The EUMETSAT Network of Satellite Application Facilities

OSI SAF
Ocean and Sea Ice

EarthTemp NETWORK

SST changes in the Arctic
(5 years of METOP-A/AVHRR results)

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METEO FRANCE
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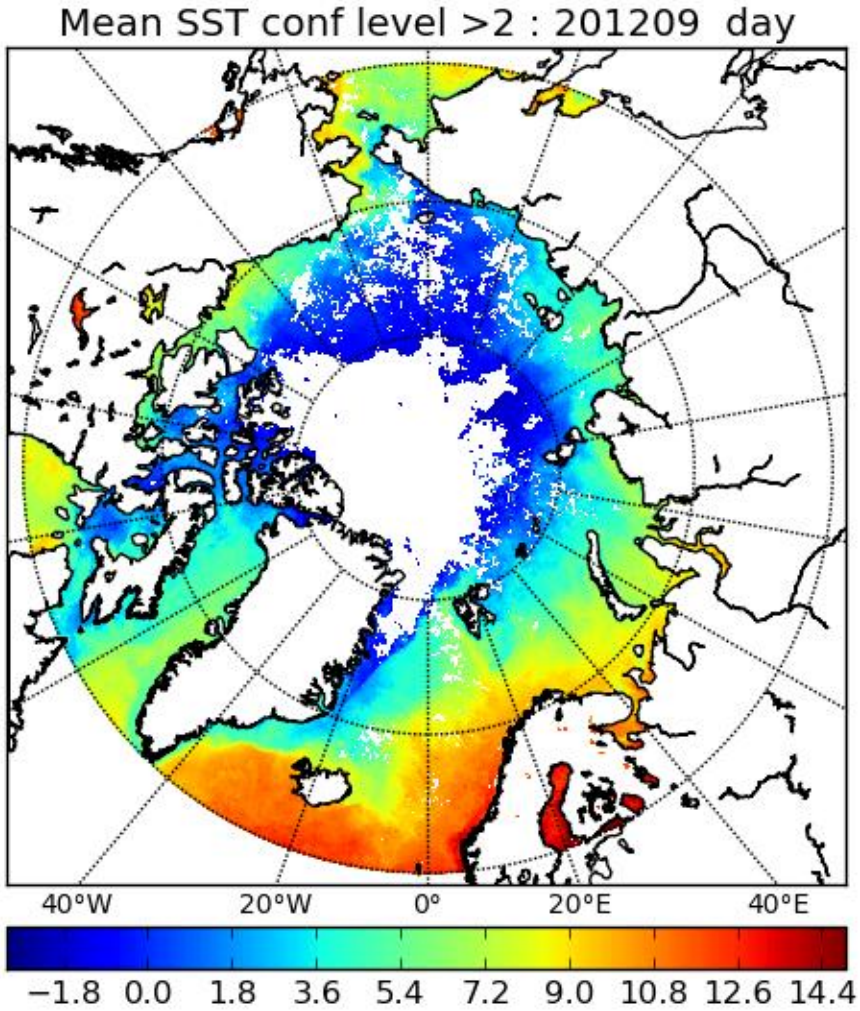
Introduction

Mean METOP-A/AVHRR derived daytime SST in September 2012

METOP-A/AVHRR:
1km resolution SST
Global coverage
Processed by OSI-SAF
At CMS since 2007



SST from IR data?
-Ice
-Cloud
-Dry & cold atmospheres
-Illumination conditions

Introduction

1) **How reliable are satellite borne IR radiometer derived SSTs?**

- Understanding errors through the METOP-A/AVHRR (daytime) example
- Solutions?

Previous works:

- Poulter & Eastwood, 2008 http://www.osi-saf.org
- Hoyer et al , 2012, *RSE*

2)**What can we observe with such data in the Arctic??**

-Diurnal warming?

-Year to year variability?

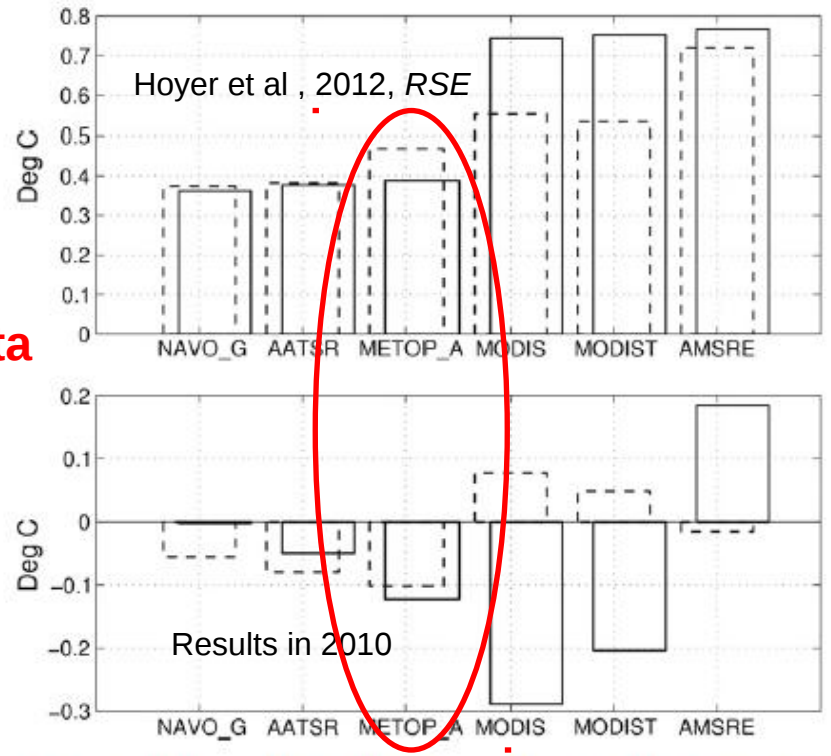


Fig. 4. Error statistics (satellite-in situ) for waters colder (solid) and warmer (dashed) than 5 °C. Upper figure shows standard deviation and lower figure shows bias.

Data : METOP SST processing overview

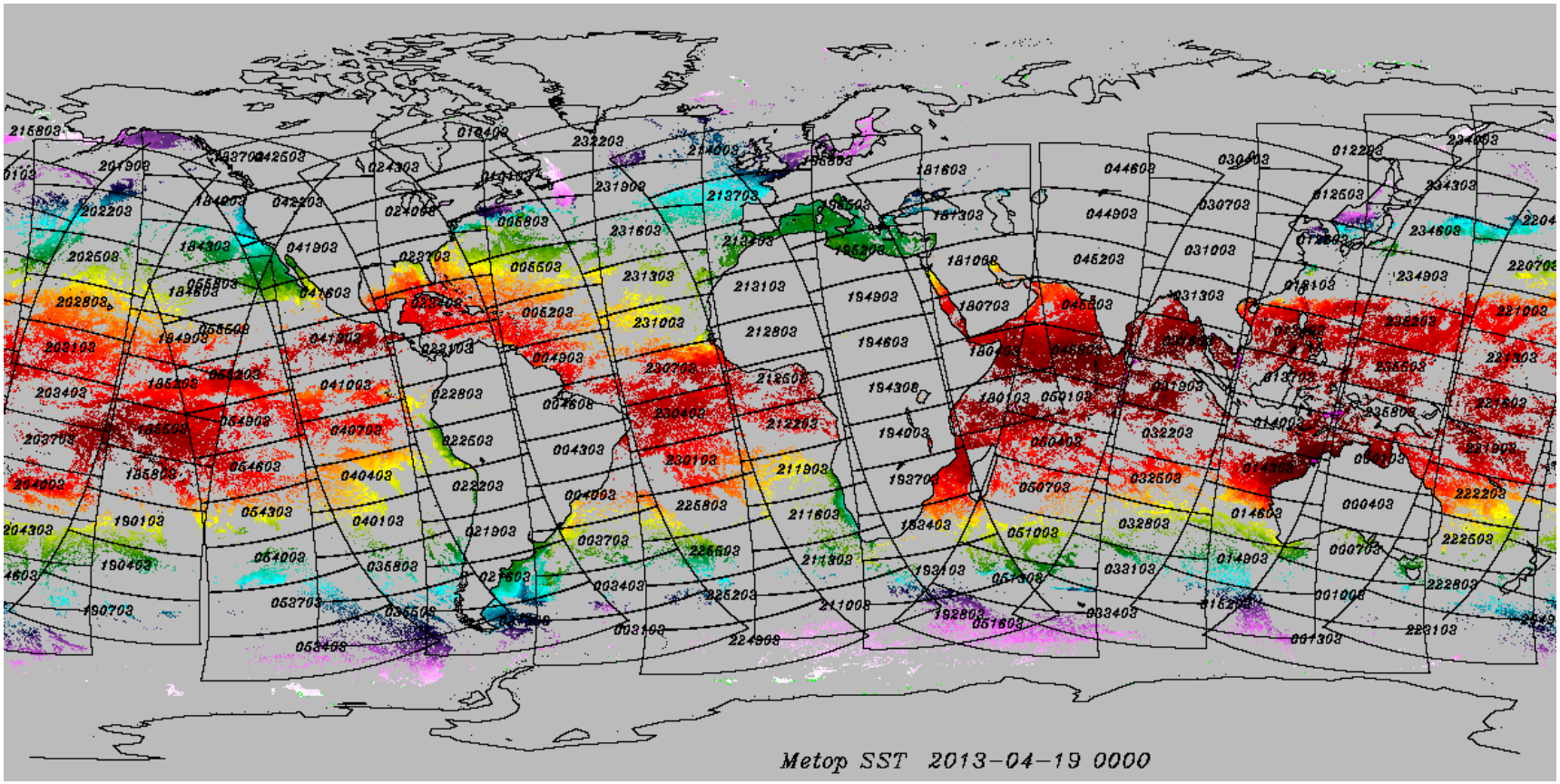
- METOP SST (see http://www.osi-saf.org)
  - Cloud mask (Maia, L. Lavanant, MF/CMS)
  - Ice mask (Ice probability, S. Eastwood, met.no)
  - Cloud/ice control
  - Daytime algorithm

$$SST = a\,T_{11} + (b\,T_{CLI} + c\,S_\theta)(T_{11} - T_{12}) + d\,S_\theta + e$$

  - Nighttime algorithm

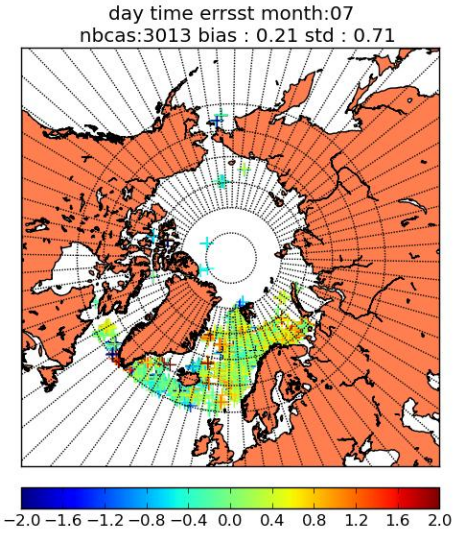
$$SST = (a + b\,S_\theta)\,T_{37} + (c + d\,S_\theta)(T_{11} - T_{12}) + e\,S_\theta + f$$

