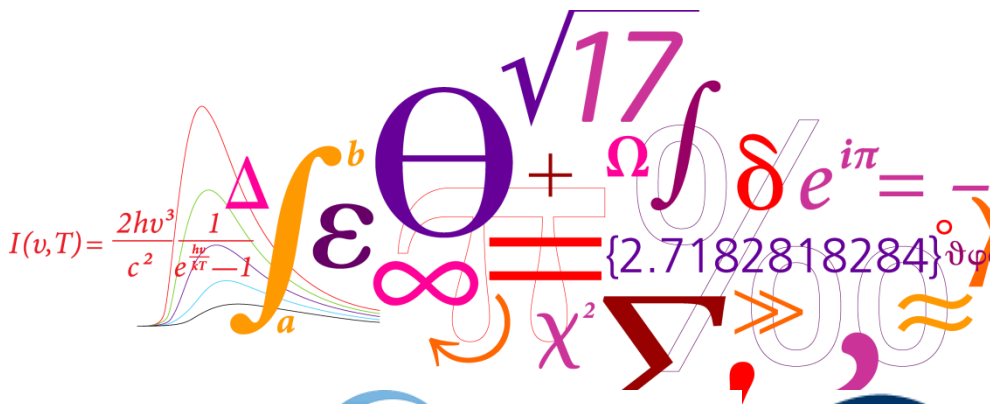


Satellite observations of ice concentration and sea ice drift

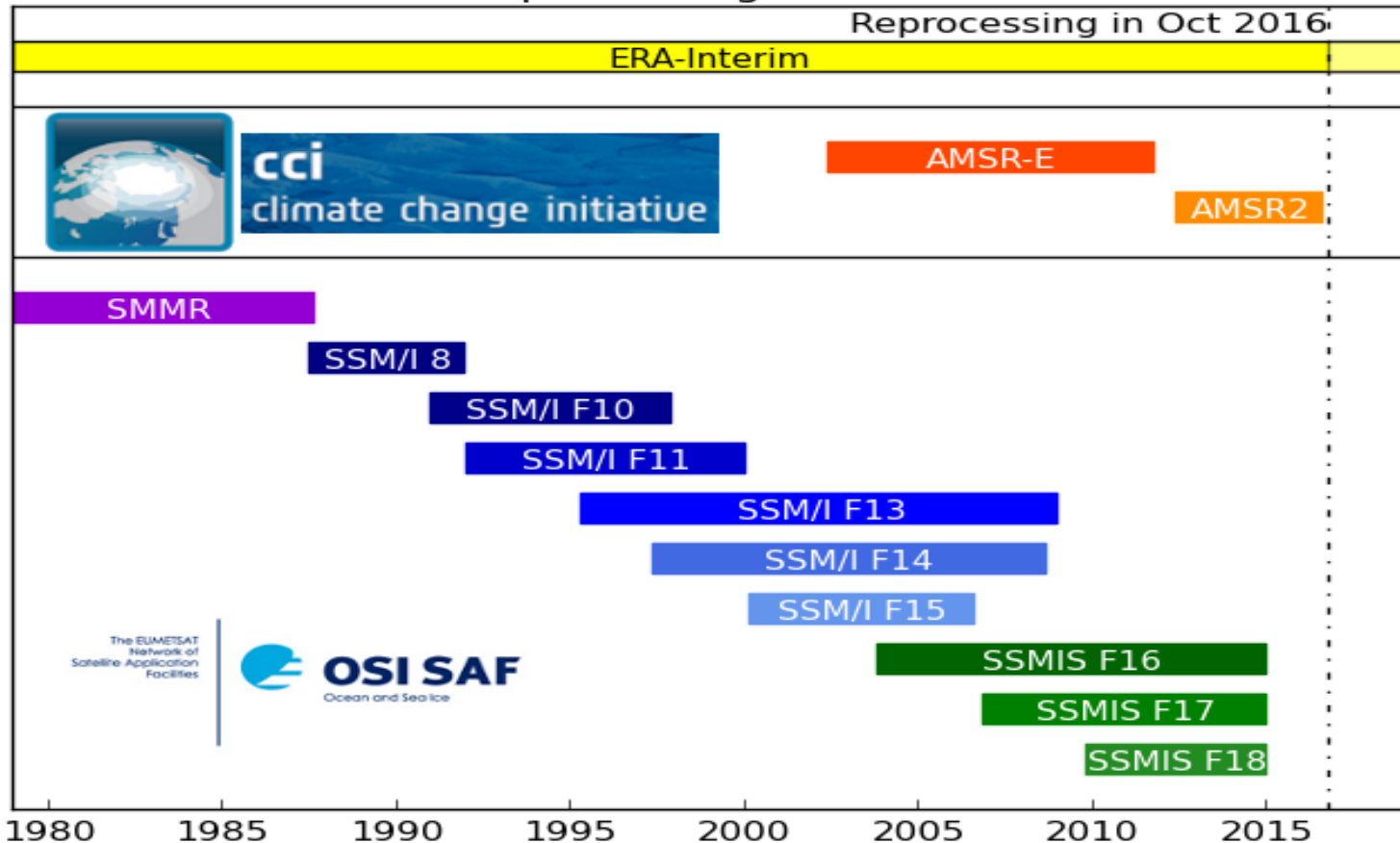
Leif Toudal Pedersen, Technical University of Denmark
Roberto Saldo, Technical University of Denmark
Thomas Lavergne, MET Norway
Matilde Brandt Kreiner, DMI
Rasmus Tonboe, DMI
Stefan Kern, ICDC Hamburg
John Lavelle, DMI






New OSISAF and CCI Sea Ice Concentration Climate Data Records

- Exploit “all” the passive microwave imagers for a new polar sea ice concentration data record.
- R&D, software developments, and production coordinated between the OSISAF and CCI teams

Satellite sensors for Sea Ice Concentration reprocessing in 2016



Taking advantage of «all» instruments

CDR	Algorithm / Channels	Instruments	Period	Grid resolution	Project
OSI-450	(19v,37v,37h)	SMMR SSM/I SSMIS	1979-2015	25x25 km	 OSISAF Operational Sea Ice Analysis and Forecasting
SICCI2 25.0km	(18v,36v,36h)	AMSR-E AMSR2	2002-2011 2012- 2017	25x25 km	 sea ice cci
SICCI2 50.0km	(06v,36v,36h)	AMSR-E AMSR2	2002-2011 2012- 2017	50x50 km	 sea ice cci

Status October 2017:

The OSISAF CDR was **released** in May 2017: <http://osisaf.met.no>;

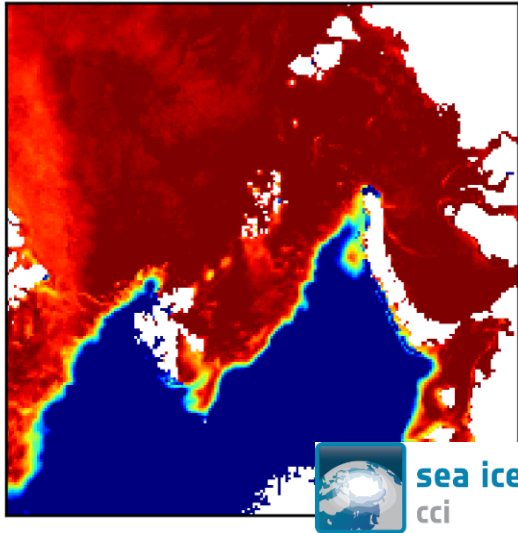
The ESA CCI CDRs are **released**: (<http://cci.esa.int/data>);

<http://cci.esa.int/data>; March 2017, v2.0, 2002-2015;

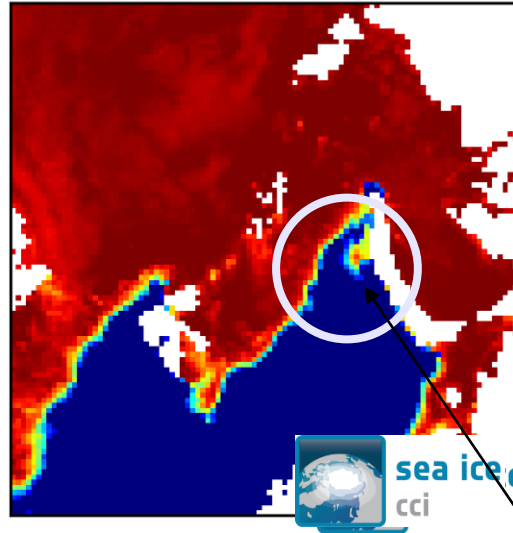
October 2017, v2.1, [extended](http://cci.esa.int/data) to 15th May 2017.

Some snapshots 20130315

CCI 12.5km



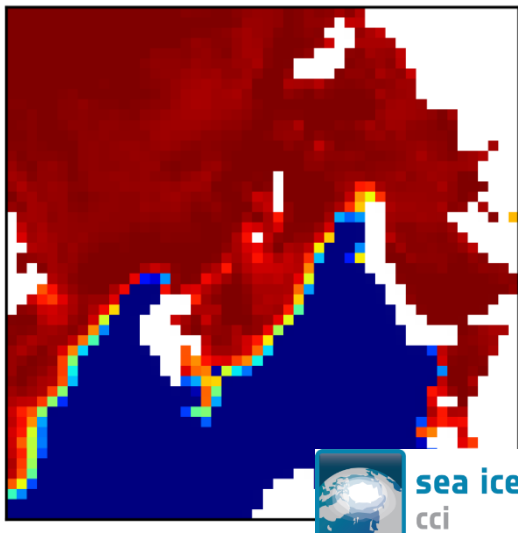
CCI 25.0km



Example maps from the 3 AMSR2 (CCI) and the SSMIS (OSI) CDRs on 15th March 2013.

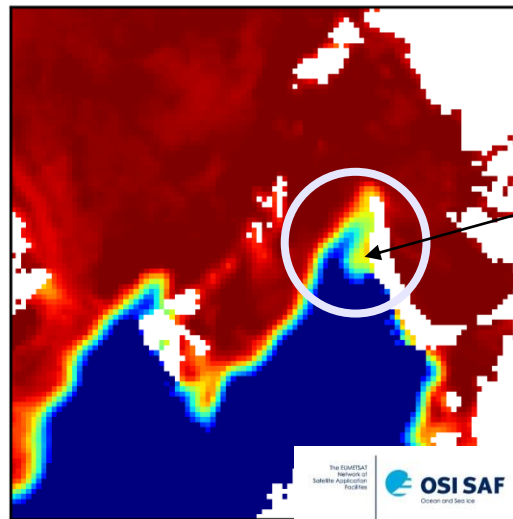
The maps from AMSR2 exhibit more details along the ice edge, except that at 50km using 6 GHz.

