A New ECV Release (v2.0) to Accurately Measure the Sea Level Change from the ESA Climate Change Initiative

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I – The Sea Level Climate Change Initiative (SL_cci) project overview

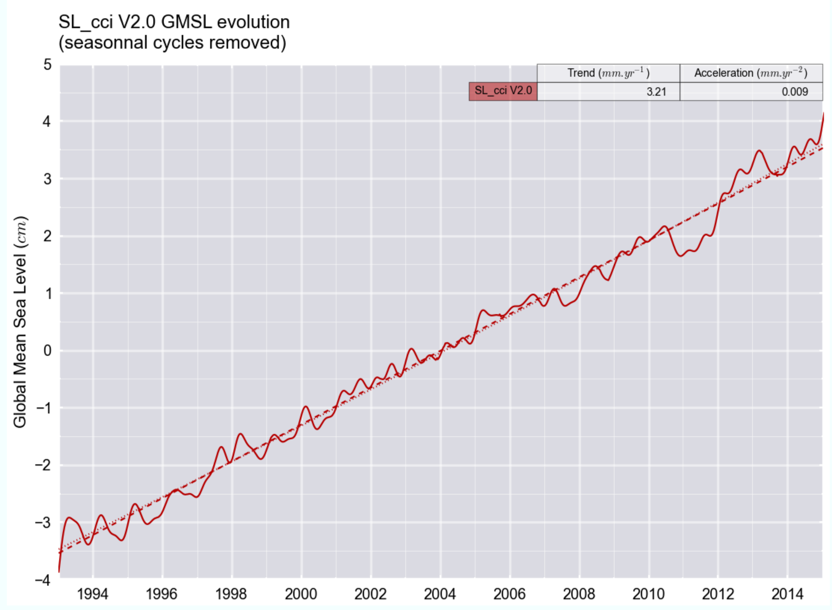
Sea Level is a **very sensitive index** of **climate change and variability**. It has been selected as an **Essential Climate Variables (ECV)** by the European Space Agency (**ESA**) which has initiated the **Climate Change Initiative** (CCI) programme, launching 13 ECV projects. It aims at providing accurate long-term **satellite-based products for climate** applications. It provides a unique opportunity to dialogue and cooperate between **Earth Observation** and **Climate Research** communities. The **first version of the Sea Level ECV** has been **produced** in 2012 and a full reprocessing of the ECV will be released in Dec. 2016. This new version is described here as well as the differences with the previous release. The project has also focused on the improvement of the **regional sea level estimation** and the better **characterization of uncertainties**.

