Summary of the ESA-supported Sentinel-6 Next generation orbital study with Eumetsat and CNES contributions

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Overview

- **Mission Goal:** The Sentinel-6 Next Generation (S6NG) mission aims to improve the accuracy and stability of sea level measurements to support climate research, building on the current Sentinel-6 mission.
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Benefits of a Lower Orbit with a higher inclination	
Cost-Effective Deorbiting	Makes deorbiting the satellite easier and cheaper, potentially extending the mission's lifespan from 5 to 7.5 years
Arctic Coverage	Provides access to the rapidly changing Arctic Ocean for monitoring
Enhanced Stability	Reduces the satellite's exposure to radiation
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Challenges of a Lower Orbit	
Loss of Tandem Phase	Eliminates the possibility of a crucial tandem phase with the current Sentinel-6 mission, which is essential for cross-calibration and data continuity.
Impact on Stability	The change in orbit could affect the stability of sea level measurements by impacting the accuracy and stability of orbit determination, environmental corrections and other unknown effects.

Study objective and work logic

➔ **Primary objective** of the S6NG orbital study (so-called ORBITAS): evaluate how a new reference orbit for S6NG will impact the **mean sea level uncertainty budget** and ensure the mission still meets the scientific requirements for stability.

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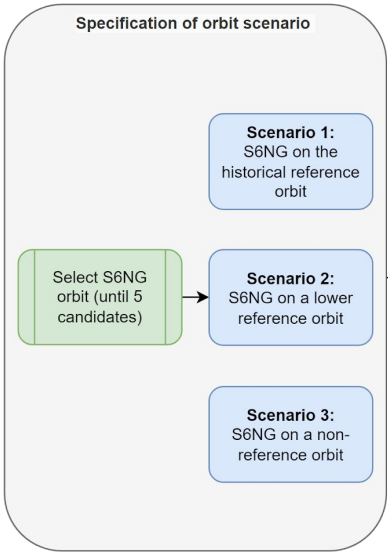

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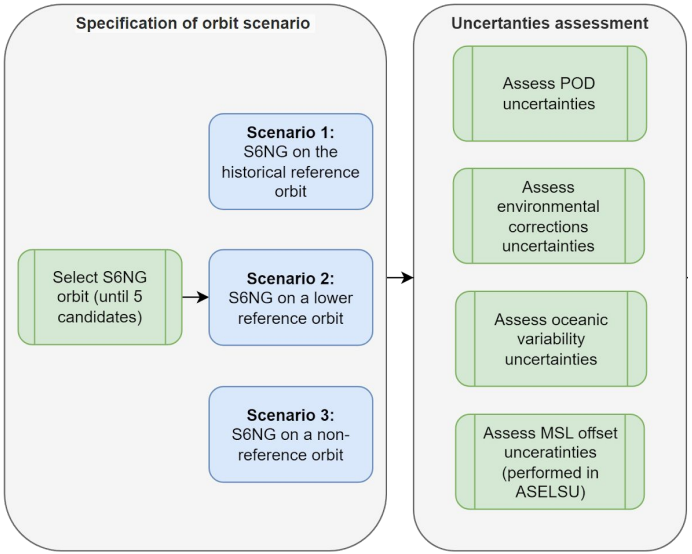

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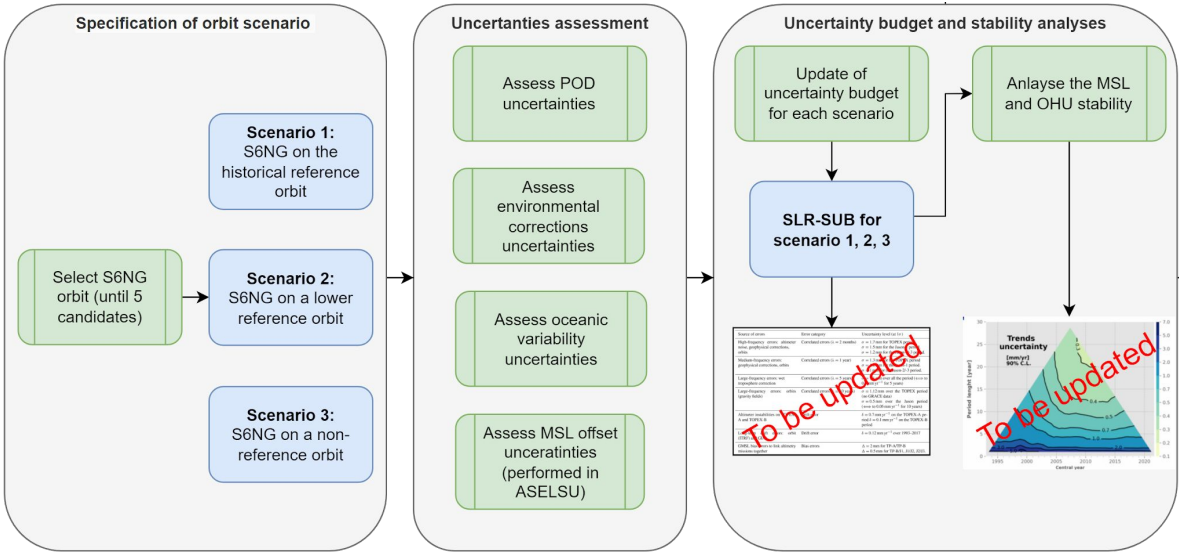

