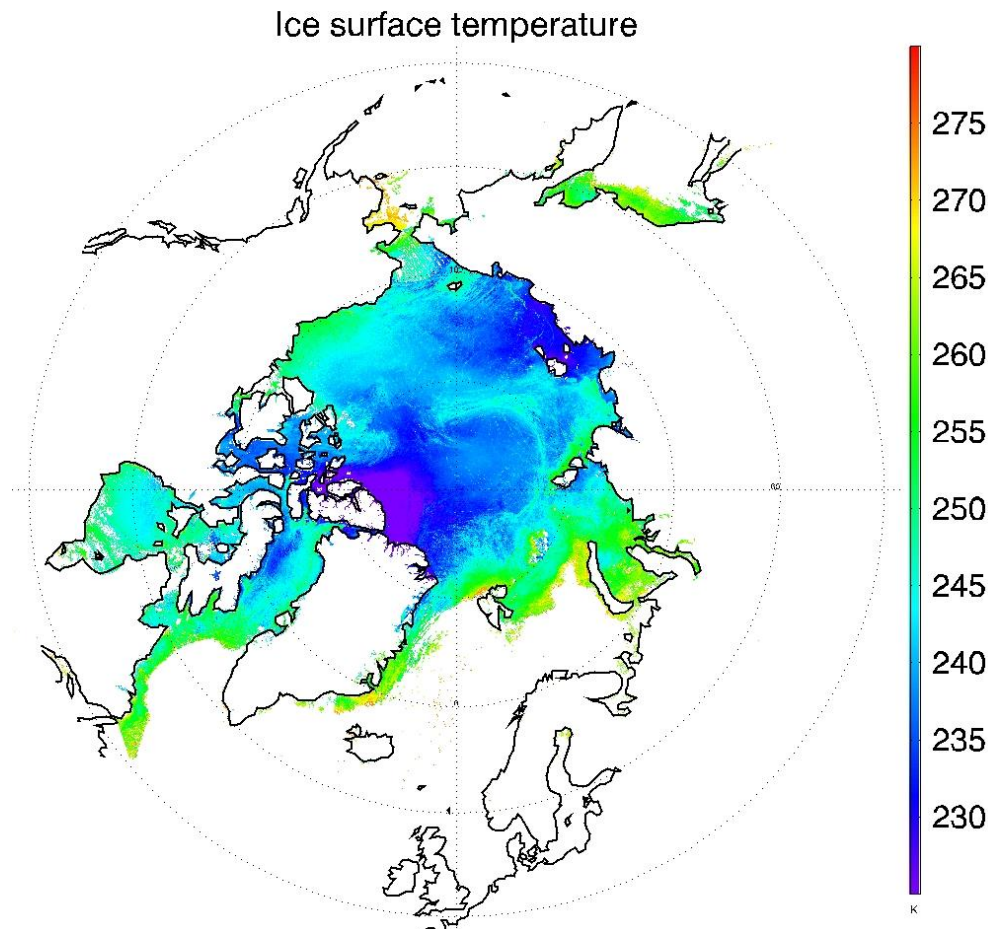




CREATING, CALIBRATING, AND VALIDATING A SATELLITE-BASED SEA ICE SURFACE TEMPERATURE PRODUCT

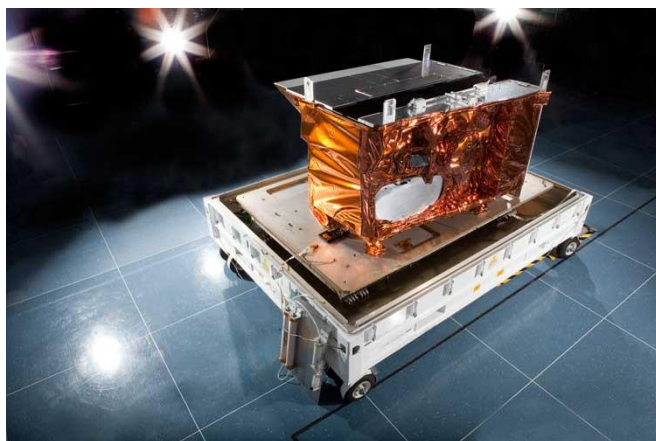
**Mark Tschudi, CCAR, University of Colorado, Boulder
303-492-8274; mark.tschudi@colorado.edu**

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.

