GSICS Working Group
- NOAA Report

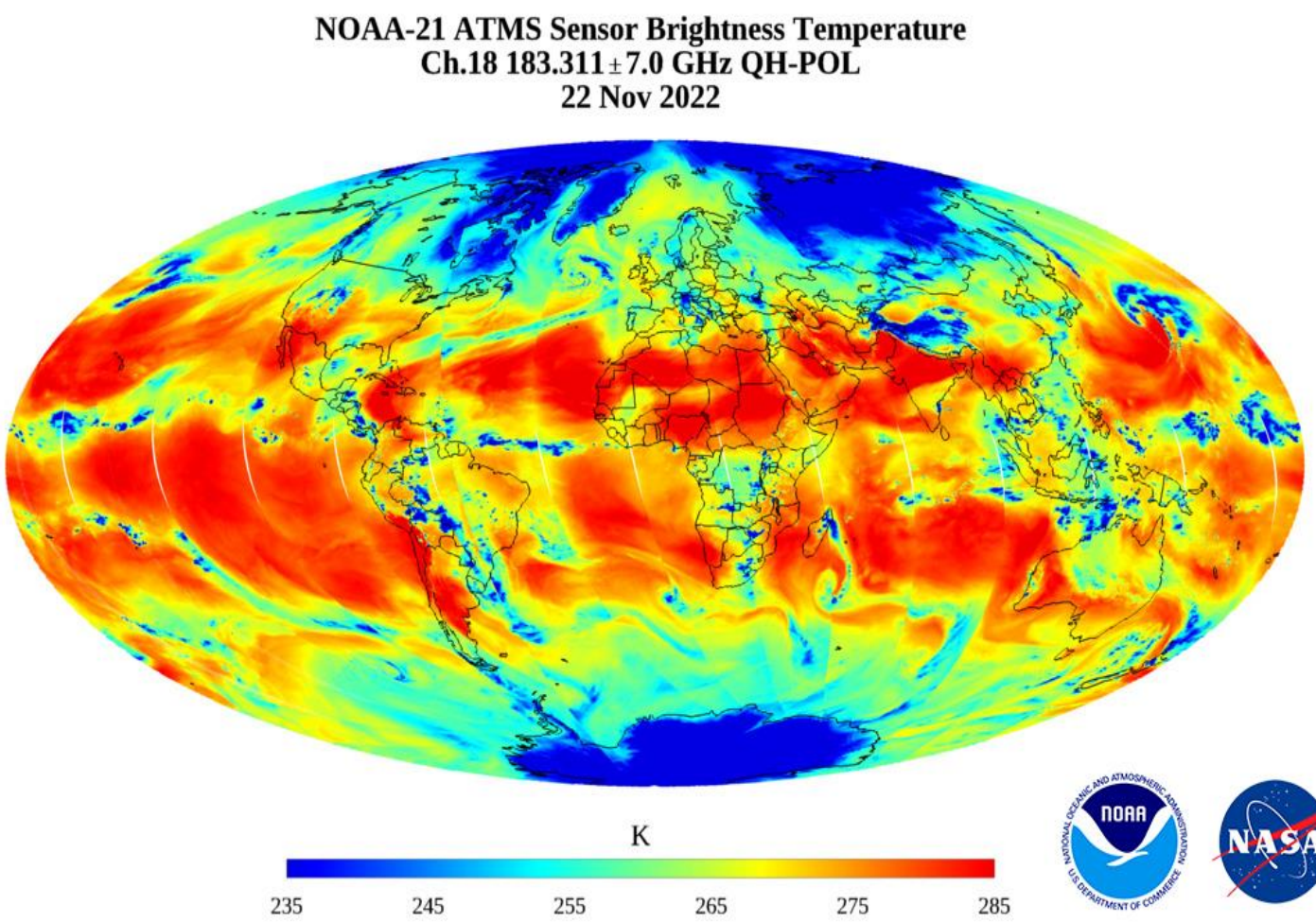
Quanhua (Mark) Liu, Cheng-Zhi Zou, Ninghai Sun, Hu (Tiger) Yang, Siena Iacovazzi

