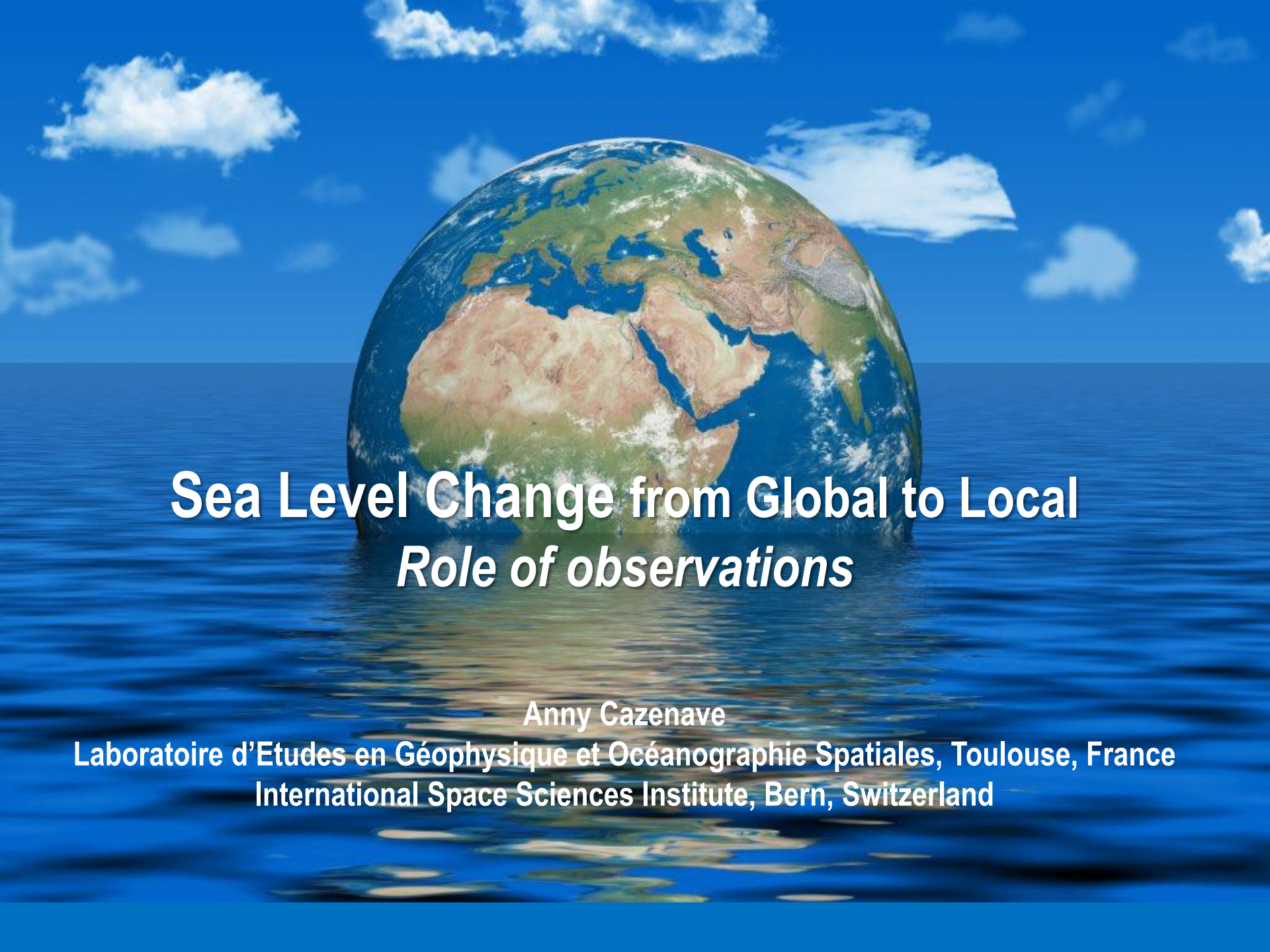
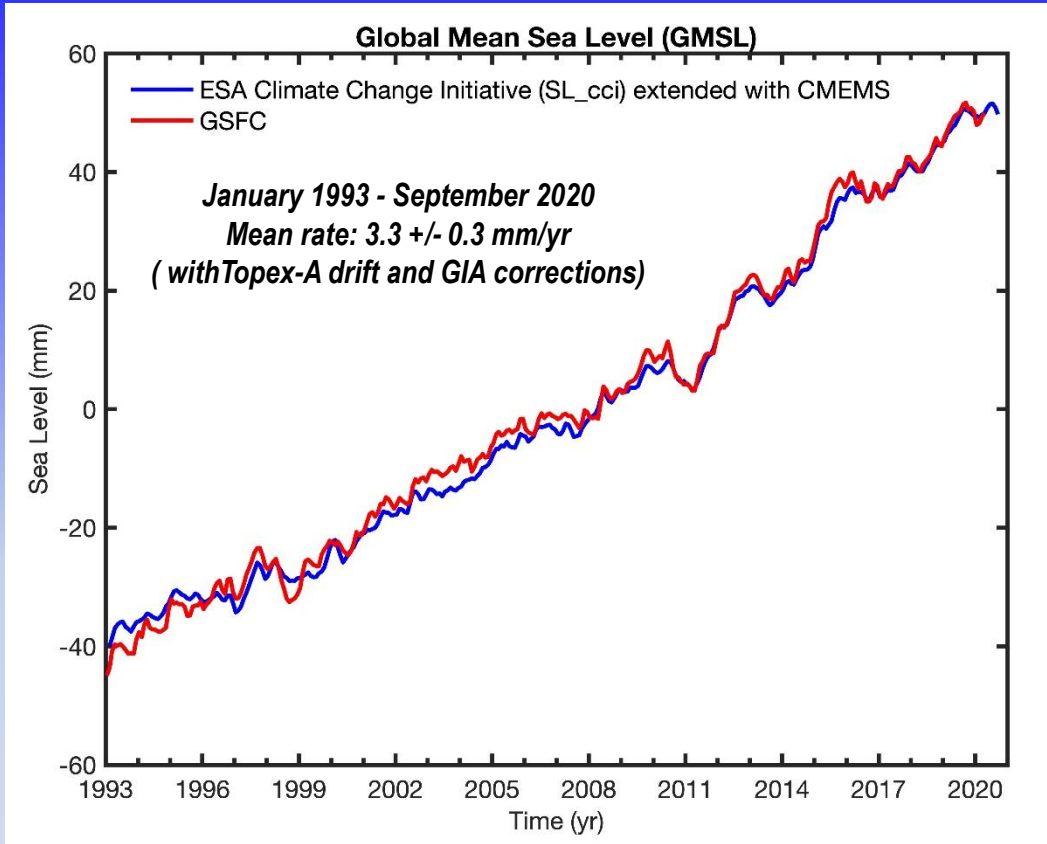


