



DORIS



de la coopération CNES-IGN au service international DORIS (IDS)



Gavdos, Crète



Syowa, Antarctique

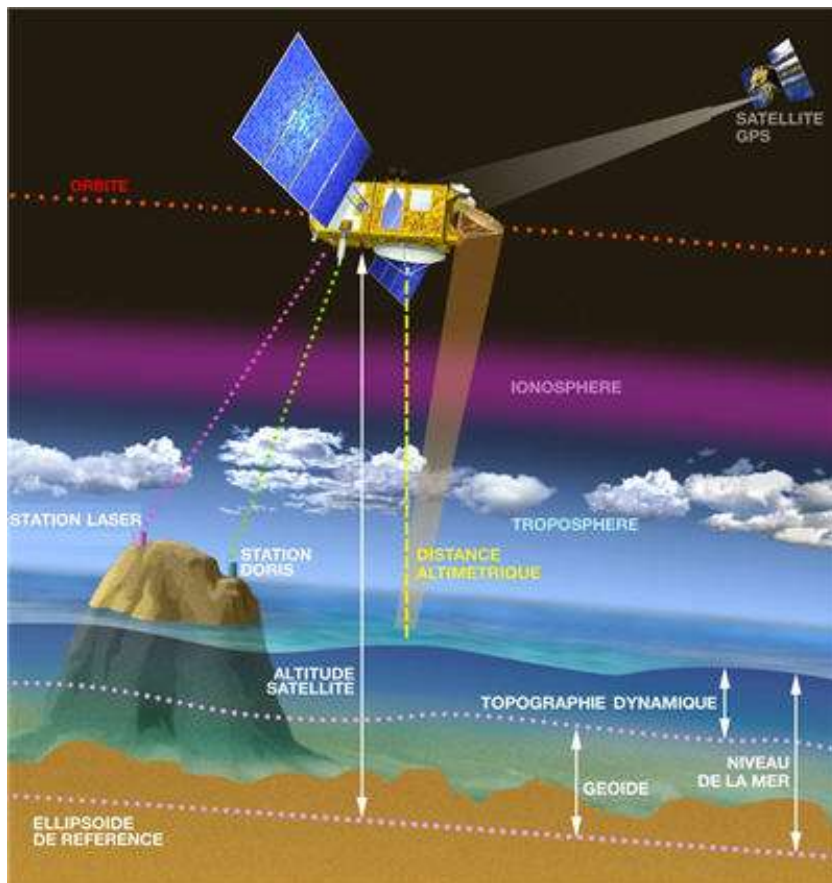
Pascal Willis

avec des contributions de
Frank Lemoine, Xavier Collilieux,...

Plan

- Présentation du système DORIS
- Aspects historiques: évolution du rôle de l'IGN
- Orbitographie précise
- Géodésie
- Géodynamique
- Sciences de l'atmosphère
- Conclusions

Génèse du système DORIS



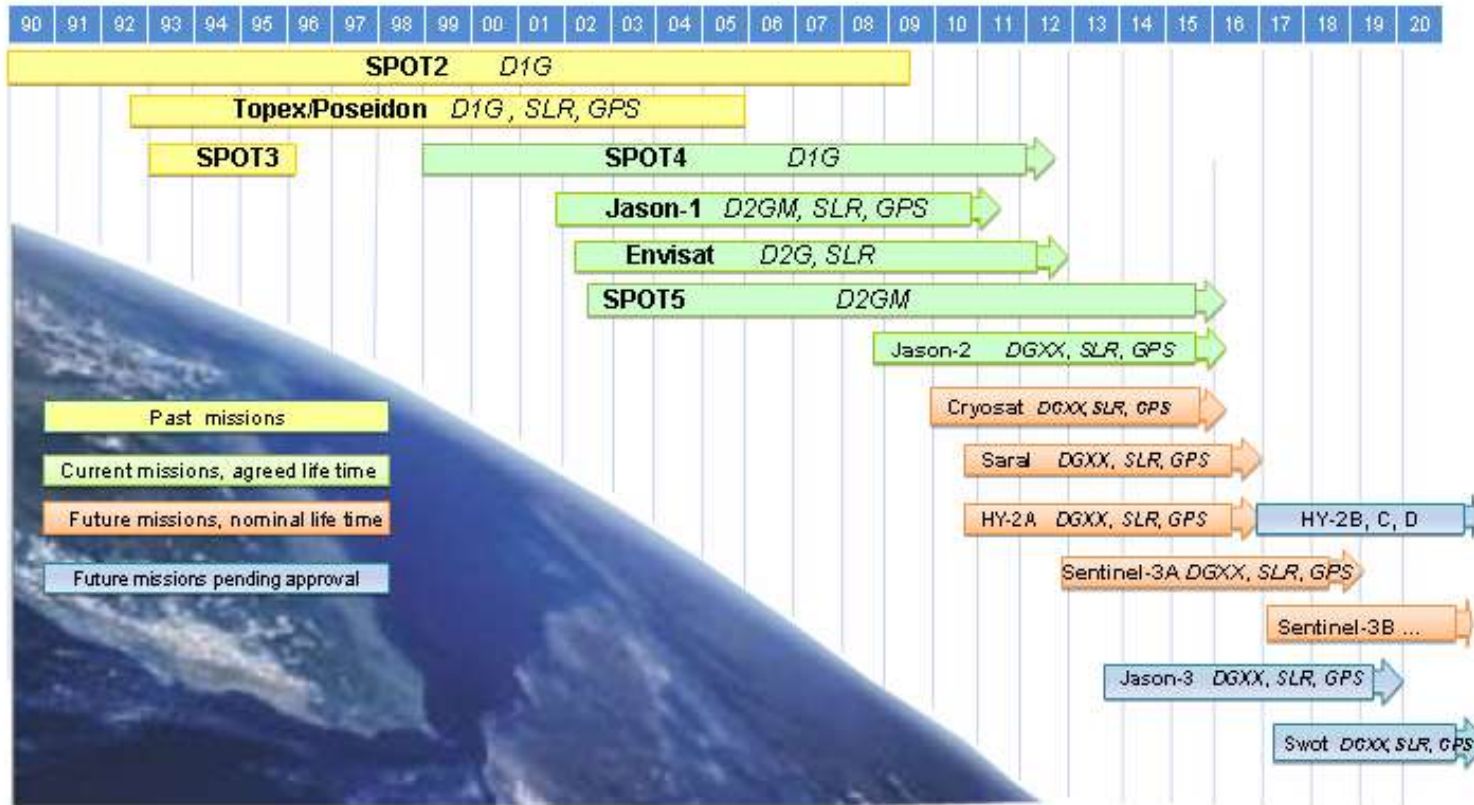
TOPEX/Poséidon, 1992
Coopération NASA/CNES

- But initial de DORIS:
- Orbitographie précise à bord du satellite
 - Système simple (Doppler)
 - Robuste



Les satellites DORIS

DORIS CONSTELLATION



Actuellement 6 satellites DORIS



SPOT2,3,4,5
800 km



TOPEX, Jason1,2
1300 km



Envisat, Cryosat2
800 km

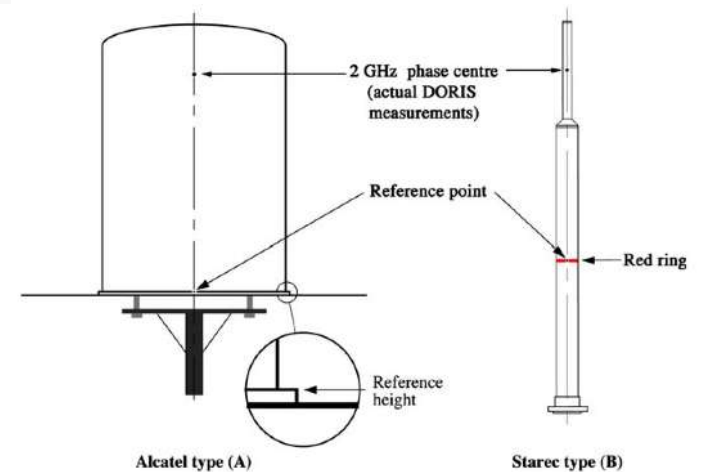
Satellites DORIS (prochains lancements)

Satellite	Agence	Altitude (km)	Inclinaison (°)	Lancement prévu
SARAL/AltiKa	ISRO (Inde)	800	98.5	Été 2011
HY2A	CNSA (Chine)	960	99.3	Juin 2011
Sentinel 3	GMES	800	98.6	Avril 2013
Jason3	EUMETSAT/NOAA/CNES	1300	66	Été 2013
SWOT	NASA/CNES	970	78	2020

Le réseau de poursuite au sol



57 stations, 2010

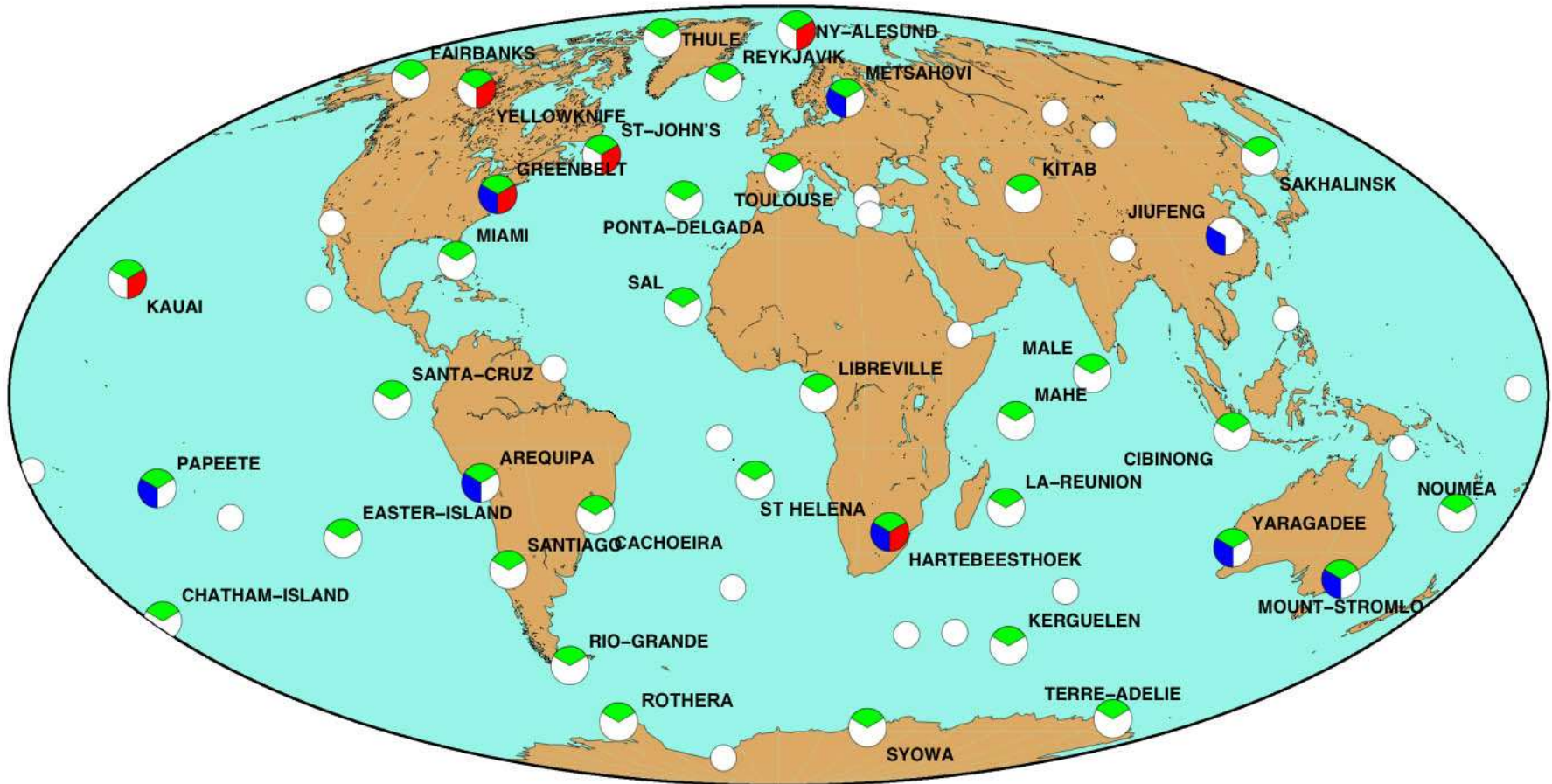


Fagard, 2006

Service d'Installation et de Maintenance des Balises (SIMB) à l'IGN

Premières installations en 1986 (avant SPOT-2, 1990)


