Request for VIIRS Ice Surface Temperature EDR Provisional Maturity

Provisional Effectivity Date: 15 October 2012 (MX 6.4)

Cryosphere Products Validation Team
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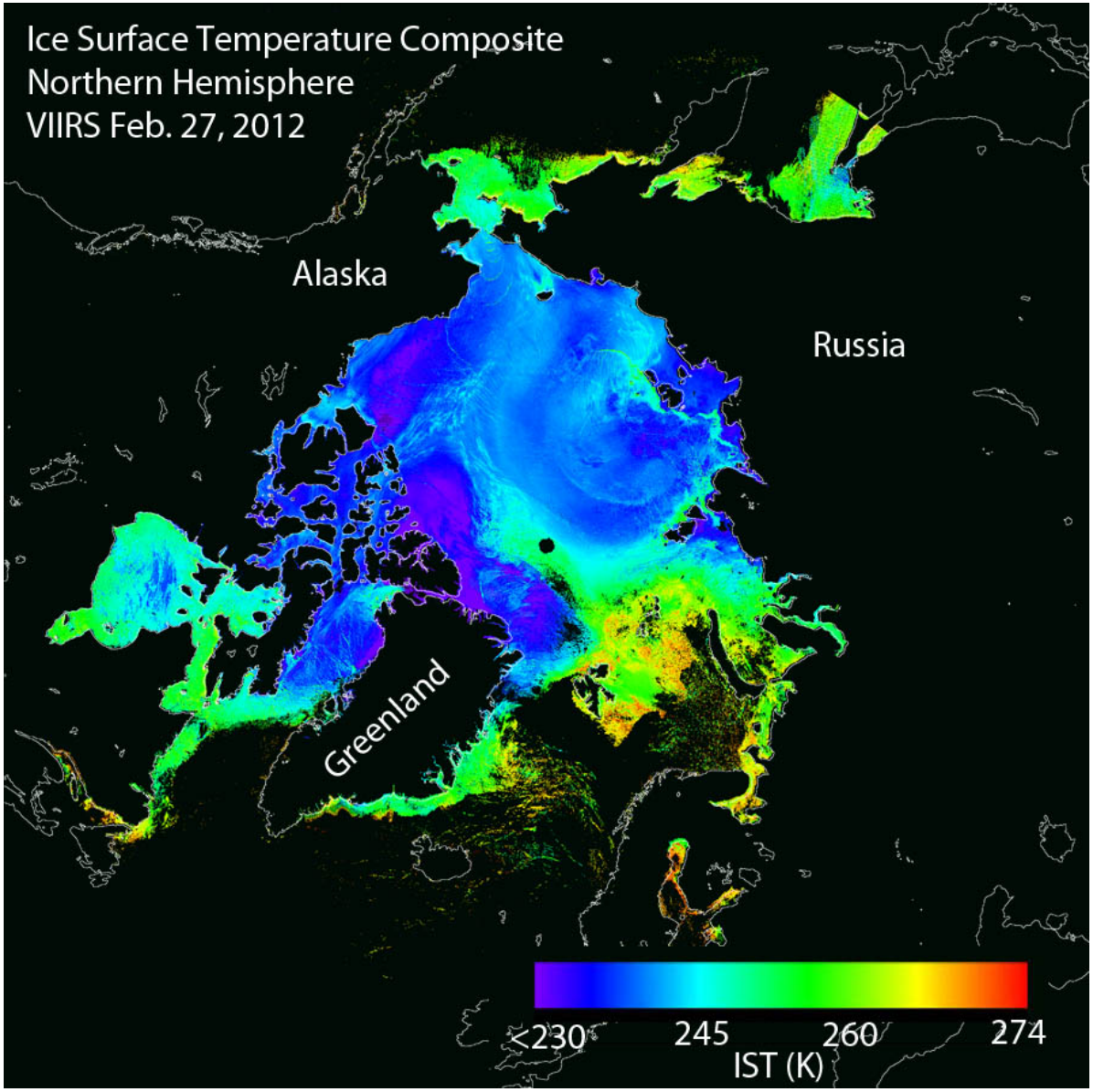
22 August 2013

VIIRS Ice Surface Temperature



Outline

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- Provisional EDR Maturity Definition
- Summary of IST EDR
- VIIRS IST EDR requirements
- History of Algorithm Changes/Updates
- Provisional Maturity Evaluation
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- Conclusions

VIIRS IST EDR Product Users

- U.S. Users
  - NIC, National/Naval Ice Center
  - Naval Research Laboratory
  - 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
  - NWS, National Weather Service, including the Alaska Ice Desk
  - CLASS, Comprehensive Large Array-data Stewardship System

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

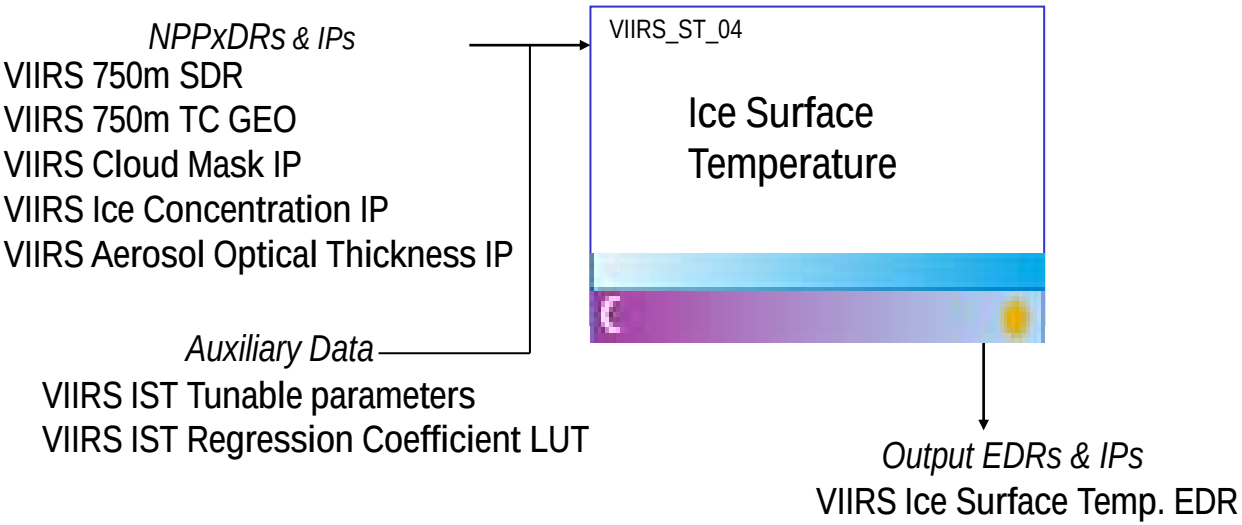
Provisional EDR Maturity Definition

- Product quality may not be optimal
- Incremental product improvements are still occurring
- Version control is in affect
- General research community is encouraged to participate in the QA and validation of the product, but need to be aware that product validation and QA are ongoing
- Users are urged to consult the EDR product status document prior to use of the data in publications
- Ready for operational evaluation

