High resolving sea ice concentration: ASI continuity, transition to AMSR2, comparisons

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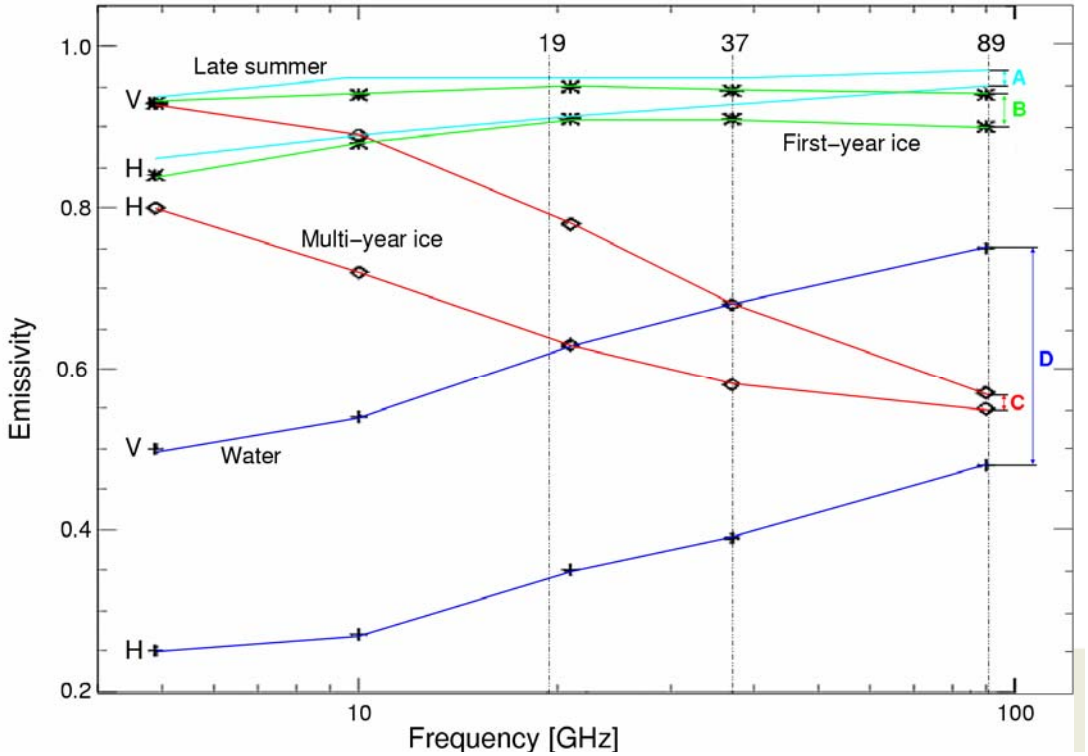
Universität Bremen

Overview

1. Research product ASI sea ice concentrations
   - 1.1 State of product
   - 1.2 Geolocation
   - 1.3 Intercomparison 89 GHz A/B scan
   - 1.4 Validation with Polarstern Bridge Observations
   - 1.5 Sea ice extent time series
   - 1.6 ESA Essential Climate Variables Initiative
2. Comparing Thin ice retrieval
3. Sea ice drift: products by IFREMER and Met.Norway
4. Conclusions

1. ASI (ARTIST Sea Ice) algorithm

- High resolution ice concentrations needed for
  - Navigation
  - NWP + climate research
- Horizontal resolution ~ λ/Aperture,
  AMSR2: 89 GHz: **3 x 5 km**
  19 GHz: 14 x 22 km
- Use **polarization differences** near 90 GHz (Svendsen et al. 1987):
- High for OW
- Low for all ice types
- 2 tie points P_0 = D
  P_1 = A ~ B ~ C
- 3 weather filters



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1.1 State of AMSR2 ASI sea ice concentration product

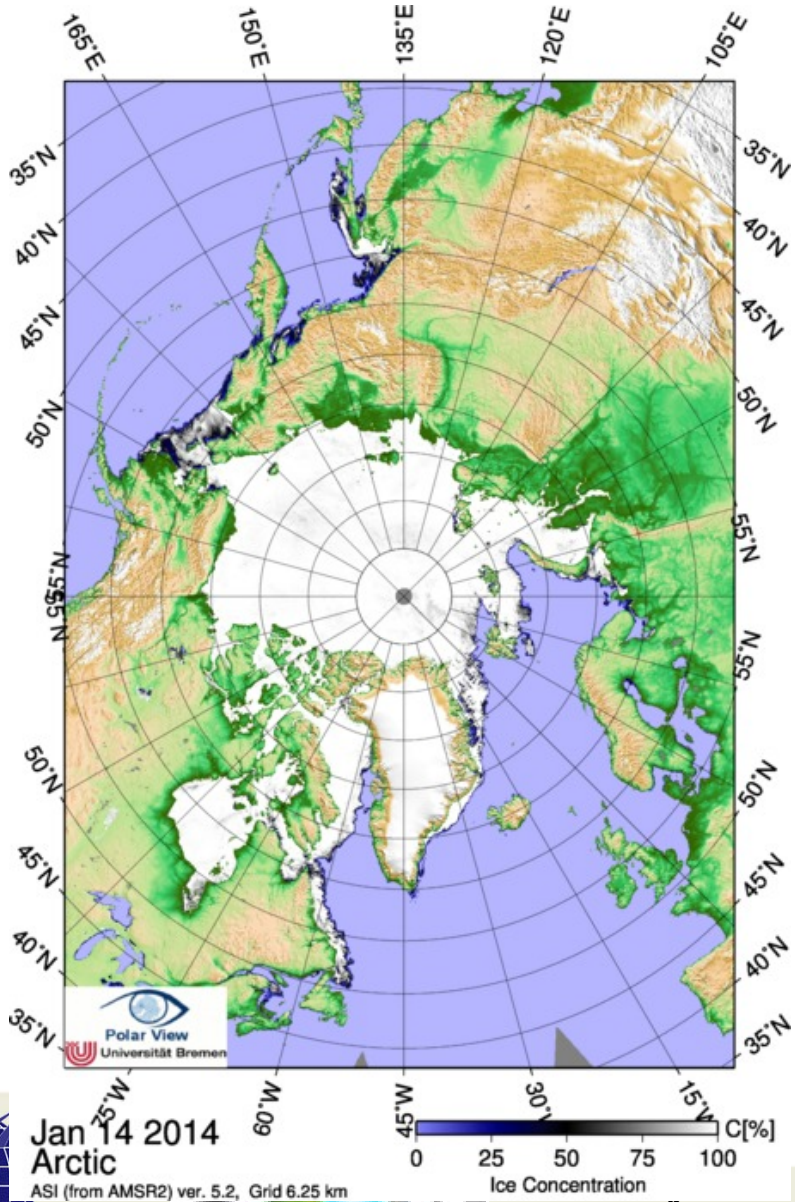
- AMSR-E stops operations 4 Oct 2011
- UB first SSMIS based maps 24 Oct 2011

- Receiving AMSR2 L1B Data since 4 Sep 2012
- Producing sea ice maps since 7 Sep 2012, internal use

- Jaxa releasing L1B data 26 Jan 2013
- UB producing public ice maps 27 Jan 2013

- ASI V5 based, AMSR2 data adjusted to AMSR-E based on JAXA calibration correction

- Little influence on ASI SIC because correction similar for 89V and 89H



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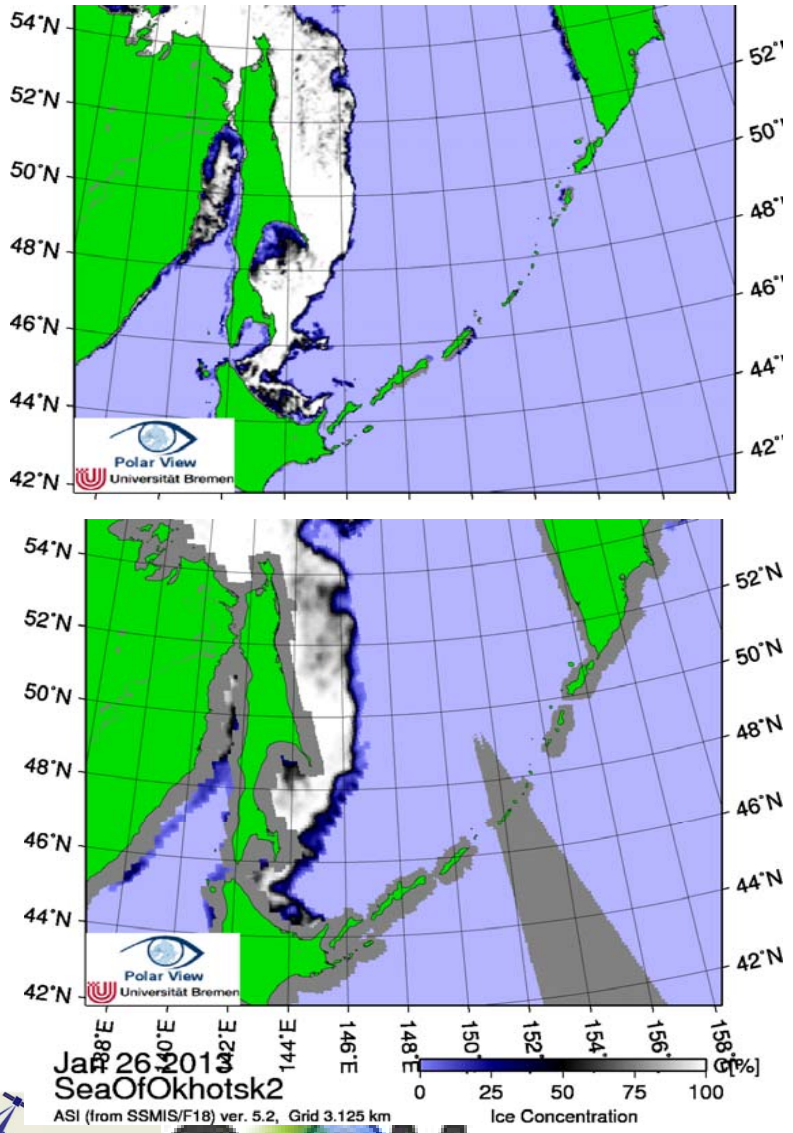
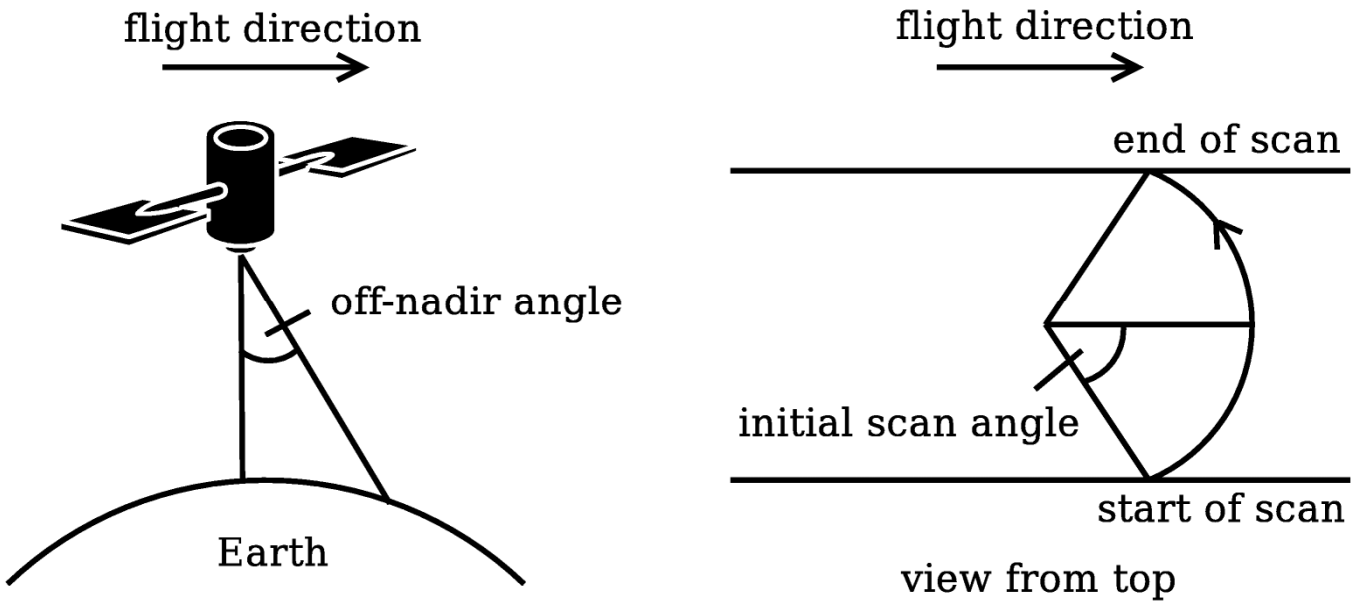
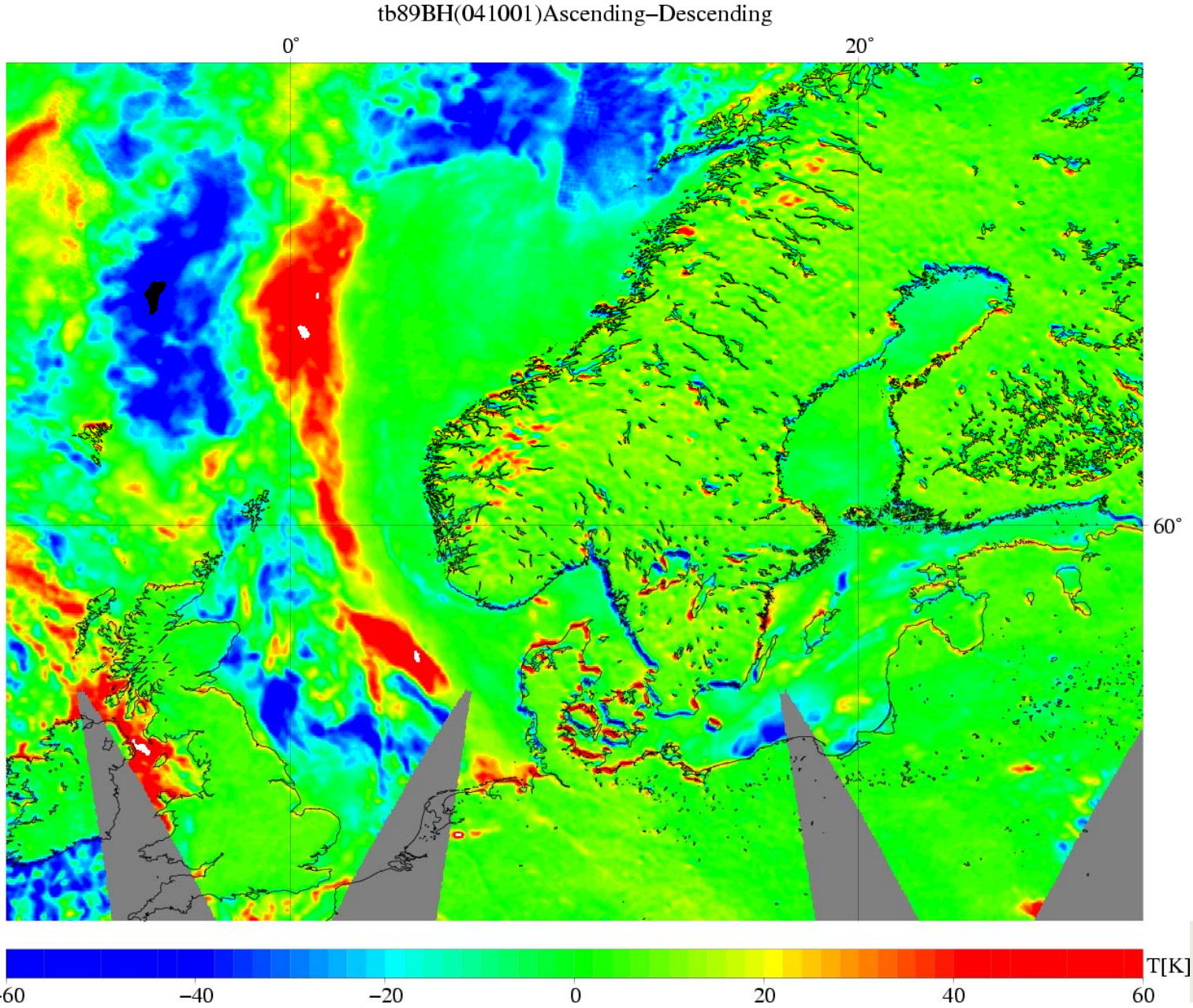


