Consortium Members

ESA Sea Level CCI

Arctic Sea Level products

Nomenclature: SLCCI_038_Arctic_Sea_Level

Issue: 1. 0

Date: May. 4, 21

Chronology Issues:			
Issue:	Date:	Reason for change:	Author
1.0	5/4/21	Creation	P. Prandi

People involved in this issue:		
Written by (*):	P. Prandi	Date + Initials:(visa or ref)
Checked by (*):	JF Legeais	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*

Index Sheet:	
Context:	Sl_cci
Keywords:	Oceanography, sea level
Hyperlink:	

Distribution:		
Company	Means of distribution	Names
CLS	Notification	

FORM-NT-GB-7-1

Reference documents

RD-1 O. Andersen and G. Piccioni, Recent Arctic Sea Level Variations from Satellites, 2016, Front. Mar. Sci., https://doi.org/10.3389/fmars.2016.00076

RD-2 J.-C. Poisson, G. D. Quartly, A. A. Kurekin, P. Thibaut, D. Hoang and F. Nencioli, "Development of an ENVISAT altimetry processor providing sea level continuity between open ocean and arctic leads", *IEEE Trans. Geosci. Remote Sens.*, vol. 56, no. 9, pp. 5299-5319, Sep. 2018. doi: 10.1109/TGRS.2018.2813061

RD-3 Peacock, N. R., and Laxon, S. W. (2004), Sea surface height determination in the Arctic Ocean from ERS altimetry, J. Geophys. Res., 109, C07001, doi:10.1029/2001JC001026.

List of Contents

1. Introduction

This report documents the regional Arctic sea level products generated during the Sea Level CCI project funded by ESA.

2. Data and Methods

In this section we describe the upstream data used to generate the final products and provide brief description of the processing.

2.1. Satellite radar altimeters

2.1.1. Envisat

ESA's Envisat was launched in March 2002 on the same orbit than its predecessor ERS-2. Envisat carries, among other instruments, a dual frequency radar altimeter operating in Ku and S bands. Only the Ku band data is used in this study.

Envisat provides sea surface height data up to 81.5°N making it useful for the observation of the Arctic Ocean. The mission ended in May 2012.

2.1.2. SARAL/AltiKa

SARAL/AltiKa is joint CNES/ISRO mission launched in March 2013. SARAL/AltiKa uses the historical ERS orbit with observations up to 81.5°N. SARAL/AltiKa carries a single frequency radar altimeter (AltiKa) operating in Ka band. This allows for better horizontal and vertical resolution, at the cost of higher sensitivity to water in the atmosphere.

For both Envisat and SARAL/AltiKa, S-GDR high frequency data are used in this study.

2.2. Data processing pipeline

2.2.1. Overview

Estimations of sea surface heights in the Arctic Ocean relies on the identification of leads in the ice pack: in these open cracks, liquid water surfaces and provides a tie point to estimate sea level.

The data processing can be separated into 5 steps:

1. Waveform classification,
2. Retracking,
3. SSH estimation,
4. Editing,
5. Gridding.

Each step is briefly described in the following sections.

2.2.2. Waveform classification

Waveform classification aims at identifying radar altimeter echoes coming from open ocean and sea-ice leads, as both these echoes originate from the ocean surface. Several classification algorithms have been used in previous studies (e.g. Peacock and Laxon, 2004, RD-3), most of them are based on empirical pulse peakiness thresholds.

Here we rely on a newly developed method proposed by Poisson et al., 2018 (RD-2) which uses a neural network to separate individual waveforms into 16 classes which are displayed on Figure 1.

To isolate open ocean and sea ice leads, only waveforms attributed to classes 1 and 2 are retained. The open ocean/sea ice lead selection method is complemented by sea ice concentration and backscatter coefficient info.