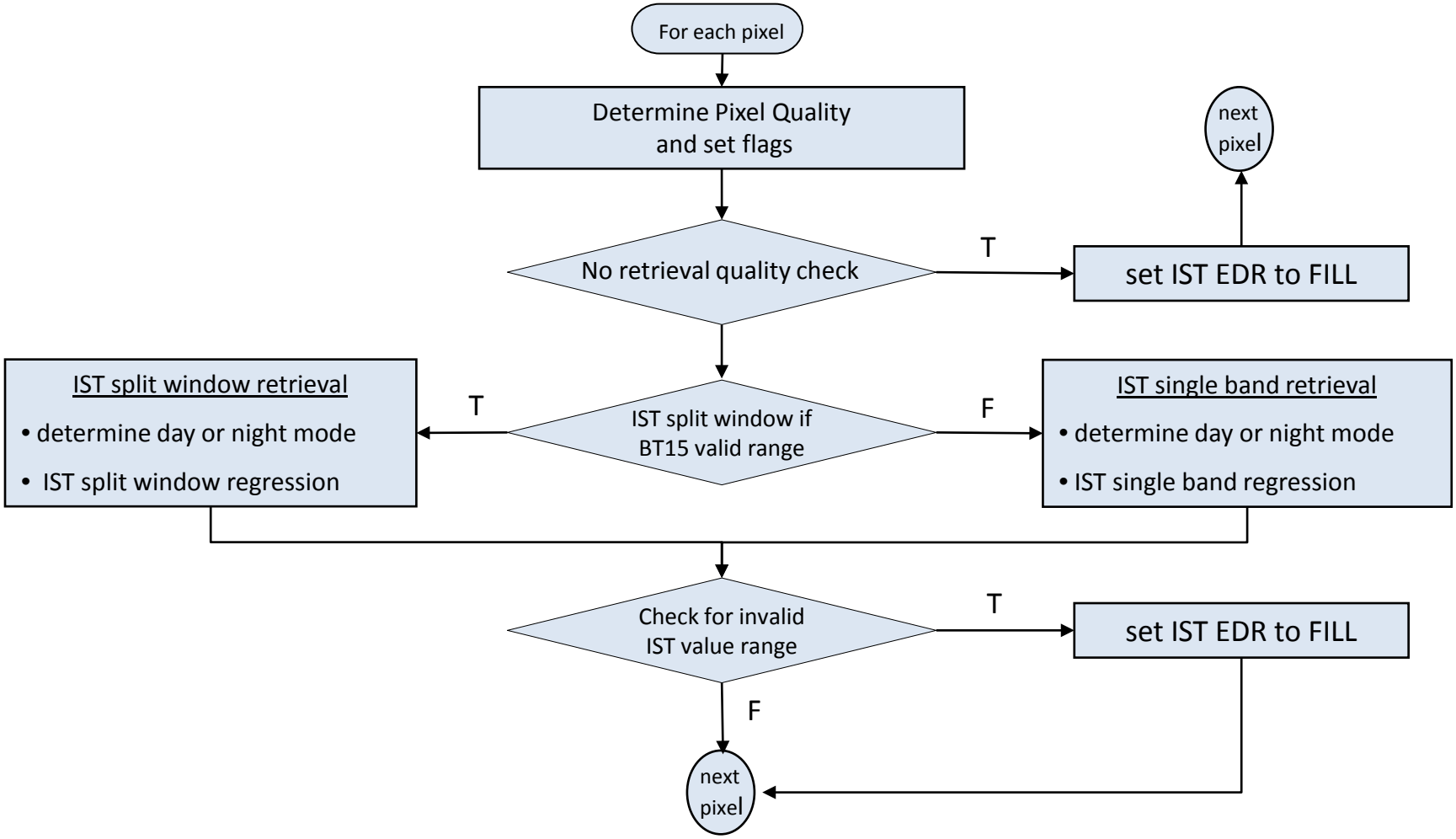
Summary of the VIIRS IST EDR

- The VIIRS Ice Surface Temperature (IST) EDR provides surface temperatures retrieved at VIIRS moderate resolution, for snow/ice covered oceans for both day and night.
- The baseline split window algorithm statistical regression method uses two VIIRS Infrared bands, 10.76 µm (M15) and 12.01 µm (M16) for both day and night and is based on the Advanced Very High Resolution Radiometer (AVHRR) heritage IST algorithm (Yu *et al*., 1995).
- IST EDR performance is dependent upon on the quality of the input SDR brightness temperatures, VIIRS Cloud Mask IP cloud confidence, Ice Concentration IP, Aerosol Optical Thickness IP and regression coefficients derived from matchups between the VIIRS M15 and M16 top of atmosphere (TOA) brightness temperatures and truth surface temperature sources for snow/ice covered ocean surfaces

Summary of the VIIRS IST EDR Algorithm Inputs



Summary of VIIRS IST EDR Processing Flow



VIIRS IST EDR L1RD Requirements

Ice Surface Temperature (IST)

“IST is the radiating, or "skin", temperature at the ice surface. It includes the aggregate temperature of objects comprising the ice surface, including snow and melt water on the ice. Inland water bodies and coastal ice temperatures will be obtained from the LST EDR.

As an objective, the Ice Surface Temperature EDR shall measure the atmospheric temperature 2 m above the surface of the ice.

VIIRS IST EDR L1RD Requirements (Continued)

