SUOMI-NPP VIIRS ICE SURFACE TEMPERATURE STATUS

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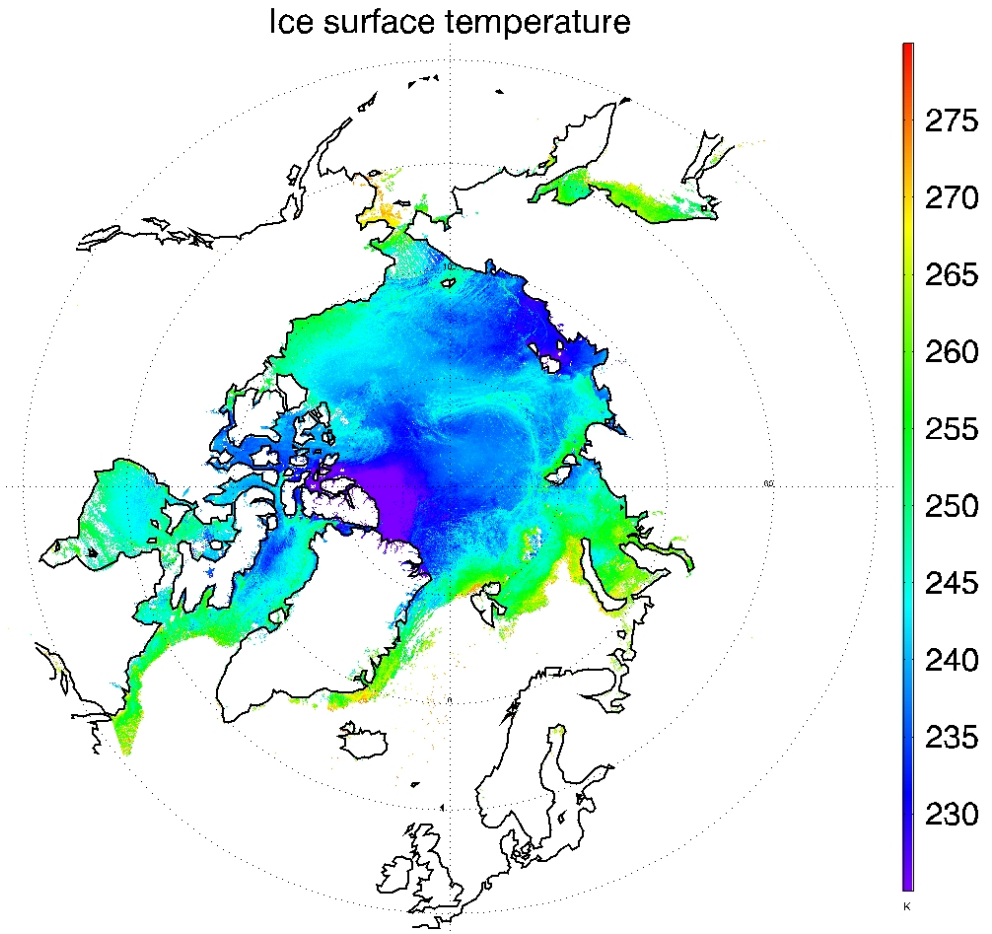
IST Cal/Val Team

PI	Organization	Team Members	Roles and Responsibilities
J. Key	NESDIS	M. Tschudi (CU/CCAR)	IST cal/val
		Y. Liu (UW/CIMSS)	IST development and cal/val
		R. Dworak (CIMSS)	IST cal/val
		D. Baldwin (CCAR)	IST cal/val
		X. Wang (CIMSS)	IST application

IDPS VIIRS Ice Surface Temperature

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.

