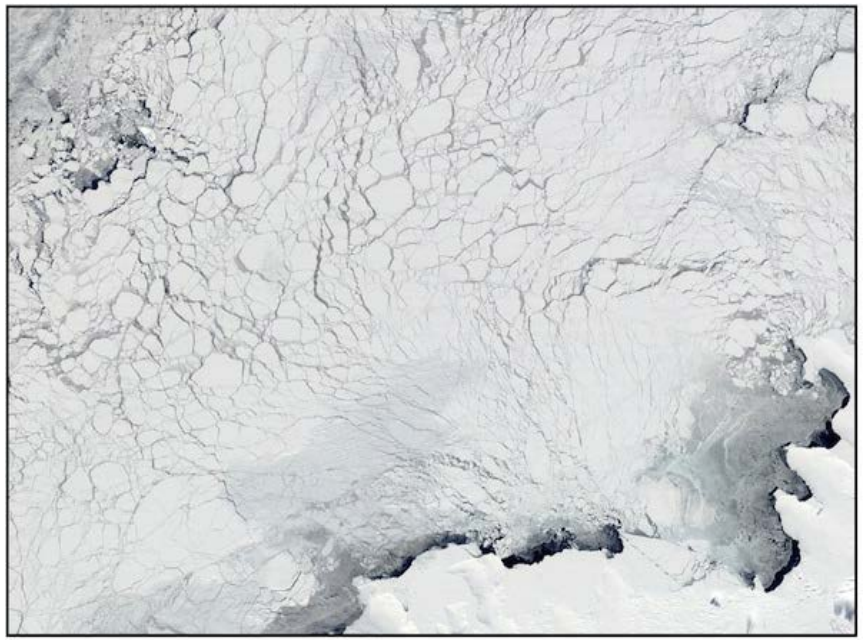
NOAA AMSR2 SNOW AND ICE PRODUCTS



Jeff Key

NOAA/NESDIS
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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) and an age class (first-year or multiyear concentration)

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

Cryosphere Team

- **Jeff Key** (lead), NOAA/NESDIS
- **Yong-Keun Lee**, University of Wisconsin: snow
- **Cezar Kongoli**, CICS/University of Maryland: snow
- **Walt Meier**, NASA: sea ice
- Scott Stewart, Julienne Stroeve, U. Colorado: sea ice

NOAA AMSR2 SNOW PRODUCTS

Yong-Keun Lee[1] and 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

Snow Cover and Depth Requirements

Table 5.0 GCOM Snow Cover/Depth		
EDR Attribute	Threshold	Objective
Applicable conditions		Delivered under "all weather" conditions
Sensing depth	0 – 60 cm	1 m
Horizontal cell size	10 km	5 km
Mapping uncertainty, 3 sigma	5 km	1 km
Snow depth ranges	5 – 60 cm	> 8 cm; > 15 cm; > 30 cm; > 51 cm; > 76 cm
Measurement uncertainty		
-- Clear	80% probability of correct snow/no snow classification; Snow Depth: 20 cm (30 cm if forest cover exceeds 30%)	10% for snow depth
-- Cloudy	80% probability of correct snow/no snow classification; Snow Depth: 20 cm	Not Specified
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified

SWE Requirements

Table 11.0 GCOM Snow Water Equivalent		
EDR Attribute	Threshold	Objective
Applicable conditions		Delivered under "all weather" conditions
Horizontal cell size	10 km	5 km
Mapping uncertainty, 3 sigma	5 km	1 km
Measurement range	10 – 200 mm	Not Specified
Measurement uncertainty		Not Specified
-- Shallow to moderate snow packs (10 – 100 mm)	20 mm or 50%	Not Specified
-- High snow accumulation (above 100 mm)	70%	Not Specified
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified

Snow Detection Algorithm

- Grody's 1991 SSMI Algorithm
  - The most cited microwave snow cover algorithm
  - Continues to be a baseline algorithm
  - Applied to SSMIS and AMSU instruments at similar AMSR-E channels.
  - Matured through 30 years of improvements at NOAA/NESDIS
  - NOAA's AUTOSNOW (input to IMS) uses Grody's SSMI algorithm

