

## DORIS/DIODE Real-Time orbit determination on-board Sentinel-6B

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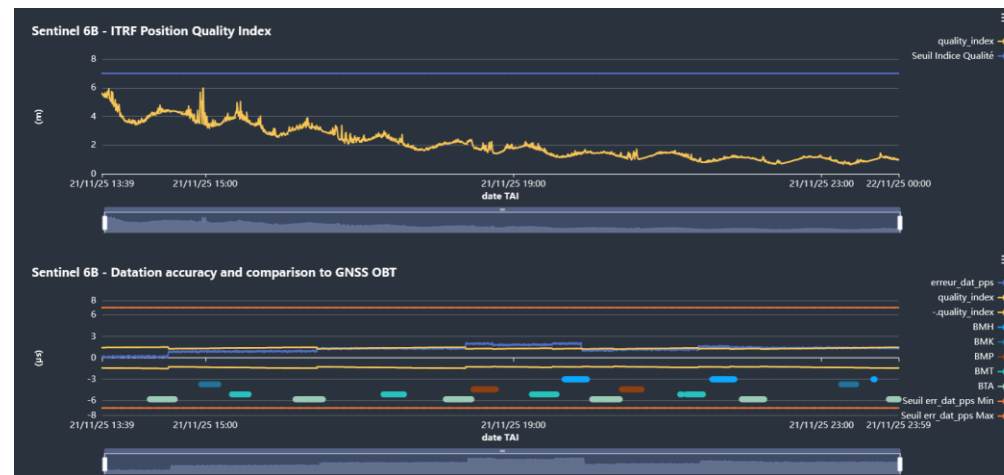
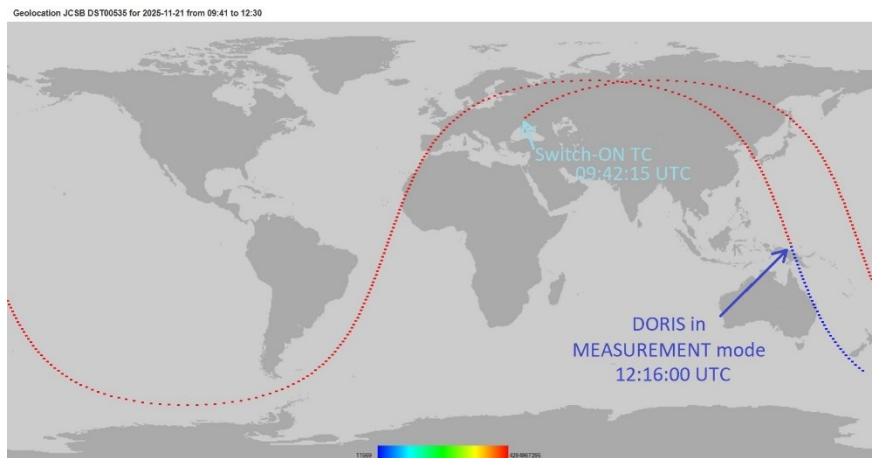
# DORIS activation on-board Sentinel 6B



Sentinel 6B launched: November 17<sup>th</sup>, 2025

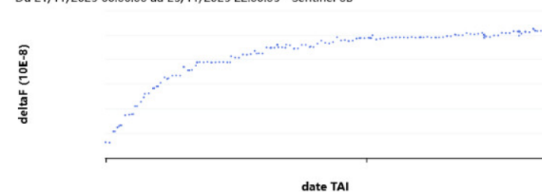
DORIS ON: November 21<sup>st</sup>, 2025, 9h42 UTC (Lost In Space)

Measurement mode and convergence reached in less than 2 orbits.



