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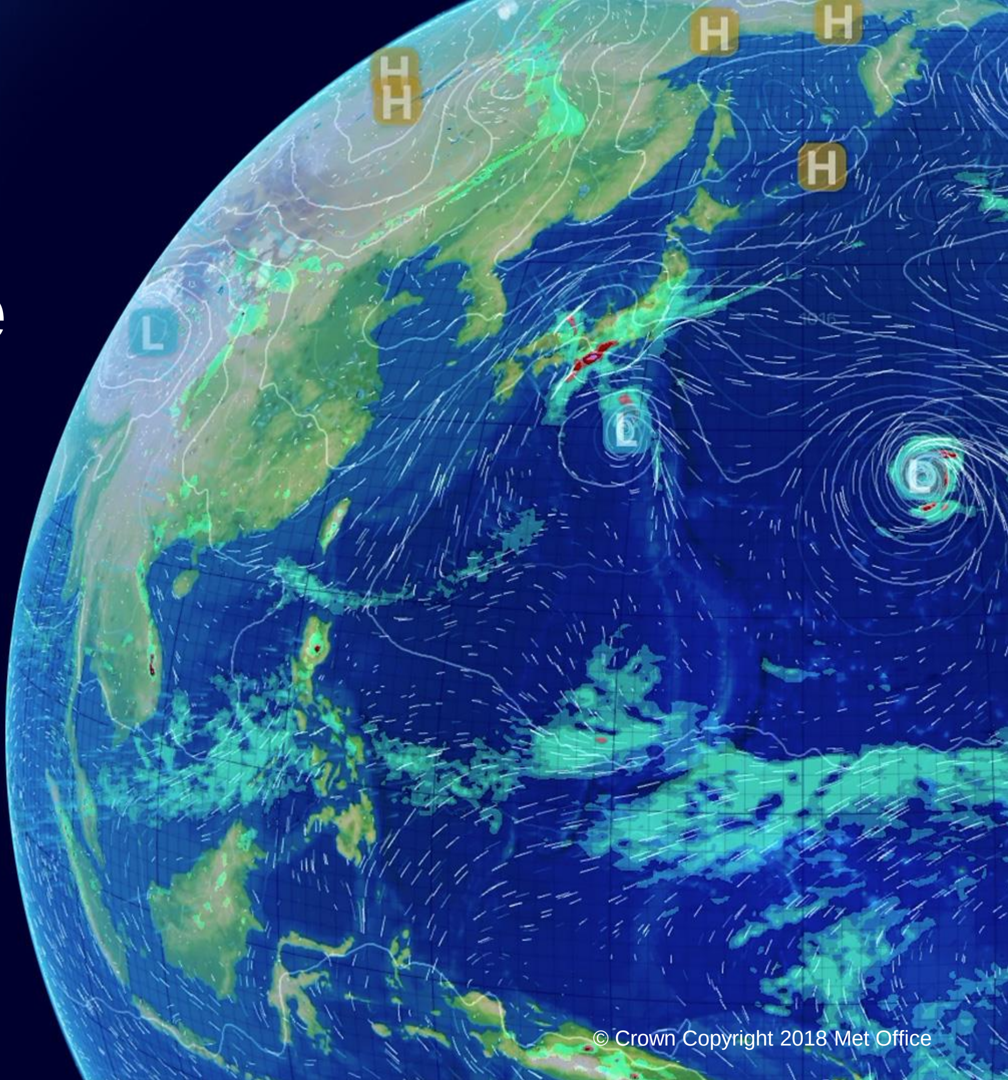
The Operational Sea Surface Temperature and Ice Analysis (OSTIA) system

Simon Good

23 January 2018

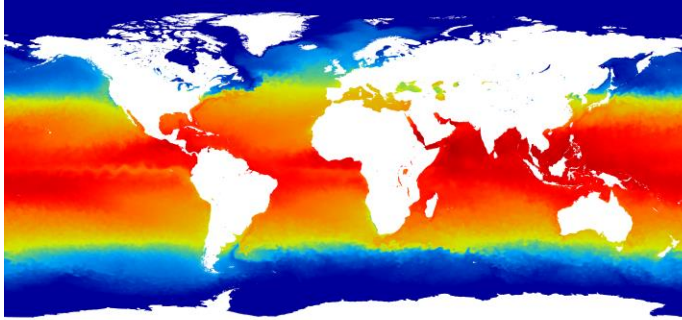
ECMWF SST and sea ice workshop



Outline

- Introduction to OSTIA
- SST processing
- Sea ice concentration processing
- SST and sea ice concentration interconnections
- Where to get our data and who to contact

Introduction to OSTIA



- Operational Sea Surface Temperature (SST) and Ice Analysis system
- Produces L4 (globally complete, gridded) analyses of SST and sea ice using observations from satellite and in situ platforms
- A major use of OSTIA is for weather prediction
- Donlon et al. (2012), Remote Sensing of Environment, 116, 140-158, doi:10.1016/j.rse.2010.10.017

https://www.ghrsst.org/ghrsst-data-services/products/

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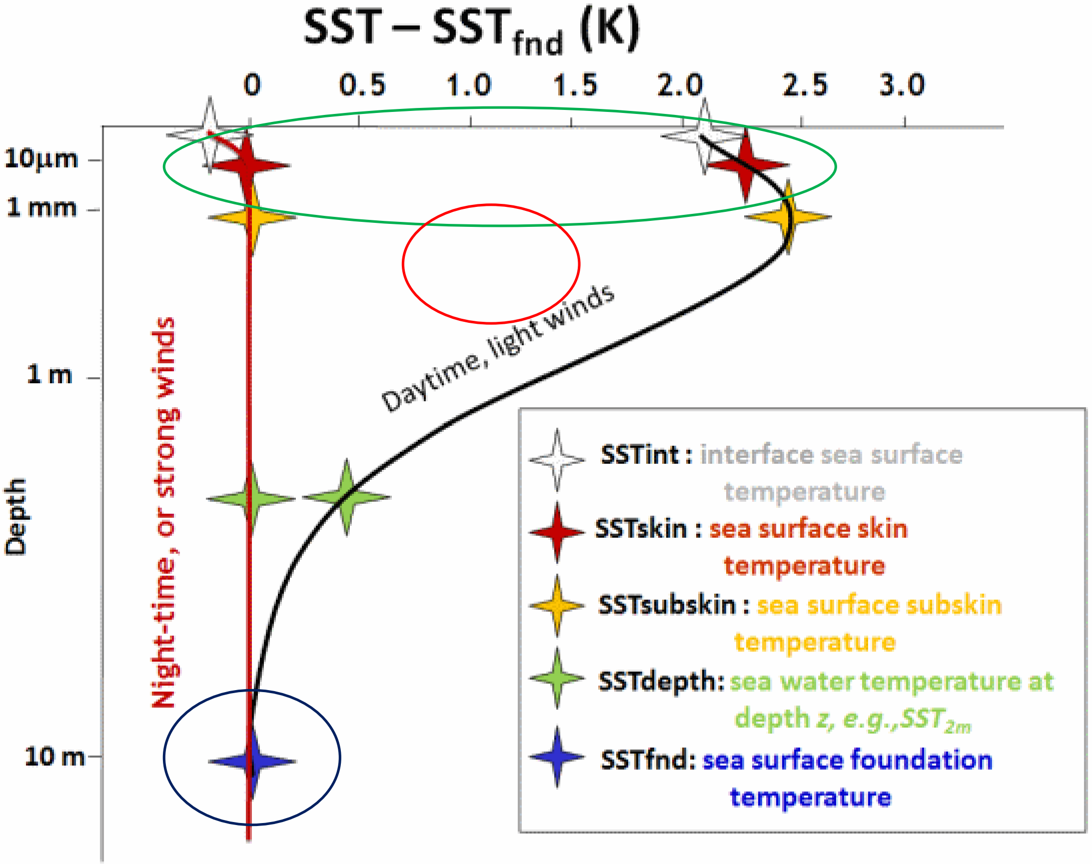
Introduction to OSTIA

