Can the Sentinel-3 Next Generation Topography Altimeter Mission's continuity with Sentinel-3 be assessed with a 4-Hour Tandem Phase?

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SWOT Science Team Meeting

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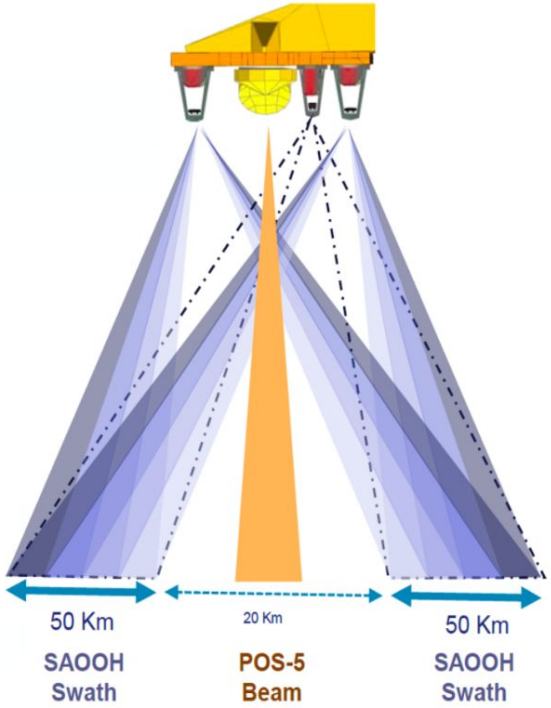
Sentinel-3 NG-TOPO Mission Concept

- S3NG-TOPO is the Copernicus mission for continuity and enhancement of the current Sentinel-3 altimetry constellation
- Constellation of **two large spacecrafts**, flying in formation on a sun-synchronous orbit with a **6:00 p.m. LTAN**
- Same ground-track as Sentinel-3 A/B
- Constellation can achieve global 5-day revisit with an effective ocean spatial resolution of 50 km



Sentinel-3 NG-TOPO Mission Objectives

- S3NG-TOPO is the Copernicus mission for continuity and enhancement of the current Sentinel-3 altimetry constellation
- Constellation of **two large spacecrafts**, flying in formation on a sun-synchronous orbit with a **6:00 p.m. LTAN**
- Same ground-track as Sentinel-3 A/B
- Constellation can achieve global 5-day revisit with an effective ocean spatial resolution of 50 km
- **Mission Aim:** Ensure **continuity** of S3 capabilities from **2030 to 2050**, for all topography variables *(SSH, Hs, U10, Sigma0, sea ice, land ice, rivers and lakes)*
- The S3NG mission **primary objective** is to ensure the continuity of topography measurements.

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Copernicus Sentinel-3 Next Generation Topography (S3NG-T) Mission Requirements Document (MRD)

4 S3NG-T MISSION AIMS AND OBJECTIVES

4.1 S3NG-T Mission Aim

Considering the User needs expressed by the European Commission and concisely articulated in the previous sections, the **aim** of the Copernicus Next Generation Sentinel-3 Topography (S3NG-T) Mission is:

To ensure continuity of Sentinel-3 in flight performance topography capability in the 2030-2050 timeframe.

4.2 S3NG-T Objectives

Mission requirements are then derived from mission Objectives.

The primary objectives of the S3NG-T mission are to:

PRI-OBJ-1. **Guarantee continuity of Sentinel-3 topography measurements**[9] for the 2030-2050 time frame **with performance at least equivalent to Sentinel-3 in-flight performance** as defined in Table 2.4-1 ('baseline mission').

PRI-OBJ-2. Respond to evolving user requirements and **improve sampling, coverage and revisit** of the Copernicus Next Generation Topography Constellation (S3NG-T and Sentinel-6NG) to ≤50 km and ≤5 days (CMEMS, 2017) in support of Copernicus User Needs.

PRI-OBJ-3. **Enhance sampling coverage, revisit and performance for Hydrology Water Surface Elevation** measurements in support of Copernicus Services.

PRI-OBJ-4. Respond to evolving user requirements and **enhance topography Level-2 product measurement performance**.