- Algorithms have been developed, tested and implemented to produce Ice Surface Temperature (IST) products using observations from the **Suomi-NPP** (National Polar-Orbiting Partnership) **VIIRS** (Visible Infrared Imaging Radiometer Suite)
 - Suomi NPP launched Oct. 2011
- 3 VIIRS IST Products: NOAA NDE (operational), NASA (Tschudi et al.), IDPS (Raytheon)
- IST products will also be produced for the Joint Polar Satellite (**JPSS**) VIIRS instrument
 - planned launch date = Nov 10, 2017
 - the JPSS-1 satellite will become NOAA 20 after reaching orbit



VIIRS
(<http://www.jpss.noaa.gov/viirs.html>)

- 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:

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

T_{11} and T_{12} : TOA TB's for ~11 and 12 μm bands

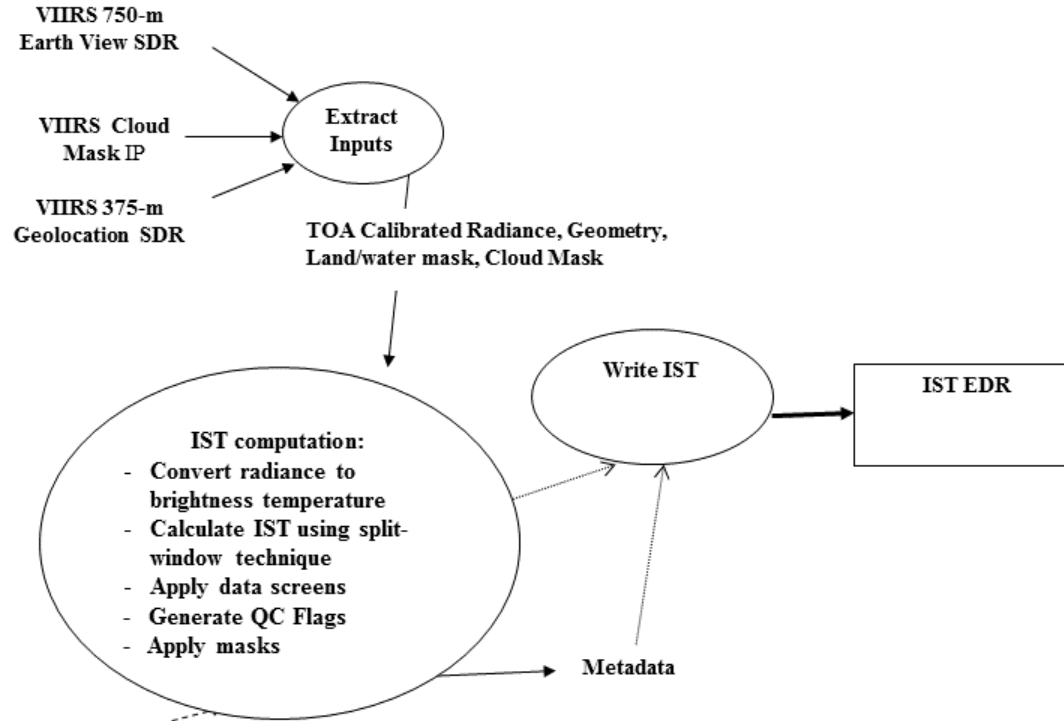
z: satellite zenith angle

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.