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

Status of Upstream Products

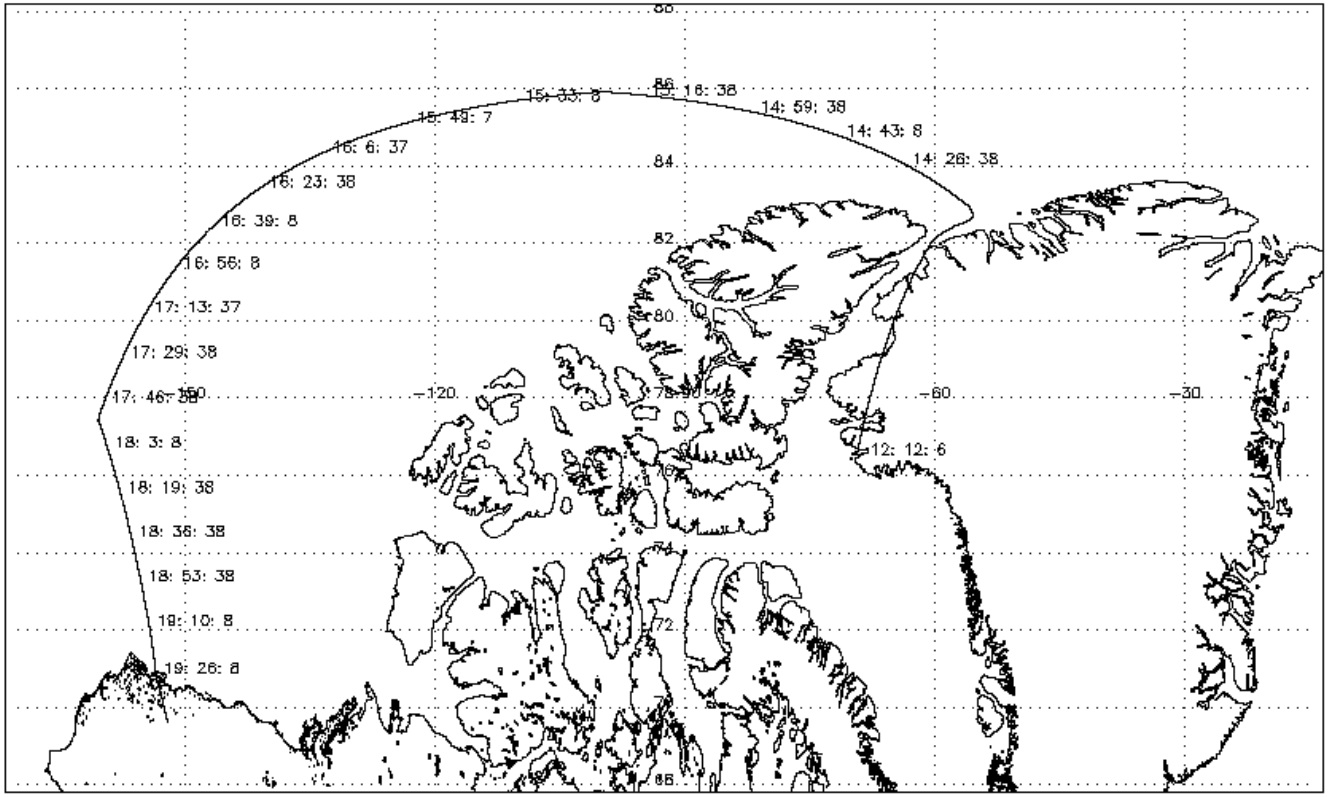
IST EDR performance is dependent on VIIRS SDR, VIIRS Cloud Mask IP, Ice Concentration IP, Aerosol Optical Thickness IP and IST Regression Coefficients

- VIIRS SDR Cal and Geo products reached provisional maturity in March, 2013.
- VIIRS Cloud Mask IP reached provisional maturity in February, 2013
- VIIRS Aerosol Optical Thickness reached beta maturity in September 2012 and provisional in March 2013
- VIIRS Ice Concentration IP reached beta maturity in March 2013.

Provisional Maturity Evaluation

- Provisional Maturity Evaluation Approaches
  - Visualizations and quantitative comparisons of daily global gridded VIIRS IST, comparison with MODIS IST and NCEP surface air temperature, Ice Bridge flight IST
  - Time series analysis and bias analysis
    - NH analysis dates: 1/29/2012, 2/1/2012, 3/14/2012
    - SH analysis dates: 4/10/2012
    - Beaufort Sea analysis dates: 3/14/2012 (IceBridge), 2/12/2012, 2/25/2012, 2/26/2012, 3/30/2012
    - Terra Nova Bay analysis dates: 2/12/2012, 2/25/2012, 2/26/2012, 3/30/2012

Provisional Maturity Evaluation – Comparison VIIRS IST EDR with IceBridge Flight IST



Track of the NASA P-3 aircraft for the March 14, 2012 IceBridge flight. UTC times are shown along the track. The P-3 flew at an altitude of 1000 ft over the sea ice. Among several instruments, it carried a KT-19: a downward-pointing, IR pyrometer that measures the surface temperature (in this case, the IST).

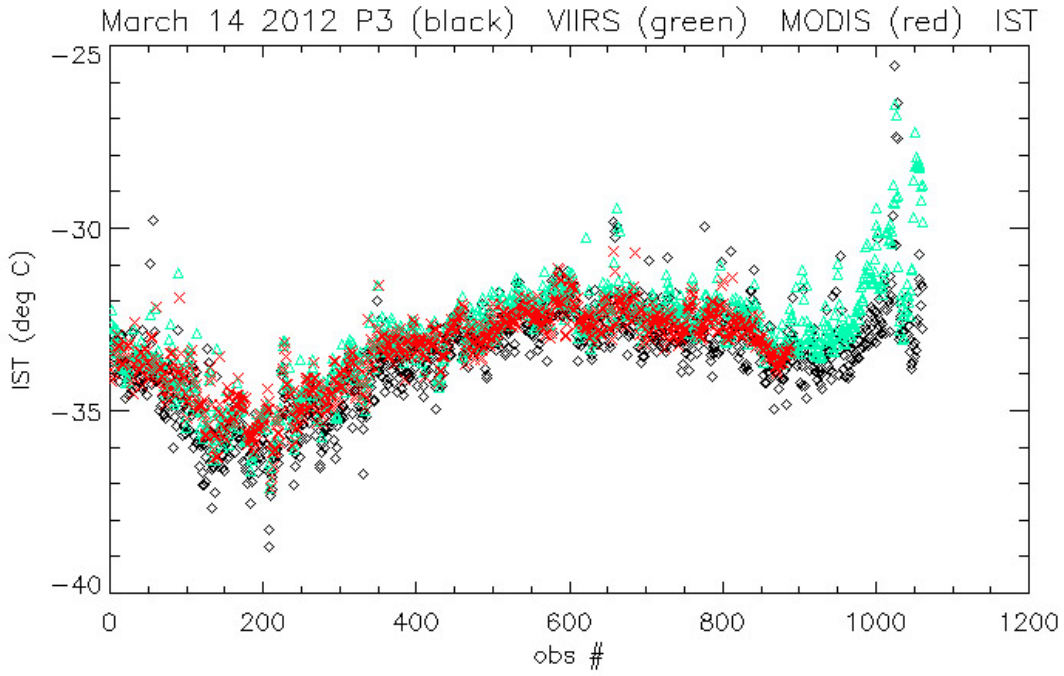
Provisional Maturity Evaluation – Comparison VIIRS IST EDR with IceBridge Flight IST

NASA's Land PEATE re-processed portions of the VIIRS IST EDR that are co-incident with IceBridge flights over sea ice during March and April 2012. The resulting VIIRS IST EDR shows much better agreement with the ice surface temperature observed by the IceBridge P-3 aircraft ‘s KT-19 instrument than the previous IST EDR data produced in March 2012.

