Consortium Members

ESA Sea Level CCI

SL_cci CCN5: DTU/TUM Arctic and Antarctic Altimeter Sea Level – Dataset #2

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People involved in this issue:		
Written by (*):	Microsoft Office User	Date + Initials:(visa or ref)
Checked by (*):	G. Timms	Date + Initial:(visa ou ref)
Approved by (*):	JF Legeais	Date + Initial:(visa ou ref)
Application authorized by (*):	J. Benveniste	Date + Initial:(visa ou ref)

In the opposite box: Last and First name of the person + company if different from CLS

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Applicable documents

AD 1 Sea level CCI project Management Plan
CLS-DOS-NT-10-013

Reference documents

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List of acronyms

Envisat	**Environmental Satellite**
DTU	**Technical University of Denmark**
ERS	**European Remote Sensing**
LARS	**Lars Altimetry Retracking System**
LRM	**Low Resolution Mode**
RADS	**Radar Altimetry Database System**
SAR	**Synthetic Aperture Radar**
SARIN	**SAR Interferometric**
SLA	**Sea Level Anomaly**
TUM	**Technical University of Munich**

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1. Introduction

This report describes dataset #2, which is part of the outcome of the SL_cci option work (CCN#5) carried out within collaboration between TUM (Technical University of Munich) and DTU (Technical University of Denmark).

The main objective of this project has been to improve sea level estimates in high latitudes, which are often obstructed by the presence of sea ice. This makes it challenging to obtain accurate sea level estimates from satellite altimetry. The input data as well as the data processing is described, and the dataset is validated against several high latitude tide gauges both in the Arctic and the Antarctic.

2. Data processing

2.1. Input data

The improved sea level record was created using satellite altimetry data from 1991 to 2016, providing a dataset covering 25 years. To obtain a record this long, data from multiple altimetry missions were used. Each mission and the corresponding data are described in the following sections.

Various geophysical corrections were applied to the data: dry and wet tropospheric corrections, ionospheric correction, solid earth tide, and geocentric polar tide. In contrast to dataset #1, which included ALES+ retracking (Passaro et al., 2017), this dataset has also been corrected for the inverse barometer effect, which was not done for dataset #1.

Here, we present an updated version of the DTU Arctic Ocean altimetric sea level dataset (Cheng and Andersen, 2015) called Version 3. This dataset has been updated and extended to more than 25 years in total (1991-2017) and now covers not only high latitudes in the northern hemisphere, but also the southern, to accommodate users interested in Antarctic waters.

The DTU Arctic Altimetric Sea level record has been derived to maximize the spatial and temporal extent of the altimetric data. Version 3 of the Arctic record was implemented by merging ERS-1, ERS-2, ENVISAT and CryoSat-2 missions within the regions 66°N - 82°N and 65°S - 82°S in order to extend the time-series until 2017. These data were tailored, edited and processed according to Cheng and Andersen (2015), and are referenced to the DTU13 Mean Sea Surface (Andersen et al., 2015).

The raw DTU Arctic dataset is based on the Radar Altimetry Database System (RADS). RADS contains 1-Hz data for 9 missions, and it has the advantage to ensure consistency among the different missions in terms of reference (Scharroo et al., 2013) and corrections (Andersen and Scharroo, 2011).

In the Arctic region, the CryoSat-2 SAR+SARIn data are acquired from DTU's in-house Lars Altimetry Retracking System (LARS) (Stenseng, 2011) to utilize the 20Hz data and thereby allow for retrieval of sea level in leads. The LARS dataset contains data processed with eight different empirical retrackers, tailored to perform over highly specular surfaces, i.e. leads where SAR and SARIn data are retracked at 20-Hz with a simple threshold retracker. The subsequent processing of data closely followed the method described by Cheng et al. (2015).

3. Results

The dataset provides monthly grids containing sea level anomaly estimates, which e.g. can be used to assess the mean annual trend or look at seasonal behaviour.

3.1. Arctic

A map of the mean annual trend is seen in Figure 1 for the Arctic Ocean and in Figure 2 for the Antarctic ocean.

