

# Sea level along the world's coastlines can be measured by a network of virtual altimetry stations

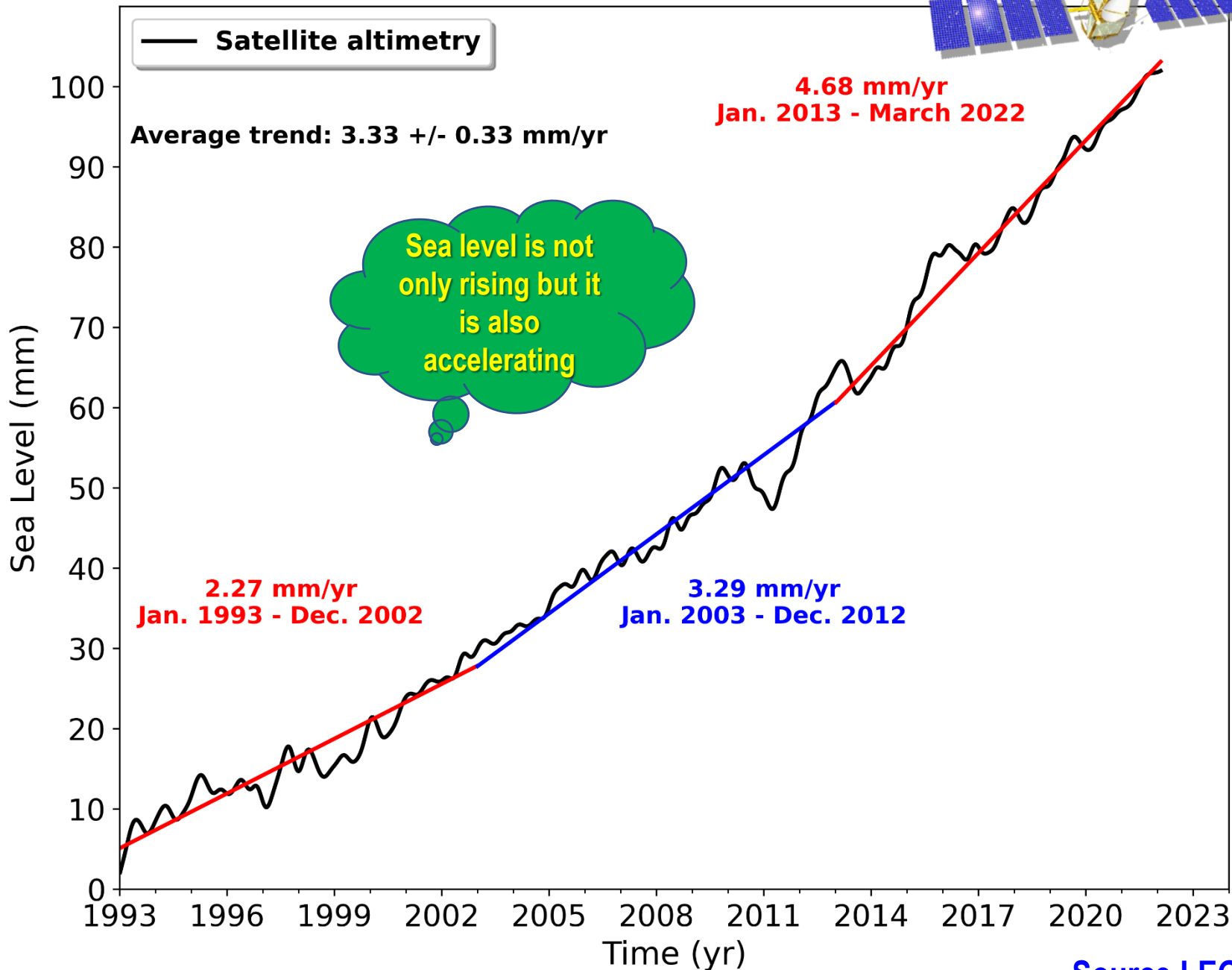
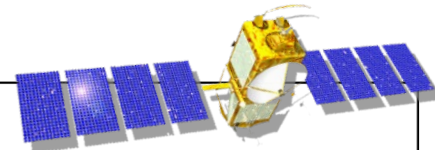
A. Cazenave, J.F. Legeais, Y. Gouzenes, F. Birol, F. Leger, M. Passaro,  
F. M. Calafat, A. Shaw, F. Nino, J. Oelsmann, M. Restano and J. Benveniste



