EARTH OBSERVATION

Science for Earth care

Sentinel-3 Next Generation Topography Mission Performance and Uncertainty Assessment (S3NGT-MPUA)

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Context

The **Sentinel-3 Next Generation Topography (S3NGT)** mission is designed to ensure the continuity of the existing Copernicus **Sentinel-3** nadir-altimeter measurements from 2030 to 2050 while also improving measurement capabilities and performance.

It introduces advancements in satellite instrumentation, including the across-track interferometry swath altimeter (SAOOH) and synthetic aperture radar (SAR) nadir altimeter (Poseidon-5). The SAOOH instrument builds upon the swath altimetry advancements pioneered by the **Surface Water and Ocean Topography (SWOT)** mission, launched in December 2022 with the KaRIn instrument. However, the SAOOH instrument differs from KaRIn in several key aspects, including a shorter baseline (3 m instead of 10 m) and a different Signal-to-Noise-Ratio (SNR) of the antenna compared to SWOT/KaRIn's.

Given these differences, it is imperative to pay utmost attention to the performance of the S3NGT mission before its launch to ensure its success. This study **assess the performances** of the future mission, derives an **end-to-end uncertainty model** and associated uncertainty budget, **develops new cross-calibration methods** applied to S3NGT specificities, **investigates the 4-hour tandem phase** for continuity verification between S3 and S3NG-TOPO (see oral on 14 October), and explores **novel cross-calibration methods**.

Generation of S3NGT-like dataset

Over ocean

- Two datasets, one derived from real **SWOT in-flight data**, one from **OGCM model**.
- Considered noise for SAOOH SSH:
  - Interferometric random error
  - Impact of Wet troposphere
  - Systematic errors
- Generation of data on different orbits (1-day and 21-days SWOT, S3NGA, S3NGB)

Over inland waters

- L2 HR dataset derived from L2 HR SWOT Pixel Cloud in-flight data
- Addition of **random errors** (specifications provided by ESA) to SWOT PIXC w.r.t **sigma0 and cross track distance** based on S3NG-T and SWOT behaviours over inland waters

