

# Level Budget Closure” Project (2017-2019) (ESA Climate Change Initiative)



sea level  
budget closure  
cci

## 10 European partner groups

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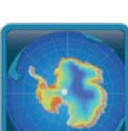
sea level  
cci

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Science Leader, CCI Sea Level project & CCI+ Coastal Sea Level project

# ESA "Sea Level Budget Closure" project

**Objective:** Assess closure of the global mean sea level budget using products from the ESA "Climate Change Initiative" for sea level and components

-  sea level  
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-  sea surface temperature  
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-  glaciers  
cci
-  ice sheets  
greenland  
cci
-  antarctic  
ice sheet  
cci

Plus data from other sources

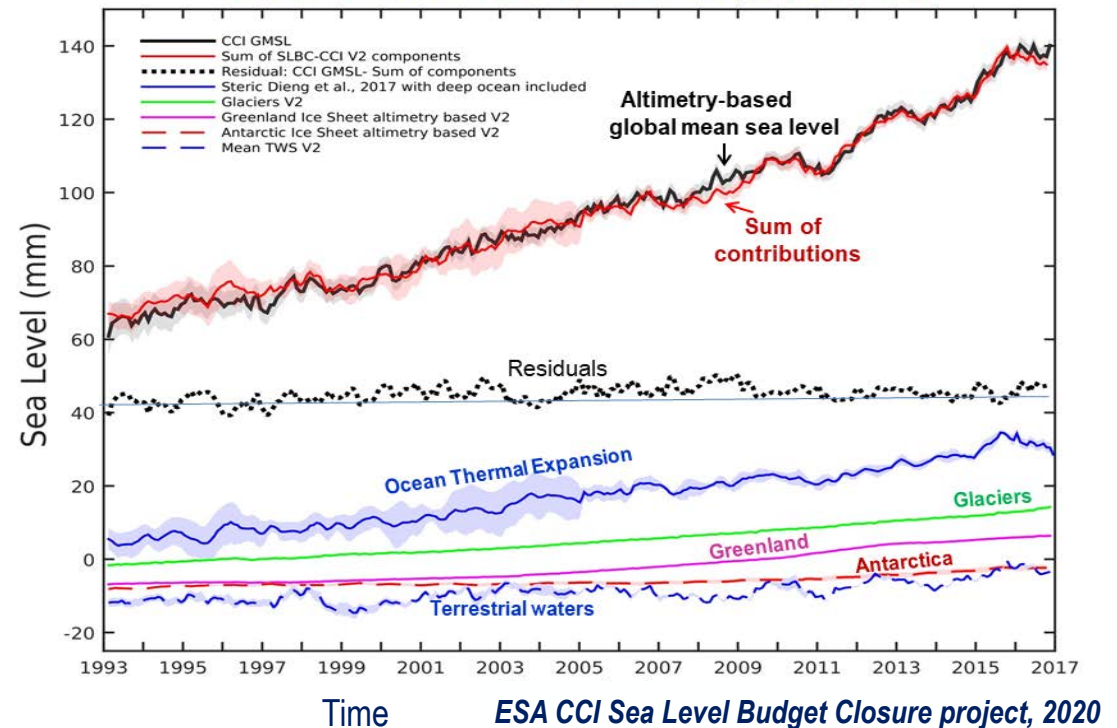
**Products:**

- Data package containing final improved time series of individual components of the sea level budget (version 2)
- Product Description Document + Description of data sets and uncertainty assessment (version 2)
- 10+ articles, including Horwath et al., ESSD, 2020.