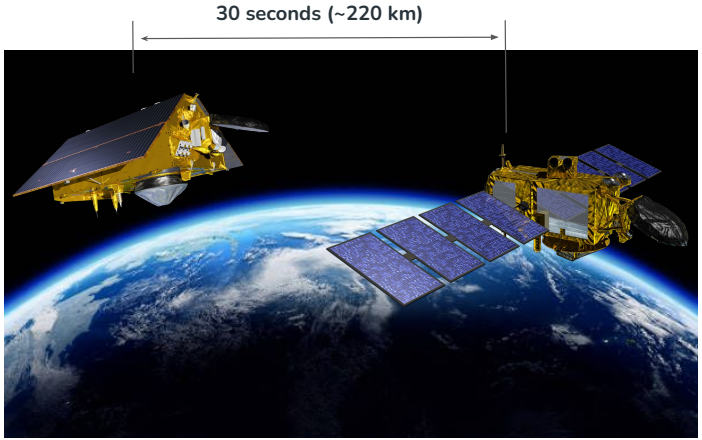
The **secondary objectives**[10] of the S3NG-T mission are to:

SEC-OBJ-1. Provide directional wave spectrum products that address evolving Copernicus user needs.

SEC-OBJ-2. Provide new products[11] that address evolving Copernicus user needs.

Continuity

- Continuity between missions is established through a comparison of SSH time series generated by successive altimetry missions
- Achieved via **tandem flight phases**, where satellites fly less than 30 seconds apart
- For S3 and S3NG missions, the standard tandem phase is not feasible due to orbital constraints : imposes a **4-hour time lag** between observations

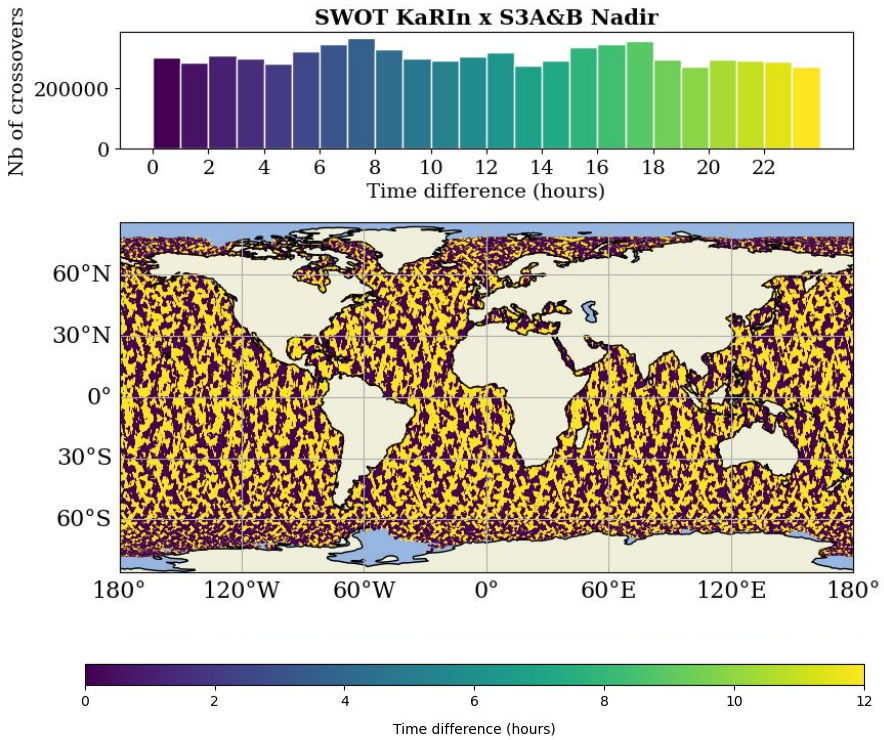


- The 4-hours temporal ocean variability (Δv_{hf}) is not negligible and may increase the uncertainty of the cross-calibration method.
  - **SWOT KaRin data** enables to quantify Δv_{hf} at 4 hours

Use of KaRIn SWOT data to quantify the sea level variability at 4-hours

➔ **Use KaRIn (swath) and Sentinel-3A/3B (nadir) crossovers data:**

- Use of the science phase : ~ 1 year of data
- High number of crossovers & extensive spatial coverage
- SWOT KaRin data (V1.0.2) and S3A & B nadir data L2P DT2022



