

Precise Orbit Determination of DORIS satellites by CNES/CLS IDS Analysis Center in the frame of our contribution to the ITRF2020 and beyond

> Hugues Capdeville (CLS), Jean-Michel Lemoine (CNES), Adrien Mezerette (CLS)

> > **CNES/CLS AC (GRG)**

#### OSTST 2022, Venice, Italy October 31 - November 4, 2022











## Outline

□ Models and Standards update for the ITRF2020 realization

□ Processing Strategy update for the ITRF2020 realization

**POD** results of our contribution to the ITRF2020

□ Impact on the GRG multi-satellite solution

□ Introduction of Sentinel-6MF, HY-2C and HY-2D in GRG processing chain

- □ Status of POD for Sentinel-6MF, HY-2C and HY-2D
- DORIS RMS of fit
- Comparison to GPS-only internal and external orbits

**Ongoing and future work** 



## Models/Standards update for the ITRF2020 realization

#### □ Models and standards recommended by IERS

Models/Standards		OLD	NEW
Earth rotation	Mean pole	IERS2010	Linear mean pole from updated IERS conventions
	Subdaily pole model	Previous IERS convention	Desai & Sibois from updated IERS conventions
Gravity model	Time variable gravity field	EIGEN-GRGS.RL03	EIGEN-GRGS.RL04
	Oceanic/Atmospheric gravity Dealiasing Products	Νο	AOD 1B RL06 (GFZ)
Ocean tides	Station displacements (ocean loading)	FES2012	FES2014b
	Gravitational attraction	FES2012	FES2014b
Phase Law		Alcatel, STAREC-B/C	New Alcatel, STAREC-B/C



## Processing strategy update for the ITRF2020 realization

#### □ Processing strategy (GINS/DYNAMO software)

Theme	OLD	NEW
Attitude modelling (Spacecraft + Solar array)	Attitude model for all satellites	Quaternions for Jason-1, Jason-2 and Jason-3
Coefficient Solar Radiation pressure Cr	Satellite dependent estimated and fixed	Satellite and time dependent Adjusted per arc (Not done for ITRF2020 but planned)
Estimated measurement parameters	One frequency bias per pass	One frequency bias and drift for SAA stations per pass (for Jason-1, Jason-2 and Jason-3)
Elevation cut-off and data downweighting	Cut-off 12° downweighting: elev²/400 for elev < 20°	Cut-off 10°
Integration Step Size	60 sec	30 sec
SAA mitigation	Corrected data for Jason-1 and SPOT-5 Using SAA data from the most affected satellites only for POD (only for Jason-1)	Corrected data for Jason-1 and SPOT-5 Using SAA data from the most affected satellites only for POD (for Jason-1, Jason-2&3, Sentinel-3A&B)

## Processing strategy update for the ITRF2020 realization

## □Available DORIS data have been processed from 1993/01 to 2020/12 to contribute to the realization of the ITRF2020



ITRF2020= ITRF2014 + new missions (Jason-3, Sentinel-3A, Sentinel-3B)



### **POD results of our contribution to the ITRF2020**

#### **DORIS RMS of fit and OPR Acceleration Amplitude / Radiation pressure coefficient**

SATELLITE	DORIS RMS (mm/s)	OPR amplitude average (10 <sup>-9</sup> m/s <sup>2</sup> )		Solar radiation
		Along-track	Cross-track	coefficient Cr
SPOT-2	0.42	1.8	3.6	1.07
SPOT-3	0.44	1.1	3.4	1.07
SPOT-4	0.42	1.4	2.9	1.16
TOPEX	0.46	1.5	5.8	1.03
JASON-1	0.32	2.1	2.9	0.94
SPOT-5	0.34	1.6	1.8	1.05
ENVISAT	0.39	1.0	2.0	1.05
JASON-2	0.32	4.0	2.1	0.97
CRYOSAT-2	0.35	2.9	2.6	1.0
HY2A	0.34	0.5	3.1	0.86
SARAL	0.34	1.4	2.4	1.0
JASON-3	0.36	0.9	2.2	0.99
SENTINEL-3A	0.37	2.3	1.4	1.0
SENTINEL-3B	0.38	1.4	1.5	1.0

 Mean on overall time span of available DORIS satellite data for the ITRF2020 reprocessing

• For the two directions, Along-track and Cross-track, the mean amplitudes are lower than 4x10<sup>-9</sup> m/s<sup>2</sup>, reflecting a satisfying level in the modeling of the satellite macromodels and the attitude law.



