OSI SAF Sea Ice Products

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Outline

- Sea Ice introduction
  - Project
  - Web portal / Distribution
- Operational products
  - Characteristics
  - Validation / Performance
  - Plans for CDOP2
- Reprocessed data set
- Products to come
- Future plans for CDOP3

Introduction

- Sea Ice part in the EUMETSAT OSI SAF is a collaboration between MET Norway and DMI
- The development is partly joint between the sea ice teams at DMI and MET Norway, both on scientific issues and in coding
- Operational production split on specific products
- Distribution through joint channels (FTP, Thredds, EUMETCast and EDC)

User services

- Registered users can receive service messages on production anomalies and product updates
- More information available on the high latitude web portal http://osisaf.met.no
  - Production status
  - Quicklook archive
  - Documentation
  - Validation results
  - News

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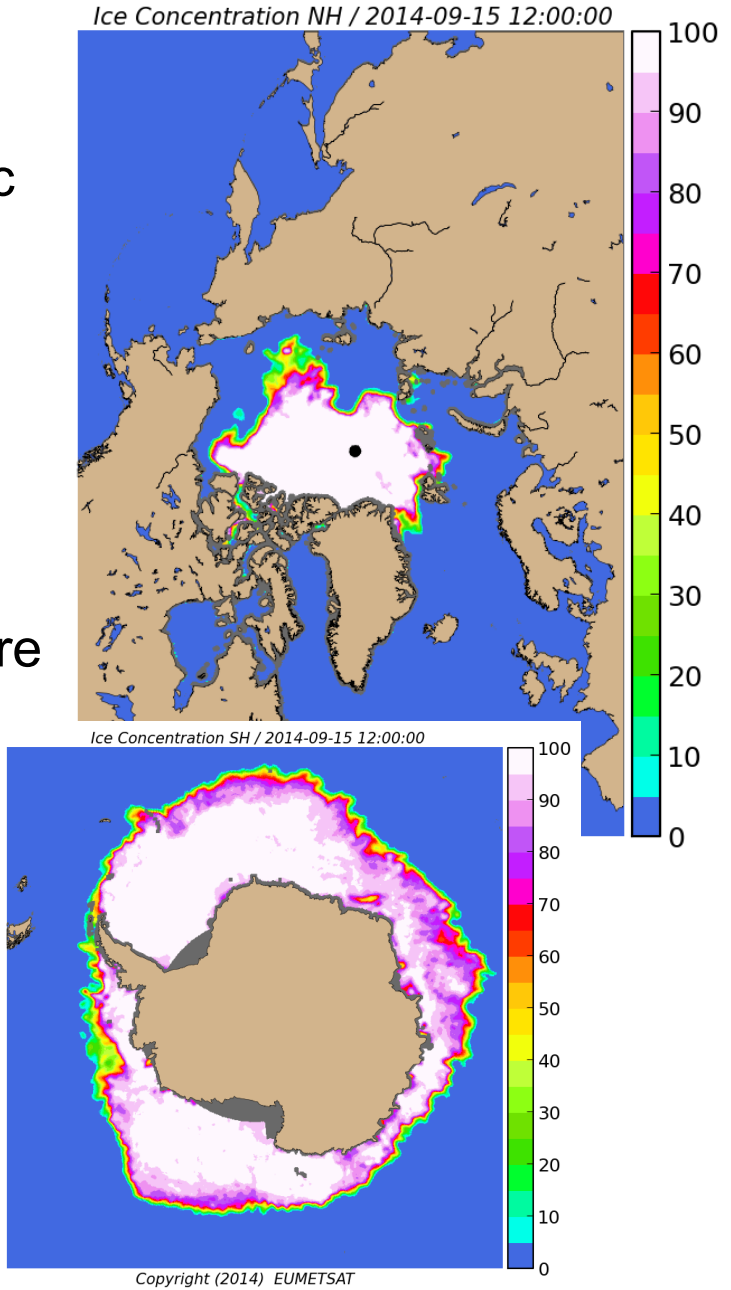
OSI SAF Sea Ice products

The goal of OSI SAF is to serve the modelling, environmental monitoring and climate communities with data on the sea ice state and sea ice cover. Our current products includes:

- Sea Ice Concentration (OSI-401)
- Sea Ice Edge (OSI-402)
- Sea Ice Type (OSI-403)
- Sea Ice Emissivity (OSI-404)
- Low Resolution Sea Ice Drift (OSI-405)
- Medium Resolution Sea Ice Drift (OSI-407)
- Reprocessed Sea Ice Concentration (OSI-409)

Ice Concentration (OSI-401)

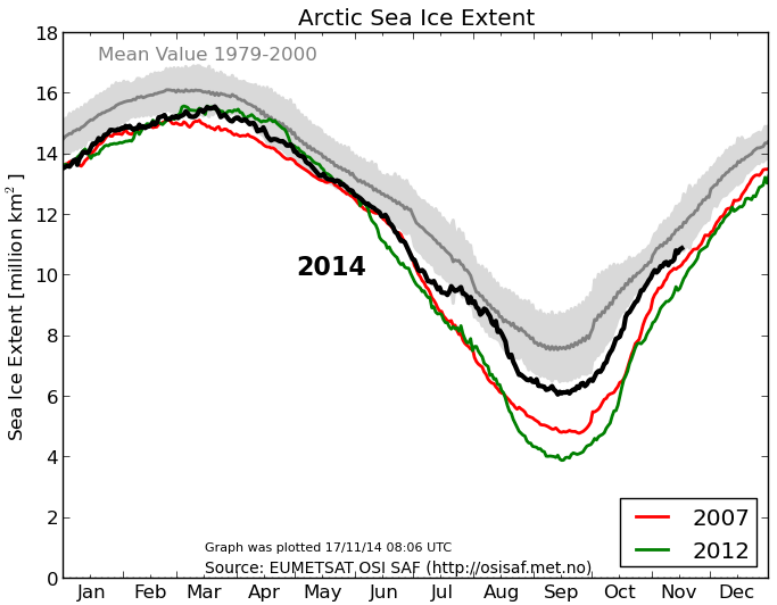
- Daily gridded product of sea ice concentration (0-100%) and quality field, on 10km polar steregraphic grid
- Based on passive microwave data from SSMIS
- Ice conc algorithm is a smooth combination of two algorithms: Bristol (high conc) and Bootstrap frequency mode (low conc)
- An atmospheric correction of brightness temperature based on radiative transfer model using ECMWF NWP model data (water vapour content and wind roughening) is applied



Arctic and Antarctic ice concentration, 15.09.2014

Ice Concentration (OSI-401)

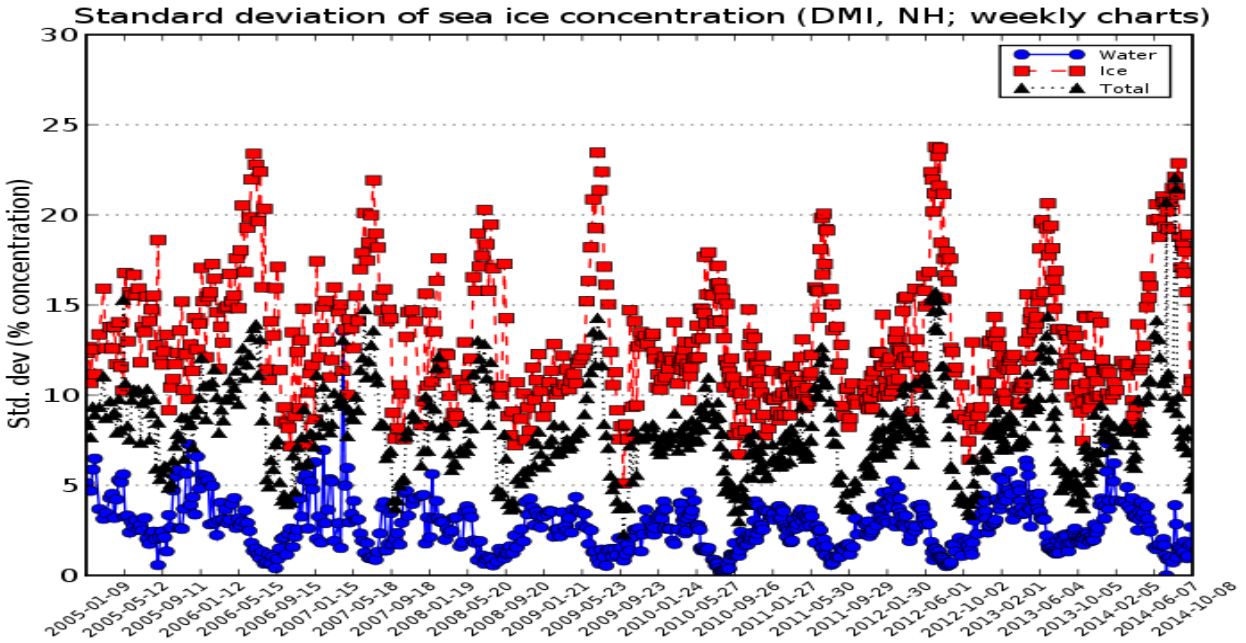
- Using monthly set of typical emissivities for first year ice, multiyear ice and open water – called tiepoints – allows to account for the mean annual cycle in sea ice emissivity and atmospheric transmissivity
- Presently using fixed monthly tiepoints, will switch to dynamical tiepoints early next year
- Also working on corrections of land-spill-over and improving the uncertainty estimates



Arctic sea ice extent (cutoff at 15% conc.)

