DORIS data analyses at Geodetic Observatory Pecný

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GOP analyses center

- Geodetic Observatory Pecný, Research Institute od Geodesy, Topography and Cartography , Ondrejov, dist. Prague-East, Czech republic
- Modified version of Bernese GPS software
- DORIS data analyses since 2004
- Official IDS analyses center since 2007
- Standard weekly solutions
- Participation on IDS campaigns
- Own investigations
- Developed dynamical orbital model (joint project with TUM)
- ITRF reprocessing

GOP ITRF reprocessing 2013 vs. 2008

- **Data span 1993.0-2014.0**
- **Dynamical orbit modeling instead of empirical-stochastic approach**
- **Corrected minor error in ocean tides model application (gravity)**
- **Ground antenna phase center law (Alcatel and Starec)**
- **IERS 2010 conventions**
- **Time-varying gravity field model EIGEN-6S2 after 2002.0**
- **SPOT-5 SAA corrected data**

Detail description http://ids-doris.org/contribution-itrf2013.html

New dynamic orbit model vs. old empirical-stochastic model

Modeling	For ITRF 2008	For ITRF 2013
Satellite attitude and geometry	Not considered	Nominal Box-Wing model
Atmosphere density model	Not applied	MSIS-86
Atmosphere drag	Absorbed by along track stochastic parameters	Scaling coefficients estimated
Solar radiation pressure	Absorbed by empirical constant parameter in sun-satellite direction	Scaling coefficient estimated
Earth radiation	Not applied	A priori model, visible and infrared radiation
1-per revolution empirical modeling	Sun-Satellite and Y-direction (constrained)	Along and cross track (?)
Additional empirical parameters	Constant Y-direction*	No

Orbit parameters

- **Strategy optimized according to testing results summarized in** Stepanek et al. 2014. Impact of orbit modeling on DORIS station position and Earth rotation estimates, ASR, http://dx.doi.org/10.1016/j.asr.2014.01.007
- **Contrary to other ACs, <u>SRP is not fixed on pre-defined values</u>**
- **Data processed in iterative process**
  - **first iteration: 1 SRP/day, 1drag/day, no 1-rev parameters**
  - **second iteration: 1 SRP/day, 6 drag/ day (T/P, Jason) or 48 drag/day („low“ satellites), 1-rev parameters**
    - SRP and drag estimates from 1st run taken in second iteration as a priori with constraints
    - SRP in second iteration strongly constrained (nearly fixed) 0.0001
    - Drag softly constrained in second iteration (constraint =1).
- **Two version, with adjustment of cross track harmonics (wd42) and without (wd43)**
  - **Adjustment of cross track harmonics degrades the ERP estimation, while does not improve station parameters.**
  - **Albedo CERES model (Latitude, Longitude and time dependent)**

Modeling issues

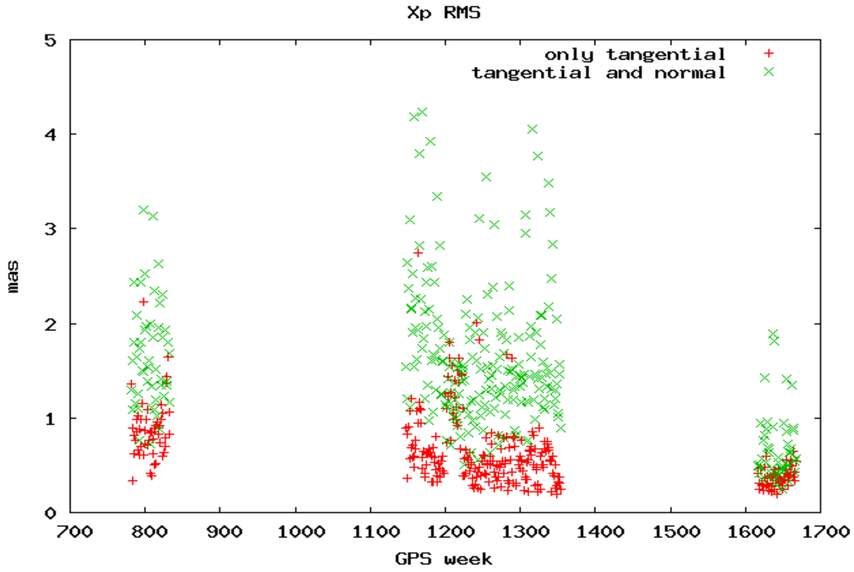
- **testing campaign 2011.0-2012.0**
- **how frequently estimate the drag scaling coefficient for low satellites?**
  - 30 minutes better than 2 hours (30 minutes or 1 hour?)
- **are the cross track harmonics realy helpful?**
  - no geocenter improvement
  - slight improvement of station RMS w.r.t. DPOD08 and std. dev.
  - pole Xp,Yp degradation