- Near real time and reprocessed (1985 – 2007) foundation SST with uncertainties and ice concentration on a 1/20 degree grid available from CMEMS (observation only product)
- Near real time hourly diurnal skin SST on ¼ degree grid from CMEMS
- Reprocessed 20 cm daily average SST for climate users from ESA SST CCI (1991 – 2010) and (soon) short delayed mode from C3S
- Both reprocessings to be updated
- Download locations will be provided at the end of the talk



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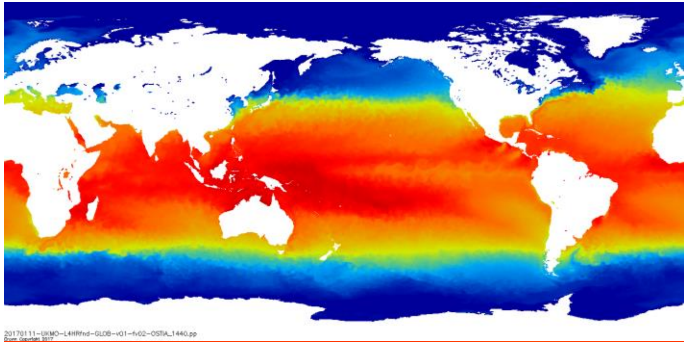
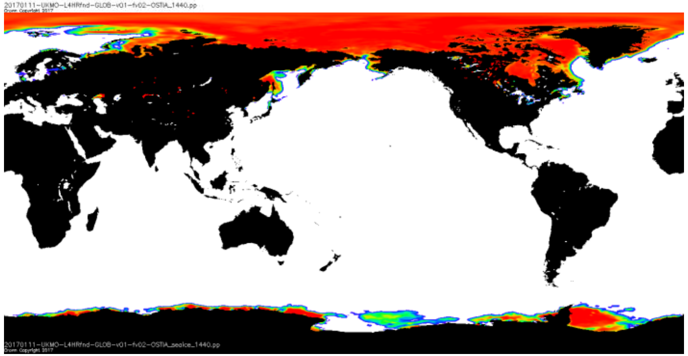
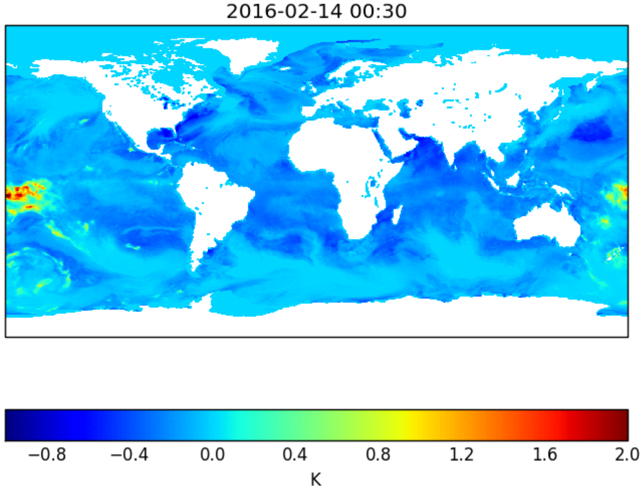
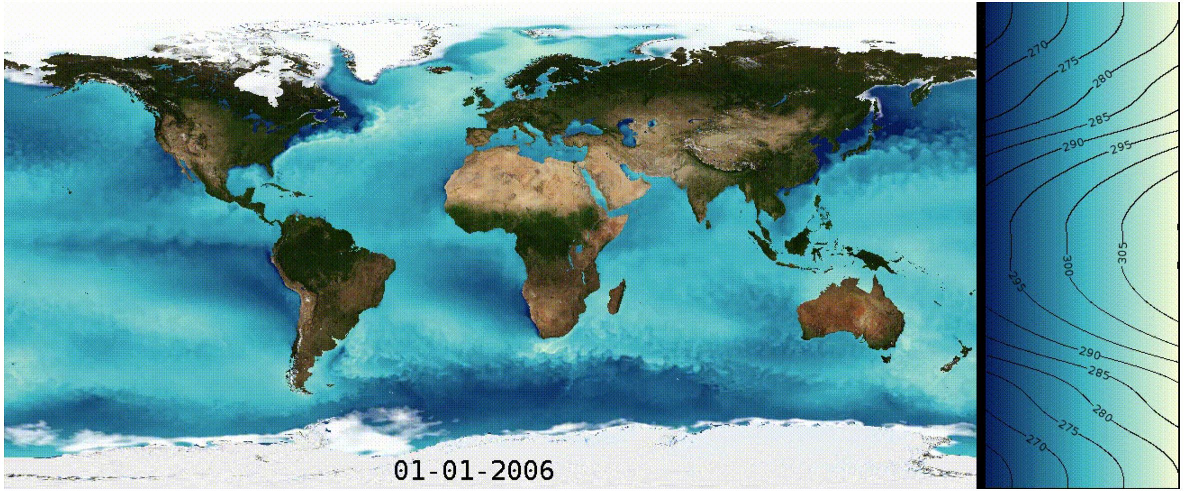
Introduction to OSTIA





- Some examples of each product





SST CCI movie: Extract from Merchant, Christopher J; Griffiths, Guy (2014): ESA SST CCI Analysis -- Movie of sea surface temperature contrasts. figshare.http://dx.doi.org/10.6084/m9.figshare.1246151Retrieved 15:46, Sep 29, 2015 (GMT)

Introduction to OSTIA

- This talk focuses on the near real time version of OSTIA
- Also includes lake surface temperature and ice concentrations in the foundation SST product
- This system has been updated over time - latest update is to change the data assimilation scheme used to produce the foundation SST analyses to NEMOVAR from an optimal interpolation-like scheme
- Major change to generation of sea ice concentration data from a simple regridding to a data assimilation approach
- Papers describing the new approach are being prepared: Good et al. – overview of the system and Fiedler et al. – describes work on developing the background error covariance approach that is used

SST processing in OSTIA

- SST data used in OSTIA
- Preprocessing
- Foundation SST processing
  - Bias correction
  - Analysis of the data
  - Issues – matching performance estimates to performance in user applications
- Diurnal skin SST processing
- Future outlook

SST data used in OSTIA

Satellite Product	Wavelengths	Platforms	Notes
NAVO AVHRR-18 and -19	Infra-red	Polar orbit	
MetOp-B AVHRR	Infra-red	Polar orbit	Not diurnal
SEVIRI	Infra-red	Geostationary	
GOES-E	Infra-red	Geostationary	Not currently used
GOES-W	Infra-red	Geostationary	Diurnal only
VIIRS Global	Infra-red	Polar orbit	Not diurnal
RSS AMSR2	Microwave	Polar orbit	Not diurnal
In situ	-	-	Not diurnal

