Two decades of global and regional sea level observations from the ESA-CCI Project

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Context

UNFCCC

GCOS — GLOBAL CLIMATE OBSERVING SYSTEM

Requirements to meet the needs of the CC community

Essential Climate Variables (ECVs)

Domain	Essential Climate Variables	
Atmospheric (over land, sea and ice)	Surface:	Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour.
	Upper-air:	Earth radiation budget (including solar irradiance), Upper-air temperature, Wind speed and direction, Water vapour, Cloud properties.
	Composition:	Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases, Aerosol properties.
Oceanic	Surface:	Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea Ice, Current, Ocean colour (for biological activity), Carbon dioxide partial pressure.
	Sub-surface:	Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton.
Terrestrial	River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Biomass, Fire disturbance, Soil moisture.	

Objective: provide stable, long-term, satellite-based ECVs data products for climate modellers and researchers.

Context

CCI PROGRAM

aerosol cci

ozone cci

ocean colour cci

cloud cci

sea ice cci

land cover cci

fire cci

cmug cci

sea level cci

sst cci

ghg cci

glaciers cci

soil moisture cci
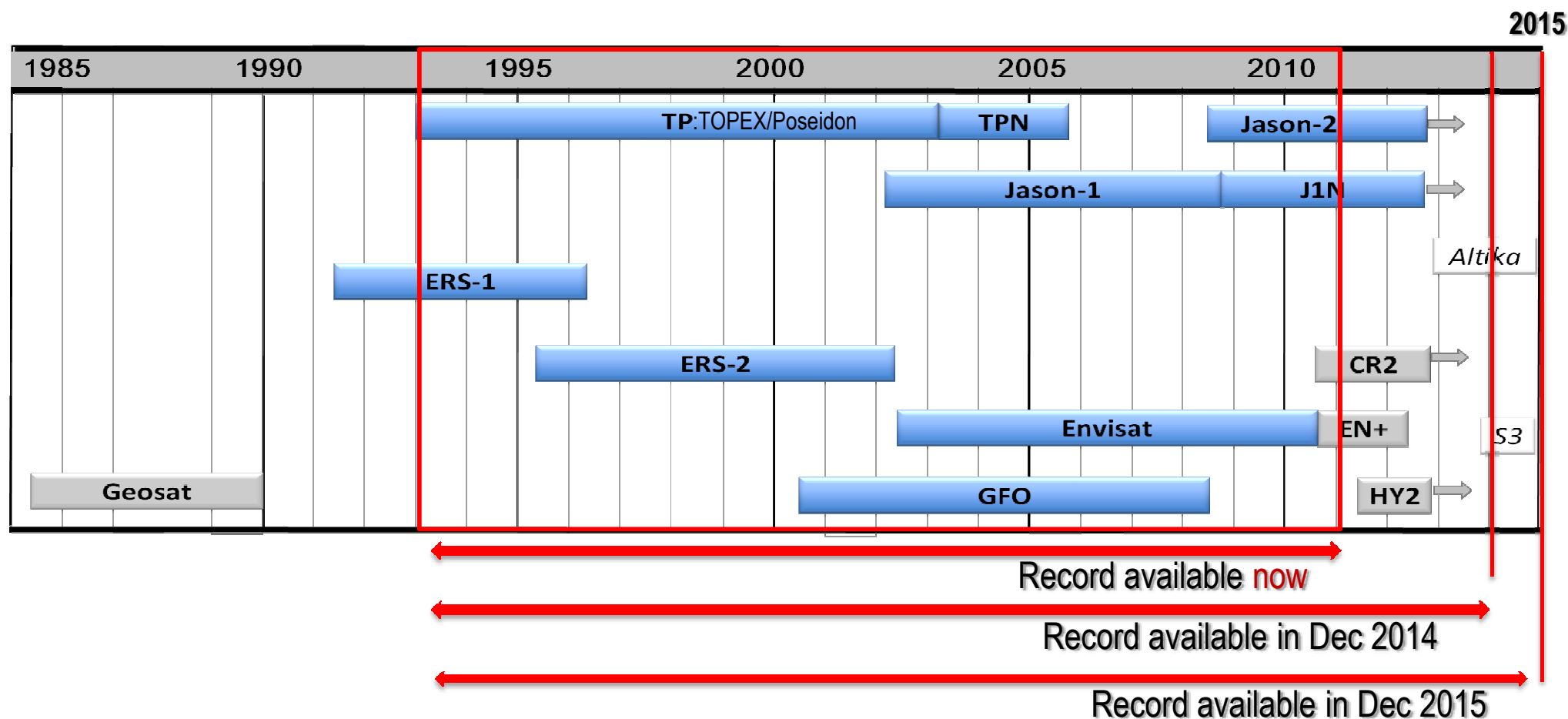
ice sheets cci

esa

European Space Agency

Objective: To realise the best long term ECVs records the full potential of the long-term global Earth Observation archives from satellites (not just ESA but all sources via international collaboration) as a significant and timely contribution to the ECV databases required by UNFCCC

What is in the CCI-sea level product?

