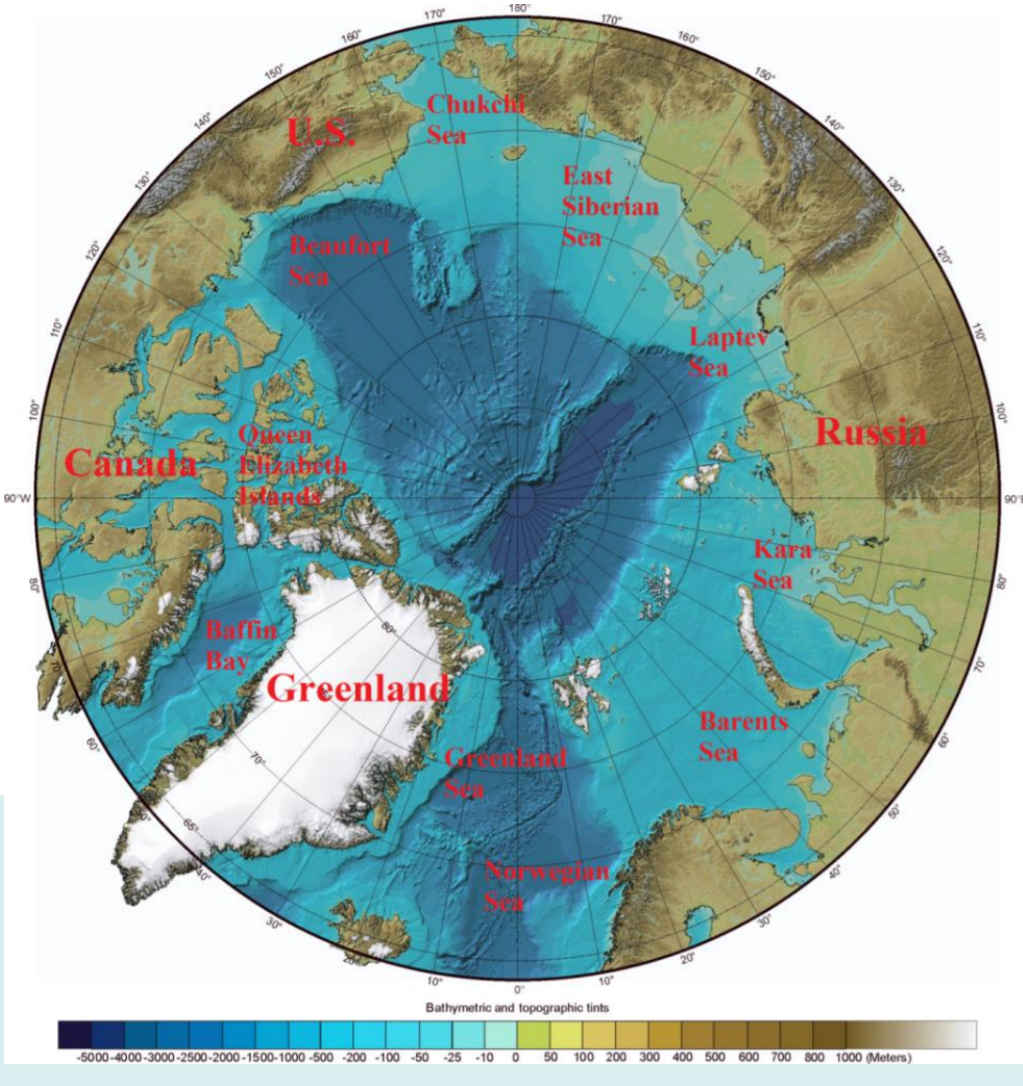


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## Abstract

The Arctic Ocean process severe limitations on the use of altimetry and tide gauge data for sea level studies and prediction due to the presence of seasonal or permanent sea ice. In order to overcome this issue we reprocessed all altimetry data with editing tailored to Arctic conditions, hereby more than doubling the amount of altimetry in the Arctic Ocean with up to 10 times the amount of data in regions like the Beaufort Gyre region compared with AVISO and RADS datasets. With recent data from the Cryosat-2 SAR altimetry the time-series now runs from 1991-2015 a total of nearly 25 years. Good altimetric data is seen to be crucial for sea level studies and profoundly for sea level reconstruction where we present a 60 years sea level reconstruction based on this new data set.