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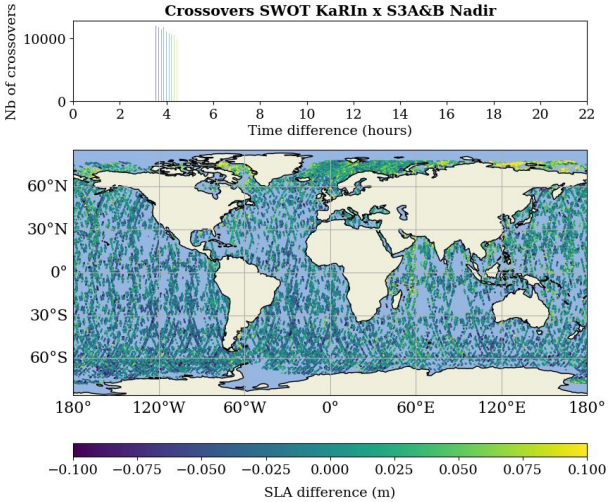
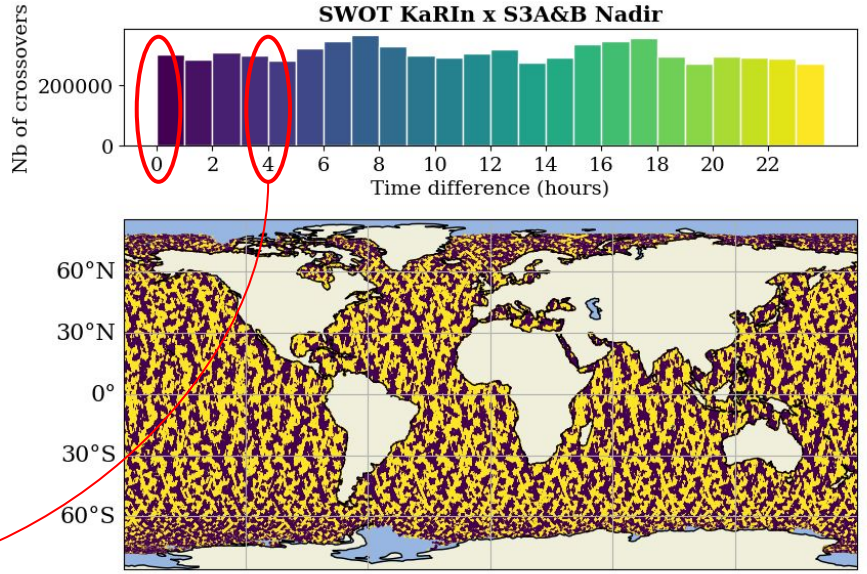




