JPSS STAR Science Team Annual Meeting

Cryosphere EDR Team Overview

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Cryosphere Team Lead

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Overview of Data Products

1. Sea ice characterization
   - Currently this is an age category: no ice, new/young ice, other ice
2. Sea Ice concentration IP
   - Fractional coverage of ice in each pixel
3. Ice surface temperature (IST)
   - Radiating temperature of the surface (ice with or without snow)
4. Snow cover

   4a. Binary snow cover

   4b. Fractional snow cover (currently 2x2 averages of binary mask)

Notes:

- Information on ice and snow cover is needed by other EDRs.
- AMSR2 on GCOM-W1 will be used to generate other snow and ice products: Ice Characterization, Snow Cover, Snow Depth, and Snow Water Equivalent (SWE).

Cryosphere Team Membership and Funding

EDR	Name	Organization
Lead	Jeff Key	NESDIS/STAR
Co-Lead	Pablo Clemente-Colón	NESDIS/STAR and NIC
Wisconsin:		
Ice	Yinghui Liu	CIMSS/U. Wisconsin
Ice	Xuanji Wang	CIMSS/U. Wisconsin
Ice	Rich Dworak	CIMSS/U. Wisconsin
Maryland:		
Snow	Peter Romanov	CREST/CCNY
Snow	Igor Appel	IMSG
Colorado:		
Ice	Mark Tschudi	U. Colorado
Ice	Dan Baldwin	U. Colorado
Other:		
All	Paul Meade	DPE
All	Robert Mahoney	NGAS

Snow and Ice Product Users

- U.S. Users
  - NIC, National/Naval Ice Center
  - Naval Research Laboratory
  - NWS, National Weather Service, including the Alaska Ice Desk
  - OSPO, Office of Satellite and Product Operations
  - STAR, Center for Satellite Applications and Research
  - University of Washington, Polar Science Center
  - GSFC, NASA/Goddard Space Flight Center Hydrological Sciences Branch

- User Community
  - Navigation
  - Emergency Management
  - Operational Weather Prediction
  - Climate Research
  - DOD