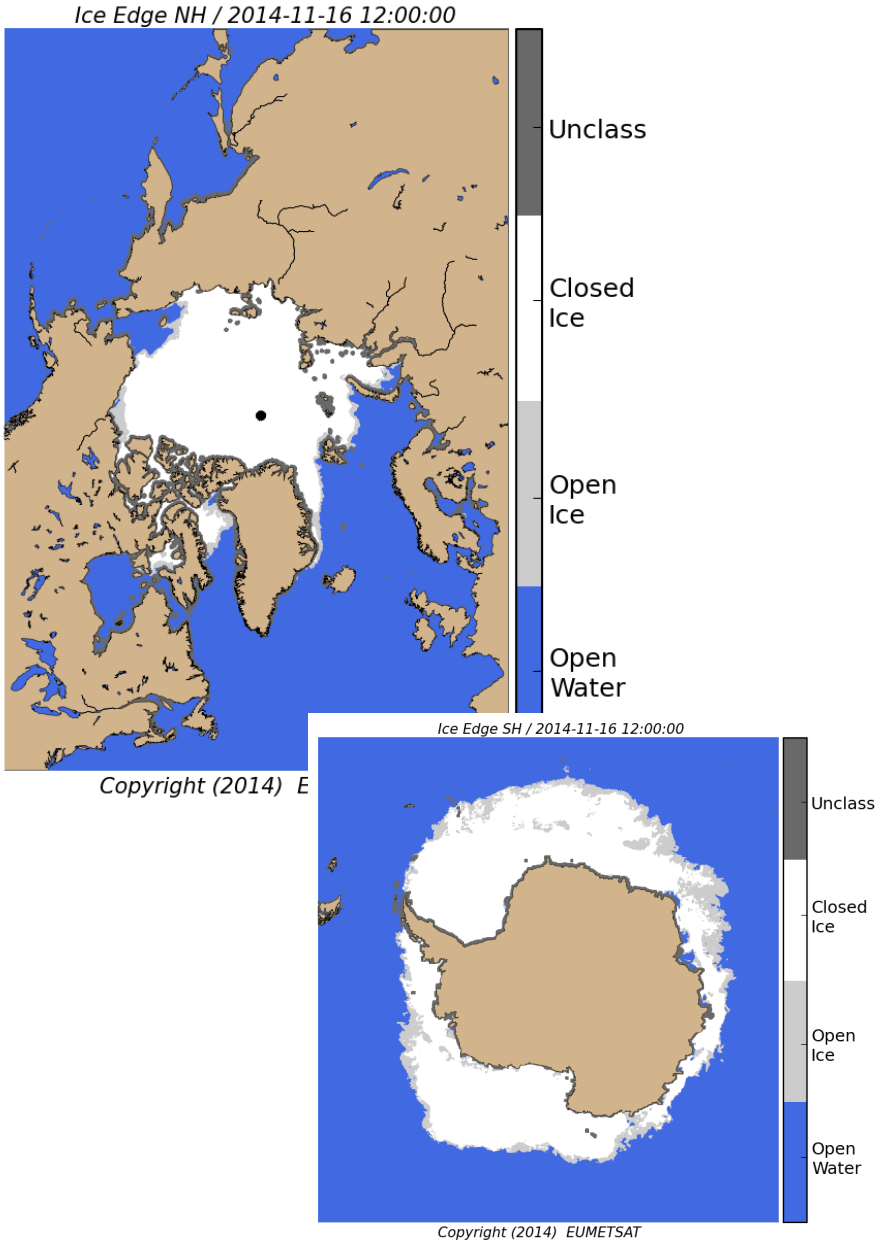
Ice Concentration (OSI-401)

- The product is continously validated against navigational ice charts originating from the operational ice charting services at DMI, MET Norway and NIC



Validation results, NH product against ice charts.

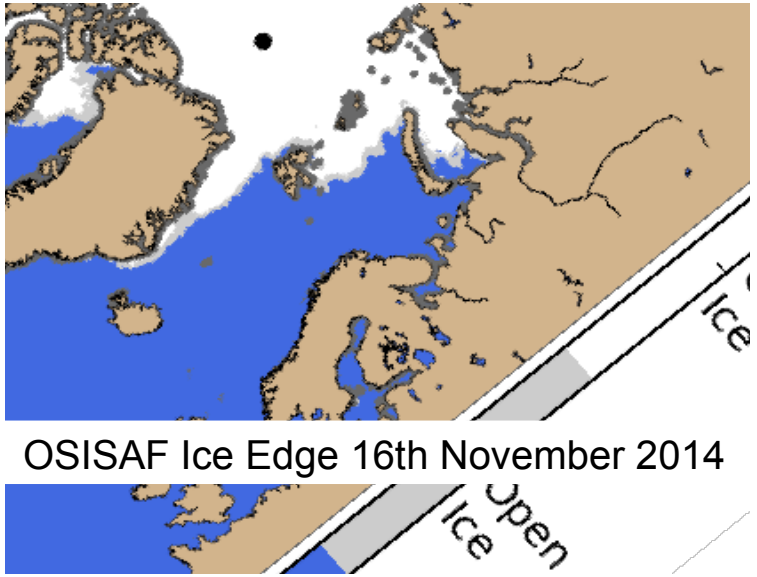
Ice Edge (OSI-402)



Sea Ice Edge product:

- Classification product that distinguish between Open Water, Open Sea Ice (30-70%) and Closed Sea Ice (>70%)
- Data used: SSMIS brightness temperature (uses ECMWF NWP for atmospheric correction) and ASCAT backscatter values
- Method: Combines data from different sensors with Bayesian approach to determine most probable ice class.
- Daily product on 10km grid
- Coverage: Northern Hemisphere and Southern Hemisphere
- Improvement CDOP-2: Dynamical Bayesian approach

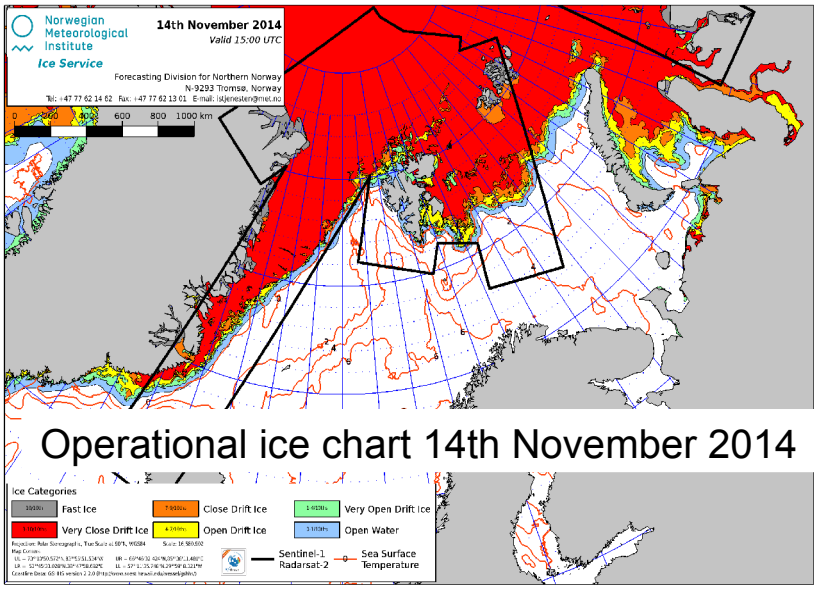
Ice Edge (OSI-402)



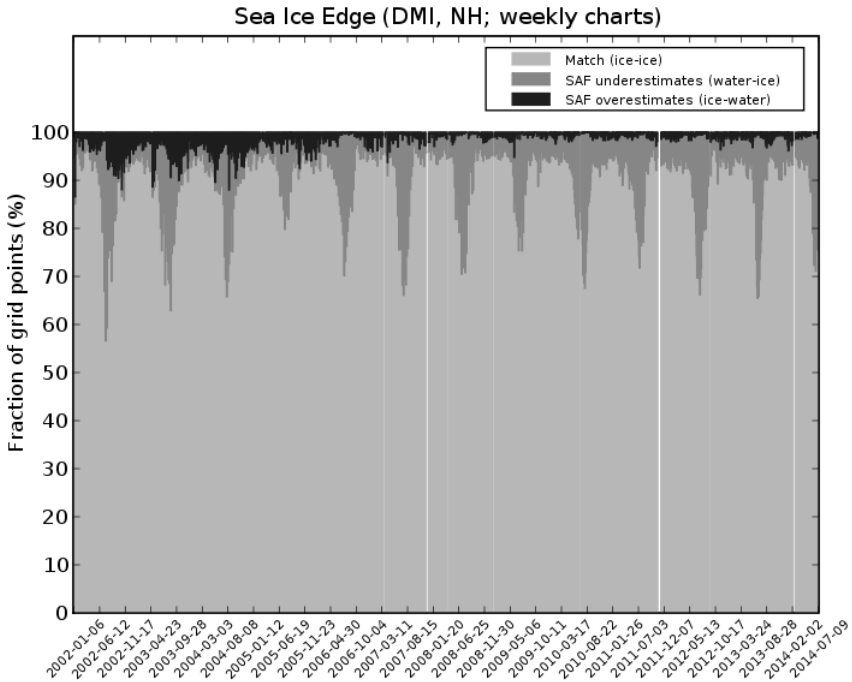
OSISAF Ice Edge 16th November 2014

Validation of Sea Ice Edge product:

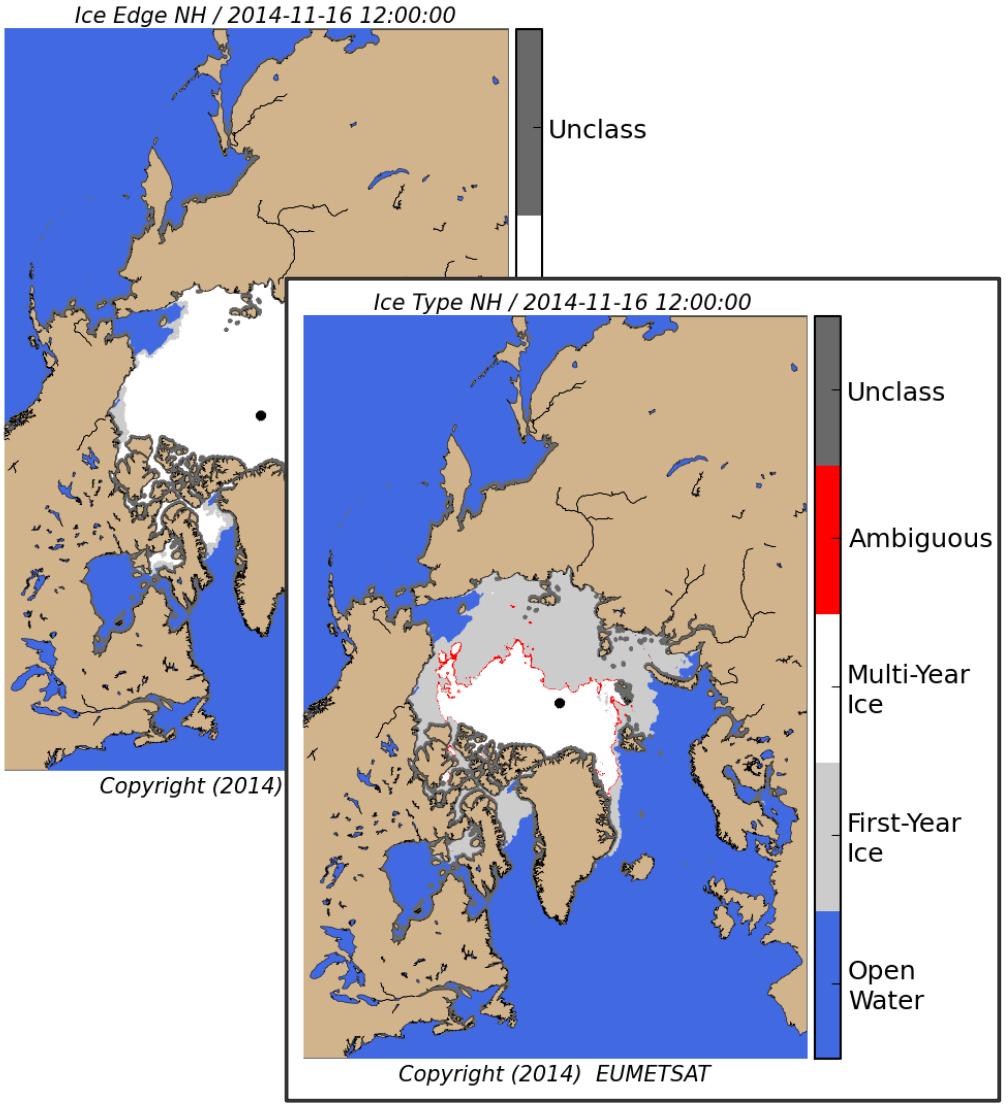
- For validation of the OSI SAF ice edge is compared with operational ice charts:
  - Primarily based on SAR (Sentinel-1 and Radarsat-2), AVHRR and MODIS
  - Validation focused on areas around Greenland and Svalbard



Operational ice chart 14th November 2014



Ice Type (OSI-403)



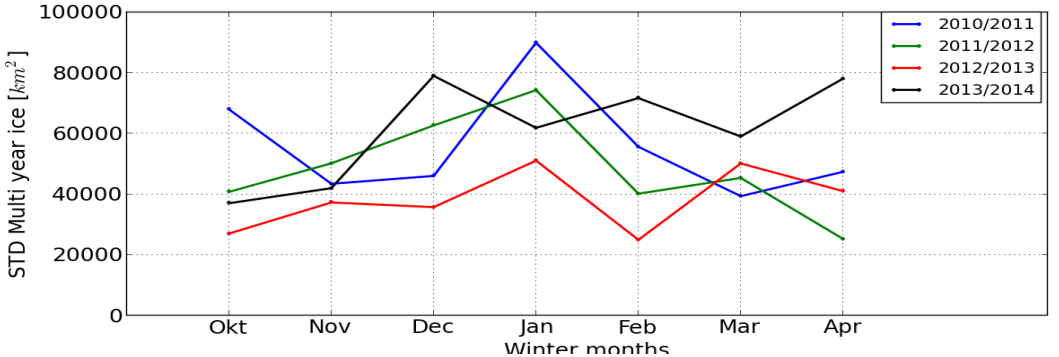
Sea Ice Type product:

- Classification product that distinguish between First Year Ice (new ice from this winter) and Multi Year Ice (ice that has survived at least one summer)
- … Uses the same data and multi-sensor method as for OSISAF Ice edge...
- Daily product on 10km grid
- Provided October - May
- Coverage: Northern Hemisphere (Southern Hemisphere fixed to FYI)
- What is Ambiguous ice? Sometimes – especially during the melting season – it is difficult to distinguish beween First Year Ice and Multi Year Ice. As a result the summer season is classified as *uncertain*

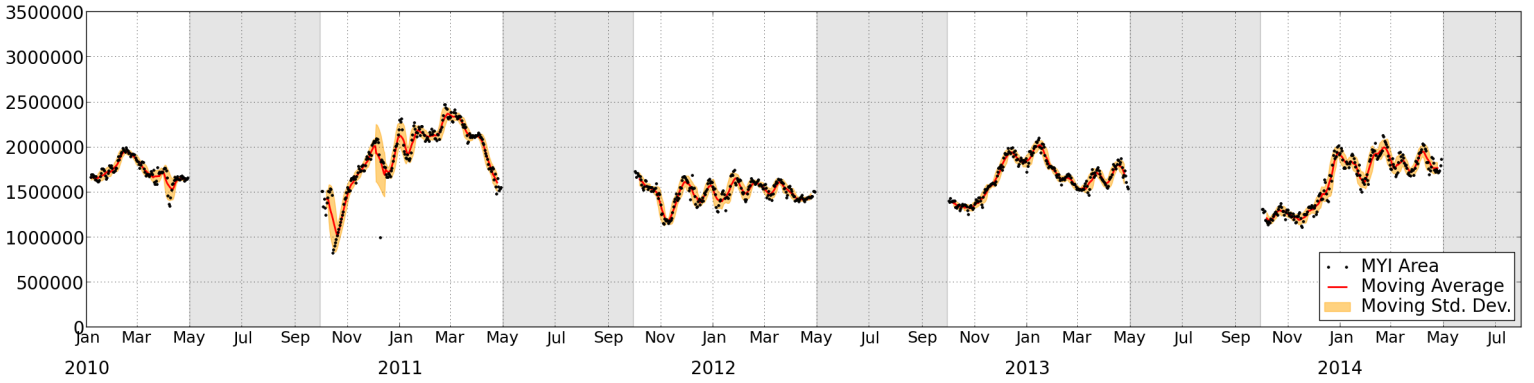
Ice Type (OSI-403)

Validation of Sea Ice Type product:

- In lack of ice type observations, we quality control the Ice type product by monitoring the daily area coverage of the sea ice type in order to see if the product has temporal stability.
- OSISAF's requirement is that the monthly standard deviations of the daily variability (shown below for 2010-2014) is below 100,000 km².



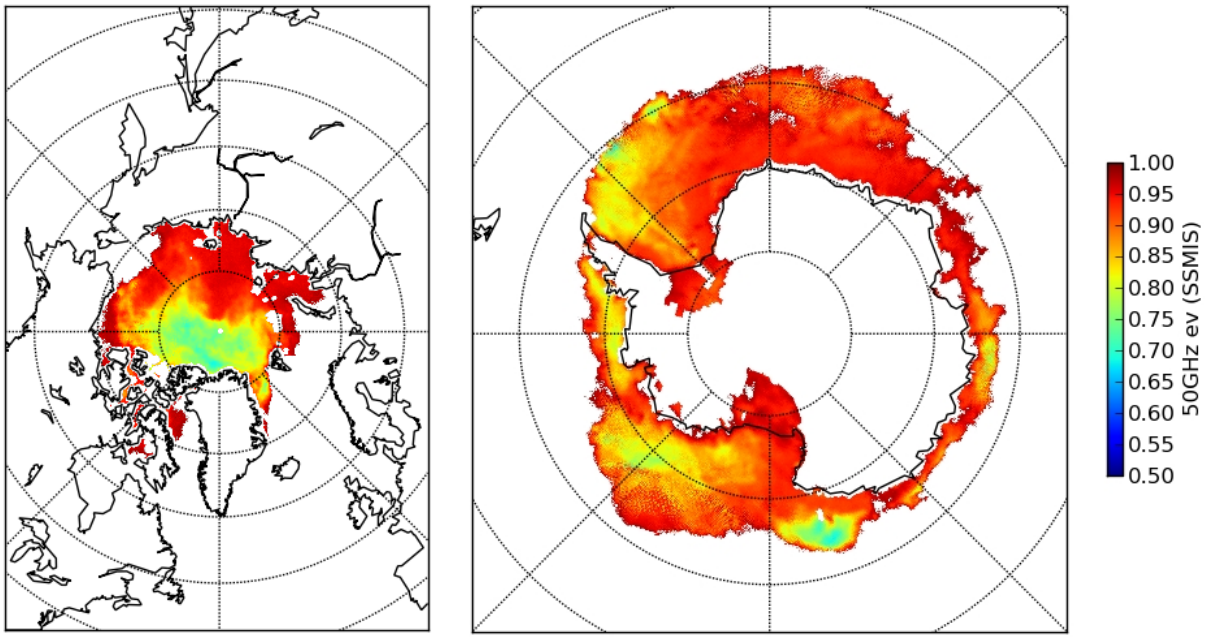
Daily estimate of multi-year ice area coverage during 2010-2014 [in km²]



Ice Emissivity (OSI-404)