Suomi-NPP VIIRS IST Algorithm Flow Chart



VIIRS IST Validation Approach

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

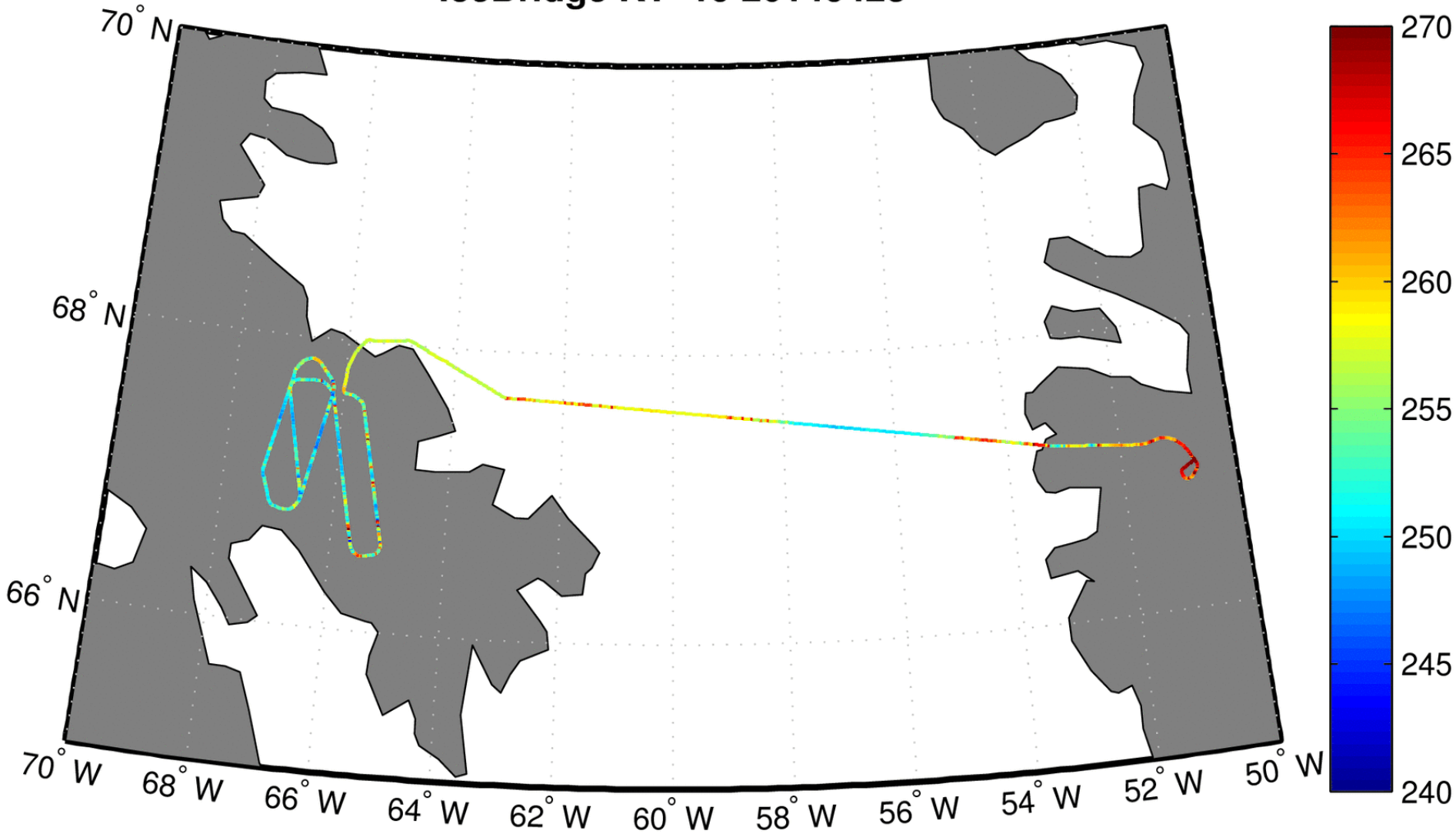
VIIRS IST EDR Validation with IceBridge IST

- IceBridge NASA P-3 aircraft carries a KT-19: a downward-pointing, IR pyrometer that measures IST
- No atmospheric corrections applied
- Spot size = 15m
- 25m spot separation
- Resolution = 0.1° C

