The main results of the DORIS data processing in the INASAN Analysis Center for the ITRF2014

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IDS products delivered by INASAN AC for ITRF2014 validation

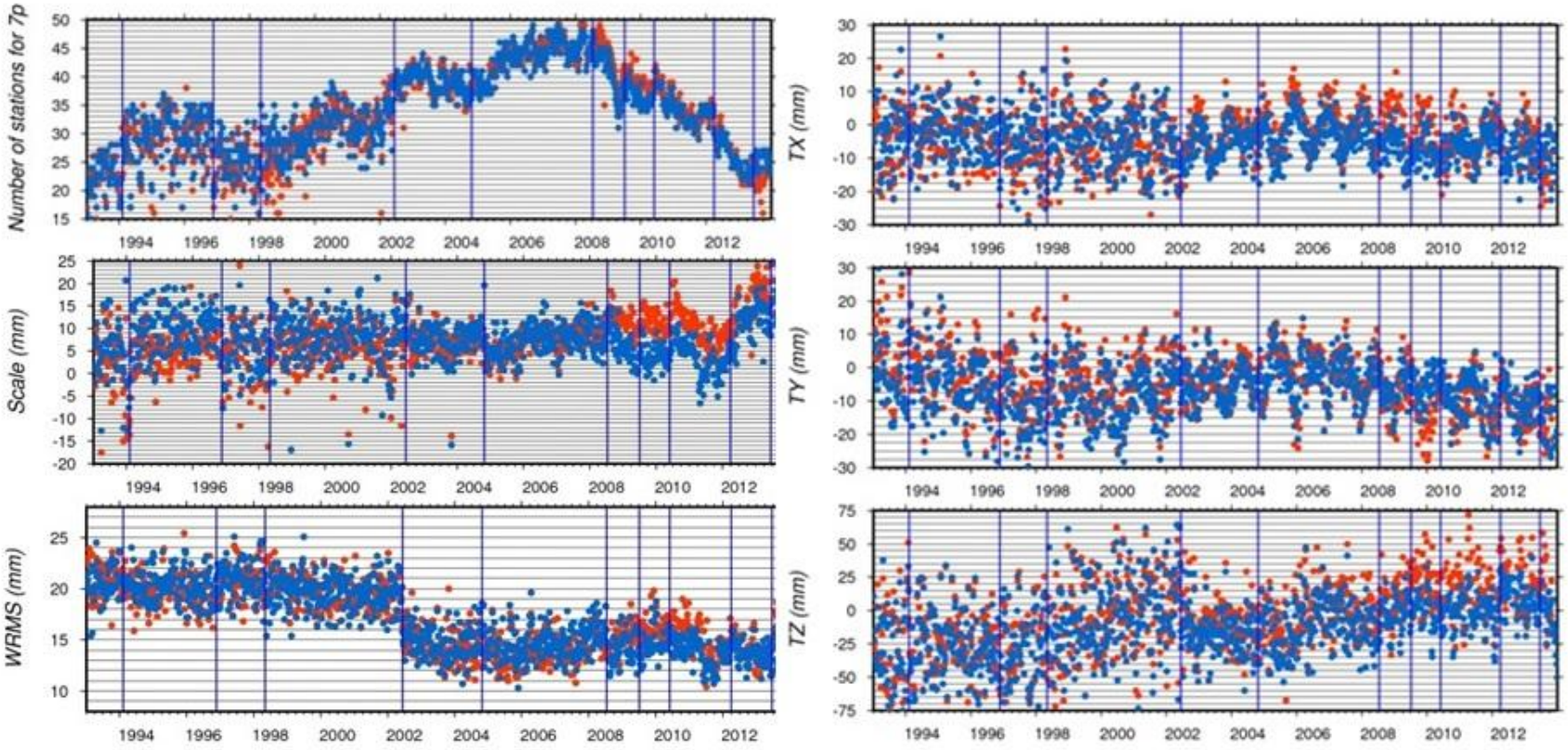
Product	Latest solution	Format	Data span
Weekly station coordinates and daily EOPs (free-network)	inawd08	SINEX	1993.0-2015.0
Station coordinates differences	ina14wd08	STCD	1993.0-2015.0
Weekly geocenter variations	ina10wd01	IDS	1993.0-2015.0
EOPs	ina10wd01	IGS	1993.0-2015.0