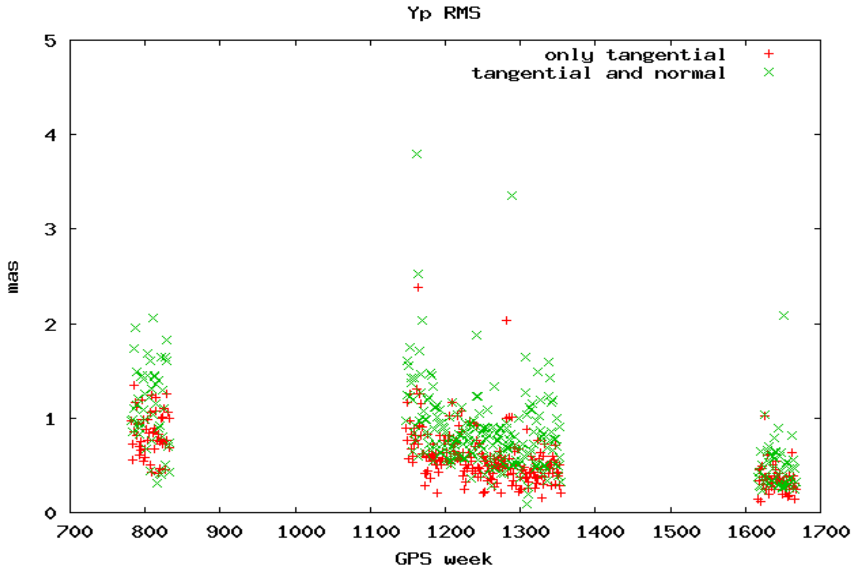
Sol.id.	Type of sol.	Drag/day (low sat)	1-rev harmonics	Annual mean Xp (mas)	Annual mean Yp(mas)	Std. dev. Xp (mas)	Std. dev. Yp(mas)
D-1	dyn	48	along, cross	0.49	0.38	0.75	0.58
D-2	dyn	48	along	0.25	0.33	0.53	**0.53**
D-3	dyn	12	along, cross	0.44	0.38	0.74	0.57
D-4	dyn	12	along	0.19	0.36	**0.52**	**0.53**
E/S	emp-stoch	96 (stoch)	Sun-satellite	0.00	0.10	0.70	0.57

Sol.id.	Mean (mm and ppb) Tx	Ty	Tz	Sc	Std. dev. (mm and ppb) Tx	Ty	Tz	Sc	RMS (mm)	Std.dev. (mm)
D-1	-1.4	-4.9	1.3	0.10	4.1	4.9	12.3	**0.31**	**16.38**	**11.62**
D-2	-1.1	-4.7	-2.0	0.09	4.2	4.9	11.4	0.32	16.51	11.71
D-3	-0.4	-7.3	2.0	0.03	5.6	4.3	13.1	0.55	16.74	12.05
D-4	-0.3	-7.3	-0.9	0.02	5.6	**4.2**	12.1	0.54	16.91	12.14
E/S	-0.9	-5.9	3.2	**0.36**	**3.5**	4.9	**9.9**	0.34	16.79	11.86

Pole RMS w.r.t. C04 (weekly mean removed) – solution with and without adjustment of cross track harmonics