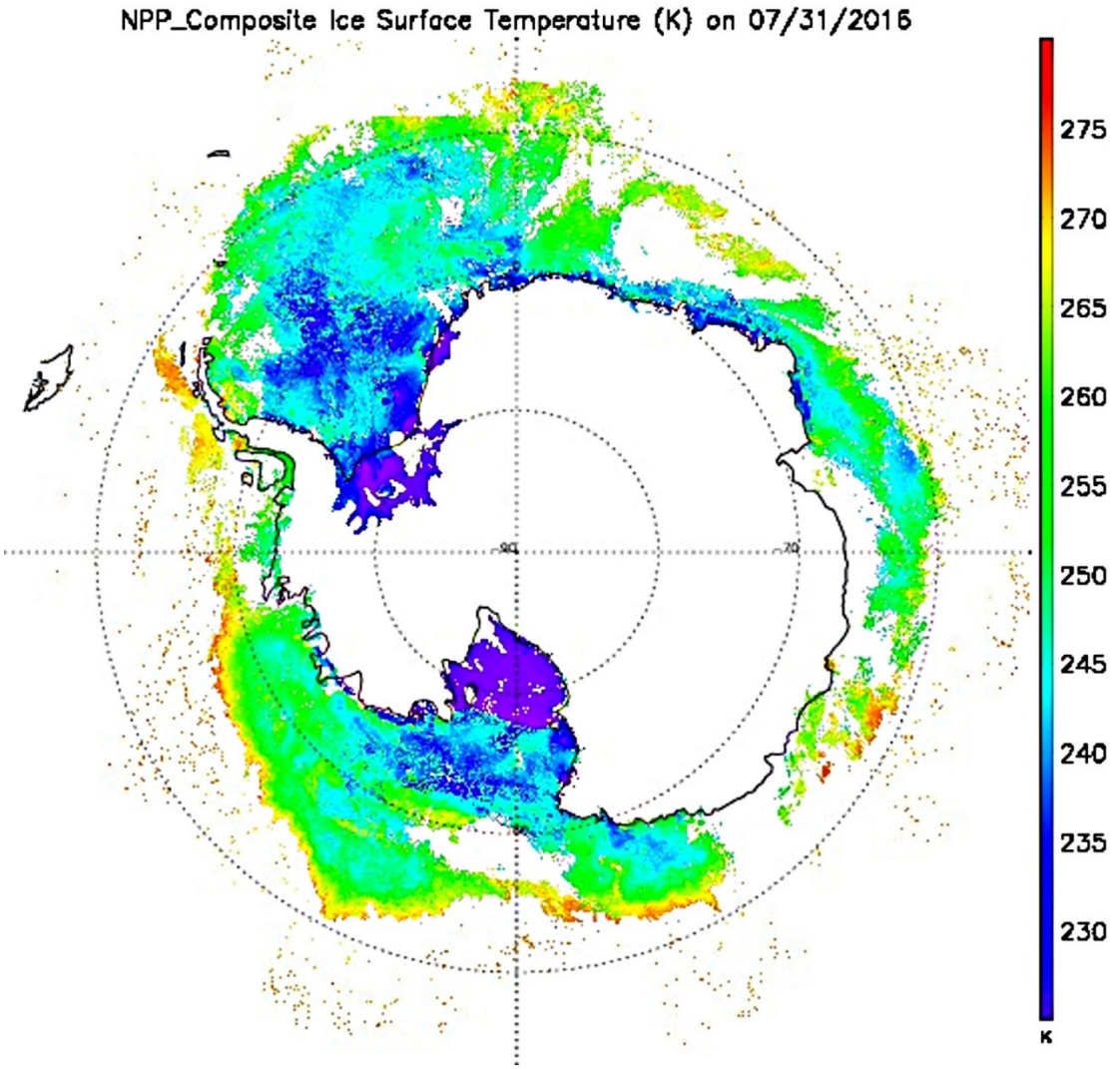


Ice surface temperature (IST) composite from all overpasses over the Arctic on March 1, 2015. From *Liu et al.*, 2015.