The main recent improvements in the inawd08 solutions, submitted to IDS for the ITRF2014 validation, compared to our previous solutions inawd07 include the use of the following updated models :

- a new time-variable gravity field model (GOCO02S)
- all types of tides
- polar motion and UT1 values (IERS bulletin A)
- DPOD2008_1.13 reference frame
- atmospheric density model DTM2000
- troposphere mapping function from the GMF model
- the new elevation angle cutoff (12 instead of 15 degrees)
- corrected data of SPOT-5 SAA (South Atlantic Anomaly) starting from 2006.0
- IERS2010 Conventions for the instrument reference point displacements
- different weights for the combination of the single satellite solutions

Weekly comparison of the INASAN inawd07 (red color) and inawd08 (blue color) solutions with the ITRF2008 solution

(figure by Guilhem Moreaux)

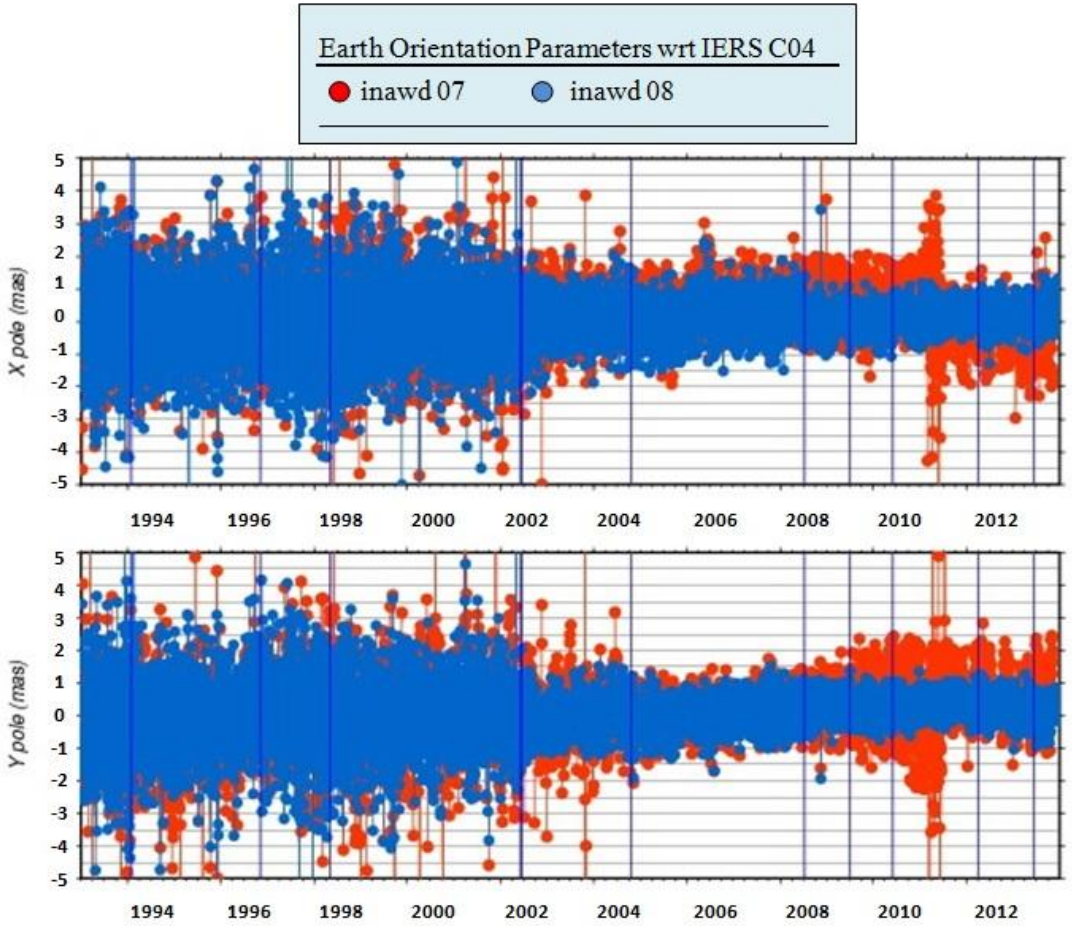


