G11C. Terrestrial Reference Systems: Theory, Realizations, and Applications
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IDS contribution to ITRF2008

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ABSTRACT

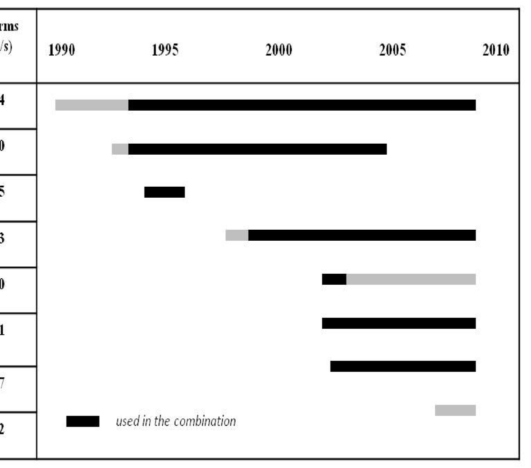
The International DORIS Service (IDS), in operation since 2003, submitted three sets of solutions to ITRF2005 from the IGN/JPL, LEGOS/CLS, and INASAN analysis centers, but no DORIS technique combination. Since that time new analysis centers have become operational including the Geodetic Observatory Pecny (GOP), the European Space Operations Center (ESOC), Geoscience Australia (GAU), the NASA Goddard Space Flight Center (GSC), and the University of Newcastle (NCL). These analysis centers run different software, including Gypsy (IGN & INASAN), GINS (LCA), Bernese (GOP), NAPEOS (ESOC), GEODYN (Geoscience Australia and NASA GSFC) and FAUST (NCL). In order to contribute to ITRF2008, seven analysis centers processed DORIS data from TOPEX/Poseidon, SPOT2, SPOT3, SPOT4, SPOT5, and ENVISAT from 1992 to 2008, producing weekly SINEX solutions or normal equations. The weekly SINEX files from seven AC's were processed with the CATREF software. Three iterations of an IDS weekly combined time series were completed. The IDS-1, and IDS-2 combinations were preliminary station-only solutions. In the final combination, IDS-3, both stations and the Earth Orientation Paramters (EOP's) were adjusted. Between each of the IDS combinations the combination strategy (station filtering, outliers, weighting, scale or geocenter contributions) was improved and the AC's SINEX series were refined. In effect, some series were extended in data span and others were recomputed to correct anomalies or improve the quality of the submissions, based on feedback from the combination analyses and intercenter comparisons. For example in IDS-1, both the GAU and GSC solutions were affected by a 20 mm scale offset that was removed in IDS-2 and IDS-3 after the application of improved troposphere modelling in the GEODYN software. The analysis for IDS-1 showed a higher station position WRMS in the vicinity of the high solar flux periods (late 2001-2002). Consequently for IDS-2, several AC's (LCA, GAU, GSC) recomputed their orbits to estimate drag coefficients more frequently to mitigate this effect. The analysis of the frequency and amplitude of geocenter and scale signals was used to define the AC contributions to geocenter and scale in the final combination IDS-3. The comparisons of IDS-3 w.r.t. ITRF2008 are presented. Future prospects and plans for the IDS DORIS analyses are discussed.