Chris Grassotti, Yong-Keun Lee, Xun (John) Yang, XingMing Liang

Outlines

- NOAA-21 ATMS
- Microwave Integrated Retrieval System (Chris Grassotti, MiRS)
- Microwave Long-term Sensor Data Records for Climate Studies (Cheng-Zhi Zou, NOAA/STAR)
- Lunar Disk-Averaged Brightness Temperature Database for Microwave Sounder Calibration (Hu Yang and Martin Burgdorf)
- TROPICS Pathfinder (John Yang, MiRS)
- Radio Osculation data for Microwave Sensor Data Monitoring (Siena Iacovazzi, ATMS)
- Microwave Imagery Product
- AI-based Radiative Transfer Model (Mark Liu, XingMing Liang, NOAA/STAR)

NOAA-21 ATMS First Light Image

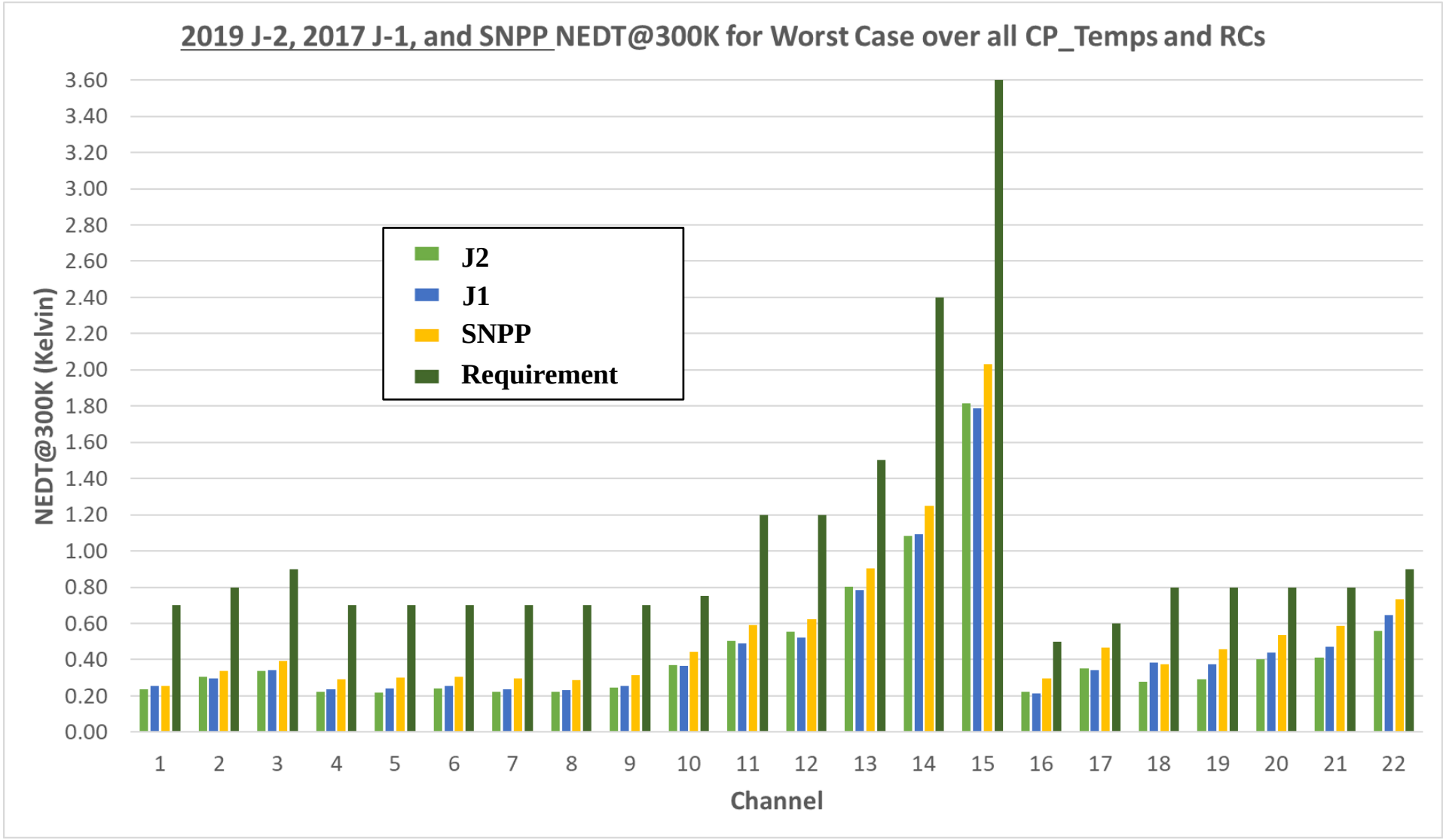


The ATMS instrument gives weather forecasters a global 3D picture of our atmosphere's temperature and moisture—the most fundamental information needed by weather models that forecast daily weather and warn us of hurricanes, floods, droughts, heat waves, snowstorms, and other weather events.

- **Mission:** Provides sounding profiles of atmospheric temperature and moisture
- **Satellites:** SNPP (2011), NOAA-20 (2017), NOAA-21 (2022).
- **Instrument Type:** Total power microwave radiometer.
- **Number of channels:** 22 channels.
- **Frequency range (GHz):** 23 GHz to 183 GHz.
- **Nadir resolution:** 74.8 km (K/KA band), 31.6 km (V-band), 15.8 km (W/G band).
- **Scanning Technique:** Cross-track 96 earth FOVs per scan.
- **Swath width:** 2500+ km.
- **Coverage/Cycle:** Near-global coverage twice per day.