Comparative statistical characteristics (mean values) of the INA analysis center contribution to ITRF2008 (inawd07), ITRF2014 (inawd08) and IDS combined solution submitted for ITRF2014 realization (idswd09). The reference frame for comparison is ITRF2008 for all time series

AC series (time interval)	Scale (mm)	Tx (mm)	Ty (mm)	Tz (mm)	Scale rate (mm/year)	Tx rate (mm/year)	Ty rate (mm/year)	Tz rate (mm/year)
idswd09 (1993.0-2015.0)	13.23±4.01	-4.45±4.92	-3.45±5.45	-13.02±17.86	0.32±0.02	-0.17±0.02	-0.21±0.03	0.05±0.08
inawd08 (1993.0-2015.0)	7.44±5.41	-4.92±6.99	-6.58±8.39	-12.24±23.23	0.18±0.03	-0.13±0.03	-0.36±0.04	1.31±0.11
inawd07 (1993.0-2013.8)	7.71±5.55	-3.80±7.81	-5.07±8.83	-6.06±24.82	0.52±0.03	0.04±0.04	-0.44±0.05	2.46±0.13

Differences of X-pole and Y-pole components of the inawd08 and inawd07 time series with respect to IERS C04 solution

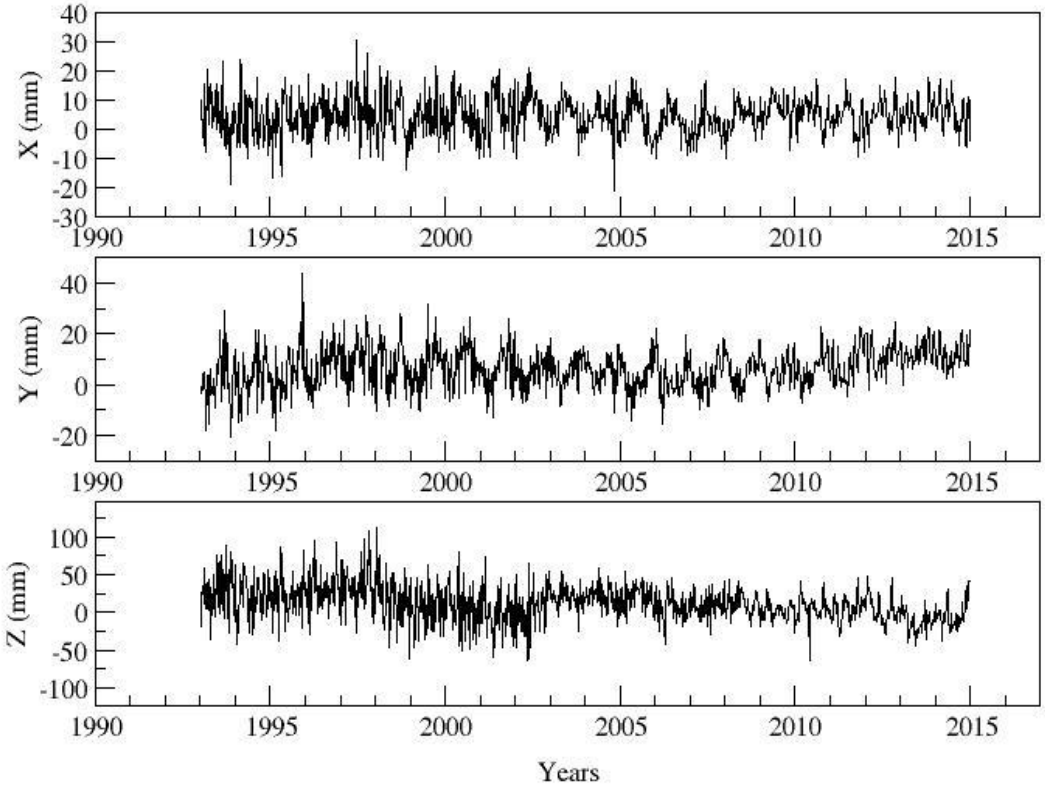
(figure by Guilhem Moreaux)



