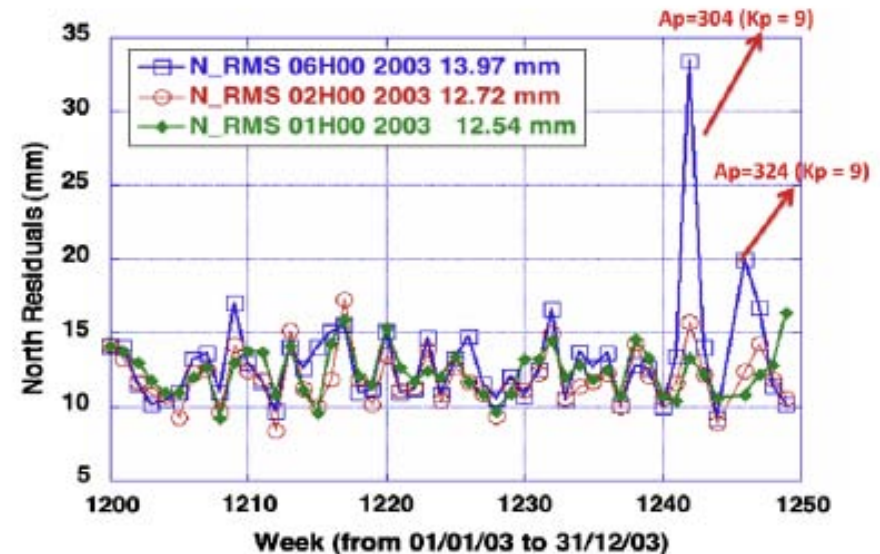


Fig. 7. Weekly DORIS station precision in the North component when using different strategies to reset the drag parameter.

Processing Standards Summary (1)

AC	Gravity	Atmos. Gravity	Ocean Tides	Troposphere + Met Data + Mapping Function	Elev. Cutoff (Deg)
ESOC	EIGEN- GL05C (120x120)	NCEP	FES2004	GMF+GPT + GMF	10°
GAU	GGM02C	NCEP	GOT4.7	Hopfield + GPT+ Niell	12°
GOP	EIGEN- GL04S (100x100)	ECMWF	CSR3	GMF+ GPT + GMF	10°
GSC	EIGEN- GL04S1 (120x120)	ECMWF	GOT4.7	Hopfield + GPT+ Niell	10°
IGN	GGM03S (120x120)	-	FES2004	GMF+ formula +GMF	10°
INA	GGM01C (120x120)	-	CSR3	Lanyi+ formula+ Lanyi	15°
LCA	EIGEN- GL04S	ECMWF	FES2004	(1)	12°
(1) After 2002. Dry and Wet Interpolated from ECMWF grids; Before 2002, use DORIS Met. Data. Mapping function Guo and Langley (2003).					

Table 3a, Valette et al., 2010.

Processing Standards Summary (2) (Nonconservative force models)

AC	Solar Radiation Pressure Modelling	Atmosphere Density Model	Drag Coefficient Estimation	Planetary Radiation Pressure
ESOC	Envisat : ANGARA Doombos et al. (2002) T/P & SPOT's : Box-wing	MSIS90	Cd/2.4 hrs	Knocke et al. (1988)
GAU	T/P, SP2, SP3 : GSFC(1) box-wing (untuned) SP4, SP5, Envisat : CNES box-wing (untuned) (2)	MSIS86	SPOT's & Envisat : Cd/6 hrs T/P : Cd/8hrs	Knocke et al. (1988)
GOP	N/A (3)	N/A (3)	(3)	N/A (3)
GSC	T/P, SP2, SP3 : GSFC (tuned) (1) SP4, SP5 : CNES (tuned) (2) Envisat : UCL, Sibthorpe (2006)	MSIS86	SPOT's & Envisat : Cd/2hrs. Cd/1hr 2001-2002 T/P : Cd/8 hrs	Knocke et al. (1988)
IGN	CNES box-wing (tuned) Gobinddass et al. (2009)	DTM94	SPOT's & Envisat : Cd/1hr T/P :Cd/day	Knocke et al. (1988)
INA	CNES box-wing (untuned) (2)	DTM94	SPOT's & Envisat : Cd/6hrs T/P : Cd/day	Not Applied
LCA	CNES box-wing (untuned) (2)	DTM94	T/P: Cd/12 hrs SPOT's & Envisat: Cd/4 hrs Cd/1 hr 2001-2002	Albedo & IR values from 6-hr ECMWF grids

(1). See Le Bail et al. (2010) for GSFC macromodel summaries.

(2). CNES macromodels available from the IDS data centers.