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From slide by Emma Fiedler

Benefits of new data

Argo minus OSTIA for January 2016, global statistics

Experiment	Mean diff to Argo (K)	Standard deviation of diff to Argo (K)	RMS diff to Argo (K)
Control	0.12	0.49	0.50
+ AMSR2	0.12	0.43	0.44
+ VIIRS	0.10	0.43	0.44
+ AMSR2, VIIRS	0.11	0.41	0.42

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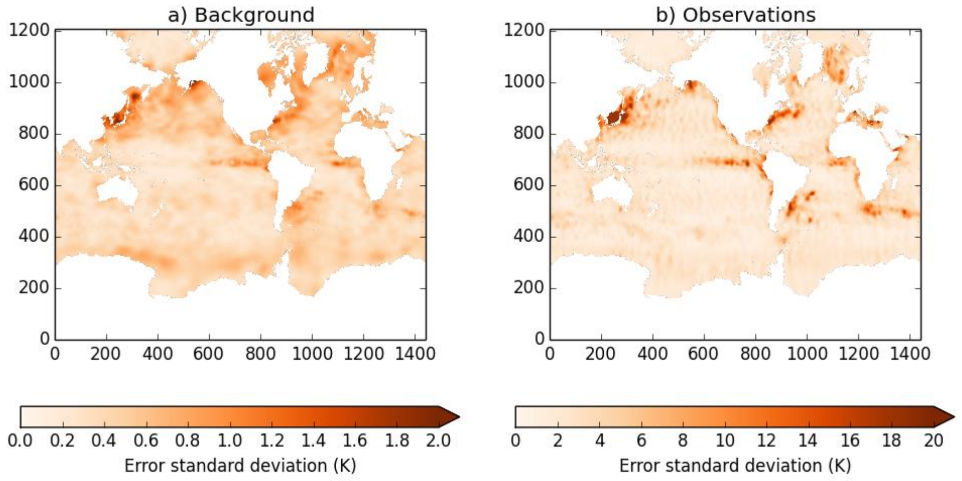
Preprocessing

- Preprocessing is applied to the input observations before they are combined into the analysis:

- Subsampling of the data to approximately the resolution of the final OSTIA grid (1/20 degree)
- Removal of SSES (single sensor error statistic) bias provided with satellite data
- Quality control of the data
- Removal of observations affected by diurnal warming (foundation analysis only)

Foundation SST - bias correction



- A reference SST sensor and in situ observations are used to correct other satellite data
- Currently VIIRS nighttime data are used as the reference sensor
  - This was changed from MetOp A AVHRR in November 2016
- Matchups between the reference dataset and the other sensors are found (25 km and 1 day matchup criteria)
- The differences are analysed on a ~1/4 degree grid with 7 degree background error covariance lengthscale
- Bias correction has a clear impact on the quality of the analyses

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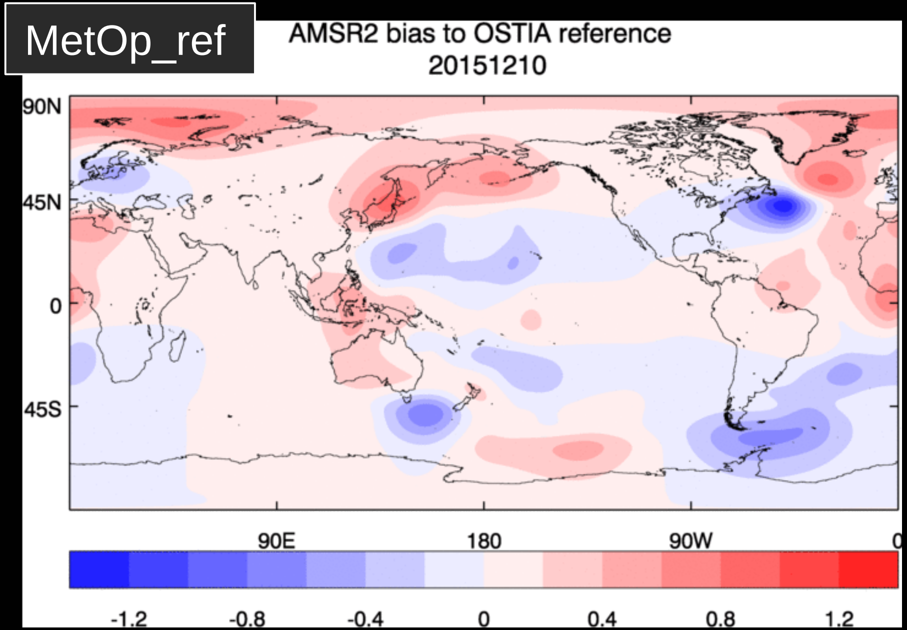
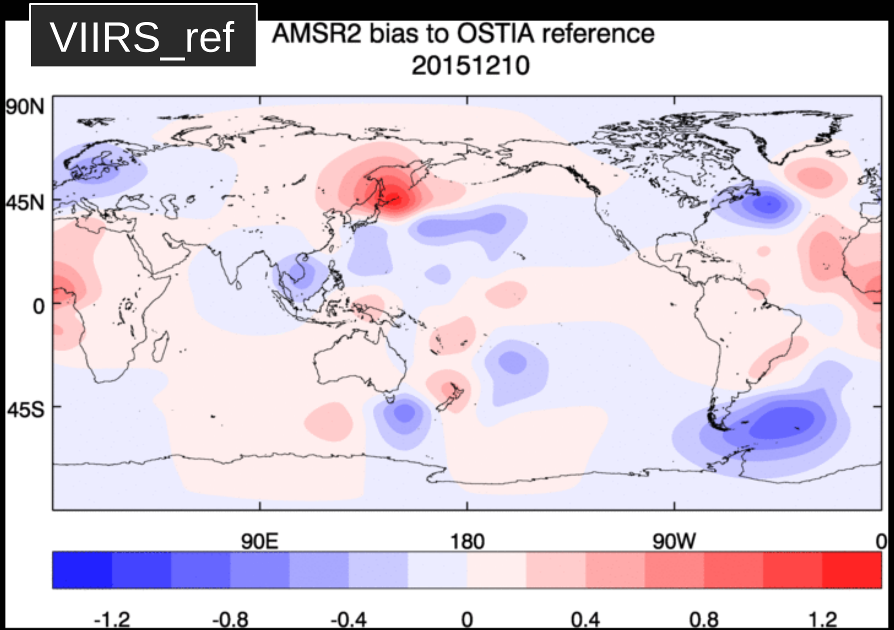
Bias correction