National  
Oceanography Centre  
NATURAL ENVIRONMENT RESEARCH COUNCIL



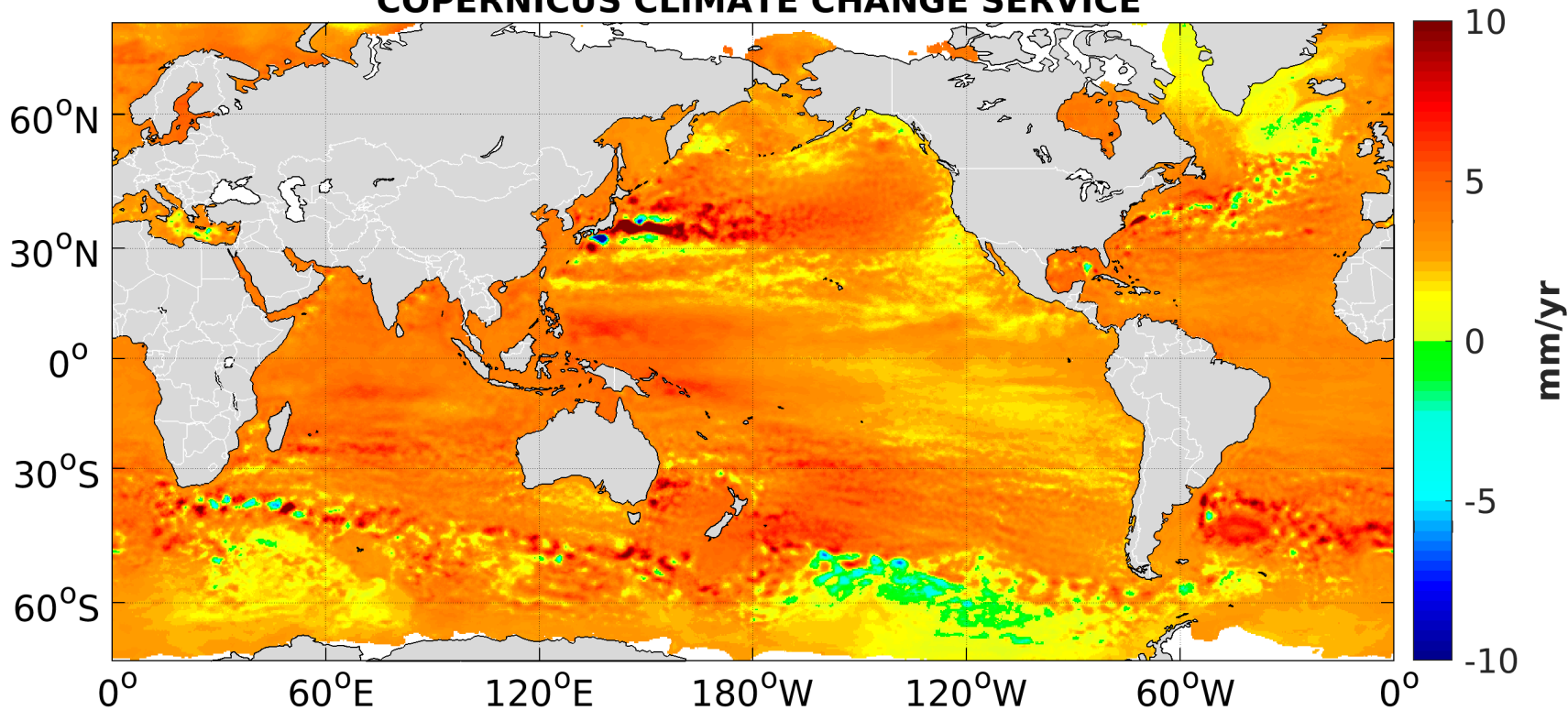
# GLOBAL MEAN SEA LEVEL



Source LEGOS

# Regional sea level trends (1993-2021) (mm/yr)

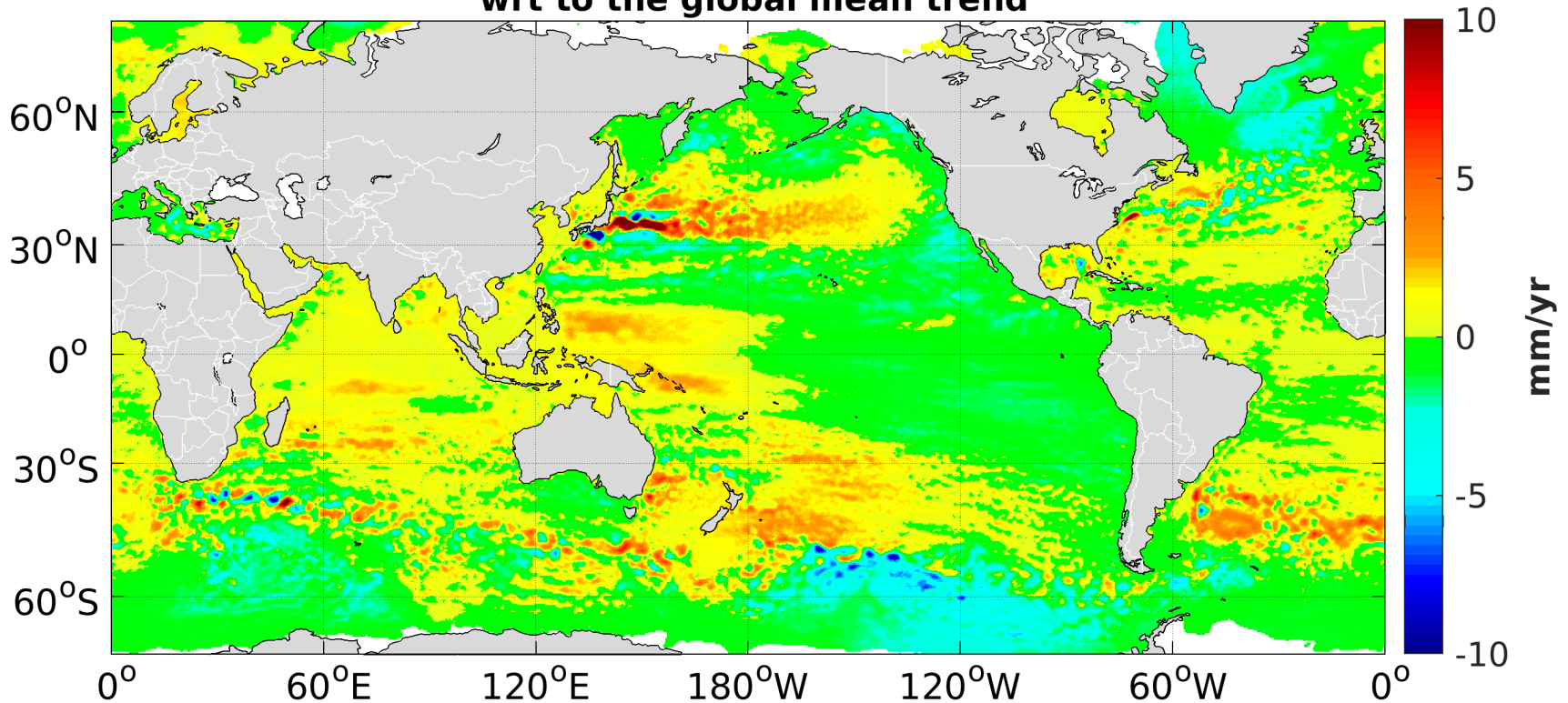
**REGIONAL SEA LEVEL TRENDS | January 1993 - August 2021  
COPERNICUS CLIMATE CHANGE SERVICE**



E.U. Copernicus, CNES, LEGOS, CLS

# Regional sea level trends (1993-2021) (mm/yr) Global mean trend (3.3 mm/yr) removed

**REGIONAL SEA LEVEL TRENDS | January 1993 - August 2021  
wrt to the global mean trend**



E.U. Copernicus, CNES, LEGOS, CLS

**Question:**

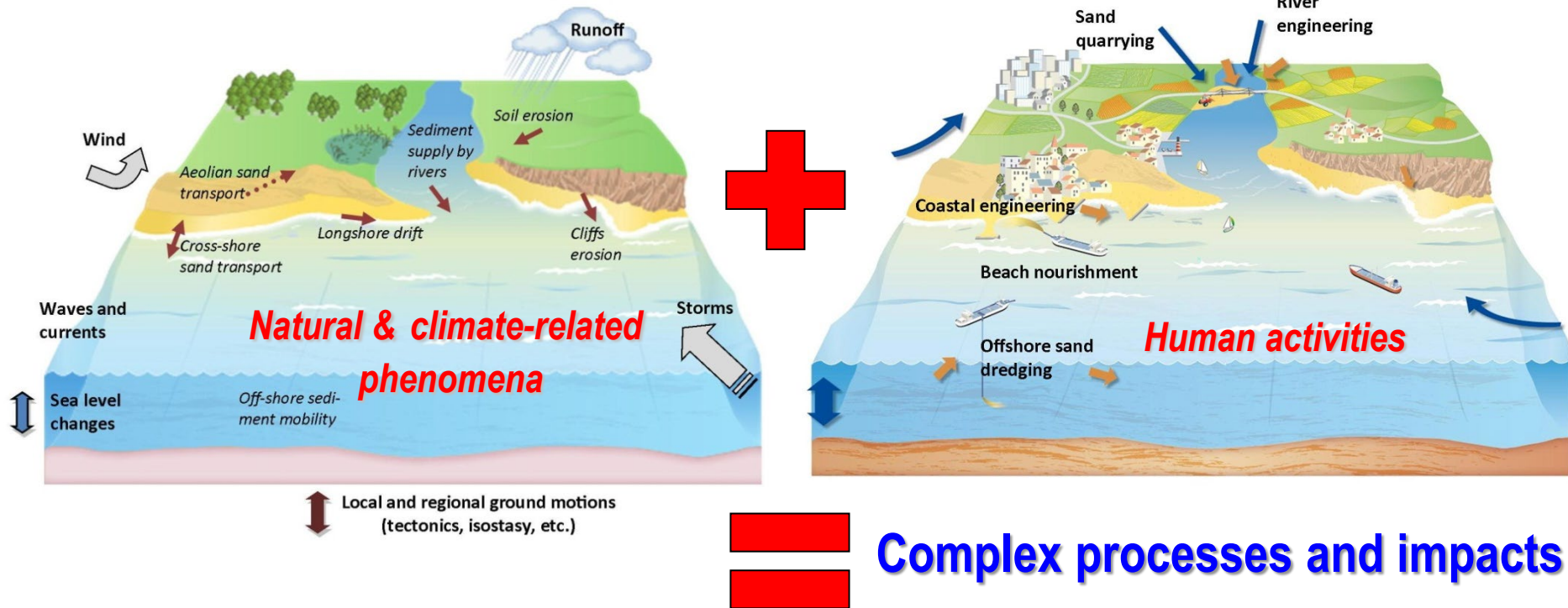
**« Does sea level at the coast rise at the same rate as in the open ocean? »**

**Coastal sea level rise = global mean rise + regional variability + small-scale coastal processes**



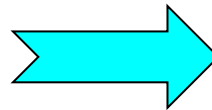
**Ex. of small-scale coastal processes: shelf currents, small-scale eddies, trends in waves, fresh water input from river runoff in deltas and estuaries....**