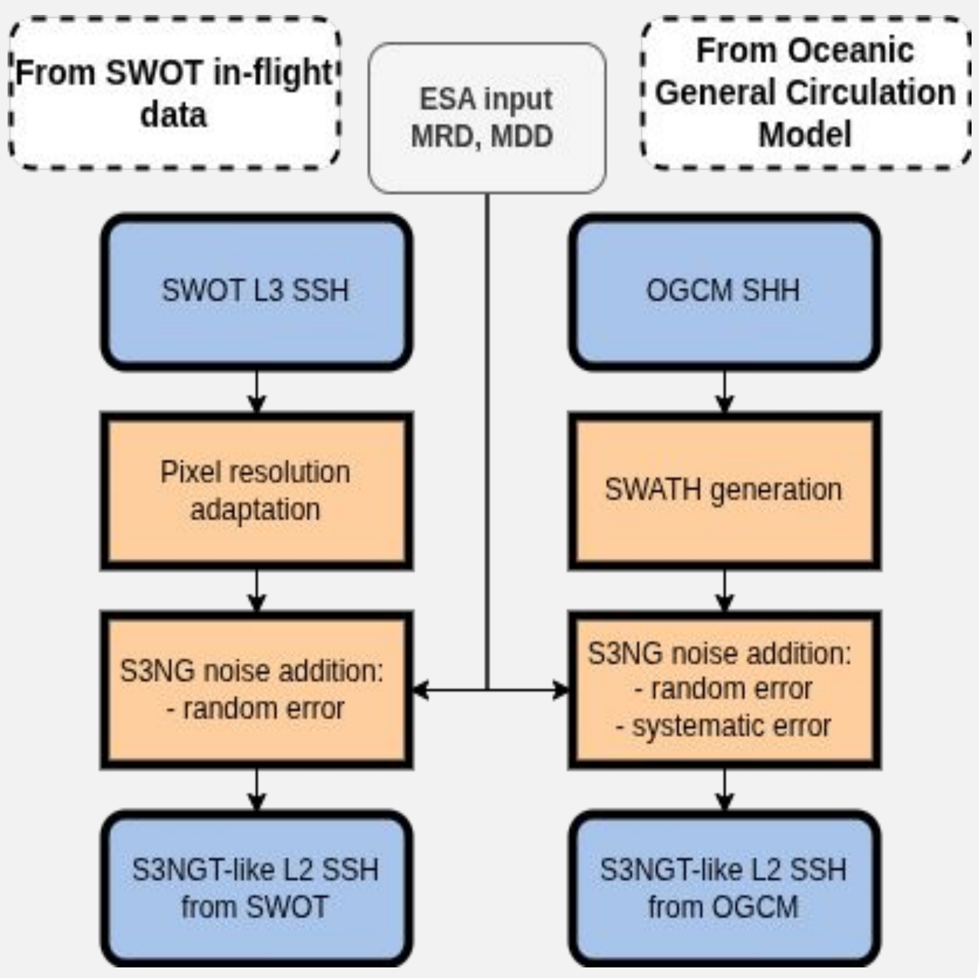

Figure 1: Data generation strategy over ocean surface

End-to-End Uncertainty Model

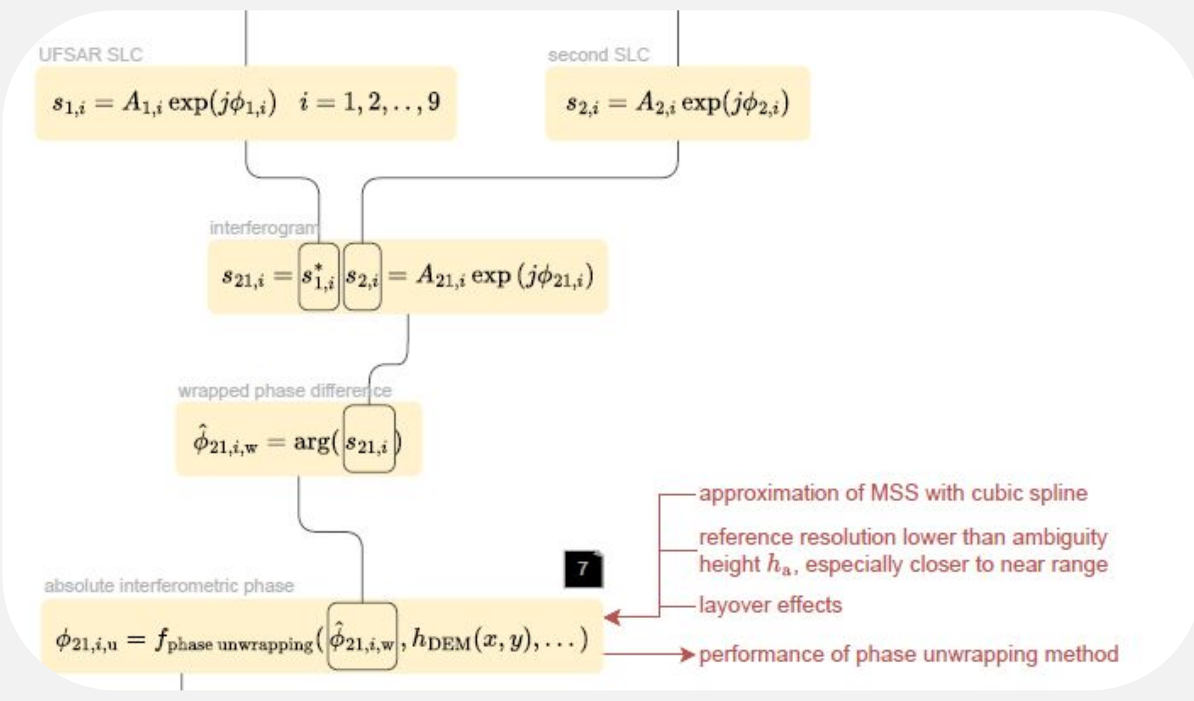

Figure 2: Segmented uncertainty tree diagram. Interferogram formation.