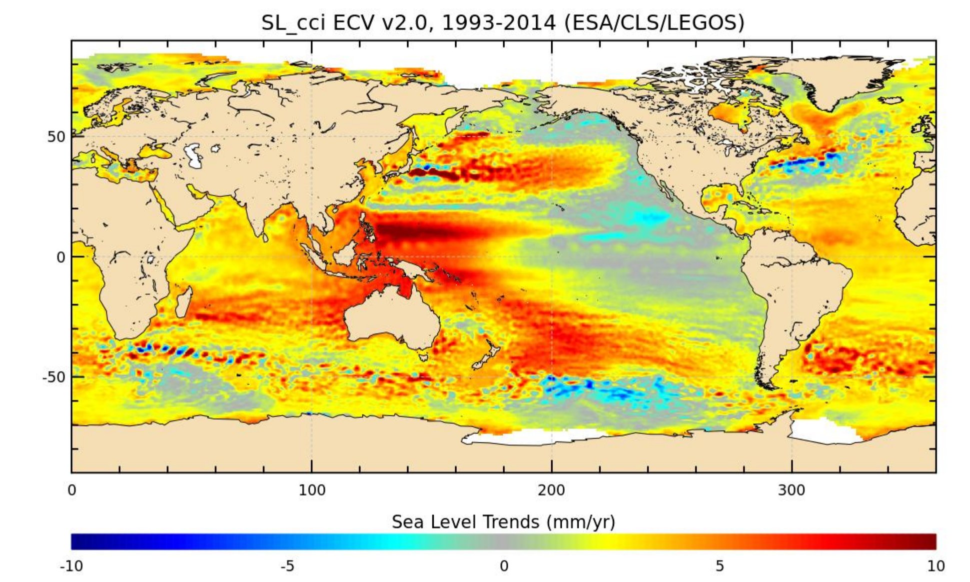
II - The Sea Level CCI ECV products

The **SL_cci ECV v2.0 maps of the sea level** are generated **from 1993 to 2015**. They will be available (in Dec. 2016) upon request at info-sealevel@esa-sealevel-cci.org. The Product User Guide and Specification Document can be found on the website project: www.esa-sealevel-cci.org

Associated **Climate Sea Level** indicators are also available for users. They concern:

- The **global Mean Sea Level (MSL) evolution** and its **trend** (left figure)
- The **map of regional MSL trends** (right figure)
- The **amplitude and phase** of the **annual cycle** of the sea level (not shown)



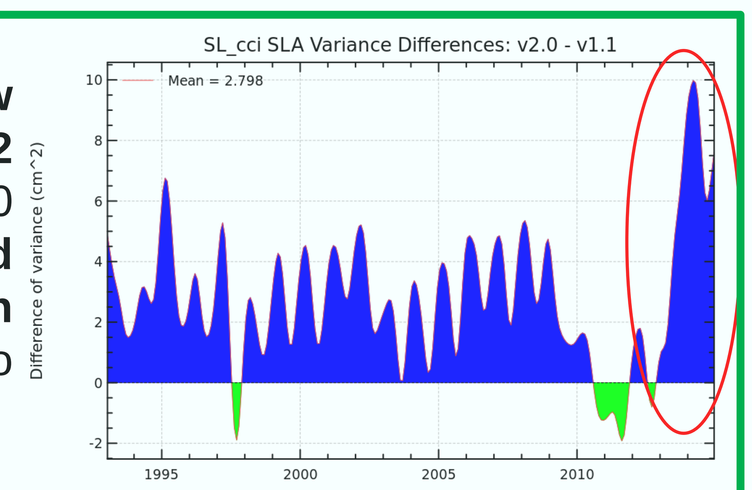


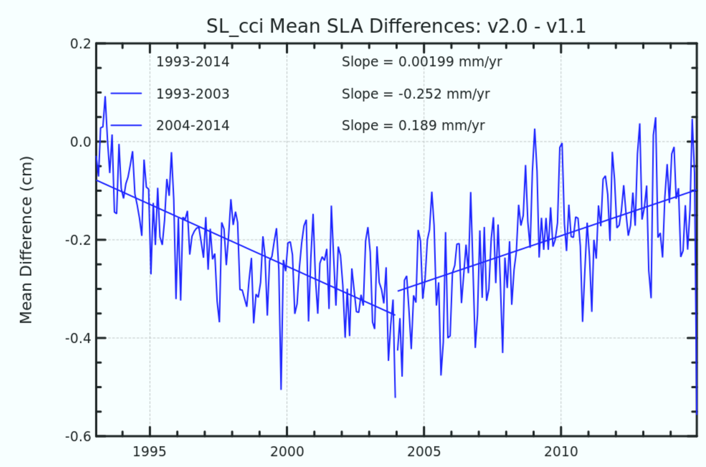
III – Comparison of v2.0 versus v1.1

For the **v2.0 ECV** (1993-2015), many algorithms have been developed and tested for the numerous **altimeters corrections.** A **formal validation protocol** has been developed to select the **standards** that contribute to **increase the ECV homogeneity** and **reduce the errors**. The major evolutions compared with the previous release are described in the table below at the different climate scales and illustrations are provided.

