

Continued,  
enhanced ocean altimetry  
and climate monitoring  
from space

31 October > 4 November 2022

IDS workshop  
OSTST meeting



In partnership with:



Venice - Italy



<https://ostst-altimetry-2022.com/>

# DORIS/DIODE the last improvements

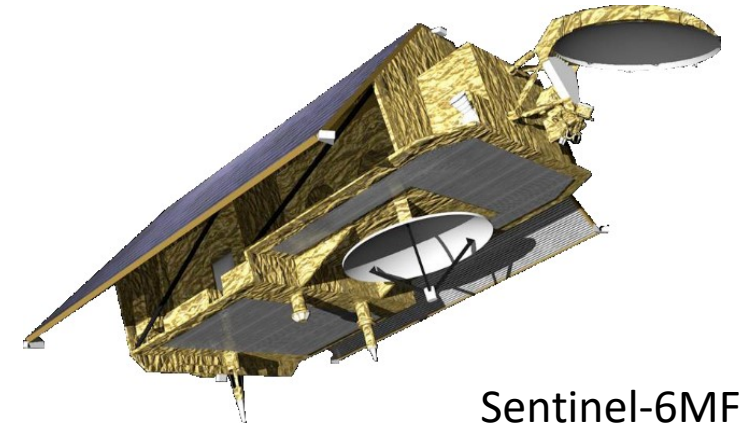
CHAUVEAU Jean-Pierre (CLS)

# Agenda

- A new DORIS/DIODE issue on board Jason-3, Sentinel-3A and 3B
  - And available for Sentinel-6MF and SWOT
- A new DORIS product for SWOT
- And next?

# DORIS/DIODE v5.05 models, main evolutions

- Earth gravity field: updated
  - Previous version: Eigen 6S extrapolated to 01/01/2013
  - Updated to Eigen GRGS RL03 Static mean field (up to degree and order 78) extrapolated to 01/01/2021
- Satellite modelization: improved
  - From box and wings to N-faces
  - Improved modelization for Solar Radiation Pressure (direct, albedo, infrared) and Drag accelerations
- Extrafine regime optimized
  - Execution time reduced
  - On board and on ground USO frequency drift estimation
  - Pole drift estimation
  - Tightened parametrization