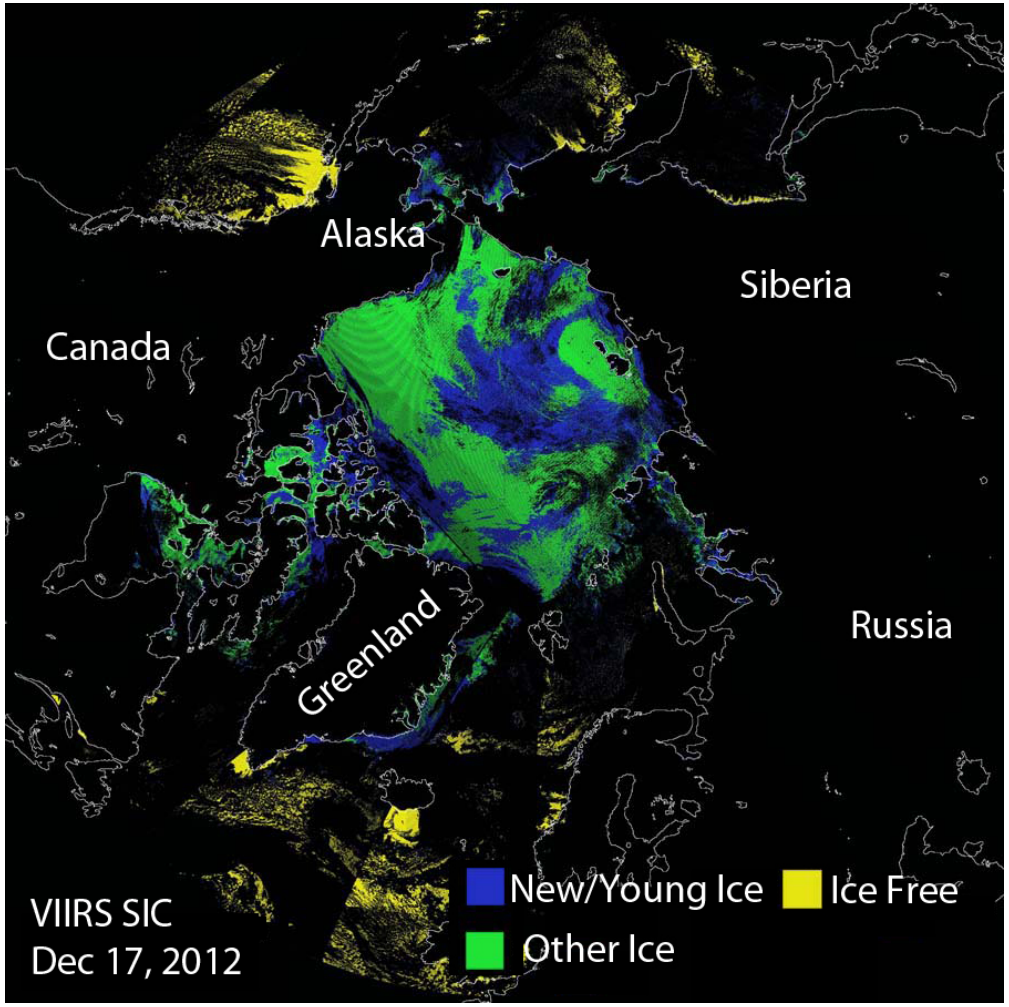
Cryosphere Accomplishments for FY14

- Maturity reviews:
  - IST: Provisional, Validated Stage 1
  - Sea Ice Characterization: Provisional
  - Snow Cover: Provisional, Validated Stage 1 for binary
- CCRs: 10
- Three Technical Interchange Meetings (TIMs) were held.
- Improved gridding significantly and made recommendations, though more could be done.
- Completed new, comprehensive validation studies for snow and ice products with in situ, aircraft, and satellite products. Automated validation is in place for some products.
- Implemented and began testing new fractional snow cover algorithm.
- Provided Land Team with help on update of the Surface Type EDR to perform a fall back to use the granulation of the gridded snow ice tiles.
- Published paper on snow and ice products and validation (JGR special issue).

See the breakout session presentations for more accomplishments and details!

Sea Ice Characterization

Description: An ice age classification for the categories: Ice -free, New/Young Ice (less than 30 cm thickness), and All Other ice. Freshwater ice is not included.



Sea ice characterization composite for 17 December 2012 New/young ice (less than 30 cm) is blue; older ice is green.

VIIRS Sea Ice Characterization EDR L1RD Requirements

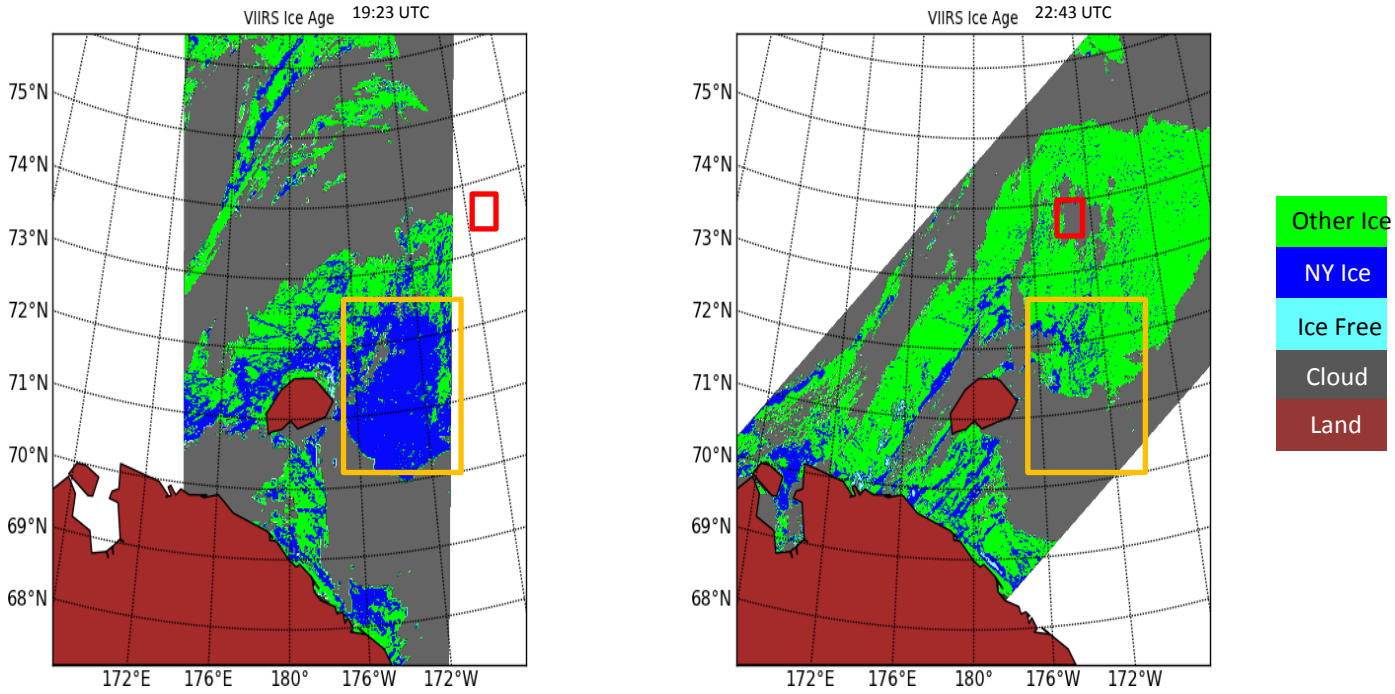
Sea Ice Characterization Requirements from L1RD version 2.4