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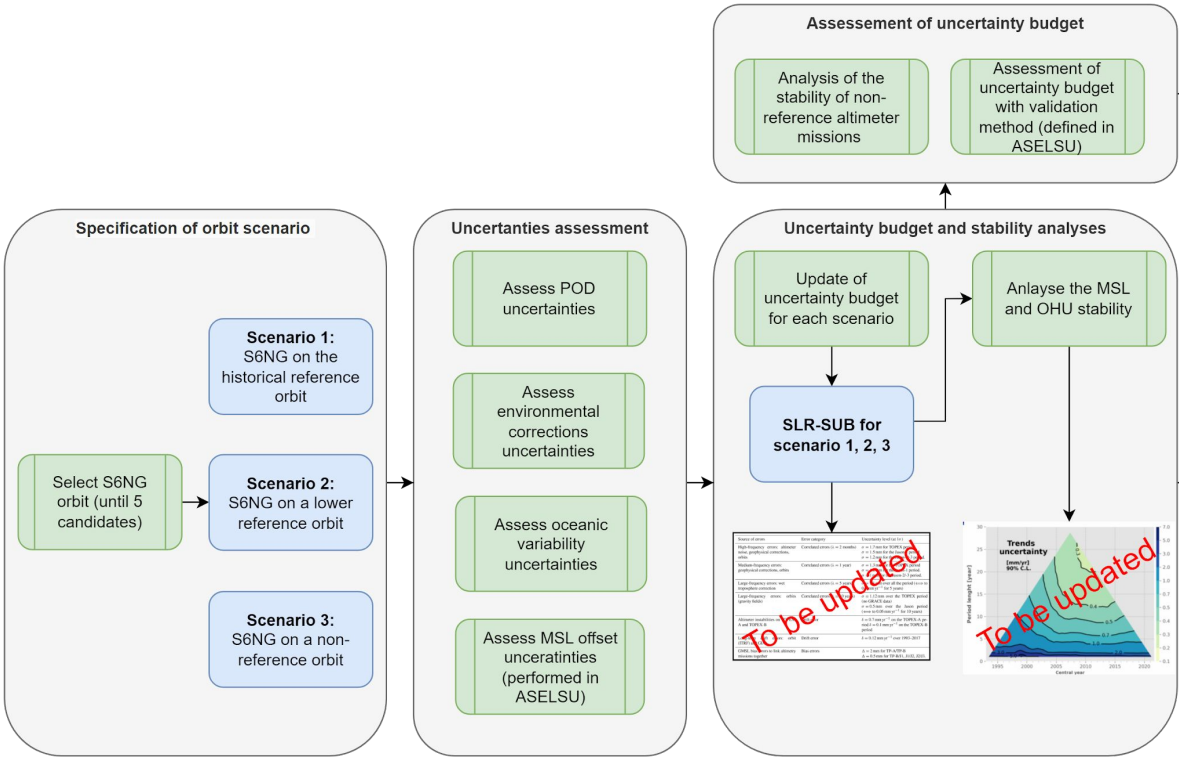

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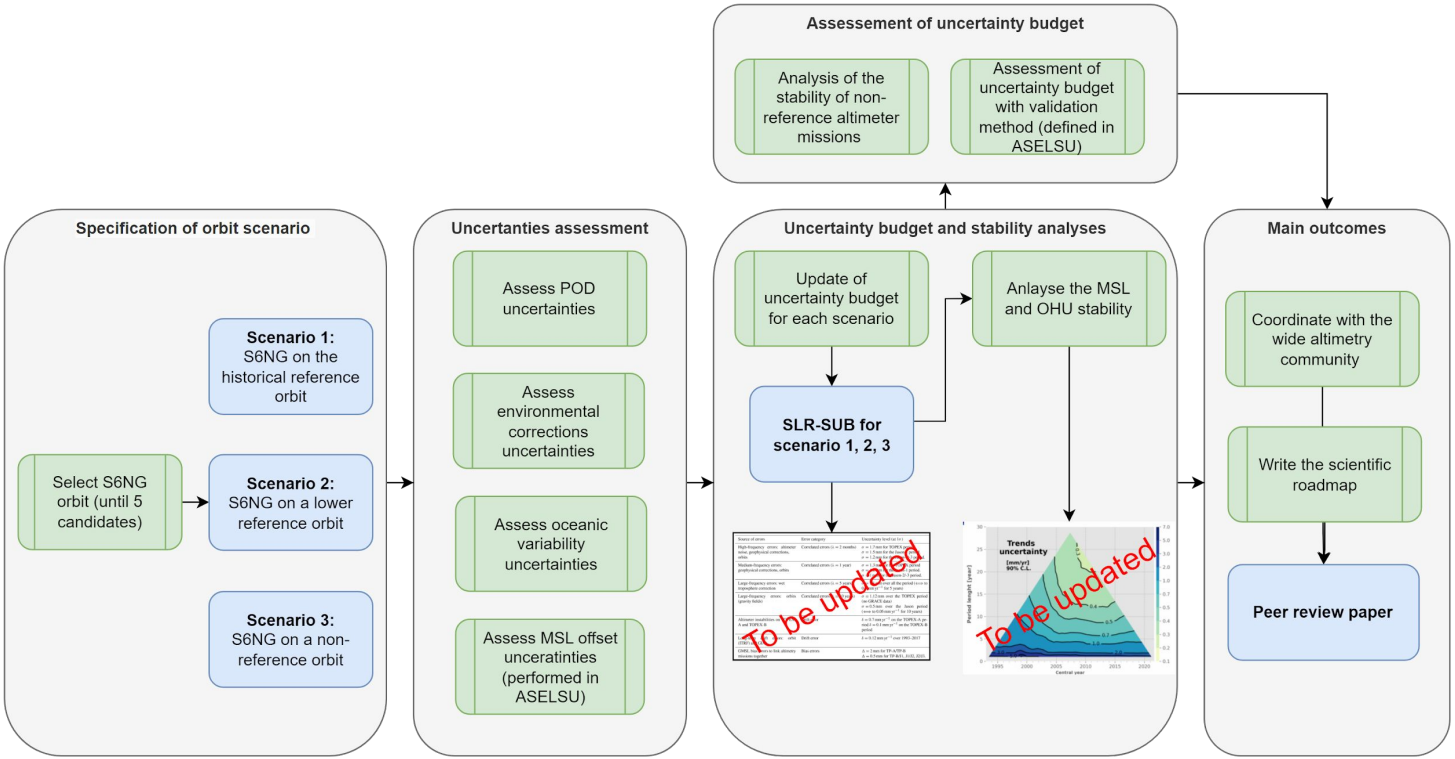
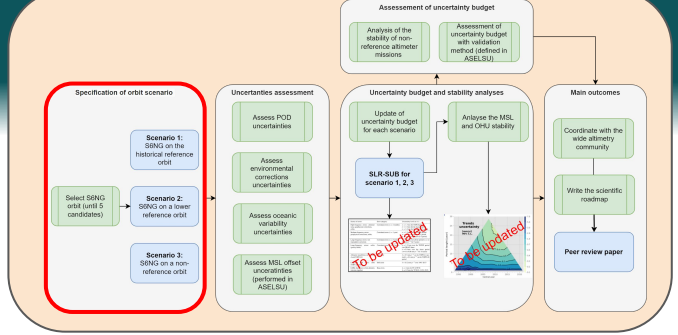