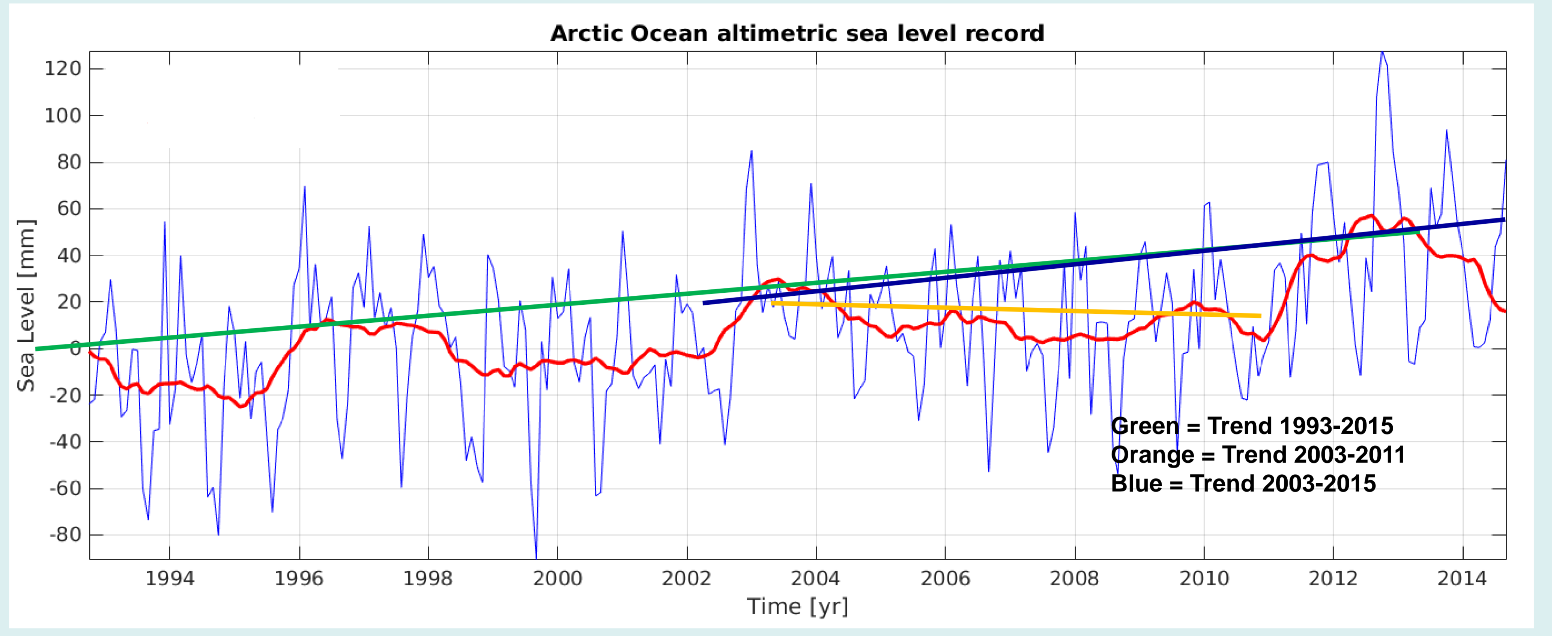
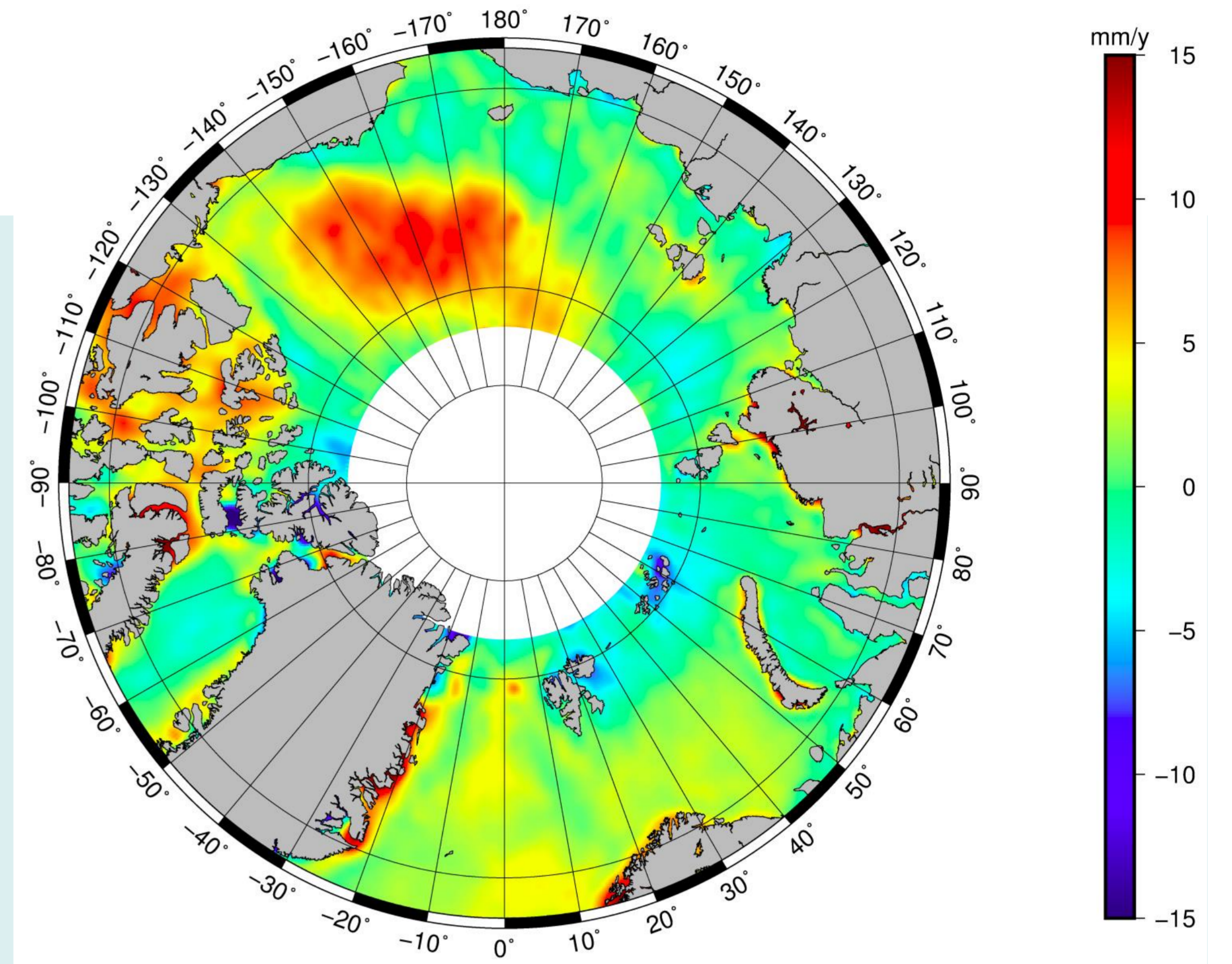
We here present the multi-decade altimetric dataset from the ESA CCI initiative. This dataset is currently being improved by close corporation between DTU and TUM. We attempts an innovative new attempts to reprocessing and retracking using the ALES retracker and REAPER data for in order to evaluate sea level variations. We also analyze sea level variations from a 60 year reconstruction of sea level based on this together with tide gauge information.