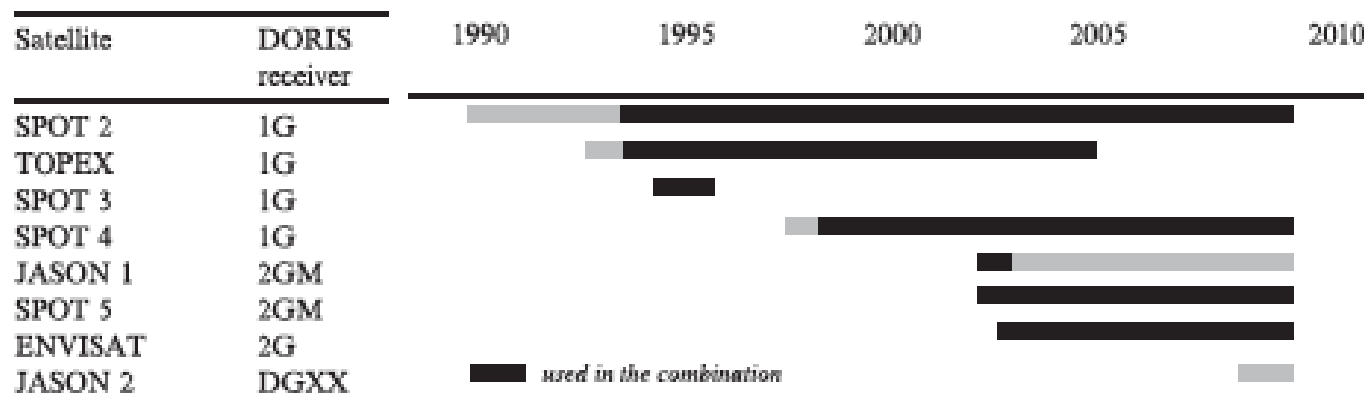
(3). No exact models for non-conservative forces. Empirical constant and harmonic parameters in Sun and y-directions ; Stochastic parameters along-track every 15 minutes (Stepanek et al., 2006)

Analysis Center Orbit Comparison & Validation Summary

(SPOT5 example for 2005)

Series Compared (<i>RMS orbit diffs., cm</i>)	Radial	Cross-tr.	Along-tr.	N
AUS5 vs GSFC-base.	0.36	2.20	1.26	48
AUS5 vs GOP	1.54	4.60	5.44	27
AUS5 vs IGN3	1.25	4.33	3.59	328
GOP vs GSFC-10dg	1.51	4.68	5.37	30
IGN3 vs GSFC-base.	1.29	4.33	4.38	356
GOP vs IGN3	1.69	4.44	5.44	28
IGN3 vs GSFC-base.	1.26	3.77	4.47	359
IGN3 vs INA2	0.93	2.04	1.89	285
IGN3 vs LCA	1.23	3.62	3.20	312
INA2 vs GSFC-10dg	1.39	4.13	4.57	287

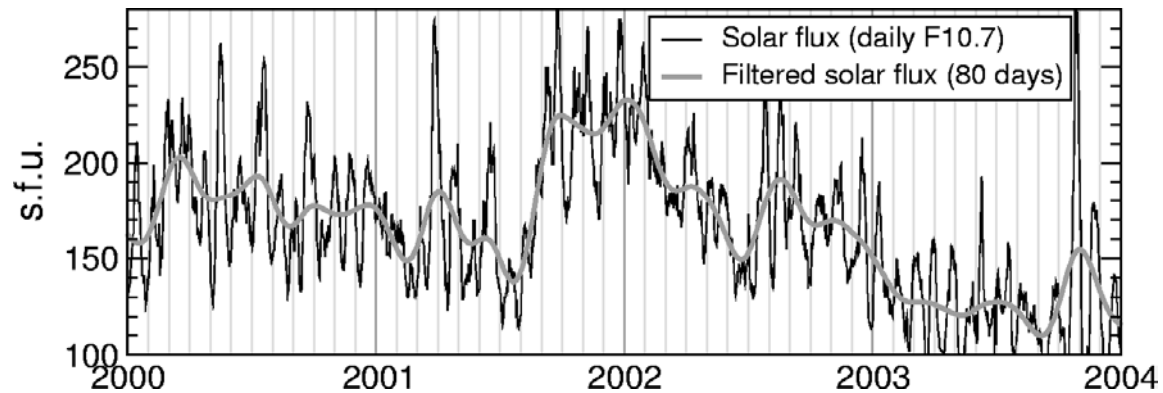
DORIS data used in ITRF2008



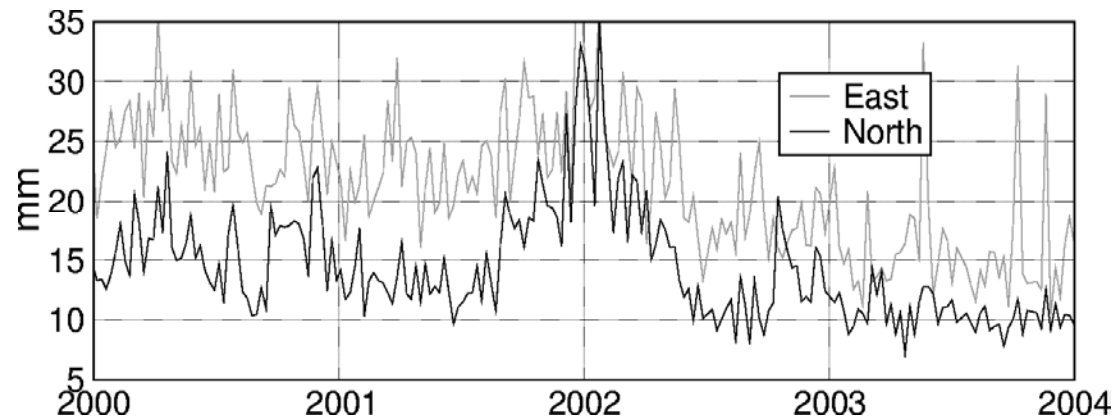
- 1993 to end of 2008.
- TOPEX, SPOT2, SPOT3, SPOT4, SPOT5, Envisat.
- Only 1 yr of Jason 1 (one AC) due to Instability of Jason-1 DORIS USO.
- No Jason-2 (Launched in June 2008) since POD modelling was not validated before submissions had to be completed.