https://www.nesdis.noaa.gov/news/first-light-image-noaa-21s-atms-sensor

NOAA-21 ATMS Pre-launch Instrument Evaluation – NEΔT



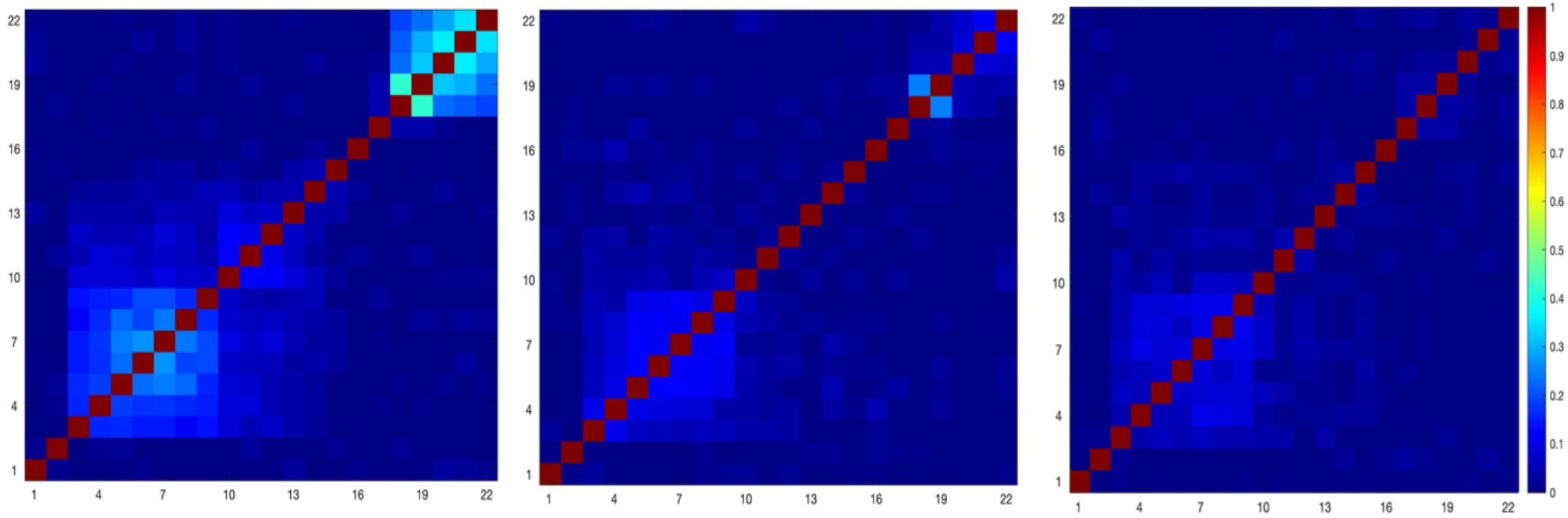
NASA/GSFC

All J2 results are in family with J1 and SNPP. J2 NEDT better than J1 & SNPP for CH 18-22.

NOAA-21 ATMS On-orbit Channel Correlation

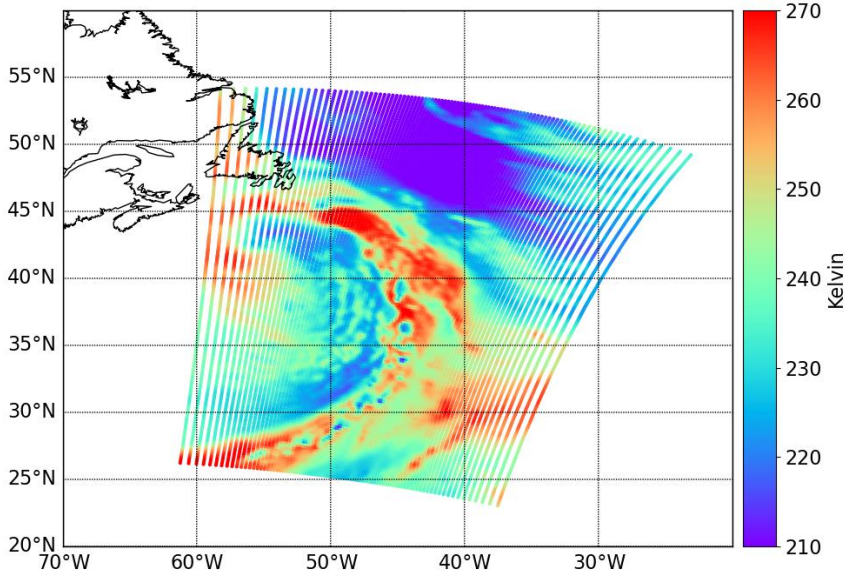
- G-band channel correlation further reduced in NOAA-21 compared to NOAA-20