## Arctic Sea Level Trend (1993-2015)

Using the EXISTING DTU reprocessed 23 years ERS-1/ERS-2/ENVISAT/Cryosat-2 data (1992-2015 – up to 82N)

The dataset is available as part of the ESA SL-CCI V1.1 dataset.  
Data is also available from <ftp.space.dtu.dk/pub>

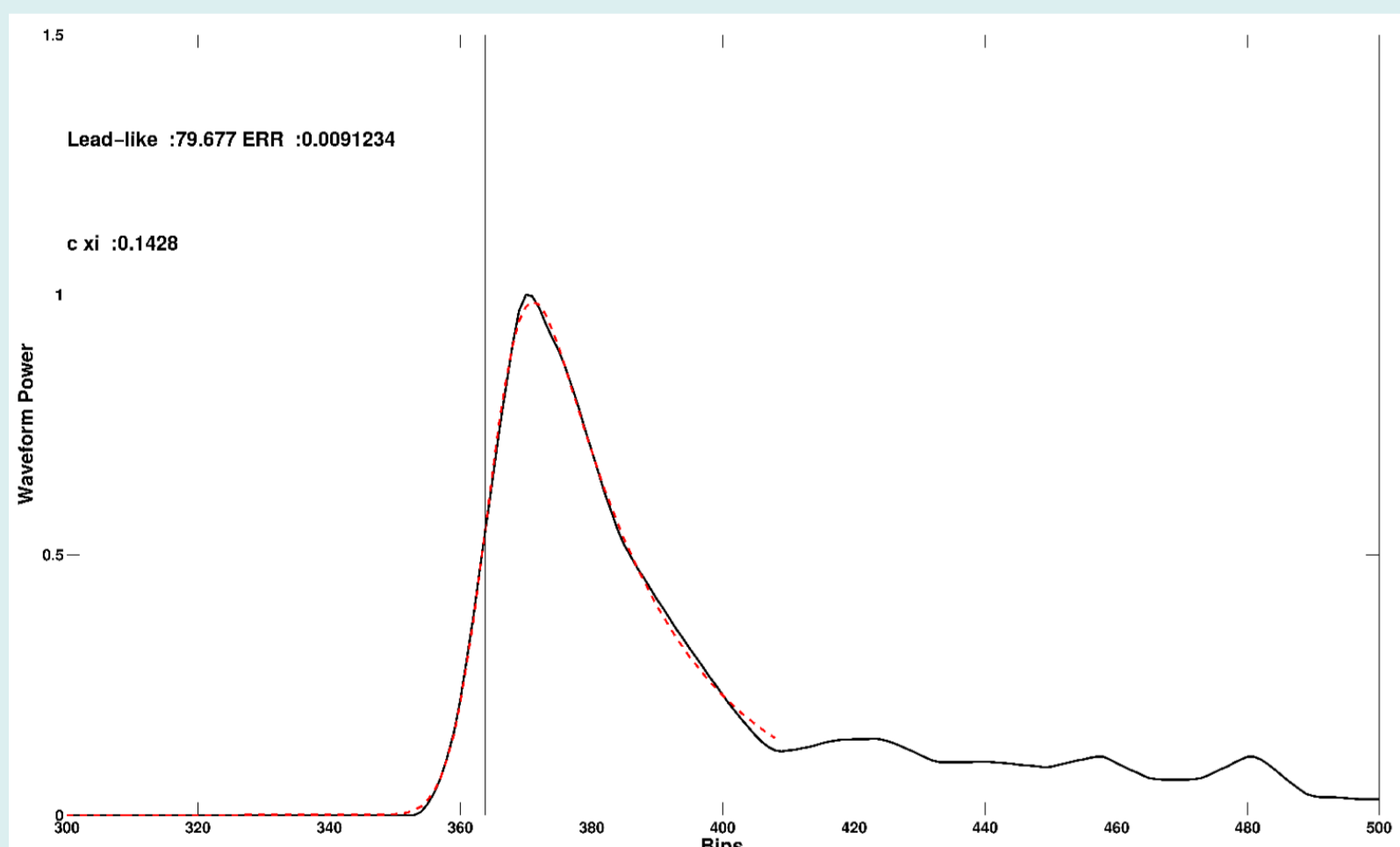
Sea Level trend over the 1993-2011 period 2.0 mm/year  
Over the 2003-2015 period the trend is 2.4 mm/year  
Over shorter period 2003-2011 it might even be negative.



