The ESA Climate Change Initiative Sea Level project: validation phase

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ABSTRACT. Precisely measuring sea level is a major objective for climate change studies. Since about two decades, sea level is routinely measured from space using altimetry techniques. But to address a number of important questions relevant to sea level studies (is sea level rise accelerating? Can we close the sea level budget? What are the causes of the regional and interannual variability? What are the coastal impacts of sea level rise? etc.), the accuracy of altimetry-based sea level measurements at global and regional scales need to be improved. This was the goal of the ESA CCI Sea Level project that started 3 years ago. Using multi-mission satellite altimetry data, the project developed a new satellite altimetry-based sea level processing system, with dedicated algorithms and data processing strategies, in order to generate high-accuracy altimetry-based sea level products for the last two decades. Here we present validation results of the ESA CCI Sea Level products. Validation includes comparison with tide gauges-based sea level, sea level budget closure studies, and comparisons with ocean reanalyses and coupled climate model outputs at global and regional scales. Impacts of assimilating the ESA CCI sea level products in numerical ocean models are also discussed. Plans for future improvements are presented.

Project objectives

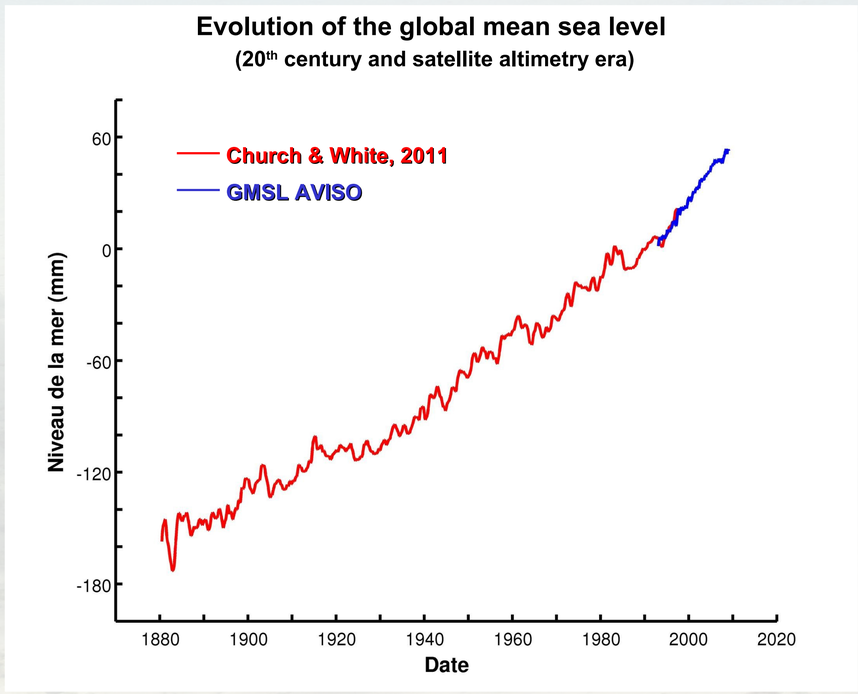
Provide a long, accurate space-based sea level record

Specific requirements:

- Reduce errors on the global mean sea level trend to <0.3 mm/yr
- Reduce errors on the interannual variability to <1 mm
- Reduce errors on regional sea level trends to <1 mm/yr

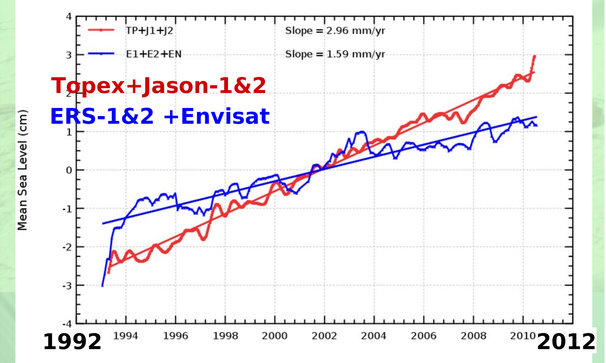
Key scientific questions

- Is the rate of sea level rise accelerating? Is the current rate of rise unusual?
- Can we close the sea level budget?
- What are the causes of the interannual variability?
- In addition to thermal expansion and salinity effects, can we detect in the spatial sea level trend patterns, the fingerprint of post-glacial rebound (PGR) and ongoing land ice melt?
- What is the life time of observed, altimetry-based spatial patterns?
- Are the spatial trend patterns due to the internal variability of the climate system or to anthropogenic forcing?
- Can we predict the future total relative sea level rise?
  i.e., global mean sea level rise + climate-related regional variability + regional variations due to PGR and future land ice melt
- Ultimately, what we want to know is the future total relative sea level rise at coastal locations
  Adapt or Protect or Retreat