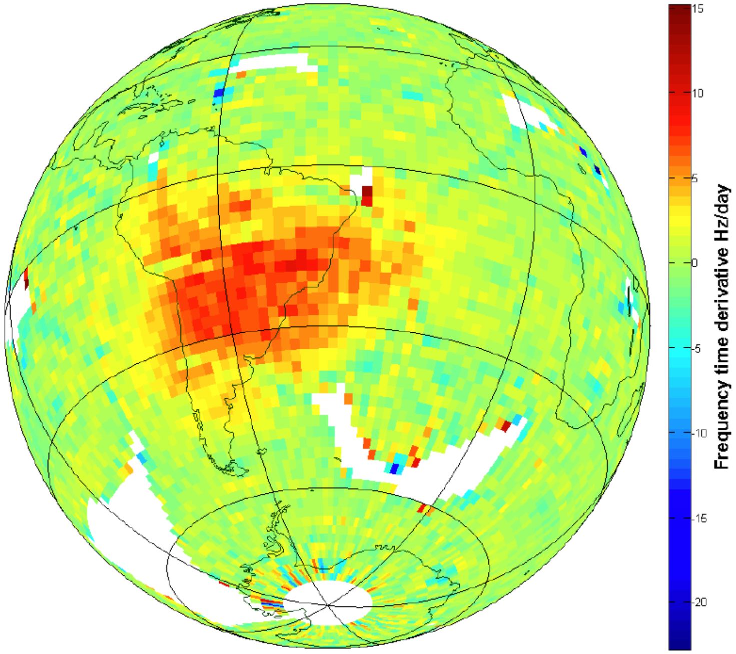
Red – without corss track harmonics
Green – with cross track harmonics

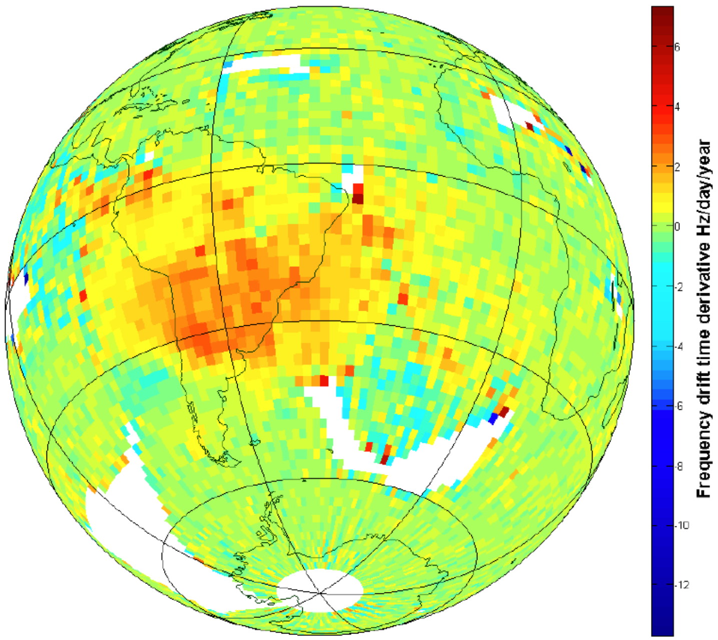




SPOT-5 SAA corrections

- We discovered the effect and developed first data corrective model for SPOT-5
- Out model is based on grid map, basic principles follows the approach of JM Lemoine corrective model for Jason-1
- Ground antenna phase center law (Alcatel and Starec)
- The grid map of Frequency drift and its time derivative fro data 2008.0-2012.0





GOP or LCA SPOT-5 data corrective model ?