A comparison of IST measured by the NASA P-3 aircraft's KT-19 instrument (J. Yungel, PI) and the VIIRS IST EDR

mean VIIRS = -33.2 ˚C
mean KT-19 = -33.7 ˚C
mean MODIS = -33.4 ˚C

RMS differences:
VIIRS - KT-19 = 0.6 ˚C
MODIS- KT-19 = 1.2 ˚C
VIIRS – MODIS = 1.1 ˚C

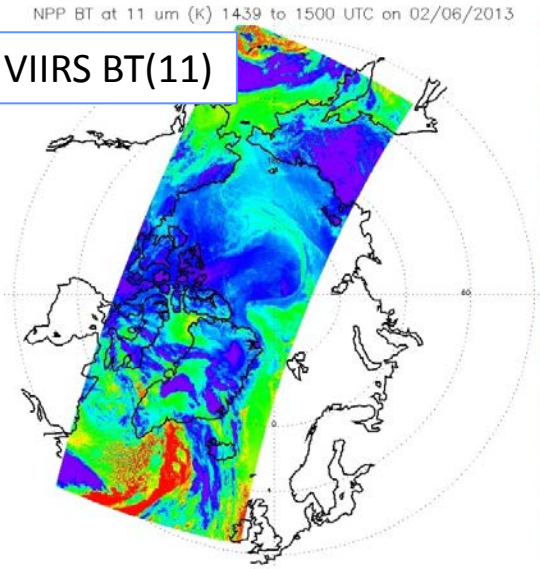


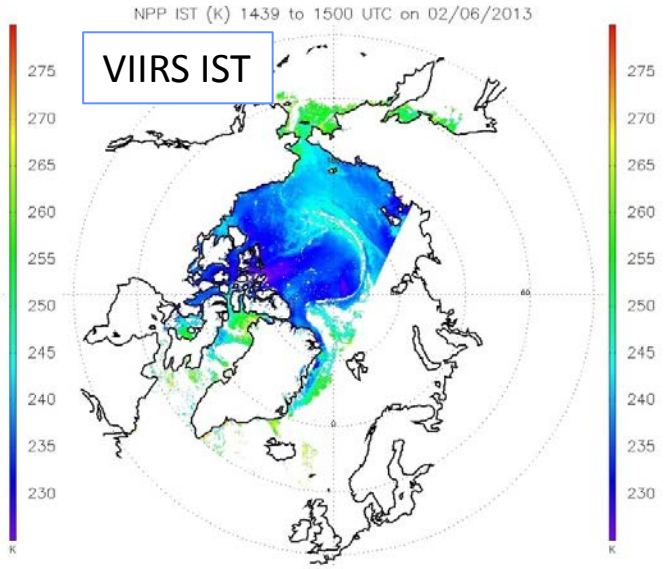
Comparison between the IST (in deg C) measured by the KT-19 (in black, smoothed over 100 points), the nearest VIIRS IST measurement (in green) and MODIS observation (red). The comparison is for the leg from 16:03:37 -19:10:08 (west of -120 lon). The VIIRS overpass occurred from 16:01 - 16:06 UTC . VIIRS, MODIS, and the KT-19 IST's show consistent good agreement along the flight track, with VIIRS close to meeting the 0.5 ˚C (or K) spec.

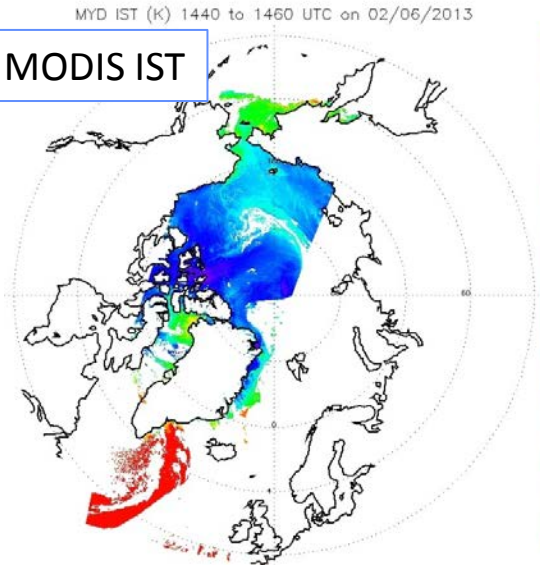
Provisional Maturity Evaluation – Comparison VIIRS IST with MODIS and NCEP

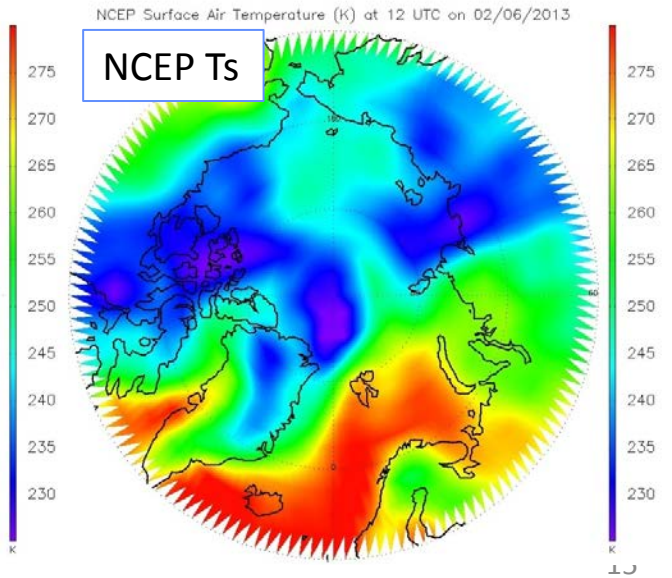
Ice Surface Temperature (IST) EDR validation activities have shown that VIIRS IST has a 1-2 K cold bias relative to the MODIS Ice Surface Temperature product. The bias for VIIRS Land Surface Temperature over the ice sheet (not shown) is less than for IST.

Comparisons to NCEP and International Arctic Buoy Program (IABP) air temperatures show a similar spatial pattern but yield a VIIRS warm bias of 1 K or more, which is the opposite of the MODIS comparison. The comparison confirms the validity of the MODIS IST.





