International Doris Service

IDS REPORT 2016

IERS Directing Board Meeting

San Francisco, California USA

December 10, 2016

IDS IERS members:
Hugues Capdeville (CLS)
Jean-Michel Lemoine (CNES)
Jérôme Saunier (IGN)

Guilhem Moreaux (CLS)
Pascale Ferrage (CNES)

IDS

DORIS

DORIS Constellation Status - Current Missions (6)

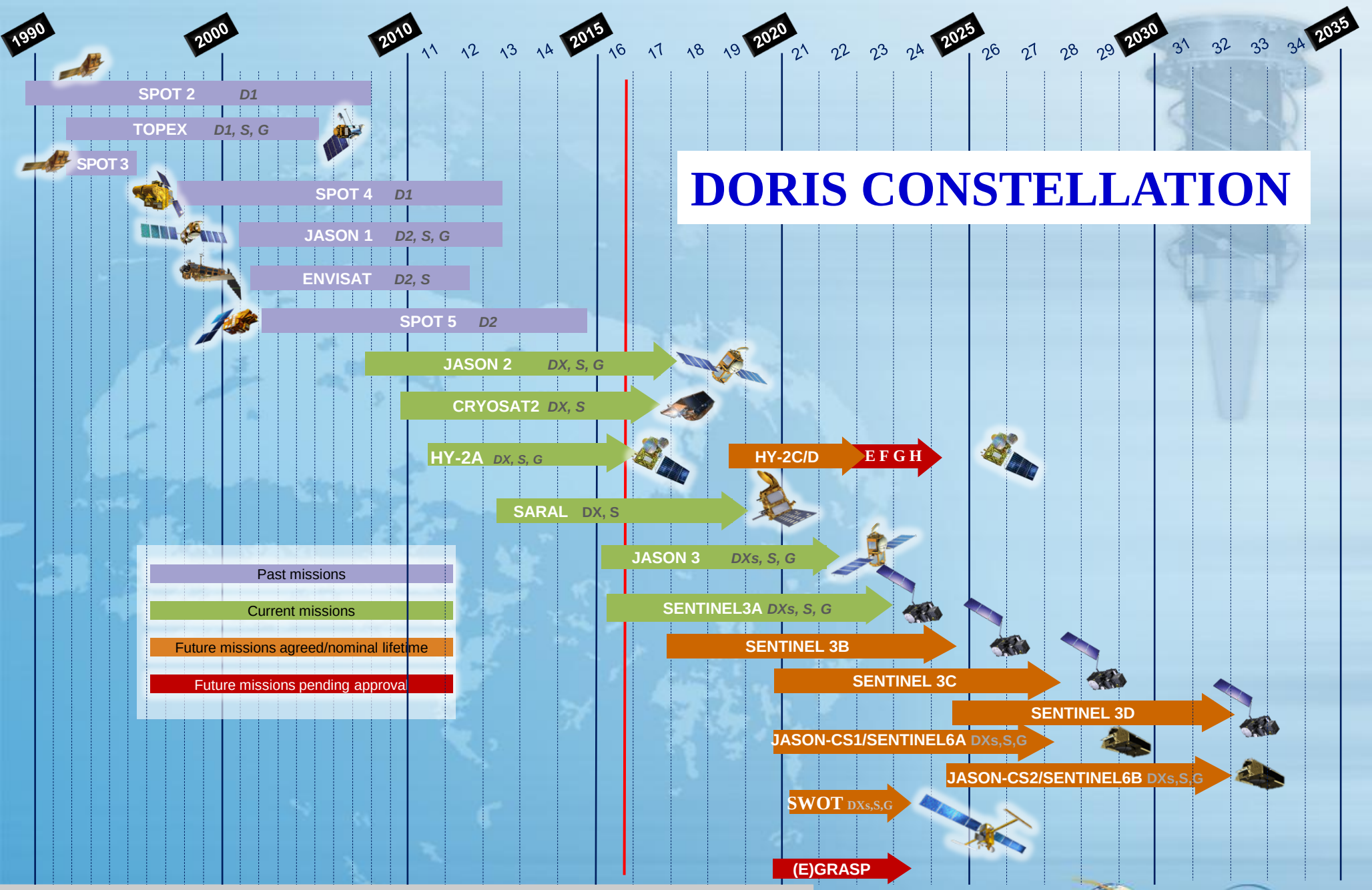
6 DORIS missions in flight with DGXX(S) Receiver (7 channels)

