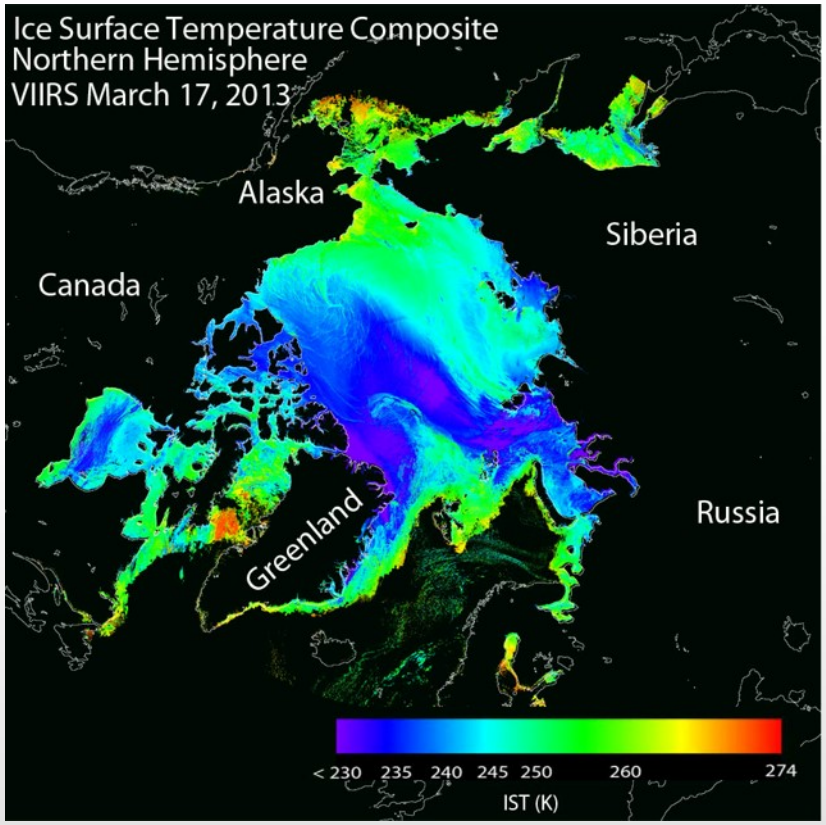
Suomi- NPP VIIRS Ice Surface Temperature Status

Mark Tschudi (CU)*

Yinghui Liu (UWisc), Richard Dworak (UWisc), Dan Baldwin (CU), Jeff Key (NOAA)

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.



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 AVHRR heritage IST algorithm *(Key and Haeflinger.,* 1992)

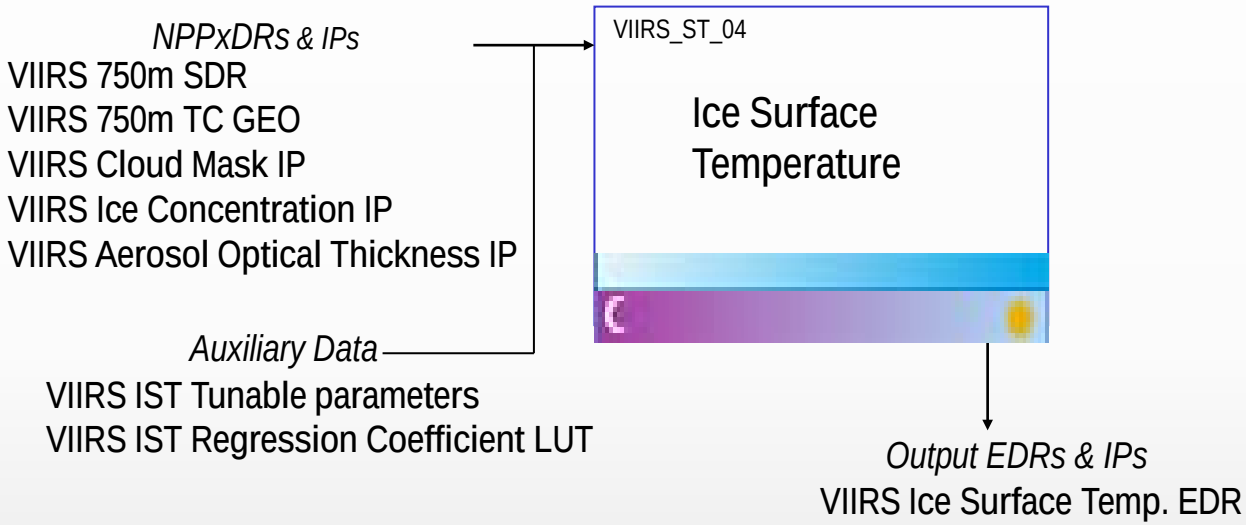
$$IST = a_o + a_1 T_{M15} + a_2 (T_{M15} - T_{M16}) + a_3 (\sec(z) - 1)$$

T_{M15} and T_{M16} : VIIRS TOA TB's for the VIIRS M15 and M16 bands
z: the satellite zenith angle
a_o, a_1, a_2, a_3 : 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.