ITRF2008 results (1)

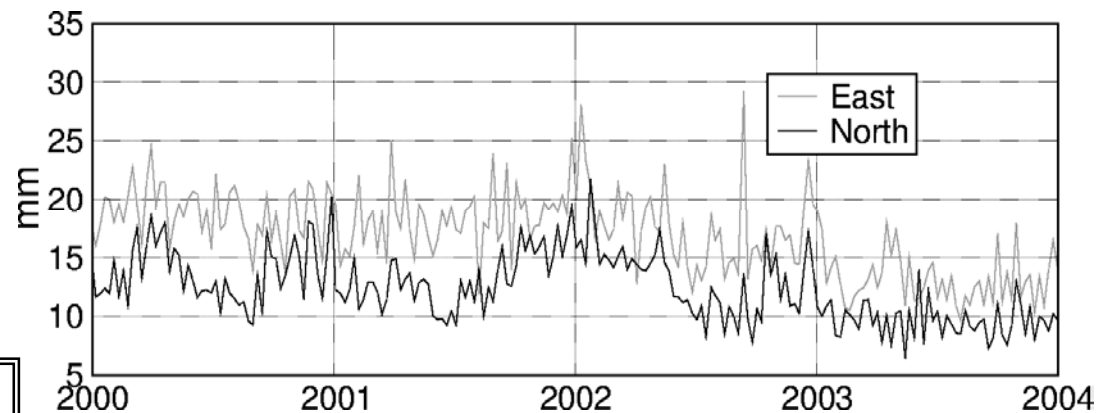
Solar Flux



IDS-1
Horizontal Residuals



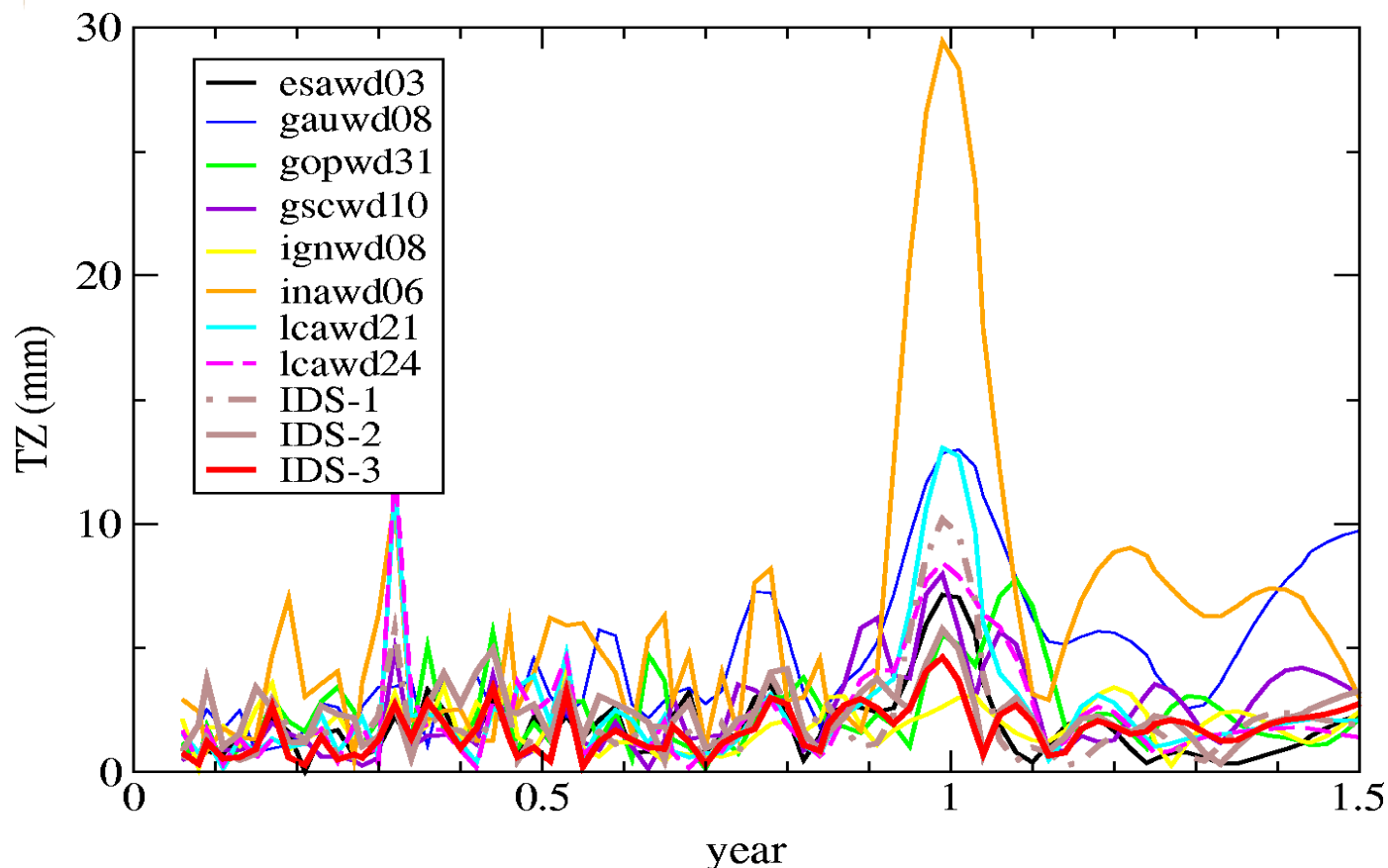
IDS-3
Horizontal Residuals



*After 2 AC's reprocessed
data with more frequent cd
parameterization*

Valette et al., 2010.