S-NPP **NOAA-20** **NOAA-21**

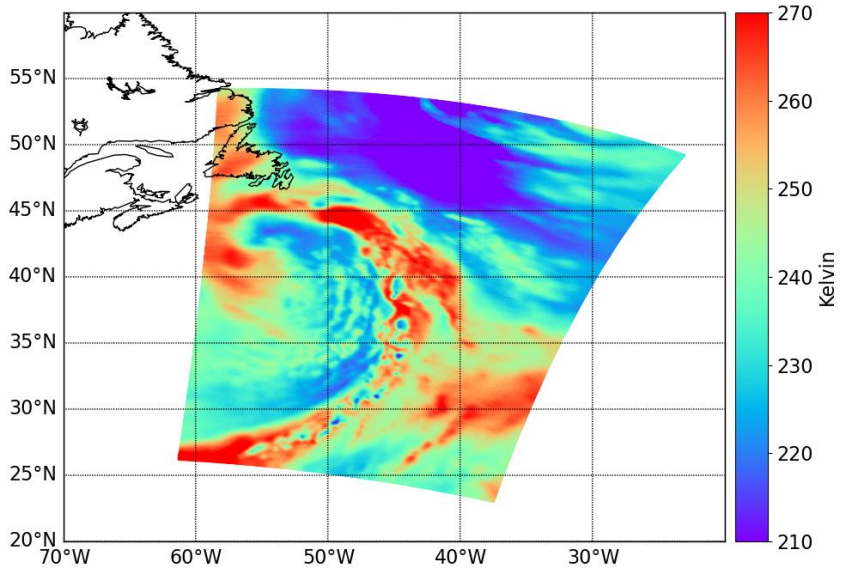


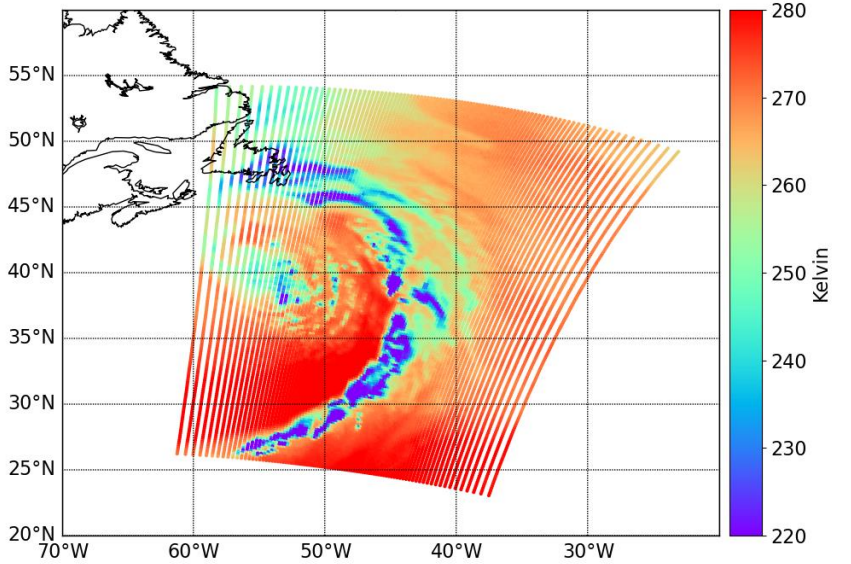
The reduced NOAA-21 cross-channel noise correlation will ease data assimilation into forecast models compared to previous ATMS builds