# World Coastal Zones



## Climate & Other Drivers

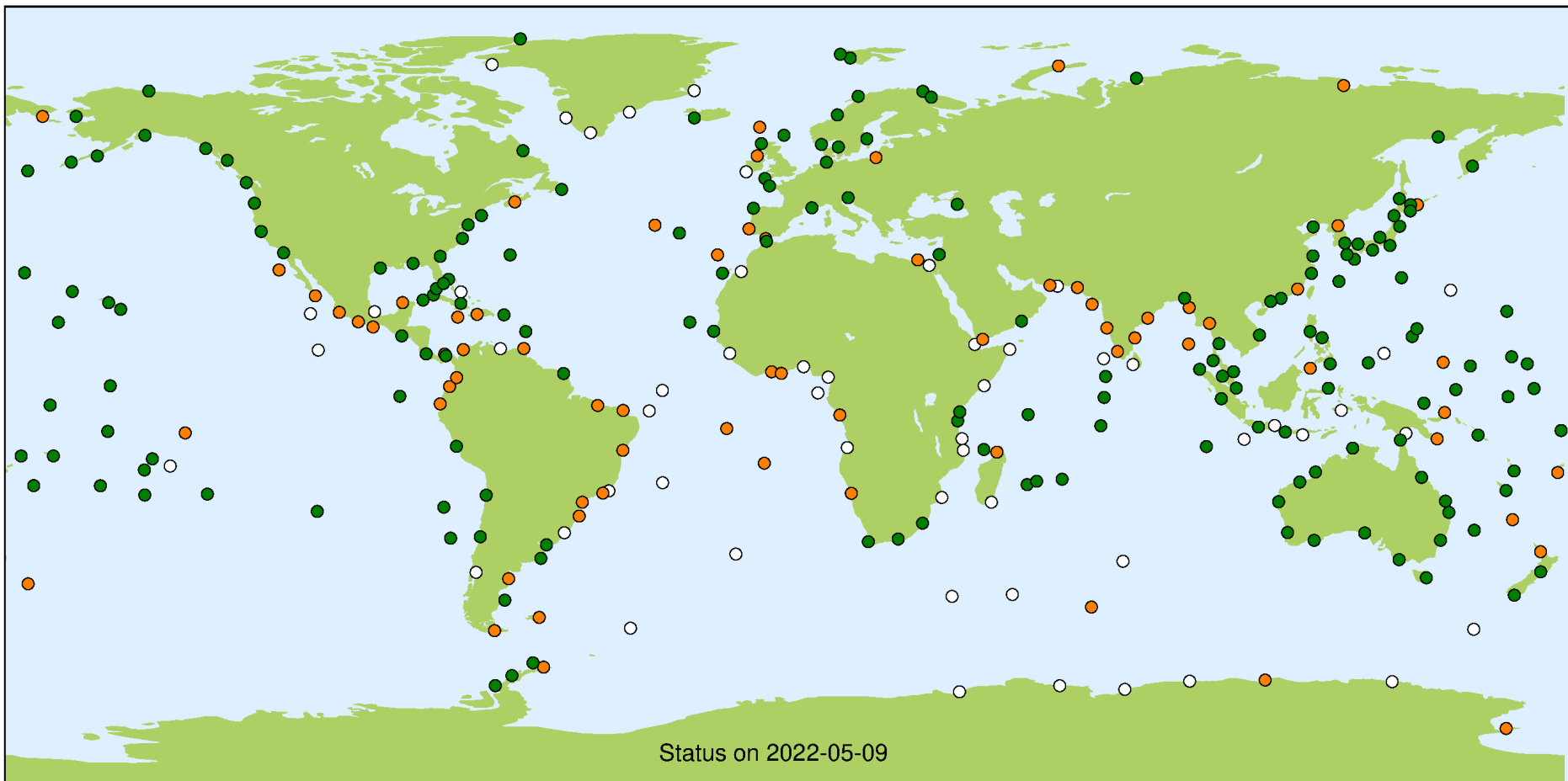
- **Sea level rise**
- Hurricanes, Storm surges
- Extreme waves and winds
- Changes in sea state, coastal currents & eddies, nutrient supply
- River floods
- Ground subsidence
- Coastal engineering
- etc.....



## 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.....

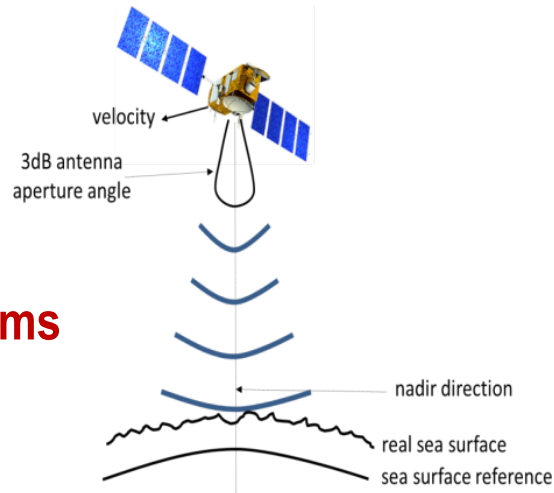
# Current Tide Gauge Network GLOSS/PSMSL (May 2022)



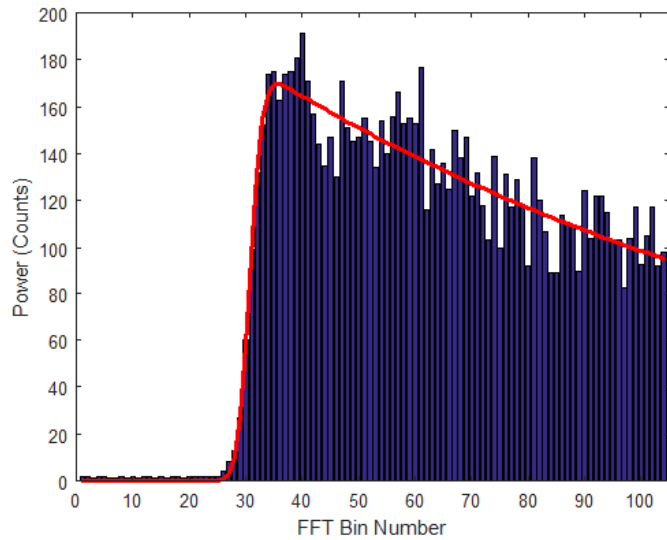
● Updated in past 5 years (172)

● Has some data (69)

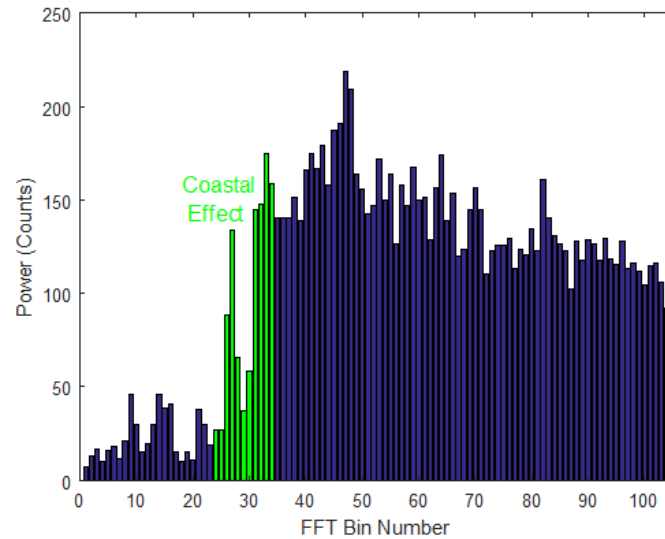
○ No data (53)



## Radar altimetry waveforms



*Typical open ocean radar waveform  
(Brown model)*



*Example of radar waveform  
in the coastal zone*





**sea level**  
cci

# ESA Climate Change Initiative Coastal Sea Level Project

## Objective:

Reprocessing of altimetry data of the Jason-1, 2, 3 missions  
in the world coastal zones over 2002-2020