Data : METOP SST

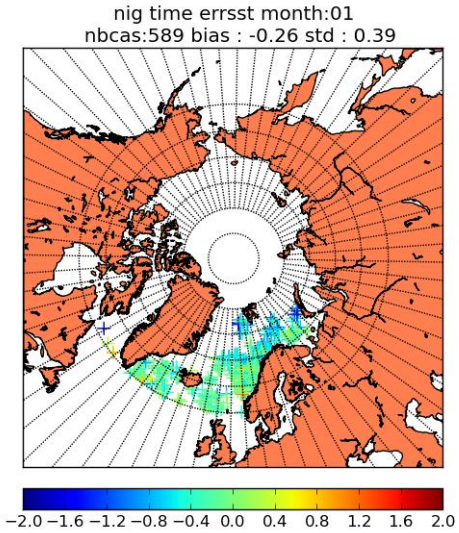


DATA: buoy measurements

- October 2007 till September 2012 (inclusive)
- North of 60N
- Matchups at full resolution; buoy location in central pixel within 3 hrs
- Few data but in « European Arctic »



Daytime July

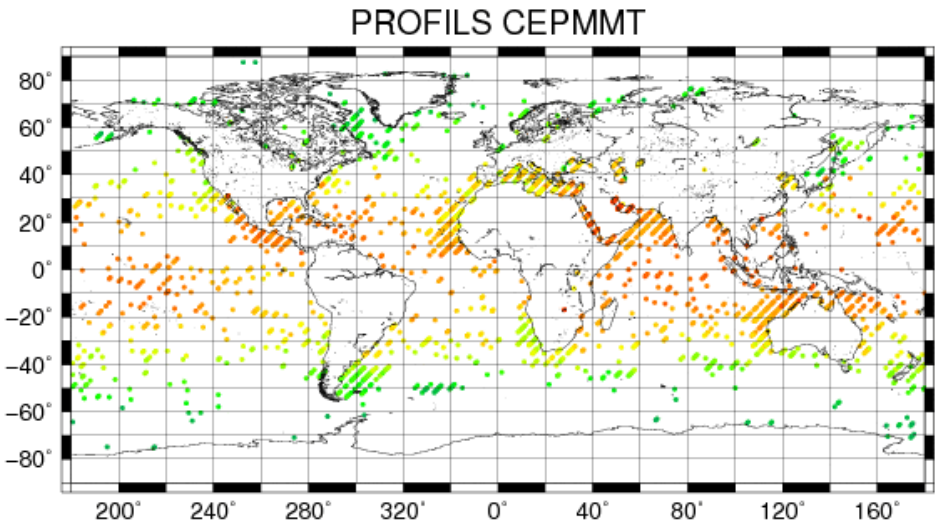


Nighttime January

DATA: ECMWF output derived BT simulations

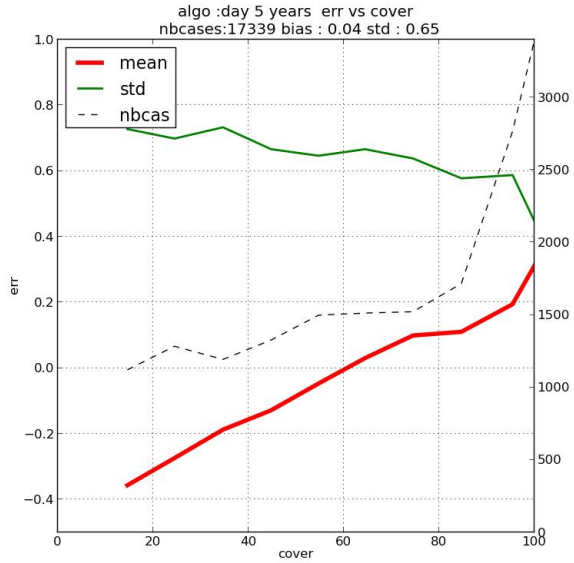
- ECMWF operational forecasts
- RTTOV version 10.2 applied onto each profiles
- BTs at 3.7, 10.8 and 12 µm

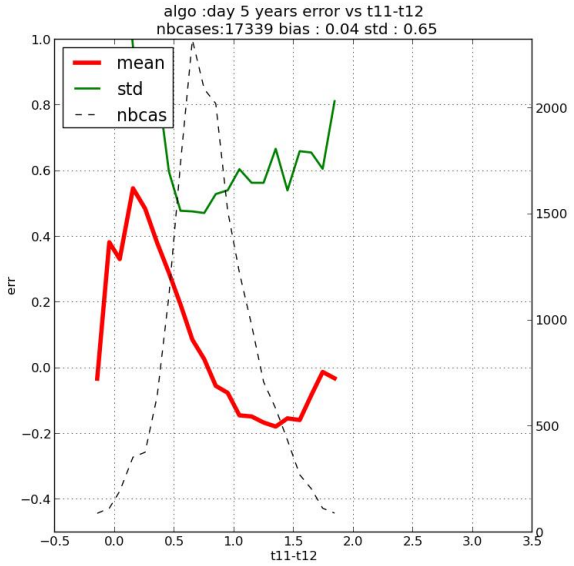
Training dataset

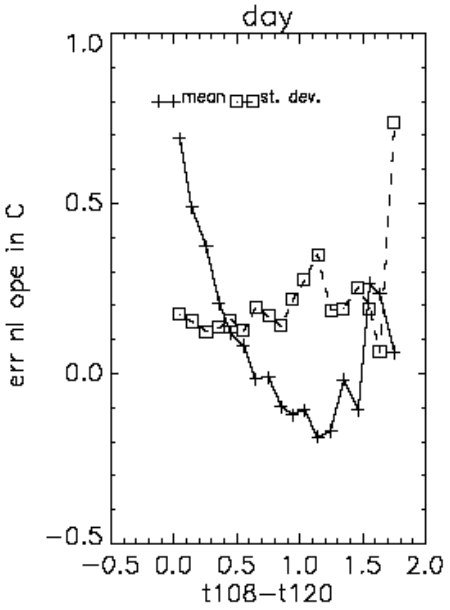


Daytime validation results

	n	δ	σ
QF 3-5	17405	0.05	0.66





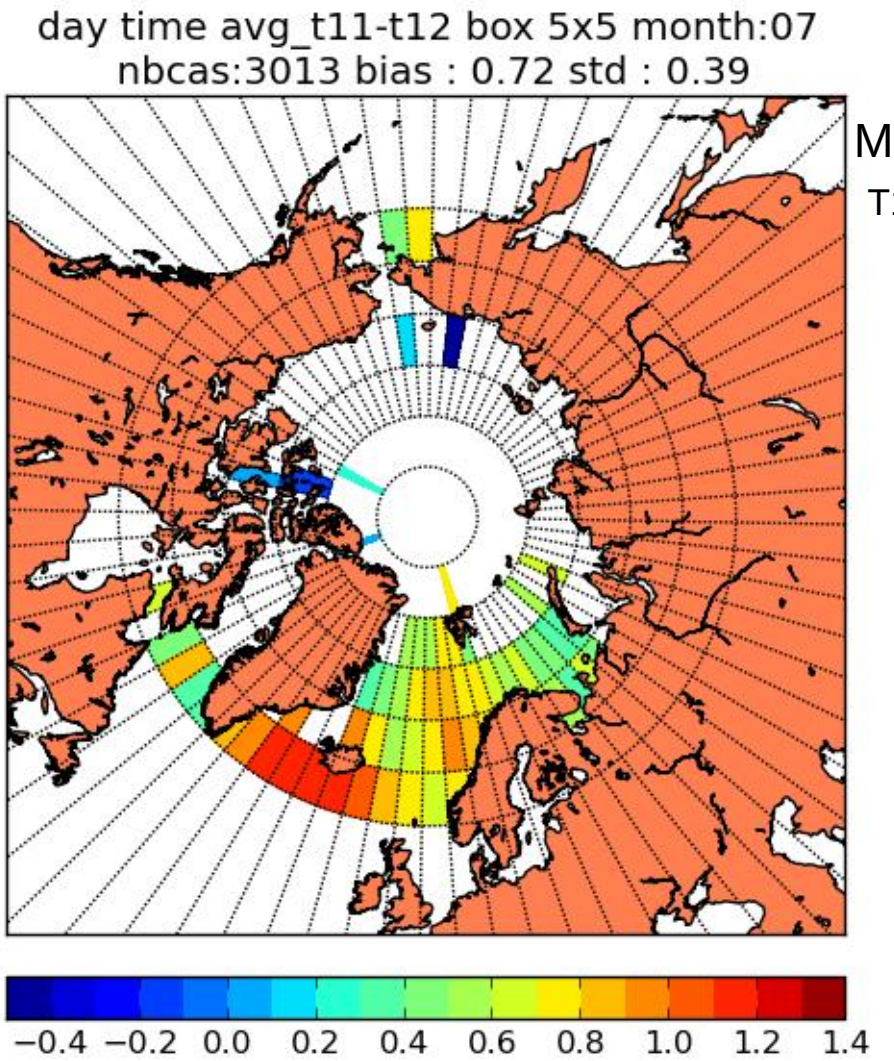


Error vs clear sky coverage:
Clouds induce negative errors
(no evidence of ice related errors)

Error vs T11-T12

Simulated Error vs T11-T12

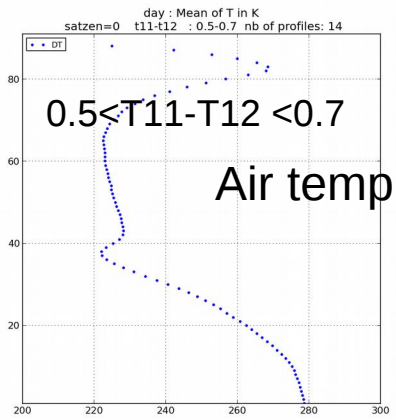
Regional distribution (July)

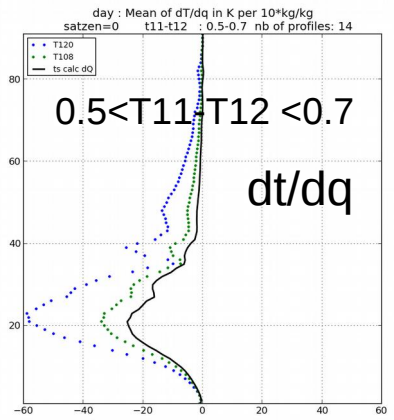


Mean daytime T11-T12 in July

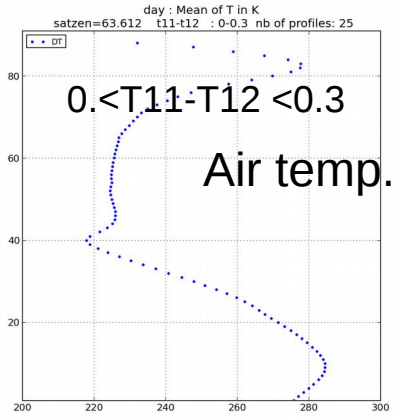
Summertime error origin

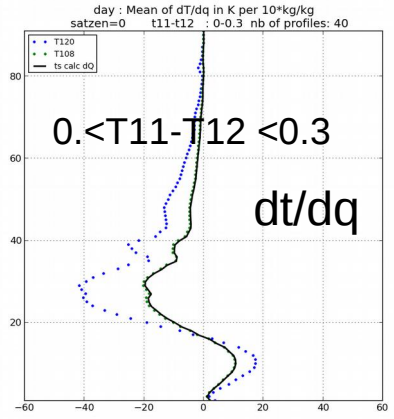
Normal case





Summer Arctic case





(see also LeBorgne et al, EUMETSAT Oslo 2011)