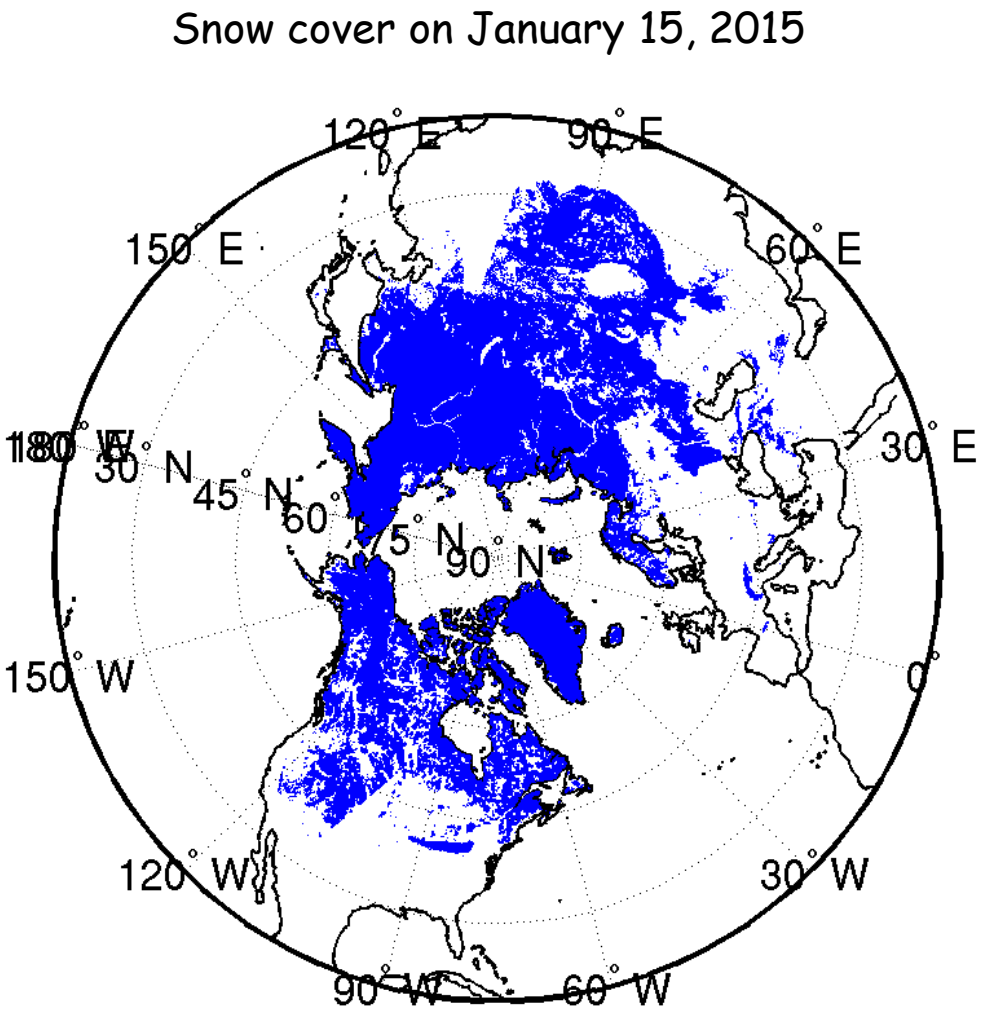
- Enhancements to Grody SSMI algorithm
  - Climatology test: probability of snowfall occurrence from IMS
  - Wet snow exclusion using 36 GHz brightness temperature
  - Adapt the algorithm to AMSR2 configuration