CCI 50.0km



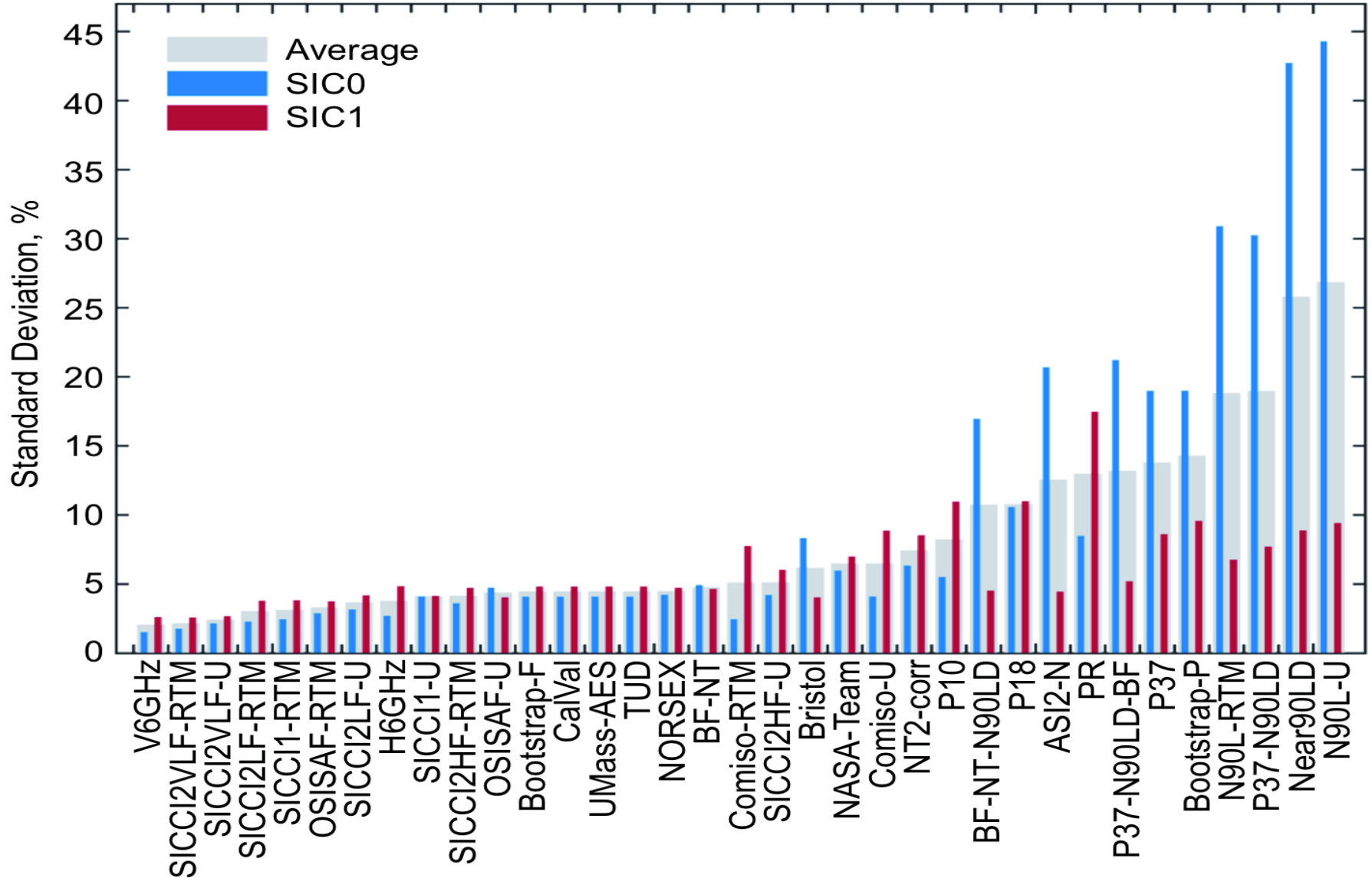
20130315

OSI 25.0km

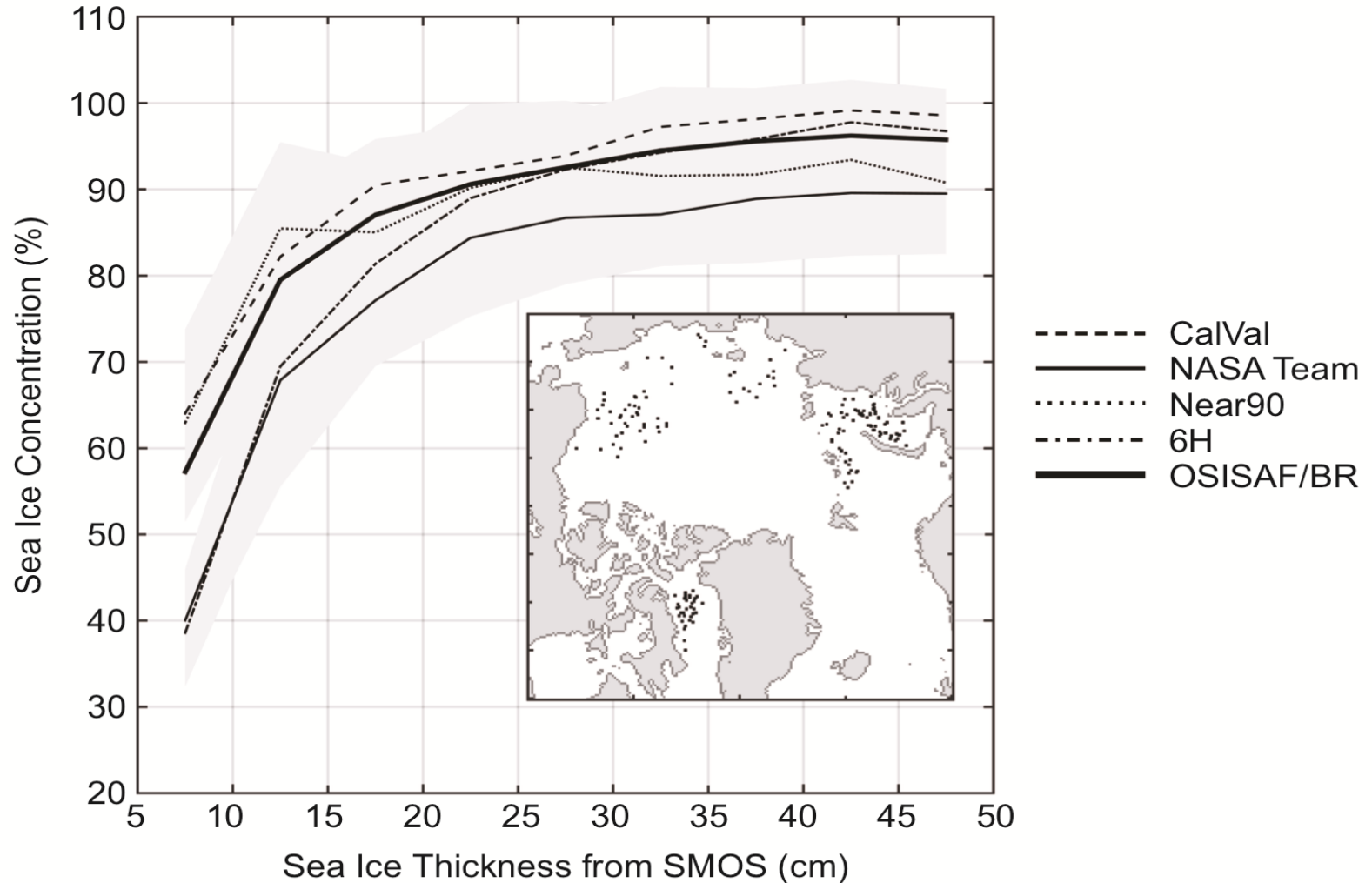


Much finer Marginal Ice Zone details with CCI/AMSR data.

Algorithm selection

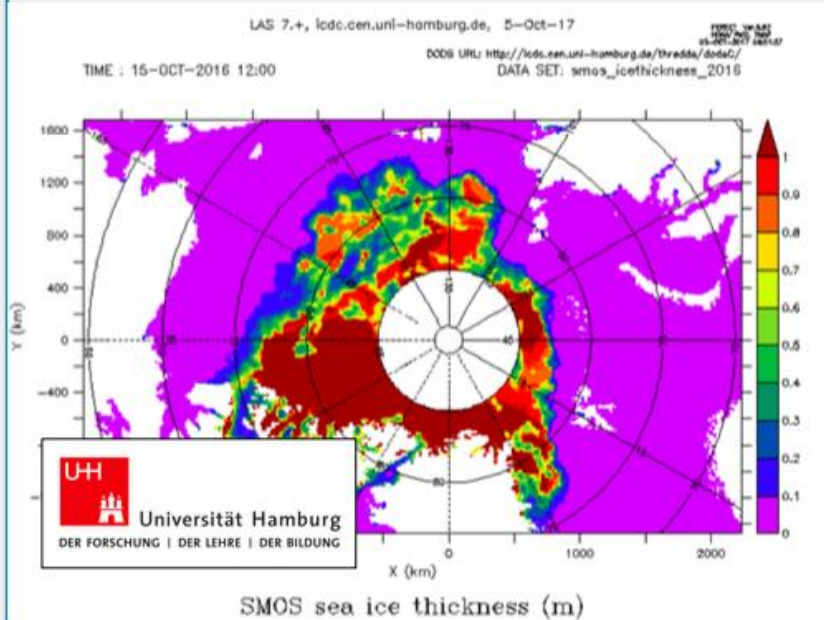


"Concentration" of thin ice

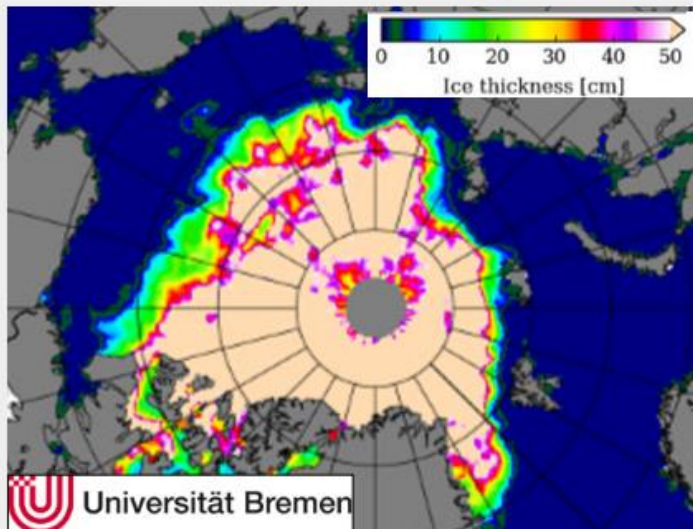
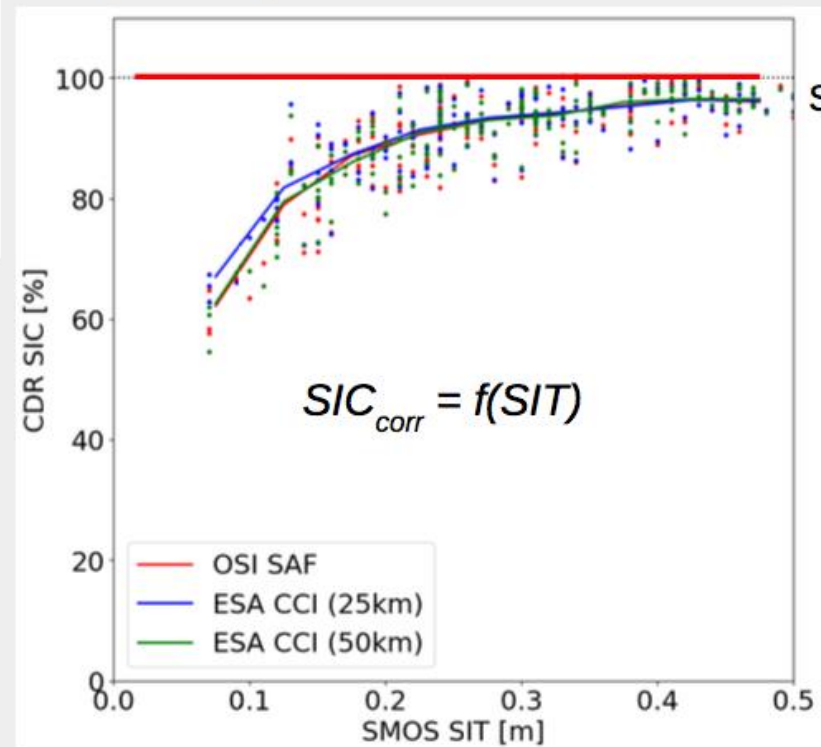




SURF: Thin Sea Ice



- Thin sea ice thickness monitored in near-real-time with ESA's SMOS mission (L-band radiometer)
- Cross-checked with Sentinel-1 SAR to select ~400 cases with 100% SIC and SIThickness [5;50cm].