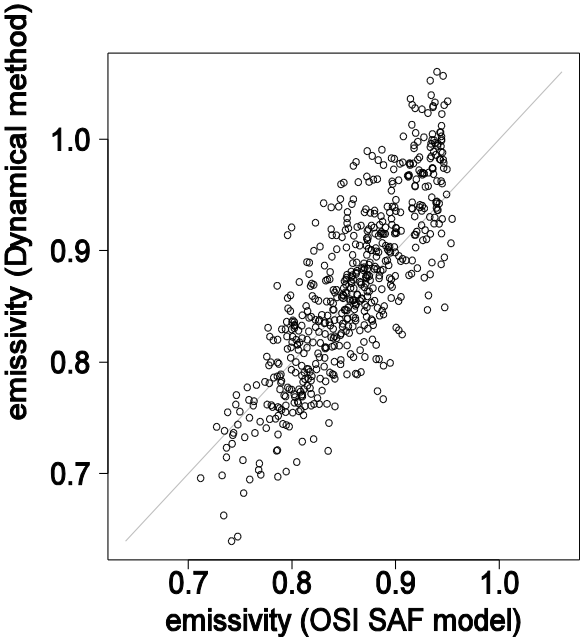
- The near 50GHz sea ice emissivity is a new product, available since 01.04.2014
- In combination with the effective temperature it provides an estimate of the sea ice thermal emission near the tropospheric temperature sounding channels at 50GHz
- The product is valid in areas where the ice concentration is near 100% and where the primary variability is due to scattering, snow cover and temperature variations

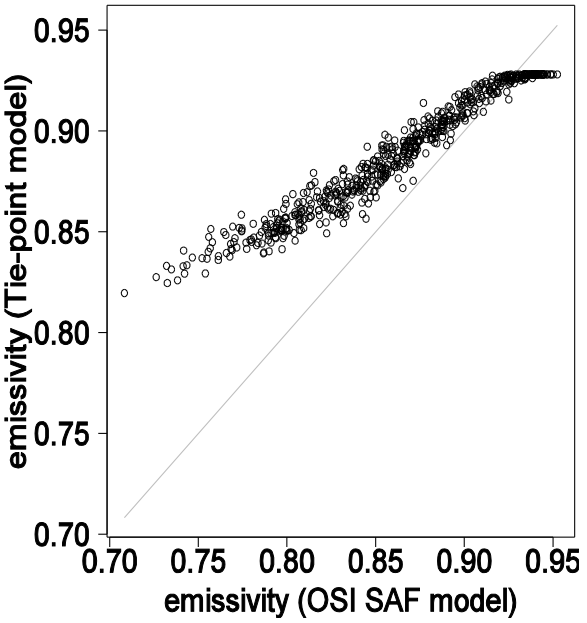
- Together with the emissivity, OSI SAF provides spatially varying parameters for a model which can be used for computing the emissivity at two polarizations and at incident angles from 0-60º



Ice Emissivity (OSI-404)

- Full impact studies are still pending. Comparison with other emissivity estimates and quanification of spatially and temporally varying uncertainties is part of the current phase of the project.
- The idea is to use the product for atmospheric temperature sounding over sea ice.

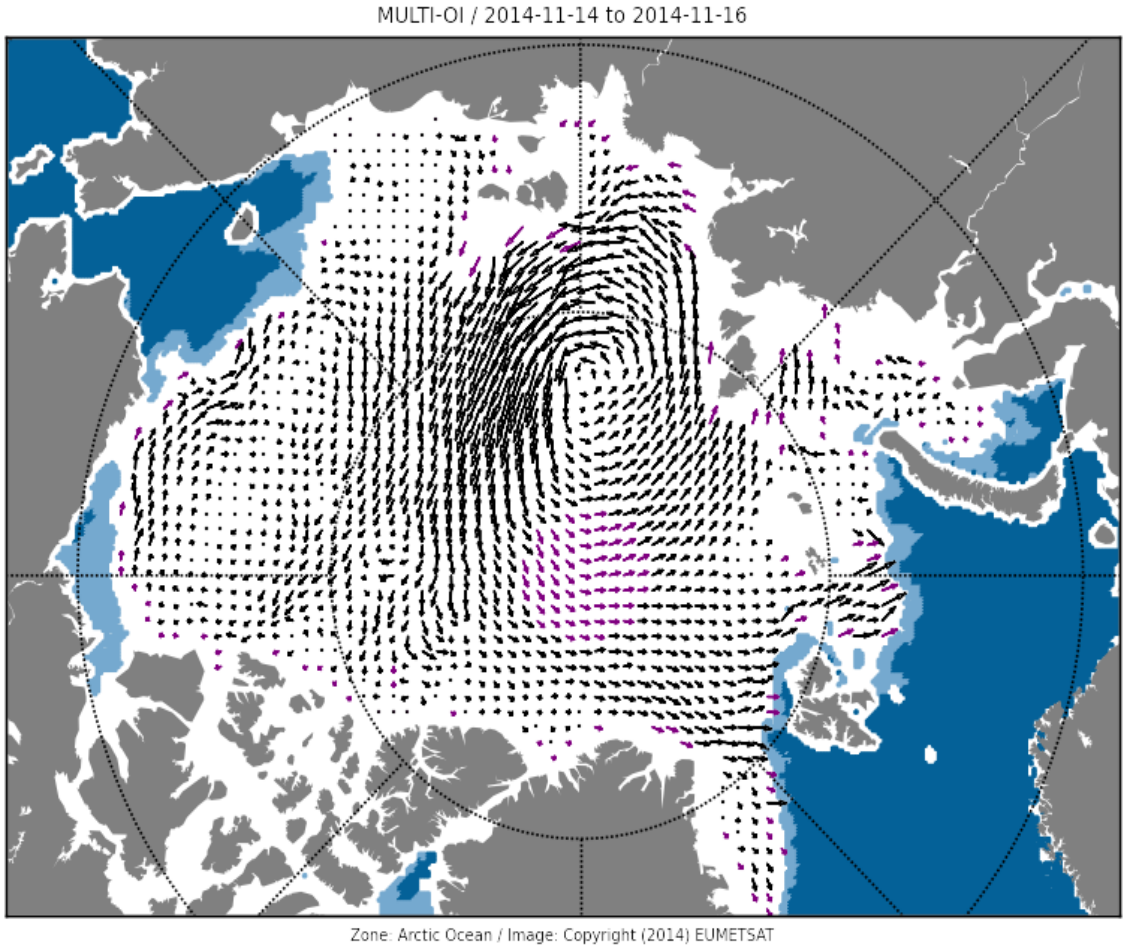




Reference: *R. Tonboe et al 2013: The EUMETST OSI SAF near 50GHz sea ice emissivity model. Tellus 65A, 18380.*

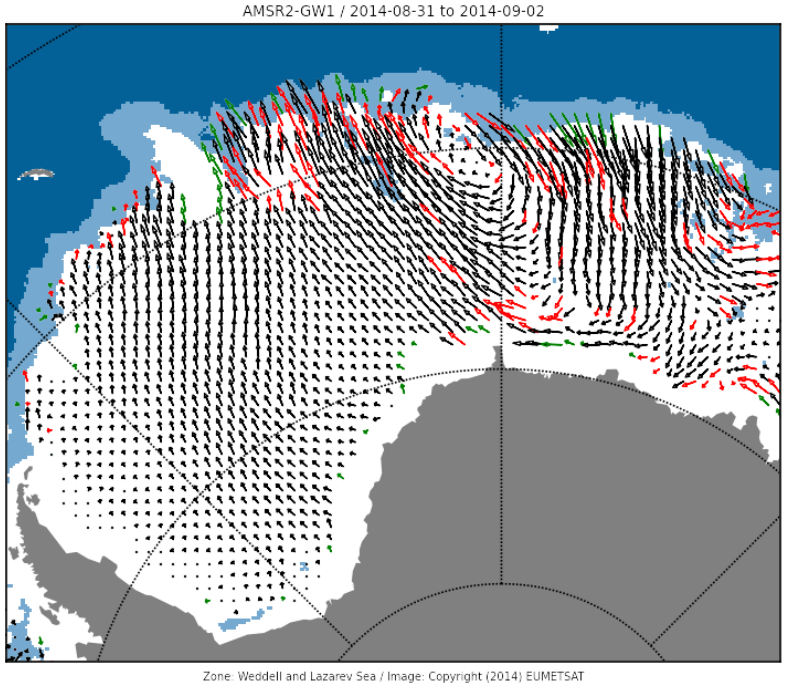
LR Ice Drift (OSI-405)

- Implements the Continuous Maximum Cross Correlation algorithm (CMCC, Lavergne *et al* 2009)
- 2009: operational coverage of NH
- 2013: global coverage
- Currently from SSMIS (F17), ASCAT (Metop-A), and a multi-sensor analysis
- JAXA AMSR2 (GCOM-W1) coming soon
- Available October to May
- 62.5km grid, NetCDF



Right: recent example of OSI-405 NH daily map (Multi-sensor analysis)

LR Ice Drift (OSI-405)



Single-sensor product: AMSR2 (GCOM-W1)								
Period	b(X) [km]	b(Y) [km]	s(X) [km]	s(Y) [km]	a	b [km]	corr	N
Oct2013	-0.302	-0.432	2.361	2.692	0.97	-0.172	0.98	384
Nov2013	-0.167	-0.271	2.766	3.265	0.94	+0.150	0.98	401
Dec2013	+0.133	-0.211	1.664	2.517	0.97	-0.037	0.99	342
Jan2014	+0.500	+0.059	2.652	2.675	0.97	+0.185	0.98	290
Feb2014	+0.105	-0.165	1.817	1.688	0.99	-0.039	0.99	280
Mar2014	-0.113	-0.104	1.578	1.471	0.98	-0.077	0.99	359

Web: Updated validation results at http://osisaf.met.no/validation/val_lrsid.shtml

Above: Validation results of NH AMSR2 ice drift product (Oct 2013 -> Mar 2014)