Flow for the VIIRS Operational (IDPS) IST



VIIRS IST EDR Validation with IceBridge IST

- IceBridge NASA P-3 aircraft carries a KT-19: a downward-pointing, IR pyrometer that measures IST
- No atmospheric corrections applied
- Spot size = 15m
- Resolution = 0.1° C
- Sampling = 10Hz



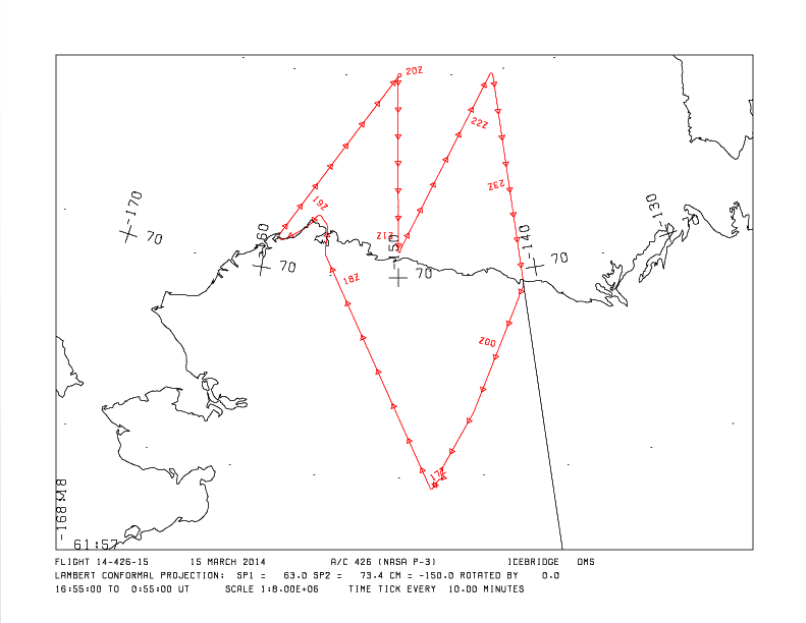


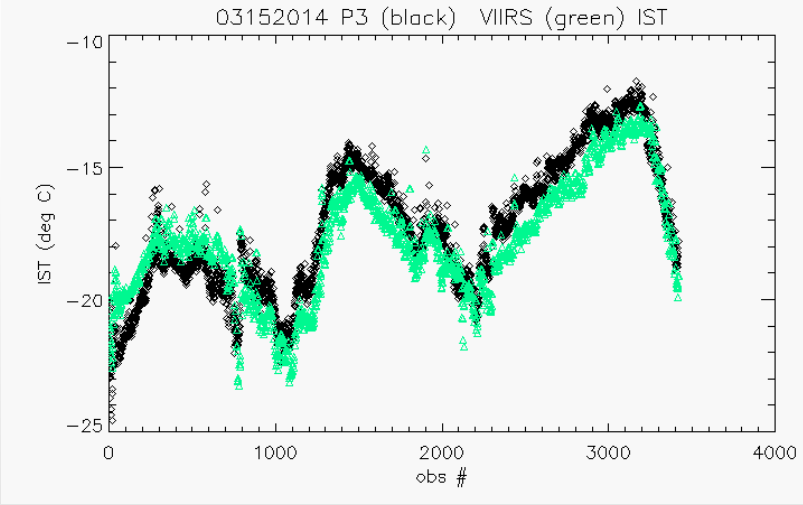
Krabill, W. B. and E. Buzay. 2012, updated 2014. IceBridge KT19 IR Surface Temperature. Boulder, Colorado USA: NASA DAAC at the National Snow and Ice Data Center.

VIIRS IST IceBridge Validation

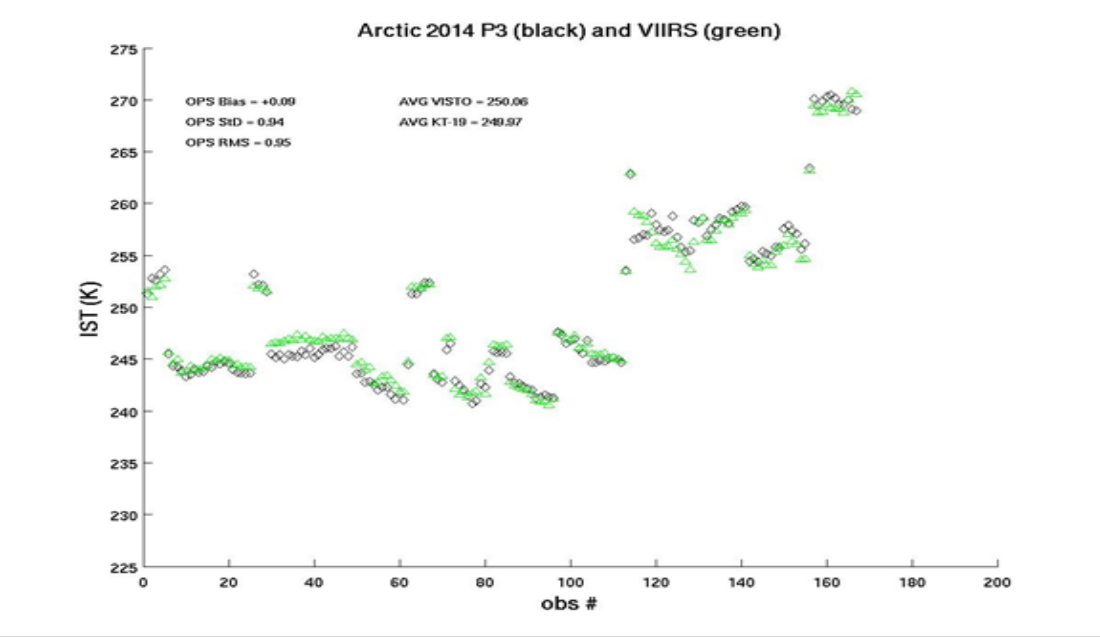
Flight track (left) and comparison (right) between the IST measured by the KT-19 (in black, smoothed over 100 points) and the nearest VIIRS Operational (IDPS) IST measurement (in green), March 15, 2014