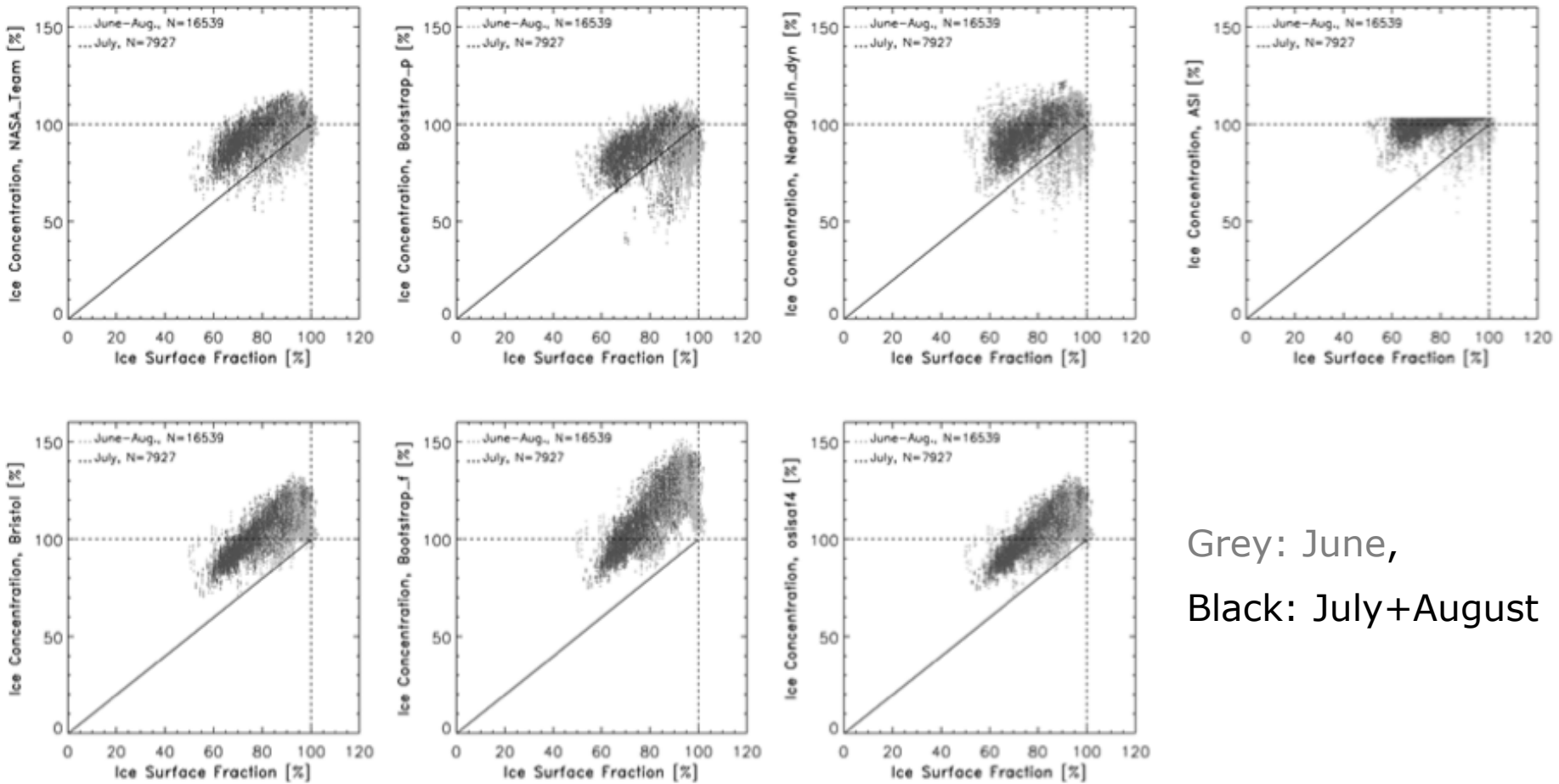


Thin ice

- 100%, thin (<20cm) sea ice will be systematically retrieved as lower concentration of sea ice.
- 100%, thin (>20cm, <50cm) can also be biased low because it is typically more saline, smooth, snow-free.
- EO community cannot “fix” this consistently unless we bring external SIT information, e.g. from models.
- EO community provides operators $f(\text{SIC}, \text{SIT})$ to modelers for translating model (SIC, SIT) to PMR SIC

SIC and melt ponds

Ice surface fraction is the fraction of the surface which is ice (NOT melt-pond and NOT lead/open water)



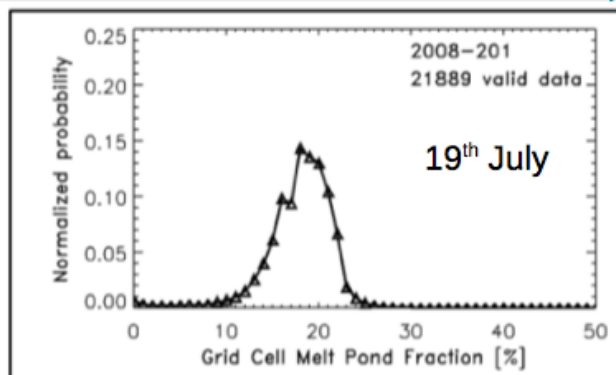
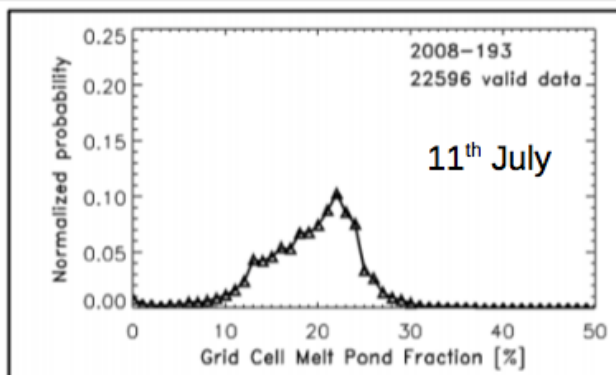
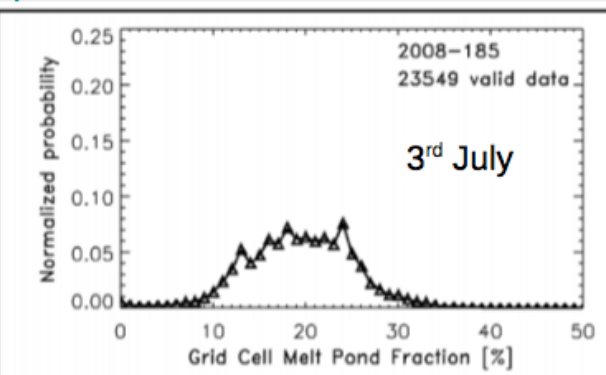
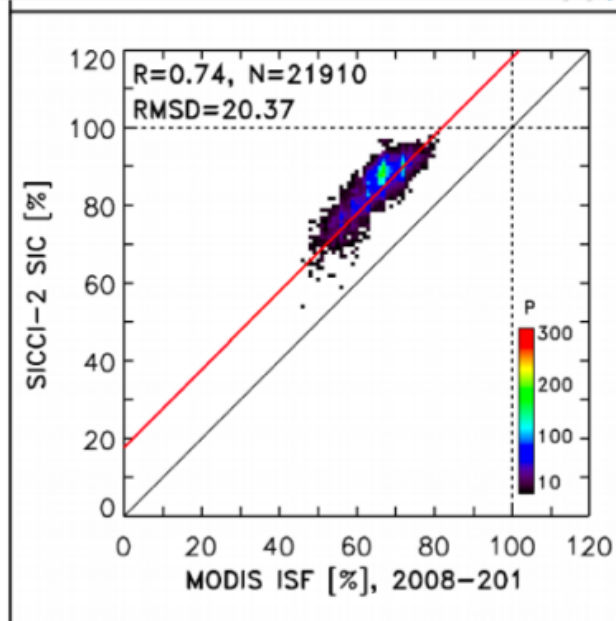
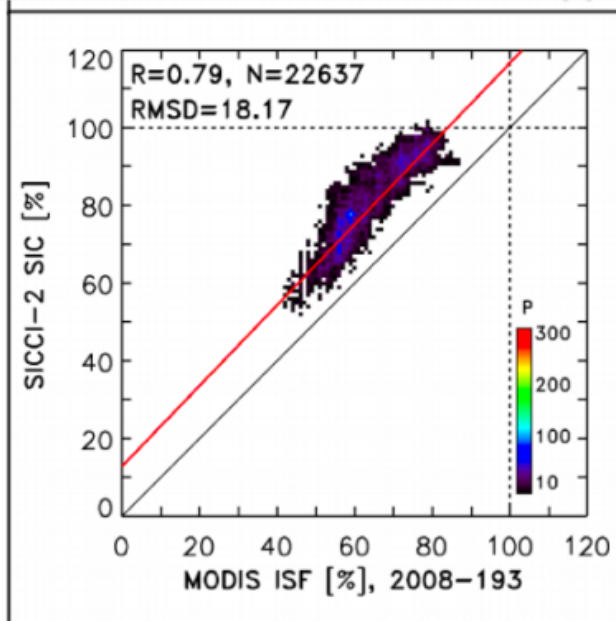
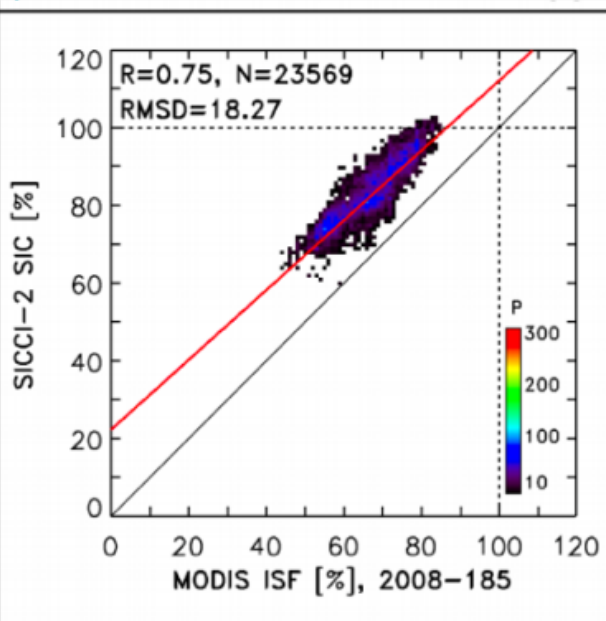
Grey: June,
Black: July+August

SURF: Melt-pond water

What modelers
get today



Credit: S. Kern, ICDC, Univ Hamburg



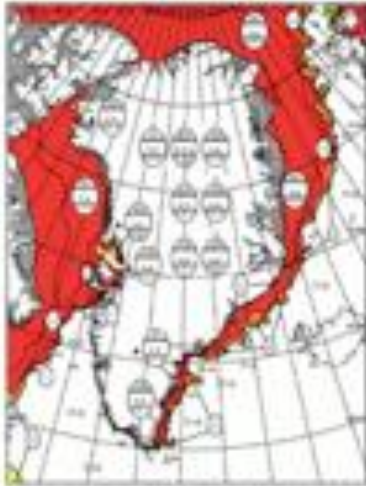
Melt ponds

- At the PMW channels we use for SIC retrievals, there is no difference between the emission of sea water (leads) and melt water (ponds).
 - $PMR\ SIC = ISF = 1 - (LeadFraction + MeltPondFraction)$
 - EO data producers cannot correct for this, unless by bringing extra information (model data, melt-pond parametrization,...).
-
- Choice for modelers:
 - 1) get and use an accurate, time-consistent ISF?
 - 2) have EO scientists break physics to get "nice" results?

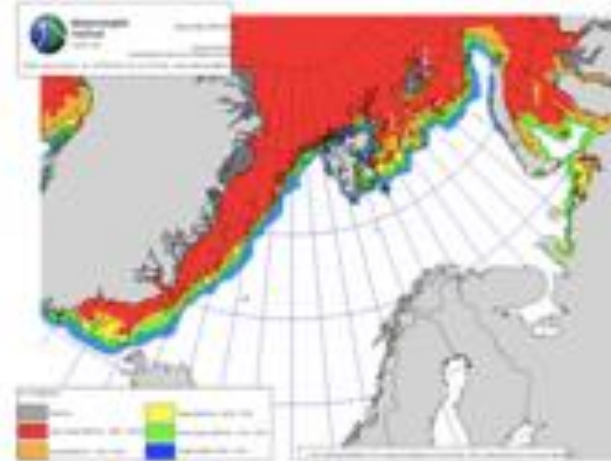
Sea ice concentration, area and extent

- What the satellites measure is more or less the fraction of the resolution cell covered by ice at the surface.
 - Often data are provided on a finer grid than the resolution!
- It is the misinterpretation of melt ponds that has led to the invention of the concept of sea ice extent (all grid cells with a concentration above 15%)
- The 15% threshold was introduced since most sea ice concentration algorithms deploy a so-called weather filter to remove spurious weather induced ice but which on average also removes ice up to 15% (sometimes more).
- Note that sea ice extent calculation will depend on resolution – finer resolution will lead to smaller extent – be sure to use the same resolution when comparing extents

Icechart to OSISAF SIC intercomparison



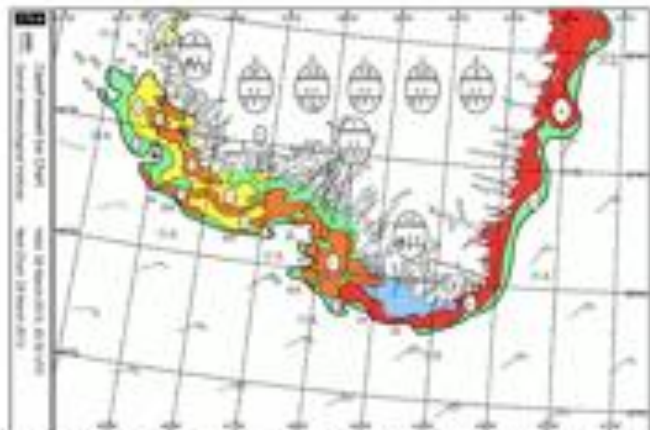
DMI Greenland Overview Ice Chart



Met.no Svalbard Ice Chart



DMI
Vejr, klima og hav



DMI Greenland Regional Ice Chart (example)