**National  
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**Partners**

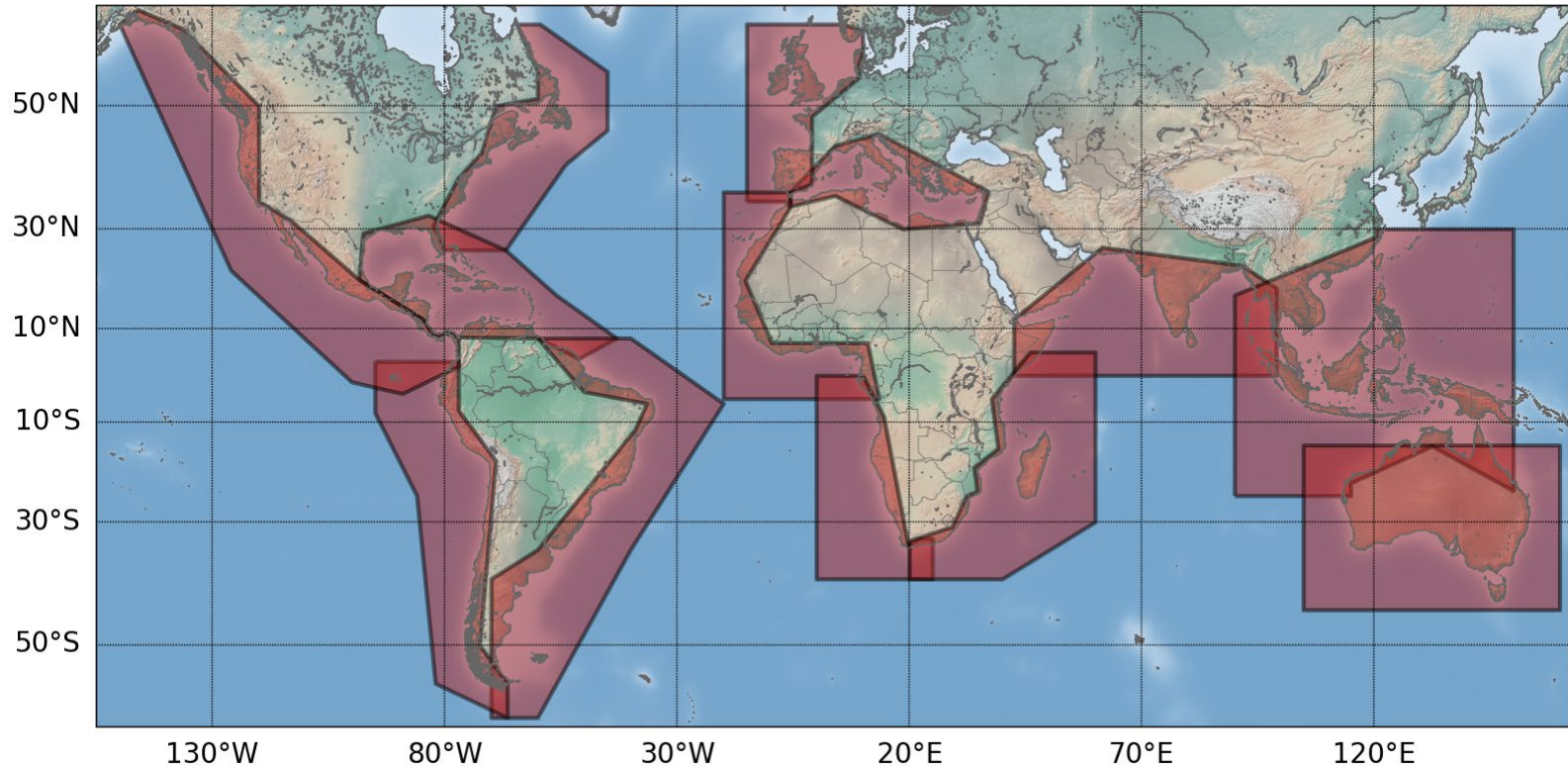
## Objective:

- Reprocessing of along-track data from the Jason altimetry missions (retracking of radar waveforms + improvement of the geophysical corrections)

## Method:

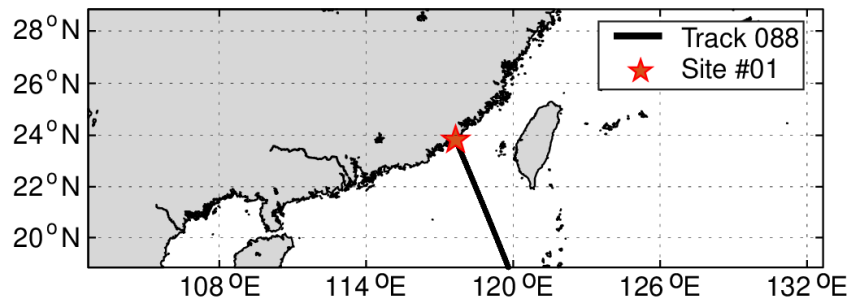
- Use of **ALES (Adaptative Leading Edge Subwaveform)** retracking
  - developed by Passaro et al. 2014
  - + associated Sea State Bias (SSB) (Passaro et al., 2018)
- Use of **X-TRACK** processing system developed at LEGOS (Birol et al., 2021)
- Missions reprocessed: **Jason 1, Jason 2, Jason 3**
- Resolution : 20 Hz along track (**350 m**)
- Temporal coverage: Jan 2002 to Jan 2020: **18 years**
- Selection of valid data between **0 and 20 km from the coast** at numerous coastal site
- Strict editing performed in order to remove outliers (based on trend errors, % of missing data, trend continuity between successive 20 Hz points, ...)