- data span 2011.0 – 2012.0
- SPOT-5 solution compared to S4+EN+J2+CR solution
- ZTD compated to the GNSS estimates

	Unc. (mm)	GOP (mm)	LCA (mm)
Arequipa	-68	8	10
Cachoeira Paulista	-98	-17	13
Santiago	-54	4	8
Kourou	-35	-7	-4

ZTD bias w.r.t. GNSS PPP

	Uncorrected			GOP corrections			Reduction %	
	Lat mm	Lon mm	Up mm	Lat mm	Lon mm	Up mm	Horiz.	Vert.
Arequipa	101	-80	-162	35	18	-39	69	76
Cachoeira Paulista	-61	128	-330	-50	123	-79	6	76
Santiago	-170	-75	-131	-49	27	-8	70	94
Kourou	90	-54	14	19	-49	-22	50	-
Ascension	58	-16	-47	9	-8	-30	80	36
St-Helene	-19	55	-26	-25	-17	-18	48	31

Stations coordinate Bias – GOP corrective model

	Uncorrected			LCA corrections			Reduction %	
	Lat mm	Lon mm	Up mm	Lat mm	Lon mm	Up mm	Horiz.	Vert.
Arequipa	101	-80	-162	33	32	**-7**	64	96
Cachoeira Paulista	-61	128	-330	37	101	**13**	24	96
Santiago	-170	-75	-131	-25	58	**-24**	66	82
Kourou	90	-54	14	-8	-71	**-16**	32	-
Ascension	58	-16	-47	29	-55	**-10**	-	79
St-Helene	-19	55	-26	-26	19	**-4**	45	85

Stations coordinate Bias – LCA corrective model

Decision : both models strongly reduces the effect, but LCA model achieves better overall result -> LCA model applied in ITRF reprocessing

Jason-1 include or not?

- SAA corrected data, study 2005.0-2006.0
- Solutions 4X without Jason-1, solutions 5X with Jason-1
- reduces Tz bias, but degrades station WRMS and RMS w.r.t. DPOD
- Decision: not to include

RMS w.r.t. DPOD 2008

Sol.	North (mm)	East (mm)	Up (mm)
42	14.5	18.9	14.7
43	14.4	18.8	14.7
52	16.7	24.0	17.1
53	16.7	24.4	17.3

