

## International DORIS Service (IDS)

<http://ids-doris.org/>

*Chairman of the Governing Board: Pascal Willis (France)*

### Overview

Over the past four years, the International DORIS Service (IDS) has evolved significantly. There are now seven Analysis Centers from six different countries using five different software packages, all providing regular products to the IDS. These centers cooperate through an Analysis Working Group (AWG), which held six technical meetings during this four-year period. These meetings led to a significant improvement in the precision of the results, and for the first time, seven solutions were available to the IDS for combination and submission for the ITRF2008 combination. To obtain these solutions, several test campaigns were organized to compare results between groups for precise orbit determination as well as for precise ground geodetic positioning. The goal of this document is to present the various activities related to the International DORIS Service within the last four years.

### Activities

#### 1. DORIS system

##### 1.1 DORIS satellites

As described in Table 1.1, two new satellites were launched in the last four years: Jason-2 and Cryosat-2, both using the new 7-channel DG-XX DORIS receiver on-board the satellite. The DORIS constellation then steadily increased, including currently six satellites at altitudes of 800 and 1300 km, with almost polar or TOPEX-like inclination (66 deg).

Table 1.1: DORIS data available at IDS data centers. As of March 2011

Satellite	Start	End	Space Agency	Type
SPOT-2	31-MAR-1990 04-NOV-1992	04-JUL-1990 15-JUL-2009	CNES	Remote sensing
TOPEX/Poseidon	25-SEP-1992	01-NOV-2004	NASA/CNES	Altimetry
SPOT-3	01-FEB-1994	09-NOV-1996	CNES	Remote sensing
SPOT-4	01-MAY-1998	PRESENT	CNES	Remote sensing
Jason-1	15-JAN-2002	PRESENT	NASA/CNES	Altimetry
SPOT-5	11-JUN-2002	PRESENT	CNES	Remote sensing
Envisat	13-JUN-2002	PRESENT	ESA	Altimetry, Environment
Jason-2	12-JUL-2008	PRESENT	NASA/CNES	Altimetry
Cryosat-2	30-MAY-2010	PRESENT	ESA	Altimetry, ice caps

In the next few years, more DORIS satellites are foreseen: SARAL/AltiKa (India), HY-2A (China), Jason-3 (USA). The Chinese HY-2A satellite for altimetry could be followed by other satellites of the same type (HY-2B, HY-2C, HY-2D). Furthermore, other missions are in consideration. Of particular interest is GRASP (Geodetic Reference Antenna in Space, USA),

providing on board the same spacecraft several well calibrated geodetic systems such as GNSS, DORIS, SLR, and VLBI. The following figure displays the evolution of the DORIS constellation, since the first launch, and also including already foreseen satellites.

Figure 1.1 summarizes the evolution of the DORIS constellation since the launch of the SPOT-2 satellite in 1990. It must be noted that in the past last years, four or more DORIS satellites were available to IDS users, which is a key requirement for the precision of the geodetic products.

