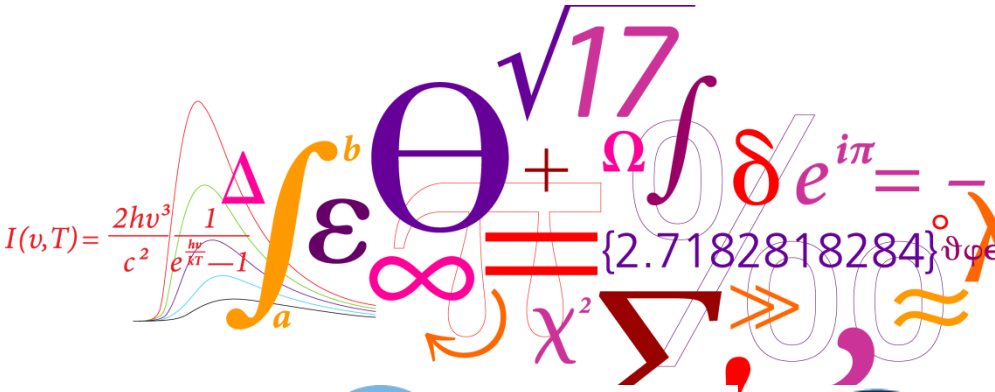
Satellite observations of ice concentration and sea ice drift

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



Technical University of Denmark

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The EUMETSAT Network of Satellite Application Facilities

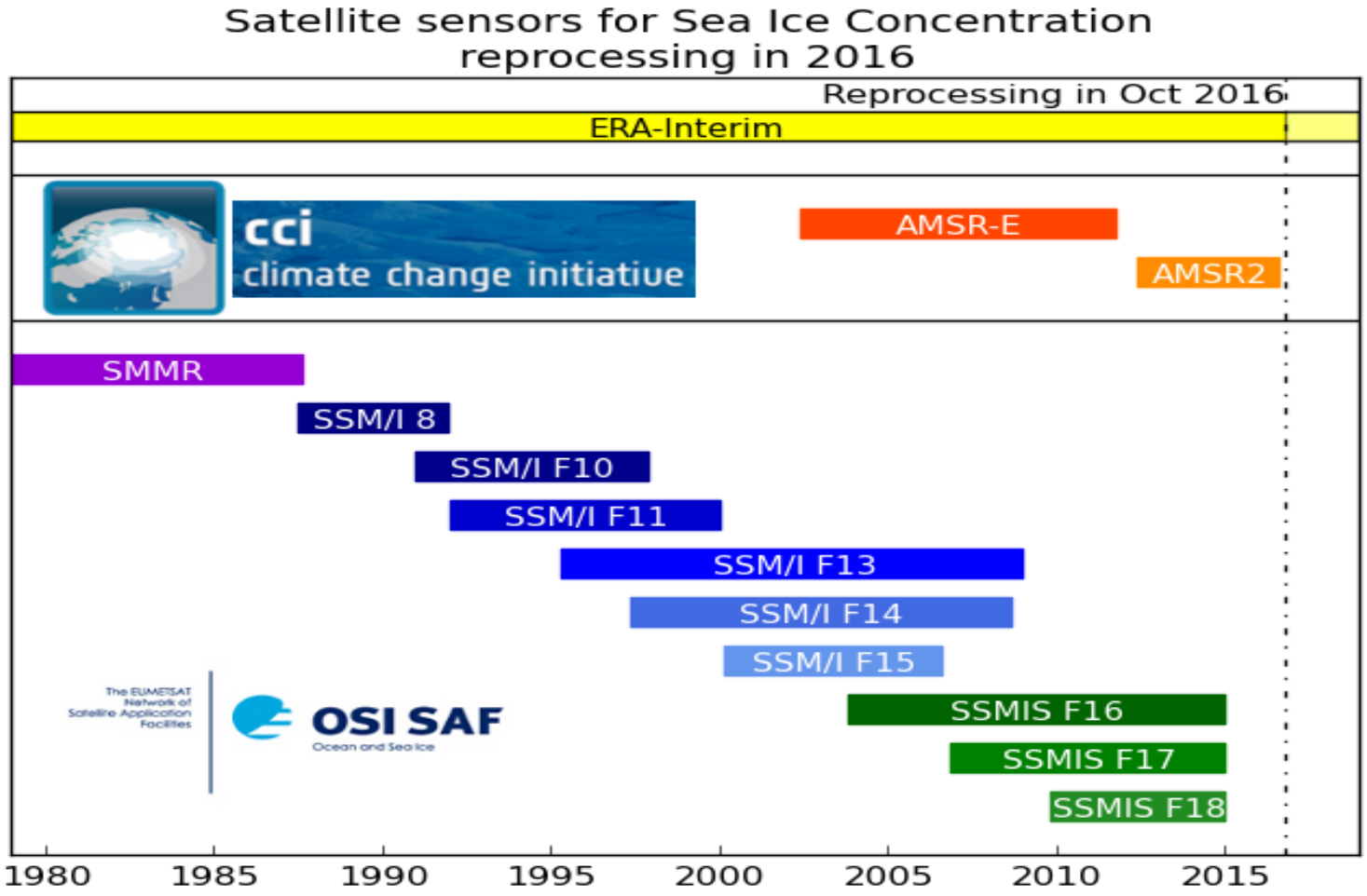
OSI SAF Ocean and Sea Ice

opernicus Europe's eyes on Earth

Polar View

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



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	OSI SAF
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

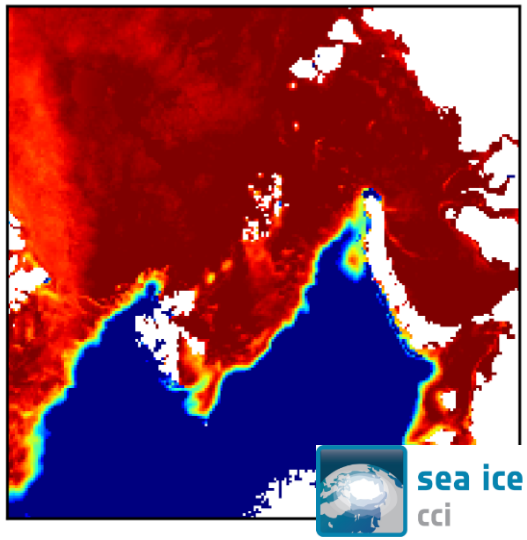
Status October 2017:

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

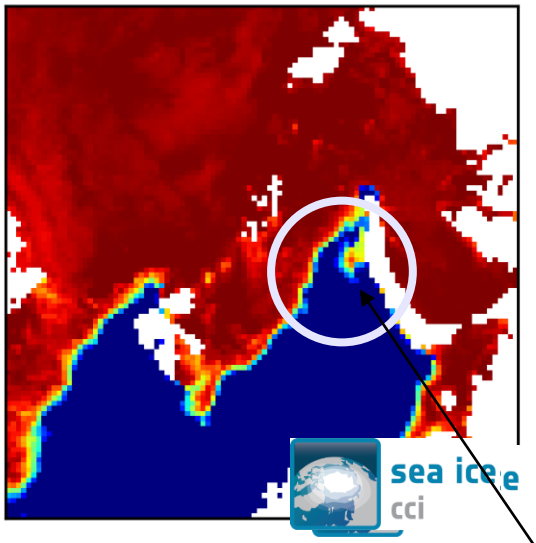
The ESA CCI CDRs are **released**: (http://cci.esa.int/data);
March 2017, v2.0, 2002-2015;
October 2017, v2.1, extended to 15th May 2017.

Some snapshots 20130315

CCI 12.5km

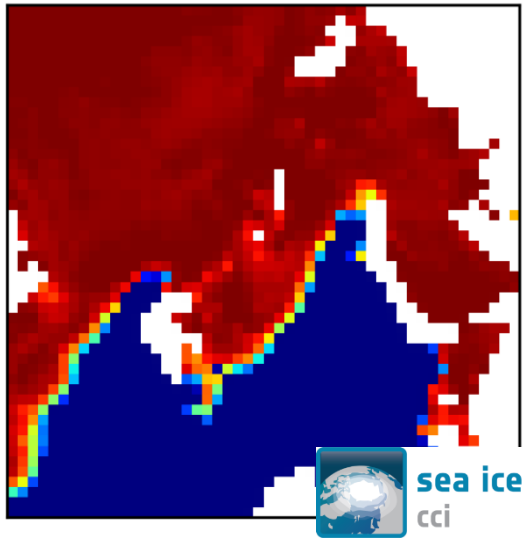


CCI 25.0km

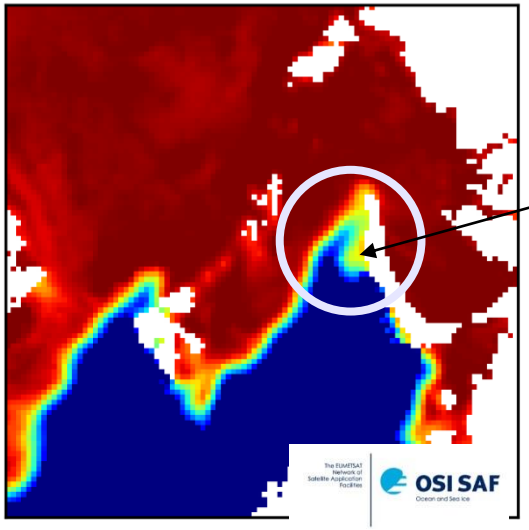


20130315

CCI 50.0km



OSI 25.0km

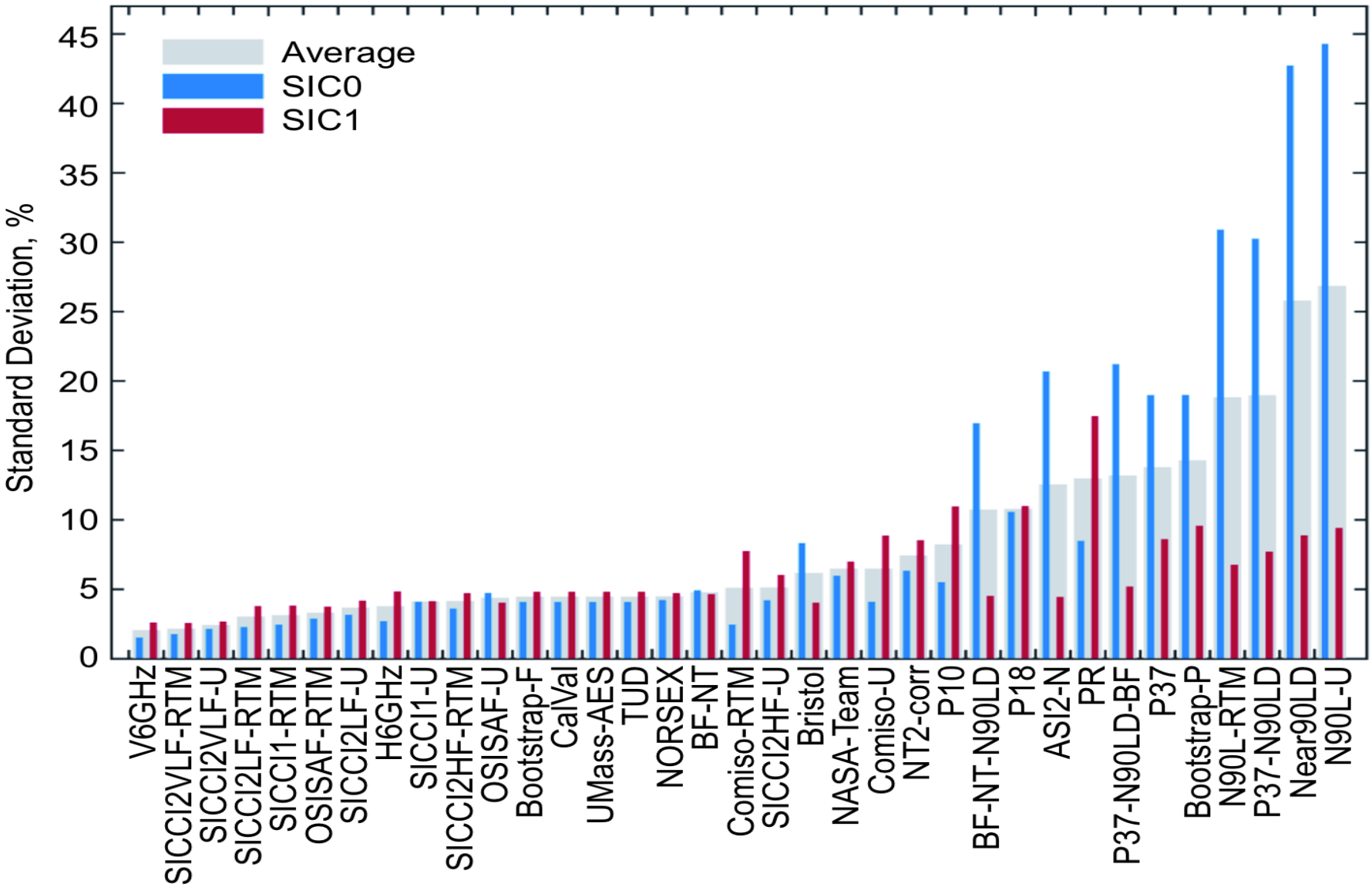


Example maps from the 3 AMSR2 (CCI) and the SSMIS (OSI) CDRs on 15th March 2013.

