EARTH OBSERVATION

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How to reach the scientific uncertainty requirements for scientific questions in future altimetry missions?

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Context

Since 1993, **altimetry** data have enabled monitoring of global mean sea level (GMSL) rise. Uncertainty requirements defined by the GCOS in 2011 have now been reached (Table 1). Recently, **new stability uncertainty requirements** have been established in order to address scientific questions related to climate change like closing the sea level budget, detecting and attributing the signal in sea level forced by the greenhouse gas emissions and monitoring the Earth's energy imbalance (see Table 1 and Meyssignac et al., 2023).

The aim of the ASELSU project is to identify if **instrumental improvements** are needed for **Sentinel-6 Next Generation** altimetry missions in order to meet the new scientific requirements. We present here the current level of uncertainties, the objectives and the main directions to follow in order to reach these new requirements in the coming decades.

		GMSL rates	GMSL acceleration	SL (~100 km) rates
Current uncertainty over 20 years (Guérou et al., 2022; Prandi et al., 2021)		0.3-0.5 mm/yr	0.7-1.2 mm/yr/decade	0.78-1.22 mm/yr
GCOS (2011) requirements		< 0.3 mm/yr	Not defined	< 1 mm/yr
New requirements for scientific questions (Meyssignac et al., 2023)	**Closing the sea level budget**	Detection: **±0.1 mm/yr** Quantification: ±0.02 mm/yr		Detection: ±0.3 mm/yr Quantification: ±0.07 mm/yr
	Detecting and attributing signal forced by greenhouse gas emissions	Detection: ±1.5 mm/yr Quantification: ±0.7 mm/yr		Detection: **±0.5 mm/yr** Quantification: ±0.01 mm/yr
	Estimating the EEI	Detection: ±0.1 mm/yr Quantification: ±0.03 mm/yr	Detection: **±0.5 mm/yr/decade** Quantification: ± 0.1 mm/yr/decade	

Table 1: Requirements and state-of-the-art estimates for the global mean and local sea level (SL) stability uncertainty (5-95 % confidence interval). Values in bold font indicate the values set as requirements within the ASELSU projet.

Current uncertainties and objective

The current sea level uncertainty budget has been established by Ablain et al. (2019) and Guérou et al. (2022) at **global scale** (Figure 1) and by Prandi et al. (2021) at **local scale**. Over the last 20 years, the main sources of uncertainties in the GMSL are the noise with correlation durations below 1 year, the wet troposphere correction (WTC) and the precise orbit determination (POD) involving the International Terrestrial Reference Frame (ITRF) (Figure 1). At local scales, the main uncertainty contributions are the inter-mission offset corrections, the noise with correlation durations below 1 year and the WTC.

An ambitious but realistic scenario is proposed to reduce the GMSL uncertainties in the coming decades so that the scientific requirements are met (Figure 1). This scenario requires to make progress on all components of the uncertainty budget, with a priority on the main contributions mentioned above.