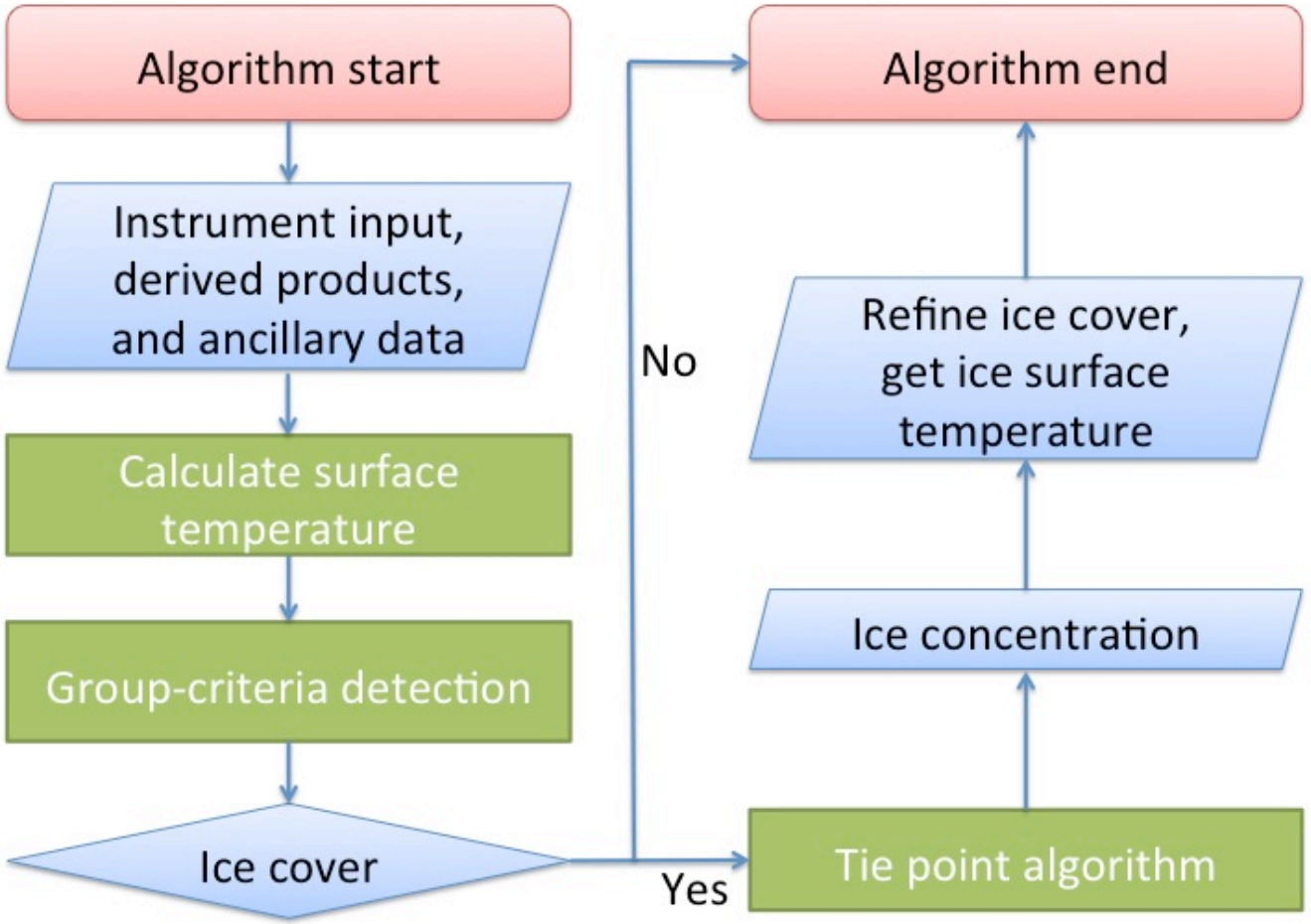
Enterprise VIIRS IST on Aug 5, 2016

From U. Wisc/CIMSS near real-time VIIRS ice products, based on JPSS Enterprise algorithms

https://stratus.ssec.wisc.edu/ice-products/anibrowser/



JPSS VIIRS Enterprise IST flow chart



Summary of the VIIRS IST EDR

- The VIIRS Ice Surface Temperature (IST) EDR provides surface temperatures retrieved at VIIRS moderate resolution (750m), for Arctic and Antarctic sea ice for both day and night.
- The baseline split window algorithm statistical regression method is based on the IST algorithm of *Key and Haefliger (1992) and Key et al. (1997)*:

$$IST = a + bT_{11} + c(T_{11}-T_{12}) + d(T_{11}-T_{12})(\sec(z)-1)$$

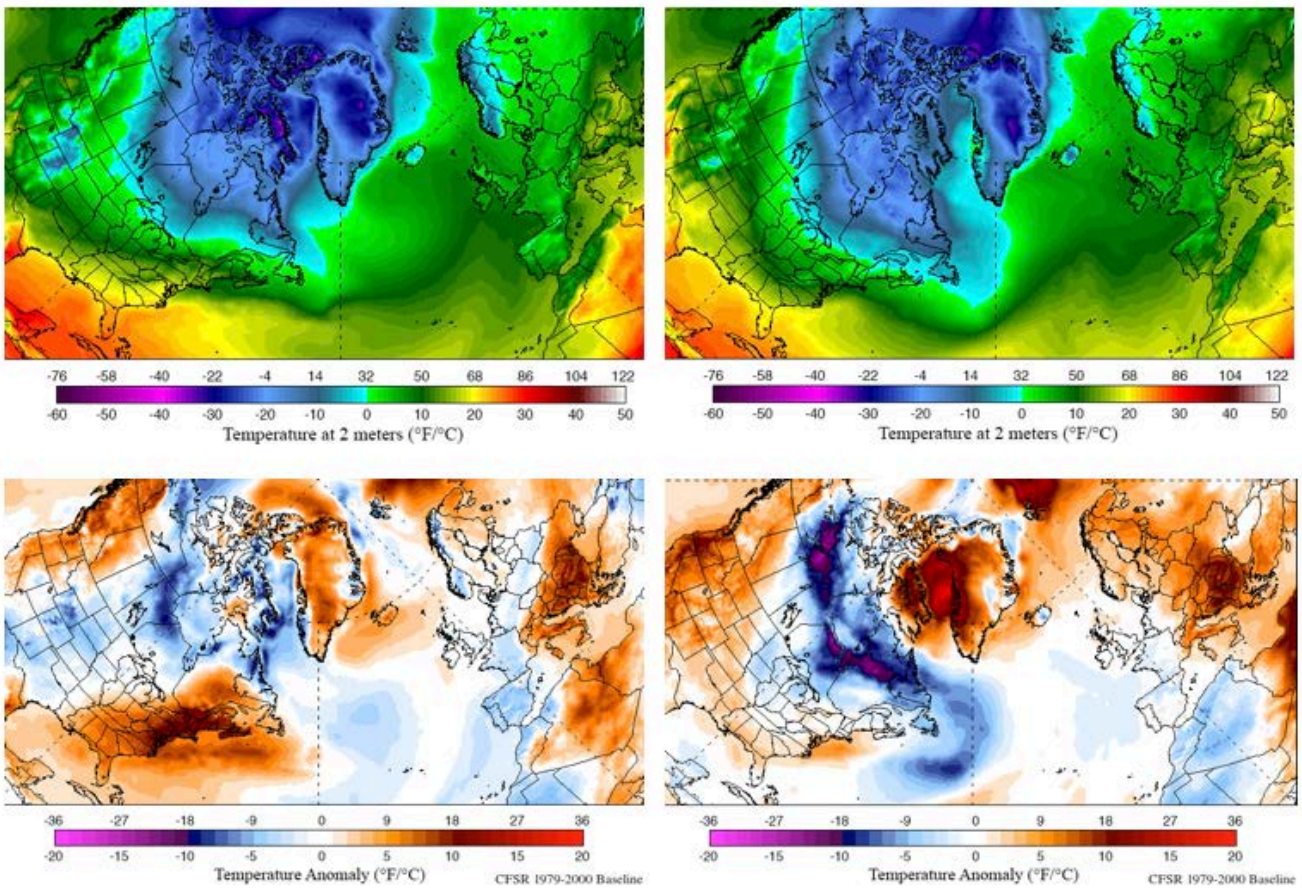
T_{11} and T_{12} : TOA TB's for ~11 and 12 μm bands
z: satellite zenith angle
a, b, c, d: regression coefficients.

- Threshold Measurement Uncertainty = **1K** over a measurement range of 213–275 K.

Key, J., and M. Haefliger (1992), Arctic ice surface temperature retrieval from AVHRR thermal channels, J. Geophys. Res., 97(D5), 5885–5893.

Key, J., J. Collins, C. Fowler, and R. Stone, 1997. High-latitude surface temperature estimates from thermal satellite data. Remote Sensing Environ., 61, 302-309.