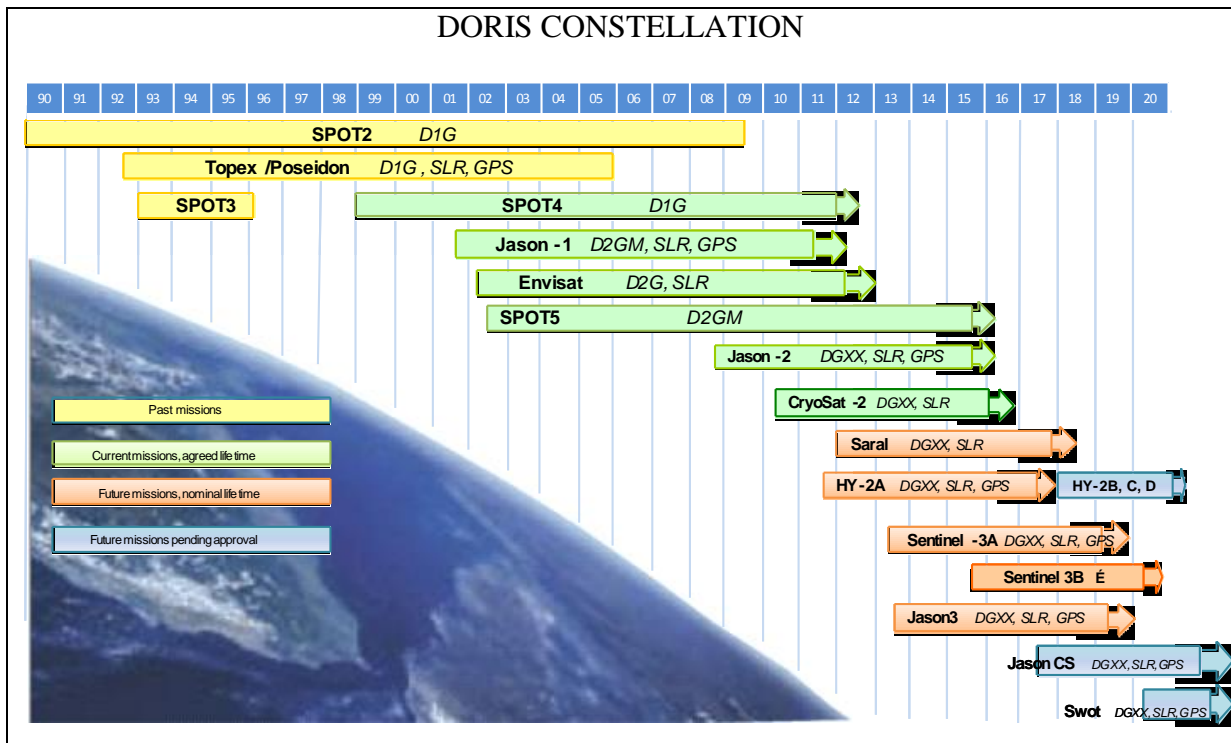


Figure 1.1: DORIS satellite constellation. As of March 2011.

### 1.1 DORIS network

The DORIS tracking network remains very stable (Figure 1.2). More than 50% of the DORIS antennas are in co-location with other space geodetic techniques (GNSS (38), SLR (9), VLBI (6)) and several are also in co-location with other instruments such as tide gauges and absolute gravimeters. Transmissions at Monument Peak station have been stopped since February 2010. DORIS actively participates in the GGOS (Global Geodetic Observing System) network of the International Association of Geodesy (IAG).

The rejuvenation of the DORIS network, started in 1999 is now complete. All sites are now equipped with the latest generation Alcatel antenna (3.0 model) and a large number of antennas are now installed using improved criteria for geodetic stability.



Table 2.2: Composition of the IDS Governing Board (2009 to 2011, current)

Name	Institution	Country	Mandate
Hervé Fagard (*)	IGN	France	Network representative
Pascale Ferrage	CNES	France	Member at large
Frank Lemoine	NASA/GSFC	USA	Analysis coordinator
Chopo Ma	NASA/GSFC	USA	IERS representative
Carey Noll	NASA/GSFC	USA	Data flow coordinator
Michiel Otten	ESOC	Germany	IAG representative
John Ries	U. Texas/CSR	USA	Member at large
Laurent Soudarin	CLS	France	Director IDS Central Bureau
Pascal Willis (chair)	IGN+IPGP	France	Analysis center representative

(\*) in 2010, Hervé Fagard resigned as network representative and was replaced by Bruno Garayt (IGN). Current activities related to DORIS tracking network is now performed by Jerome Saunier.

## 2.2 IDS Central Bureau

During the last four years, the Central Bureau reorganized the IDS Web site, using better tools and changing the URL address to <http://ids-doris.org>. The IDS Web site archives information of interest to IDS users and participants including:

- DORIS results such as plots of station coordinates time series at <http://ids-doris.org/network/ids-station-series.html>.
- DORIS station site logs providing information and pictures of the DORIS antennas at <http://ids-doris.org/network/sitelogs.html>.
- daily statistics of DORIS residuals for Precise Orbit Determination at <http://ids-doris.org/system/poe.html>.
- historical records of specific events affecting DORIS satellites (maneuvers, change of on-board receiver, on-board software update,...) or stations (discontinuities, data gaps, temporary failures,...)
- A bibliography of DORIS-related papers in the published literature, and an archive of presentations at Analysis Working Group meetings and IDS workshops (see sections 4.2 and 4.3 of this report).