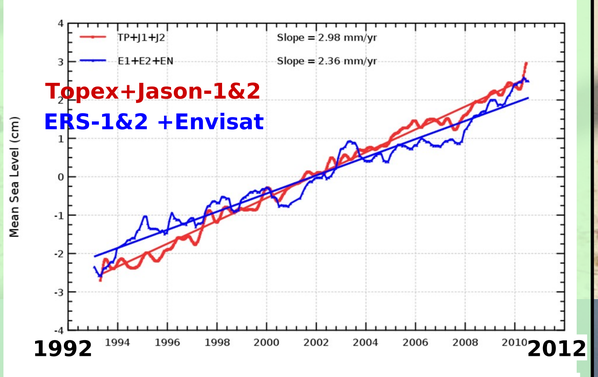


Improvements from the Sea Level CCI project

ERS-1&2 + Envisat-based global mean sea level time series

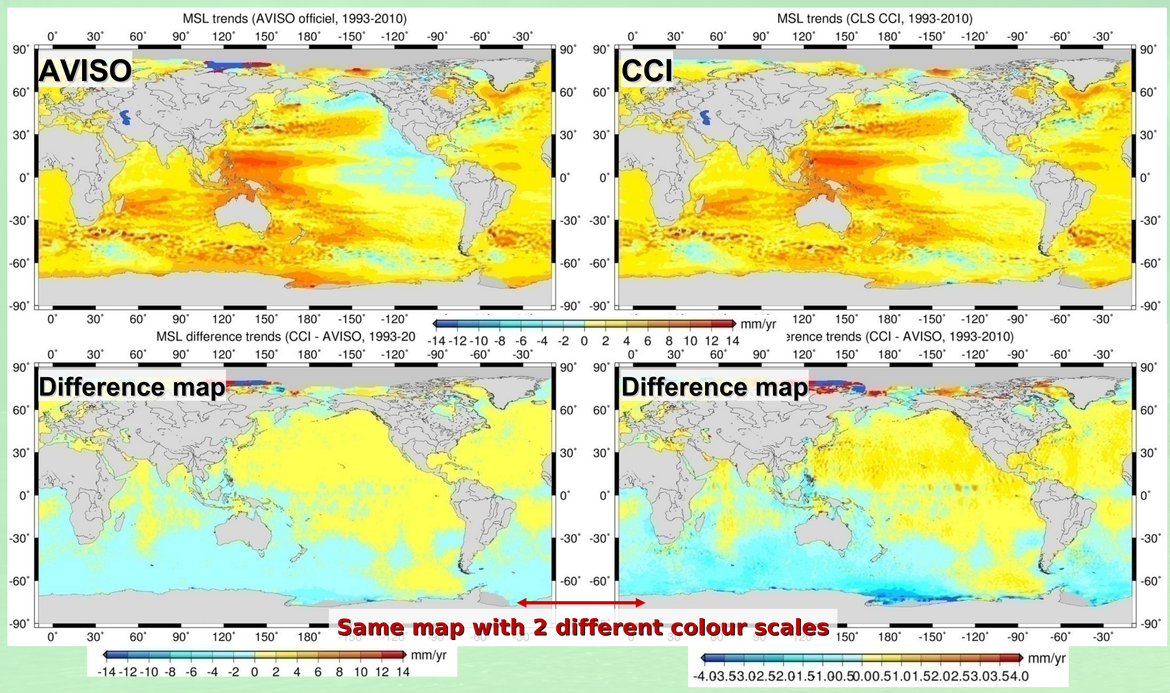


Before the Sea Level CCI project



After the Sea Level CCI project

Comparison of spatial trend patterns: AVISO and CCI SL, and difference map



→ *Michael Ablain's presentation*

Conclusions

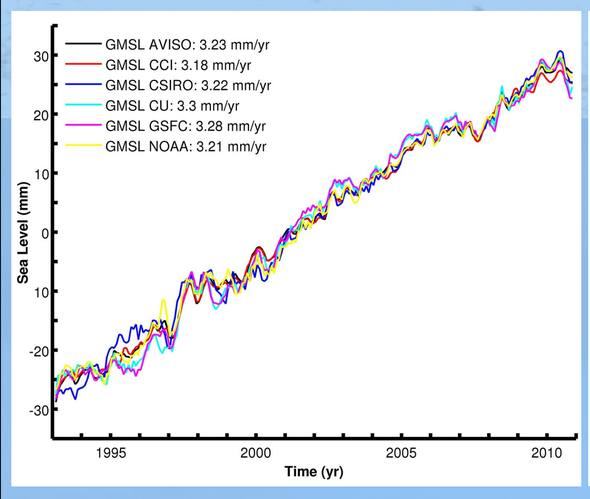
- In spite of a 20-year long background in satellite-based sea level data processing, **errors are still found …**
- Owing to the CCI 'Sea Level' project, **many improvements have been realized during the past 3 years**, both in terms of **averaging method** and **geophysical corrections** (not only for the ESA missions but also the Jason-1&2)
- **Validation** of the phase-1 CCI 'Sea Level' products is **in progress** but more work is needed **to understand and reduce remaining errors** (→**Phase 2**)
- **Specific efforts** are needed to provide accurate sea level data **in the high-latitude** (Arctic) **ocean** (inclusion of Cryosat and Altika →Phase 2); Extend the CCI GMSL beyond 2010 (→ **Phase 2**)
- Finally, CCI-type effort required for ALL available satellite altimetry missions (→ **Phase 2**)