OSISAF Ice Concentration data

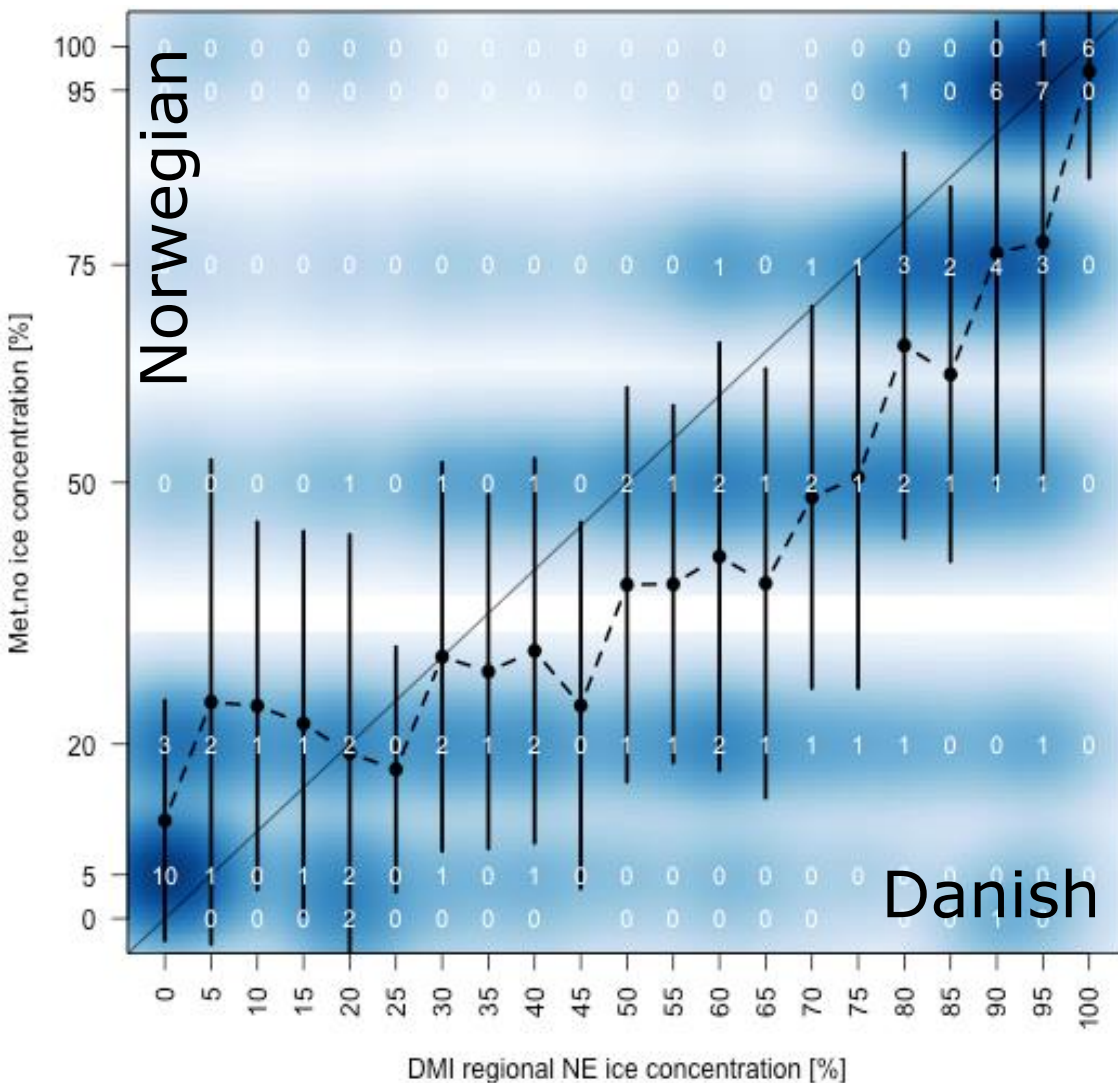
Icechart to icechart SIC intercomparison

East Greenland Area

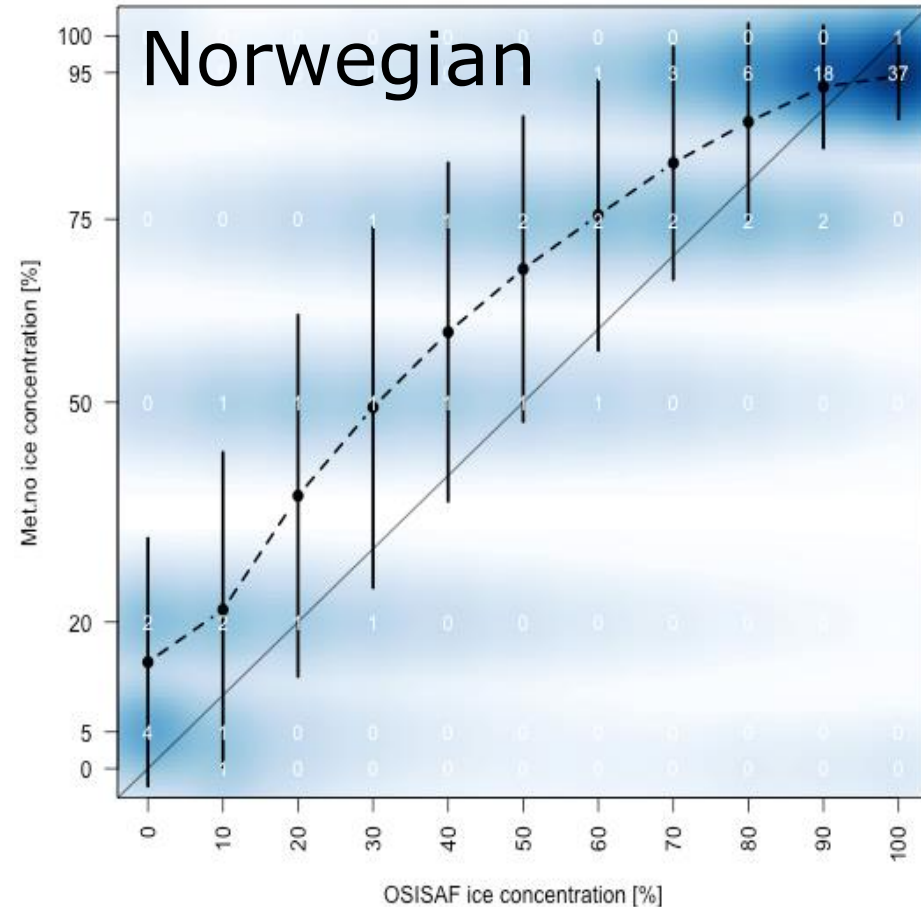
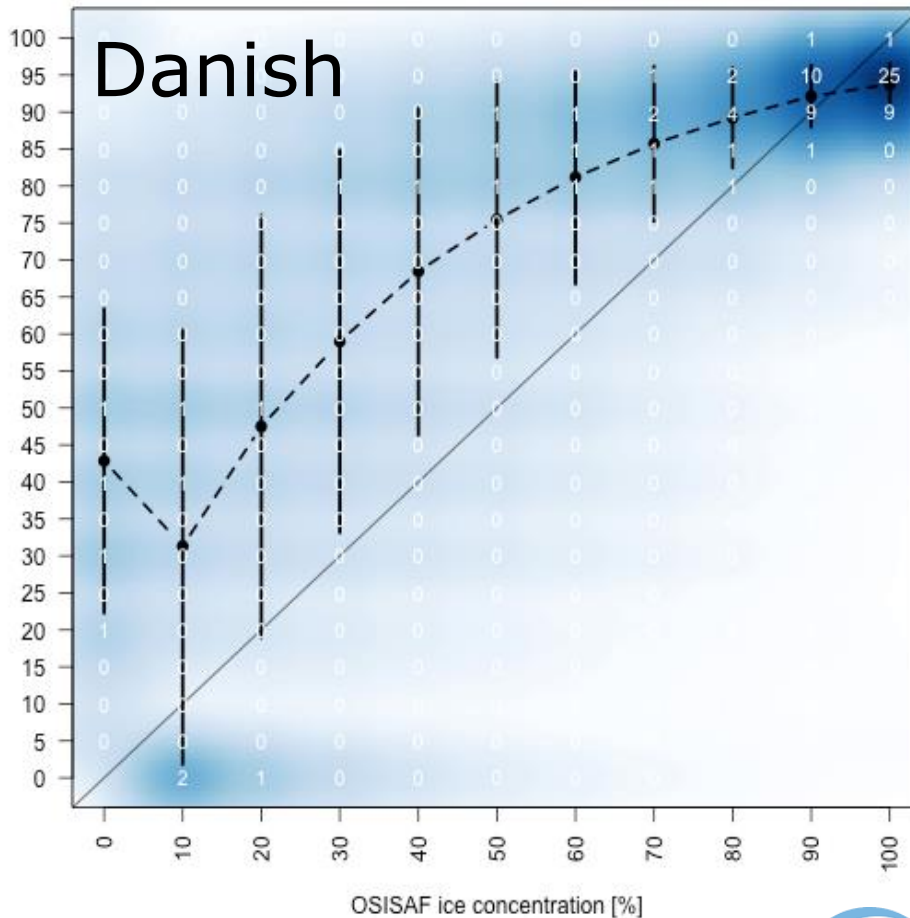


See also:

Karvonen, Juha, Jouni Vainio, Marika Marnela, Patrick Eriksson, and Tuomas Niskanen, *A Comparison Between High-Resolution EO-Based and Ice Analyst-Assigned Sea Ice Concentrations*, IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING, VOL. 8, NO. 4, APRIL 2015



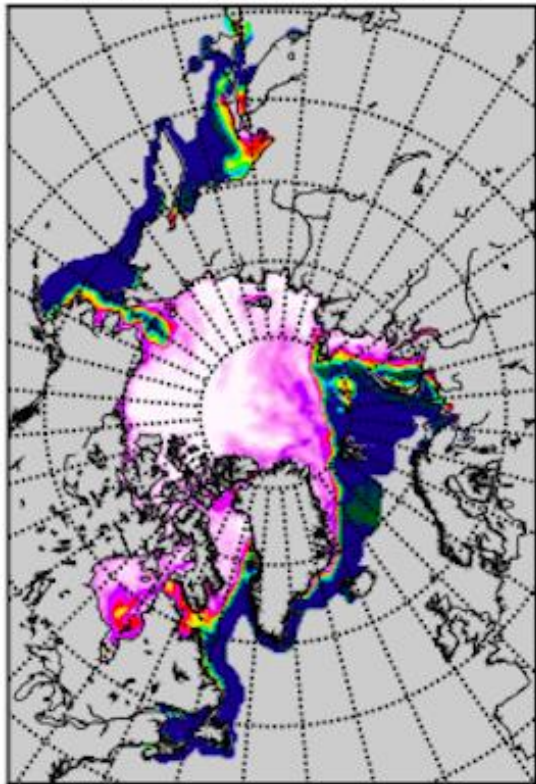
Icechart vs OSISAF SIC intercomparison



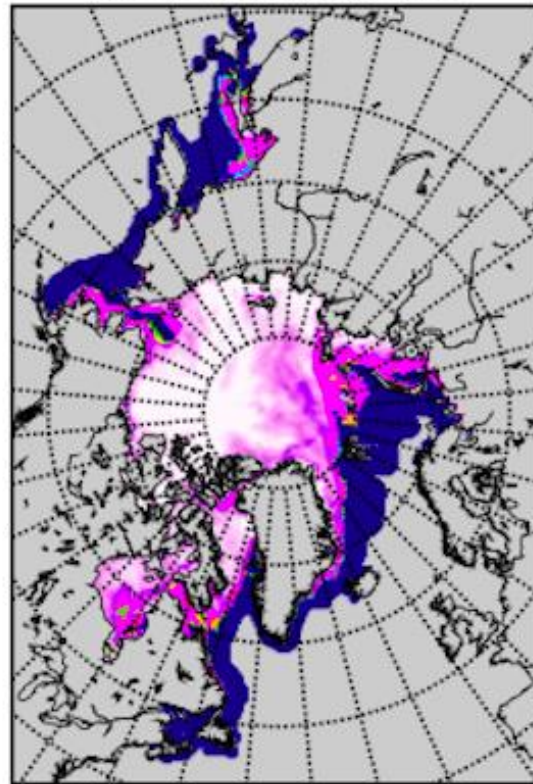
Icechart vs OSI-SAF ice concentration

Sea Ice Concentration (OSI SAF vs NIC) Comparison 2016-12-22

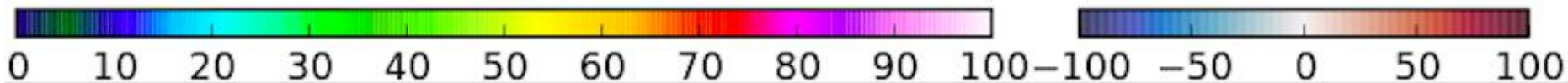
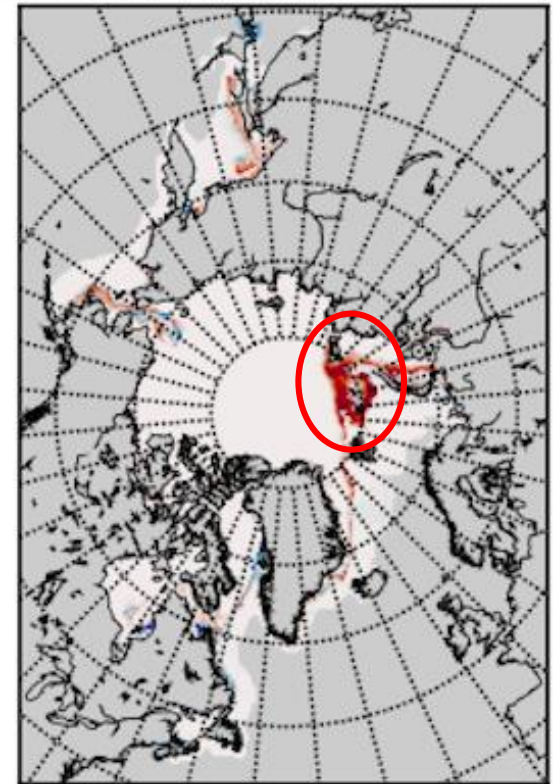
OSI SAF Percentage SIC



