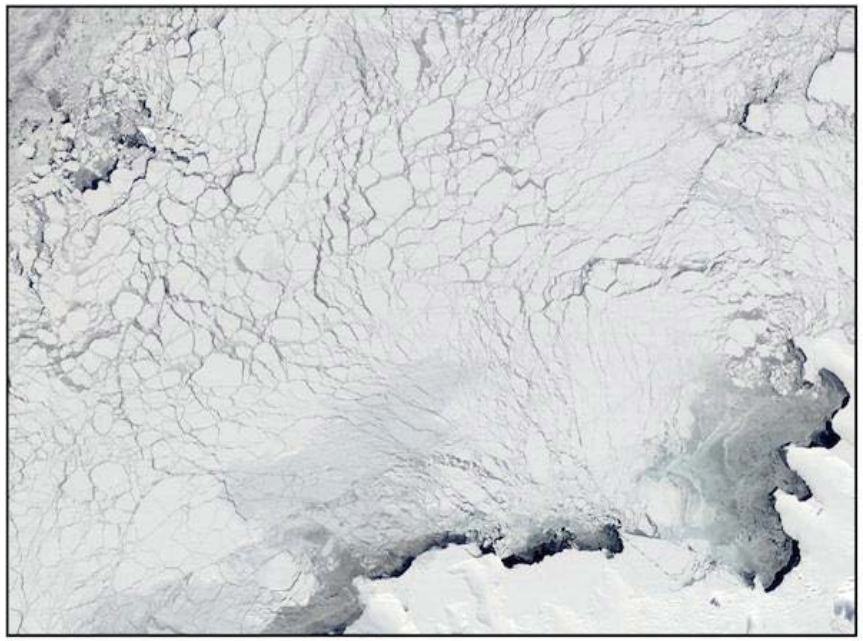
NOAA AMSR2 SNOW AND ICE PRODUCTS



Jeff Key

NOAA/NESDIS
Madison, Wisconsin USA

AMSR-2 Snow and Ice Products

- **Snow Cover** (SC) – Presence/absence of snow
- **Snow Depth** (SD) – The depth of snow on land
- **Snow Water Equivalent** (SWE) – The amount of water in the snowpack
- Sea Ice Characterization (SIC) –
  - **Ice concentration** (area fraction in a pixel)
  - **Ice type** or Age class (first-year or multiyear ice)

Snow and ice algorithms are built around heritage products with important, but low-risk, improvements.

All products are now operational (September 2016 for snow; March 2017 for ice).

Team Members

EDR	Name	Organization
Lead; Snow, ice	Jeff Key	NESDIS/STAR
Wisconsin:		
Snow products	Yong-Keun Lee	CIMSS/U. Wisconsin
Maryland:		
Snow	Cezar Kongoli	CICS
Colorado:		
Sea ice	Walt Meier	NSIDC (formerly NASA GSFC)
Sea ice	Scott Stewart	CU Contractor
Sea ice	Florence Fetterer	NSIDC

NOAA AMSR2 SNOW PRODUCTS

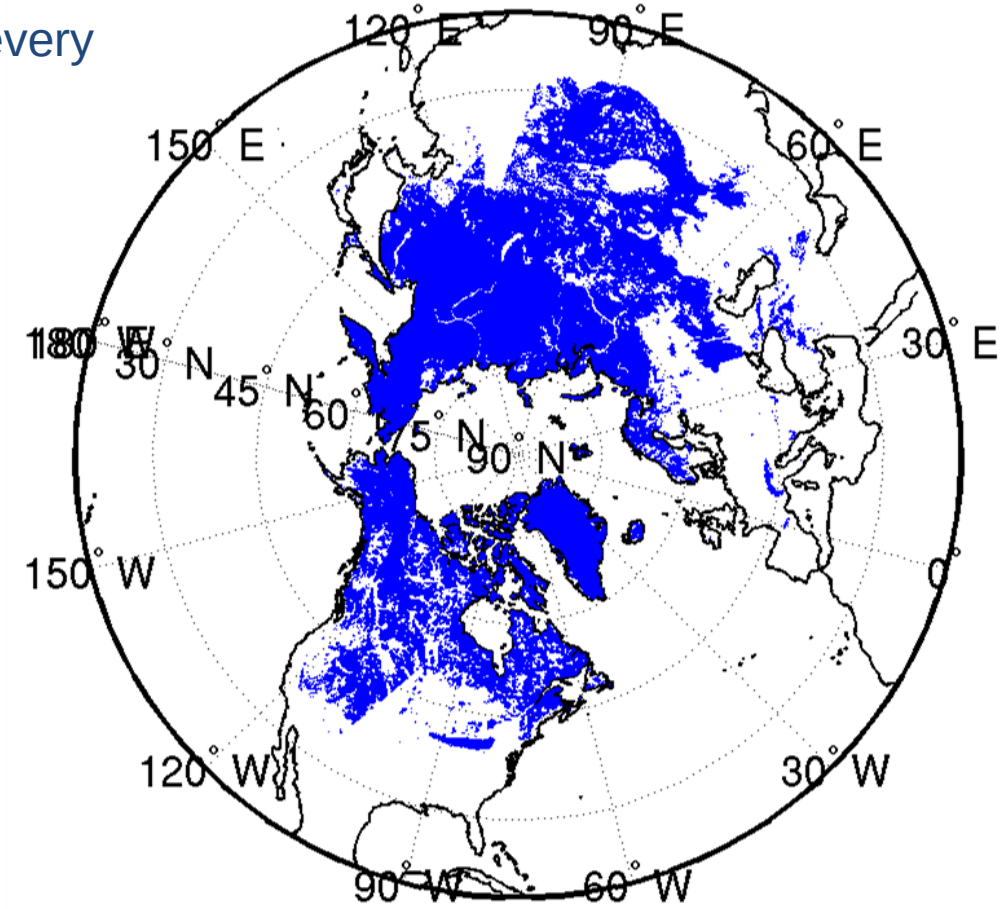
Yong-Keun Lee[1], Cezar Kongoli[2], Jeff Key[3]

[1]Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin-Madison
[2]Cooperative Institute for Climate Studies (CICS), University of Maryland
[3]NOAA/NESDIS

Product Examples: Snow Cover

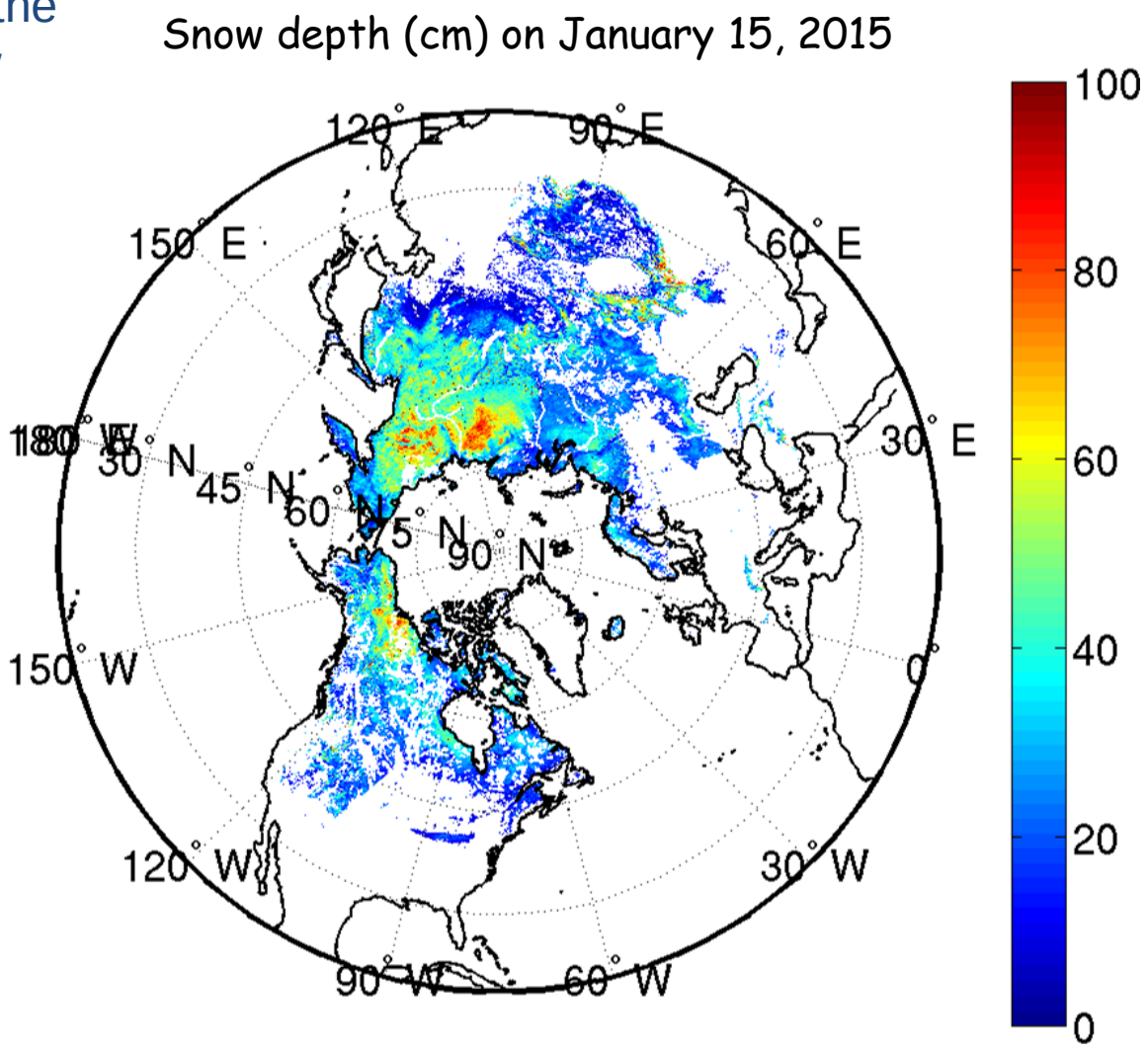
The **Snow Cover** product provides the presence/absence of snow cover for every pixel.