### Impact on the GRG multisatellite solution

GRG multisatellite solution (weekly) compared to DPOD2014 (v5)
Helmert parameters and station position residuals (3D and by component)
GRG ITRF2014 like (in red) vs GRG ITRF2020 (in blue)



Improvement in East and North component.



# Introduction of Sentinel-6 MF, HY-2C and HY-2D in GRG processing chain

#### Status of the routine DORIS data processing

We processed DORIS data until end July 2022 (Serie grgwd42, ITRF2020 configuration) We provided Sentinel3-A&B and Sentinel-6MF orbits to CPOD QWG until end September 2022

#### Latest additions:

- Introduction of Sentinel-6MF in the GRG DORIS processing and in the multi-satellite solution Macromodel available at: <u>https://ids-doris.org/documents/BC/satellites/DORISSatelliteModels.pdf</u> Attitude: Quaternions
  - Radiation pressure coefficient strongly constrained to 1.05
- Introduction of the DORIS data from HY-2C and HY-2D satellites in our processing chain Macromodel available at: <u>https://ids-doris.org/documents/BC/satellites/DORISSatelliteModels.pdf</u> Attitude: nominal attitude law implemented



# Introduction of Sentinel-6 MF, HY-2C and HY-2D in GRG processing chain

**POD summary** DORIS RMS of fit and OPR Acceleration Amplitude / Radiation pressure coefficient

	DORIS RMS (mm/s)	OPR amplitude average (10 <sup>-9</sup> m/s <sup>2</sup> )		
SATELLITE		Along-track	Cross-track	Solar radiation coefficient
Cryosat-2	0.369	2.6	2.4	1.00
Saral	0.346	1.4	2.0	1.00
Jason-3	0.369	1.0	2.2	0.99
Sentinel-3A	0.377	2.5	1.6	1.00
Sentinel-3B	0.390	1.5	1.9	1.00
Sentinel-6MF	0.363	1.9	2.7	1.05
HY-2C	0.405	1.3	2.5	1.00
HY-2D	0.370	0.6	2.1	1.00

 Results for active DORIS missions
Mean of 90 weeks (from December 2020 to September 2022) and 57 weeks for HY-D (from August 2021)

- DORIS RMS of Sentinel-6 at the same level of Jason-3.
- DORIS RMS HY-2C higher than HY-2D.

• For the two directions, Along-track and Crosstrack, the mean amplitudes are lower than 4x10<sup>-9</sup> m/s<sup>2</sup>, reflecting a satisfying level in the modeling of the satellite macromodels and the attitude law.

CLS

## **POD Status for Sentinel-6 MF**

#### **DORIS RMS of fit**



- The level of DORIS RMS residuals for Sentinel-6 is slightly lower than Jason-3.
- There is a ~59 days periodic signal for Jason-3 satellite, even when we use quaternions for attitude satellite.
- There is also a signature in the Sentinel-6A DORIS RMS residuals.



## POD Status for HY-2C and HY-2D

#### DORIS RMS of fit



• For HY-2C and HY-2D, the discrepancy is similar but the level of DORIS RMS residuals is higher for HY-2C (stronger SAA impact ?).

SCLS

Same signature in the DORIS residuals.

## **POD Status for Sentinel-6 MF**

#### □ Comparison to GPS-only GRG orbit and external orbit

Weekly RMS and Avg. Radial orbit differences (in cm)



There is a good agreement between GRG orbit and external orbits (~0.8 cm RMS). Better with JPL and worse with GSFC.
For Jason-3 and Sentinel-6, there is a 59 days periodic signal in the radial component, especially with POE-F orbit.
Probably due to the use of a different solar radiation pressure model (direct solar).

## POD Status for HY-2C and HY-2D

#### **Comparison to POE-F orbit**

Weekly RMS and Avg. Radial orbit differences (in cm)



• There is a good agreement between GRG orbit and external orbit CNES POE-F (~0.9 cm RMS) and no bias.



## On going and future work

- There is good agreement between GRG orbit and external orbit but there is still room for improvement
- We plan to continue the evaluation of GRG orbits: by comparisons to internal orbits with GNSS by comparison to external orbits by Independent SLR RMS of fit by Altimeter crossover Cycles

. . .