Based on satellite data from ESA, CNES, EUMETSAT, NASA, NOAA, US NAVY, ISRO

CCI product: same approach as AVISO with different standards

Level 0: Data acquisition

Level 1: Raw telemetry

Level 2: Altimetry data
1) instrumental errors
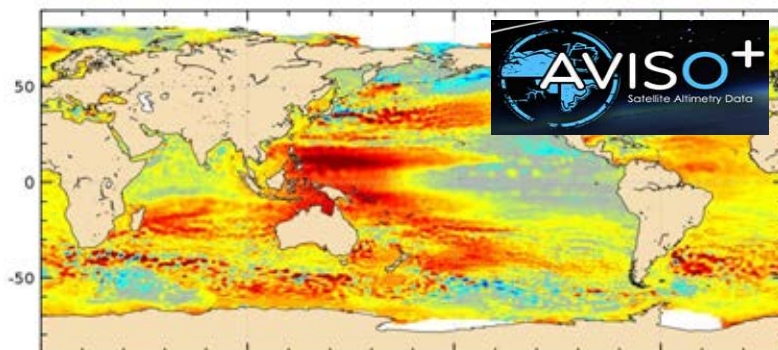2) atmospheric propagation and perturbations
3) Geophysical corrections
4) POD
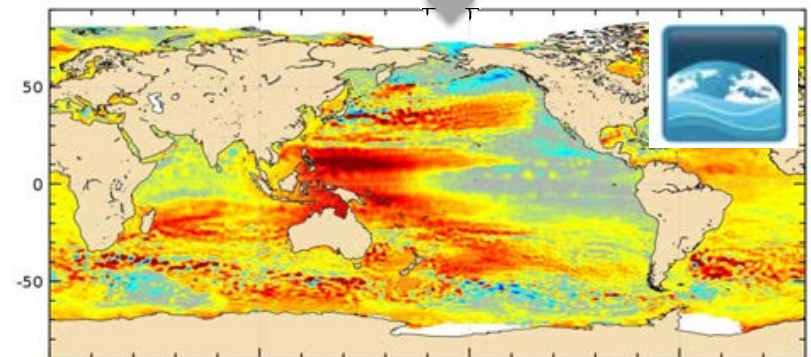
Same standards when possible

Level 2: Altimetry data
1) instrumental errors
2) atmospheric propagation and perturbations
3) Geophysical corrections
4) POD

Level 3: Cross calibration and Validation

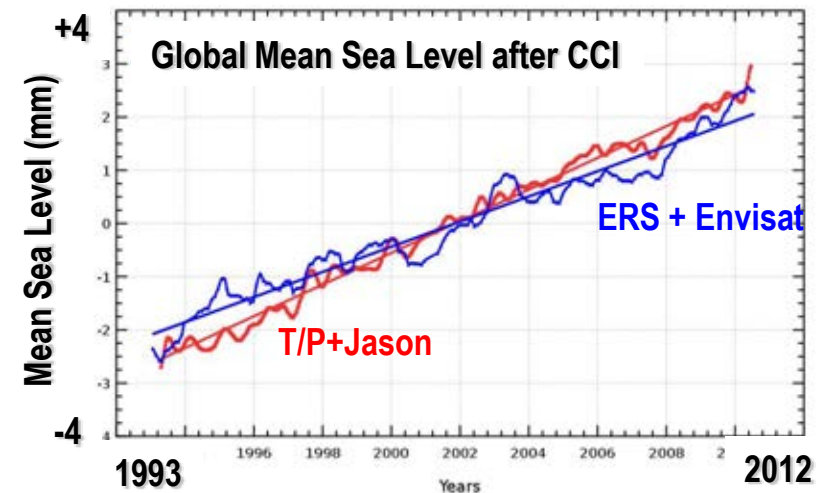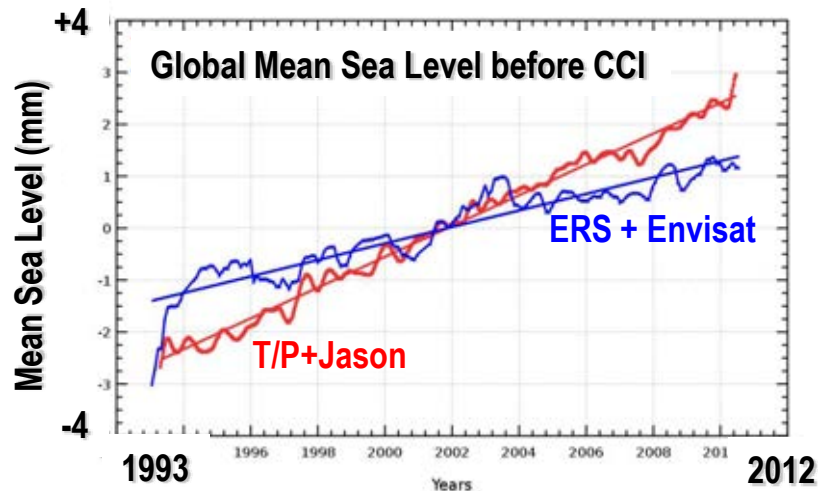**Level 4: Final products**