Sea Level Change from Global to Local
Role of observations

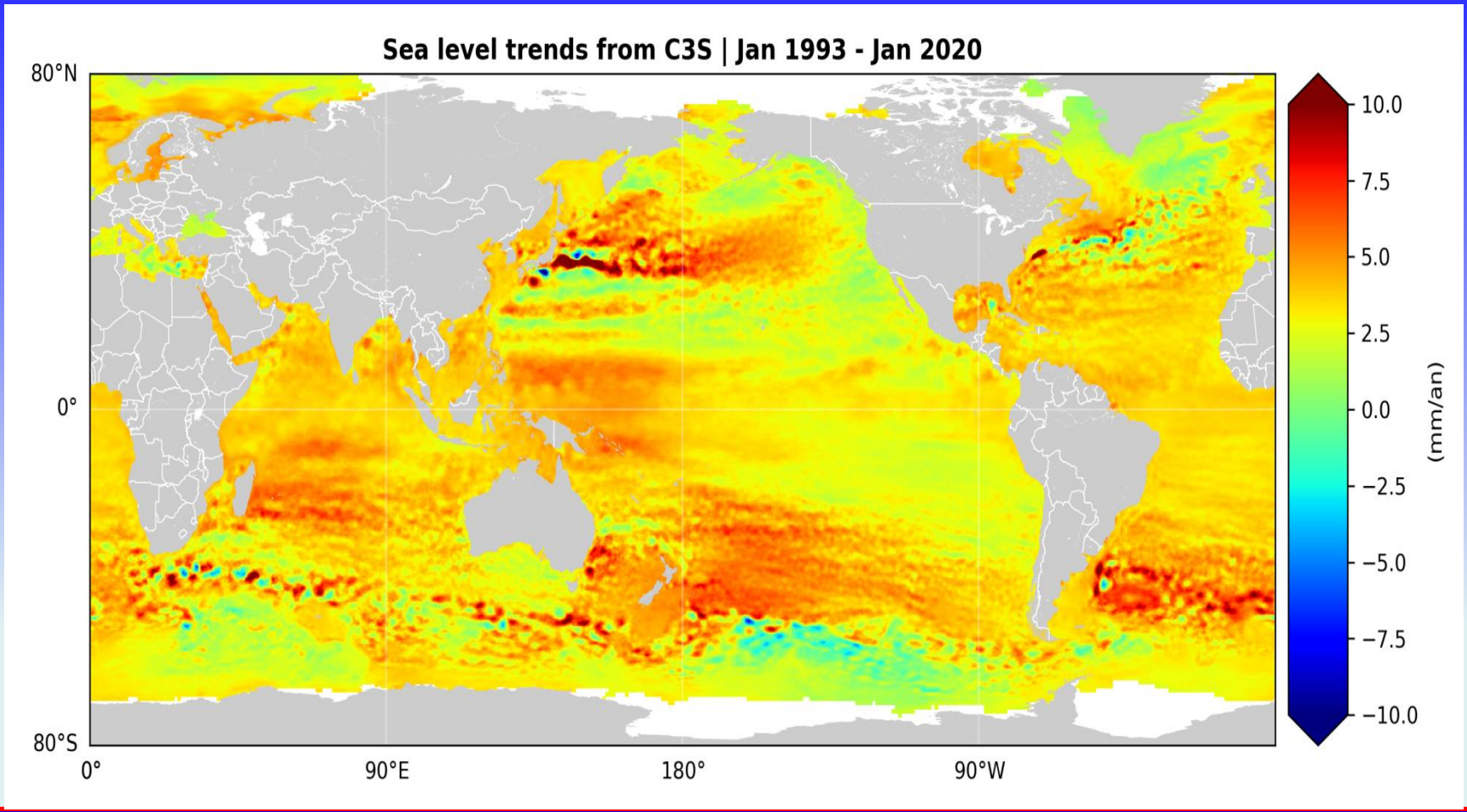
Anny Cazenave
Laboratoire d'Etudes en Géophysique et Océanographie Spatiales, Toulouse, France
International Space Sciences Institute, Bern, Switzerland

Global Mean Sea Level Rise



… A leading indicator of global climate changes
→integrated response to changes in ocean heat content, land ice & land water storage to external forcings and internal variability

Regional rates of sea level change (1993-2020) (mm/yr)