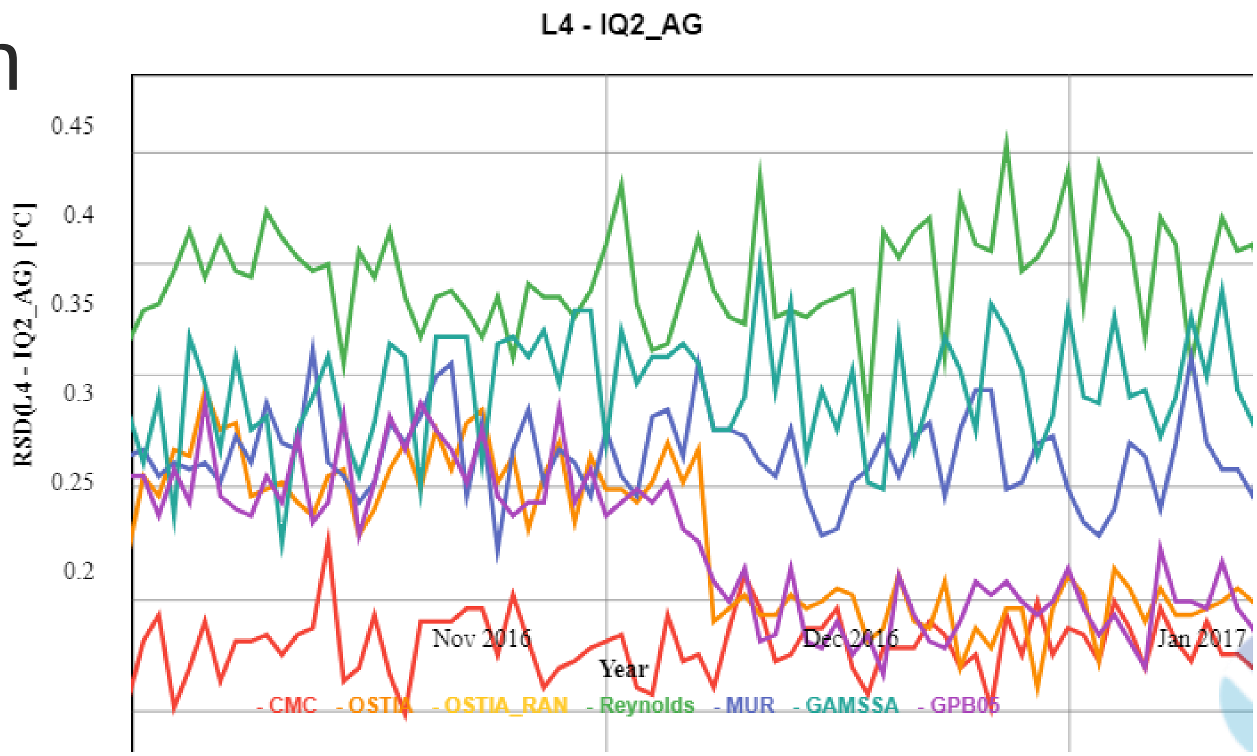
- Comparison of the daily bias fields for AMSR2 when MetOp A AVHRR was used as a reference compared to VIIRS
- Animations by Emma Fiedler





Bias correction

- Impact on Argo matchups
- From NOAA's SST quality monitor (SQuAM)
- https://www.star.nesdis.noaa.gov/sod/sst/squam/analysis/l4

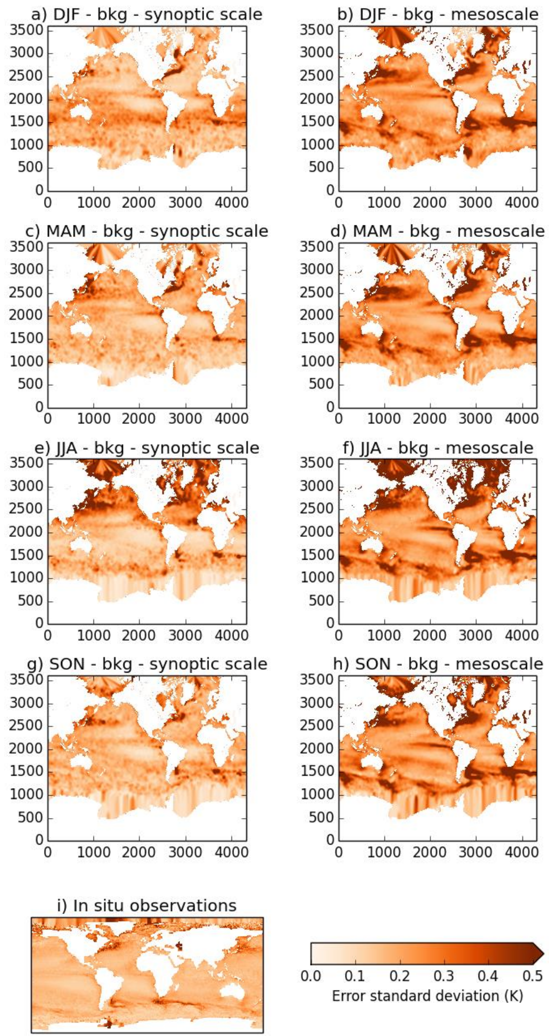


Foundation SST - analysis

- Performed using NEMOVAR
- Background is damped anomaly persistence forecast
- Satellite observation error variances from SSES provided with the data, in situ observation error variances are predefined
  - GHRSST group being spun up to understand better the utility and requirements for SSES
- Background error covariances are based on work by Jonah Roberts-Jones (2016), Remote Sensing of Environment, 176, 117-138, doi:10.1016/j.rse.2015.12.006, under ESA SST CCI
- Parameterised into two components with their own error variances and lengthscales
- Work done to improve the representation of features by adjusting the shorter lengthscale and adaptively varying the ratio of the two components

Error standard deviation fields

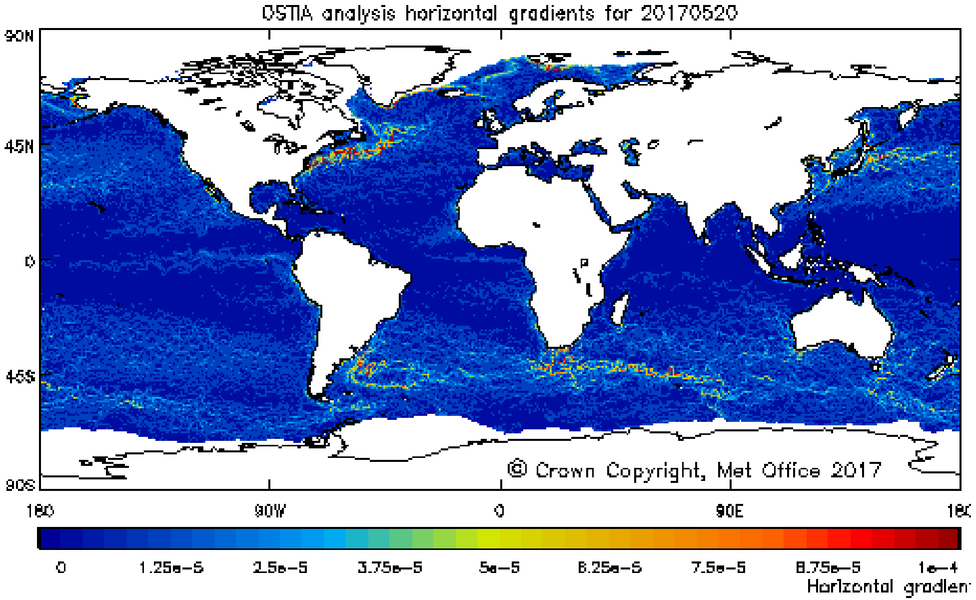
- Monthly background error standard deviations
- Each decomposed into two components
- Length scales are ~300 km and 40 km (near real time) / 15 km (climate)
- Single field for in situ observation standard deviation