Level 4: Final products

Objective: get the best long-term trends and decadal variability possible.
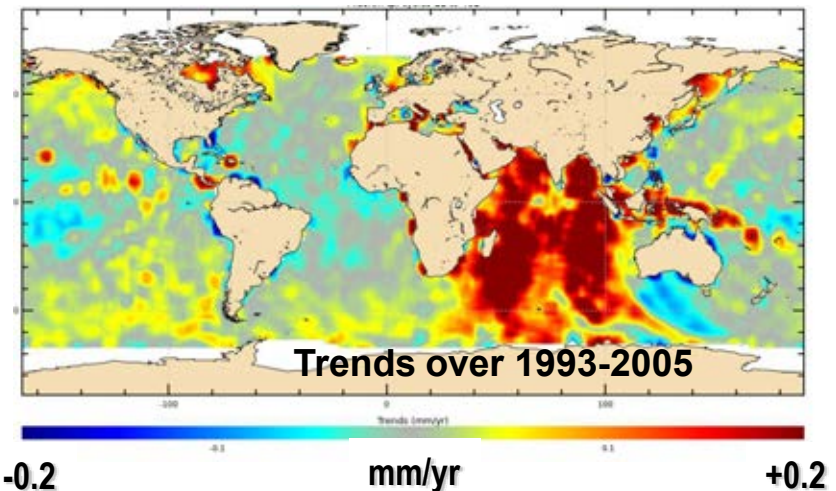
Improvements of the sea level record for climate studies: on the GMSL

- **New instrumental correction for ENVISAT: GMSL trend more consistent between ERS-ENVISAT and Topex-Jason**

Global Mean Sea Level before CCI

Mean Sea Level (mm)

ERS + Envisat

T/P+Jason

1993   2012

Global Mean Sea Level after CCI

Mean Sea Level (mm)