# Studied Regions

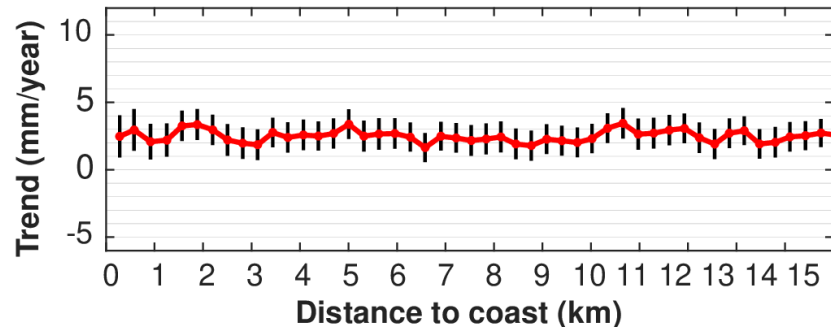


*The ESA Climate Change Initiative Coastal Sea Level project*

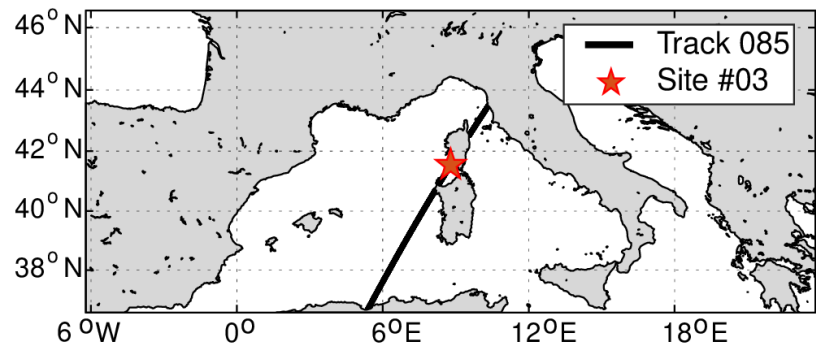
Asia Jason track 088 - Site #01



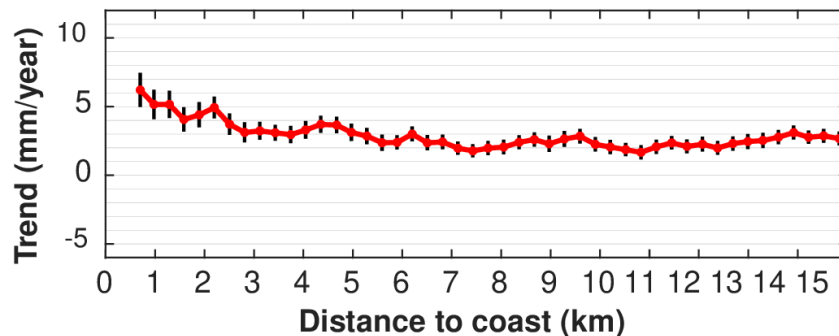
Sea Level trends



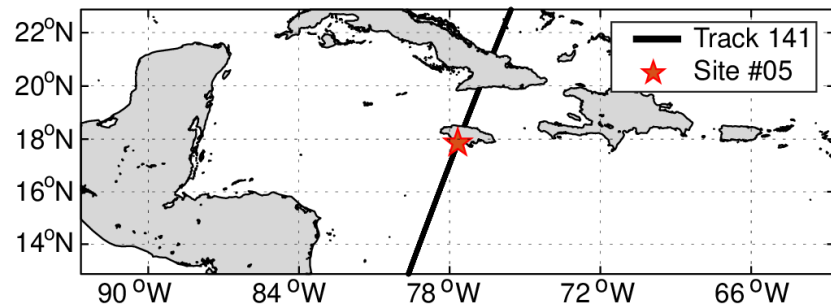
Mediterranean Sea Jason track 085 - Site #03