Validation conclusions

- Significant influence of cloud contamination
  - Improved cloud/ice detection effort: met.no
- Errors determined by the shape of atmospheric profiles:

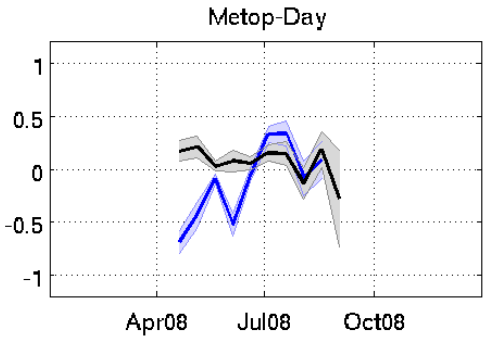
(ex: summer temperature inversion cases lead to large positive errors)

- Errors well reproduced by simulations

Solutions

1) Multisensor Bias corrections (*Hoyer et al, 2013, RSE, in press*)

AATSR and NAVOCEANO GAC data as reference



2) Regional algorithms

$$SST = (a + b\,S_\theta)\,T_{11} + (c + d\,T_{CLI} + e\,S_\theta)\,(T_{11} - T_{12}) + f + g\,S_\theta$$

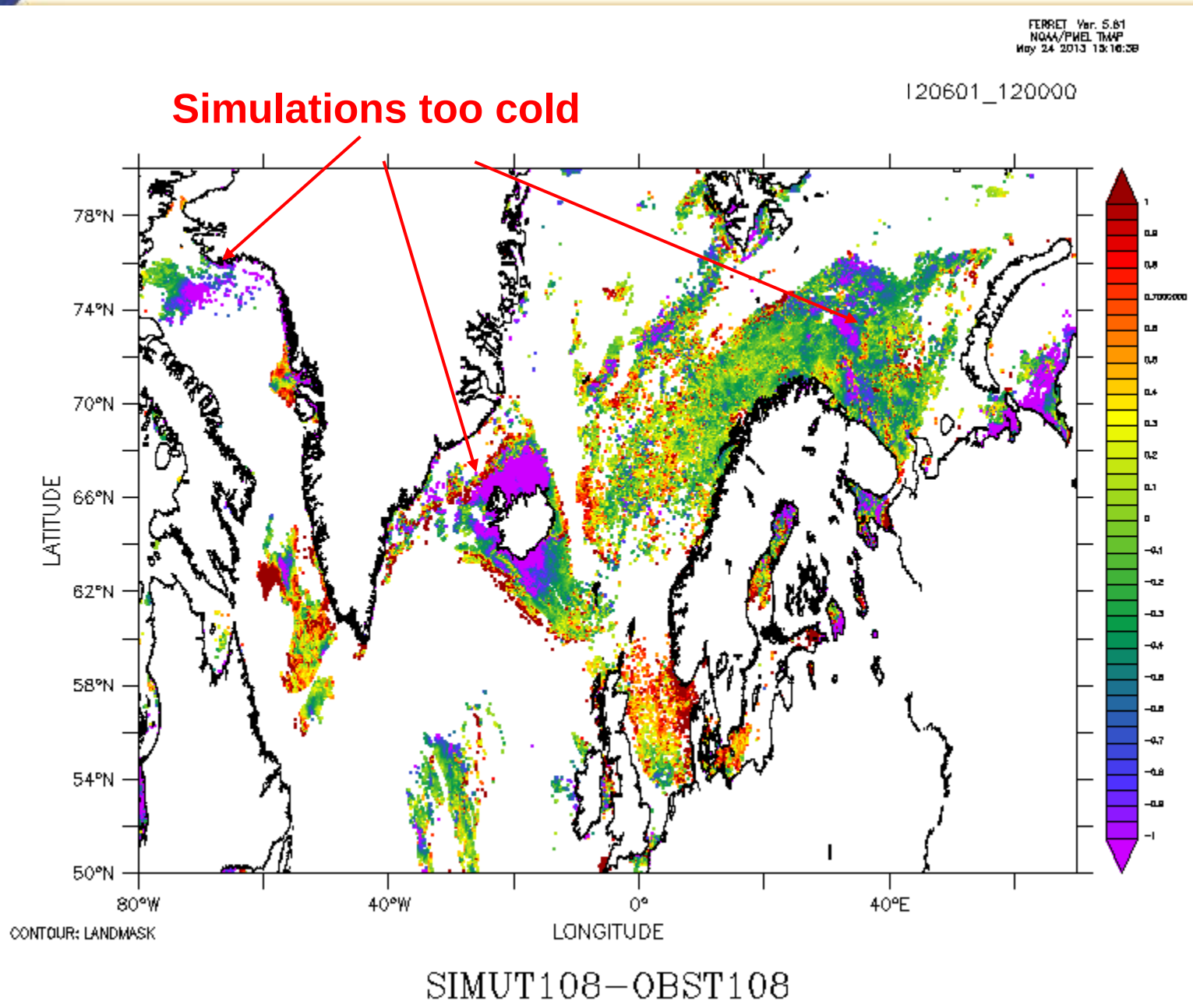
See Hoyer 2012 CCI report

3) **NWP derived correction methods**

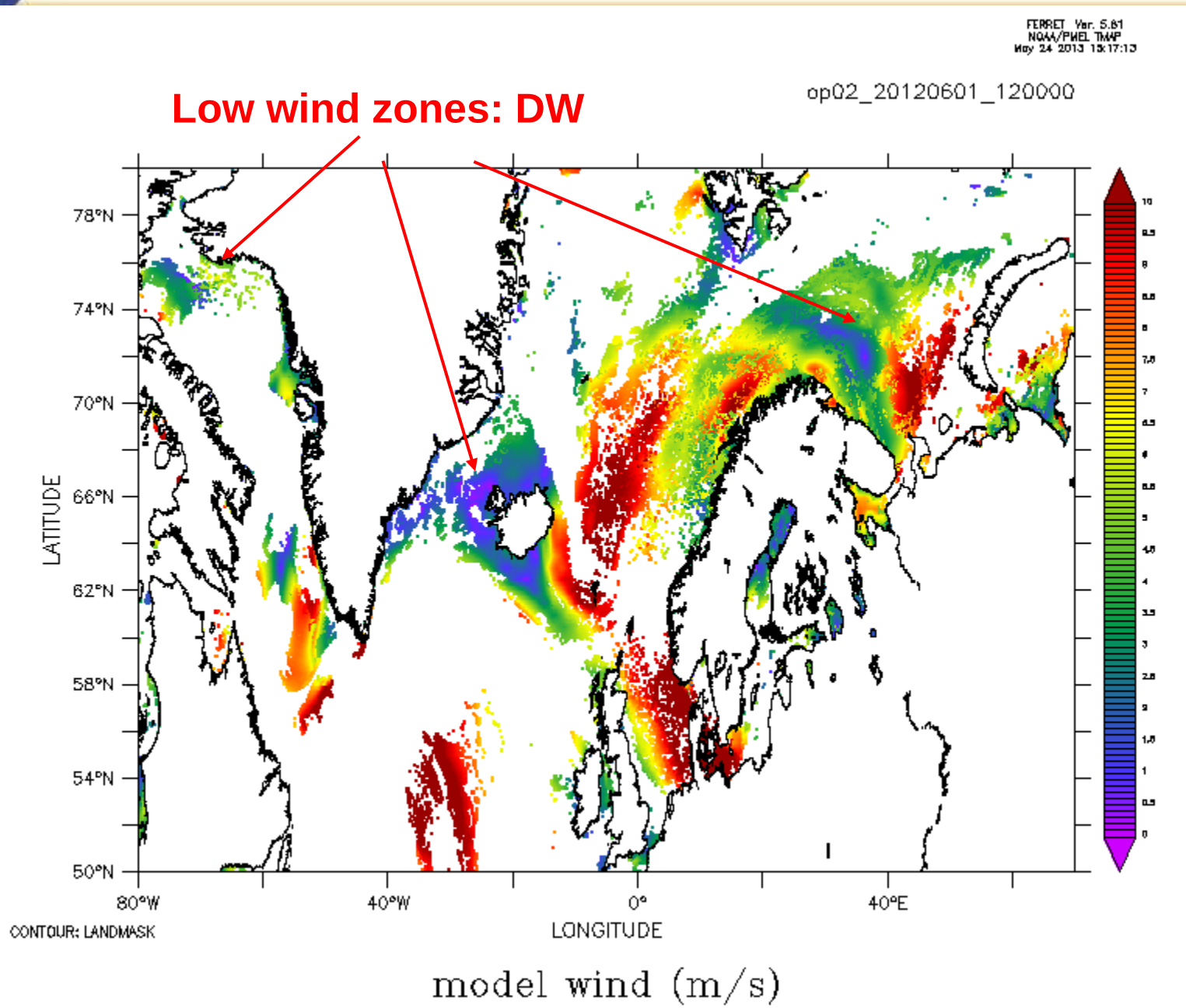
NWP derived methods

- Accounting for actual atmospheric absorption?
- 2 main (BT simulation based) approaches:
  - OE (Merchant et al 2008,2009,2013)
  - Bias correction (LeBorgne et al, 2011, Petrenko et al, 2011)
- SST= guess + Σ ai ($obsBT_i$-$simBT_i$)
- Simulations must be « exact »: they should produce the same BTs as would be observed, given a surface temperature and atmospheric profiles:

A BT simulation adjustment step is necessary


Simulations too cold
FERRET Ver. 5.81
NOAA/PMEL TMAP
120601_120000
78°N
74°N
70°N
66°N
62°N
58°N
54°N
50°N
LATITUDE
80°W
40°W
0°
40°E
LONGITUDE
CONTOUR: LANDMASK
SIMUT108−OBST108

Ear


FERRET Ver. 5.81
NOAA/PMEL TMAP
May 24 2013 13:17:13
op02_20120601_120000
Low wind zones: DW
78°N
74°N
70°N
66°N
62°N
58°N
54°N
50°N
LATITUDE
80°W
40°W
0°
40°E
LONGITUDE
CONTOUR: LANDMASK
model wind (m/s)