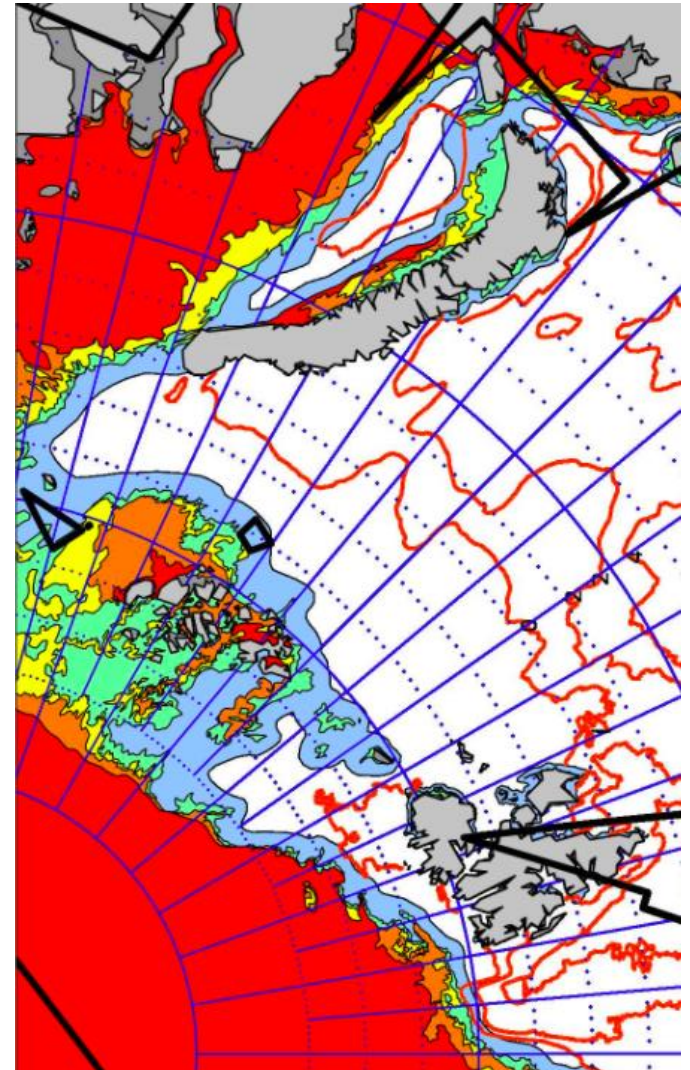
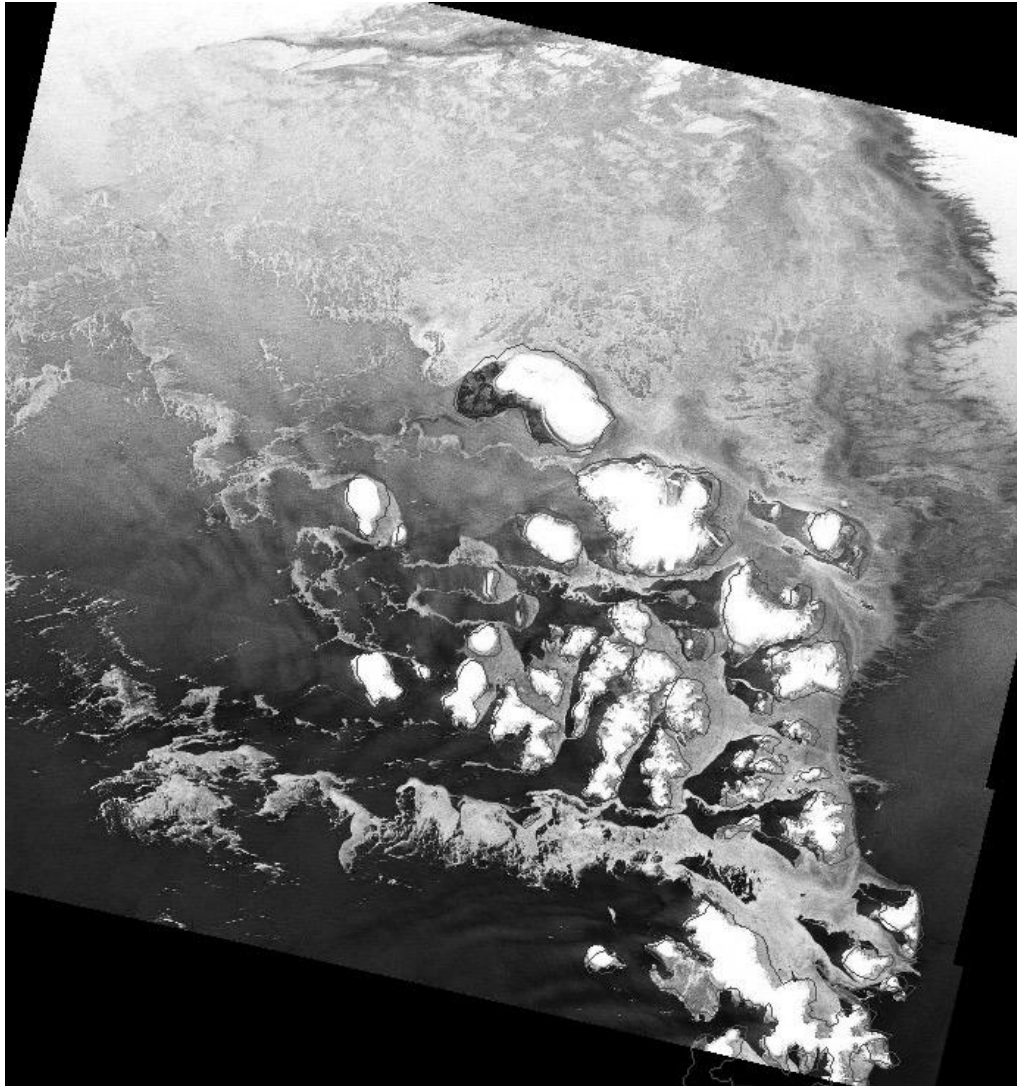
NIC Percentage SIC



SIC Anomaly ('NIC' - 'OSI SAF')



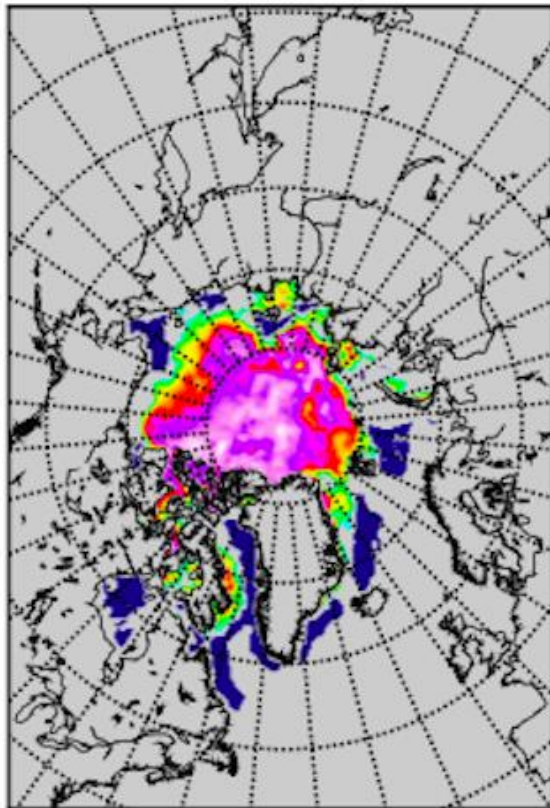
Sentinel-1 SAR and MET Icechart 2016-12-22 – NIC chart clearly overestimated the sea ice concentration



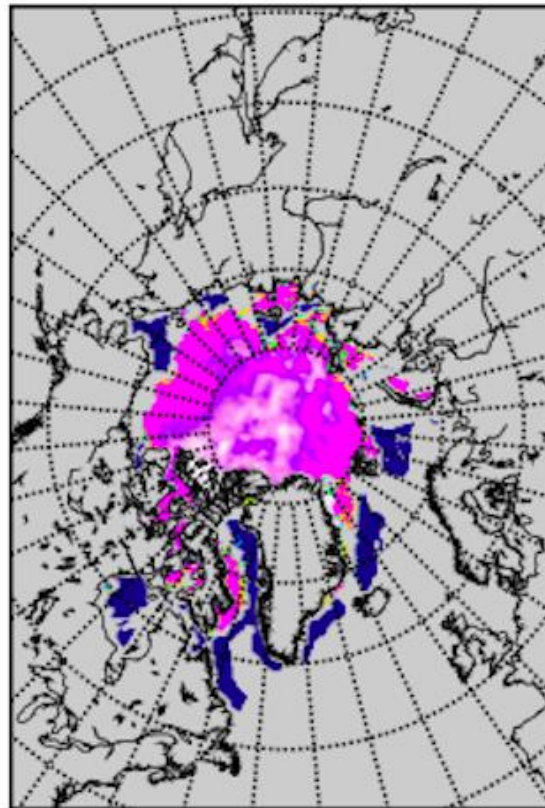
Icechart vs OSI-SAF ice concentration

Sea Ice Concentration (OSI SAF vs NIC) Comparison 2017-07-20

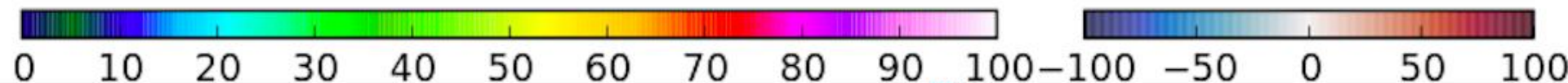
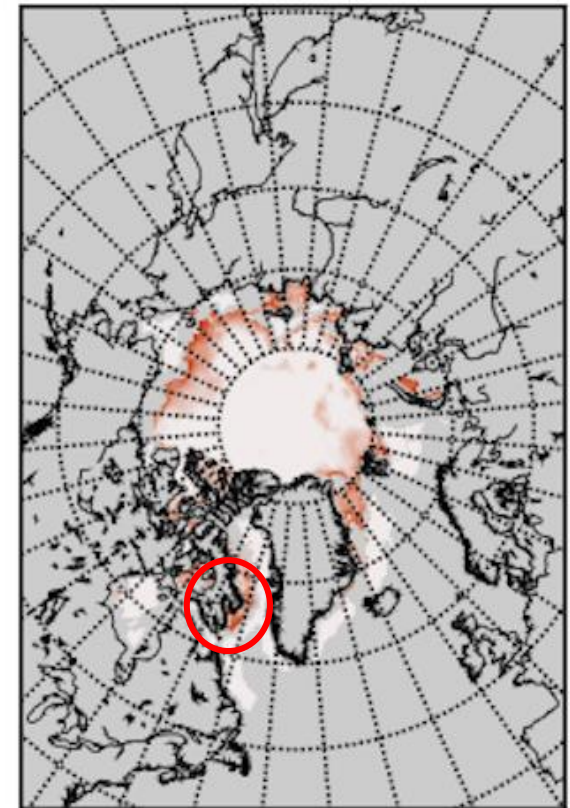
OSI SAF Percentage SIC



NIC Percentage SIC

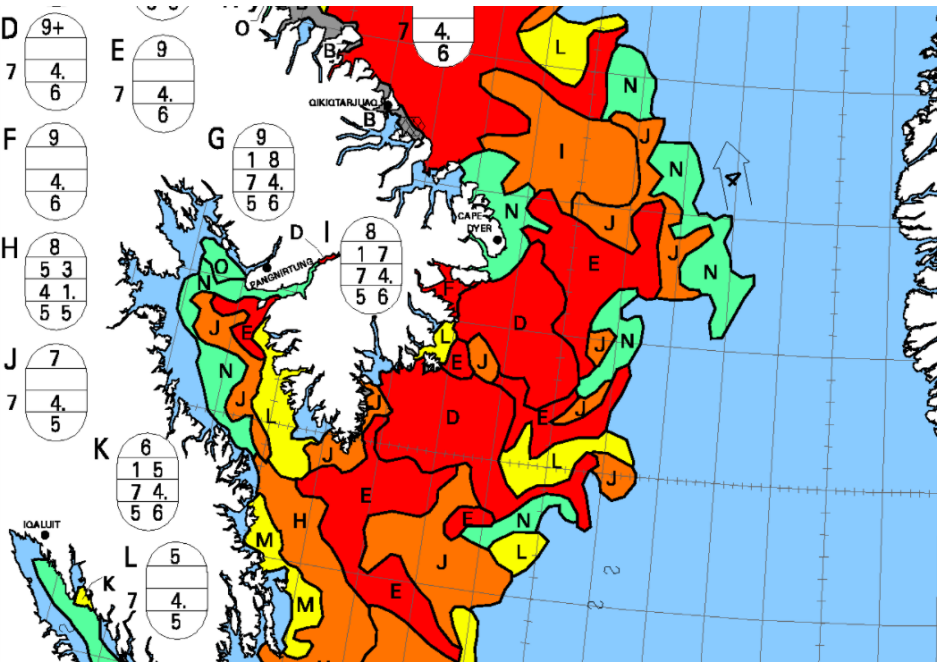


SIC Anomaly ('NIC' - 'OSI SAF')