1.2 Geolocation

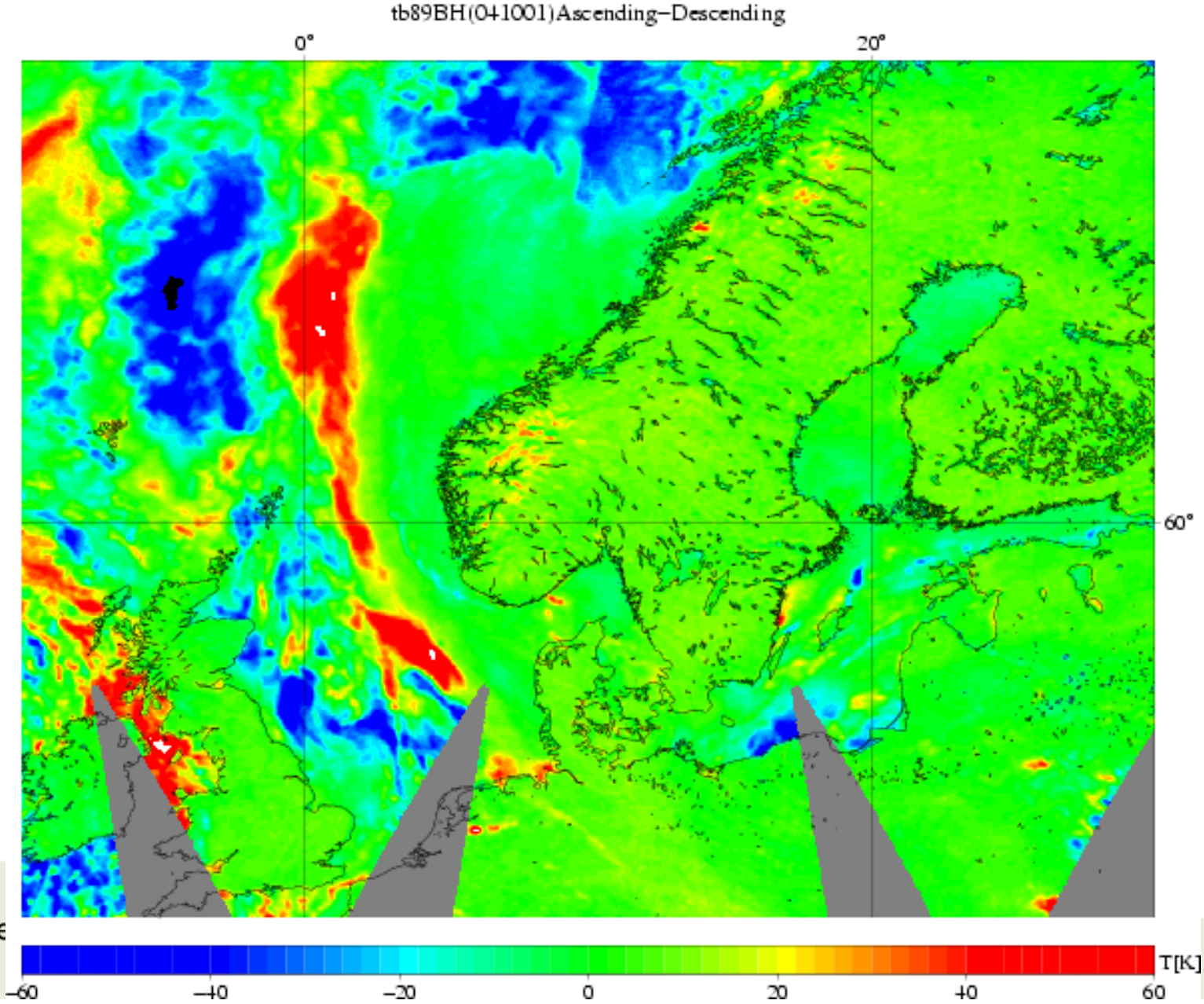
- for AMSR-E (Wiebe et al. 2008)



AMSR-E 2006: |TB(asc) – TB(desc)| original geolocation

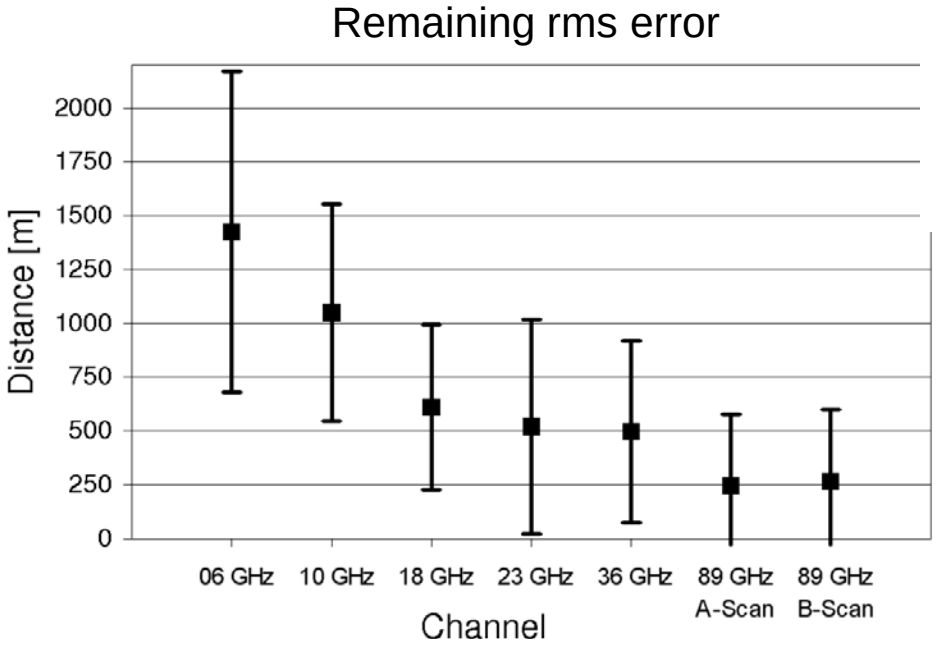


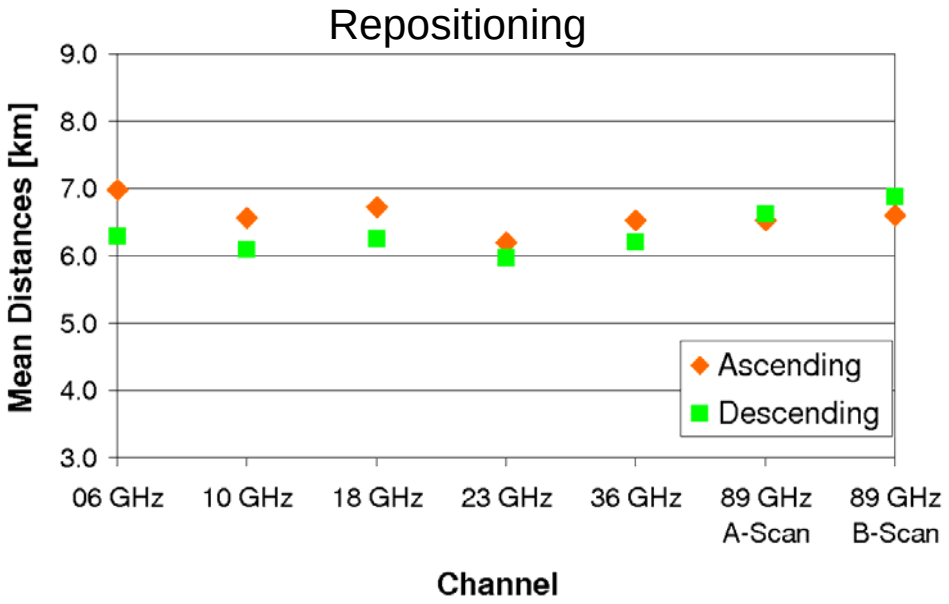
AMSR-E 2006: |TB(asc) – TB(desc)| optimized gelocation



Geolocation

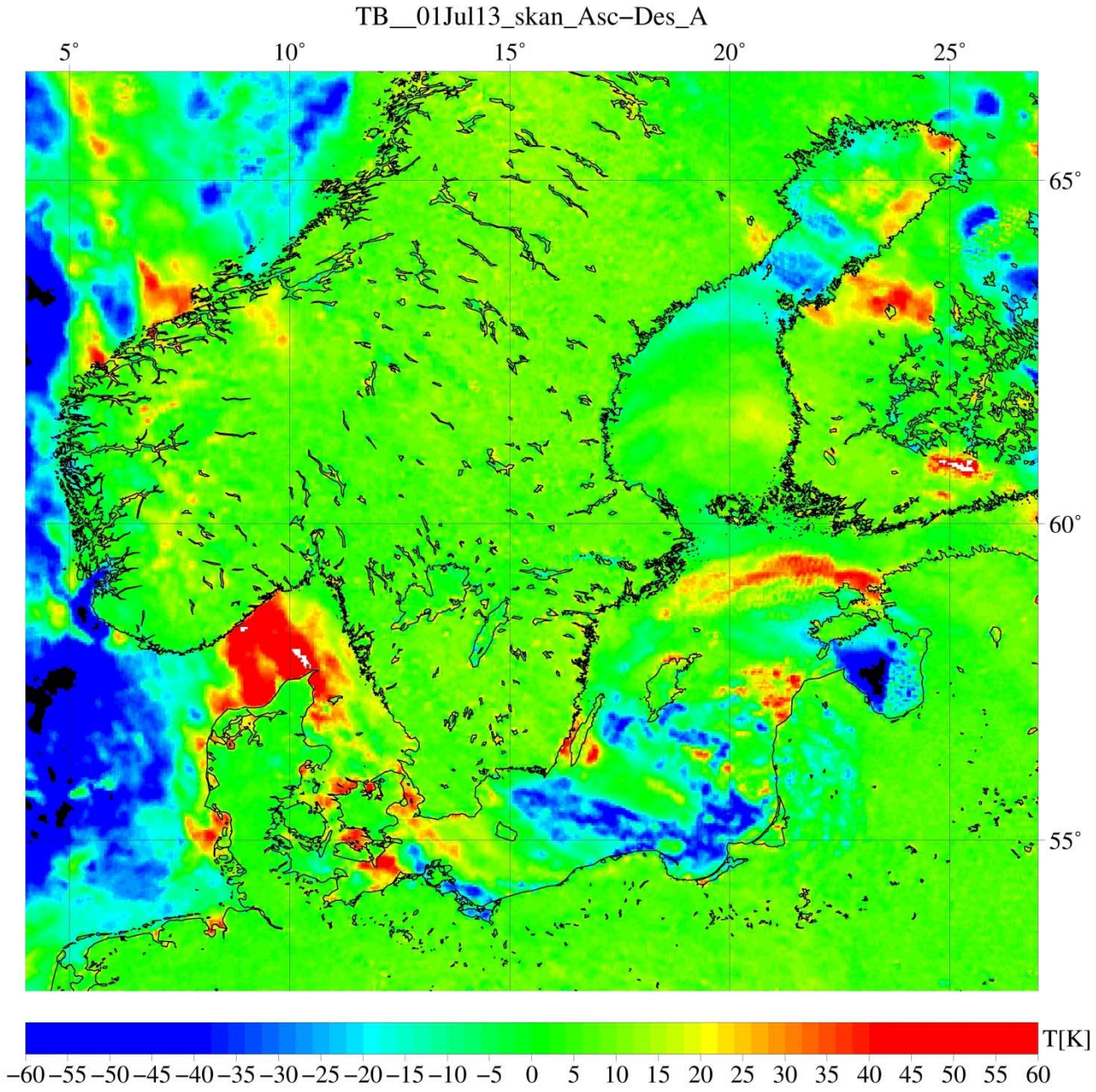
- for AMSR-E (Wiebe et al. 2008)



