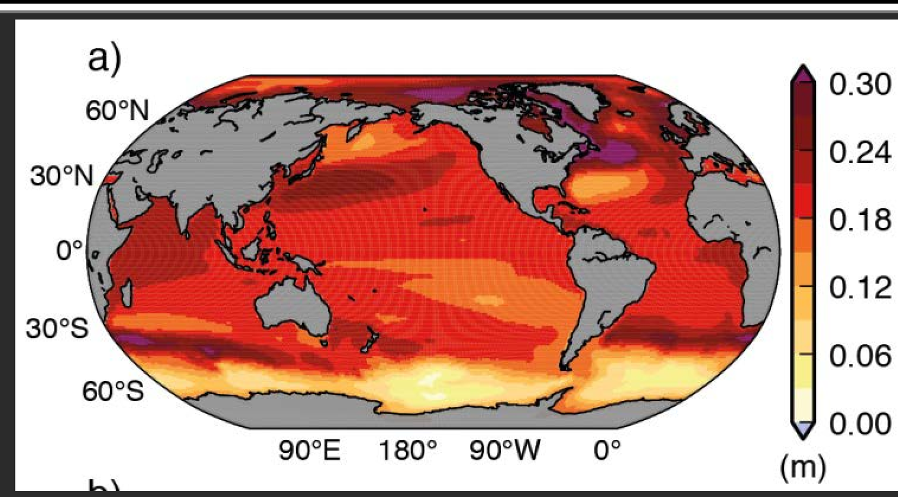
Extending and Improving Sea Level Measurements in the Ice Covered Arctic Ocean

P. Prandi, L. Zawadzki, J.-C. Poisson, P. Thibaut, M. Ablain, G. Quartly, J. Benveniste, N. Picot

The Arctic is an area undergoing rapid climatic changes, among which the dramatic reduction of sea ice extent. Models also predict that the Arctic Ocean will be experiencing large changes in the future and altimetry data could be very useful to evaluate past, present and future changes. To date, the Arctic Ocean remains poorly observed by satellite altimetry, mainly due to sea-ice cover that prevents measurements.

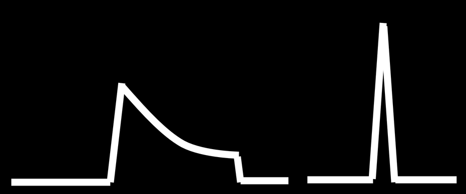
In recent years, several teams have been working towards a better knowledge of Arctic Sea Level Anomalies (e.g. Prandi et al. 2012, Giles et al. 2012, Andersen et al. 2015). In this study we use a new waveform classification and retracking algorithm (Poisson et al., in prep) to derive accurate SLA maps from the ice-covered Arctic. We describe the editing and mapping process used and the first results from Envisat (ESA CCI) and AltiKa data (CNES PEACHI).



Expected change in Mean Sea Level from CMIP5, largest values are observed in the Northern Altlantic & Arctic Oceans (from IPCC AR5)

Waveform Classification	Retracking	Sea Level Anomaly (SLA) computation	SLA Filtering	SLA Along-Track Editing	SLA Temporal Editing	SLA Weekly Gridding
P	R	O	C	E	S	S

Waveform Classification



Class 1: open ocean — *Class 2: leads*

see Poisson oral

Retracking

4 parameters: see Poisson oral

Sea Level Anomaly (SLA) computation

Standards Selection	
MSS	DTU 13
Ocean Tide	FES 2014
Dry Tropo.	ERA-Interim
Wet Tropo.	ERA-Interim
IB	ERA-Interim
Dyn. Atmo.	ERA-Interim
Iono	GIM
Sea State Bias	0 in leads - Non parametric SSB in ocean

SLA Filtering

Iterative method

SLA Along-Track Editing

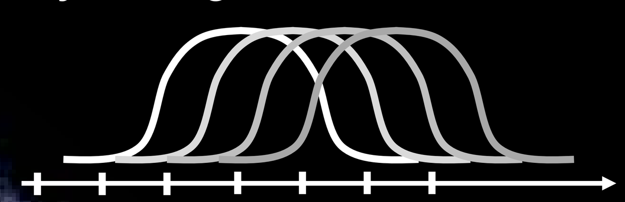
Iterative method

SLA Temporal Editing

- over 1.5 m
- over 2.5σ in each 2°x2° box over 1-year periods

SLA Weekly Gridding

- Weighted average in 2°x2° box with a 35-day sliding-window



This process results in a set of weekly SLA grids from EnviSat and SARAL/AltiKa data, covering 12 years from 2003 onwards

