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How to monitor the Ocean?

Sea Level Rise

Anny Cazenave

LEGOS-CNES

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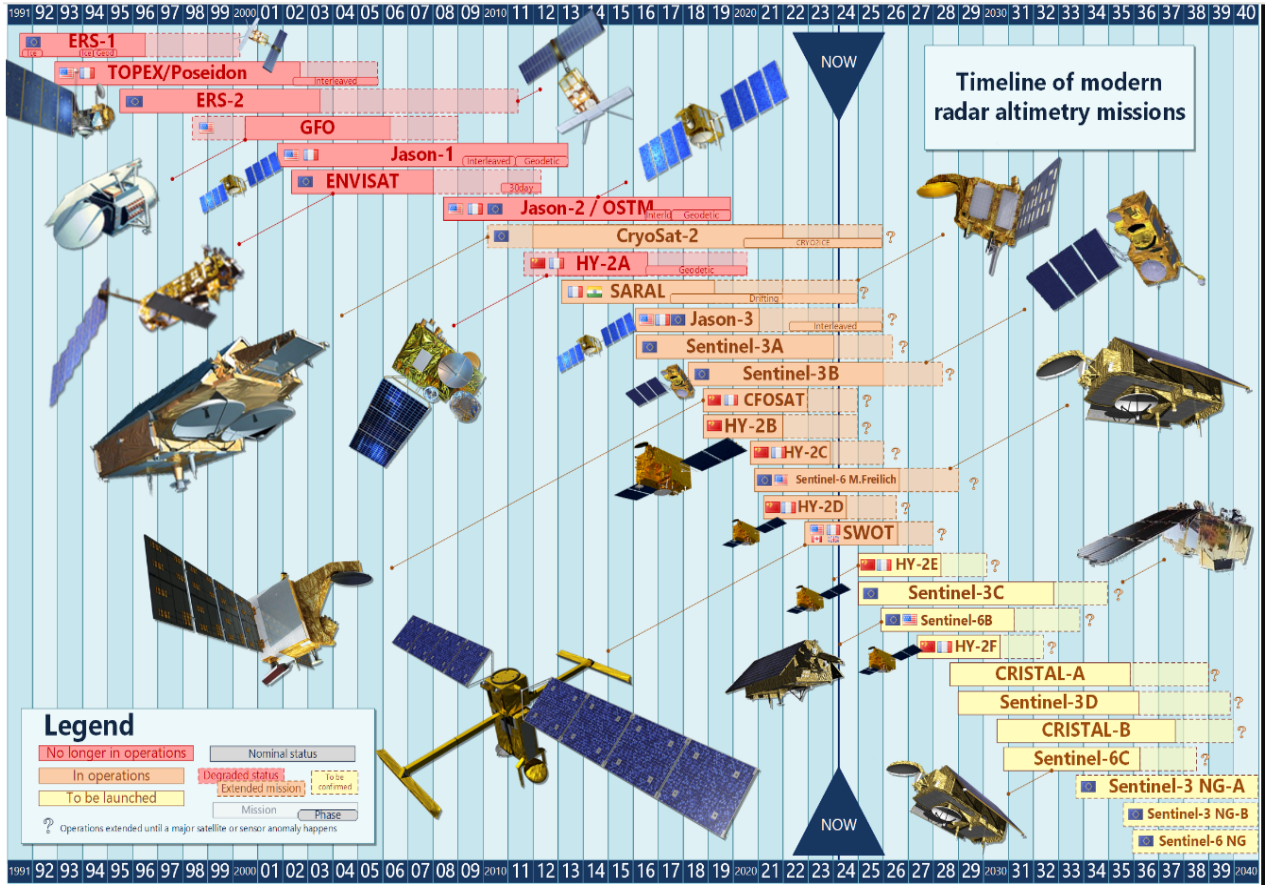
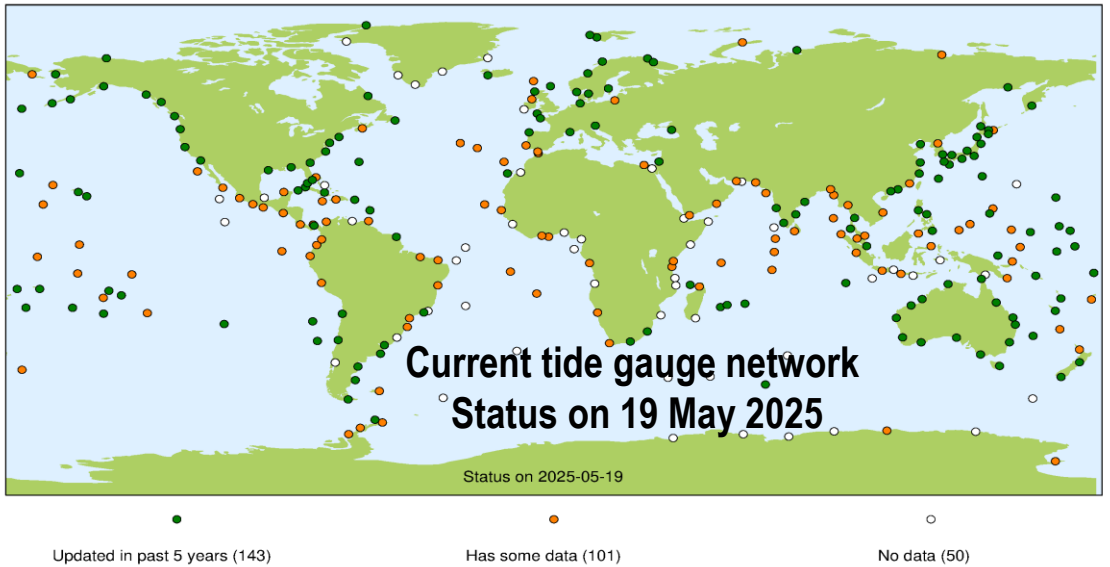
The international constellation of high-precision altimeter satellites