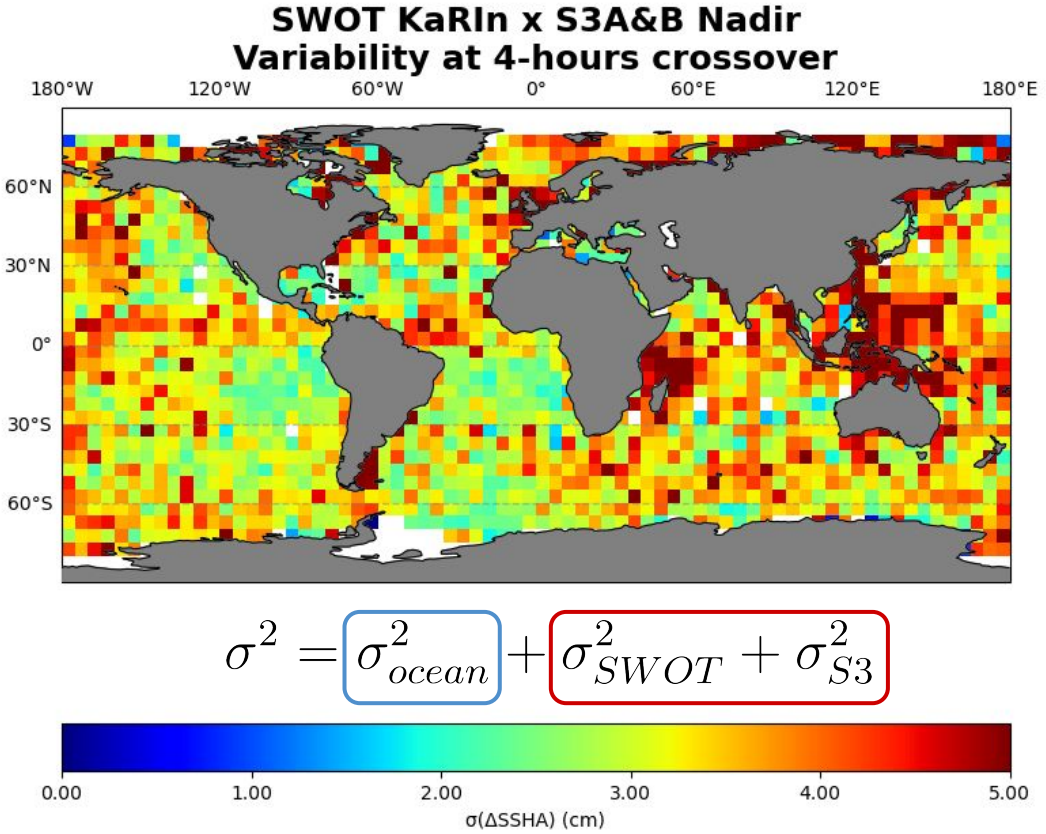
➔ **Estimation of Δv_{hf} at 4-hours:**

- Characterisation of standard deviation of SSHA differences
- Separation of ocean variability and SSHA errors

Use of KaRIn SWOT data to quantify the sea level variability at 4-hours

Calculation of Δv_{hf} at 4-hours

- ➔ Generate a map of SSH anomalies at **Δt = 4h** in boxes of 5*5°
- ➔ This map encompasses both **oceanic variability** and **systematic errors**
- ➔ Limitation : gaps appear below 5x5 degrees



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Calculation of Δv_{hf} at 4-hours