mean KT-19 IST =-17.27°C, mean VIIRS IST = -17.75°C. RMS difference = 0.118



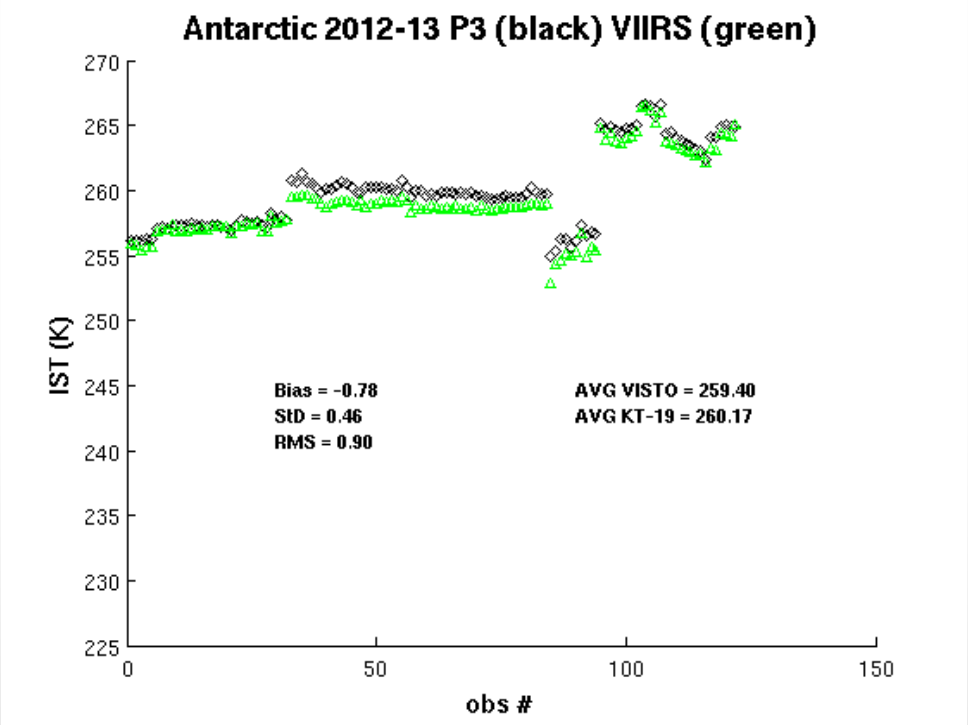


VIIRS IST IceBridge Validation



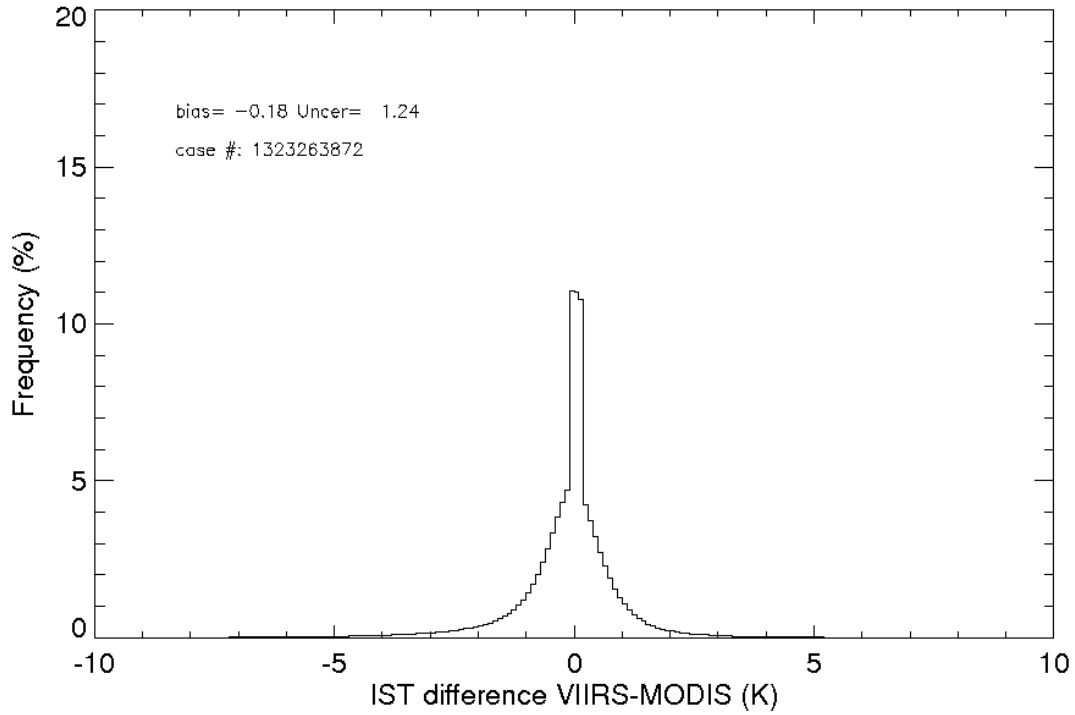
Operational S-NPP VIIRS IST (OPS) vs. airborne KT-19 IST for all coincident, cloud-free observations over the Arctic for all of the IceBridge Spring 2014 flights.

