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New ideas for Earth-relevant space applications

Space-borne observations for detecting and forecasting sea ice cover extremes

Deliverable: D3.2

Retrieval methodology to retrieve applied WMO ice classes from RA data

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Document details

Overview of the document

This document describes the demonstration of retrieval of adjusted WMO ice classes (ice types relevant for navigation in ice covered waters) from Cryosat-2 data. The demonstration is published in a peer reviewed research article “Utilisation of CryoSat-2 SAR altimeter in operational ice charting” by Rinne and Similä in The Cryosphere 2016. This document much overlaps with the article, and can be understood as a recap of it. However, much of the details is omitted in this document. Thus, for a scientific reader or anyone looking for precise information, we strongly encourage refererring to the research article in addition to this document.

Document Information

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Main Authors	Eero Rinne
Main Authors’ Institutions	Finnish Meteorological Institute
Main Author’s emails	Eero.Rinne@fmi.fi
Contributors	
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V1.0	10/12/2016	First version	Eero Rinne

Reference Documents

- Grant Agreement no: 640161, Annex 1 - Description Of Action (part A)
- Grant Agreement no: 640161, Annex 1 - Description Of Action (part B)
- D3.1 - Adjusted sea ice classification methodology to satellite altimeter data based on existing airborne altimeter methodology

Acronyms

Acronym	**Definition**
WMO	World Meteorological Organization
CS-2	CryoSat-2
PP	Pulse Peakiness
MY	Multi Year
FY	First Year
RA	Radar Altimeter
PP	Pulse Peakiness
SSD	Stack Standard Deviation
LEW	Leading Edge Width
TPP	Tail to Peak Power

Introduction

We endeavored to build methodology to use Cryosat-2 radar altimeter (RA) data to support navigation in ice covered waters. The most straightforward way of doing this is to build a system to convert CS-2 measurements into the ice classes used in operational ice charts following the WMO convention [WMO SEA ICE NOMENCLATURE]. We chose an approach where an unsupervised classifier is taught with CS-2 measurements and past operational ice charts.

This classification demonstration is only shortly presented in this document. This document serves more like an executive summary of the demonstration. For detailed description, we instruct the reader to refer to the Rinne and Similä [2016] paper available online: http://www.the-cryosphere.net/10/121/2016/

Data

Cryosat-2 data used in the demonstration is the Cryosat-2 L1b Baseline-B product. Note that this product has been made obsolete by the Baseline-C release in 2016 and adjustments must be made for the future products. The operational ice charts are the weekly ice charts published by the Arctic and Antarctic Research Institute (AARI). The AARI ice charts are available online from http://www.aari.ru/

Adjusted WMO ice classes

The WMO nomenclature defines seven different stages of development: nilas, grey ice, gray-white ice, thin first year (FY) ice, medium FY ice, thick FY ice and old ice. During out work it become soon apparent that distinguishing all of these from Cryosat-2 data is virtually impossible. Thus, we settled to use use only three different stages of development: thin (< 70 cm) FY (WMO categories nilas, gray, gray-white and thin FY), thick (> 70 cm) FY (WMO categories medium and thick FY) and MY ice (WMO category old ice).

Methodology

Waveform characteristics

We chose four characteristics, pulse peakiness (PP), leading edge width (LEW), tail to peak power ratio (TPP) and stack standard deviation (SSD) to describe the CS-2 waveform. The PP, TPP and LEW are easily derived from the waveform and the SSD is delivered in the L1B data product. For the definition of the waveform characteristics, please see Rinne and Similä [2016].

Filtering

Prior to the classification we filter the data. All waveforms with LEW larger than 14 are excluded from analysis. We also want to remove potential leads from data to limit the confusion between different ice types. For this we used thresholds: PP>40 and either PP_left>20 or PP_right>15. (See Rinne and Similä 2016 for the definitions of PP_left and PP_right)

Conditions for mixed ice

The AARI charts provides partial concentrations for up to three ice types for each polygon, we assign just one ice type to a single polygon. Thus a fraction of the polygon represents in reality some other ice development stage than what we have labeled it to be. To mitigate this, we filter out polygons with the partial concentration of the dominant ice type less than 75%.

Classifier

We built a kNN -classifier, that is taught with stages of development from operational ice charts from past two weeks. For the details, check Rinne and Similä [2016].

Results

In November thin FY ice, old ice and open water are present both in the CS-2 data as well as in the AARI chart (Figure 1).The open water is classified right in 98 \% of the cases. The thin FY ice mixes somewhat with old ice: 46 % of CS-2 measurements in polygons marked to consist mostly of thin FY ice in the AARI charts are classified to be old ice based on CS-2. Analogously 8% of CS-2 measurements from polygons where old ice is dominant is classified as thin FY ice. Part of the inconsistency is natural. In reality there are inclusions of FY ice within the old ice area as well as inclusions of old ice in the FY ice area. However, there are CS-2 measurements classified as old ice south of 80^{o} N. It is unlikely that these are in reality old ice. We assume these to be areas of deformed ice where the large scale surface roughness is more akin to old ice than recently formed FY ice. If this is the case, the information about deformed ice, most likely an obstacle to navigation, would be valuable for operational ice charting. Sadly, we have no means to test our assumption.