Analysis Centers & SINEX Submissions

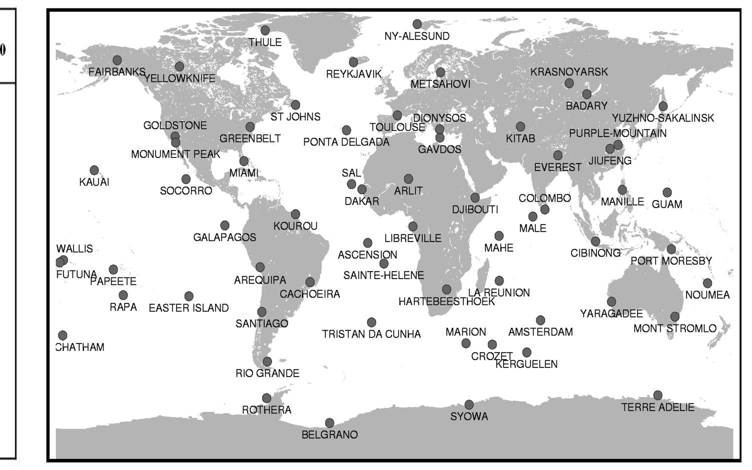
Analysis Center	AC	Software	Sol. Id.	Type (1)	Data span	EOPs
ESA/ESOC, Germany European Space Agency/European Space Operations Center	**GOP**	BERNESE 5.0	**wd31**	var-cov	1993.0-2008.0 15 yrs	motion, rate
Geoscience Australia (with support of GSFC)	**INA**	GYPSY/OASIS 4.03	**wd03**	var-cov	1997.0-2008.8 12 yrs	motion rate (constrained) LOD, UT1
Geodetic Observatory Pecny, Czech Republic	**LCA**	GINS/DYNAMO	**wd21 to wd24**	var-cov	1993.0-2009.0 16 yrs	Motion
GSFC, USA NASA Goddard Space Flight Center	**IGN**	GYPSY/OASIS 5.0	**wd08**	var-cov	1993.0-2009.0 16 yrs	motion rate (constrained) LOD rate, UT1
IGN/IPGP, France Institut Géographique National (IGN)/ Institut de Physique du Globe de Paris (IPGP)	**GAU**	GEODYN	**wd06 to wd08**	var-cov	2002.1-2009.0 7 yrs	motion UT1
Institute of Astronomy, Russian Academy of Sciences (INASAN), Russia	**ESA**	NAPEOS	**wd03**	NEQ	1993.0-2009.0 16 yrs	motion, rate LOD
CNES/CLS, France Centre National d'Etudes Spatiales (CNES) Laboratoire d'Etudes en Géophysique Océanographie Spatiale (LEGOS) Collecte Localisation Satellites (CLS)	**GSC**	GEODYN	**wd03 to wd10**	NEQ	1992.8-2008.9 16 yrs	Motion

DORIS Inputs

Satellite	DORIS receiver	Mean daily data	POE rms (mm/s)
SPOT 2	1 G	5500	0.44
TOPEX	1 G	7000	0.50
SPOT 3	1 G	5500	0,45
SPOT 4	1 G	6000	0.43
JASON 1	2 GM	13000	0.40
SPOT 5	2 GM	10000	0.41
ENVISAT	2 G	11000	0.47
JASON 2	DGXX	26000	0.42



Doris dataset and satellite/instrument series main characteristics
(G : Generation, POE: Precise Orbit Ephemeris from CNES)



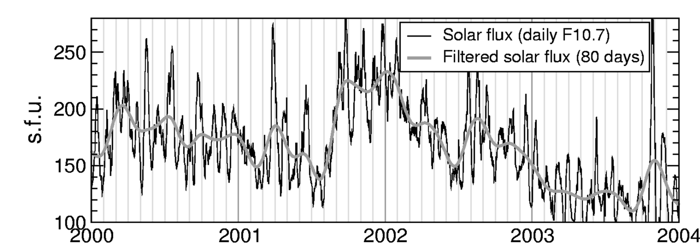
DORIS station network
(1993.0-2009.0 and > 2.5 yrs of obs.)

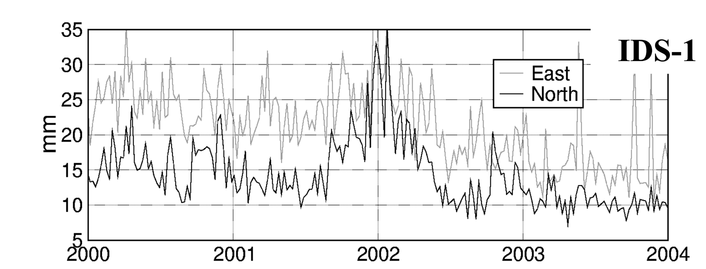
IDS-1 to IDS-3 Combination Strategy Updates