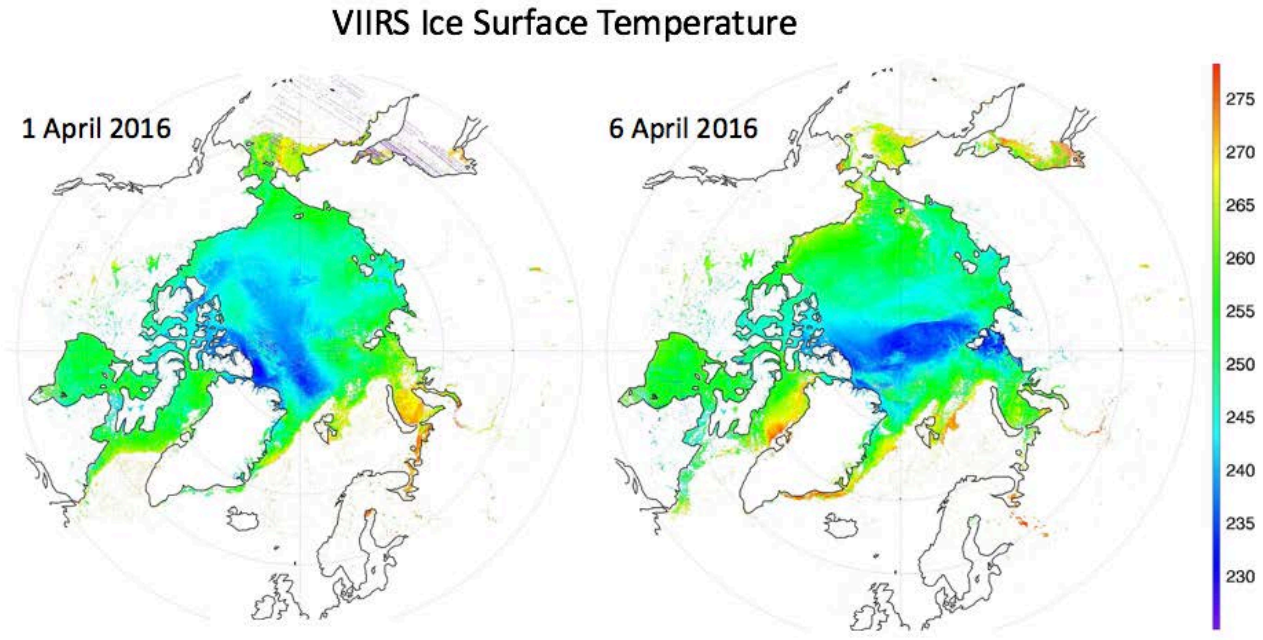
April surface warming event over Baffin Bay



During the first week of April 2016 a significant surface warming event was observed over Baffin Bay (left). Mean surface temperatures over the area from The NCEP Climate Forecast System Version 2 (CFSv2) Reanalysis ranged from -30 to -10º C on 1 April 2016 with anomalies of -10º C in the south to +5º C in the north. By 7 April 2016 the mean surface temperatures rose by 10 to 20º C with surface temperature anomalies of up to 20º C off the west central coast of Greenland.

Top row is daily mean 2-meter temperatures for 1 April 2016 left and 7 April 2016 right. Bottom row is daily mean temperature anomaly. Data from CFSv2 provided by the University of Maine Climate Change Institute Climate Reanalyzer (http://cci-reanalyzer.org/)