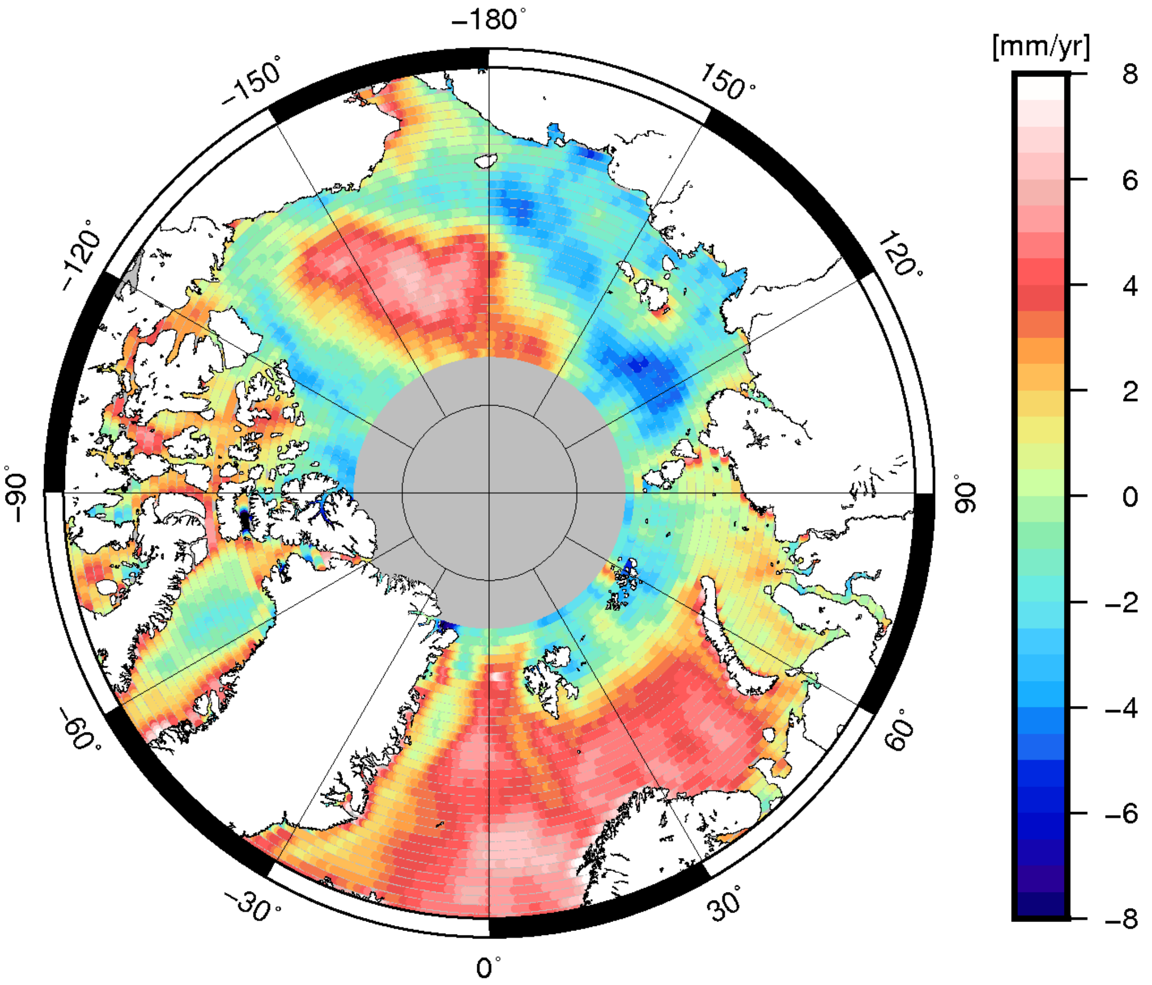

Figure 1 - Mean trend in SLA in the period from 1992 to 2017 for the Arctic Ocean