## Improving the Arctic Sea level determination.

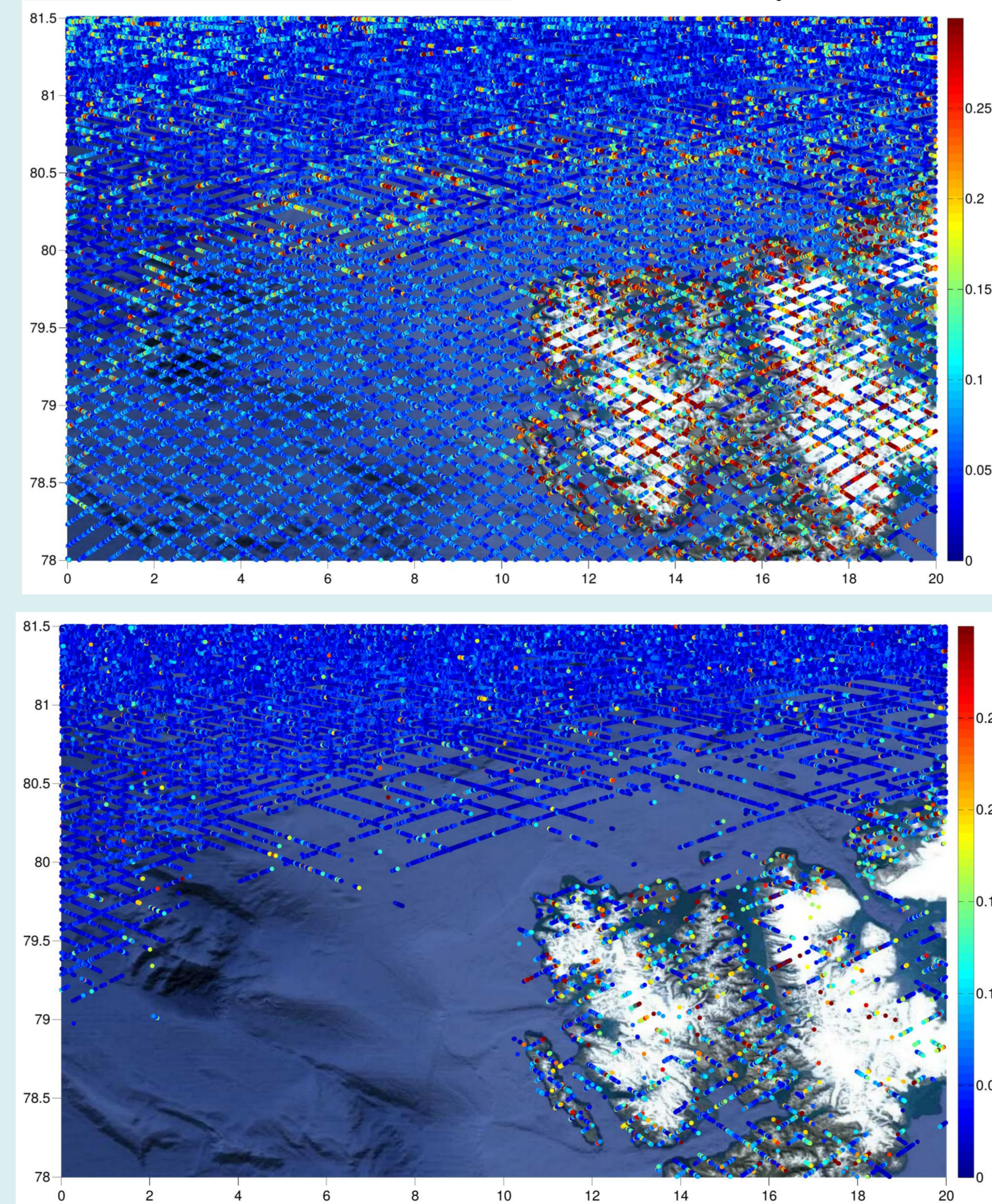
### ALES derived sea level

ALES+ is an upgraded version of the Adaptive Leading Edge Subwaveform Retracker that has been developed to improve data quality and quantity in the coastal ocean, without degrading the results in the open ocean. ALES+, which is currently under development, aims at retracking peaky waveforms typical of lead reflections without modifying the fitting model used in the open ocean. Key features of ALES+ include, in the case of peaky waveforms, a better subwaveform identification and the input of the slope of the trailing edge as external parameter.



Black curve: zoomed lead-like waveform after 8x oversampling of the original data. Red curve: experimental ALES+ subwaveform retracking

Preliminary results on the fitting error on the leading edge (in normalised power units) with ALES+ (Envisat cycle 10) for all waveforms in the Svalbard area (upper) and for only non-oceanic waveforms (lower). Results show how ALES+ is able to fit the ice and lead waveforms in most of the domain.