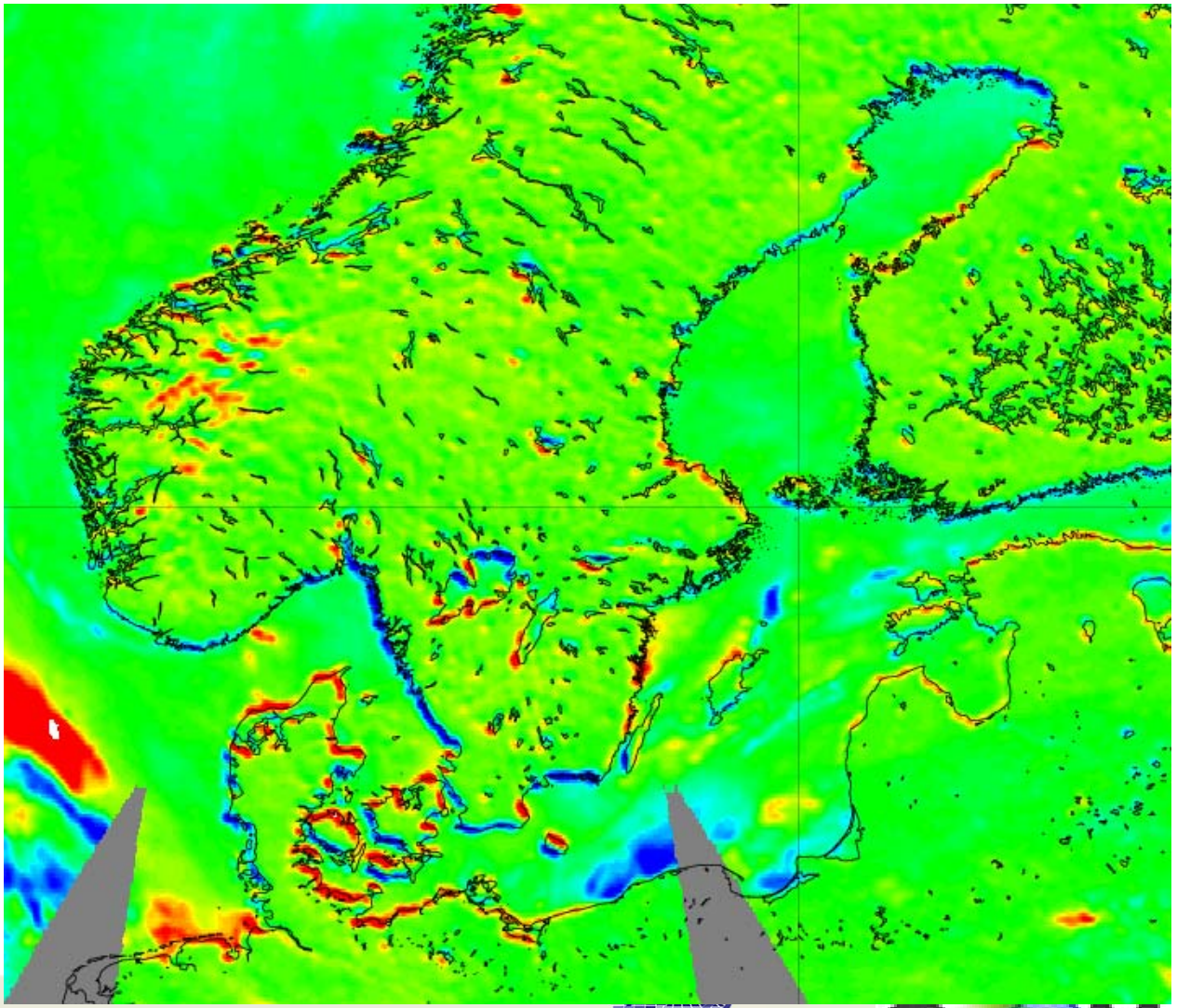


4 year residual geolocation error

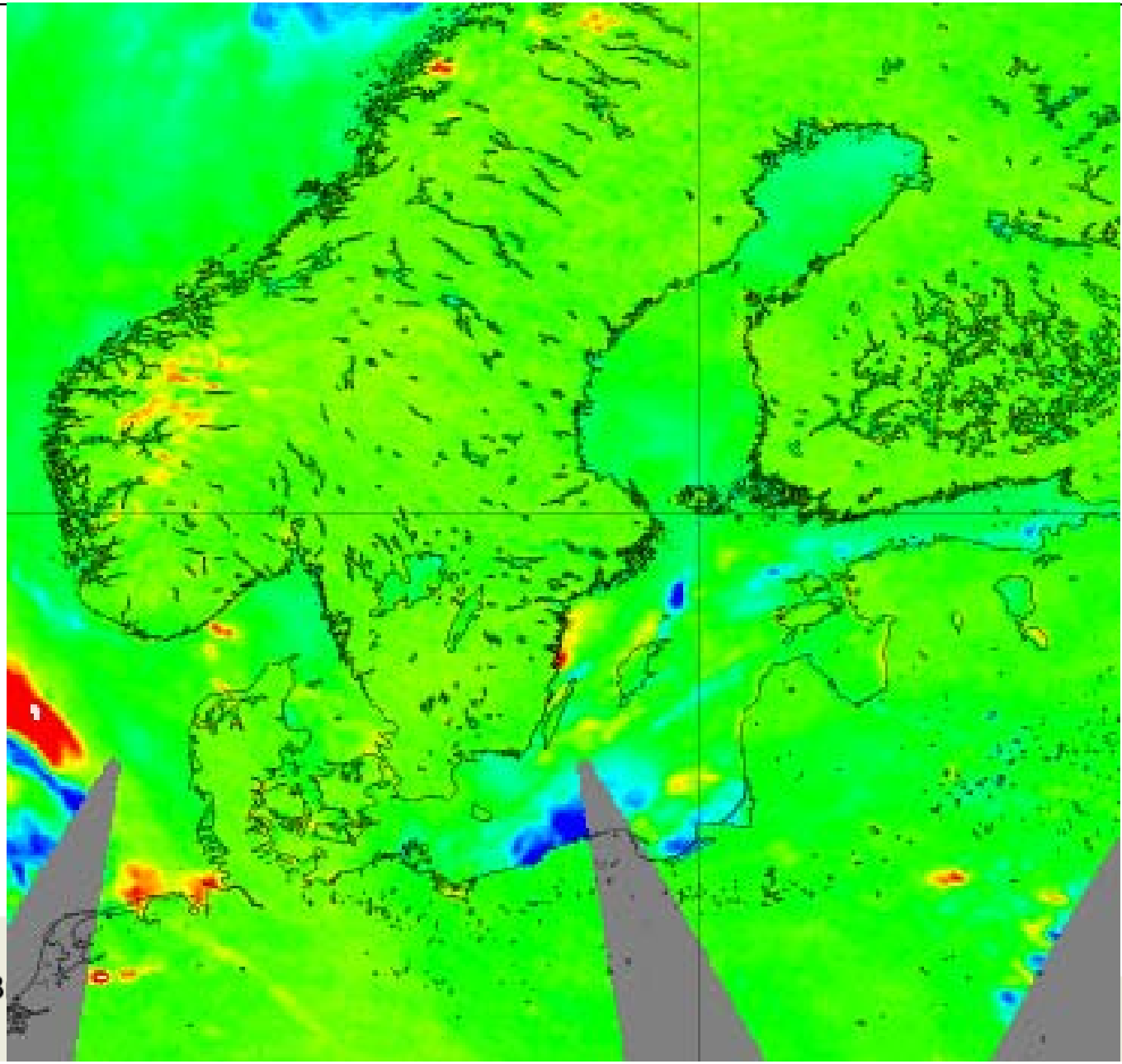
AMSR2 2013: |TB(asc) – TB(desc)|



AMSR-E 2006: |TB(asc) – TB(desc)| original gelocation

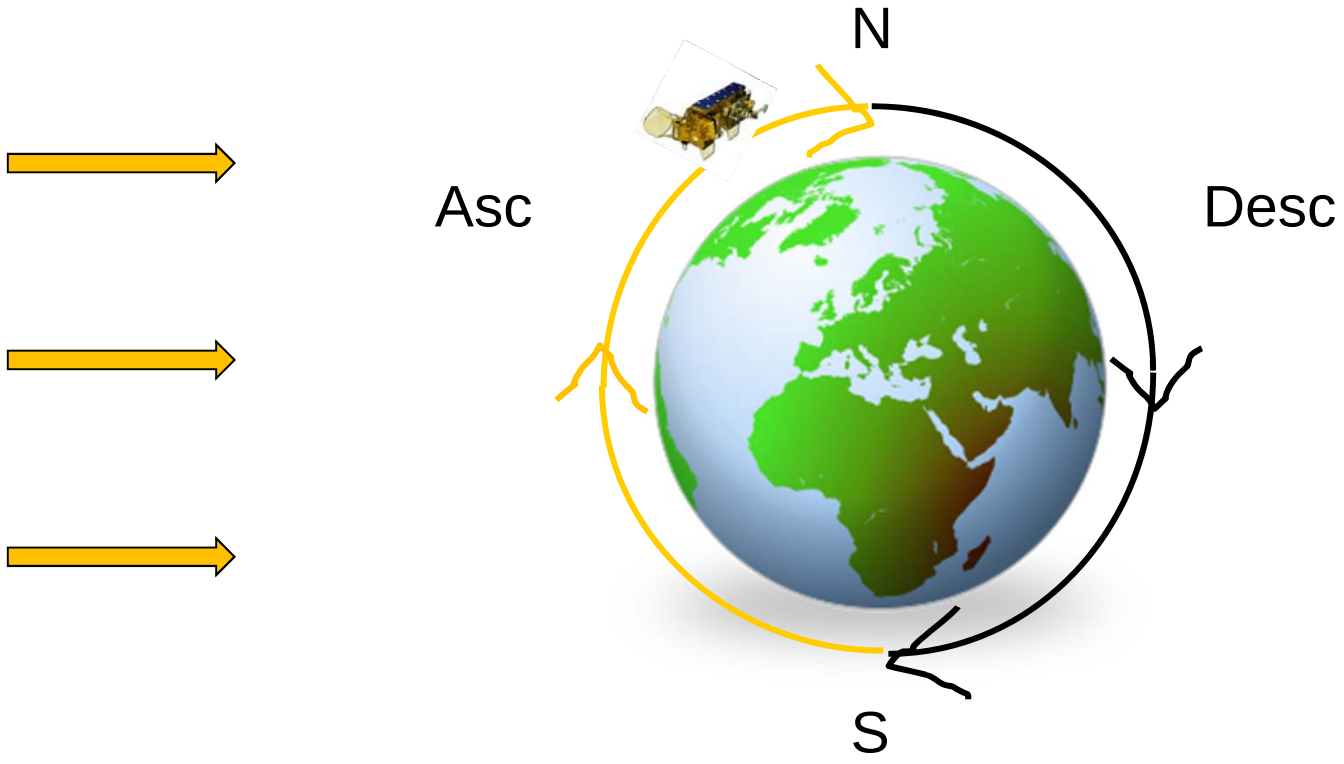


AMSR2 2006: |TB(asc) – TB(desc)| optimized gelocation



1.3 Intercomparison 89 GHz A/B scan

Ascending / Descending conditions in polar regions



From the point of thermal memory,
near the poles asc/desc corresponds to N / S

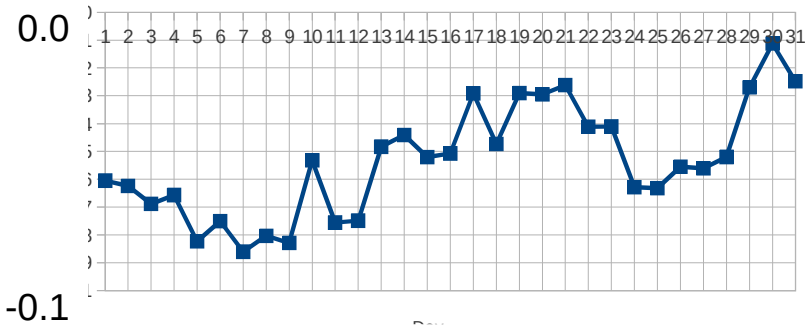
Daily avg differences (A scan – B scan) for Dec 2012 and Jun 2013

December

Bias (Scan A TB - Scan B TB)

December 2012 - Arctic

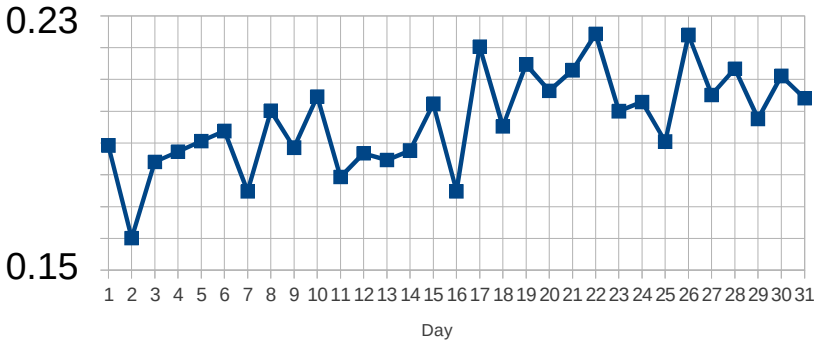
Arctic



Bias (Scan A TB - Scan B TB)

December 2012 - Antarctica

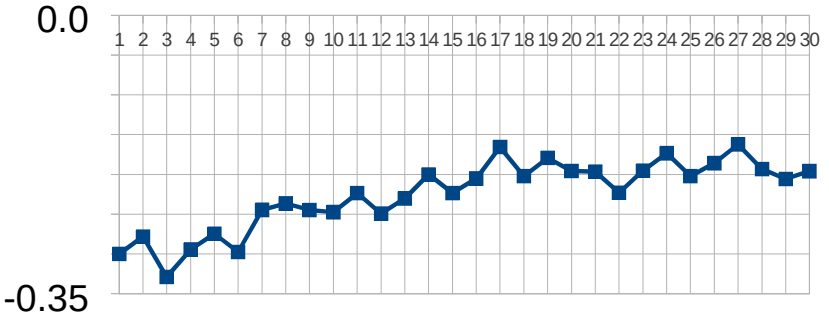
Ant-arctic



June

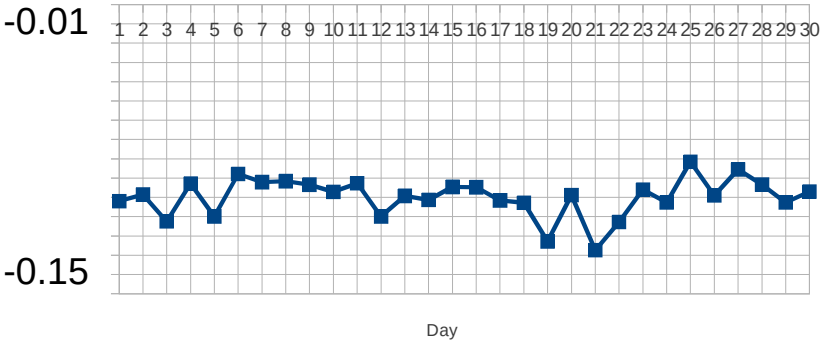
Bias

June 2013 - Arctic



Bias

June 2013 - Antarctica



- **All values clearly < 0.3 K**

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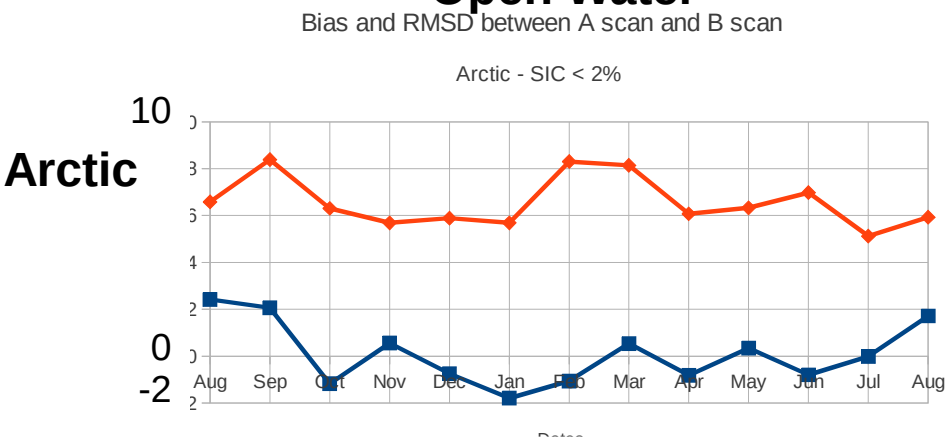
iup