3.2. Antarctic

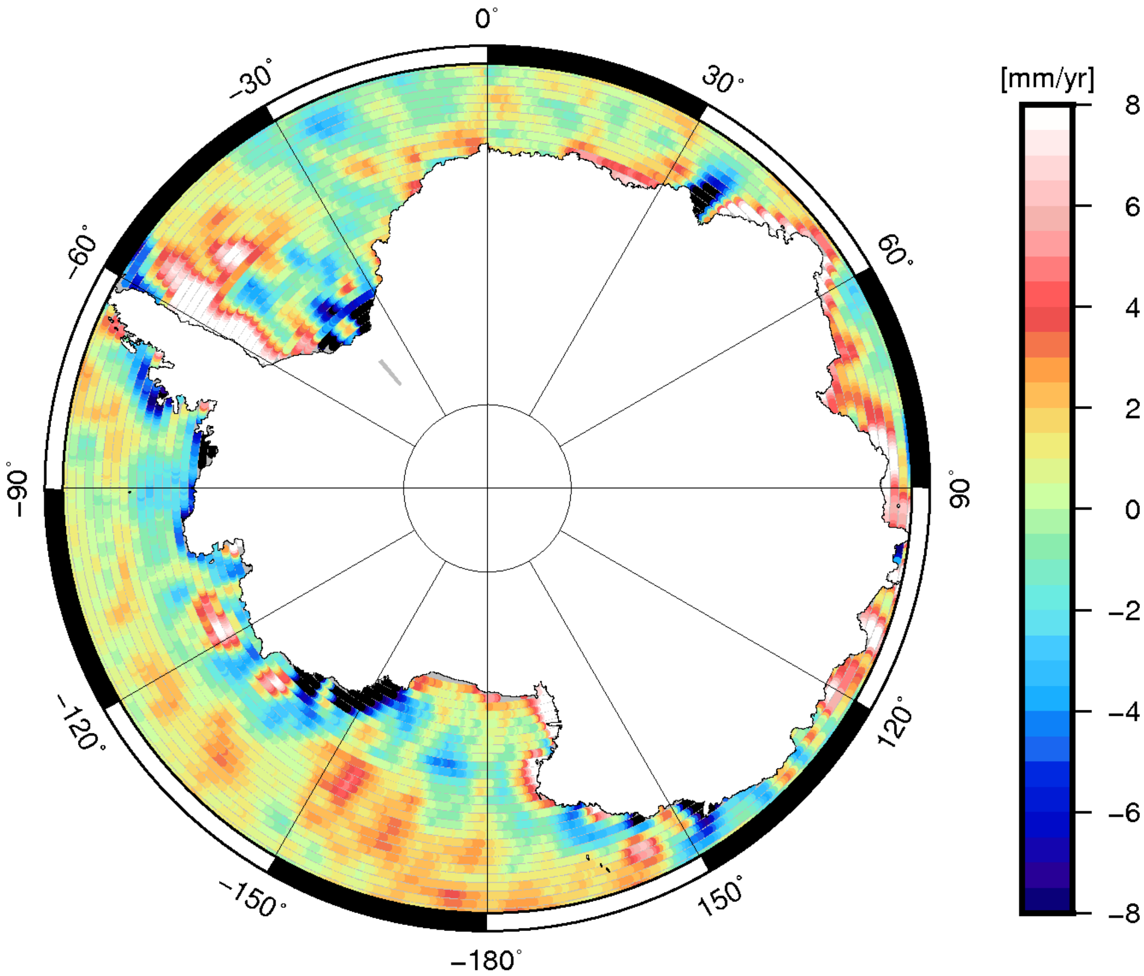

Figure 2 - Mean trend in SLA in the period from 1991 to 2017 for the Antarctic Ocean

4. Validation

A brief comparison with tide gauge data has been performed to evaluate the high latitude data product. Altimetric data were extracted within a radius of 350 km of each tide gauge station, and monthly means are compared.

4.1. Arctic Ocean

In the Arctic Ocean the time series derived from the altimetric data product have been compared with the Ny-Ålesund (78.9N,11.94E) and Prudhoe Bay (70.4N, 148.5W) tide gauge stations. Data were downloaded from the Permanent Service for Mean Sea Level (PMSL) data base (http://www.psmsl.org). Both dataset #1, which includes data acquired using the ALES+ retracker, and dataset #2 are compared with the in situ data in order to see the difference between the two altimetric products derived in this project.

Error! Reference source not found. and **Error! Reference source not found.** show the comparison of the observed SLA from the two tide gauges.