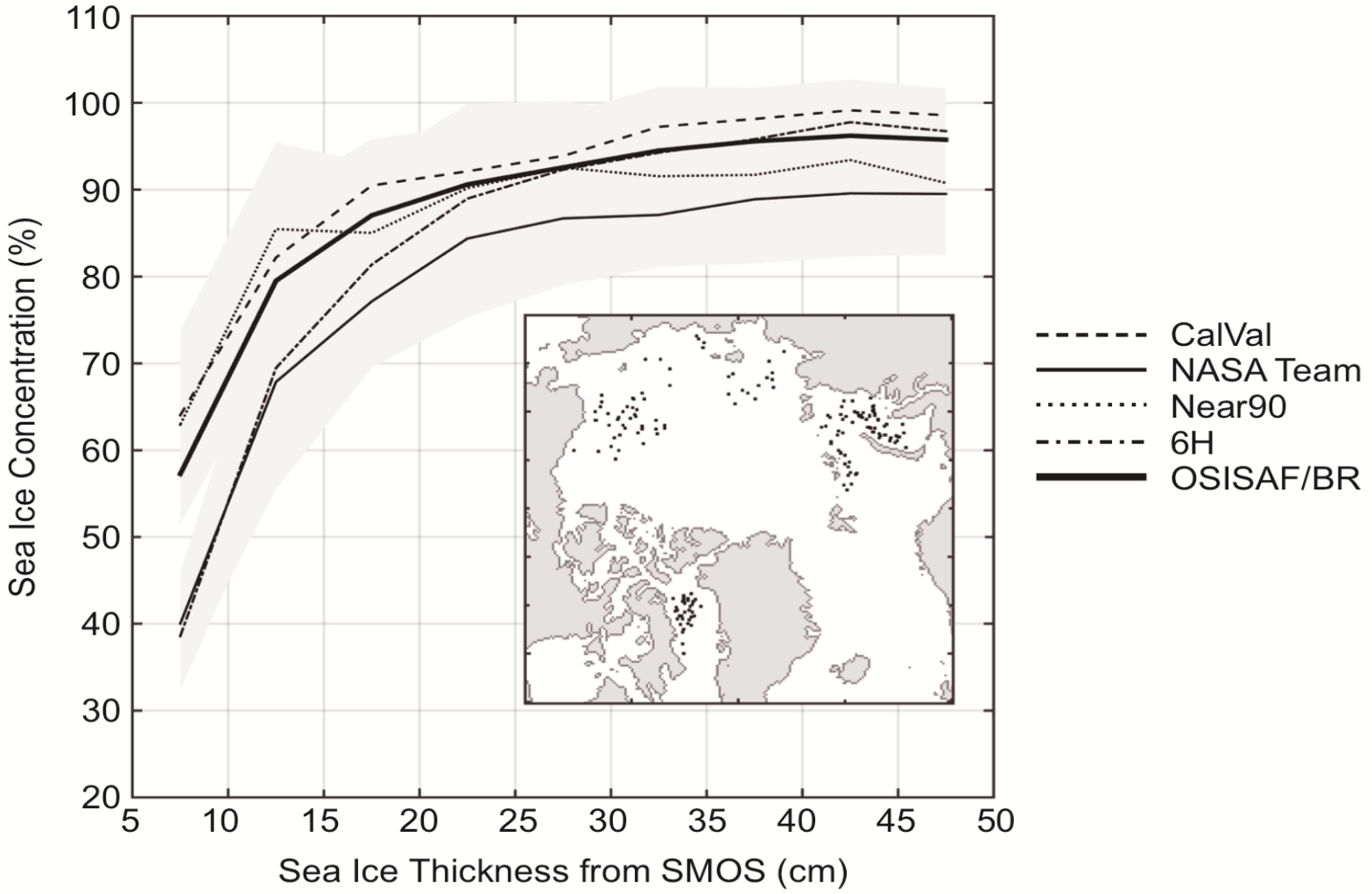
The maps from AMSR2 exhibit more details along the ice edge, except that at 50km using 6 GHz.

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

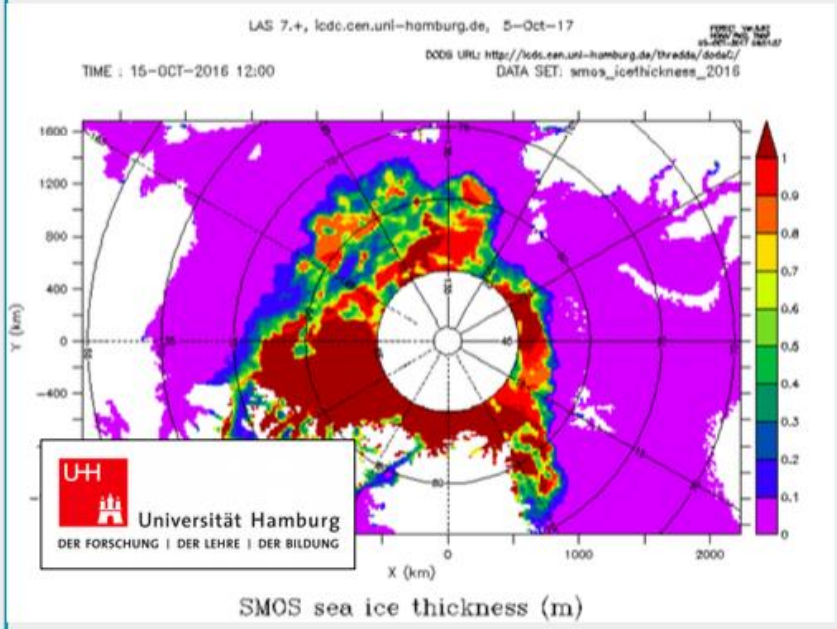
Algorithm selection



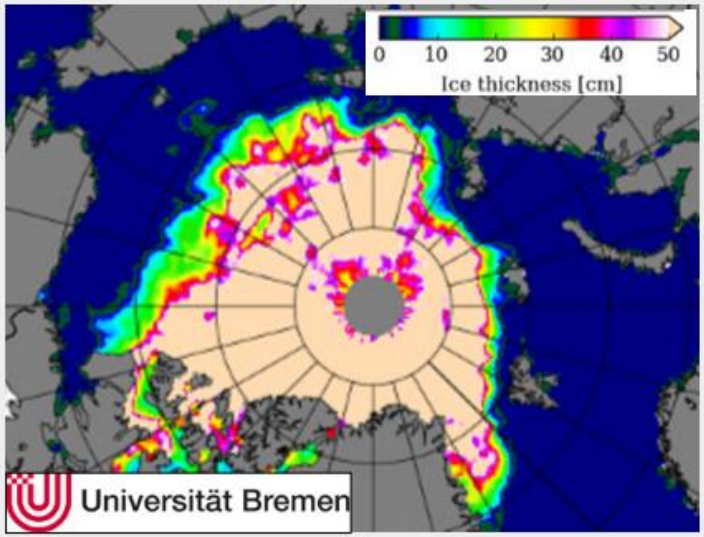
"Concentration" of thin ice



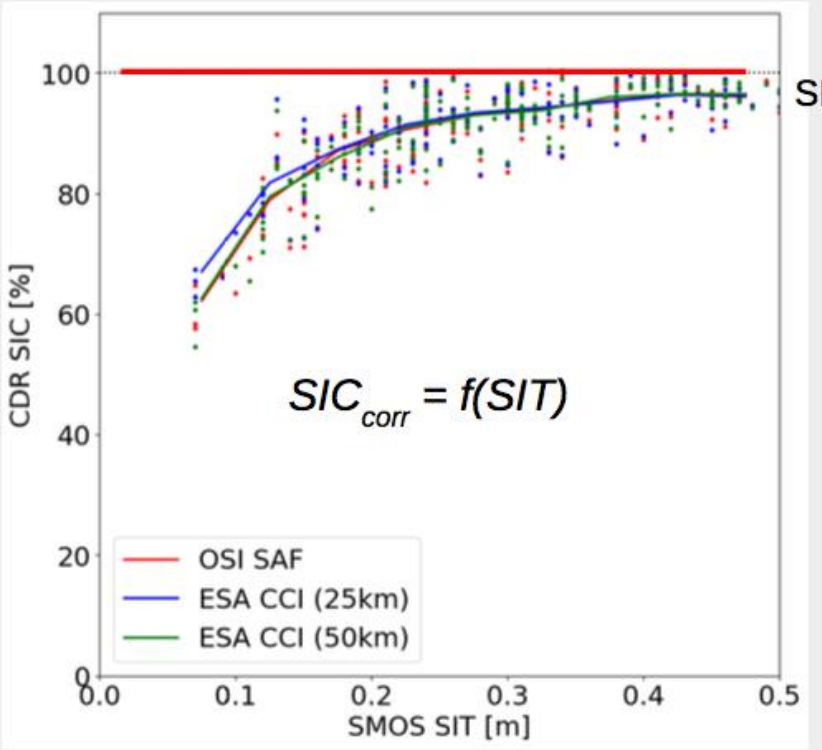
SURF: Thin Sea Ice



SMOS sea ice thickness (m)



- 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].

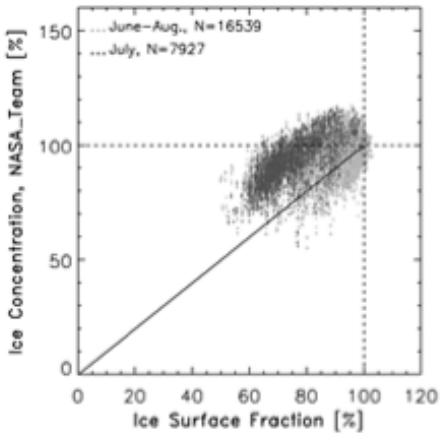


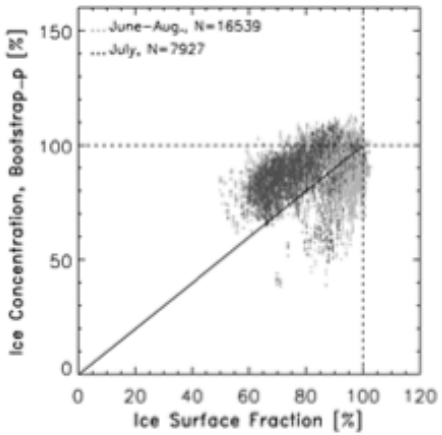
Truth: SIC=100%

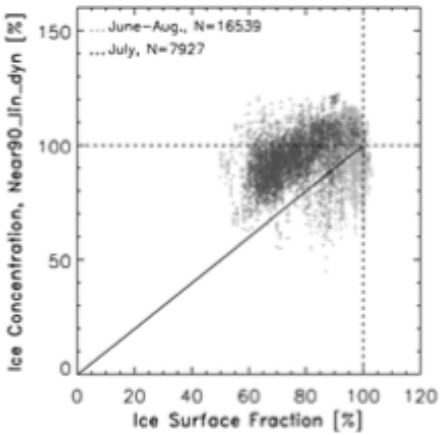
Thin ice

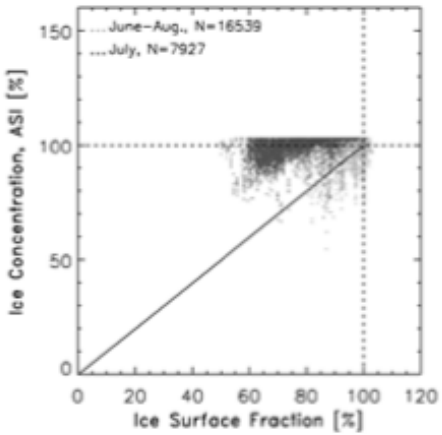
- 100%, thin (<20cm) sea ice will be systematically retrieved as lower concentration of sea ice.
- 100%, thin (>20cm, <50cm) can also be biased low because it is typically more saline, smooth, snow-free.
- EO community cannot “fix” this consistently unless we bring external SIT information, e.g. from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

