S6NG Orbit Workshop

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The S6NG Orbit Challenge

- As the Sentinel-6 Next Generation (S6NG) mission is currently under design for a 2036 launch, an old key question has re-emerged:
- **Is it still necessary to place S6NG in the historical TOPEX/JASON/S6 reference orbit to meet its scientific and operational goals, or could an alternative orbit (lower altitude, higher inclination) provide equivalent or improved outcomes?**

- **To provide a scientifically sound answer to this critical question, detailed discussions and additional studies are required.**
- S6NG aims to:
  - Ensure continuity of high-precision climate data.
  - Improve the accuracy of global and regional sea level rise observations and the inference of related processes, such as ocean heat content change.
- At the same time, we need to optimize the use of an altimeter constellation in the context of truly global sea level observations and optimize mission costs.

Sentinel-6 Next Generation Orbital Discussion

- While planning for the Sentinel-6 Next Generation (S6NG) mission, we need to review mission design requirements, including (especially) its orbit choice and all that follow from it.
- This special session will initiate a re-evaluation of altimetry reference mission orbits to develop a globally optimized, sustainable constellation in support of operational oceanography and climate monitoring.
- We are here to:
  - Remember and agree on what the role of a reference altimetric mission is.
  - Identify key questions that need to be investigated and initiate studies that need to be performed to assess implications of orbit changes.
- Results will be presented in a second in person workshop to be held early in 2027 and will be used to develop a joint scientifically based recommendation by the altimetric community regarding the S6NG orbit.

Goal of the Workshop

- Agree on the role of a reference altimetric mission.
- Discuss potential benefits or negative impacts of changing the altimeter reference mission orbit from the historic T/P- JASON orbit, starting with the future S6NG mission.
- Identify studies that are required to quantify in a scientifically founded way negative impacts of such a shift, should they exist.

As a reminder:

- Any resulting obit choice should aim to:
  - Ensure continuity of high-precision climate signals, avoiding tidal and orbital aliasing.
  - Maximize the observability of global, regional coastal sea level variability and change.
  - Potentially reduce mission costs through lower altitude orbits.

Planning the Future

- Over the past 15+ years, significant progress has been made also on the scientific front:
- Daily monitoring of sea surface height and geostrophic circulation on a ¼° × ¼° spatial grid with ~1.5 cm precision per individual SSH measurement.
- Global mean sea level are now monitored with ±0.3 mm/year accuracy over 20 years.
- Major tidal aliasing issues have been effectively addressed by significantly improving tide models over the open ocean not covered by sea ice.
- By the end of 2035, two Sentinel-3 Next Generation Topography satellites are expected to be operational, featuring both nadir and wide-swath altimetry on a sun-synchronous orbit near the current S3 configuration (high inclination).
- Sentinel-3 nadir altimeters, equipped with both DORIS and GPS, have demonstrated comparable in-flight performance to S6.
- The Surface Water and Ocean Topography (SWOT) mission has showcased the excellent performance of wide-swath altimetry as a promising extension of traditional capabilities, enhancing coverage in both open ocean and coastal zones.
- Interest to cover high latitudes has grown. However, there are satellite missions like Sentinel-3 or CRISTAL that will do this already.

New Science Challenges in 2025

- Can mesoscale circulation be resolved at finer spatial and temporal scales, including coastal zones?
- How can we better observe the ever-increasing sea-ice free high latitude regions not covered by altimetry before?
- Can we observe the global mean sea level budget to within 0.1 mm/year over a 20 years time scale, to detect signals from deep and high-latitude ocean warming and the sea level response to interannual/decadal changes in the Earth energy budget?
- Can we identify regional sea level trends at 0.3 mm/year to detect and attribute regional sea level rise induced by anthropogenic climate change and inform adaption strategies?
- Can we resolve non-linear internal tides and trends in tidal behavior induced by climate change?
- These and other advanced science questions:
  - demand the highest precision and stability from the next generation of altimetry missions.
  - **raise the question whether or not a high-precision reference orbit exactly on the TOPEX orbit as part of a future altimeter constellation remains critical to achieving such goals justifying its high cost.**

New Engineering Boundary Conditions in 2025

- The TOPEX orbit was selected to improve the understanding the ocean geostrophic circulation and its variability. A high-precision repeat-orbit reference altimeter mission was needed at a repeat cycle of close to but not exactly 10 days. This required a stable along-track mean SSH, a close to 90° at mid-latitude cross-over points, minimal orbit determination errors and the need to avoid aliasing of major tidal constituents into the mean or the seasonal cycle.
- Today the situation has changed on the engineering front and on the scientific front. With the introduction of the debris mitigation law, satellites in orbits below 2000 km must now be deorbited at end-of-life.
- Satellites operating on the TOPEX/JASON/Sentinel-6 (S6) type orbit are costly to launch, because of:
  - their relatively high-altitude orbit (high fuel costs).
  - requirement of a controlled deorbiting of any spacecraft at its end-of-mission time, increases mission costs even further.
- These costs have become so significant that they directly impact spacecraft design and raise concerns about the economic viability of future recurrent missions.

Agenda

- 8.30-8.50 am Opening and scope of the workshop, Detlef Stammer
- 8.50-9.10 am Background information on S6NG and other future altimeter missions, **Alejandro Egido**
- 9.10-9.40 am Summary of previous studies and information regarding the reference orbit, **Lauren Carrere** (remote)
- 9.40-10 am Summary of planned ESA and EUMETSAT S6NG Orbital Study, **Michaël Ablain**
- 10-10.30 am Break
- 10.30-11.10 am Summary of impact of orbit shift on
  - Cal/Val: Results of past tandem missions – **Michaël Ablain and Eric Leuliette**
  - Precise Orbit Determination POD - **Alexandre Couhert and Frank Lemoine**
  - Continuity of global and regional sea level record – **Noemie Lalau**
  - Tidal studies – **Richard Ray**
  - Continuity in the estimate of the ocean heat content (including deep ocean), ocean heat uptake and earth energy imbalance - **Maria Hakuba and Benoit Meyssignac**
- 11.10am-11.30am Conclusions and discussion (identify required additional studies and define timeline and next meeting date), Detlef Stammer

Charge to Speakers

- 8 min. to present your thoughts and suggestions regarding the orbit choice for S6NG, focusing on the above questions.
- Identify studies that are required to obtain a quantitative answer about negative impacts of an orbit change.
- Brainstorming about possible funding sources for additional study.