S6NG Orbit Selection



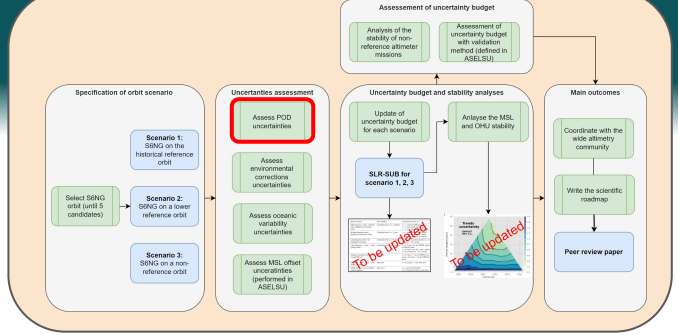
- ➔ Propose a set of orbits (5 maximum), as the S6NG orbit candidates.
- ➔ Review post-EPS orbit optimization assessment outcomes (about 20 orbits pre-selected).
- ➔ One important criterion for selecting S6NG potential orbit solutions is that they differ enough to quantify the uncertainties of offset, POD, environmental corrections and ocean variability in different conditions : **this will provide the lower and upper bounds of MSL trend uncertainties**.

	Altitude (km)	Inc (deg)	Cycle (days)	Exact repeat cycle (days)	Tide Aliasing	Tide separability (years)	Optimisation for 2 satellites	Sub-cycle (days)	S1 aliasing (days)	rev/day
A878_i66_c10	878.731	66	10	9.901936	K1 included	3.5 y	no	1	100.97	13+9/10
A1150_i72_c11	1150.317	72	11	10.917843	No K1	4 y	yes	5	132.89	13+2/11
A964_i74_c19	964.879	74	19	18.860482	No K1	5 y	yes	3	135.18	13+13/19
A835_i75_c19	835.619	75	19	18.860551	No K1	5 y	yes	1	135.25	14+1/19
A1076_i68_c11	1076.855	68	11	10.904653	no K1, but alias K1>2cpy afterall	6y	yes	3	114.36	13+4/11
A801_i71_c22	801.857	71	22	21.810438	K1 inluded	6 y	no	7	115.05	14+3/22
A1361_i65_c11	1361.612	65	11	10.905338	K1 included	6 years	yes	3	115.20	12+7/11
A912_i70_c11	912.147	70	11	10.905479	K1 included	8 years	yes	5	115.37	13+9/11
A822_i68_c15	822.474	68	15	14.858551	K1 included	8 years	yes	1	105.04	14+1/15
A1104_i76_c16	1104.802	76	16	15.895629	K1<2cpy	-	no	3	152.3	13+5/16
A923_i67_c9	923.365	67	9	8.915522	K1>2cpy	-	no	4	105.53	13+7/9
A926_i67_c13	926.436	67	13	12.878103	K1>2cpy -	-	no	4	105.64	13+10/13