SWE Algorithm

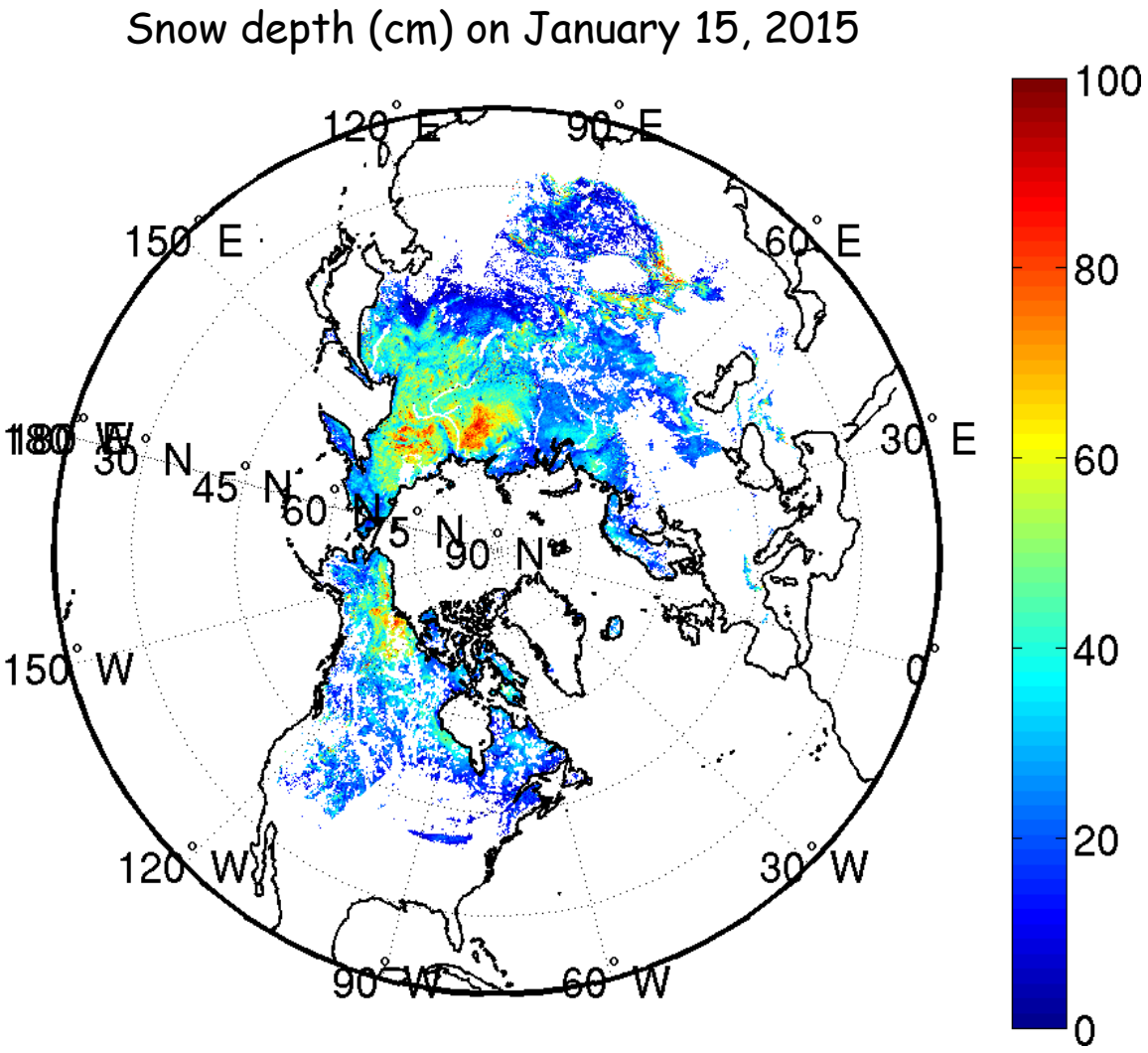
NASA AMSR-E SD/SWE approach (Kelly, 2009; Tedesco and Narvekar, 2010)

- Brightness temperature differences at 10, 18 and 37 GHz (the Chang et al. approach) but with non-linear spatially and varying coefficients computed from brightness temperatures at horizontal and vertical polarizations
- Use of 10 & 18 GHz channels over the non-forested portion of the AMSR-E pixel for deeper snow retrievals
- Retrievals of pixel SD are weighted between forest and non-forest fractions
- Algorithm coefficients are tuned to SD, and SWE is estimated using a spatially and seasonally varying snow density climatology.