Snow cover on January 15, 2015



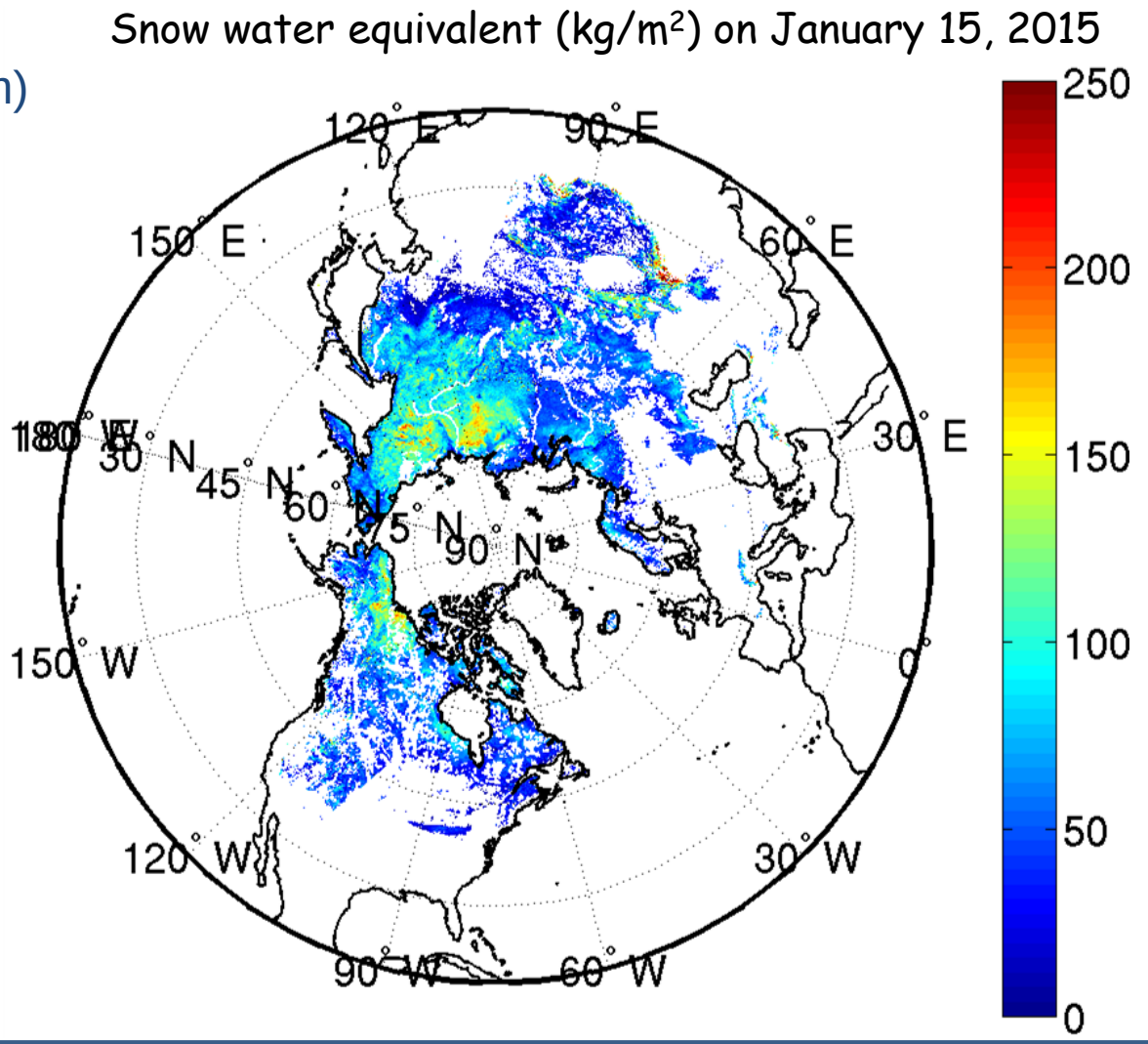
Product Examples: Snow Depth

The **Snow Depth** product provides the depth of the snow cover (cm).

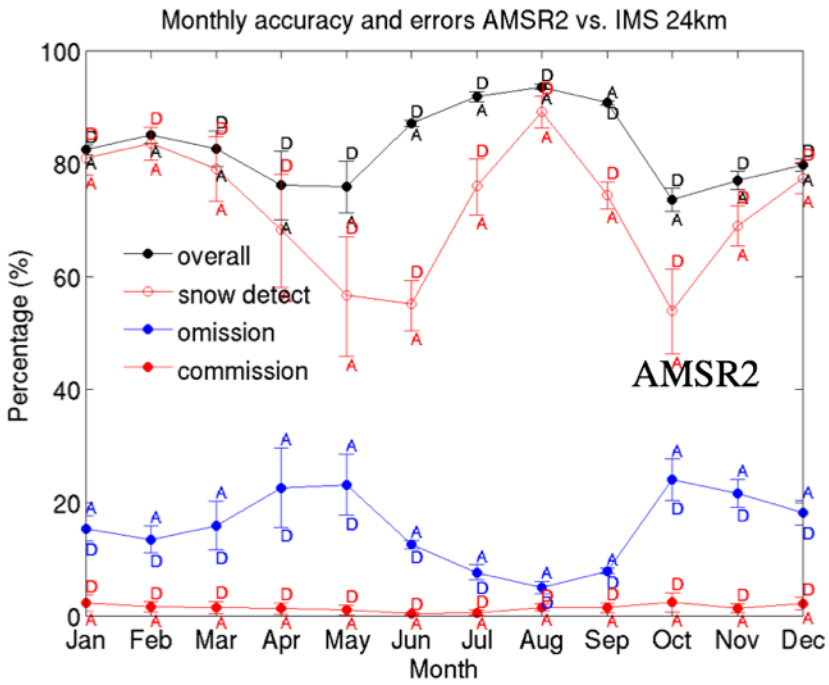


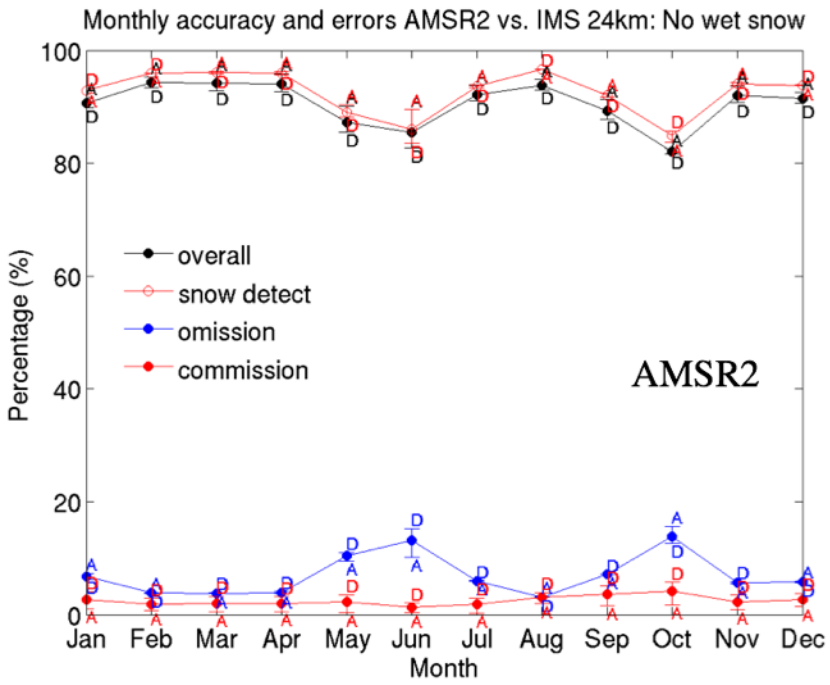
Product Examples: SWE

The **Snow Water Equivalent** (SWE) product provides the water equivalent (mm) of the snow cover.



