# Pre-Launch Performance Assessment of the VIIRS Ice Surface Temperature EDR Using Global Synthetic and MODIS Proxy Data

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## *Abstract*

The VIIRS Ice Surface Temperature (IST) algorithm utilizes a split-window approach with Long-wave Infrared (LWIR) channels at 10.76 μm (M15) and 12.01 μm (M16) to correct for atmospheric water vapor in order to retrieve surface temperature on sea-ice surfaces at VIIRS moderate resolution (750 m) during day and night. The split-window approach is AVHRR heritage and is similar to the MODIS formulation using the same LWIR channels. The algorithm relies on VIIRS Cloud Mask IP for identifying cloudy and ocean pixels, VIIRS Ice Concentration IP for ice pixels, and VIIRS Aerosol Optical Thickness IP for high aerosol exclusion. In this paper, we will report the testing and pre-launch performance assessment of the IST retrieval. We have taken two separate approaches to perform this assessment, one based solely on global synthetic data and the other based entirely on proxy data from MODIS on EOS-Terra. Results of the split-window algorithm will be assessed by either comparisons to synthetic "truth" or results of the MODIS retrieval**.** We will also show that the results of the testing with proxy data are consistent with those obtained using the global synthetic data.

## VIIRS IST EDR System Specifications (Version N)

The IST EDR is required to meet system specification only for ice-covered ocean pixels under "Confident Clear" retrieved by VIIRS Cloud Mask with quality M15 and M16 brightness temperatures. The EDR is also produced under less optimum conditions with the appropriate quality flags. Retrievals are made both day and night.

| Paragraph | Attributes | System Specification |
|---|---|---|
| | Horizontal Cell Size (HCS) | |
| 40.7.3-1 | Nadir | 0.75 km |
| 40.7.3-9 | Worst Case | 1.60 km |
| 40.7.3-2 | Horizontal Reporting Interval | 1.00 km |
| 40.7.3-3 | Horizontal Coverage | Ice-Covered Ocean |
| 40.7.3-4 | Measurement Range | 213 K – 275 K (-76 °F – 35.6 °F) |
| 40.7.3-5 | Measurement Uncertainty | 0.5 K |
| 40.7.3-6 | Mapping Uncertainty at Nadir | 0.4 km |
| 40.7.3-10 | Latency | NPP - 140 min, NPOESS - 28 min |
| 40.7.3-11a | AOT > 1.0 Exclusion | |
| 40.7.3-11b | Inland Water Exclusion | |
| 40.7.3-11c | Coastal Water Exclusion | |
| 40.7.3-11d | Thin Cirrus Exclusion | |

## VIIRS IST EDR Retrieval Algorithms

**Baseline split window algorithm:**

Statistical regression methods using 2 VIIRS LWIR bands, 10.76 μm (M15) and 12.01 μm (M16), from the Advanced Very High Resolution Radiometer (AVHRR) IST algorithm (Yu *et al*., 1995) for both day and night baseline situations

$$IST = a_0 + a_1 T_{M15} + a_2 (T_{M15} - T_{M16}) + a_3 (\sec\theta - 1)$$

**Fallback single channel algorithm:**

Revert back to a single-band, 12.01 μm (M16) algorithm for both day and night fallback situations

$$IST = b_0 + b_1 T_{M16} + b_2 (\sec\theta - 1)$$

where $T_{M15}$ and $T_{M16}$ are measured top-of-atmosphere brightness temperatures at bands M15 and M16, $\theta$ is the sensor zenith angle, $a_i$ and $b_i$ are known regression coefficients.

**Main source of errors that impact IST EDR performance:**

- Accuracy of the surface state (ice water mixing and different ice types)
- Errors in atmospheric correction (due mainly to water vapor)
- Sensor performance errors (sensor noise, calibration errors, geolocation, and band-to-band registration)