ERS + Envisat

T/P+Jason

1993   2012

- **New wet troposphere corrections based on the GNSS path delays**

Trends over 1993-2005

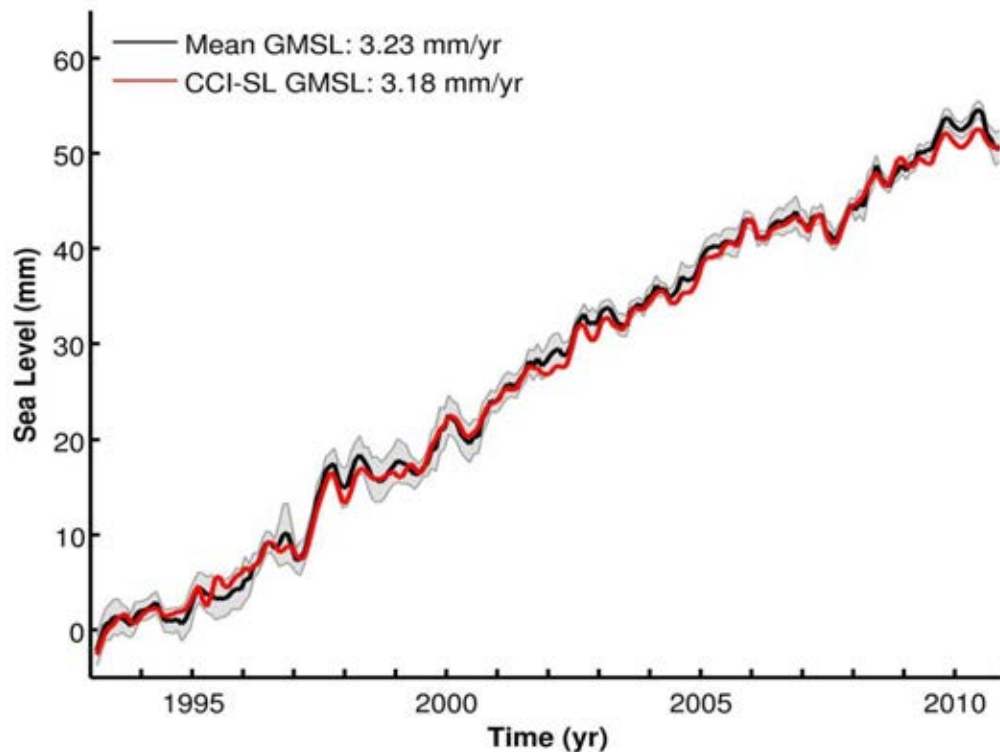-0.2   mm/yr   +0.2
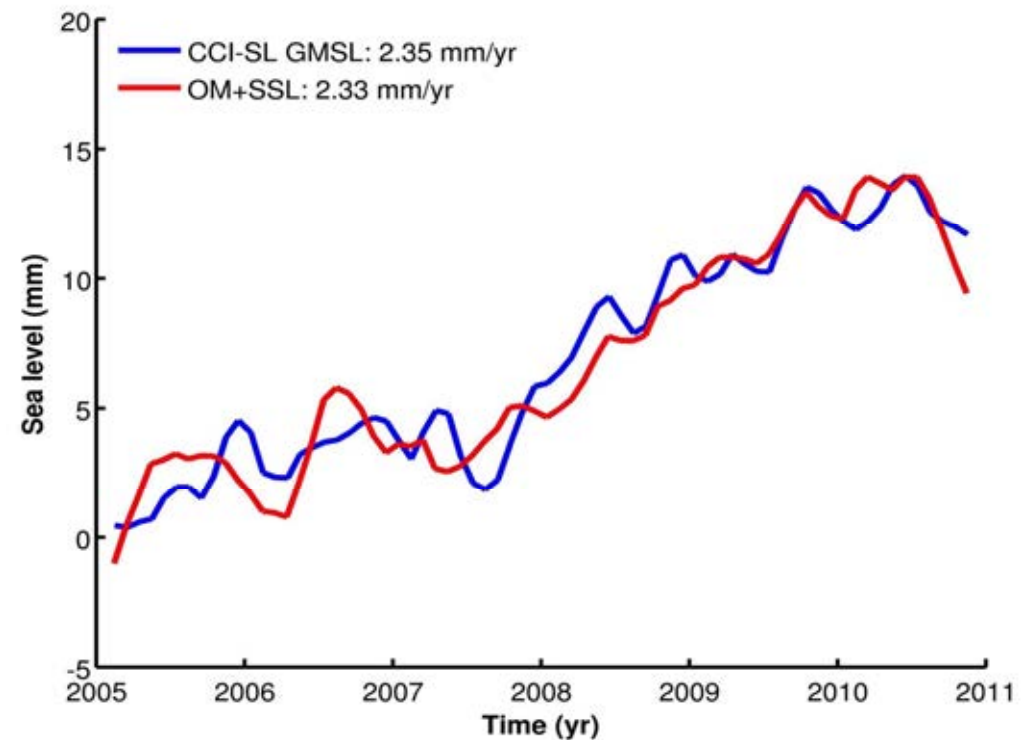
Improvements of the sea level record for climate studies: Validation

CCI Global mean sea level

Global mean sea level (average of AVISO, Colorado University, NOAA and GSFC data)