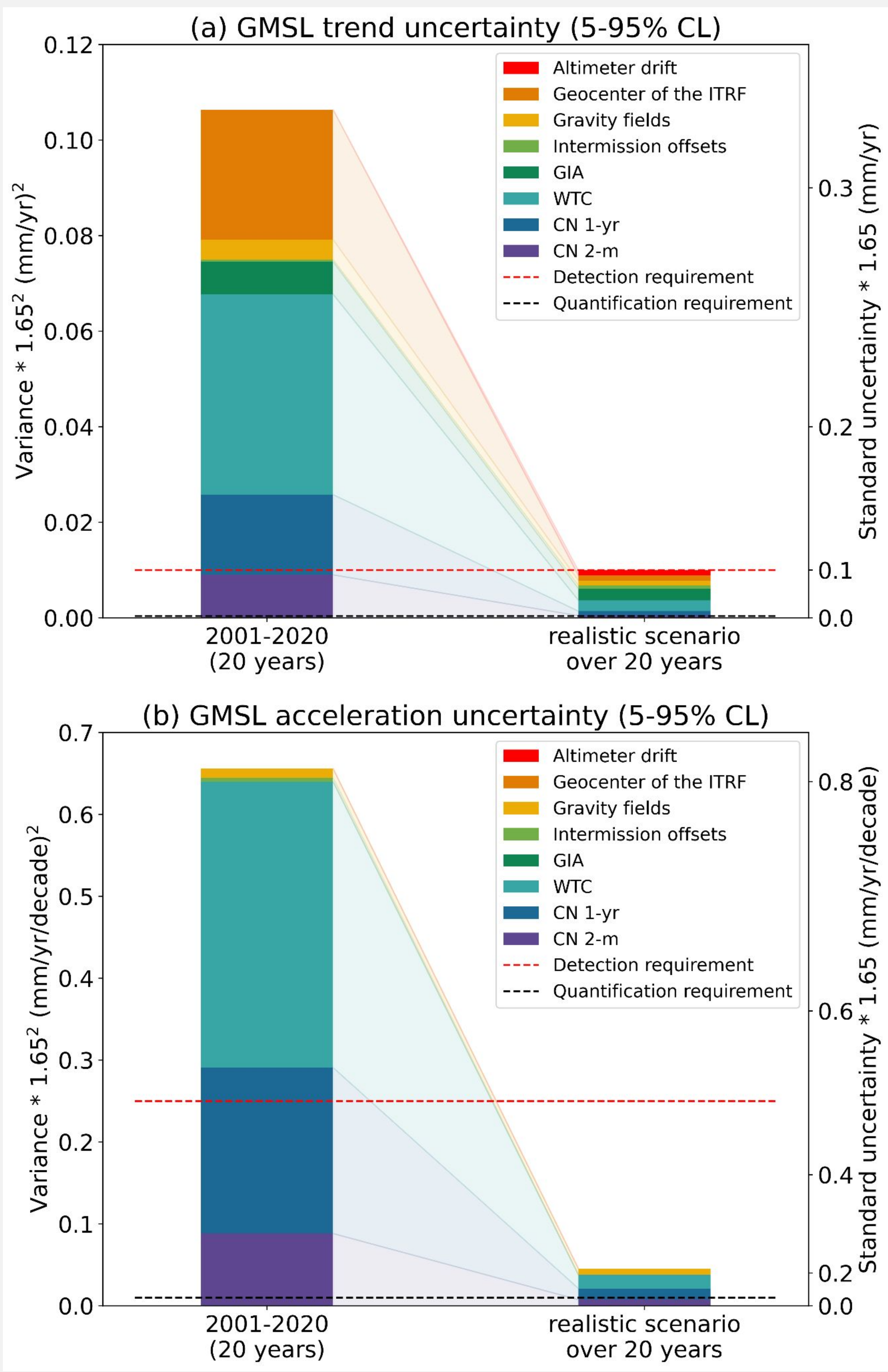

Figure 1: Current GMSL trend and acceleration uncertainty over 20 years and possible scenario to reach the requirements with future altimetry missions (Meyssignac et al., 2023).