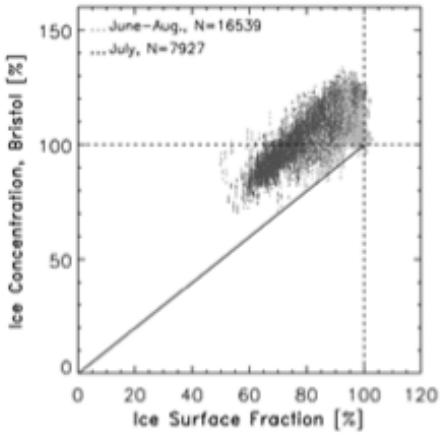
SIC and melt ponds
Ice surface fraction is the fraction of the surface which is ice (NOT melt-pond and NOT lead/open water)

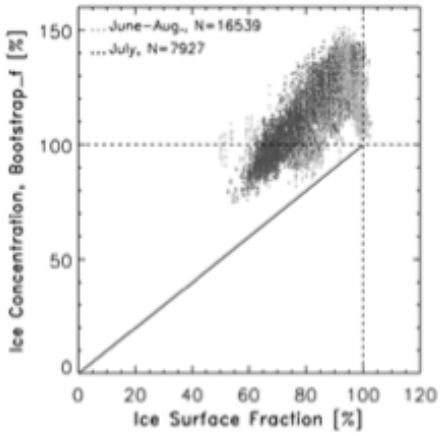


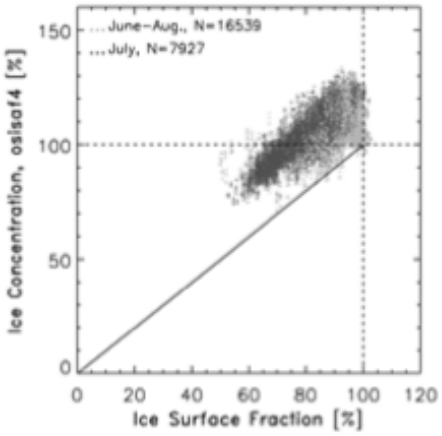












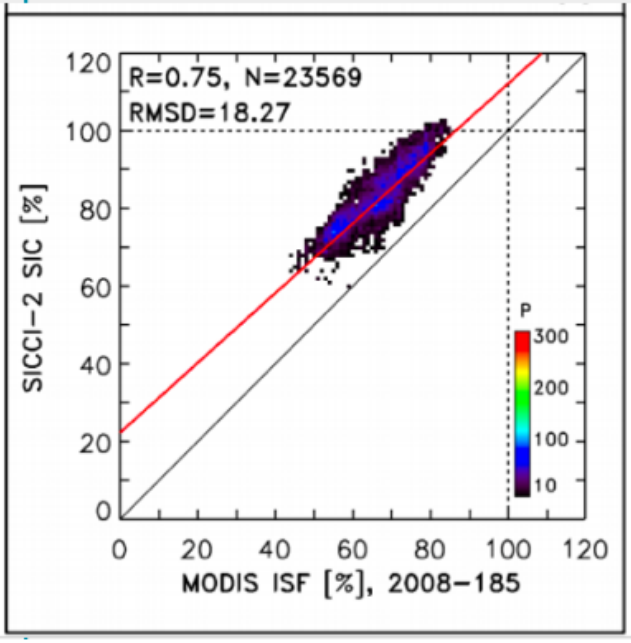
Grey: June,

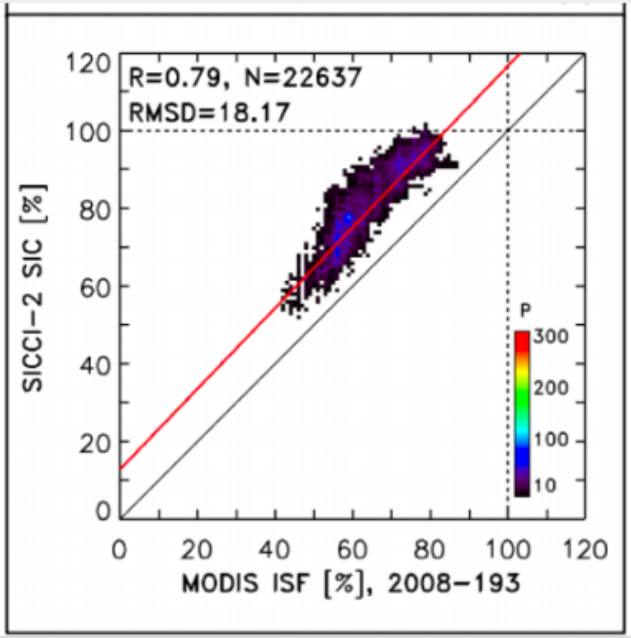
Black: July+August

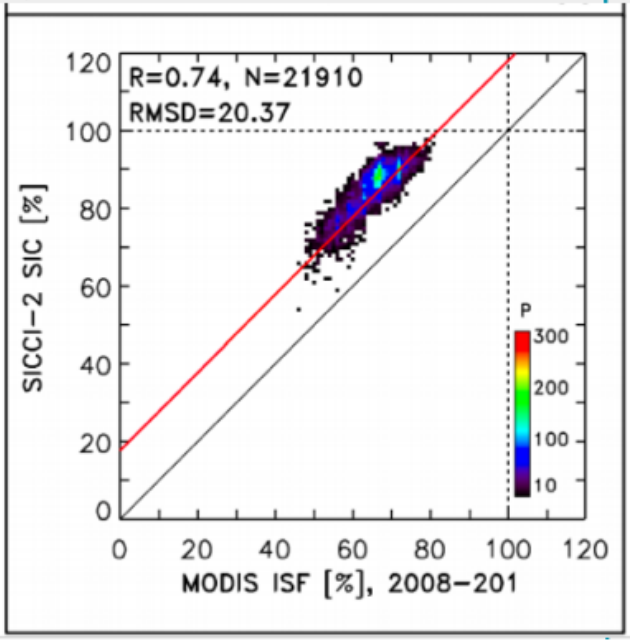
SURF: Melt-pond water

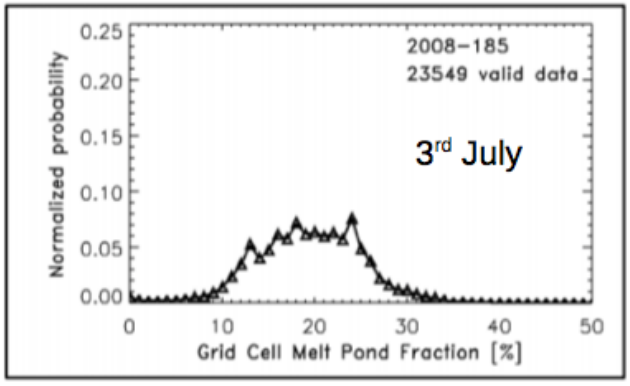
What modelers get today

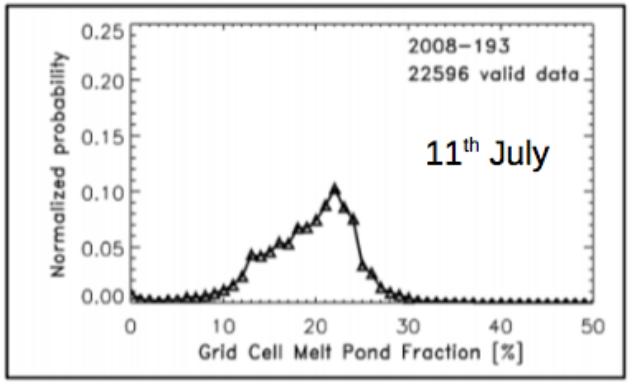
Credit: S. Kern, ICDC, Univ Hamburg

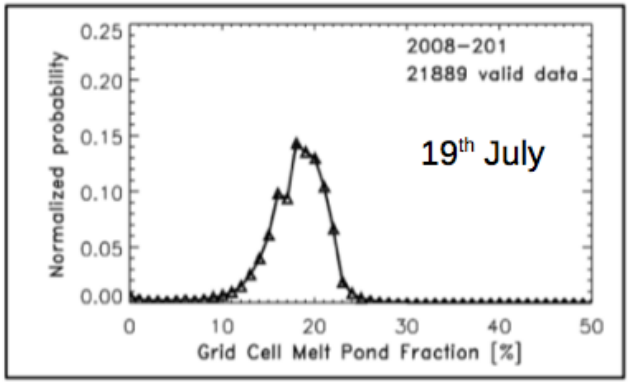












Melt ponds

- 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:

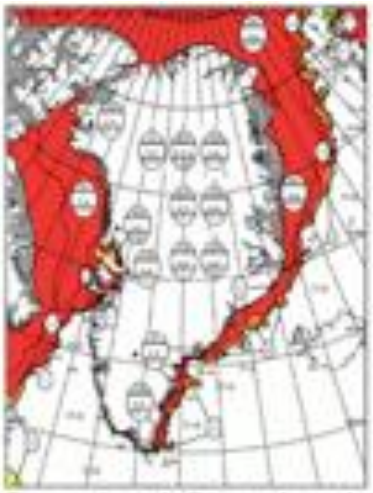
1) get and use an accurate, time-consistent ISF?

2) have EO scientists break physics to get "nice" results?