- SENTINEL3A (ESA): 814km, 98.65° — February 16, 2016 → 2023 (+LR)
- JASON3 (NASA/CNES): 1336km, 66° — January 17, 2016 → 2021 (+LR)
- SARAL (CNES/ISRO): 800km, 98.5° — February 2013 → 2018 (+LR)
- HY2-A (CNSA, NSOAS): 960km, 99° — August 2011 → as long as possible (+LRA+GPS)
- CRYOSAT-2 (ESA): 717 km, 92° — April 2010 → end 2017 (+ LRA)
- JASON2 (NASA/CNES): 1336 km, 66° — June 2008 → 2017 (+LRA+GPS)

DORIS Constellation Status – Many Future Missions

- SENTINEL3B (ESA) , 3C, 3D — 2018, 2020, 2025 (7 years + 3)
- HY2-C, 2-D (CNSA, NSOAS): 960km, 99° — 2019, 2020 (3 years)
  - HY-2 E…H To be confirmed — 2024
- JASON-CS1/SENTINEL6A (Eumetsat/NOAA) : 1336 km, 66° — 2020 (7 years)
  - *Jason-CSB/SENTINEL6B:* — *2025 (7 years)*
- SWOT (NASA/CNES) : 970km, 78° — post 2021 (3 years)
- E-GRASP/Eratosthenes (ESA Earth Explorer-9 mission) : an improved version of the proposal will be submitted to the new ESA/EE9 call in 2017

