

# **DORIS Analysis Strategies: Analysis Coordination and steps required towards generation of IDS Products**

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# Outline

- Introduction: Presentation of Position Paper
- Availability of DORIS Products: Review
- Action items from May 2004 IDS Workshop: Status.
- Recommendations for 2006  
e.g. Analysis campaigns,  
Refinements to analysis procedures.
- Conclusion

## Introduction

- IDS accepted as service of the IAG (July 2003).
- Station renovation is nearing completion (Fagard, this workshop).
- Multiple groups contribute products on a regular basis:  
IGN/JPL, INASAN, LEGOS/CLS, SSALTO.
- New Analysis Centers: Pecny/CODE; Geoscience Australia.
- Contribution to ITRF2005.
- Special Issue: Journal of Geodesy: 18 papers submitted (Oct. 2005- Feb. 2006).
- DORIS has reached a level of maturity and is at a crossroads.

Our challenge is continue to improve the geodetic products and transition to routine delivery of IDS products.

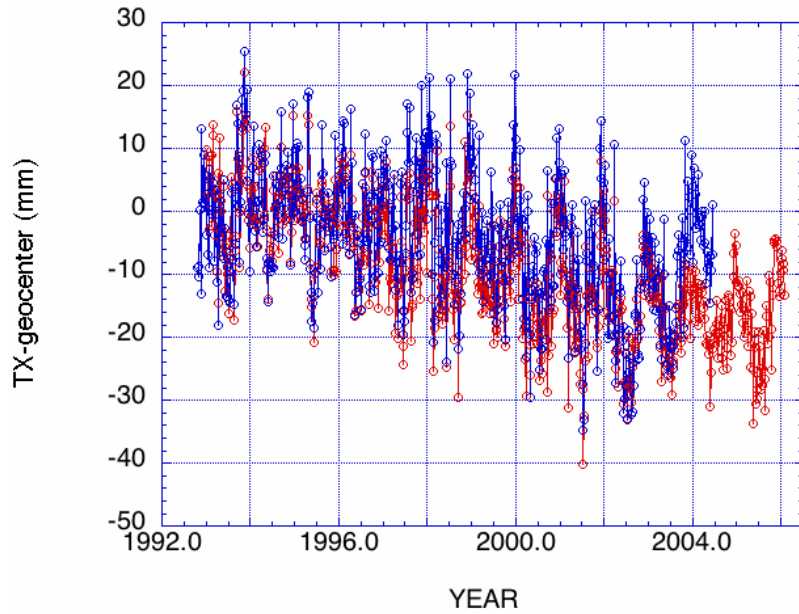
## Current IDS Products (March 2006)

Product	Present AC	Previous AC (no recent solution)	Proposed AC	Combined product
Cumulative solutions (positions/velocities)	IGN/JPL LEGOS/CLS*		INASAN Geoscience Australia IAA	No
Weekly series	IGN/JPL INASAN LEGOS/CLS SSALTO	SOD GSFC (1 yr)	Geoscience Australia IAA Pecny/CODE	No
Monthly series		IGN/JPL INASAN LEGOS/CLS SSALTO	Geosciences Australia IAA	No
Geocenter	IGN/JPL INASAN	LEGOS/CLS		No
EOP	IGN/JPL	LEGOS/CLS	INASAN	No
Orbits		LEGOS		No
Ionosphere	SSALTO			No

\* Not at CDDIS.

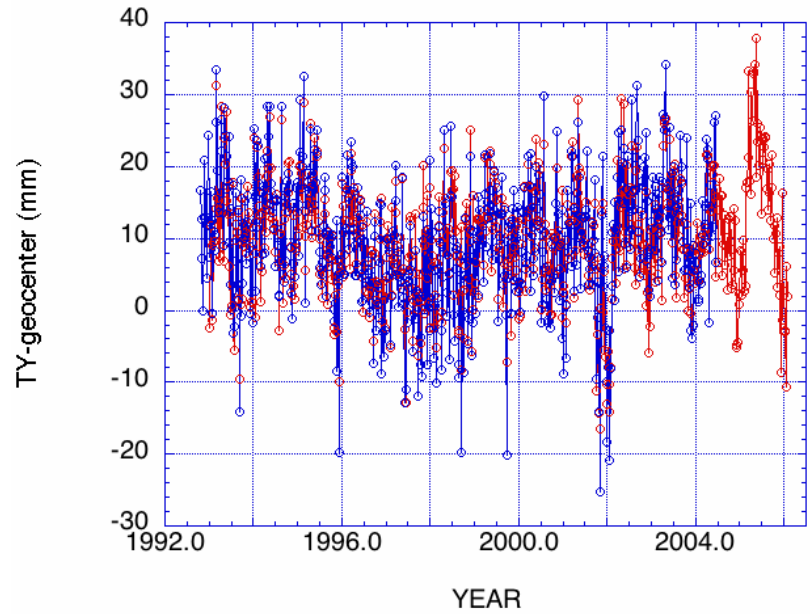
○ TX IGN  
○ TX INA

**DORIS Geocenter TX**  
(time series at NASA/CDDIS)



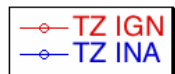
○ TY IGN  
○ TY INA

**DORIS geocenter TY**  
(time series at NASA/CDDIS)

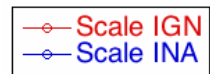
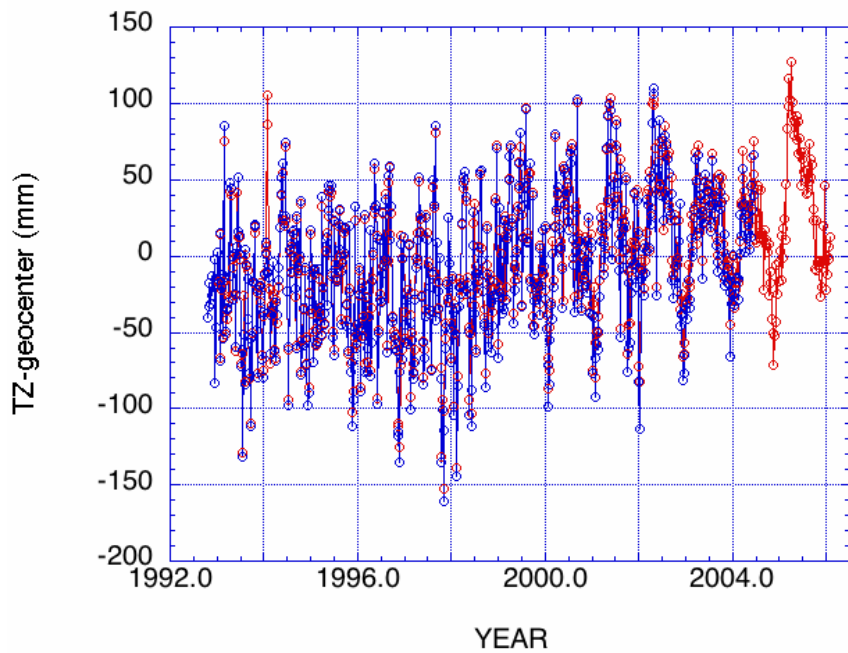


QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

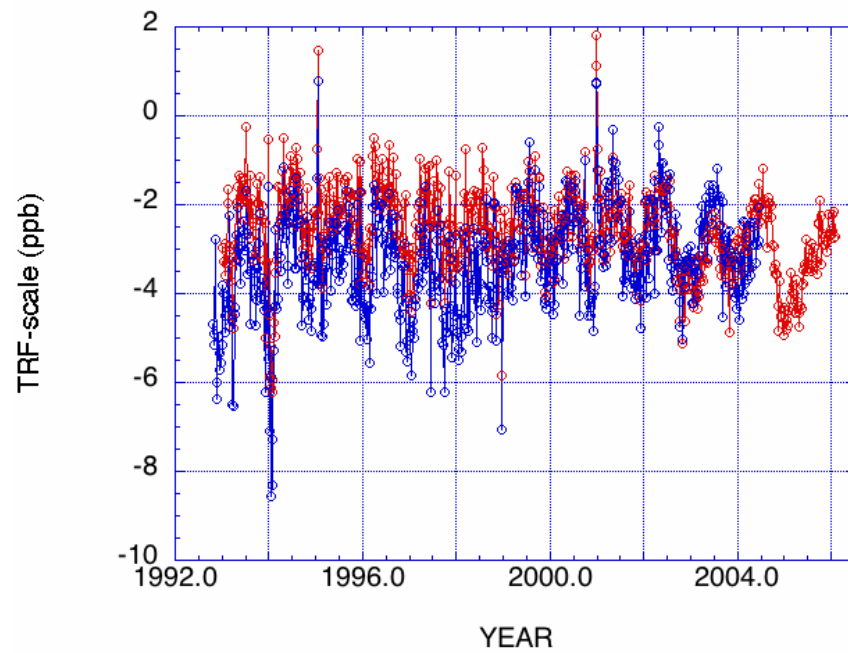
QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.



**DORIS geocenter TZ**  
(time series at NASA/CDDIS)



**DORIS TRF scale**  
(time series at NASA/CDDIS)



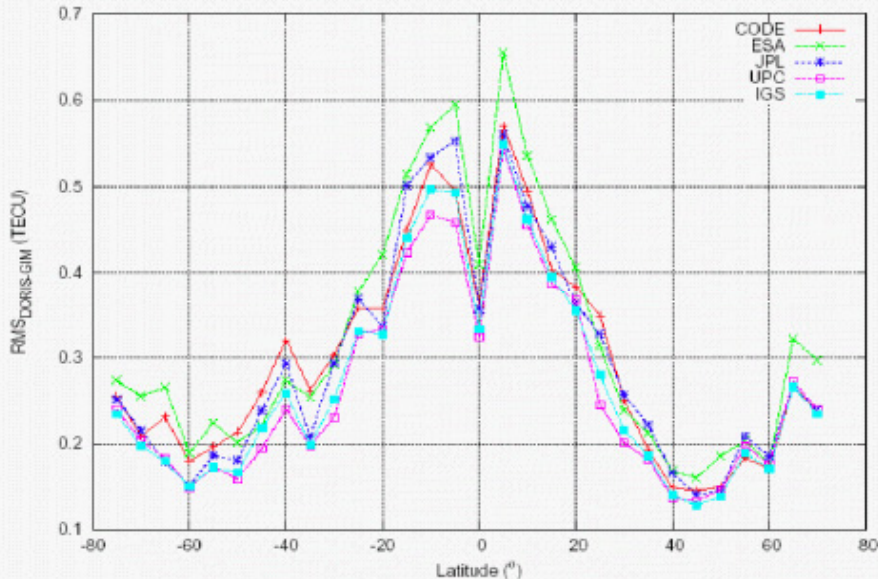
## DORIS Ionosphere product (1)

- Ionosphere correction calculated routinely and part of normal data record.
- Supplementary IONO file contains additional information, including elevation angle & geometry

The format is :- for the header (for each satellite pass over a beacon) :s  
satellite, beacon mnemo, number of observations, max of satellite pass elevation,  
local time (deg), meteorological data : Pressure (mb), T (deg), Humidity (%)  
ex : SPOT2 SALB 27 57.954 22.6091012 21 68

- for the data :  
CNES julian date, second in the day of the observation (TAI),  
elimination criteria,  
count interval (2 GHz channel),  
count interval (400 Hz channel),  
Tropospheric correction (2 GHz channel),  
Tropospheric correction (400 MHz channel),  
Ionospheric correction (2 GHz channel),  
Ionospheric correction (400 MHz channel),  
Elevation angle, Azimuth, Station-satellite distance (m),  
Acquisition mode,  
Received power level (400 Mhz), Received power level (2 Ghz),  
Ponderation (0 if eliminated or 1),  
Doppler count (400 Mhz), Doppler count (2 Ghz).

## DORIS Ionosphere product (2)



**IONO Files Available:**  
Jason-1: from Aug. 2002.  
Spot2/4: from Jan. 2001.  
Spot5: from May 2004.  
Topex: Jan. 2001- Nov. 2004.

Figure 2: Comparison of DORIS derived vertical total electron content (VTEC) for JASON in 2004 with VTEC results from different IGS analysis centers. The display indicates the RMS difference between each IGS center and DORIS for 2004. The units are TECU. At the Jason altimeter frequency of 13.6 GHz, 1 cm of range corresponds to 4.6 TECU. (from M. Pajares, April 2004-2005, IGS working group report)



# Station Coordinate Differences (STCD)

```
+FILE/REFERENCE
DESCRIPTION      SSALTO (ALTIMETRY LOCATION MULTI-MISSION GROUND SEGMENT)
OUTPUT           Weekly routine solutions
CONTACT          Jean-Jacques.Valette@cls.fr   info-doris@cls.fr
SOFTWARE         CLS/IGN
HARDWARE         DIGITAL ALPHA/VMS
INPUT            All satellite DORIS data, MOE 48h delay orbits from CNES/SOD
-FILE/REFERENCE
-----
+FILE/COMMENT
*
* Solutions have been transformed into ITRF2000
*
-FILE/COMMENT
*-----
* Fields : MJD dX sX dY sY dZ sZ dNorth sNorth dEast sEast dUp sUp
*
* MJD : Modified Julian Day
*
* Decimal Year = 2000.0000 + (MJD - 51544.03)/365.2422
*
* Earth Ellipsoid reference :
* Equatorial radius (m)    :      6378136.3000
* Flattening factor        :           298.2570
*
+SITE/ID
*CODE PT DOMES____ T STATIONS DESCRIPTION__ APPROX LONG APPROX LAT APP HEI
YELB A 401275008 D Yellowknife           245 31 12.5 62 28 51.9 182.7
-SITE/ID
*-----
+SOLUTION/APRIORI
*
*INDEX TYPE__ CODE PT SOLN _REF_EPOCH__ UNIT S , __ESTIMATE VALUE____STD_DEV__
1 STAX YELB A 1 01:000:00000 m 2 -.122440518731400E+07 .000000E+00
2 STAY YELB A 1 01:000:00000 m 2 -.268921646962410E+07 .000000E+00
3 STAZ YELB A 1 01:000:00000 m 2 0.563364961189510E+07 .000000E+00
-SOLUTION/APRIORI
*-----
53739.5000 -0.015 0.006 -0.001 0.004 0.022 0.005 0.004 0.005 -0.013 0.006 0.023 0.00
53746.5000 -0.018 0.006 -0.004 0.004 0.007 0.004 -0.007 0.004 -0.015 0.005 0.011 0.00
53753.5000 -0.026 0.006 -0.009 0.004 0.007 0.004 -0.013 0.004 -0.020 0.005 0.015 0.00
53760.5000 -0.011 0.006 -0.009 0.004 0.010 0.004 -0.007 0.004 -0.006 0.005 0.015 0.00
53767.5000 -0.038 0.006 -0.010 0.004 0.039 0.004 -0.003 0.004 -0.030 0.006 0.046 0.00
53774.5000 -0.033 0.007 0.002 0.005 0.021 0.005 -0.001 0.005 -0.031 0.006 0.024 0.00
```

# Station Position Residuals (STCD)

(accessed from <http://ids.cls.fr/html/doris/ids-station-series.php3>)

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TIFF (Uncompressed) decompressor  
are needed to see this picture.