GCOM Global Change Observation Mission

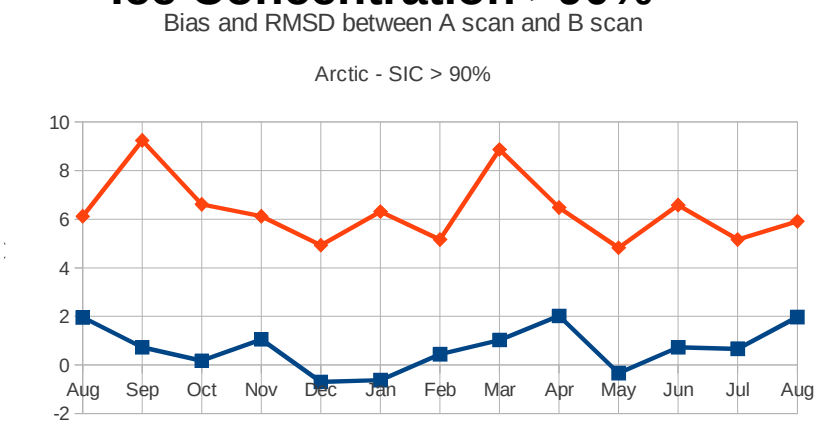
Bias and RMSD between A scan and B scan

first day of each month

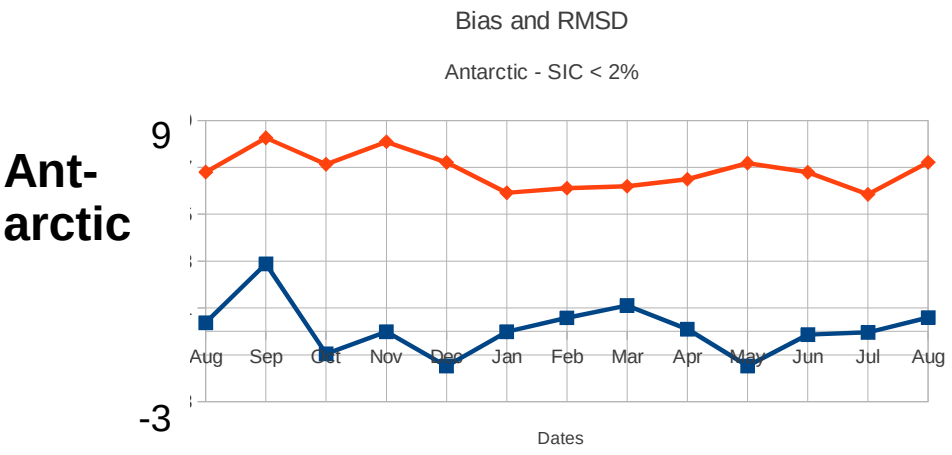
Open Water

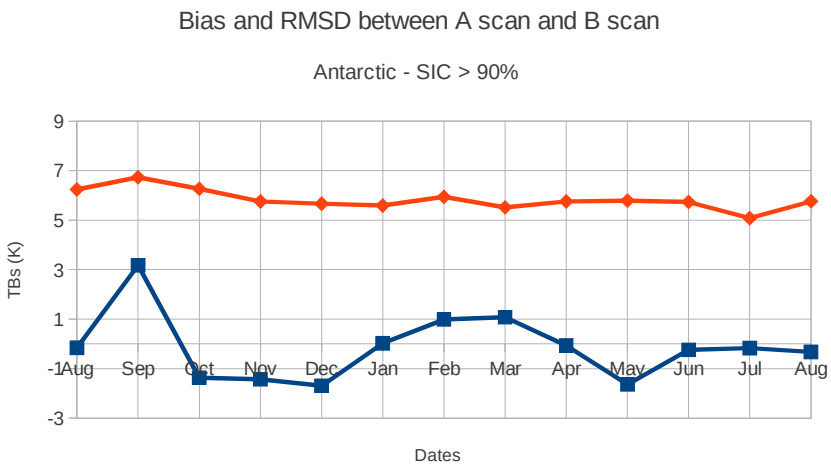


Ice Concentration >90%



Arctic

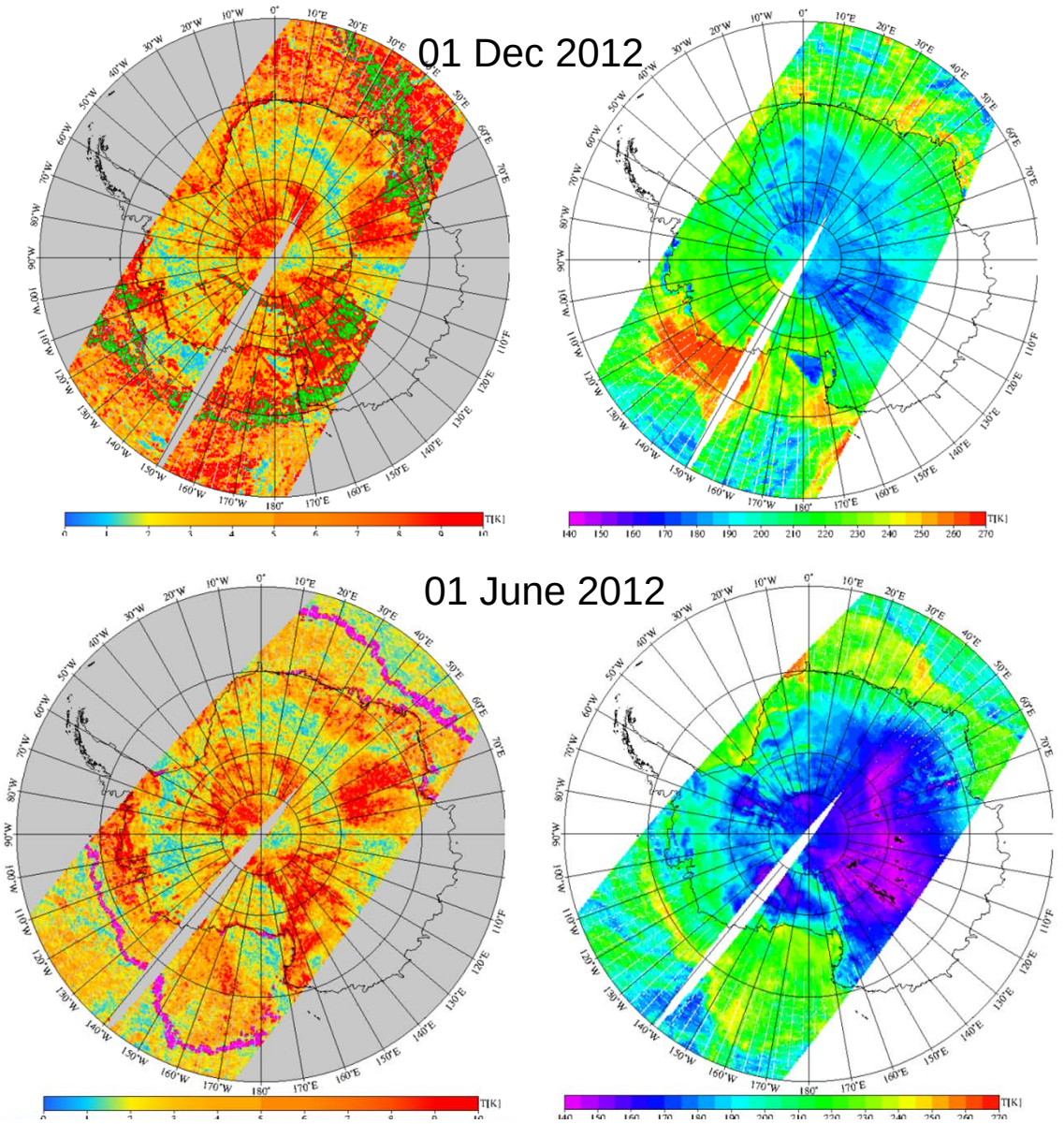




Ant-arctic

- **No significant bias**
- **RMSD Arctic higher variability than Antarctic**

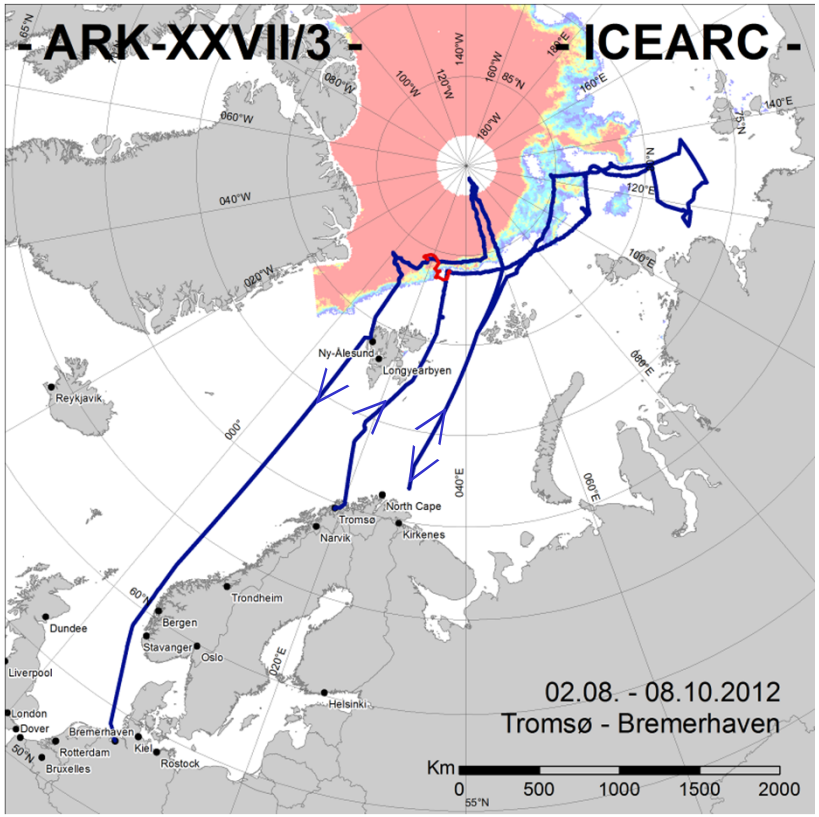
Antarctic A/B scan differences and TBs of individual swaths

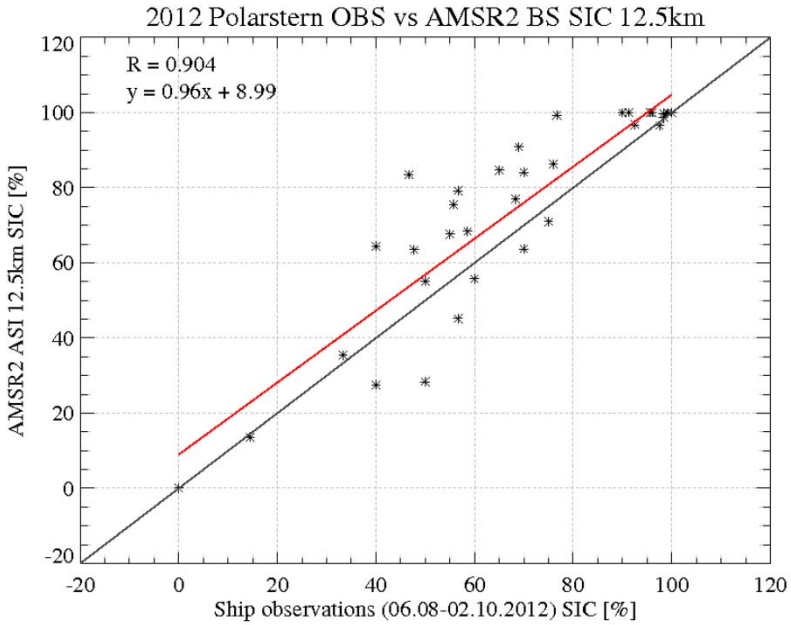


- Dec: largest differences near MIZ (light green)
- Differences over land appear in same regions for both maps: topographic features, not seasonal variations
- Similar differences appear both on land and on sea ice: only the surface features relevant, not surface type
- Overall: No significant A/B scan differences in polar regions, in agreement with EORC findings for lower latitudes

1.4 Validation with Polarstern bridge observations

IceArc 2012





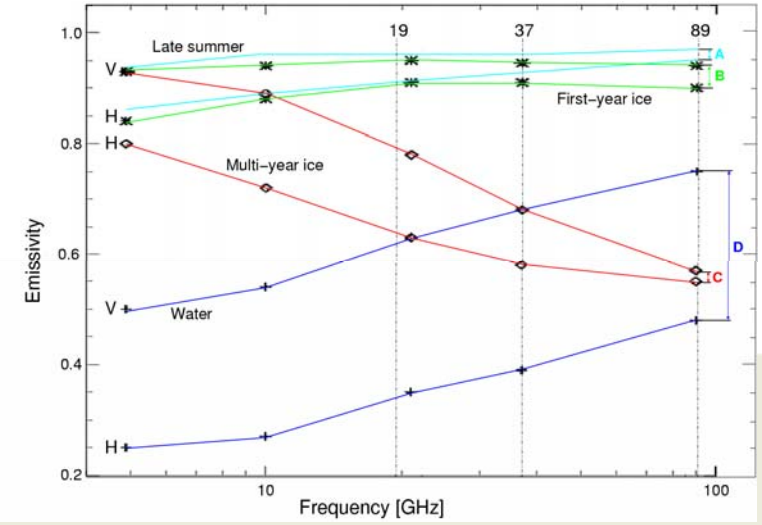
323 observations
09 Aug-19 Sep 2012
daily averages

R	0.9	
Bias	6.07	K
RMSD	12.46	K

Validation with Polarstern bridge observations

- All biases >0: satellite sensors overestimate. Ship seeks leads
- Bootstrap lowest RMSD, highest R
- AMSR2 bias

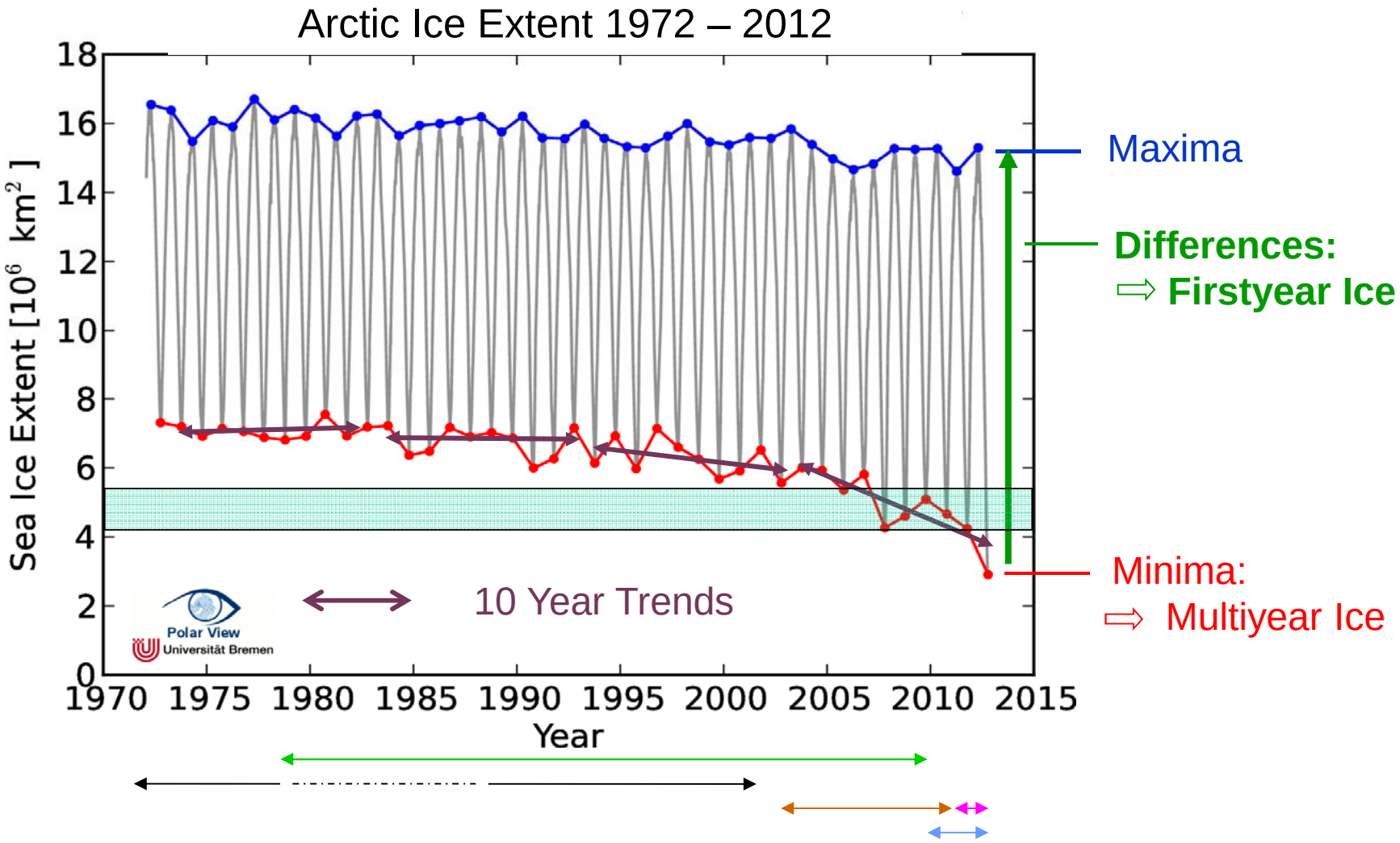
2012 – Polarstern cruise (06.08 – 02.10.2012)					2011 – Polarstern cruise (09.08 – 19.09.2011)			
Algorithm	ASI			Bootstrap	ASI			Bootstrap
Instrument	AMSR 2		SSMIS	AMSR 2	AMSR-E		SSMIS	AMSR-E
R	0.85	0.85	0.84	0.9	0.84	0.84	0.69	0.89
Bias	9.08	8.68	9.88	6.07	5.83	5.84	4.54	2.19
RMSD	16.4	16.23	16.91	12.46	11.79	11.67	15.25	8.98
Resolution	6.25 km	12.5 km	6.25 km	12.5 km	6.25 km	12.5 km	6.25 km	12.5 km