INA AC Earth Orientation Parameters Residuals wrt IERS C04

Series	Period days	X pole (mas)		Y pole (mas)	
		mean	std	mean	std
inawd07	7519	0.198	1.186	0.034	1.226
inawd08	7637	0.062	0.941	0.065	0.852

DORIS derived inawd08 geocenter time series from network shift approach

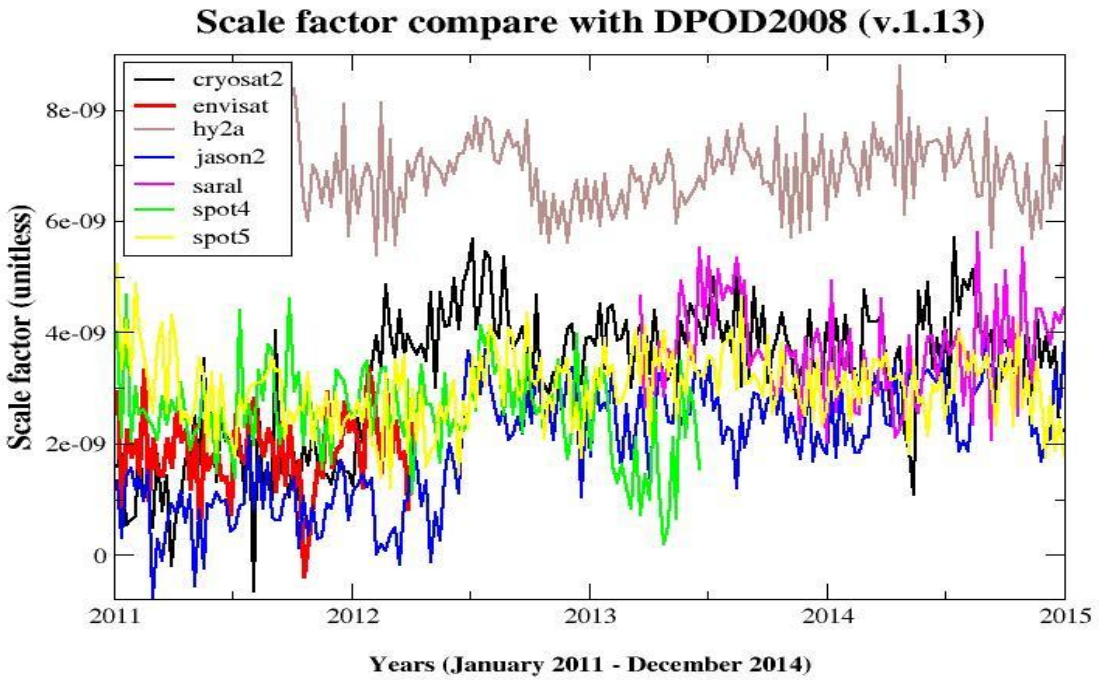


Comparison INA annual signal variations of the geocenter motion with the other measurements types and models (solutions). The amplitudes A and phases φ are modeled by $A\cos\omega(t - t0 - \varphi)$. $t0$ is defined as January 1 of a particular year, ω – angular frequency.