Co-locations DORIS



 GPS (IGS)

 SLR

 VLBI

 No active co-location < 10 km

Exemples de stations DORIS



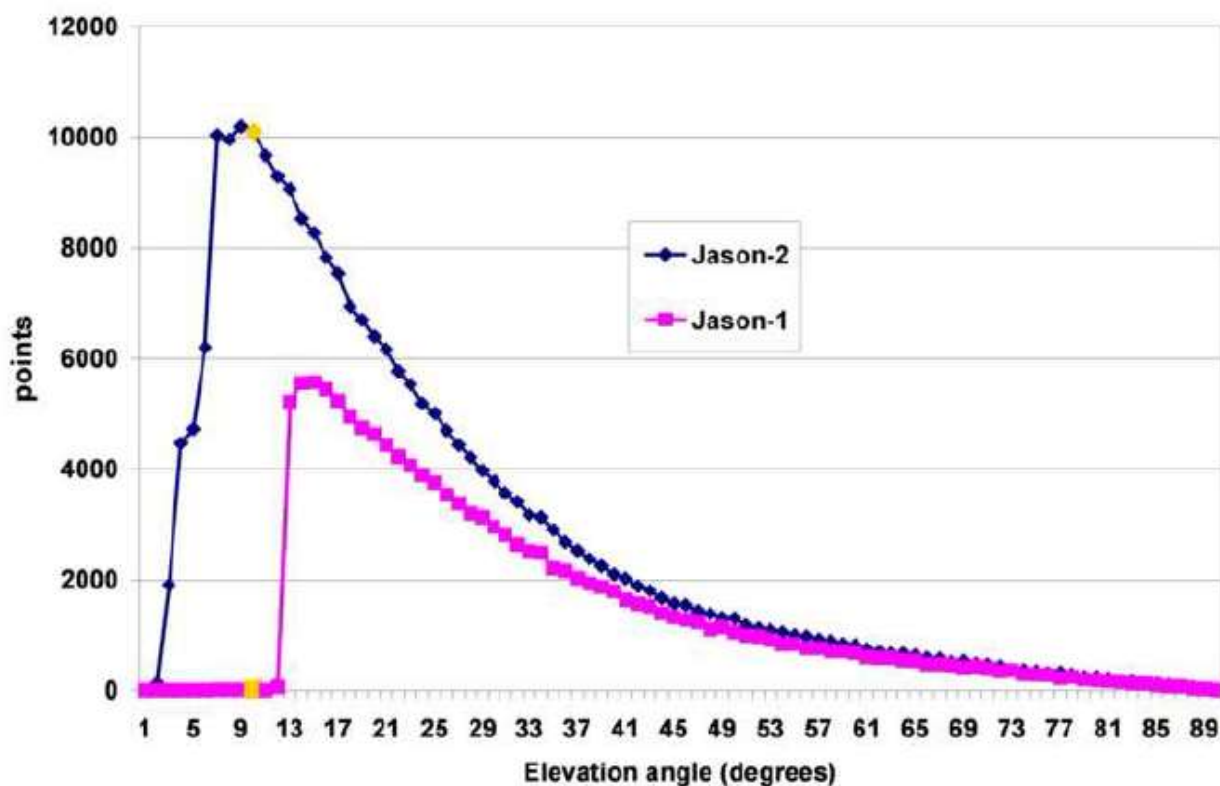
Rikitea, Polynésie



Ny Alesund, Norvège

<http://ids-doris.org/network/sitelogs.html>

Evolutions technologiques récentes



Récepteur numérique

DGXX

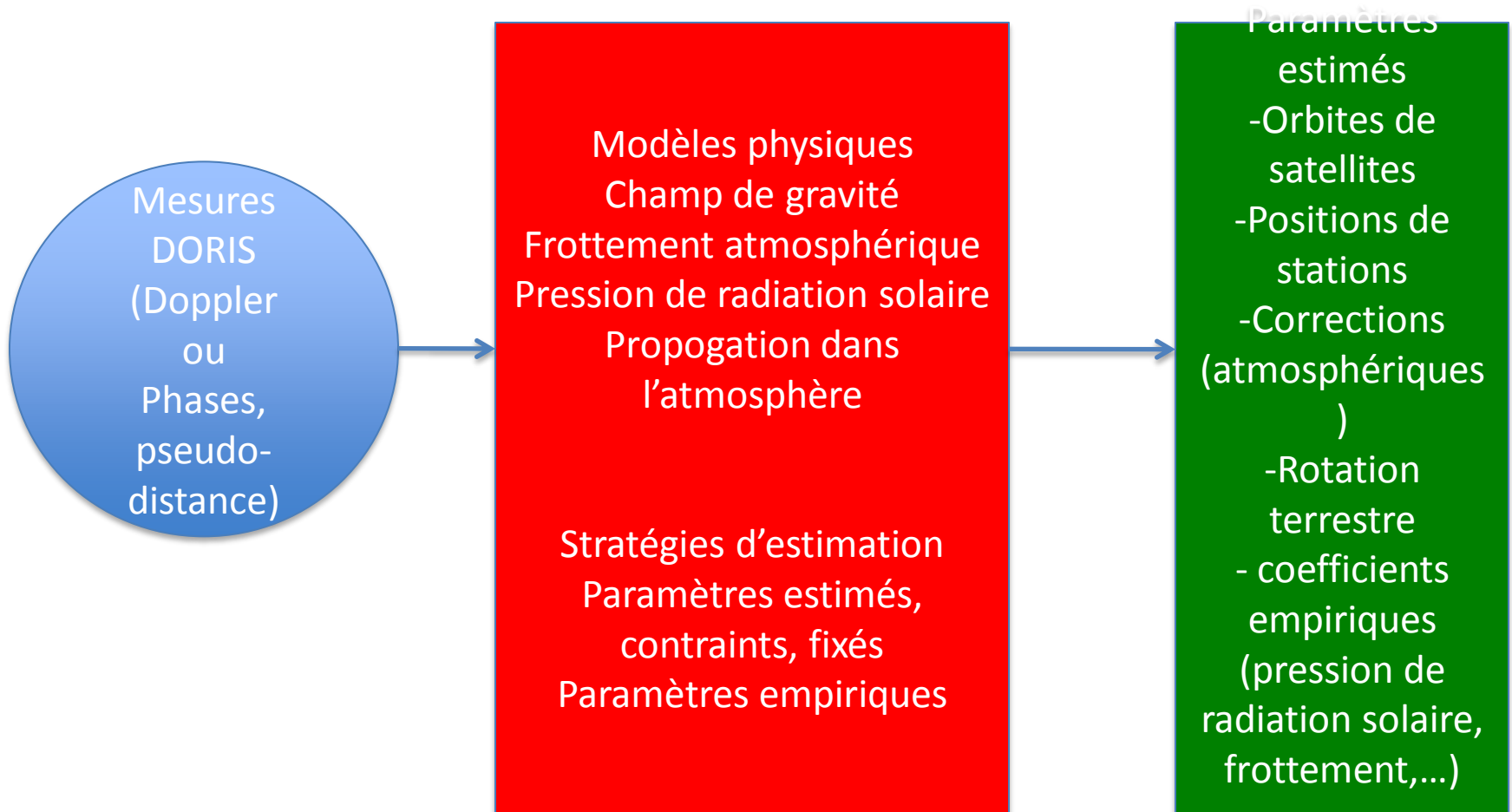
7 canaux

RINEX (phase vs. Doppler)

Applications du système DORIS

- Orbitographie précise
- Champ de gravité (satellites bas 800-1300 km)
- Positions des stations
- ..
- Mouvement du pôle de la rotation terrestre
- Atmosphère (troposphère, ionosphère)

Calculs DORIS



Historique: évolution du rôle de l'IGN

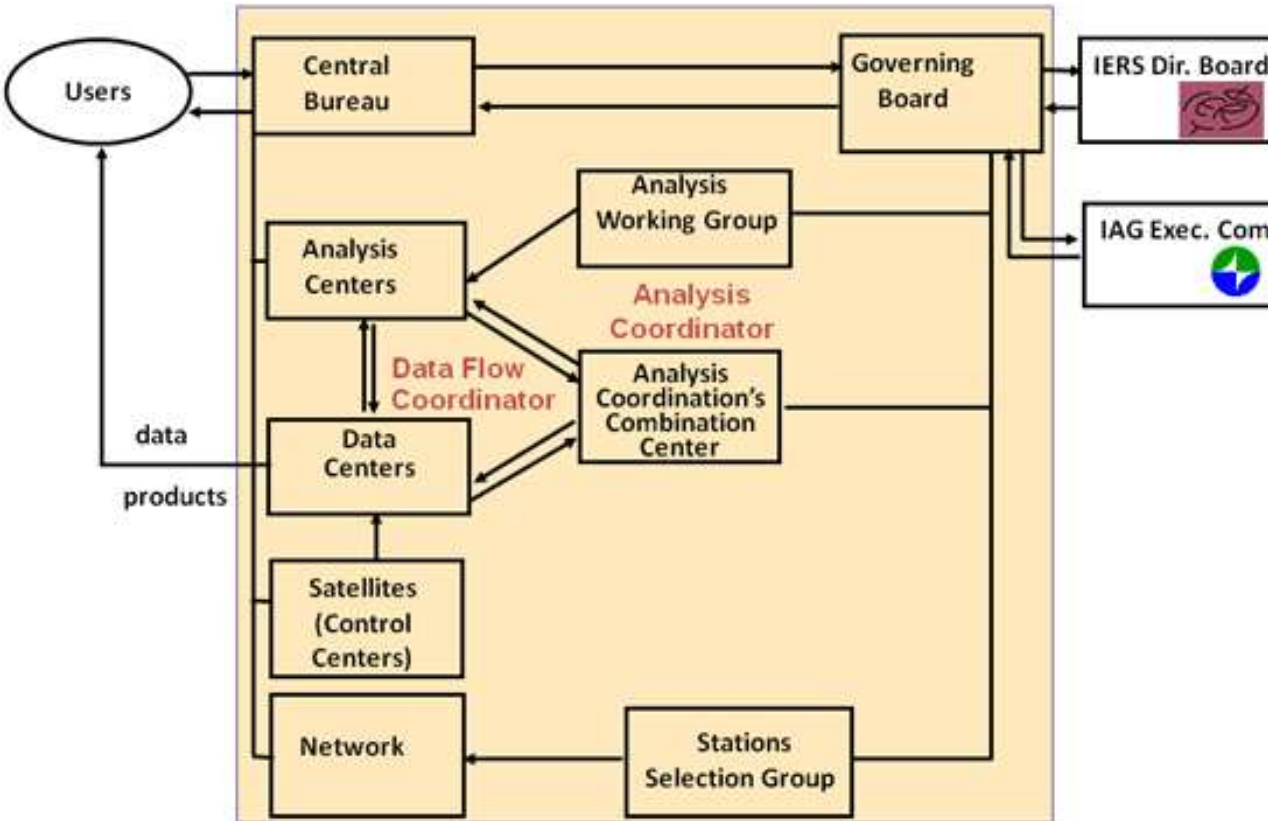
- ~1986 -1992
 - Réseau de poursuite
 - Système de référence terrestre (T/P)
 - Logiciel interne IGN (GDVS) + spécifications technique pour un logiciel CLS
- ~1990
 - Logiciel GIPSY/OASIS (Jet Propulsion Laboratory, USA)
 - Calculs / recherches DORIS
- ~2000
 - DORIS Pilot Project → International DORIS Service (2003)
 - Centre d'Analyse DORIS à l'IGN
 - Centre de données à l'IGN
- ~2005
 - Résultats DORIS pour d'autres (géophysique)

