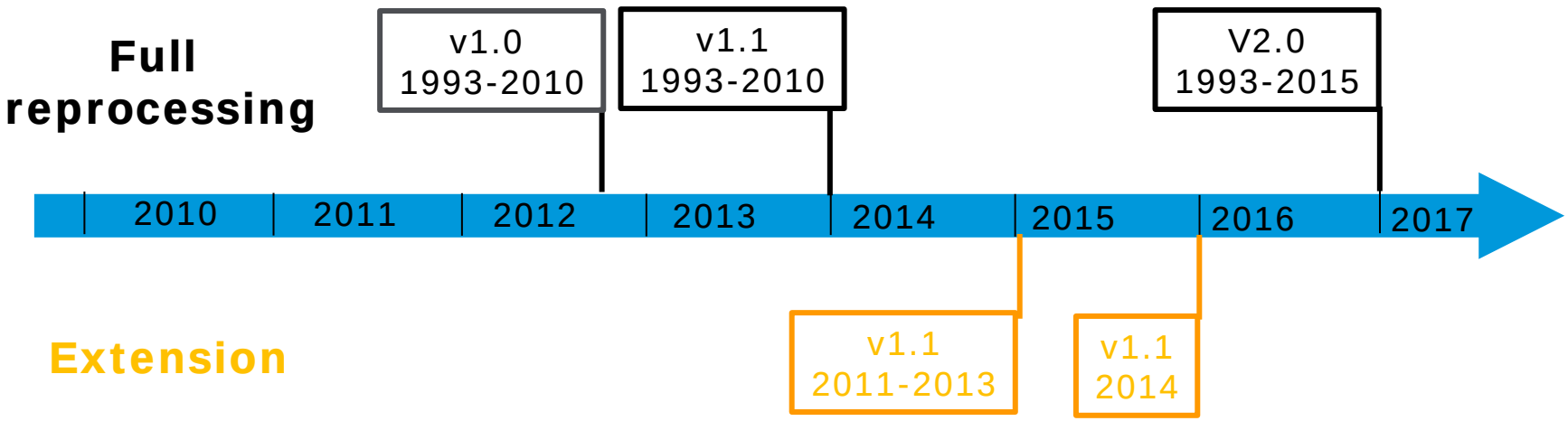
Sea Level CCI status

CMUG meeting
13-14 Feb. 2017

Outline

1. Strengths and features of the final dataset
2. Consistency with other ECVs and other Earth obs data
3. Examples of data use
4. Future possible research directions
5. Obs4MIPs status

Overview of products delivery

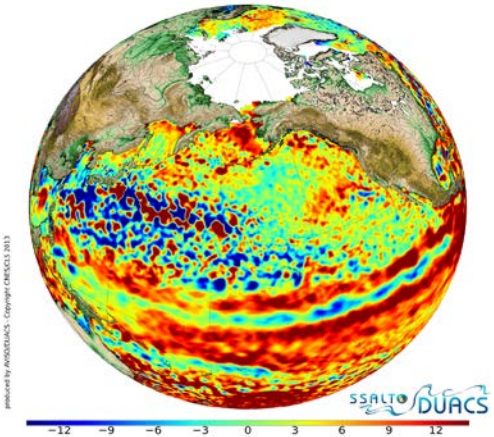


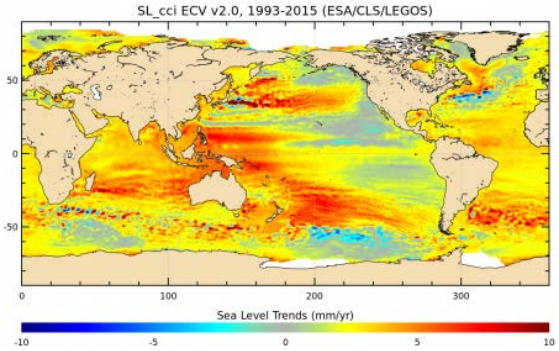
SL_cci v2.0

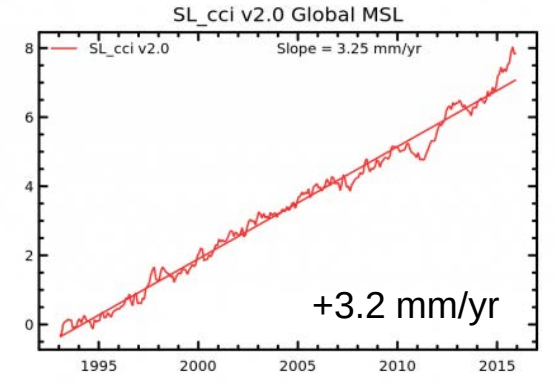
1- Global Product
2- Arctic Ocean
3- Coastal areas
4- Quality Assessment and Uncertainties

