The Version 2 VIIRS+CrIS Fusion Radiance (NASA FSNRAD) products

E. Eva Borbas, Elisabeth Weisz, W. Paul Menzel, Bryan Baum, and Geoff P. Cureton

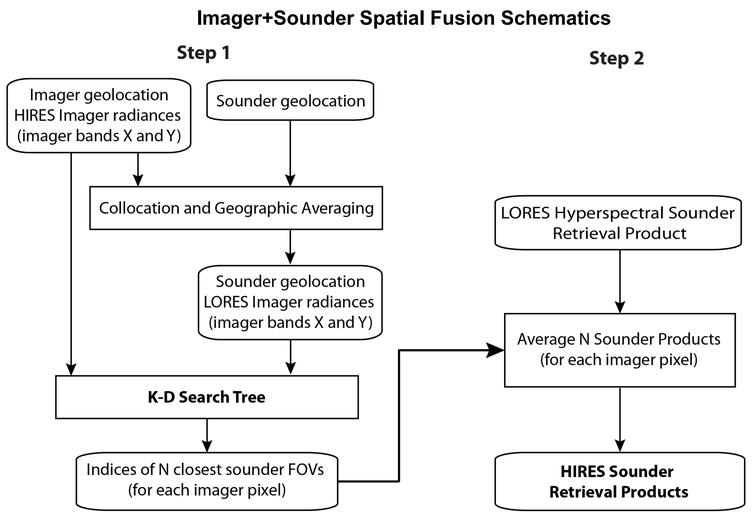
Space Science and Engineering Center, University of Wisconsin-Madison, Madison, Wisconsin, USA

Contact: Eva.Borbas@ssec.wisc.edu

GOAL

- The VIIRS+CrIS Fusion Radiance (FSNRAD) products have been created to provide a path for continuity of products based on the Terra, Aqua, SNPP, and NOAA-20 platforms.
- *Why is this work important?* MODIS has three channels sensitive to CO_2 in the 4.5 μm CO_2 band, four channels in the broad 15 μm CO_2 band, 2 channels sensitive to H_2O near 6.7 μm, and an ozone channel near 9 μm. VIIRS has none of these IR absorption bands. The lack of the CO_2 and H_2O channels results in a degradation of the accuracy of the cloud mask especially at night in high latitudes, other cloud products (cloud top pressure/height and thermodynamic phase) and the moisture products (total precipitable water vapor, upper tropospheric humidity).
- We addressed this restriction by constructing similar Aqua MODIS IR band radiances for VIIRS based on a fusion method that uses collocated VIIRS and CrIS data.

METHOD



LORES/HIRES … low/high spatial resolution

STATUS

Product Name	Description	Available at
FSNRAD_L2_VIIRS_CRIS_SNPP	S-NPP/VIIRS Fusion Radiances	LAADS DAAC
FSNRAD_L2_VIIRS_CRIS_NOAA20	NOAA20/VIIRS Fusion Radiances	LAADS DAAC
FSNRAD_L2_VIIRS_CRIS_SS_SNPP	S-NPP/VIIRS Subsetted Fusion Radiances	Atmosphere-SIPS
FSNRAD_L2_VIIRS_CRIS_SS_NOAA20	NOAA20/VIIRS Subsetted Fusion Radiances	Atmosphere-SIPS

- **V2 (2.0.0dev3) released at NASA LAADS DAAC: March 8, 2022**
  - DOI: 10.5067/VIIRS/FSNRAD_L2_VIIRS_CRIS_SNPP.002
  - https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/products/FSNRAD_L2_VIIRS_CRIS_NOAA20
  - https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/viirs/VIIRS+CrIS_DataFusion_UG_v2.0_Dec_2021.pdf
- **Per request from the CERES team, subset of fusion radiances for SNPP and NOAA-20 data records on A-SIPS**:
- https://sips.ssec.wisc.edu/#/products/availability;id=14372
- **Note for SNPP:** CrIS anomaly in LW data
- May 21 –July 12, 2021: -fill value for Band 30-36 (anomaly of CrIS LW channels)
- July 14, 2021 - fill value for Band 27, 28, B30-36 restored (Side 1 -> Side 2)

FSNRAD VERSION 2 UPDATES

- Updated to current VIIRS & CrIS calibration (V3.0.0)
- **New K-D tree**: MU (empirical, band-specific scaling factor) is eliminated by scaling radiances (additionally to lat and lon) in the KD tree search
- **Radiance is replaced with the BTdiff** (11-12 micron) for Band 27 and Band28 (differences are more sensitive for the atmospheric layer instead of the surface (individual channels).
- **QC improvement**: VIIRS granule quality check is done by scanline now, so partially good granules can be processed. Before the whole granule was checked at once, and only fully best quality granule was processed.
  - Granules with BB WUCD operation and lunar calibration are processed now.
- A **new CrIS-VIIRS collocation implementation** has been developed that provides two main improvements:
  - scans with missing geolocation data are now simply ignored instead of causing whole-granule failures.
  - False negative allocation of VIIRS pixels in the AIRS FOV is fixed.
- The yield for the fusion radiance product is now greater than 99.9% for NOAA20.