Global coverage



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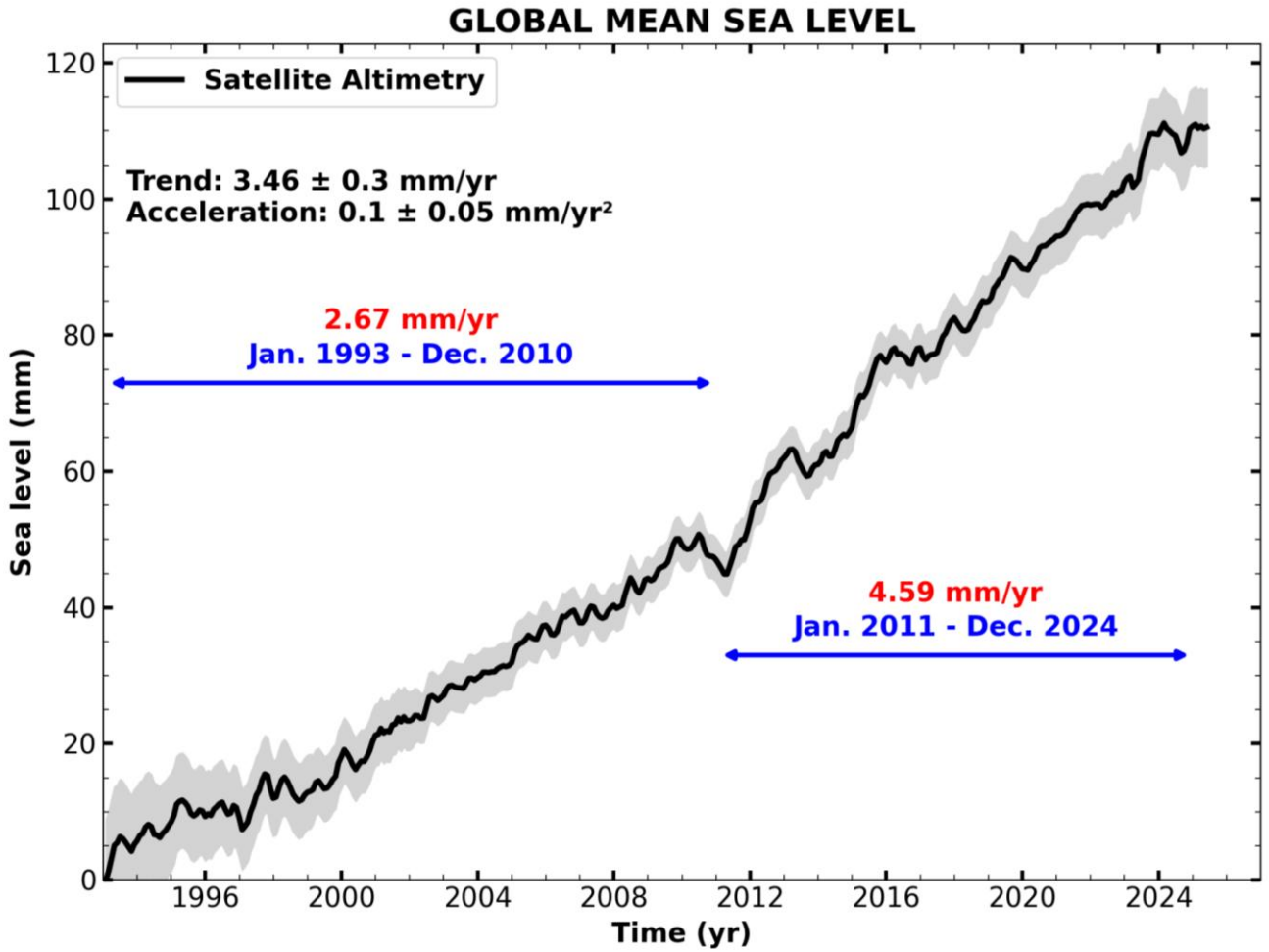
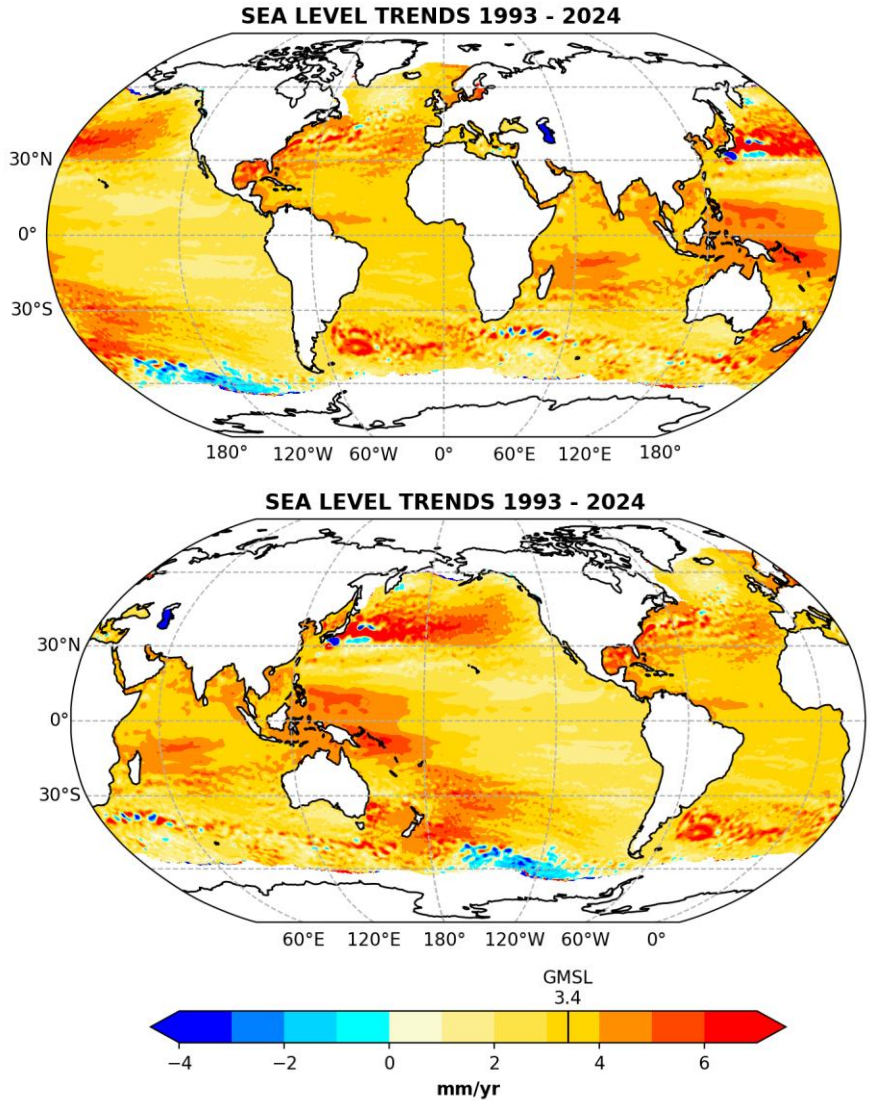
Global mean sea level rise measured from space (1993-2025)



Regional trend patterns (1993-2024)