The SL_cci ECV v2.0 consists in **monthly sea level maps (1/4°)** and associated **ocean indicators**

- Period: 1993-2015
- 9 altimeter missions: TOPEX/Poseidon, Jason-1/2, ERS-1/2; Envisat, Geosat-FO, CryoSat-2 and SARAL/AltiKa
-
- 70 cumulated years



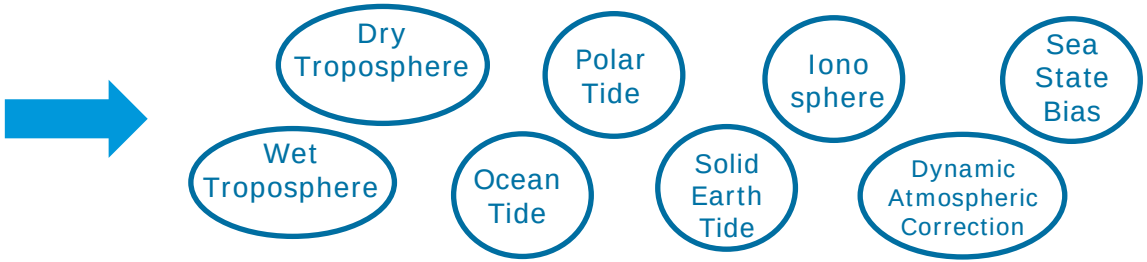




Available via www.esa-sealevel-cci.org
Request at info-sealevel@esa-sealevel-cci.org

The altimeter sea level estimation relies on **various different subsystems**

Altimeter Sea Level
=
Orbit
- Altimeter Range
- ∑ Geophysical Corrections



⇒ A **huge amount of different algorithms** (Level 2) is required.

⇒ Main outcome of CCI: to set up **a formal protocol to develop, validate and select** the best algorithms that contribute to increase the **ECV homogeneity, stability**

Climate Applications	Temporal Scales	Algo 1 vs Algo 2
Global Mean Sea Level	Long-term evolution (trend)	?
	Inter annual signals (> 1 year)	?
	Periodic Signals	?
Regional Mean Sea Level	Long-term evolution (trend)	?
	Periodic Signals	?
Mesoscale	Signals < 2 months	?

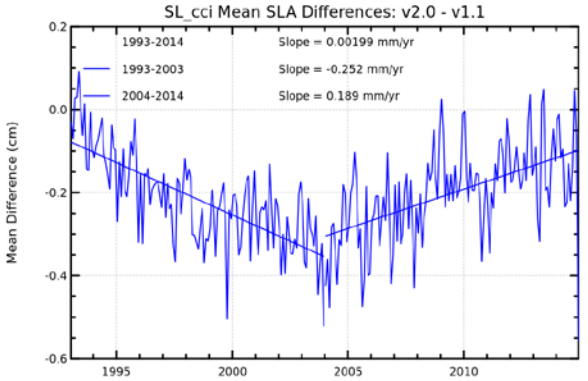
SL_cci v2.0

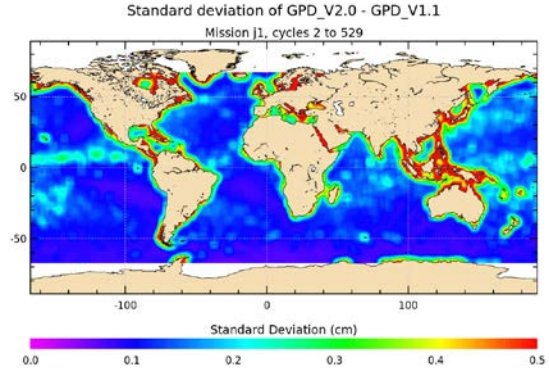
1- Global Product
2- Arctic Ocean
3- Coastal areas
4- Quality Assessment and Uncertainties

Climate Applications	Temporal Scales	v2.0 vs v1.1
Global Mean Sea Level	Long-term evolution (trend)	+ +
	Inter annual signals (> 1 year)	+
	Periodic Signals	+
Regional Mean Sea Level	Long-term evolution (trend)	+ + +
	Periodic Signals	+ +
Mesoscale	Signals < 2 months	+ +

Illustrations of the major impacts of the new altimeter L2 corrections:

• New GPD+ wet troposphere correction (Fernandes et al., 2015) impacts: - The **global MSL decadal signals**,
- **Mesoscale signals in coastal areas**.