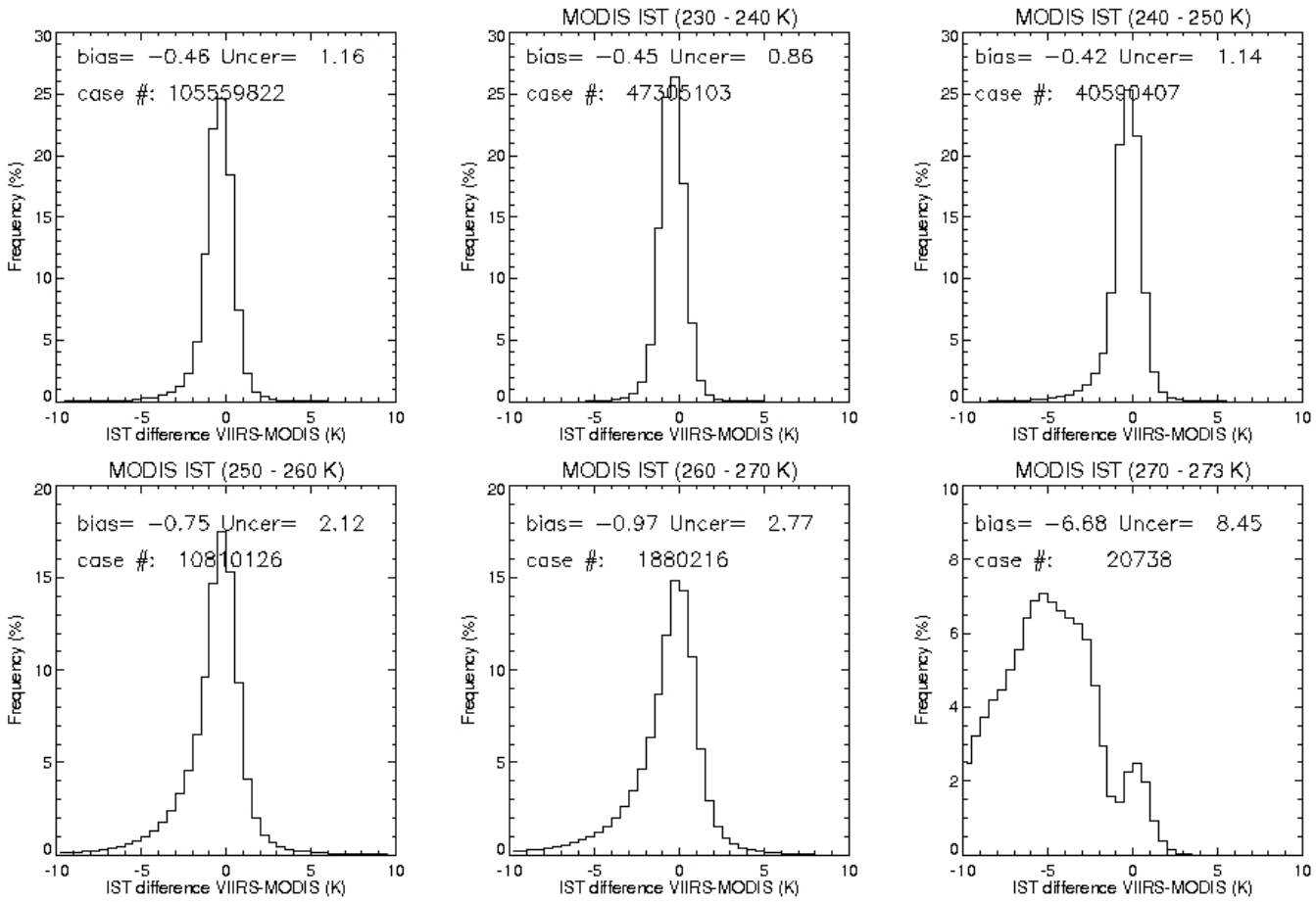




Provisional Maturity Evaluation – VIIRS IST vs MODIS IST

VIIRS is biased low (too cold) relative to MODIS, though the bias is relatively small for most of the temperature range.

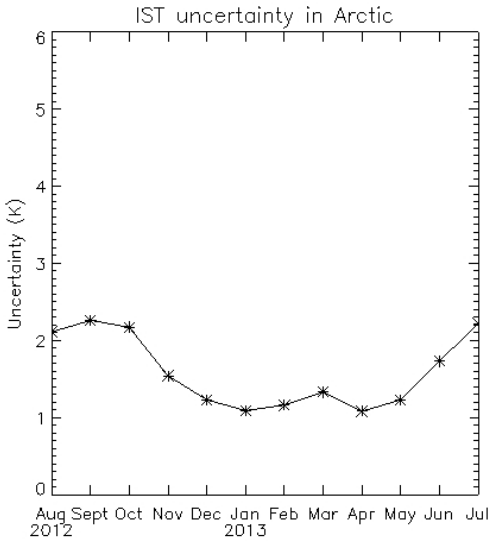
Of greater concern is the uncertainty, which is large at higher temperatures.

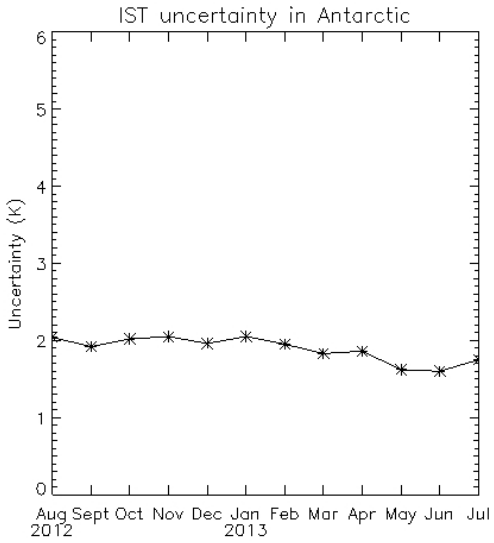


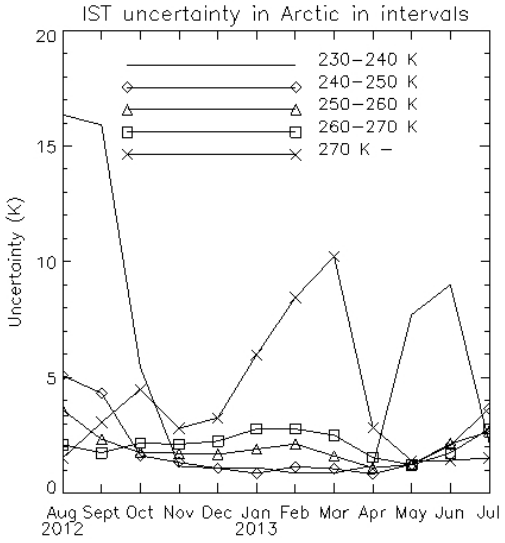
Histogram of ice surface temperature differences of NPP VIIRS and MODIS (Aqua and Terra) in February 2013 in the Arctic for all cases (upper left), and for cases with MODIS ice surface temperature in the ranges 230-240 K, 240-250 K, 250-260 K, 260-270 K, and 270- 273 K. Measurement bias (bias) and measurement uncertainty (Prec) are indicated for each bin.