VIIRS IST IceBridge Validation



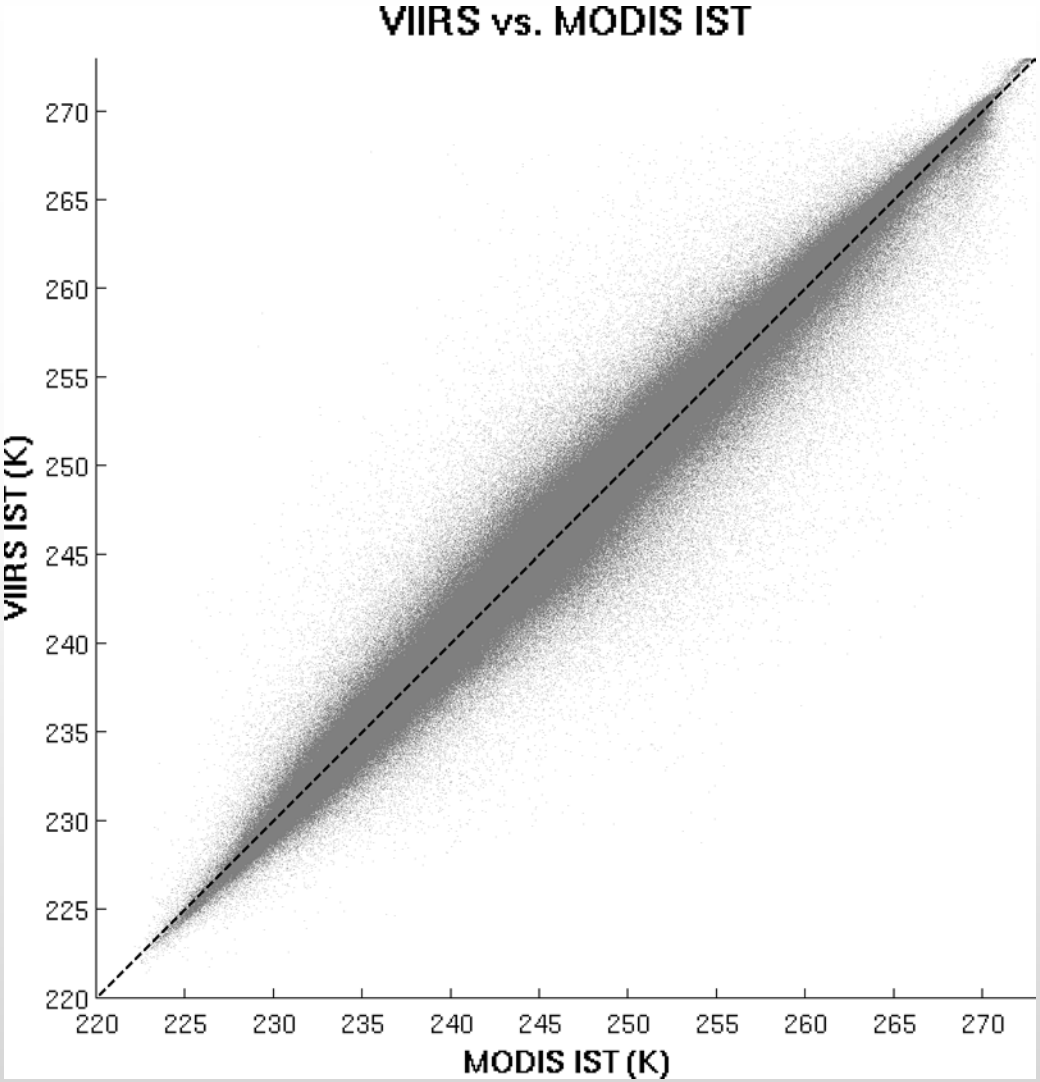
Operational S-NPP VIIRS IST (OPS) vs. airborne KT-19 IST for all coincident, cloud-free observations over the Antarctic for all of the IceBridge Fall 2012 & 2013 flights.