2011:

- More pixels in mid-range ICs than 2012
- ice observers more educated
- comparison between years difficult

1.5 Sea ice extent time series



Sea ice extent time series

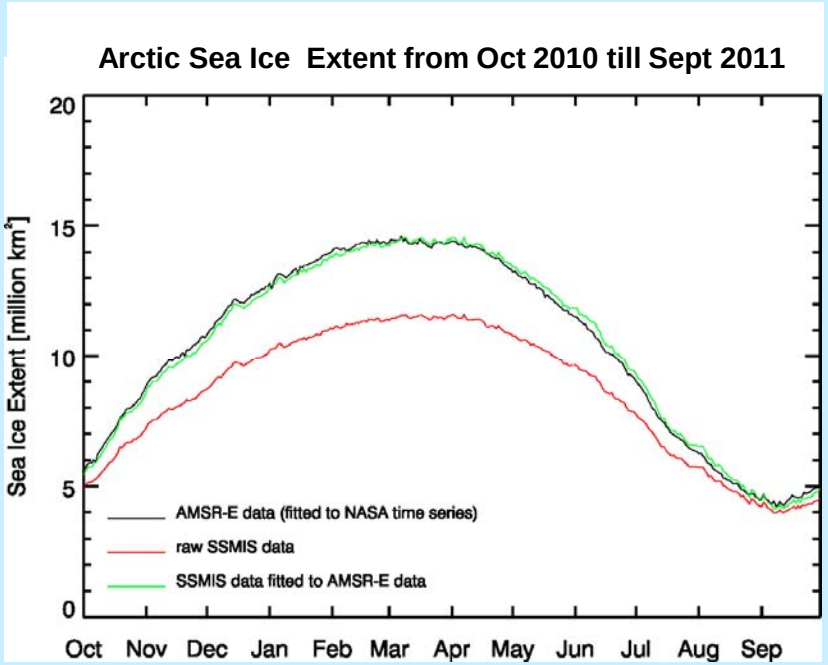
Adaptations:

#	Period	Alg.	Sensor, Frequencies, Source	Adapted to	Overlap period
1.	1972 - 2002	NASA Team	SMMR & SSM/I, 19 and 37 GHz from NSIDC (1)	#2.	1989 - 2002
2.	Oct 26, 1978 - Dec 2010	NASA Team	NIMBUS-7 SMMR and DMSP SSM/I-SSMIS, 19 and 37 GHz, from NSIDC(2)	reference only, gaps 1978 - 1988	
3.	2003 - Oct 4, 2011	ASI	AMSR-E, 89 GHz	#2.	2002 - 2007
4.	Oct 5, 2011 - Jul 2, 2012	ASI	SSMIS F-17, 91 GHz	#3.	Sep 2010 – Sep 2011
5.	Jul 3, 2012 to date	ASI	AMSR2, 89 GHz	#2. (same fit parameters as #3)	Jul 3, 2012 – Jan 20, 2013 (preliminary)

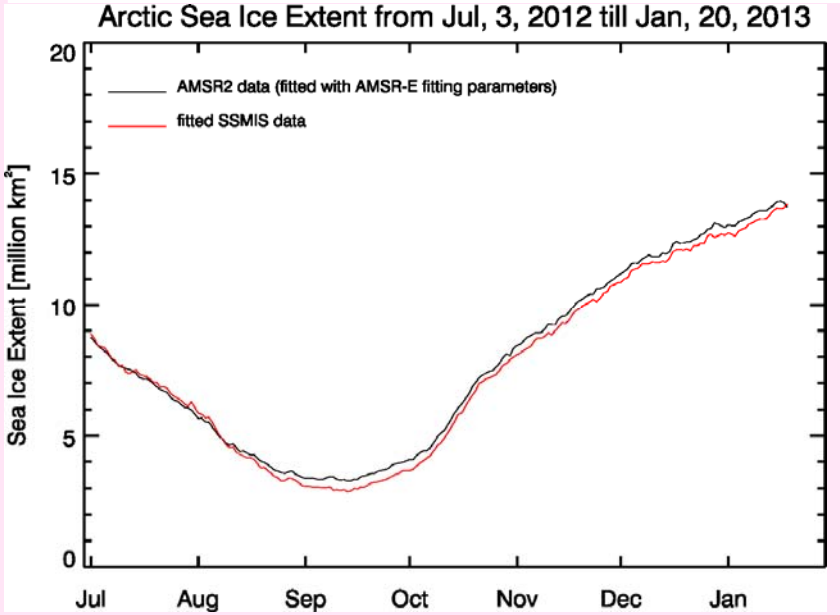
(1) http://nsidc.org/data/smmr_ssmi_ancillary/area_extent.html#merged. Cavalieri et al. 2003
(2) http://nsidc.org/data/nsidc-0051.html Cavalieri et al. 1996

Sea ice extent time series

- AMSR-E: until Oct 3, 2011
- SSMIS F17: from Oct 2010 ongoing
- $$E_{fit} = (E_{SSMIS} - \overline{E_{SSMIS}}) \cdot \frac{\sigma_{AMSRE}}{\sigma_{SSMIS}} + \overline{E_{AMSRE}}$$



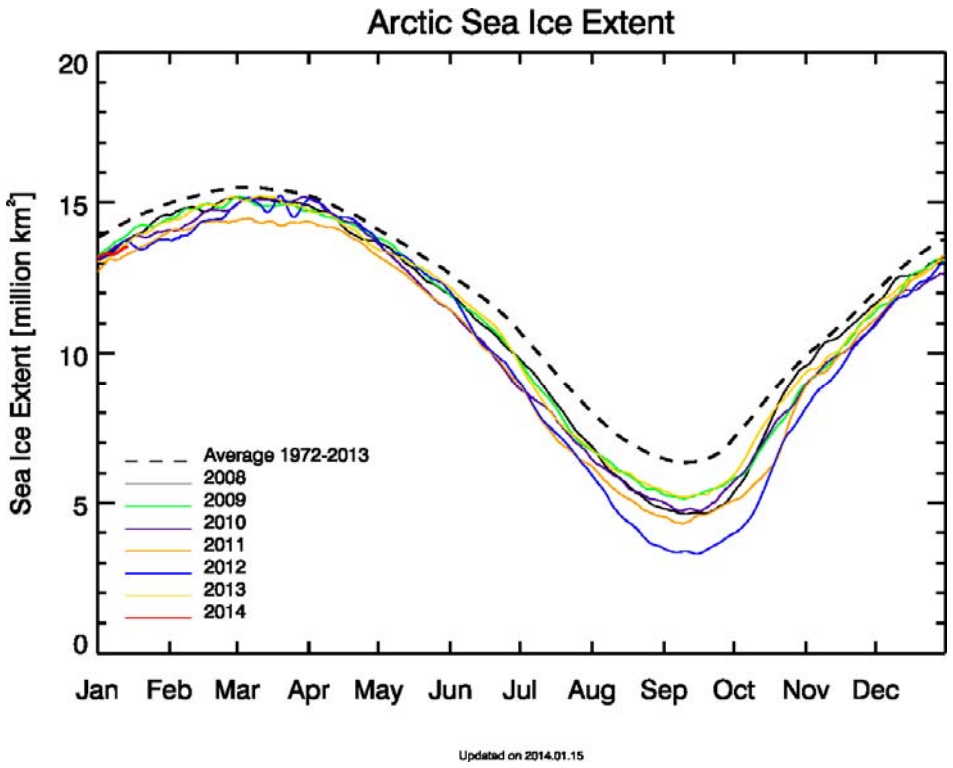
- AMSR2: from Aug 2012 ongoing (preliminary):
- Using identical fit as AMSR-E



Sea ice extent time series

- AMSR-E: until Oct 3, 2011
- SSMIS F17: from Oct 2010 ongoing
- AMSR2: from Aug 2012 ongoing

- Daily updated at iup.uni-bremen.de:8084amsr2



1.6 ESA's Climate Change Initiative CCI

- provides 13 highly stable, long-term satellite-based time series of essential climate variables
- that have been addressed via the
  - Global Climate Observing System (GCOS) and
  - the Committee on Earth Observation Satellites (CEOS).
- The sea ice CCI project, lead Stein Sandven, will provide *quality-controlled*
  - *Ice concentration and*
  - *Ice thickness*

  data sets for the Arctic and Antarctic from 1979 to present, based on passive microwave data.
- To this end, a set of natural and synthetic sea ice key conditions has been identified.

Aerosols
Clouds
Fire
Greenhouse Gases
Glaciers
Land Cover
Ocean Color **Ozone** **Sea Level** **SST** **Sea Ice** **Soil Moisture** **Ice Sheets**

ESA's Climate Change Initiative: Essential Climate Variables Sea Ice

- 19 ice concentration algorithms
- Without weather filters
- Test results on
  - –Natural scenes:
    - •100% ice concentration from SAR converging drift,
    - •0% concentration, and
    - •thin ice from SMOS
    - •Summer ice with melt ponds
  - –Synthetic scenes: 15%, 25%, 75%, 85% concentration
  - –2008 Wentz AMSR-E L2A TBs V10
  - –Averaged to 70 km (footprint @ 6.9 GHz)

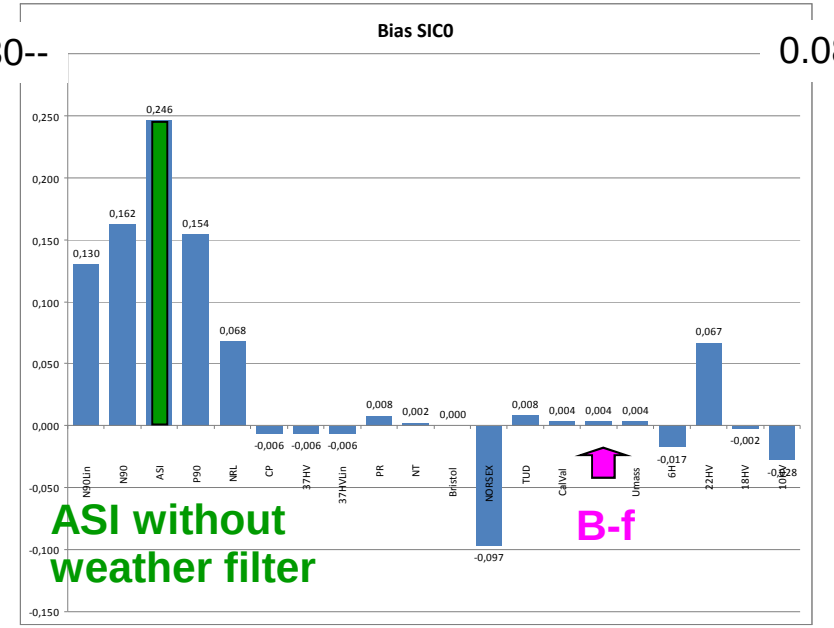
Some example results (from Leif Toudal, Robert Saldo, Natalia Ivanova and complete SICCI team):

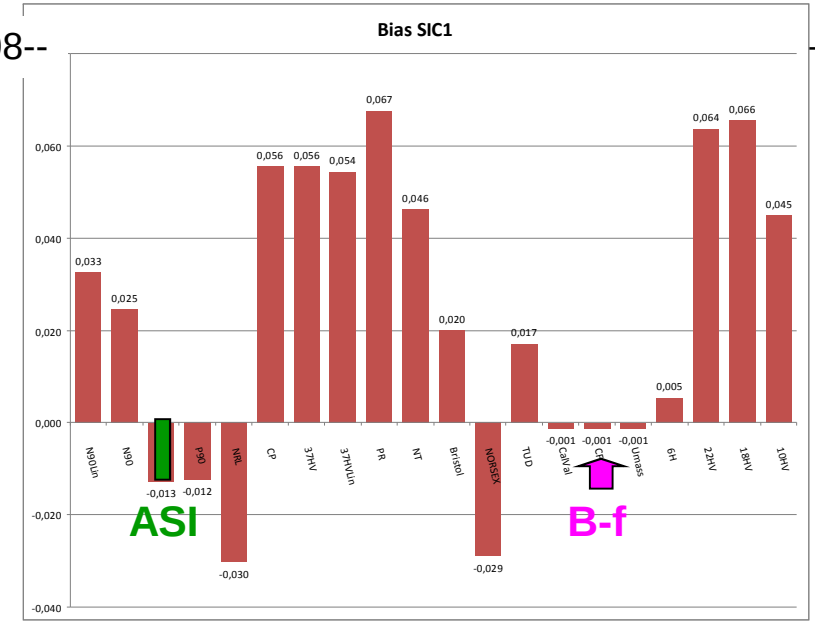
One-Channel
Bootstrap-f
Cal/Val
UMass_AES
Two-Channel10
NASA-Team
Bristol
PR
Two-Channel18
TUD
Two-Channel23
Bootstrap-p
Two-Channel-37
Two-Channel37_lin
NRL
Near90_lin
Near90GHz
ASI
P90