EDR Attribute	Threshold	Objective
a. Vertical Coverage	Ice Surface	Ice Surface
b. Horizontal Cell Size **1. Clear** **2. All weather**	 1.0 km No capability	 0.5 km 1 km
c. Mapping Uncertainty, 3 sigma **1. Clear** **2. Cloudy**	 5 km No capability	 0.5 km 1 km
d. Measure Range **1. Ice Age** **2. Ice Concentration**	 Ice Free, New Young, all other ice 0/10 to 10/10	 Ice free, Nilas, Gray White Grey, White, First Year Medium, First Year Thick, Second Year, Multiyear, Smooth and Deformed Ice 0/10 to 10/10
e. Measurement Uncertainty **1. Probability of Correct Typing (Ice Age)** **2. Ice Concentration**	 70% Note 1	 90% 5%
f. Refresh	At least 90% coverage of the global every 24 hours (monthly average)	6 hrs
g. Geographic coverage	All Ice-covered regions of the global ocean	All Ice-covered regions of the global ocean

Notes:
1. VIIRS produces a sea ice concentration IP in clear sky conditions, which is provided as an input to the ice surface temperature calculation

Ice Characterization

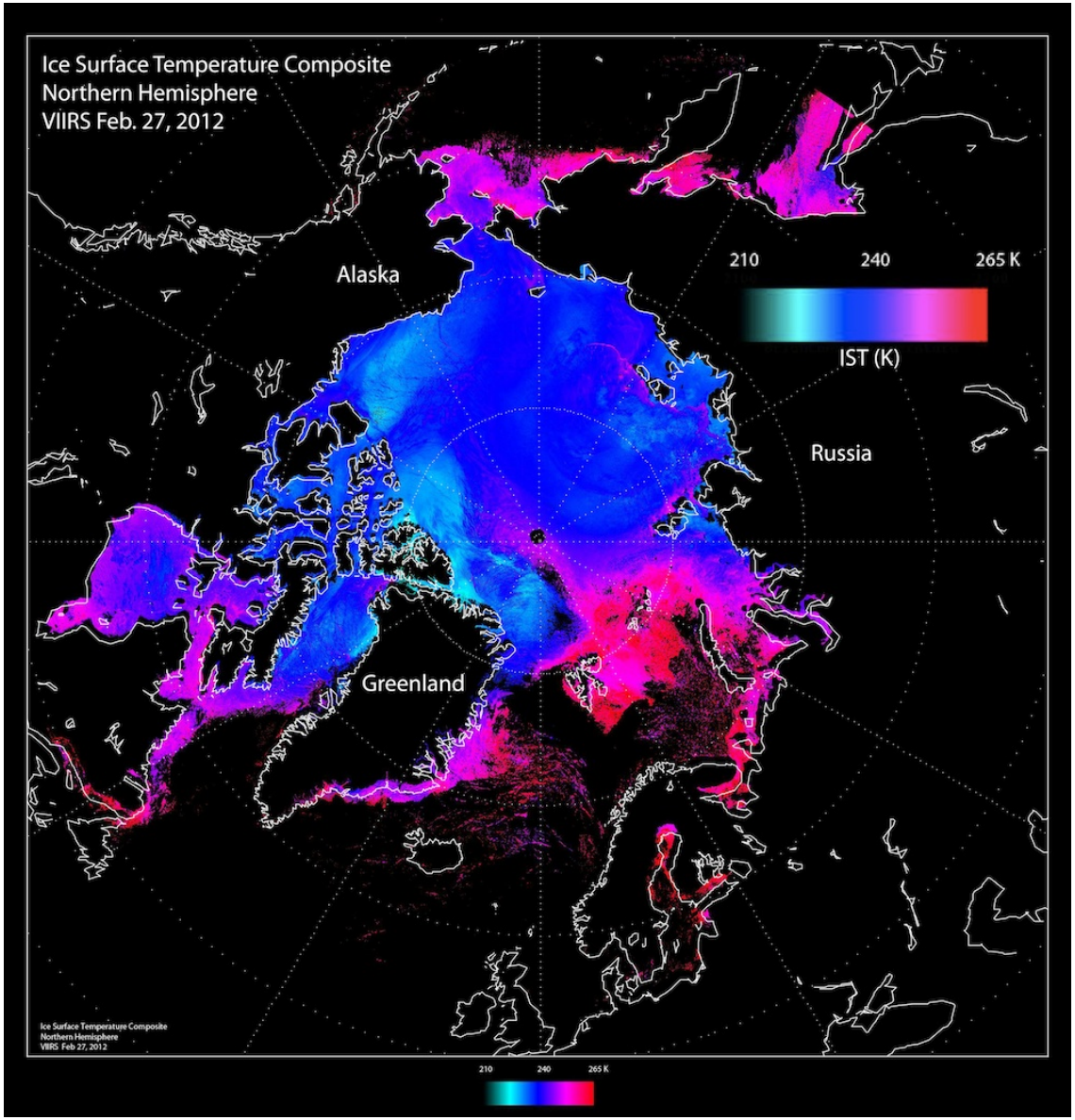
There are times when performance is good, and other times (too many) when performance is not good. Overall, it does not appear to be meeting the accuracy requirements. This is a complex algorithm where improvements may be required in a number of areas.