April surface warming event over Baffin Bay



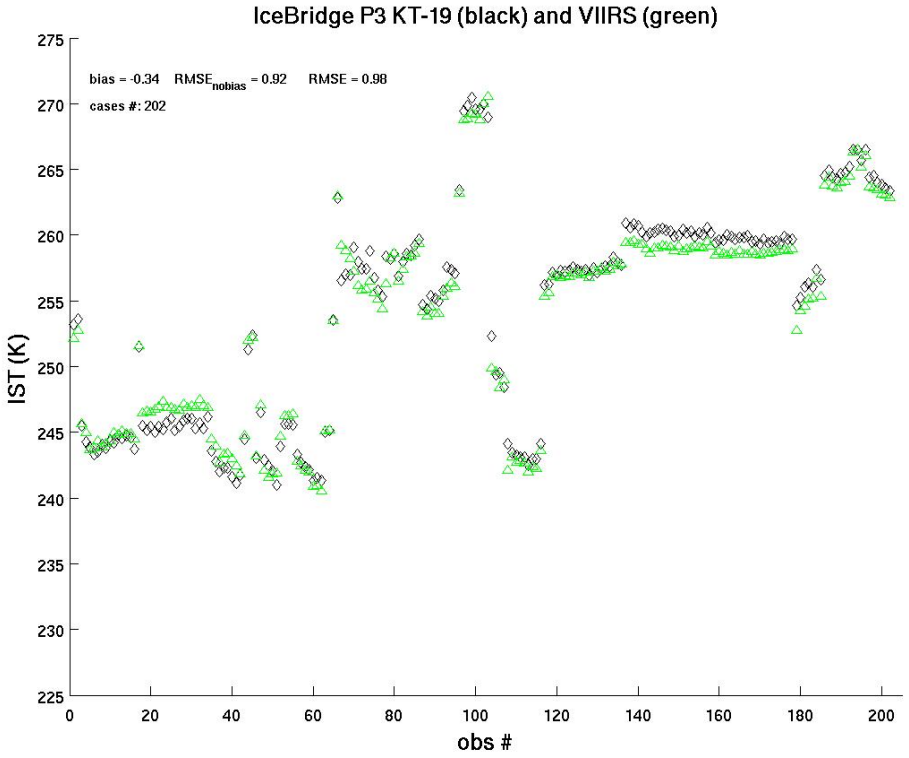
Daily composites of S-NPP VIIRS Ice Surface Temperature using the Enterprise algorithm. Left: 1 April 2016; right: 6 April 2016.

The NPP VIIRS Ice Surface Temperature (IST) Enterprise algorithm observed the same warming event over the 1 to 6 April period (left). IST was in the range of 245-265 K on 1 April, warming to 255-275 K by 6 April. A strong ridge of high pressure developed over Greenland, allowing warm air from the south to be advected over the Baffin Bay region. On a related but broader scale, a record-breaking level of surface melt on the Greenland ice sheet has been observed for this early in the year. *By R. Dvorak*

VIIRS IST Validation Approach

Validation Dataset	Parameter	Spatial Resolution	Spatial Coverage	Temporal Coverage
NASA IceBridge KT-19 IR Surface Temperature	Snow/ice temperature	15 x 15 m	Arctic and Antarctic	Arctic: 2012-2014 Antarctic: 2012-2013
MODIS Ice Surface Temperature	Snow/ice temperature	1 km	Arctic and Antarctic	August 2012-July 2015
MODIS simultaneous nadir overpass	Snow/ice temperature	0.05 degree longitude by 0.05 degree latitude	Arctic	March 2013 – April 2014
Arctic drifting buoy	2 m air temperature	Point observations	Arctic	August 2012 - June 2014
NCEP/NCAR reanalysis	Air temperature at 0.995 sigma level	2.5 x 2.5 degree latitude/longitude	Arctic and Antarctic	August 2012-July 2015