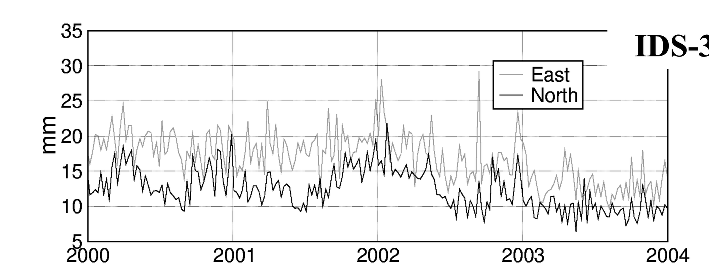
Iterations	Sinex Series & changes	Combination Strategy: Parameters	Combination Strategy: Weigths	Combination Strategy: EOPs	Ref. System Problem
IDS-1 (Fev. 09)	gopwd31 (1998.0-2008.0) inawd06 (1997.0-2008.8) lcawd20 (1993.0-2008.8) ignwd08 (1993.0-2008.8) gauwd06 (2003.0-2008.8) esawd03 (1993-2008.0) gscwd06 (2003.0-2008.8)	Geocenter : IC(3) for all series Scale: GAU, GSC estimated, IC for others	var. factor no deweight	no	Scale offset (gau & gsc) high residuals : 2002 solar activity
IDS-2 (May. 09)	Same as above except : gopwd31 : 1993.0-2008.0 lcawd21 : 1h Cd(1) (2002) gauwd08 : new tropo, 2h Cd(1) ,2002.0-2003.0 gscwd10 : new tropo +2h Cd(1) , 1992.8-2003.0	Geocenter : INA, LCA estimated IC for other series Scale : IC for others	deweight: INA : 4 LCA : 2	no	Periodic signals TZ: 118 & 365 days Scale : 365 days
IDS-3 (Aug., 09)	Same as above except: lcawd24 : SRP(2) fixed	Geocenter and Scale: GSC, GAU, INA, LCA estimated IC for ESA, GOP, IGN (validation step for all series with 5 cm residual threshold)	var. factor no deweight	yes	-

Cd(1) Satellite drag coefficient estimated per 2 hours or higher during Sept.2001-March2002
SRP(2) Solar Radiation Pressure fixed to avoid TZ periodic signals at 118 days and 1 year
IC(3) Internal Constraints

High Residuals at Solar Max

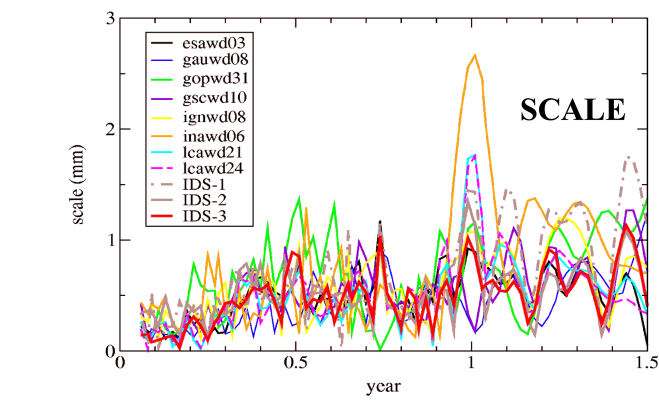


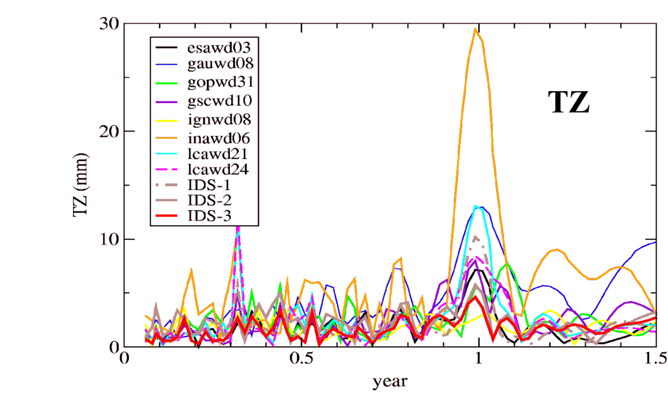




High residuals during 2001-2002 in IDS-1 are compensated by estimating drag coefficients every two hours and once an hour