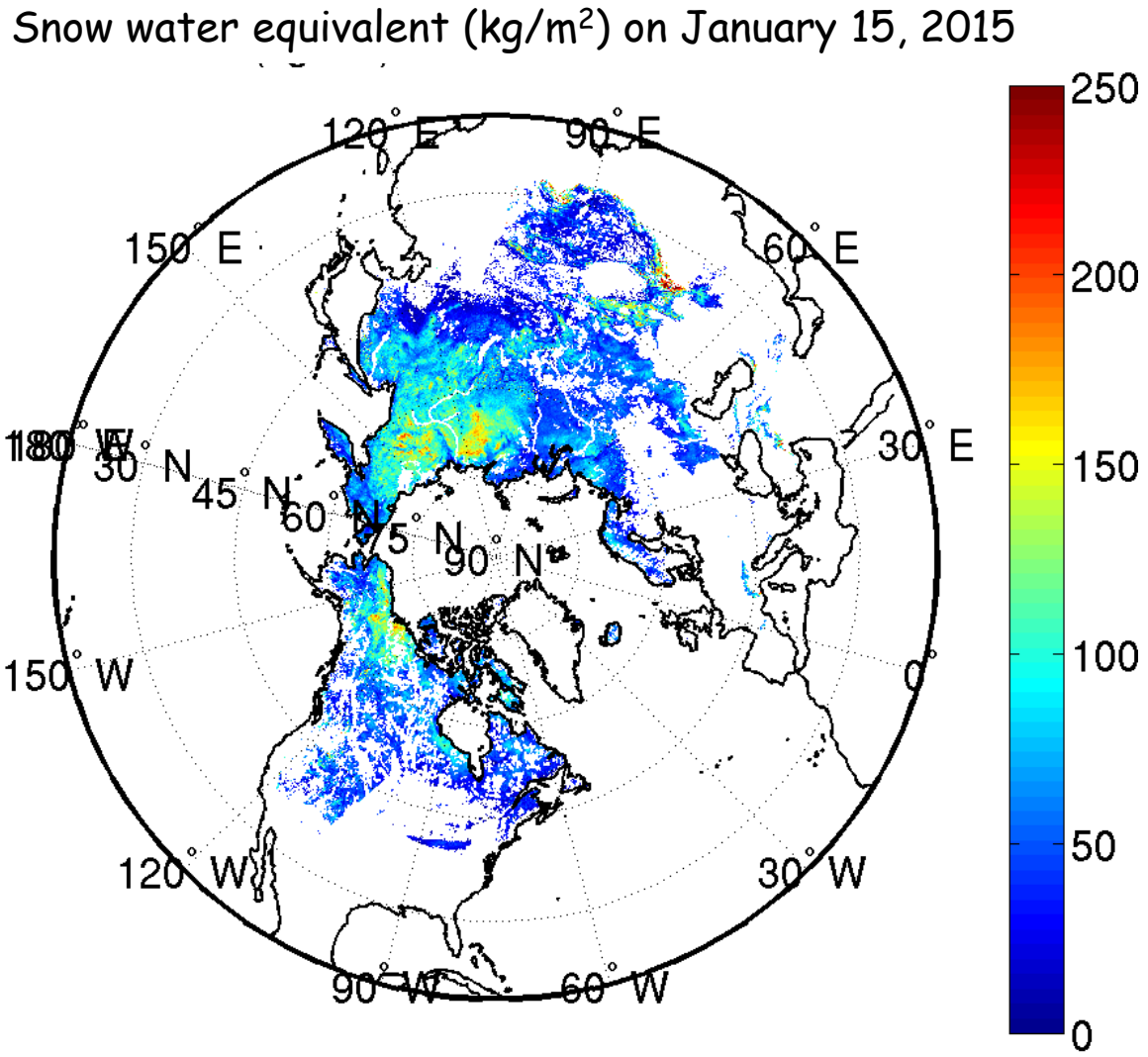
Product Examples: Snow Cover



Product Examples: Snow Depth



Product Examples: SWE



Validation Results

Snow cover	GAASP
Overall accuracy	81.17 %
Snow detection rate	78.34 %
Commission	1.78 %
Omission	17.05 %
Number of pixels	1504245

See notes section for validation strategy.

Snow depth	GAASP
bias	-0.50 cm
RMSE	18.7 cm
Number of pixels	2432

SWE	GAASP
bias	-0.22 mm
RMSE	31.35 mm
Number of pixels	26639
Mean (AMSR2)	62.06 mm

Valid on January 15, 2015

GAASP: GCOM AMSR2 Algorithm Software Package

Future Plans for Snow Products

- Evaluation of AMSR2 snow products over a long period for regionally and globally.
- Further investigation is needed for wet snow detection and each criteria regarding precipitation, cold desert, and frozen ground (for snow cover detection).
- Atmospheric correction can be considered for the further improvement in snow products.
- Adjustment of the weights for each channel may improve the snow depth calculation.

AMSR2 SEA ICE CHARACTERIZATION

Walt Meier[1], Scott Stewart[2], Julienne Stroeve[2]

[1]NASA Goddard Space Flight Center

[2]National Snow and Ice Data Center
Cooperative Institute for Research in the Environmental Sciences
University of Colorado, Boulder

Requirements

Table 8.0.1 GCOM Sea Ice Characterization		
EDR Attribute	Threshold	Objective
A		
V		
H		
M		
Measurement range		
-- Ice concentration	1/10 – 10/10	0 – 100%
-- Ice age classes	Ice free, first-year, multiyear ice	Ice free, nilas, grey grey-white, white, first year medium, first year thick, second year, and multiyear; smooth and deformed ice
Measurement uncertainty		
-- Ice concentration	10%	5%
Probability of correct typing of ice age classes	70%	90%
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)	Not Specified
Geographic coverage	All ice-covered regions of the global ocean	All ice-covered regions of the global ocean