Region near Wrangle Island showed significant amounts of sea ice that were correctly classified as thicker "Other Ice" in 22:43 UTC orbit being misclassified as NY in the 19:23 UTC orbit

Ice Surface Temperature

Description: The surface (skin, or radiating) temperature of sea ice.



Composite of VIIRS Ice Surface Temperature on 27 Feb 2012.

VIIRS IST EDR L1RD Requirements

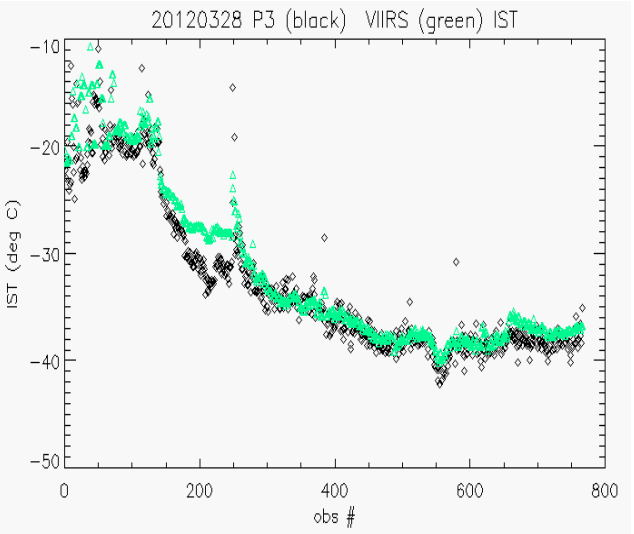
Ice Surface Temperature (IST) Requirements from L1RD Supplement. V2.9 (27 June 2013)

