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

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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)

• 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 IST Algorithm

- 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.

Suomi-NPP VIIRS IST Algorithm Flow Chart

- **VIIRS 750-m Earth View SDR**
- **VIIRS Cloud Mask SDR**
- **VIIRS 375-m Geolocation SDR**

Extract Inputs

- TOA Calibrated Radiance, Geometry, Land/water mask, Cloud Mask

Write IST

- IST computation:
  - Convert radiance to brightness temperature
  - Calculate IST using split-window technique
  - Apply data screens
  - Generate QC Flags
  - Apply masks

Metadata

IST EDR
# VIIRS IST Validation Approach

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

IceBridge & NOAA NDE IST

IceBridge KT–19 20140423
2013-14 Arctic IceBridge P3 KT-19 and VIIRS NDE and IDPS

IDPS Bias = -0.91
IDPS Std = 0.98
IDPS RMS = 0.98

NDE Bias = 0.15
NDE Std = 0.99
NDE RMS = 1.00

AVG KT-19 = 249.74
AVG IDPS = 249.73
AVG NDE = 249.90
AVG M15 = 249.42
AVG M16 = 249.13
VIIRS IST IceBridge Validation - Antarctic

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

IDPS Bias = -0.74
IDPS Std = 0.45
IDPS RMS = 0.87

NDE Bias = -1.08
NDE Std = 0.57
NDE RMS = 1.22

AVG KT-19 = 260.16
AVG IDPS = 259.41
AVG NDE = 259.08
AVG M15 = 258.20
AVG M16 = 257.49
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
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
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.
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
In closing…

• 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