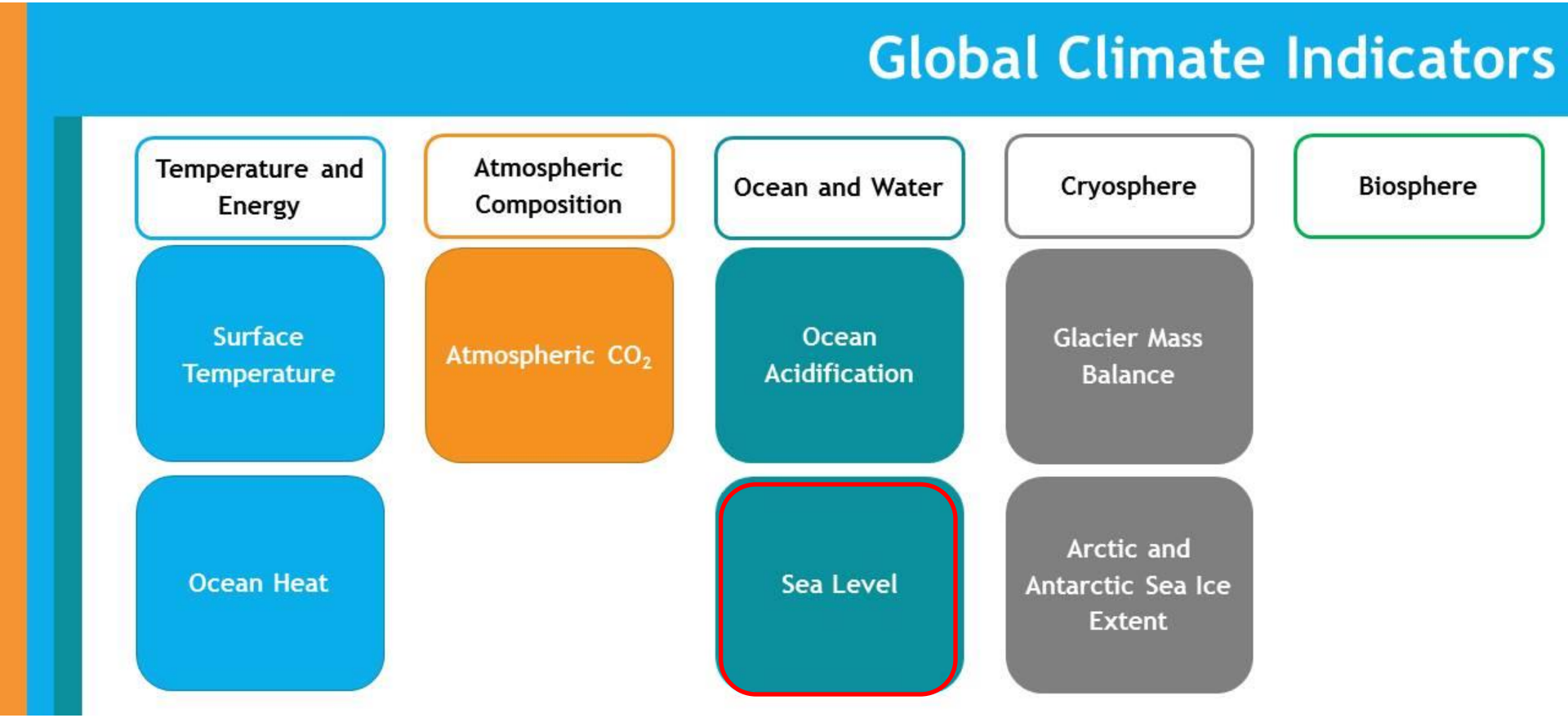
Spatial trend patterns amplify the global mean rise

→ **Regional rates can be up to 2-3 times larger than the global mean sea level rise**

Coastal Sea Level Changes

result from the superposition of the global mean rise, regional variability and small-scale coastal processes