International DORIS Service

<http://ids-doris.org>

The screenshot shows the homepage of the International DORIS Service. At the top left is the logo, which consists of a globe with the letters 'IDS' and the text 'International DORIS Service'. To the right of the logo is a search bar with the text 'search...' and a 'SEARCH' button. Below the logo and search bar is a navigation menu with the following items: Mails, Bibliography, Sitelogs, Time series, System events, Stations events, MOE statistics, and POE statistics. The main content area is divided into three columns. The left column contains a navigation menu with the following items: Home, Site map, FAQ, Glossary, IDS, Organization, Data & Products (with sub-items: Documents, Meetings, Reports & Mails, Contacts & links (with sub-items: Contacts, Links, Directory)), DORIS SYSTEM (with sub-items: Official web site, Network, System monitoring), and ANALYSIS COORDINATION (with sub-items: Presentation, Combination, Documents, Doris related events, Discussion). The middle column features a banner image of six DORIS stations in various locations, with the text 'International DORIS Service' below it. Below the banner is a paragraph describing DORIS as a Doppler satellite tracking system developed for precise orbit determination and precise ground location. It is onboard the Jason-1, Jason-2 and ENVISAT altimetric satellites and the remote sensing satellites SPOT-4 and SPOT-5. It also flew with SPOT-2, SPOT-3 and TOPEX/POSEIDON. Below this is a paragraph describing IDS as an international service which provides a support, through DORIS data and products, to geodetic, geophysical, and other research and operational activities. New proposals for Analysis Centers and temporary or permanent DORIS stations are welcome. See the call for participation. Below this is a paragraph stating that the site is composed of three parts: 'IDS' describes the organization of the service and includes documents, access to the data and products, event announcements, contacts and links; 'DORIS' allows to access general description of the system, and gives information about the system events and the tracking network; 'Analysis Coordination' provides information and discussion areas about the analysis strategies and models used in the IDS products. It is maintained by the Analysis Coordinator with the support of the Central Bureau. Below this is a paragraph stating that you may come back at any time to the Home Page by clicking on the IDS logo at the left upper top. The right column contains a 'Highlights' section with the following items: New launch date for CryoSat-2 confirmed, DORIS 20th Anniversary, IDS Workshop, Lisbon, Portugal, 21-22 October 2010, IDS AWG at ESOC, 20-21 April 2010, New address of the IDS web site: http://ids-doris.org, New address of the IDS ftp site: ftp://ftp.ids-doris.org/pub/ids/. Below the highlights section are two boxes: 'What's new on IDS' and 'What's new on DORIS' (with sub-item: Site updates), and 'Acknowledge IDS' (with sub-item: Whenever your use of IDS data or products results in a publication, please include a proper citation).

International DORIS Service



Coordination:

Frank Lemoine (NASA)

Combination:

Jean-Jacques Valette (CLS)

7 Analysis Centers

France (2)

USA (1)

Germany (1)

Czech Rep. (1)

Russia (1)

Australia (1)

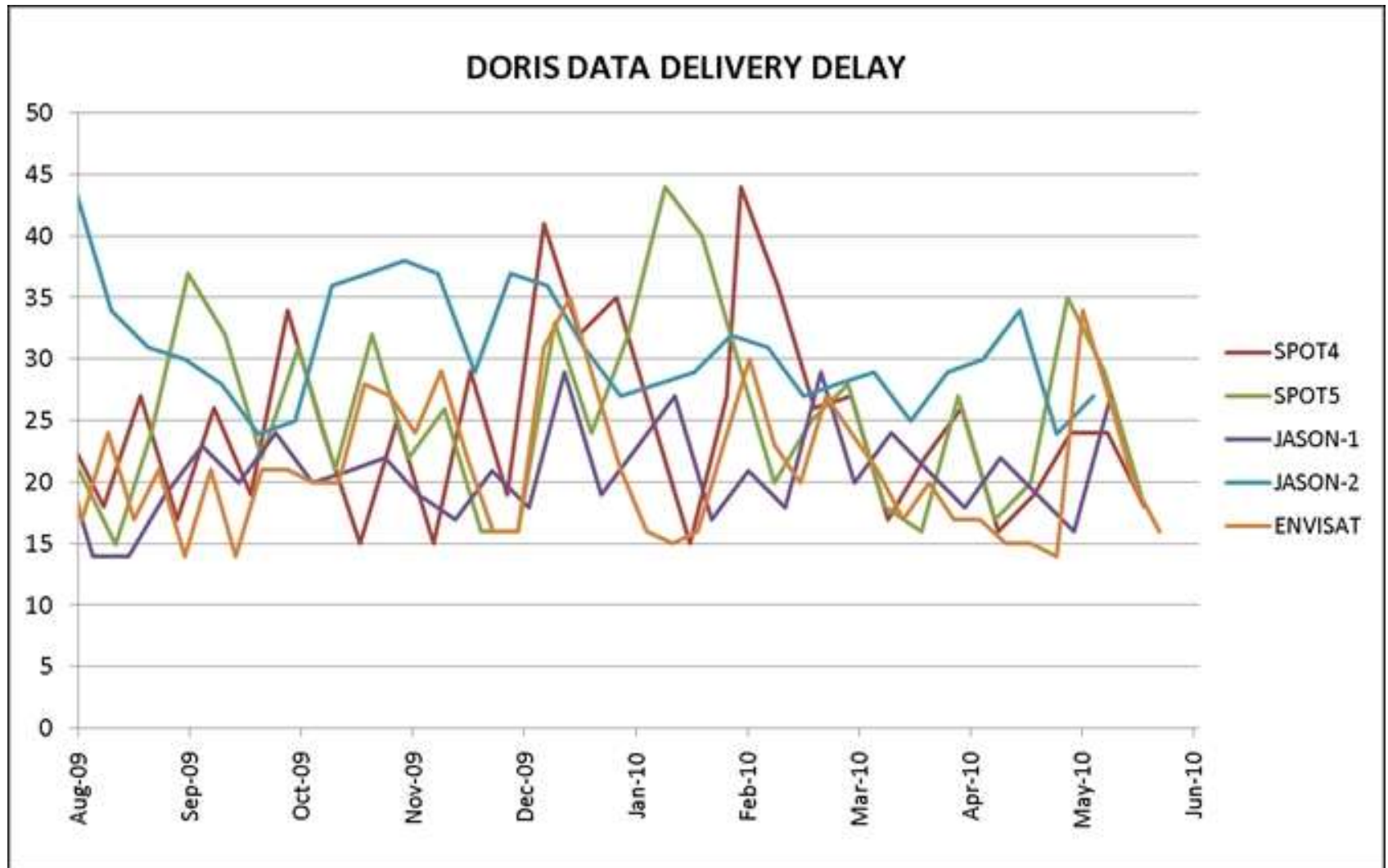
2 centres de données

NASA

IGN

<http://ids-doris.org>

Livraison des données DORIS à l'IDS



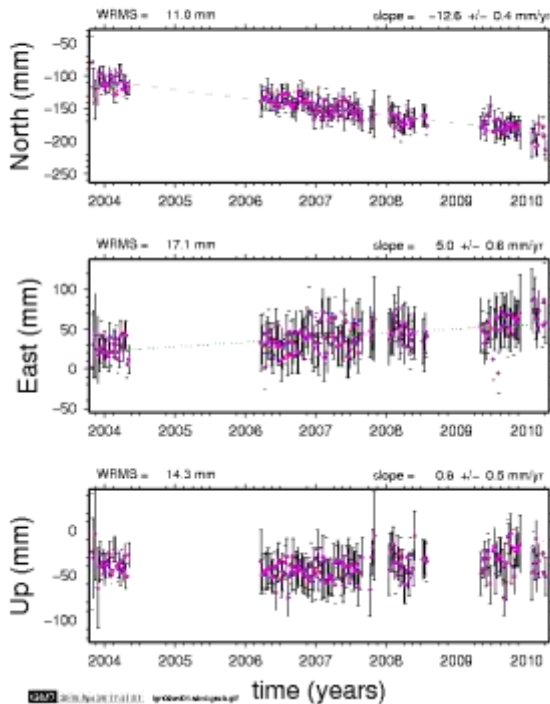
Résultats DORIS/IGN (mis à jour toutes les semaines)

DORIS weekly solutions – IGN/JPL Analysis Center

DORIS weekly solutions – IGN/JPL Analysis Center

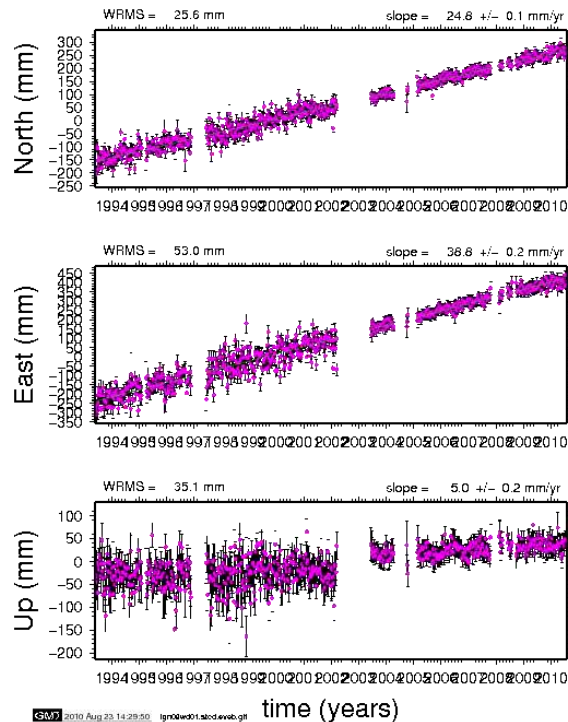
DORIS weekly solutions – IGN/JPL Analysis Center

ign09wd01 GAVB



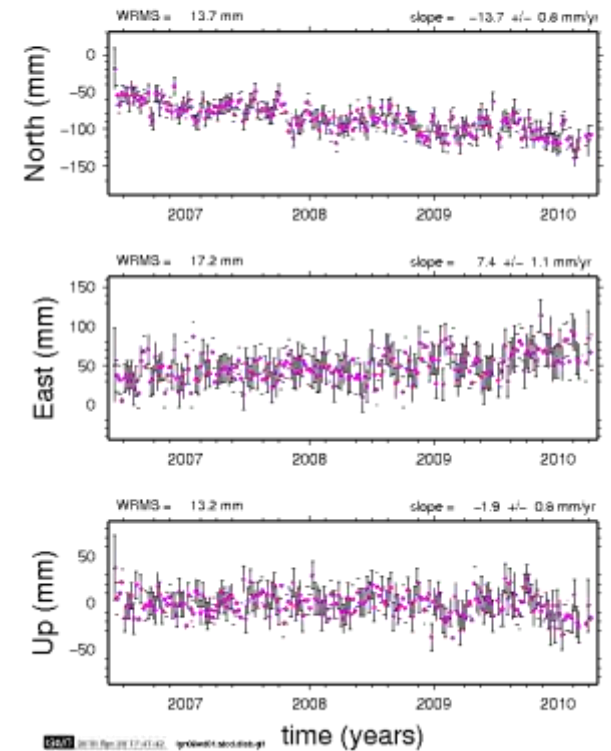
IGS07 2010 Nov 20 12:11:01 ign09wd01.acd.gavb.gll