VIIRS / MODIS IST Intercomparison



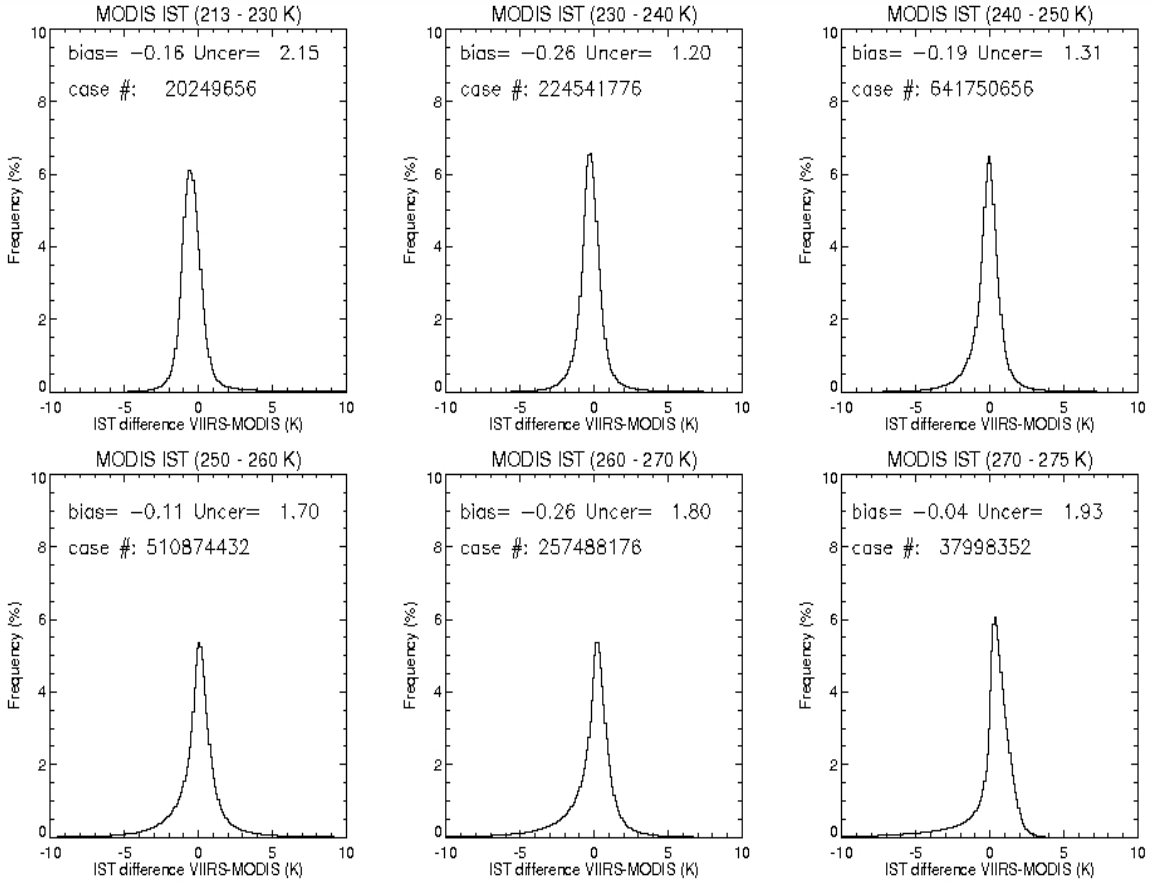
Differences between NPP VIIRS OPS and MODIS (Aqua and Terra) IST in the Arctic for all cases from August 2012 to July 2015.

VIIRS IST vs. MODIS IST



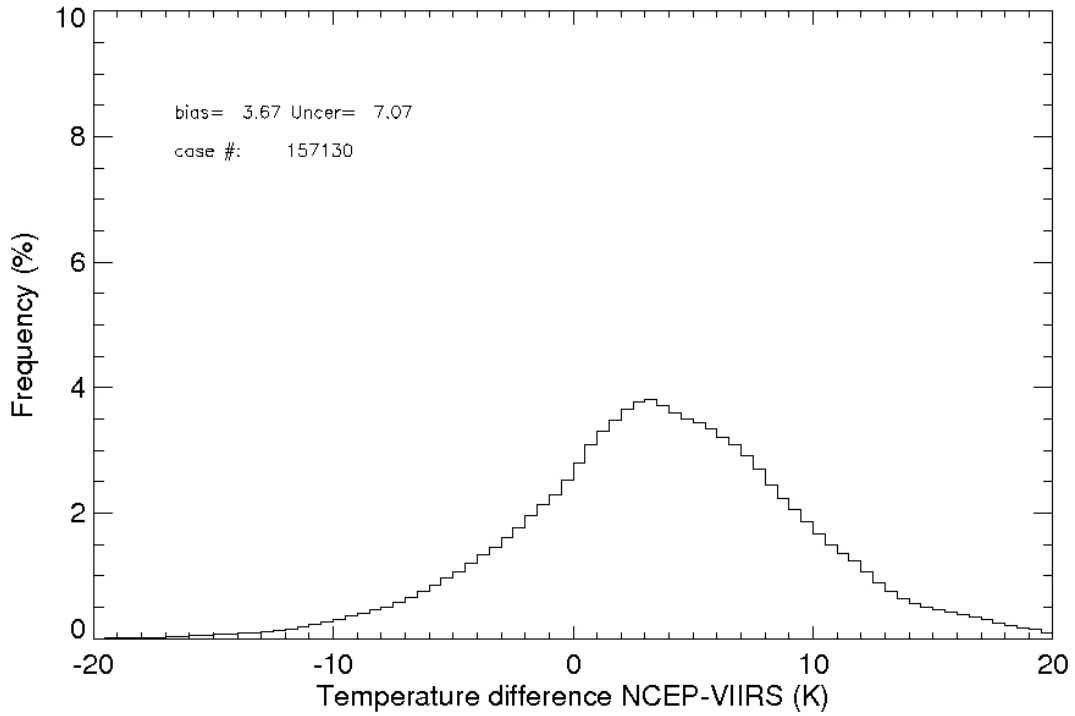
Scatterplot of OPS IST from 20 NPP VIIRS and MODIS Aqua simultaneous Nadir Overpass, with overall difference (VIIRS-MODIS) of 0.032 K and uncertainty (RMS)=1.187 K