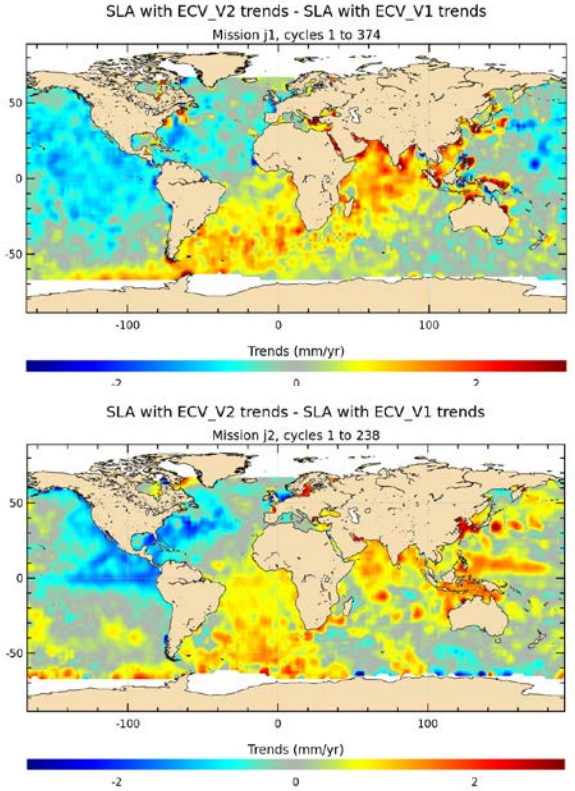




Illustrations of the major impacts of the new altimeter L2 corrections:

• New GPD+ wet troposphere correction (Fernandes et al., 2015) impacts: - The **global MSL decadal signals**,
- **Mesoscale signals in coastal areas**.

• The new POE-E, GFZ and GSFC std15 **orbit solutions** affect the **regional MSL trends**.

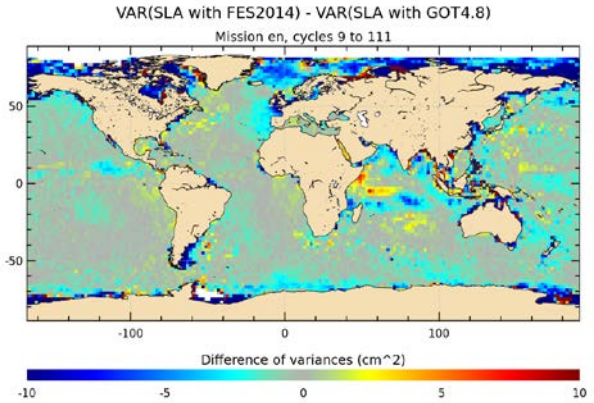


Illustrations of the major impacts of the new altimeter L2 corrections:

• New GPD+ wet troposphere correction (Fernandes et al., 2015) impacts: - The **global MSL decadal signals**,
- **Mesoscale signals in coastal areas**.

• The new POE-E, GFZ and GSFC std15 **orbit solutions** affect the **regional MSL trends**.

• **Reduced sea level variance** in many **coastal areas** and at **high latitudes** due to the **new FES2014 ocean tide model**



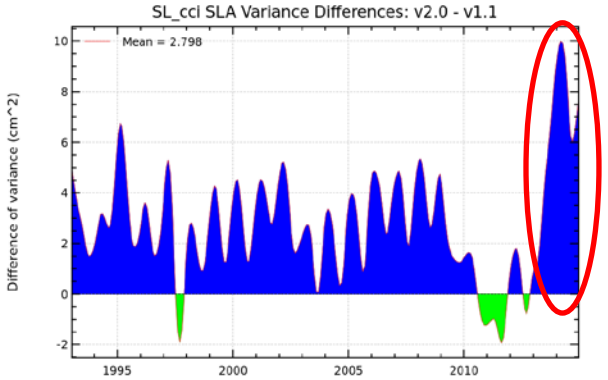
Illustrations of the major impacts of the new altimeter L2 corrections:

• New GPD+ wet troposphere correction (Fernandes et al., 2015) impacts: - The **global MSL decadal signals**,
- **Mesoscale signals in coastal areas**.