### REAPER derived Arctic Sea Level.

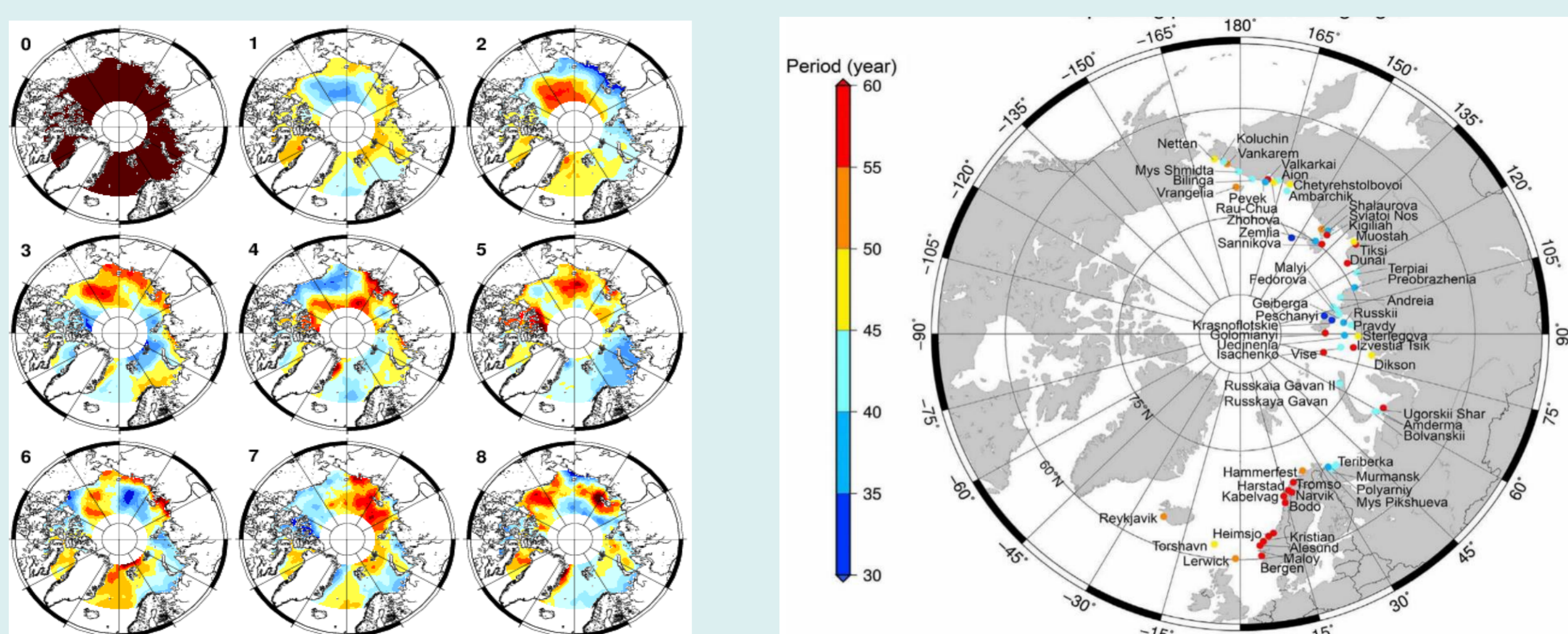
Comparison of raw sea surface anomalies from RADS and the reprocessed 20 hz ERS1 data (REAPER) of a satellite track through Svalbard region



The top panel of the figure shows the two retracked heights ice1 (blue) and sitrack (orange) from REAPER w.r.t DTU15 MMS and the RADS (purple) sea surface anomalies. The ice1 is an OCOG retracker optimized for ice sheets and sitrack is a sea ice threshold retracker optimised for peaky waveforms. The running mean (green) and standard deviation of ice1 are also shown. The RADS data only contain data over the ocean due to the 1 hz resampling and the high filtration level. The lower panel shows the backscatter and peakiness with their respective running mean and standard deviations.