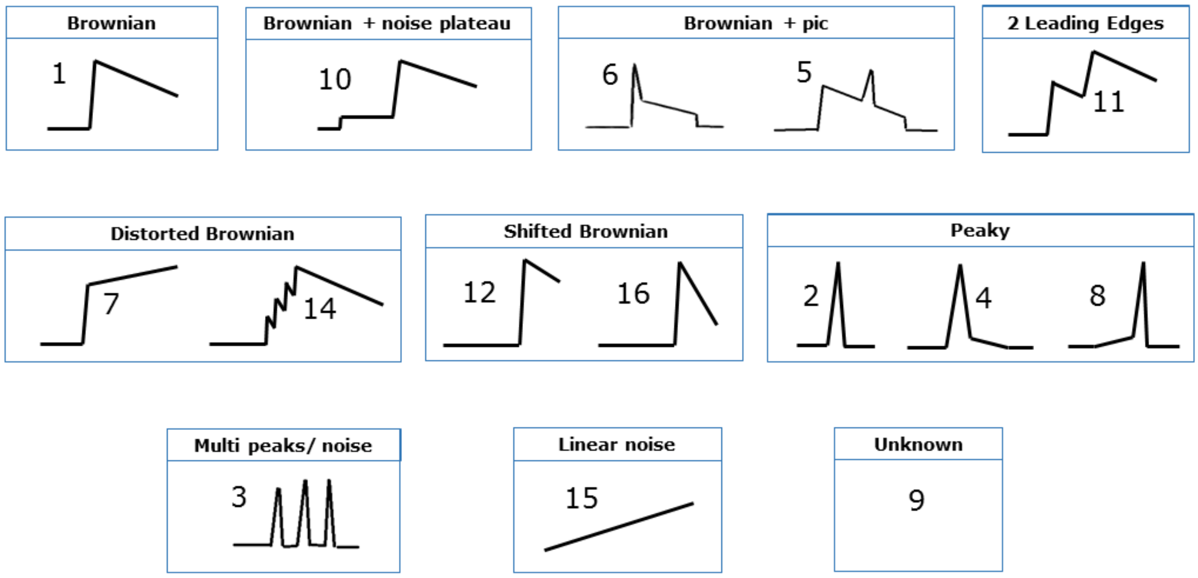

Figure 1, typical echo shape for each waveform class.

The decision tree used to select open ocean and sea-ice lead echoes is shown on Figure 2.

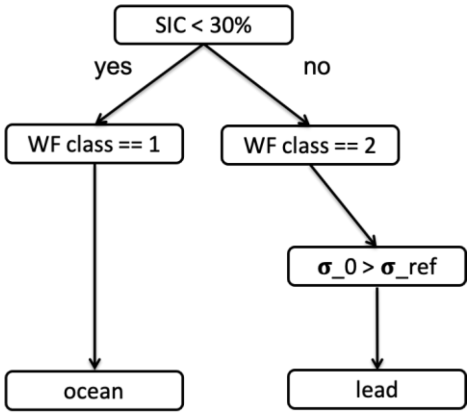

Figure 2, decision tree for the selection of open ocean and sea ice leads radar waveforms

2.2.3. Retracking

Retracking is used to estimate geophysical parameters (range, backscatter, SWH, …) from the radar waveform. Sea ice leads act as bright targets in the radar footprint and the corresponding waveforms are very peaky. Typical waveform shapes for open ocean and sea-ice lead are shown on Figure 3. This implies that retracking algorithms designed for open ocean echoes are not able to process sea ice lead echoes. In general this problem is alleviated by using different retracking algorithms over the two surfaces: MLE3 or MLE4 for open ocean echoes and OCOG of TFMRA for sea ice leads.

While this provides valuable measurements over sea ice, it introduces a bias between the two surfaces that needs to be empirically estimated and corrected. In this study we rely on a new retracking algorithm called the ‘Adaptive’ retracker that is able to process both open ocean and peaky echoes through a fit of a mean square slope parameter (Poisson et al., 2018, RD-2).