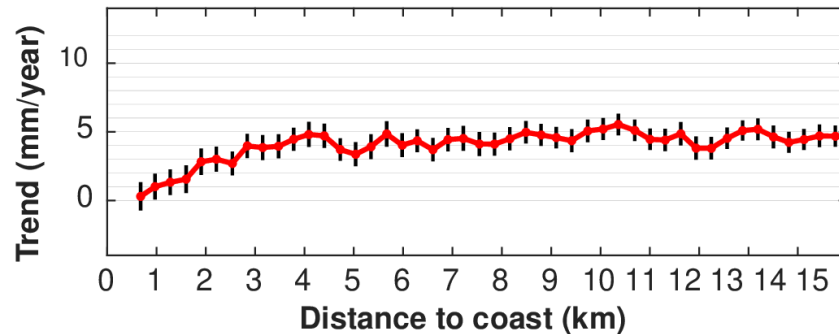
Sea Level trends



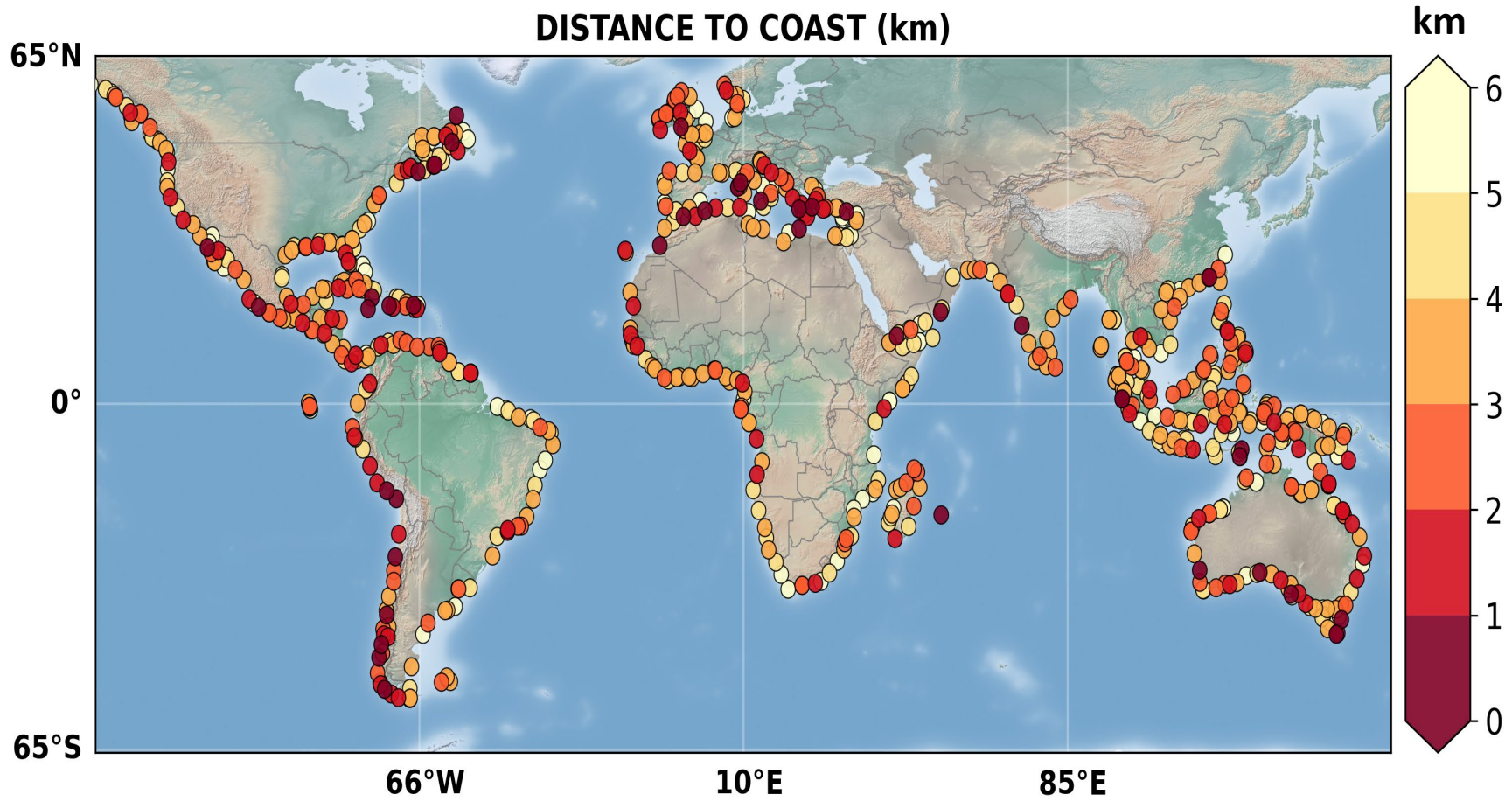
Caribbean Jason track 141 - Site #05



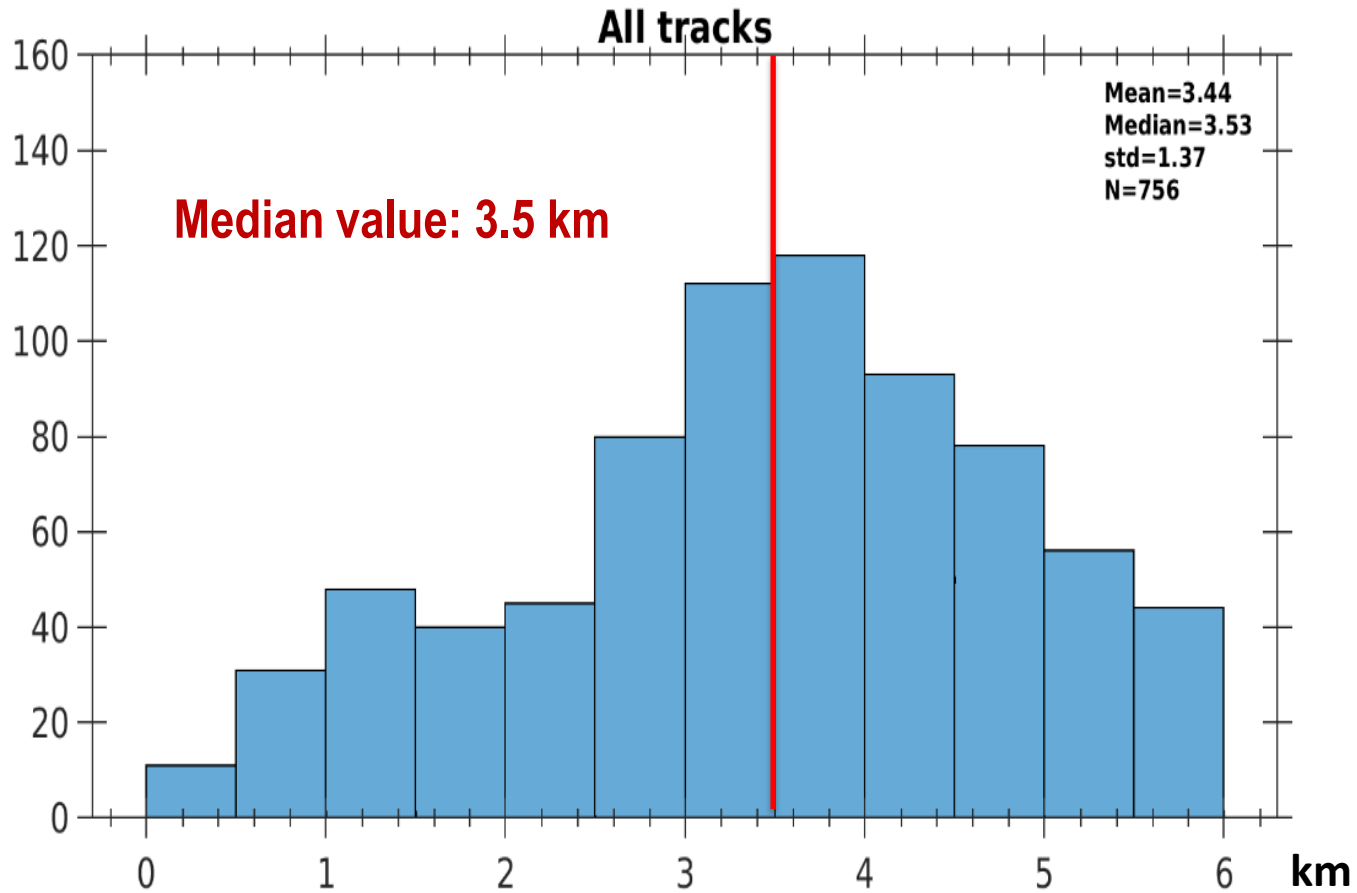
Sea Level trends



Distance (km) to the coast of the 1st valid point along the satellite track  
→ Concept of 'virtual' coastal altimetry stations



## Distance to coast of the first valid point (km) for all regions



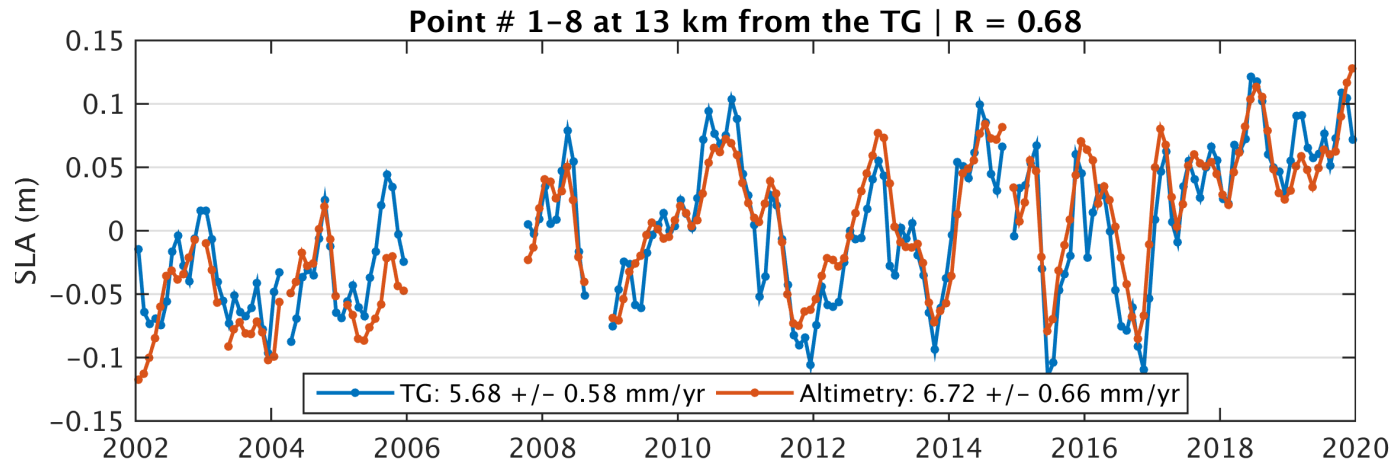
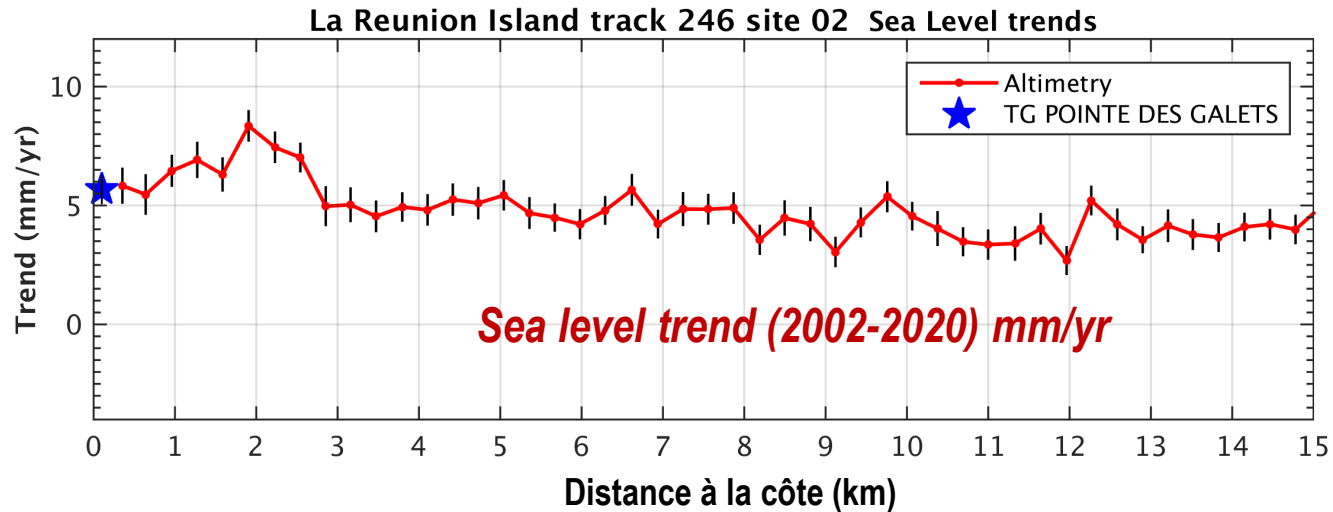
# **New network of virtual coastal altimetry stations**