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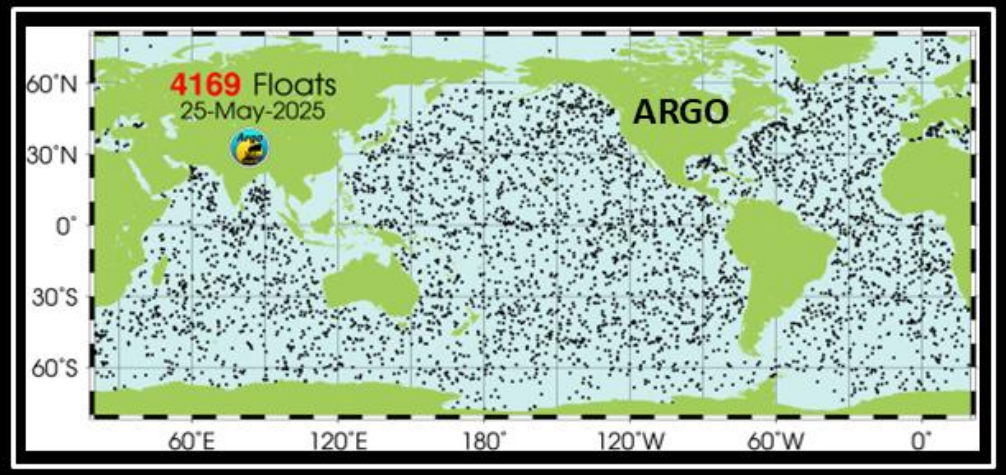
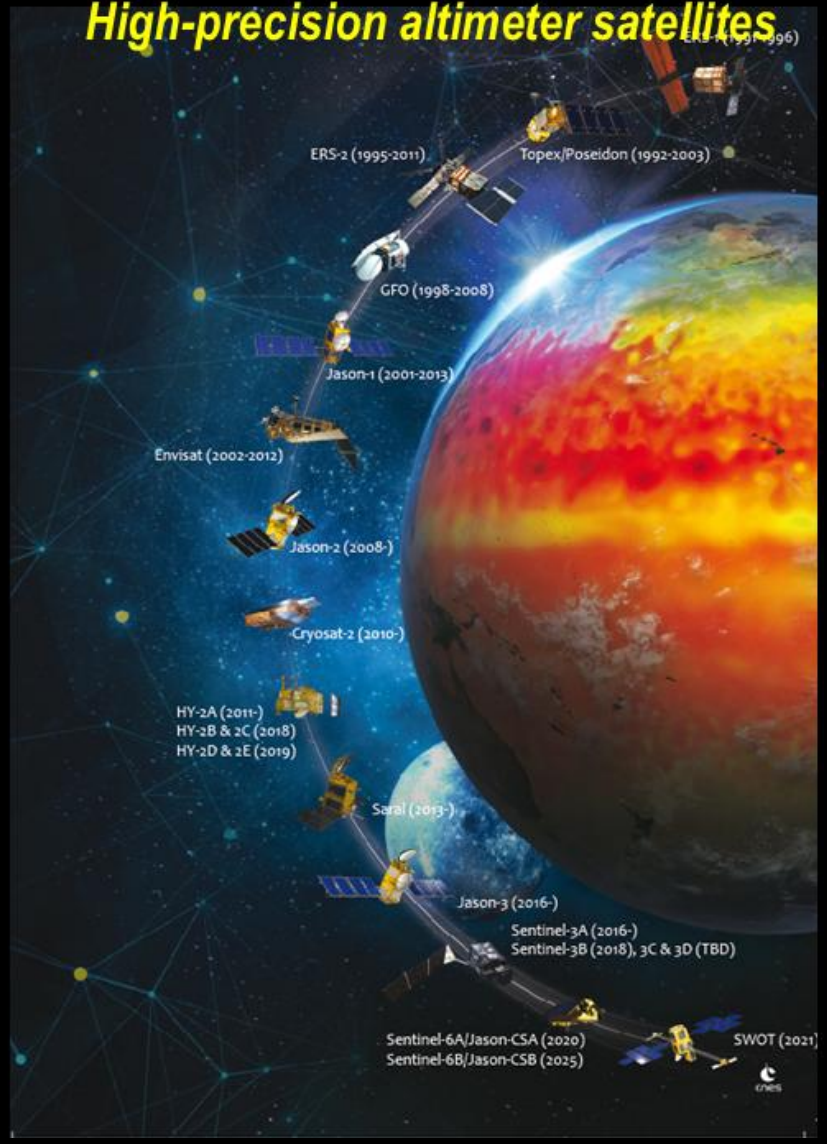
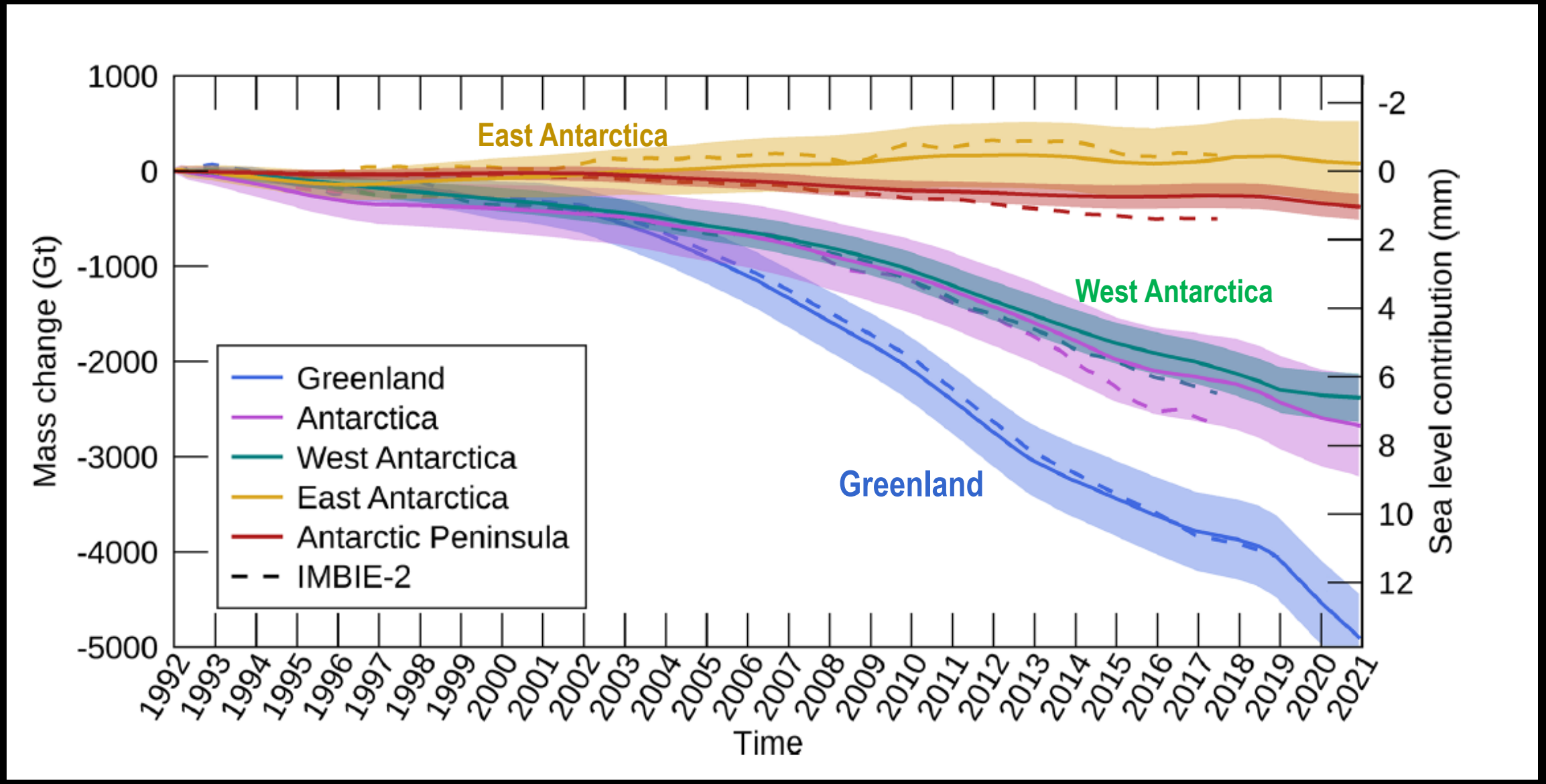
Different observing systems are available for estimating the causes of sea level rise...