VIIRS OPS IST vs. MODIS IST



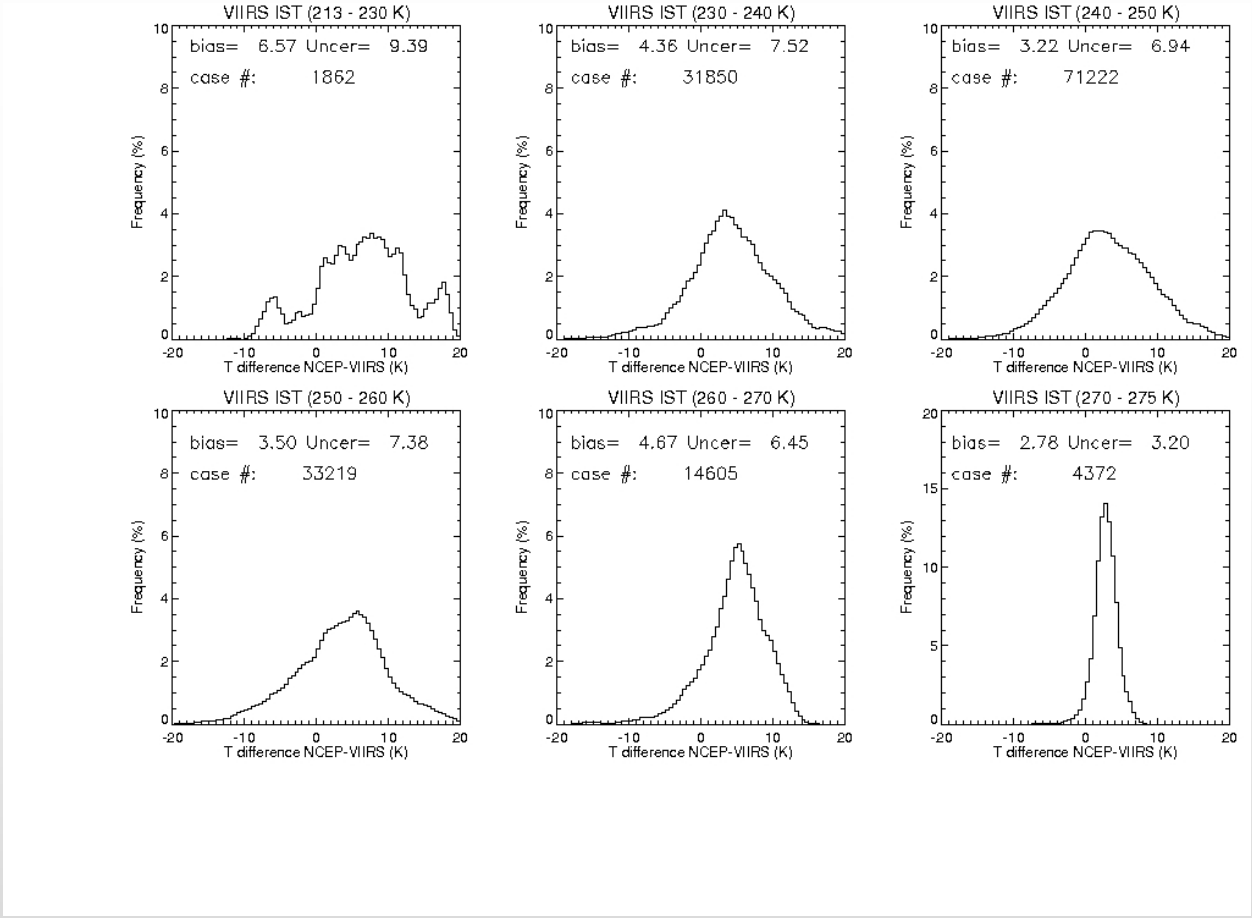
NPP VIIRS and MODIS (Aqua and Terra) IST differences in the Arctic and Antarctica from August 2012 to July 2015 for cases with MODIS ice surface temperature in range bins. Measurement bias and uncertainty (RMS) are indicated for each bin.