## Performance Testing with Global Synthetic Data

**Testing Procedure:**

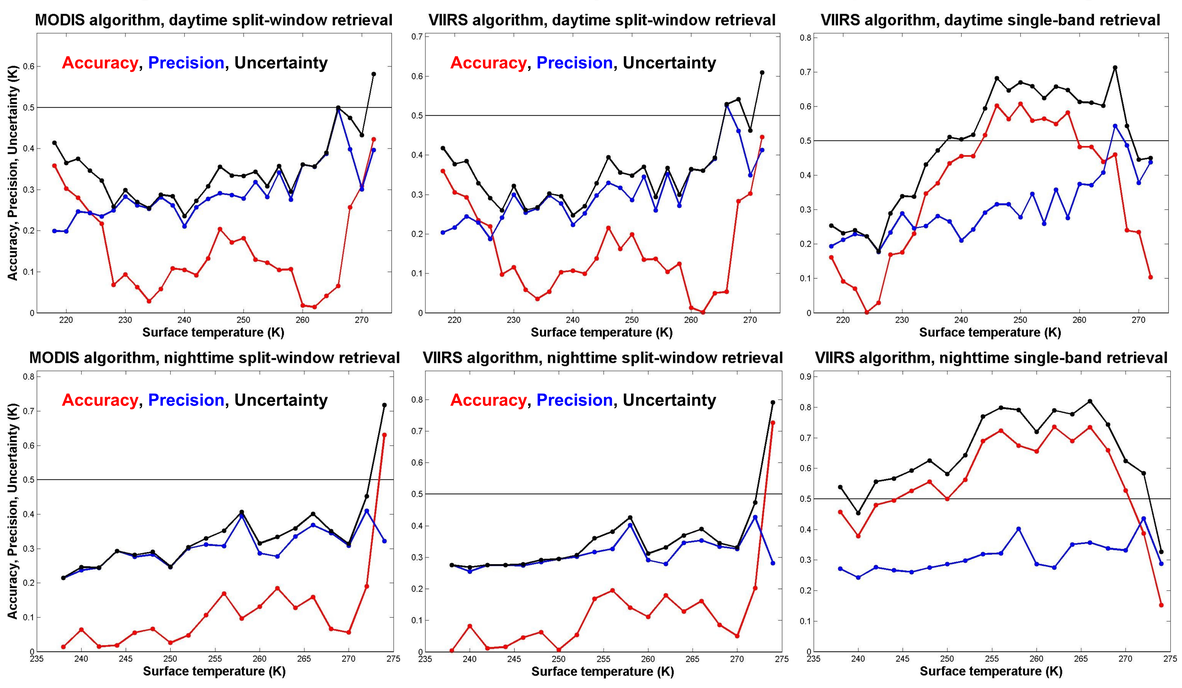
Based upon NGST global synthetic data composed of heterogeneous land types (using PRA land cover data base classified into 17 IGBP types) without cloud.
All snow pixels are modeled as ice pixels with pure ice properties.
Generate initial regression coefficients from a subset from 33% random pixels in the dataset for the NPP 1330 orbital plane with ideal sensor and with VIIRS sensor model.
Derive the predicted IST EDR performance based on the remaining 67% of pixels.
Summarize the split-window & single-band algorithms performance by computing the EDR accuracy, precision, and uncertainty based on the NGST global synthetic ice data.
Compare to retrieval results using MODIS IST algorithm on the same NPP synthetic dataset.

**Synthetic IST Distribution**


**IST EDR Performance Summary**

| Algorithm | MODIS IST algorithm | | VIIRS IST algorithm | | | | |
|---|---|---|---|---|---|---|---|
| Sensor model / Algorithm | U / SW | N / SW | U / SW | N / SW | U / SB | N / SB | |
| Accuracy | 0.024 | 0.024 | 0.024 | 0.025 | 1.278 | 0.477 | Day |
| Precision | 0.365 | 0.386 | 0.381 | 0.409 | 0.375 | 0.396 | |
| Uncertainty | 0.365 | 0.387 | 0.382 | 0.410 | 1.332 | 0.620 | |
| Accuracy | 0.008 | 0.015 | 0.008 | 0.014 | 1.333 | 0.573 | Night |
| Precision | 0.404 | 0.374 | 0.416 | 0.387 | 0.435 | 0.385 | |
| Uncertainty | 0.404 | 0.374 | 0.416 | 0.387 | 1.403 | 0.690 | |