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TIFF (Uncompressed) decompressor  
are needed to see this picture.

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TIFF (Uncompressed) decompressor  
are needed to see this picture.

## DORIS (IGN/JPL, 2006/0303)

### Weekly series

<ftp://cddis.gsfc.nasa.gov/pub/doris/products/stcd/ign03wd01/ign03wd01.stcd.paqb.gif>- Updated weekly.

## DORIS (LCA 2005.0603)

### Monthly series

<ftp://cddis.gsfc.nasa.gov/pub/doris/products/stcd/lca05md01/lca05md01.stcd.paqb.gif>. Last updated 2005.0603

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TIFF (Uncompressed) decompressor  
are needed to see this picture.

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

## Station Coordinate Differences (STCD) (PAQB comparison with GPS for collocated site, THTI, Tahiti)

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

Series	Latitude	Longitude	Height
IGN/JPL ign03wd01	37.5 mm/yr	-63.5 mm/yr	-1.9 mm/yr
LCA lca05md01	35.1 mm/yr	-69.3 mm/yr	2.4 mm/yr
GPS Heflin 2004.0	$33.40 \pm 0.04$ mm/yr	$-66.78 \pm 0.10$ mm/yr	$-0.47 \pm 0.21$ mm/yr

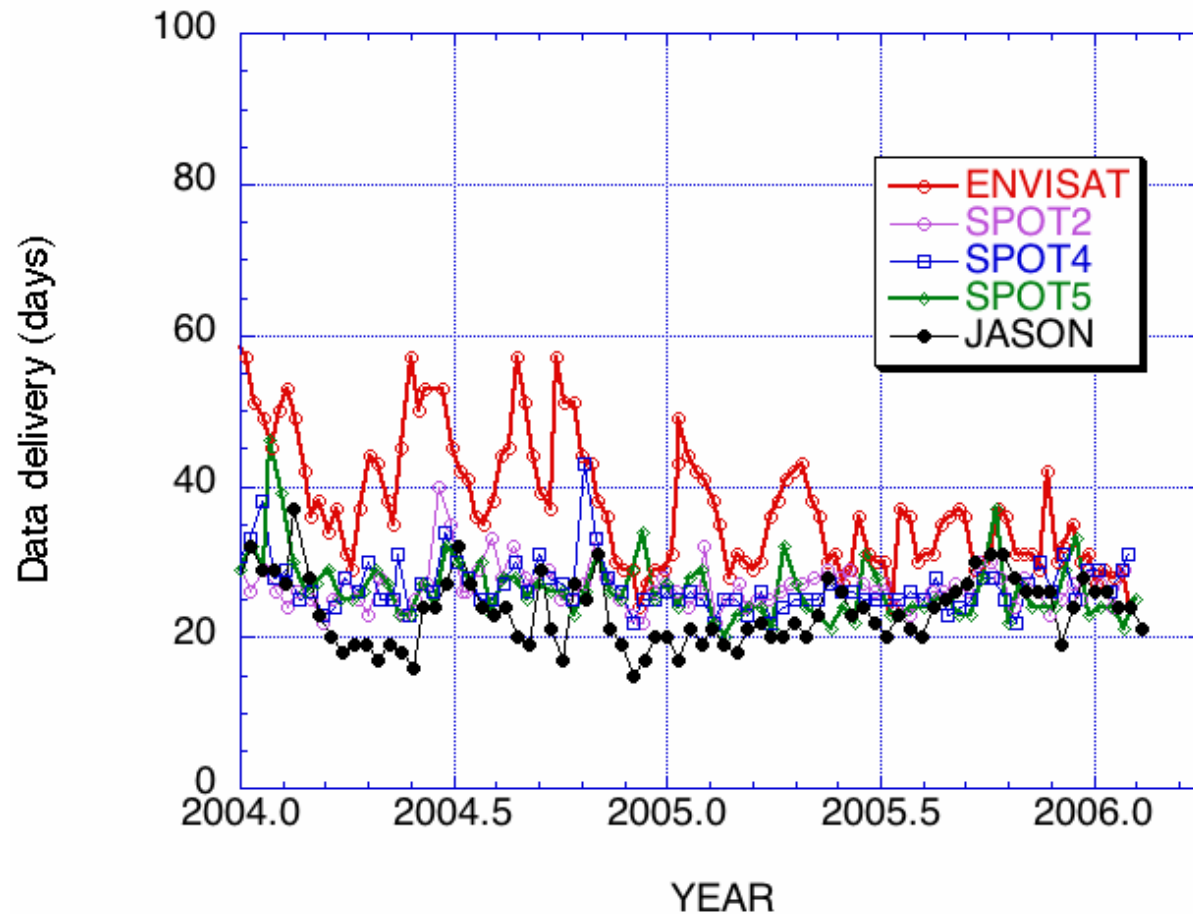
### GPS (Heflin, 2004.0)

<http://sideshow.jpl.nasa.gov/mbh/series.html>

Not updated since MBH left JPL.