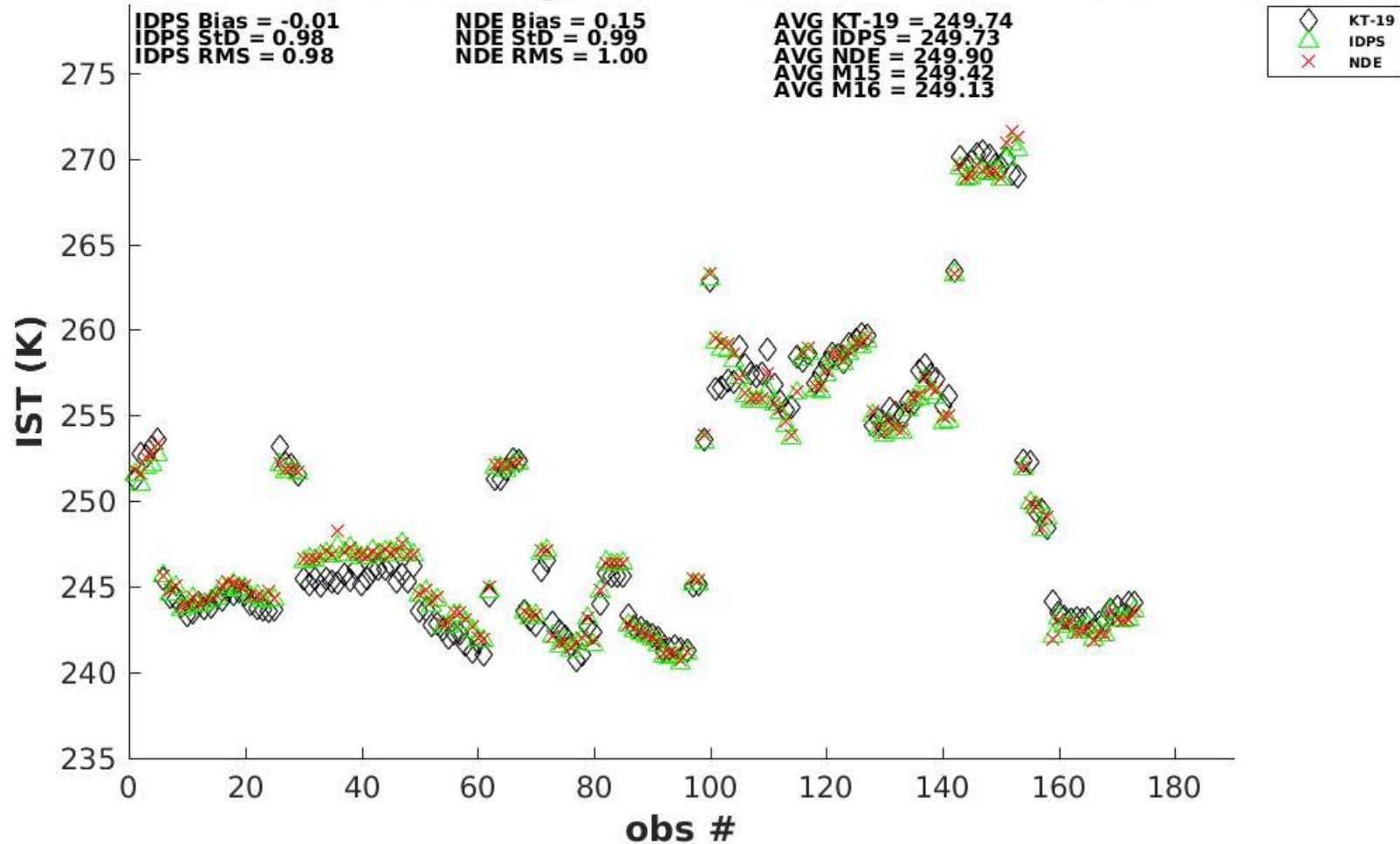


Krabill, W. B. and E. Buzay. 2012, updated 2014. IceBridge KT19 IR Surface Temperature. Boulder, Colorado USA: NASA DAAC at the National Snow and Ice Data Center.