Snow Cover Validation

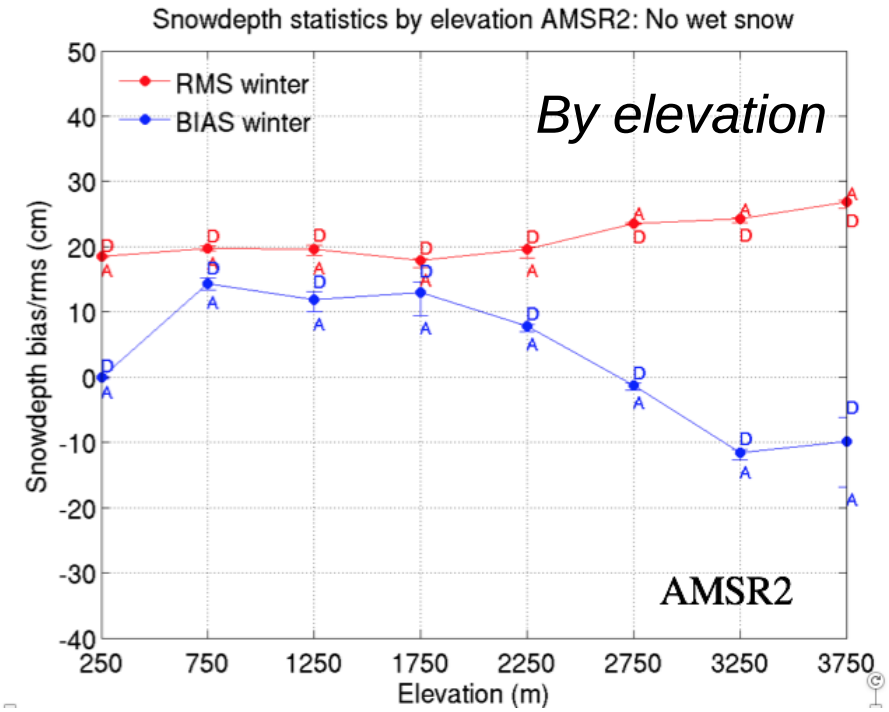


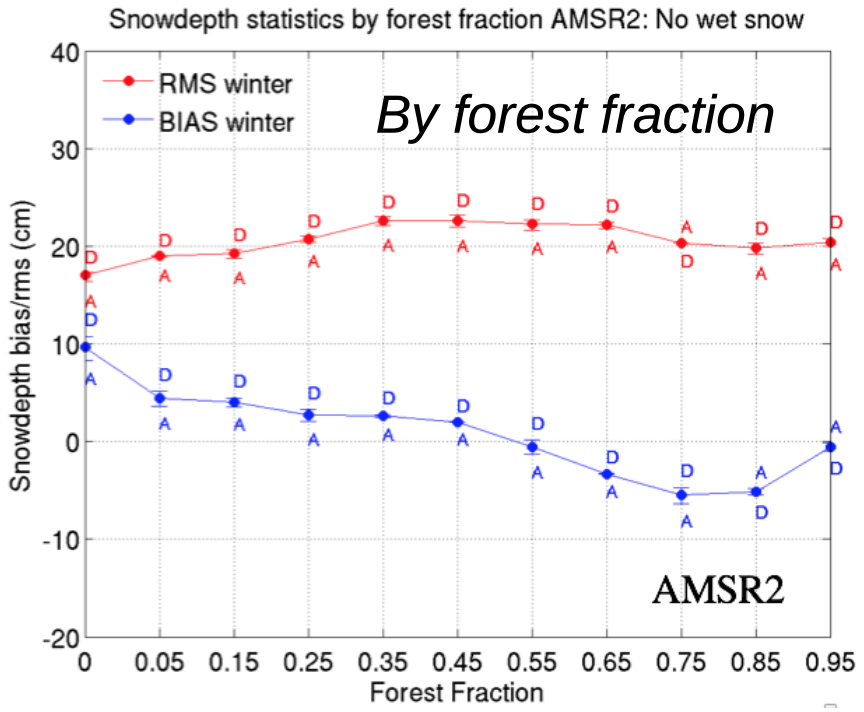


If wet snow is not included, detection accuracy is higher.

	Tundra	Taiga	Maritime	Ephemeral	Prairie	Alpine
Overall Accuracy	94.6%	97.4%	80.9%	71.7%	74.0%	86.9%

Snow Depth Validation





	Tundra	Taiga	Maritime	Ephemeral	Prairie	Alpine
RMSE (cm)	18.77	20.96	19.37	14.95	18.93	21.97
Bias (cm)	4.51	3.77	-5.34	6.05	2.75	-4.45
Mean (cm) of in-situ obs	25.10	19.18	20.20	8.40	18.49	25.14

Snow Water Equivalent Validation

SWE comparison between AMSR2 retrievals and **GHCN**

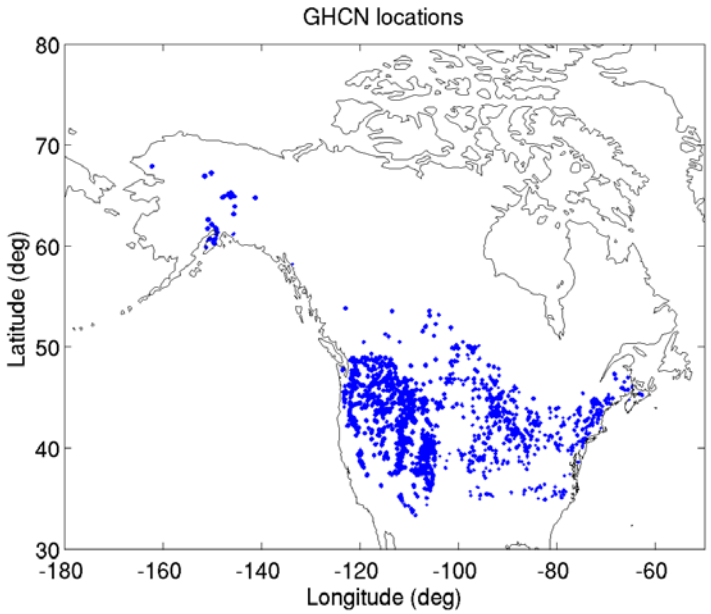
When 10 < AMSR2 SWE < 100 and 10 < GHCN SWE < 100 and the location altitude < 3000m:

bias	std	rmse	mean1	mean2	number of pixels
-7.97	30.77	31.79	46.54	54.52	45033

When 100 < AMSR2 SWE and 100 < GHCN SWE and the location altitude < 3000m:

bias	std	rmse	mean1	mean2	number of pixels
-29.91	50.91	59.05	115.56	145.47	657

mean1: average of AMSR2 SWE
mean2: average of GHCN SWE
bias: mean of AMSR2 SWE - GHCN SWE
GHCN: Global Historical Climatology Network



Error Budget

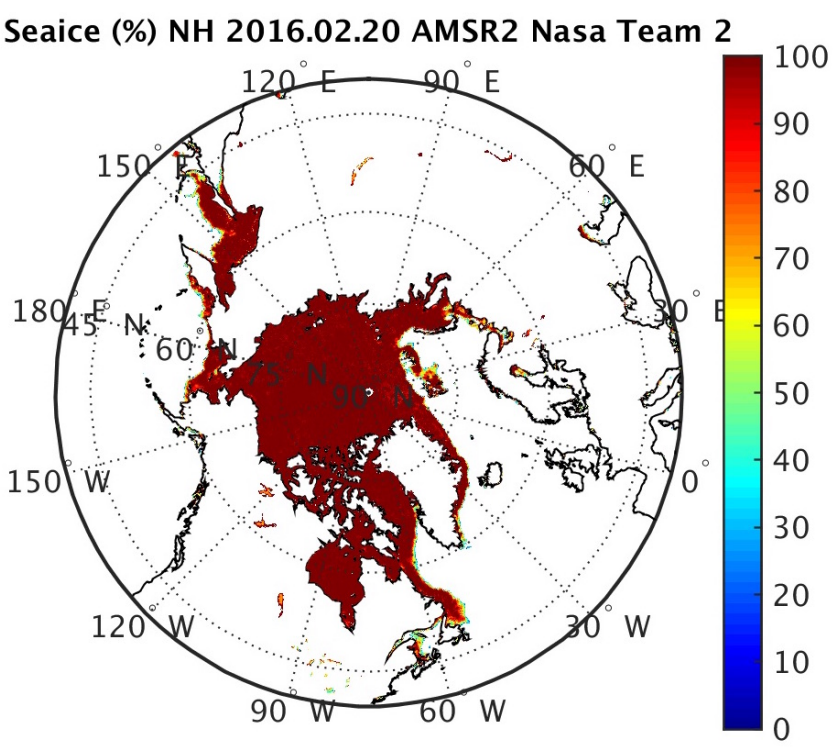
Attribute Analyzed	L1RD Threshold	Validation Result	Error Summary	Meets Requirement?
Snow cover	80% prob of correct snow/no-snow classification	72-97% correct classification	If wet snow is excluded, 90+% correct	**Y**
Snow depth	20 cm snow depth uncertainty	15-22 cm depth uncertainty	If alpine excluded, depth uncertainty < 20 cm	**Y**
SWE	50-70% uncertainty (shallow to thick snowpacks)	20-60%	Larger validation dataset would improve reliability of results. More thin snowpack cases needed.	**Y** (marginally)

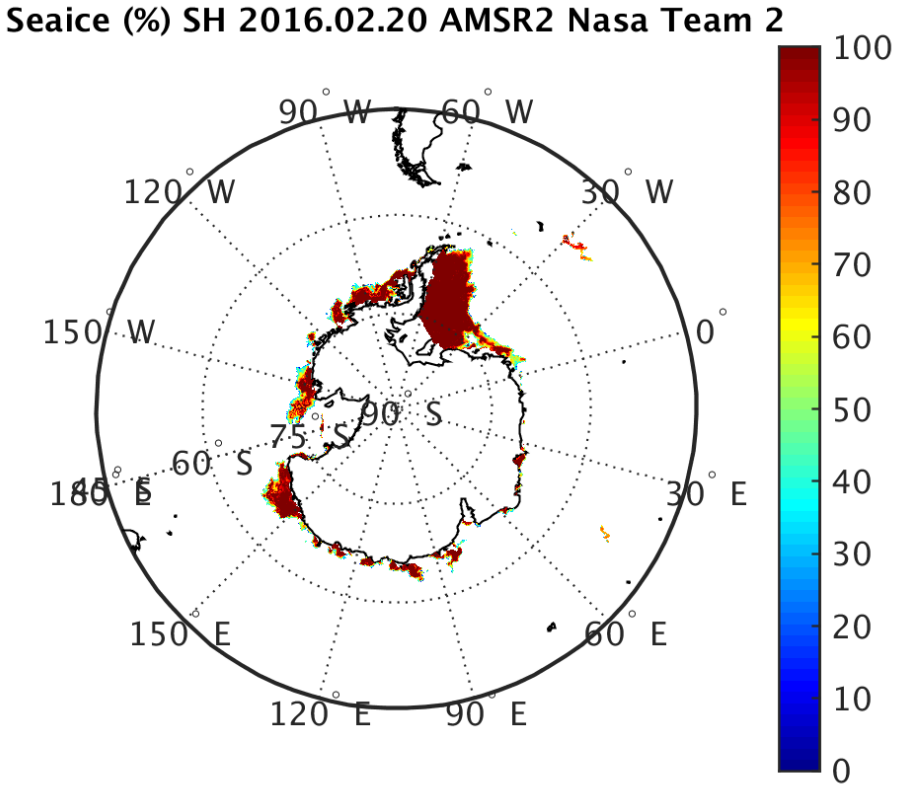
AMSR2 SEA ICE CHARACTERIZATION

Walt Meier[1] and Scott Stewart[2]