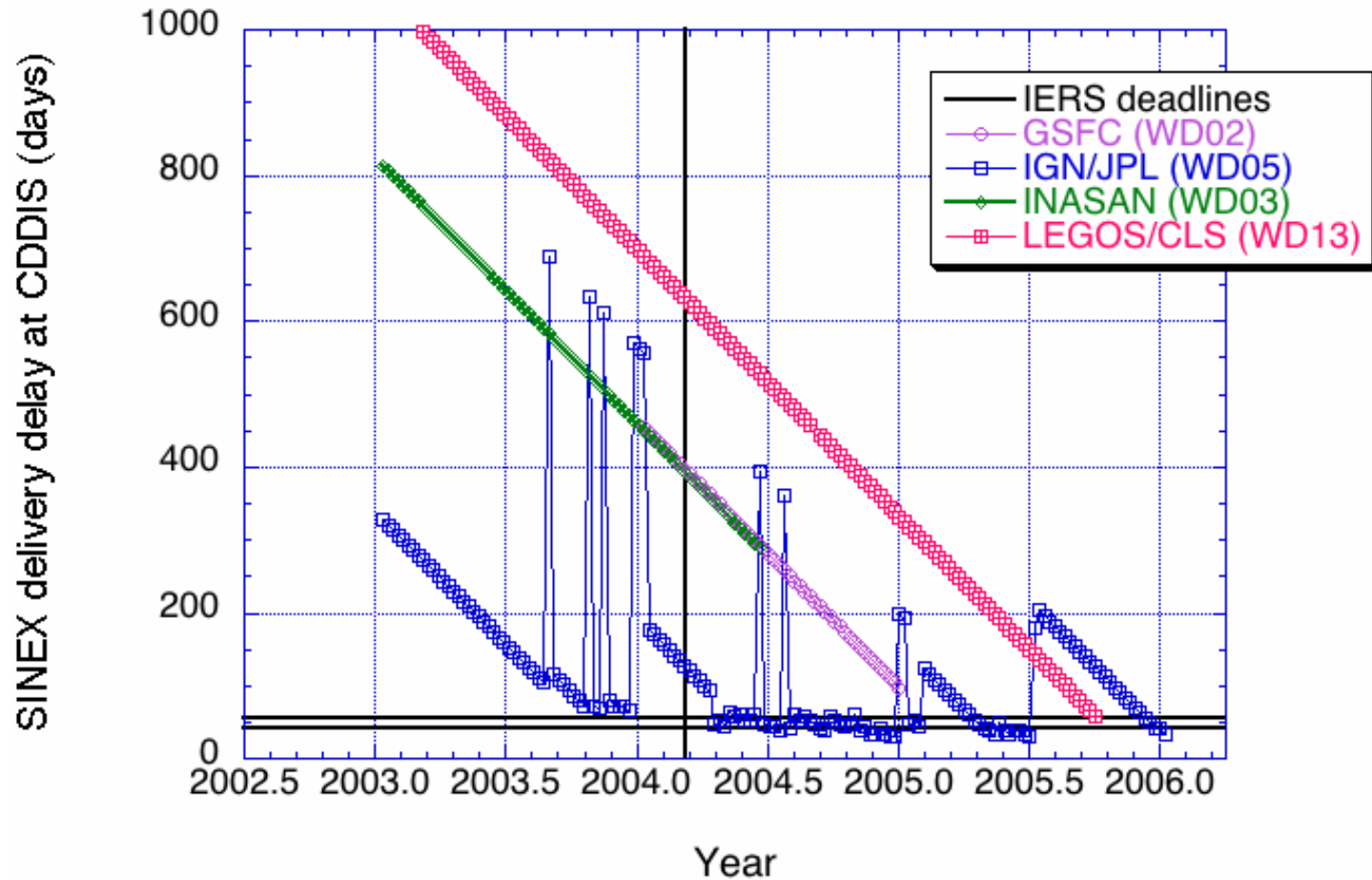
# DORIS Data Delivery to NASA CDDIS

## DORIS data delivery (March 8, 2006)



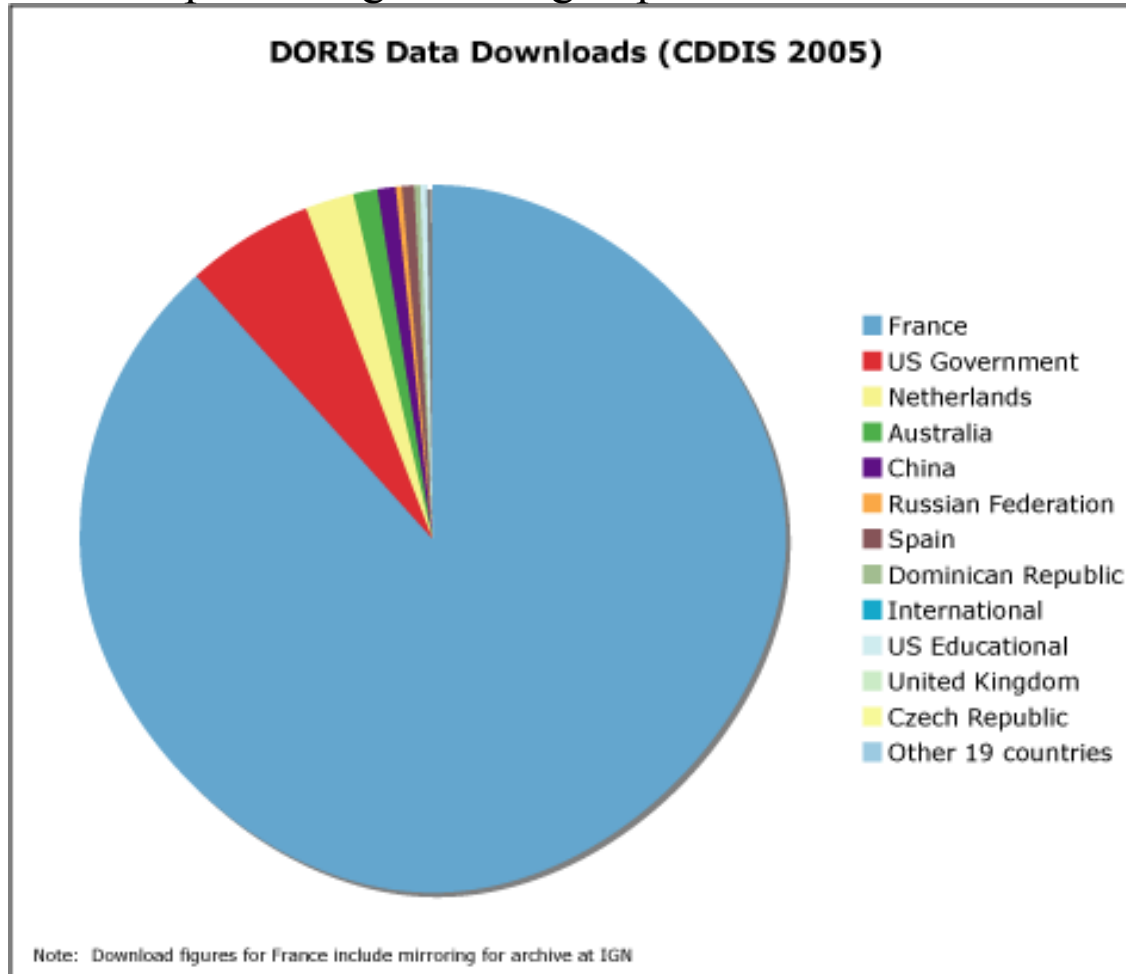
# DORIS Product Delivery to NASA CDDIS

Start of IERS CPP Campaign



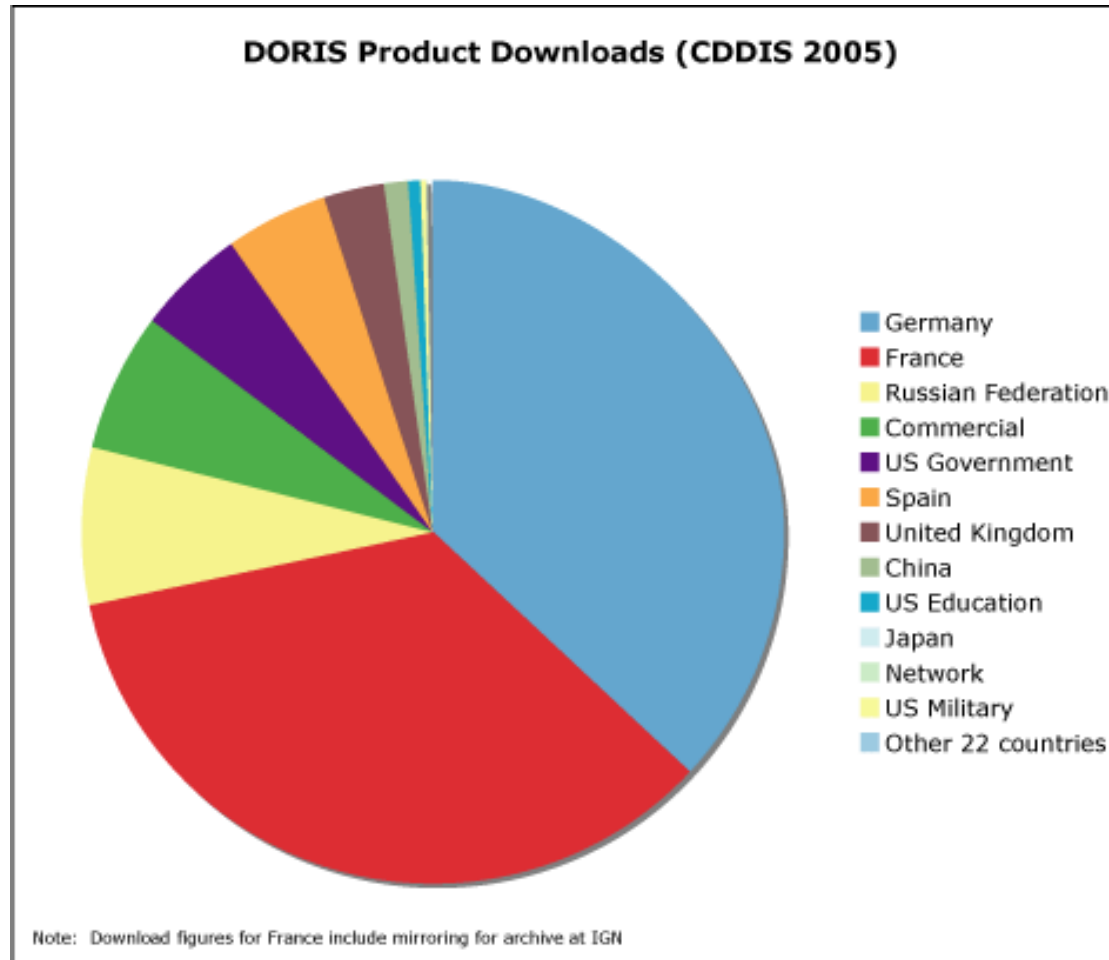