The 7 global indicators of present-day climate change



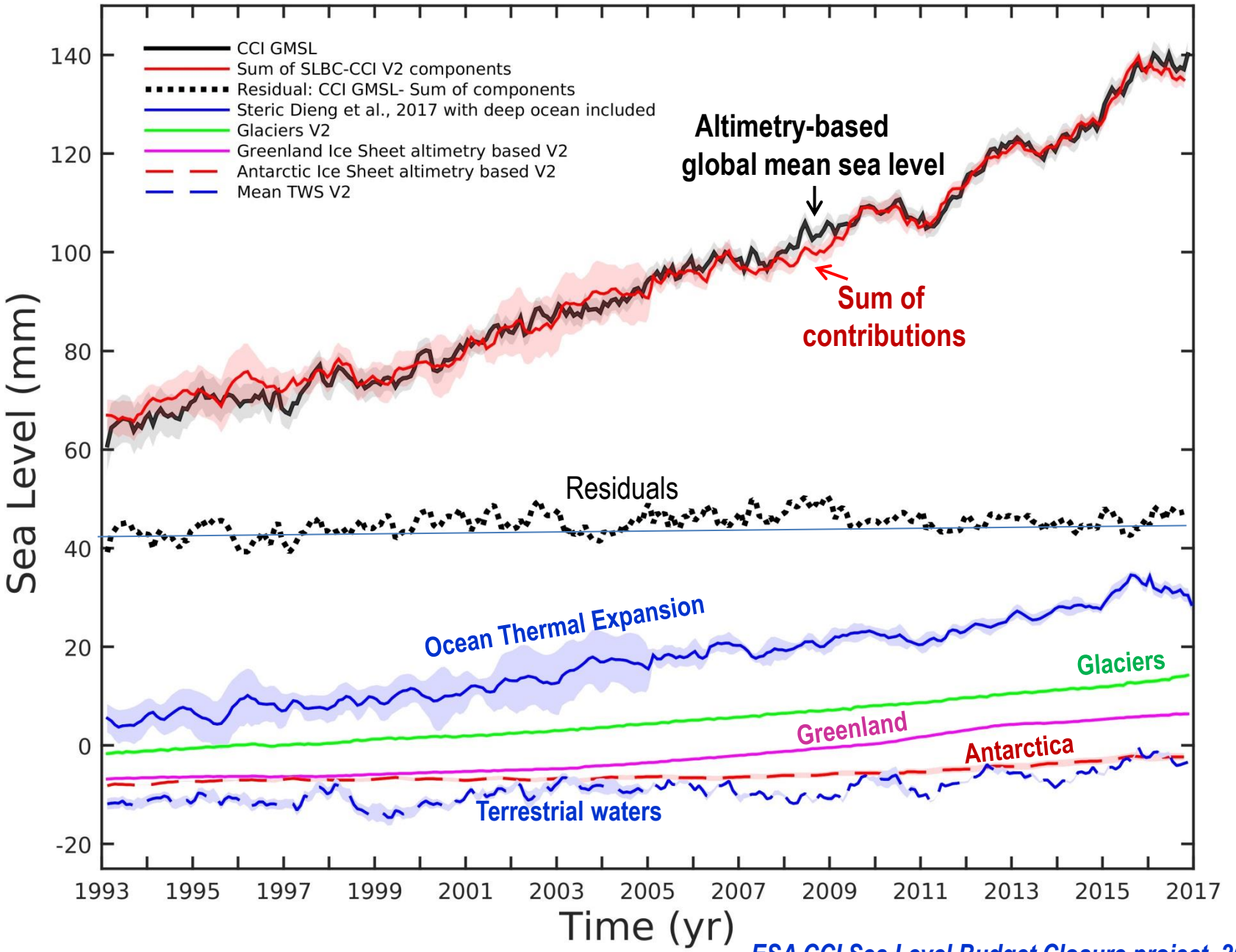
defined by GCOS (Global Climate Observing System) and WMO (World Meteorological Organization)

GCOS, 2018; WMO, 2018

Global Mean Sea Level Rise: Key Questions

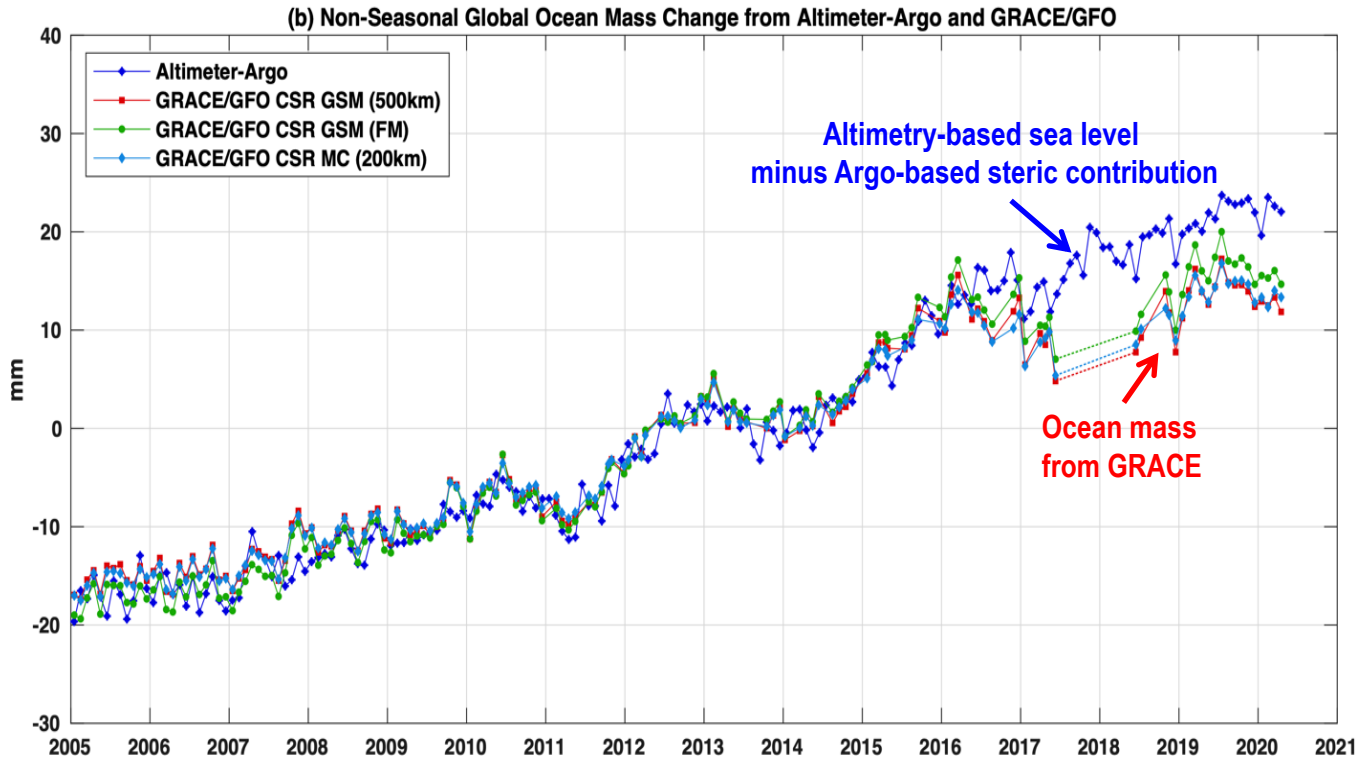
- How accurately can we estimate the Global Mean Sea Level (GMSL) acceleration?
- Can we detect new regimes, runaway changes (tipping points)?
- Can we close the sea level budget? With what accuracy?
- Can we place bounds on poorly known or missing contributions (e.g., total land water storage, deep >2000m ocean warming not sampled by Argo …)
- Is the GMSL record (and components) accurate enough to constrain the current Earth Energy Imbalance and study global Water and Energy cycles?
- …..