DORIS CONSTELLATION

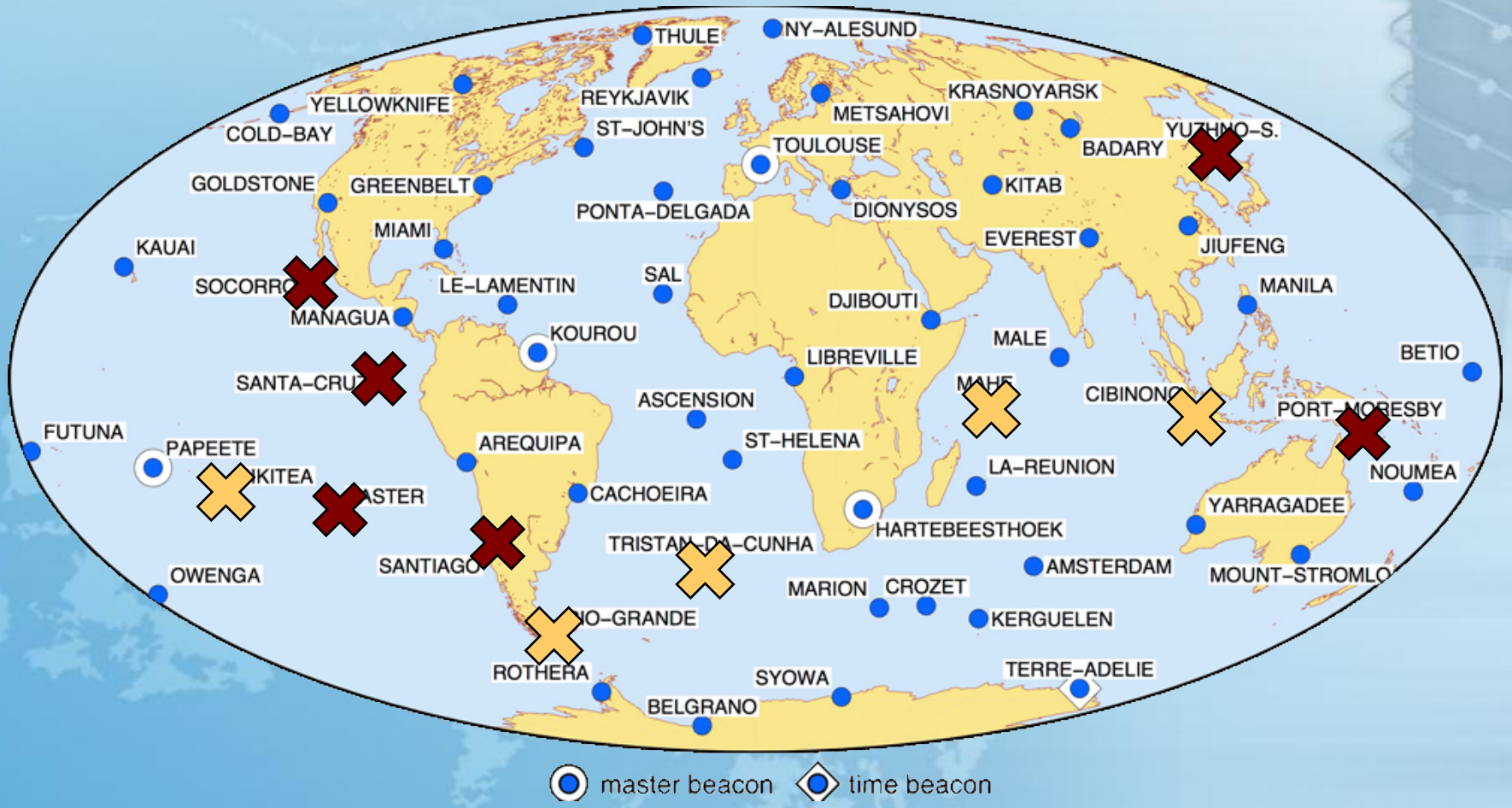


On board instruments:

D1, D2, DX, DXs: DORIS/versions, **S**:SLR, **G**:GNSS

Current DORIS tracking network (Dec. 2016)

Network Operational Status



59 stations of which: 11 beacons are out of order (6 for over a year)

Worrying coverage gap in the Pacific: every effort is made to restore the situation

Network Evolution

- **RECENT Network EVENTS**
  - *Apr. 2016: new DORIS site at Managua, Nicaragua*
  - *Jun. 2016: re-location at Kitab, UZ (major renovation to get better visibility)*
  - *Sep. 2016: new station at Wettzell, DE (4 techniques site)*

- **SHORT TERM (Next 6 Months):**
  - *Socorro, MX: restarting (equipment replacement)*
  - *San Juan, AR: new station installing in place of Santiago (3 techniques site)*
  - *Easter Island, Chile: relocating (hosting migration)*
  - *Guam, US: new station to near IGS station, GUUG.*

- **LONGER TERM:**
  - *Katherine, AS: new station installing in place of Port-Moresby (3 techniques site)*
  - *Ny-Ålesund, Spitzberg, NO: relocating to the new geodetic observatory (4 techniques site)*
  - *Changchun, CN: new station installing in place of Yuzhno-Sakhalinsk*
  - *Reykjavik, IS: relocating (site closure)*
  - *Tahiti, FR: new 4 techniques site*

Analysis Update

1. Six active DORIS Analysis Centers (ESA, GOP, GSC, IGN, INA, GRG)

from 6 different institutions with 5 different software packages for orbit determination

2. Processing routine

IDS Combination Center has done the extension of combined series from 2014 doy 362 to 2016 doy 178

3. Work in progress

- *Another requirement for IDS Analysis Centers, is to implement DORIS RINEX data processing since the launch of Jason-3, Sentinel-3A. (help of Analysis Coordinators)*
  DORIS data is only delivered in RINEX-like format – The ACs must all verify their processing of these observables as well as verify the content of their SINEX files.
- *Work on the open points following ITRF reprocessing*
  DORIS scale increase in 2012 (understood)
  Scale issues on SPOT-5 (sawtooth pattern)
  Increase of DORIS residuals from Jan. 2013 for all missions
  …
- *Jason-2 and Jason-3 USOs are sensitive to the SAA*
- *Construction of a new DPOD associated to ITRF2014 and based on a DORIS cumulative solution*
- *Switch to ITRF2014 for IDS operational products*