[1]National Snow and Ice Data Center (NSIDC; formerly NASA GSFC)
Cooperative Institute for Research in the Environmental Sciences
University of Colorado, Boulder
[2]NSIDC contractor

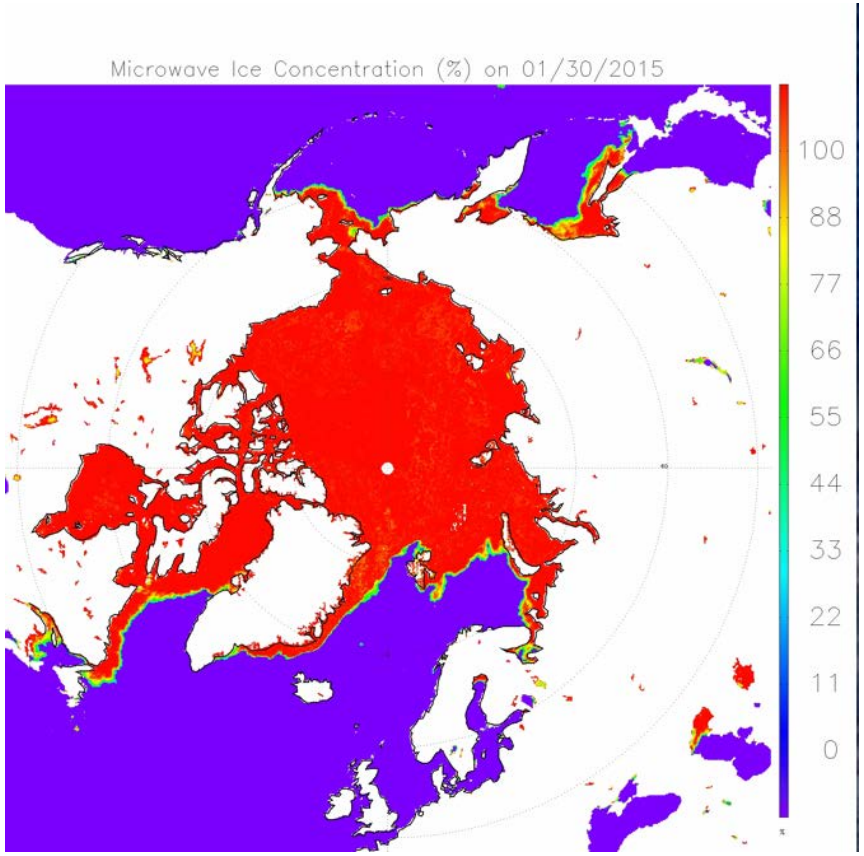
AMSR2 Sea Ice Concentration Examples



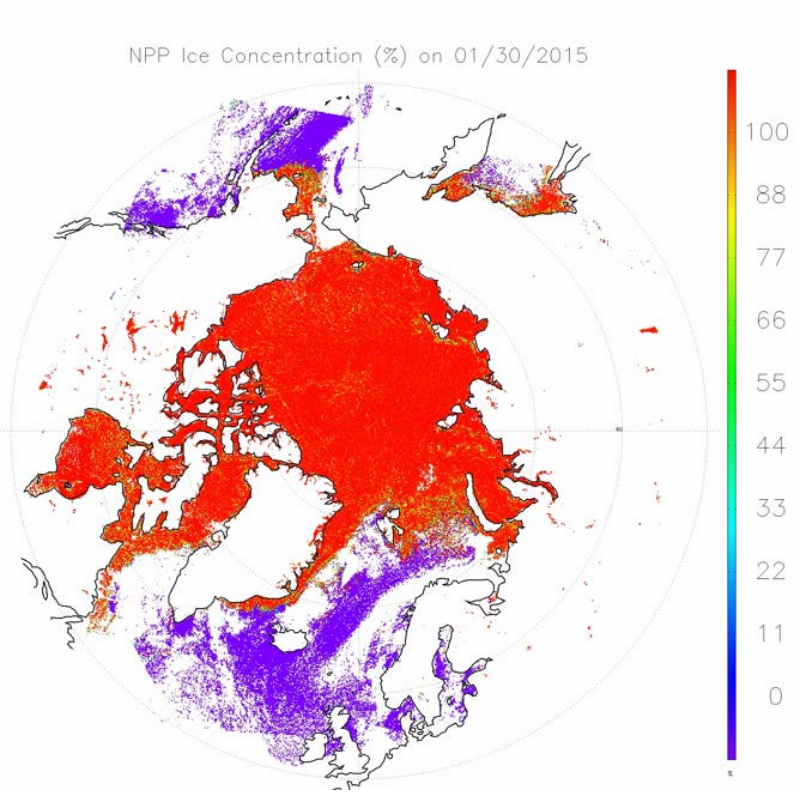


Examples of AMSR2 sea ice concentration over the Arctic (above) and Antarctic (right) on 20 February 2016.

Validation



Comparison of AMSR2 (left) and VIIRS (below) sea ice concentration over the Arctic on 31 January 2015.

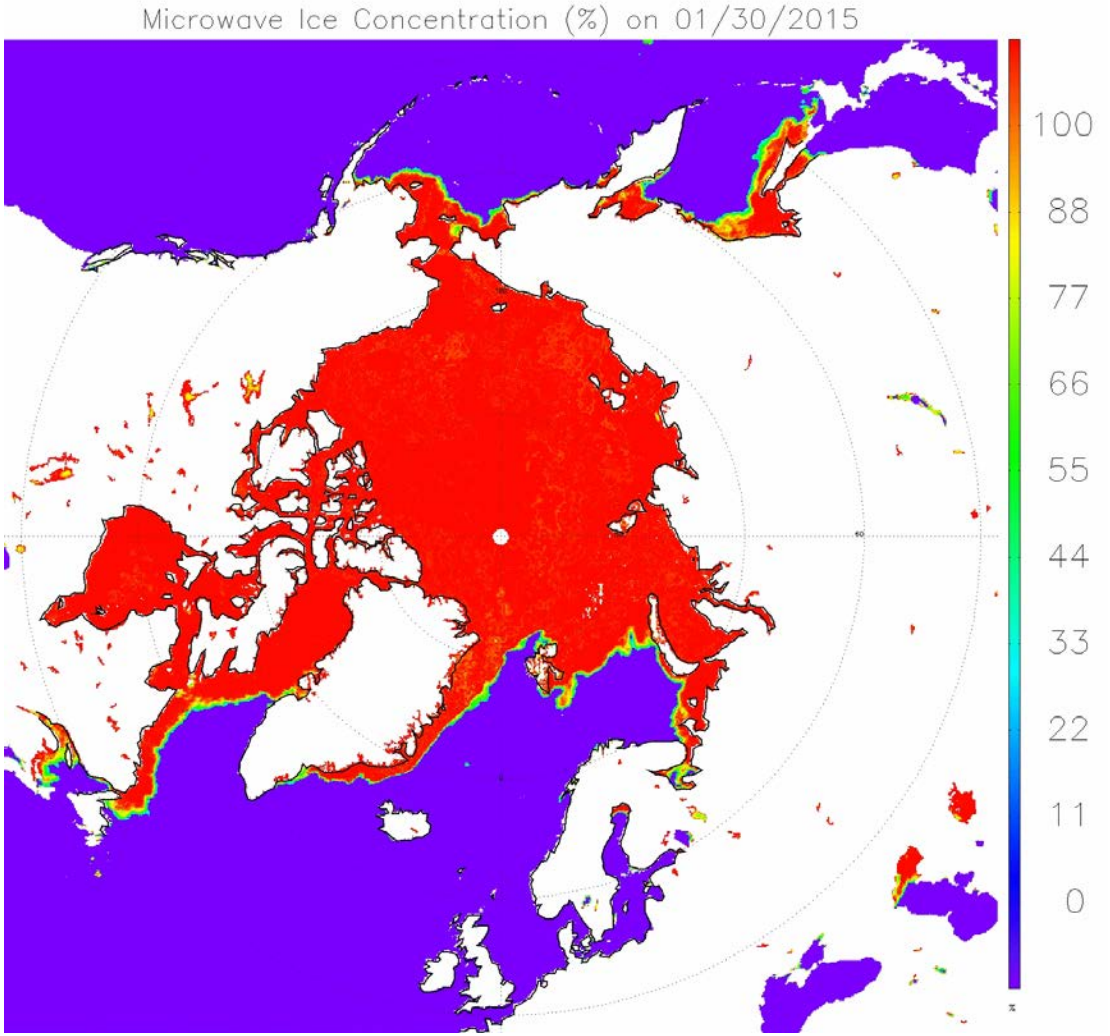


Additional information on validation is in the notes section of this slide

Sea Ice Concentration Validation

Comparison of AMSR2 and VIIRS sea ice concentration over the Arctic on 31 January 2015.

