EARTH OBSERVATION

Science for Earth care

Sea level rise due to climate change: What do we know? What are the next questions to address? How does metrology help us to answer?

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Motivation

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 the understanding of the Earth's water and energy cycles at global and regional scales (see Table 1 and Meyssignac et al., 2019; in prep.). 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.

	GCOS (2011) requirements	Current uncertainty over 20 years	New requirements
GMSL trend	< 0.3 mm/yr	0.3-0.5 mm/yr	< 0.1 mm/yr
GMSL acceleration	Not defined	0.07-0.12 mm/yr^2	< 0.05 mm/yr^2
MSL trend (~100 km)	< 1 mm/yr	0.78-1.22 mm/yr	< 0.5 mm/yr
MSL acceleration	Not defined	0.06-0.12 mm/yr^2	Not defined

Table 1: Requirements (GCOS, 2011; Meyssignac et al., 2019) and state-of-the-art estimates (Ablain et al., 2019; Prandi et al., 2021) for the global and regional mean sea level (MSL) rise stability uncertainty (5-95 % confidence level).

Level 3 GMSL uncertainty budget

The current mean sea level uncertainty budget has been established for **Level 3** altimetry data 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 1993-2021, the GMSL rose by +3.3 +/- 0.33 mm/yr (90 % confidence level) and accelerated by 1.2 +/- 0.6 mm/yr per decade (updated from Ablain et al., 2019 and Guérou et al., 2022).

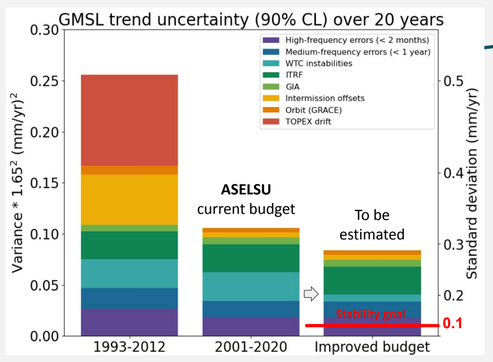

Figure 1: GMSL trend uncertainty partitioning from the Level 3 uncertainty budget of Ablain et al. (2019) and Guérou et al. (2022).

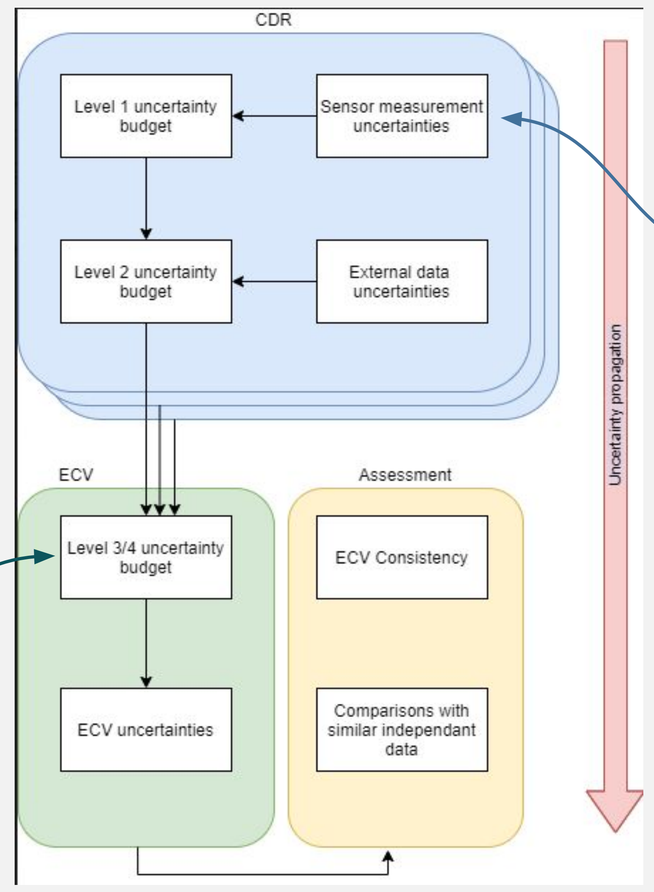

Figure 2: Uncertainty propagation scheme from climate data records (CDR) to essential climate variables (ECV).

The **Level 3 uncertainty budget** (Figure 2) allows a robust estimation of the GMSL trend and acceleration uncertainties. However, an end-to-end uncertainty budget is necessary to know the **relative contribution** of each source of uncertainty from the raw measurements, hence to identify whether instrumental improvements would enable reaching the new uncertainty requirements for climate studies.