→ The second study objective is to develop a comprehensive **uncertainty model and budget** following established metrological principles:

a. Metrological assessment of the S3NGT mission
b. Verify and validate the S3NGT uncertainty budget

→ Create a clear metrological traceability diagram representing the Swath altimeter

→ Identify (and later quantify) individual sources of uncertainty.

In-orbit calibration

- The calibration strategy can highly impact the quality of prim ary products with respect to requirements.
- S3NGT will have a number of specifi cities (w.r.t. SWOT) that will impact the strategy (sun-synchronous orbit, two spacecraft, instrument speci fications, stricter latency requirements..)
- Calibrations implemented: Astro-XP; Hydra; new S3NGT-specific algorithm

➔ **New orbital filter with very promising results.** But need to refine error inputs for a more realistic calibration.

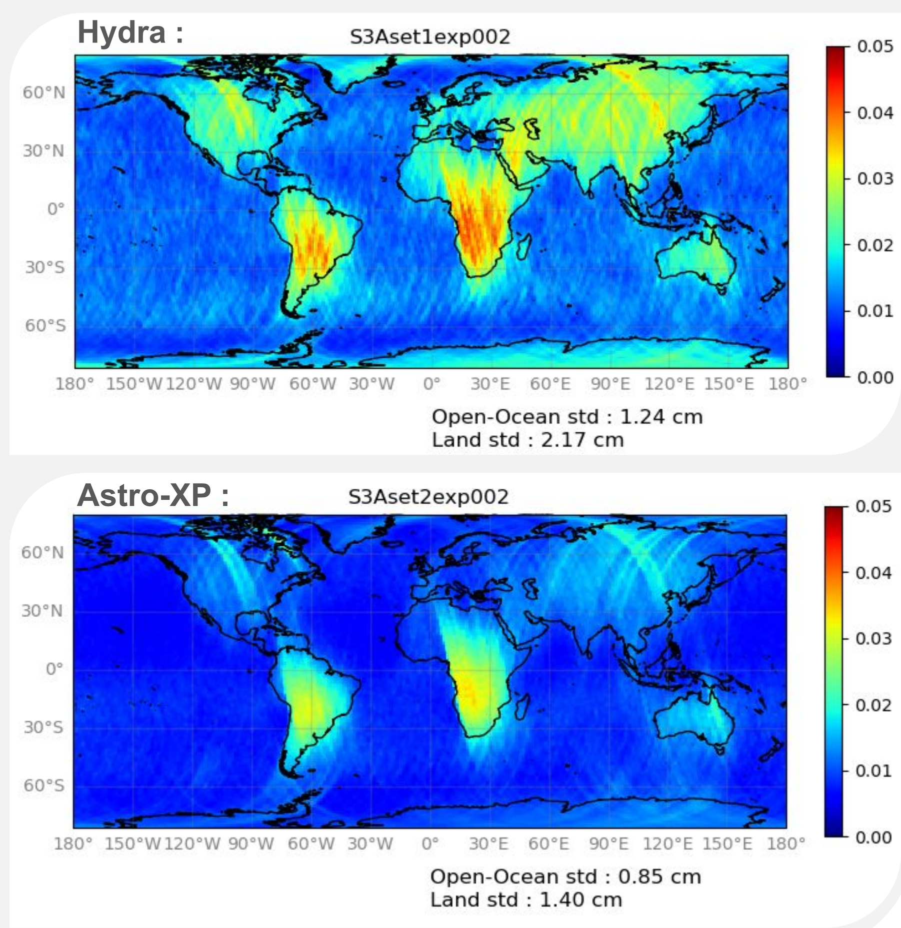

Figure 3: Results for two different calibration calibration algorithms: Hydra (top) and Astro-XP (bottom). Algorithms developed for SWOT, applied here to S3NGT dataset.

Performances firsts results

→ Key metrics developed to describe the mission's performance for several variables including sea surface height, sea state, systematic errors, and inland water surface elevation.

→ Comparison with the S3NGT Mission Requirements Document (MRD).

→ Highlights areas where the mission design can be refined to meet operational requirements.