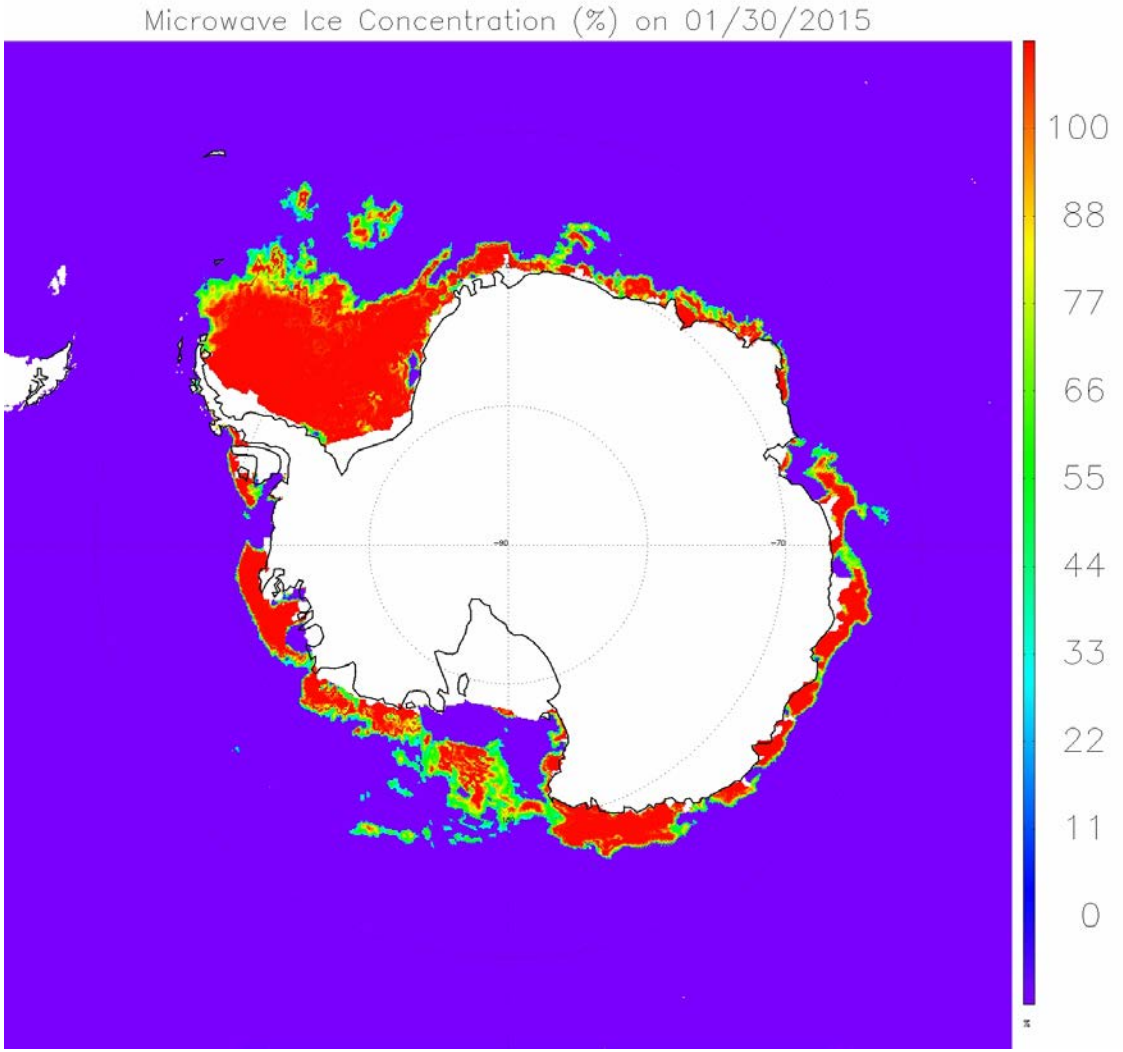
(animation)



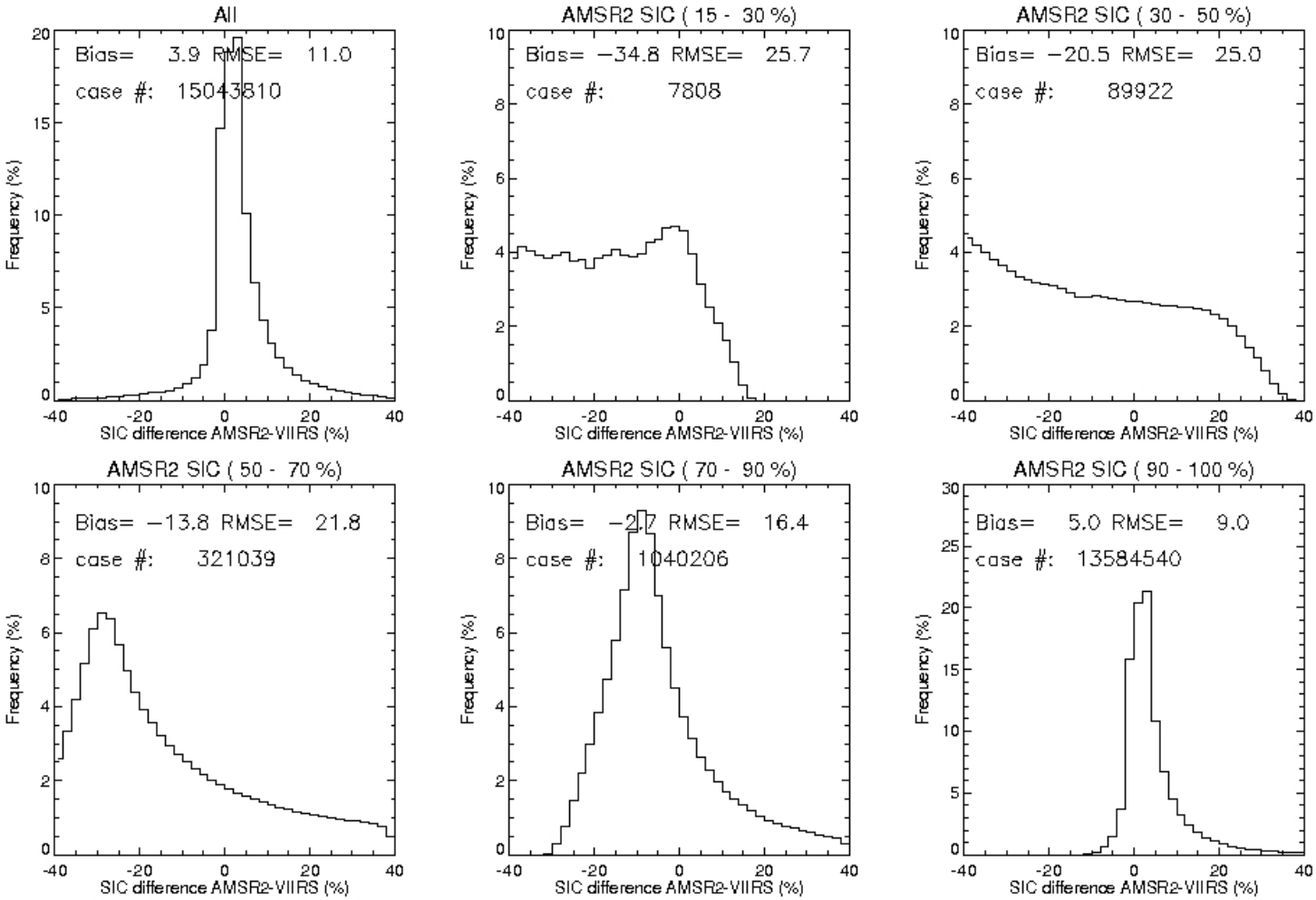
Sea Ice Concentration Validation

Comparison of AMSR2 and VIIRS sea ice concentration over the Antarctic on 31 January 2015.

(animation)