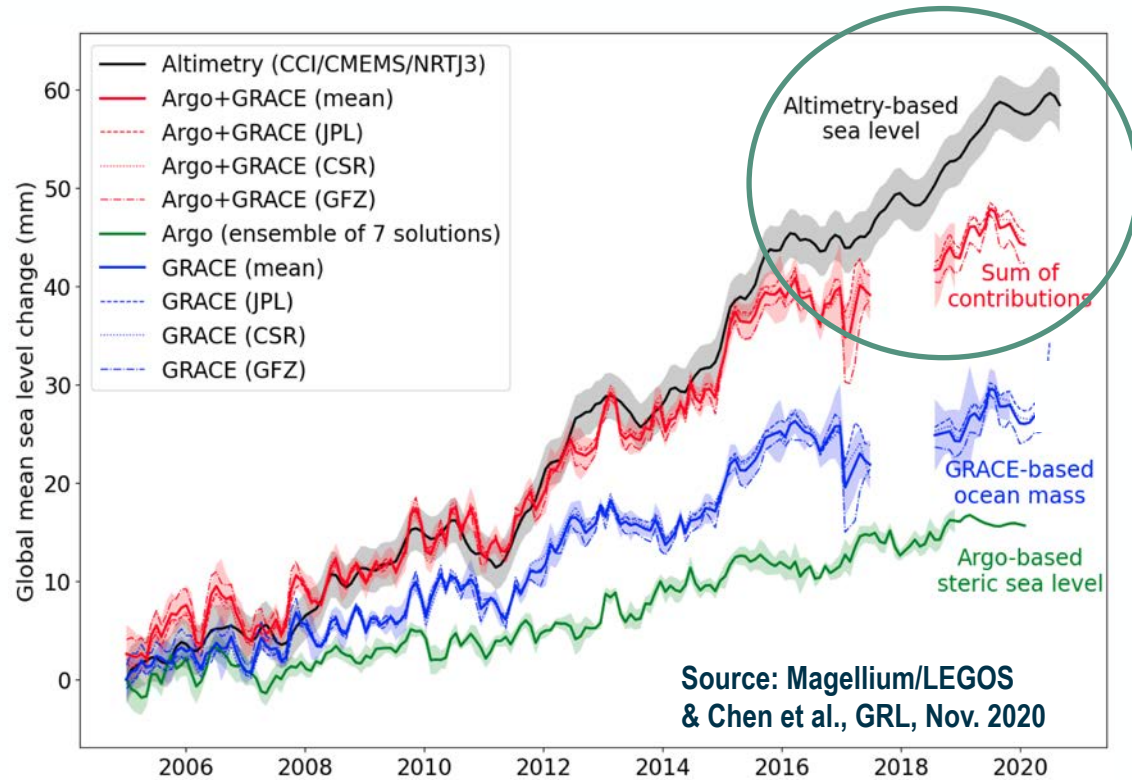
$$\text{Observed Global Mean Sea Level} = \text{Ocean Thermal Expansion} + \text{Ocean Mass}$$

$$\Delta M_{\text{ocean}} = -\Delta M_{\text{Glaciers}} - \Delta M_{\text{Greenland}} - \Delta M_{\text{Antarctica}} - \Delta M_{\text{Land Waters}} - \Delta M_{\text{Water Vapor}} - \dots$$

Closure of the Global Mean Sea Level Budget (1993-2016)



# 1. OPEN QUESTIONS: Global Mean Sea Level and Ocean Heat Content



- Why is the sea level budget no more closed since 2017?
- Important consequence on the evaluation and quantification of the *Earth Energy Imbalance (EEI)* and *Earth Heat Inventory*
- The absolute value of EEI is the most critical metric defining the status of global warming and climate change!
- Both **EEI** and **Heat Inventory** can be best estimated from combined analysis of EO & in situ data, and models.

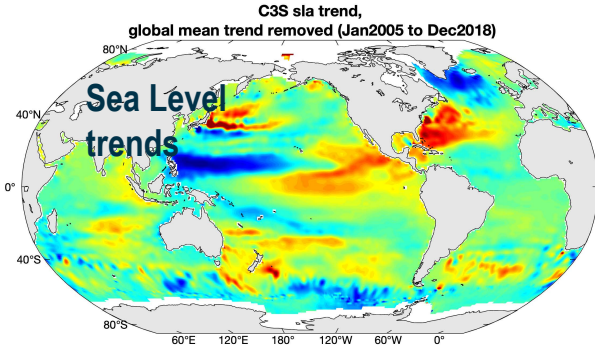
## OUTLOOK FOR THE NEW CLIMATE PROGRAMME:

Include « **Earth Energy Imbalance and Heat Inventory** » in the future CCI++ programme

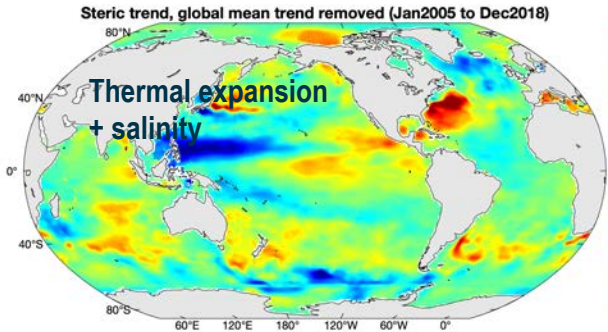
(**Ocean Heat Content based on altimetry and space gravimetry** + Atmospheric Heat Content + Land Heat Content + Heat available to melt ice)