ign09wd01 EVEB



IGS07 2010 Aug 23 14:29:50 ign09wd01.acd.eveb.gll

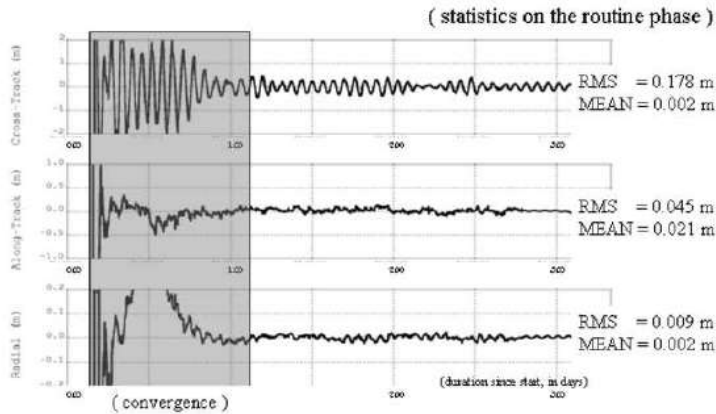
ign09wd01 DIOB



IGS07 2010 Sep 28 12:41:42 ign09wd01.acd.diob.gll

<http://ids-doris.org/network/ids-station-series.html>

Orbitographie précise

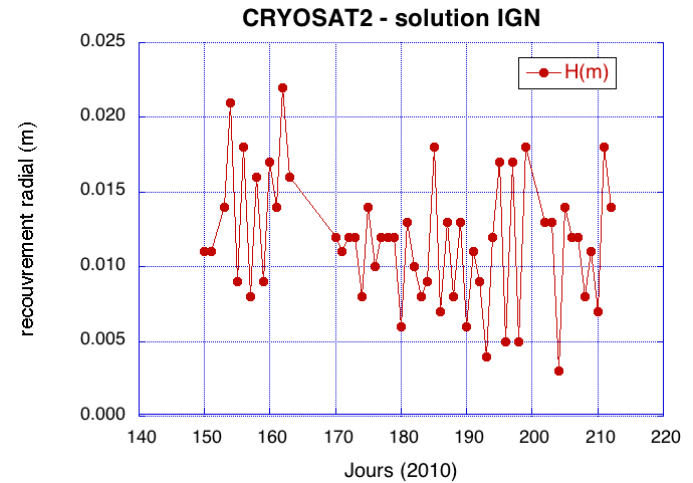
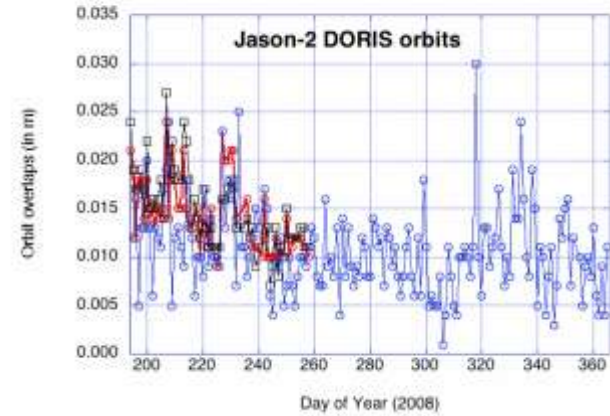


Logiciel **DIODE**/CNES
 Calculs d'orbite à bord du satellite
 Jayles et al., 2010

5 cm temps réel à bord du satellite

■ DORIS vs GPS dyn (H)
■ DORIS vs GPS red dyn (H)
○ DORIS vs DORIS (H)

DORIS vs GPS dyn (30 hour overlaps) : 14 mm (median RMS)
 DORIS vs GPS red dyn (30 hours overlaps) : 13.5 mm (median RMS)
 DORIS vs DORIS (6 hour overlaps) : 10 mm



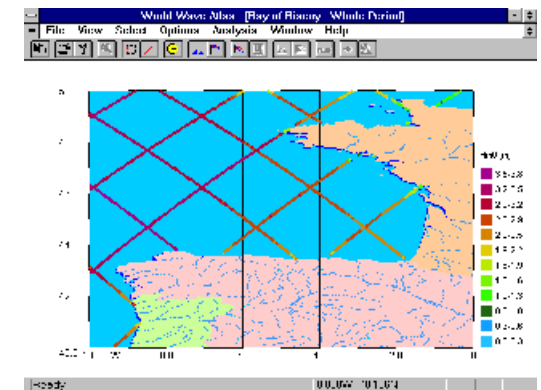
Résultats IGN: 10 mm
 A posteriori

Comparaisons d'orbites (entres centres d'analyse IDS) (SPOT2)

Orbit 1	Software 1	Orbit 2	Software 2	Number of comparisons	Radial (mm)	Cross-track (mm)	Along-track (mm)
GAU-5	GEODYN	GSC-base	GEODYN	43	5.7	25.2	38.3
GAU-5	GEODYN	IGN-2	GIPSY/OASIS	311	13.5	55.5	43.8
GOP	Bernese	GSC-10deg	GEODYN	20	19.2	51.3	82.2
GOP	Bernese	IGN-2	GIPSY/OASIS	19	21.3	49.9	73.2
IGN-2	GIPSY/OASIS	GSC-base	GEODYN	347	13.4	39.3	55.2
IGN-2	GIPSY/OASIS	INA-2	GIPSY/OASIS	344	9.1	21.1	22.3
INA-2	GIPSY/OASIS	GSC-10deg	GEODYN	333	15.5	44.7	57.6
LCA	GINS/DYNAMO	GSC-base	GEODYN	95	10.2	31.6	46.4

Validation externe des orbites DORIS

SLR-only, POD	number stations	average points / cycle	average rms residuals (cm)	
			SLR	XOVER
TOPEX/Poseidon Sept. 25, 1992 Ğ July 17, 1993				
LPOD2005	36	4623	2.219	6.010
ITRF2008	36	4623	2.140	5.984
ITRF2008d	36	4623	2.134	5.979
TOPEX/Poseidon, Jan. 15, 2002 Ğ Aug. 11, 2002				
LPOD2005	35	4102	1.537	5.565
ITRF2008	34	4095	1.448	5.548
ITRF2008d	34	4094	1.423	5.542
Jason-1, July 11, 2008 Ğ Jan. 26, 2009				
LPOD2005	32	2690	1.029	5.555
ITRF2008	32	2690	1.014	5.531
ITRF2008d	32	2691	0.990	5.521
Jason-2, Jan. 26, 2009 Ğ Jan. 28, 2010				
LPOD2005	32	5149	0.999	5.649
ITRF2008	32	5146	0.950	5.651
ITRF2008d	32	5145	0.947	5.648



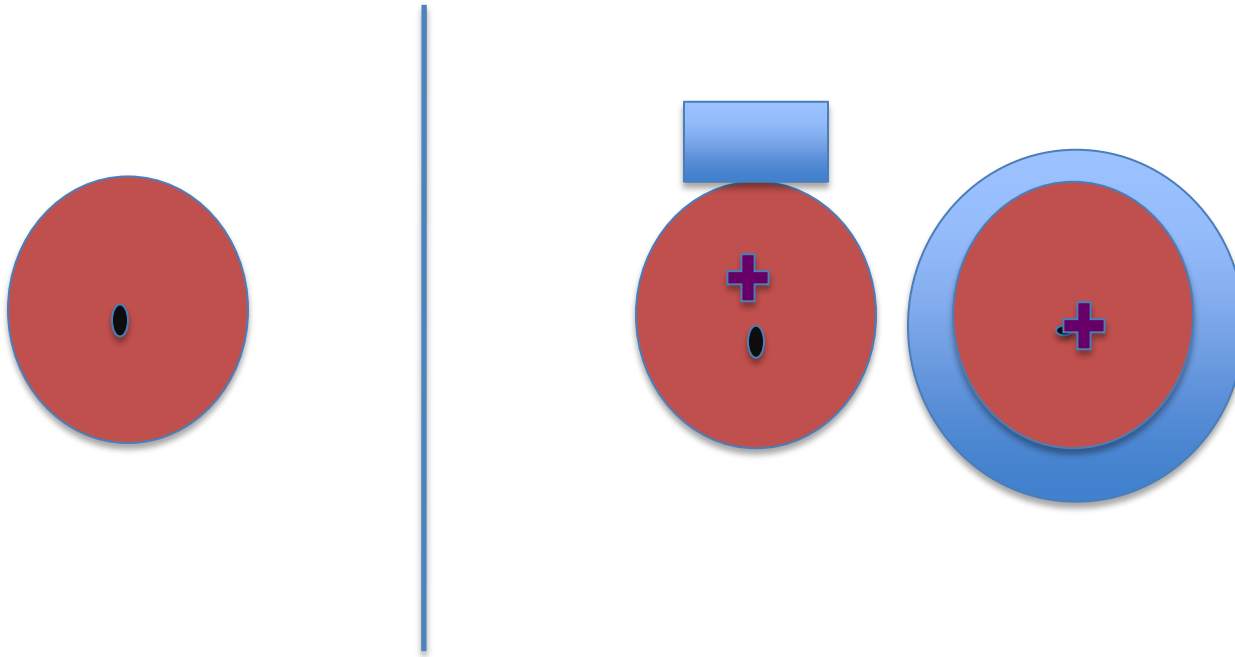
(source AVISO)

Géodésie

(système de référence)

- Géocentre
- niveau des mers
- Facteur d'échelle

Géocentre

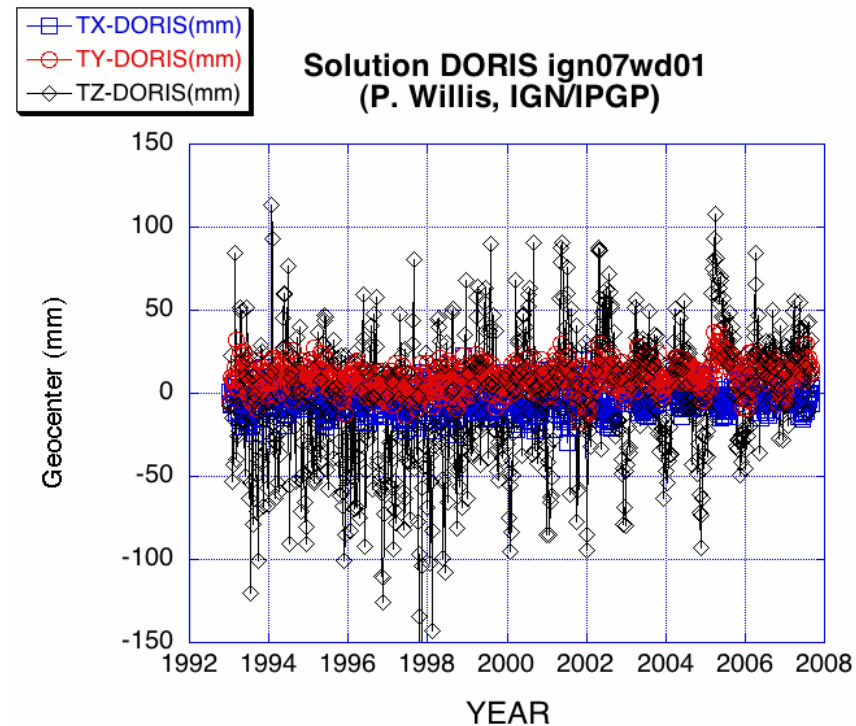
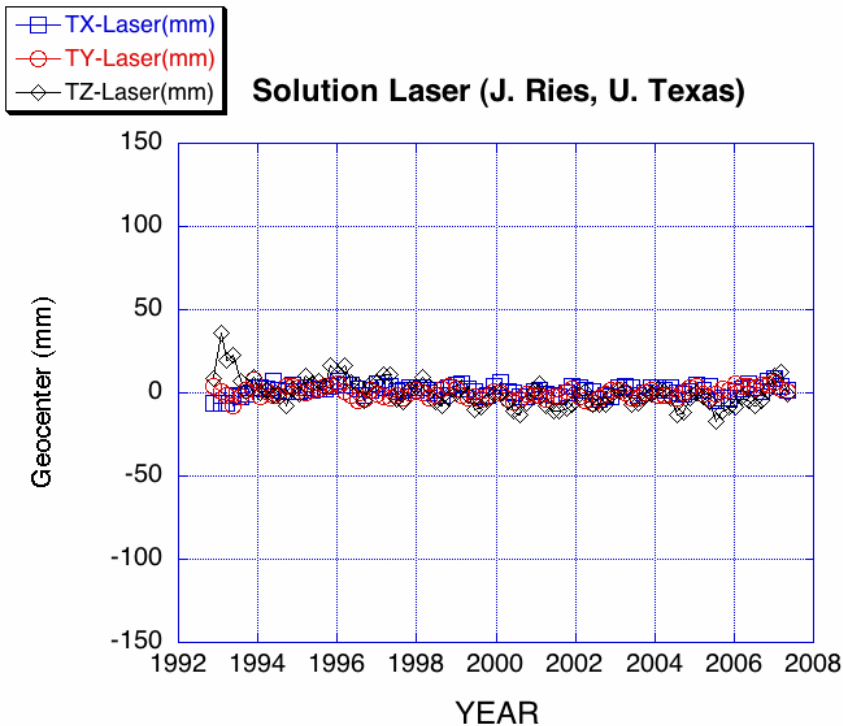