Solution (model)	Type	X		Y		Z		Time span
		A, mm	*Phase, days*	*A, mm*	*Phase, days*	*A, mm*	*Phase, days*	
DORIS inawd06	DORIS measurements	6.7 ±0.2	61 ± 5	5.5 ±0.1	36 ± 7	28.9 ±1.1	31 ± 5	1993.0 – 2009.0
DORIS inawd08	DORIS measurements	3.4 ±0.5	24 ±7	4.4 ±0.5	51 ±6	3.3 ±1.0	43 ±23	1993.0 – 2015.0
DORIS ignwd15	DORIS measurements	2.9 ±0.3	27 ±7	3.4 ±0.4	52 ±7	3.1 ±1.3	40 ±28	1993.0 – 2015.0
Dong et al., 1997, 2003	Geophysical model	4.2	47	3.2	295	3.5	36	1992.0 – 1995.0
Cheng et al., 2010	SLR, kinematic approach	3.2 ±0.4	31 ±5	2.6 ±0.4	305 ±5	4.3 ±0.3	31 ±5	2002.0– 2010.6
Rebischung et al., 2010	GPS, network shift	2.9	363	3.2	319	3.0	168	1997.0 – 2009.0
Collilieux et al., 2009	Geophysical model	2.1 ±0.1	28 ±2	2.1 ±0.1	342 ±2	2.7 ±0.1	49 ±2	1993.0 – 2006.0
ITRF2008, Altamimi et al., 2011	IDS combined solution	3.9 ±0.2	53 ±3	4.6 ±0.3	25 ±3	4.4 ±1.1	18 ±14	1993.0 – 2009.0
ITRF2014, Altamimi et al., 2016	IDS combined solution	2.5 ±0.1	25 ±3	3.5 ±0.2	50 ±2	0.5 ±0.7	24 ±71	1993.0 – 2015.0

Scale factor time series of the single satellite campaign for 2011-2014

The plot shows the scale jump for CryoSat-2 and Jason-2 satellites in the mid of 2012. The scale factor variations for the HY-2A satellite are rather stable but up-biased for about 4.00 ppb (about 24 mm) compared to other satellites