# 2. OPEN QUESTIONS : Regional Sea Level Trends

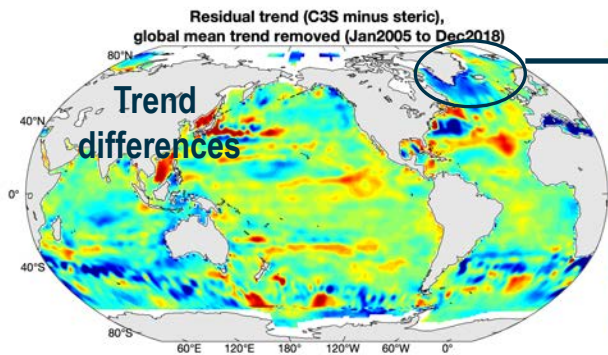
ALTIMETRY



ARGO



RESIDUALS



???  
Fingerprints of ongoing land ice melt?



- Can we close the sea level budget at regional scale?
- What are the respective roles of atmosphere-ocean heat/mass fluxes and wind forcing on ocean heat and mass redistribution, hence on regional sea level?
- Are sea level trend patterns 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 regional sea level trends corrected for steric effects? Are the data accurate enough?

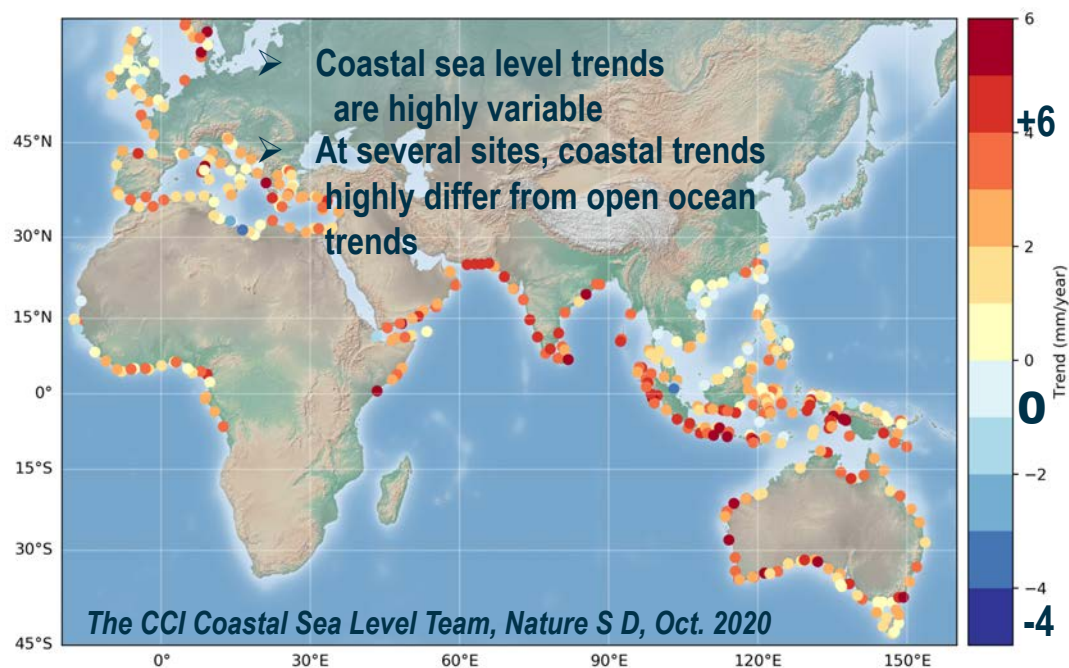
**OUTLOOK FOR THE NEW CLIMATE PROGRAMME:**  
 Include the « **Regional Sea Level Budget Closure** »  
 → Important for validating climate models developed to simulate future regional sea level changes