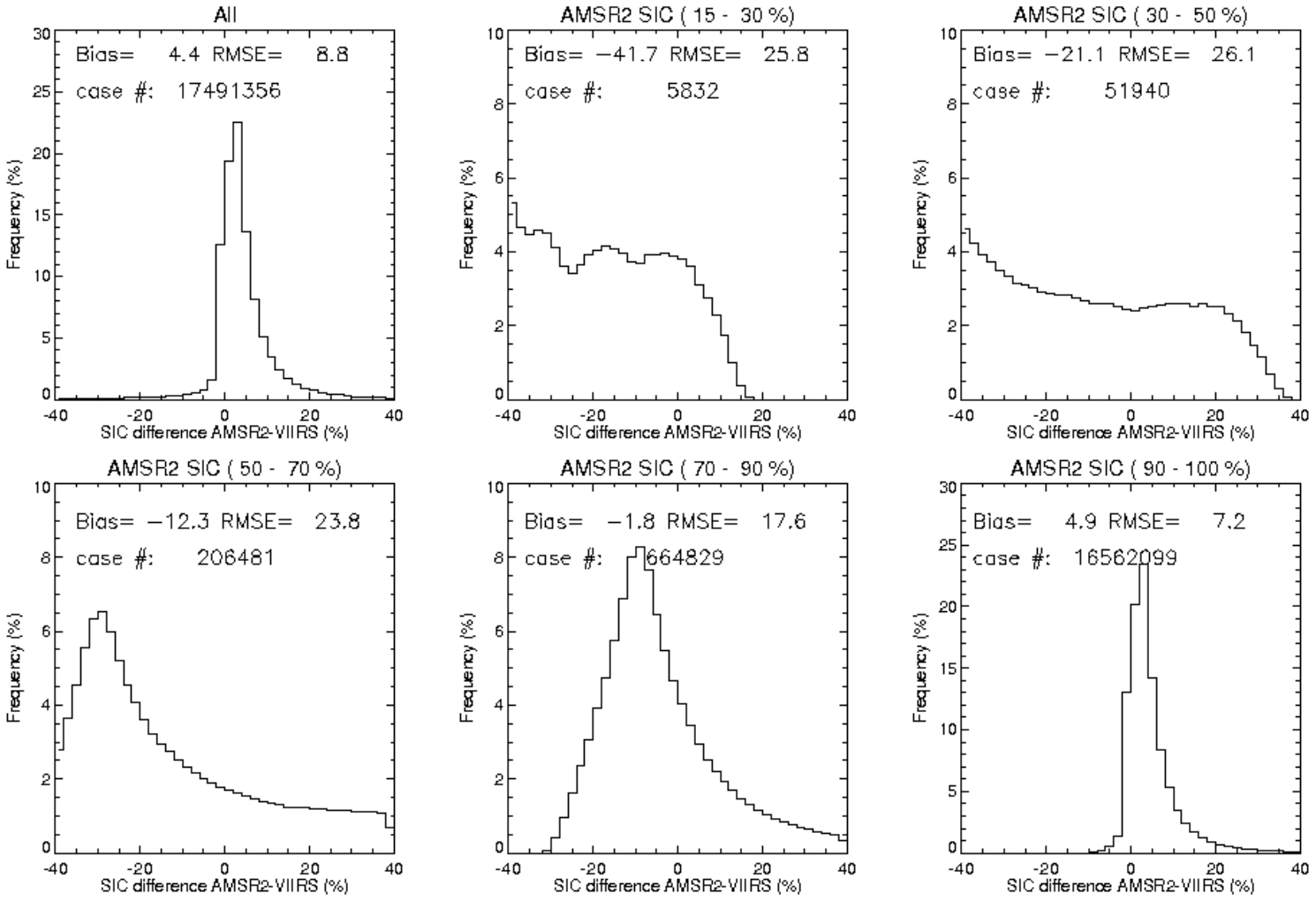


Sea Ice Concentration Validation



Comparison of AMSR2 minus VIIRS ice concentrations for different AMSR2 ice concentration ranges/bins in the Arctic. Note that the y-axis range is different for "All", "90-100%", and the other plots. Data are from January to October 2016.

Sea Ice Concentration Validation



Same as previous slide except for the Antarctic.

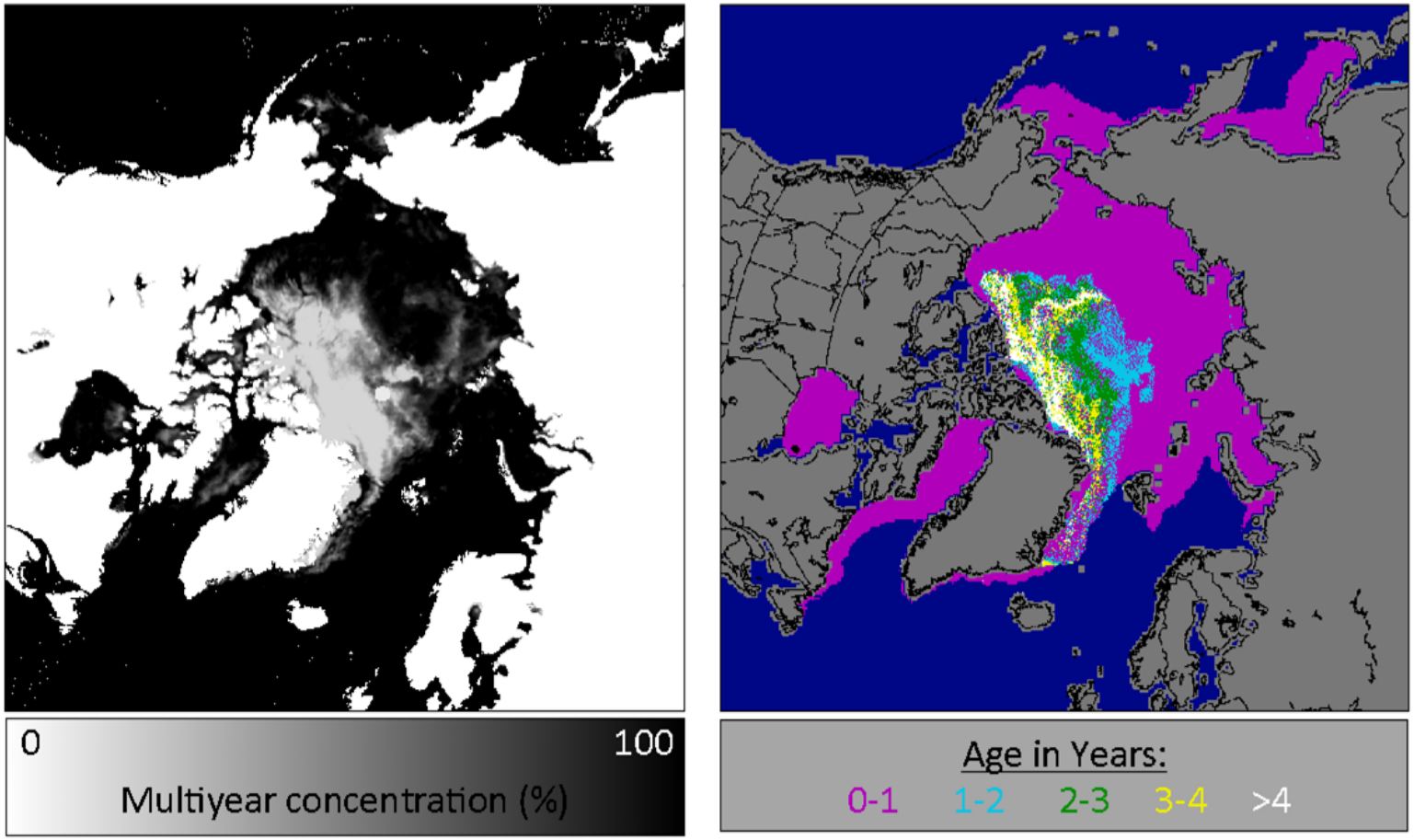
Sea Ice Concentration Validation

Statistical results of the comparison in sea ice concentration between AMSR2 and VIIRS.

Maximum (red) and minimum (blue) values in each column are highlighted.

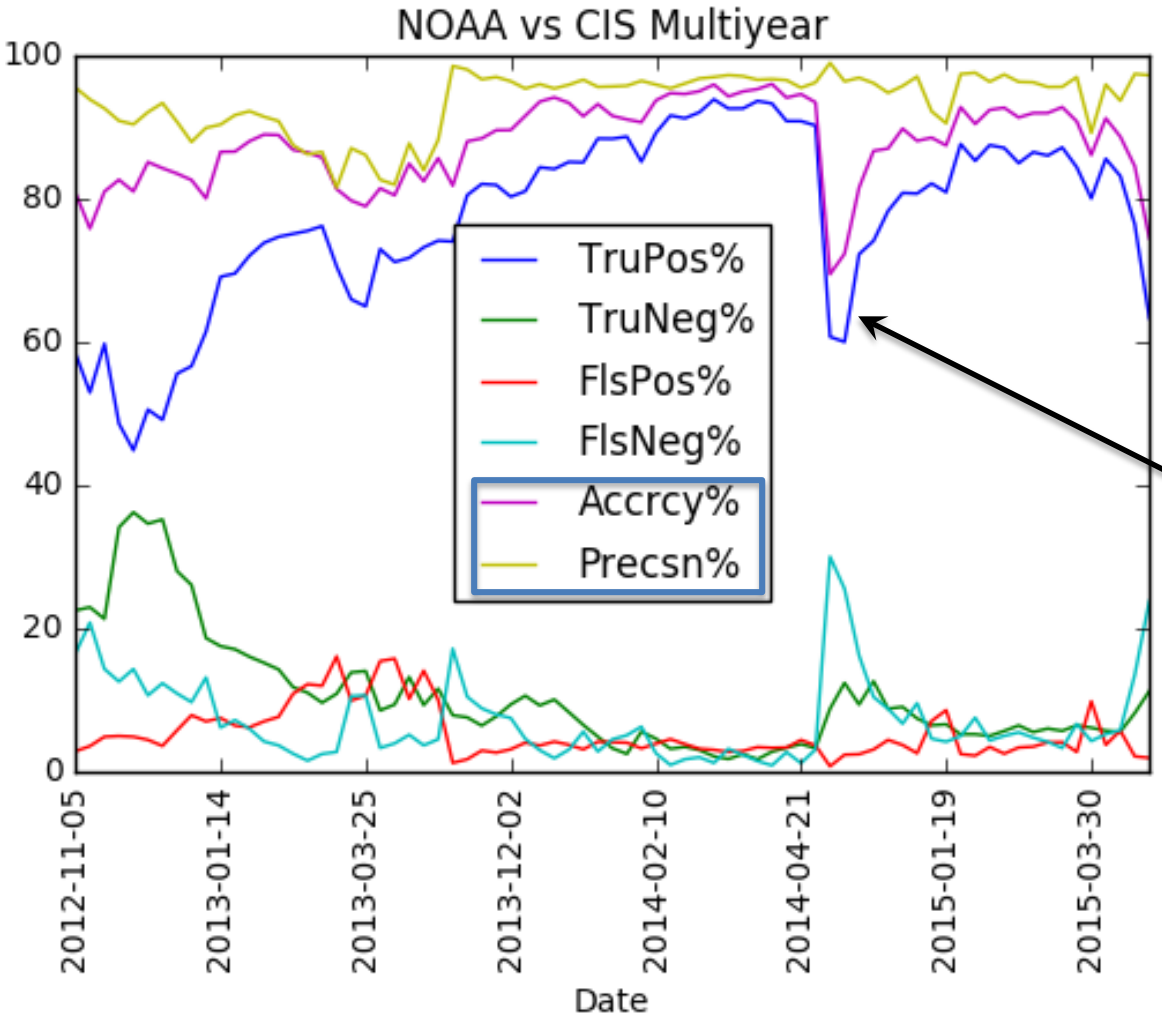
	Arctic			Antarctic		
	Accu	Prec	Cases	Accu	Prec	Cases
01/30	1.61	***8.76***	123747	0.50	21.45	22776
01/31	1.62	9.10	***124514***	1.53	***22.03***	***19556***
02/27	2.05	9.91	122376	1.04	20.19	20101
02/28	2.03	9.35	120343	***0.21***	20.88	22256
03/30	2.45	10.01	122108	1.52	14.90	48343
03/31	2.12	9.39	118841	2.48	15.24	43737
04/30	3.02	11.98	88959	1.85	12.64	79228
04/31	3.01	11.87	79756	2.24	12.62	82094
05/30	3.20	11.46	65418	2.19	13.03	99093
05/31	***3.22***	11.92	70990	1.80	12.97	104142
06/30	2.19	14.05	56864	1.55	***11.08***	121964
06/31	1.89	14.41	55580	1.56	11.78	123805
07/30	1.89	18.33	35577	2.43	12.62	***142350***
07/31	2.53	18.20	38069	2.58	12.34	138524
08/30	***0.25***	***18.48***	28727	2.79	11.87	133027
08/31	0.61	17.19	***27315***	***2.95***	12.71	142208