# DORIS Data Downloads by Source

<ftp://cddis.gsfc.nasa.gov/pub/doris/data>

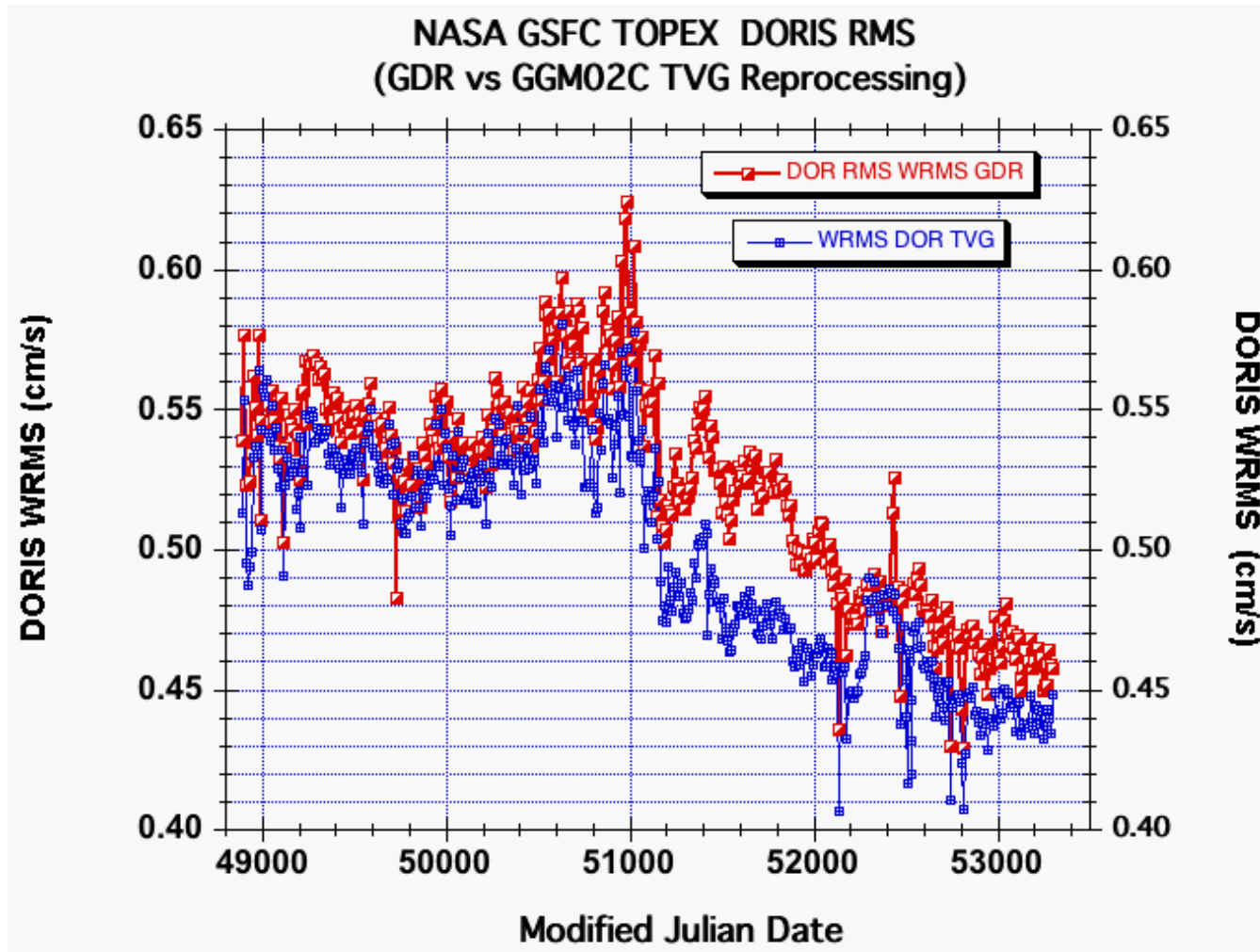


# DORIS Product Downloads by Source

<ftp://cddis.gsfc.nasa.gov/pub/doris/products>

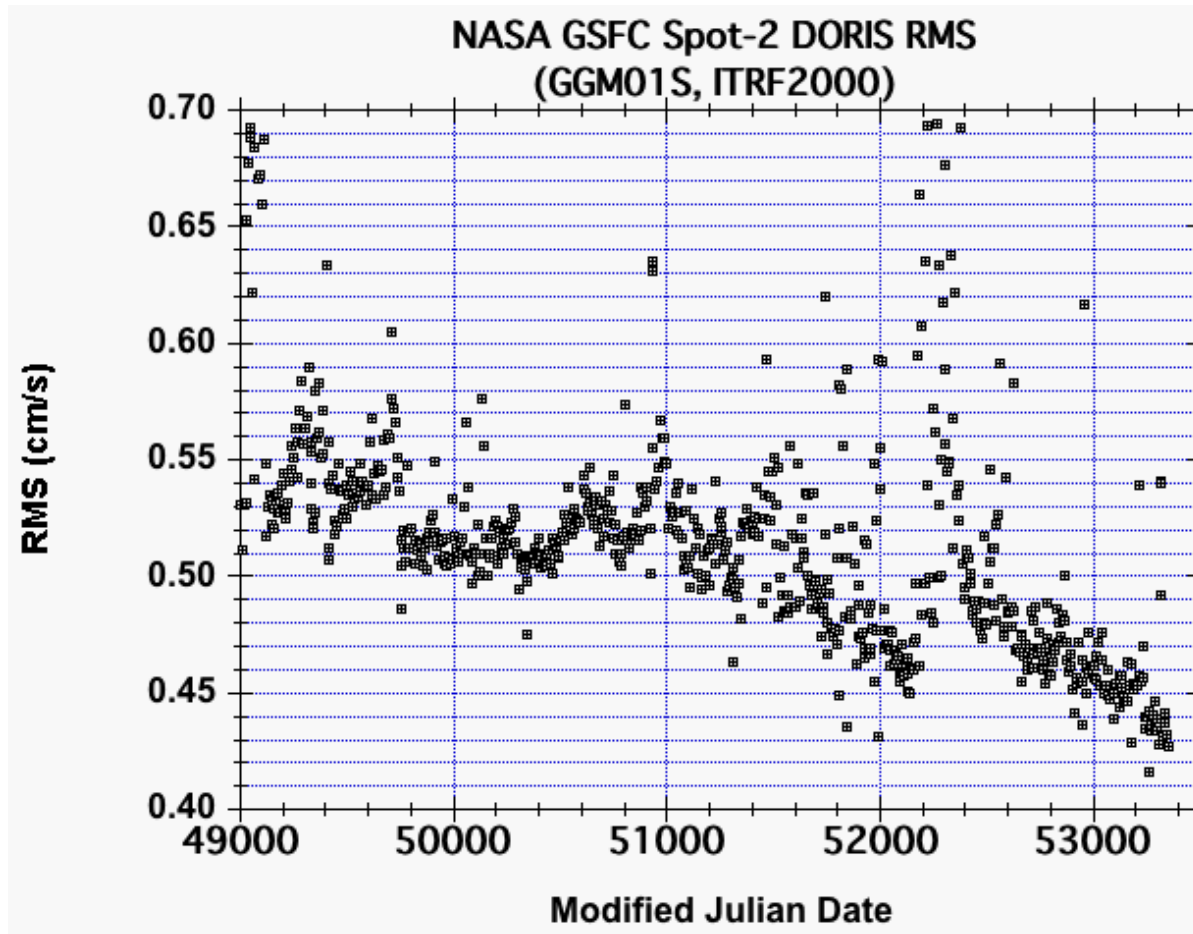