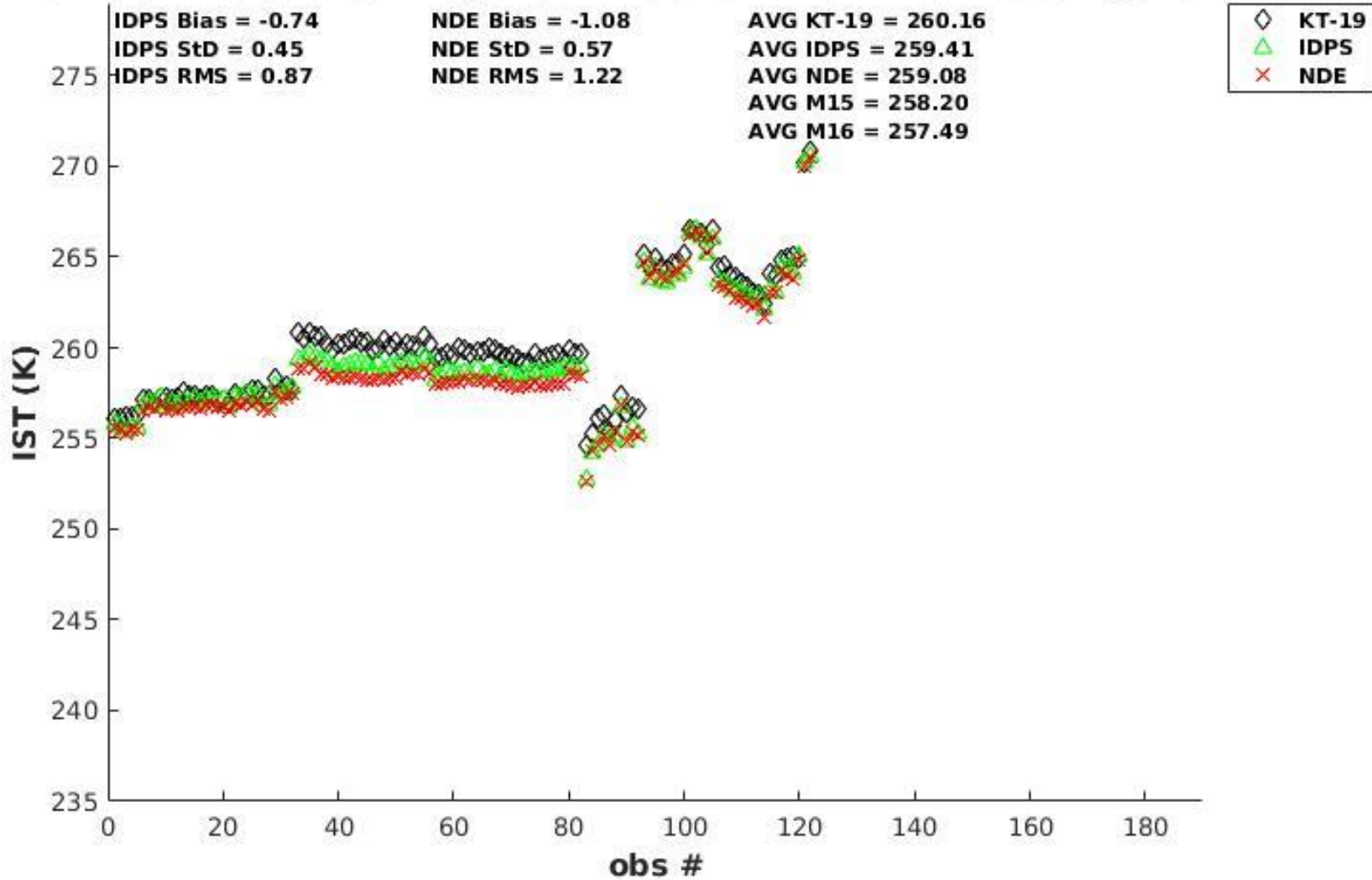
IceBridge KT-19 20140423



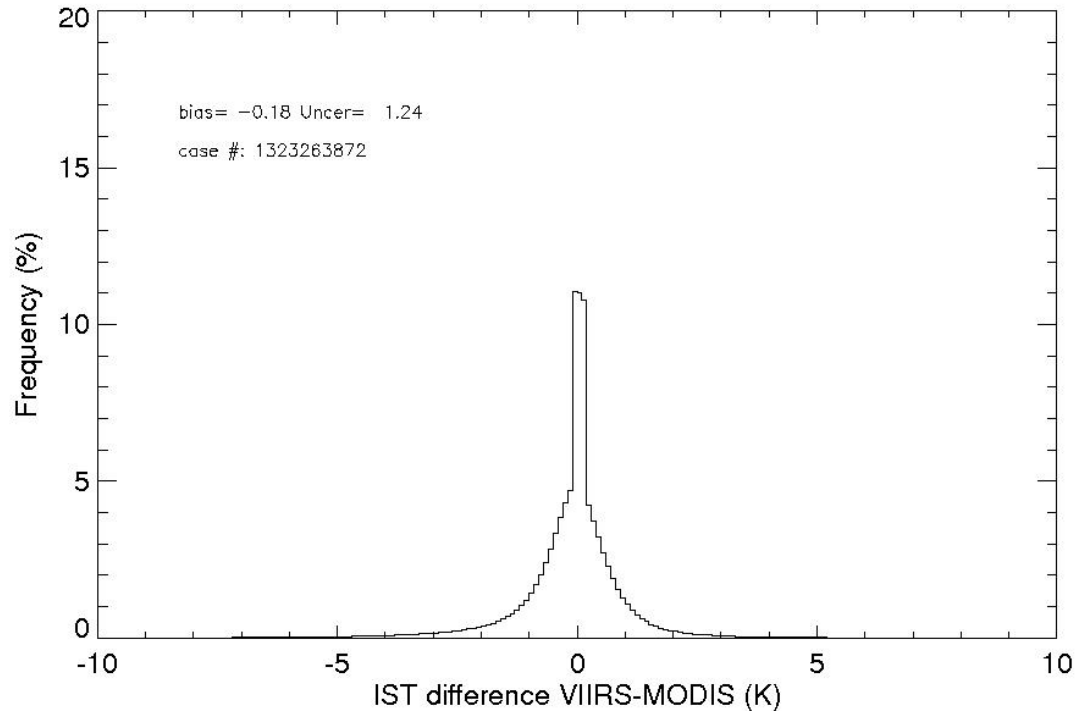
2013-14 Arctic IceBridge P3 KT-19 and VIIRS NDE and IDPS



2012-13 Antarctic IceBridge P3 KT-19 and VIIRS NDE(Ant Coeff.) and IDPS