Periodic Signals in TRF Parameters

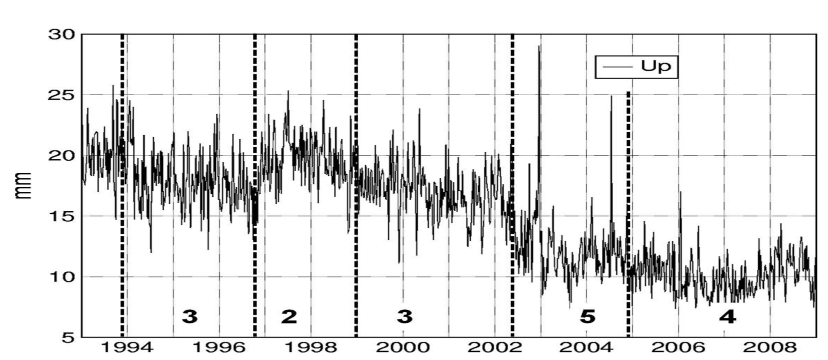


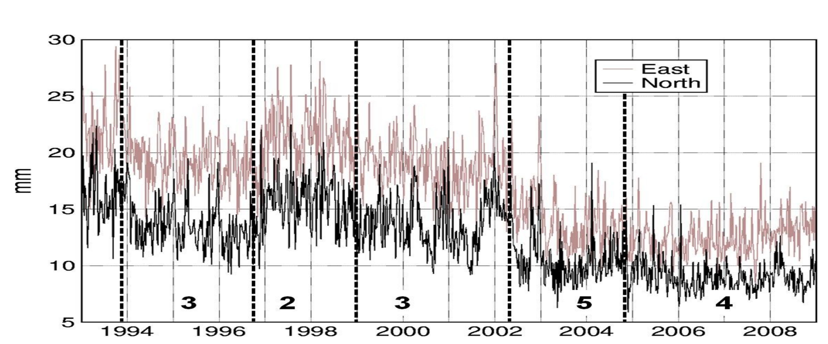


Mismodelling of solar radiation pressure induced systematic errors in the DORIS geocenter at the draconitic period for TOPEX (118 days) and the SPOT and Envisat satellites (1 year). Fixing CR per satellite complete mission reduce this effect of lcawd24 wrt lcawd21 plots (Gobinddass, et al 2009)

IDS-3 Final Solution

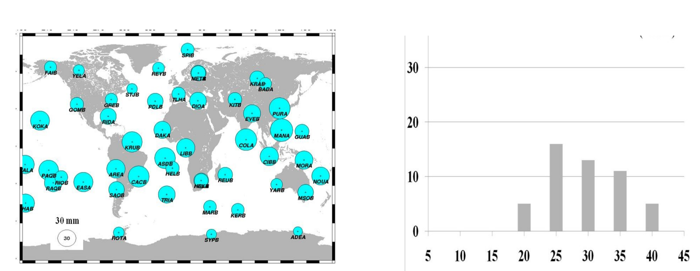
WRMS



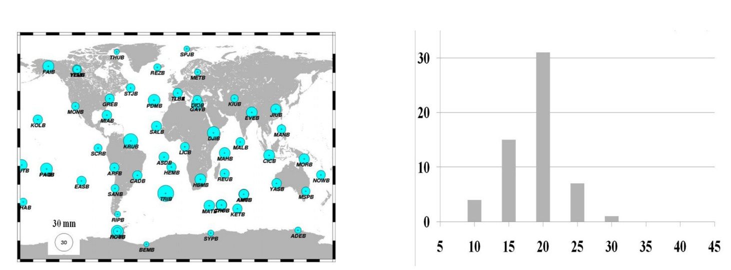


IDS-3 weekly solutions WRMS of the stations residuals, figures indicate the number of satellites used

Station residuals (mm)