Jason-2 and Jason-3 USOs are sensitive to SAA

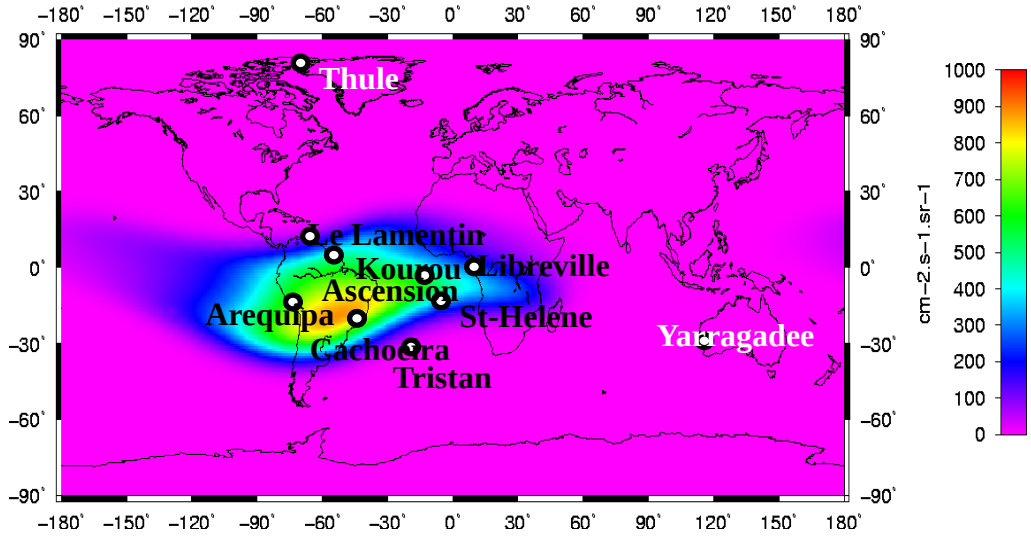
SAA impact on the station position estimation

Single satellite Solution compared to DPOD2008 (computed by CATREF)

Differences between the Jason-2/Jason-3/Sentinel-3A and Cryosat-2 solutions in the NEU component

As the Cryosat-2 USO is not affected by SAA, we use the Cryosat-2 single satellite solution as a reference.
(Mean of 30 weeks from 21 February to 24 September 2016)

Station	Jason-2 (in cm)			Jason-3 (in cm)			Sentinel-3A (in cm)		
	North	East	Up	North	East	Up	North	East	Up
Cachoeira	3.9	4.5	8.2	7.2	3.2	21	1.4	-1.8	0.2
Arequipa	-1.6	4.2	8.5	-2.4	10.7	19.1	1.2	-1.1	1.4
Kourou	-2.4	-1.3	0.3	-6.8	0.6	4.0	0.8	1.1	0.1
Ascension	0.8	-6.0	5.6	1.7	-2.2	14.4	1.2	-0.6	-0.2
Saint Helene	5.1	-1.8	1.9	9.9	-6.5	9.7	0.2	-0.9	-2.2
Tristan	-2.3	0.2	-2.1	-2.9	-0.1	-5.3	-0.2	-2.0	1.3
Le Lamentin	-0.7	-0.4	-4.2	-2.8	-1.9	-6.2	1.2	0.3	-1.0
Libreville	-3.8	-1.1	2.7	-7.2	0.4	9.2	1.0	0.5	0.1
Yarragadee	*-1.5*	*-0.4*	*0.3*	*-1.4*	*0.4*	*-0.3*	*0.9*	*0.3*	*1.0*
Thule	*1.6*	*-0.5*	*-0.1*	*2.8*	*-1.1*	*-1.2*	*-0.2*	*1.2*	*-1.5*



- *Jason-2 USO is sensitive to the SAA but not at the same level as Jason-1 and SPOT-5.*
Compared to Cryosat-2 solution, the Jason-2 single satellite solution has an important bias (higher than 4 cm) in at least one of the NEU components for the following SAA stations. As a consequence, the multi-satellite solution provided for ITRF2014 contribution can be impacted by the Jason-2 solution for the SAA stations.
- *Jason-3 USO is more sensitive to the SAA than Jason-2. Compared to Cryosat-2 solution, the Jason-3 solution gives a bias in at least one of the NEU components for the SAA stations, higher than those obtained with Jason-2.*
- *The differences between the single satellite solutions for Sentinel-3A and Cryosat-2 are low enough (under 2 cm) for the SAA stations to conclude that the sensitivity of the Sentinel-3A USO is not strong enough to affect the station position estimation.*
- ***A strategy to minimize the SAA impact on the positioning is currently under development***

Construction of a new DPOD associated to ITRF2014 and based on a DORIS cumulative solution

Elaboration Scheme

- *DPOD2014 is constructed by the IDS Combination Center as a DORIS cumulative position/velocity solution based on the IDS combined series. DPOD2014 does not include Post-Seismic Deformation corrections. Pure linear displacement model.*
- *The DPOD2014 construction consists of 5 main steps:*

1.Construction of the IDS combined series from the six IDS Analysis Center multi-satellite weekly solutions starting in 1993.0.

2.Update of the position discontinuity and velocity constraint files.