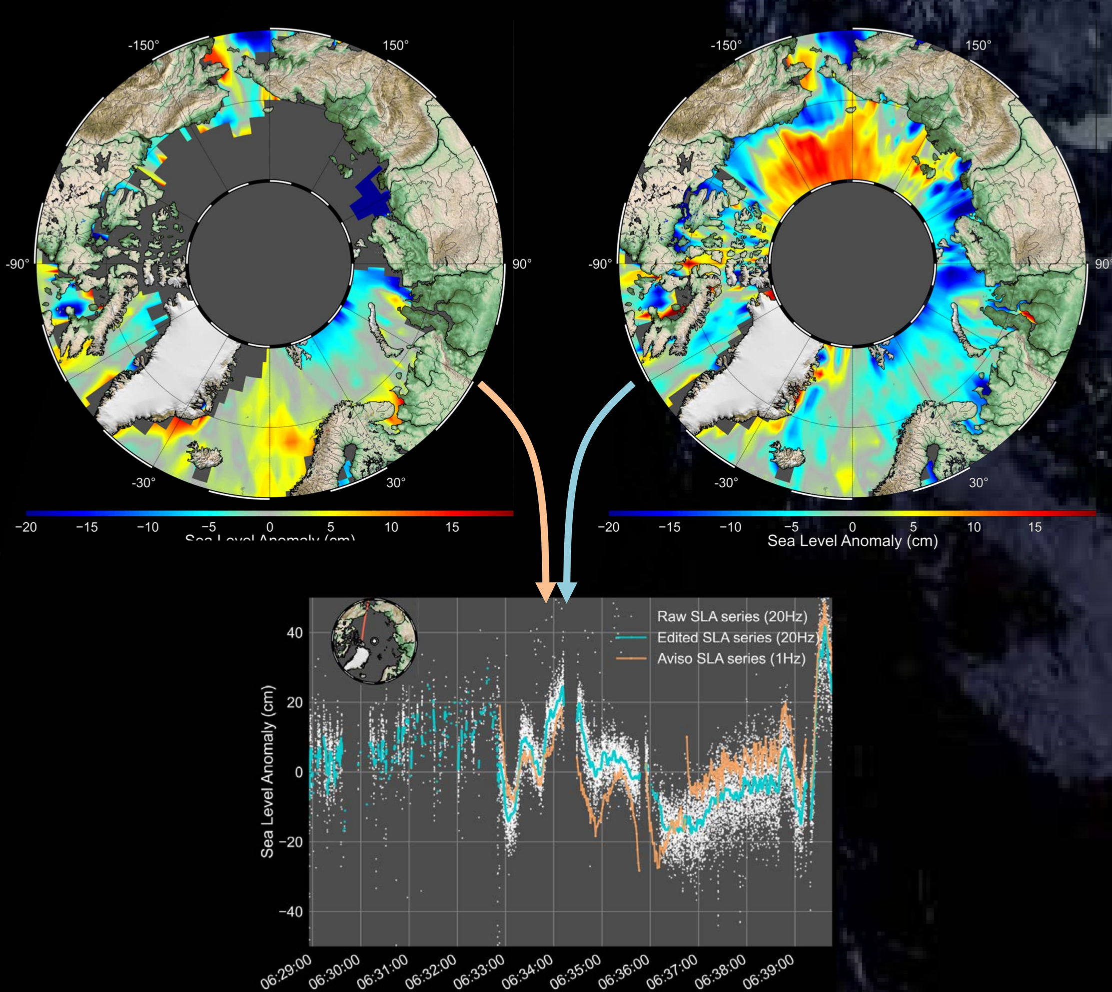


Fig. 1: Upper panel, gridded SLA SARAL/AltiKa over cycle 7, computed with Aviso (Left) and CLS/PML Arctic (Right) data. Lower panel, Along-track SARAL/AltiKa SLA (Cycle 7/Pass 2) with raw (white) and final (blue) 20Hz CLS/PML Arctic product and Aviso (orange) product.