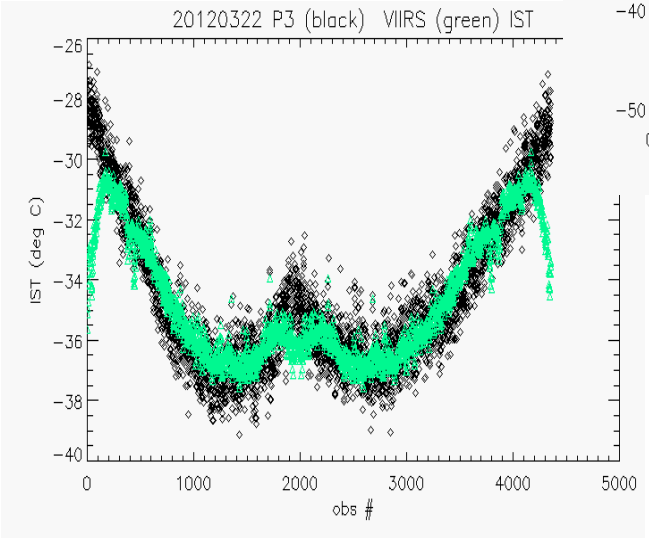
EDR Attribute	Threshold	Objective
IST Applicable Conditions **1. Clear, only**		
a. Sensing Depth	Ice Surface	Ice Surface
b. Horizontal Cell Size **1. Nadir** **2. Worst Case**	 1 km 1.6 km	 0.1 km 0.1 km
c. Mapping Uncertainty, 3 sigma **1. Nadir** **2. Worst Case**	 1 km 1.6 km	 0.1 km 0.1 km
d. Measure Range	213-275 K	213-293 K (2 m above ice)
e. Measurement Uncertainty	1 K	
f. Refresh	At least 90% coverage of the global every 24 hours (monthly average)	12 hrs
g. Geographic Coverage	Ice-covered oceans	All ice-covered waters

IceBridge KT19 vs VIIRS IST, 2012

BIAS = VIIRS - KT19

DATE	KT19	VIIRS	BIAS	RMS
3/14	-33.71	-33.15	0.56	0.08
3/15	-32.22	-33.05	-0.84	0.63
3/16	-29.88	-28.87	1.01	0.71
3/21	-36.01	-36.56	-0.55	0.41
3/22	-34.45	-34.66	-0.21	0.14
3/27	-31.15	-31.02	0.12	0.21
3/28	-32.61	-31.49	1.12	0.53
3/29	-37.85	-37.39	0.46	0.10
4/02	-33.36	-32.70	0.66	0.19

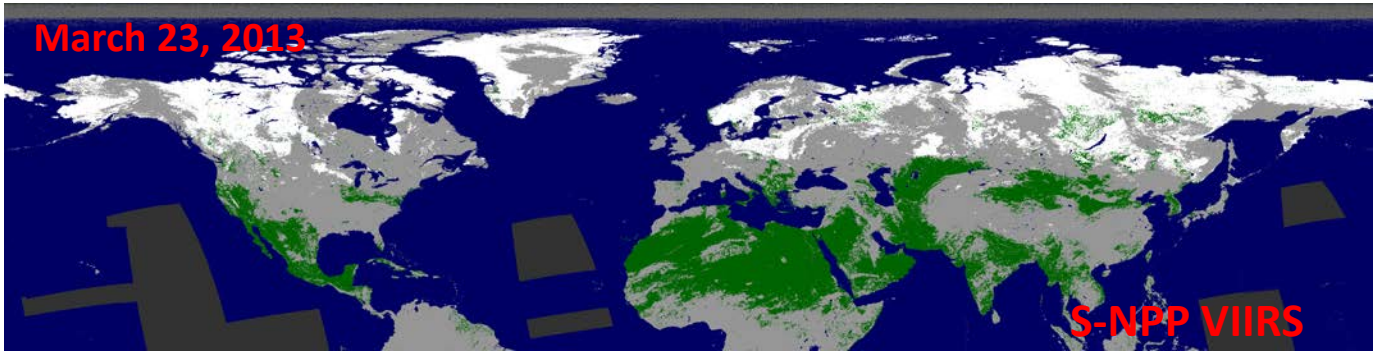




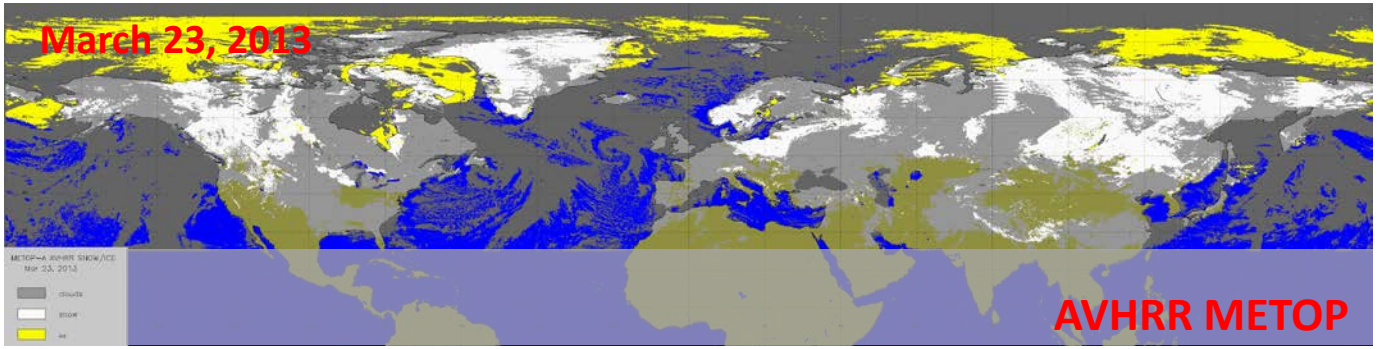
VIIRS IST has a 0.5+ K *cold bias* relative to the MODIS Ice Surface Temperature product. Comparisons to NCEP and International Arctic Buoy Program (IABP) air temperatures yield a VIIRS *warm bias* of 1 K. It meets the accuracy requirement under most conditions.

