

SLBC: Sea Level Budget Closure

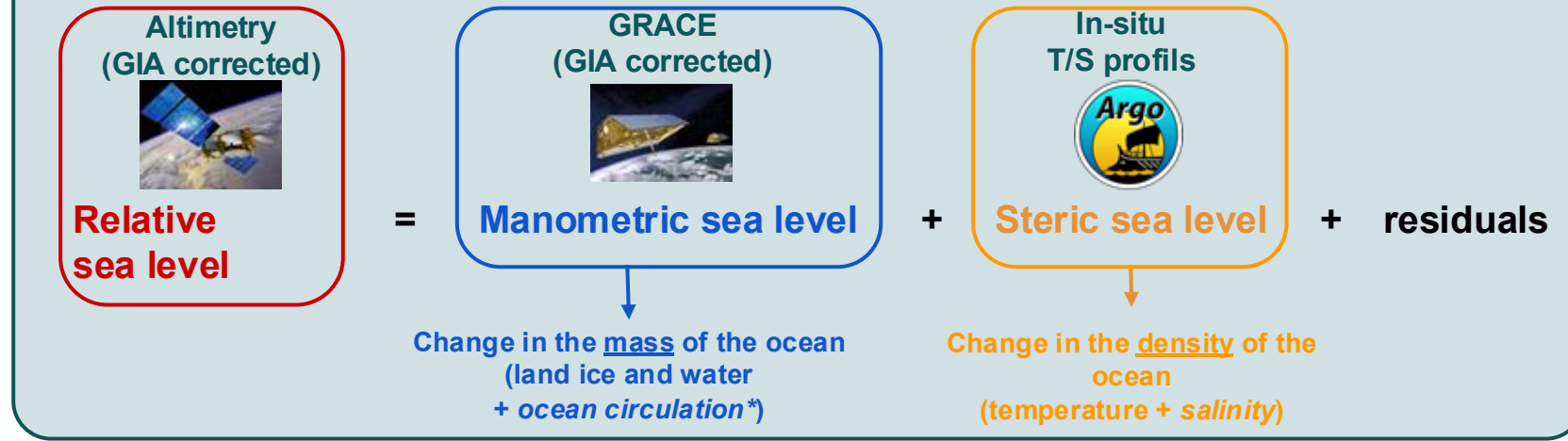
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on behalf of the SLBC team



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- The first phase of the Climate Change Initiative Sea Level Budget Closure (SLBC_cci) ended in 2019
- In the first phase, the SLBC was analyzed over period 1993-2015 at global mean within uncertainties (Horwath et al, 2022)
- The second phase of the SLBC CCI project (SLBC_cci+) started in 2023 and will end in May 2026
- The project has three main objectives:
 - to update the study of Horwath et al. (2022) after 2015 and to extend the sea level budget assessment to the regional scale.
 - to improve the characterization of uncertainties at both global and regional scales
 - to provide new insights on the sea level budget analysis by introducing a new sea level budget closure assessment based on an objective approach.