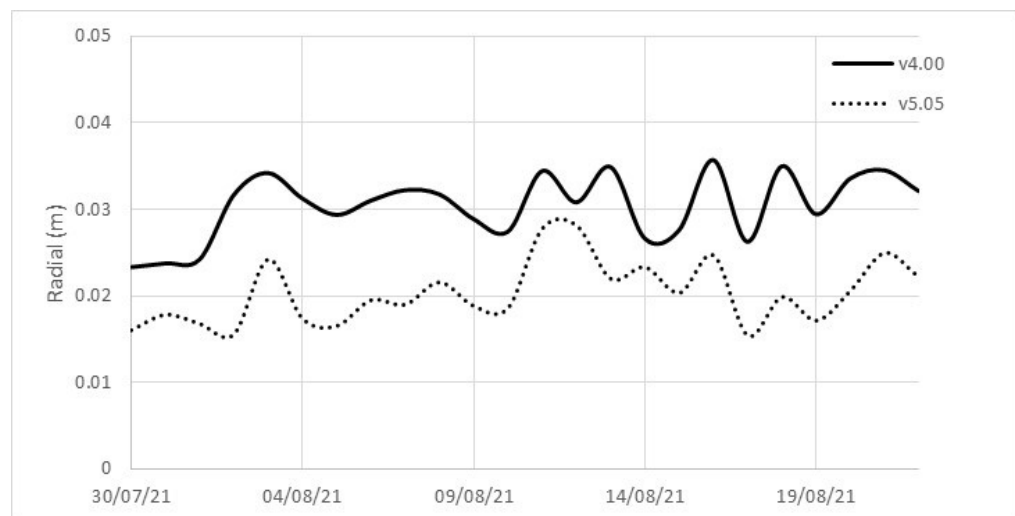
Sentinel-6MF

# DORIS/DIODE v5.05 models, main evolutions

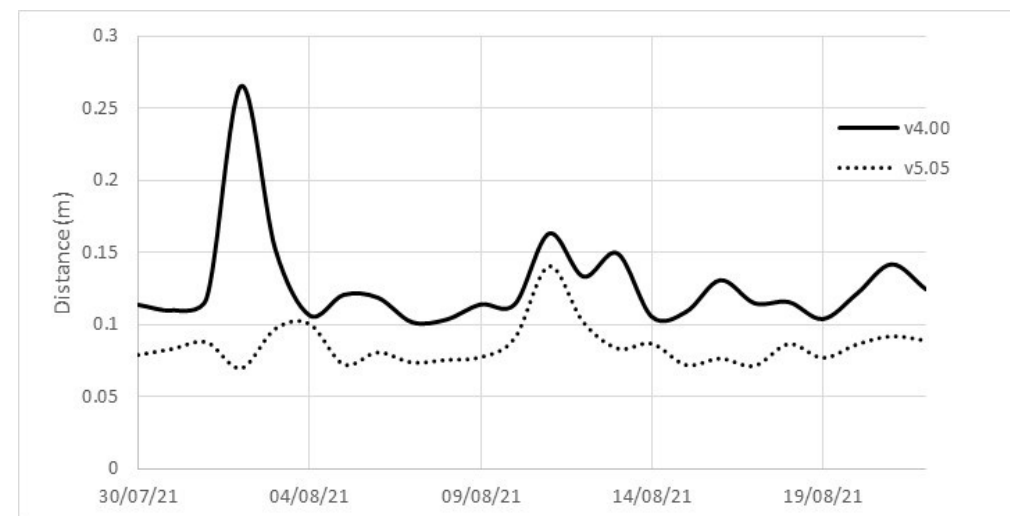
- Ocean tides: new model
  - FES 2014 model
  - 10 tides: K1 ( $\infty$ ), P1 (182.62d), Mm (27.55d), Mf (13.66d), O1 (13.66d), Q1 (9.13d), N2 (0.527d), M2 (0.517d), S2 (0.5d), K2 (0.498d)
  - Up to degree and order 5
- Solid and ocean pole tides: new model
  - IERS conventions 2010
- Beacons position correction due to solid Earth and pole tides: improved
- Software adaptation to comply with ECSS standards

# DORIS/DIODE v5.05 on board Jason-3

- DIODE-POE orbit differences
  - Previously on Jason-3: v4.00
  - Ground retreatment based on the same data as on board (25 days, w/o manoeuver)
  - POE: Precise CNES POD Team orbit



Radial rms



3D rms

# DORIS/DIODE v5.05 on board Jason-3

- Statistics of DIODE-POE orbit differences over a 25 days period (one point every 60s)