Ice Concentration = 0

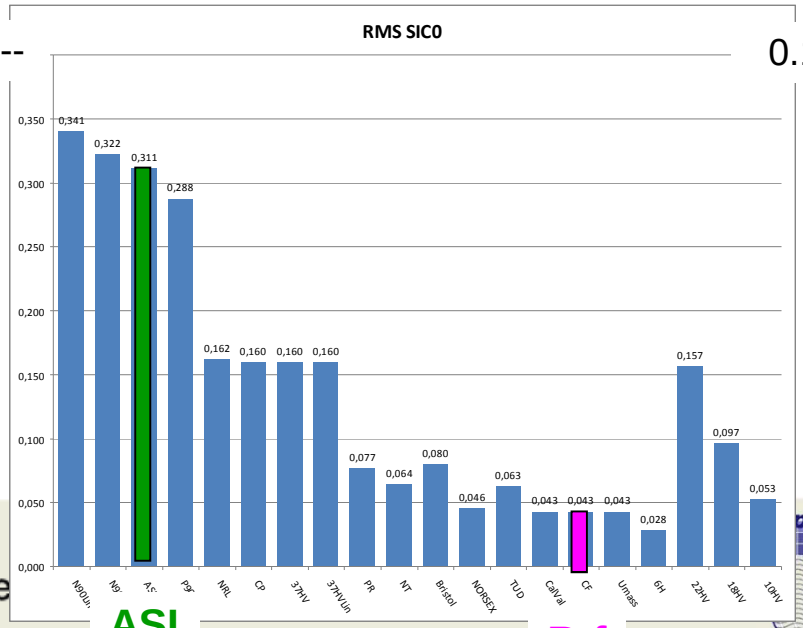
Ice concentration = 1

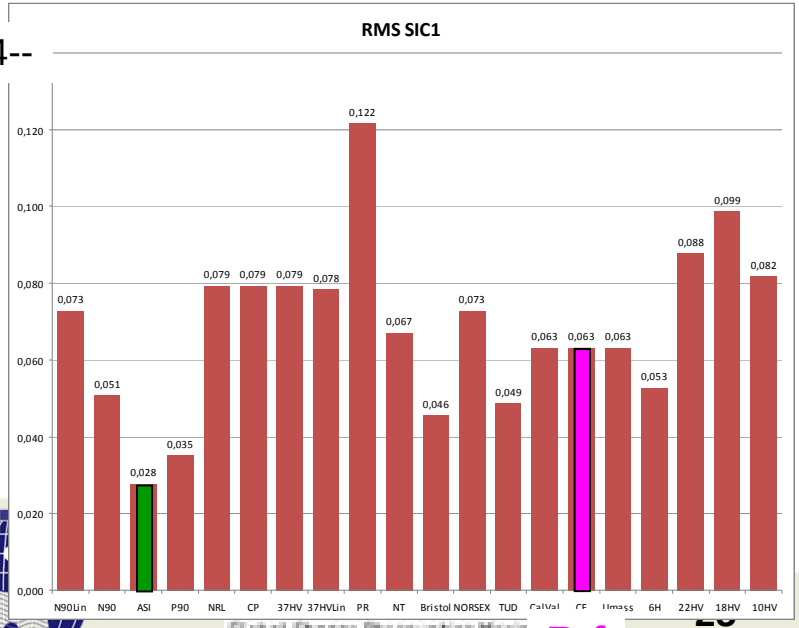
Bias



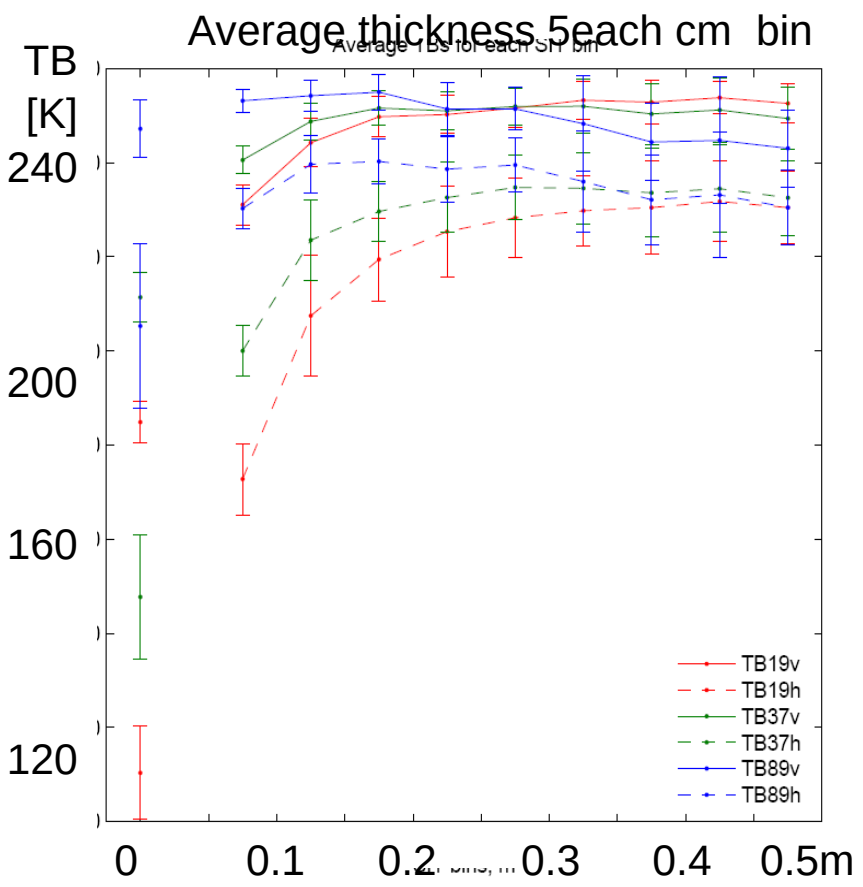


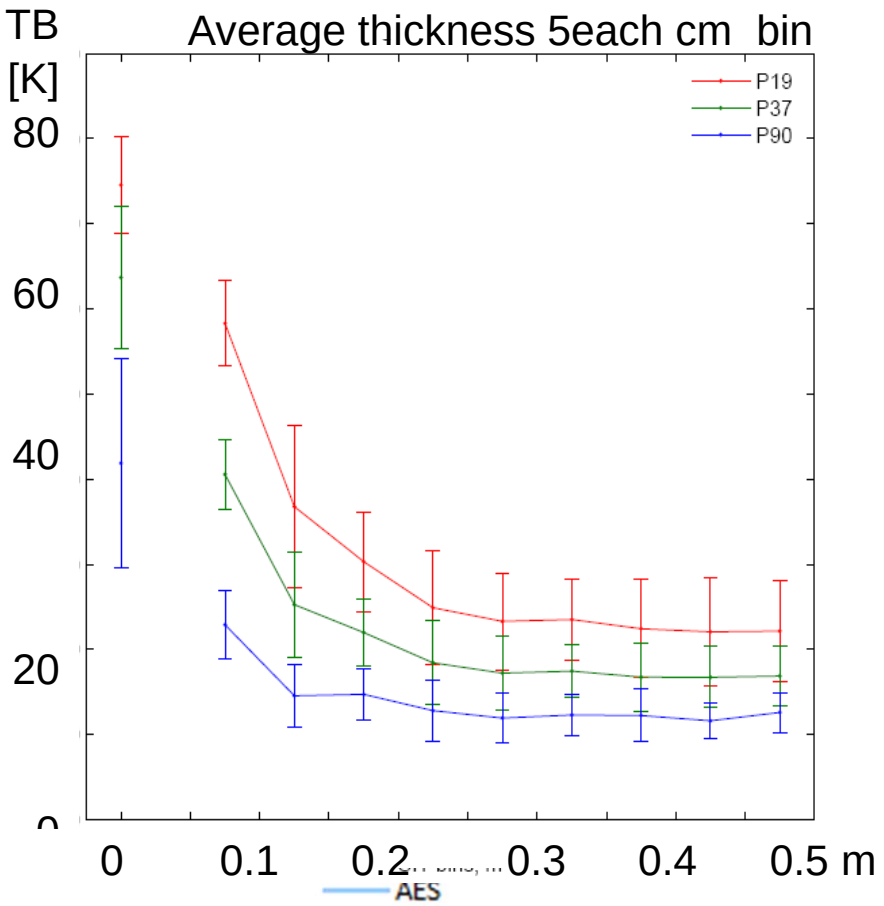
RMS





Role of thin ice – retrieved from SMOS + SAR

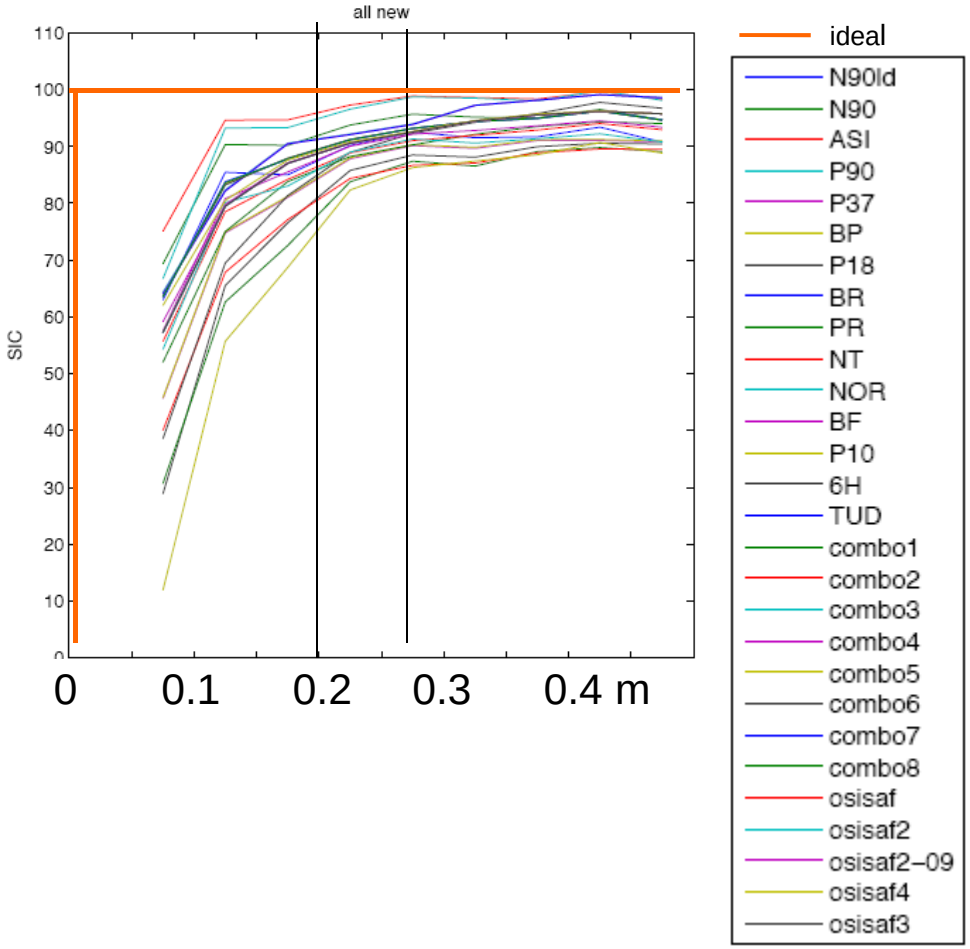




- Thickness influence starting between 0.1 m (89GHz) and 0.2 m (19 GHz)
- TB decreasing towards OW, more pronounced for TBh than TBv
- TB slightly decreasing towards high SIT, most pronounced 89H
- Polarization Difference increasing towards OW

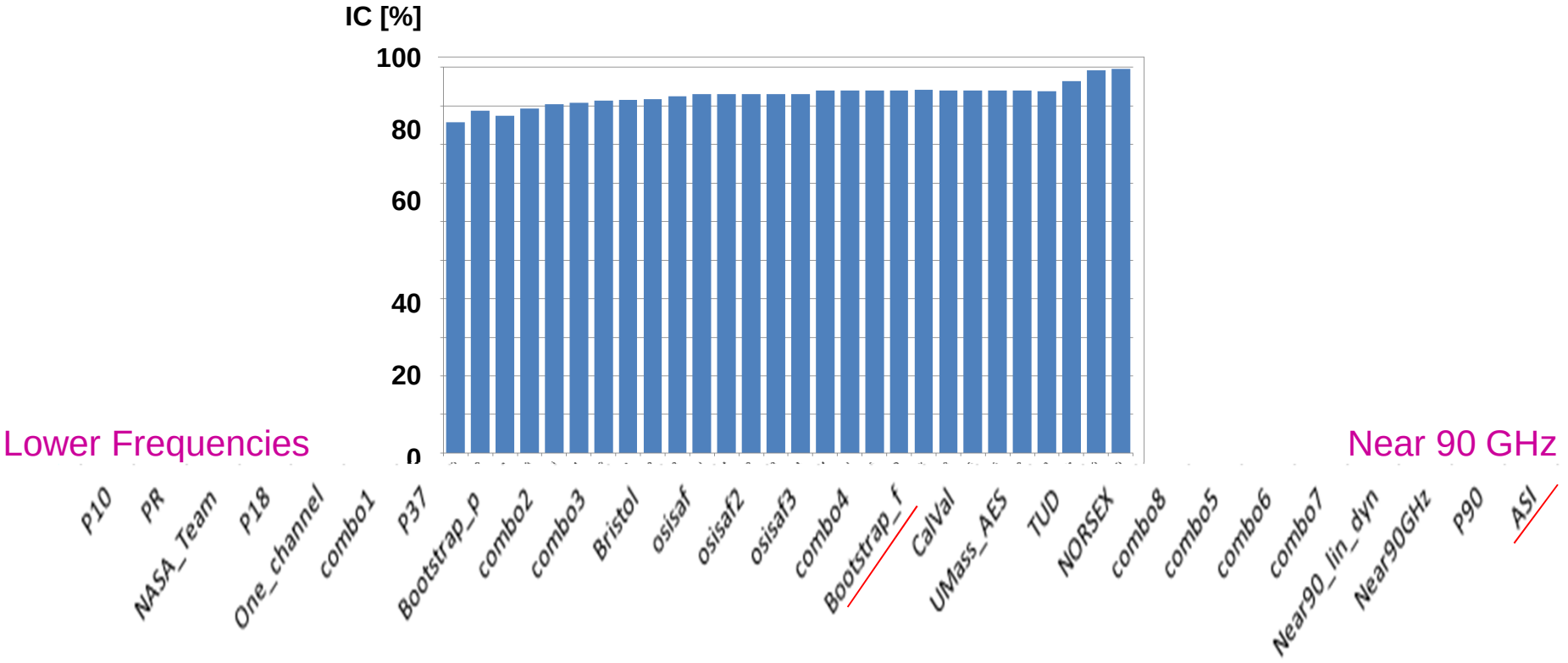
Influence of thickness on ice concentration retrieval