CIS Icechart vs Sentinel-1 SAR

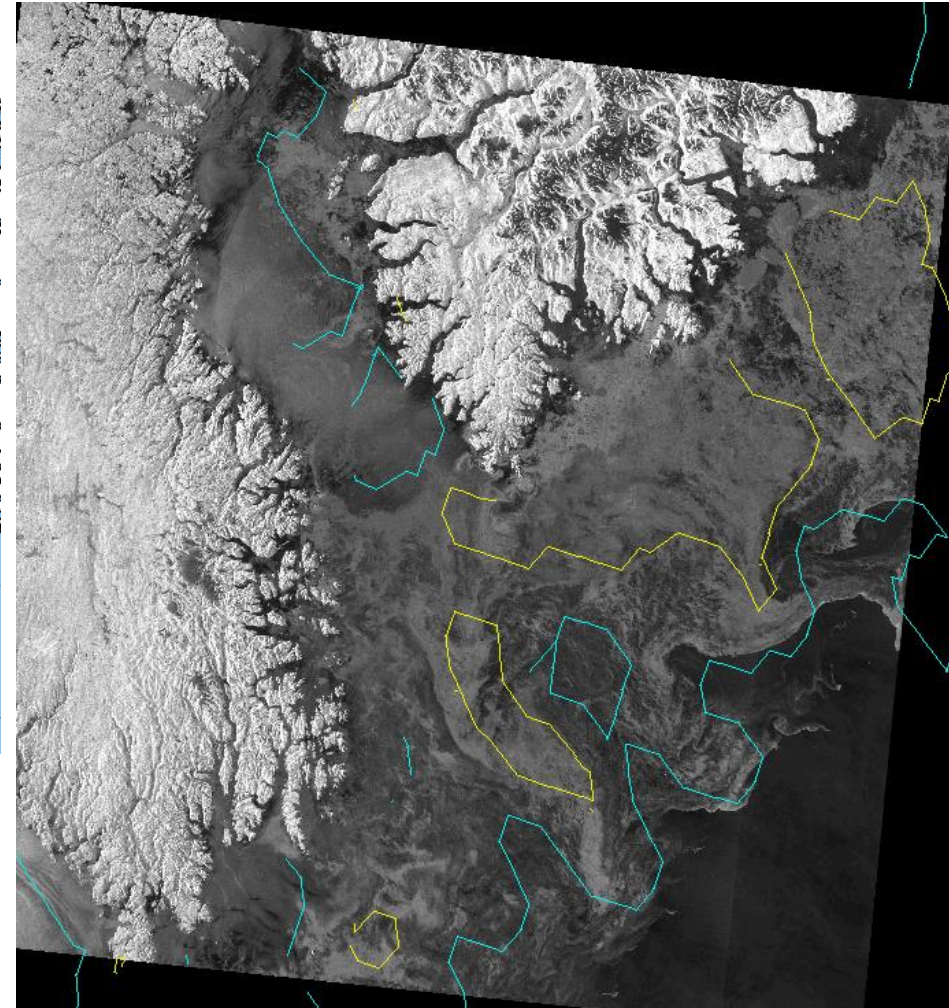
NIC and CIS icecharts clearly overestimate the intermediate concentrations



CIS daily ice chart on July 20, 2017

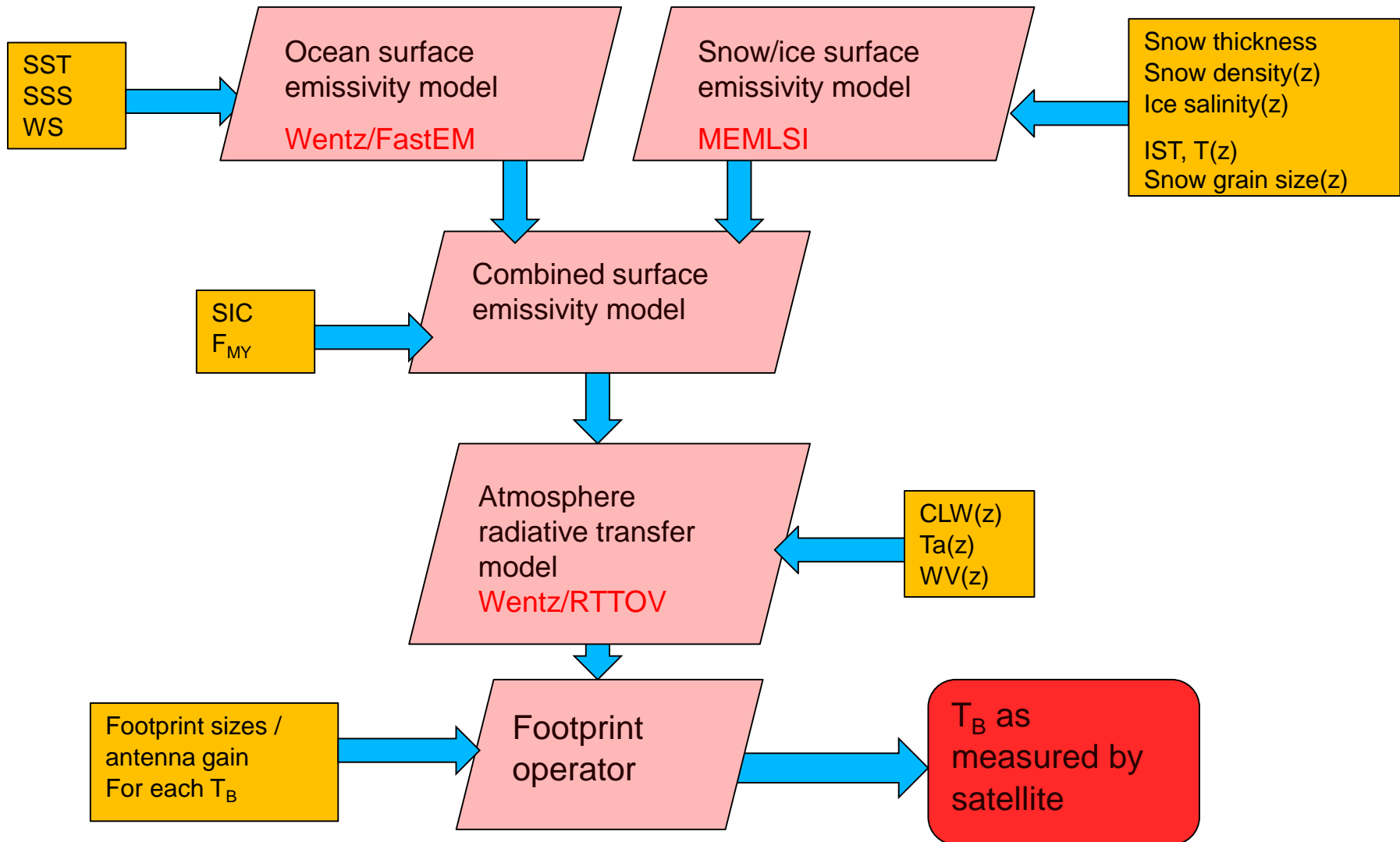
Red D-areas are 9+ in icechart

Same areas are clearly not 9+ in SAR image. Yellow contour is 60% in PMR.



Sentinel-1 SAR on July 20, 2017

Observation operator(s)



A step back is a move forward

$$\frac{\partial C}{\partial t} = \dots$$

Y: value, quantity, uncertainty

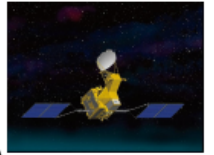


Obs Oper

Obs Oper

Obs Oper

Satellite Retrievals



T_b
radiances

~~X=SIC~~

~~X=ISF~~

X=Ice
Surface
Fraction
(+thin ice
corr)