VIIRS OPS IST vs NCEP



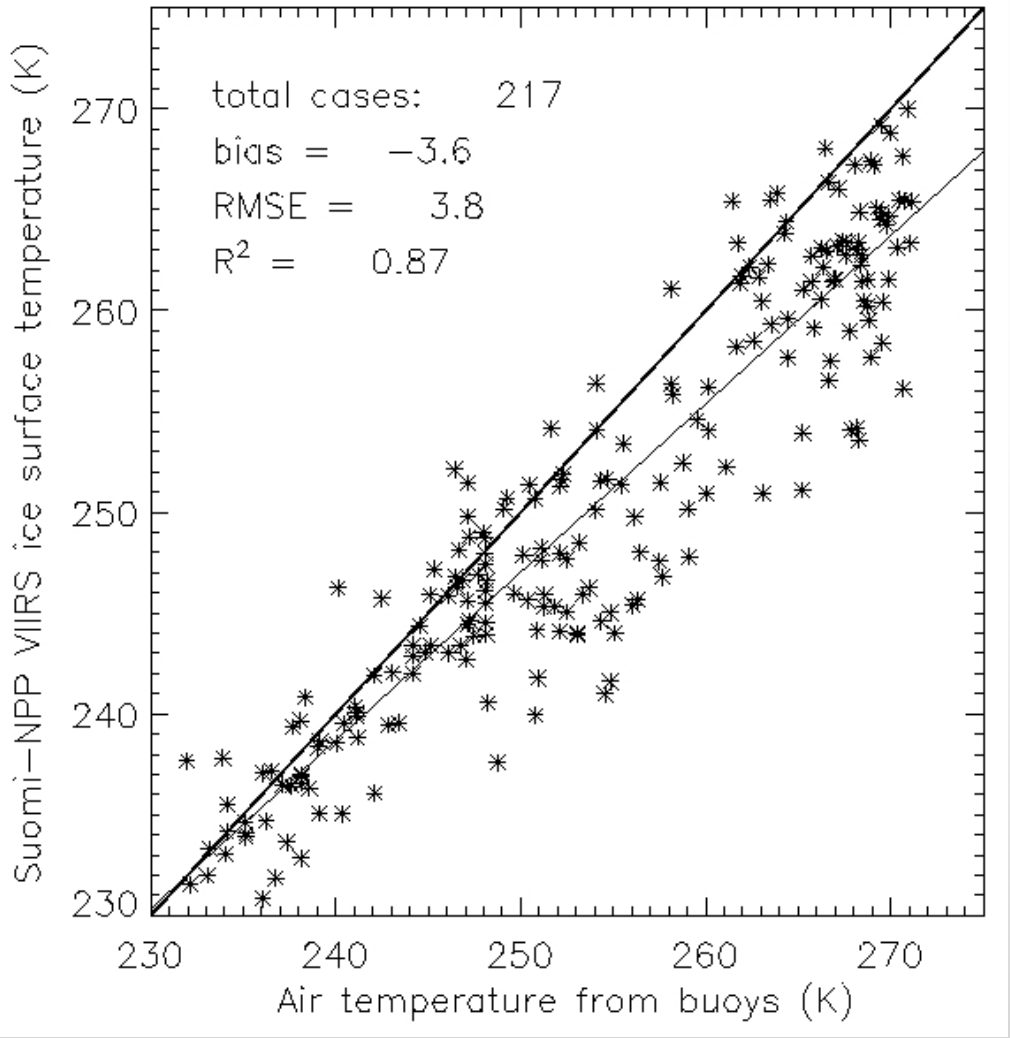
Differences between NCEP-NCAR surface air temperature and NPP VIIRS OPS IST in the Arctic for all cases from August 2012 to July 2015.

VIIRS OPS IST vs NCEP



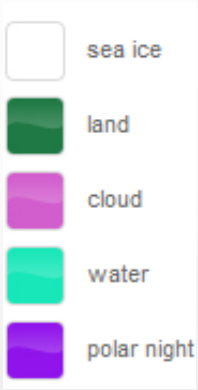
NCEP-NCAR surface air temperature and NPP VIIRS IST difference in the Arctic from August 2012 to July 2015 for cases with MODIS ice surface temperature in range bins. Measurement bias and uncertainty (RMS) are indicated for each bin.