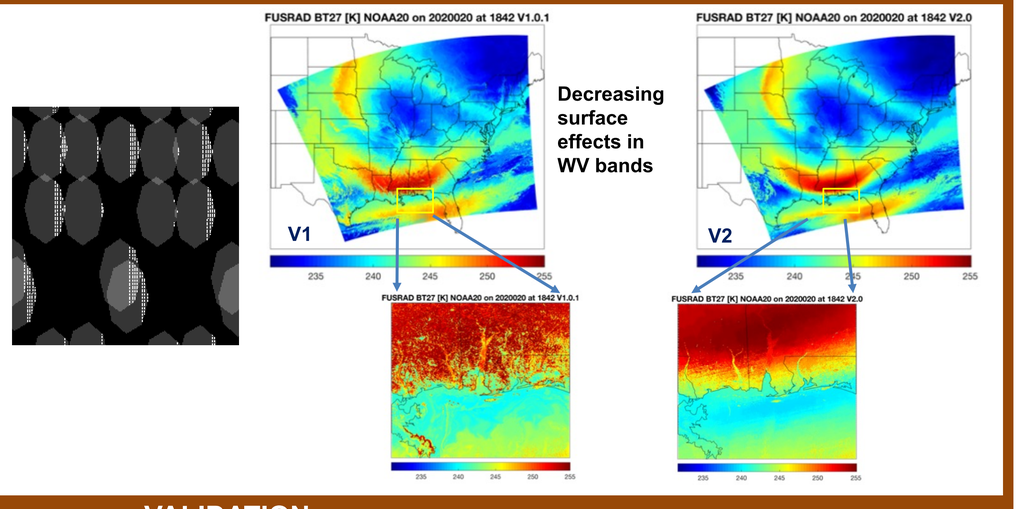
COLLOCATION FIX

The old collocation code missed VIIRS pixels that should have been identified as residing within a CrIS FOV (false negatives).

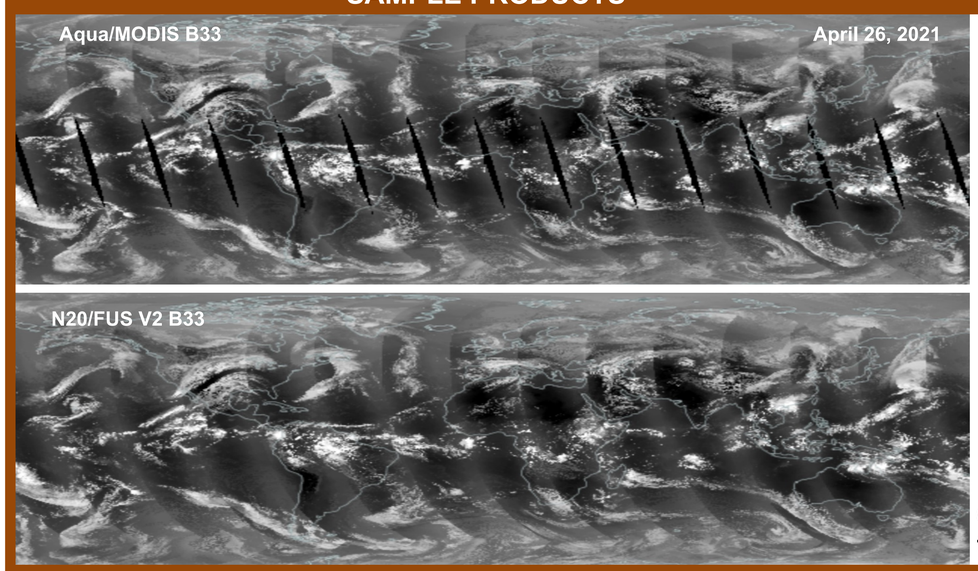
The image shows an area where the false negative problem was especially prominent. Each small white rectangle is a VIIRS pixel that was not identified in the old collocation code.

Overall, an average granule was missing a bit under 1% of collocated VIIRS pixels (for a sense of scale the new code has 189 false negatives for all of August 2020, while the old code had about 286 million).