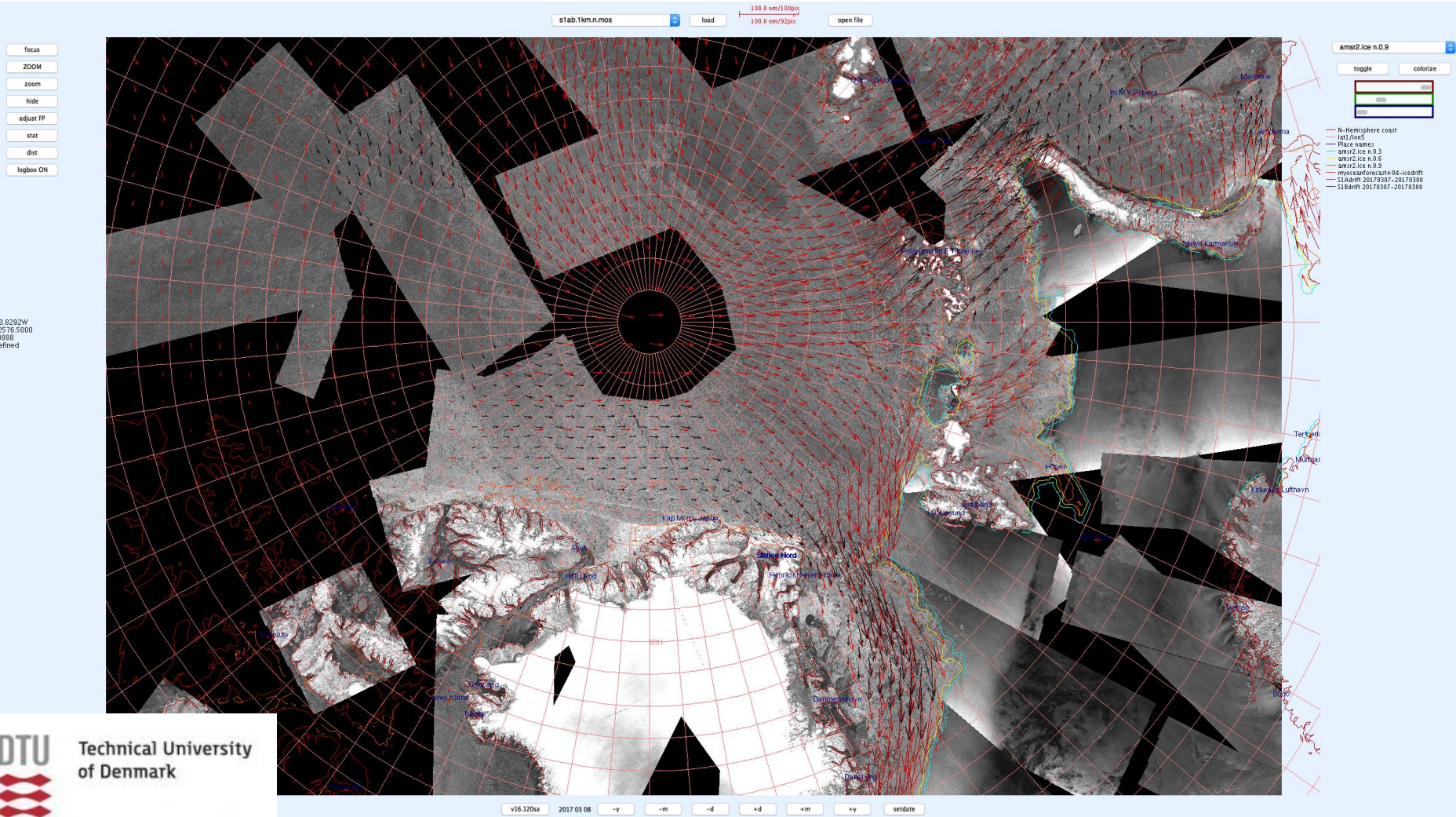
@lavergnetho

X: what the variable is, its definition

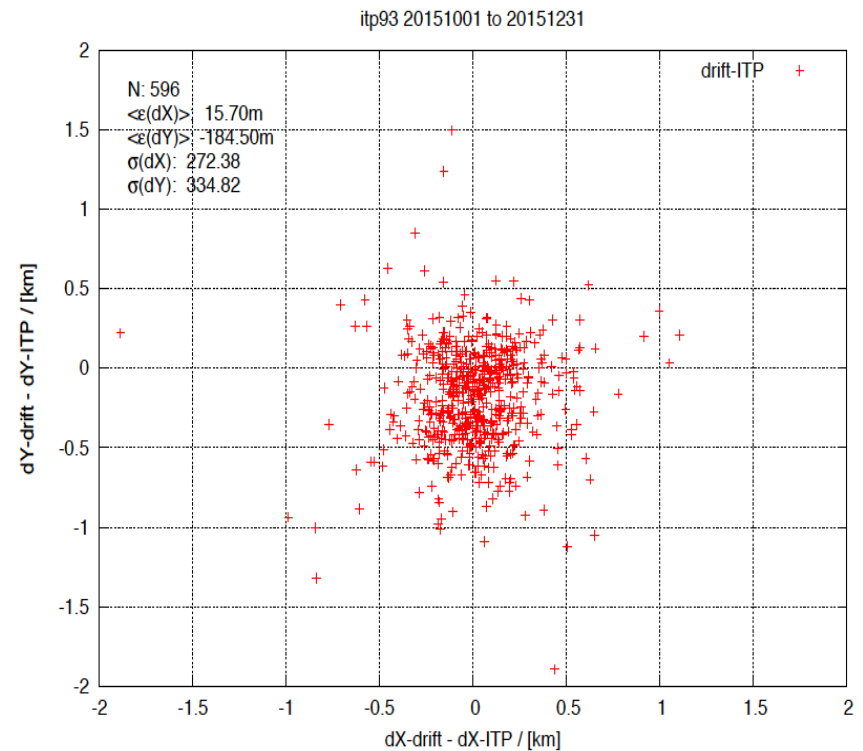
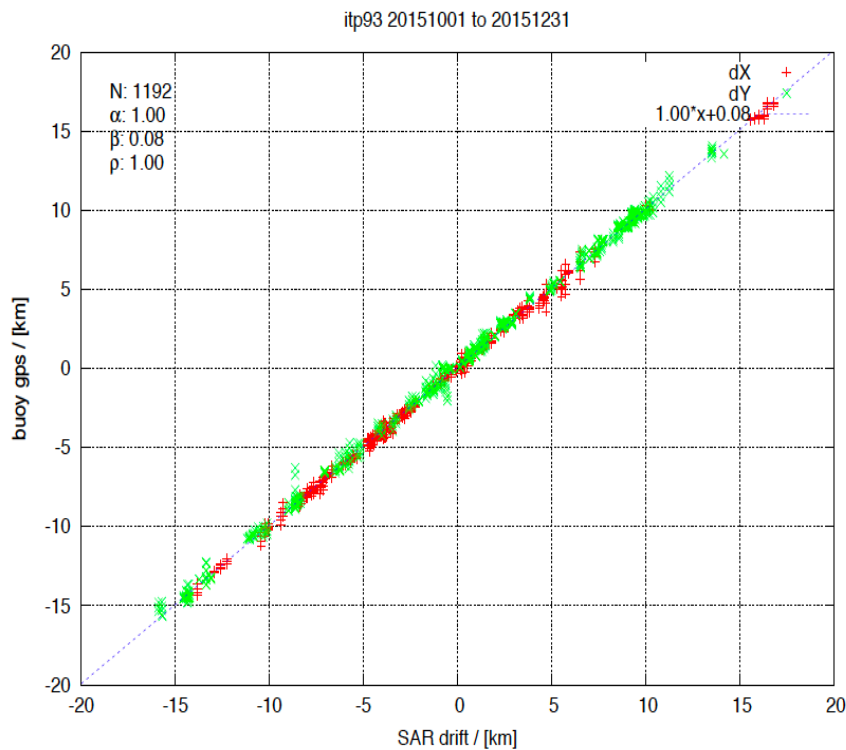
Model

Obs

DAILY NRT SENTINEL-1 A+B ICE DRIFT



Daily NRT Sentinel-1 A+B ice drift Validation with GPS buoys



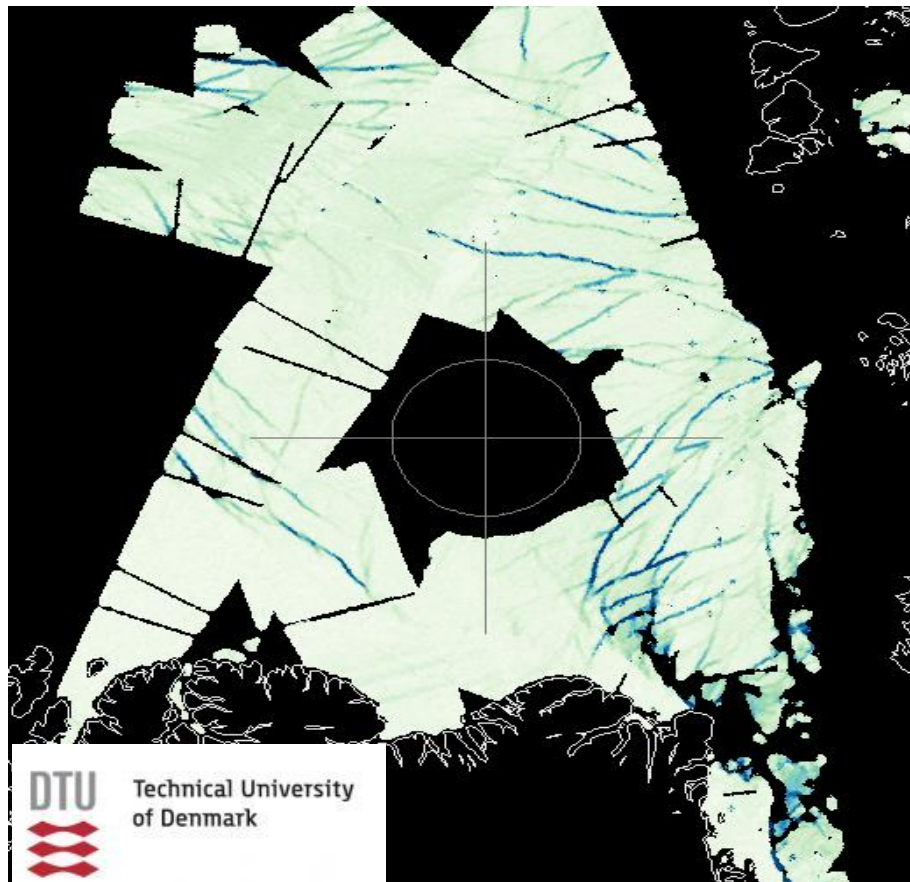
Convergence/Divergence Shear rate

For initializing ice damage/strength
2016-02-27 -> 28

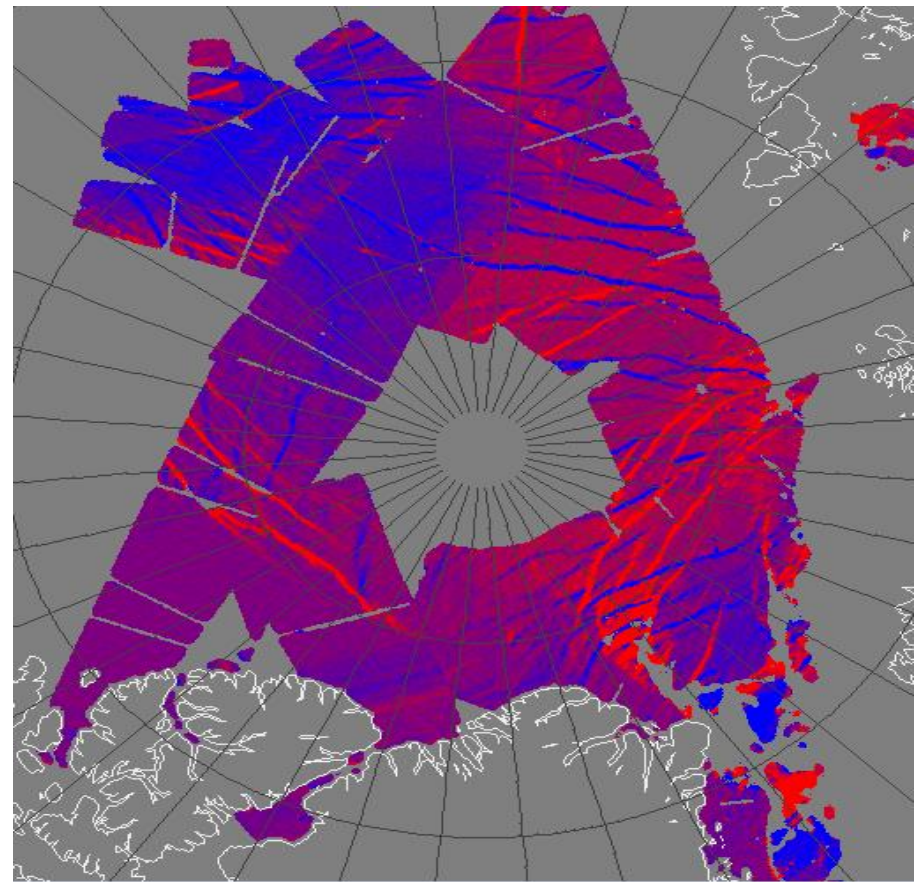
From more than 500.000 daily ice drift vectors at 2 km spacing



Shear rate



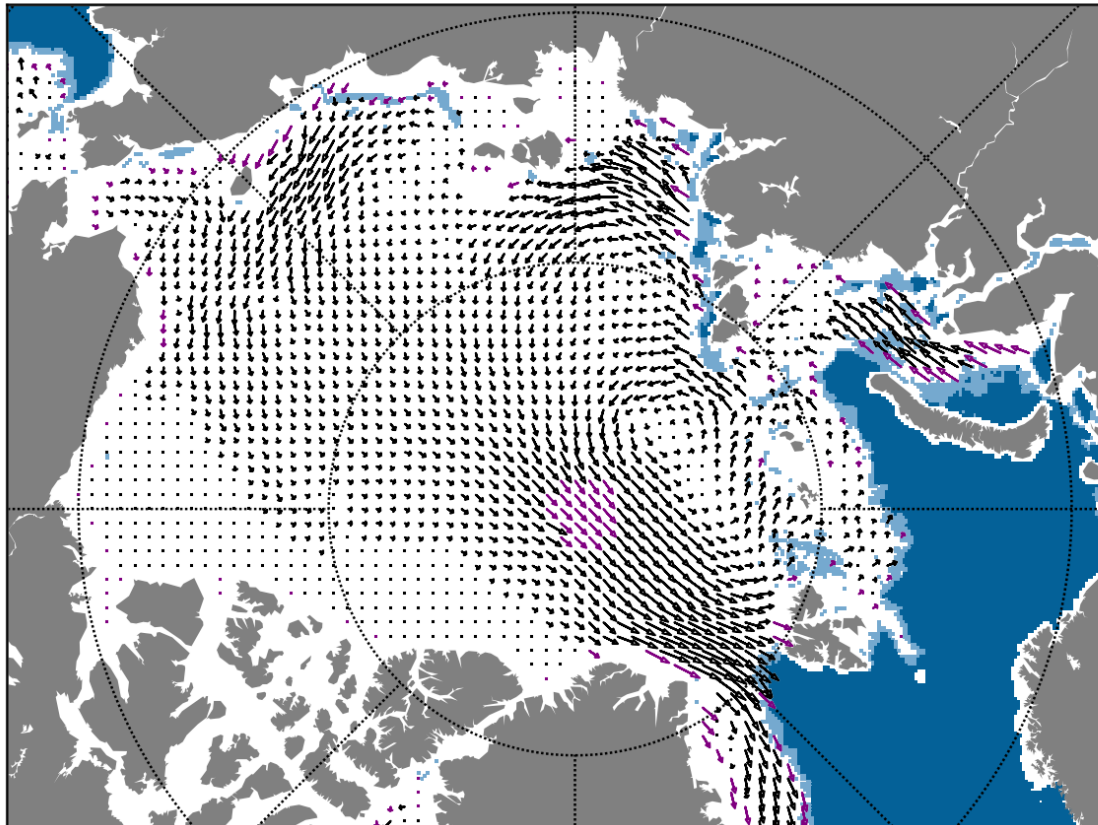
Convergence/Divergence





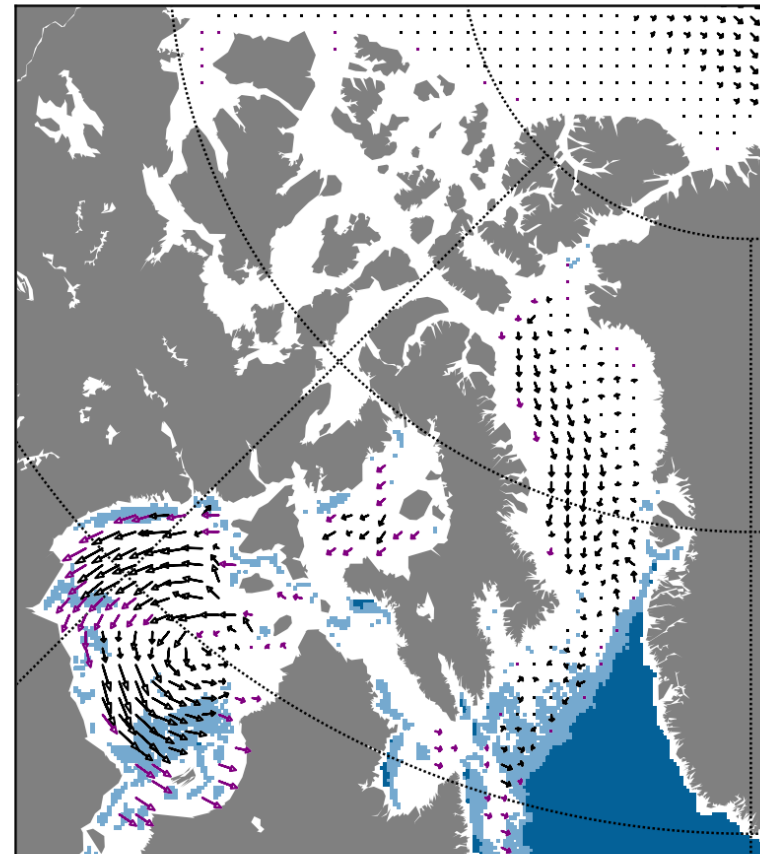
The OSISAF operational sea ice drift product