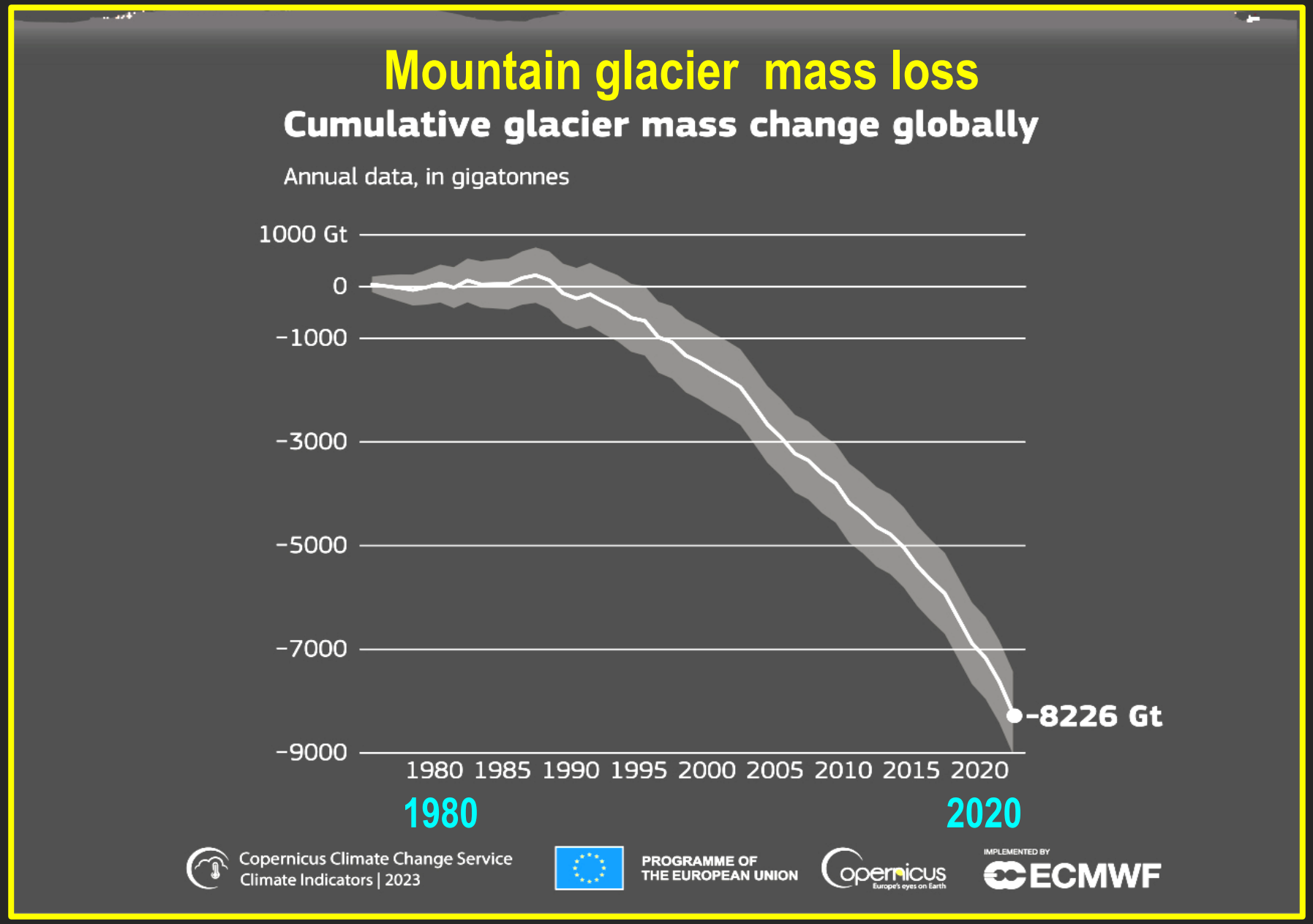


Ice mass loss from the Antarctica and Greenlaand ice sheets based on different space techniques



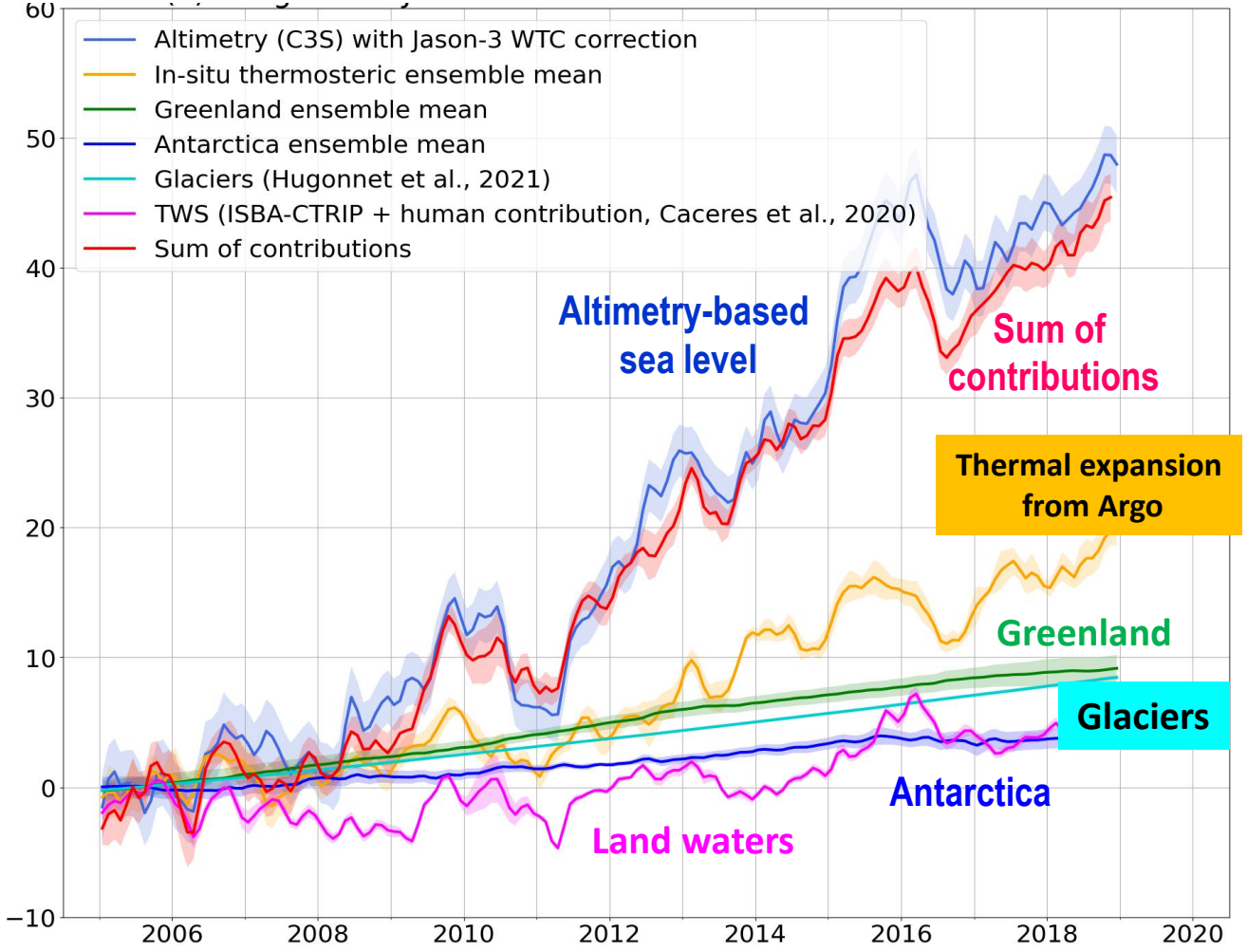
Otosaka et al., 2023

Mountain glacier mass loss



Update from Hugonnet et al. 2021

Global mean sea level budget (2005-2019)



CONTRIBUTIONS to the global mean sea level rise (since 2005)

- **Ocean thermal expansion: ~40%**
- **Total land ice melt (glaciers+Greenland +Antarctica) + land waters ~60%**