NOAA-21 ATMS Limb-corrected and AI Resolution Enhanced Images

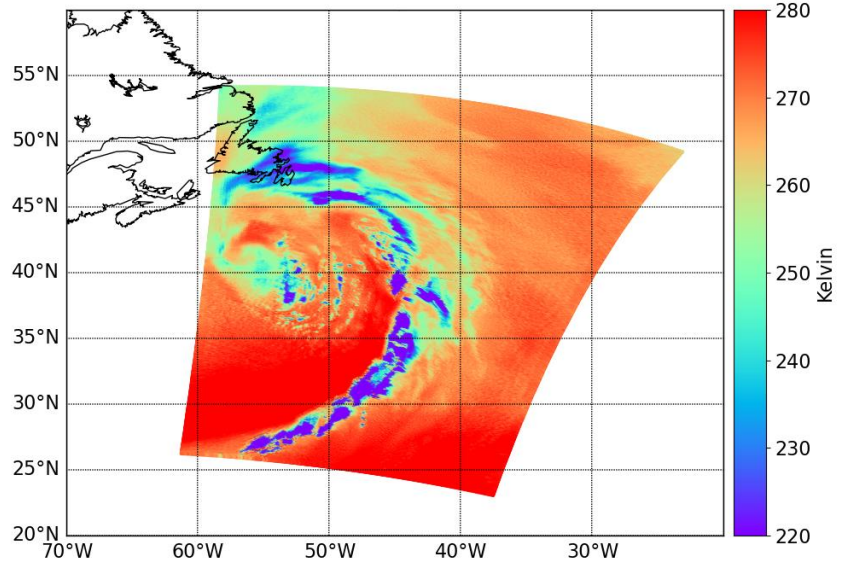


Ch.16





Ch. 18



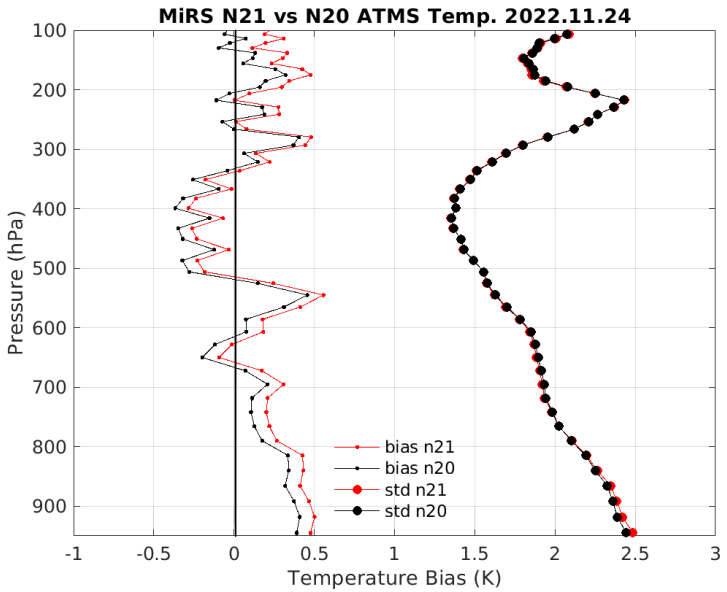
Limb-correction makes cross-scan observations as a nadir-looing.

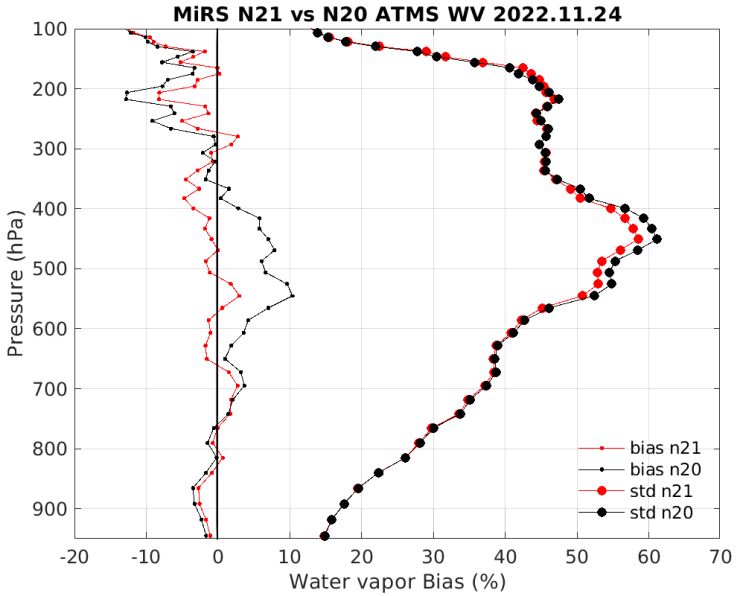