MULTI-OI / 2017-03-19 to 2017-03-21



Zone: Arctic Ocean / Image: Copyright (2017) EUMETSAT

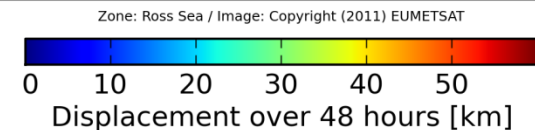
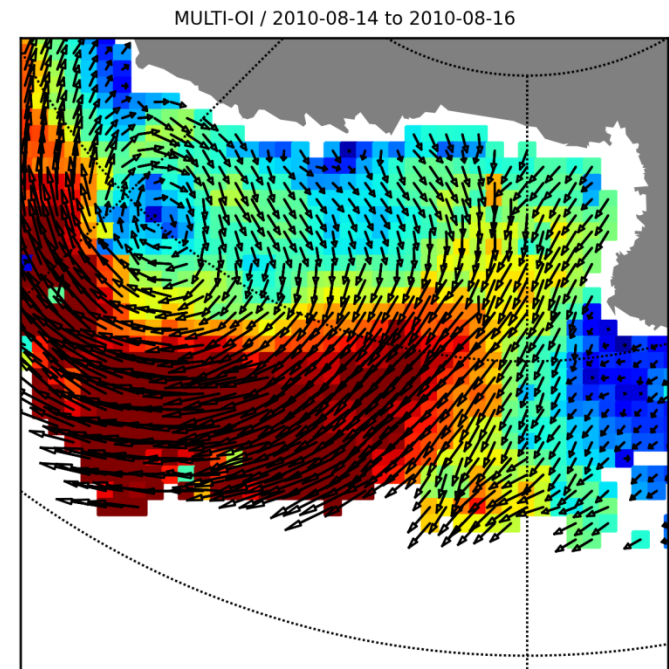
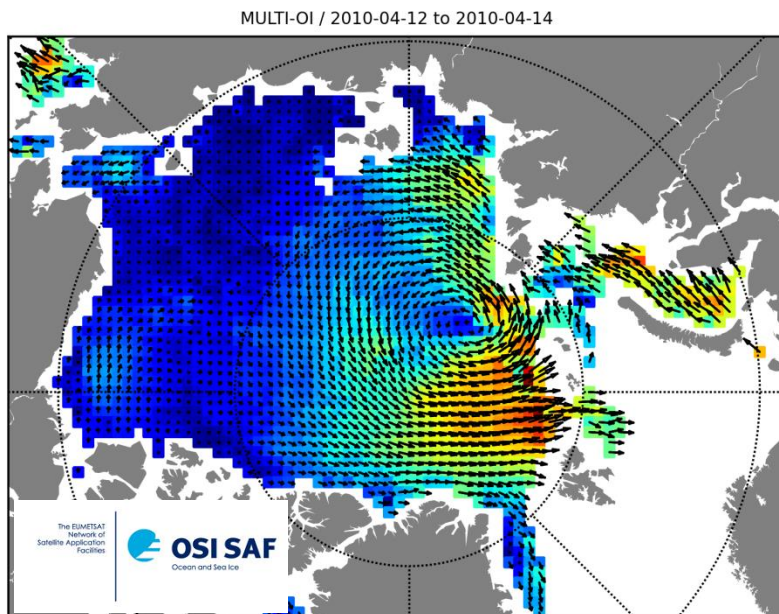
MULTI-OI / 2017-03-19 to 2017-03-21



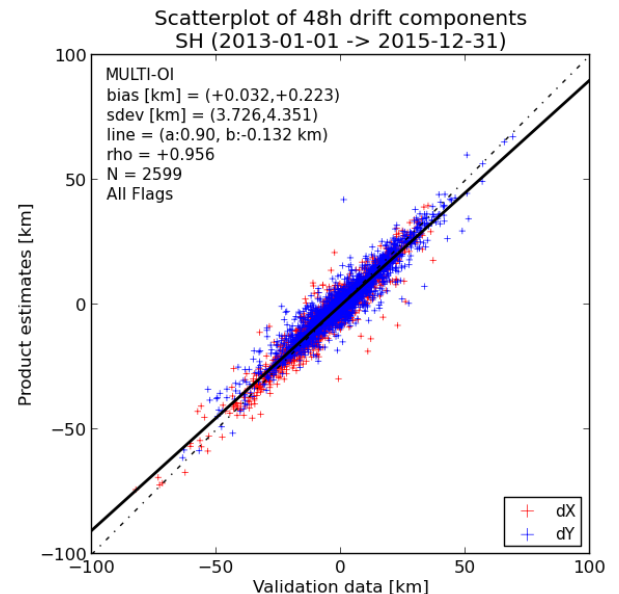
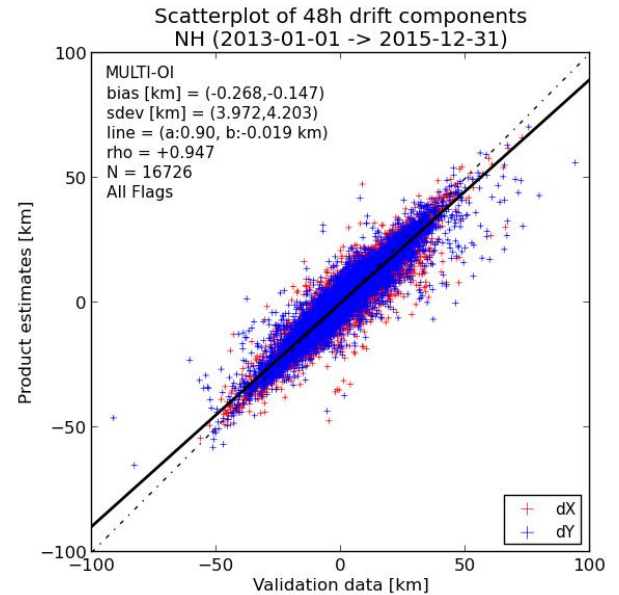
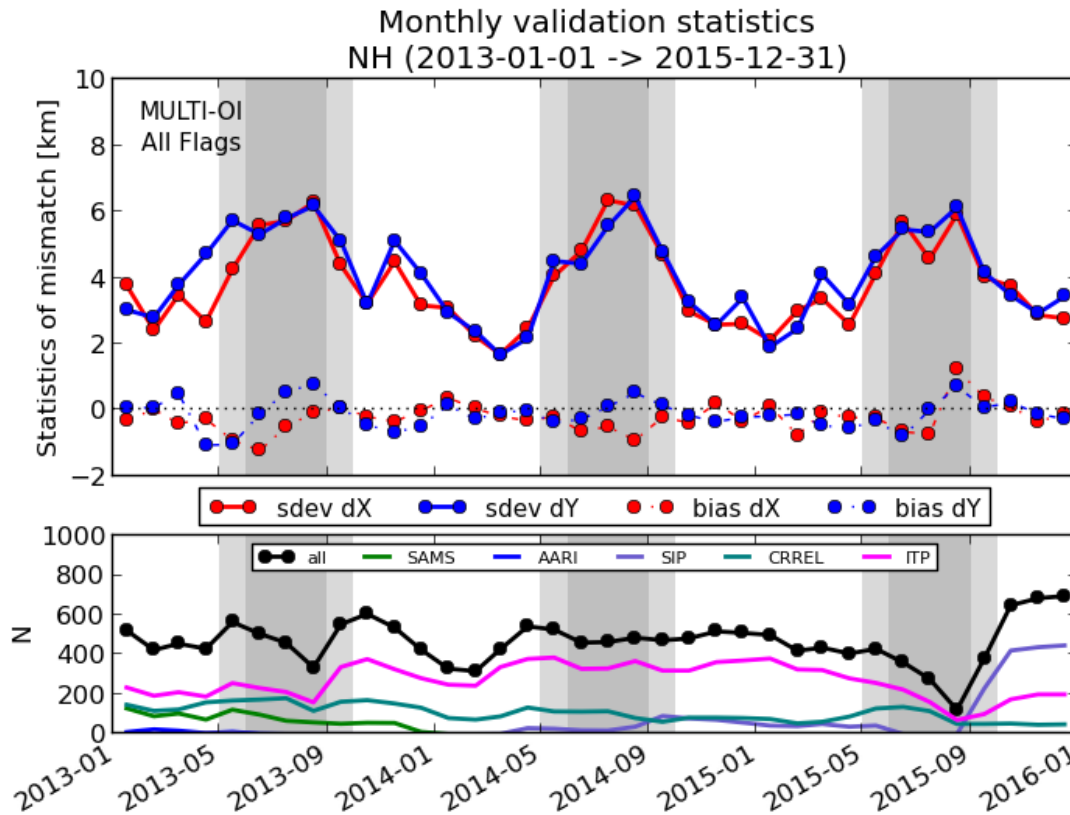
Zone: West Greenland and Canada / Image: Copyright (2017) EUMETSAT

Data access

- Daily updated on <http://osisaf.met.no>, free data access from <ftp://osisaf.met.no> (includes archive).
- To receive news and updates about the products, please register at www.osi-saf.org.



Validation



Validation for 3 years of OSISAF multi-sensor ice drift product. Above: monthly results in NH; Right: scatterplot for 3 years in NH (top) and SH (bottom)

Conclusions

- Satellite data products are NOT the truth
 - All SIC algorithms underestimate thin ice
 - All SIC algorithms see melt-ponds as 0% ice
 - Icecharts are NOT the truth either
 - They typically overestimate intermediate ice concentrations
 - They are not necessarily consistent from day to day
- 4 reasons why icechart and PMR SIC products differ
1. Thin ice is underestimated in PMR SIC
 2. Melt ponds are seen as open water in PMR SIC (PMR SIC = ISF)
 3. Wet snow on ice may lead to regional overestimation – tie-points are hemispheric
 4. Ice charts often overestimate intermediate concentrations
- However, when used with caution, satellite data (and icecharts) provide a wealth of useful information about sea ice and its snow cover
 - Data providers should provide quantitative estimates of known issues – ask them for specifications for observation operators!!

Available now...

Sea Ice Analysis and Forecasting

Towards an Increased Reliance on
Automated Prediction Systems

Edited by Tom Carrieres,
Mark Buehner, Jean-François Lemieux
and Leif Toudal Pedersen



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Sea Ice Analysis and Forecasting Towards an Increased Reliance on Automated Prediction Systems

Editors:

Tom Carrieres, *Environment and Climate Change Canada*
Mark Buehner, *Environment and Climate Change Canada*
Jean-François Lemieux, *Environment and Climate Change, Canada*
Leif Toudal Pedersen, *Technical University of Denmark, Lyngby*

Hardback, ISBN: 978-1-108-41742-6
Price: £95.00 £76.00* / \$125.00 \$100.00*
Published: October 2017, 236pp

This book provides an advanced introduction to the science behind automated prediction systems, focusing on sea ice analysis and forecasting. Starting from basic principles, fundamental concepts in sea ice physics, remote sensing, numerical methods, and statistics are explained at an accessible level. Existing operational automated prediction systems are described and their impacts on information providers and end clients are discussed. The book also provides insight into the likely future development of sea ice services and how they will evolve from mainly manual processes to increasing automation, with a consequent increase in the diversity and information content of new ice products. With contributions from world-leading experts in the fields of sea ice remote sensing, data assimilation, numerical modelling, and verification and operational prediction, this comprehensive reference is ideal for students, sea ice analysts, and researchers, as well as decision-makers and professionals working in the ice service industry.

- Provides a solid introduction to sea ice analysis and an up-to-date summary of the latest advances in automated forecasting systems for researchers as well as those who use ice services
- Reviews basic concepts involved in automated prediction systems enabling non-experts in the fields of satellite remote sensing, data assimilation, and numerical weather prediction to better understand the applicable techniques
- Proposes ideas for the evolution of ice services as a result of ongoing improvements to automated prediction systems for sea ice



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