- *These two files are updated after analysis of the station coordinate time series.*
- *Velocity constraints are used to constrain velocities to the same value over multiple segments unless a velocity discontinuity was observed.*

3.Update of the DORIS-to-DORIS tie vector file from IGN.

The DORIS-to-DORIS tie vector is used to constrain station positions.

4.Update of the DORIS core network used to align by No-Net-Rotation (NNR) condition the solution on ITRF2014

5.Computation of the cumulative solution by stacking of the weekly solution files with the IGN CATREF software.

Construction of a new DPOD associated to ITRF2014 and based on a DORIS cumulative solution

Internal Validation

The internal validation is a first quality check done by the IDS CC before delivering the DPOD solution to the validation team. The internal validation consists in looking at:

1. *The station position residuals.*
2. *The DORIS-to-DORIS tie vector residuals.*
   Differences between the DPOD2014 coordinates of 2 successive stations (at the starting date of the most recent station) and the IGN tie vector.
3. *The position and velocity differences with ITRF2014.*
   The position differences are estimated at the mean epoch of the observations.
4. *The DORIS-to-GPS tie vector discrepancies at co-located sites.*
   Differences between the DPOD2014 and the ITRF2014-IGS positions (at the starting date of the most recent station) and the IGN tie vector.
5. *The prediction and analysis of the position formal errors at T+3 years.*

External Validation

To validate the DPOD2014 for POD, an independent group was created. That group is composed by: P. Willis from IGN (chair), F. Lemoine (NASA), N. Zelensky (NASA), A. Couhert (CNES) and H. Ait Lakbir (CNES).

The validation tests include to:

1. *Verify that all DORIS stations are provided in the DPOD solution.*
2. *Verify that the coordinates of the new stations are consistent with the latest available DORIS data.*
3. *Verify that POD solutions are not degraded by looking at:*
   - *DORIS residuals and comparisons with ITRF2014 and DPOD2008 performances.*
   - *SLR residuals and comparisons with ITRF2014 and DPOD2008 performances.*
   - *Long term orbit drift as shown with the Mean Z ITRF2008 orbit differences.*

   ...

Switch to ITRF2014 for IDS operational products

- *IDS CC is building a new version of the DPOD2014 including stations operated before 1993.0 and since 2015.75*
  Review of the following stations: FLOA, SAKB, SANA, SANB.
  Add of the stations before 1993: ARLA, HVOA, KRUA, RICA, SOCA, TROA
  from DORIS-to-DORIS tie vector or from DPOD2008 v1.14
  Add of TLIA (same DOMES number than TLHA)

- *The new DPOD will be provided by IDS CC to the IDS DPOD validation group by mid-December*
  Validation group feedback expected at the end of January

- *After validation, the first release of the DPOD2014 will be made available to the IDS users (including IDS ACs) in February 2017*

- *The switch to ITRF14 will be adopted when the ACs will use this DPOD2014 for their next submission to IDS CC (from 2016 doy 179)*

IDS NEWS

1. DORIS Special Issue (Adv. Space Research)

Scientific Applications of DORIS in Space Geodesy
Special Issue of Advances in Space Research
Vol 58, Number 12, Dec 15, 2016
Edited by Frank G. Lemoine, Ernst J.O. Schrama

2. IDS Newsletter Launch of the IDS Newsletter in Apr. 2016, 2 newsletters already on line **at** http://ids-doris.org/report/newsletter.html