## USO frequency monitoring

Du 21/11/2025 00:00:00 au 23/11/2025 22:00:05 - Sentinel 6B

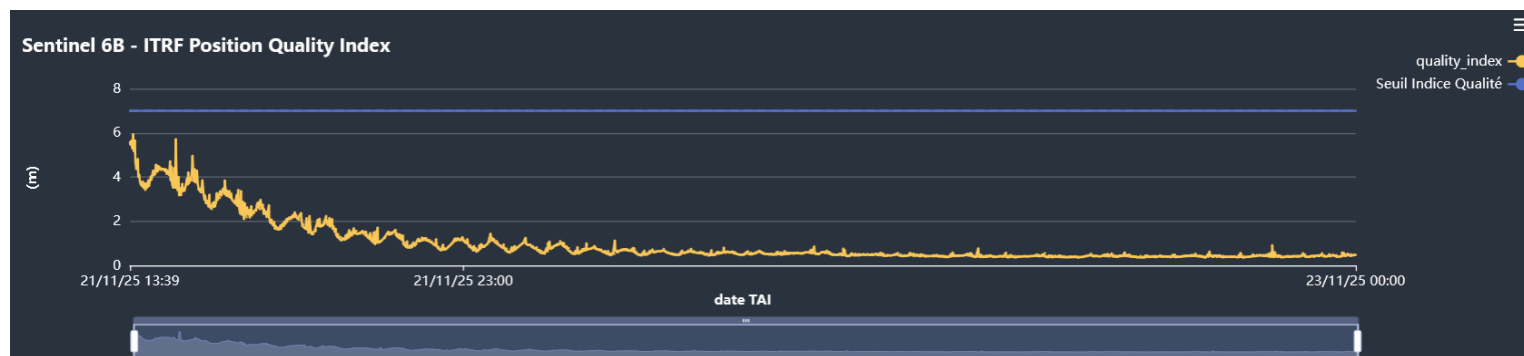


After 4H, still in USO warming period, the accuracy was already better than 6m in position and 3µs in time restitution.



# DORIS/DIODE performances

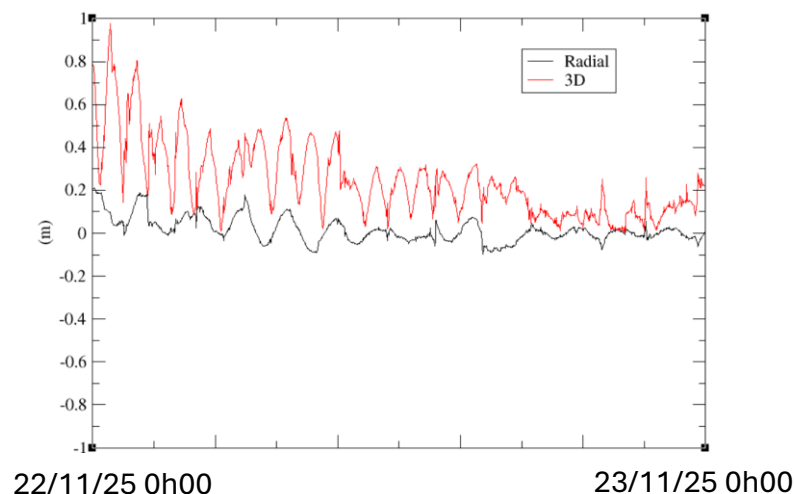
Looking at the Quality Index, full performances of the on-board navigator are reached in less than one day. The QI is a self-estimation of its positioning error. It is the only error estimator available in real time.