• The new POE-E, GFZ and GSFC std15 **orbit solutions** affect the **regional MSL trends**.

• **Reduced sea level variance** in many **coastal areas** and at **high latitudes** due to the **new FES2014 ocean tide model**

• Impact of the satellite constellation: **introduction of new missions** (CryoSat-2 and SARAL) increases the variance of products.



SL_cci v2.0 2- Arctic Ocean

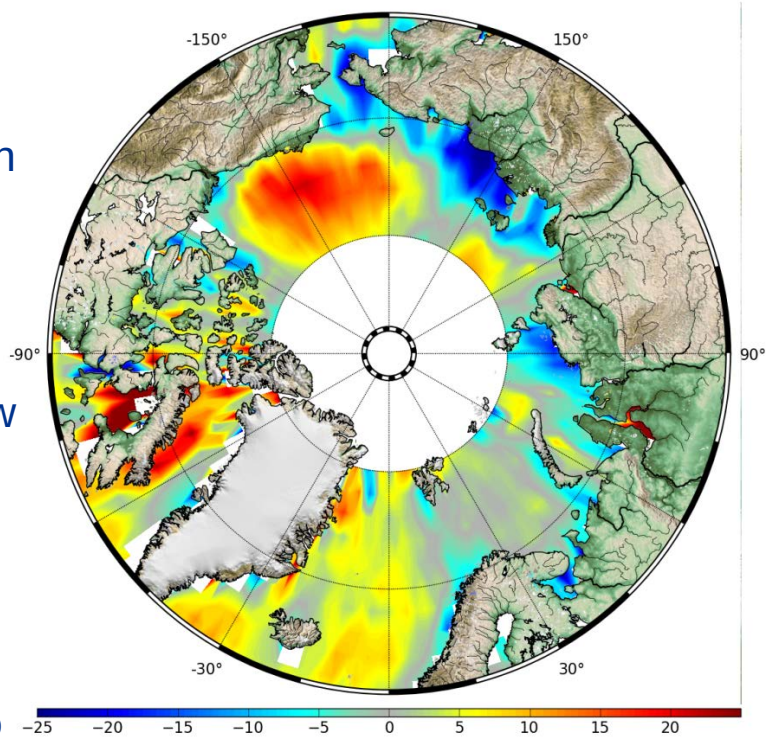
Improved sea level estimation in the **Arctic Ocean:**

→ **New arctic Sea-Level products available (demo)** : new waveform classification and retracking algorithm for Envisat and SARAL missions (CLS, PML; Poisson et al., in prep)

→ Improved data coverage

→ on going work: Regional Closure budget seems to show that CCI product seems better than DTU ERS-1/2 product (Carret et al, 2016)

Monthly sea level maps from Envisat and SARAL data

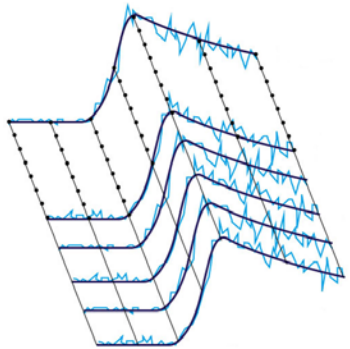


- **Coastal improvements of the altimeter measurements:**

→ New **wet troposphere correction** based on radiometer and **GNSS** measurements (GPD)

→ New **ocean tide models** (FES14)

→ Improved retracking of the altimeter radar echo in coastal areas (**2D waveform retracker**) (NOC)



SL_cci v2.0 3- Coastal areas

- **Coastal improvements of the altimeter measurements:**

→ New **wet troposphere correction** based on radiometer and **GNSS** measurements (GPD)