Flow dependent lengthscales

From slides by Chongyuan Mao and Emma Fiedler

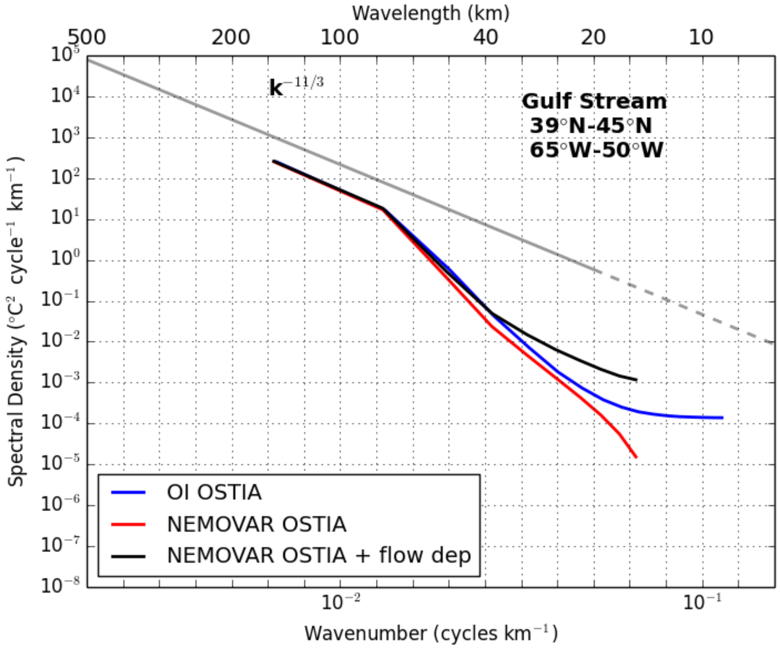
- A flow-dependent component determining the length scale ratio has been developed under the ESA SST CCI project. The total horizontal gradient of the background SST field is used to identify highly variable regions, where the effective length scale should be shortened to improve the resolution of SST features.
- The flow-dependence method linearly reduces the ratio of the two length scales where SST gradients are between 20 and 50 mK/km, and sets the shortest length scale (40 km or 15 km) above 50 mK/km.



Impact of flow dependence

From slides by Chongyuan Mao and Emma Fiedler

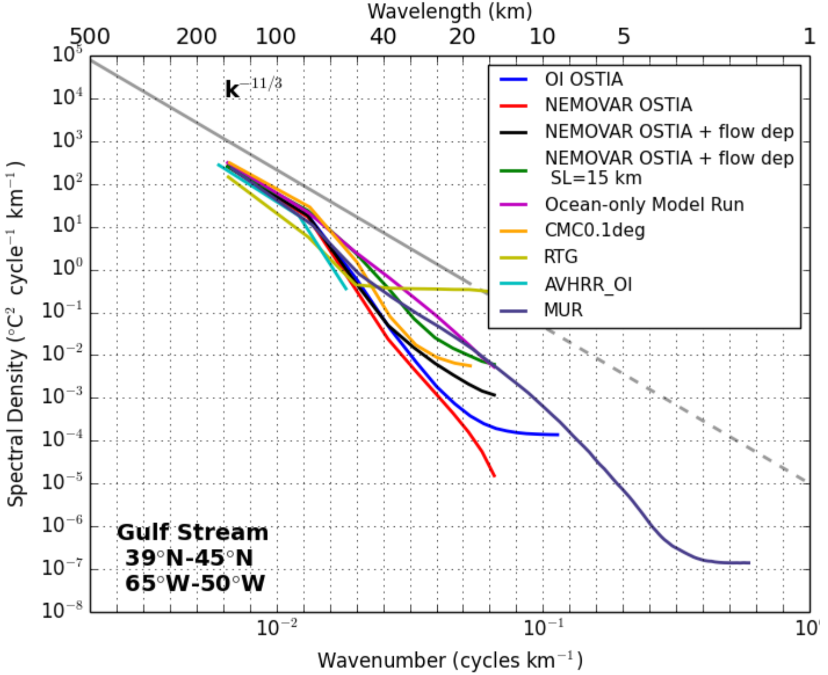
- All three OSTIA runs follow the $k^{-11/3}$ power law between ~150 – 75 km
- NEMOVAR OSTIA falls off faster than the other two runs
- OI OSTIA and NEMOVAR + Flow Dependent OSTIA separate at ~40 km (the short length scale in NEMOVAR OSTIA) and NEMOVAR version maintains higher power at lower wavelengths
- The power law for shorter scales is still under debate, especially those below the Rossby radius, which is ~20 km for this latitude[1]
- [1] Chelton et al., 1998: Geographical variability of the first-baroclinic Rossby radius of deformation, JPO, 28, 433-460



Adjusting the short lengthscale

From slides by Chongyuan Mao and Emma Fiedler

- For near real time system the shorter covariance lengthscale is set to ~40 km
- Tuning the lengthscale to ~15 km gives better results in spectral analysis and against Argo
- But, does not perform as well in NWP trials
- 15 km used for climate reprocessing but not in the near real time system



Adjusting the short lengthscale

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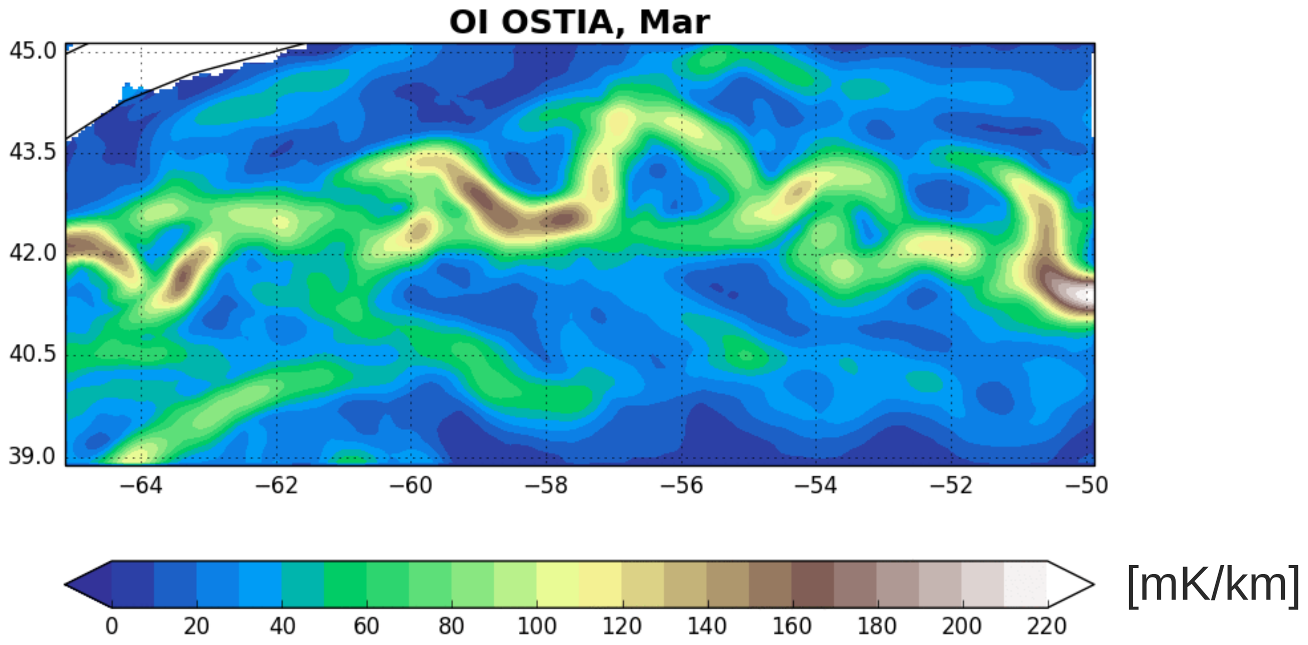