- **756 virtual stations <6 km from the coast**

## **Including**

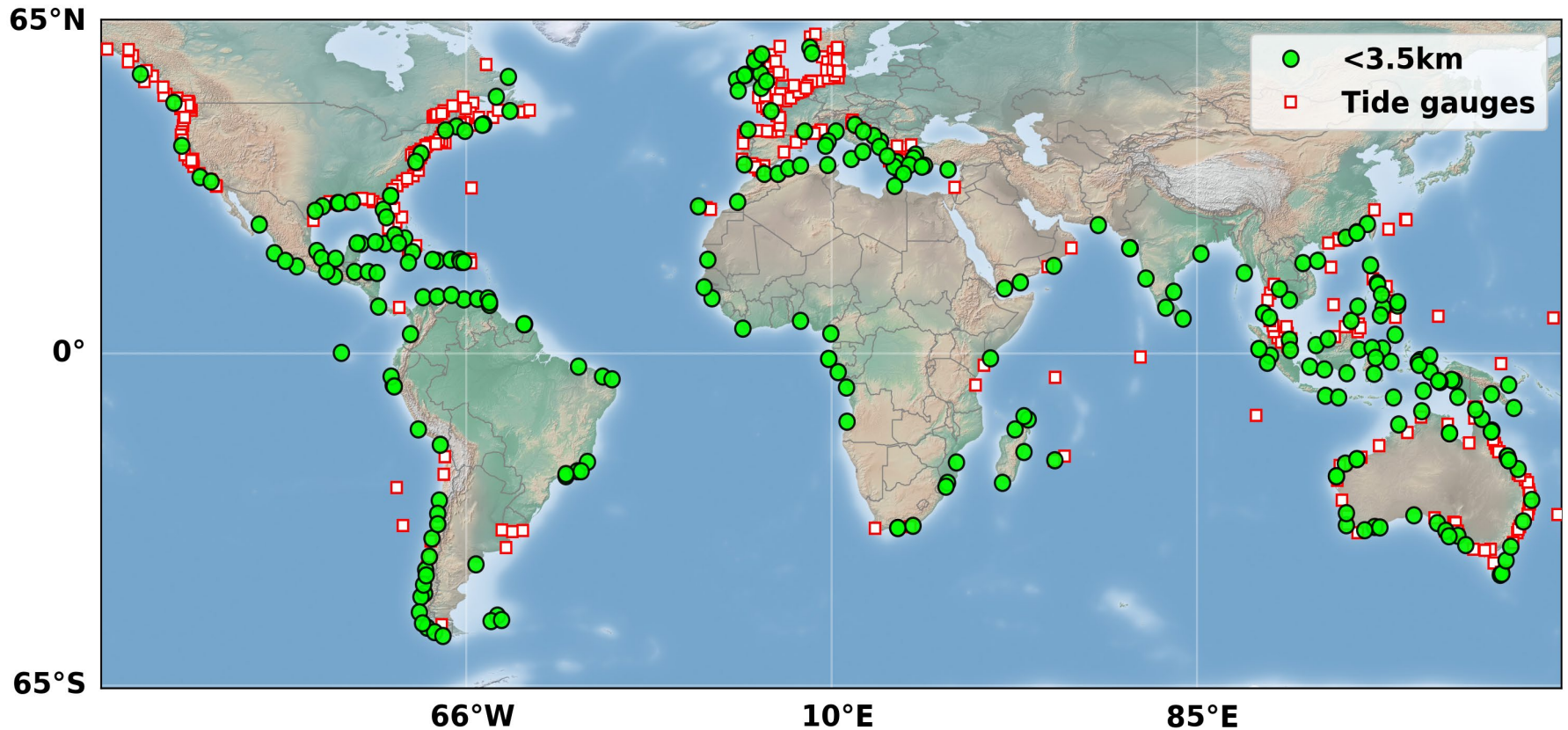
- **271 virtual stations <3.5 km from the coast**

# Comparison altimetry-tide gauge at La Réunion

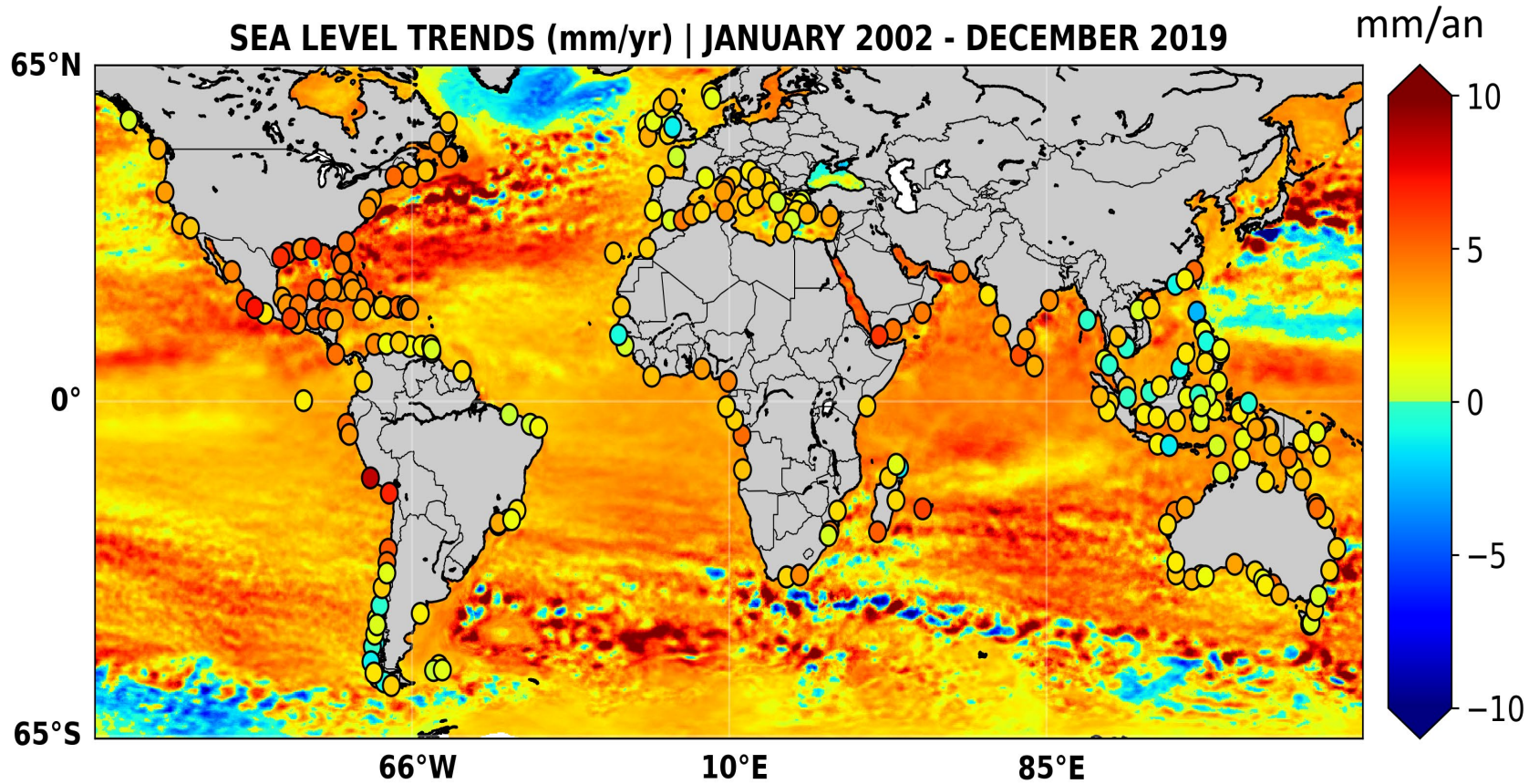




**Virtual coastal stations <3.5 km  
and tide gauge sites with available data over 2002-2020  
(24 month data gap allowed in the tide gauge records)**