# DORIS Evolution from TOPEX analysis





## DORIS Evolution from Spot2 analysis



# DORIS Evolution from Analysis of SINEX Weekly Series

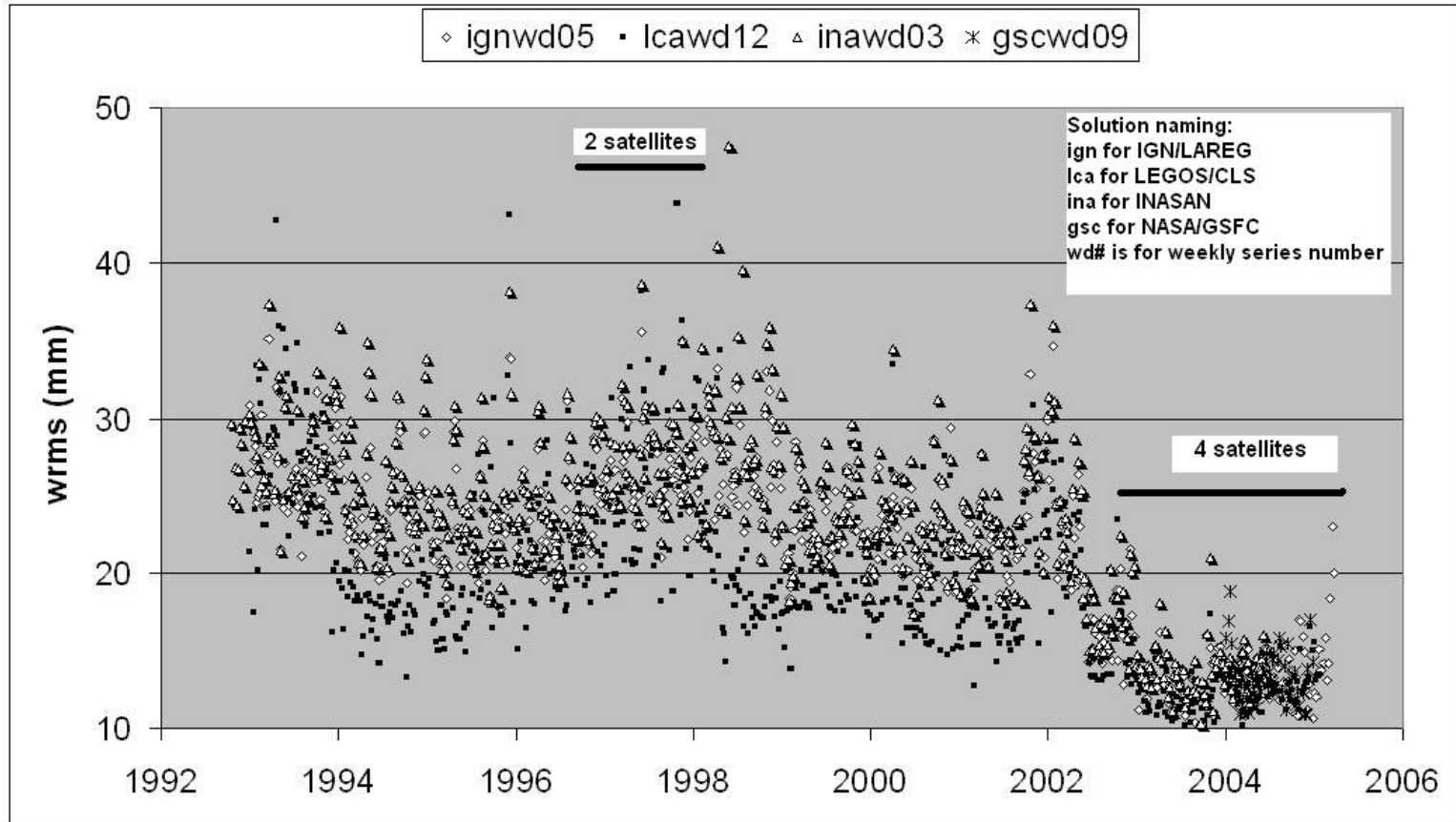
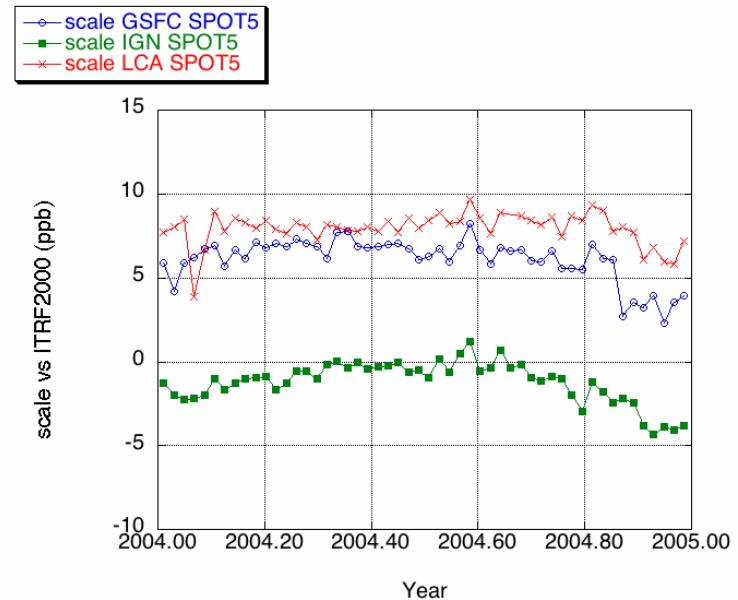
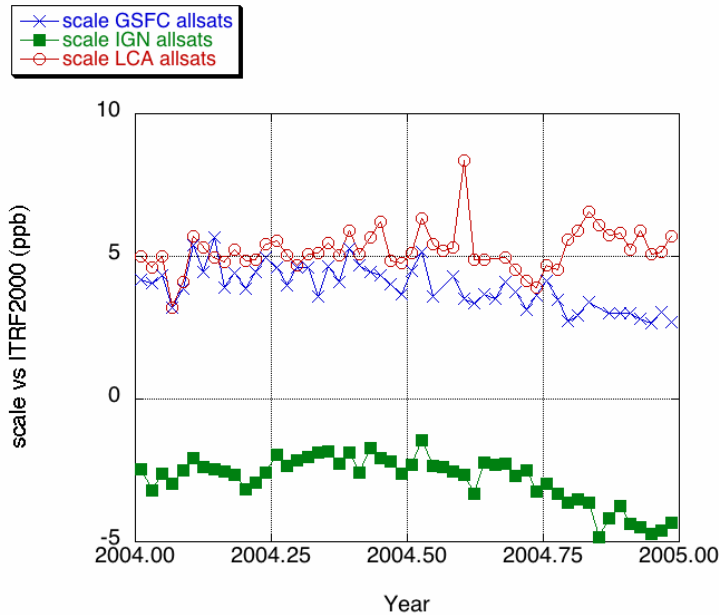