In addition a kml file has been created to allow a virtual tour of the DORIS network using GoogleEarth, providing key information on its exact location and of surrounding geodetic equipment. It can be found at <http://ids-doris.org/network/googleearth.html>

The Central Bureau also manages the different IDS mailing lists: DORIS-mails for general information on DORIS and DORIS-reports for technical reports mostly from the IDS Analysis Centers. More information on the DORIS email facility is available at <http://ids-doris.org/report/emails.html>.

## 2.3 IDS Data centers

Since the beginning of the IDS, two data centers have provided open access to IDS data and products: the CDDIS, located in the U.S. and funded by NASA/GSFC (<ftp://cddis.gsfc.nasa.gov>) and IGN in France using two mirroring sites (<ftp://doris.ign.fr> and <ftp://doris.ensg.ign.fr>). In the last four years, a major activity was conducted between the two

groups to ensure a more operational mirroring of the information contained in these data centers.

#### 2.4 IDS Analysis centers

In the last four years, the organization of the IDS drastically changed to include more international participants. There are currently seven active Analysis Centers, using five different software packages, as displayed in Table 2.3.

Table 2.3: IDS Analysis centers. As of March 2011.

Acronym	Analysis Center	Country	Software Package
ESA	European Space Operation Center	Germany	NAPEOS
GAU	Geoscience Australia	Australia	GEODYN
GOP	Geodetic Observatory Pecny	Czech Rep.	Bernese
GSC	Goddard Space Flight Center	USA	GEODYN
IGN	Institut Geographique National	France	GIPSY/OASIS
INA	INASAN	Russia	GIPSY/OASIS
LCA	Centre National d'Etudes Spatiales + Collecte Localisation Satellite	France	GINS/DYNAMO

This group worked together within the Analysis Working Group, under the initiative of the IDs Analysis Coordinator (Frank Lemoine, NASA/GSFC) discussed their analysis strategy and provided tests solutions to IDS, as well as operational solutions in view of the ITRF2008 realization.

#### 2.5 IDS Combination

For ITRF2005, the IDS did not construct a technique-level combination. The DORIS-combination was done by the IRF Product Center. For ITRF2008, the IDS developed a technique level combination based on the seven individual AC submissions (ESA, GAU, GOP, GSC, IGN, INA AN LAC). The steps in the combination development are described in Valette et al. (2010), however we note the level of coordination among the AC's to intercompare their analysis strategies, and that in large part the processing strategies of the individual ACs adhered to the IERS standards. This careful attention to modelling standards was one of the reasons for the improvement in the quality of the DORIS geodetic products in ITRF2008 compared to ITRF2005. Three iterations of the combination were completed by CLS (Jean-Jacques Valette) to provide the best IDS combination to the IERS for inclusion with the submissions of the other technique services in the development of ITRF2008. In the course of the IDS development, the ACs worked to improve their analysis strategies and submitted updated solutions to eliminate troposphere-derived biases in the solution scale, to reduce drag-related degradations in station positioning, and to reduce remaining periodic signals in the individual AC geocenter and scale solutions. Both the evaluation and combination process were successfully achieved with the IGN/LAREG CATREF package. As the final result, IDS-3 combination included solutions for 130 DORIS stations on 67 different sites of which 35 have occupations over 16 years (1993.0-2009.0). More information about the IDS contribution to ITRF2008 is available at [IDS](http://ids-doris.org/analysis-combination.html) web site (<http://ids-doris.org/analysis-combination.html>) or in Valette et al (2010).

In line with the successful DORIS contribution to ITRF2008, IDS decided to extend the IDS3/ITRF2008 combination process to forge an operational service. At this time, this operational service is still in development, and AC's are requested to periodically submit

SINEX solutions. In addition to the realization of weekly combined solutions, the combination center is also in charge of the evaluation of ACs series release as well as analysis of AC submissions to support specific analysis campaigns. These analysis campaigns, included an evaluation of the impact of Jason-2 in the combination solutions, a satellite-by-satellite analysis (Envisat, Jason-2, SPOT-2, SPOT-4, SPOT-5) of the TRF-related parameters (scale and geocenter), and validation of improved or new SINEX time series from individual ACs.. Analysis of these single satellite solutions is completed at the IDS Central Bureau, under the responsibility of the Analysis Coordinator, and has helped all Analysis Centers to better understand limitations in their previous modelling, and to improve the consistency and accuracy of the IDS products.

### 3. IDS products

Table 3.1 presents the current IDS products available through the two IDS data centers. All Analysis Centers provided at a least a long-term weekly solution of SINEX files.