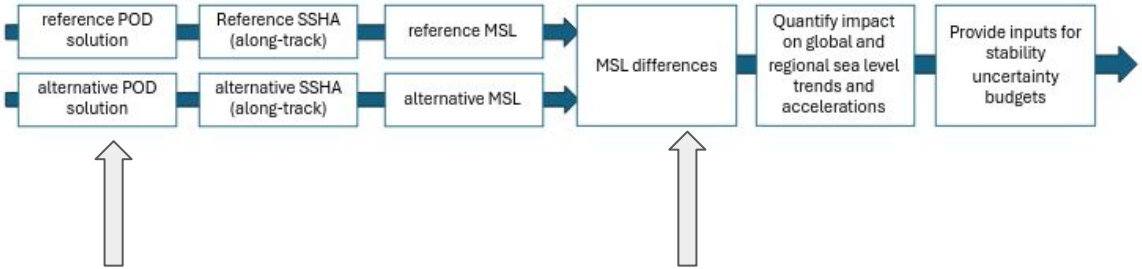
9 selected on tidal criteria

3 when relaxing tidal criteria

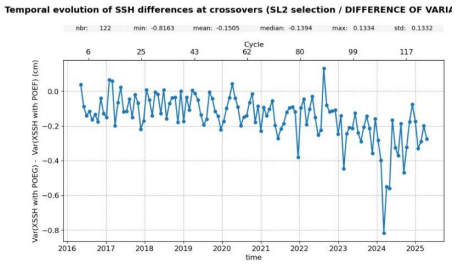
Assess POD uncertainties



- Characterise the impact of geocenter motion model for the reference (e.g. S6) and higher inclination orbits (e.g. S3)
- Generate POD solution using different geocenter motion model (from ITRF2024).
- Analyse the impact of POD techniques and networks (GNSS, DORIS, laser-ranging stations) have in the POD uncertainty
- **Contribution from CNES (A. Couhert)**

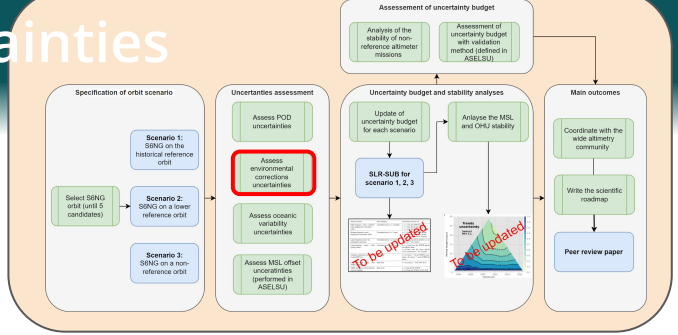


gravity field
geocenter motion
networks/techniques
reference frame



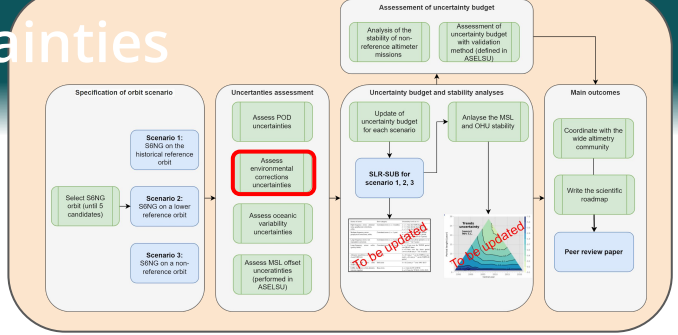
from L. Rinchiuso (CLS)

Assess environmental correction uncertainties



- ➔ Assess the impact of tide observability for the different orbit configurations.
- ➔ Assess the impact of trend uncertainties in the ocean tides, dynamical atmospheric corrections, and the dry tropospheric correction for the different orbit configurations.
- ➔ Assess the impact of coastal MSL and MSS error for the different orbit configurations

Assess environmental correction uncertainties



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Uncertainties on tide amplitude phase for the main waves

u_A, u_φ, u_ω

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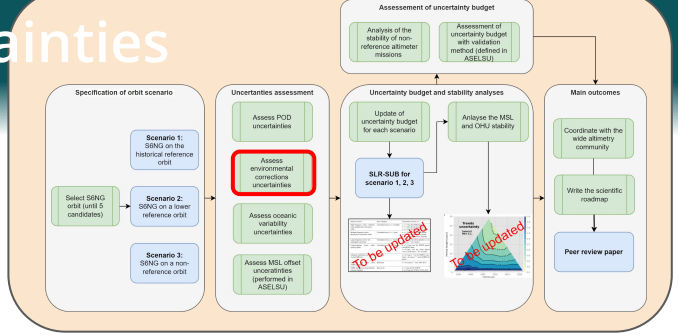

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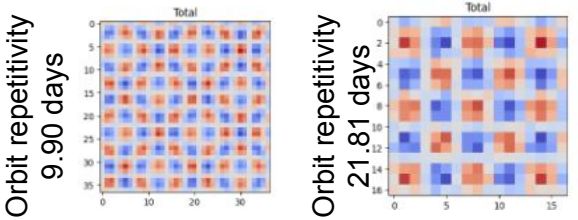
Calculation of the ocean tide trend uncertainties from an analytical formulation for several orbit solutions

u_A, u_φ, u_ω



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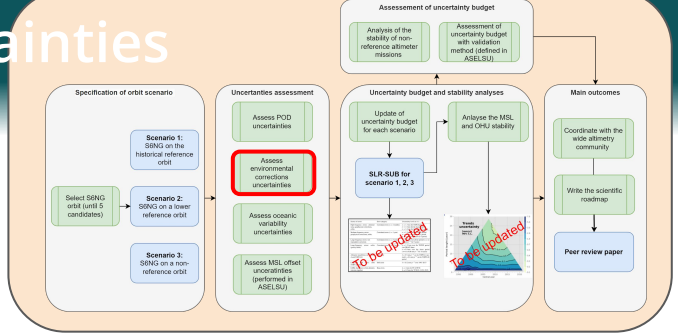