Binary Snow Cover

Description: Snow Cover is defined to be the horizontal and vertical extent of snow cover. In addition, a binary product gives a snow/no-snow flag.



snow land cloud No data



Binary Snow Cover Requirements

Parameter	Specification Value
a. Binary Horizontal Cell Size,	
1. Clear – daytime (Worst case)	0.8 km
2. Clear – daytime (At nadir)	0.4 km
3. Cloudy and/or nighttime	N/A
b. Horizontal Reporting Interval	Horizontal Cell Size
c. Snow Depth Range	> 0 cm (Any Thickness)
d. Horizontal Coverage	Land
e. Vertical Coverage	> 0 cm
f. Measurement Range	Snow / No snow
g. Probability of Correct Typing	90%
h. Mapping Uncertainty	1.5 km

1. The probability of correct snow/no-snow detection applies only to climatologically snow-covered regions.
2. The accuracy of snow detection does not apply over forested/mountainous areas where snow may be hidden by vegetation or topographic shading.

[Joint Polar Satellite System (JPSS) Program Level 1 Requirements SUPPLEMENT – Final Version: 2.9 June 27, 2013]

VIIRS, AVHRR, MODIS Snow vs IMS

Mean agreement to IMS and cloud-clear fraction of daily automated snow products in 2013 Northern Hemisphere

	Agreement to IMS (%)	*Cloud-clear(%)**
VIIRS	**98.0**	**38.6**
MODIS (T)	97.3	49.1
MODIS(A)	97.1	48.3
AVHRR	97.9	55.0

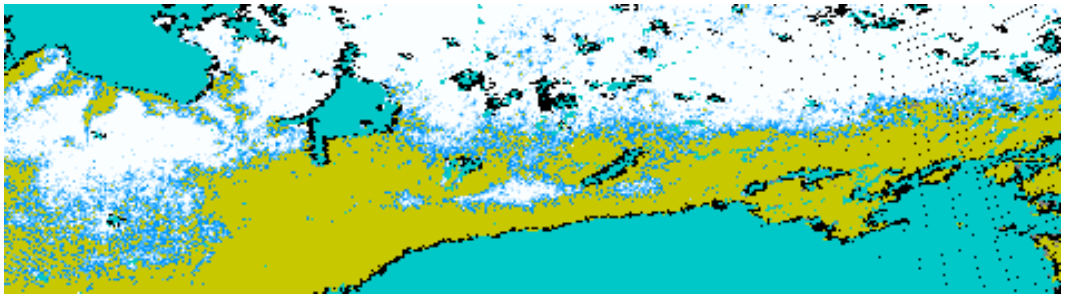
*Cloud-clear fraction is estimated in 25-60^{0}N latitude band

- Binary snow cover meets the accuracy requirement.
- Most issues are related to cloud masking; e.g., somewhat overestimated cloud extent and corrupted land/water mask.
- Some potential exists to improve the algorithm and the product, e.g., geometry-dependent threshold values.

Fractional Snow Cover

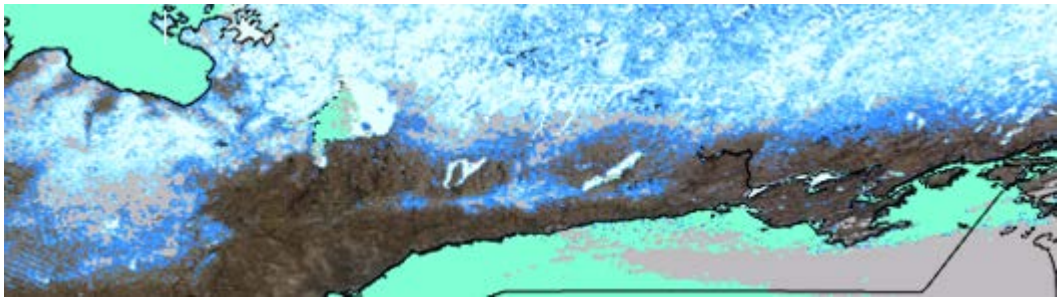
Description: VIIRS Snow Cover Fraction is derived from the Binary Snow Map as an aggregated snow fraction within 2x2 pixel blocks. The spatial resolution of the product is 750 m at nadir