For dataset#2, the correlation between altimetry and the tide gauge at Ny-Ålesund is only 30%. It is worth noticing the improvement obtained by using the ALES+ retracker in dataset#1, which gives a much higher correlation of 67% for the entire data period, or approximately 91% for the period between 2000 and 2010, which consists entirely of ALES+ data from ERS-2 and Envisat. In the same period, the correlation between dataset #1 and in-situ data is 39%.

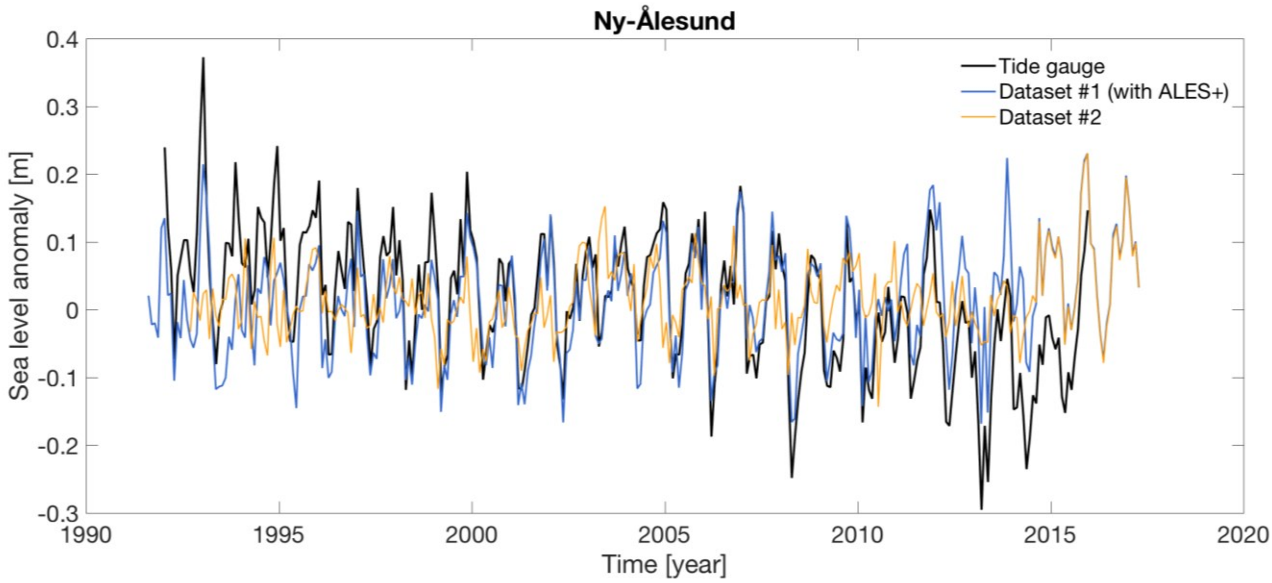

Figure 3 - Ny-Ålesund time series. Comparison of monthly data from altimetry and tide gauge.