→ Noise level for the different wave classes: [0.6 - 1.05] cm at 10 km. The noise values are well below the 2.18 cm (at 1 Hz for Hs = 2 m) of the MRD and even **below the enhanced goal** of 1.65 cm (at 1 Hz for Hs = 2 m, the equivalent at 10 km is 1.42 cm).

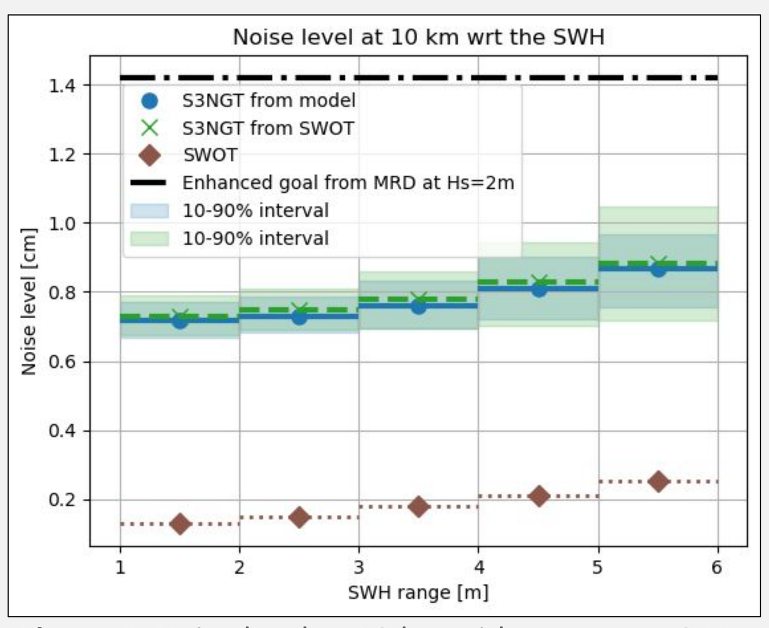

Figure 4: Noise level at 10 km with respect to SWH for the two S3NGT-like datasets. The same metric for SWOT L3 inflight data has been added for comparison

→ Simulated S3NG-T data (from SWOT PIXC during the CalVal phase) and WSE comparisons (median value within the swath) w.r.t in situ data

→ 1σ |WSE_{Error}| ~ 5,1 cm Bias: 0,1 cm

→ **First performance assessment meets the mission requirements (WSE_{Error}<24cm)**

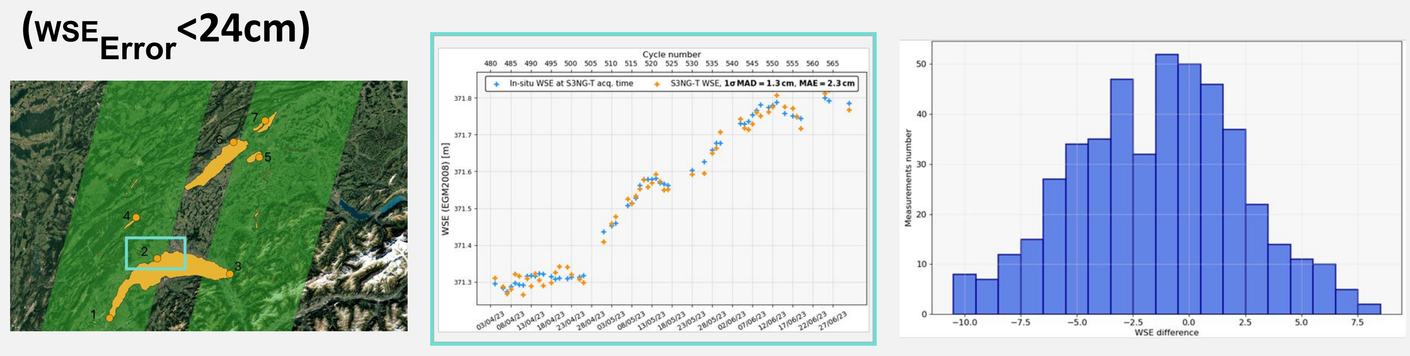

Figure 5: Comparisons of simulated S3NGT products and the Swiss in situ lake dataset (generated from SWOT PIXC products during the 1-day validation orbit March-July 2023)

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