all algorithms



Onset of thickness influence between 0.2 and 0.27 m SIT

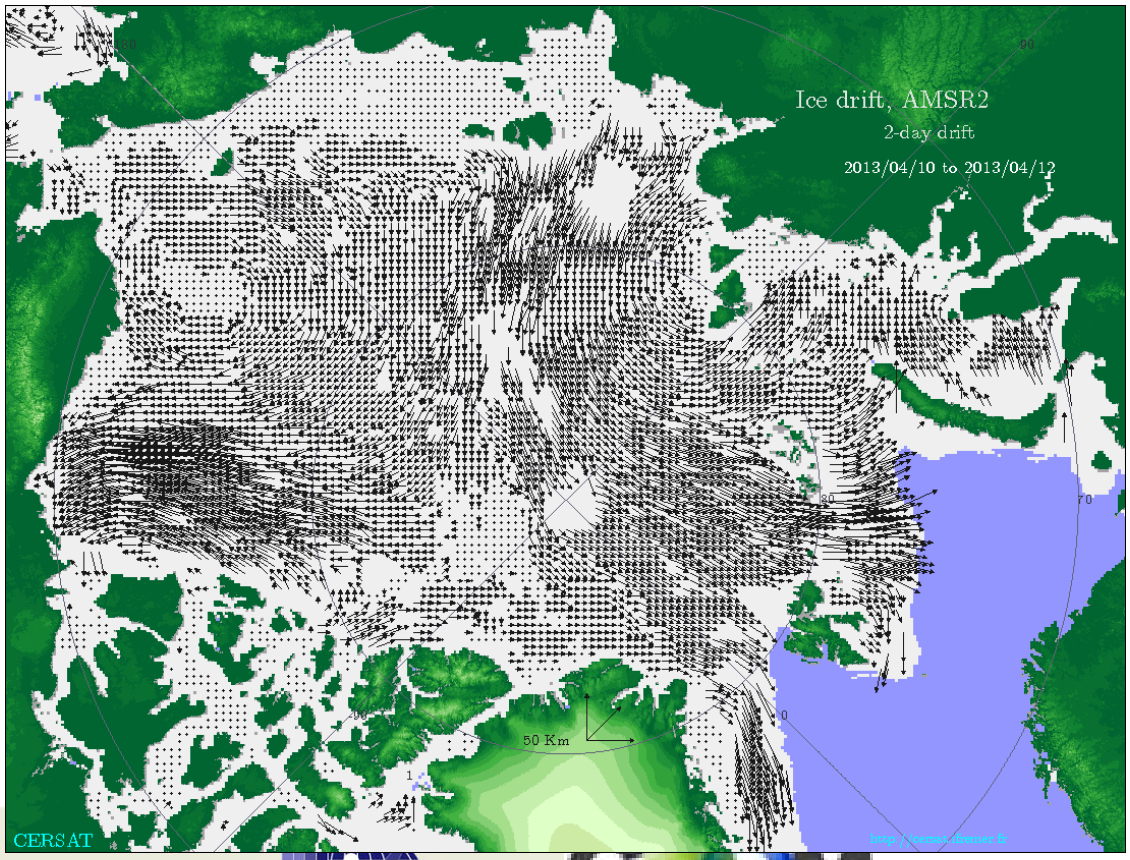
SIC estimations for 25 cm thick ice



SICCI project will construct best algorithm form b-f and Bristol to build time series, including individual error estimates

3. Sea Ice Drift

- Maximum Cross Correlation (MCC) of image pairs
- Done at
    1. IFREMER, Brest (France)



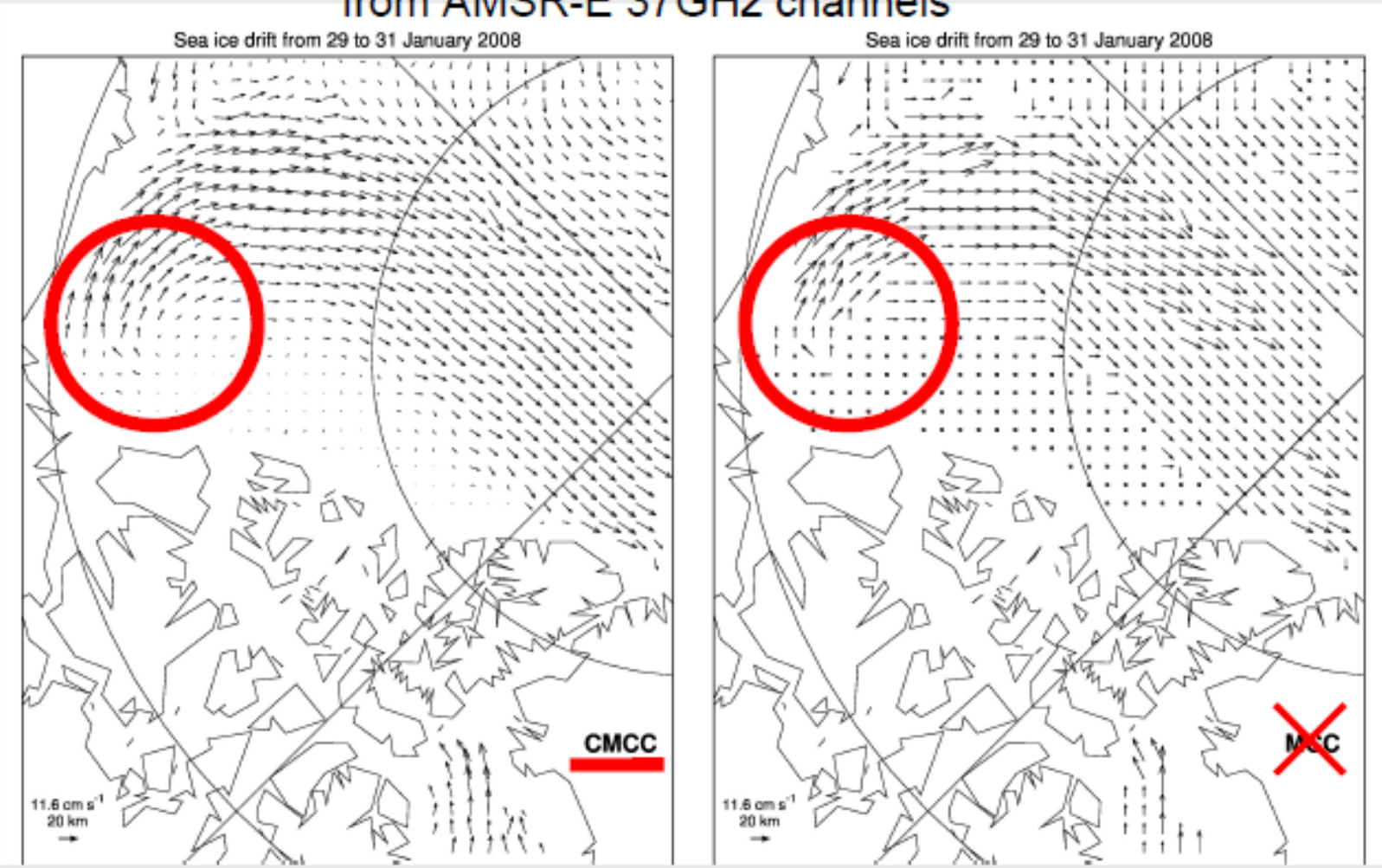
3. Sea Ice Drift

- Maximum Cross Correlation (MCC) of image pairs
- Done at
  1. IFREMER, Brest (France)
  2. MET. Norway, Oslo (T. Lavergne),
     EUMETSAT's Ocean and Sea Ice Satellite Application Facility
     www.OSISAF.metno.no

     – Continuous MCC (CMCC)
     – Various sensors and combinations of SSM/I, AMSR-E/2, scatterometer

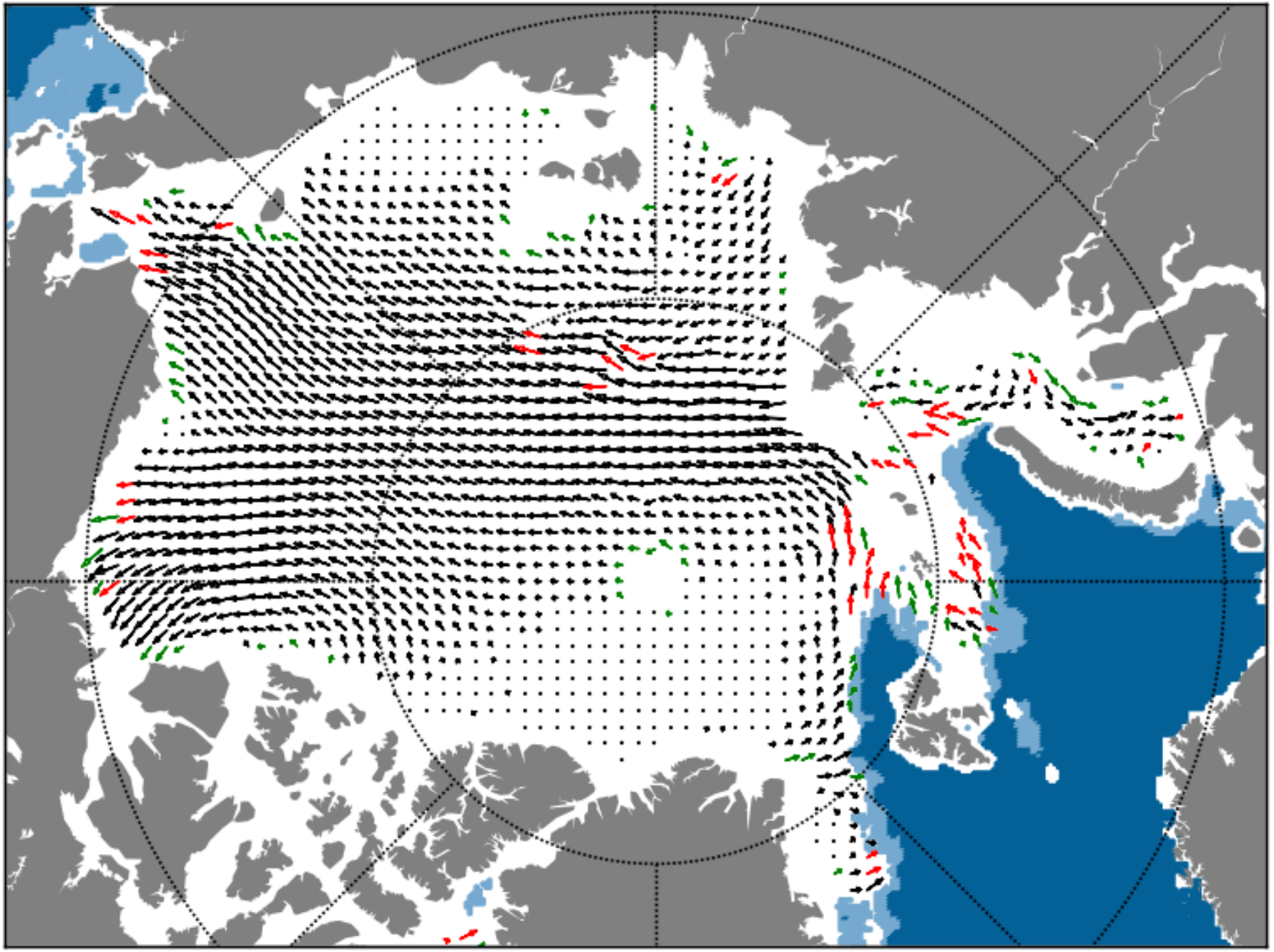
3. Sea Ice Drift

from AMSR-E 37GHz channels



Lavergne *et al.* 2010 Sea ice motion from low resolution satellite sensors: an alternative method and its validation in the Arctic. J. Geophys. Res., 115, C10032, doi:10.1029/2009JC005958.

AMSR-GW1 / 2014-01-10 to 2014-01-12



Zone: Arctic Ocean / Image: Copyright (2014) EUMETSAT

Sea ice motion from AMSR2 at Met Norway

- Motion implemented at OSISAF with SSMIS and ASCAT ,
  can be produced from AMSR2 quite soon (in 2014)

- Met Norway reads currently NRT L1 Tbs from JAXA's SFTP service

- discussions between JAXA and EUMETSAT for dissemination of
  NRT L1 Tbs over EUMETSATCast

- Target accuracy 5 km RMSE for 2-days drift position:
  Reached with ASCAT and SSMIS,
  AMSR-E/2 expected to improve greatly overall quality

4. Conclusions

- **ASI Production continuity: switched**
  - Oct 4, 2011 to SSMIS
  - Sep 7 2012 to AMSR2; released Jan 28, 2013
- **Validation under summer conditions:** looks ok, more to be done
- **Sea ice extent time series:** simple adaptation procedure
- **ESA ECV Sea Ice study: homogeneous time series**
- **ASI little sensitive to reduced ice thickness**
  SMOS based thickness (<0.5 m) + SAR used
  - compare thickness retrievals from optical, AMSR and SMOS
- **Ongoing ASI-2**: adaptive tie points, weather correction from model

Support from

Polar View

Polar Ice

ESA Climate Change Initiative – Sea Ice

Thank you for your attention

Research algorithm ASI for sea ice concentration

Name ASI – ARTIST Sea Ice algorithm (Arctic Radiation and Turbulence Interaction Study, EU project 1998-2000)

Status: ASI V5 for AMSR-E validated (3 publications below).
V5 for AMSR2 validated with Polarstern in situ observations (2013 GCOM workshop report)
V6 for AMSR2 planned with adaptive tie points, atmospheric correction.

Implementation Running operationally at UB since 2003.
Results in polar stereographic grid 6.25 (hemispherical) and 3.125 km (regional) maps in png, hdf, nc, geo-tif.

Goal accuracy:
resolution: 5 km, reached
IC: 5% in inner ice pack, 10% in marginal ice zone (Spreen et al. 2008)

Validation plan:
V5 validated with Landsat, SAR, in situ Polarstern and large-scale comparison with NT and Bootstrap (Spreen et al. 2008, Heygster et al. 2009, Wiebe et al. 2009)

V6 validation planned with open water and 100% ice concentration data as done for ASI V5 in ESA intercomparison study SICCI.

References for ASI Validation

Heygster, G., H. Wiebe, G. Spreen, L. Kaleschke 2009:
AMSR-E geolocation validation of sea ice concentrations based on 89 GHz data.
J. of the Remote Sens. Soc. of Japan 29(1), p. 226-235.

G. Spreen, L. Kaleschke and G. Heygster 2008:
Sea ice remote sensing using AMSR-E 89 GHz channels.
J. Geophys. Res 113, C02S03.

Wiebe, H., G. Heygster, T. Markus 2009:
Comparison of the ASI Ice Concentration Algorithm With Landsat-7 ETM+ and SAR Imagery,
IEEE Transactions on Geoscience and Remote Sensing 47(9), p. 3008-3015.

Backup Slides

SMOS (Soil Moisture and Ocean Salinity)

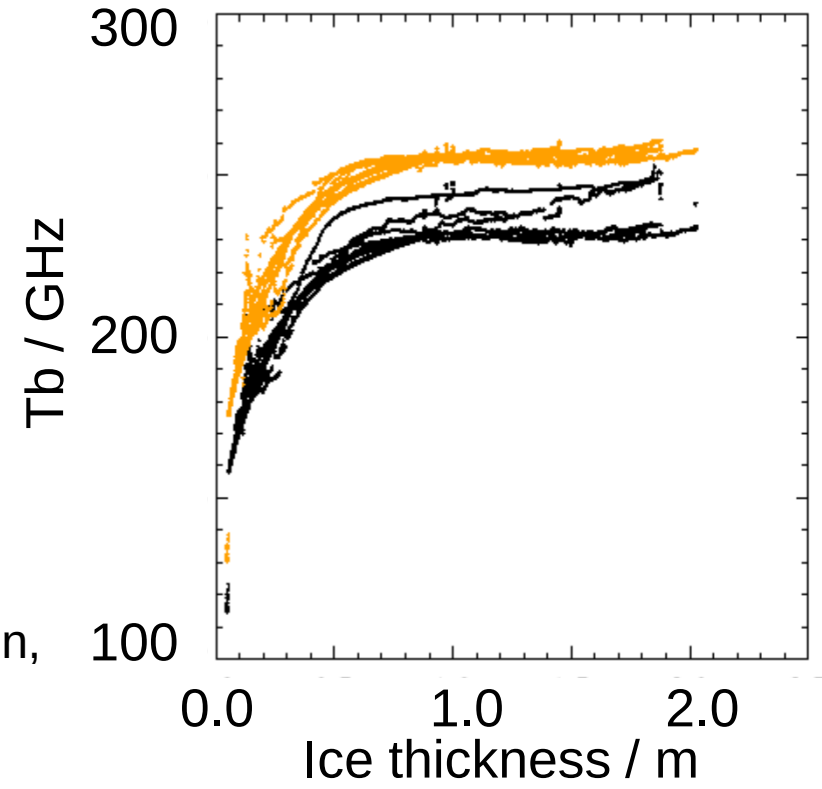
SMOS observes daily and globally at 1.4 GHz

What can it tell us about sea ice?
About ice thickness?