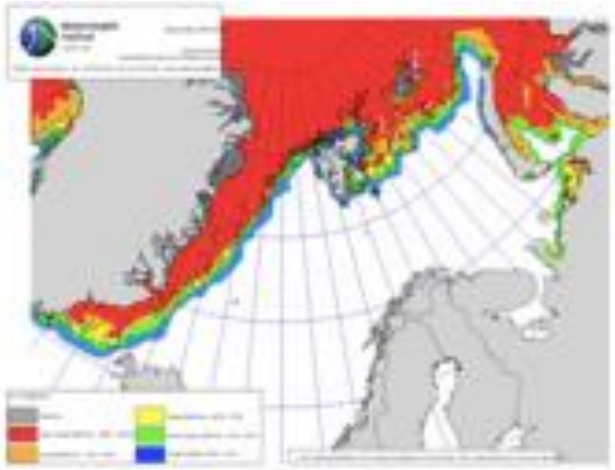
Sea ice concentration, area and extent

- 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

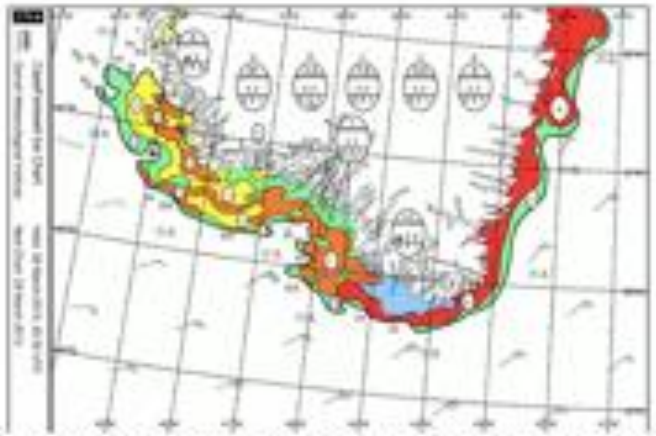


DMI Greenland Overview Ice Chart

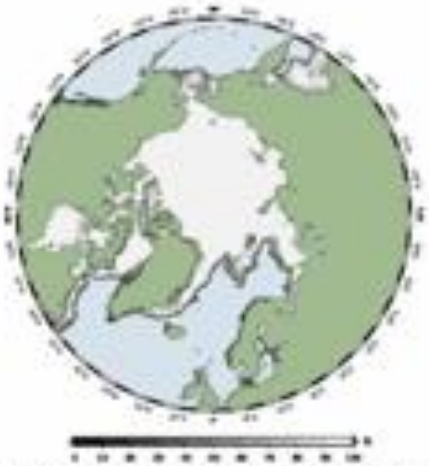


Met.no Svalbard Ice Chart

DMI
Vejr, klima og hav



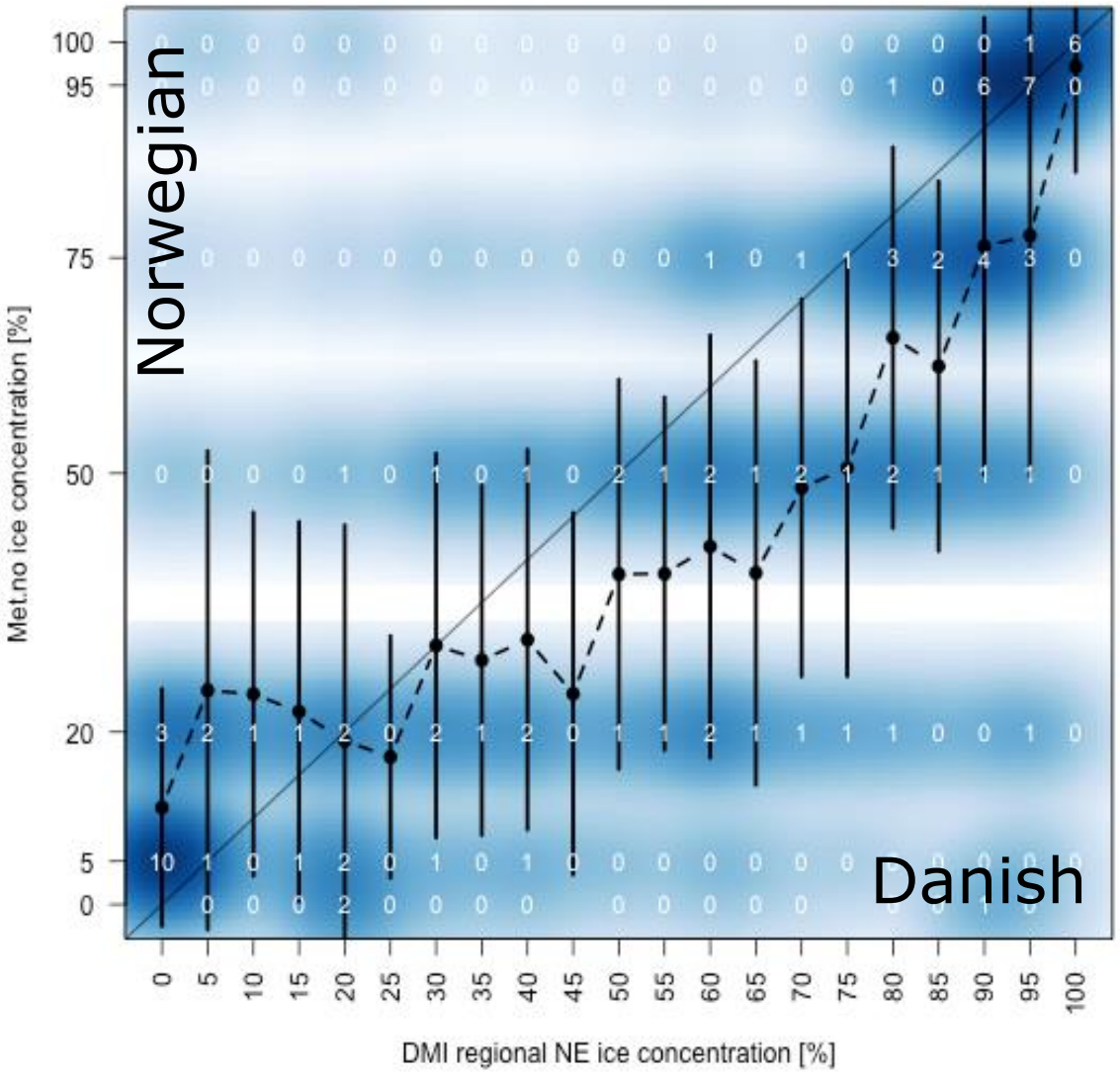
DMI Greenland Regional Ice Chart (example)



OSISAF Ice Concentration data

Icechart to icechart SIC intercomparison

Danmarks Meteorologiske Institut



East Greenland Area

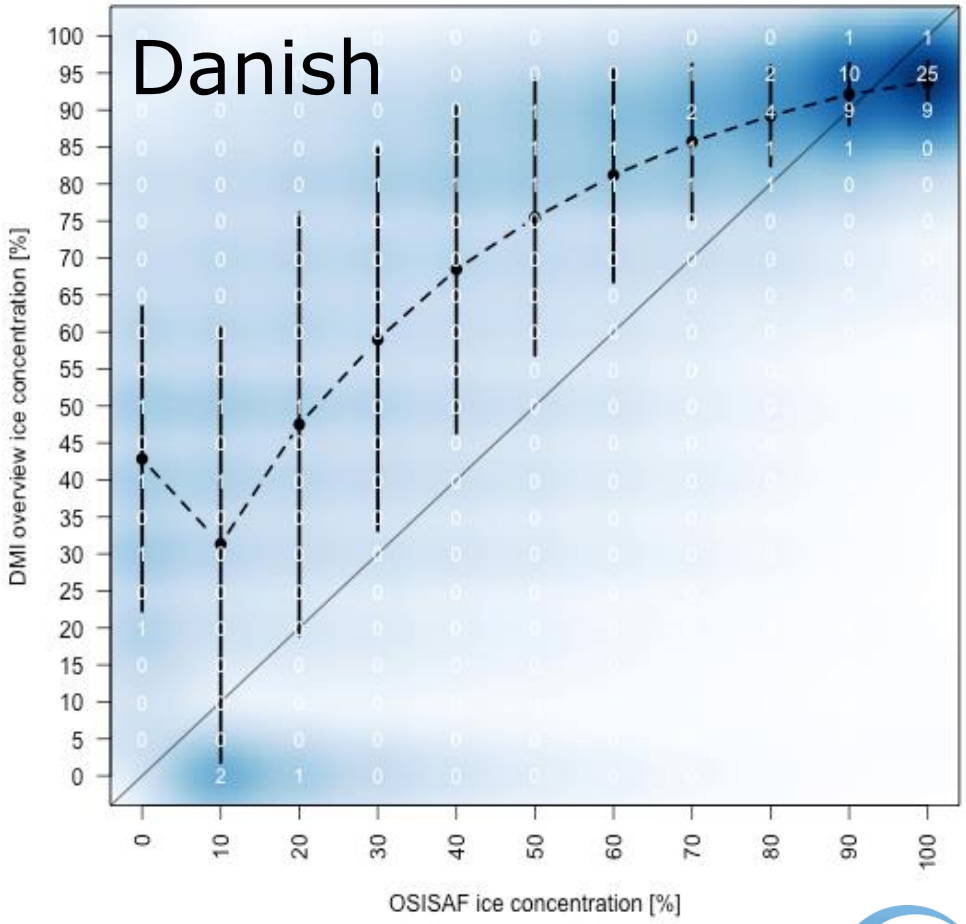
Copernicus Europe's eyes on Earth

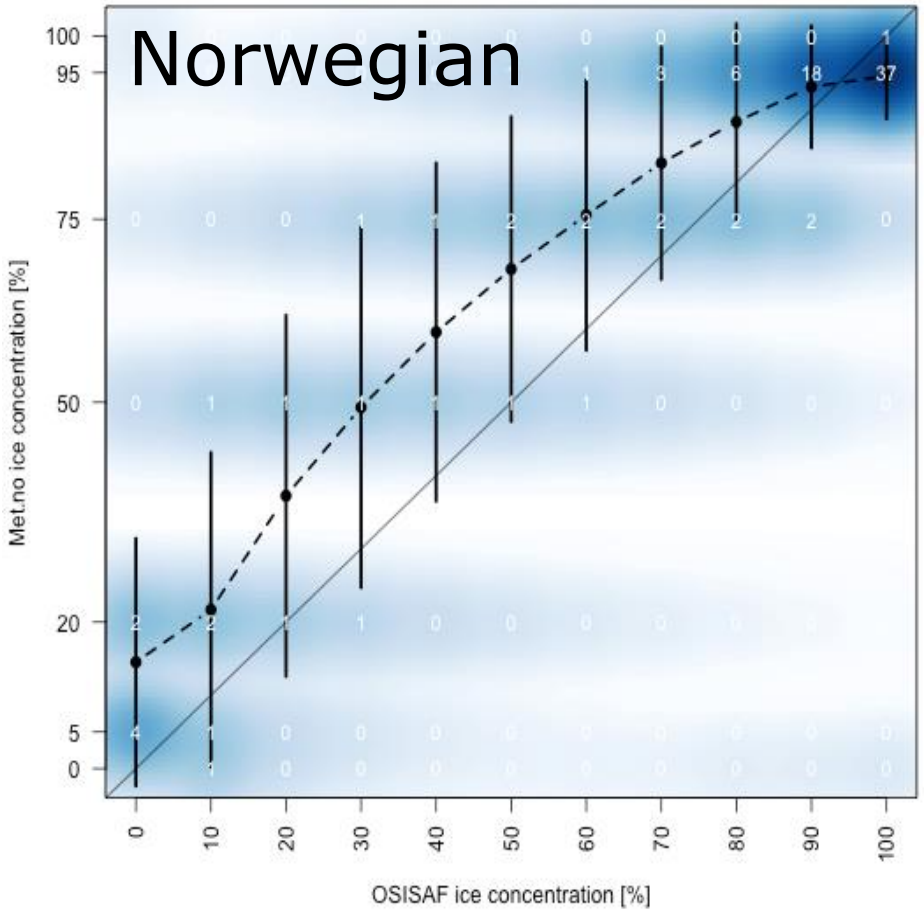
See also:

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

Danmarks Meteorologiske Institut

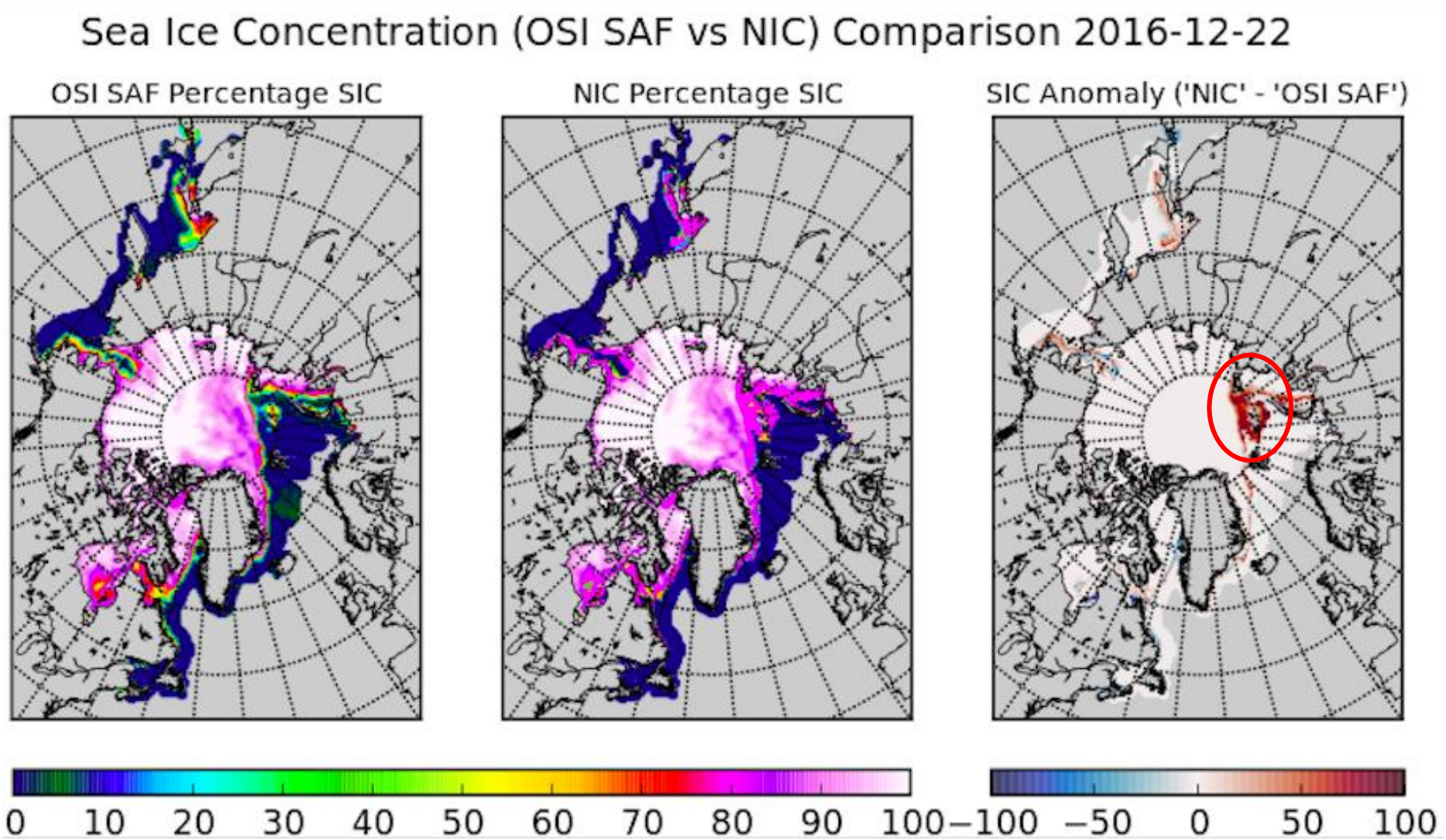




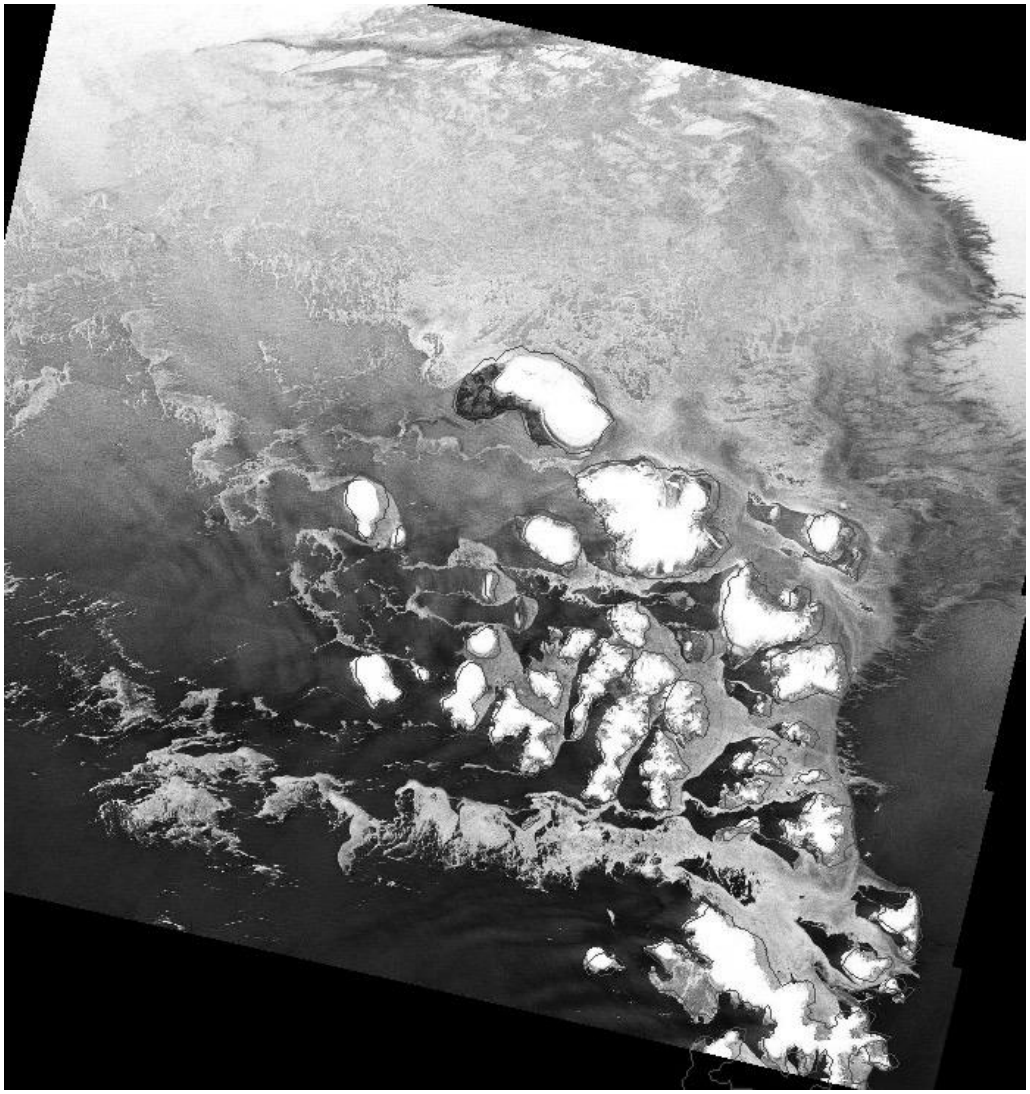
Copernicus Europe's eyes on Earth

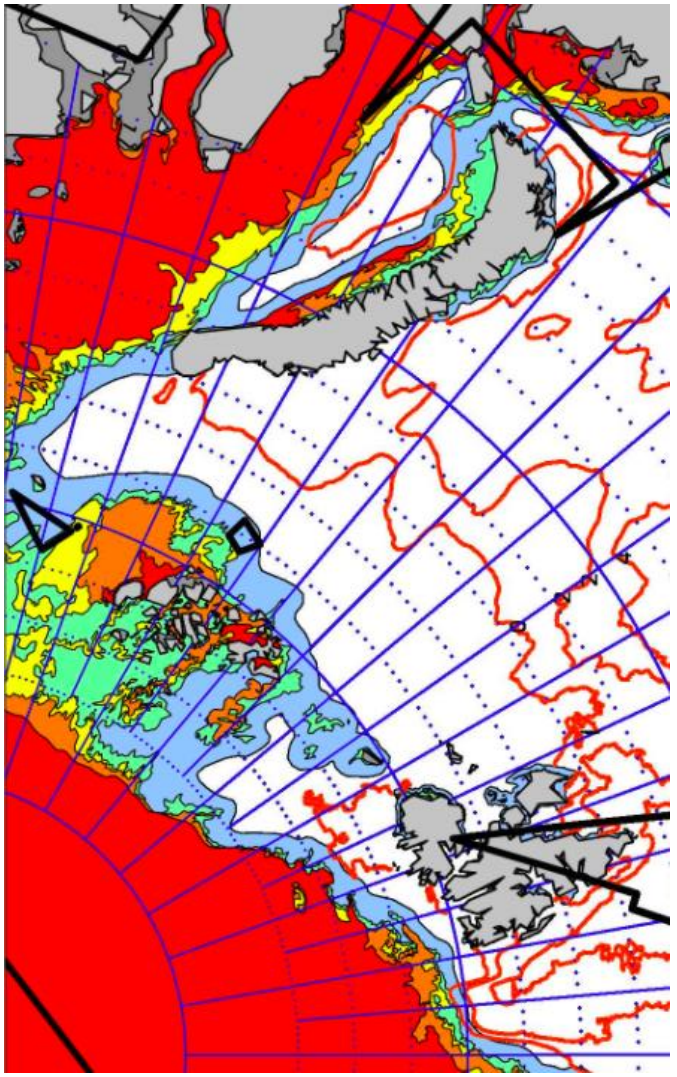
Icechart vs OSI-SAF ice concentration

Danmarks Meteorologiske Institut



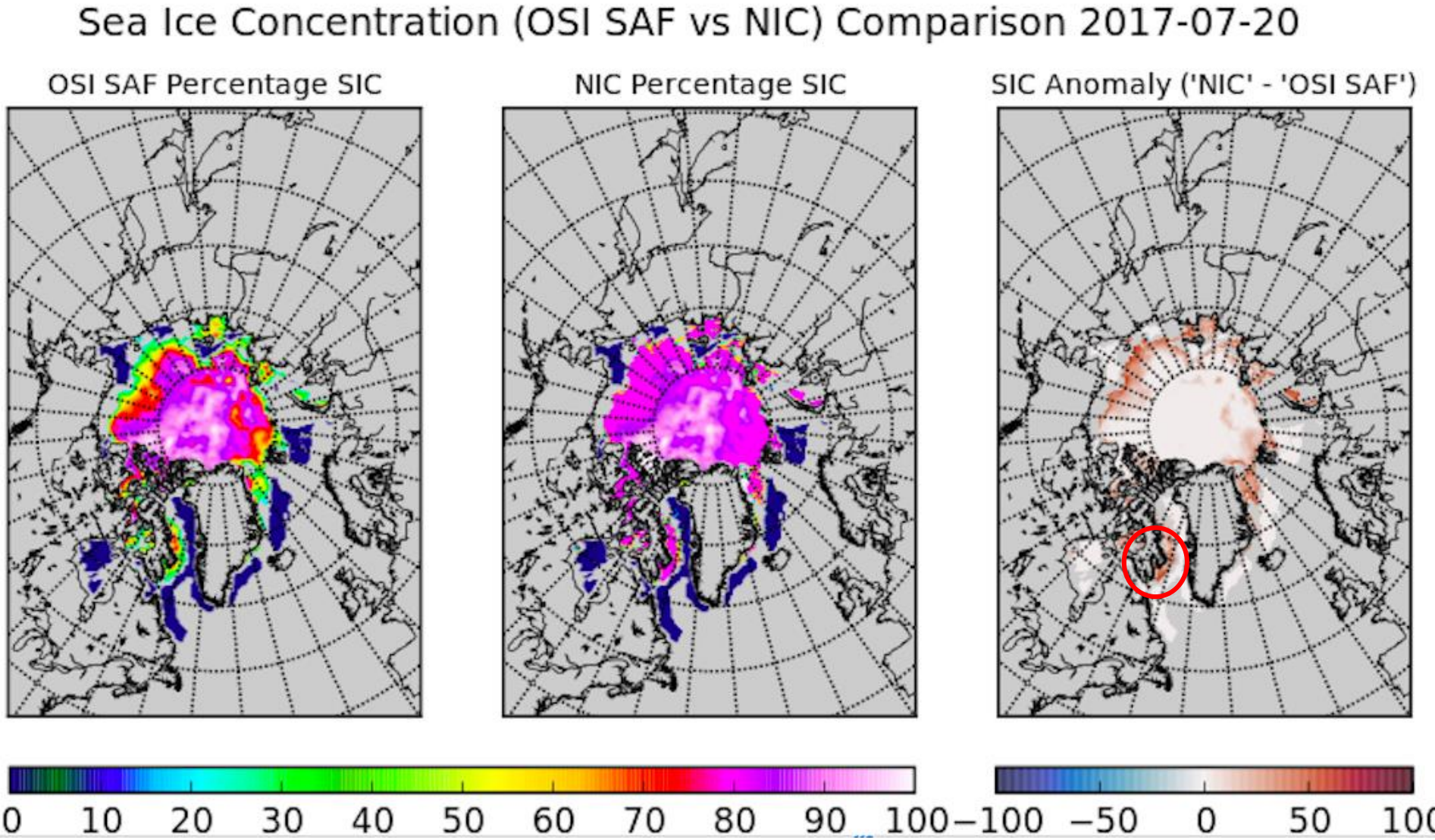
Sentinel-1 SAR and MET Icechart 2016-12-22 – NIC chart clearly overestimated the sea ice concentration