Table 3.1: IDS products available at IDS data centers. As of March 2011.

Product	Format	ESA	GAU	GOP	GSC	IGN	INA	LCA		IDS
Weekly station coordinates	SINEX	X	X	X	X	X	X	X		X
Weekly station coordinates	STCD					X	X	X		
Cumulative solution (position/velocity)	SINEX					X		X		
Geocenter motion	text					X	X	X		
EOPs	IGS					X	X	X		
orbits	sp3	X	X	X	X	X	X	X		

### 4. IDS meetings and publications

#### 4.1 IDS meetings

IDS organizes two types of meetings:

- IDS Workshops (every two years), opened to a large public and related to scientific aspects or applications of the DORIS systems
- Analysis Working Group Meetings (AWG) (when needed), more focussed on technical issues, and usually attended by representatives of Analysis Centers.

The following Table summarizes all the IDS meetings held during the last four years.

Table 4.1: IDS meeting (July 2007 – June 2011).

Meeting	Location	Country	Dates
DORIS AWG Meeting	Paris	France	13-14 March 2008
DORIS AWG Meeting	Paris	France	5-6 June 2008
IDS Workshop	Nice	France	12-14 November 2008
DORIS AWG Meeting	Paris	France	23-24 March 2009
DORIS AWG Meeting	Darmstadt	Germany	26-27 May 2010
IDS Workshop	Lisbon	Portugal	21-22 October 2010
DORIS AWG Meeting	Lisbon	Portugal	22 October 2010

DORIS AWG Meeting	Paris	France	23-24 May 2011
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#### 4.2 IDS publications

During the last four years, IDS published several annual reports (by chronological order) :

Tavernier, G., Ferrage, P., Fagard, H., Lemoine, F., Noll, C., Noomen, R., Ries, J.C., Soudarin, L., Valette, J.J., Willis, P., Stepanek, P., Otten, M., Kuzin, S., Moore, P., Govind, R., The International DORIS Service, January 2006- December 2008 report, 93 pages, 2009.  
[http://ids-doris.org/documents/report/IDS\\_Report\\_2006\\_2008.pdf](http://ids-doris.org/documents/report/IDS_Report_2006_2008.pdf)

Ferrage, P., Garayt, B., Govind, R., Kuzin, S., Lemoine, F., Ma, C., Noll, C., Otten, M., Ries, J.C., Saunier, J., Soudarin, L., Stepanek, P., Valette, J.J., Willis, P., The International DORIS Service, January 2009 – December 2009 report, 83 pages, 2010.

Willis, P., International DORIS Service (IDS), Report of the International Association of Geodesy 2007-2009, Travaux de l'Association Internationale de Geodesie, 2009.  
[http://ids-doris.org/documents/report/IDS\\_Report\\_2007\\_2009\\_for\\_IAG.pdf](http://ids-doris.org/documents/report/IDS_Report_2007_2009_for_IAG.pdf)

Ferrage, P., Garayt, B., Govind, R., Kuzin, S., Lemoine, F., Ma, C., Moreaux, G., Noll, C., Otten, M., Ries, J.C., Saunier, J., Soudarin, L., Stepanek, P., Willis, P., The International DORIS Service, January 2010 – December 2010 report, 94 pages, 2010.  
 (in preparation)

#### 4.3 peer-reviewed publications related to DORIS

Following a first DORIS Special Issue published in Journal of Geodesy, a call for participation was issued by the Guest Editor (Pascal Willis) for a new DORIS Special Issue in Advances in Space Research (ASR). A large number of manuscripts were received and 23 articles were published in 2 issues of ASR: 45(12) in June 2010 and 46(12) in December 2010.

IDS also maintained on its Web site a complete list of DORIS-related peer-reviewed articles published in international Journals (<http://ids-doris.org/report/publications/peer-reviewed-journals.html>). In the last four years, the following articles were published (by year):

#### 2007

Altamimi, Z.; Collilieux, X.; Legrand, J.; Garayt, B.; Boucher, C., 2007. ITRF2005, A new release of the International Terrestrial Reference Frame based on time series of station positions and earth orientation parameters, JOURNAL OF GEOPHYSICAL RESEARCH, 112(B9), B09401, DOI: [10.1029/2007JB004949](https://doi.org/10.1029/2007JB004949).