The second step AI algorithm enhanced the limb-corrected Images by a factor of 4.

The two steps algorithms deliver good visualization for weather patterns.

NOAA-21 Preliminary, Non-Operational Data

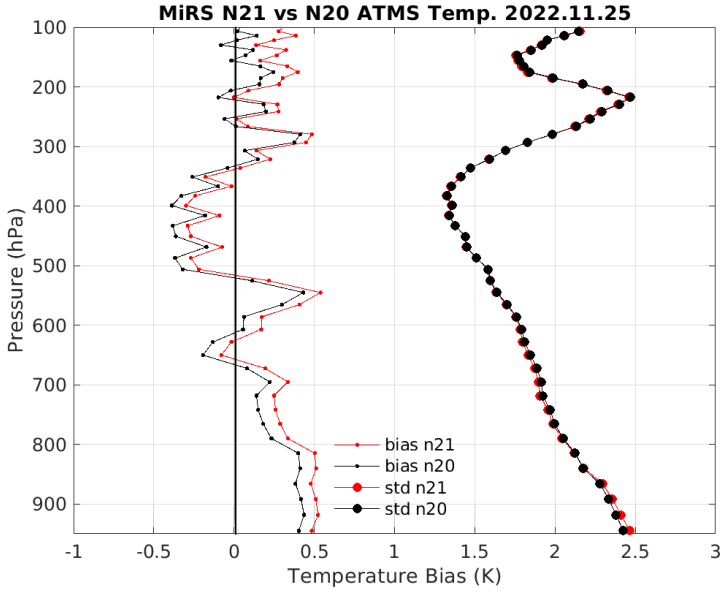
MiRS N21 and N20 Temperature & Moisture Profiles Comparison with ECMWF