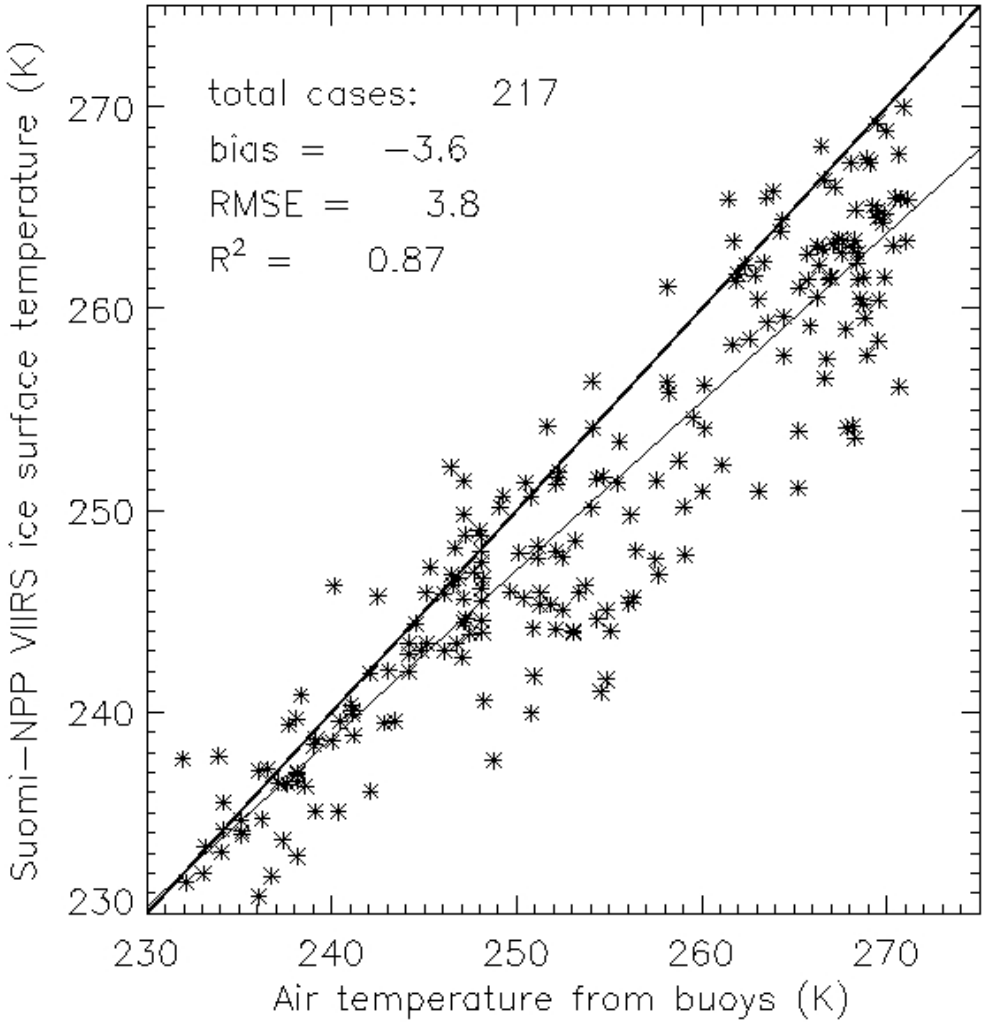
VIIRS IST IceBridge Validation



VIIRS IST (green) and KT-19 IST (black) for all coincident IceBridge flights with cloud-free observations over the Arctic (March-May 2014) and Antarctic (October-November 2012-13).

From: *Yinghui Liu, Jeffrey Key, Mark Tschudi, Richard Dworak, Robert Mahoney, and Daniel Baldwin*, 2015: Validation of the Suomi NPP VIIRS Ice Surface Temperature Environmental Data Record, *Remote Sens.* **2015**, *7*, 13507-13527; doi:10.3390/rs71013507