• Sea level budget

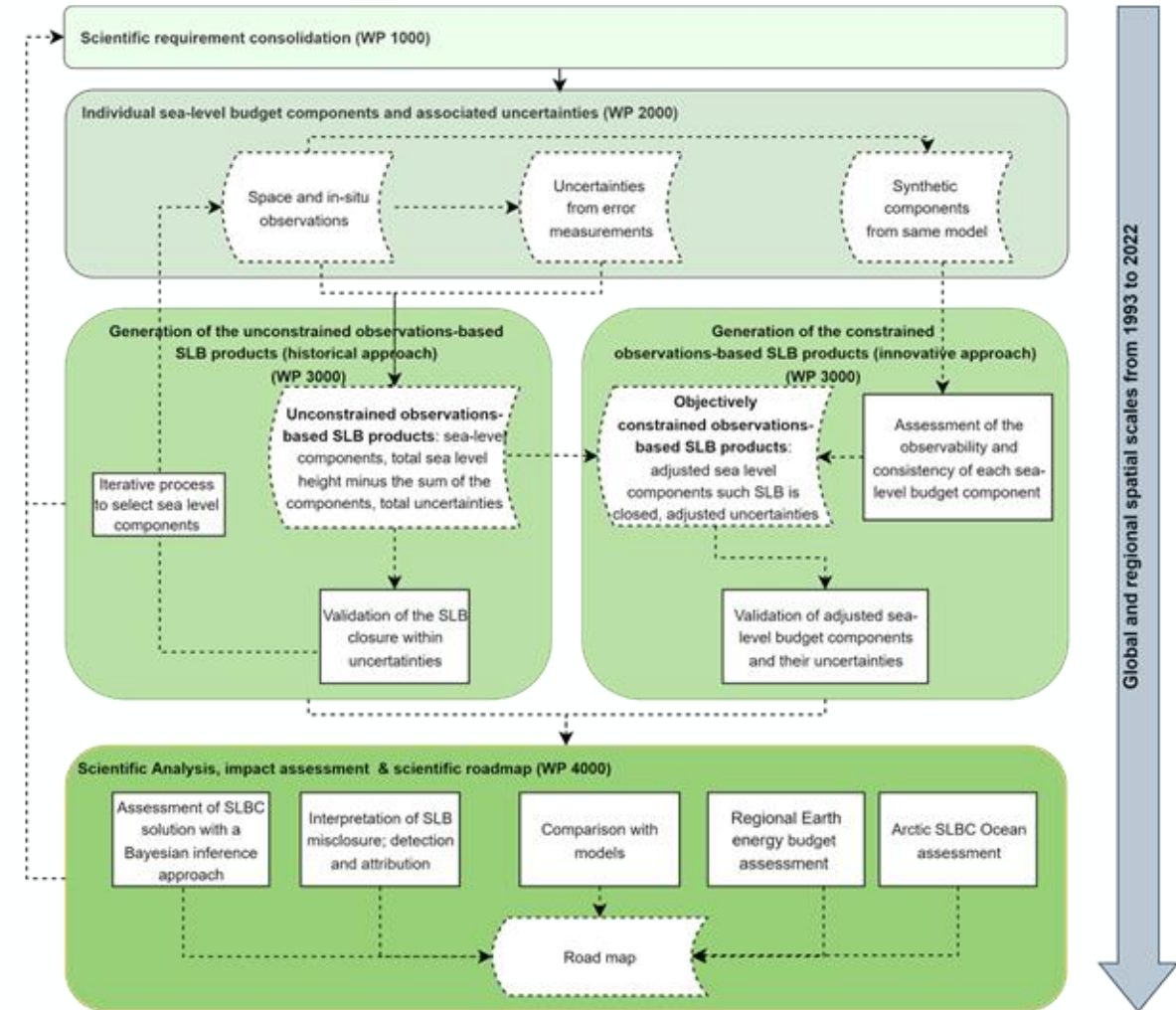


Closing the sea level budget to:

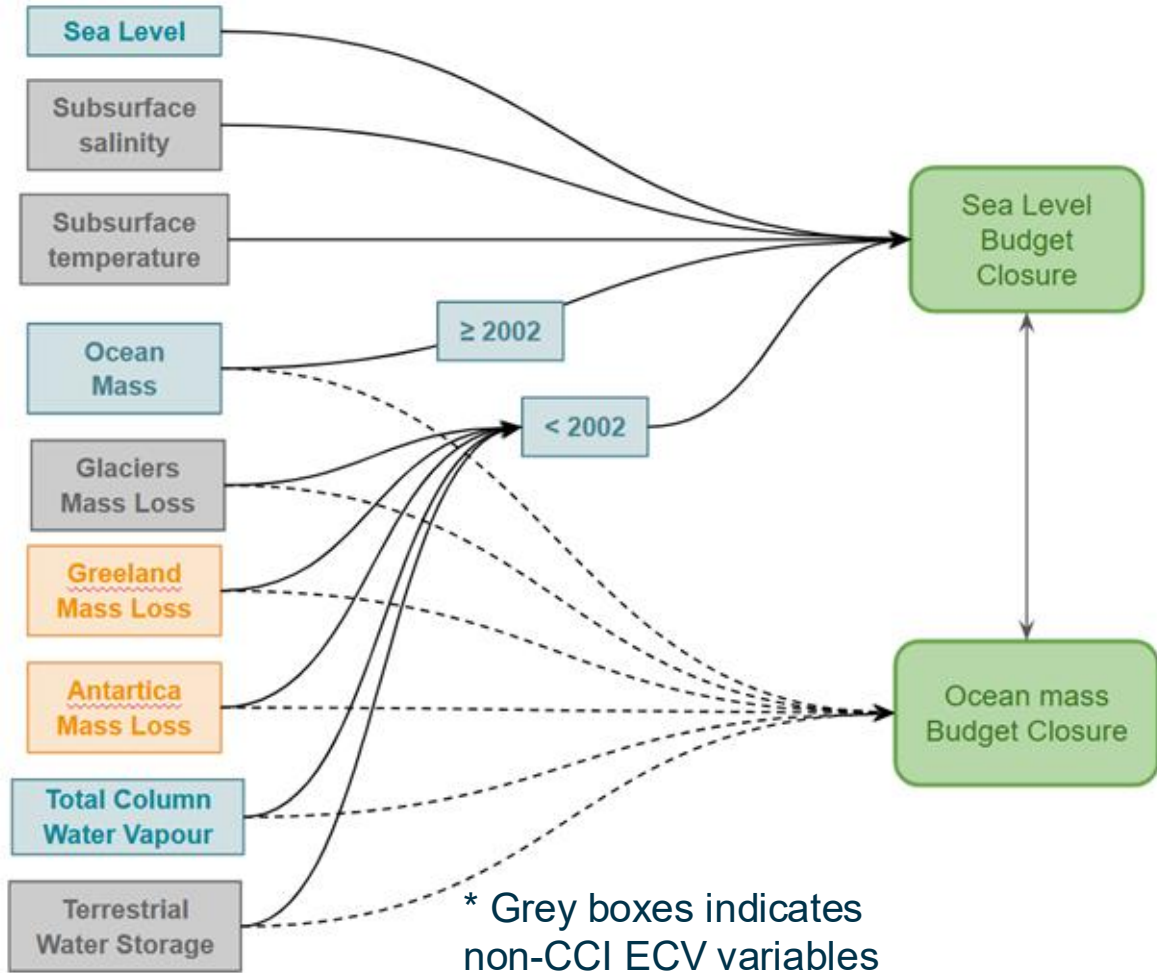
- Test the consistency of different observed integrals of the climate system including sea level, ocean temperature and ocean mass, with regard to conservation laws including those of mass, energy and freshwater.
- Cross-validate worldwide complex observing systems to keep a close watch on their performance.
- Ensure that we understand the causes for sea level rise (no missing contributions).

Skeleton overview of the approach

- Project is divided into different tasks
- First one to estimate individual SLB components and associated uncertainties
- Then, 2 methods for estimate the SLBC will be assessed:
 - First one based on the classic approach (i.e. sum of SLB components)
 - Second one is based on an objective solution with inverse method to optimally close SLB
- Finally, scientific analysis will be carried out based on the SLB product, such as:
 - Assessment of SLB in Arctic
 - Comparisons with models