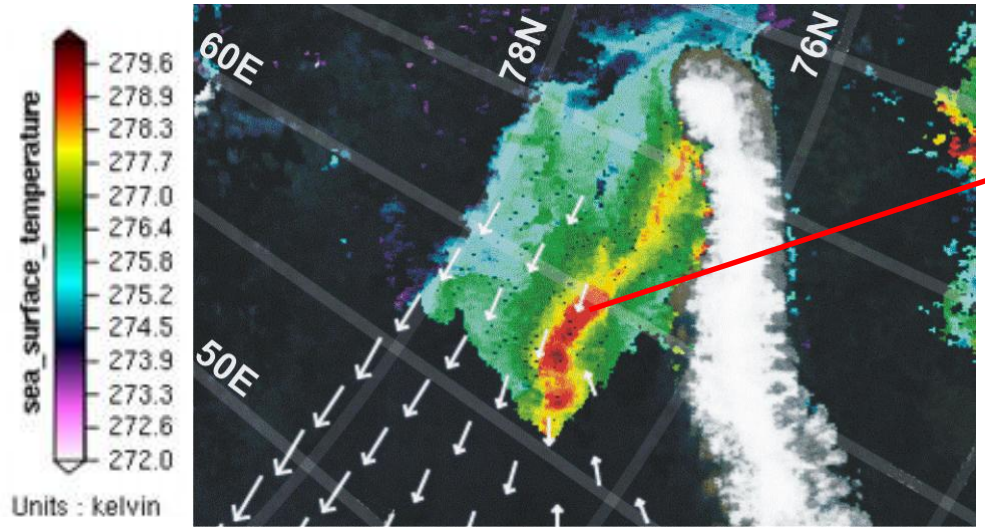
Ear

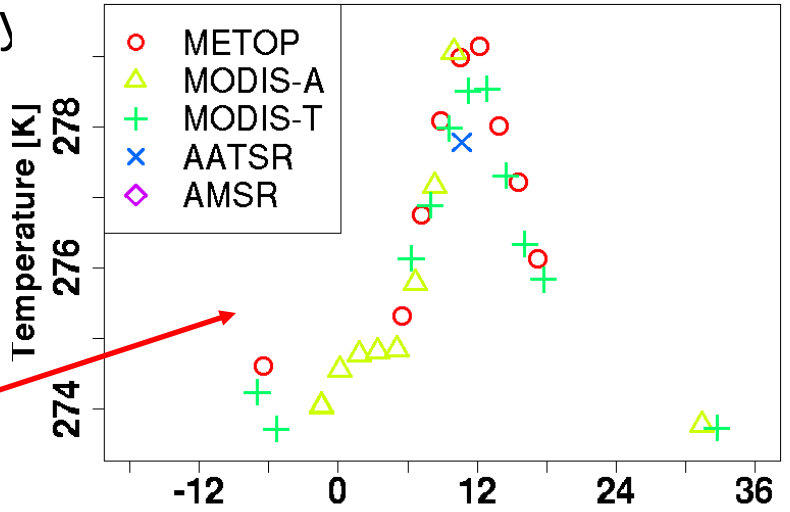
NWP derived methods in Arctic

- Simulations are reliable and OE or bias correction methods are promising
- Main issue: adjusting BTs ?
- OSTIA (foundation SST) based simulations are underestimated in case of DW
- Simulation adjustment must be revised in permanent daytime conditions! (ongoing)

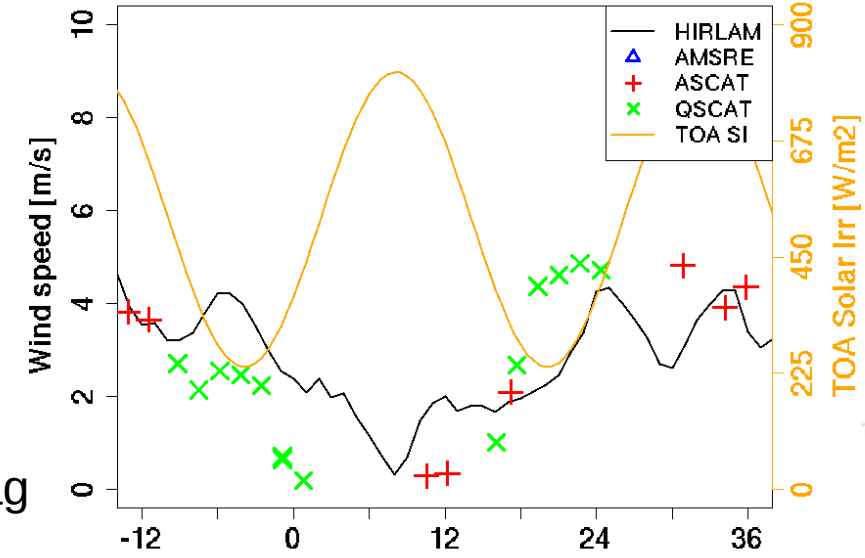
DW in the Arctic?

Case study of Arctic warm spots off Novaya Zemlya on the 2nd of July 2008
(Eastwood et al, 2011)





Middle point located at 76.8N, 59.2E



Metop/AVHRR SST and ASCAT wind at 12:11 UTC.

Earthtemp workshop 12-14 June, Copenhag

Diurnal warming from buoys measurements

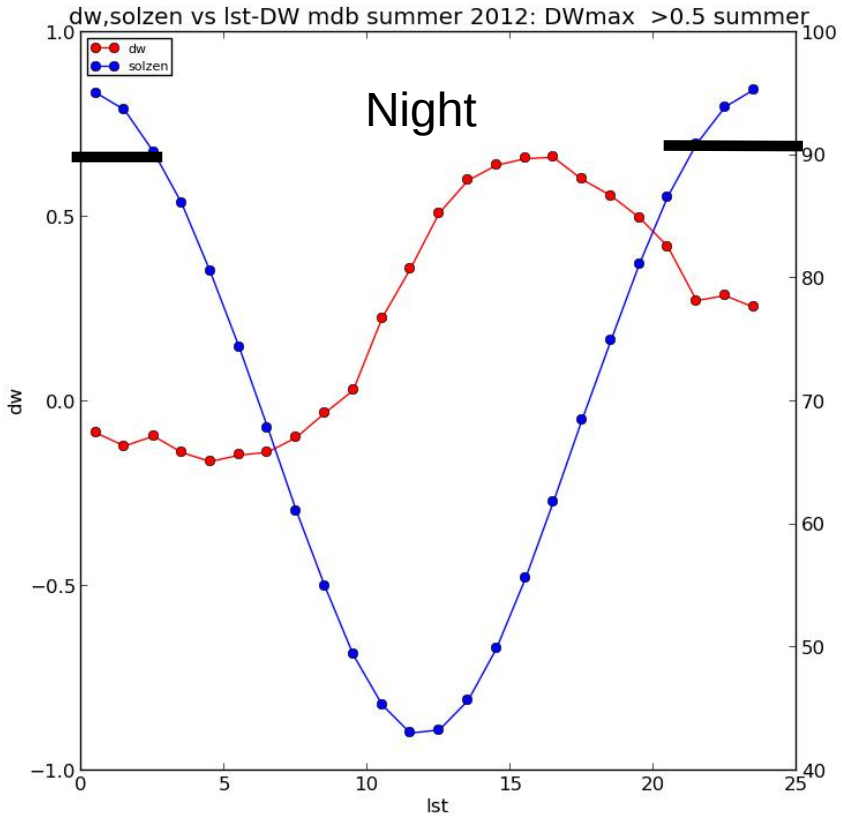
Buoy derived DW (daily max >0.5)

Same method as that
used for SEVIRI
(Le Borgne et al, RSE, 2011)

Latitudes > 60N, summer 2012

« Foundation » SST:
mean SST for LST < 10
Or LST> 20

DW=SST-Found. if wind below 8ms-1
Data from the CMS DW dedicated MDB



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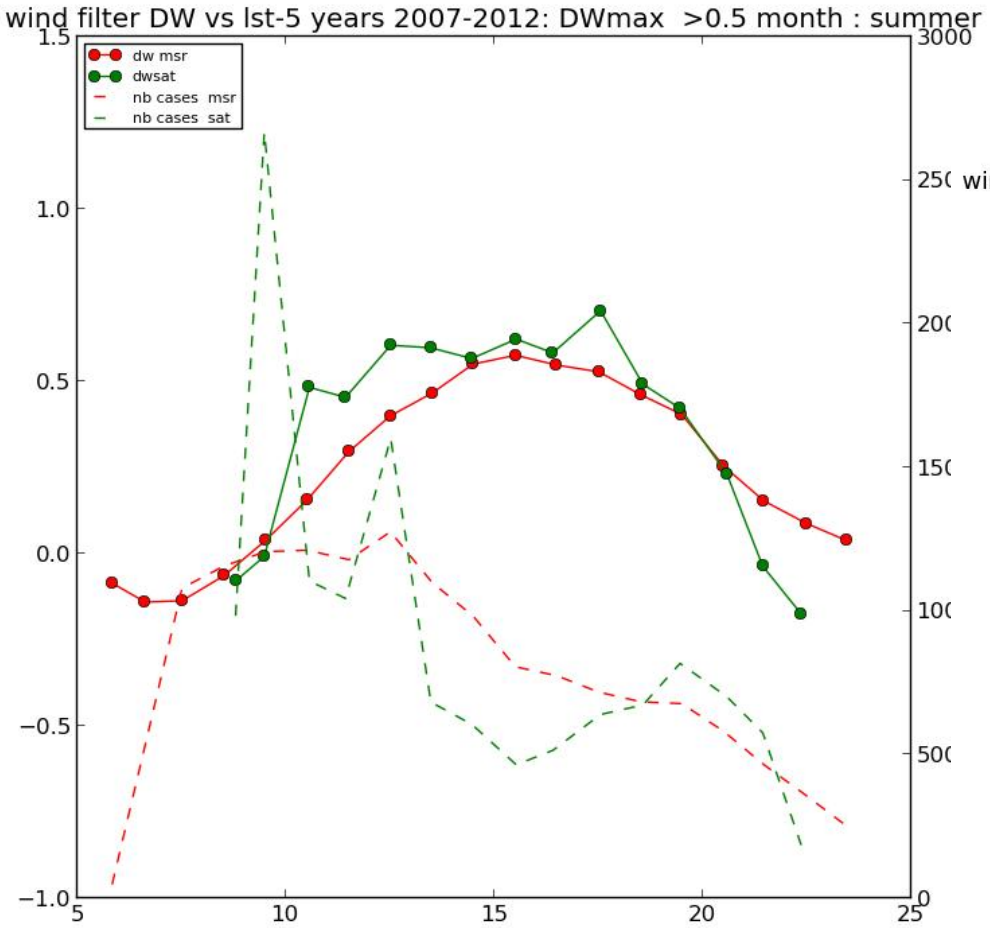
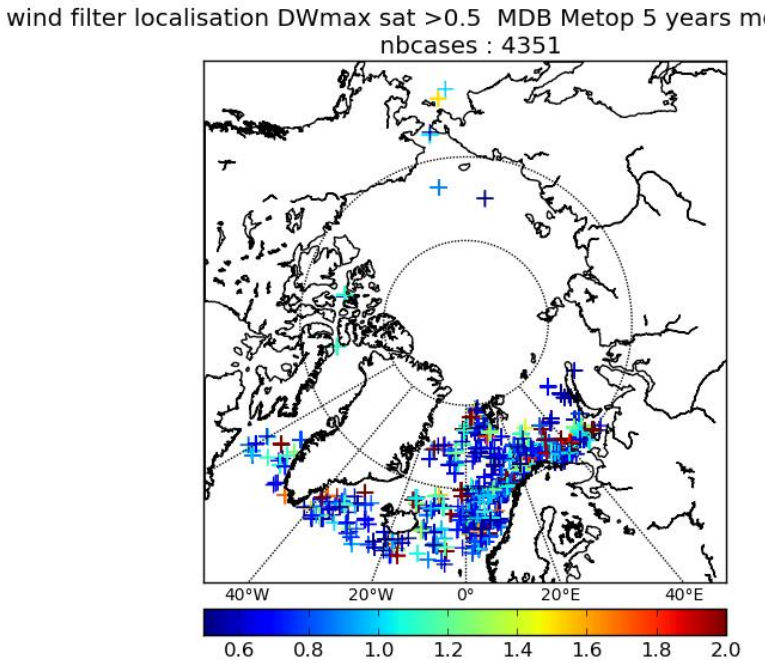
METOP/AVHRR vs buoy DW cycle (max >0.5)