Closure of the global Mean Sea Level Budget



ESA CCI Sea Level Budget Closure project, 2020

Since 2017, the Global Mean Sea Level Budget is no more closed…



Jianli Chen et al., GRL, in revision

Regional sea level budget: Key Questions

- While regional trends are dominated by non-uniform thermal expansion and salinity changes, how ocean mass changes contribute regionally?
- What are the respective roles of atmosphere-ocean heat/mass fluxes and wind forcing on ocean heat and mass, hence regional sea level?
- Are regional trend patterns in sea level still dominated by natural climate modes, i.e., internal climate variability?
- Or is the forced (anthropogenic) signal already emerging? And where?
- Can we already detect the "fingerprints" (solid-Earth effects) of present-day land ice melt in the regional sea-level trends corrected for steric effects? Are the data accurate enough?
- ….

What do we need in terms of observations and data processing?

1. Global Mean and Regional Sea Level

- **A long, accurate global and regional sea level record:**
  - → Continuity of the high-precision altimetry record beyond the Sentinel-6-Michael Freilich mission
  - → Regular reprocessing of old missions to improve the accuracy of the GMSL record
  - → Problem of the Topex-A drift
  - → Coverage of the Arctic Ocean; possibility to modify the orbital characteristics of the reference missions
  - → ….

1. Global Mean and Regional Sea Level- *Follow-up*

Steric component:

- Maintain support for Core Argo; Deep Argo; Perform regular subsurface temperature measurements in poorly-covered areas (e.g., marginal seas, high latitudes, shallow areas); Ensure quality control procedure for Argo measurements

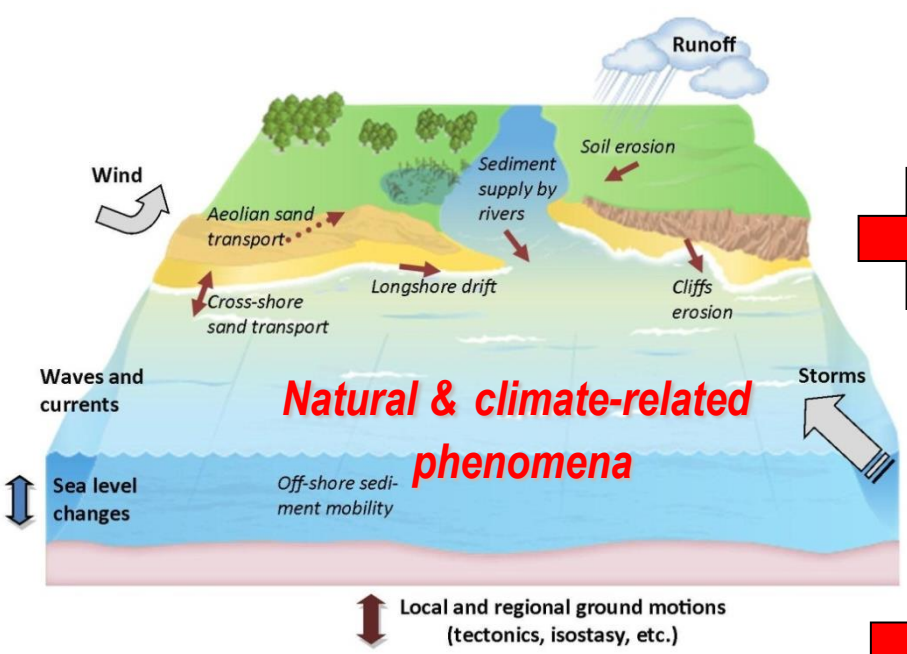
Mass components:

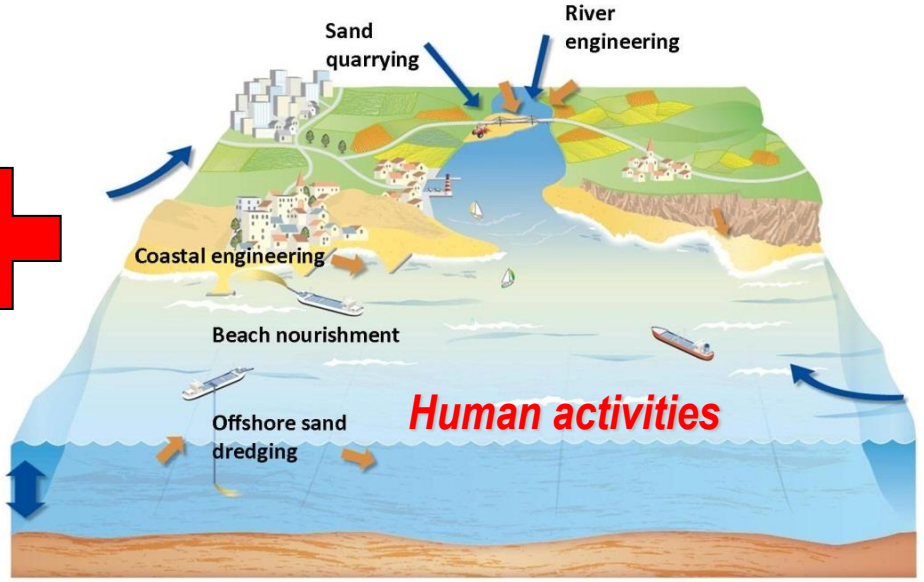
- Sustained measurements of ocean mass changes, ice sheet and glaciers mass balances, and land water storage changes from a GRACE-type mission with improved performances, especially in terms of spatial resolution,
- Sustained monitoring of land ice bodies using various remote sensing systems (InSAR, radar and optical imagery, standard radar as well as SAR/SARIN, and laser altimetry) and modeling
- Improvement of global hydrological models
- Continuing modeling efforts for factors not yet easily accessible by observations; This includes improvement of GIA models

Coastal Sea Level Rise: Unanswered Key Questions

1. Is coastal sea level rising at the same rate as open ocean sea level?
2. What is the role of sea level rise on shoreline erosion and retreat?