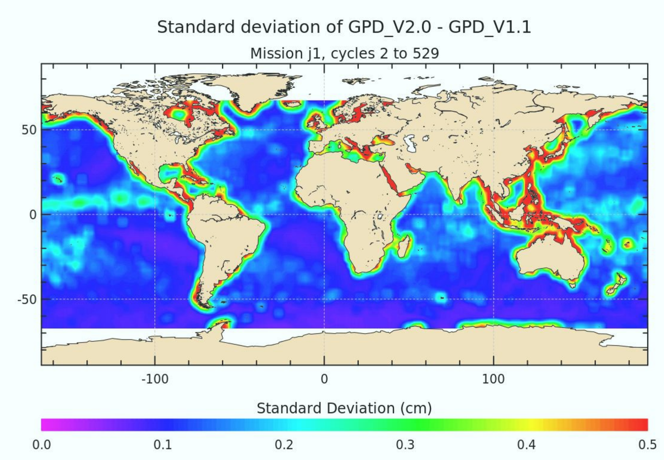
Climate Applications	Temporal Scales	v2.0 vs v1.1	Standard change mainly responsible for impact
Global Mean Sea Level	Long-term evolution (trend)	++	• Wet troposphere correction: GPD → GPD+ (Fernandes et al., 2015)
	Inter annual signals (> 1 year)	+	• Wet troposphere correction: GPD → GPD+ (2008 jump in Jason-1) (Fernandes et al., 2015)
	Periodic Signals	+	• GOT4V8 → FES2014 for J1/J2 (60-day signal) • Polar Tide: Wahr, 85 → Desai, 2015
Regional Mean Sea Level	Long-term evolution (trend)	+++	• Orbits: GSFC std15 (T/P), POE-E (J1/J2), GFZ (E1/E2/EN) • Polar Tide: Wahr ,85 → Desai, 2015
	Periodic Signals	++	• Polar Tide: Wahr ,85 → Desai, 2015
Mesoscale	Signals < 2 months	++	• 2 new missions : Saral/AltiKa and CryoSat-2 • Envisat: GPD → GPD+ with Radiometer V3.0 • Envisat: SSB Tran, 2015 • Ocean Tide: GOT4V8 → FES2014 (especially high latitudes and coastal areas)

The inclusion of **new missions (CryoSat-2 and SARAL)** in the v2.0 leads to an **improved mesoscale estimation after 2012** compared to v1.1 (see figure).