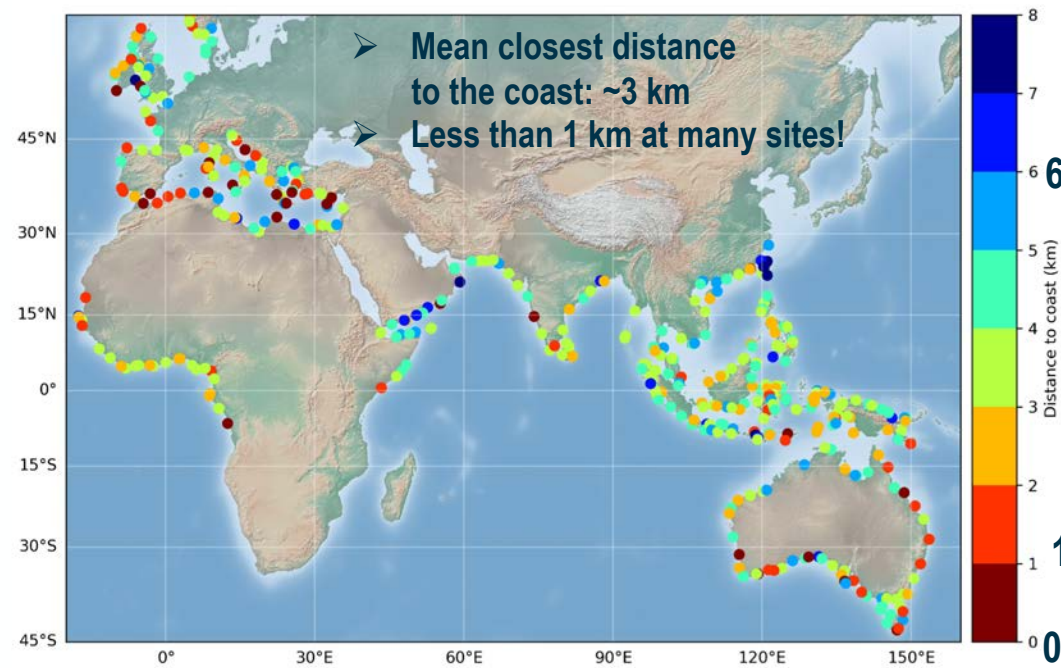
# Altimetry-based Coastal Sea Level » Project (ESA CCI+ project 2019-2022)

Objective: Retracking of the Jason-1/2/3, Envisat, Saral/AltiKa, Sentinel-3A/B altimetry data in the world coastal zones in order to answer the question:

« *Is coastal sea level rising at the same rate as in the open ocean?* »



Coastal sea level trends (mm/yr; 2002-2018)



Closest distance to coast (km) reached by retracked altimetry

OUTLOOK FOR THE FUTURE CLIMATE PROGRAMME: Implement a long-term, systematic monitoring from space of **sea level rise** in the **world coastal zones**, as well as of associated coastal process based on space-based & in situ EO data (e.g., T/S, coastal winds, waves, curenets, river discharge in estuaries, coastal bathymetry changes, etc.)

### 3. OPEN QUESTION: Can we predict Coastal Impacts due to natural and anthropogenic forcings on the world coastal zones?

- **Coastal zones** are the most populated regions on Earth. They suffer multiple stresses due to a broad variety of natural and anthropogenic forcing factors (e.g., extreme events, climate-related sea level rise, river floods in estuaries, pollutions, marine ecosystems destruction, ground subsidence (→ relative sea level rise), coastal and along-river engineering (→ sediment loss and shoreline modifications), urbanization, etc.
- **Negative impacts** due to the coastal response to the above drivers are numerous. These include : flooding (temporary and permanent), shoreline erosion and retreat, loss of sediment supply, loss of biodiversity, salinization of land and aquifers, etc.
- Several CCI EO-based ECVs are involved in the monitoring of coastal zones (e.g., **Sea Surface Temperature, Sea Surface Salinity, Sea Level, Ocean Colour, River runoff in estuaries, Soil Moisture, Land Use Change...**); In addition, other space-based techniques provide information on ground subsidence (**GNSS, InSAR**), sediment transport (**hyperspectral imagery**), shoreline position changes (**high resolution imagery**), trends in winds and waves, coastal currents (**multi-sensor approach**)...

**OUTLOOK FOR THE NEW CLIMATE PROGRAMME: Develop a Multidisciplinary « Coastal Impacts » Project → (1) Process EO data to build a coastal zones change database; (2) Combine EO data/products with socio-economic data; (3) Provide a new type of indicators: « **Impact Indicators** » to inform on exposure and vulnerability of the world coastal zones**