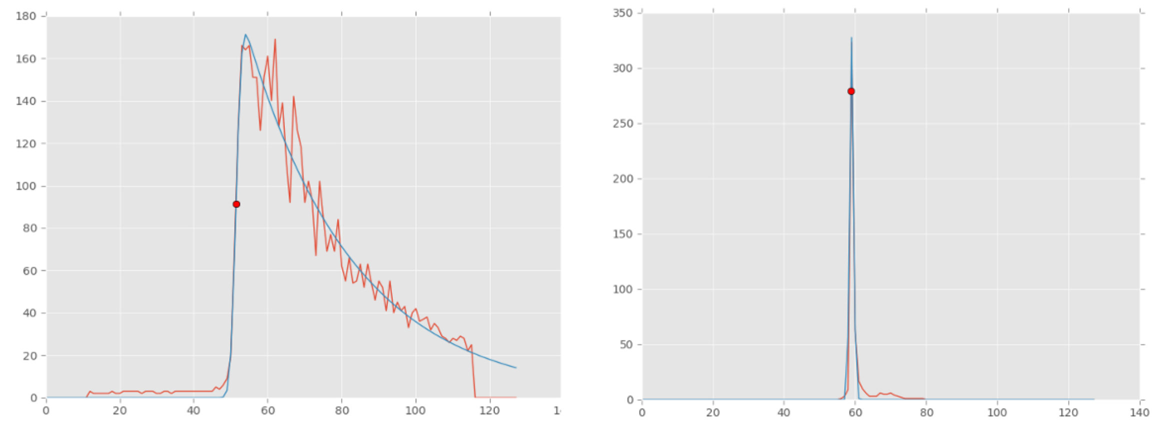

Figure 3, typical waveforms over open ocean (left) and sea ice leads (right), red is the actual waveform, model fit in blue.

Relying on one single retracking algorithm provides processing continuity between the open and ice-covered oceans and removes the need for a bias estimation.

2.2.4. Sea surface height estimation

Sea level anomalies are estimated classically from retracking outputs by applying the standard atmospheric and geophysical corrections:

$$SLA = Orbit - Range - \sum Corrections - MSS$$

Noticeable differences with respect to a global processing are:

- The use of an accurately defined MSS over the Arctic Ocean (DTU15 MSS),
- The use of the model based wet tropospheric rather the radiometer derived one,
- Inverse barometer rather than DAC correction in ice-covered areas,
- No application of the sea state bias in leads.

2.2.5. Data editing

SLA estimates are still very noisy and a data editing procedure must be applied. In this study we successively apply several techniques to remove erroneous data.

1. MQE and backscatter thresholds,
2. Remove hooking points through local along-track backscatter corrections,
3. Iterative editing based on local SL variance prior.

Please note that any data editing balances error level with data availability.

2.2.6. Gridding

After the editing process, we are left with a set of along-track measurements unevenly distributed in space and time. In order to build a dataset with a regular temporal and spatial distribution we must grid the data. Here we use a basic gridding technique based on box-averages. Hence monthly grids represent the mean sea level state rather than a snapshot of the underlying SL field.

After gridding the dataset is referenced to the global MSL record through differences with respect to the TOPEX/Jason series on the 50-66°N area.

3. Product description

The final product is distributed as daily NetCDF grid files including 30 days of data and thus reflecting a monthly mean sea level. A regular grid un cartesian coordinates is used, the grid resolution is 2° by 1° to avoid very elongated grid cells near the pole. The dataset covers latitudes from 50°N to 82°N. This represents 2697 files for Envisat and 1017 files for SARAL/AltiKa with the following nomenclature: MSL_Grid_Arctic_*MIS*_4P_*jjjjj*.nc, where *MIS* is AL (SARAL/AltiKa) or EN (Envisat), 4P relates to the four parameters derived from the retracking and *jjjjj* is the date of the observations in julian days since 01/01/1950.

4. Product validation

Validation is difficult in the Arctic Ocean: not many products are available to cross-compare to, and in-situ data are scarce. Here we use comparisons with one available dataset (Andersen et al., 2016, RD-1, hereinafter DTU) using satellite radar altimetry and a few tide gauges in the basin.