Better than 1m after one day

Orbital error signal due to EOP estimation convergence

## Comparison to CNES on-ground MOE



*Requirements (ITRF reference frame):*  
5 cm RMS radial component  
1m RMS 3D

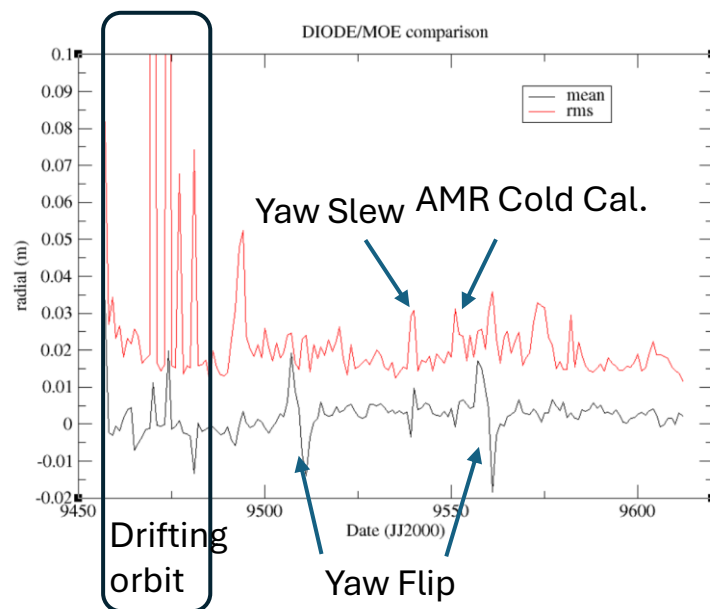
✓ Reached in one day

*Time restitution accuracy: 5  $\mu$ sec RMS*

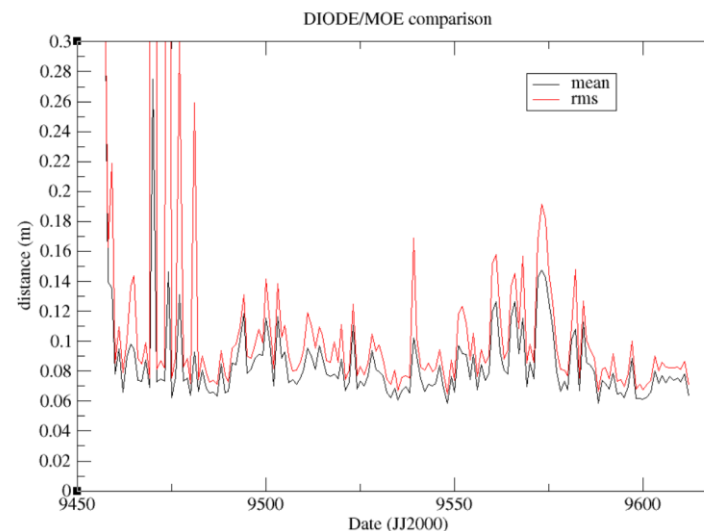
✓ Reached in 4H

# DORIS/DIODE performances

Comparison to CNES on-ground MOE on a longer period (November 21<sup>st</sup> – May 1<sup>st</sup>)