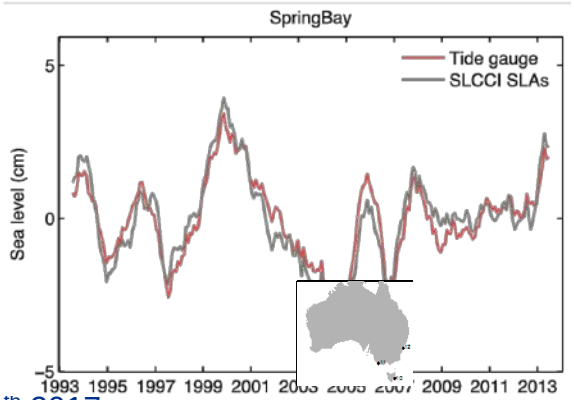
→ New **ocean tide models** (FES14)

→ Improved retracking of the altimeter radar echo in coastal areas (**2D waveform retracker**) (NOC)

- **Coastal areas MSL validation (on going work, TUD):**

→ Regional **in-situ validation** against **geodetic data** (tide gauges + GPS)

→Validation with **tide gauges** and estimation of the **total relative sea level** at the coast



SL_cci v2.0

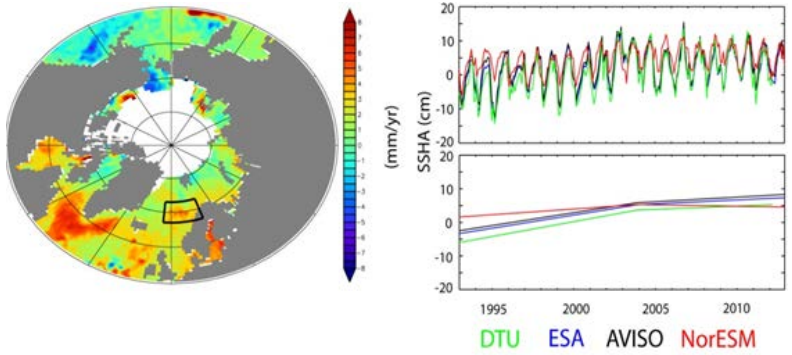
4- Quality Assessment and Uncertainties

The **quality of the Sea Level ECV** is assessed through:

1- Internal validation:
Multi missions **inter comparisons** and **consistency analyses**

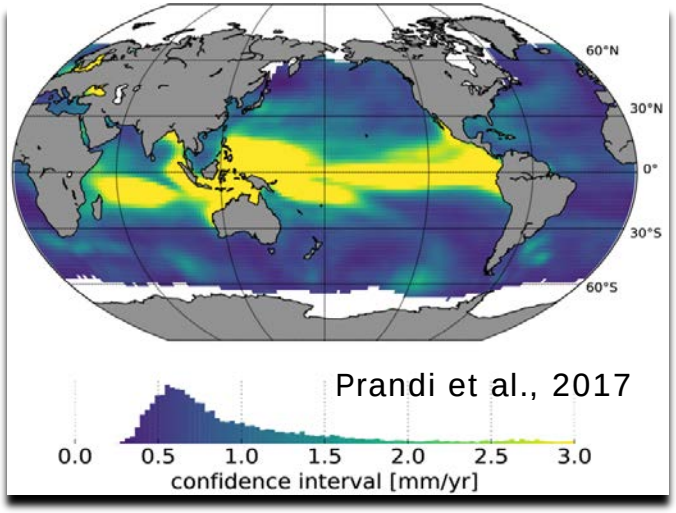
2- Closure budget approach:
The **Global Mean Sea Level** is compared with the **sum of mass and steric components**

3- Comparison with ocean and coupled models outputs:
- Analysis of **MSL trends** and subtropics signals,
-Comparison of the SL_cci ECV with **model outputs at high latitudes**
- Impact of the **assimilation of the Sea Level ECV** on the performances of ocean models



- Altimetry measurements errors have been specified at different climate scales (Ablain et al., 2015),
- The regional MSL trends uncertainties have characterized (Prandi et al., in preparation)

Spatial Scales	Temporal Scales	User Requirements	Altimetry errors CCI products
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 < 1mm 60-day < 5 mm**



Ablain et al., 2015

Cross-ECVs consistency

The **Sea Level ECV** can be validate by budget approach :

Observed Global Mean sea Level

=

Ocean Thermal Expansion + Ocean Mass

mean of 6 altimetry-based products
(AVISO, CCI_V2.0, Colorado Univ., CSIRO, GSFC, NOAA)