**VIIRS IST Algorithm Performance based on Global Synthetic Data and Comparison to MODIS Algorithm**

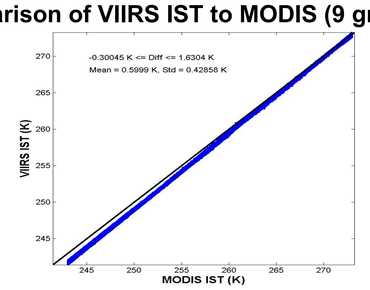



## Testing with MODIS Proxy Data

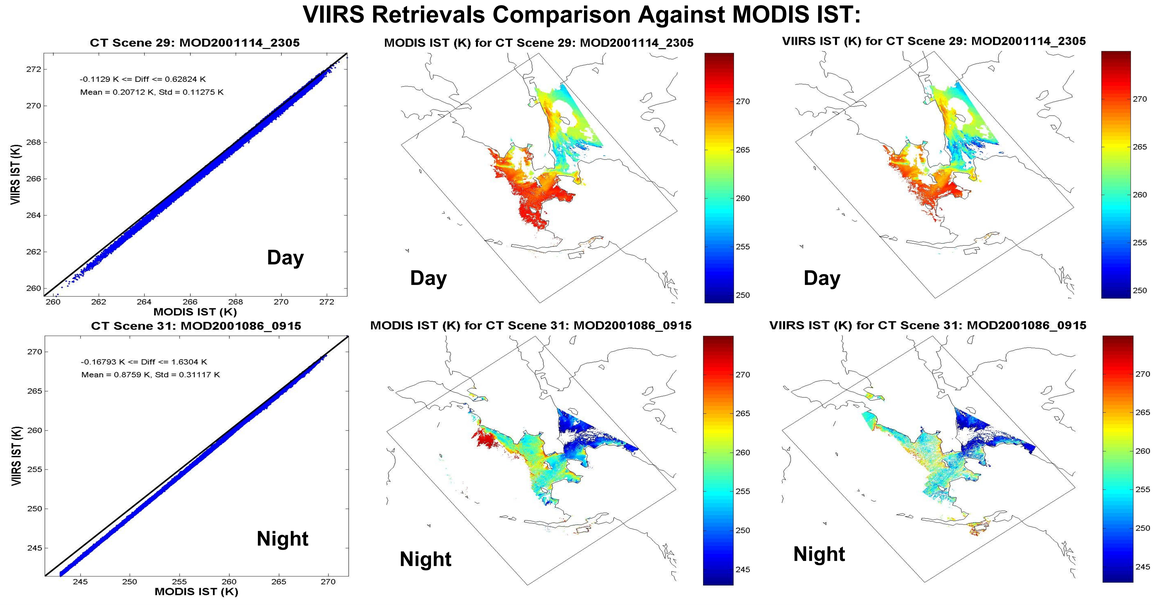
**Testing Procedures:**

- Populate the VIIRS IST regression coefficients using the NGST NPP synthetic ice data.
- Only the best quality MODIS clear ice pixels are used.
- Algorithm performance is assessed with MODIS MOD29 IST products from 9 granules.
- Comparison results are shown from a day scene, MOD2001114_2305 and a night scene, MOD2001086_0915.

**Comparison of VIIRS IST to MODIS (9 granules)**




**VIIRS Retrievals Comparison Against MODIS IST:**




## Concluding Remarks

- Retrieval results based on the NGST global synthetic ice data show that the VIIRS IST algorithm meets the uncertainty requirement of 0.5 K, and that the performance is comparable when the MODIS algorithm is used.
- Results show significant degradation in accuracy and uncertainty using the single-band fallback algorithm instead of the 2-band split window baseline; hence the single-band algorithm is not likely to satisfy the uncertainty requirement for IST.
- Retrieval results show that the pre-launch IST regression coefficient LUT generated from the global synthetic data is a reasonable surrogate until the post-launch Cal/Val exercise.
- IST regression coefficient LUT for day and night, 2-band split-window and single-band algorithms has been populated based on the NGST global synthetic data.
- The predicted accuracy, precision, and uncertainty for the IST EDR based on the NGST global synthetic data are 0.025, 0.409, and 0.410 for daytime, and 0.014, 0.387, and 0.387 for nighttime, respectively using the baseline split-window algorithms.
- Results of testing with MODIS data are consistent with those obtained using the NGST global synthetic data. The observed bias is probably due to the use of regression coefficients derived from the global synthetic data for the VIIRS, not the MODIS, bands. Also the regression assumes a bare sea-ice surface rather than a snow-covered ice surface.