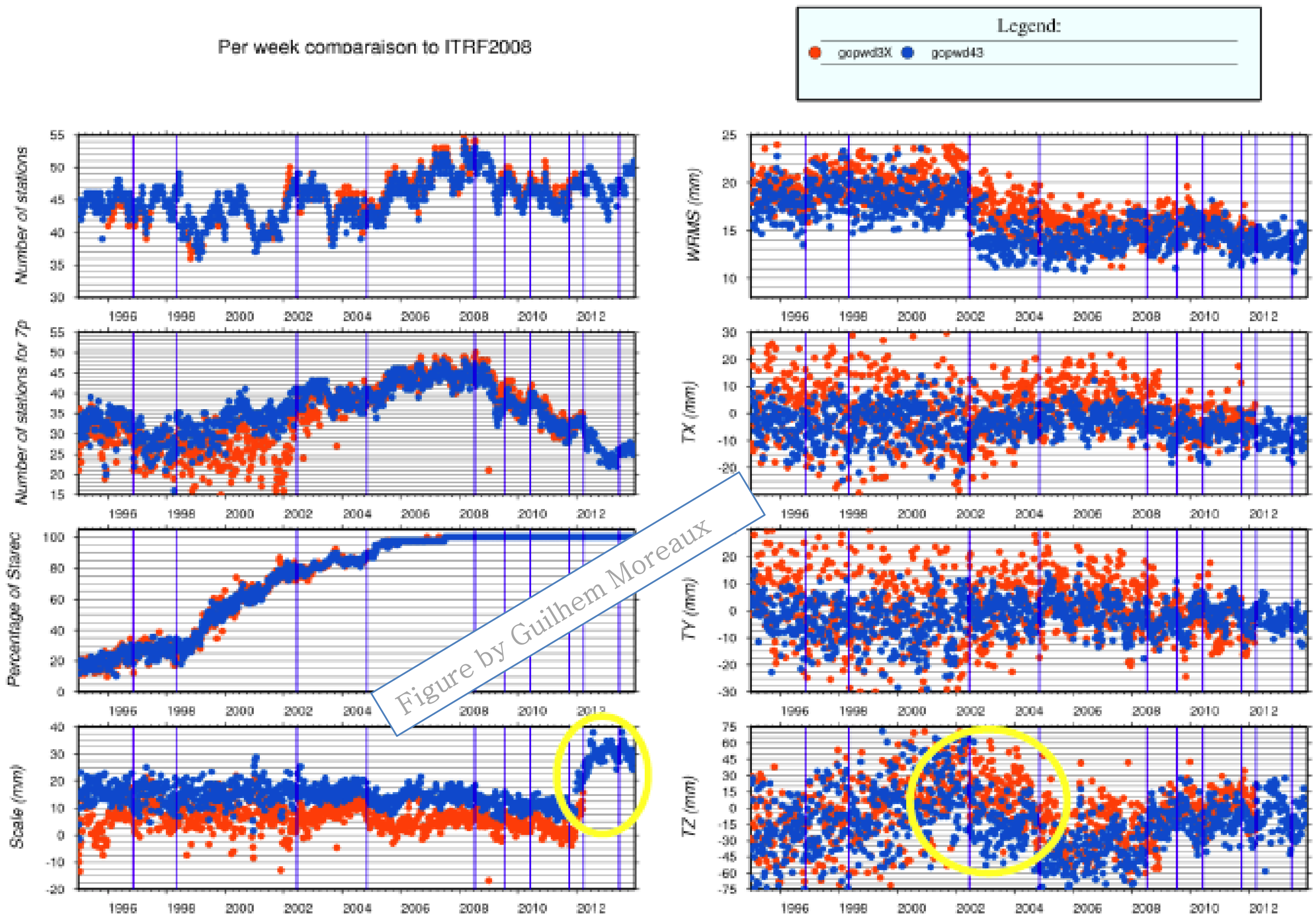
Repeatability WRMS

Sol.	North (mm)	East (mm)	Up (mm)
42	10.0	12.7	10.6
43	10.1	12.7	10.8
52	10.3	14.2	11.1
53	10.3	14.3	11.1