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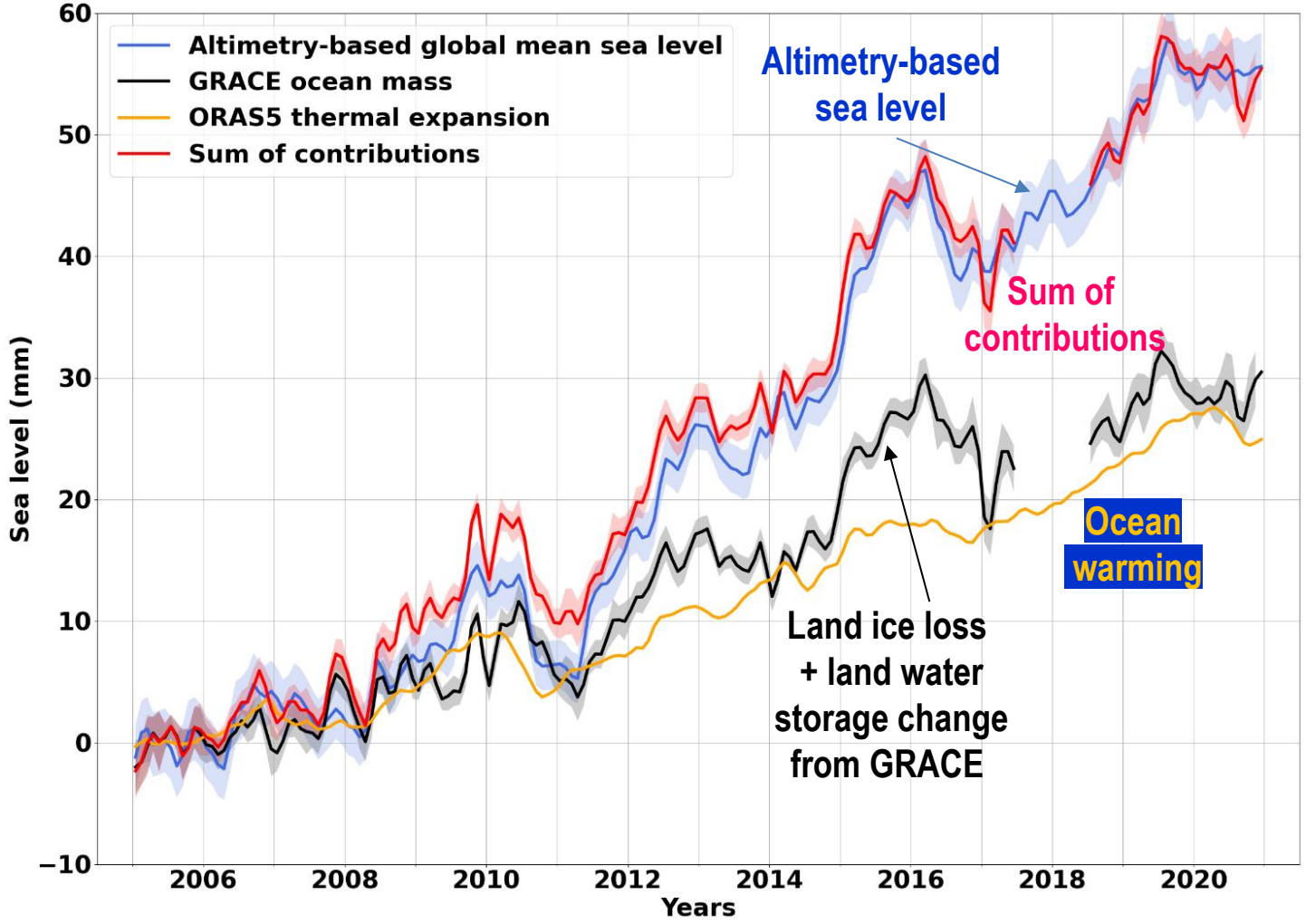
Global mean sea level budget (2005-2022)



CONTRIBUTIONS to the global mean sea level rise (since 2005)

- **Ocean thermal expansion: ~40%**
- **Total land ice melt (glaciers+Greenland +Antarctica) + land waters ~60%**

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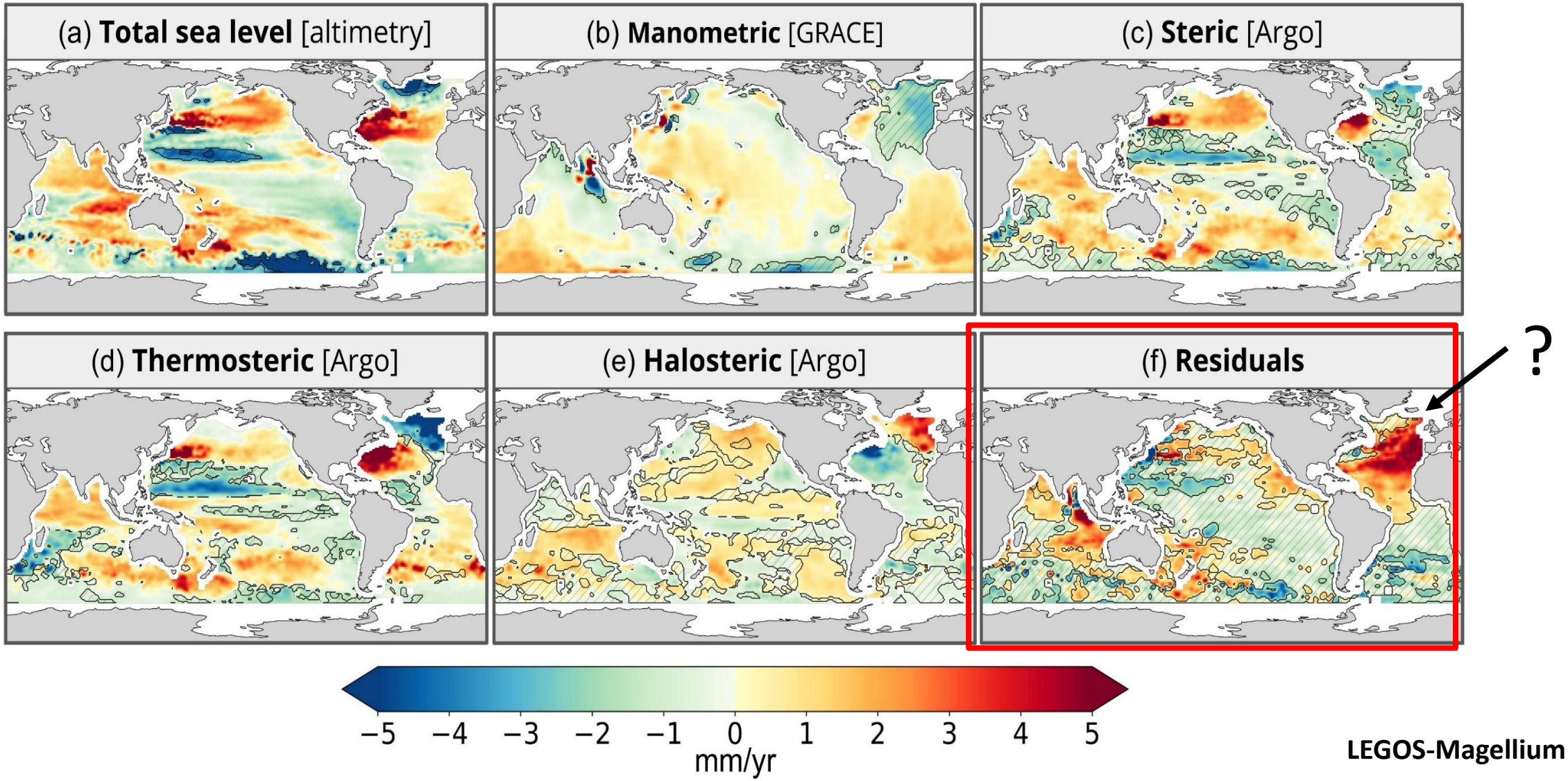
Regional sea level trend budget (2004-2022)