Left:
example OSI-405 SH daily map with AMSR2 (GCOM-W1)

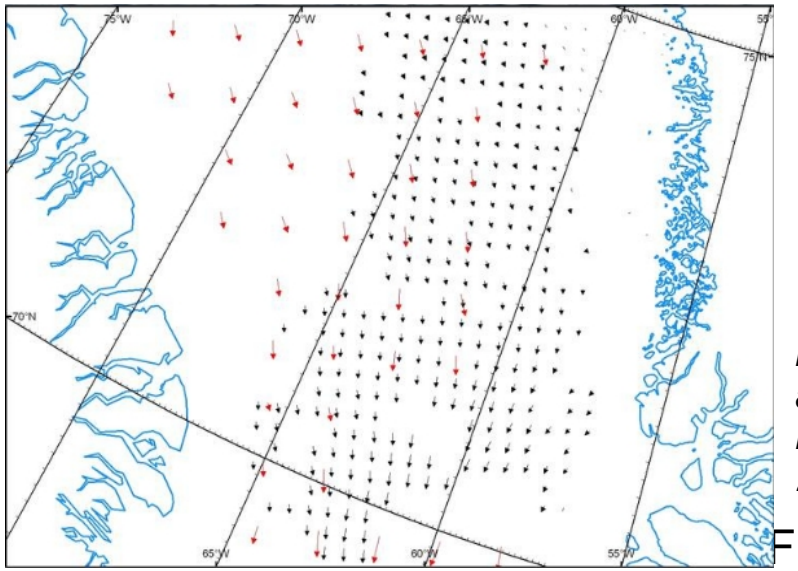
During the remaining of CDOP-2, we plan to:

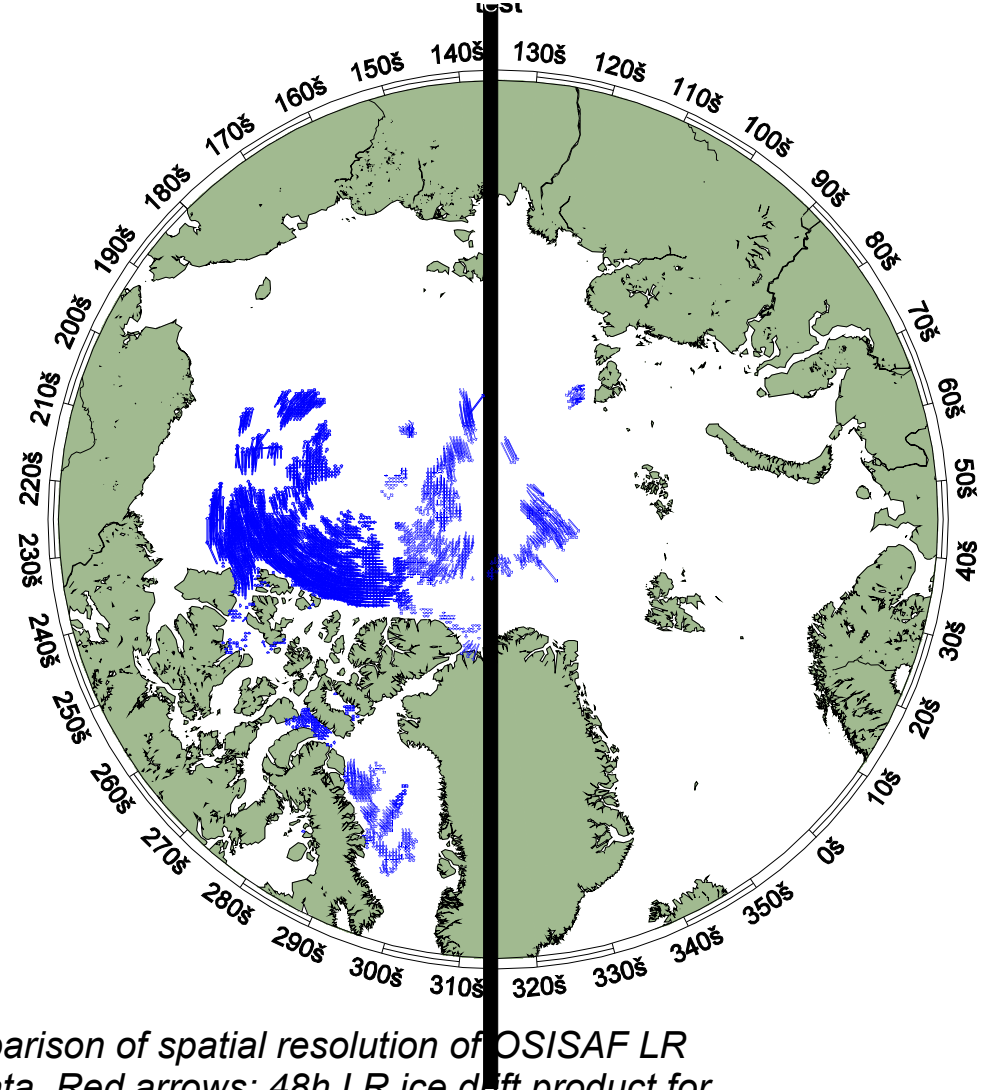
- Investigate how to provide maps of uncertainties (*error-bars*) for the motion vectors;
- Use these uncertainties in the multi-sensor analysis;
- Process AMSR2 18GHz imagery for summer ice drift (May-Sep in NH);

MR Ice Drift (OSI-407)

PRODUCT/PRODUCTION CHARACTERISTICS:

- Maximum Cross Correlation methodology.
- 24h ice drift – for cloud free areas only
- IR based from September to April
- VIS based from May to August.
- Level 2 output - twice daily.
- Northern Hemisphere coverage.
- Polarstereographic grid in 20km resolution.
- Output data in netCDF





Left: Comparison of spatial resolution of OSISAF LR and MR data. Red arrows: 48h LR ice drift product for March 24th 12z to March 26th 12z, and black arrows: 24h MR ice drift product for March 25.

MR Ice Drift (OSI-407)

Comparison of displacements errors with other data sets:

Standard deviation of errors for dY (left) and dX sea ice displacements as a function of spatial match-up constraints(km) to a given GPS buoy position.

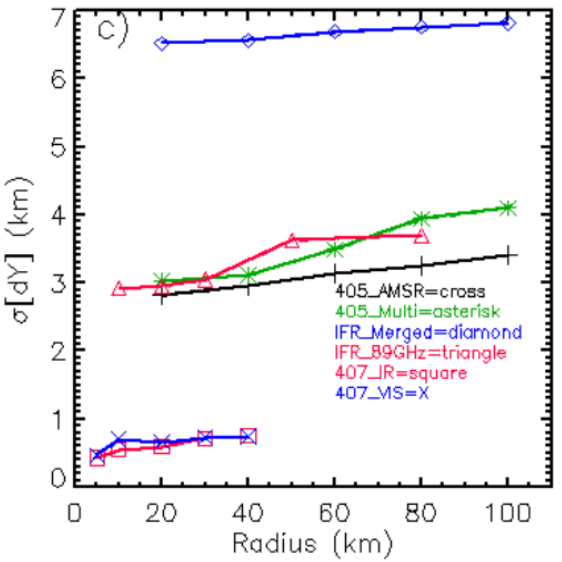
- From the top:
- blue is Ifremer merged product,
- red is Ifremer 89 GHz product,
- green is OSISAF multi PMW product
- black curve is the OSISAF LR product

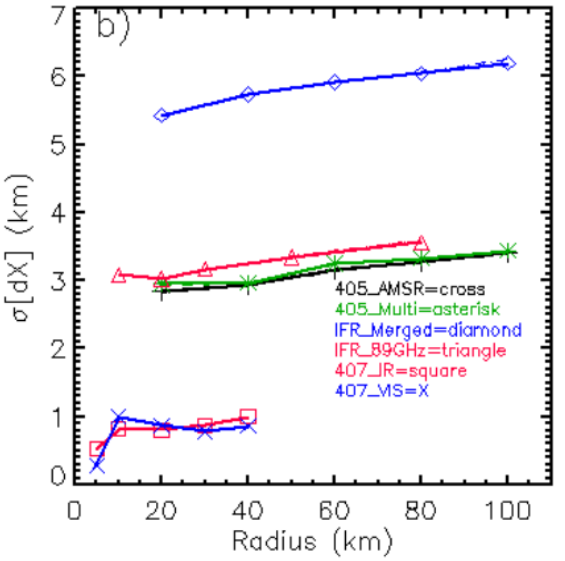
with AMRS data only.

- Bottom red and blue curves are

MR ice drift product.

[Graphic Phil Hwang, OSISAF_VSReport_V0.1].