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Arctic DW summary

- Frequent polar orbiter swaths at same location allow evaluation of DW in the Arctic

- Drifting buoy and METOP/AVHRR derived DW estimates shows a reasonable agreement

Variability and anomalies

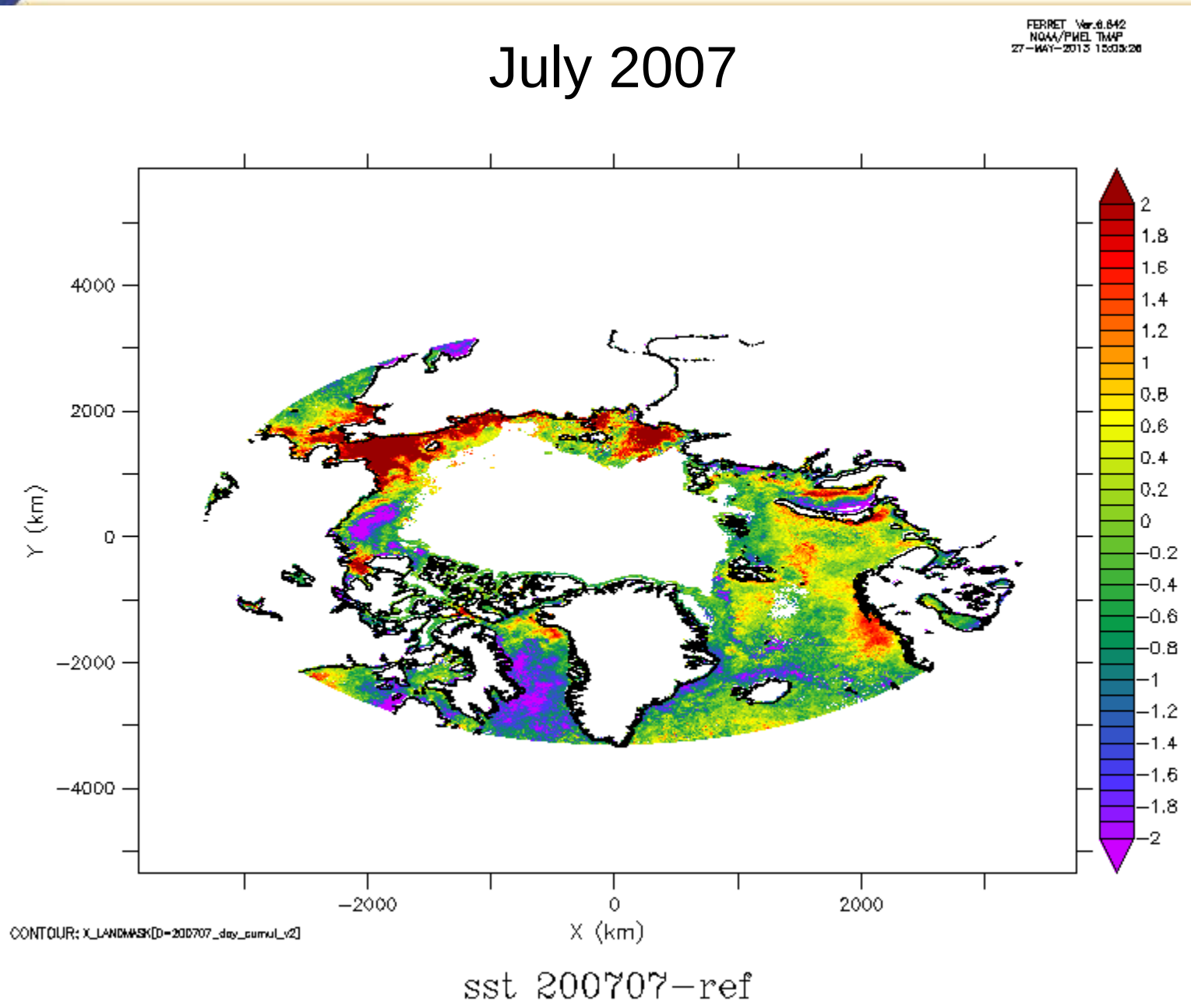
METHOD:

- Determination of monthly means (OSI-SAF ice concentration and SST for Ice concentration < 50%)
- Determination of a mean over 5 years
- Anomaly= monthly mean – mean over 5 years

- Comparison with ARC Arctic anomalies (*Llewellyn-Jones et al, 2011, GHRSST XIII*)

- Ice and SST anomalies??

July 2007



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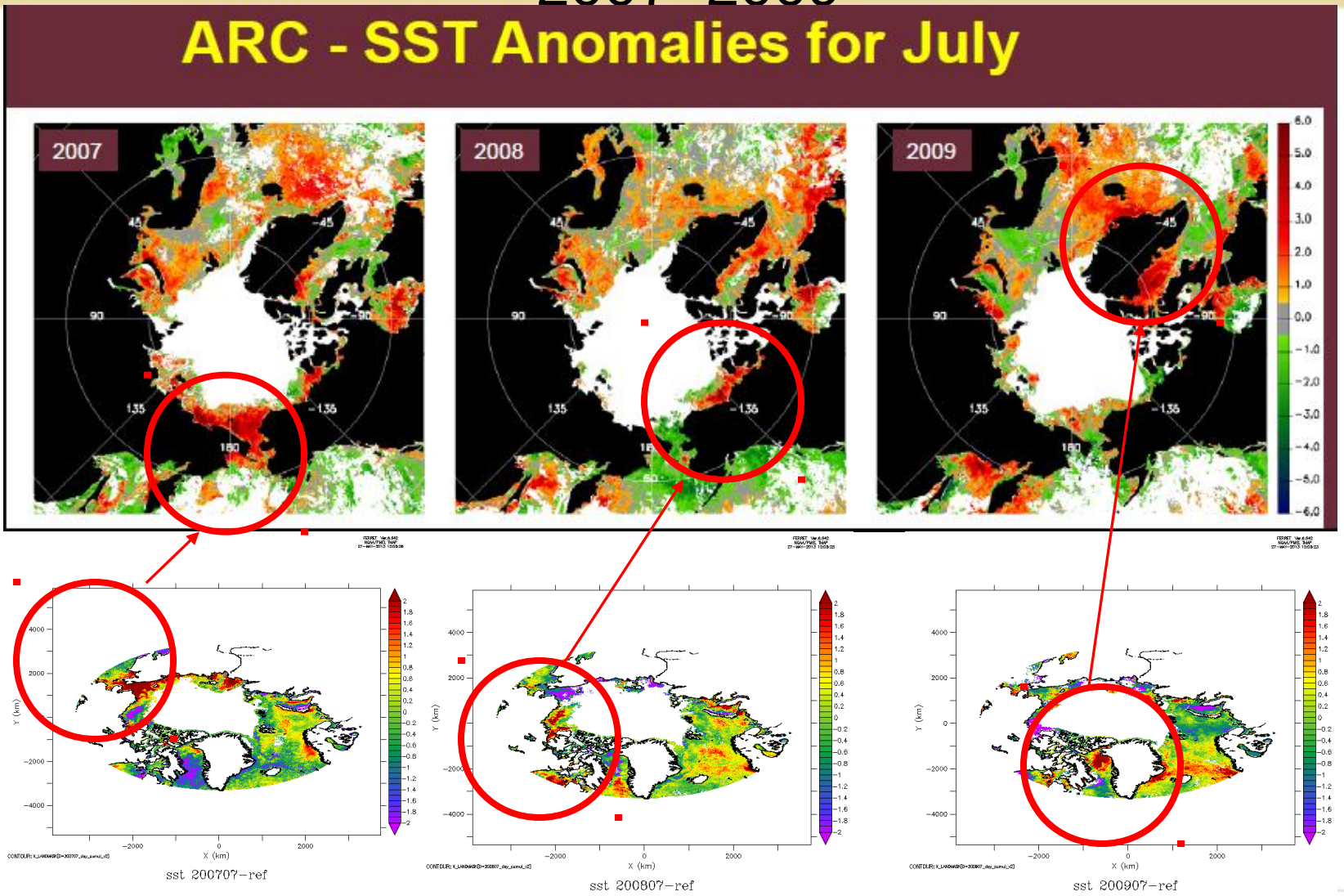
ARC vs METOP-A SST anomalies 2007 2009



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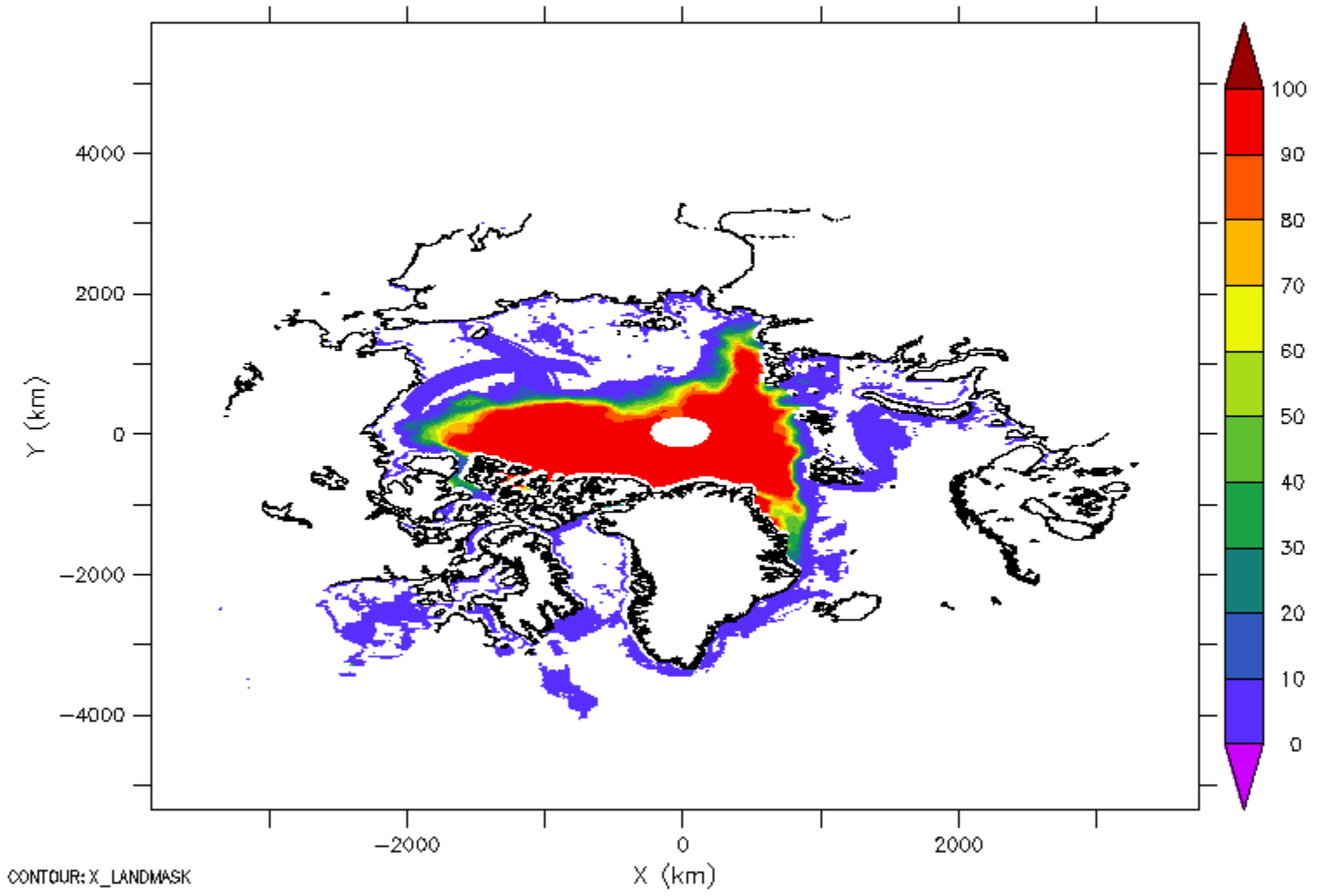
Ice concentration in September 2007