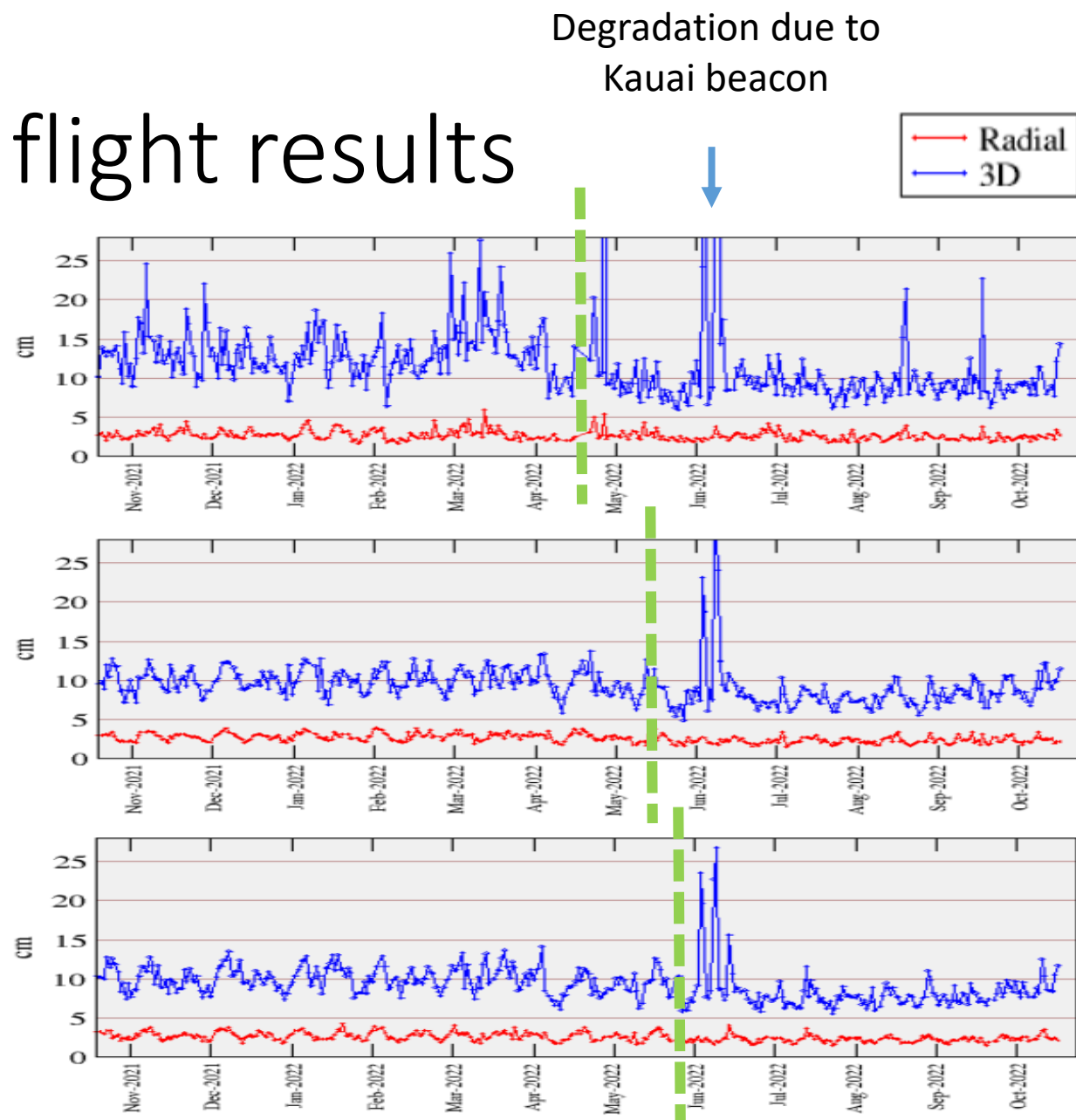
	NB POINTS *****	RMS (m) v4.00 *****	RMS (m) v5.05 *****	% improvement *****
Radial	36042	0.030374	0.020689	31.8
Along-track	36042	0.076037	0.062102	18.3
Cross-track	36042	0.102089	0.062397	38.8
3D Distance	36042	0.130868	0.090432	30.9
Radial velocity	36042	0.000065	0.000051	16.4
Along-track velocity	36042	0.000028	0.000019	32.1
Cross-track velocity	36042	0.000094	0.000057	39.3
3D velocity	36042	0.000117	0.000079	32.4



# DORIS/DIODE v5.05 in flight results

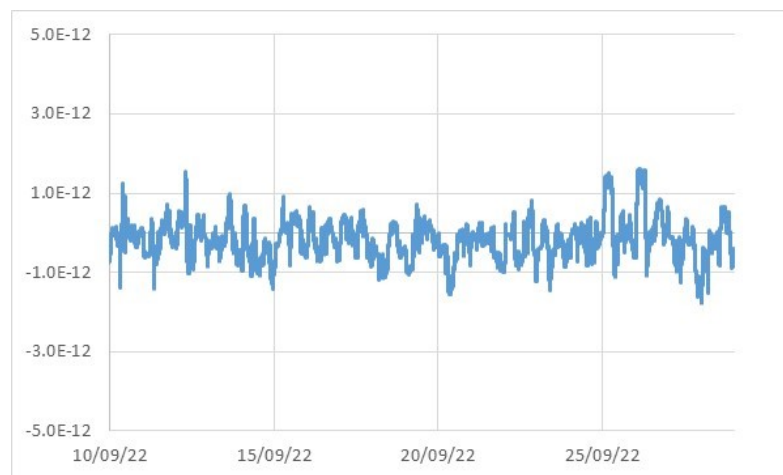
- Comparison DIODE-MOE
  - On board Jason-3 on 18/04/2022
  - On board Sentinel-3A on 13/05/2022
  - On board Sentinel-3B on 24/05/2022