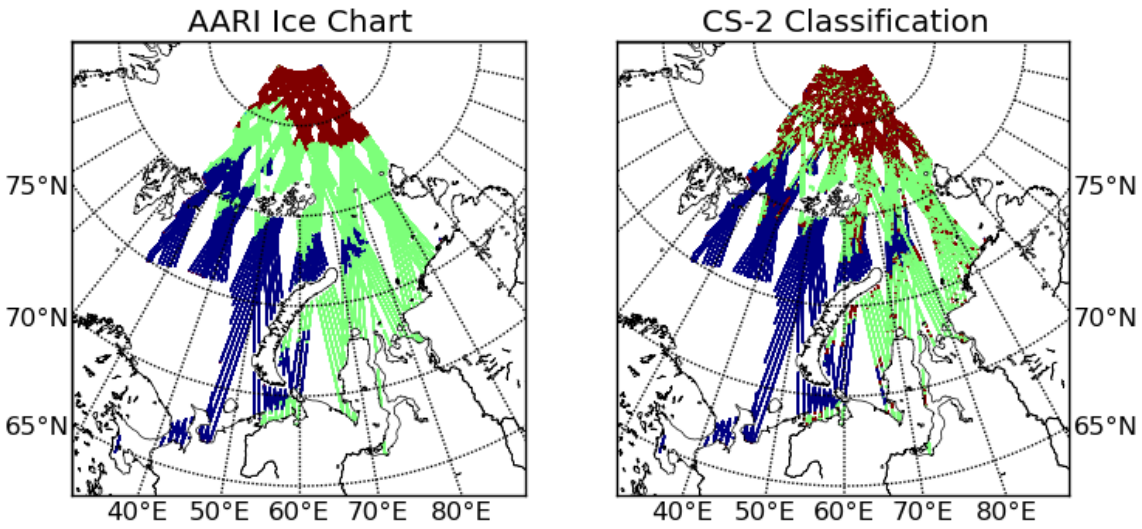

Figure 1: Automatic classification test for November 2013. AARI Ice Chart sampled at CS-2 footprints (left) and the classification result from CS-2 measurements. November 15.-30. 2013. Blue = Open water, Green = FY < 70 cm and Red = MY.

For March (Figure 2) the results are similar to November. The overall correspondence of AARI maps and the CS-2 classification is good. The two FY ice classes mix considerably. Furthermore there are inclusions of thin FY ice within the thick FY and vice versa. The results for open water (93% right) and old ice (83% right) are good. It may be that our classification exaggerates the amount of old ice, especially in the areas where heavy deformation is likely to occur. However, for the purposes of operational ice charting, a cautious approach is often preferred.

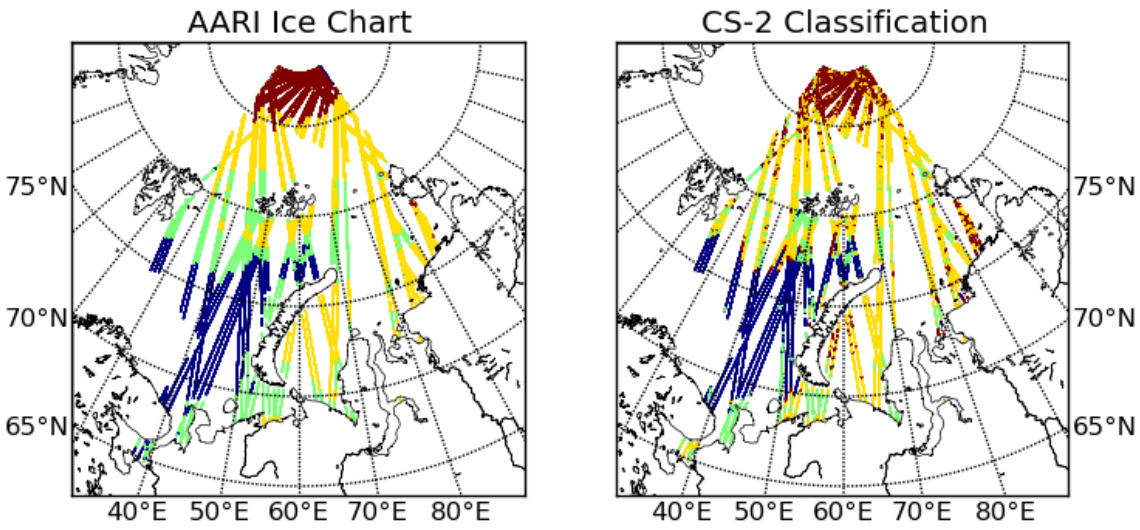

Figure 2: Automatic classification test for March 2014. AARI Ice Chart sampled at CS-2 footprints (left) and the classification result from CS-2 measurements. March 15.-30. 2014. Blue = Open water, Green = FY < 70 cm, Yellow = FY > 70 cm and Red = MY.

Limitations and challenges

We have demostrated the classification to work well enough to support ice navigation. Due to sparseness of Cryosat-2 data, our product will never replace the current use of imaging SAR in ice services but it is able to support it, as well as mitigate situations where no SAR data is available.

Plans for the operational product (D3.4)

For the SPICES deliverable D3.4 we shall build a system for the American sector of the Arctic using ice charts from the Canadian Ice Service. The system shall use the methodology described in Rinne and Similä [2016], but will be built on the ESA CCI Pysiral software package.

References

Rinne, E. and Similä, M.: Utilisation of CryoSat-2 SAR altimeter in operational ice charting, The Cryosphere, 10, 121-131, doi:10.5194/tc-10-121-2016, 2016.

WMO SEA ICE NOMENCLATURE: A snapshot of the WMO Sea Ice Nomenclature (WMO No. 259, volume 1 – Terminology and Codes, Volume II – Illustrated Glossary and III – International System of Sea-Ice Symbols)by March 2014 (5th Session of JCOMM Expert Team on Sea Ice) Available online at: http://www.jcomm.info/index.php?option=com_oe&task=viewDocumentRecord&docID=14598