ECVs being used



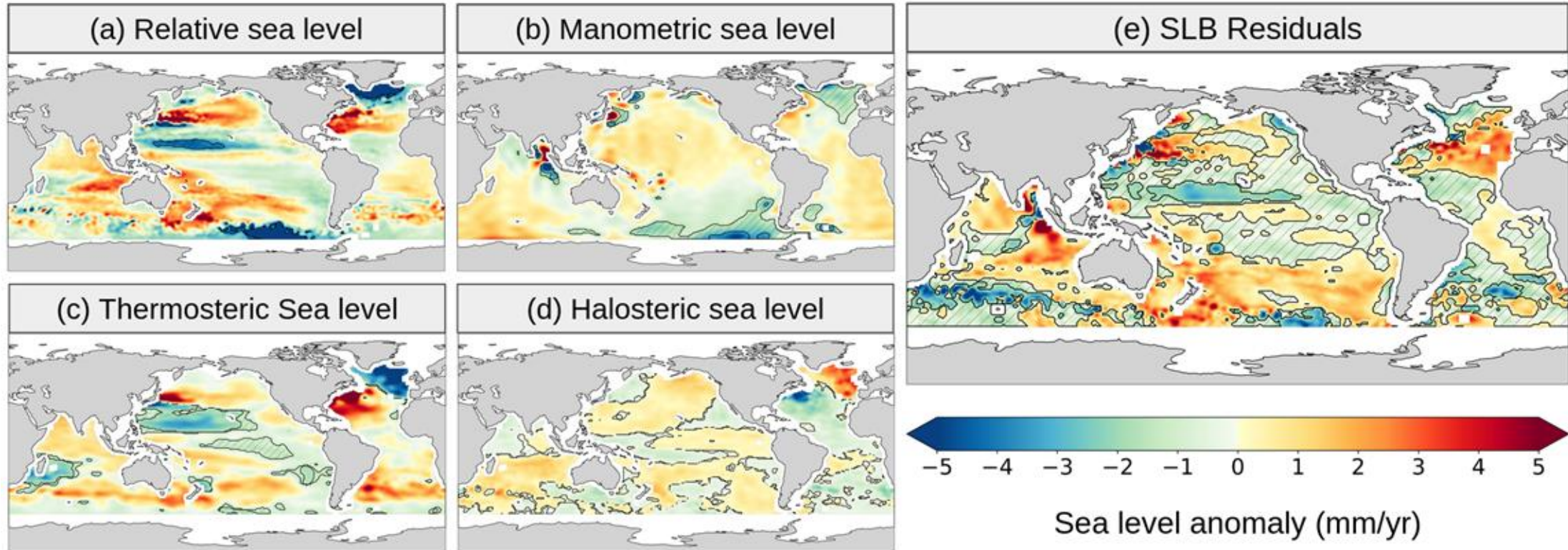
- Sea level budget is assessed with CCI ECV (blue and orange) and non-CCI ECV (grey)
- Ocean mass component is calculated within the SLBC_cci+ project from:
 - GRACE and GRACE-FO after 2002
 - The sum of mass components before 2002
- **While Ocean Mass is not defined as an ECV (GCOS), it remains critical to refine and extend this time series** for: sea level budget, ocean mass budget, ocean heat content (MOTECUSOMA project)

- Summary of the ECV datasets used and main limitations identified during the project:

ECV	CCI dataset limitation	Dataset used
Total Column Water Vapour	time coverage (≥ 2002) no ocean coverage	ERA5
Sea level	Error covariance matrix not provided within the product	C3S
Ice sheet	time coverage (≥ 2002)	IMBIE
Terrestrial Water Storage	no anthropogenic contribution	WGHM
Glaciers	Mass Balance not provided, only provide glacier area	Zemp et al. Dussaillant et al.
Subsurface salinity and temperature	No CCI Dataset	Argo T/S profiles
Ocean mass		DRESDEN Mascon solution