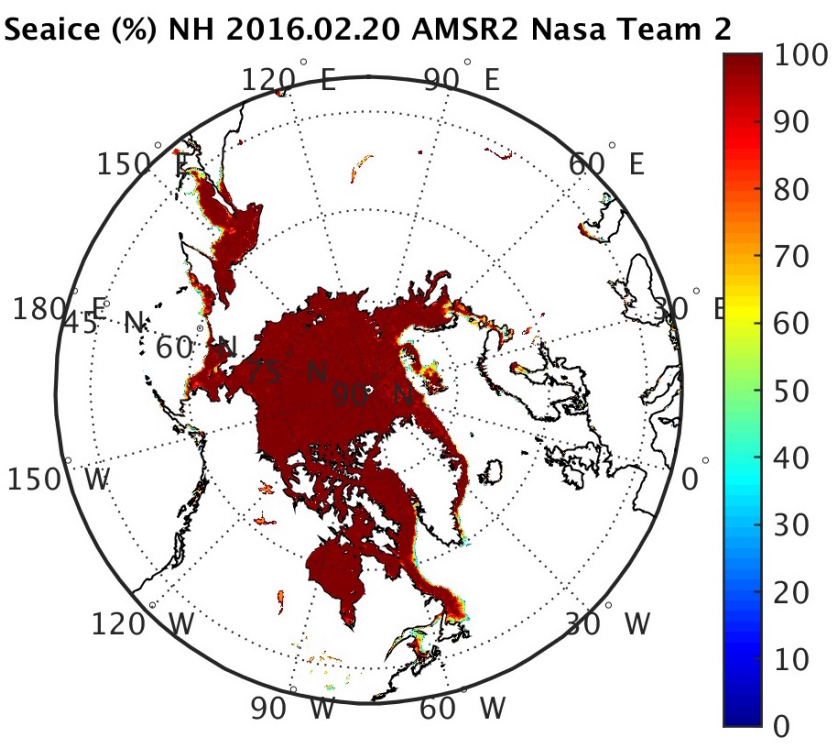
As noted in the ARR, ”Uncertainty” may be the incorrect term. Using “accuracy” (absolute value of mean bias) and the same value (10%) would be consistent with ice concentration requirements for GOES-R ABI (accuracy: 10%) and JPSS VIIRS (accuracy: 10%; uncertainty: 25%). Perhaps accuracy is what was intended.