Mean GMSL: 3.23 mm/yr
CCI-SL GMSL: 3.18 mm/yr

CCI-SL GMSL: 2.35 mm/yr
OM+SSL: 2.33 mm/yr
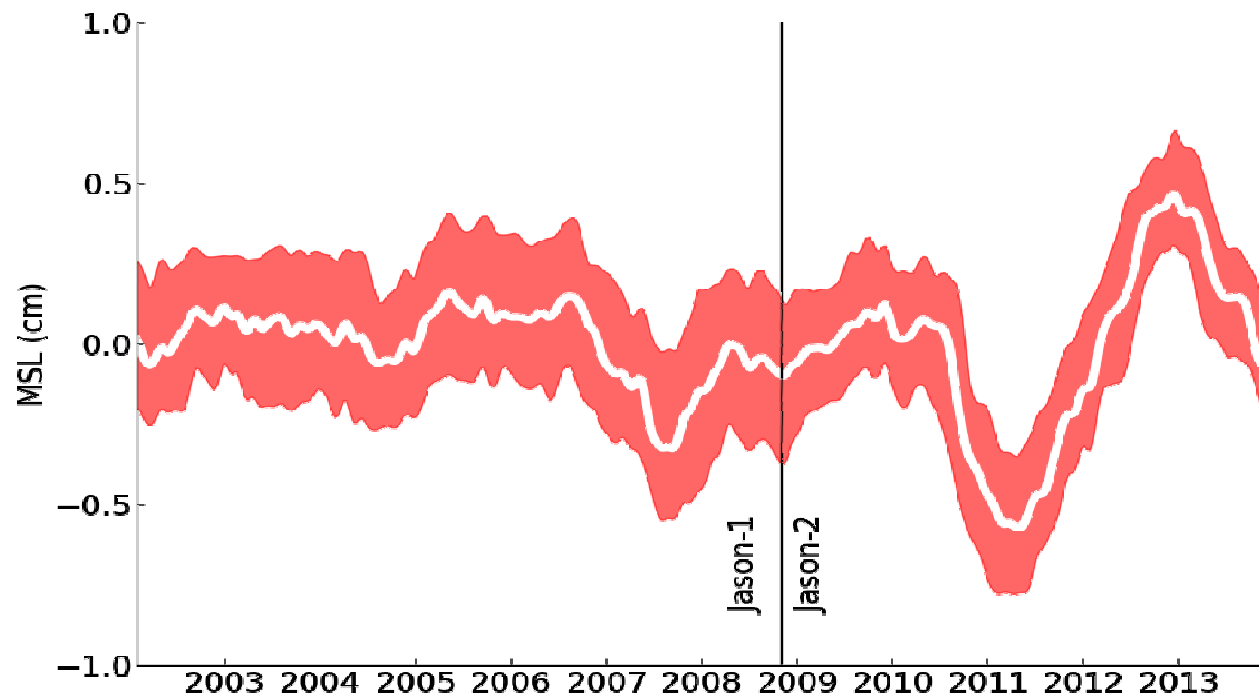
Global mean sea level trend

Comparison with GRACE+ARGO

ESA Sea_Level_cci: Uncertainties

• **Uncertainty in GMSL trend:**
±0.5 mm/yr over 1993-2010 and **±0.36 mm/yr** over 2000-2010

• **Uncertainty in GMSL variations (available in the next release): ~±2. mm**

More details in poster n°152 (Thu, Oct 30 2014, 09:00 - 10:30): Ablain et al.

« Confidence envelop of the global MSL time series deduced from TOPEX, Jason-1 and Jason-2 altimeter missions. »
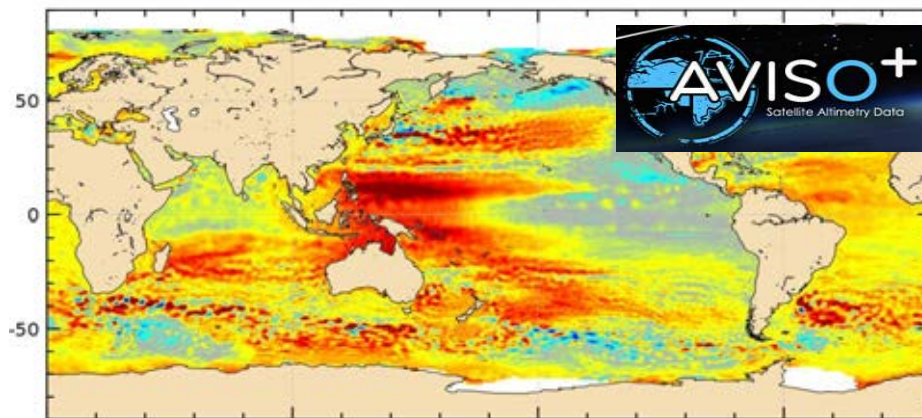
ESA Sea_Level_cci: Uncertainties