- Comparison to Aviso monomission product (see Fig. 1, left) shows tremendous **improvement of data coverage** in ice-covered and coastal areas at high latitudes.
- The use of a single retracking algorithm for open ocean and leads results in spatial consistency, without the need for a retracking bias estimation.
- First comparisons of this monomission product to DTU multimission Arctic SLA product (see Fig. 2, right) shows a good consistency.

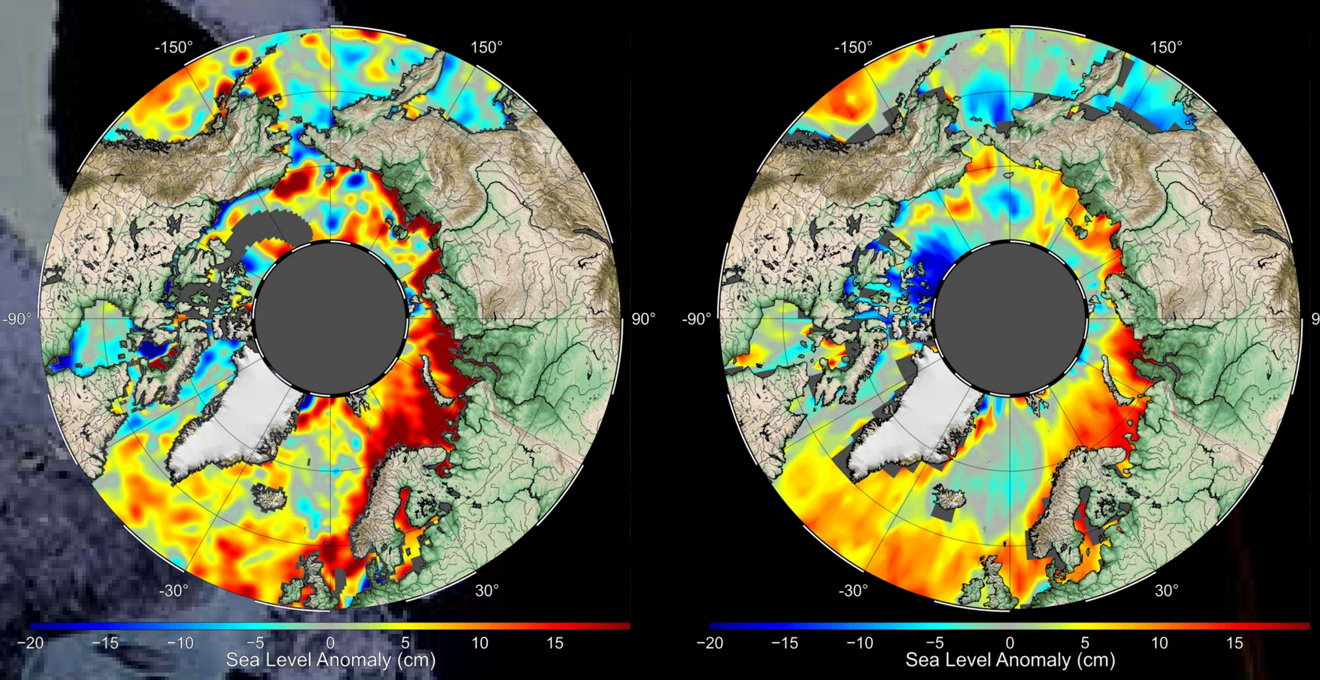


Fig. 2: DTU SLA product averaged over 10/2005 (Left) and CLS/PML gridded SLA Arctic product (Right) over corresponding period.