(1) prior to Argo: mean of 3 data sets (NOAA, Jamstec, EN4)
(2) as of 2005: mean of 4 Argo data sets (CORIOLIS, IPRC, Jamstec, SCRIPPS)

$$\Delta M_{ocean} = -\Delta M_{LI} - \Delta M_{LW} - \Delta M_{WV} - \Delta M_{Snow} - \ldots\ldots$$

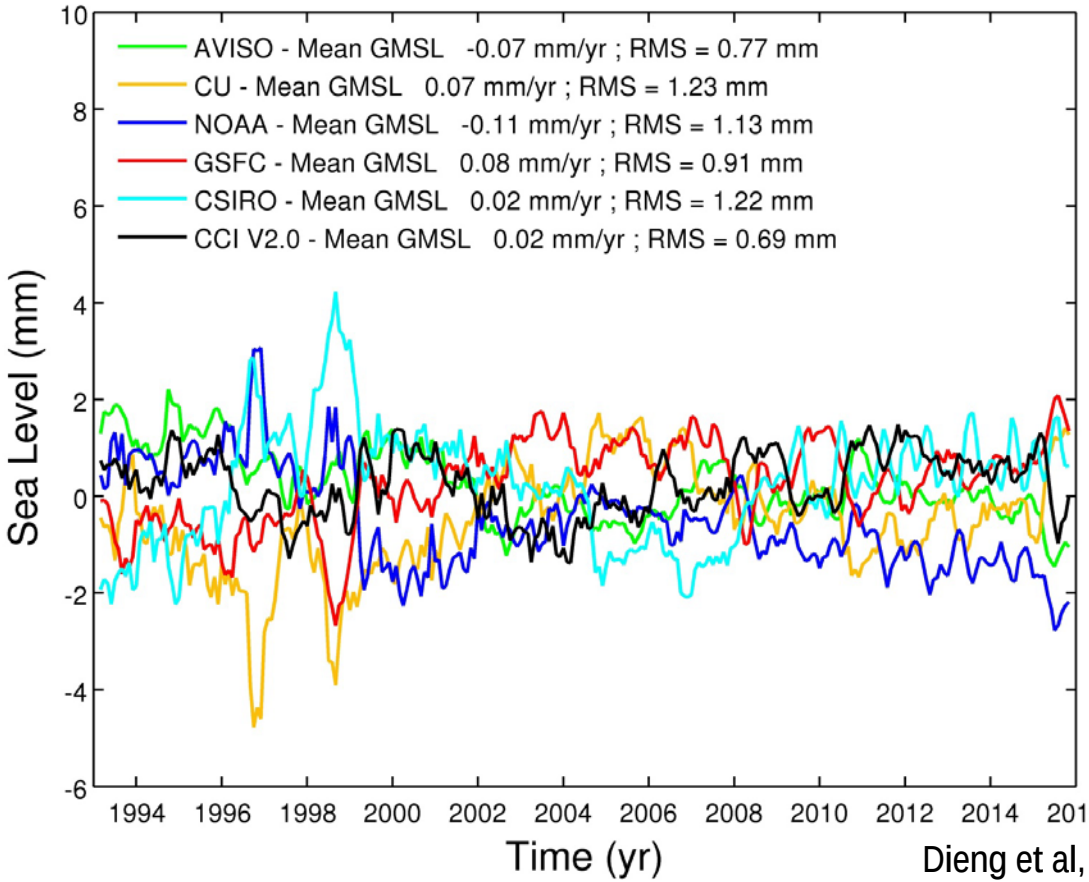
Ocean mass — *Land ice* — *Land waters* — *Atmospheric water vapor* — *Snow*

- Glaciers: mean of 3 data sets (Marzeion, Leclercq, Cogley)
- Ice sheets: IMBIE data up to 2003; data from the CCI project as of 2003
- Land Waters: 4 hydrological models (ISBA/TRIP, WGHM, GLDAS, MERRA) + long-term trend from Wada et al. (2016) for anthropogenic factors
- Atmospheric water vapour: data from the ERA Interim reanalysis