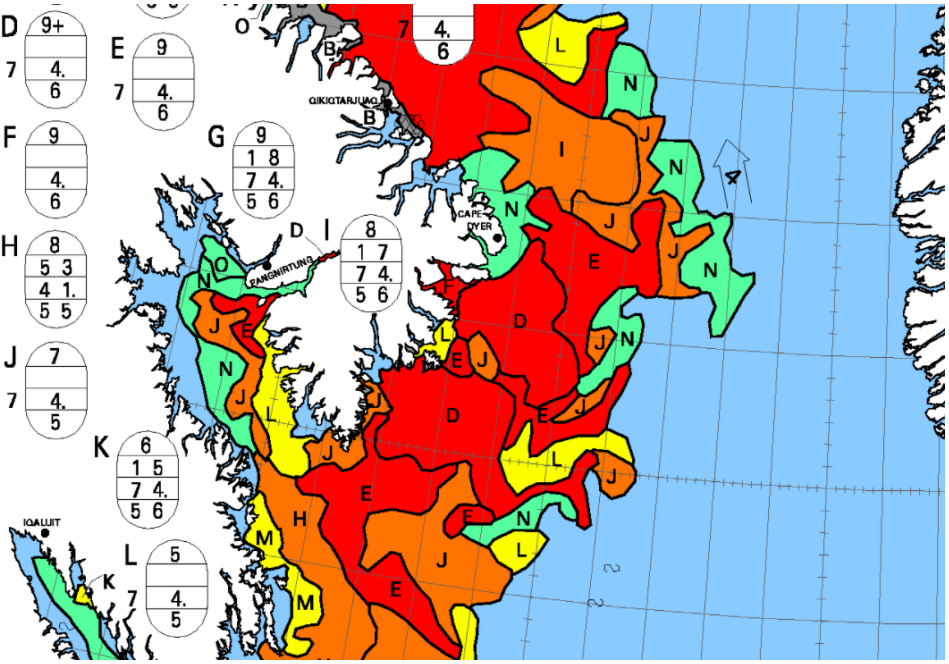


Icechart vs OSI-SAF ice concentration

Danmarks Meteorologiske Institut



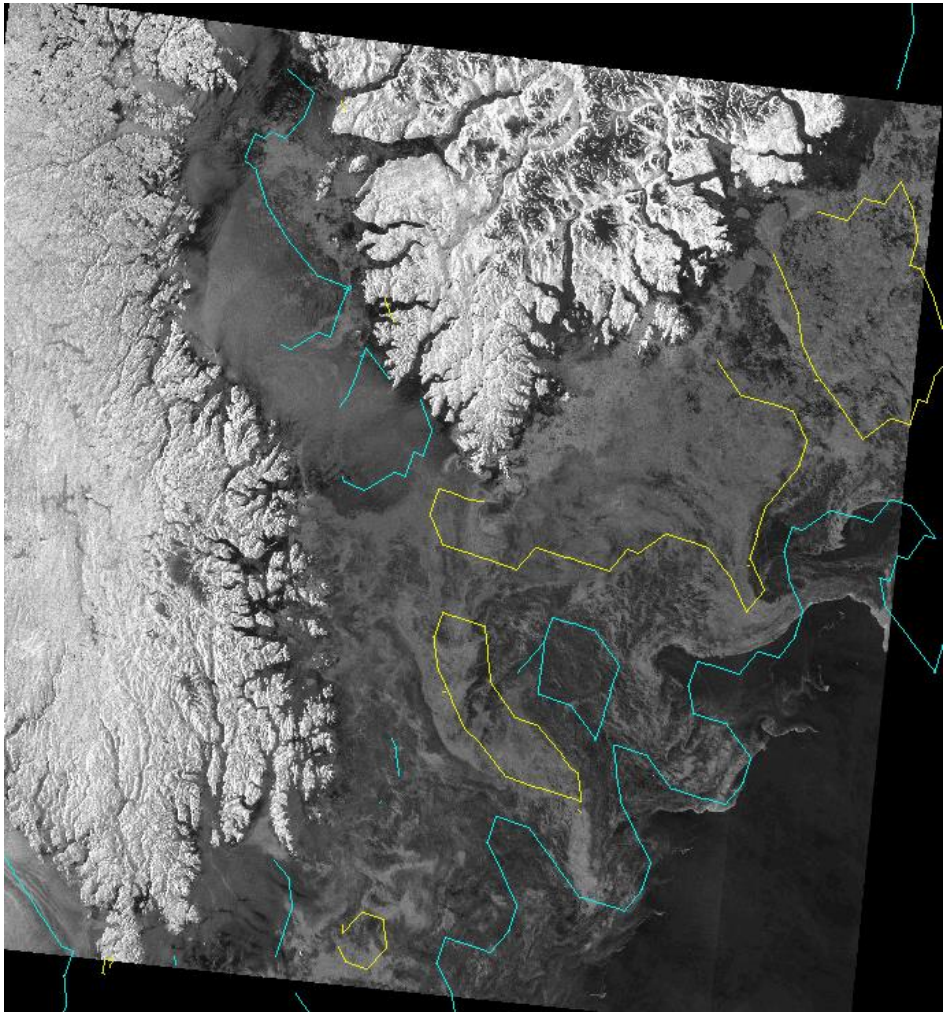
CIS Icechart vs Sentinel-1 SAR
NIC and CIS icecharts clearly overestimate the intermediate concentrations



CIS daily ice chart on July 20, 2017

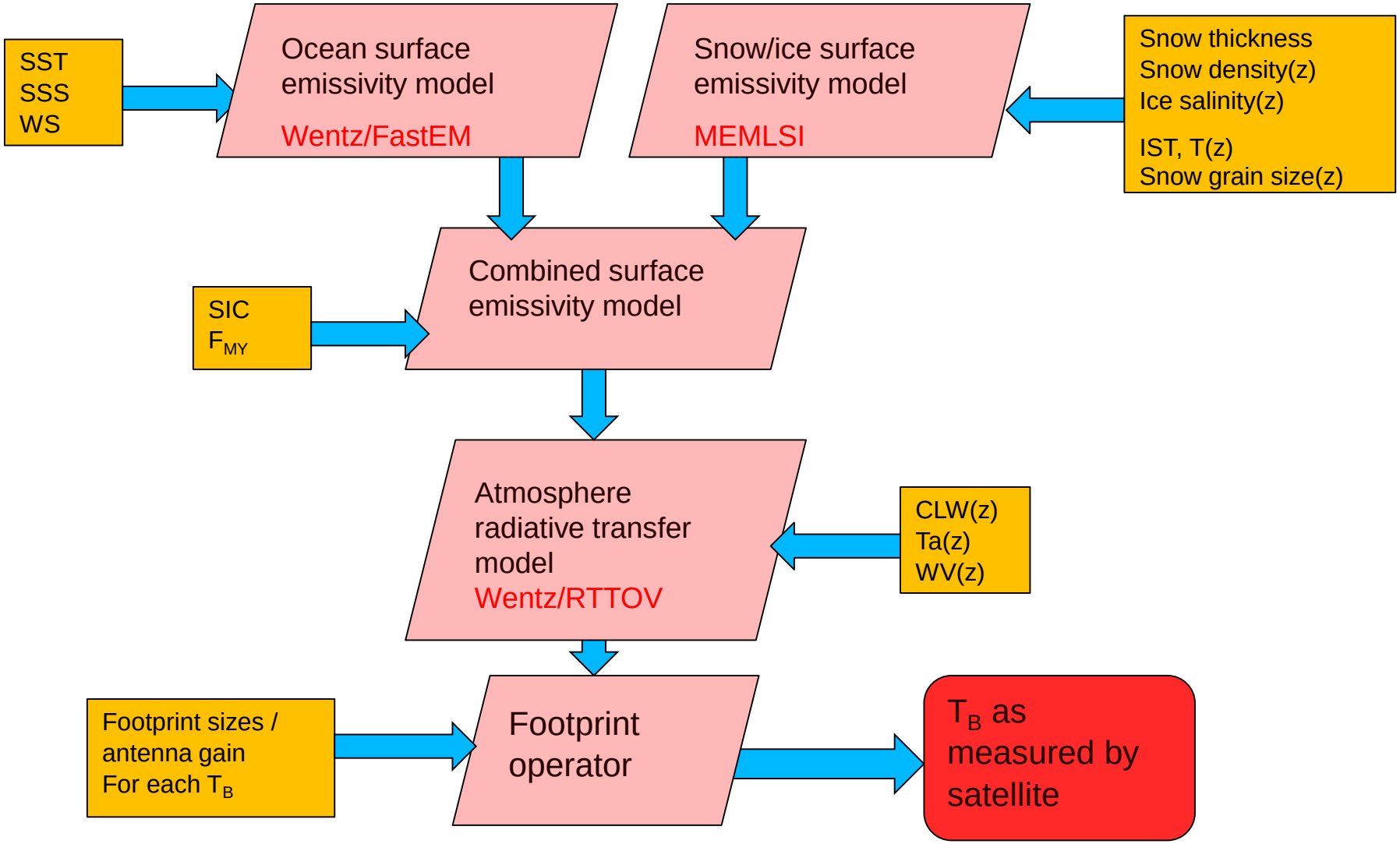
Red D-areas are 9+ in icechart

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

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

T_b radiances

Agreement (within uncertainty range)

Satellite Retrievals

Obs Oper

Obs Oper

Obs Oper

Y: value, quantity, uncertainty

X=SIC

X=ISF

X=Ice Surface Fraction (+thin ice corr)