Radial RMS: ~2cm with no bias



3D RMS: ~9cm

*Requirements (ITRF reference frame):*

*5 cm RMS radial component*

*1m RMS 3D*

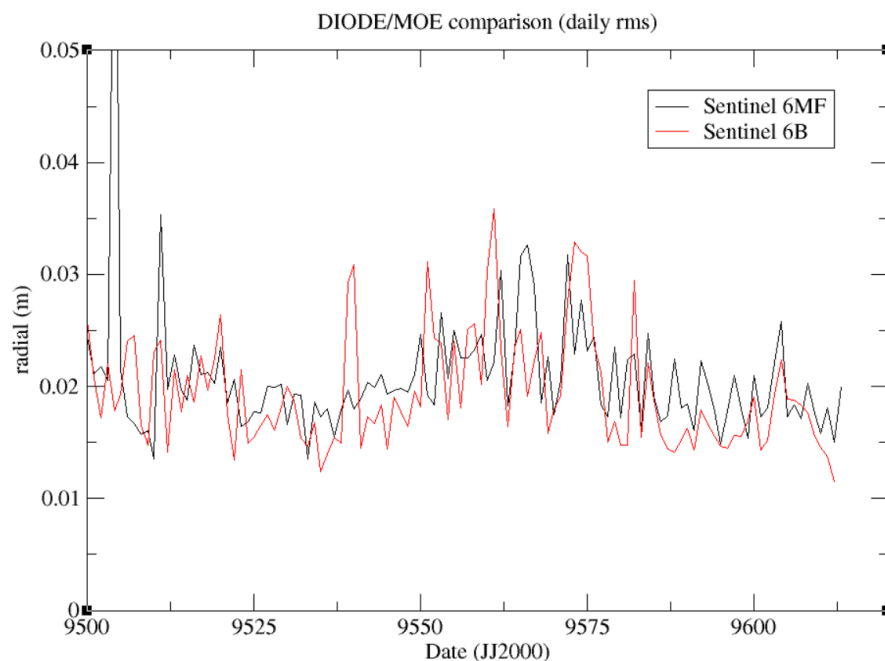
✓ Ok

# Comparison with Sentinel-6MF

Same orbit: Sentinel-6MF is 30s ahead of Sentinel-6B  
Same platform  
Same DORIS DGXX-Sev type receiver with OBSW v5.05

Same performances?

Performances should be better for S-6MF due to Authorized Extrafine Regime, using more models and allowing to estimate frequencies drifts, EOP drifts and finally positioning more precisely. Extrafine Regime is systematically inhibited at the beginning of life for all missions, while observing the USO stabilization and its behavior. It is still inhibited for Sentinel-6B.



Sentinel-6B shows better results, except during attitude maneuvers.

This was unexpected.

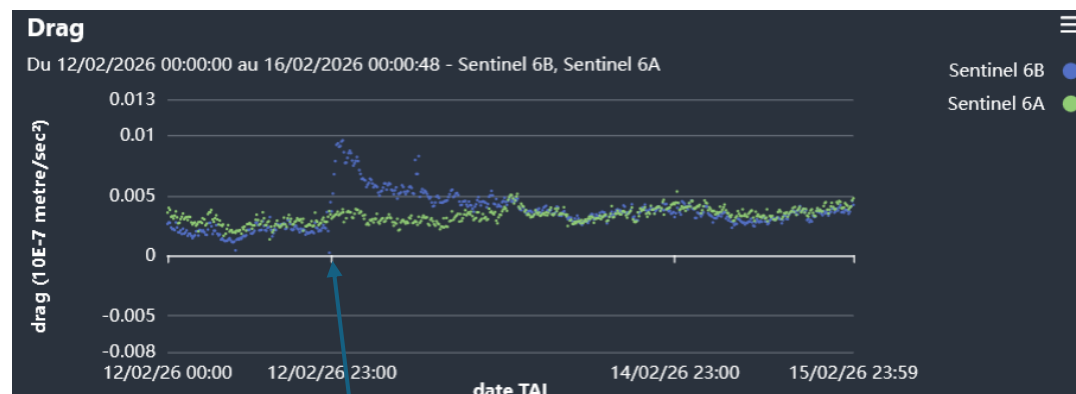


# DIODE estimated parameters

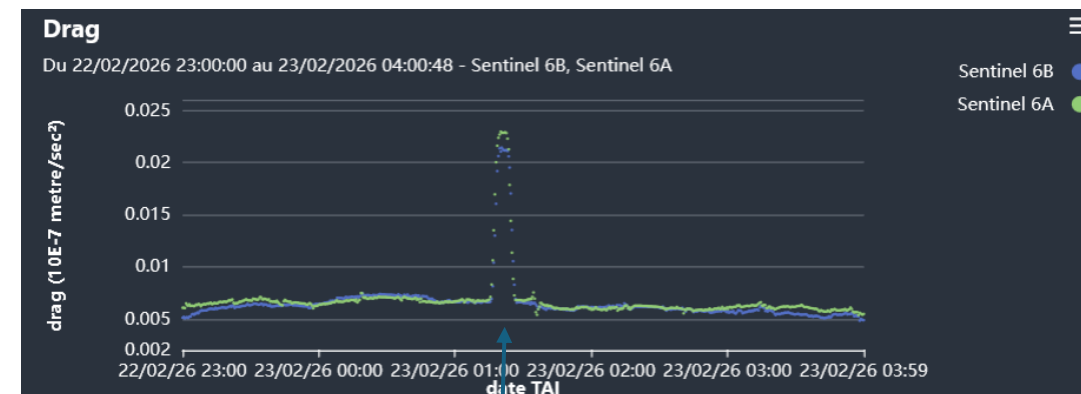
DIODE is based on force models and a 32-parameter Kalman filter

- Position, Velocity
  - Drag
  - Pole coordinates
  - Empirical Hill parameters
  - Onboard frequency
  - Beacons frequencies
  - Beacons tropospheric bias
- Global parameters
- Local parameters

Drag : very similar for both missions at the orbital period.