MOE: CNES Mean Orbit Ephemeris



# DORIS/DIODE v5.05 frequency restitution

- Ny-Alesund beacon connected to the VLBI maser in August 2022
- Multi-satellites mixed frequency restitution ( $\frac{\delta f}{f}$ )
  - Ground retreatment (Saral, Cryosat-2, Jason-3, Sentinal-3A, Sentinel-3B)



$$\text{Rms} \approx 7 \cdot 10^{-13} \left( \frac{\delta f}{f} \right)$$

- On board and beacons frequency biases and drifts available in TM v5.05



# KaRin Bulletin for SWOT



- KaRin: Ka-band Radar interferometer
- DIODE will deliver to KaRin a new product
  - Goal: the altimeter will use it to predict its position relative to the reference ellipsoid WGS84, during a time window of 20 seconds in the future
  - Requirements:
    - Altitude propagation coefficients with error less than 1m on the predicted altitude in the time window
    - Discontinuities between successive height updates of less than 1mm
    - Latitude and longitude predictions 20s later with absolute accuracy of  $10^{-04}$  degree, equivalent to 10m in ITRF cartesian position
  - Reminder: 20s later the satellite is already 140km away!

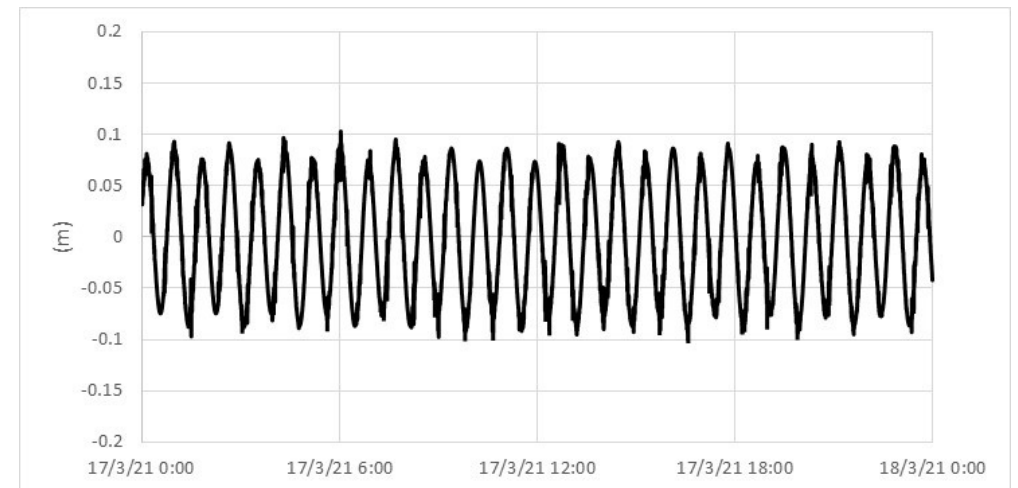
# KaRin Bulletin for SWOT



- Solution: fourth order polynomial with assured continuity from one polynomial to another

$$\textit{Altitude estimation } (t - t_0) = a + b(t - t_0) + c \frac{(t - t_0)^2}{2} + d \frac{(t - t_0)^3}{6} + e \frac{(t - t_0)^4}{24}$$

Error = DIODE altitude error ( $\approx 3\text{cm}$ )  
+ prediction error ( $< 0.15\text{m}$ )  
 $< 1\text{m}$  required



Prediction error = difference between current altitude and altitude predicted 20s earlier

# Perspectives

- DORIS Neo receiver (under development)
  - Faster processor
    - DGXX generation = 12MHz
    - DGXX-S generation = 36MHz
    - Neo = at least 100MHz
      - New and more complex force models for DIODE
      - Better positioning
  - SDR technology for signal tracking
    - Better control of signal tracking by DIODE
    - Better attenuation of interference due to the number of beacons in visibility
    - Allow to fly at higher altitude

# Conclusions

- The new DORIS/DIODE 5.05 is performing very well
  - Improvement of ~30% for Jason-3 w.r.t previous version 4.00
  - Improvement of ~20-25% for Sentinel-3A and 3B w.r.t previous version 5.02
  - Available for Sentinel-6MF in December 2022
  - Available for SWOT during Satellite in Orbit Validation
  - On board and beacons frequency biases and drifts available in TM
- KaRin bulletin tested soon on board SWOT
- DIODE towards the centimeter in orbit with next DORIS generation