Roadmap and recommendations

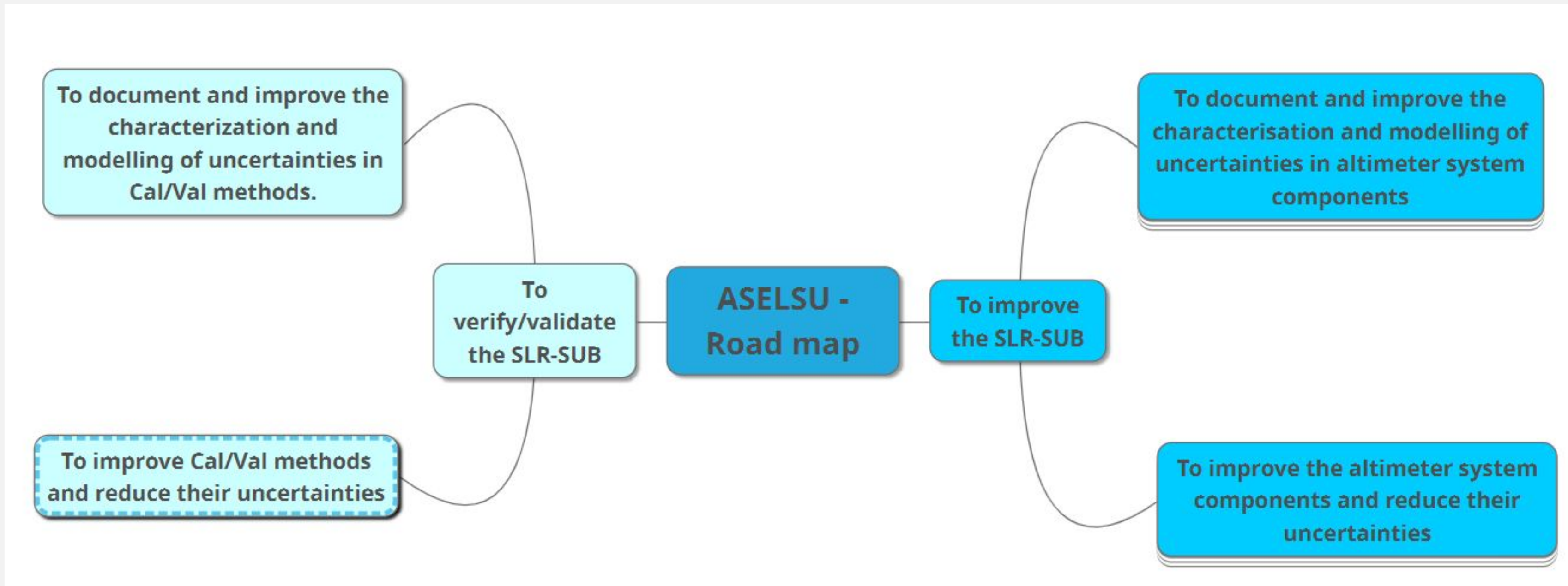

Figure 2: Schematic view of the ASELSU roadmap.

The work done within the ASELSU project has resulted in the following high-level recommendations, summarized by Figure 2:

- Documenting and improving the characterisation of the uncertainty in each component of the altimeter system, with priority given to the WTC, POD (e.g. ITRF), altimeter parameters (e.g. sea state bias) and local sea level offsets.
- Reducing the uncertainty of each component of the altimeter system with priority given to the WTC and POD.
- Documenting and improving the characterization and modelling of uncertainty in historical calibration and validation methods.
- Reducing the uncertainty of historical calibration and validation methods and develop new methods with improved ability to detect drift, i.e. with lower uncertainties.
- To perform the above tasks, the FIDUCEO (fidelity and uncertainty in climate data records from Earth observation) formalism (Mittaz et al., 2019) should be applied to improve the traceability and calculation of uncertainties (Figure 3).

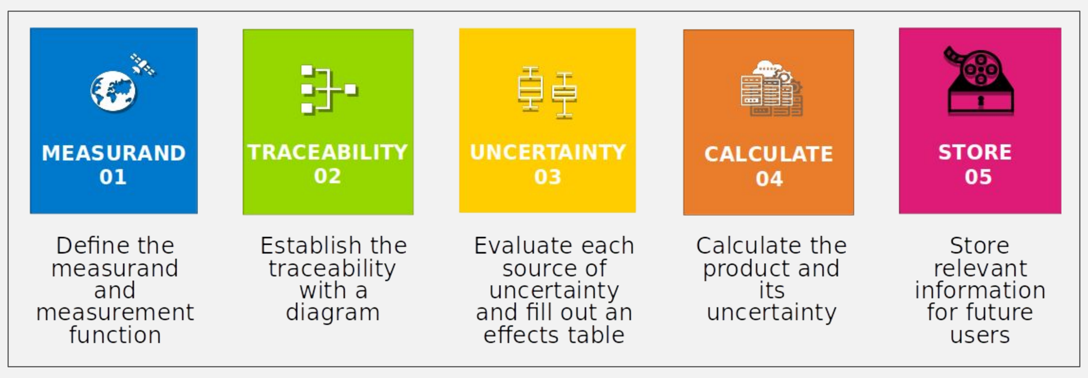

Figure 3: Modified FIDUCEO workflow.

Conclusions and outlook

For future altimetry missions to meet the new stringent scientific requirements for the long term stability of sea level measurements, we need to intensify our work on uncertainty characterisation over the next decade:

- updating the uncertainty estimate as the altimeter measurement system capability evolves (e.g. WTC, POD, altimeter parameters and processing, geophysical corrections) for continuity and future applications,
- providing updated and improved uncertainties which are needed for climate studies, for example to better constrain the water and energy budgets.

References

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