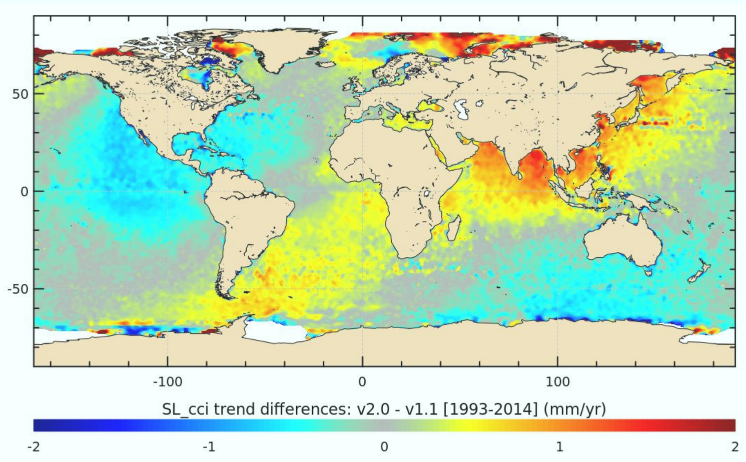


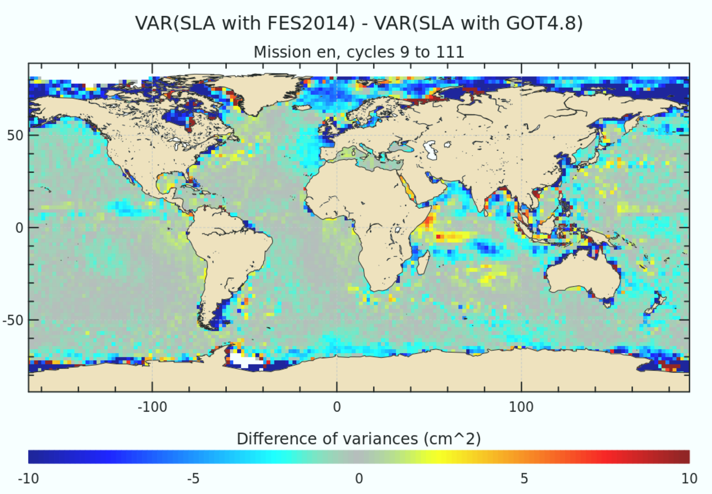


The use of the **new GPD+ wet troposphere correction** (Fernandes et al., 2015) significantly impacts the **global MSL decadal signals** (left figure) and the sea level **mesoscale** signals in coastal areas (right figure**)**. At **inter annual scale**, the 2008 global MSL jump (1 mm) previously observed in the v1.1 has been reduced (left figure).



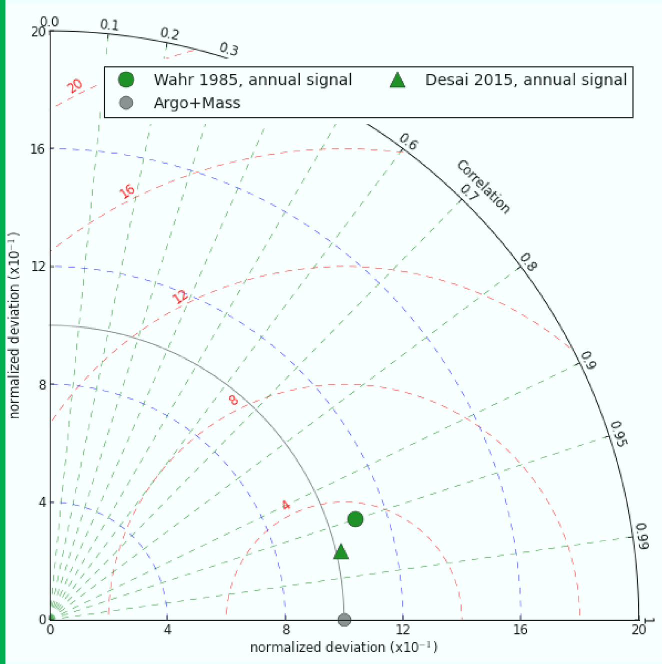
The new **POE-E, GFZ and GSFC std15 orbit solutions** (all using the same gravity field) used for the different missions improve the sea level estimation. It affects the **regional v2.0 MSL trends** compared to v1.1 (see figure).





The **FES 2014 ocean tide model** leads to a reduced variance of the sea level, in many coastal areas and at high latitudes (see figure).

The new **Polar Tide correction** (Desai, 2015) impacts the estimation of the **annual signal** and the comparison with in-situ data highlights the improvement (see below).

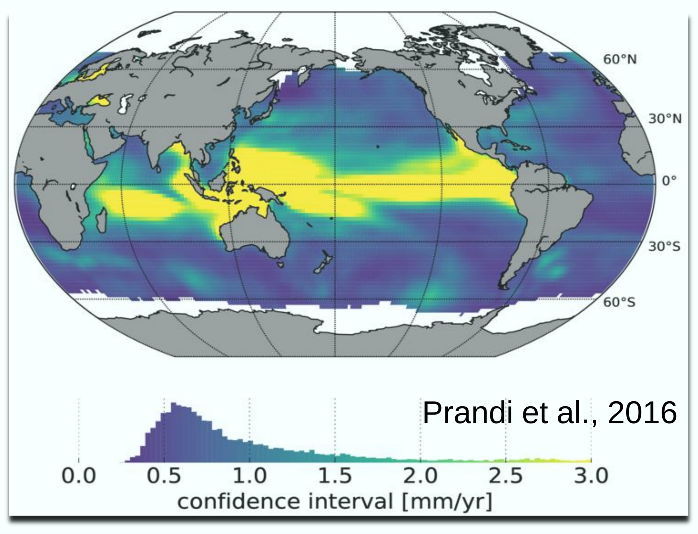


IV – Quality assessment, Arctic and coastal sea level

Error Characterization of Sea Level CCI ECV

The **sea level** ECV products **error budget** has been determined **at climate scales** (see table) through the analysis of **each source of error**. The comparison with the **user requirements** (defined in the CCI project and the last GCOS report) allows us to define the **level of altimetry errors at climate scale**: null, low or strong.