At first look at regional averages shows that the Arctic product is consistent with the DTU dataset (Figure 4)

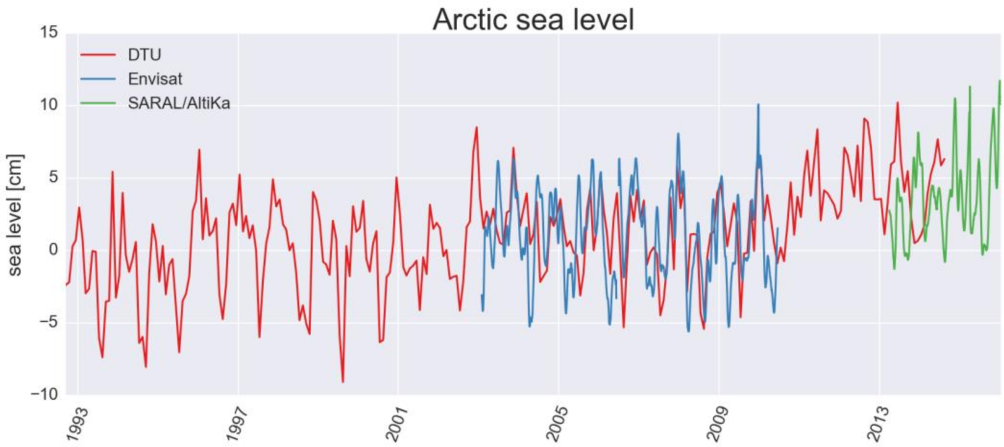

Figure 4, Arctic regional sea level time series

The geographical distribution of SLA standard deviation is shown on Figure 5. We do not expect the SLA variance to rise in the ice covered areas. In the Envisat and SARAL datasets, SL variance is trapped at the coast. In the DTU dataset, higher variance levels are observed in the Arctic interior, which suggest a mix between leads and floes echoes. This is to be expected when using low rate (1 Hz) data.

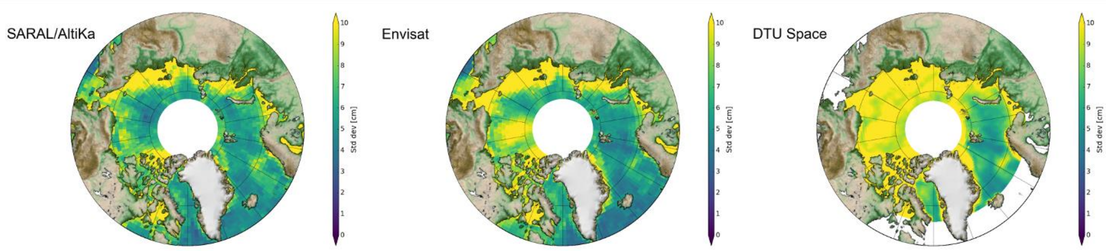

Figure 5, maps of the standard deviation of SLA, in cm

Comparisons with tide gauges also suggest a good performance of the dataset, as shown on Figure 6. The spread of the differences is reduced with respect to the DTU dataset.

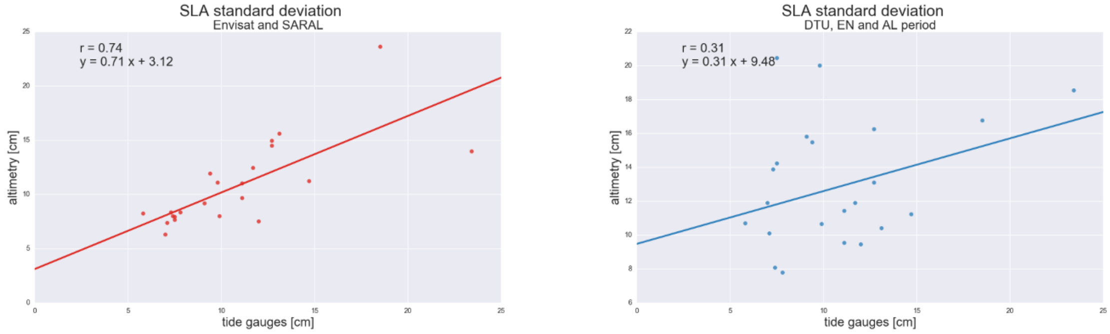

Figure 6, altimetry versus tide gauges comparisons for this dataset (left) and the DTU dataset (right)

<End of Document>