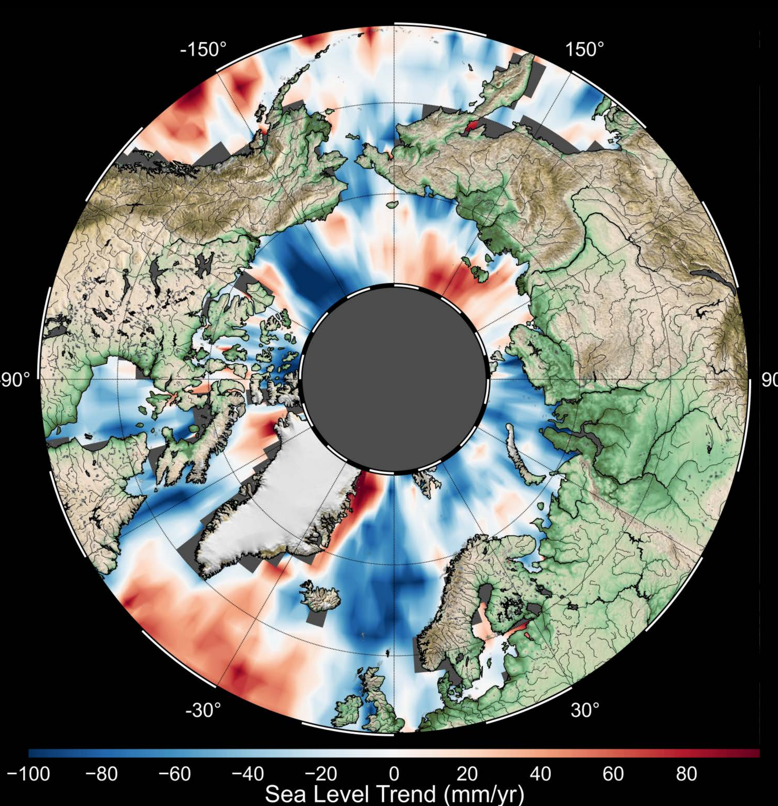


Fig.3: Sea Level trend over over 2003-2010 computed with EnviSat CLS/PML Arctic product

Work is on-going but preliminary analyses lead to a great improvement of SLA computation in Arctic ocean, mainly in sea-ice covered surfaces:

- Very good spatial sampling with a SLA averaging per box of 2°x2°: AVISO coverage is lower by 20% (Winter) and 10% (Summer)
- SLA structures are most of the time very well correlated in space and time : *e.g.* Beaufort Gyre
- Dubious SLA measurements were observed with AVISO close to ice-covered areas: they are now removed (most of the time)

Considerable efforts will be needed for the validation:

- To understand the signals observed along-track and in grids
- To describe and correct remaining errors : L1 processing, MSS, tides, DAC, SSB, Brownian echoes from ice floes …

This work could benefit to future multi-missions sea-level products (*e.g.* CMEMS and SL_cci), but also to Mean Sea Surface and Mean Dynamic products, and tide models, …

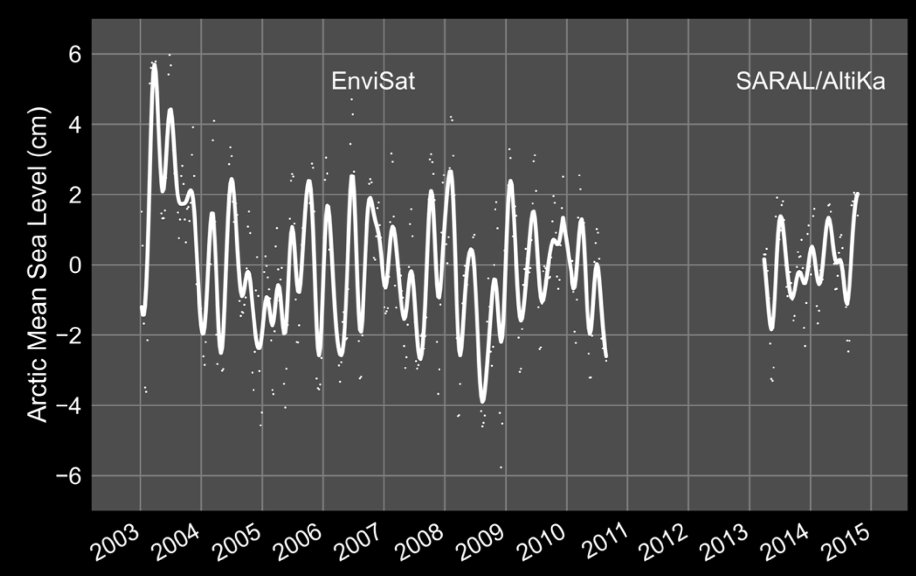


Fig.4: Mean Sea Level over 65° latitude computed with EnviSat and SARAL/AltiKa SLA grids

Envisat Sea Level Anomaly Animation over 2003-2010 (scan QR Code on the right)