@lavergnetho

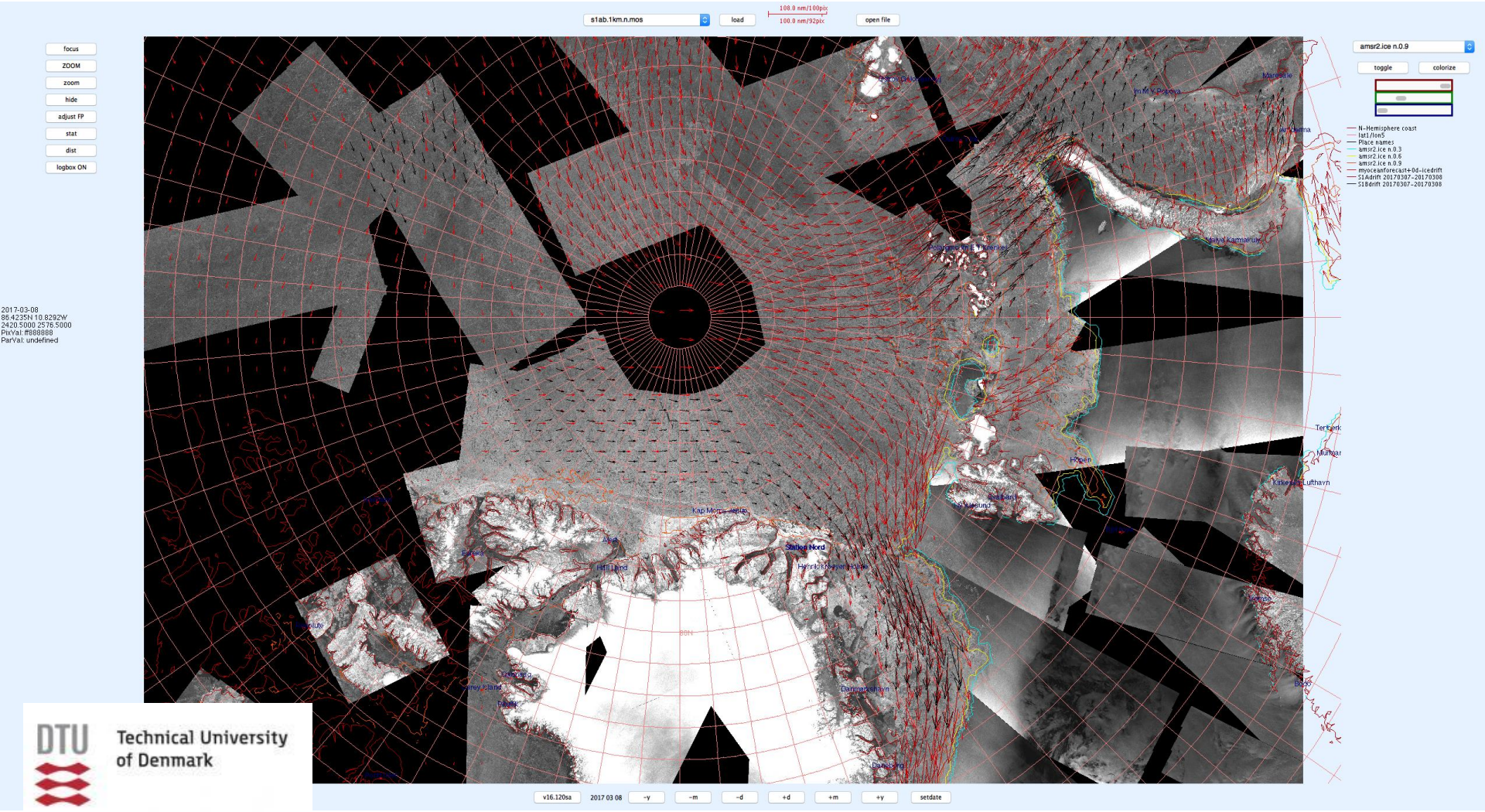
X: what the variable is, its definition

Model

Obs

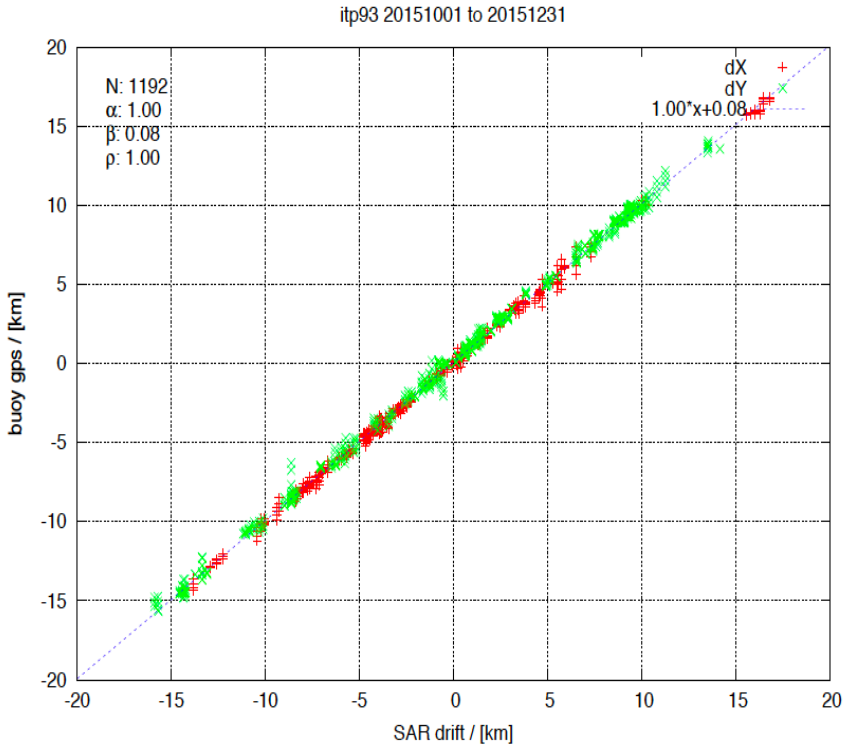
Thomas Lavergne, MET, Norway

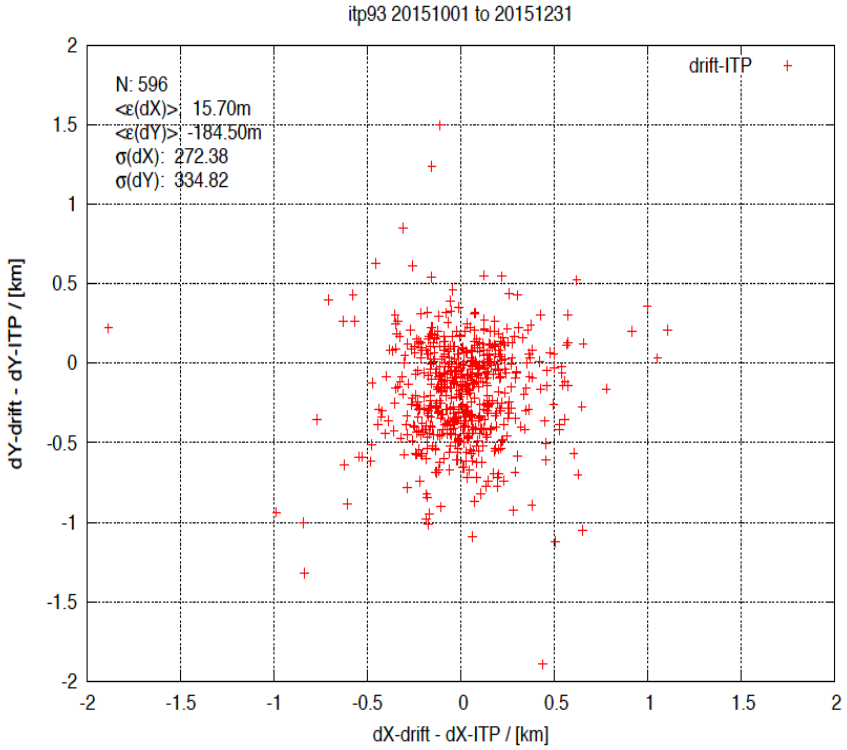
DAILY NRT SENTINEL-1 A+B ICE DRIFT



Technical University of Denmark

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

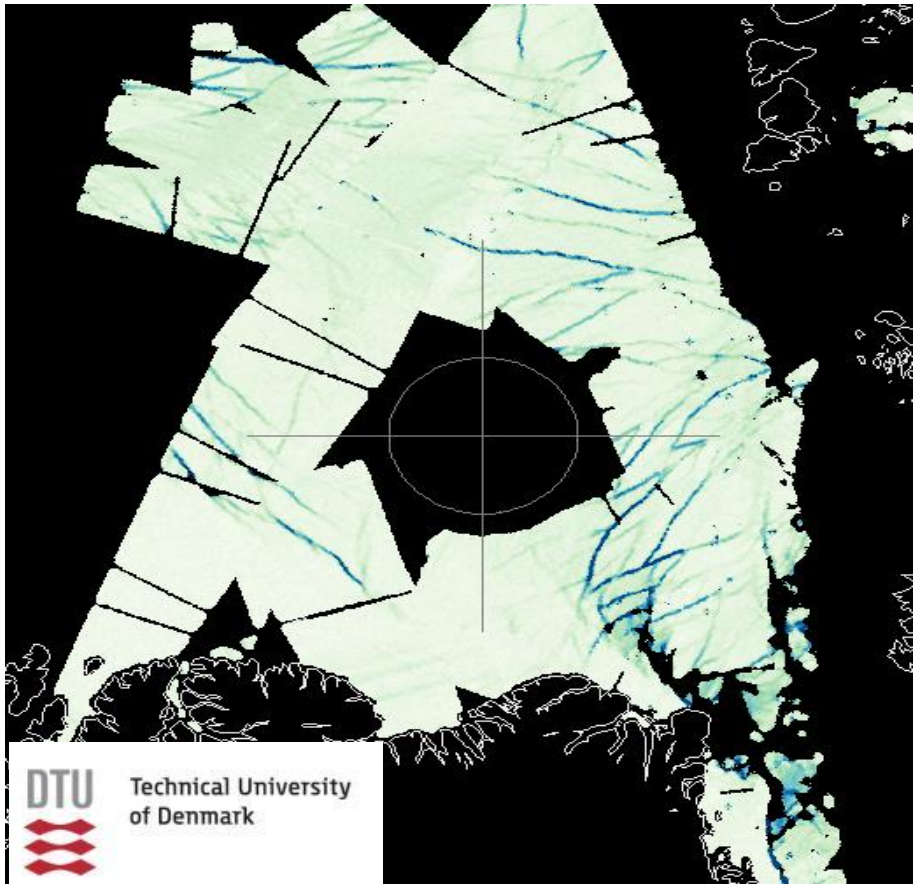




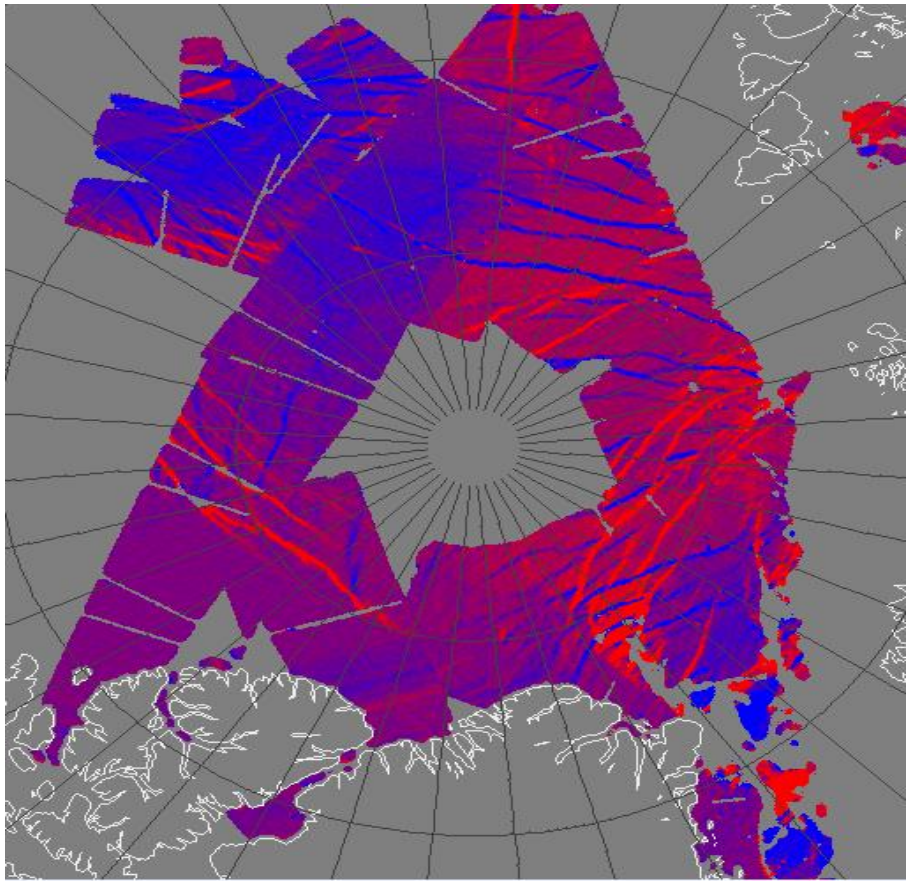
Convergence/Divergence
Shear rate
For initializing ice damage/strength
2016-02-27 -> 28