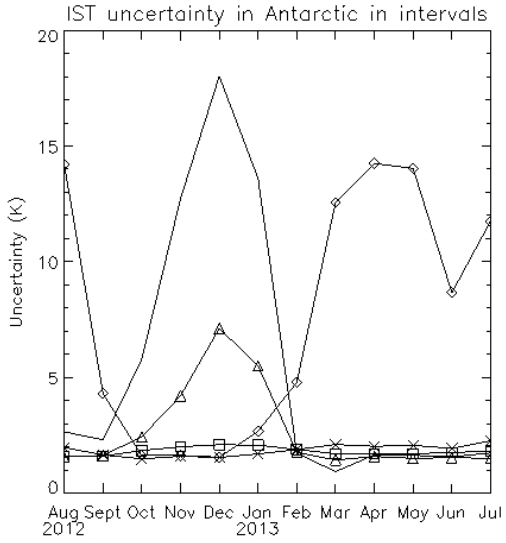
Provisional Maturity Evaluation – VIIRS IST vs MODIS IST

Uncertainties of VIIRS ice surface temperature (IST) based on collocated VIIRS and MODIS (Terra and Aqua) from August 2012 to July 2013 for all cases in the Arctic (upper left), for all cases in the Antarctic (upper right), for cases in different MODIS IST intervals in the Arctic (lower left), and in the Antarctic (lower right).





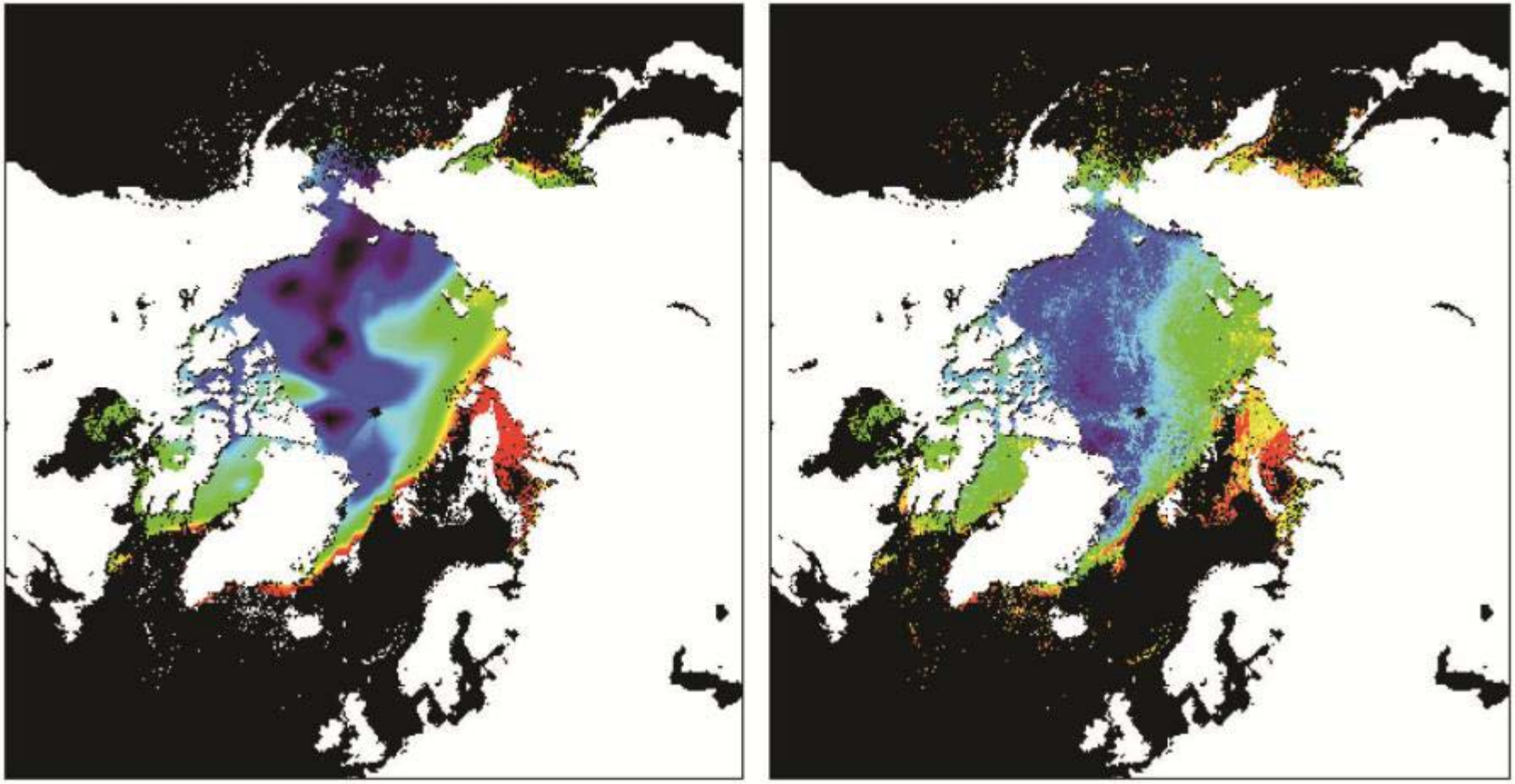




Provisional Maturity Evaluation – NH comparison

NCEP surface temperature (range = 220K to 270K)

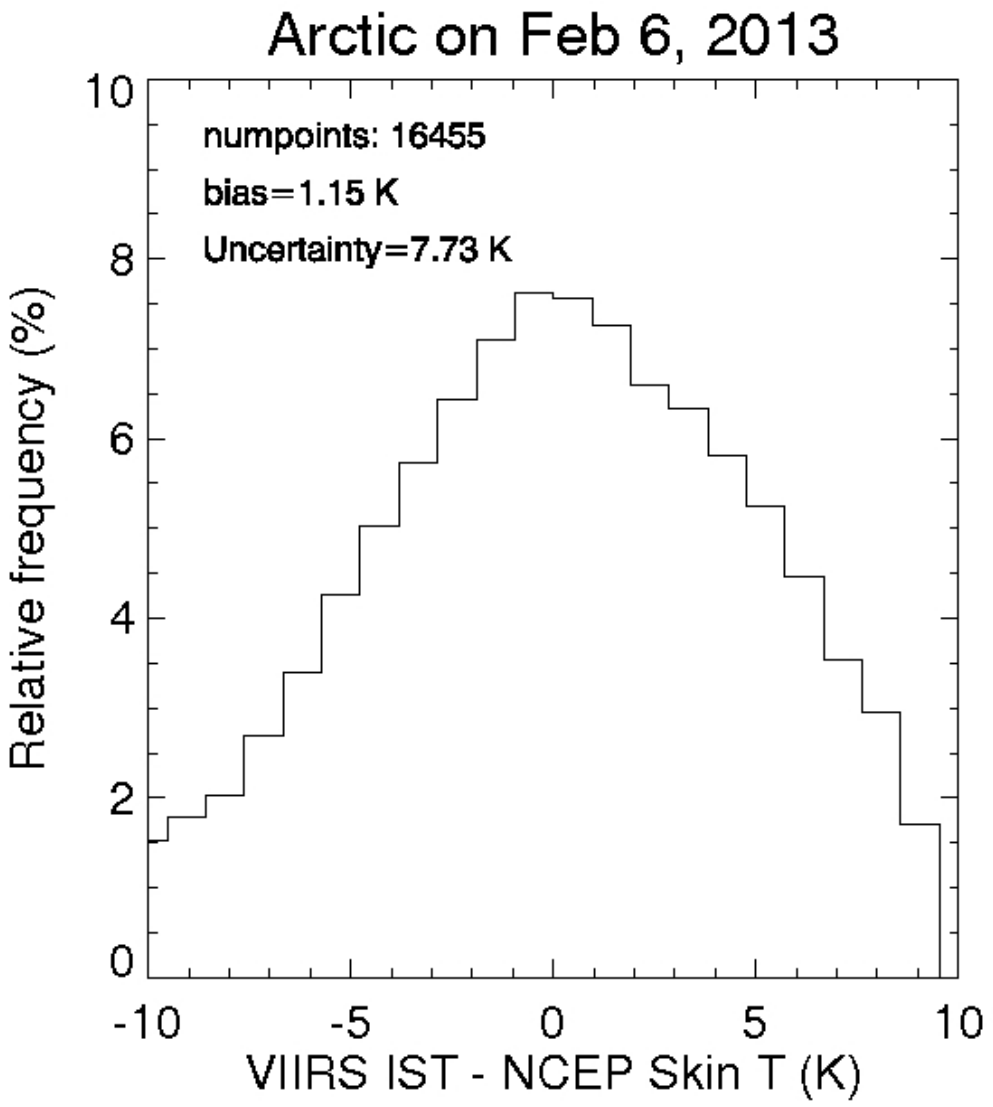
VIIRS IST (range = 220K to 270K)