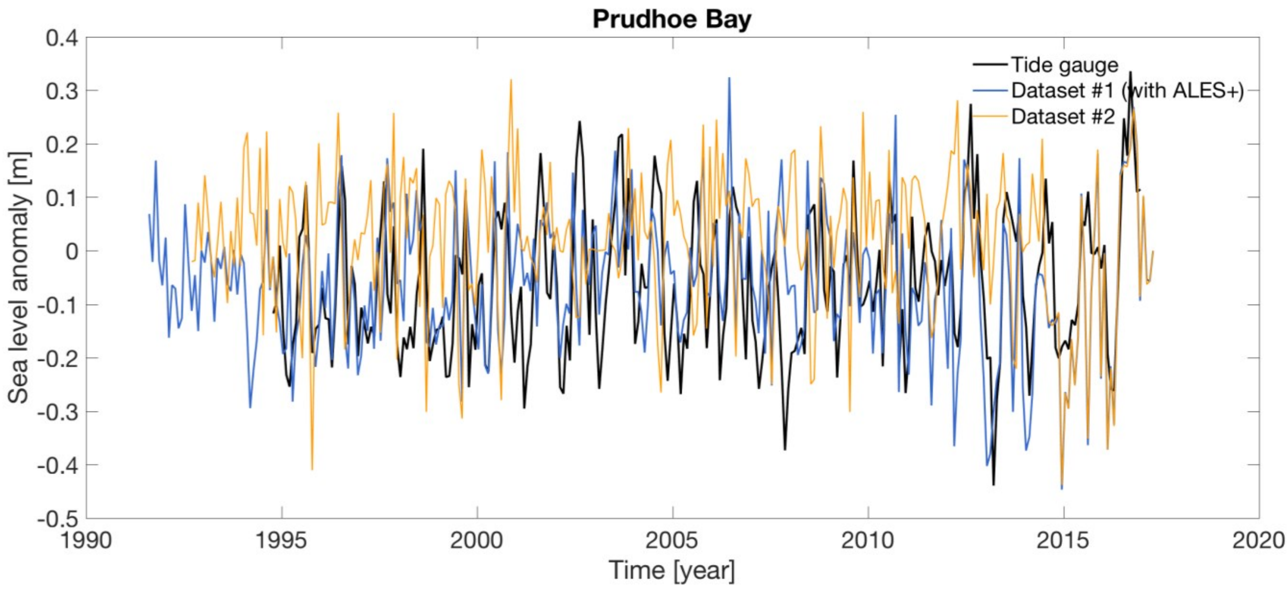

Figure 4 - Prudhoe Bay time series. Comparison of monthly data from altimetry and tide gauge.

4.2. Antarctic Ocean

On the southern hemisphere, the altimetric data are compared to the tide gauge stations Syowa (69.5S, 39.36E) and Faraday (65.15S, 64.16W). As **Error! Reference source not found.** and **Error! Reference source not found.** show, the correlation between satellite altimetry and in-situ data is not as convincing as for the Ny-Ålesund tide gauge in the Arctic Ocean, which needs further investigations, as well as the higher amount of missing/rejected data from RADS.

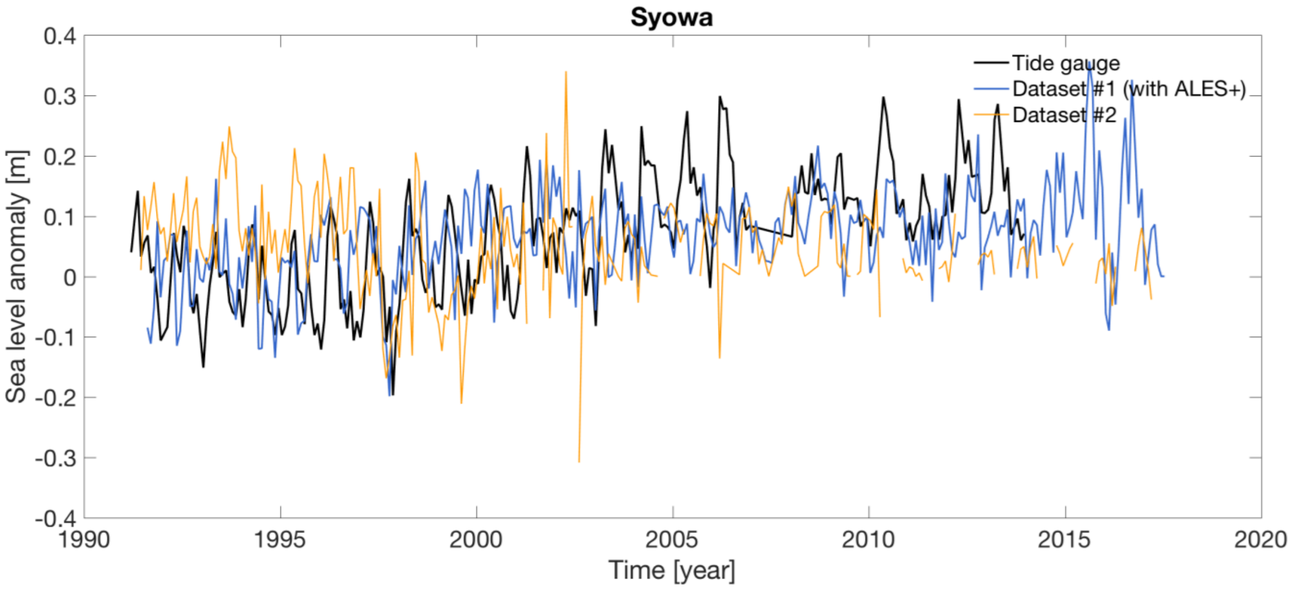

Figure 5 - Syowa time series. Comparison of monthly data from altimetry and tide gauge.