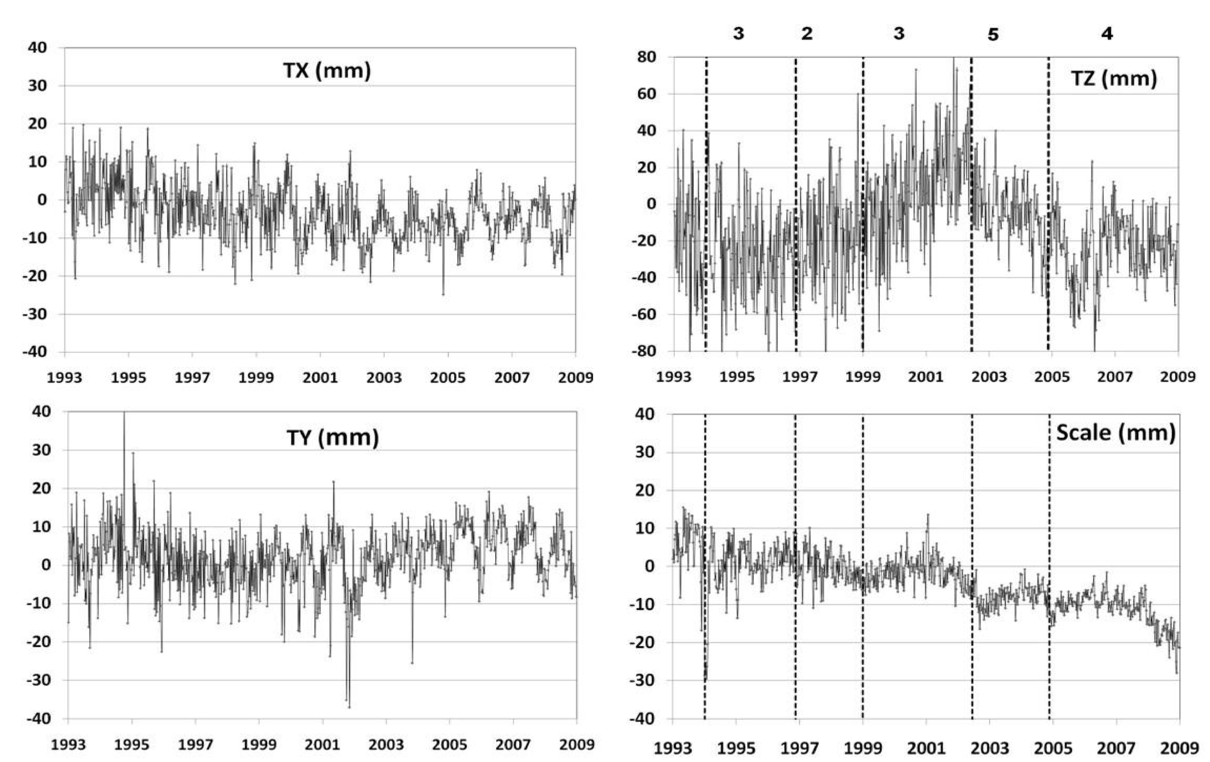
2000 (2 satellites available)



2007 (4 satellites available)

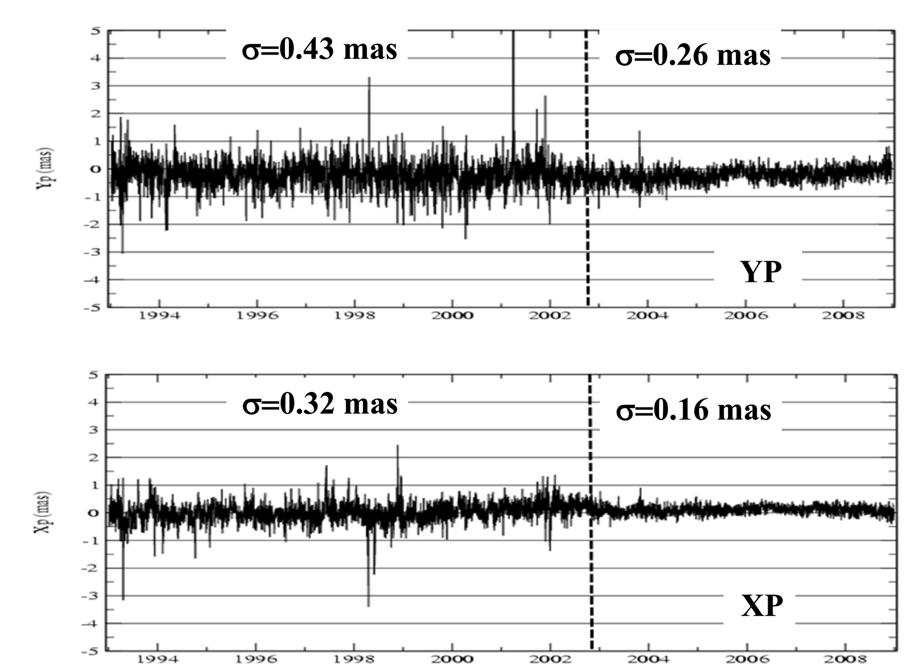
Station residual (mm) distributions of IDS-3 in 2000 and 2007 (Inner Constraints)