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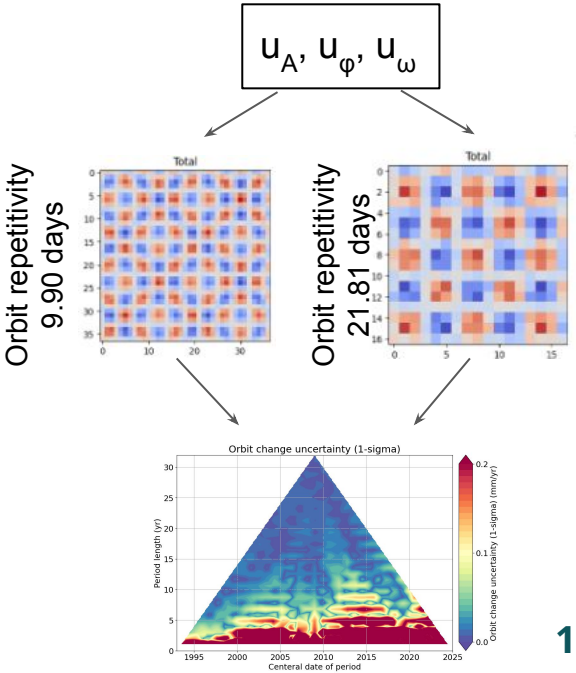
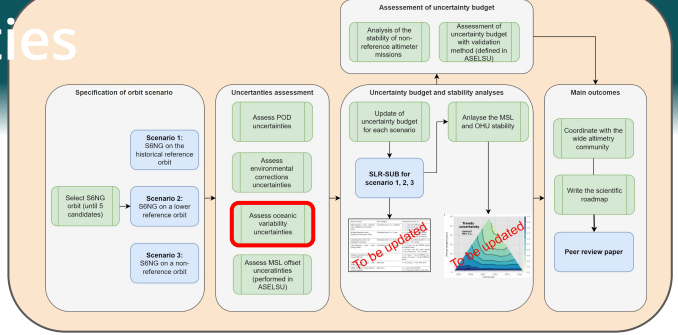
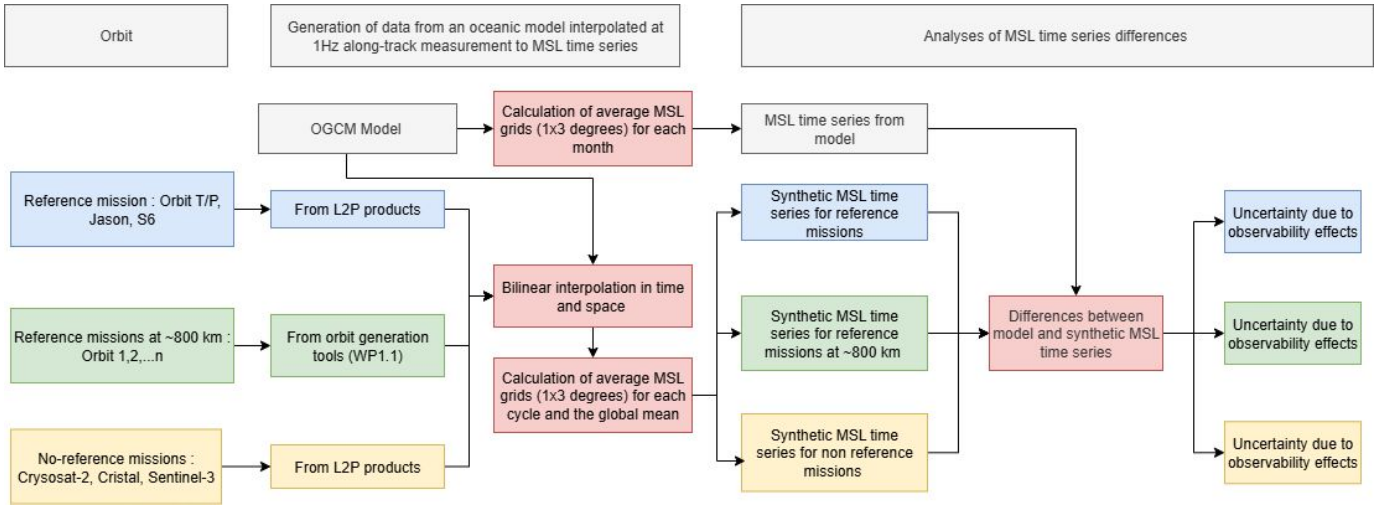
Assessment of the uncertainties estimates by comparison with ocean tide error realisation due to orbit change



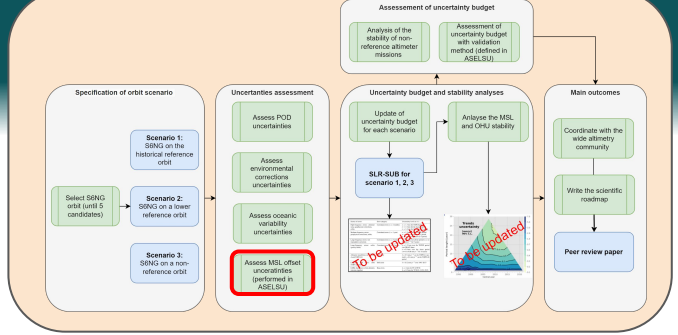
Assess the oceanic variability uncertainties