Géocentre = **centre des masses** du
Système Terre-Atmosphère-Océans
(foyer des orbites de satellites)

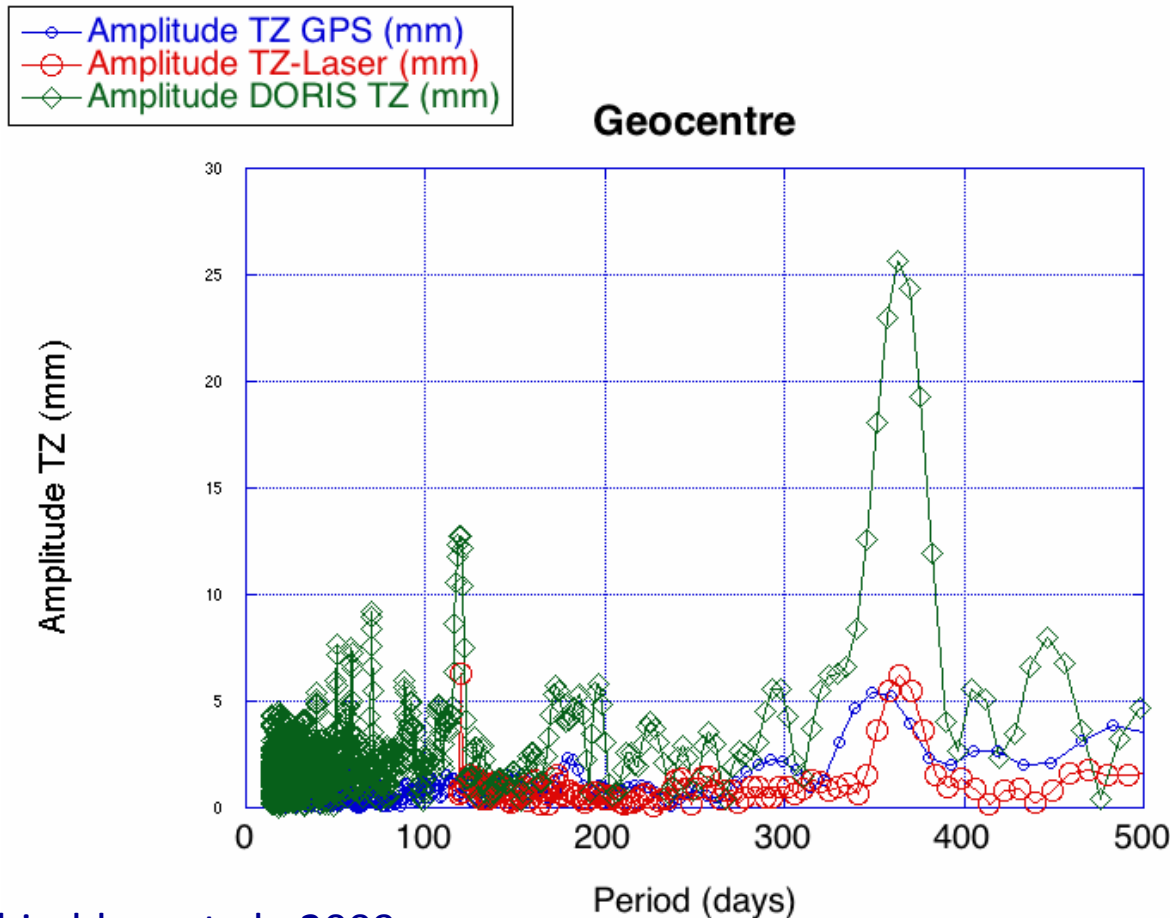
Origine = point lié à la **Terre solide**
(pour repérer les coordonnées de stations
À la surface terrestre)

Géocentre hebdomadaire

Analyse de l'ancienne solution DORIS (soumise pour l'ITRF2005)



Géocentre / analyse en fréquence



Composante principale

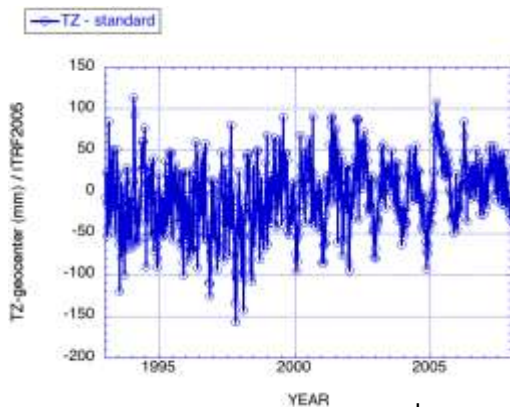
Géophysique:
1 year = \approx 5 mm

Laser/ U. Texas:
1 an = 6 mm

GPS/ IGS (combiné):
1 an = 5 mm

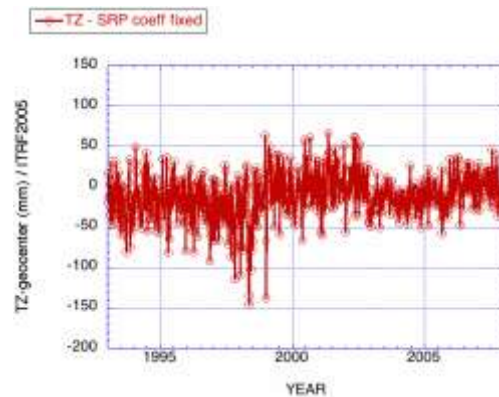
DORIS/IGN
1 an = 26 mm ???
118 jours = 13 mm???

Estimer ou fixer le paramètre de pression de radiation solaire?

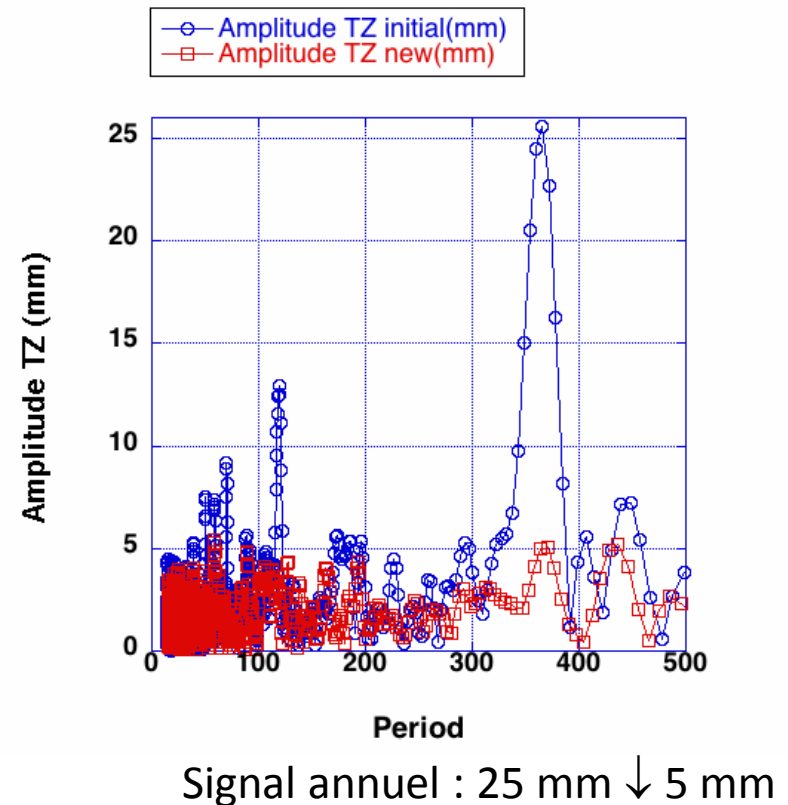


Pour l'ITRF2005

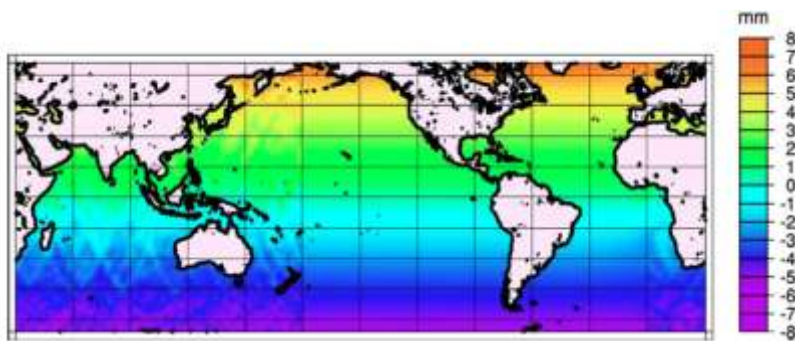
SP2/TP : RMS 46.6 mm ↓ 30.1 mm



Pour l'ITRF2008



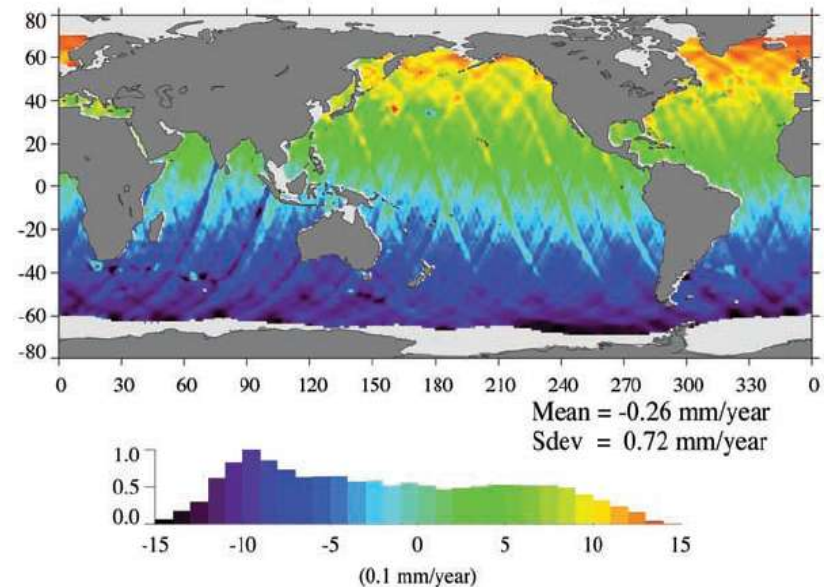
Pourquoi s'intéresser à l'origine du repère? (Niveau des mers)