VIIRS fraction



Image

MODIS fraction



In 2x2 snow fraction (top) snow to no snow transition regions are unrealistically narrow compared to the MODIS based snow fractions.

Specification of VIIRS Snow Fraction

Parameter	Specification Value
a. Horizontal Cell Size,	
1. Clear – daytime (Worst case)	1.6 km
2. Clear – daytime (At nadir)	0.8 km
3. Cloudy and/or nighttime	N/A
b. Horizontal Reporting Interval	Horizontal Cell Size
c. Snow Depth Ranges	> 0 cm (Any Thickness)
d. Horizontal Coverage	Land
e. Vertical Coverage	> 0 cm
f. Measurement Range	0 – 100% of HCS
g. Measurement Uncertainty	10% of HCS (Snow/No Snow)
h. Mapping Uncertainty	1.5 km

Snow Fraction Alternative Algorithms

The 2x2 pixel aggregation scheme can only provide a small set of values (0, 25, 50, 75, 100% if no missing pixels) and therefore cannot meet the 10% accuracy requirement throughout the measurement range.

A number of different snow fraction algorithms are available; the first two are being tested:

1. NDSI-based (Solomonson/Appel, Hall/Riggs)
2. Visible reflectance –based (Romanov/Tarpley)
3. Multiple endmember multispectral approach (Painter)