VIIRS / MODIS IST Inter-comparison



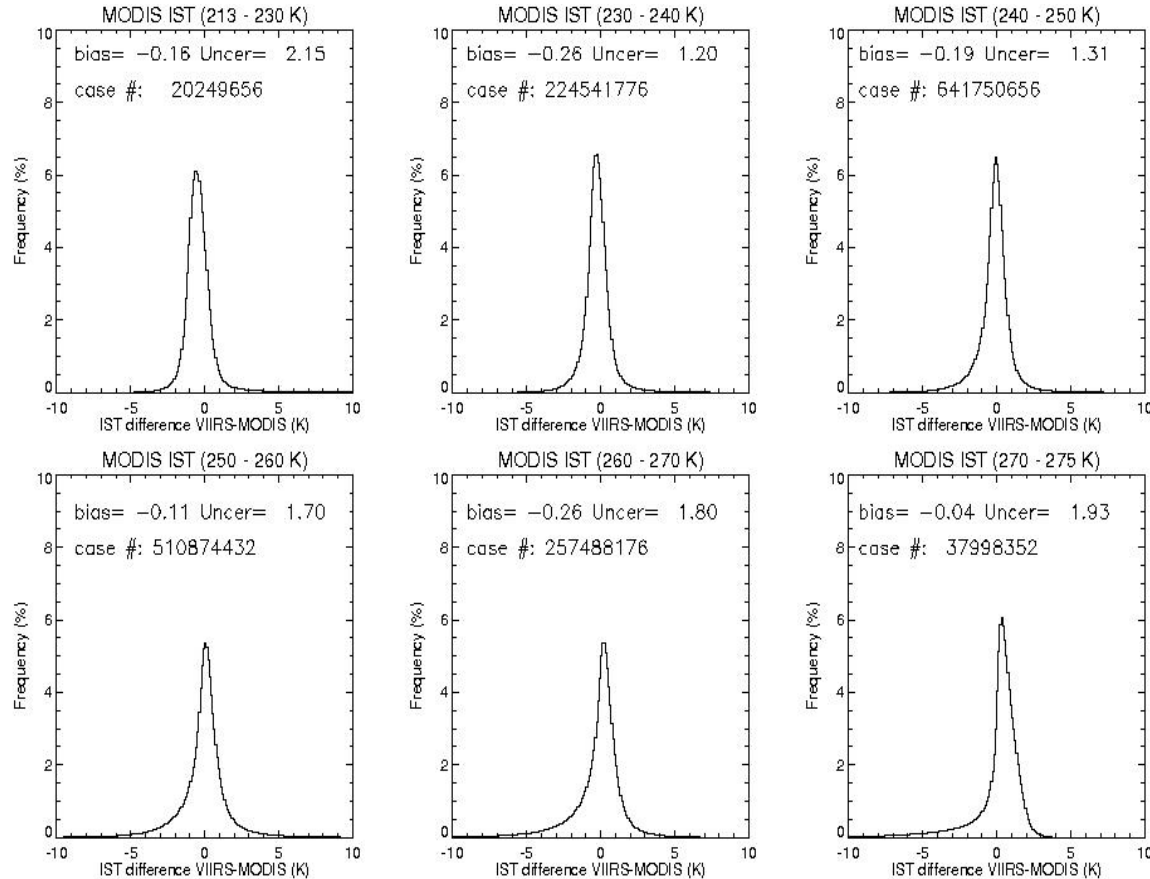
Differences between
NPP VIIRS and
MODIS (Aqua and
Terra) IST in the
Arctic from August
2012 to July 2015.