SMOS-Ice: ESA STSE project

(Support To Science Element) :

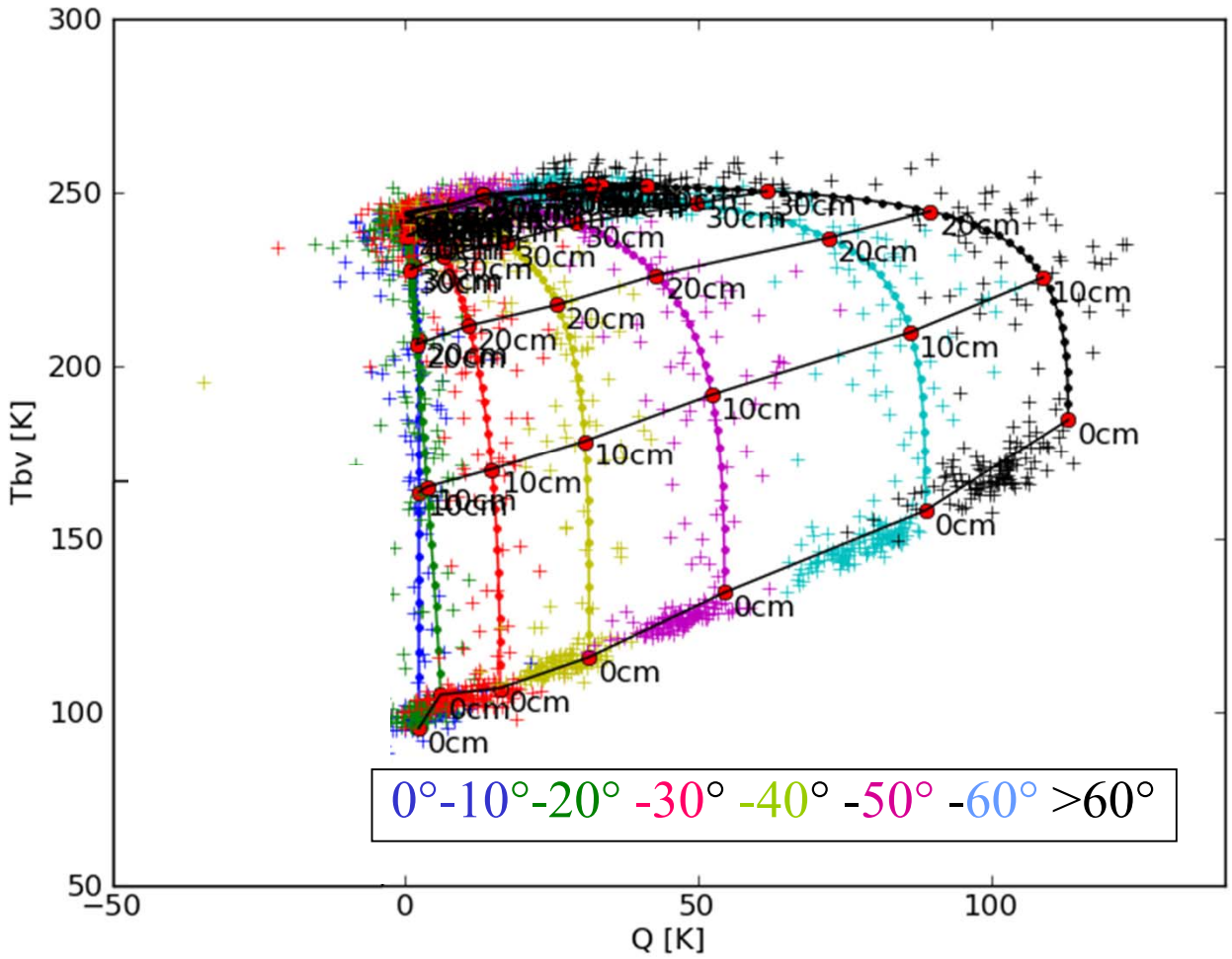
- U Hamburg (lead L. Kaleschke)
- U Bremen
- FMI Finish Met Institute
- DMI Danish Met Institue
- AWI Alfred Wegener Institute Bremerhaven, Germany



(R. Tonboe, DMI in Heygster et al. 2009)

Here reporting only U Bremen results

Retrieval curve for all incidence angles ϑ, 10° intervals



Tbv:

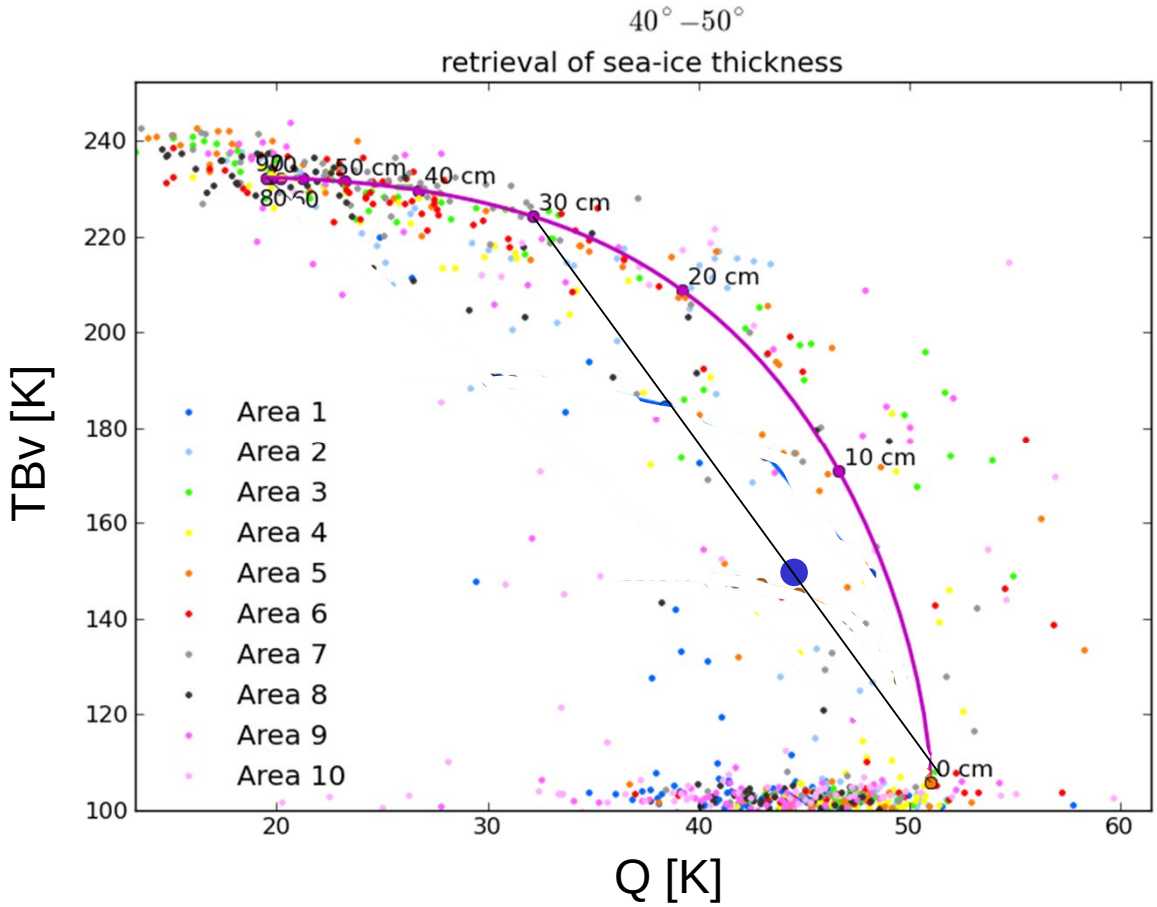
dynamic range decreases with ϑ

Q:

range increases with ϑ

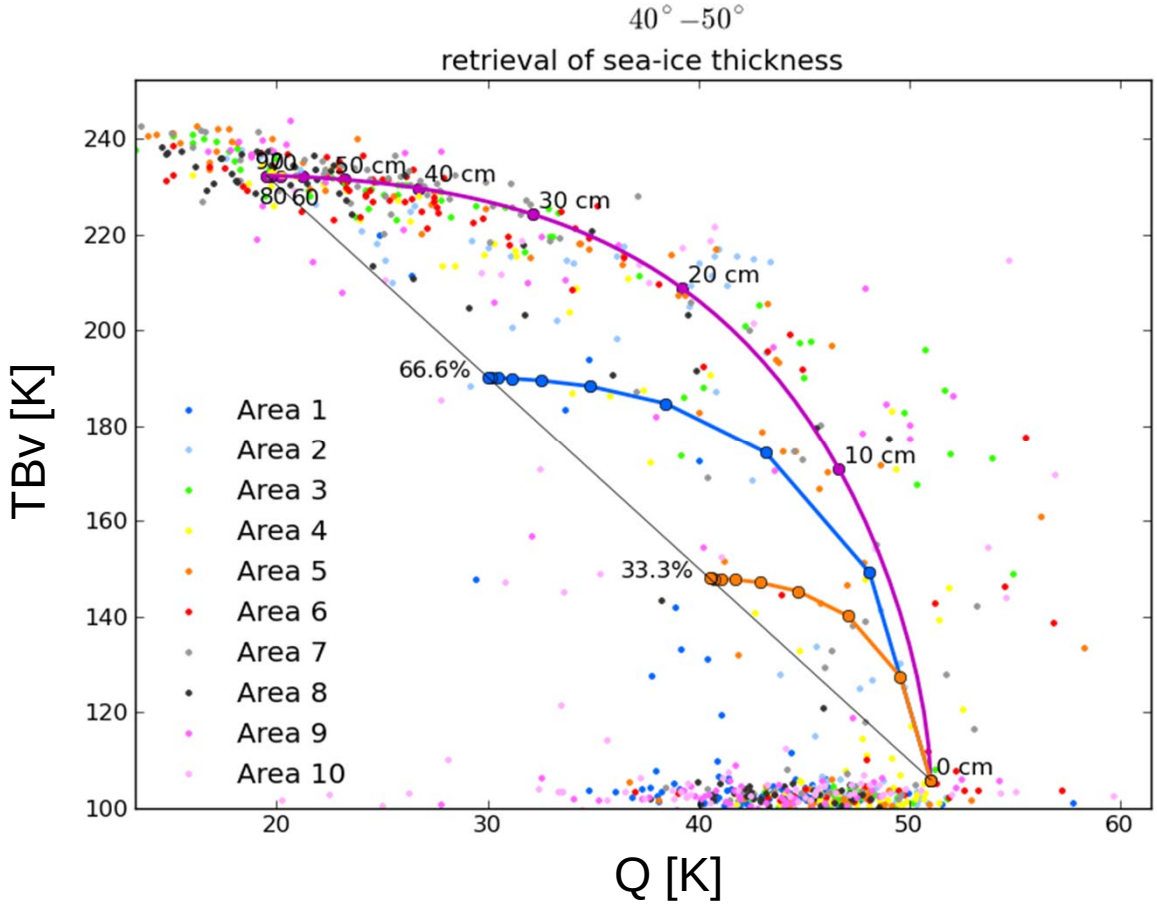
Use both to stabilize retrieval

Potential to retrieve thickness and concentration



- 2 input parameters Tbv, Q:
- Chance to retrieve 2 parameters:
  = 40% ice, 30 cm thick
  + 60% open water
- Requires curved retrieval line →
  higher incidence angle

Potential to retrieve thickness and concentration



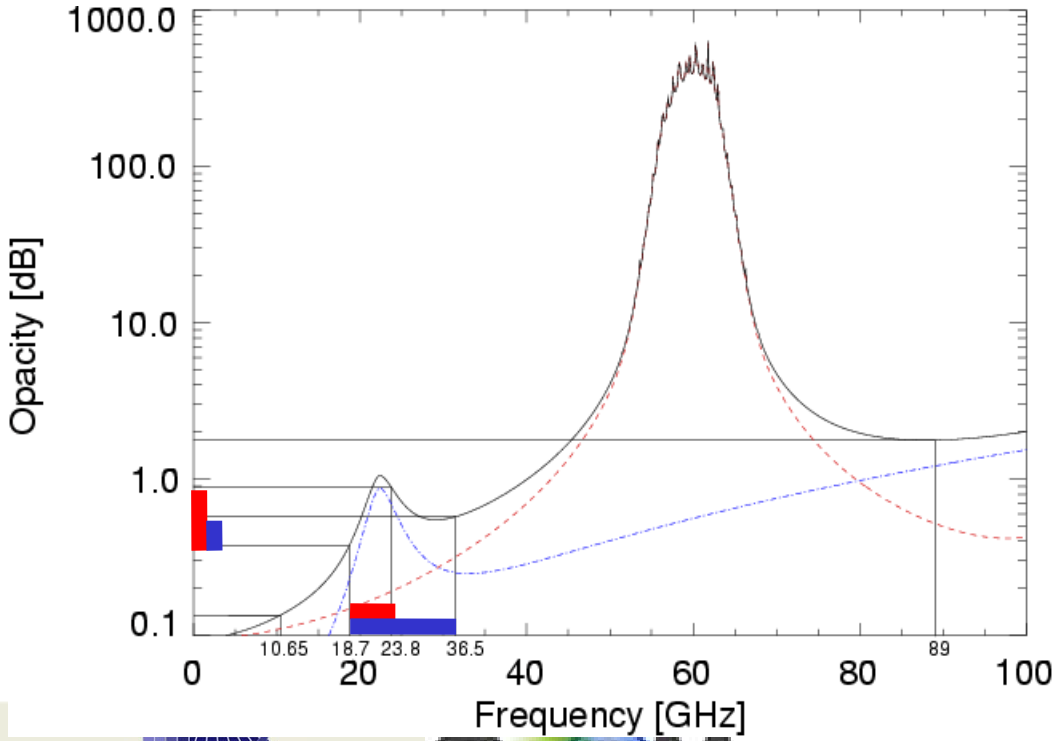
Approach 2:

- Ice concentration from AMSR
- adjust thickness retrieval to known concentration

ASI algorithm (2)

Hybrid algorithm:

- Modified 89 GHz Svendsen et al. (1987) algorithm for ice covered regions → *higher resolution*
- Lower frequencies for ice-free ocean → *less atmospheric effects*
- 3 weather filters:
  - GR(36/19),
  - GR(24/19),
  - Bootstrap algorithm (where *C*=0)



Svendsen et al. 1997

Kaleschke et al. 2001