Amalvict, M.; Willis, P.; Shibuya, K. 2007. Status of DORIS stations in Antarctica for precise geodesy, in Dynamic Planet, Monitoring and understanding a dynamic planet with geodetic and oceanographic tools, P. Tregoning, C. Rizos (Eds.), IAG SYMPOSIUM, 130:94-102, DOI: [10.1007/978-3-540-49350-1\\_17](https://doi.org/10.1007/978-3-540-49350-1_17).

Beckley, BD; Lemoine, FG; Luthcke, SB; Ray, RD; Zelensky, NP 2007. A reassessment of global and regional mean sea level trends from TOPEX and Jason-1 altimetry based on revised reference frame orbits, GEOPHYSICAL RESEARCH LETTERS, 34(14), L14608, DOI: [10.1029/2007GL030002](https://doi.org/10.1029/2007GL030002).

Coulot, D.; Berio, P.; Biancale, R.; Loyer, S.; Soudarin, L.; Gontier, A.-M., 2007. Toward a

- direct combination of space-geodetic techniques at the measurement level: Methodology and main issues, *JOURNAL OF GEOPHYSICAL RESEARCH*, 112(B5), B05410, DOI: [10.1029/2006JB004336](https://doi.org/10.1029/2006JB004336).
- Doornbos, E; Willis, P 2007. Analysis of DORIS range-rate residuals for TOPEX/Poseidon, Jason, Envisat and SPOT, *ACTA ASTRONAUTICA*, 60(8-9), 611-621, DOI: [10.1016/j.actaastro.2006.07.012](https://doi.org/10.1016/j.actaastro.2006.07.012).
- Feissel-Vernier, M.; de Viron, O.; Le Bail, K. 2007. Stability of VLBI, SLR, DORIS and GPS positioning, *Earth Planets and Space* 59(6), 475-497. **Free access**
- Li, F.; Parrot, M. 2007. Study of the TEC data obtained from the DORIS stations in relation to seismic activity, *ANNALS OF GEOPHYSICS*, 50(1), 39-50.
- Poretti, G; Mandler, R; Lipizer, M. 2007. The GPS station at the Pyramid geodetic Laboratory. *BOLLETTINO DI GEOFISICA TEORICA ED APPLICATA* 48(1), 25-32.
- Willis, P. 2007. Analysis of a possible future degradation of the DORIS results related to changes in the satellite constellation, *Advances in Space Research* 39(10), 1582-1588, DOI: [10.1016/j.asr.2006.11.018](https://doi.org/10.1016/j.asr.2006.11.018)
- Willis, P.; Haines, B.J.; Kuang, D. 2007. DORIS satellite phase center determination and consequences on the derived scale of the Terrestrial Reference Frame, *ADVANCES IN SPACE RESEARCH* 39(10), 1589-1596, DOI: [10.1016/j.asr.2007.01.007](https://doi.org/10.1016/j.asr.2007.01.007)
- Willis, P.; Lemoine, F.G.; Soudarin, L. 2007. Looking for systematic error in scale from Terrestrial Reference Frame derived from DORIS data, in *Dynamic Planet, Monitoring and understanding a dynamic planet with geodetic and oceanographic tools*, P. Tregoning, C. Rizos (Eds.), IAG Symp., 130:143-151, DOI: [10.1007/978-3-540-49350-1\\_23](https://doi.org/10.1007/978-3-540-49350-1_23).
- Willis, P.; Soudarin, L.; Jayles, C.; Rolland, L. 2007. DORIS applications for Solid Earth and Atmospheric Sciences, *CR GEOSCIENCE*, 339(16), 949-959, DOI: [10.1016/j.crte.2007.09.015](https://doi.org/10.1016/j.crte.2007.09.015)

## 2008

- Stamps, DS; Calais, E; Saria, E; Hartnady, C; Nocquet, JM; Ebinger, CJ; Fernandes, RM, 2008. A kinematic model for the east African rift, *GEOPHYSICAL RESEARCH LETTERS*, 35(5):L05304, DOI: [10.1029/2007GL032781](https://doi.org/10.1029/2007GL032781)