S6B Yaw Slew for  
POS-4 pointing

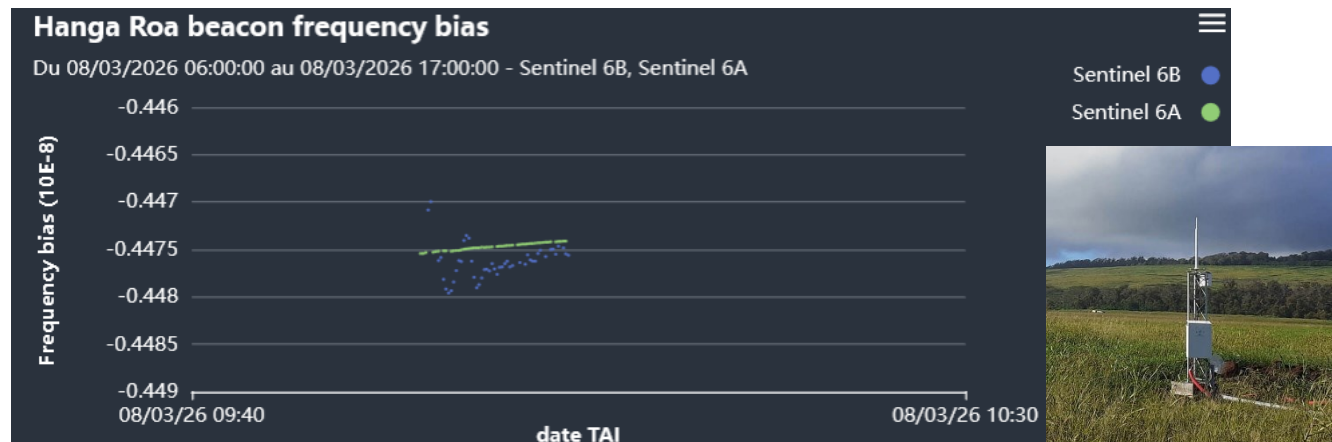


Both missions  
AMR Cold Cal.

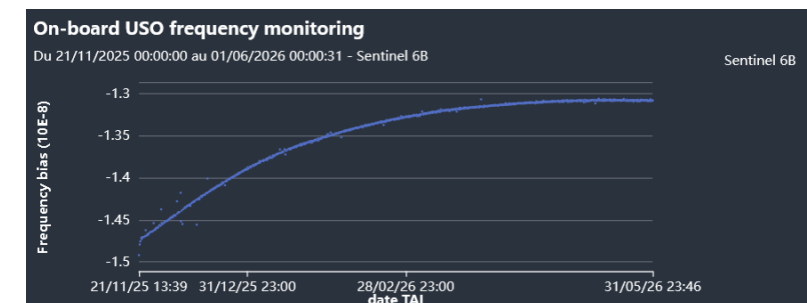
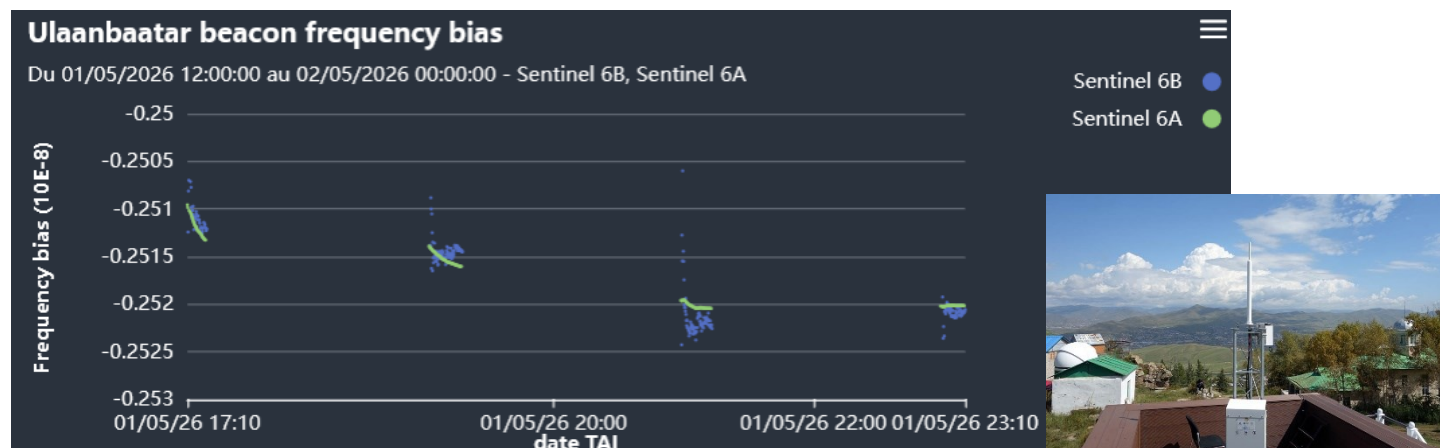