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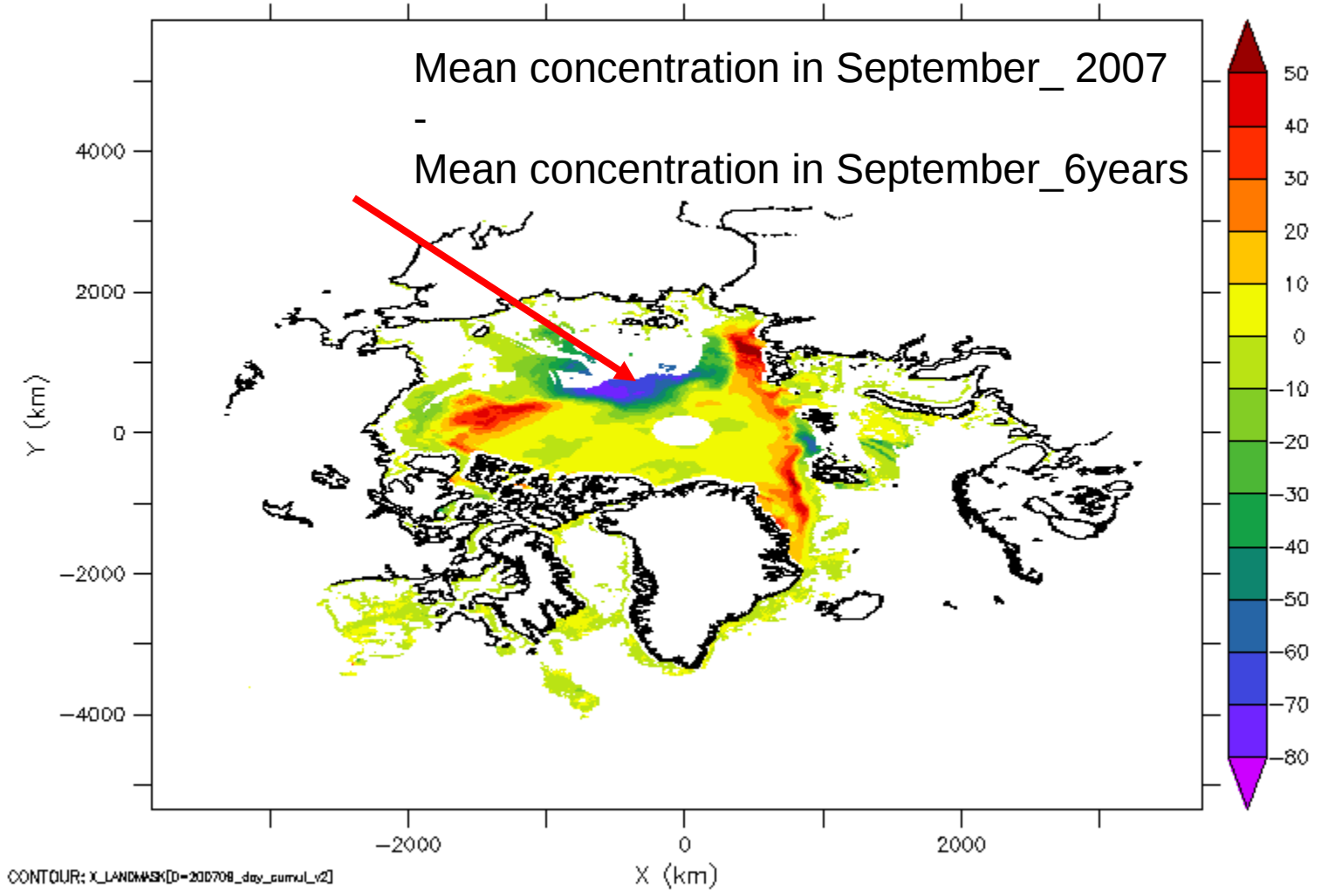
Ice concentration anomaly in September 2007



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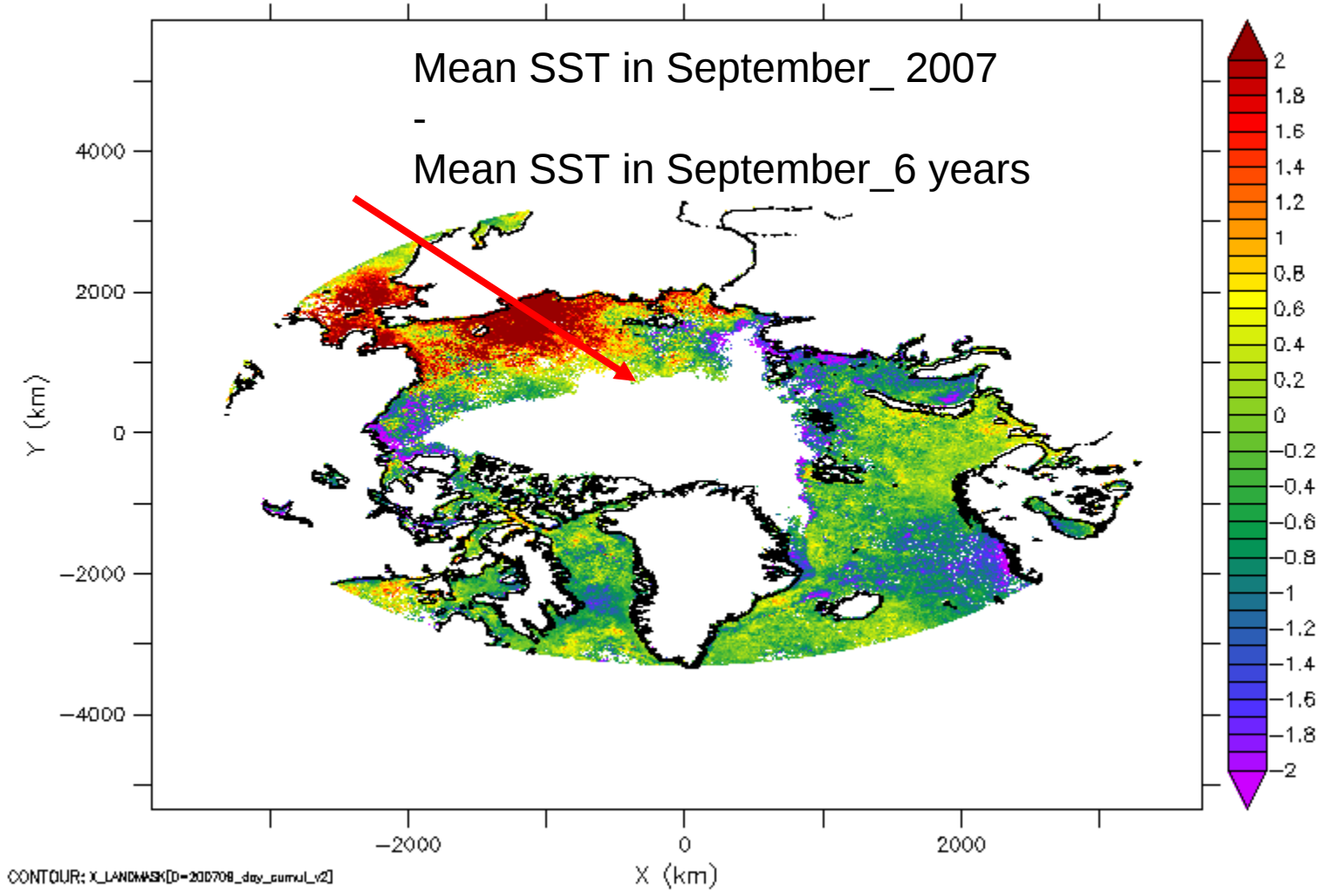
SST anomaly in September 2007



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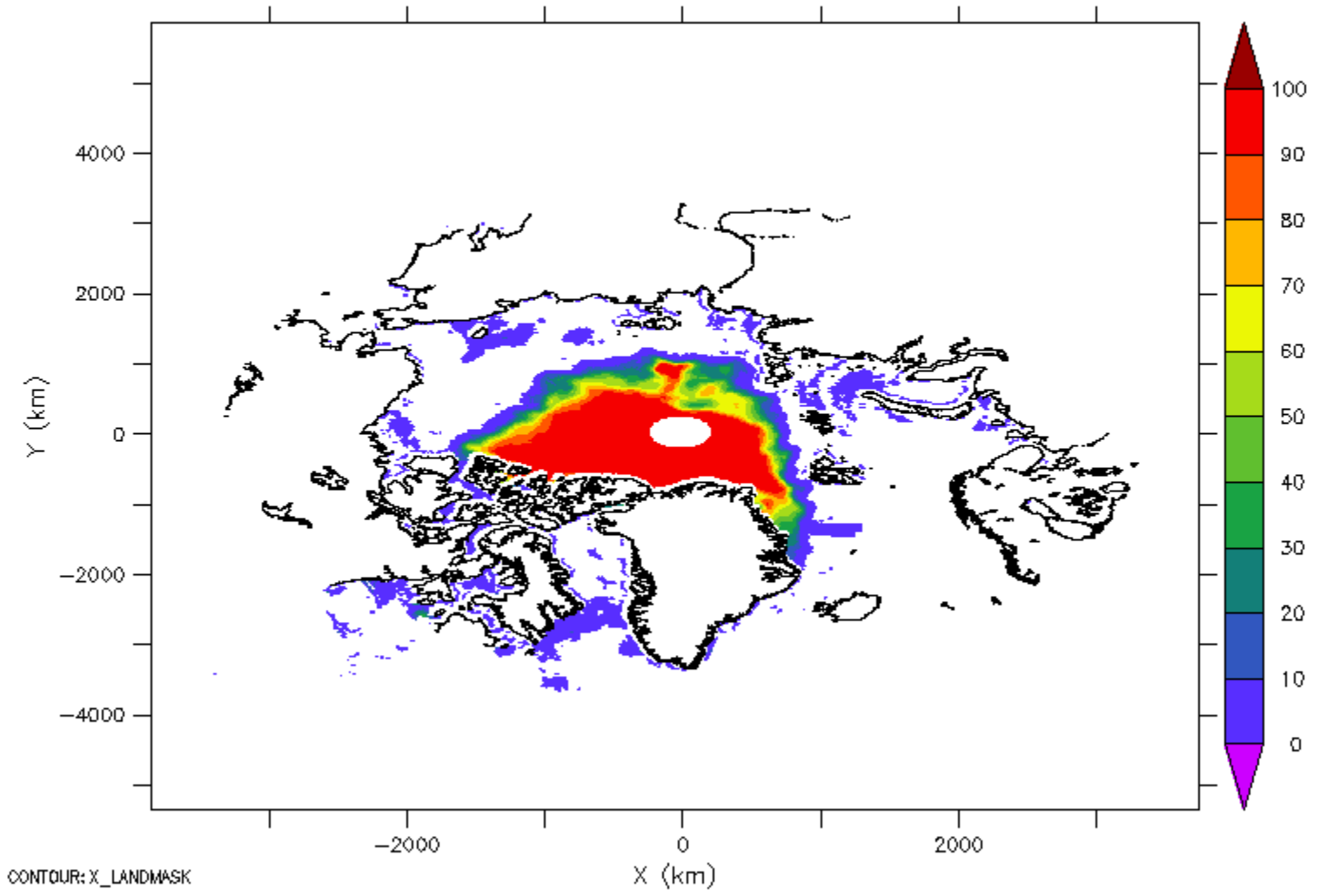
Ice concentration in September 2012