Coastal Zones





Complex processes and impacts

Climate & Other Drivers

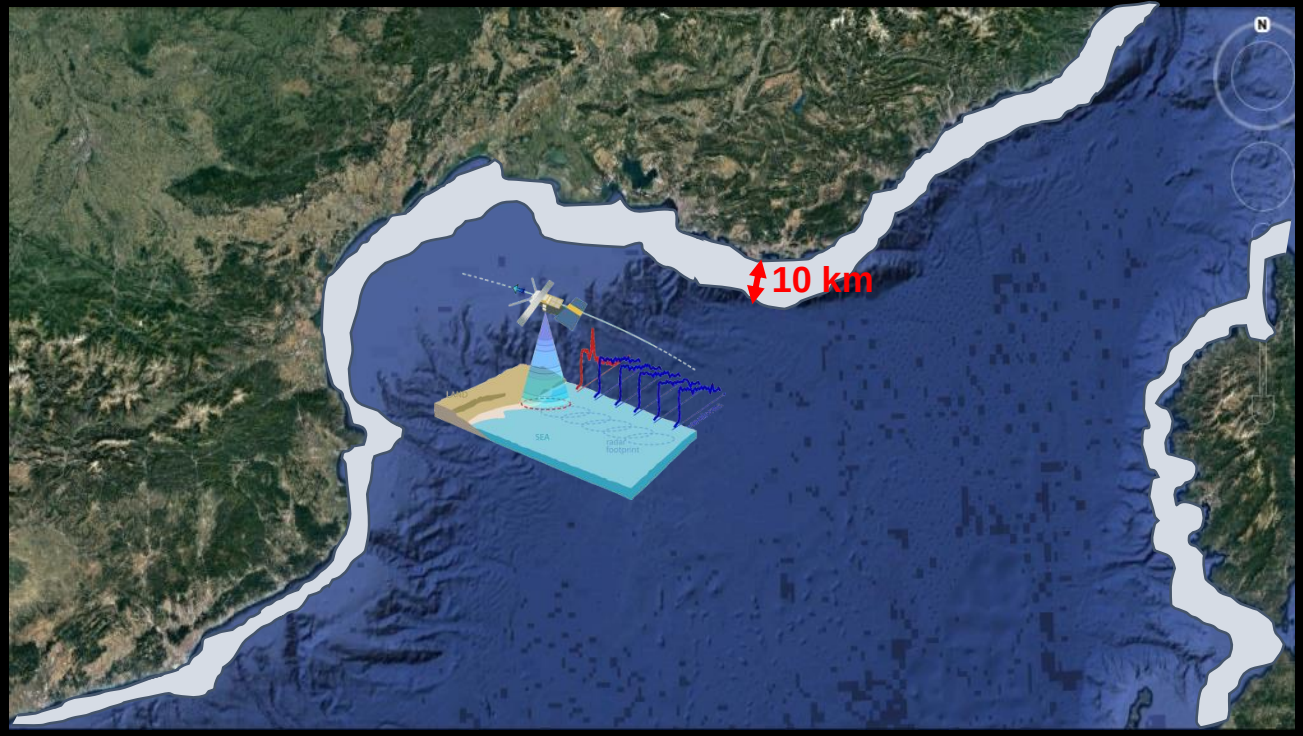
- Sea level rise
- Hurricanes, Storm surges
- Extreme waves and winds
- Changes in sea state, coastal currents & eddies, nutrient supply
- River floods
- Ground subsidence
- Coastal engineering
- etc……