# DIODE estimated parameters

## Beacon USO frequency



Smoothed solution for S-6MF due to the extrafine regime and estimation of the frequency drifts.



Sentinel-6B USO is stable enough to authorized the extrafine regime and benefits from it.

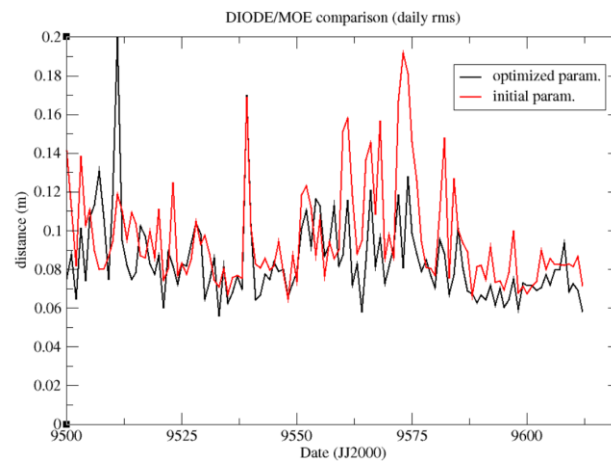
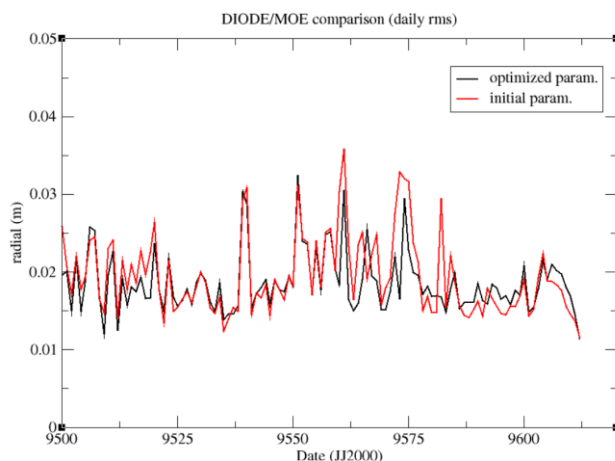


# DIODE filter optimization

Tuning was optimized for previous DIODE version 5.02.

DIODE v5.05 showed 20% improvement w.r.t. v5.02, only due to refined models.

Satellite parameters for Sentinel-6B (Mass, Centre of Mass position) needed also to be adjusted to take into account the beginning of life maneuvers.