MR ice drift perfornance:

Product	N	δ[dX]	δ[dY]	σ[dX]	σ[dY]	a	b	r
OSISAF MR VIS Ice drift	583	-0.08	0.04	**1.00**	**0.75**	0.98	-0.02	0.98
OSISAF MR IR Ice drift	63	0.12	0.04	**0.87**	**0.74**	1.04	0.09	0.98

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Reprocessed data set

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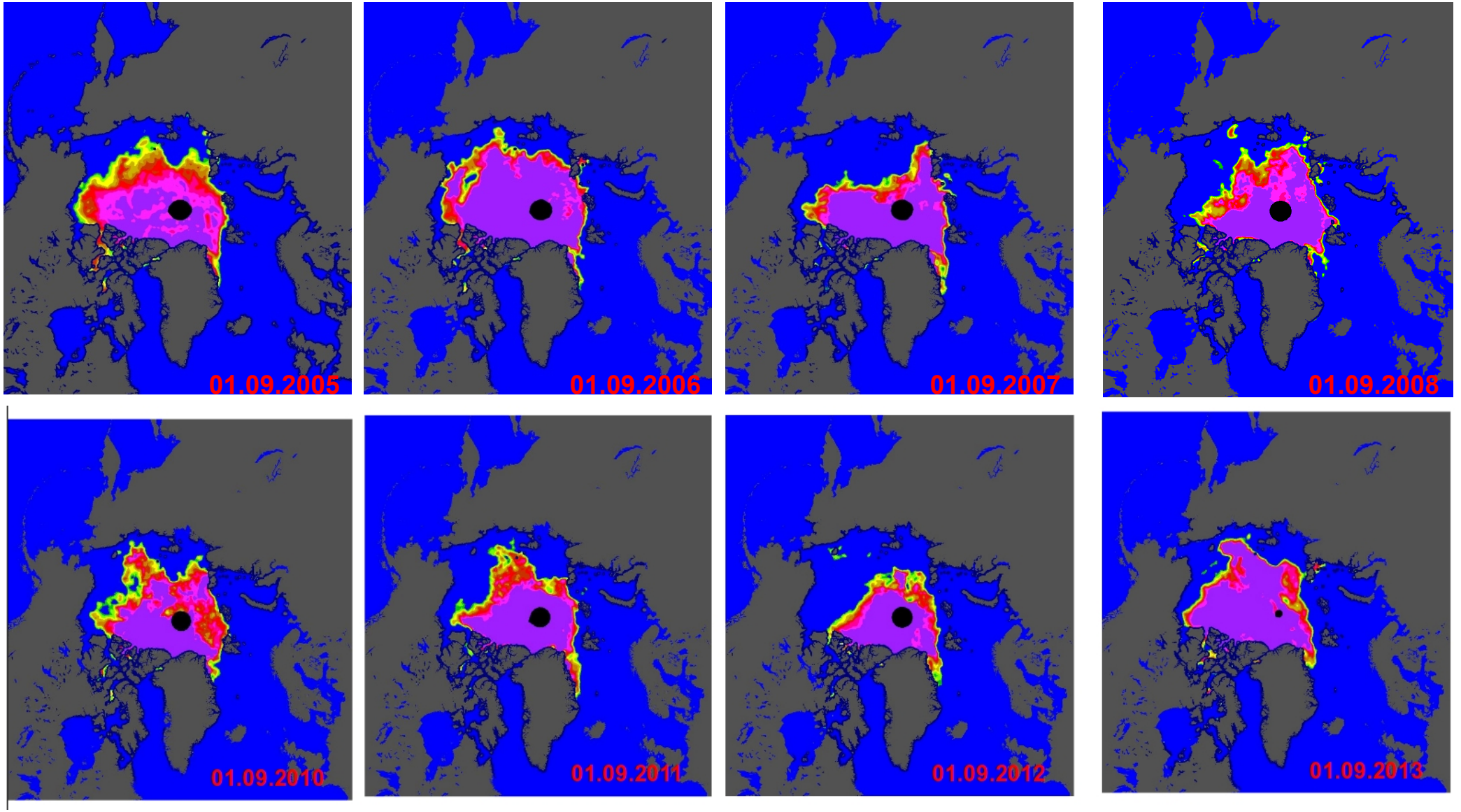
Reproc Ice Conc (OSI-409)

- The operational ice concentration product is available since 2005



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Reproc Ice Conc (OSI-409)

- The operational ice concentration product is available since 2005
- Users want longer time series, so we have produced a longer climate data record (released 2010)
- Cooperation with UK MetOffice and NSIDC to reprocess SSM/I and SMMR from 10.1978 - 10.2009
- The reprocessing introduced a method for using dynamical tiepoints, for better handling of season changes and inter-satellite changes, and therefore produce a more climate consistent dataset
- Also introduced uncertainty estimate
- Daily product, provided on NetCDF format, in polar stereographic (10.0km grid) and lambert azimuthal (12.5km grid) projections

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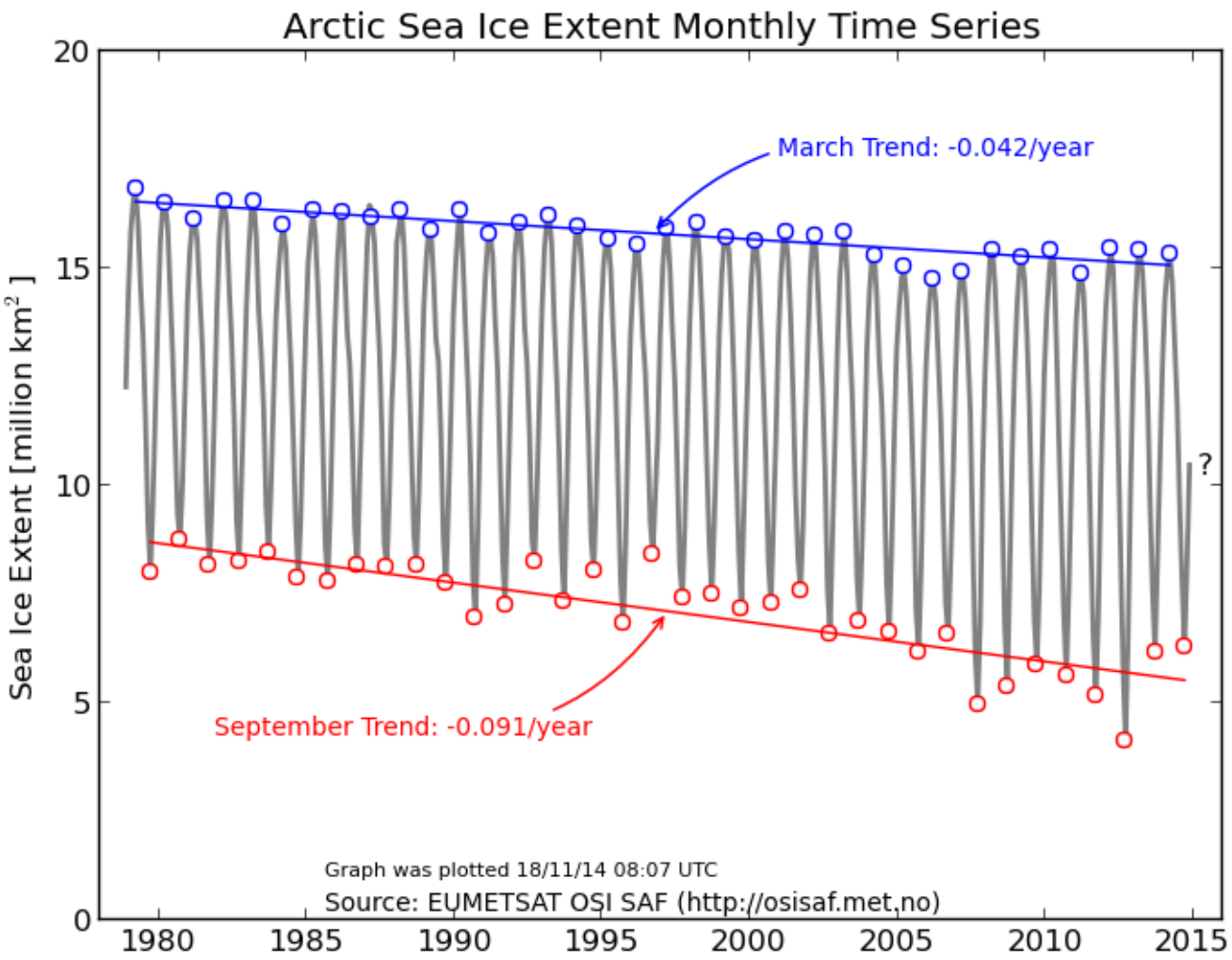
Reproc Ice Conc (OSI-409)



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Reproc Ice Conc (OSI-409)

Plans for CDOP-2

- In March 2015 this data set will be extended to also cover the period 11.2009-12.2014
- We also hope to release a new version with improved algorithms and processing in coordination with ESA Sea Ice CCI in 2016

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Reproc Ice Conc (OSI-409)

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- In March 2015 this data set will be extended to also cover the period 11.2009-12.2014
- We also hope to release a new version with improved algorithms and processing in coordination with ESA Sea Ice CCI in 2016
- Plan to use the CM SAF FCDR for SMMR, SSM/I and SSMIS

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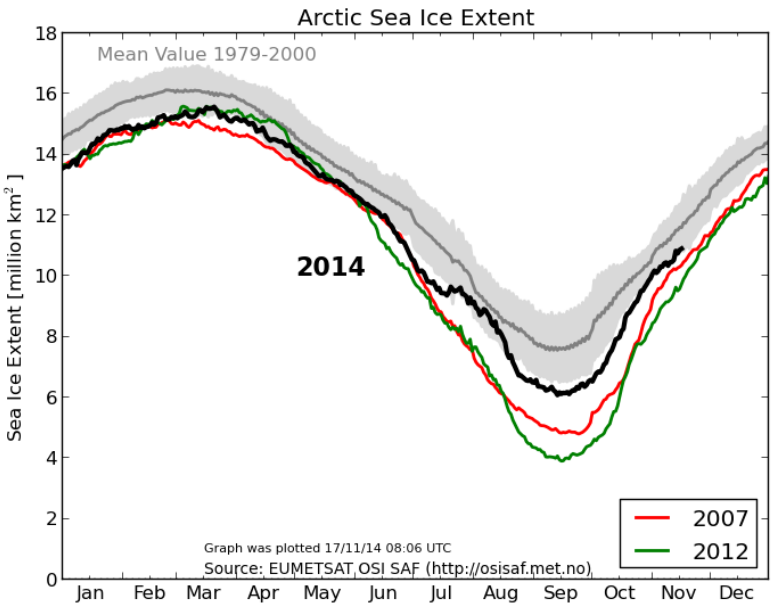
Upcoming products