- ➔ Generate a map of SSH anomalies at Δt = 4h in boxes of 5*5°
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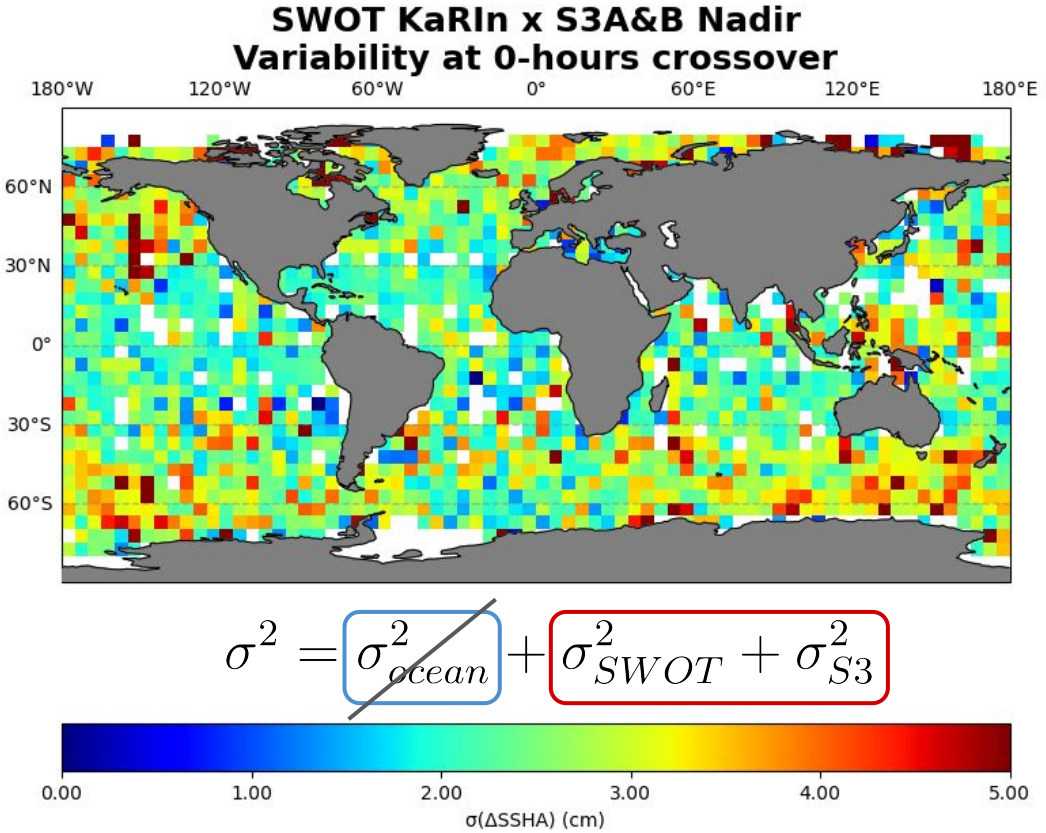
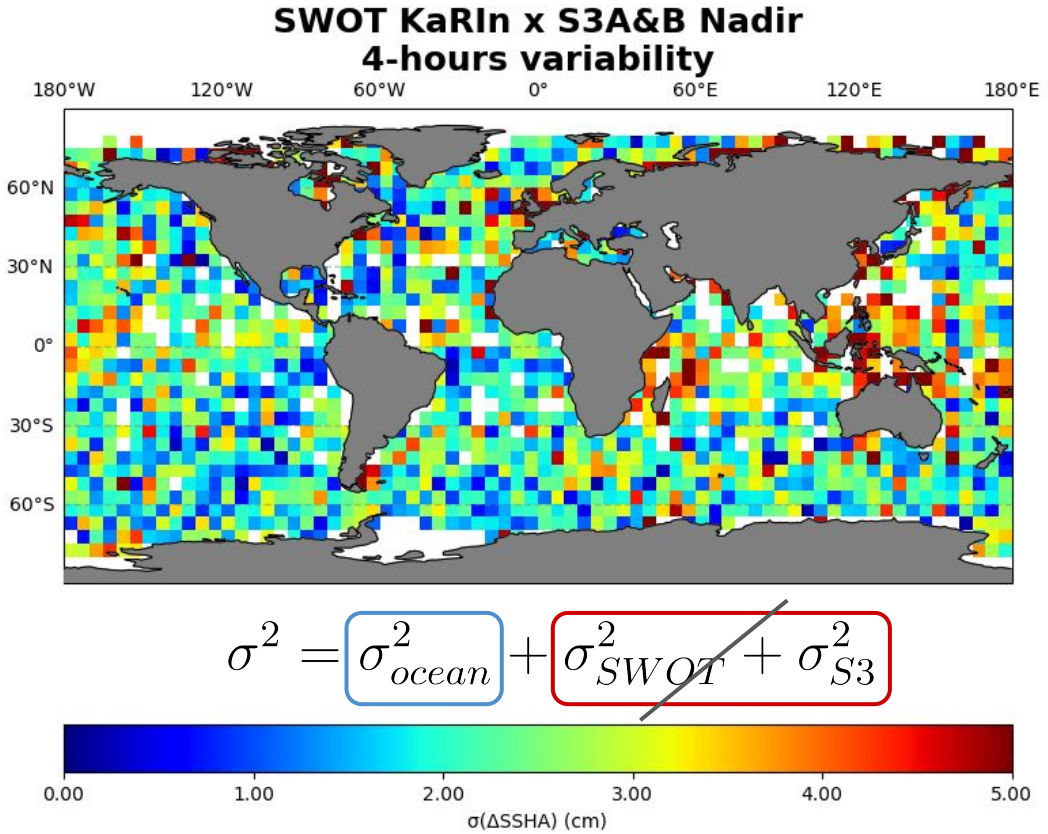
- ➔ Generate a map of SSH anomalies at **Δt → 0h** that **isolates systematic errors** in SSH anomalies ($\sigma_{ocean}(\Delta t \rightarrow 0h) = 0$)