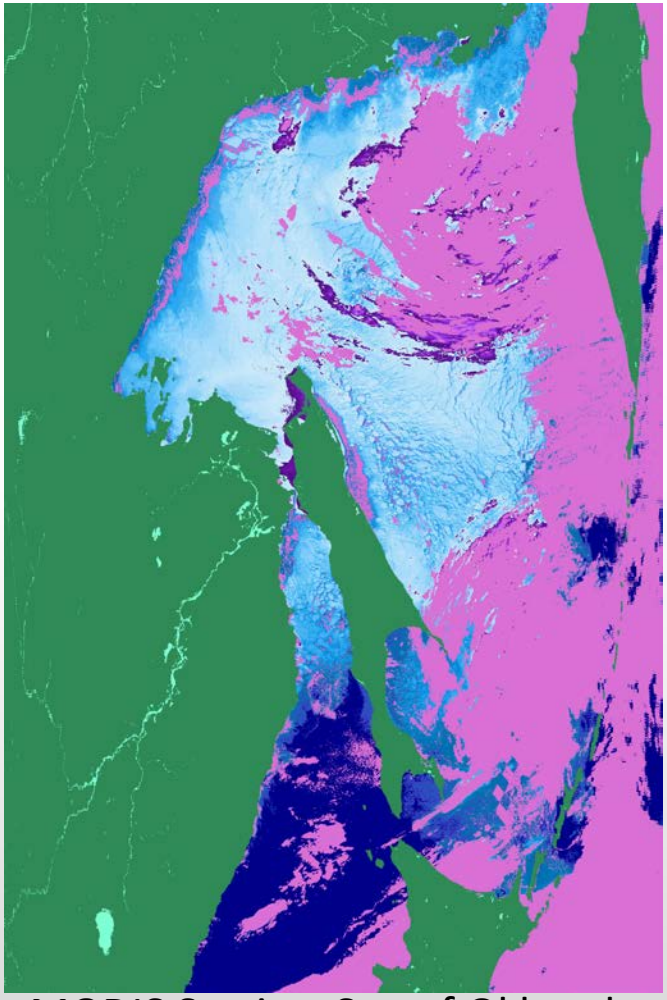
VIIRS OPS IST vs. buoys



Scattering plot of surface air temperature from Arctic buoys and NPP VIIRS OPS 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.

NASA VIIRS Sea Ice Extent Product

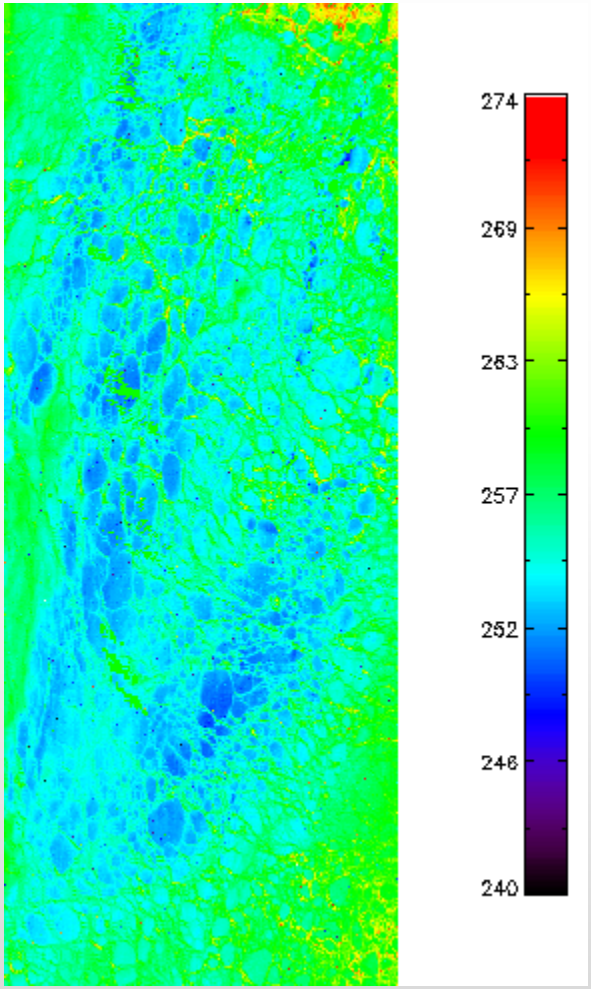




MODIS Sea ice, Sea of Okhotsk, March 17, 2002

- 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

Suomi-NPP VIIRS IST – NASA product



- Utilizes enhanced split window:
  $IST = a_o + a_1 T_{M15} + a_2(T_{M15} - T_{M16}) + a_3(\boldsymbol{T_{M15} - T_{M16}})(\sec(z) - 1)$
- 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

Conclusions

- Operational (OPS) VIIRS IST in several but not all cases meets the requirement of 1K measurement uncertainty
- OPS VIIRS IST shows a *cold* bias compared to MODIS and to several IceBridge KT-19 measurements, typically <1K
- Improvements in OPS IST EDR performance have been realized as the VIIRS Cloud Mask IP matures
- More VIIRS OPS IST improvement is expected as additional quality flags become available in the VIIRS Ice Concentration IP to avoid IST retrievals near clouds.
- NASA's Sea Ice Extent and IST product provide continuity from the MODIS product
  - No sea ice extent product is currently produced from VIIRS
  - Provides unique approach (NDSI) for sea ice identification

Future Plans and Issues

- No VIIRS IST code changes currently planned
- Update IST regression coefficients based on matchup with MODIS and airborne/other IST sources
- Additional quality checks in the VIIRS Ice Concentration IP (e.g. for cloud shadowing) will be passed to the VIIRS OPS IST
- NASA VIIRS IST
  - Add quality flags, based on MODIS product
  - Inter-comparison with MODIS, IDPS IST
  - validation with IceBridge IST, buoys
  - Complete ATBD
- NASA VIIRS Sea Ice Extent
  - Finalize code, add quality flags
  - inter-compare with MODIS, AMSR-2, VIIRS Ice Concentration, etc.
  - Validation with Digital Globe, IceBridge
  - Add quality flags , based on MODIS product
  - Complete ATBD



- Both IST products and NASA extent product: Improvements anticipated with continued upgrades to the VIIRS cloud mask