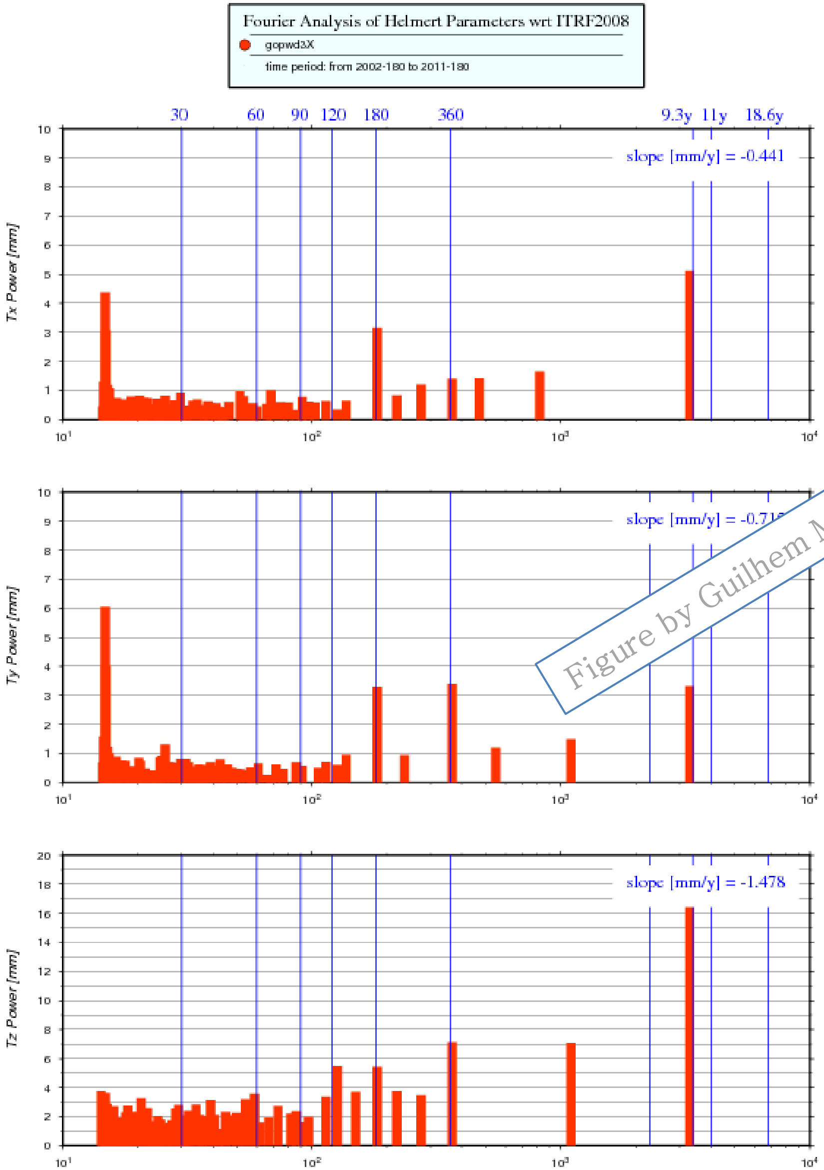
Helmert parameters w.r.t. DPOD08

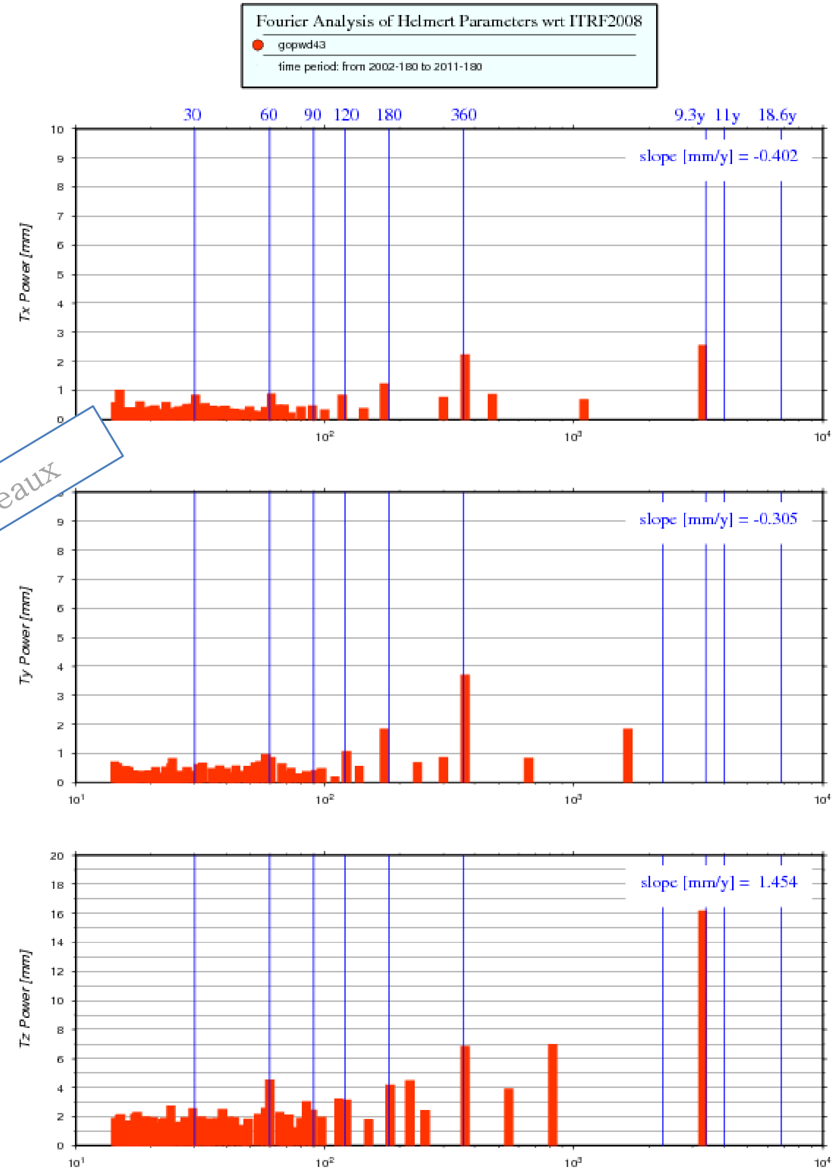
Sol.	Tx (mm)		Ty (mm)		Tz (mm)		Scale (mm)	
	Mean	RMS	Mean	RMS	Mean	RMS	Mean	RMS
42	-1.1	4.9	2.0	5.0	-45.7	15.6	14.2	2.2
43	-1.2	5.0	2.1	5.1	-46.0	16.4	14.0	2.2
52	-1.7	5.0	0.9	4.7	-24.2	18.4	15.6	2.2
53	-1.8	4.9	1.0	4.7	-25.5	17.6	15.5	2.4