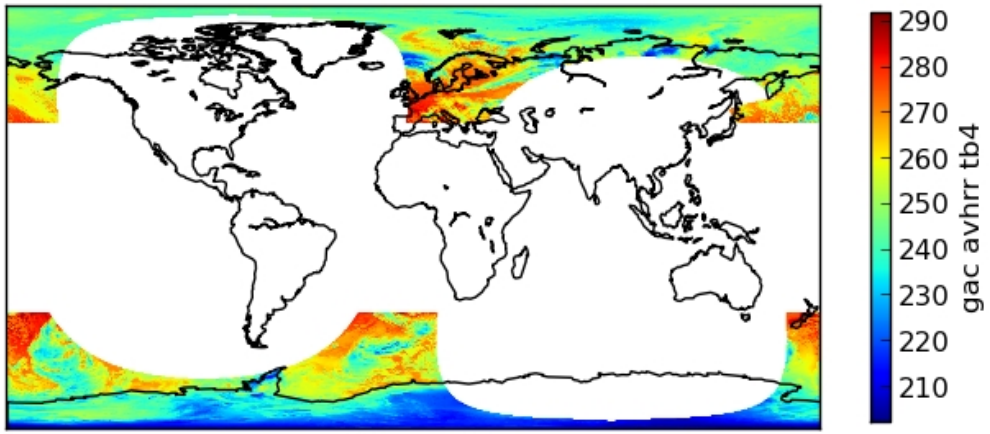
Cont ice conc reproc (OSI-430)

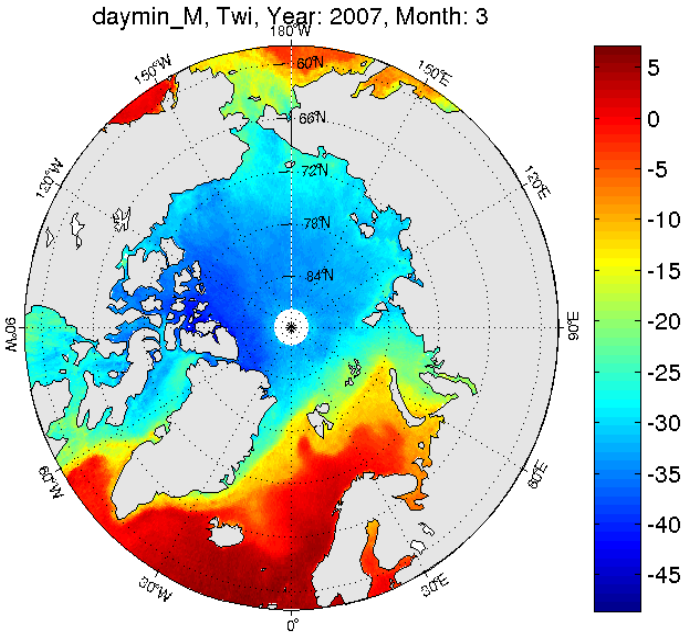
- To fill the gaps between each new release of the reprocessed ice concentration data set, a new product will be released in March 2015
- The continuous ice concentration reprocessing product will have the same specifications as OSI-409
- It will be delivered daily, with a 31-days delay



Ice Surface Temp (OSI-205)

- **Integrated Ice, Sea and Marginal Ice Zone Surface Temperature.**
- **Input is Metop-AVHRR Thermal InfraRed swath data in full temporal and spatial resolution, i.e multiple daily, ~1km**
- **Output is Metop-AVHRR swath Surface temperature fields in full temporal and spatial resolution, i.e multiple daily, ~1km.**
- **Coverage: North of 50N + South of 50S**
- **Cloud mask from NWC SAF, PPS.**





Top plot: Coverage of 1 Metop-AVHRR swath – projected on to a global map.

Bottom plot: Example of a monthly mean and gridded integrated temperature field, based on level-2 data.

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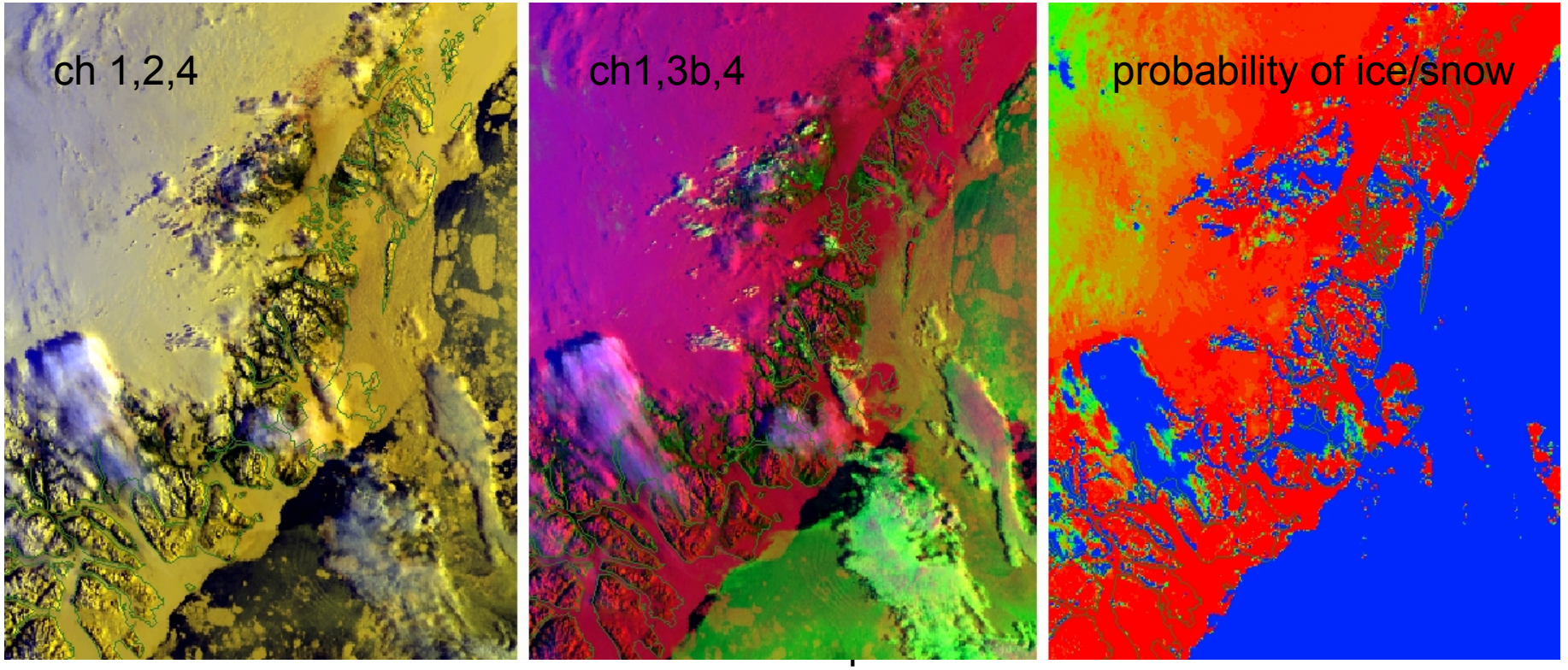
Regional Ice Edge (OSI-406)

- AVHRR based product, using a Bayesian probabilistic approach to calculate probability of clouds, cloud-free ice and cloud-free sea
- In cloud-free areas, the probabilities are used for a ice/sea classification, presented as daily regional maps
- Operationalization has been delayed, expect this product to be available late 2015



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Plans for CDOP-3 (2017-2022)

General

- Focus on preparation for new sensors on EPS-SG in existing OSI SAF products (e.g. first EUMETSAT PMW imager).
- Possibilities with Sentinel-3, e.g. Ice Surface Temperature from SLSTR.
- As a continuation of the work in CDOP-1 and 2, extend the use of forward models for error reduction and for model inversion.

Possible new products

- Level 2 sea ice concentration (orbital product).
- Ice albedo from optical sensors.
- Should OSI SAF engage in sea ice thickness?

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Plans for CDOP-3

Further development of existing products

- Integration / further integration of **RTM** (RTTOV?) and a physical model system (model inversion using all available data).
- Ice conc/edge/type products – improve **land spill-over model.**
- Ice conc/edge products – improvements on **dynamical tie-points**: selection, regional, summer issues, melt-ponds.
- Develop / further development of **climate records**; concentration, drift, emissivity, IST.
- Test and use of **new frequencies** in ice drift (150GHz, 183GHz) and emissivity products (1-200GHz, Infrared).
- Determine/compensate for **diurnal variability** over sea and ice in the Arctic for SST and IST.
- Improve **uncertainties**: develop new uncertainty algorithms or use model inversion.
- Further improvements through **validation work** over sea ice for IST and radiative fluxes.