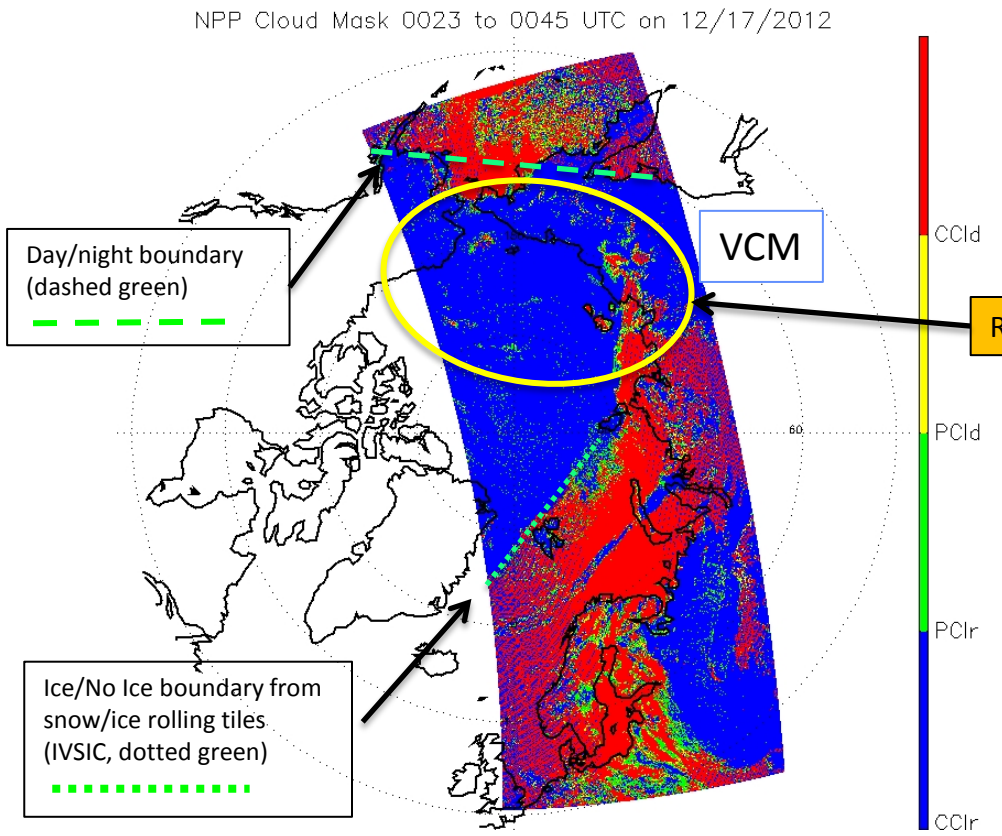
NCEP vs. VIIRS IST, Feb 27, 2012. Spatial patterns appear consistent.

Provisional Maturity Evaluation – global comparison

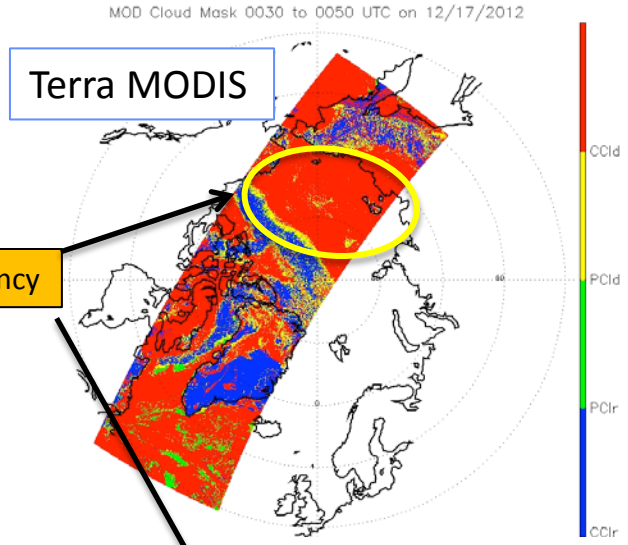
VIIRS is biased high (warm) compared to NCEP reanalysis. However, the NCEP skin temperature used in this analysis is a forecast, not an analysis. This result is the opposite of the MODIS & IceBridge results.

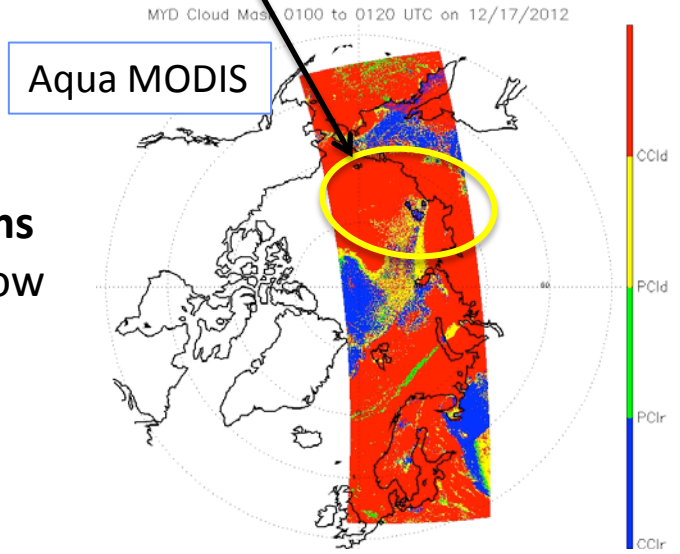


Provisional Maturity Evaluation – Cloud Mask Impacts



Region of discrepancy





The VIIRS Cloud Mask (VCM) continues to exhibit problems in the polar regions, which can significantly impact the snow and ice products. The figure above illustrates significant differences between daytime and nighttime, as well as discontinuities along ice/no-ice boundaries.