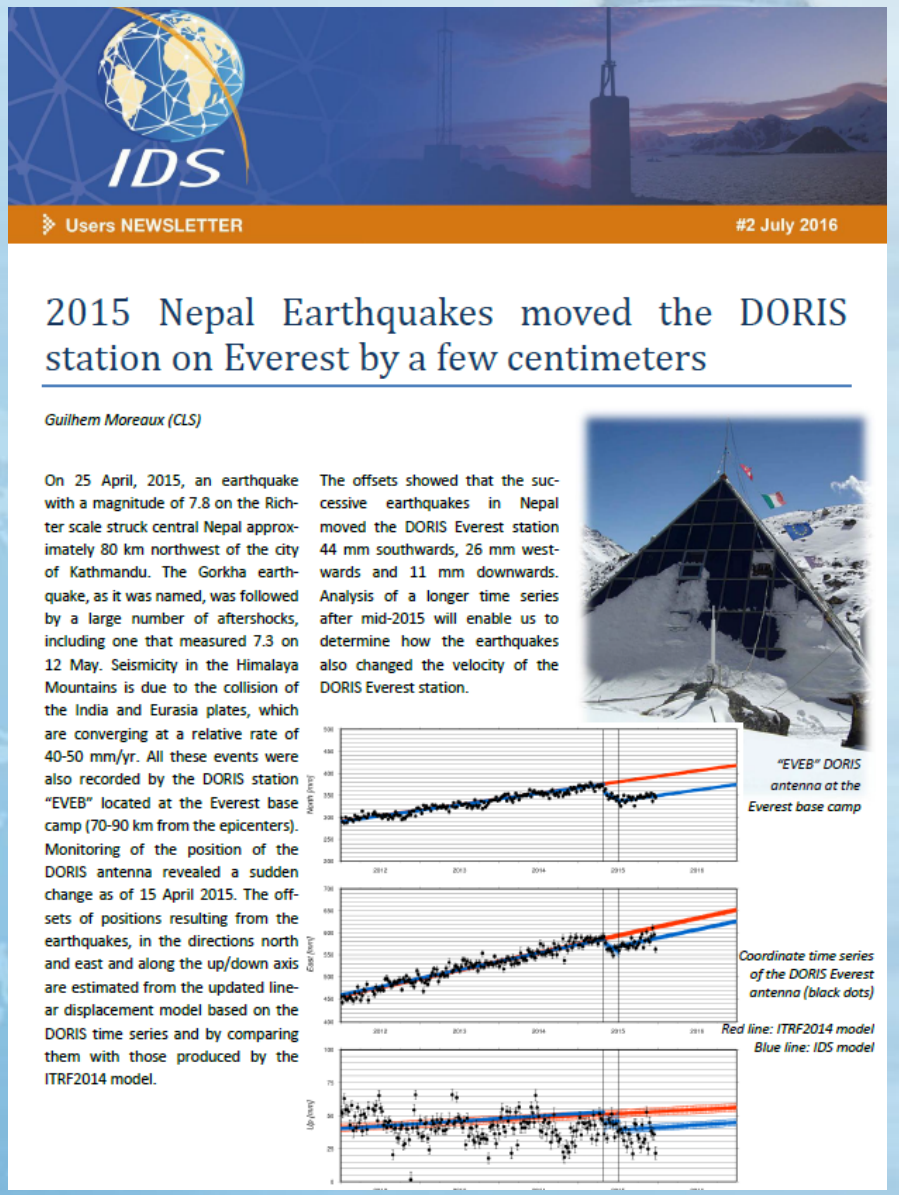
Newsletter#3 in preparation: will focus on the DORIS missions, the network status and report on the IDS workshop in La Rochelle (November 2016)

IDS Meetings

IDS WORKSHOP, 2016 (31 Oct.-01 Nov.), in conjunction with Ocean Surface Topography Science Team meeting in La Rochelle (France)

Next IDS AWG, in London (UCL), May 2017 TBC

IDS NewsLetter # 2



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Users NEWSLETTER #2 July 2016

2015 Nepal Earthquakes moved the DORIS station on Everest by a few centimeters

Guilhem Moreaux (CLS)

On 25 April, 2015, an earthquake with a magnitude of 7.8 on the Richter scale struck central Nepal approximately 80 km northwest of the city of Kathmandu. The Gorkha earthquake, as it was named, was followed by a large number of aftershocks, including one that measured 7.3 on 12 May. Seismicity in the Himalaya Mountains is due to the collision of the India and Eurasia plates, which are converging at a relative rate of 40-50 mm/yr. All these events were also recorded by the DORIS station "EVEB" located at the Everest base camp (70-90 km from the epicenters). Monitoring of the position of the DORIS antenna revealed a sudden change as of 15 April 2015. The offsets of positions resulting from the earthquakes, in the directions north and east and along the up/down axis are estimated from the updated linear displacement model based on the DORIS time series and by comparing them with those produced by the ITRF2014 model.

The offsets showed that the successive earthquakes in Nepal moved the DORIS Everest station 44 mm southwards, 26 mm westwards and 11 mm downwards. Analysis of a longer time series after mid-2015 will enable us to determine how the earthquakes also changed the velocity of the DORIS Everest station.

"EVEB" DORIS antenna at the Everest base camp

Coordinate time series of the DORIS Everest antenna (black dots)
Red line: ITRF2014 model
Blue line: IDS model

http://ids-doris.org