Simulations DORIS (IGN)

$$\Delta\text{MSL (mm)} = -0.12 \cdot \Delta\text{TZ (mm)}$$

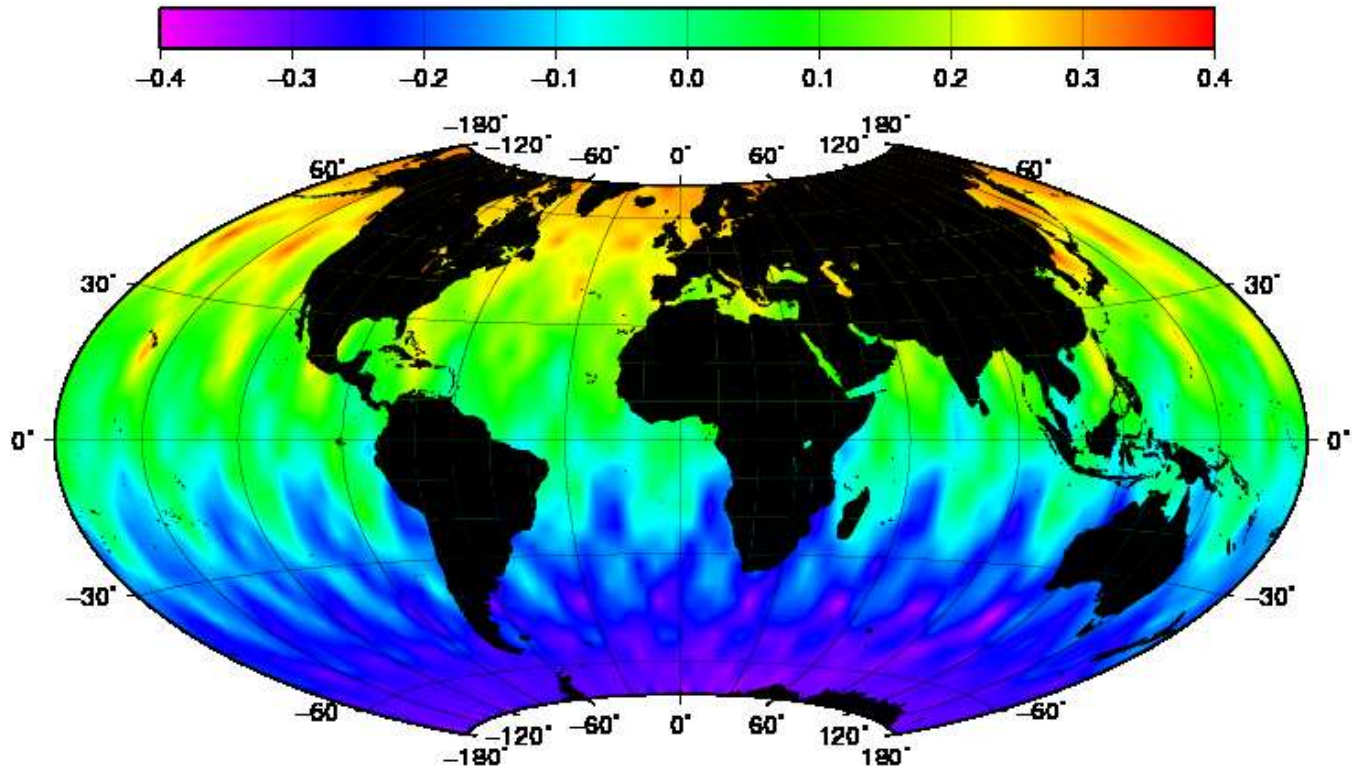
Morel and Willis, 2005



Données réelles NASA (DORIS+Laser/GPS)
ITRF2000 → ITRF2005

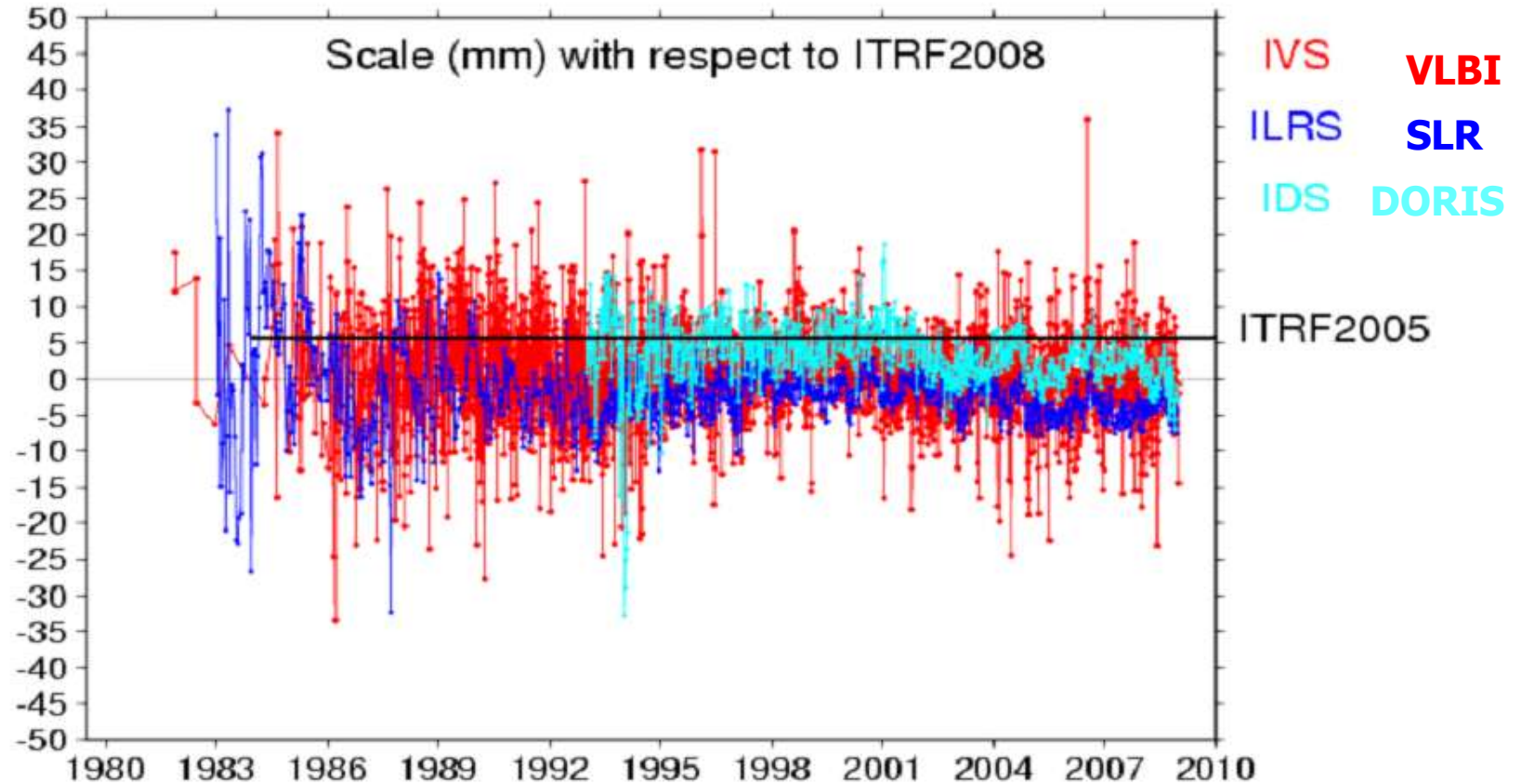
Beckley et al., 2007

Niveau moyen des mers (orbites DORIS)



RMS (océan) ITRF2008 vs ITRF2005 = +0.06 mm/an
(source NASA)

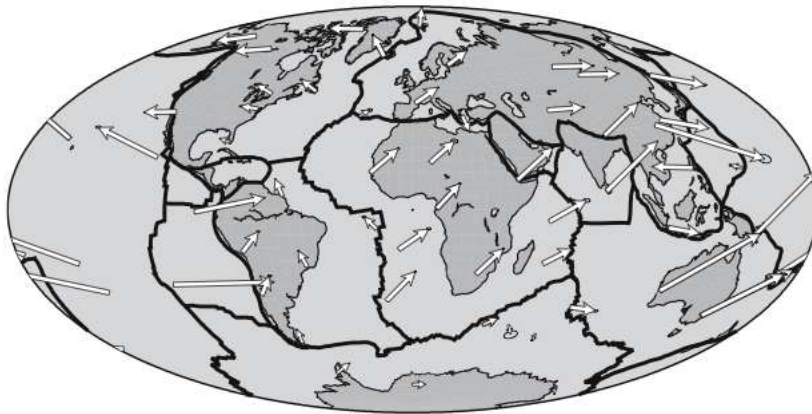
Facteur d'échelle DORIS



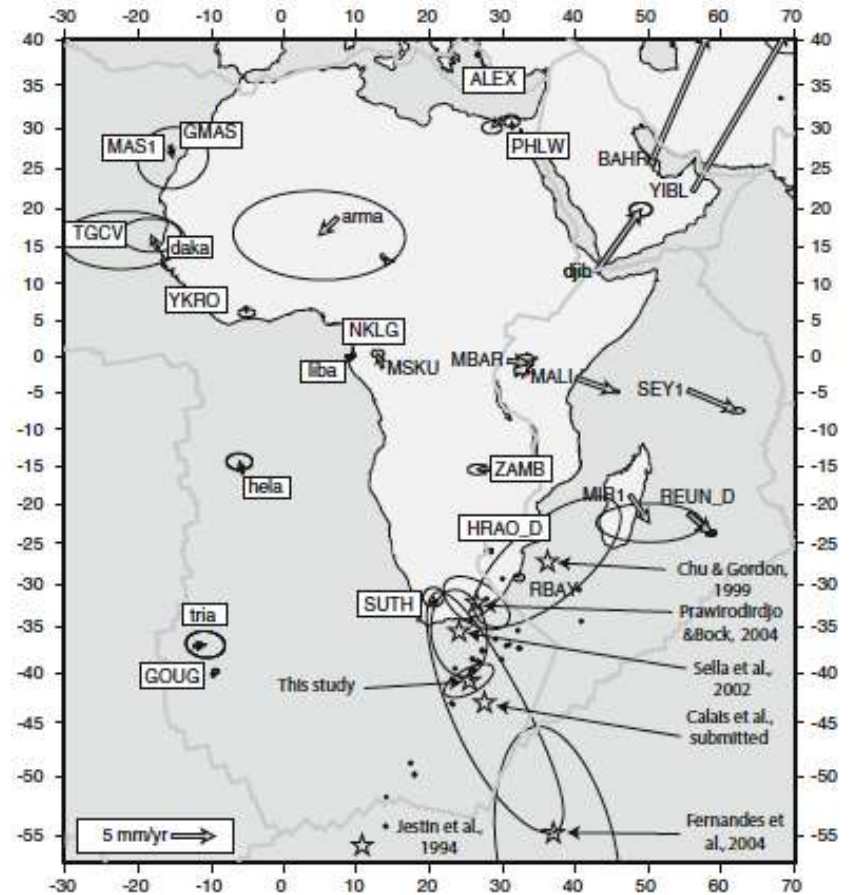
Géodynamique (exemples)

- Tectonique des plaques
- Volcanisme: Socorro
- Etude de subsidence: Tahiti
- Rebond post-glaciaire