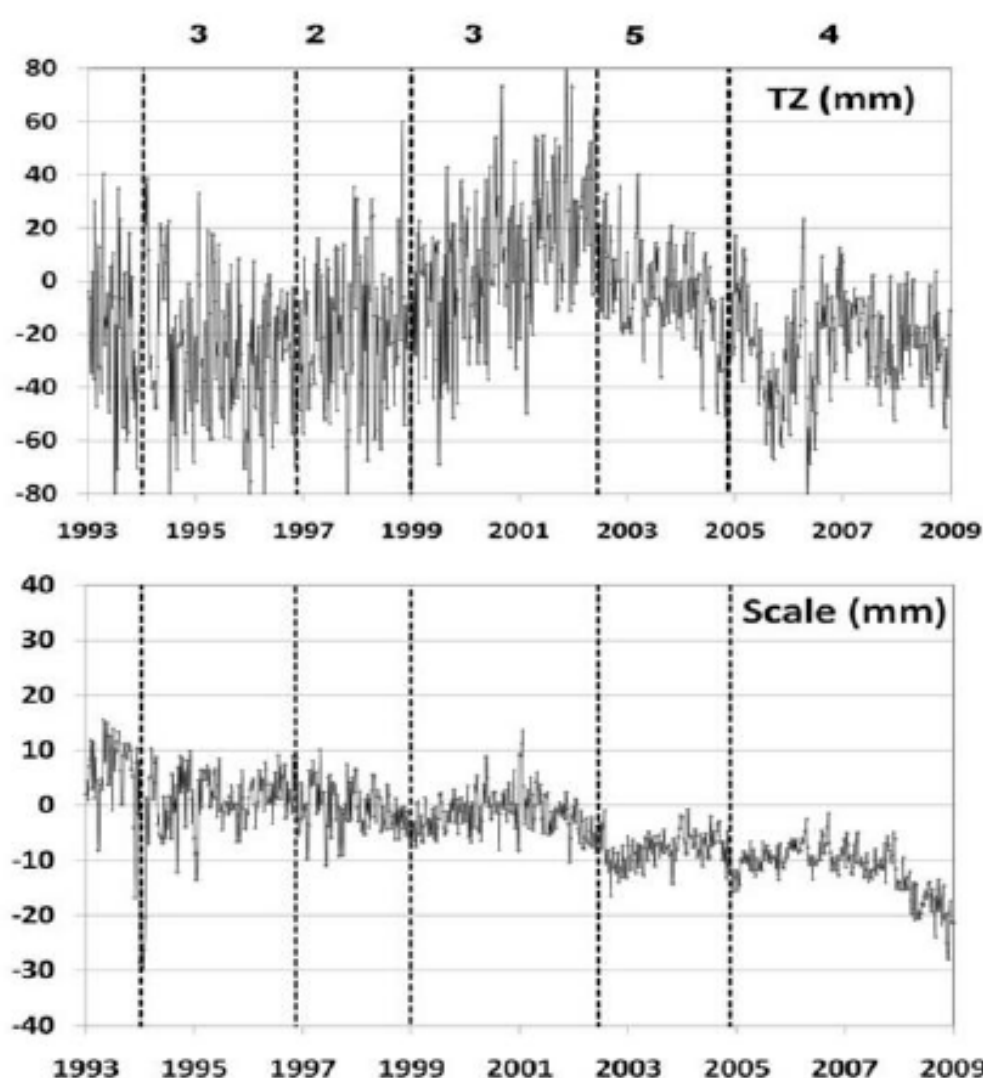
Definition of the IDS Combination



Valette et al., 2010

- Gobinddass et al. (2009) improved geocenter modelling by tuning & fixing Cr coefficient for each satellite.
- Analyzed the geocenter & scale time series of each AC contribution and looked at the 365-day and 118-day signals.
- This information used to define which AC's contribute to Combination geocenter & scale.

IDS-3 Geocenter & Scale (wrt ITRF2005)



(sat #)

Solar cycle signal?