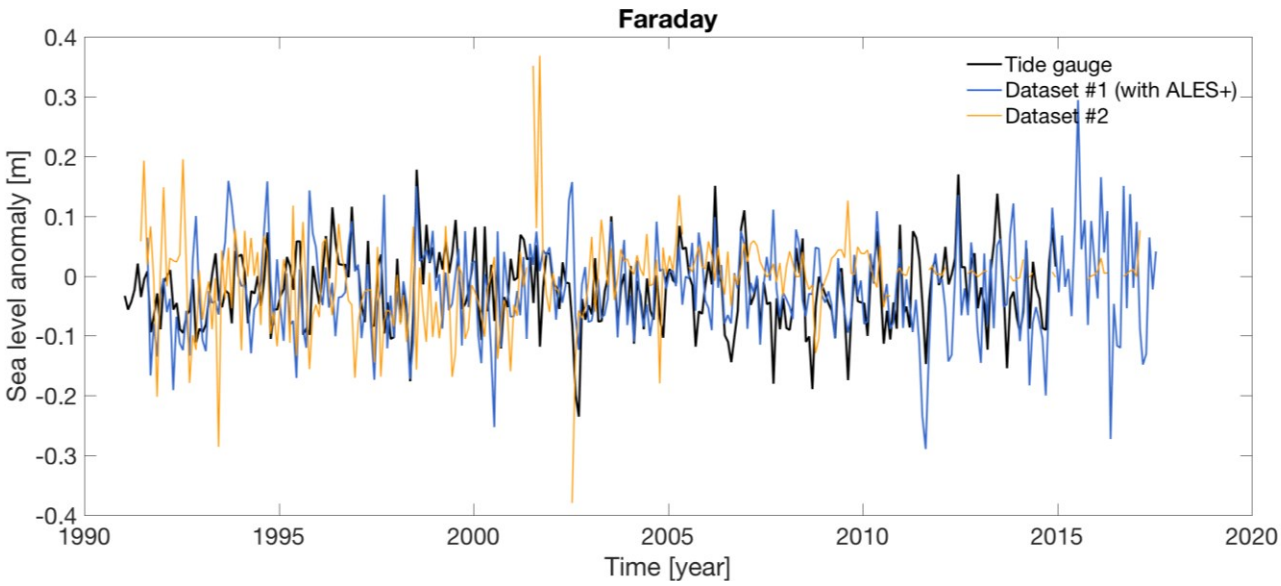

Figure 6 - Faraday time series. Comparison of monthly data from altimetry and tide gauge.

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5. Discussion and conclusions

The sea level record presented here provides 25+ years of satellite altimetry data at high latitudes. The results shown here for dataset#2 demonstrate the usefulness of satellite altimetry, but there is still room for improvement. Especially in Antarctic regions challenges remain, seen as low correlations between altimetry and tide gauge data. This disagreement needs to be further investigated.

Comparing the results of the dataset presented here, with that of dataset#1, which includes SLAs acquired by using the ALES+ retracker, it is seen that the ALES+ retracker provides much better results in the Arctic. However, it should be noted that dataset#2 has been corrected for the inverse barometric effect, making it difficult to compare directly with sea level changes from tide gauges, since the SLA given in the dataset is no longer the observed sea level change. The inverse barometric effect has a temporal variability of around 20 cm, sometimes more, and varies from model to model. The effect of the inverse barometric effects therefore needs further studying, to ensure that long-term variations in atmospheric pressure does not affect our estimates of sea level change.

6. Obtaining the high latitude sea level record

The high latitude sea level anomalies are made freely available to the users under request at info-sealevel@esa-sealevel-cci.org.

7. References:

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