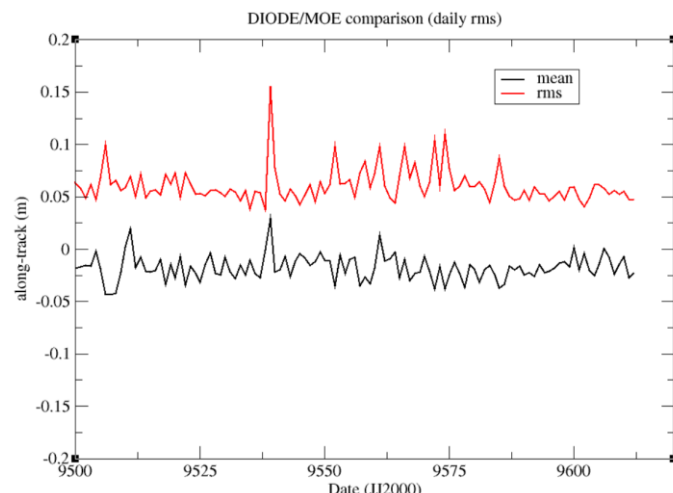


## Statistics on the full period:

|            | MINIMUM   | MAXIMUM  | MEAN      | ST DEV   | RMS             | IMPROV     |
|------------|-----------|----------|-----------|----------|-----------------|------------|
|            | *****     | *****    | *****     | *****    | *****           | *****      |
| Radial     | -0.299868 | 0.158098 | 0.003162  | 0.018673 | <b>0.018939</b> | <b>10%</b> |
| Tangential | -0.885265 | 1.194992 | -0.017518 | 0.060080 | 0.062582        | <b>10%</b> |
| Normal     | -0.278669 | 0.319734 | 0.003085  | 0.057417 | 0.057500        | <b>20%</b> |
| Distance   | 0.001480  | 1.218220 | 0.073481  | 0.046710 | 0.087071        | <b>13%</b> |

# DIODE filter optimization

Still a 1.4cm bias on the along-track component



It might be due to transit time delay (TTD) in the receiver.  
A datation error of  $1\mu\text{s}$  due to TTD is consistent with a 7mm error along-track.  
A comparison between DORIS, GNSS and Laser orbits is needed to confirm the cause (in progress).  
If confirmed, TTD can be updated on-board.

**Importance of having multi-technical systems for calibration.**

And for Sentinel-6MF, with the same optimized tuning, performances are improved by 10% and equivalent to Sentinel-6B:

|            | MINIMUM   | MAXIMUM  | MEAN      | ST DEV   | RMS      | IMPROV     |
|------------|-----------|----------|-----------|----------|----------|------------|
|            | *****     | *****    | *****     | *****    | *****    | *****      |
| Radial     | -0.702428 | 0.138586 | 0.001889  | 0.018979 | 0.019073 | <b>10%</b> |
| Tangential | -1.022486 | 0.556431 | -0.016559 | 0.059618 | 0.061875 | <b>10%</b> |
| Normal     | -0.469409 | 0.666622 | 0.001738  | 0.054613 | 0.054641 | <b>10%</b> |
| Distance   | 0.001221  | 1.024431 | 0.072302  | 0.044162 | 0.084722 | <b>10%</b> |

# Conclusion

DORIS on-board Sentinel-6B shows very good performances

- ❖ ~2cm on the radial component for a requirement of 5cm
- ❖ ~10cm in 3D for a requirement of 1m
- ❖ ~2 $\mu$ s on the time restitution for a requirement of 5 $\mu$ s

**Geodetic packet is delivered on-board to the altimeter in real time with 100% availability.**

**Geodetic packet includes altitude and altitude variation rate essential to altimeter.**

Performances are slightly better for Sentinel-6B than for Sentinel-6MF.

Tuning optimization is proposed to improve these performances on both missions

- ❖ It will be uploaded on board Sentinel-6MF during the orbit change at the end of 2026
- ❖ It will be uploaded on board Sentinel-6B this autumn
- ❖ ~10% of improvement is expected on both missions, with rms better than 2cm on the radial component

**DORIS 10MHz USO delivery to the altimeter and GNSS is done with a stable frequency.**