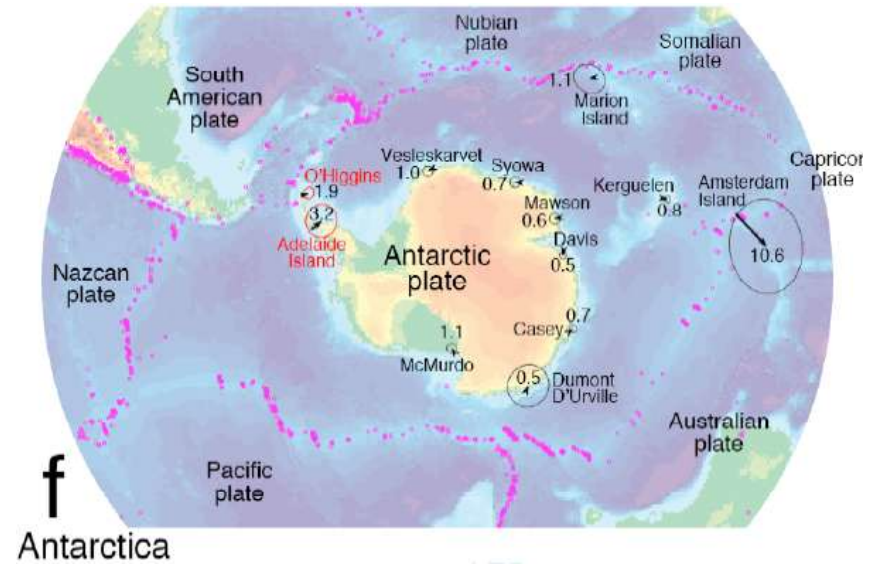
Tectonique des plaques



GPS + DORIS
Nocquet et al., 2006



Plaques tectoniques



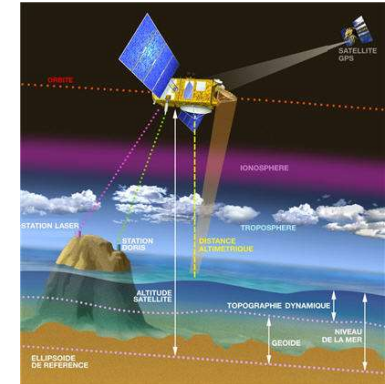
GEODVEL

GPS + DORIS + Laser + VLBI

Argus et al., 2009



Volcanologie



Mouvement vertical détecté

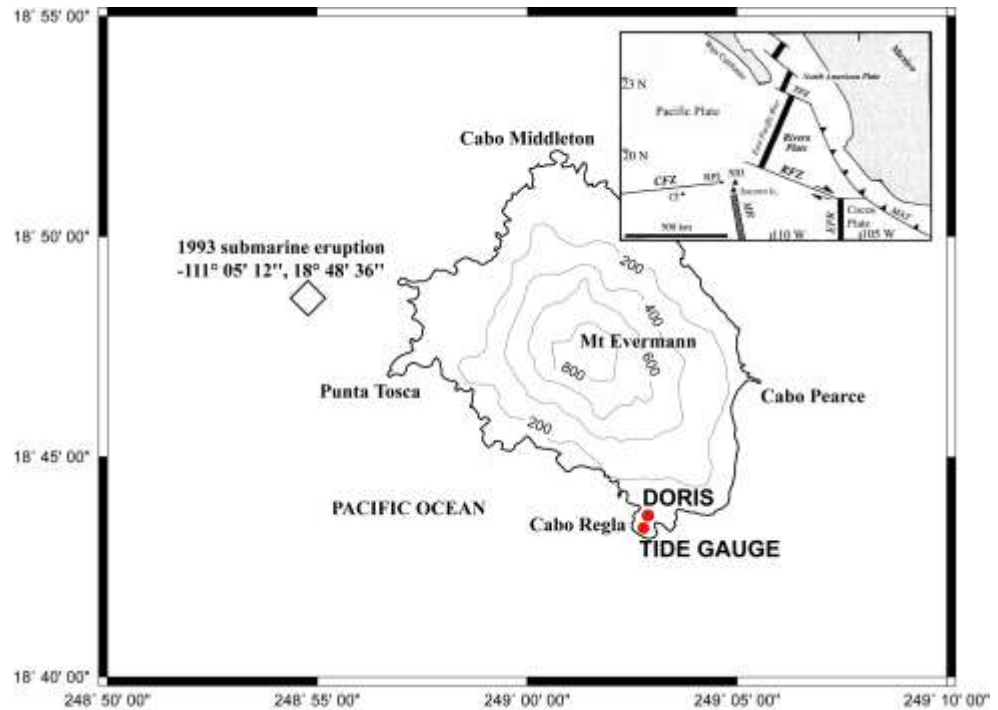
-10 cm/an pendant 3 ans

Willis et al., 1998

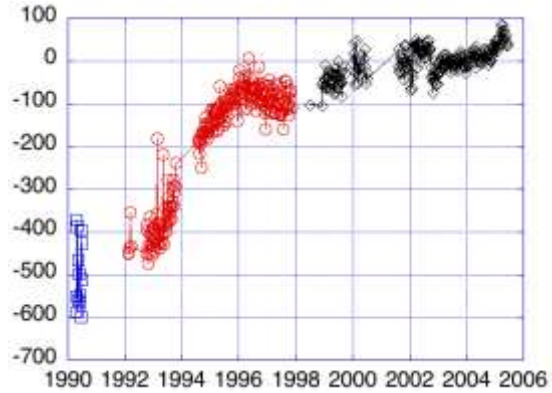
Cazenave et al., 1999

Mouvements horizontaux?

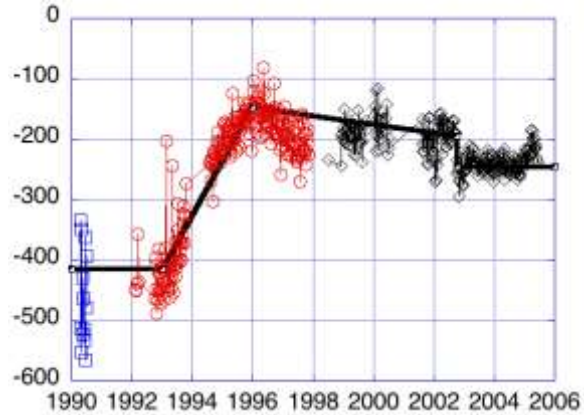
Briole et al., 2009



Volcanologie

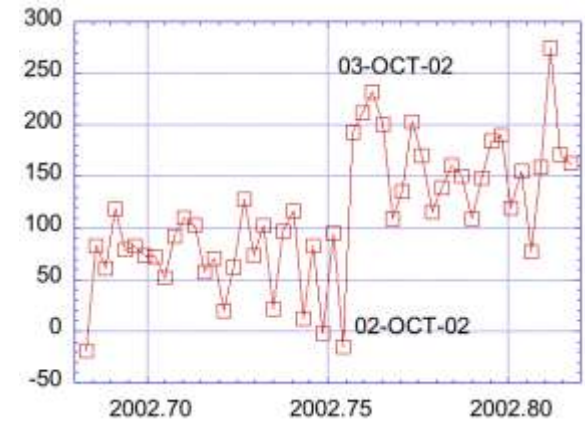
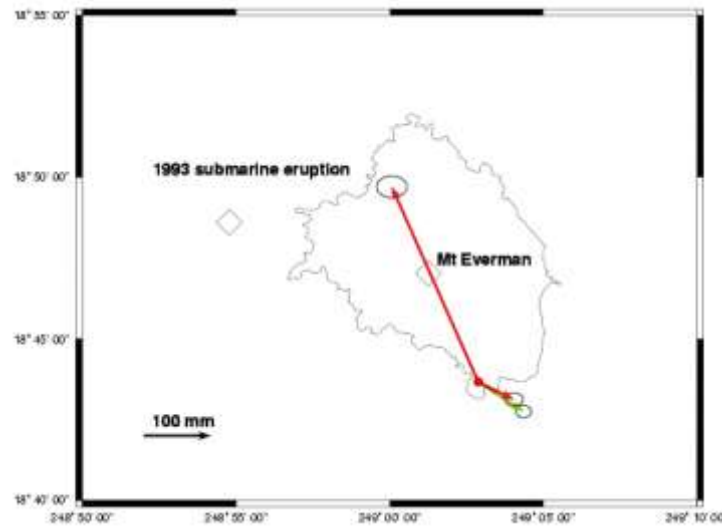


Résultats DORIS bruts



En retirant un modèle de plaque

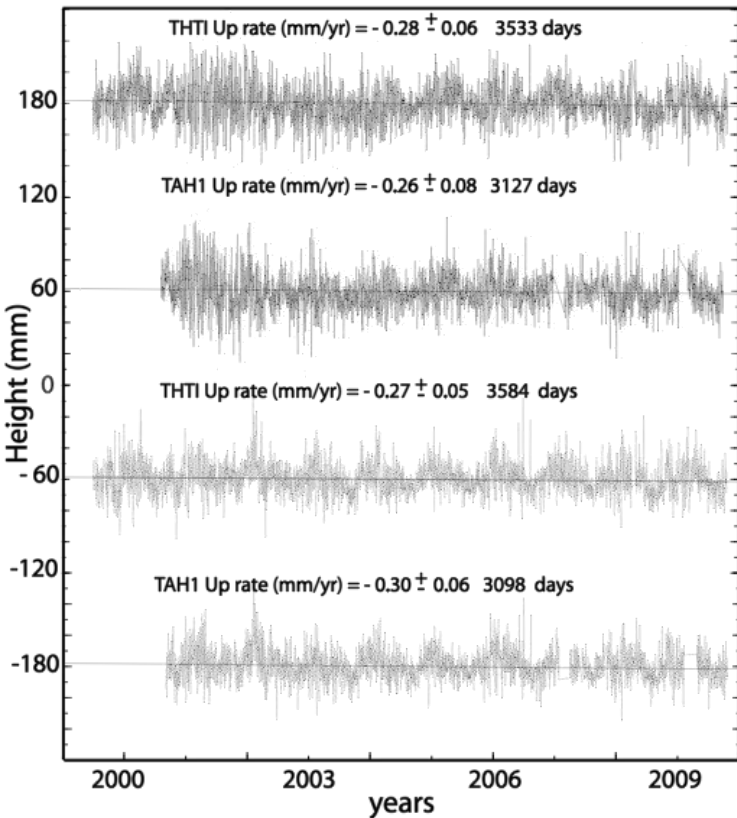
Déflation 1,8 m³/s
Profondeur 6,2 Km



Tahiti

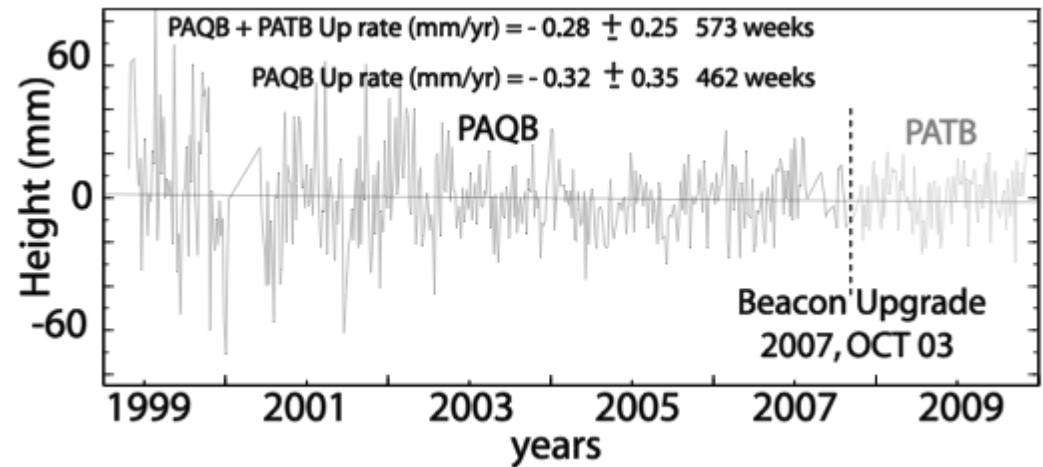
(pas de subsidence significative)