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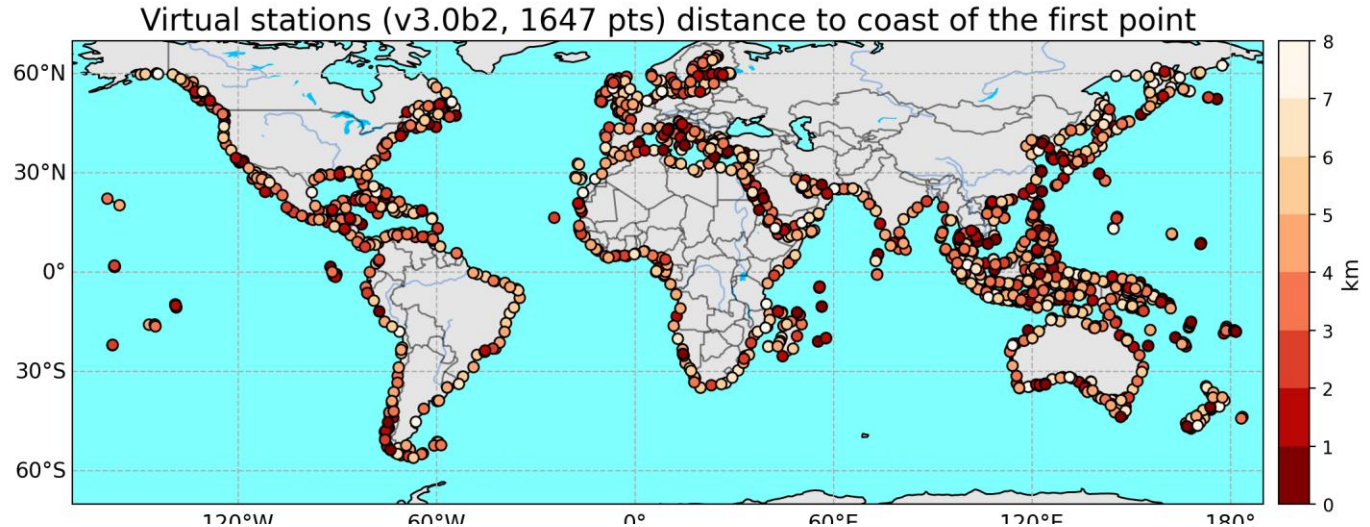
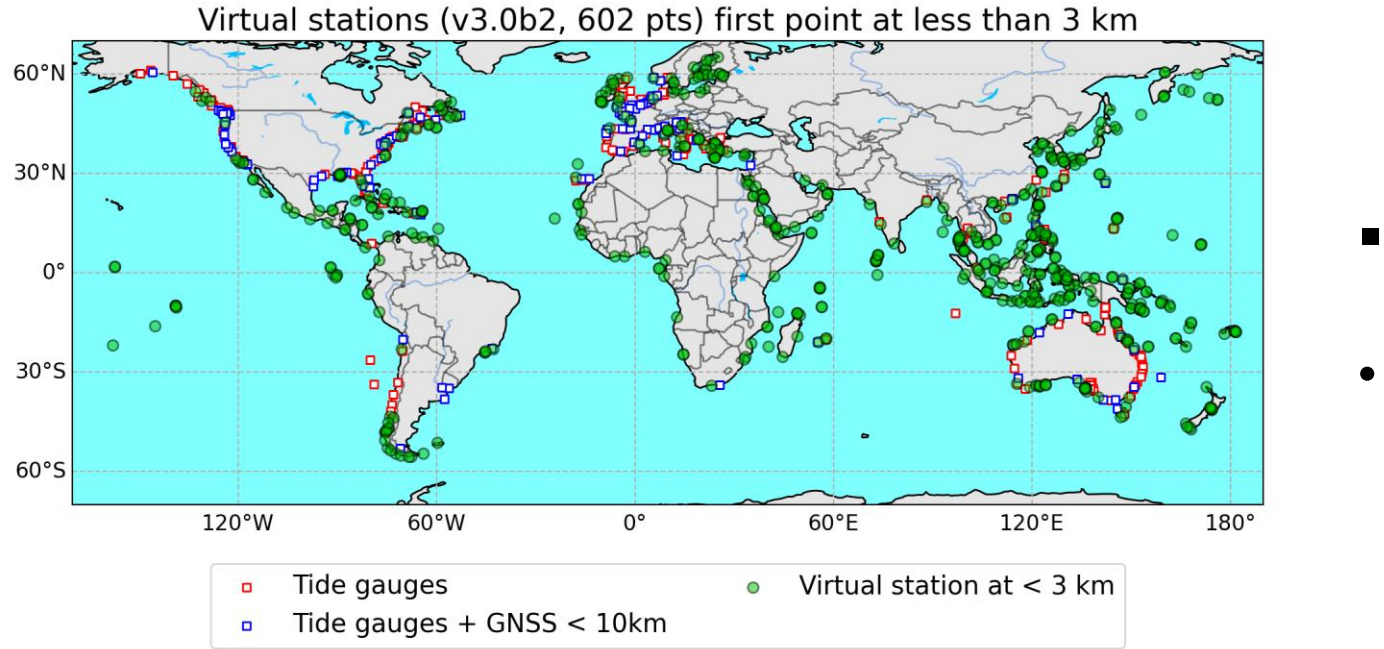




Coastal altimetry

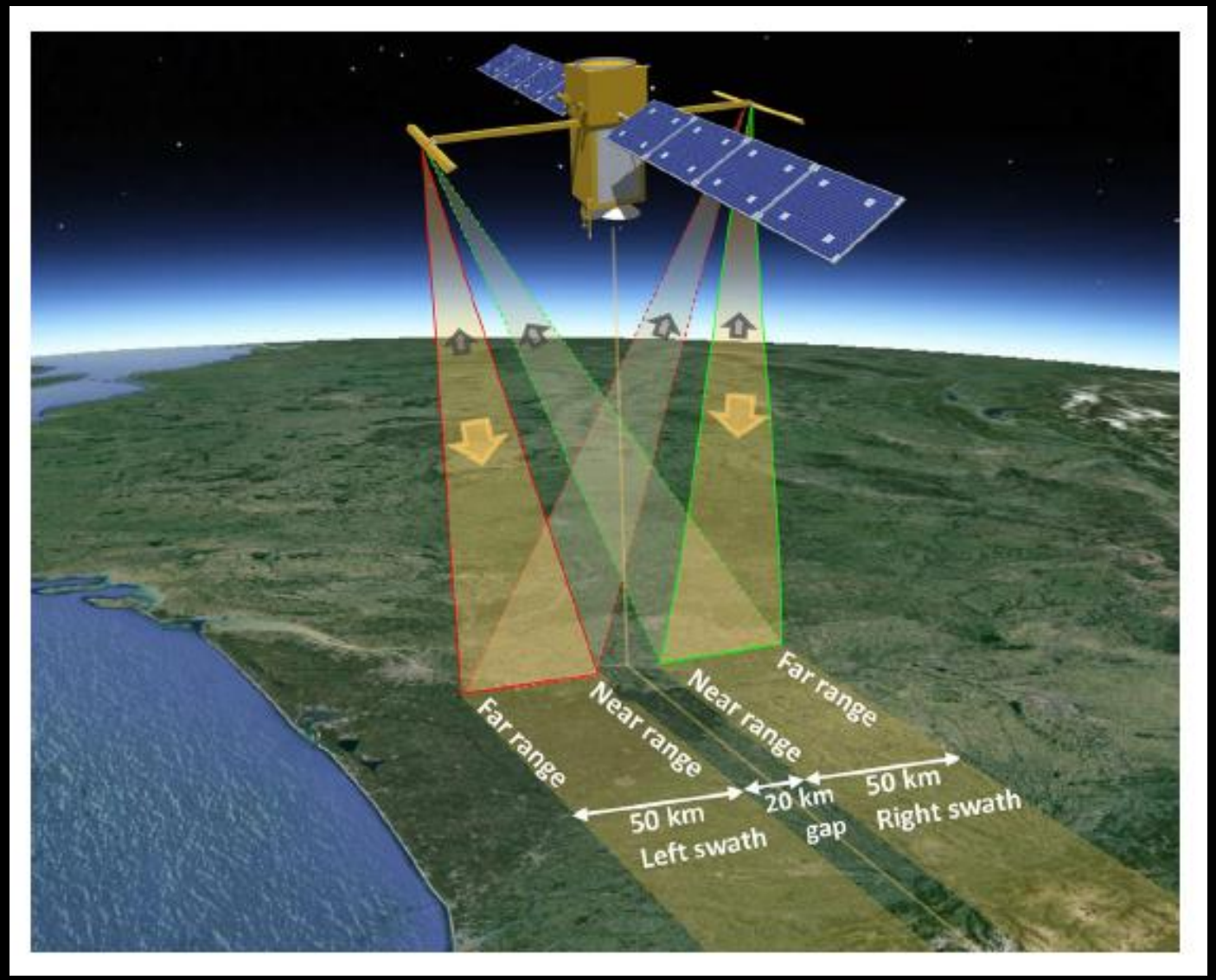
New network of 1600+ virtual coastal stations based on data reprocessing of classical altimetry missions (Jason-1, 2, 3) in the world coastal zones