Figure 9. Weighted RMS of the individual weekly time series combinations (*Tavernier et al.*, 2006).

## DORIS TRF Scale Differences



Weekly scale factor determination towards ITRF2000 using multi-satellite SINEX solutions. GSFC (circles); IGN/JPL(squares); LEGOS/CLS (crosses), Jan. - Dec. 2004. Left (all satellites); Right (Spot5 only). (*Willis et al., 2006 in press; presented at Cairns IAG, August 2005*).

# DORIS TRF Scale Differences

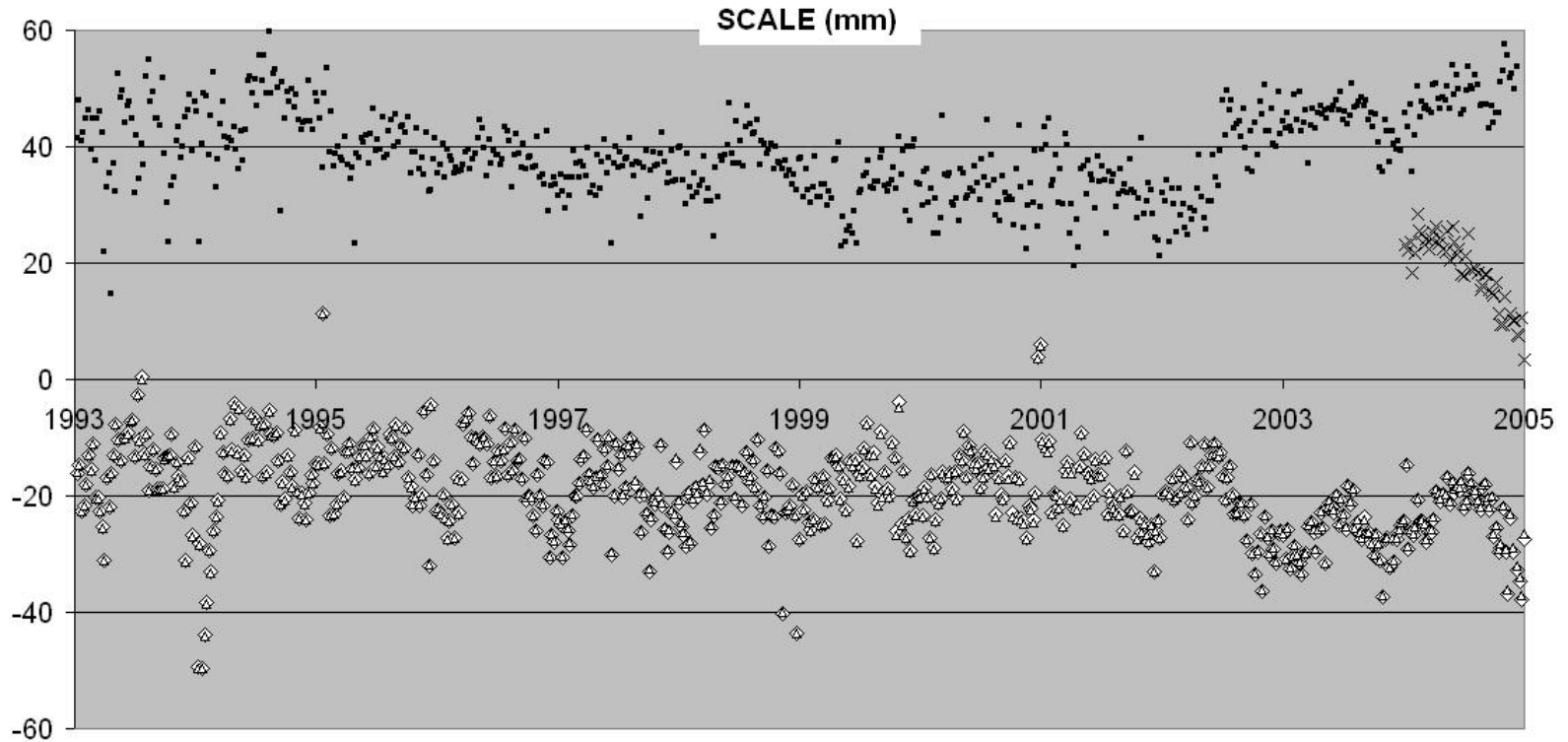
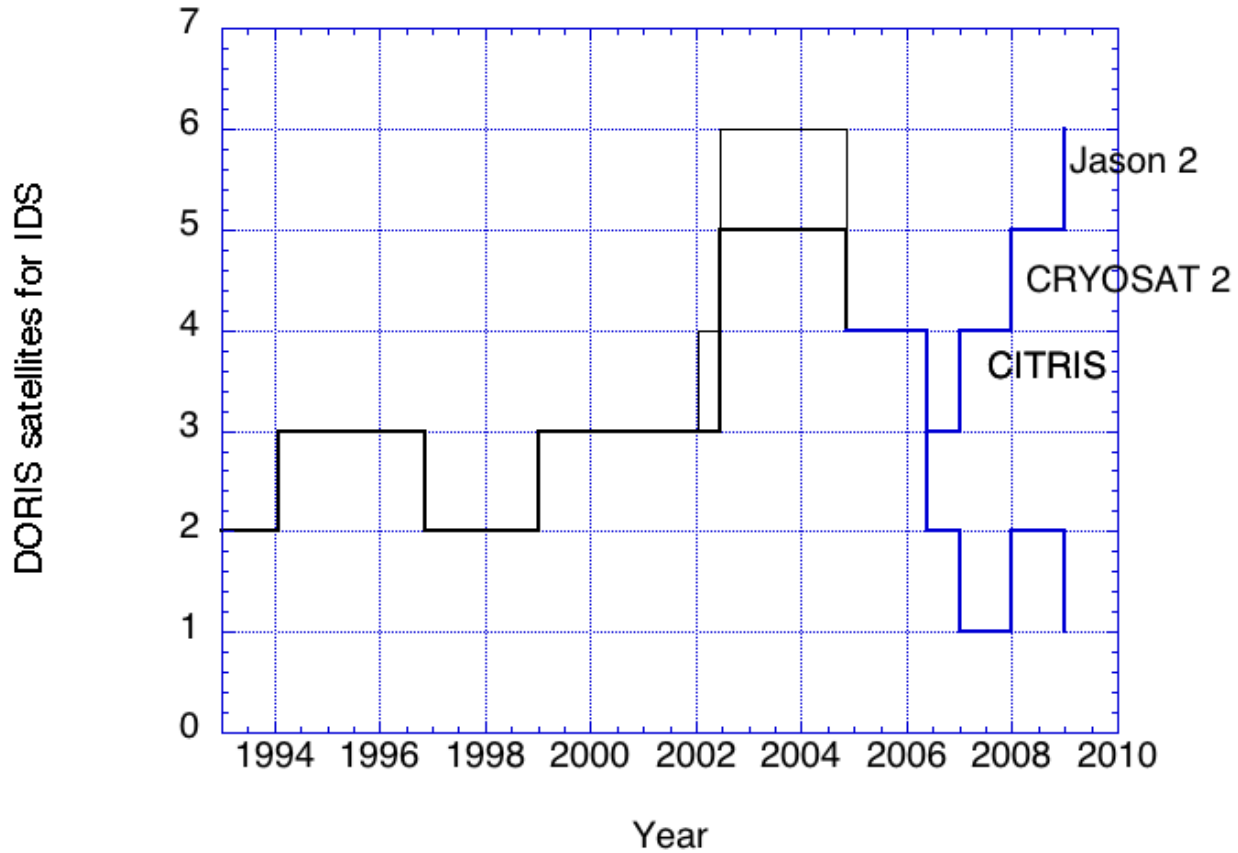