Coastal Impacts

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

Coastal sea level rise

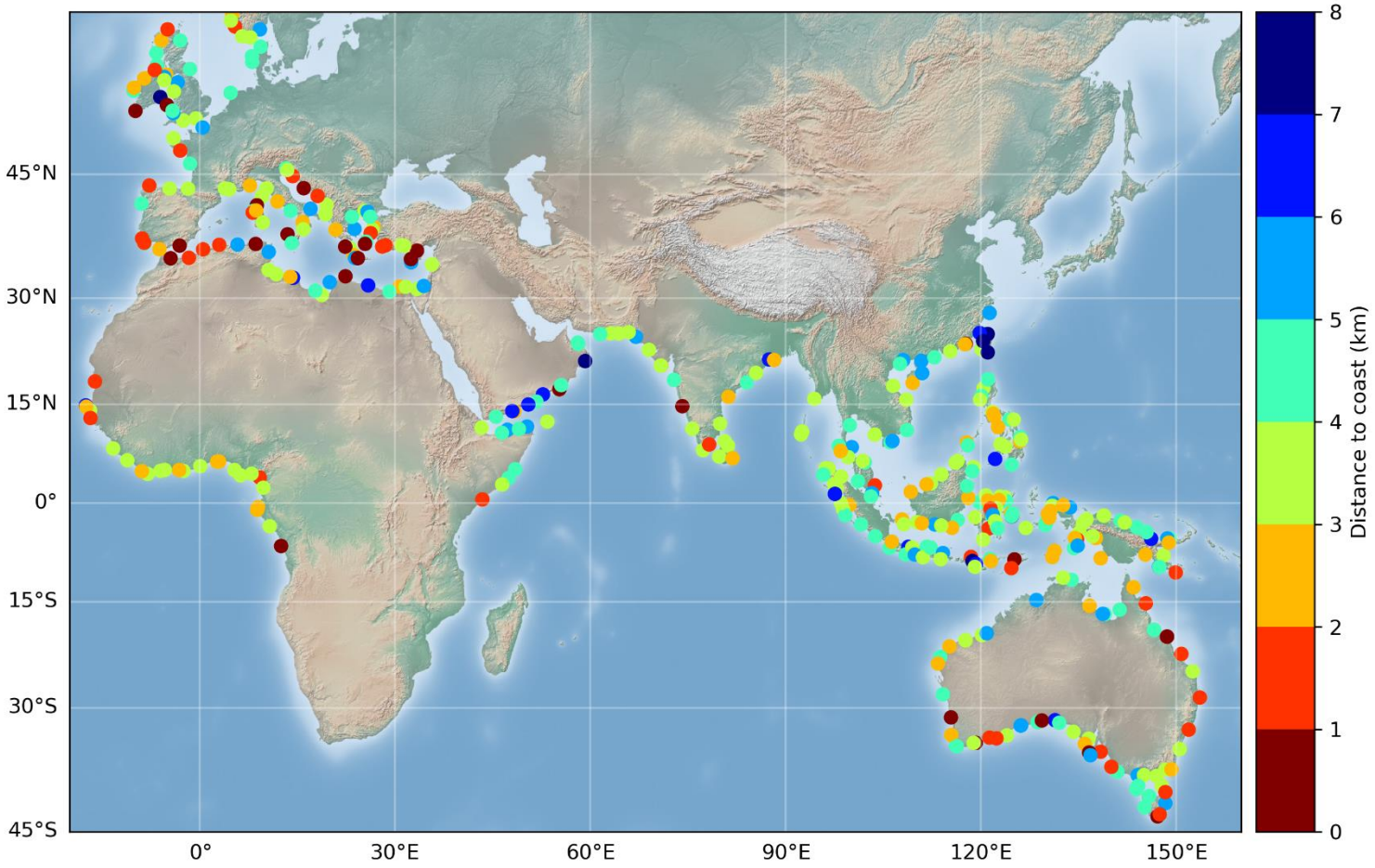
- *only known from tide gauges but with poor spatio-temporal coverage*
- *Not yet global information from satellite altimetry*



Coastal sea level change is not just an extension of open ocean (regional) sea level change:
Some processes (e.g., shelf currents, baroclinic instabilities, trends in wind and waves, fresh water input from river in deltas and estuaries, etc.) only occur at the coast, thus can impact coastal sea level and superimpose to the global mean rise and regional trends