- **Virtual coastal stations located at less than 3 km from the coast (green dots)**
- **Complement the limited tide gauge network (red & blue squares)**

LEGOS

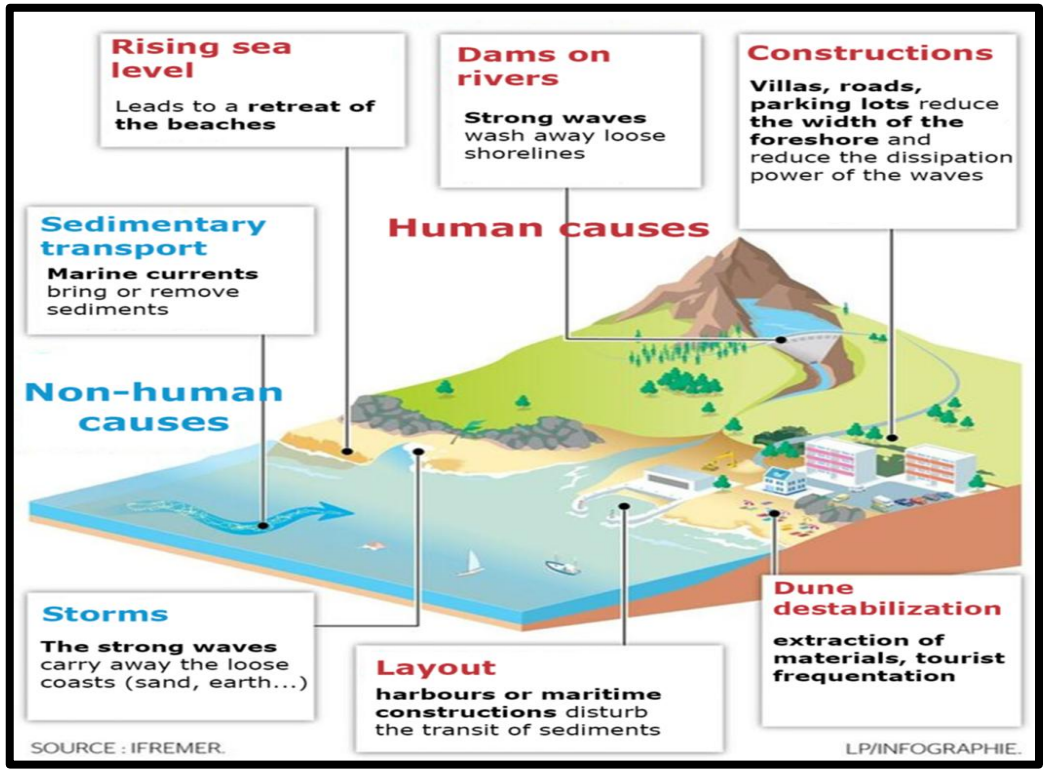
SWOT mission « Surface Waters-Ocean Topography »

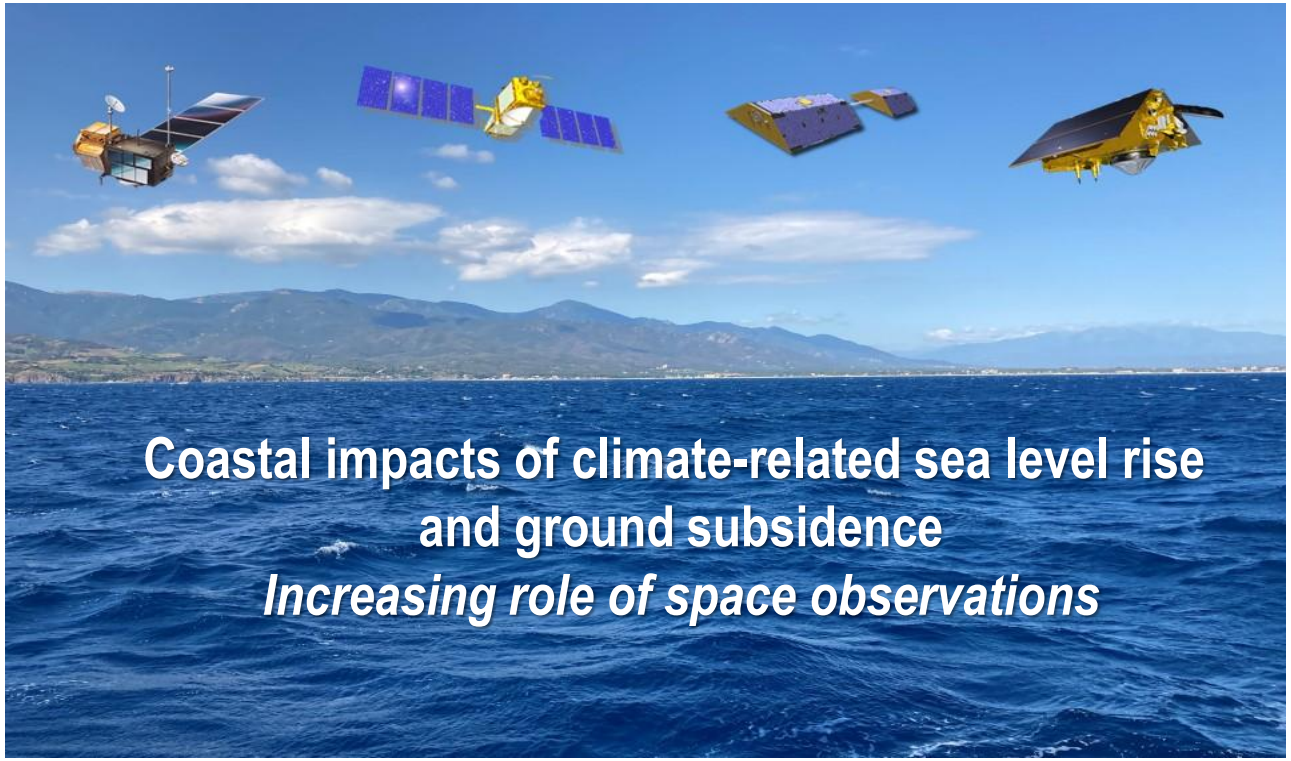
Launched in 2022



A Game Changer !