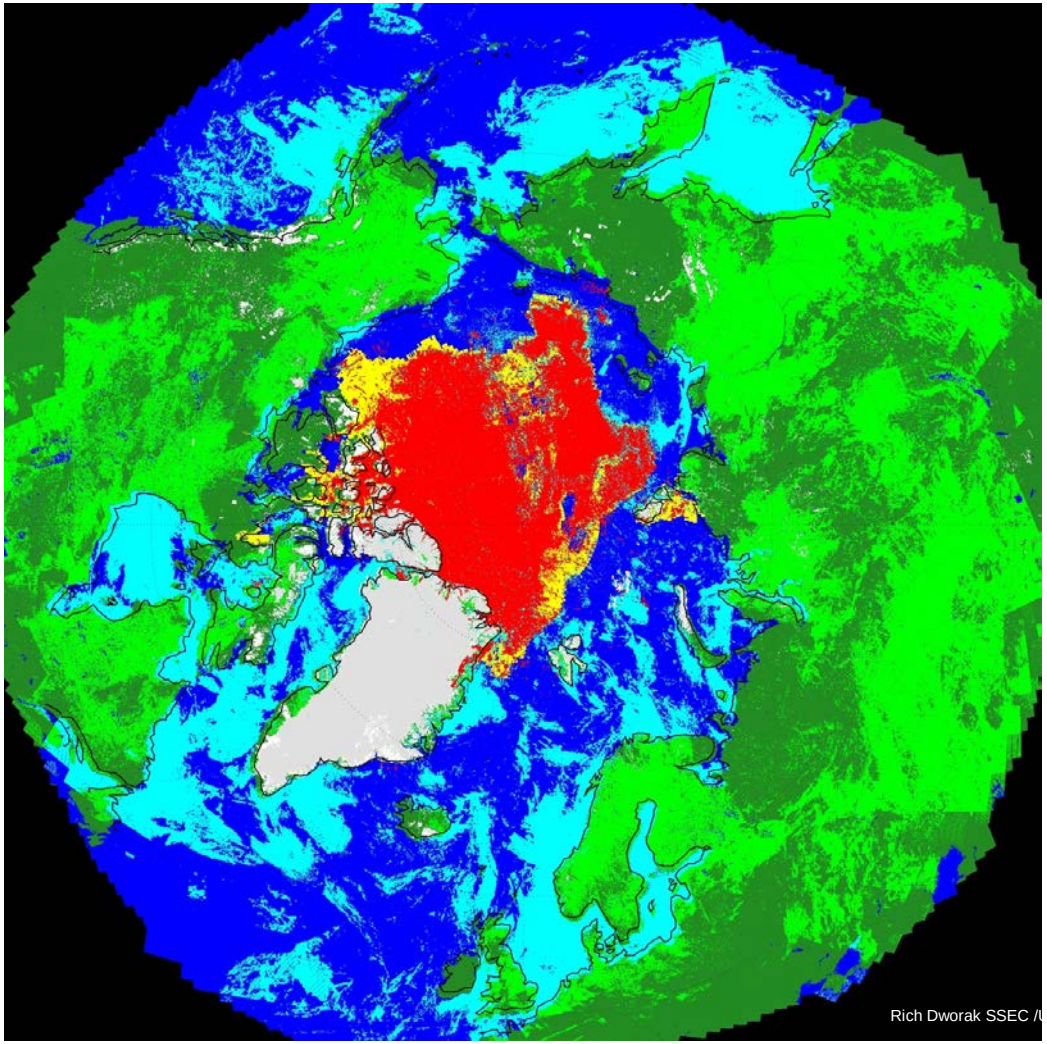
Algorithm Recommendations

Recommendations for IDPS algorithms:

Product	Through Aug 31	NPP after Aug 31	JPSS
Sea Ice Concentration IP	1	1	1 or 3
Ice Surface Temperature	1	1 or 3	3
Sea Ice Characterization/age	1	1 or 2 (TBD)	2 or 3
Binary Snow Cover	1	1	1 or 3
Fractional Snow Cover	2	2	2

1. NPOESS algorithm has evolved into the NOAA-endorsed JPSS algorithm and any needed improvements should continue.
2. NPOESS (or evolved) algorithm will not meet requirements or effort is too large, replace with NOAA-endorsed JPSS algorithm
3. NOAA-endorsed algorithm should be used even if NPOESS (or evolved) algorithm meets performance because of legacy, enterprise, blended products, and other considerations.

VIIRS Snow/Ice Gridding Tests



GMASI

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

VIIRS Updated

- Ice over water
- Snow over land
- No Snow over land
- No Ice over water

Snow/Ice Gridding Summary

- Improvements in the VIIRS gridded Snow/Ice have occurred due to the MX 7.2 VCM update and application of additional quality control criteria that included:
    1. Extended cloud adjacency applied to Sea Ice Concentration IP
    2. Standard cloud adjacency applied to Snow Cover EDR
    3. Confidently clear pixels only
    4. No thin cirrus
    5. Solar zenith angle limited to angles less than 80° (cloud shadow issue)
    6. Fallback to GMASI if no good quality VIIRS Snow/Ice after 5 days
- Sea Ice probability of detection and false alarm rate relative to NOAA AutoSnow for VIIRS gridded Sea Ice are approximately 87% and 7% respectively after testing with the proposed quality control criteria
- Significant regions were not updated by VIIRS Snow/Ice even after a 7 day gridding test period.
- Cloud shadows result in missing snow/ice in the Snow/Ice Rolling Tile grid. Further reduction in Snow/Ice gridding errors will require significant effort.

Cryosphere Team Challenges

- Unanticipated snow/ice gridding issues and problems have required the team to devote unscheduled resources. Gridding problems, including interactions with the cloud mask, have occupied all of our time and resources for the last 19 months.
- The team has had to spend a large amount of time on VCM issues, though there has been much improvement in the VCM and future work should be minimal.
- The FY14 budget is 30% less than FY13.
- The algorithm change process is cumbersome and lengthy. Too many steps and too much time for even the simplest of changes.

Plans, Milestones

	Suomi NPP	JPSS J1
FY15	• Validated Stage n (various) maturity reviews • Implement, test, and deliver new fractional snow cover algorithm • Continued validation of all products • Improve or recommend replacement of Sea Ice Characterization algorithm • Recommendations on snow/ice gridding	JPSS Risk Reduction Projects: • Run GOES-R algorithms on VIIRS products • Minor algorithm improvements
FY16	• Algorithm maintenance and minor improvements	• Hold algorithm preliminary design reviews • Define validation plan
FY17	• Long-term validation of VIIRS snow and ice products	• Hold algorithm critical design reviews • Begin transitioning to JPSS • Redefine products if needed • Generate LUTs for J1 VIIRS sensor
FY18	• Long-term validation of VIIRS snow and ice products	• J1 launch • Beta maturity status