The ESA Climate Change Initiative « Coastal Sea Level Project » 2020

→Reprocessing of Jason-1, 2 & 3 missions in the world coastal zones

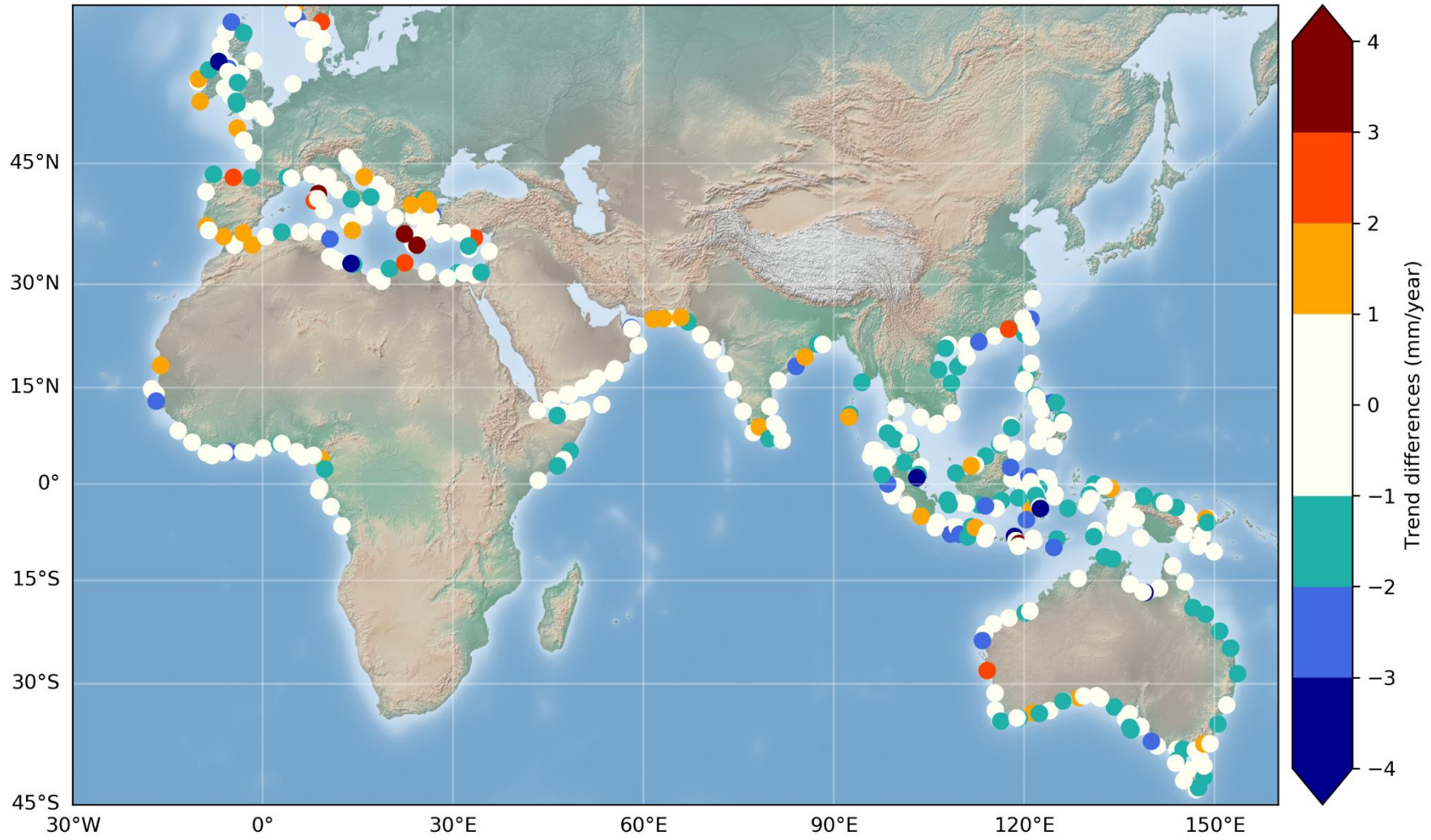


Closest distance (km) to the coast of the first valid sea level data reached along the Jason tracks at 429 selected sites.

The Climate Change Initiative Coastal Sea Level Team, Nature Scientific Data, 2020

The ESA Climate Change Initiative « Coastal Sea Level Project » 2020

→Reprocessing of Jason-1, 2 & 3 missions in the world coastal zones

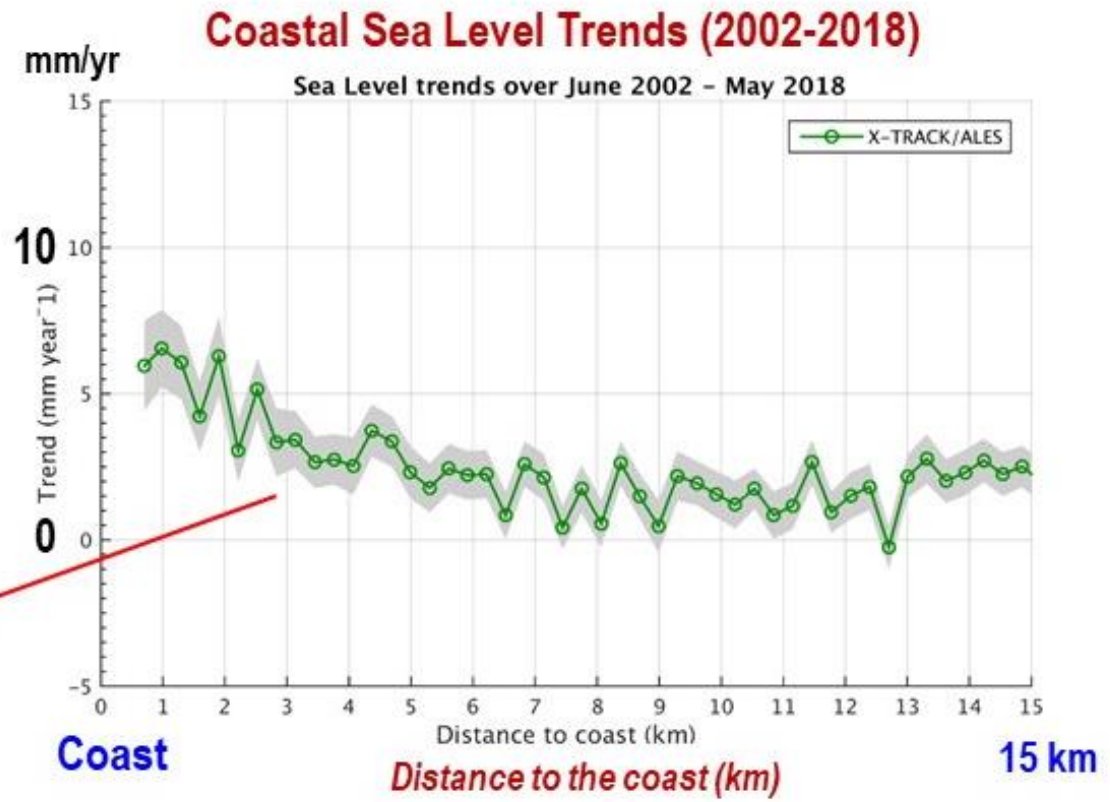


Sea level trend differences (mm/yr): Open ocean minus coastal zone (first 1-3 km) trends

The Climate Change Initiative Coastal Sea Level Team, Nature Scientific Data, 2020

SENETOSA (South Corsica)

calibration site of the T/P & Jason missions



Gouzenes et al., Ocean Sciences, 2020

What do we need in terms of observations and processing?

…to estimate 'relative' coastal sea level trends worldwide…

- A global, multi-mission **Coastal Altimetry** data set (systematic retracking of all altimetry missions of the altimetry era + use of SAR altimetry on the Sentinel-3A/B & Sentinel-6/MF missions)
- Explore GNSS reflectometry
- Estimates of Vertical Land Motions (**GNSS + InSAR**) in highly vulnerable coastal zones + denser **tide gauge** network colocated with **GNSS**

Urgent Need of Developing a Global Coastal Observing System along highly vulnerable coastlines

…to study causes and impacts of sea level rise …

Needed measurements:

- Temperature and salinity over shallow shelves
- Coastal winds, waves and currents (multi-sensor approach)
- River discharge in estuaries and deltas from current and future altimetry techniques; Sediment transport
- Shoreline change monitoring by high-resolution imagery
- High-resolution DEM / Bathymetry using satellite imagery, lidar, altimetry & other techniques
- ……


Thanks for your attention