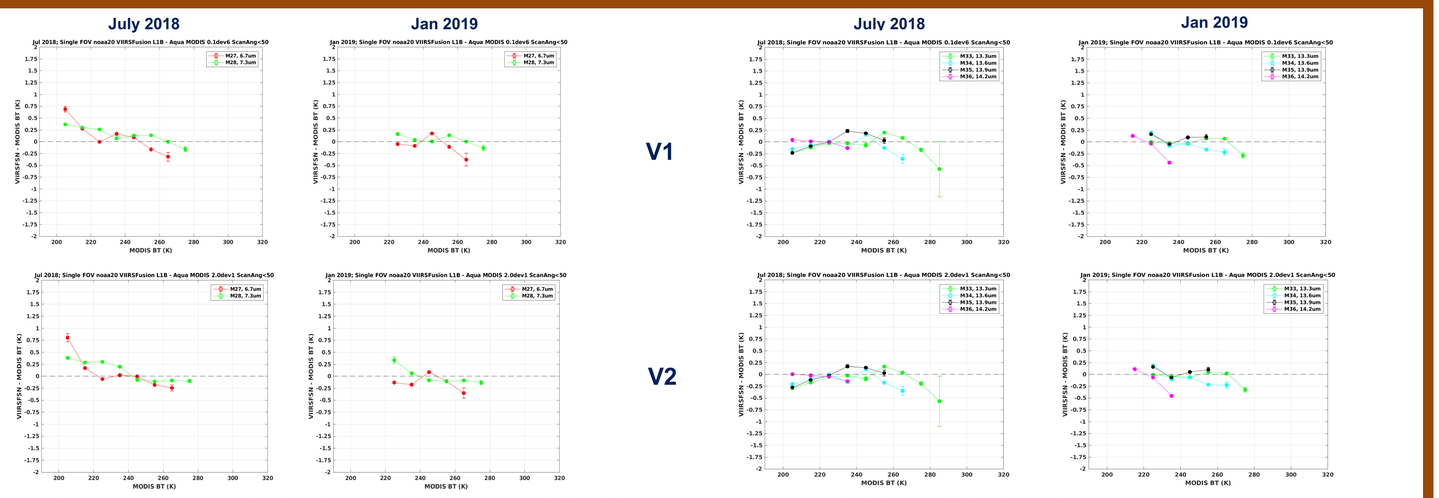
IMPROVEMENTS



SAMPLE PRODUCTS



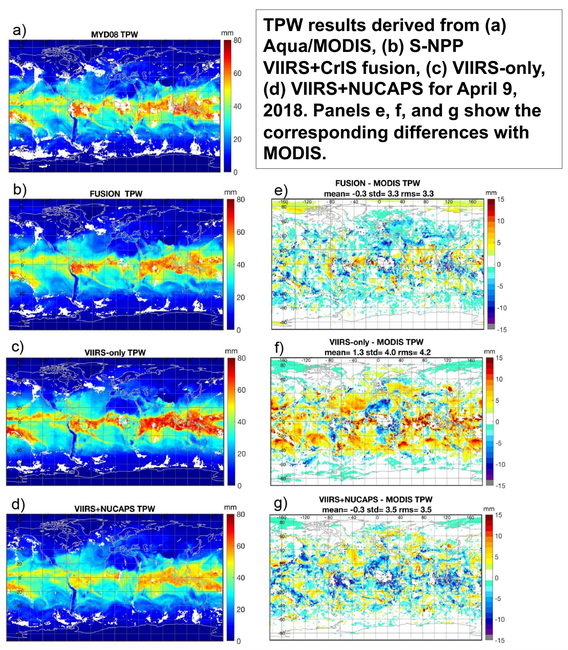
VALIDATION



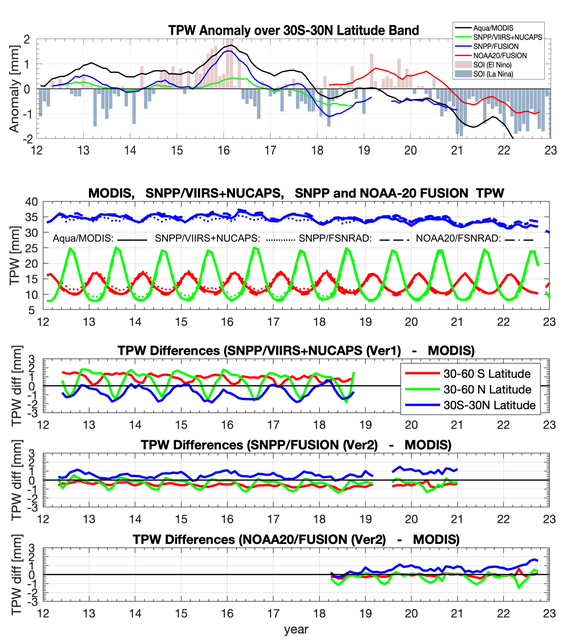
Comparison of collocated Aqua/MODIS and NOAA20 VIIRS/CrIS fusion water vapor (left) and CO2 (right) band brightness temperatures for two selected months. Each data point in the plots (within a ten-degree BT bin) represents ≥10,000 individual collocations.