Use of KaRIn SWOT data to quantify the sea level variability at 4-hours

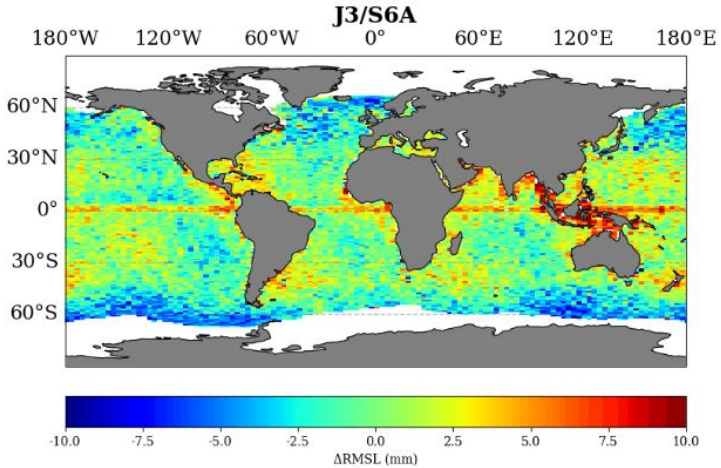
Calculation of Δv_{hf} at 4-hours

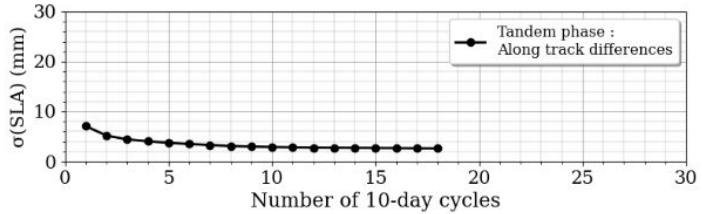
- ➔ Generate a map of SSH anomalies at Δt = 4h in boxes of 5*5°
- ➔ This map encompasses both oceanic variability and systematic errors
- ➔ Generate a map of SSH anomalies at Δt → 0h that isolates systematic errors in SSH anomalies (σ_{ocean}(Δt → 0h) = 0)
- ➔ **Subtracting those two maps** give an upper bound of oceanic variability in 4 hours (includes instrumental and environmental corrections errors)
- ➔ We obtain a map of $\sigma_{i,j}$ in boxes of 5*5°



To quantify the impact on the the sea-level continuity : results

Classical tandem phase - 3*1° boxes





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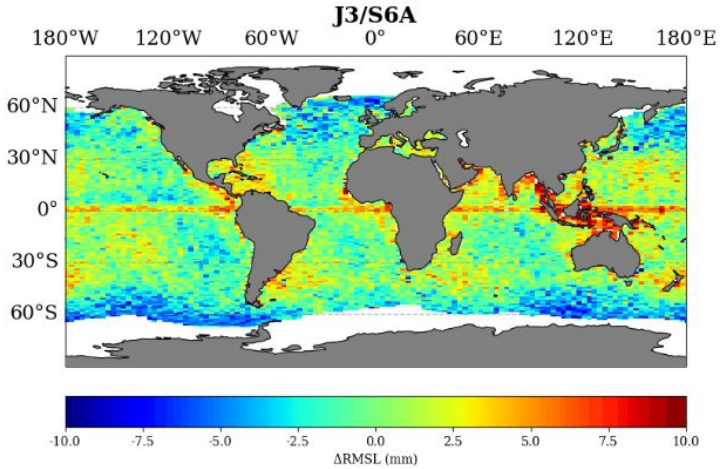
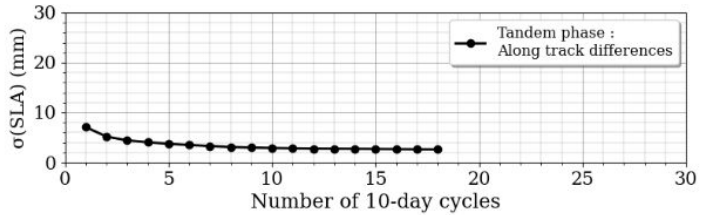
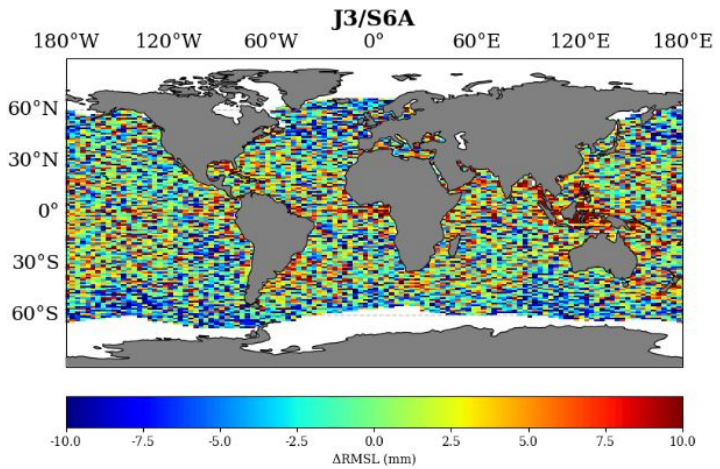
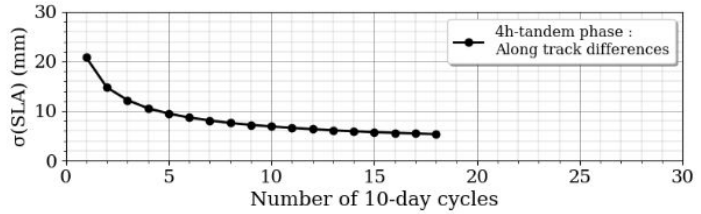