Cross-ECVs consistency

Difference time series between individual GMSL products and the ensemble mean

The smallest residual is obtained with the CCI product



Dieng et al, 2017

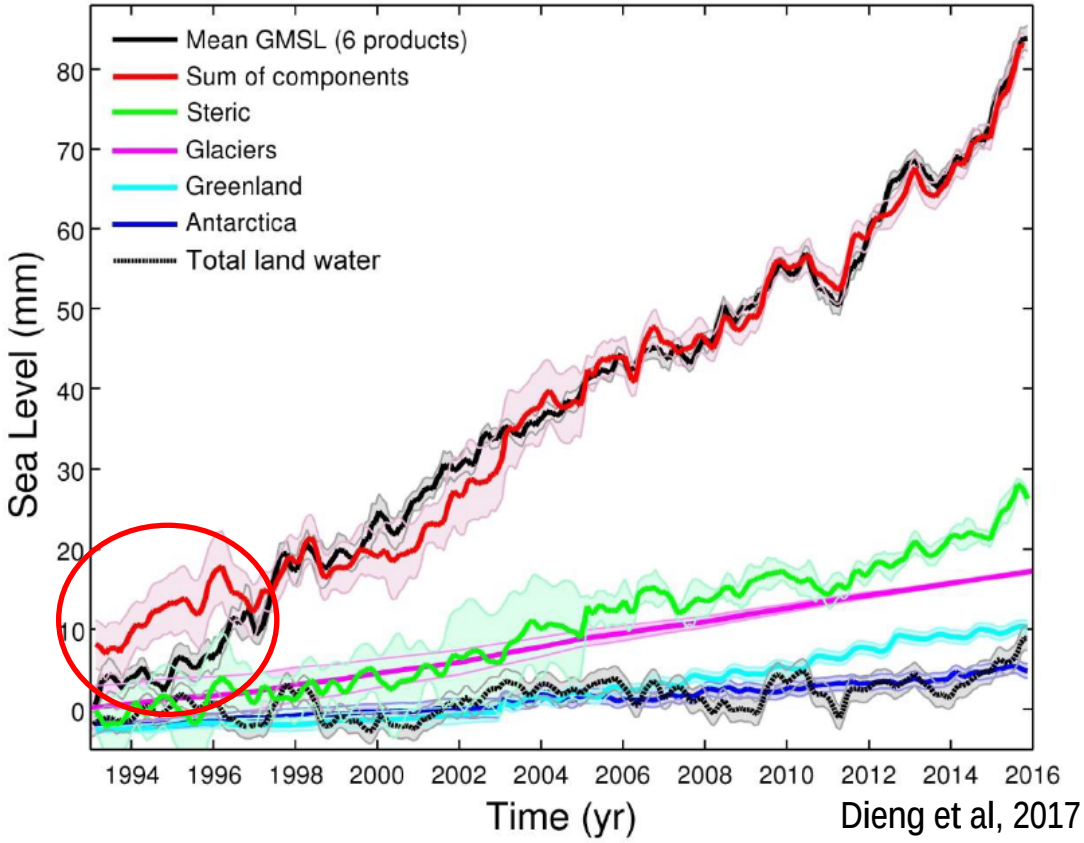
Cross-ECVs consistency

Using the sum of contributions to the GMSL provides an alternative for estimating the TOPEX A instrumental drift ?

-Zawadski et al., 2016 (comparison witt he Poseidon data) → 2.8 mm/yr

- Watson et al., 2015 (comparison with tide gauges) → 1 -1.5 mm/yr

Value estimated here (linear regression fit to the sum of components):
→1.4 +/- 0.2 mm/yr



Dieng et al, 2017

Data Use

- **User's interests obtained from contacts through CCI user-desk**

- Analyses of the **global sea level change** (ocean circulation, ocean dynamics, variability and trends) **globally** and in some **specific regions**