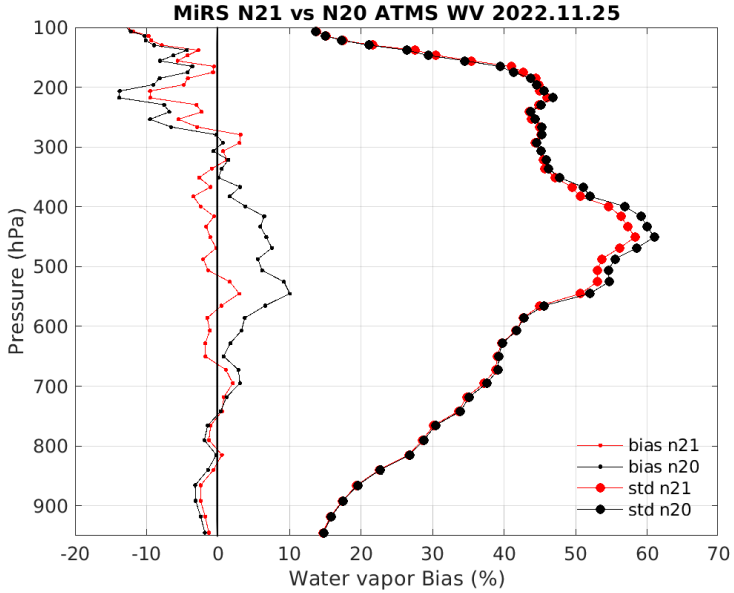




2022-11-24

Low noise of N21 water vapor channels improved water vapor retrieval (red line for N21 vs black line for N20).