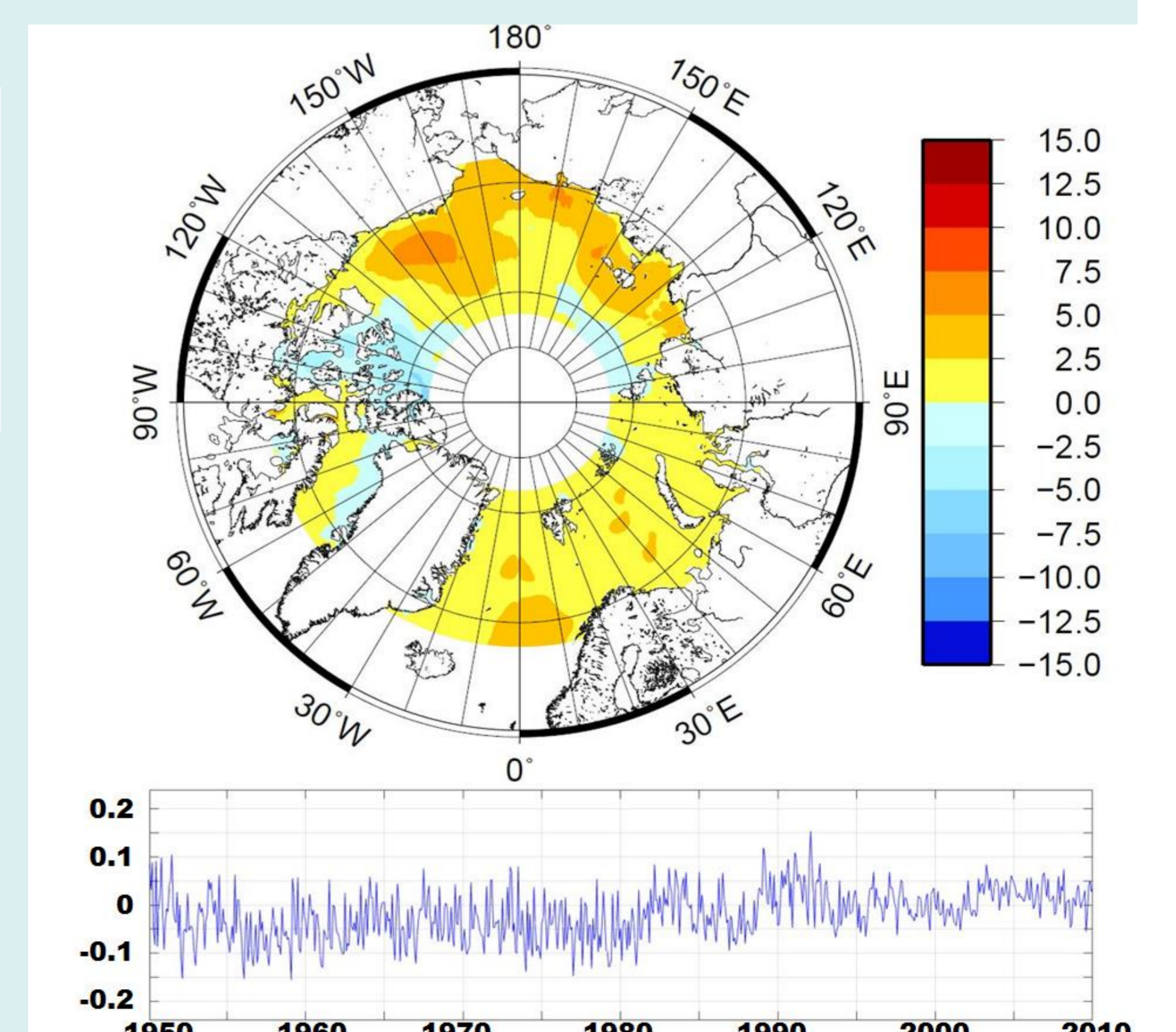
## Arctic Sea level reconstruction 1950-2010 (66N-82N)

In a recent paper by Svendsen et al., 2016 applied the datum-fit sea level reconstruction method (Ray and Douglas) to produce a very stable Arctic linear sea level trend of around 1.5 +/- 0.3mm/y for the period 1950 to 2010, between 68°N and 82°N merging the 9 dominating EOF spatial patterns of 20 years altimetry with 60 carefully selected tide gauges. This value is also in good agreement with the global mean trend of 1.8 +/- 0.3 mm/y for 1950–2000, as reported by Church et al. (2004).



	Nb Virtual gauges	Linear Trend (1950-2010) mm/y	Linear Trend (1993-2012) mm/y
Datum Fit (Ray & Douglas)	0	1.5 +/- 0.3	2.3 +/- 2.4
	50	1.5 +/- 0.3	2.0 +/- 1.0

In order to circumvent the decline in Russian tide gauges after 1991. Test was made to include virtual tide gauges after 1993 based on satellite altimetry.



Spatial pattern of sea level trend for the 1950–2010 period in mm/year and stabilized using 50 virtual tide gauges after 1993 from the datum shift estimation (Ray/Douglas)