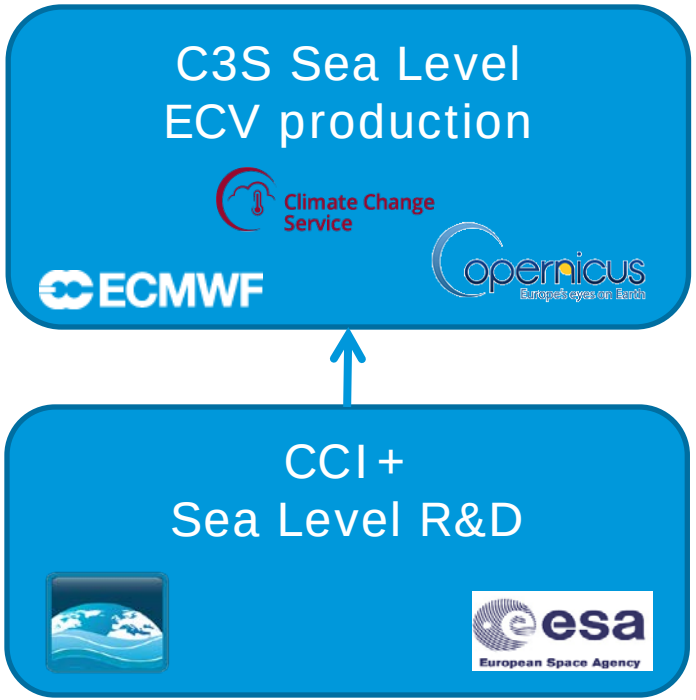
- Comparison with **ocean models** (validation) and impact of **data assimilation**

- Comparison with other ECVs (Ocean colour, SST) and independent data (tide gauges)

→ After 6 years of CCI, the Sea Level ECV is now a variable well recognised and more used by climate modelling group.

Perspectives

- End of SL_cci project phase II in early 2017
- **Copernicus Climate Change Service** (C3S, ECWMF) will set up a routine and sustained Service for the operational production of the Sea Level ECV (KO oct 2016).
- **Strong needs to continue R&D for the Sea-Level project in the following CCI+ project** (from 2018):
  - →To reach **GCOS requirements**
  - →To contribute to the **C3S service evolution**



Perspectives

- To integrate **new altimeter missions**:
  - → Jason-3, Sentinel-3a,/3b, Sentinel-6…

- To integrate, evaluate **new Level-2 products**:
  - → TOPEX/Poseidon repossessing (JPL/CNES)
  - → ERS-1/ERS-2 (ESA), …

→ Do NOT Forget the old missions !

- To **develop, integrate, evaluate new altimeter standards:**
  - → new orbit solutions (new gravity fields,..)
  - → new atmospheric corrections (ECMWF rean.)
  - → more stable wet troposphere correction
  - → new ocean tide models

Perspectives

- **Arctic Ocean:**
  - →To **extend times series** from 1993 onwards (ERS1 and ERS-2, Cryosat, Saral/Altika, Sentinel-3,…)
  - → To **improve algorithms** (classification, retracking, editing, merging…)
  - → To **validate MSL changes** (MSL closure budget, in-situ comparaisons,…)

- **Coastal Sea Level:**
  - → To extend measurements **closer to the coast**,
  - → Impact of Sentinel-3a mission (SAR mode), link with tide gauges,…
  - → Take into account **vertical land motion** impact,

Perspectives

- **To better characterize MSL uncertainties:**
  - → At global, regional & inter-annual scales
  - → For each MSL estimation
- **To perform MSL closure budget studies :**
  - → To validate the MSL content and to better know sea-level rise components

New CCI Sea Level Budget Closure project (SLBC_cci)

Kick-Off meeting: 6-7 March 2017 (ESA/ESRIN)

Nominal duration of the project : 2 years

Team: Project PI: Martin Horwatt TUDr (TU Dresden) ; LEGOS; UB (U. Bremen); UZH (U. Zürich); UoL (University of Leeds); GUF(U. Frankfurt); DTU; NERSC; U. Reading (Mercator-Ocean)

Obs4MIPs status

CCI Data Portal Task 5:

- **Objective** is to provide the CCI dataset for Climate Modelers via the **Observations for Model Inter-comparisons activity**.

- This will be an updated version of the AVISO dataset (ADT) provided in 2011.
- Long discussion with the WDAC team to agree on the key parameter to be submitted:

  The **Absolute Dynamic Topography** (ADT) derived from the **SL_cci ECV v2.0:**

  ADT = Sea Level Anomaly (SL_cci ECV) + Mean Dynamic Topography

A dedicated **technical note** has been submitted, describing the key parameters and generation process:

⇒ A positive feedback has been received.

⇒ The preparation of the ADT times series based on SL_cci SLA v2.0 is in progress.

⇒ Further conversion to the Obs4MIP netCDF format will be required with appropriate metadata

Thanks for your attention!

Final Meeting planned on 27-28 Feb. 2017

(ESRIN)