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

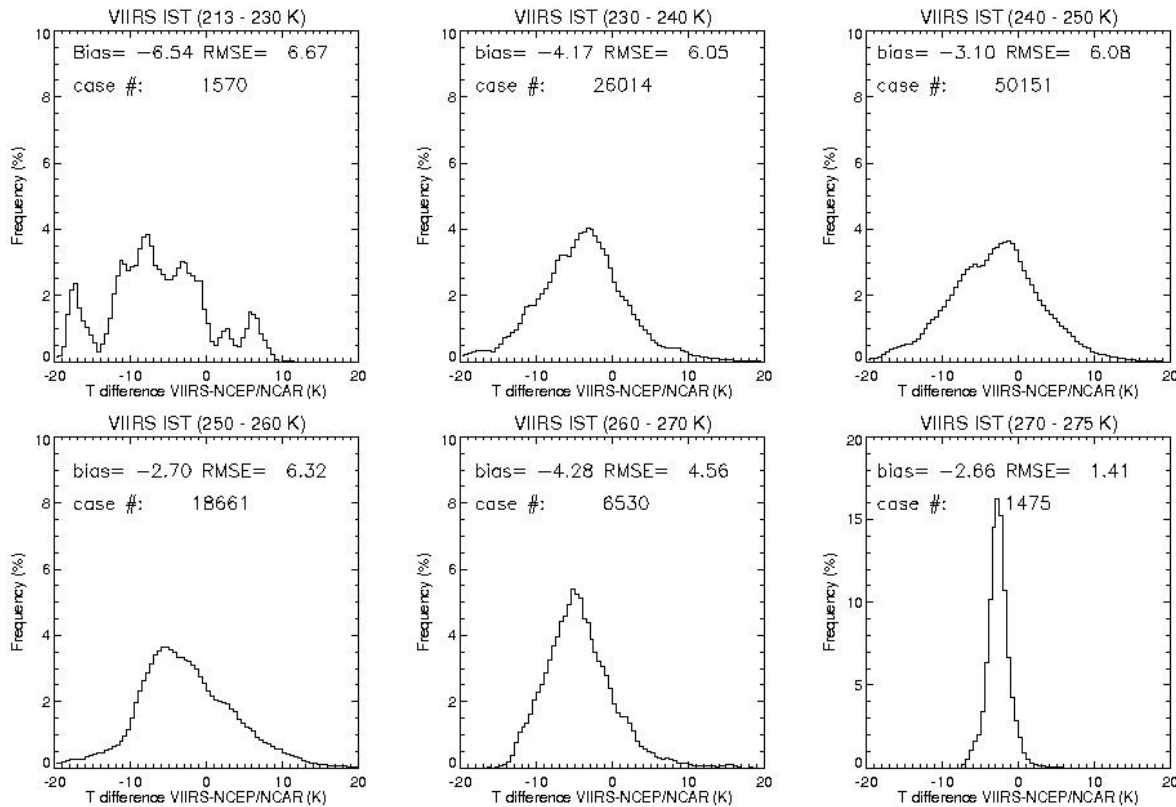
VIIRS IST vs. MODIS IST

NPP VIIRS and MODIS (Aqua and Terra) IST differences in the Arctic and Antarctica from August 2012 to July 2015. VIIRS-MODIS bias and uncertainty (RMS) are indicated for each bin.