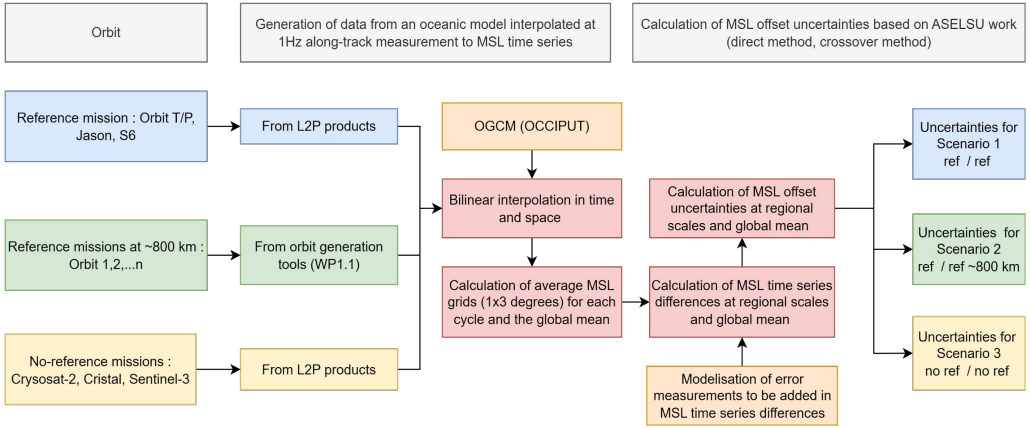
- Assess the impact of along-track sampling due to oceanic variability on global and regional trends and accelerations for the different orbit configurations using oceanic model.
- Quantify the contribution of the Arctic Ocean on GMSL trends and acceleration over periods from 1 year to 10 years based on the sampling of state-of-the-art real data.



Assess MSL offset uncertainties



- ➔ Assess the effect of the orbit choice on the MSL offset uncertainties at global and regional scales
- ➔ Use of an ocean model to calculate the MSL offset uncertainties :



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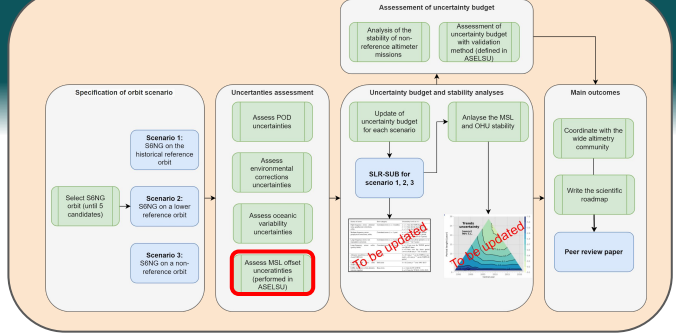
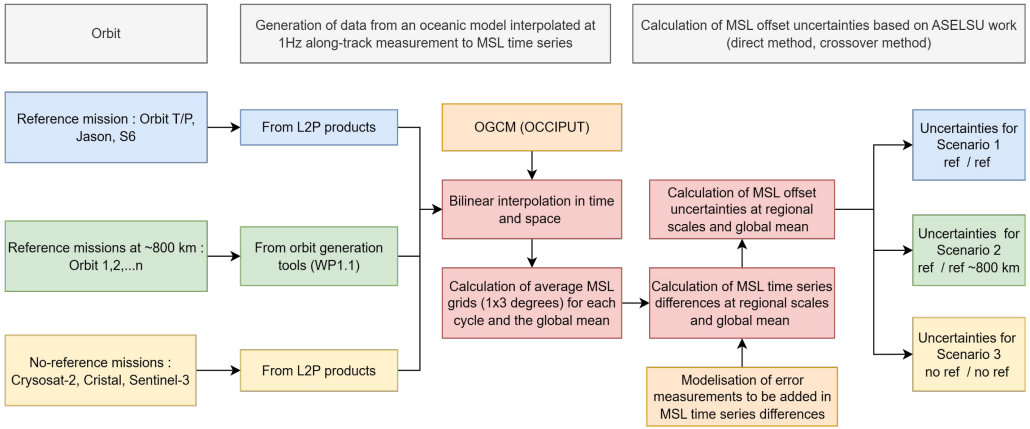
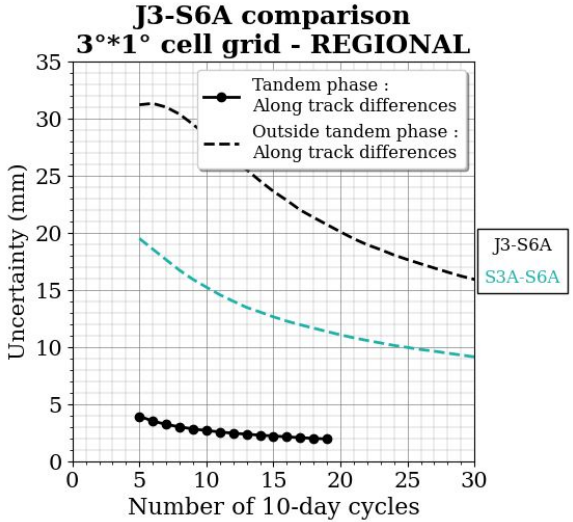
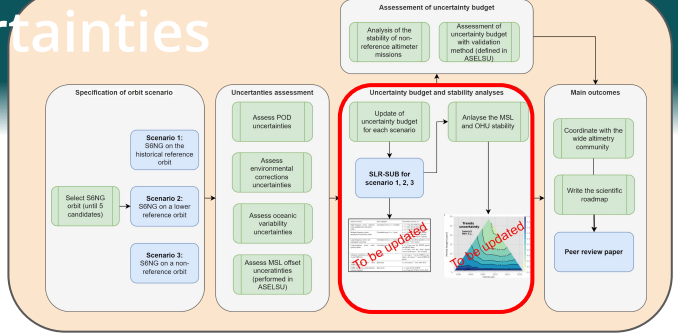