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

Shear rate



Convergence/Divergence

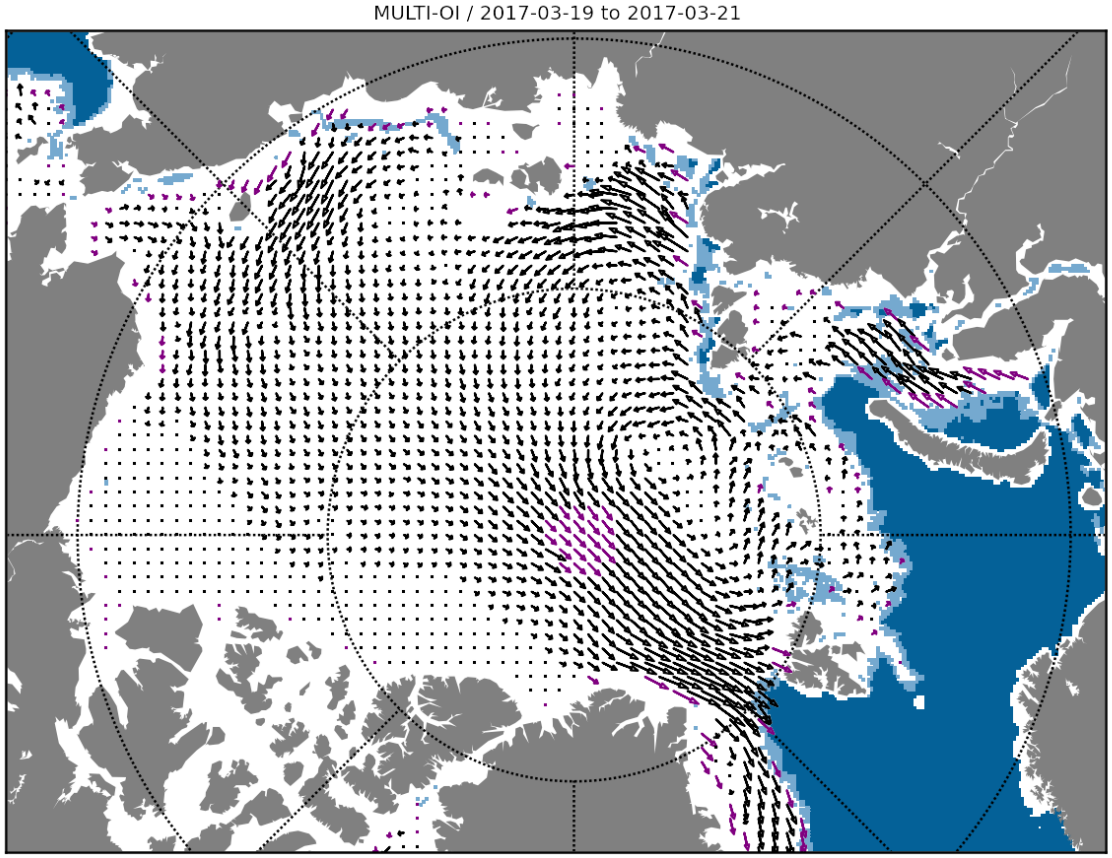


The EUMETSAT Network of Satellite Application Facilities

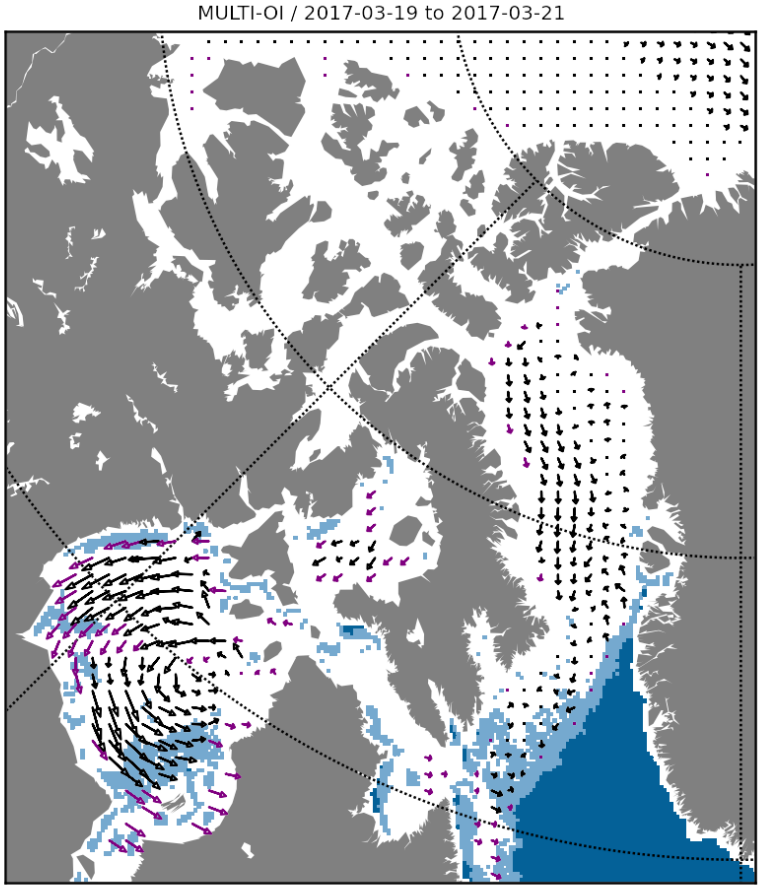
OSI SAF
Ocean and Sea Ice

DTU

The OSISAF operational sea ice drift product



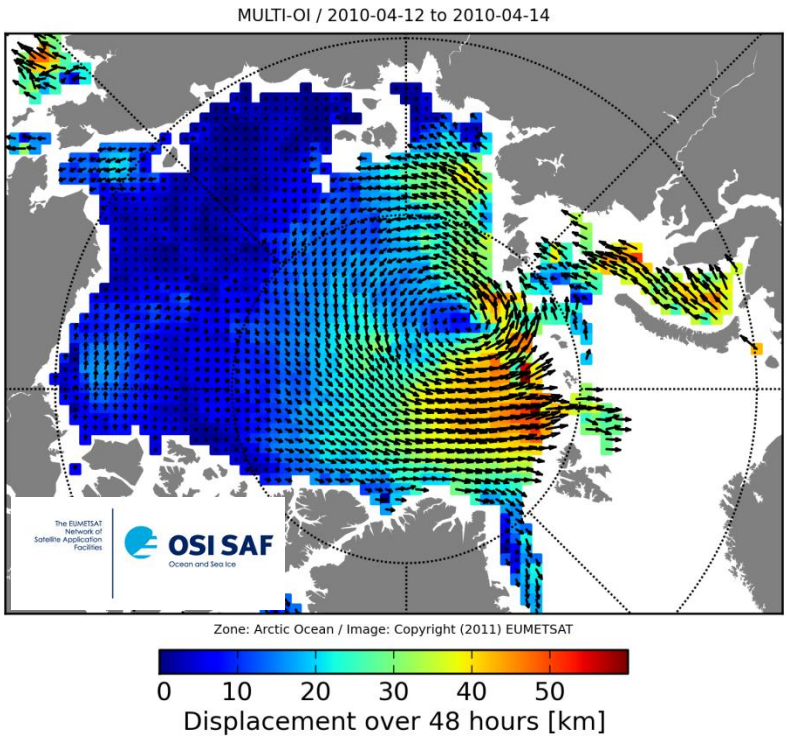
Zone: Arctic Ocean / Image: Copyright (2017) EUMETSAT

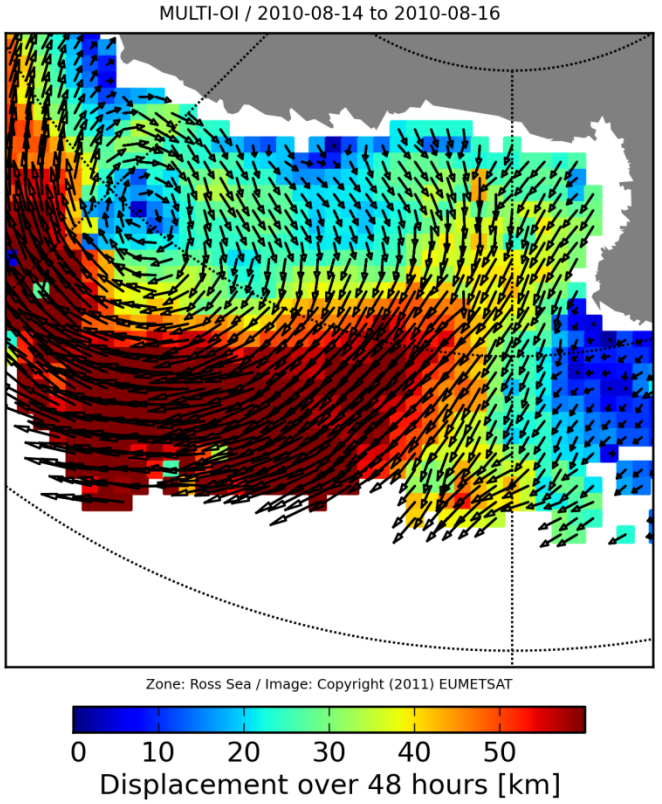


Zone: West Greenland and Canada / Image: Copyright (2017) EUMETSAT

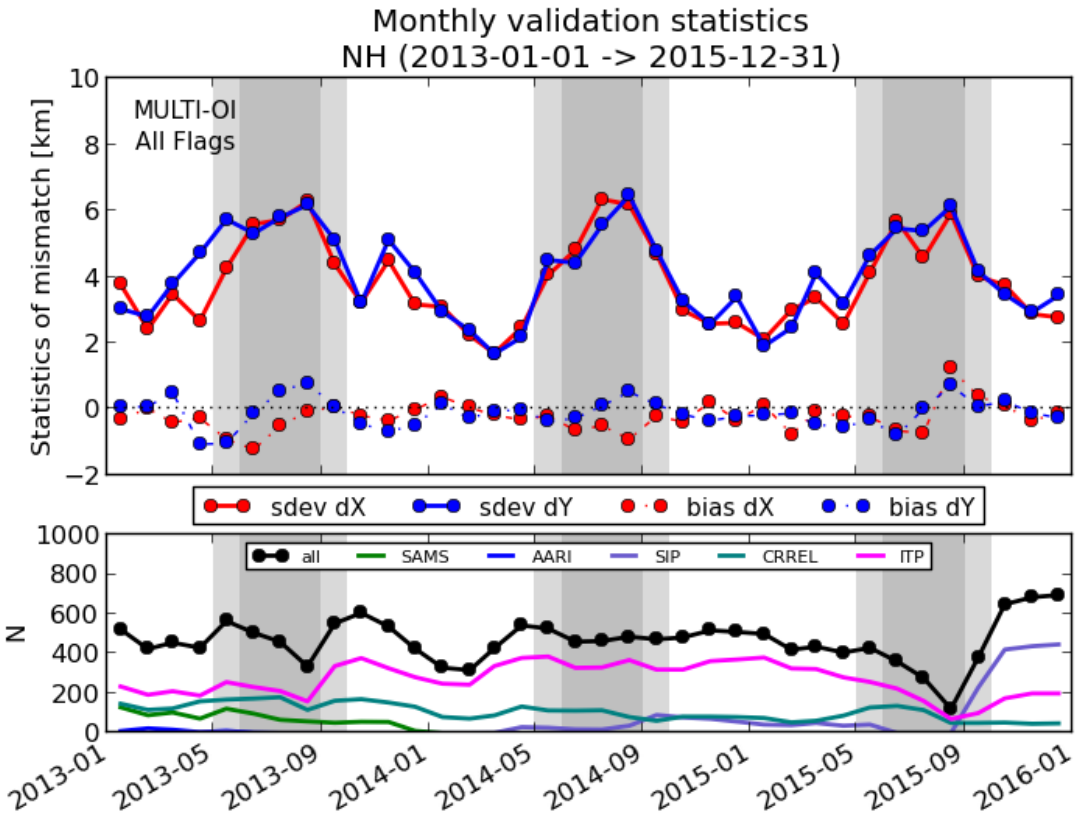
Data access

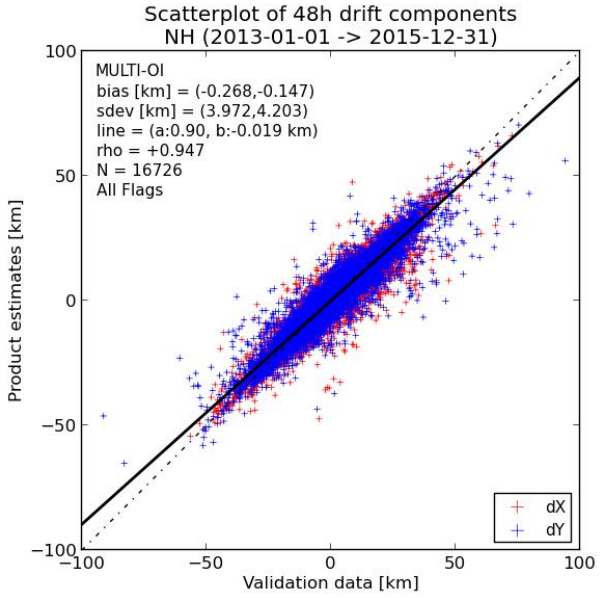
- Daily updated on http://osisaf.met.no, free data access from ftp://osisaf.met.no (includes archive).
- To receive news and updates about the products, please register at www.osi-saf.org.

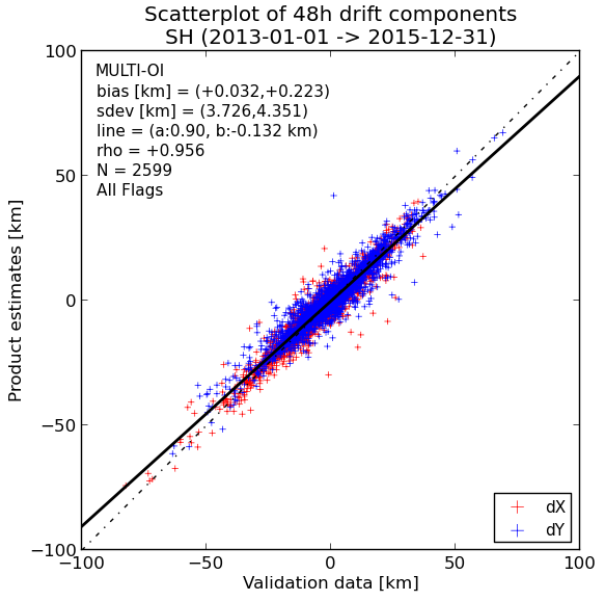




Validation







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 it's snow cover
- Data providers should provide quantitative estimates of known issues – ask them for specifications for observation operators!!