Conclusions and outlook

- Quantifying each source of uncertainty from the raw measurement is challenging.
- A comprehensive end-to-end sea level rise stability uncertainty budget will require an in-depth study of all observing systems involved in the computation of the mean sea level.
- Future works include identifying possible ways of improving the altimetry system to diminish the sea level stability uncertainty. Improvements may involve instrumental changes but also novel system configurations (e.g. two tandem phases).

Establishing the end-to-end uncertainty budget

Using the **FIDUCEO** (Fidelity and uncertainty in climate data records from Earth observation) formalism (Mittaz et al., 2019) from metrology, the objective of the ASELSU project is to establish a comprehensive end-to-end sea level rise stability uncertainty budget (Figure 3).

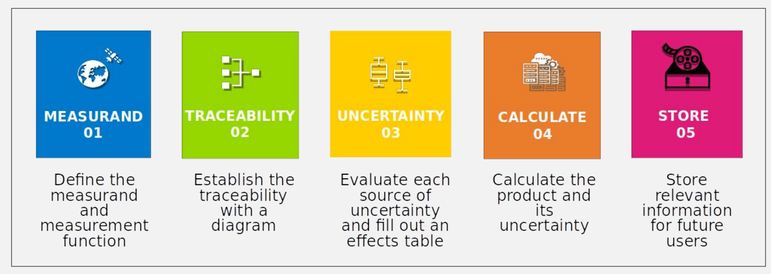

Figure 3: Modified FIDUCEO workflow.

The computation of the sea level uses information from several observations systems, e.g. altimeter, radiometer, orbit. The ASELSU project, focuses on the altimetry instrument (Figure 4).

Metrology tools applied to the altimetry sea level data are expected to improve the current GMSL uncertainty budget by:

- knowing the partitioning of the sources of uncertainty from Level 0/1 (Figure 2);
- better understanding the error correlations between altimeter and radiometer measurements;
- fully tracing and documenting the information involved in the end-to-end uncertainty budget;
- identifying known unknowns and potential unknown unknowns uncertainties;
- better modeling of the natural oceanic variability uncertainties;
- estimating spatial correlations for the regional sea level uncertainty budget.

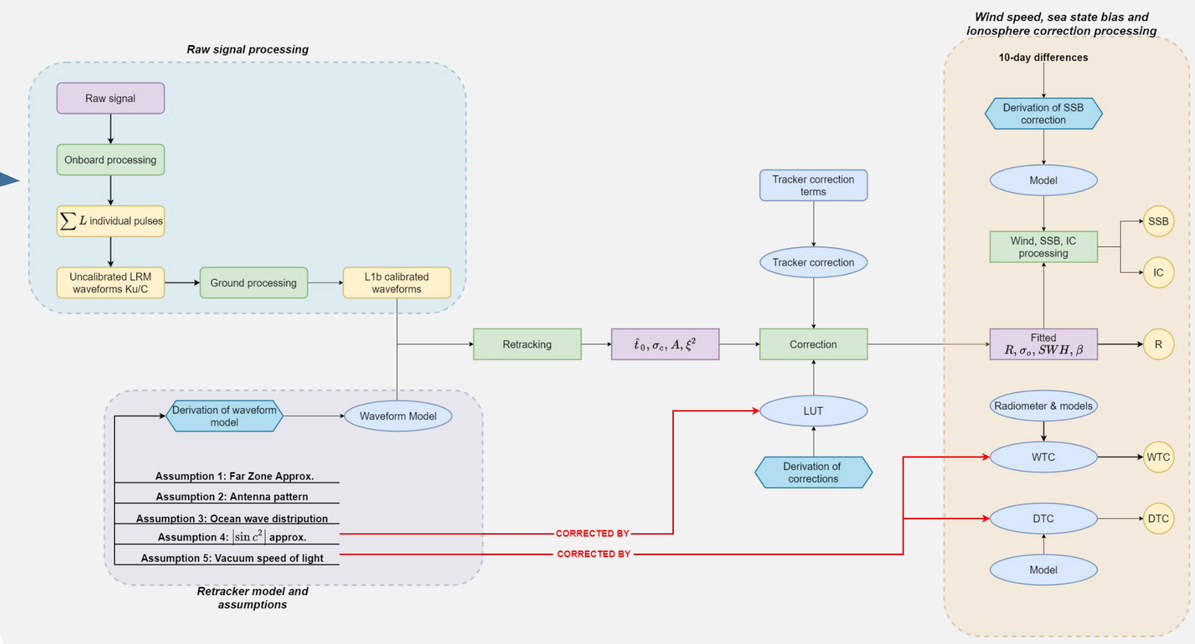

Figure 4: Identification of the main assumptions in the processing from the raw altimeter signal to the 1 Hz along-track data.

Recommendation

We recommend other science areas approach their analysis this way: identifying the uncertainty needed for new scientific understanding, and the dominant factors in the currently achieved uncertainty so system improvements can be prioritized.

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