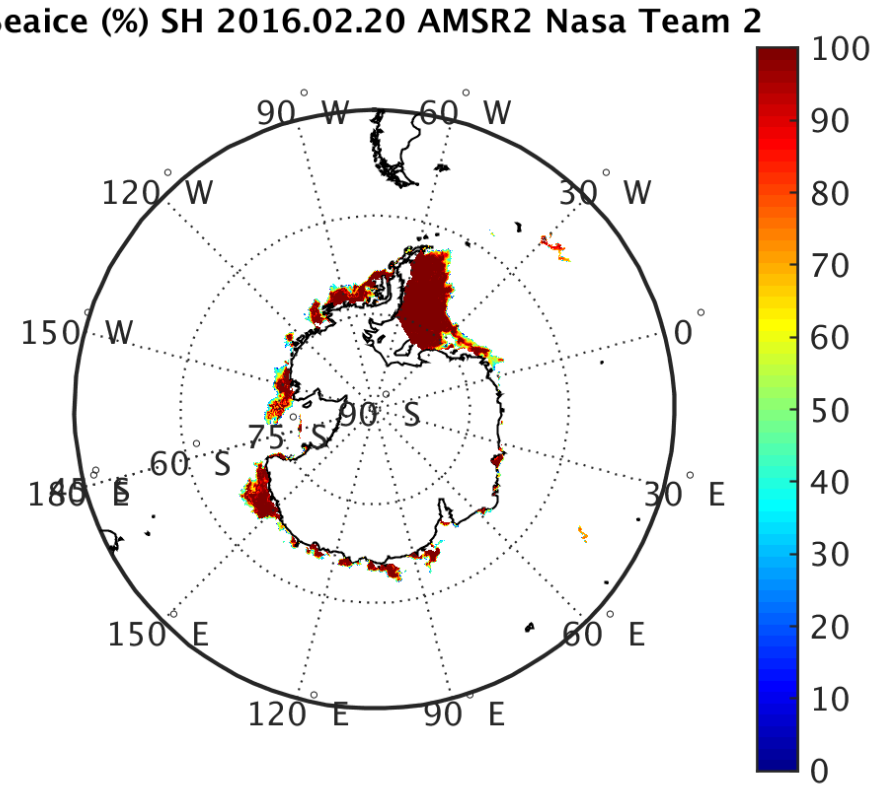
Sea Ice Algorithm

NASA Team 2 (NT2) and Bootstrap (BT) algorithms are used

- Characteristics
  - NT2 includes use of high frequency channels (89 GHz) for better sensitivity to surface variability, with an atmospheric correction to mitigate weather effects
  - BT uses heritage approach from SMMR through AMSR-E, with daily varying tiepoints to account for seasonal changes in surface properties
- The NOAA product will contain both, but NT2 is primary.
  - Allows known errors to be mitigated:
    - NASA Team 2: atmospheric emission
    - Bootstrap: low (cold) temperatures and melt
- Difference in concentrations between algorithms provides a confidence indicator
- Iteration for NASA Team 2 atmospheric correction provides a quantitative error estimate