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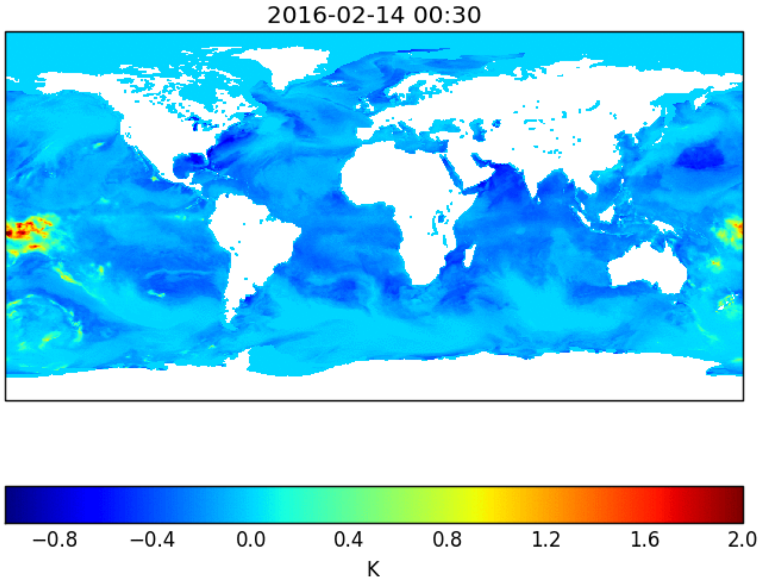
Diurnal OSTIA

For full details see J. While et al. (2017), An operational analysis system for the global diurnal cycle of sea surface temperature: implementation and validation. Q.J.R. Meteorol. Soc., 143: 1787–1803. doi:10.1002/qj.3036



Overview

- Hourly average near real time product skin SST product
- Takaya (2010) and Artale (2002) models used for the warm layer and the cool skin layer
- Uses geostationary and AVHRR polar orbiting observational data
- Assimilation into the warm layer model using NEMOVAR
- Products are available from CMEMS
- On a ¼ degree grid and include the warm skin and cool skin components in addition to the skin SSTs

Diurnal OSTIA

For full details see J. While et al. (2017), An operational analysis system for the global diurnal cycle of sea surface temperature: implementation and validation. Q.J.R. Meteorol. Soc., 143: 1787–1803. doi:10.1002/qj.3036

Observation processing

- Currently SEVIRI, GOES-W and NOAA-AVHRR
- Need to make estimates of the diurnal change for assimilation into the model
- A foundation SST analysis is performed for each sensor (slightly different method to OSTIA)
- Then, difference between SSTs and the foundation SST gives an estimate of the diurnal signal

Assimilation

- Uses a 4D VAR method (strictly speaking 2 spatial dimensions and time)
- Adjusts the heat and wind forcing and initial temperature difference
- To obtain the skin SSTs, the final warm and cool skin fields are combined with the OSTIA foundation analysis

Future outlook for SST processing

- Continue to review and improve the selection of sensors that we use for OSTIA and foundation analyses
  - Add in more geostationary sensors
  - Use SLSTR (in the long term as reference sensor)
- Continue to explore use improvements to representation of features, including in lakes and coastal regions
- Impact of correlations in observations errors and improving the analysis system to cope with them
- Representing observation footprints in the NEMOVAR system
- Coming soon:
  - New SST CCI analyses
  - With short delayed mode extension under C3S
  - New reprocessing for users who want a close equivalent to the near real time product from CMEMS

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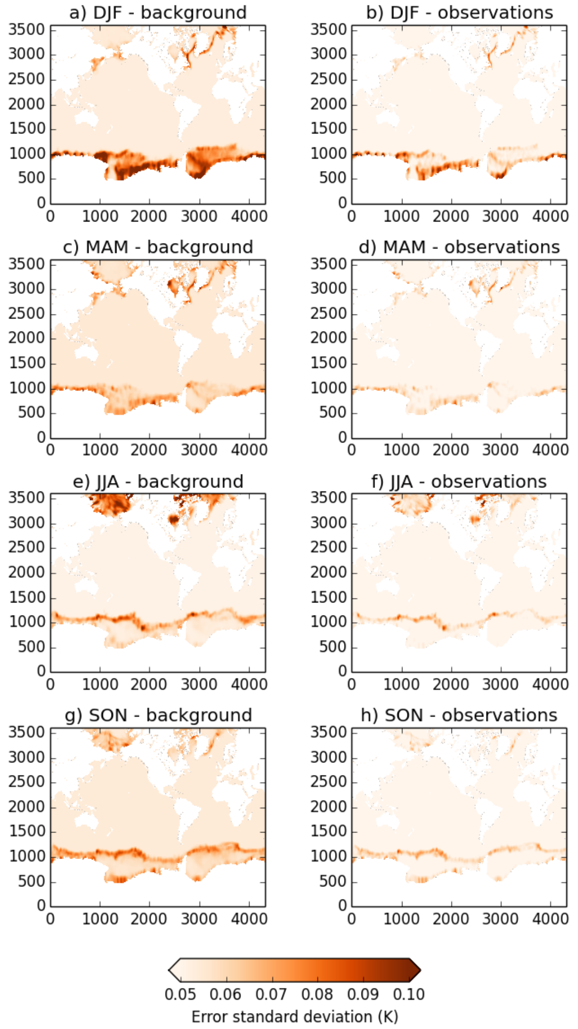
Sea ice in OSTIA

- Input observations are currently only sea ice concentrations from SSMIS produced by OSI SAF (plus NCEP for lakes)
- Currently transitioning from a regridding approach to an assimilation approach
- Background is previous day's analysis
- More robust to occasional missing observations
- Difficulties where observations are persistently missing
- Important to get right – can give large errors in NWP outputs