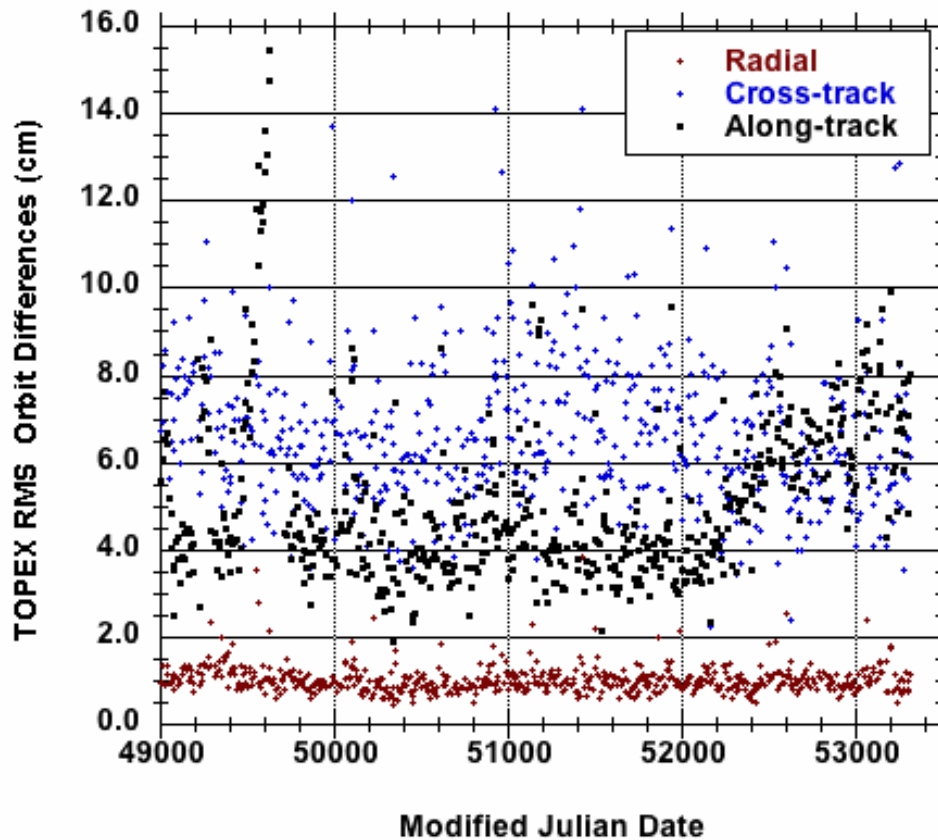
Discontinuities in
scale related to
satellites entering or
leaving solution?

Valette et al., 2010

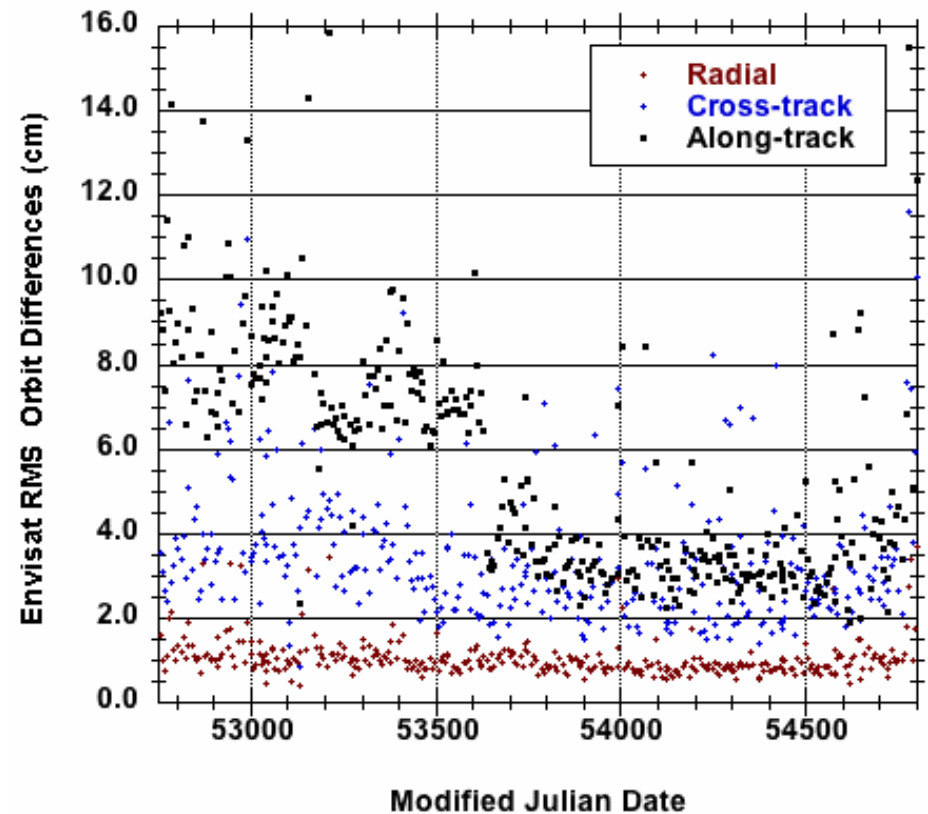
DORIS system time-bias (wrt. SLR)

(SLR/DORIS vs DORIS-only Orbit Differences)