Results & relevance to the CCI community

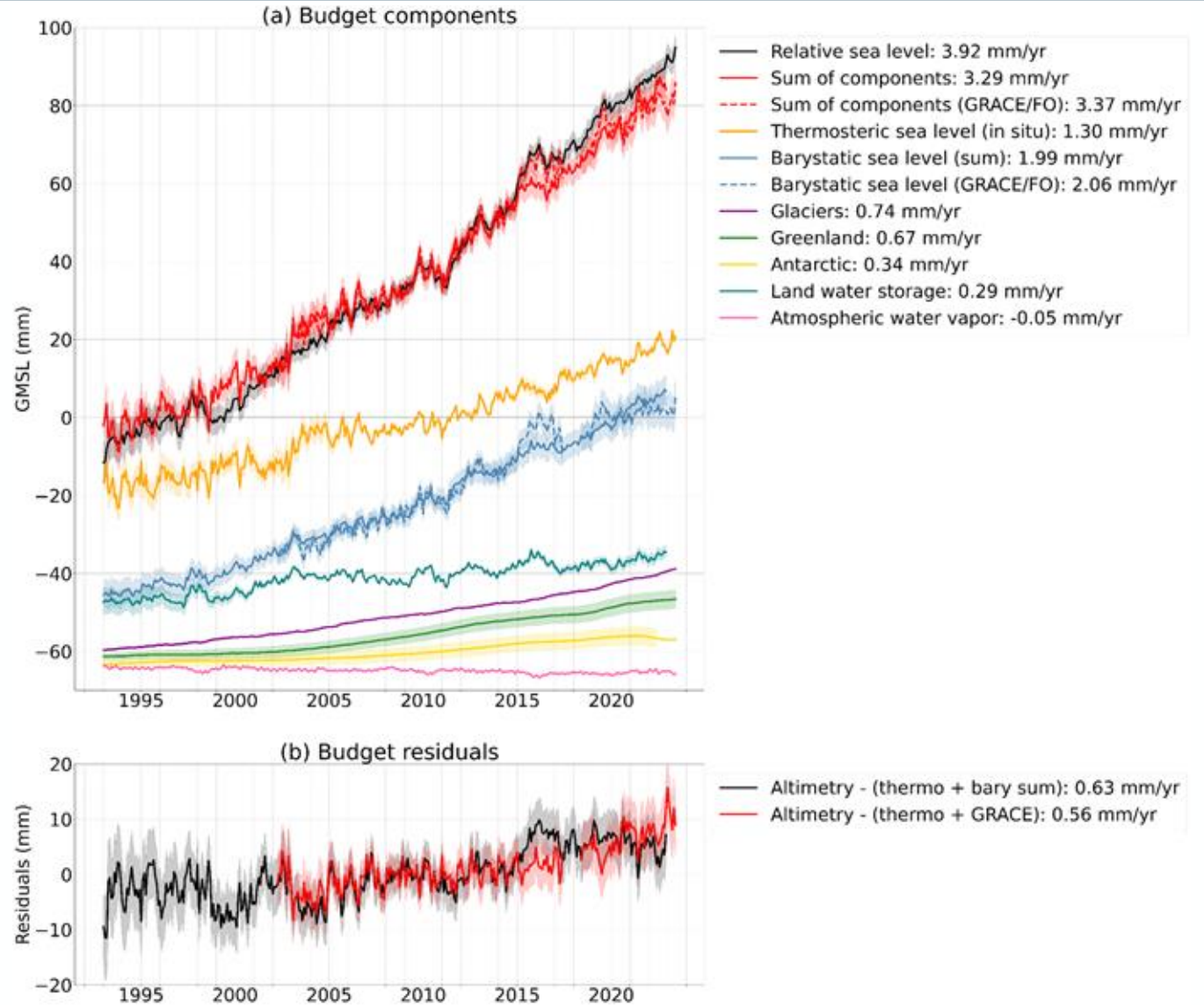
- Latest results of the project: Estimation of the SLB at regional scale over the gravimetry era (2002-2023)



- Significant trends in the regional sea level budget residuals, with large-scale spatial patterns in the North Atlantic and around Australia (non-significant trends in other regions)
- Investigations are ongoing in order to identify the possible causes