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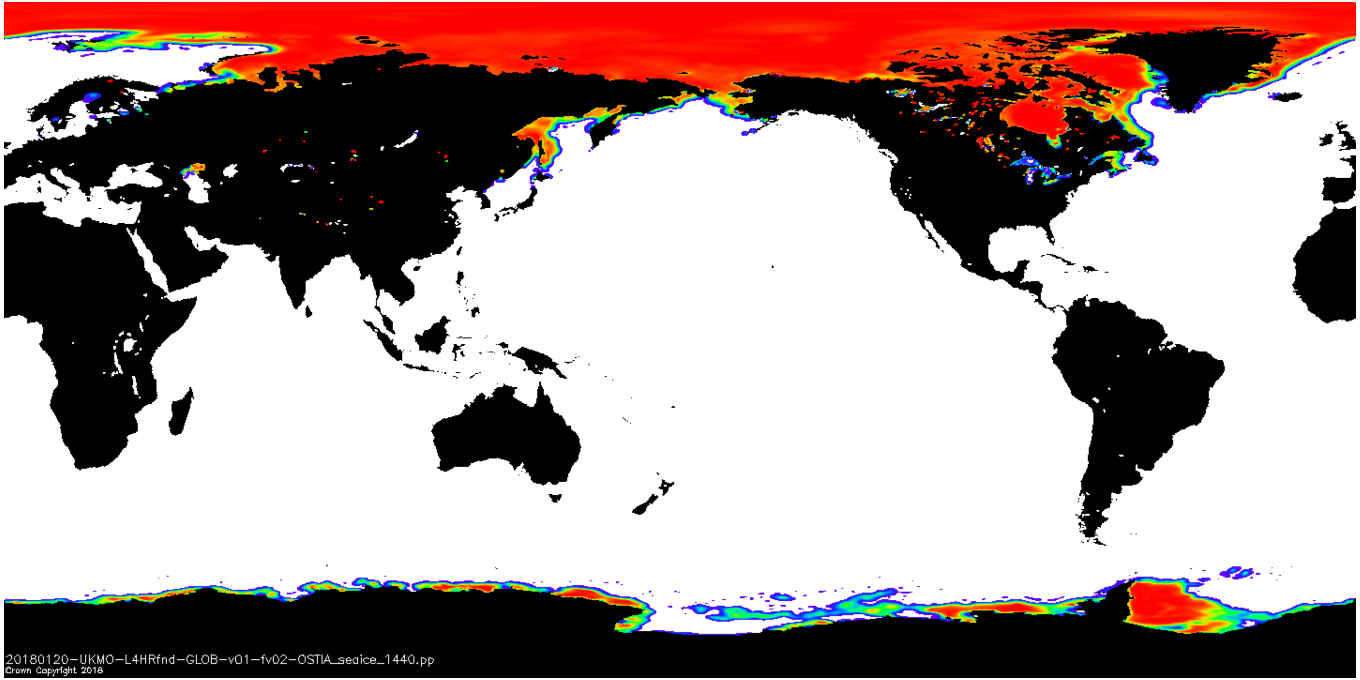
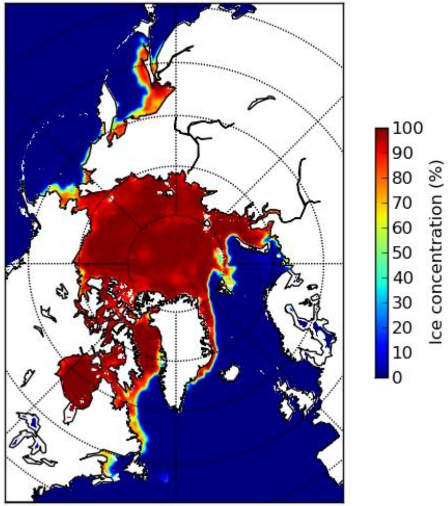
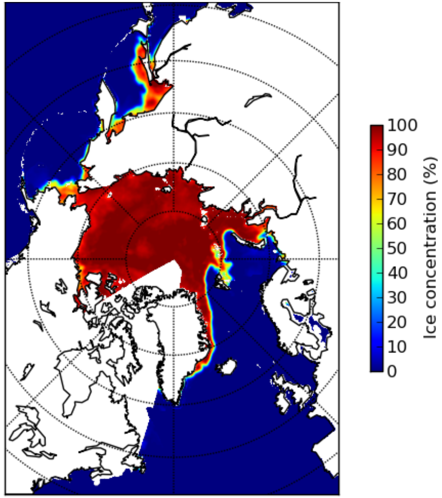
http://osisaf.met.no/p/ice/index.html

Example from the last few days



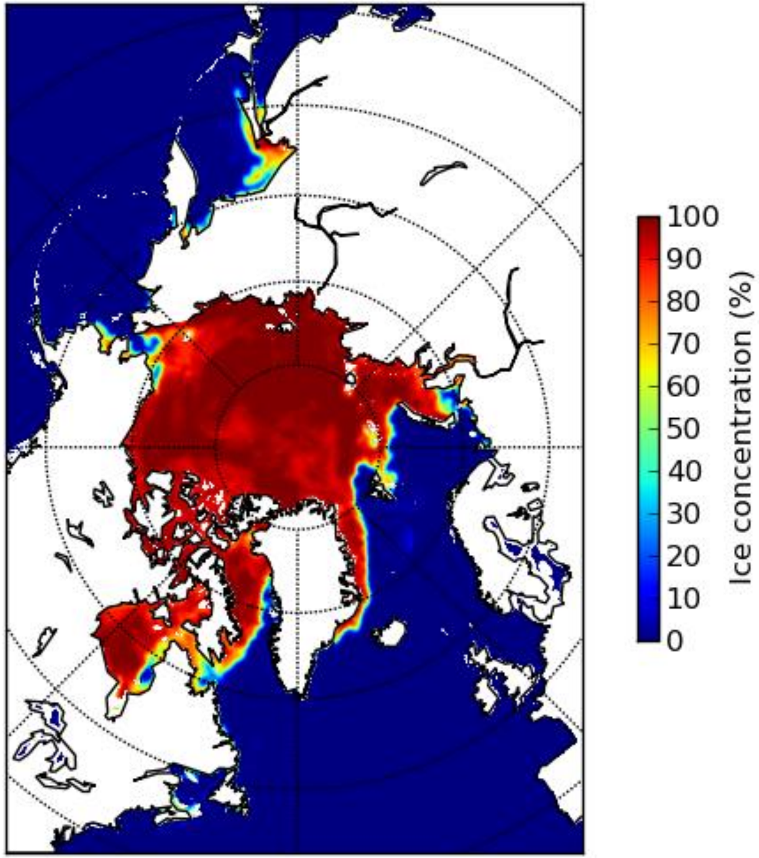




Near real time input data coverage limitations

- Have developed an infilling approach to spread concentrations from observed to non-observed regions

- Different approach in the Baltic



http://osisaf.met.no/p/ice/index.html

Use of SST and sea ice together

- Use SST to stop warm temperature observations spreading under ice
- SST under ice relaxed to -1.8 degrees in absence of observations
- Lake ice added where the surface temperature is below freezing
- Lake ice approach has been adapted for the Baltic Sea area

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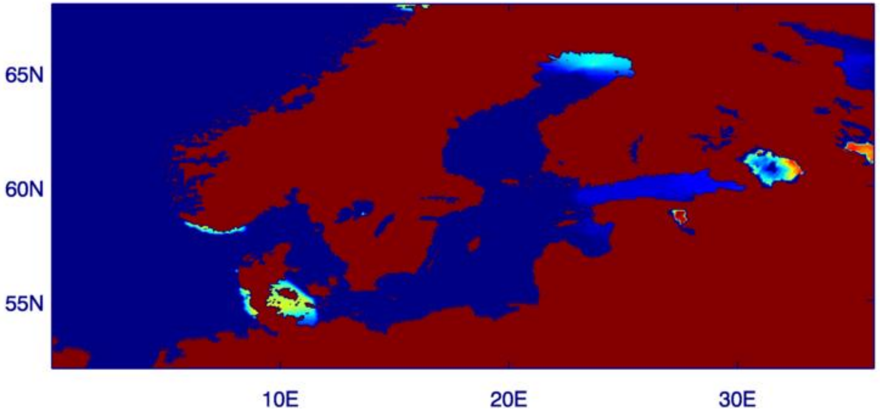
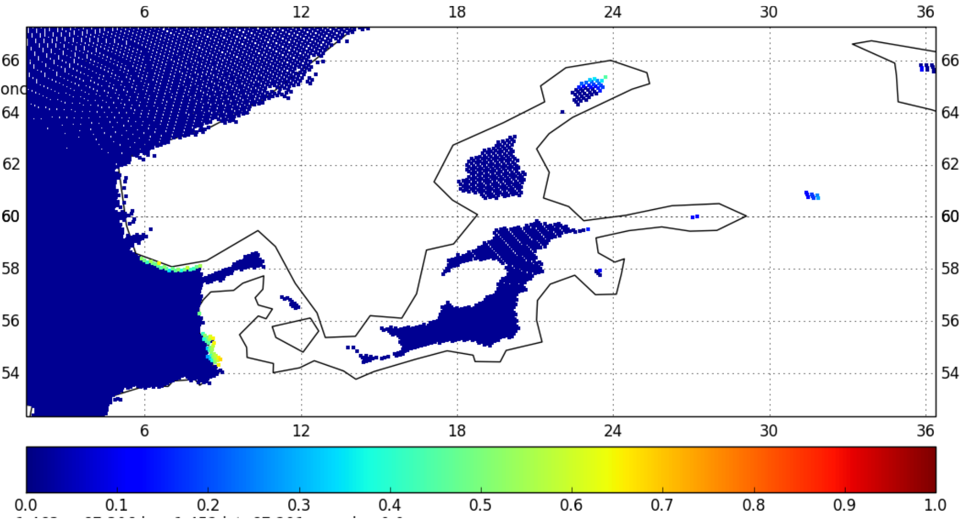
Baltic area development