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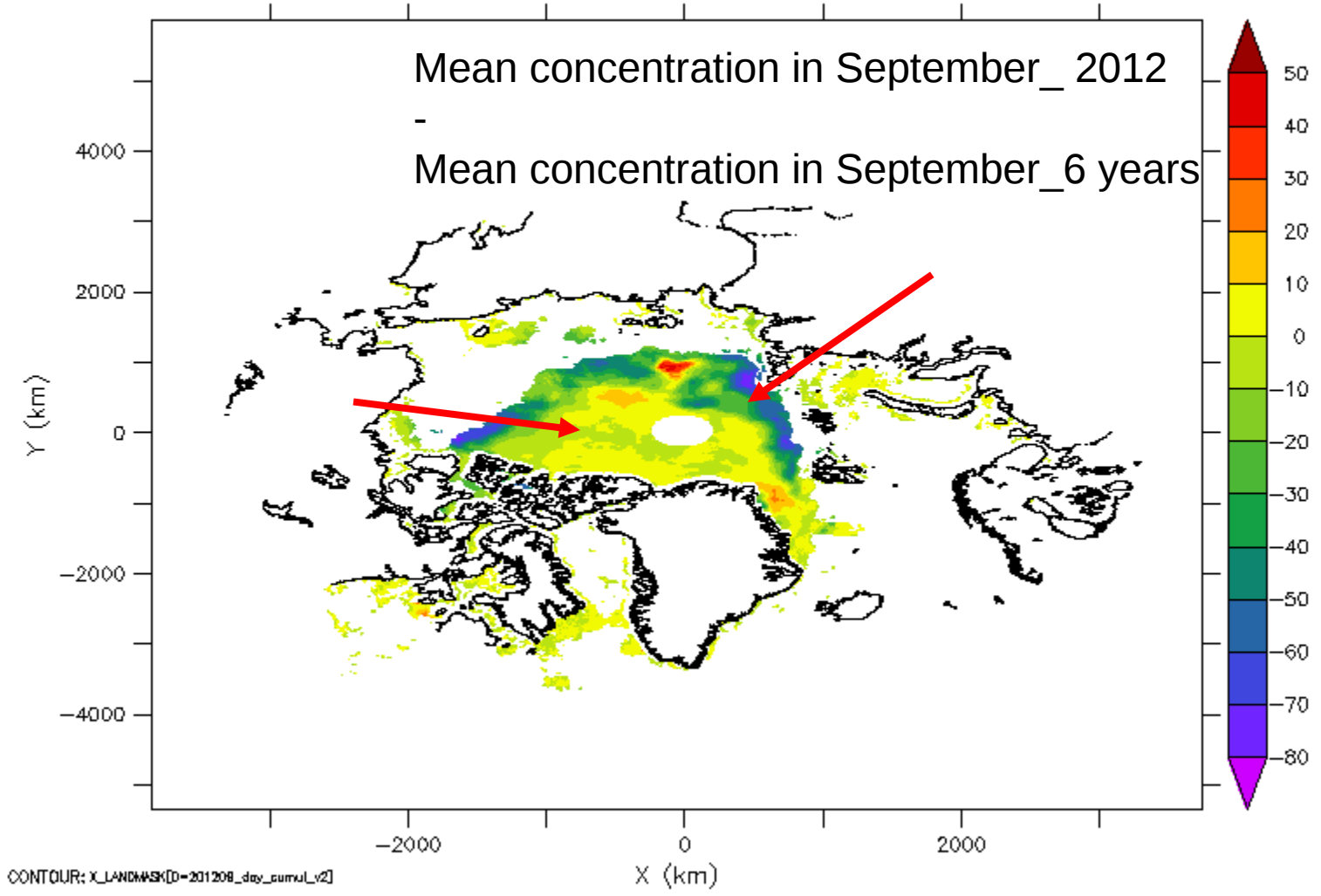
Ice concentration anomaly in September 2012



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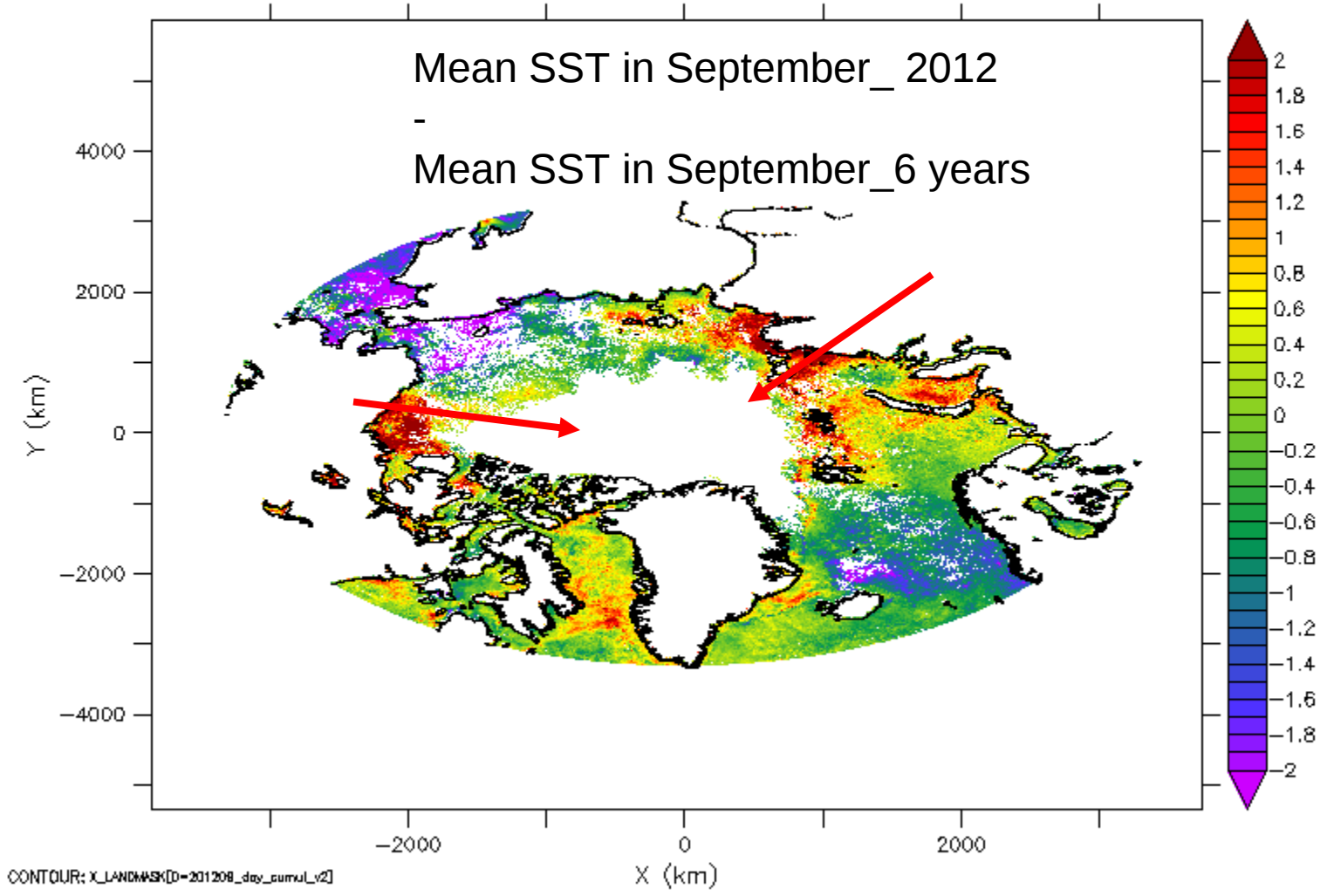
SST anomaly in September 2012



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Conclusions (1)

- METOP-A provided More than 5 years of (stable) full resolution SST data over the Arctic
- Validation results showed:
  - Cloud(ice) contamination issues
  - Algorithmic issues related to anomalous atmospheric profiles
- Simulations are reliable (improvements will come from OE or bias correction)
- BT adjustment problematic