TOPEX



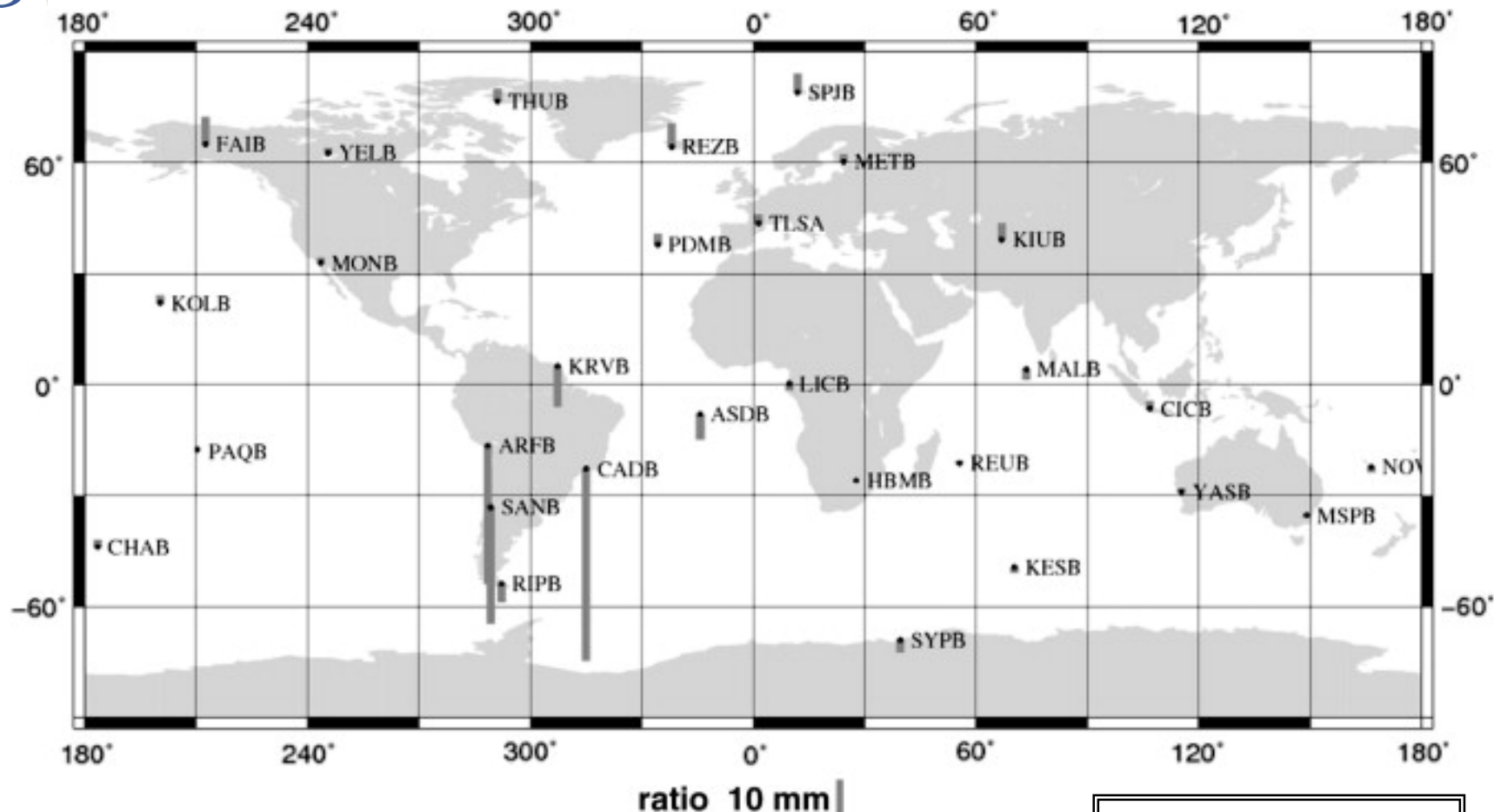
Envisat



Le Bail et al. 2010.

But what to do for the SPOT satellites?

SPOT-5 Anomaly?

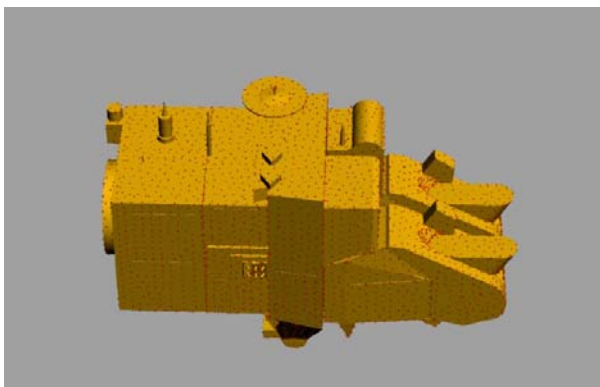


Stepanek et al. 2010.

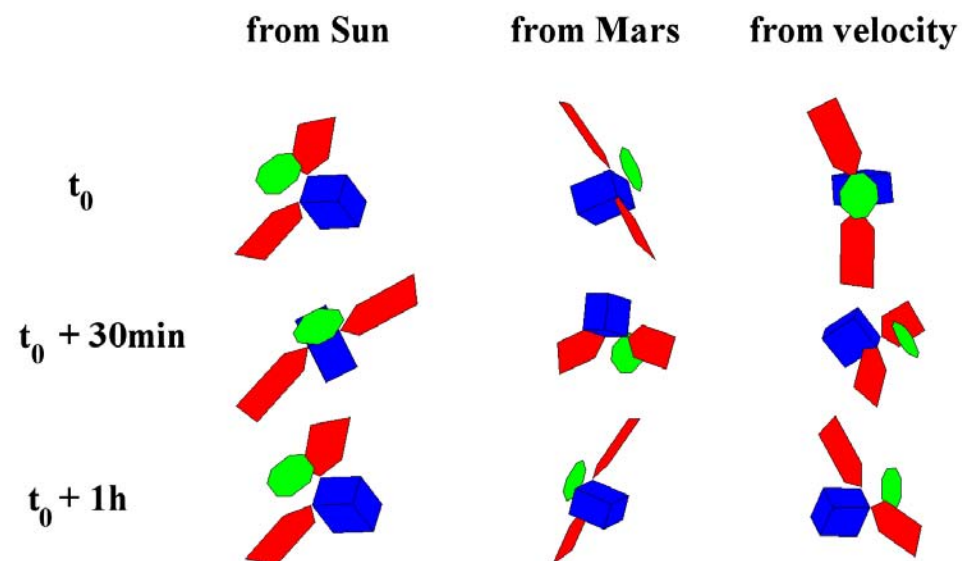
ZTD DORIS-GNSS “Double differences” (ΔZTD_2) between average value of the SPOT-2,4, Envisat individual solutions and the SPOT-5 solution.