Multiyear Ice Validation



Initial comparison with independent ice age fields (Lagrangian tracking of ice parcels) indicates good agreement in terms of spatial distribution of multi-year ice cover.

Ice Type Validation: Ice Charts

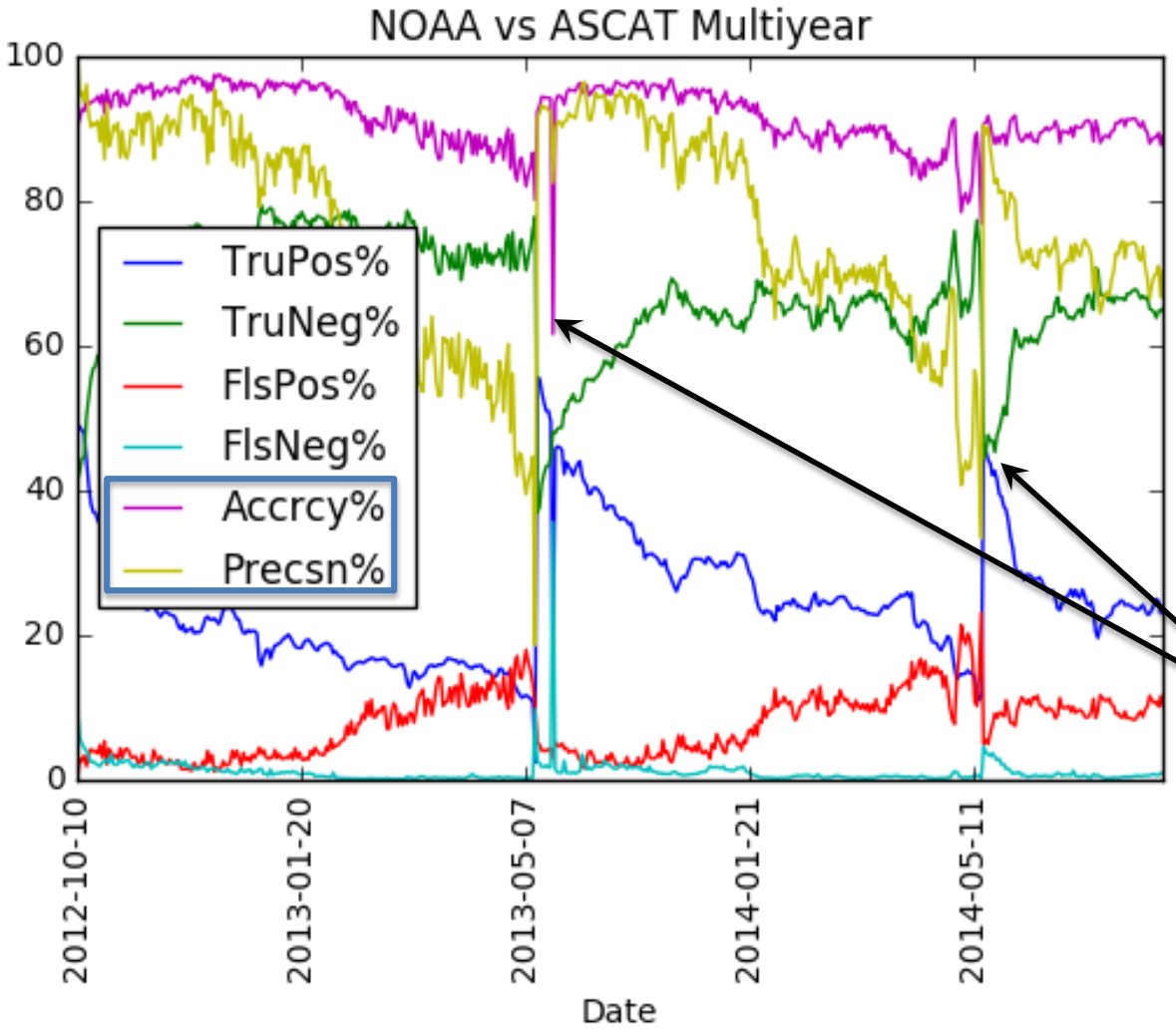


Comparison of NOAA vs. Canadian Ice Service (CIS) charts in high Arctic

Performance drops in May (melt onset)

NOTE: Summer months are not included in plot.

Ice Type Validation: ASCAT



Comparison of NOAA vs. ASCAT scatterometer

Lower performance expected from ASCAT as well

Performance drops in May

NOTE: Summer months are not included in plot.

Ice Type Validation: OSI-SAF

Confusion Matrix results, 2012-2015

- Average over all 3.5 years (Oct. 2012 – Dec. 2015)
- Mid-October through mid-April each year

	OSISAF MYI	OSISAF no-MYI
NOAA MYI	28.1%	2.1%
NOAA no-MYI	4.8%	65.1%

Accuracy: 93.2 ± 2.3%

Precision: 84.5 ± 8.5%

NOAA agrees with OSISAF
(i.e., "correct" retrieval)

Error Budget

Attribute Analyzed	L1RD Threshold	Analysis/Validation Result	Error Summary	Meets Requirement?
Concentration	10% uncertainty (see note)	1-4% accuracy 9-15% precision	Most errors well below 10% threshold, higher errors near ice edge	**Y**
Ice type (MYI)	70% correct typing	80-90% (preliminary) during Arctic winter	Multiyear ice (MYI) detection only	**Y** (preliminary)

Note: Measurement uncertainty should be changed to measurement accuracy (absolute value of the mean bias). The term “accuracy” and the specified value (10%) are consistent with ice concentration requirements for GOES-R ABI and JPSS VIIRS. It’s likely that accuracy is what was intended.

Future Plans

Snow:

- Regional assessment of biases in AMSR2 snow products and adjustment of algorithm parameters to improve retrievals;
- Explore and develop a data assimilation-based AMSR2 SWE product similar to ESA's GlobSnow.

Sea ice:

- Further development and validation of ice type and publication of ice type methodology.

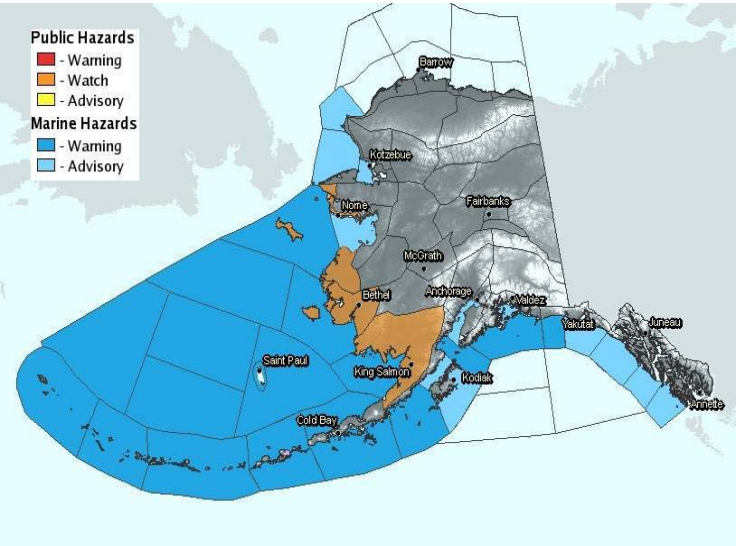
Snow and Ice Product Users (planned)