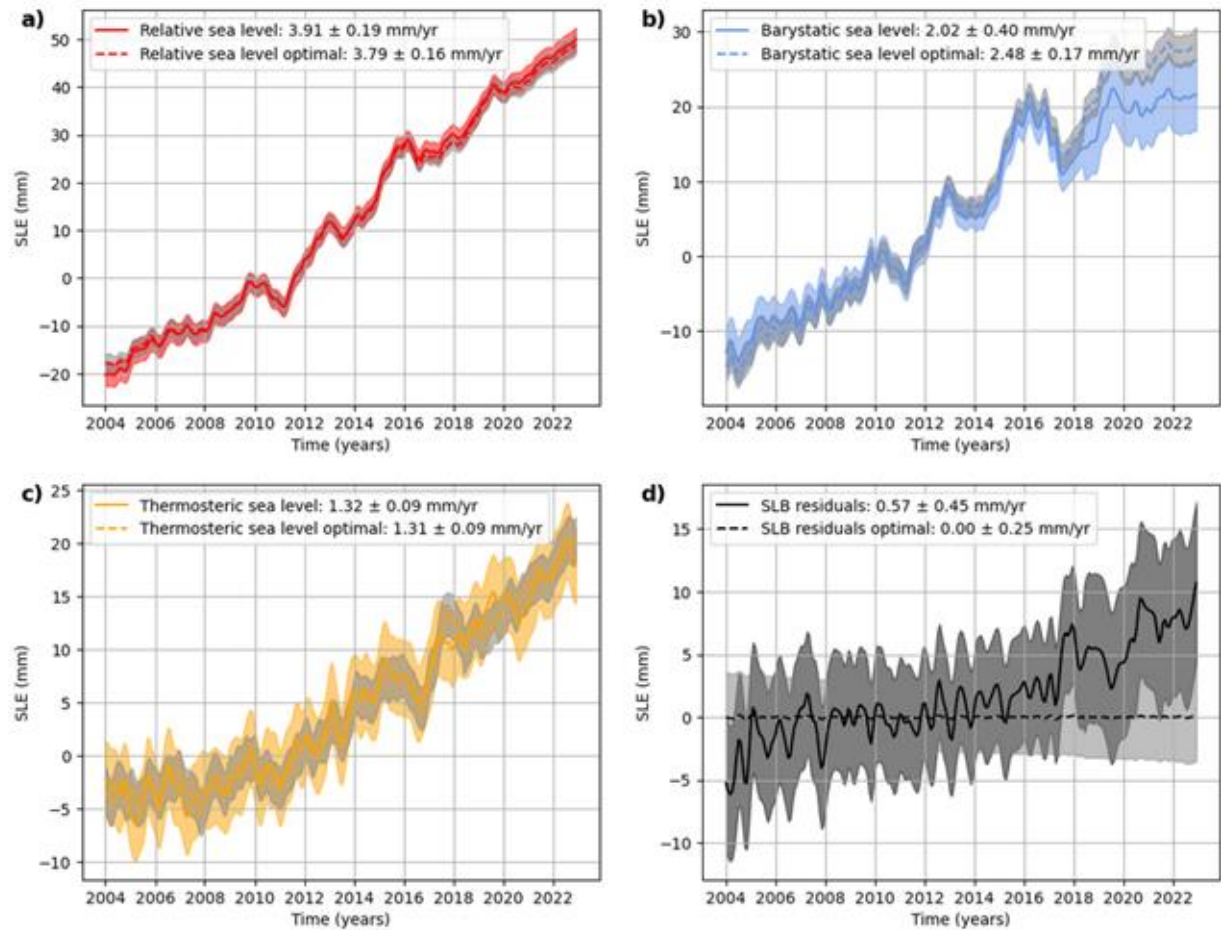
Results & relevance to the CCI community

- Latest results of the project:
 - Estimation of the SLB at global mean over the altimetry era (1993-2023) and gravimetry era (2002-2023).
 - A significant trend is detected in the GMSL budget residuals over the periods 1993–2023 and 2005–2023, using either individual mass components or gravimetric estimates.
 - An inconsistency appears between the two approaches used to estimate the barystatic component after 2016 which is under investigations.



Results & relevance to the CCI community

- To investigate on SLB misclosure, an objective approach has been developed based on an optimal combination of the contributions to sea level weighted by the instrumental uncertainty estimates (Rodell et al. (2015); L'Ecuyer et al. (2015)).
- Preliminary results shows at global mean that an optimal solution closes the SLB within the uncertainties of the observing systems.
- Main adjustments are made to the barystatic sea level (gravimetry), and to a lesser extent to the relative sea level (altimetry), after 2016.



Solid lines represent components derived directly from observations, dashed lines show those obtained through an objectively constrained optimal approach. The panels display: (a) Relative sea level, (b) Barystatic sea level, (c) Thermosteric sea level, and (d) SLB residuals.

- A scientific paper is in preparation to present all the results obtained within the SLBC_cci+ project (update of Horwath et al. 2022)
- New SLBC_cci+ dataset will be released on the CEDA platform with associated documentation
- A publication from Bouih et al. 2025 has investigated misclosure of the SLB at regional scale particularly in the North Atlantic
- Scientific roadmap of the SLBC_cci+ project has been already presented to ESA and will be finalised by the end of the project