All AC's used DTM94 or MSIS86. Use newer atmosphere models? (e.g. GRACE-derived; or JB2006, Bowman et al., 2008-J. Atmos. Sp. Physics)

UCL models for SPOT's & Cryosat-2?

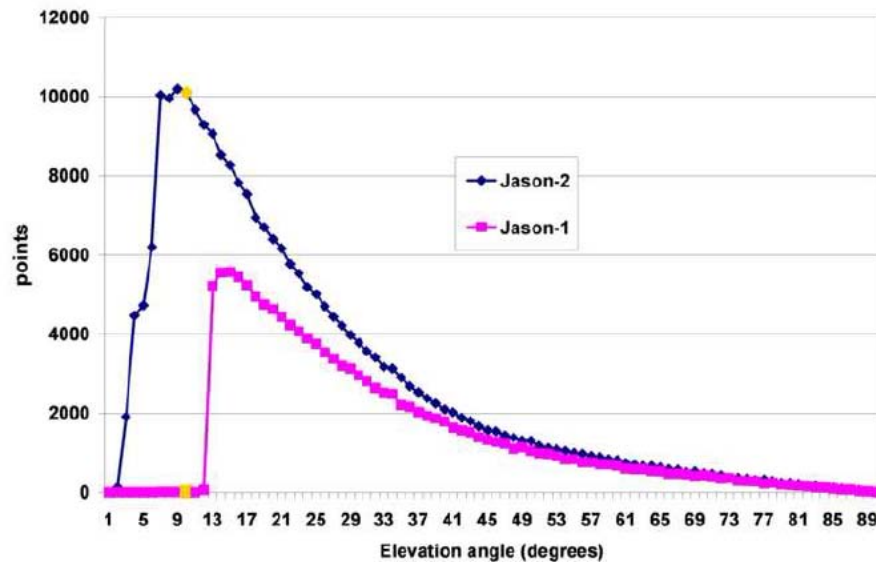


Self-shadowing as in *Mazarico et al., 2009, J. Spacecraft Rockets*, for MRO?



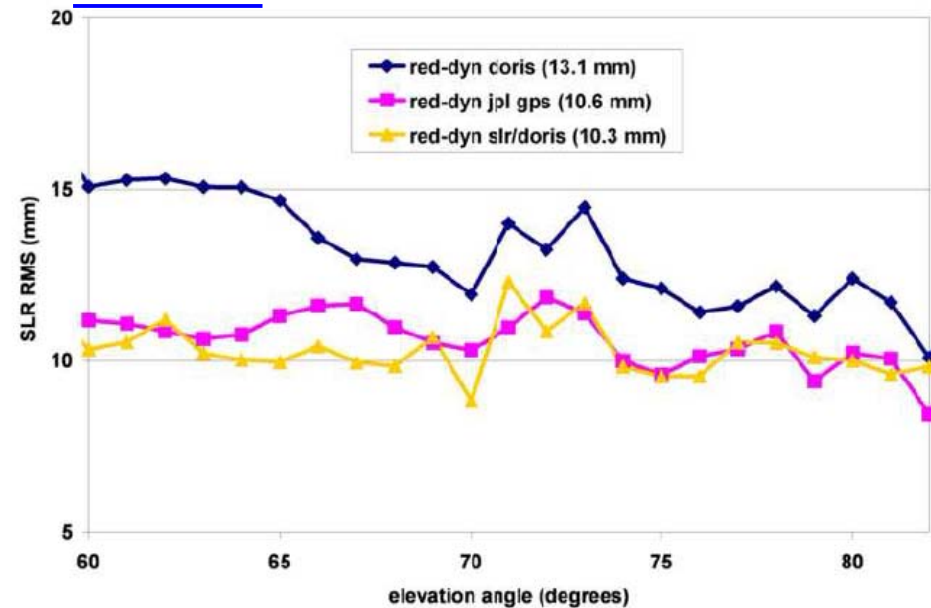
Spacecraft attitude at three different orbital positions - view from different directions.