TRF Parameters wrt ITRF2005



IDS-3 translation and scale parameters with respect to ITRF2005, dashes correspond to satellite constellation changes, upper right figures to the number of satellites

EOPs wrt IERS 05 C04



vertical line at 2002.4 indicates satellite constellation change from 2 to 4 satellites

Cumulative Solution

Solution	TRF parameters (mm): TX	TY	TZ	Scale
IDS-3	-0.4	-0.3	1.1	0.6

Translation & scale wrt ITRF2005

Solution	Ref. Epoch	RMS-Position (mm): East	North	Up	RMS-Velocity (mm/year): East	North	Up
IDS-3	2000.0	7.7	6.1	10.3	1.8	1.2	1.6

Station residuals wrt ITRF2005

In comparison to ITRF2005, the IDS-3 cumulative solution is a DORIS-only stations position, velocity and EOP solutions that covers a four years wider time series (2005-2008). It is extended to a network of 130 stations instead of 114. A core network of best stations has been defined. It is complementary to the DPOD2005 sub-network defined for precise orbit determination purposes (Willis and Ries, 2005, Willis et al., 2009).

Conclusions

The IDS-3 final solution included seven AC individual contributions. The IDS-3 geocenter and scale were defined as a mean (using Internal Constraints) of the ESA, GOP, GSC, and IGN solutions while the same parameters for GAU, INA and LCA were estimated. The WRMS of each combined solutions is at 10 mm level when as 4 satellites are available, based on a comparison to ITRF2005 or a cumulative IDS solution. Two specific areas of focus during the construction of the combination included the high positioning residuals during the maximum of high solar activity from September 2001 and April 2002 and the remaining periodic amplitude signals at 118 days or 1 year in the scale and the TZ component of geocenter. The periodic signals on TZ at 1 year for sun-synchronous satellites and 118 days for TOPEX/Poseidon, result from imperfect modelling especially in the solar radiation pressure modelling and can also contaminate also the coordinates of the high latitude stations. The use of fixed solar radiation pressure reflectance coefficient estimated over the whole period for each mission provides a significant improvement in the reduction of this effect Further efforts will be needed to improve the radiation pressure modelling for all the DORIS satellites.

Future

The current IDS processing did not include data from Jason-2, launched in June 2008. It offers the possibility of significant improvements due to its 7 channels DORIS receiver. The new receiver, which also provides dual-frequency phase observations comparable to GPS signals, on any given day delivers as much data as all the other DORIS satellites combined.
Having successfully faced the challenge of developing a group technique contribution to ITRF2008, the IDS now looks forward to the initiation of an operational service.

Valette,, J.J., F.G. Lemoine, P. Ferrage, P. Yaya, Z. Altamimi, P. Willis, L. Soudarin, IDS contribution to ITRF2008, , Adv. Space Res., 2010.
Gobinddass, M.L., Willis, P., Sibthorpe, A.J., et al., Improving DORIS geocenter time series using an empirical rescaling of solar radiation pressure models, Adv. Space Res., 44(11), 1279-1287, 2009
Willis, P., Ries, J.C., Zelensky, N.P. et al., DPOD2005, An extension of ITRF2005 for Precise Orbit Determination, Adv. Space Res., 44(5), 535-544, 2009.

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