GOP43 vs. GOP3X

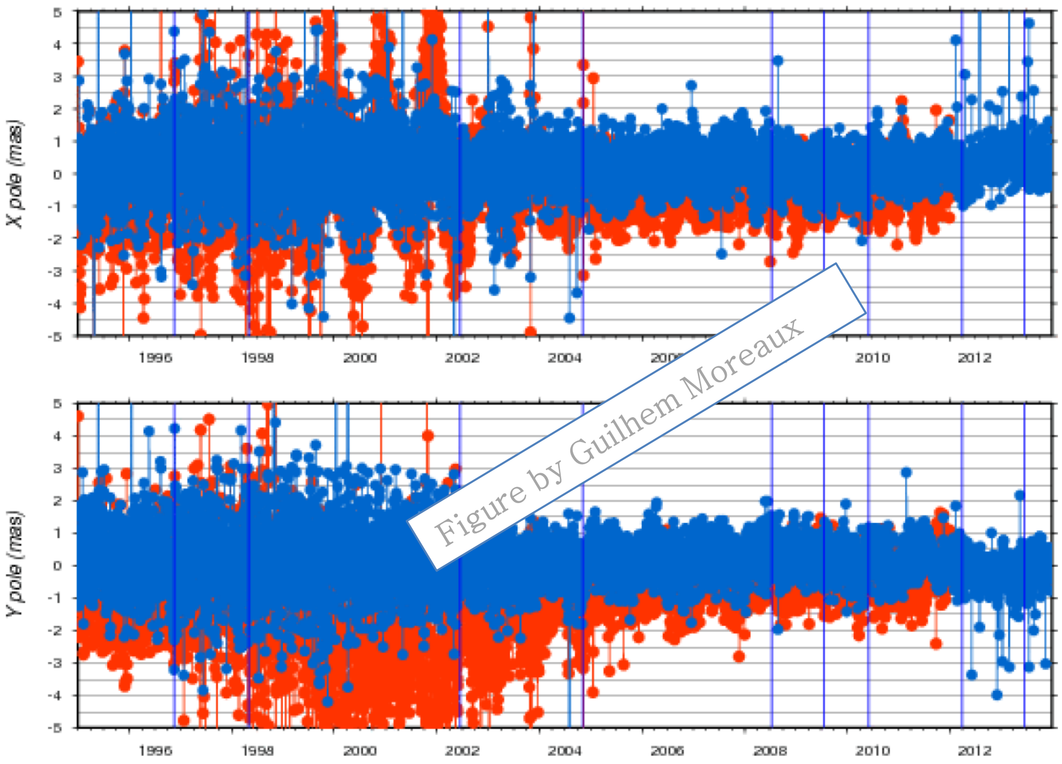


GOP43 vs. GOP3X





GOP43 vs. GOP3X

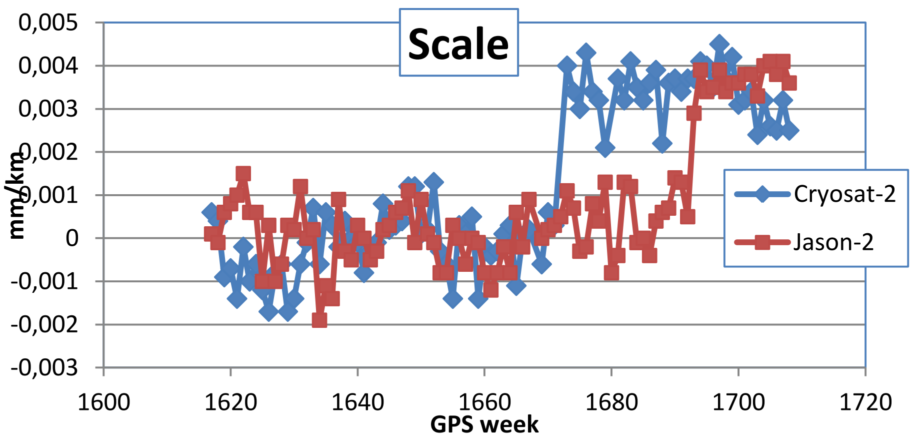


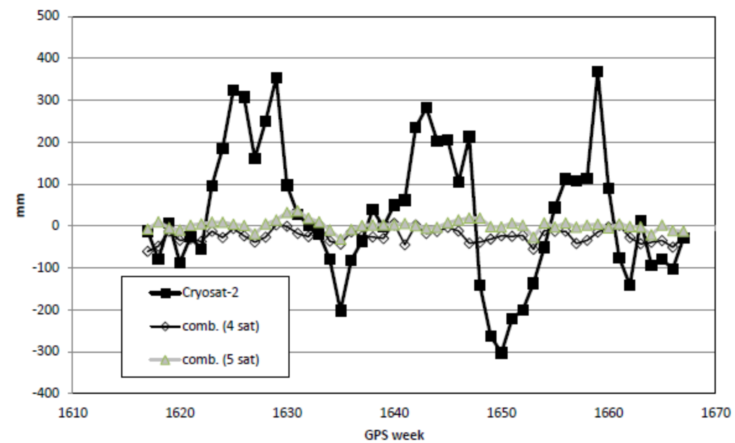
Comparison w.r.t. IERS C04 (mas)

Sol.	Xmean	Xrms	Ymean	Yrms
GOP3X	-0.291	1.167	-1.100	1.940
GOP43	0.231	0.689	0.155	0.694

Scale increment in 2012

- **From August 2011 to August 2012 the scale of GOP solution w.r.t. ITRF 2008 increased about 17 mm**
- **For the other ACs was the increment also detected, but not so strong.**
- **Hy-2A single addition in the solution the Envisat data termination do not explaine the total efect.**
- **In GOP single-satellite solutions were found about 20 mm scale „jumps" for Cryosat-2 and Jason-2**
- **Cryosat -2 week 1672/1673 (January/February 2012), Jason-2 week 1694/1695 (June/July 2012)**





Strong Tz signal in Cryosat solution

Period **106.2 ± 0.8** days, amplitude **193 ± 24 mm** (2011.0-2012.75)

For the multisatellite-solution without Jason-2 the amplitude is only 9.1 ± 3.2 mm (2011.0-2012.0)

For the **multisatellite**-solution including Jason-2 the amplitude is not significant **3.0 ± 2.3 mm** (2011.0-2012.0)

Recent publications:

Štepánek P, Rodriguez-Solano CJ, Hugentobler U, Filler V (2014). Impact of orbit modeling on DORIS station position and Earth rotation estimates, ADVANCES IN SPACE RESEARCH, 53(7): 1058-1070, DOI:10.1016/j.asr.2014.01.007

Štěpánek P, Douša J, Filler V (2013). SPOT-5 DORIS oscillator instability due to South Atlantic Anomaly: mapping the effect and application of data corrective model, ADVANCES IN SPACE RESEARCH, 52(7): 1355–1365, DOI:10.1016/j.asr.2013.07.010

Thanks for the Attention …..