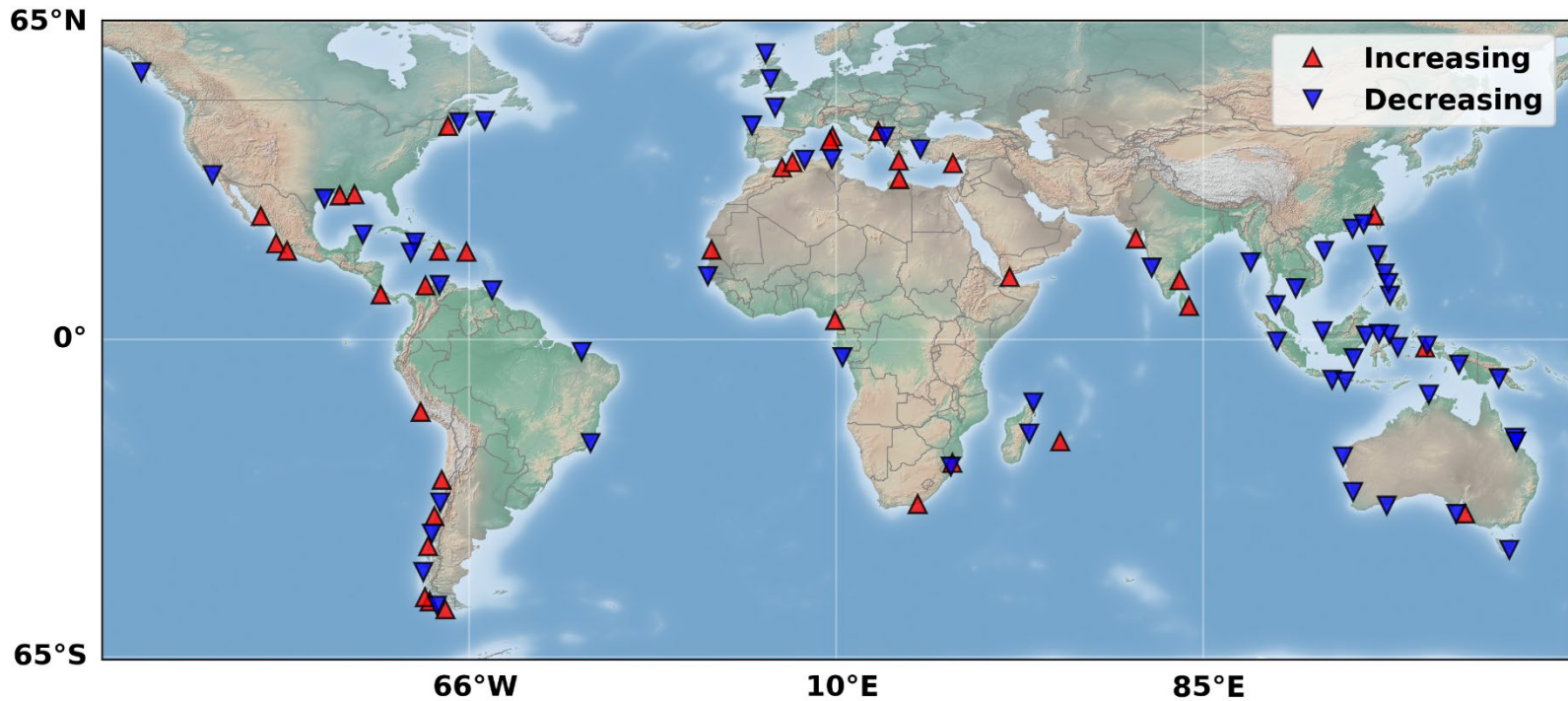
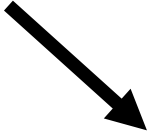
# Regional and coastal sea level trends (2002-2020)



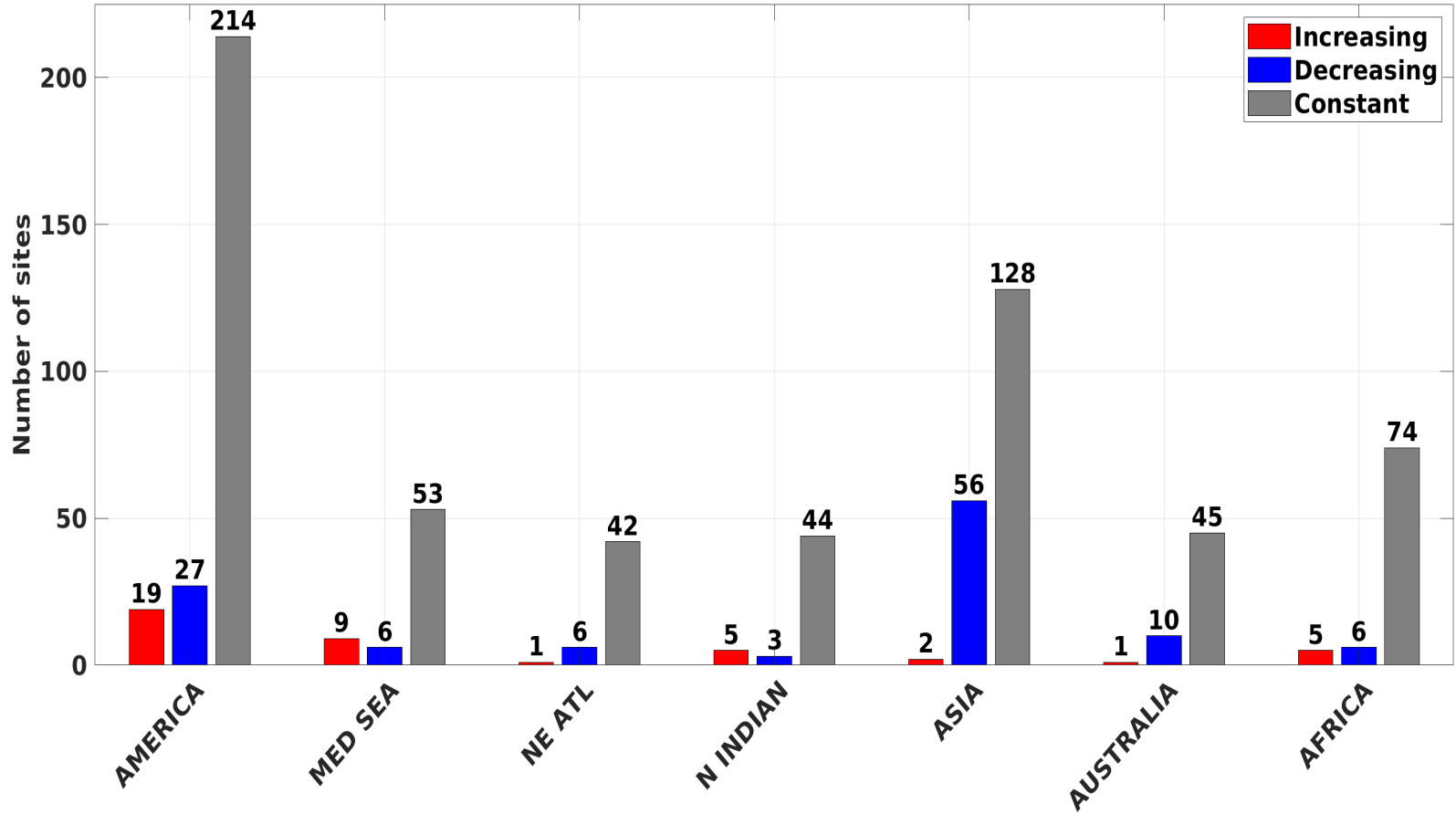
## Sea level trends at the coast

80% → constant trend against distance to the coast

20% → increasing or decreasing trend in the last 4-5 km to the coast compared to offshore



## Coastal trend trend behavior by region



# Nature communications

earth & environment




ARTICLE



<https://doi.org/10.1038/s43247-022-00448-z>

OPEN

## Sea level along the world's coastlines can be measured by a network of virtual altimetry stations

Anny Cazenave <sup>1</sup>✉, Yvan Gouzenes<sup>1</sup>, Florence Birol<sup>1</sup>, Fabien Leger<sup>1</sup>, Marcello Passaro<sup>2</sup>,  
Francisco M. Calafat <sup>3</sup>, Andrew Shaw<sup>4</sup>, Fernando Nino <sup>1</sup>, Jean François Legeais<sup>5</sup>, Julius Oelmann<sup>2</sup>,  
Marco Restano<sup>6</sup> & Jérôme Benveniste<sup>7</sup>

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# Coastal sea level time series and associated trends freely available

**Data access:**

**SEANOE** website : <https://doi.org/10.17882/74354>

**Thanks for your attention**