Figure 11: Scale factor of the individual weekly time series combinations from *Tavernier et al.* (2006). IGN/JPL (diamonds); LEGOS/CLS (black dots); GSFC (crosses).

## DORIS constellation evolution



DORIS Special Issue -  
Journal of Geodesy  
(status report, March 10, 2006)

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are needed to see this picture.

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TIFF (Uncompressed) decompressor  
are needed to see this picture.

Guest Editor: P. Willis (+ W. Featherstone when co-author)

18 papers submitted in total (Oct 2005 - Feb 2006.)

3 with a decision:

2 accepted (soon on Springer Website with DOI)

1 refused

15 currently in review:

6 in 1st review cycle

8 sent back to authors for corrections

1 in 2nd review cycle

Expected end of edition = May - June 2006

Authors from 8 different countries

Reviewers from +9 different countries

# Status of 2004 IDS Workshop Recommendations

Action	Status	Comment
2.1. Survey of current uses of IDS products	Open	Rejected during meeting.
2.2 Define procedure to accept an IDS product	Open	
2.3 Split DORISMail and create DORISReports	Closed	
2.4 Understand why some AC's have stopped	Open	
3.1 Request data delivery < 6 weeks	Closed.	
3.2 Change to backup DORIS receiver on Jason	Closed	Done, but SAA problem remains.
3.3 List of IDS Stations (network + campaigns)	Open	
3.4 Test data delivery for campaign stations	Open	
3.5 Define new format (rawer data)	Open	
3.6 Request data from Pleiades (+NPOESS)	Open	Done, but unsuccessful.
4.1 Improve products but keep continuity.	Open	
4,2 Compare AC's analysis strategies.	Open	Some documentation online.
4.3 Investigate TRF scale bias	Open	Some tests done. <i>Willis et al. (2006, in press) Cairns/IAG</i>
4.4 Investigate TZ 1998 (Spot4 data)	Closed	<i>Willis et al. J. Geod. (2006)</i>
5.1 Define validation procedures	Open	

## 2006 IDS Workshop Recommendations (to be discussed & decided during workshop)

**Recommendation 2006.1.0:** (1) Request Release of Pleiades satellite data; (2) Seek other missions of opportunity.

**Recommendation 2006.2.0:** Conduct measurement and force model inventory. Ascertain if AC's can follow IERS2003 recommendations.

**Recommendation 2006.2.1:** Analysis centers should update their analysis description forms on file at the CDDIS, IGN data centers.

**Recommendation 2006.3.0:** New POD Standards for the IDS. Form subcommittee to examine standards used for GRACE, Topex, Jason, Envisat, and recommend models IDS might/should use. Be up to date but not arbitrary (e.g. Use Grace gravity models, but do not specify exact one to use).



## 2006 IDS Workshop Recommendations (to be discussed & decided during workshop)

**Recommendation 2006.4.0:** Decide orbit format for analysis campaigns. (sp1, sp3, POE).

**Recommendation 2006.4.1:** Conduct analysis campaigns for TRF scale and geocenter. Use updated common standards (from previous recommendations). Perform single-satellite and multi-satellite solutions as well as multi-technique solutions; Compare where possible with external data (SLR, Altimeter Crossovers). Systematically compare orbits produced by AC's for this campaign as well as final products. 1-2 years (2003-2004?).

**Recommendation 2006.5.0:** Analysis campaign to validate SAA model (JM Lemoine and Capdeville, this workshop). What is impact on orbits, stations, EOP, scale?

## 2006 IDS Workshop Recommendations (to be discussed & decided during workshop)

**Recommendation 2006.6.0:** Evolve IDS to an operational service. Request AC's to submit solutions within X weeks of receipt of data. Request combination center to perform combination with Y weeks of receipt of AC solutions.

**Recommendation 2006.7.0:** Request submission of ionosphere files for years prior to 2000-2001.

**Recommendation 2006.7.1:** Publicize availability of ionosphere data.

**Recommendation 2006.8.0:** Ask analysis centers to define arcs so that overlaps are available. Conduct overlap analyses on a routine basis and make results available to IDS on routine basis in tabular and plot form.

*Comment: Orbit overlaps are a vital statistic to measure internal consistency and should be available for analysis (like the IGS).*

**Recommendation 2006.8.1:** Submit orbits to IDS so all AC orbits can be intercompared on a routine basis on same schedule as in **Rec. 2006.6.0.**

## 2006 IDS Workshop Recommendations (to be discussed & decided during workshop)

**Recommendation 2006.9.0:** Harmonize *a priori* positions in all STCD files.

**Recommendation 2006.9.1:** Ensure that all AC's can create STCD files and associated plots. Update web site to include results from all AC's.

**Recommendation 2006.9.2:** Publicize availability of STCD files and plots in geophysics community (e.g., IGSMAIL, SLRMAIL, other means).

## Other Issues

- Analysis campaign for time-variable gravity estimation.
- EOP & EOP-rates (proposal of P. Willis).
- Do we continue monthly series or only do weekly series?
- International Polar Year.
- Encouragement of new AC's.

## Conclusion

DORIS as a geodetic observing system is at a crossroads. It has achieved a level of maturity in the quality of the products that it produces. We must focus on the technical issues (e.g. modelling differences between centers) and operational issues in order to continue to refine and improve the contribution DORIS makes to satellite geodesy.