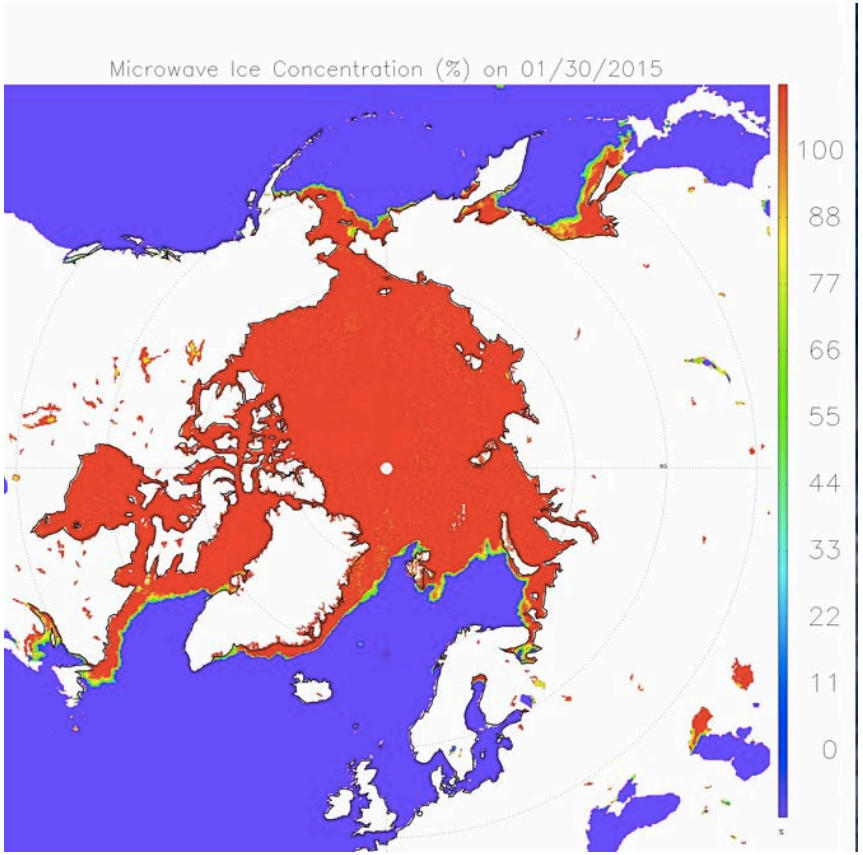
Product Examples



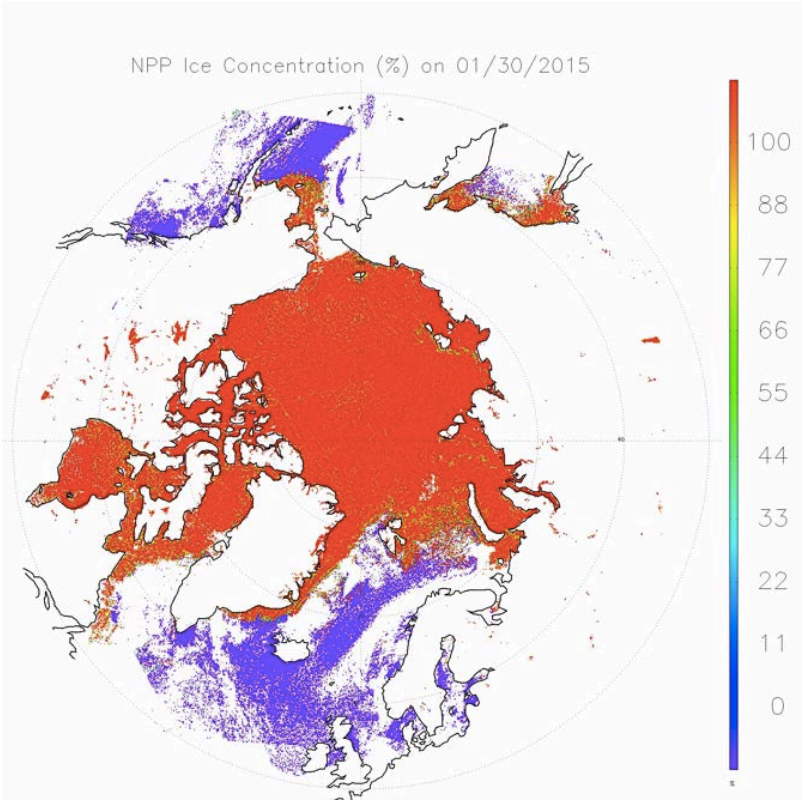


Examples of AMSR2 sea ice concentration over the Arctic (above) and Antarctic (right) on 20 February 2016.

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

Validation Results

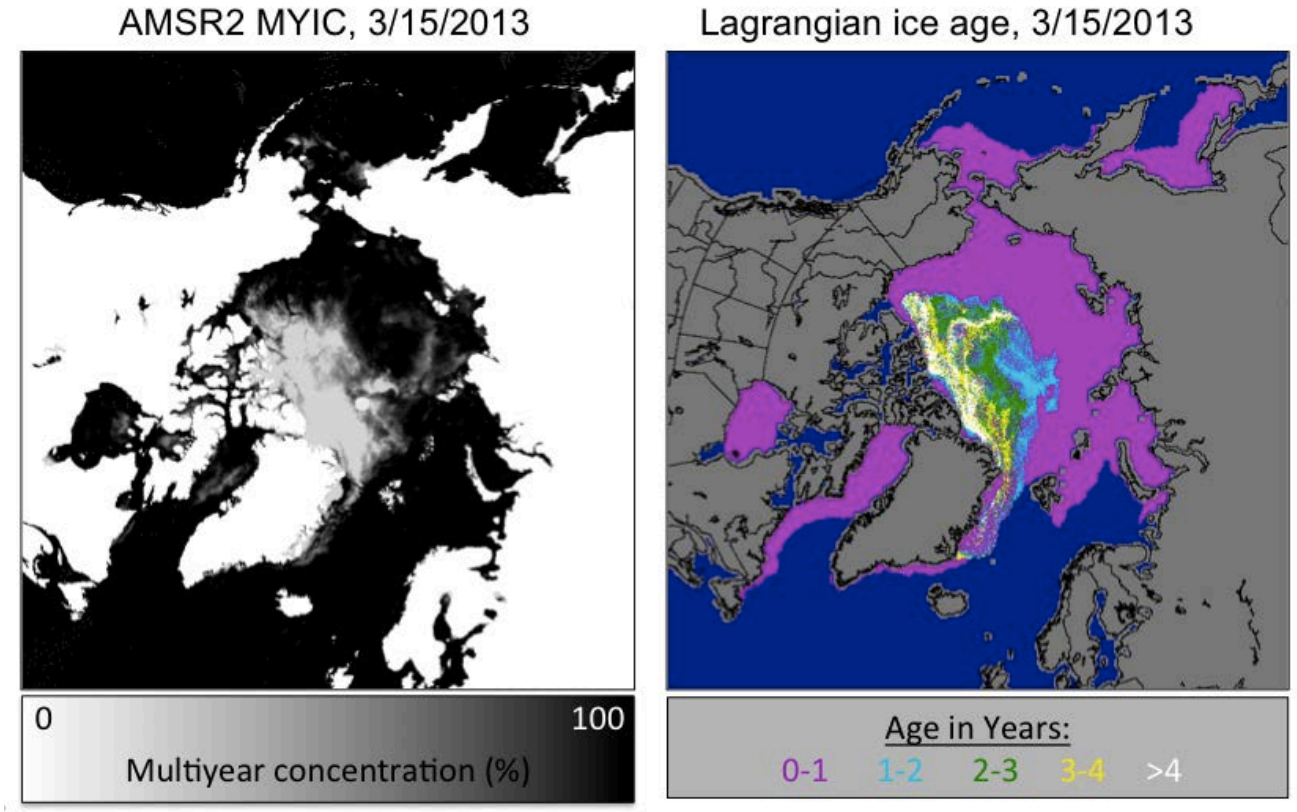
Statistical results of the comparison in sea ice concentration between AMSR2 (AIT) and VIIRS.