Discrepancy Reports (DRs)

Date	Update/DR#	Reason	Status
04-17-2013	7138	IST EDR OAD Corrections	open
04-17-2013	7137	IST EDR ATBD Section 2.3 Wording Error Correction	open
11-18-2011	4457	EDR PR to define mid quality criteria	open
11-18-2011	4456	EDR PR update to Define the exclusion criteria for quality summations	open
11-18-2011	4455	Update EDR PR to define high quality retrievals	open
12-22-2010	4136	ECR A-337 Dec 10 Look Up Table drop	request closure
07-17-2009	2936	Ice Surface Temp and IST use different emissivities for ice	Plan in place (next slide)

Path Forward Recommendation for DR 2936

Comparison of IST and Surface Temperature IP (ST IP) regression coefficients indicate that the IST coefficients currently implemented on the IDPS system are valid. However, inspection has revealed the ST IP split window coefficient value associated with view zenith angle dependence was erroneously set to 0.

The review also uncovered a sign error in the ATBD equation (second line from the top, page 34). However, the code implementation is correct.

Proposed path forward actions

1. Deliver updated STIP coefficients to close out DR 2936
2. Open DR to correct the IST ATBD equation appearing in the ATBD. The Equation should be $t11 = tI + (1-f)D$ instead of $t11 = tI - (1-f)D$

Data Quality Threshold Tables (DQTT)

Synthesizing from the EDR PR, the CDFCB-X Vol. VI, and the IST DQTT XML file:

1. There are three Data Quality Flags that are linked to potential Data Quality Notifications (DQNs):
   a) EDR Summary Quality - The percentage of pixels within a granule with a high retrieval quality
   b) Exclusion Summary - The percentage of pixels within a granule with excluded conditions
   c) Summary Range Check - The percentage of retrieved pixels outside of the expected range (213 K to 275 K)
2. For each of these, the current Data Quality Threshold Table (DQTT) specifies that a DQN will occur if (and only if) the percentage in question is less than 0% AND that this has occurred a minimum of 80 times. Furthermore, the DQN "severity" in each case (if one is issued) is "Normal" (i.e., not severe).
3. The DQTT specifies that each of the three DQN is currently OFF (the <active> tag is "false").

This appears to be just a placeholder DQTT, as none of these can be triggered as currently specified. Therefore, the Cryosphere Team needs to develop either an internal (Cal/Val team only) or cooperative (Cal/Val team plus Raytheon OAA?) plan to define appropriate DQTTs. After doing so, we will perform analysis using two days of orbits (Dec. 17-18, 2012) to determine appropriate DQN thresholds for the three flags.

Provisional Justification Summary

Product quality may not be optimal

- The product meets accuracy requirements under some, but not all, conditions.
- Evaluation is based on a limited number of focus days (global comparisons for retrieval products)
- The product has known flaws, but these products are of sufficient quality to justify use by a broader community.
- IST EDR contains retrievals over false ice retrieved by the VIIRS Sea Ice Concentration IP. Some false ice retrieved by the VIIRS Sea Ice Concentration IP has been linked to cloud leakage from a VIIRS Cloud Mask (VCM).

Incremental product improvements are still occurring

- IST EDR surface temperature performance bias exists but is expected to improve with updated regression coefficients. The bias has been observed to be reduced with more recent IDPS code, primarily due to improvements in the VCM.
- While the performance of the VCM Cloud Confidence for day continues to improve with VCM tuning, improved performance for night will be dependent on the implementation of daily NOAA Multi-sensor Snow/Ice rolling tile updates and further tuning efforts. IST EDR performance is expected to benefit from improvements to resolve the current VCM bias toward over-prediction of confidently clear regions at night in polar regions.

Provisional Justification Summary

Version control is in affect

- (Description of the development environment, algorithm version (IDPS build number), and LUTs/PCTs versions used to generate the product validation materials.)
- ATBDs are accurate, up-to-date and consistent with the product running.

General research community is encouraged to participate in the QA and validation of the product, but need to be aware that product validation and QA are ongoing

- Cryosphere IST EDR team has evaluated IDPS EDR products available from CLASS. Users can access and read the products and the product compares reasonably with the heritage satellite snow map products

Provisional Justification Summary

Users are urged to consult the EDR product status document prior to use of the data in publications

- Examination of the VIIRS IST EDR shows temperature over false ice retrieved by the Sea Ice Concentration IP. Such errors will be reduced with MX 8.0 VIIRS Cloud Mask update and implementation additional quality checks in the Sea Ice Concentration IP for future builds beyond MX 8.0
- Current IST bias should be reduced with updated IST regression coefficients based on matchup of VIIRS M15, M16 TOA brightness temperatures with surface temperature truth. Evidence of lower bias has been shown with IceBridge IST comparisons.

Ready for operational evaluation

- (Key NOAA and non-NOAA end users are identified and feedback requested.)

Additional Supporting Documentation

- TIM Meetings and Presentations
  - Cal/Val Team Meeting, April 2012

- Monthly/weekly reports
  https://groups.ssec.wisc.edu/groups/jpss/cryosphere/reports

Future Plans and Issues

- No code changes currently planned
- Detailed performance characterization requires:
  - Update of IST regression coefficients based on matchup with VIIRS and truth IST sources
  - Improvements, consistency, and stability in the VIIRS cloud mask
- Other actions:
  - Ability to check for reduced quality VIIRS Ice Concentration IP input based on quality flags with additional quality checks to be added to the Ice Concentration IP

Conclusion

- VIIRS IST EDR has met the provisional maturity stage based on the definitions and the evidence shown
  - It exceeds the definition of provisional in most cases
  - Off-line EDR product performance overall is close to meeting requirements at this time and meets requirements in some cases. It continues to improve.
- Some issues have been uncovered during validation and solutions are being evaluated.
  - Improvements in IST EDR performance may be realized as the VIIRS Cloud Mask IP matures and additional quality flags become available in the VIIRS Ice Concentration IP to avoid IST retrievals near clouds.
- The provisional effectivity date is 15 October 2012 (MX 6.4). VIIRS Cloud Mask IP improvements in this build notably improved product performance.