## 2009

- Amalvict, M.; Willis, P.; Wöppelmann, G.; Ivins, E.R.; Bouin, M.N.; Testut, L.; Hinderer, J., 2009. Isostatic stability of the East Antarctic station Dumont d'Urville from long-term geodetic observations and geophysical models, *Polar Res.*, 28(2), 193-202, DOI: [10.1111/j.1751-8369.2008.00091.x](https://doi.org/10.1111/j.1751-8369.2008.00091.x)
- Bessissi, Z.; Terbeche, M.; Ghezali, B. 2009. Wavelet application to the time series of DORIS station coordinates, *COMPTES RENDUS GEOSCIENCE* 341(6): 446-461, DOI: [10.1016/j.crte.2009.03.010](https://doi.org/10.1016/j.crte.2009.03.010)
- Briole, P.; Willis, P.; Dubois, J.; Charade, O., 2009. Potential volcanological applications of the DORIS system, A geodetic study of the Socorro Island (Mexico) coordinate time series, *Geophys. J. Int.*, 178(1):581-590, DOI: [10.1111/j.1365-246X.2009.04087.x](https://doi.org/10.1111/j.1365-246X.2009.04087.x)
- Flouzat, M.; Bettinelli, P.; Willis, P.; Avouac, J.P.; Heritier, T.; Gautam, U., 2009. Investigating tropospheric effects and seasonal position variations in GPS and DORIS time series from the Nepal Himalaya, *Geophys. J. Int.*, 178(3):1246-1259, DOI: [10.1111/j.1365-246X.2009.04252.x](https://doi.org/10.1111/j.1365-246X.2009.04252.x)
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- Kierulf, H.P.; Pettersen, B.; McMillan, D.S.; Willis, P., 2009. The kinematics of Ny-Alesund from space geodetic data, *J. Geodyn.*, 48(1), 37-46, 2009, DOI: [10.1016/j.jog.2009.05.002](https://doi.org/10.1016/j.jog.2009.05.002)
- Siefring, C.L.; Bernhardt, P.A.; Roddy, P.A.; Hunton, D.E., 2009. Comparisons of equatorial irregularities measurements from C/NOFS: TEC using CERTO and CITRIS with in-situ plasma density, *Geophys. Res. Lett.*, 36, art. L00C08, DOI: [10.1029/2009GL038985](https://doi.org/10.1029/2009GL038985)
- Willis, P.; Ries, J.C.; Zelensky, N.P.; Soudarin, L.; Fagard, H.; Pavlis, E.C.; Lemoine, F.G., 2009. DPOD2005 : An extension of ITRF2005 for Precise Orbit Determination, *Adv. Space Res.*, 44(5), 535-544, DOI: [10.1016/j.asr.2009.04.018](https://doi.org/10.1016/j.asr.2009.04.018)

## 2010

- Altamimi, Z.; Collilieux, X., 2010. Quality Assessment of the IDS Contribution to ITRF2008, in *DORIS Special Issue: Scientific Applications in Geodesy and Geodynamics*, P. Willis (Ed.), *ADVANCES IN SPACE RESEARCH*, 45(12):1500-1509, DOI: [10.1016/j.asr.2010.03.010](https://doi.org/10.1016/j.asr.2010.03.010)
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- Auriol, A.; Tourain, C., 2010. DORIS System: the new age, in *DORIS Special Issue: Precise Orbit Determination and Applications to the Earth Sciences*, P. Willis (Ed.), *ADVANCES IN SPACE RESEARCH*, 46(12):1484-1496, DOI: [10.1016/j.asr.2010.05.015](https://doi.org/10.1016/j.asr.2010.05.015)
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- Exertier, P.; Samain, E.; Bonnefond, P.; Guillemot, P., 2010. Status of the T2L2/Jason-2 experiment, in *DORIS Special Issue: Precise Orbit Determination and Applications to Earth Sciences*, P. Willis (Ed.), *ADVANCES IN SPACE RESEARCH*, 46(12):1559-

- 1565, DOI: [10.1016/j.asr.2010.06.028](https://doi.org/10.1016/j.asr.2010.06.028)
- Gobinddass, M.L.; Willis, P.; Menvielle, M.; Diament, M., 2010. Refining DORIS atmospheric drag estimation in preparation of ITRF2008, in DORIS Special Issue: Precise Orbit Determination and Applications to the Earth Sciences, P. Willis (Ed.), *ADVANCES IN SPACE RESEARCH*, 46(12):1566-1577, DOI: [10.1016/j.asr.2010.04.004](https://doi.org/10.1016/j.asr.2010.04.004)
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