4-hours tandem phase - 3*1° boxes from a global mean uncertainty

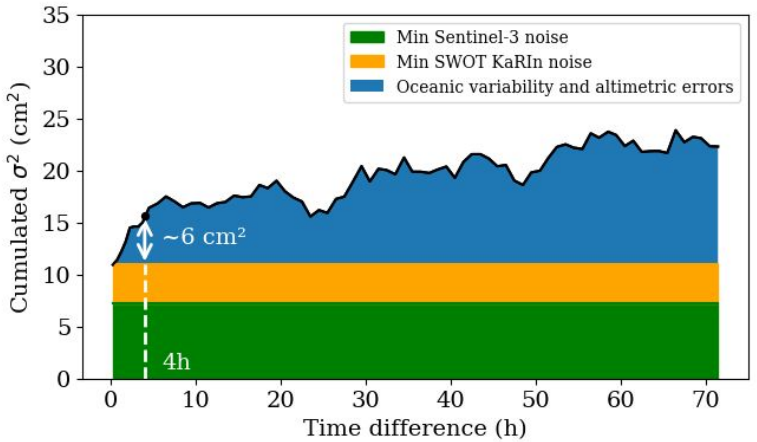




Conclusions

➔ **Summary**

- SWOT allowed to simulate the 4 hour oceanic variability to answer the S3NGT question of continuity
- The 4-hour tandem phase allows the detection of systematic SSHA differences of :
  - **± 6 mm** at 1-sigma between two altimetry missions (for 3°x3° boxes over ~ 200 days).
  - This value is reduced to **± 2 mm** at 1-sigma during a tandem phase (> 100 days).
- Outside a tandem phase, this value increases:
  - to ± [9-15] mm at 1-sigma from along-track analyses depending on the missions
- **For a non-reference mission like S3NG, such a level of performance may be sufficient to assess and ensure continuity between the S3 and S3NG missions**
- Thanks to SWOT, it is also possible to characterise the oceanic variability at different timescales.



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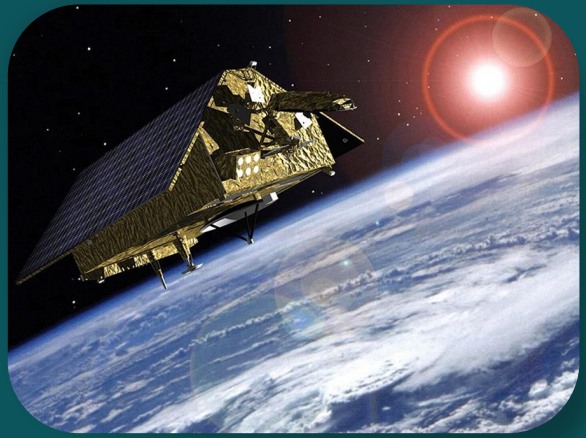

Any questions ?

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