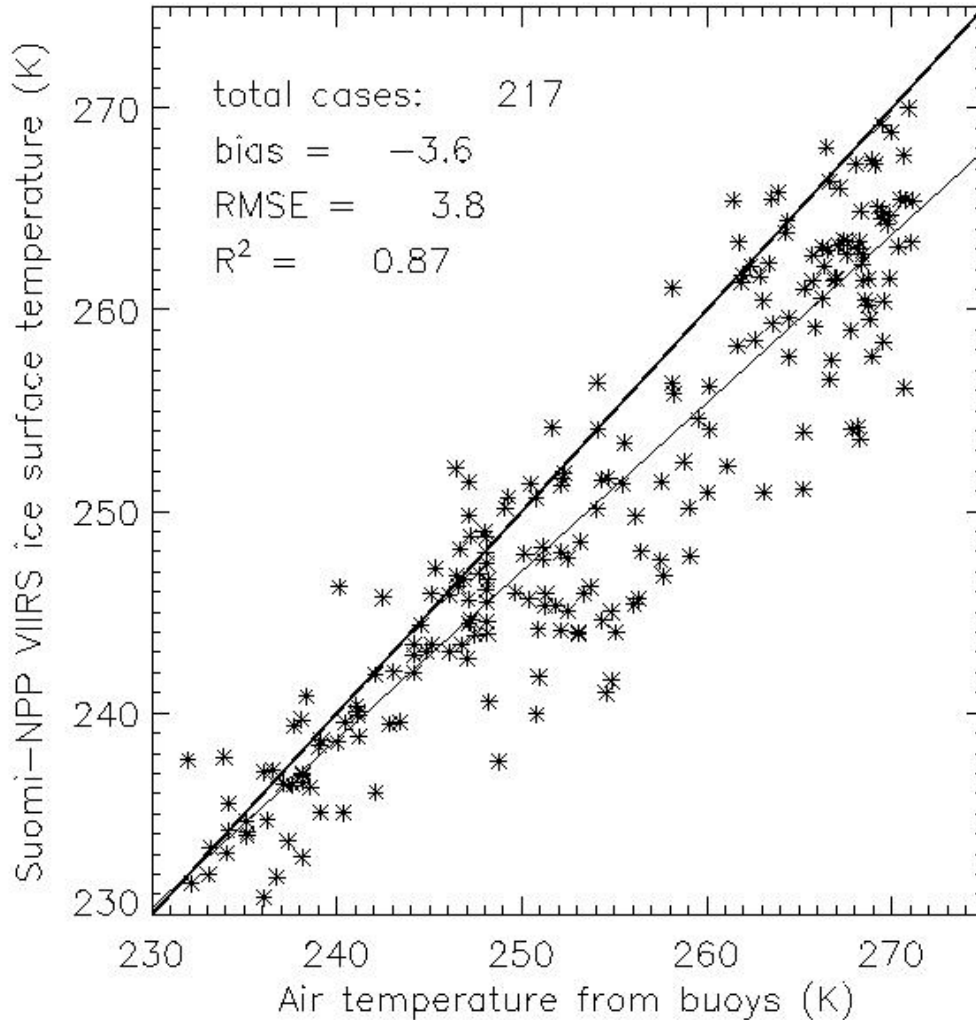
From *Liu et al., 2015*



VIIRS IST vs. NCEP/NCAR Sfc Air Temp



Histogram of ice surface temperature differences between VIIRS IST and NCEP-NCAR surface air temperature in the Arctic from August 2012 to July 2015 for cases with MODIS. From *Liu et al.*, 2015.



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



- 3 VIIRS IST product sets are available:
 - NASA VIIRS IST (Tschudi, Riggs, & Hall, at NSIDC)
 - NOAA NDE VIIRS IST (Key et al.)
 - Raytheon IDPS VIIRS IST (to be phased out)
- Airborne IST observations most useful for IST validation
 - Pre/post flight IST instrument calibration is recommended for KT-19
 - IR camera imagery provides 2D coverage, with internal calibration (e.g. FLIR). NASA is now deploying a FLIR with IceBridge.
- VIIRS IST calibration coefficients are adjusted, based on cal/val results
- Improvements in the VIIRS IST performance has improved as the VIIRS Cloud Mask matures



THANK YOU