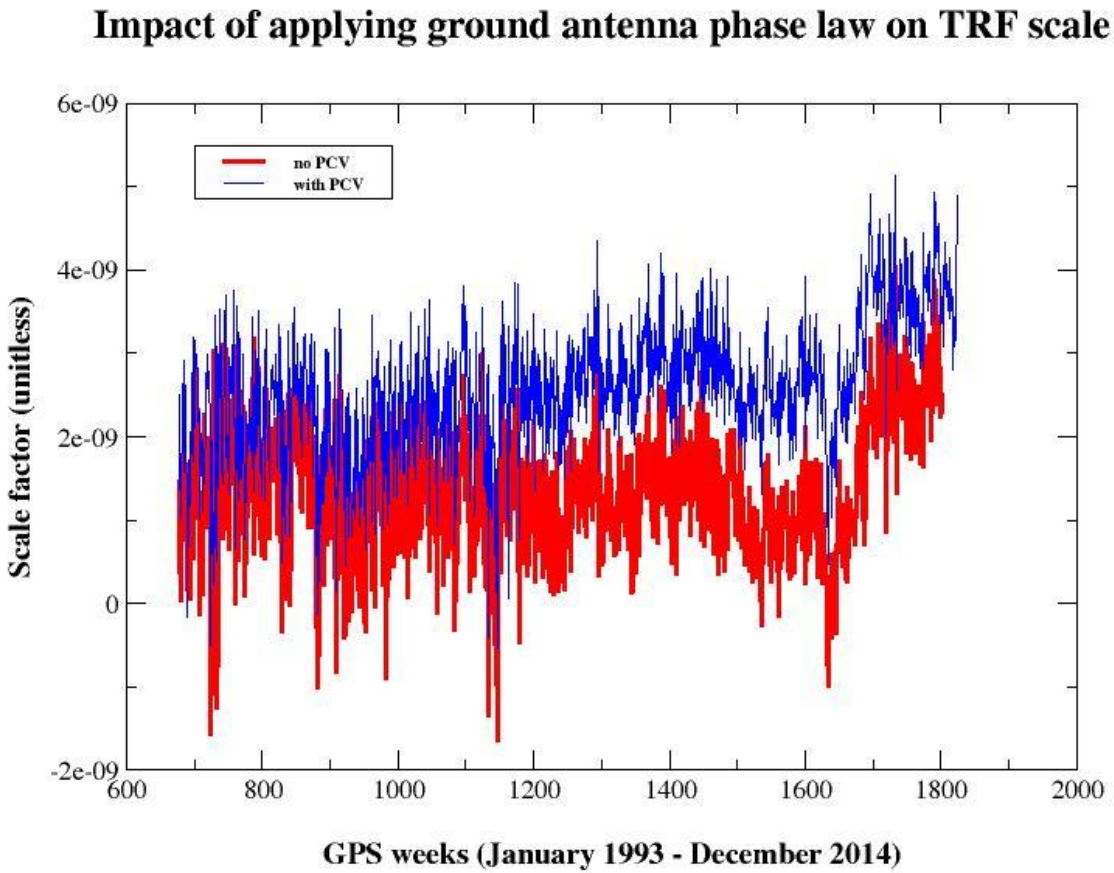


The mean values of the scale parameter compare to the DPOD2008 (v.1.13) for the single satellite campaign of 2011-2014

Satellite	Data span (years)	Mean scale (ppb)
CryoSat-2	2011.0 – 2015.0	3.23 ± 1.25
Envisat	2011.0 – 2012.3	1.86 ± 0.74
HY-2A	2011.8 – 2015.0	6.85 ± 0.63
Jason-2	2011.0 – 2015.0	2.00 ± 1.04
SARAL	2013.3 – 2015.0	3.69 ± 0.87
SPOT-4	2011.0 – 2013.6	2.55 ± 0.83
SPOT-5	2011.0 – 2015.0	3.00 ± 0.68

Phase law of ground antenna and DORIS-derived TRF scale

Comparison of scale factor variations for two weekly INA time series with respect to DPOD2008 (v.1.13): inawd08 (red line, no PCV corrections) and inawd10 (blue line, with PCV corrections). The difference between two series is 1.24 ppb (~ 8 mm).



Conclusions

- **The new applied models (time-variable gravity field model, better troposphere mapping function, corrected data of SPOT-5 satellite) slightly improve the precision of the results of the inawd08 time series analysis with respect to ITRF2008 as regards to Helmert transformation parameters and EOP**
- **The agreement with the IERS C04 solution is now better than 0.1 mas (in mean) with a dispersion of about 1 mas**
- **The evaluated amplitudes of annual geocenter variations derived from inawd08 weekly solutions are 3.4±0.5 mm, 4.4±0.5 mm, and 3.3±1.0 mm for X, Y, and Z components, respectively. These estimations are in a good agreement with those obtained by different space geodesy techniques and geophysical models both for the annual amplitudes and phases**
- **Obtained results confirm the fact that DORIS system is the appropriate technique for the geocenter monitoring and Earth rotation parameters estimation**
- **The DORIS TRF scale parameter is dependent on ground antennas PCV correction (scale offset about 1.2 ppb) and the inclusion of PCV correction should improve combined IDS solution submitted for ITRF2014**
- **However, unsolved problem of the scale rise in 2012 could distort the real scale behavior of the IDS combination for the full reprocessed period**
- **The problems of the single satellite campaign related to the scale jump around mid 2012 and up-shifted scale for the HY-2A satellite compared to the other satellites still require investigation**