APPLICATIONS

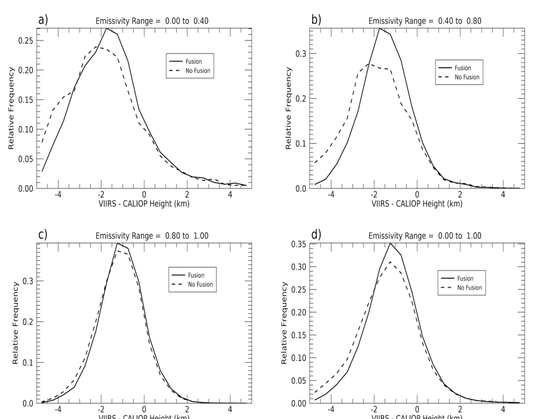
Borbas et al. (2021) show the advantage of using the VIIRS+CrIS fusion radiances for IR absorption bands at 4.5, 6.7, 7.3, 13.3, 13.6, 13.9, and 14.2 μm to determine TPW and demonstrate the potential for continuity of the Terra/Aqua MODIS infrared water vapor products. This study established the feasibility of extending the MODIS IR TPW and UTH into the future. The VIIRS+CrIS fusion TPW product, supplemented with the missing IR bands, was implemented using the same approach as the MODIS TPW product. Note that the fusion-based TPW product is in excellent agreement with MODIS. The time series of the TPW differences reveal that V2 VIIRS+CrIS fusion TPW and MODIS TPW remain within 1mm for all three latitude bands (mid-latitudes north, tropics and mid-latitudes south).



TPW results derived from (a) Aqua/MODIS, (b) S-NPP VIIRS+CrIS fusion, (c) VIIRS-only, (d) VIIRS+NUCAPS for April 9, 2018. Panels e, f, and g show the corresponding differences with MODIS.



(Li et al. 2020) shows the differences between ice cloud heights as a function of cloud emissivity between CALIOP and the CLAVR-x cloud height algorithm called ACHA (AWG Cloud Height Algorithm; AWG is the GOES-R algorithm working group). Significant improvement is found for all ice cloud emissivities but especially for semi-transparent ice clouds. Transmissive ice cloud heights compare much more closely with CALIPSO than those heights based solely on IR window channels.



Bias distribution of cloud top height between S-NPP VIIRS and CALIPSO/CALIOP for emissivity range a) 0 to 0.4; b) 0.4 to 0.8; c) 0.8 to 1.0; and d) 0 to 1.0. Solid and dashed lines indicate data with/without fusion channels.

SUMMARY / FUTURE PLANS / REFERENCES

Summary:

The fusion process is providing IR absorption channel radiances at an order of magnitude higher spatial resolution (from 14 km to 750 m) at the cost of introducing measurement offsets of 0.25 to 0.5K and noise of 0.5 to 1K. Results for the entire S-NPP and NOAA-20 archives show similarly positive results.

Future plans:

- Adjust band 28 –no effect on the FSNRAD SS subsetter products
- Continue monitoring fusion radiance quality with MODIS SNOs

References:

- Borbas, E.E., E. Weisz, C. Moeller, W. P. Menzel, and B.A. Baum, 2021: Improvement in tropospheric moisture retrievals from VIIRS through the use of infrared absorption bands constructed from VIIRS and CrIS data fusion. *Atmos. Meas. Tech.*, **14**, 1191–1203, https://doi.org/10.5194/amt-14-1191-2021
- Li, Y., B. A. Baum, A.K. Heidinger, W. P. Menzel, and E. Weisz, 2020: Improvement in cloud retrievals from VIIRS through the use of infrared absorption channels constructed from VIIRS-CrIS data fusion, *Atmos. Meas. Tech.*, **13**, 4035-4059, https://doi.org/10.5194/amt-13-4035-2020.
- Weisz, Elisabeth & Menzel, W.. (2020). Approach to enhance trace gas determinations through multi-satellite data fusion. Journal of Applied Remote Sensing. 14. 10.1117/1.JRS.14.044519. https://doi.org/10.1117/1.JRS.14.044519
- Weisz, E., B. A. Baum, and W. P. Menzel, 2017: Fusion of Satellite-Based Imager and Sounder Data to Construct Supplementary High Spatial Resolution Narrowband IR Radiances. J. of Applied Remote Sensing, 11(3), 036022 (2017). https://doi.org/10.1117/1.JRS.11.036022

Acknowledgments: This research was supported by the NASA grant 80NSSC22K0322.