Uncertainties

Spatial Scales	Temporal Scales	GCOS* Requirements	CCI product errors
Global Mean Sea Level (10-day averaging)	**Long-term evolution** (> 10 years)	0.3 mm/yr	< 0.5 mm/yr
	Inter annual signals (< 5 years)	0.5 mm over 1 year	< 2 mm over 1 year
	Periodic signals (Annual, 60-days,…)	Not defined	Annual < 1 mm 60-day < 5 mm
Regional Mean Sea Level (2x2 deg boxes and 10-day averaging)	**Long-term evolution** (trend)	1 mm/yr	< 3 mm/yr
	Inter annual signals (> 1 year)	Not Defined	Not evaluated
	Periodic signals (Annual, 60-days,…)	Not Defined	Annual < 5mm 60-day < 10 mm

* More details to the satellite-based component of the "Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (2010 Update)" GCOS-154, december 2011)
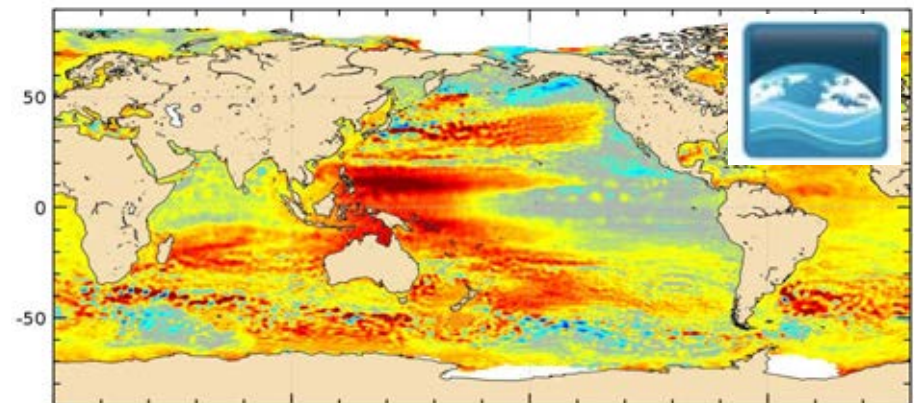
different products for different needs

Link: http://www.aviso.altimetry.fr

dataset: daily, along track or gridded (¼°x¼°)
Many products: mono and multi-mission near
RT or delayed (with update ~5month)

objectives: optimised for mesoscale and ocean
circulation. Provide frequently updated data and near RT
products, high accuracy GMSL…
common applications: sea level studies at
monthly to multi-decadal time scales, ocean
circulation studies operationnal oceanography,
assimilation in reanalysis(1993-2013).

Link: http://www.esa-sealevel-cci.org

dataset: monthly, gridded (¼°x¼°)

1 product: multi-mission, delayed (with
update ~1yr, starting in Dec 2014)

objective: optimised for long-term trends and
decadal variability
common applications: sea level studies at
interannual to multi-decadal time
scales, trend studies, assimilation
in long term reanalysis (1958-2013).

Sea_Level_cci Phase 2

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Sea_Level_cci Phase 2

The CCI phase I achievements have encouraged the continuation of the work by launching the phase II of the program. This new phase, started in 2014 for 3 additional years, will allow us to explore the new areas of improvement which arose in phase I.

Evolutions of the algorithms are central to the project since they affect the physical content of the Sea Level CCI ECV products. The strategy is thus to refine the user requirements and to focus on the improvement of the altimeter corrections which constitute the most important sources of errors with respect to the climate scales.

The main challenges are:
- Altimeter and radiometer processing: use a multi-mission instrument expertise to enhance all the altimeter and radiometer calibration accuracy.
- Improved orbits: provide the best homogeneous solution for all missions. • Sea Level corrections: homogeneous and stable time series using, for example, the most recent reanalyzed models.
- Arctic region: reduce the altimetry errors at high latitudes.
- Coastal areas: improve the sea level near the coasts.

All these developments will provide us with the opportunity to increase the synergy between the altimeter experts and other communities, particularly the atmosphere and sea ice communities.

Sea_Level_cci Phase 2

A specific task will be dedicated to the assessment of the ECV products by Climate Research Group: this will first be done through assimilation and comparison with ocean models outputs.

The error of the products will be characterized through sea level closure budget analyses and international inter comparison exercises.

This work will be performed keeping in mind the phase I achievements. This will be the opportunity to increase the link with other ECVs (SST, Sea Ice, Ice Sheets).

The new ECV versions will be distributed on request to users.