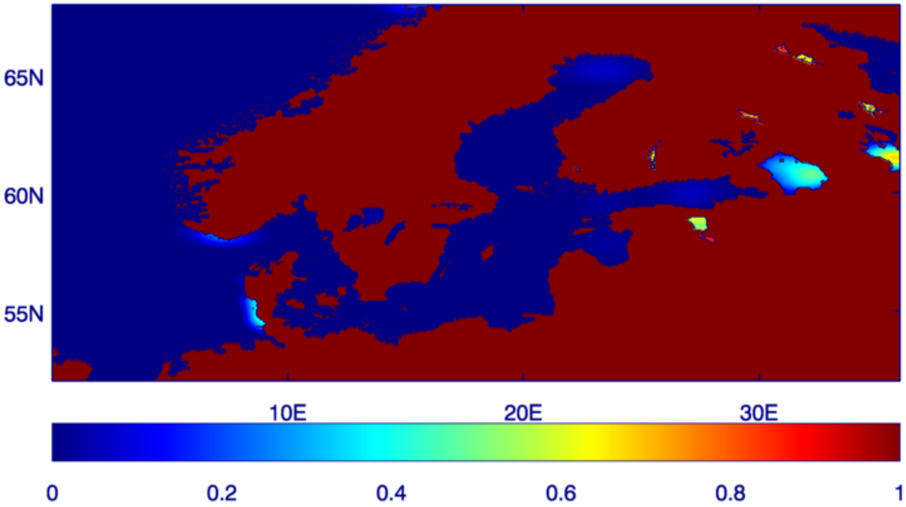
- Slides by Emma Fiedler



OSI SAF ice observations in Baltic 20170201



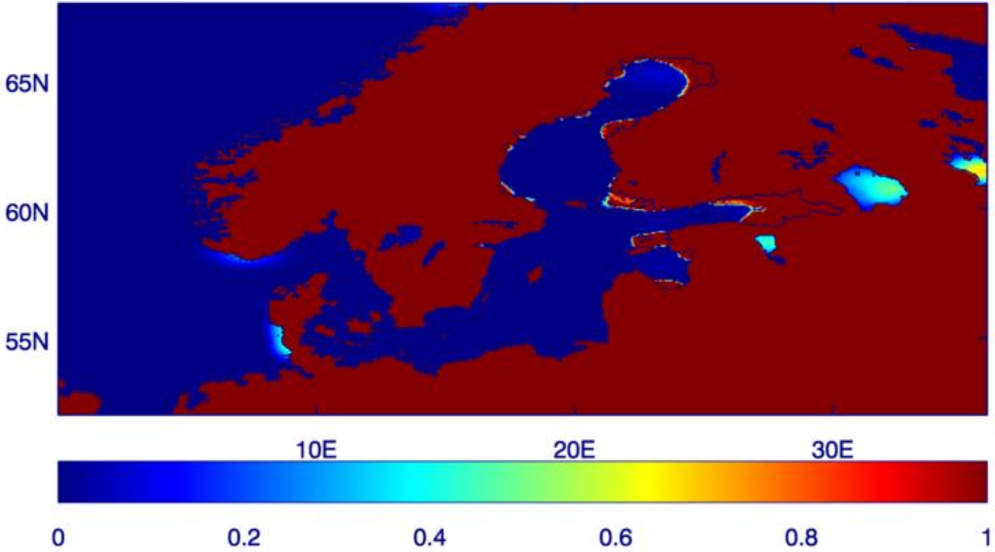
Old (above) and new (below) ice in Baltic 20170201

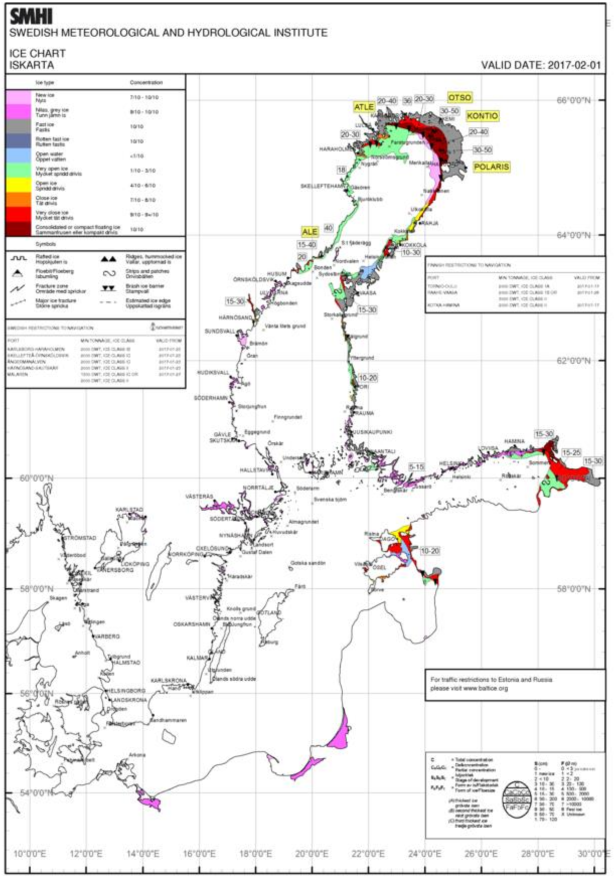


Ice chart for Baltic 20170201 (from Swedish Meteorological and Hydrological Institute)

Baltic area development

OSTDEMO ice in Baltic with SST correction 20170201





Future outlook for sea ice concentrations in OSTIA

- Working on improving Baltic Sea ice concentrations
- We are keen to broaden our range of input data to make the analysis more robust
  - As done for SST
  - First priority is to use AMSR2 concentrations from OSI SAF in addition to SSMIS data
  - In longer term could consider other data source e.g. netCDF format sea ice chart data
- Are attempting to use uncertainty from input files rather than prescribed values
- Potential to tune background error covariance lengthscales to e.g. improve lake ice

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Where to get data and help

- Users of the near real time data and its reprocessed counterpart, go to the CMEMS website below to download data and to get help:
  - http://marine.copernicus.eu

- Climate data are available from the CCI open data portal (also from CMEMS):
  - http://dx.doi.org/10.5285/2262690A-B588-4704-B459-39E05527B59A
  - http://cci.esa.int/data

- See poster about production of SST data as part of the C3S