GPS

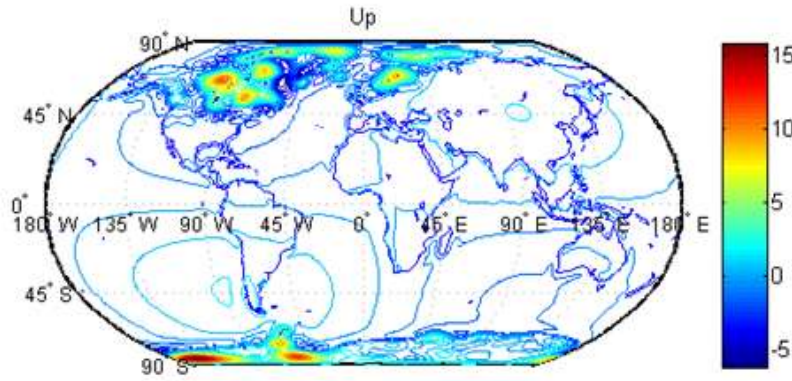


Fadil et al., submitted

DORIS

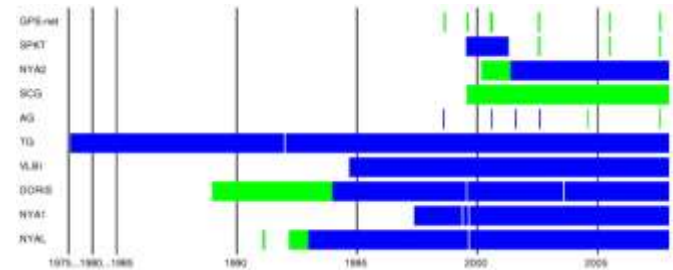


Rebond post-glaciaire



Peltier, 2004 ICE-5G VM2

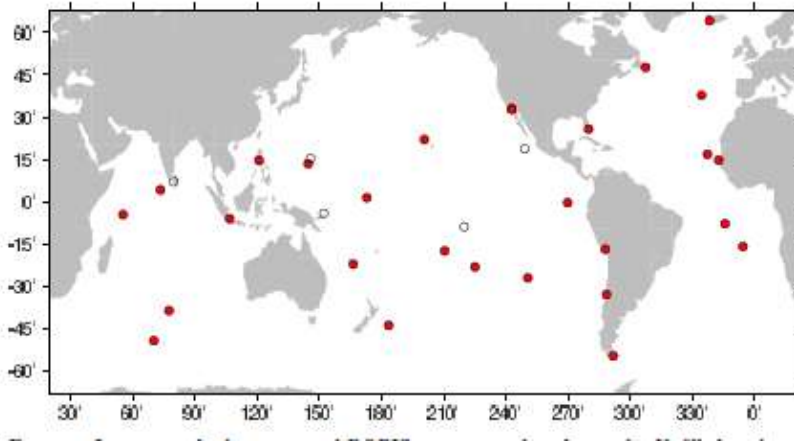
Ny Alesund
Kierulf et al., 2009



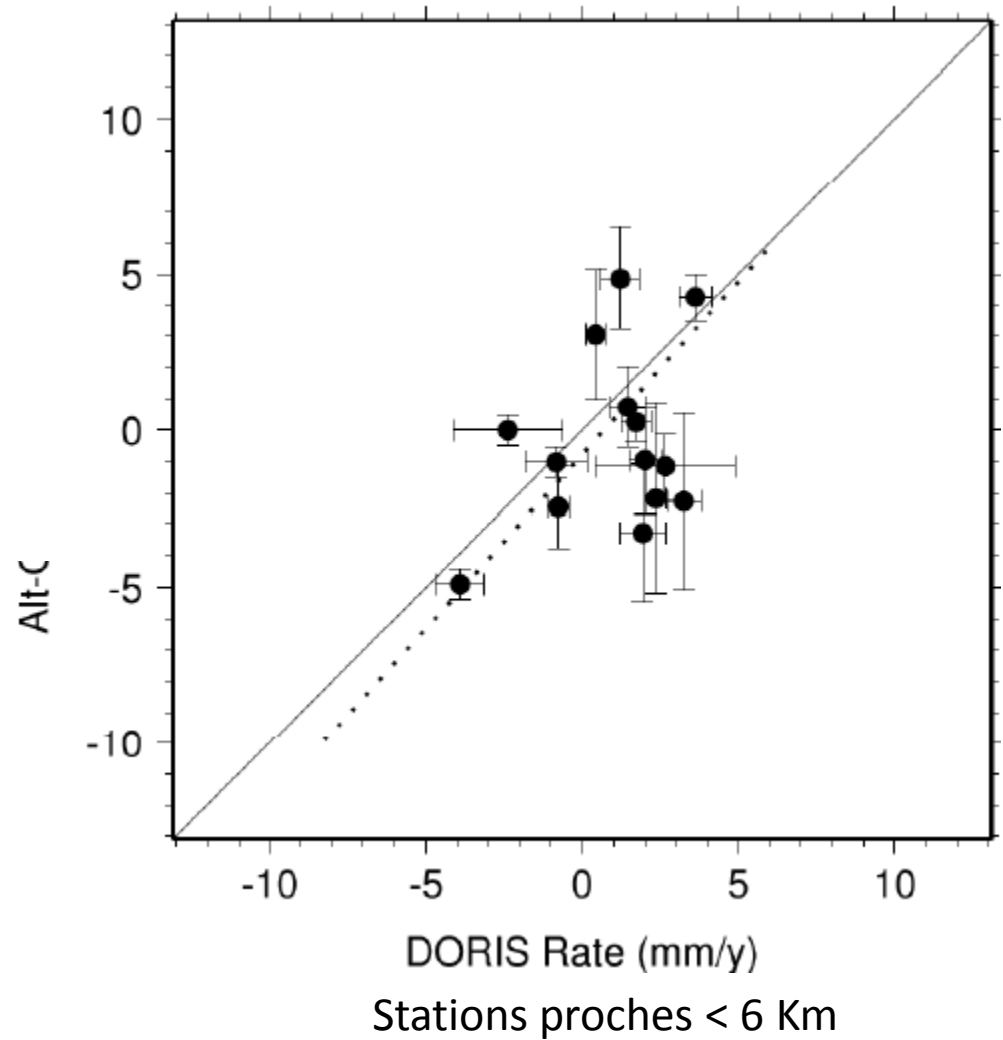
Ny Alesund

- DORIS + 7.1 mm/an
- GPS +7.7-10.8 mm/an
- VLBI +8.7 mm/an

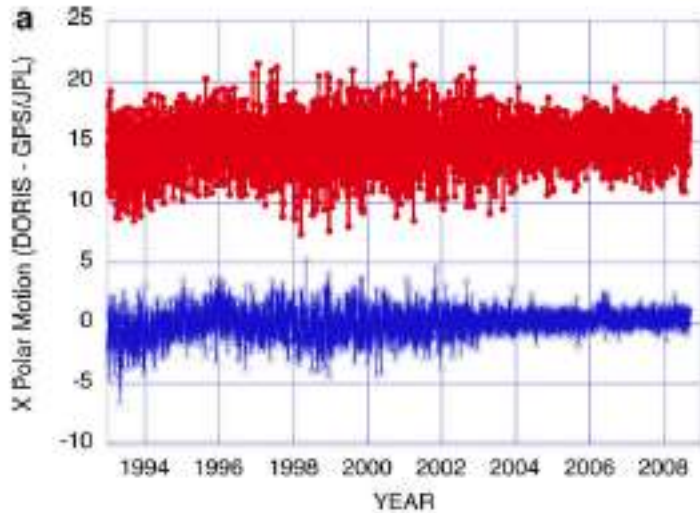
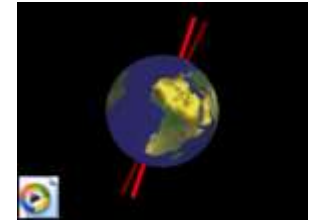
Marégraphes / niveau des mers



Ray et al., 2010

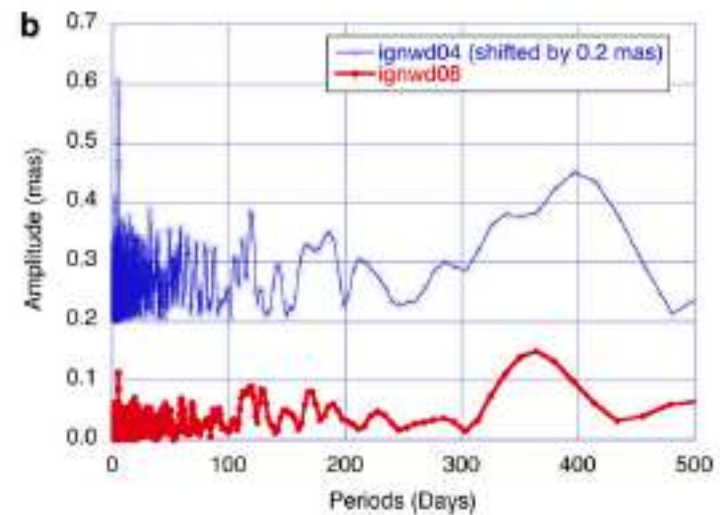


Rotation terrestre



Solution DORIS pour l'ITRF2005

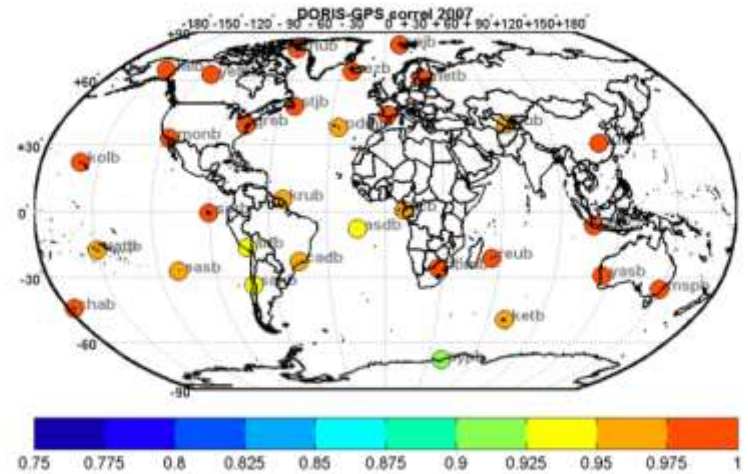
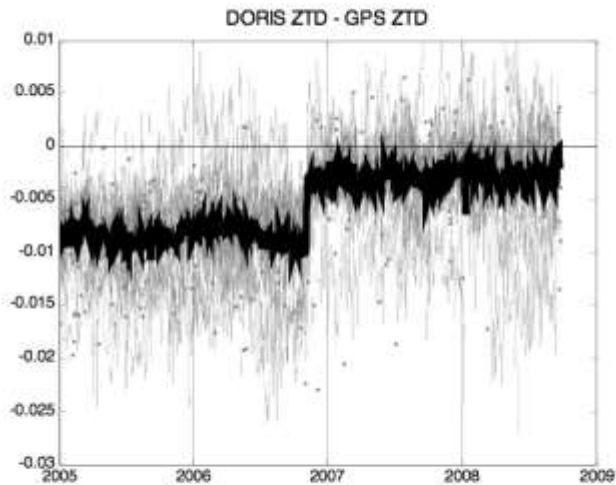
Solution DORIS pour l'ITRF2008



Diminution d'erreurs à 2.5 jours
(Sous-cycle SPOT)

Willis et al., 2010

Sciences de l'atmosphère (troposphère)



Bock et al., 2010

Co-locations GPS/DORIS

Intérêt potentiel de DORIS
Calibration, climatologie

Conclusions

- Vers une coopération internationale
 - IGN-CNES: réseau de poursuite
 - IGN-JPL, USA: logiciel GIPSY/OASIS
 - International DORIS Service: Centre d'Analyse, Centre de données
 - IGN-IPGP + autres/Géophysique: tectonique, rebond post-glaciaire, mouvements locaux, transitoires
- Amélioration significative des résultats
 - Nouvelles stratégies de calcul (pression de radiation solaire, frottement atmosphérique, thèse M.L. Gobinddass)
- Futur
 - Nouveaux satellites: HY-1A, Saral/ALTIka,...
 - Nouveaux modèles, stratégies d'estimation