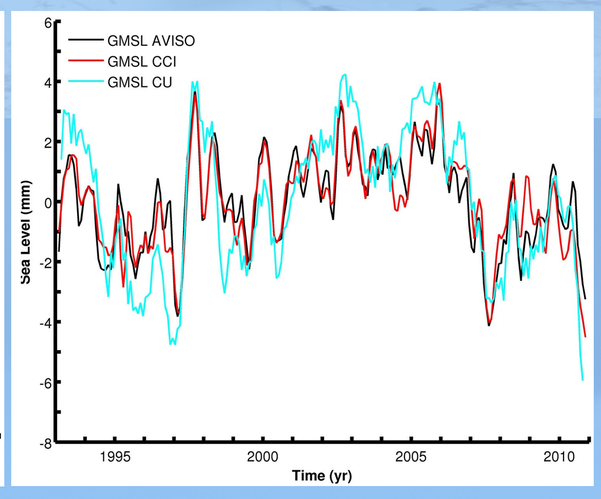
Validation of the CCI 'Sea level' products

Several approaches

- Assessment using ocean models & reanalyses (impact on data assimilation, model/data comparisons, etc.) → **work in progress**
- Comparison of the CCI 'Sea level' time series with data from other groups
- Closure of the sea level budget

Compararisons between sea level records from different groups





Validation using the sea level budget approach

It consists of comparing the CCI global mean sea level time series with the sum of the climate-related contributions

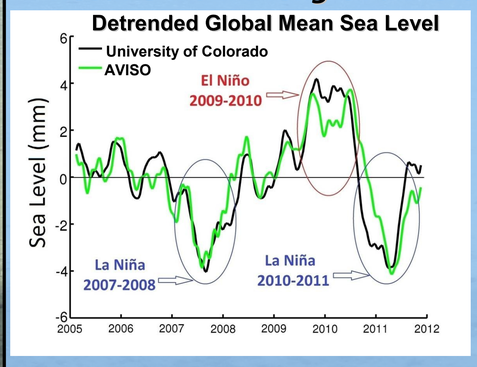
(1) Ocean temprature & salinity effects (different data bases: ARGO/Ifremer, JAMSTEC, NOAA)

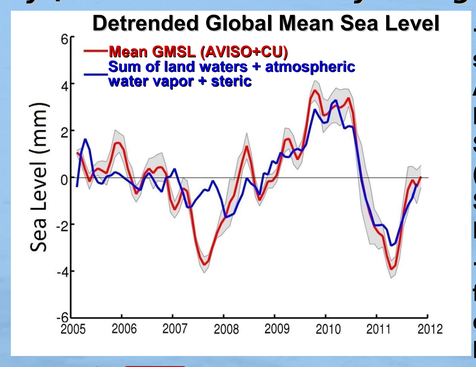
(2) Mass contributions:

→ Glaciers (from articles, CCI 'Glaciers')
→ Ice sheets (from GRACE, comparison with articles, CCI 'Ice sheets')
→ Land waters (from GRACE + hydrological models)
→ Total ocean mass (from GRACE)

→ Comparison with CCI SL trend + interannual variability

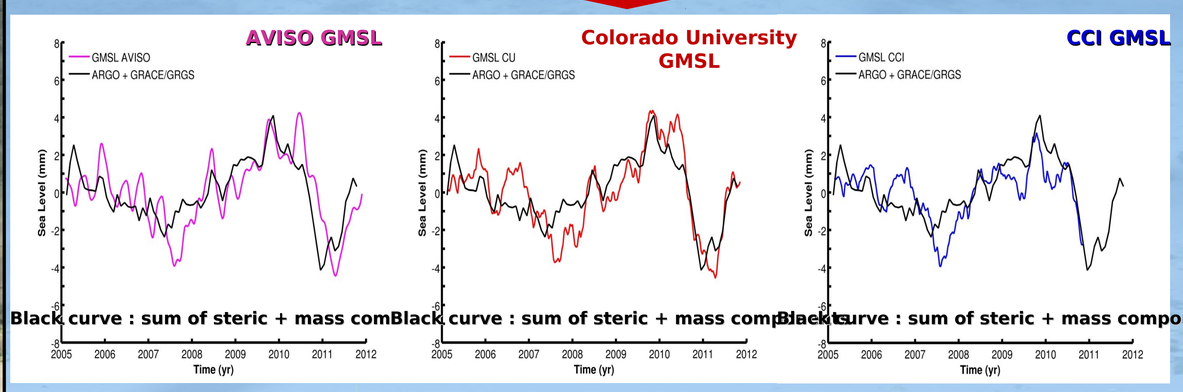
Results from Dieng et al.' study (Global and Planetary Change, submitted)





→ Temperature and salinity data from Argo processed by Karina von Schuckmann (update from von Schuckmann and Le Traon, 2011)

→ GRACE data from GRGS (various corrections applied; Dieng et al., 2013)



CCI GMSL has the highest correlation with the sum of thermal expansion + ocean mass contributions

But more work is needed to assess errors on climate-related components