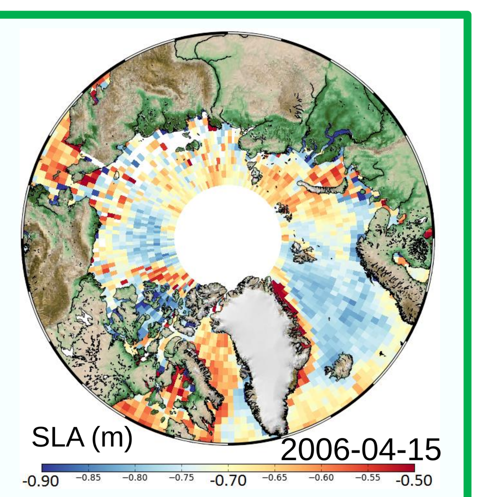
The **confidence interval of the regional MSL trends** has been characterized (see figure).



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

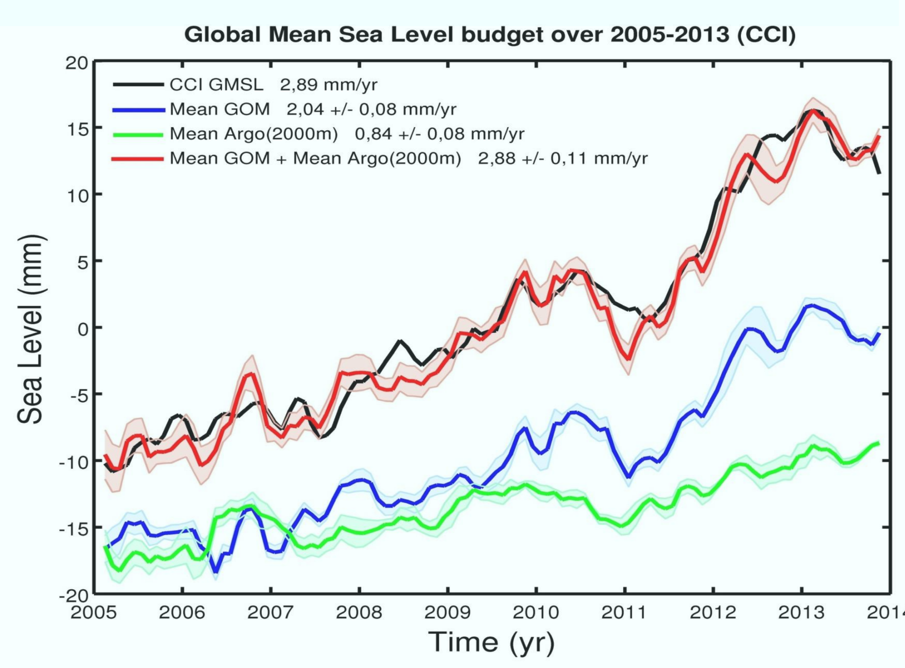
Ablain et al, 2015

- Improved sea level estimation in the **Arctic Ocean.** A new altimeter retracking allows a good **continuity** between open and ice covered ocean and a good **coverage** over leads (see figure).
- Improved altimeter measurements in **coastal areas** with a new processing of altimeter radar echoes based on a **2D waveforms retracking** and thanks to **in-situ comparisons**.



The **validation and user assessment** of the SL_cci products have been performed through:

- **Internal consistency** checks and comparison with **in-situ data**.
- **Comparison** with **ocean model assimilation experiments,** by quantifying changes of the model performances.
- **Sea level closure budget** approach by comparison with the steric (Argo) and mass (GRACE) contributions (see figure) but also from the glaciers, ice sheets and inland water.



V – Contacts

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