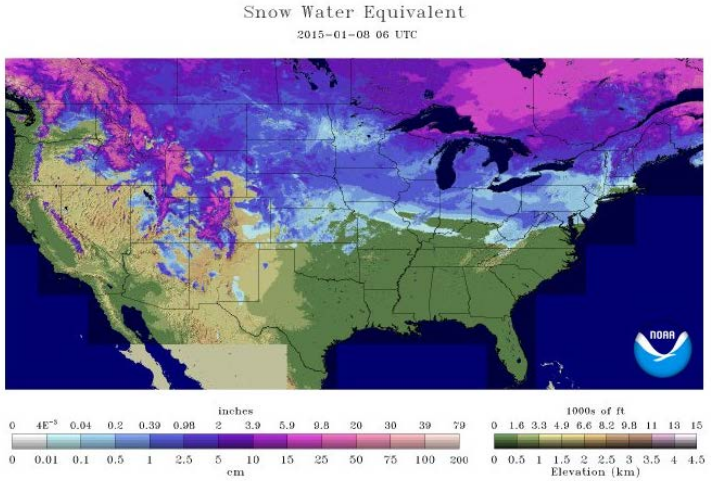
Operational Ice Services

- U.S. National Ice Service
- North American Ice Service
- Anchorage Ice Desk

Modeling

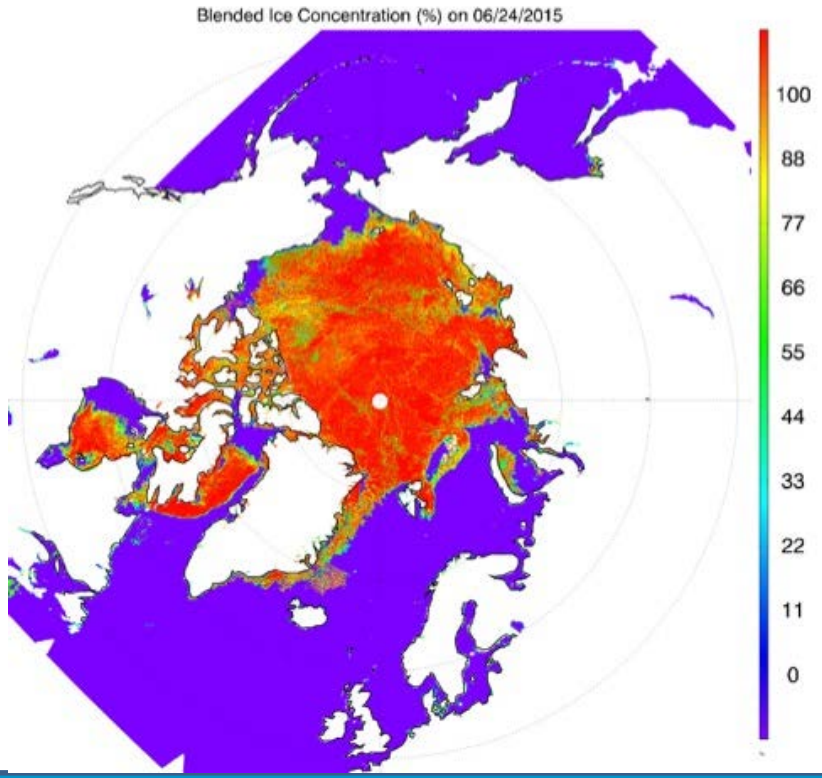
- Snow: National Operational Hydrologic Remote Sensing Center Snow Data Assimilation System (SNODAS)
- Snow: Weather forecasting, e.g., NCEP
- Ice: Naval Research Lab, Arctic Cap Nowcast/Forecast System (ACNFS)

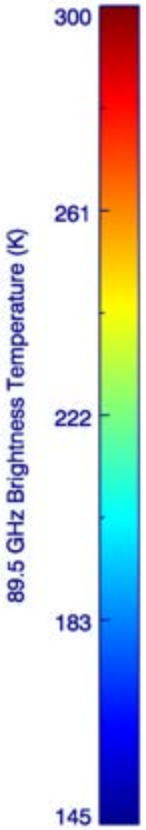


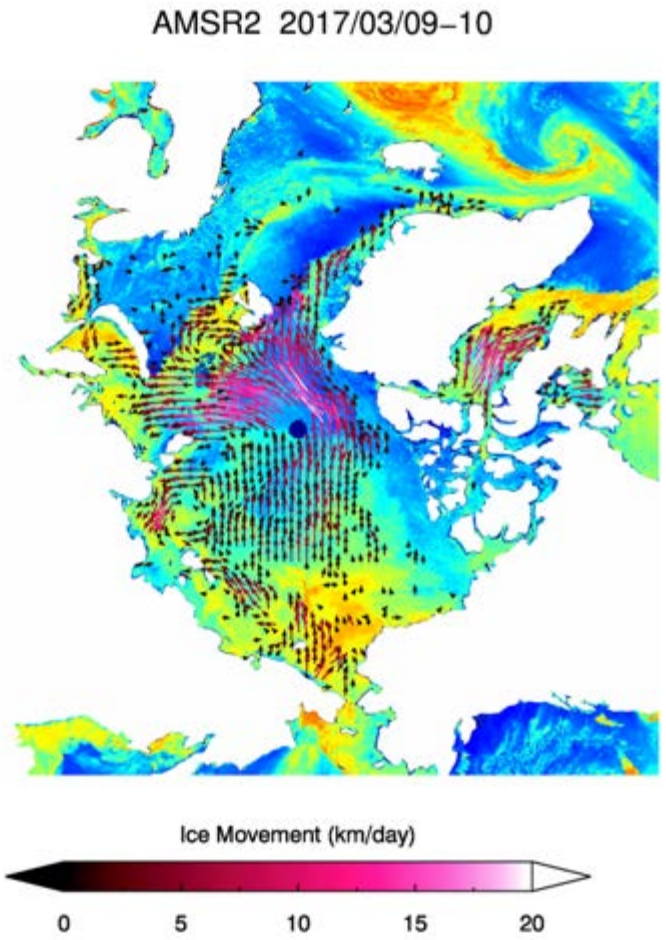


Experimental Products

Blended Ice Concentration (AMSR2 + VIIRS)



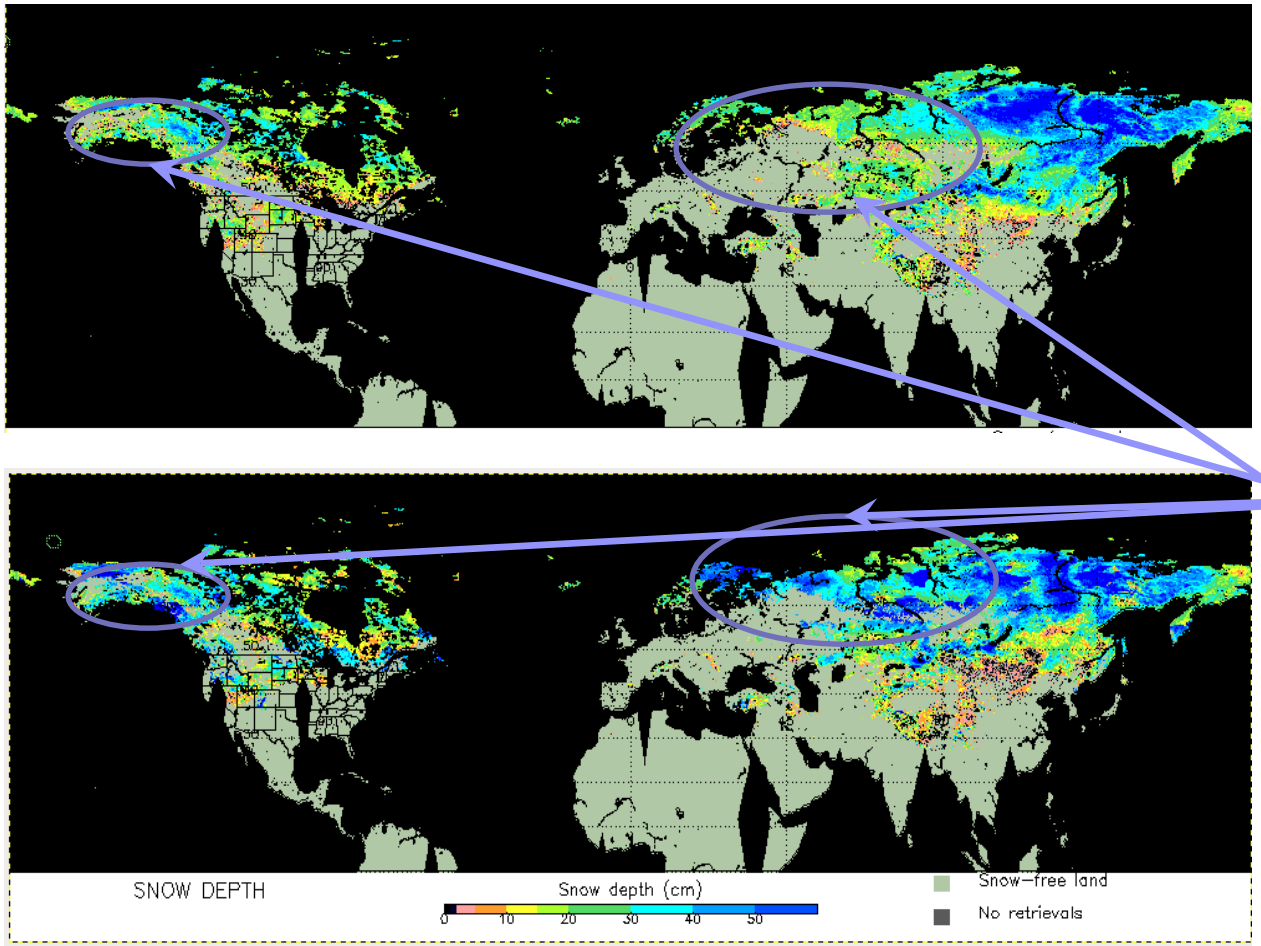




Ice Motion (AMSR2 + VIIRS)

Experimental Products, cont.

AMSR2 Snow Depth (top) and blended AMSR2 + in situ (bottom)



Improved SD areas