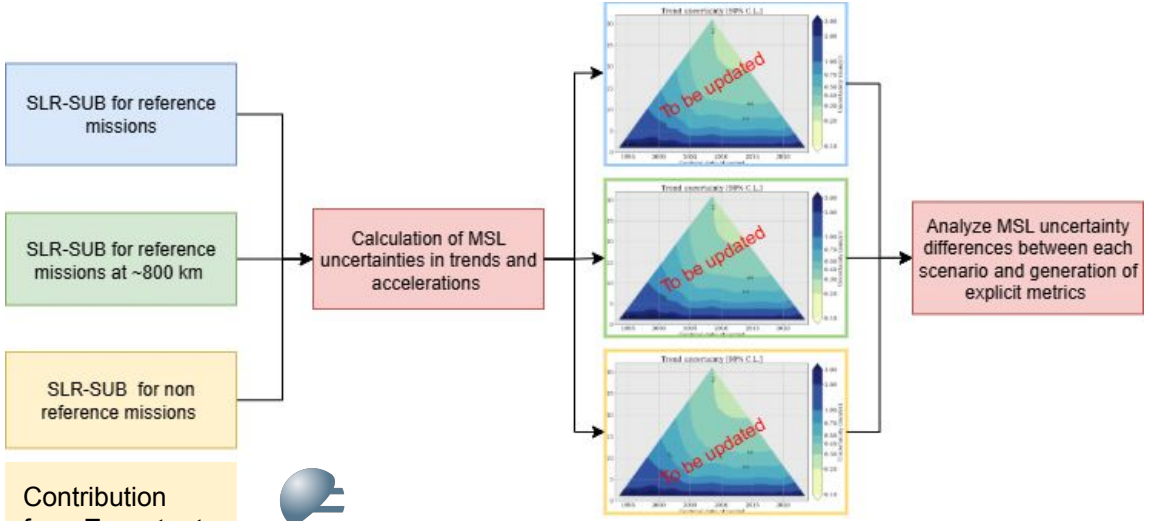


Outcome of ASELSU project : offset uncertainty is dependent of the choice of the orbit outside a tandem phase

Quantify the mean sea level trend uncertainties



- ➔ Update mean sea level uncertainty budget (noted SLR-SUB) from outcomes of previous tasks
  - ◆ for the different orbit scenarios
  - ◆ at both global and regional scales
- ➔ Quantify the impact :
  - ◆ on the mean sea level trend uncertainties
  - ◆ ocean heat uptake uncertainties



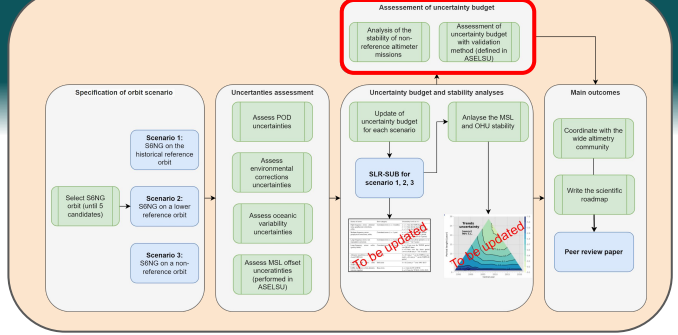
Contribution from **Eumetsat**

EUMETSAT

Explicit metrics will be defined in order to answer simple questions.

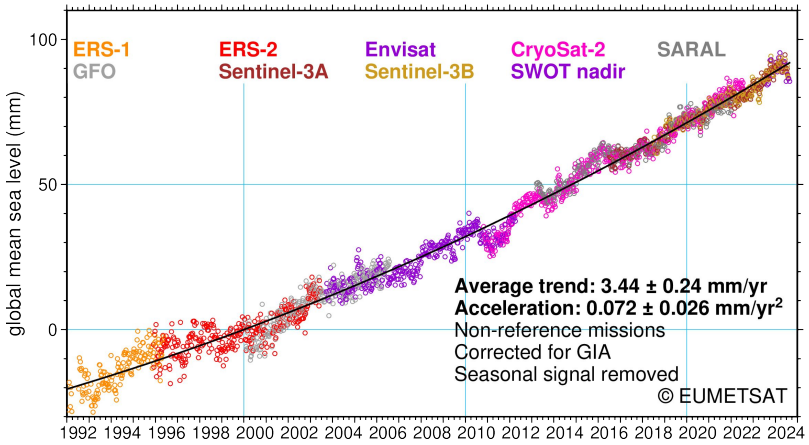
For example, how many additional years are needed with scenario 2 (green) to reach the same level of stability as with scenario 1 (blue)?

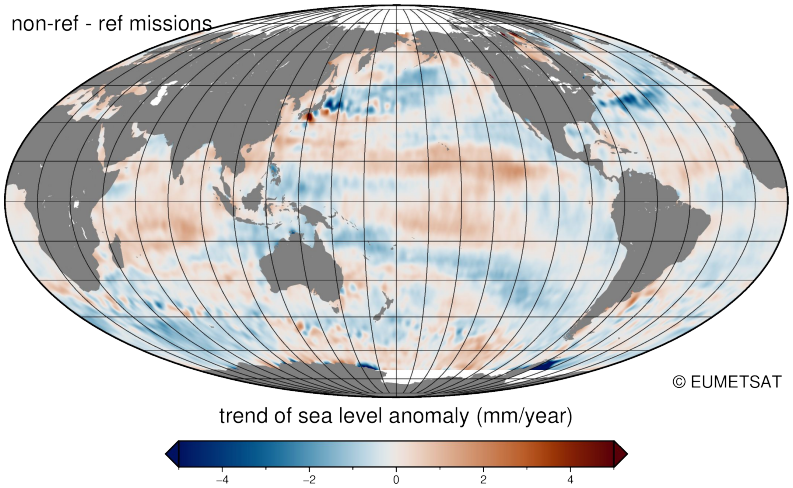
Assess the sea level uncertainty budget



- Use of non-reference missions to assess the sea level uncertainty budget
  - Compare sea level trend and acceleration
  - Analyse the closure of the sea level budget
  - Conduct energy budget closure analysis
  - Contribution from **Eumetsat**