DORIS data vs. Elevation



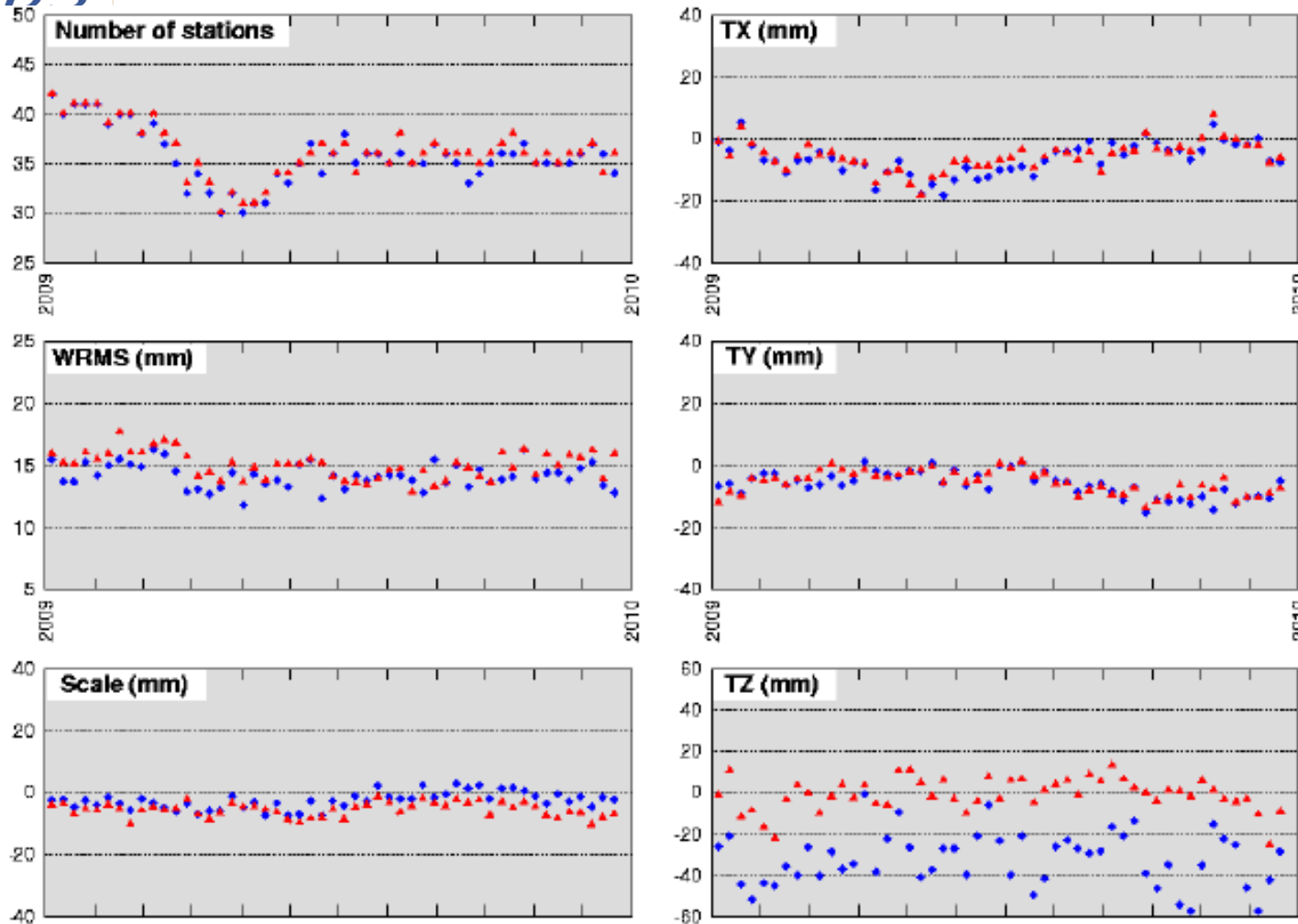
**New Jason-2 DGXX Receiver
delivers at least 2X data of
previous receivers.**

High-elevation SLR Residuals for different orbits



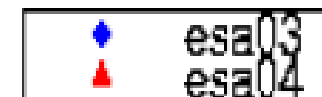
Zelensky et al. 2010.

Preliminary combinations with (esa04) & without (esa03) Jason2



Higher stability & better centering of TZ

Valette & Moreaux, IDS AWG Darmstadt, May 2010.





Summary

1. The IDS for the first time constructed an technique-level combination based on analysis by seven independent analysis centers (5 separate software packages).
2. Our goals in the near future are - integrating new satellites into the solutions (Jason2 & Cryosat2) - and developing a routine weekly combination.
3. Issues that need to be investigated: (1) time biases on DORIS data; (2) improved non-conservative force modelling for DORIS satellites; (3) better troposphere modelling including mapping functions; (4) SPOT-5 Anomaly.
4. DORIS workshop is scheduled in Lisbon, Portugal in conjunction with Jason SWT meeting (October 18-22, 2010).
5. For more details see DORIS special issue in Adv. Space Research, 2010 (two volumes).
6. **For more information see URL <http://ids-doris.org>**



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*International
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**Willis, P., Fagard, H., Ferrage, P., Lemoine, F.G., Noll, C.E; et al., (2010).
The International DORIS Service, Toward maturity, *Adv. Space Research*, 45(12),1408-1420, DOI: 10.1016/j.asr.2009.11.018. <===== NEW IDS CITATION.**

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Satellite Status & Future Missions

CRYOSAT-2 (ESA) <i>(launched April 2010. Data now available from IDS data centers).</i>	717 km, 92°	DGXX+SLR
ENVISAT (ESA) <i>(17 km orbit reduction planned in Oct. 2010).</i>	800 km, 98.5°	D2G +SLR
SARAL/ALTIKA (ISRO/CNES) <i>(Launch: January 2011)</i>	880 km, 98.5°	DGXX+SLR
HY2A (CNSA) <i>(Launch: June 2011; Then HY2B, HY2C)</i>	963 km, 99.3°	DGXX+SLR+GPS
SENTINAL 3A (GMES) <i>(Launch: April 2013)</i>	814 km, 98.6°	DGXX+SLR+GPS
JASON-3 (NOAA/EUMETSAT/CNES/NASA) <i>(Summer 2013; Follow-on to TOPEX, Jason-1, Jason-2)</i>	1336 km, 66°	DGXX+SLR+GPS
SWOT (NASA/CNES) <i>(Surface Water Ocean Topography; Launch 2018)</i>	970 km, 78°	DGXX+SLR+GPS