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

The multi-year ice concentration (MYIC) parameter has not been thoroughly validated and is still considered to be experimental. Initial comparison with independent ice age fields (using Lagrangian tracking of ice parcels) indicates good agreement in terms of the spatial distribution of multi-year ice cover.

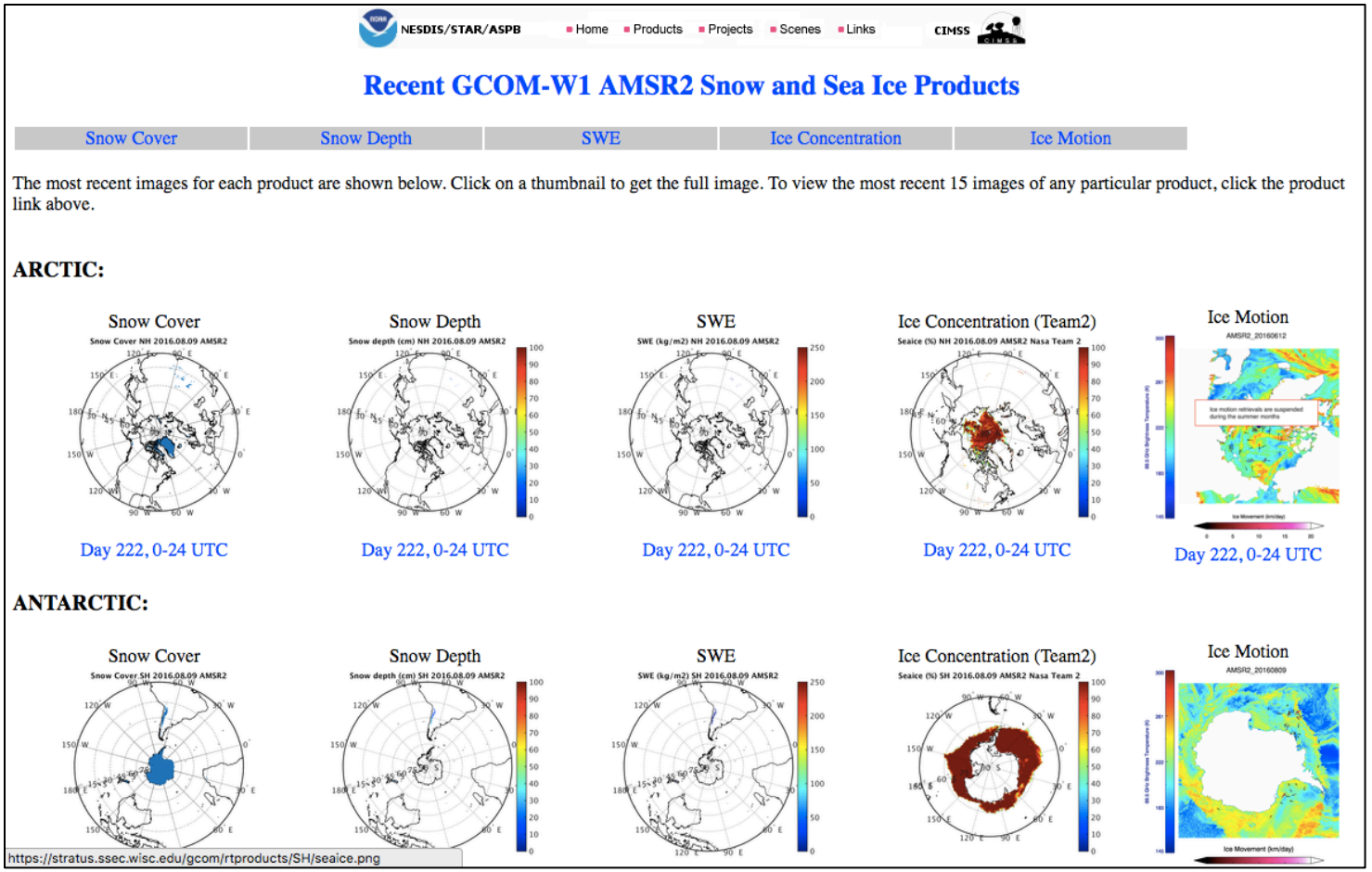


Future Plans for Sea Ice Products

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

Near Real-time Products

All products described here, plus ice motion (experimental), are generated daily at CIMSS. Plots are available at http://stratus.ssec.wisc.edu/gcom/rtproducts.



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)