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Thank you for your attention

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Extra slides

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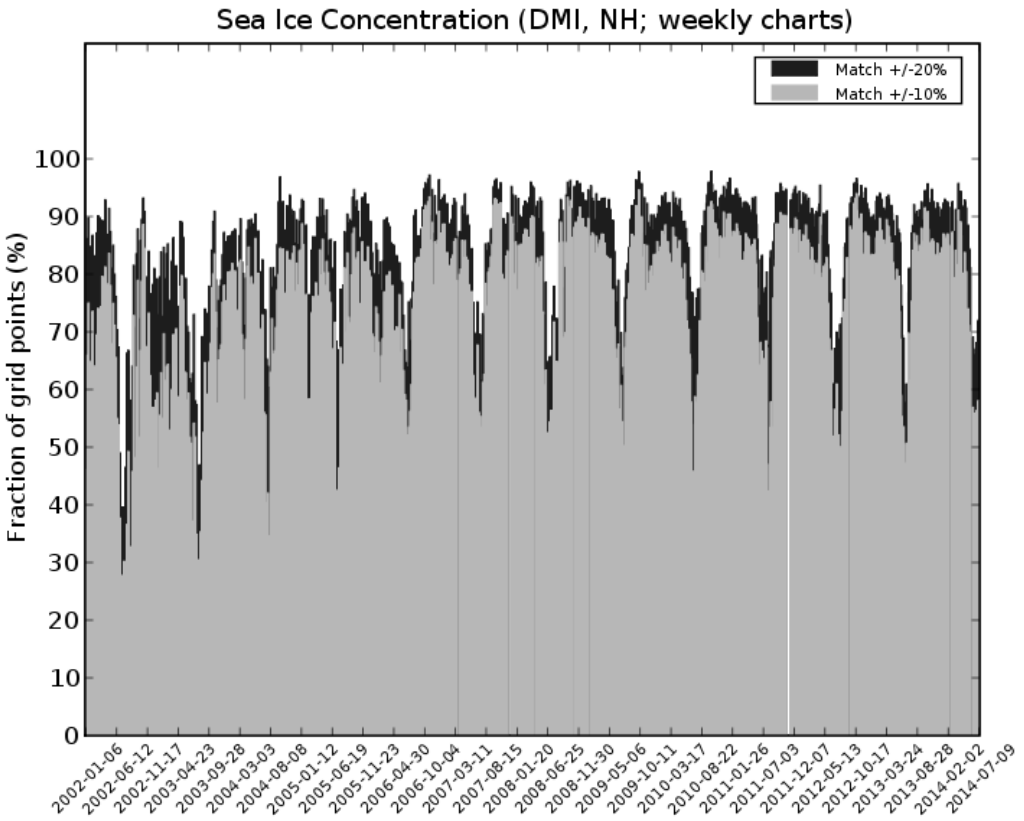

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Improvement in CDOP-2

Bayesian approach requirements:

- Pre-knowledge of the averaged relationships between a measured parameter and each surface type – expressed as a probability density distribution (PDF) with a mean and a standard deviation.

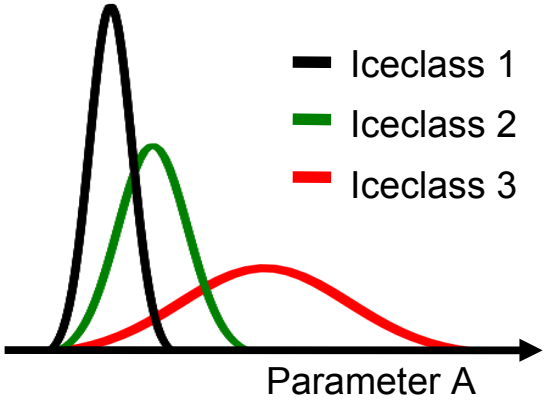
Training data set for PDF calculations:

- **CDOP-1**: A fixed year of observations (2007-2008). PDF's are static.
- **CDOP-2**: The training dataset is continuously updated from the preceding 15 days. PDF's are dynamic.

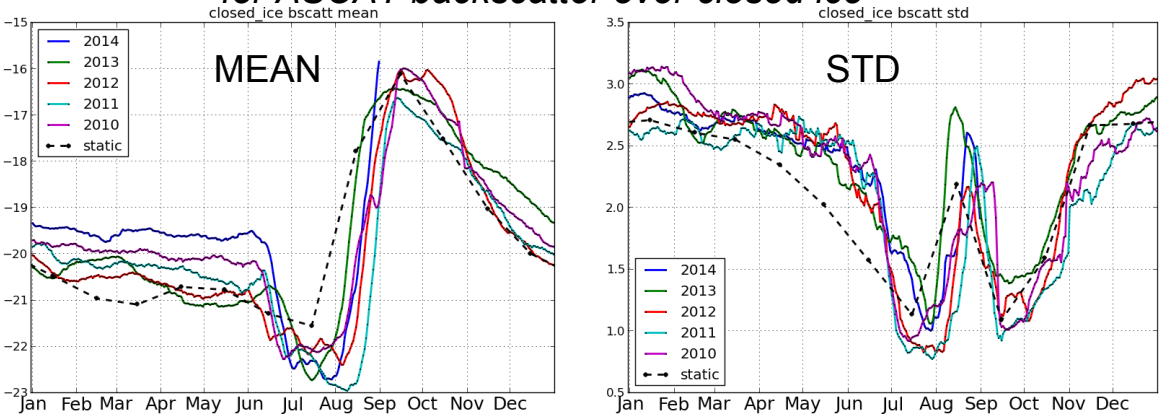
Advantages with CDOP-2 improvent:

- Dynamic PDF's account better for seasonal and interannual variability of the surface properties
- Dynamic PDF's allow for more smooth and consistent transition between sensor-upgrades and sensor-calibrations.

Illustration of PDF estimates of parameter A for 3 different iceclasses



Example of dynamical PDF's (mean & std) for ASCAT backscatter over closed ice



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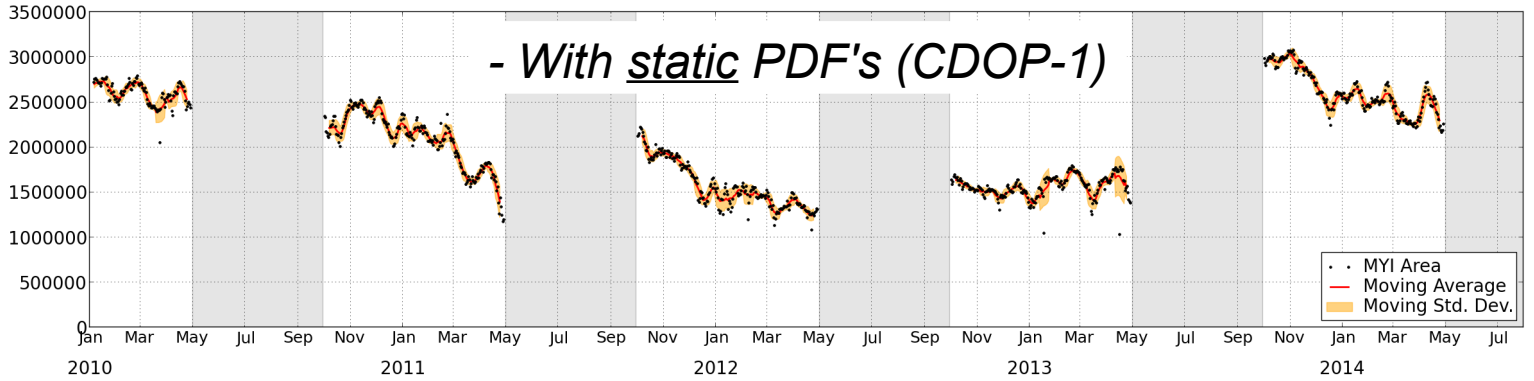
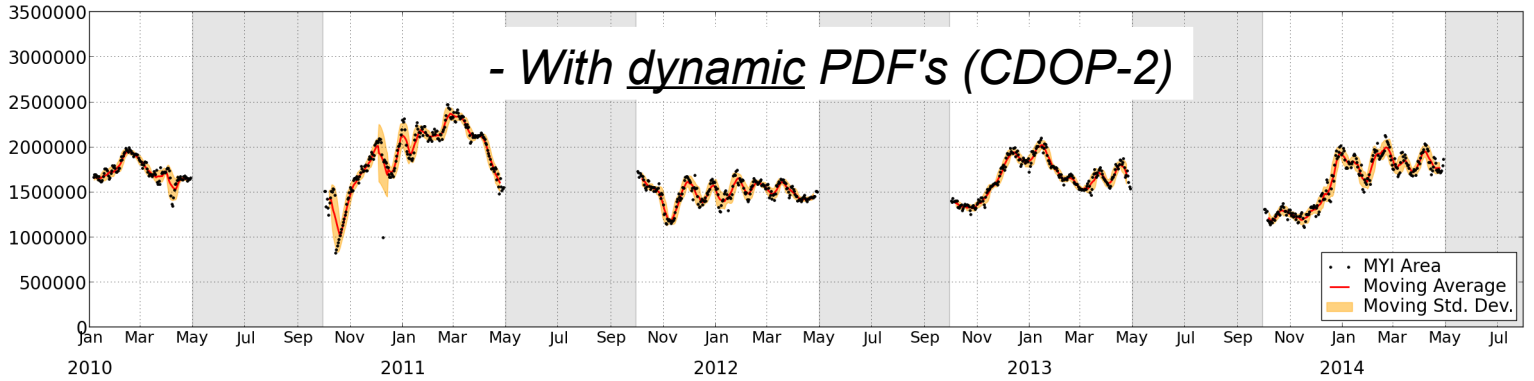
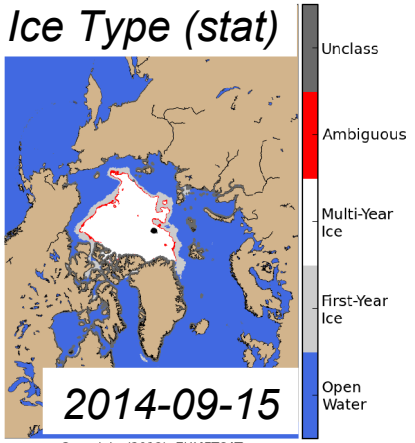
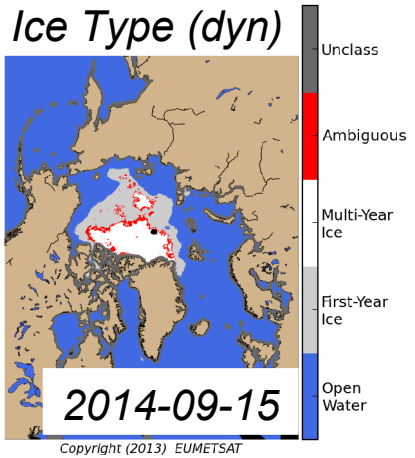
Improvement in CDOP-2

Time series showing area coverage [km²] of Multi-Year ice in the Arctic