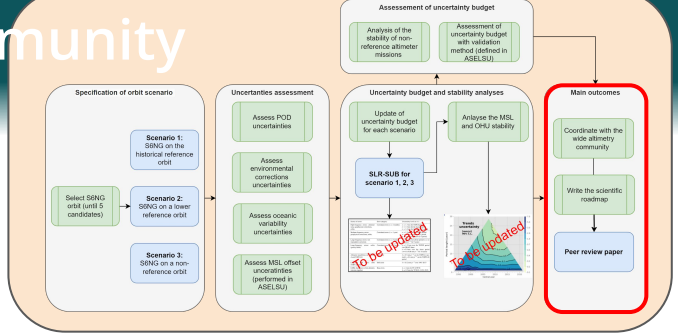
EUMETSAT





R. Scharroo, 30 YPRA symposium 2024, LPS 2025)

Coordinate with the wide altimetry community



- Coordinate with the wide altimetry community, gathering outcomes from other relevant studies that might be running in parallel to this study, relevant to the tasks performed in this study (D. Stammer & B. Meyssignac)

- Prepare a community-wide White Paper to report on the study outcomes and overall community recommendations.

Proposed Workshop Series

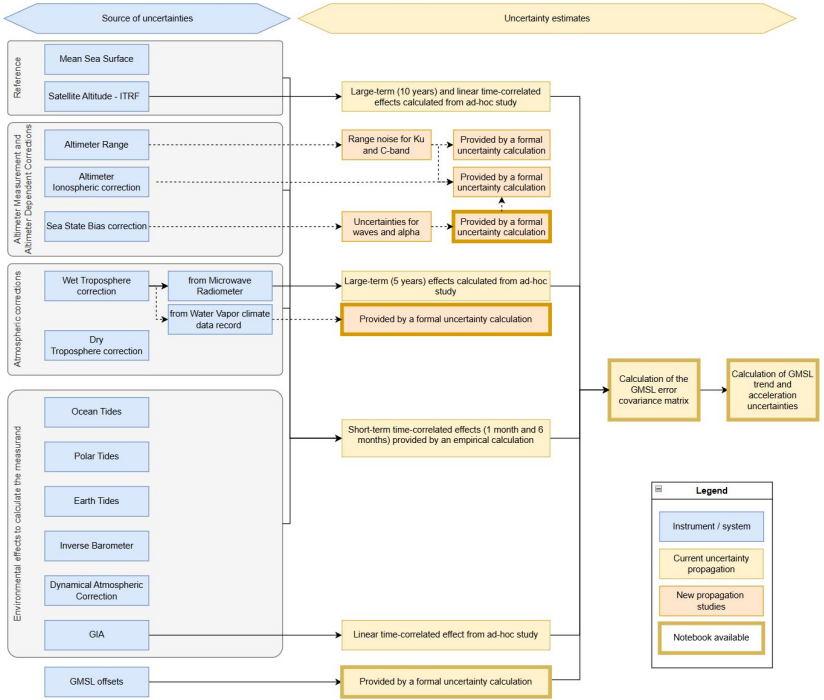
To address this complex issue, we propose organizing a **series of workshops** focusing on evaluating the necessity of maintaining high-precision nadir altimeter missions on the historical TOPEX/JASON/S6 orbit beyond 2036. These discussions will inform decisions for the design and implementation of the S6NG mission and the broader altimetric topography constellation.

Scientific input is essential to assess the opportunities and risks of transitioning S6NG to an alternative orbit. To gather comprehensive feedback, we propose two key events:

1. **Scoping Meeting (November 2025 at JPL):**
   A small, focused hybrid meeting (approx. 25 participants) to agree on the need for such a discussion, to define the scope and objectives of a larger in person workshop, identify its key questions, and identify topics that need to be prepared ahead of time through targeted analyses.
2. **In-Person Workshop (Autumn 2026):**
   A collaborative meeting to present the results of targeted studies and use results to assess the implications of orbit changes. All this will be used to develop a joint scientific feedback by the altimetric community regarding the S6NG orbit.

Summary

- The ORBITAS study aims at quantifying the impact of the potential S6NG orbit change on the sea level stability uncertainty budget with regards to the sea level stability requirements.
- Main **challenges** identified are:
  - Characterise the uncertainties of POD and environmental corrections for the different scenarios
  - Quantify the impact of known unknown (and unknown unknown) effects/errors
  - Design a cal/val network to assess sea level stability and uncertainties
- Interaction with the altimetry community and synergy with other projects **needed**
- Outcomes of this project will be also useful for the ASELSU project which aims at improving the SLR-SUB for S6 and S6NG.



Interactive uncertainty propagation diagram: https://www.aselsu.org/diagrams/uncertainty-propagation-diagram

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Thank you for your attention.

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eo@magellium.fr