Space Observations for Monitoring Coastal Zone Hazards



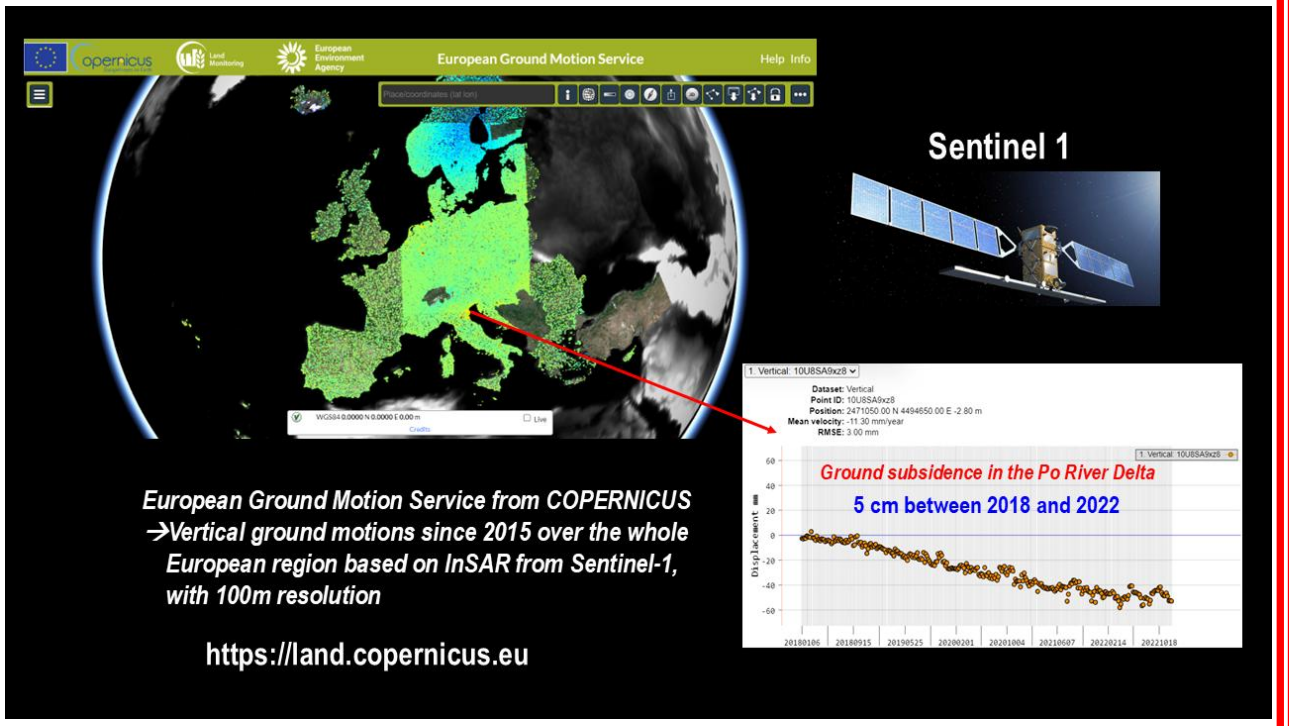


Storm surges, hurricanes, extreme waves,
Coatal currents, river floods,
Coastal engineering, urbanization,
Climate-related sea level rise
Ground subsidence…

- Shoreline erosion and retreat
- Temporary and permanent flooding
- Changes in sediment stores and seafloor topography
- Changes in estuaries morphology
- Changes in coastal ecosystems
- Salinization of coastal aquifers

2 examples….

InSAR on Sentinel 1
for measuring ground subsidence

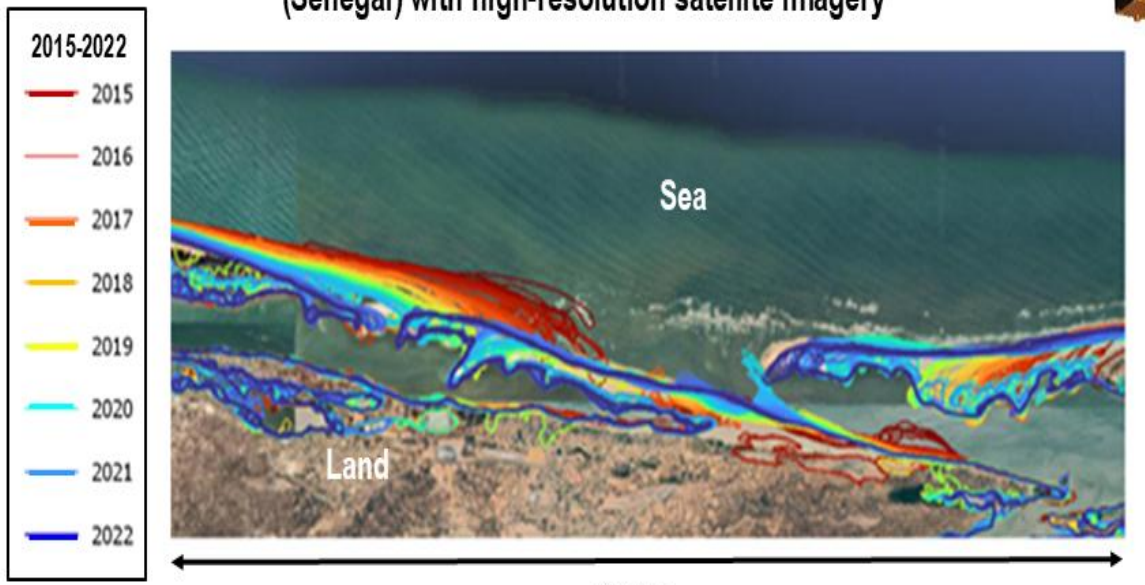


European Ground Motion Service from COPERNICUS
→Vertical ground motions since 2015 over the whole European region based on InSAR from Sentinel-1, with 100m resolution

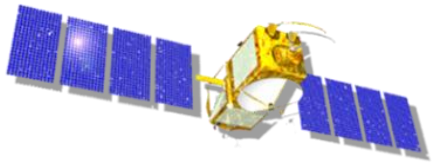
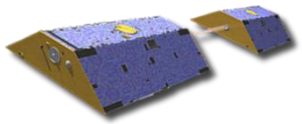
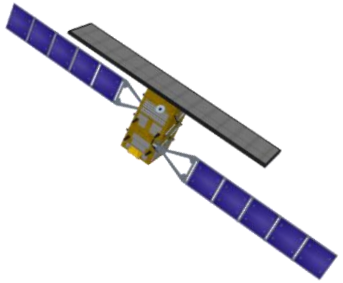
https://land.copernicus.eu

High-resolution satellite imagery for measuring shoreline retreat

Monitoring change in shoreline position in St Louis (Senegal) with high-resolution satellite imagery



Almar et al 2024

To conclude

1. Measuring sea level rise with altimetry techniques along the world coastlines and understanding local and remote drivers remain priority goals
2. Measuring ground subsidence (InSAR), especially at all coastal megacities, and combining with climate-related sea level rise is another major objective
3. It is also time to systematically monitor from space indicators of sea level rise impacts at the coast, e.g., shoreline retreat, changes in coastal bathymetry, etc…

→ MITIGATION & ADAPTATION

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Thanks for your attention

Copernicus
Europe's eyes on Earth

EU MISSIONS
RESTORE OUR OCEAN & WATERS

Copernicus
Marine Service

PAVILION IMPLEMENTED BY
MERCATOR OCEAN
INTERNATIONAL