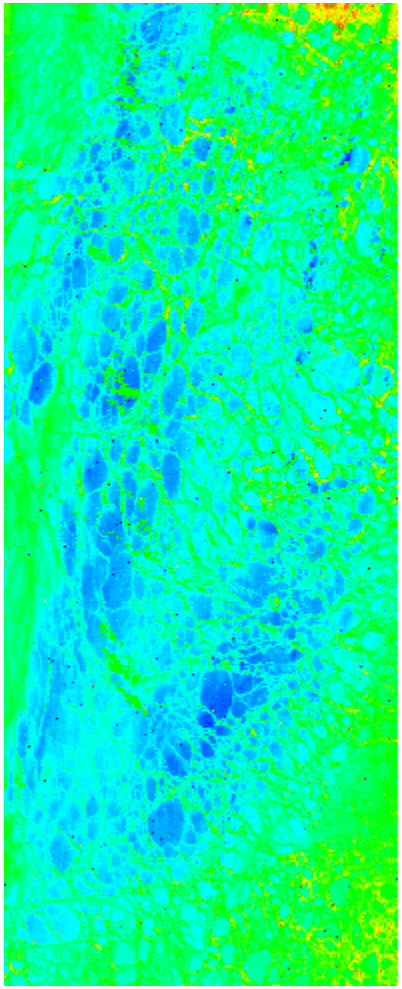
VIIRS IST vs. buoys

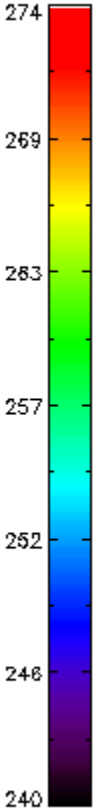


Scatter plot of surface air temperature from Arctic buoys and NPP VIIRS IST from August 2012 to June 2014, with the thick line as the 1 to 1 ratio line, and thin line as the linear regression.

From *Liu et al.*, 2015.

Suomi-NPP VIIRS IST – NASA product





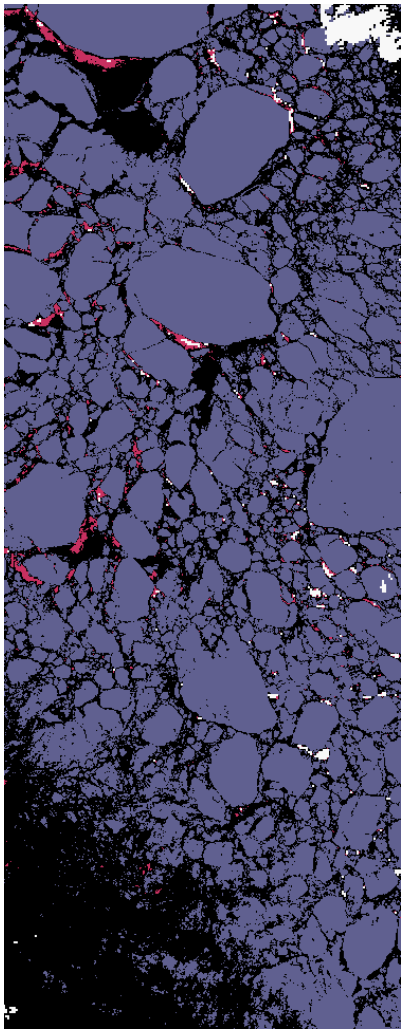
- Utilizes split window:

$$IST = a_o + a_1 T_{M15} + a_2(T_{M15} - T_{M16}) + a_3(T_{M15} - T_{M16})(\sec(z) - 1)$$

- Initial code generated from MODIS code by NASA's Science Investigator-led Processing System (SIPS)
- Code being updated for VIIRS (calibration coefficients, etc.)
- New Quality Flags to be added
- Inter-comparison: MODIS, NCEP
- Validation: IceBridge, buoys

Left: VIIRS IST (K) from the NASA VIIRS IST product
Sept 12, 2014, 21:10 UTC
Beaufort Sea, AK

NASA VIIRS Sea Ice Cover Product



NASA VIIRS Sea Ice Cover
April 7, 2015, Beaufort Sea

- NASA VIIRS Sea Ice Cover by Reflectance
- Follow-on from MODIS (D. Hall & G. Riggs)
- Code generated by NASA SIPS
- In development by M. Tschudi (CU), George Riggs (SSAI)
- Reflectance-based during daytime, nighttime uses the IST product
- Sea ice by reflectance utilizes the NDSI:
  - NDSI = [R(I1) – R(I3)] / [R(I1) + R(I3)]
  - R=reflectance, VIIRS I1 (0.64um), VIIRS I3 (1.61um)
- Ice cover is mapped:
  - Snow-covered ice:
    - NDSI > thold and R(I1) > thold2
  - Thin ice (<10 cm, no snow cover)
    - IST – SST > thold
- Validation: IceBridge, Digital Globe, …
- Intercomparison: AMSR-2, IDPS Sea Ice Age, VIIRS Sea Ice Concentration, NDE Sea Ice Thickness

Conclusions

- VIIRS IST algorithm in most cases meets the requirement of 1K measurement uncertainty
- The VIIRS IST has detected early warming in Baffin Bay which parallels other observations.
- Improvements in the VIIRS IST performance have been realized as the VIIRS Cloud Mask matures
- NASA's Sea Ice Extent and IST products will provide continuity with the MODIS product