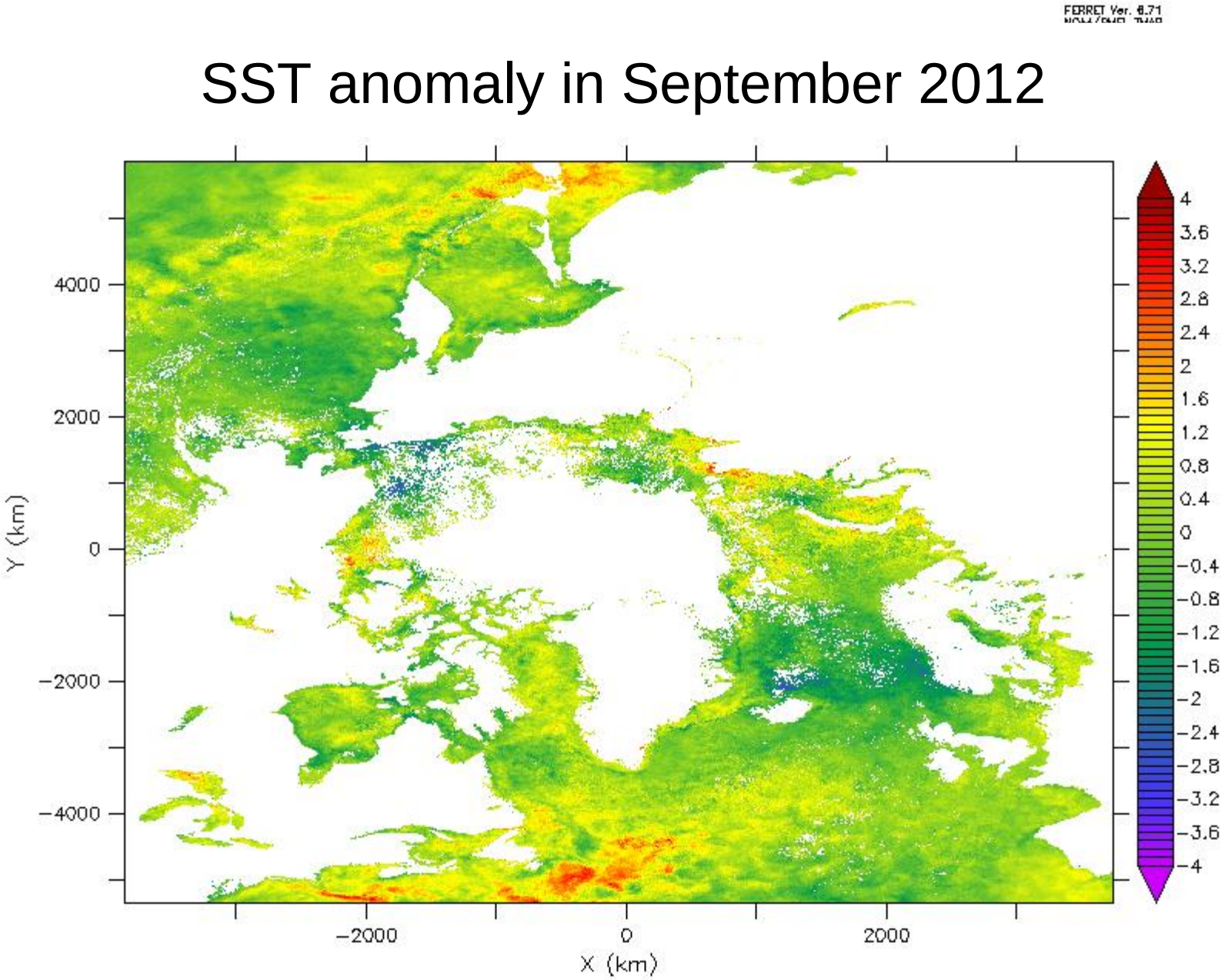
Conclusions (2)

- DW can be monitored by METOP (comparable to buoy estimates)
- METOP-A SST anomalies consistent with ARC
- Large year-to-year SST variability
- Ice extension anomalies correlated with SST anomalies
- Record Year 2007 quite distinct from Record year 2012

Discussion?

- Improving IR derived SST in the Arctic
  - Better use of simulations
  - BT corrections in permanent daytime conditions?
- DW in Arctic? What is foundation SST in Arctic summer?
- More numerous buoy measurements are requested (particulary off America and Siberia)
- Correlation between Ice extension and SST anomalies ?
- Origin of SST anomalies? (more clear sky days?

SST anomaly in September 2012



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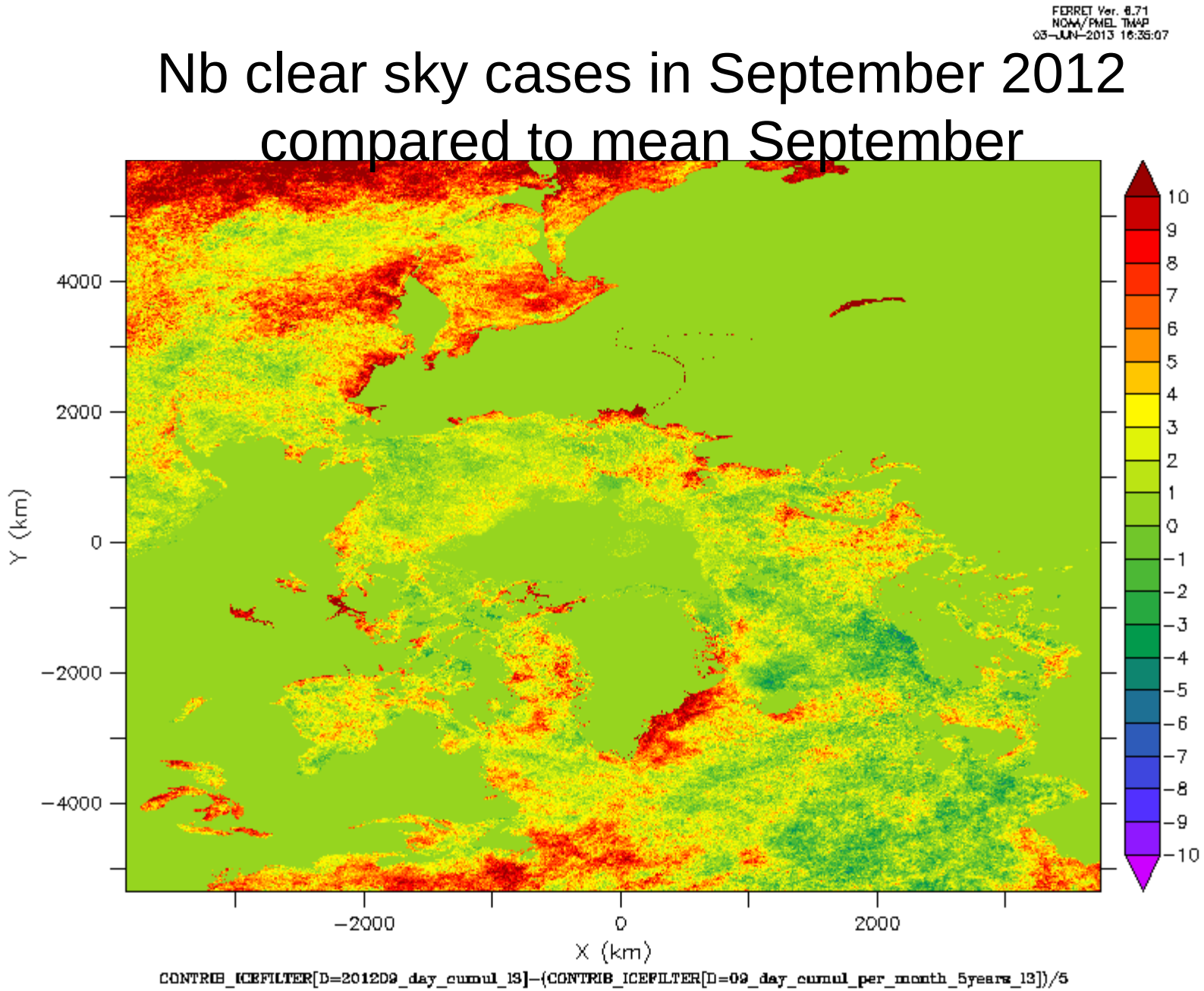
Nb clear sky cases in September 2012 compared to mean September



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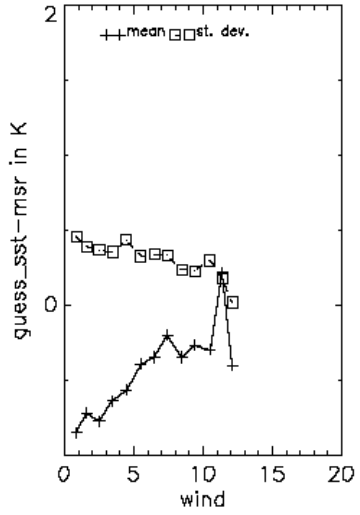
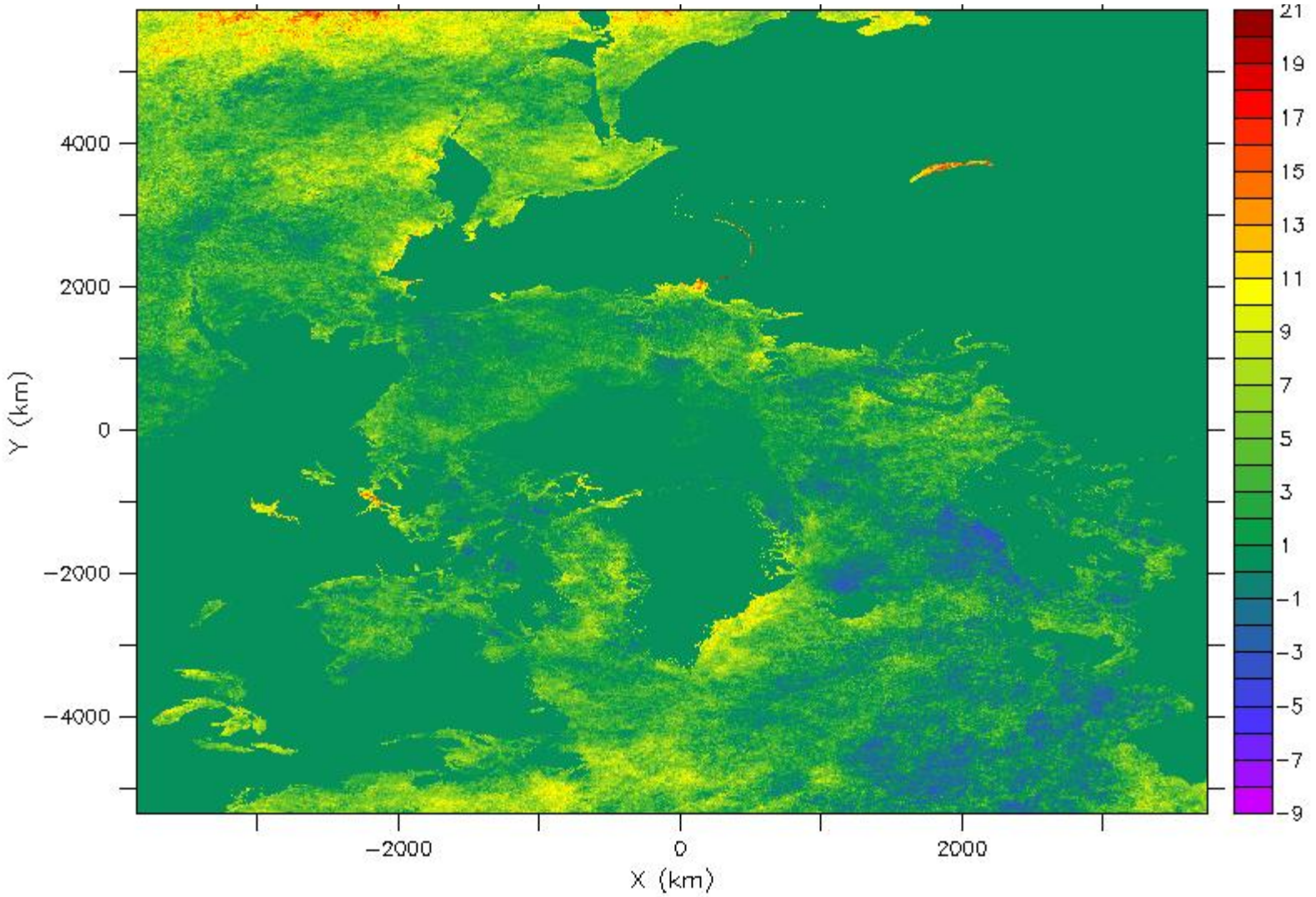
Arctic DW summary

- Frequent polar orbiter swaths at same location allow evaluation of DW in the Arctic
- Drifting buoy and METOP/AVHRR derived DW estimates shows a reasonable agreement
- OSTIA – buoy down to below –0.5K in case of low wind



Earthte June 2012 lat >60N: daytime OSTIA-buoy differences

Nb clear sky cases in September 2012 compared to mean September



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