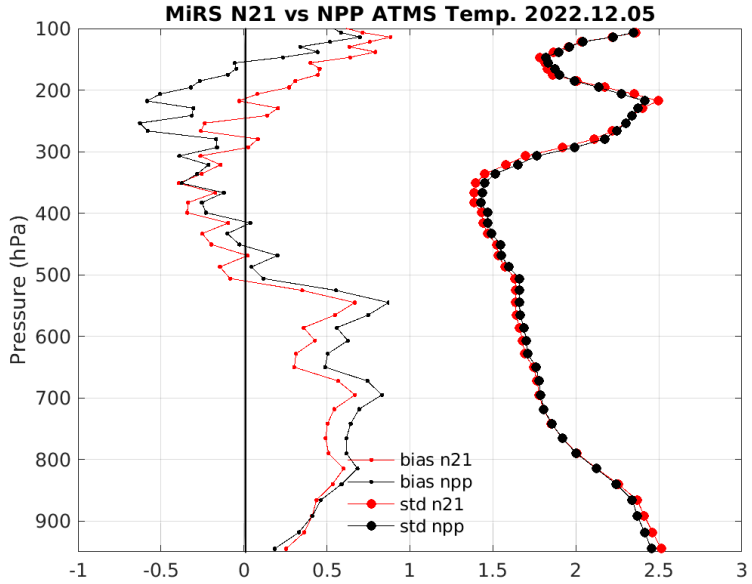


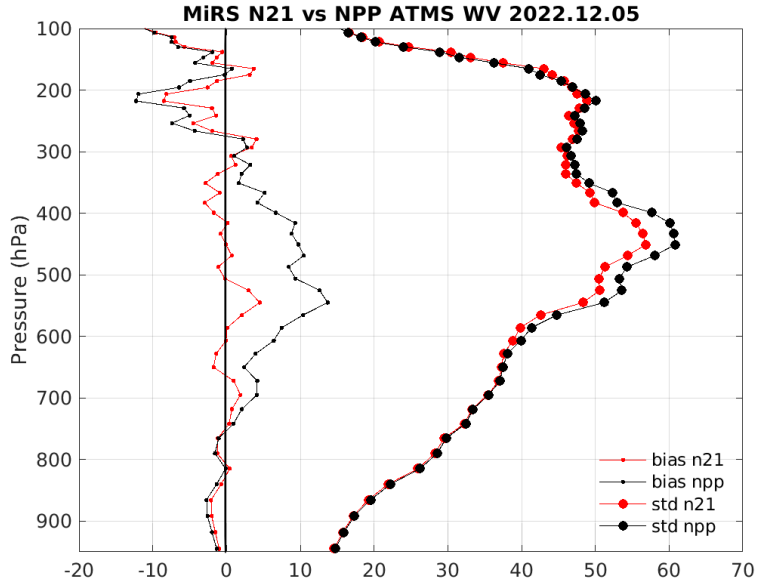


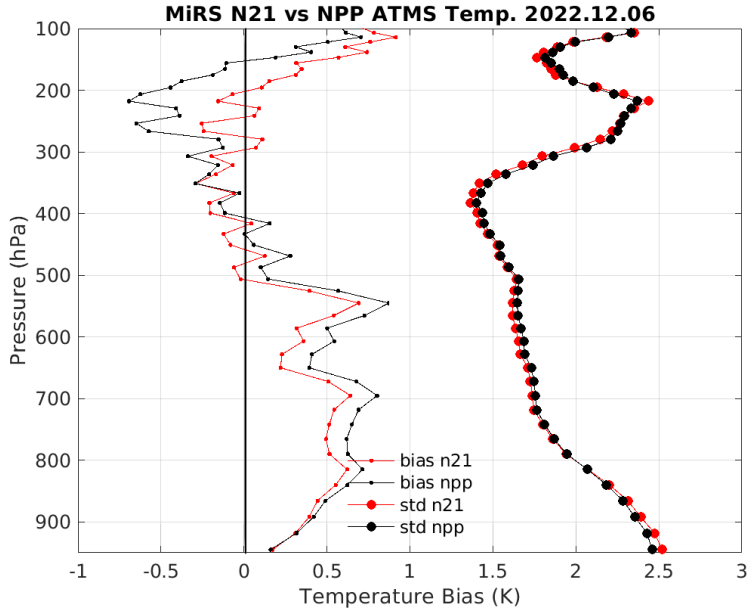
2022-11-25

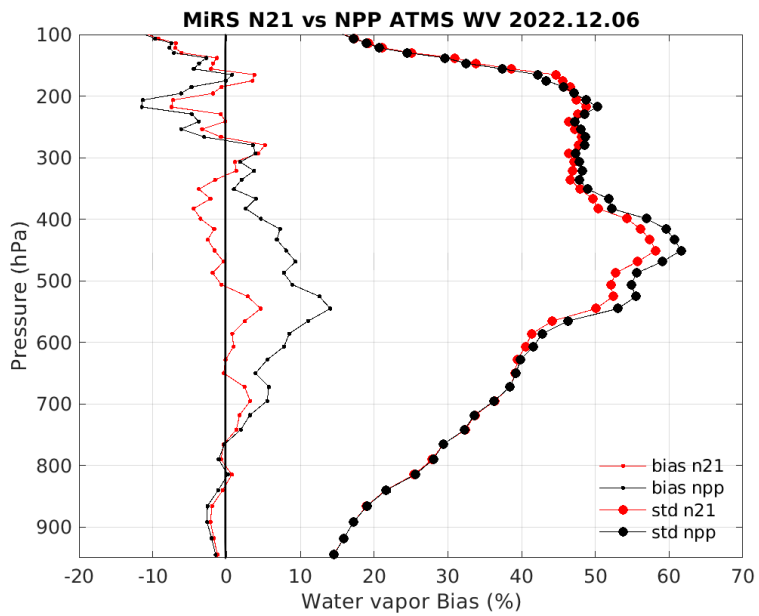
NOAA-21 Preliminary, Non-Operational Data

MiRS N21 and SNPP Temperature & Moisture Profiles Comparison with ECMWF









2022-12-05

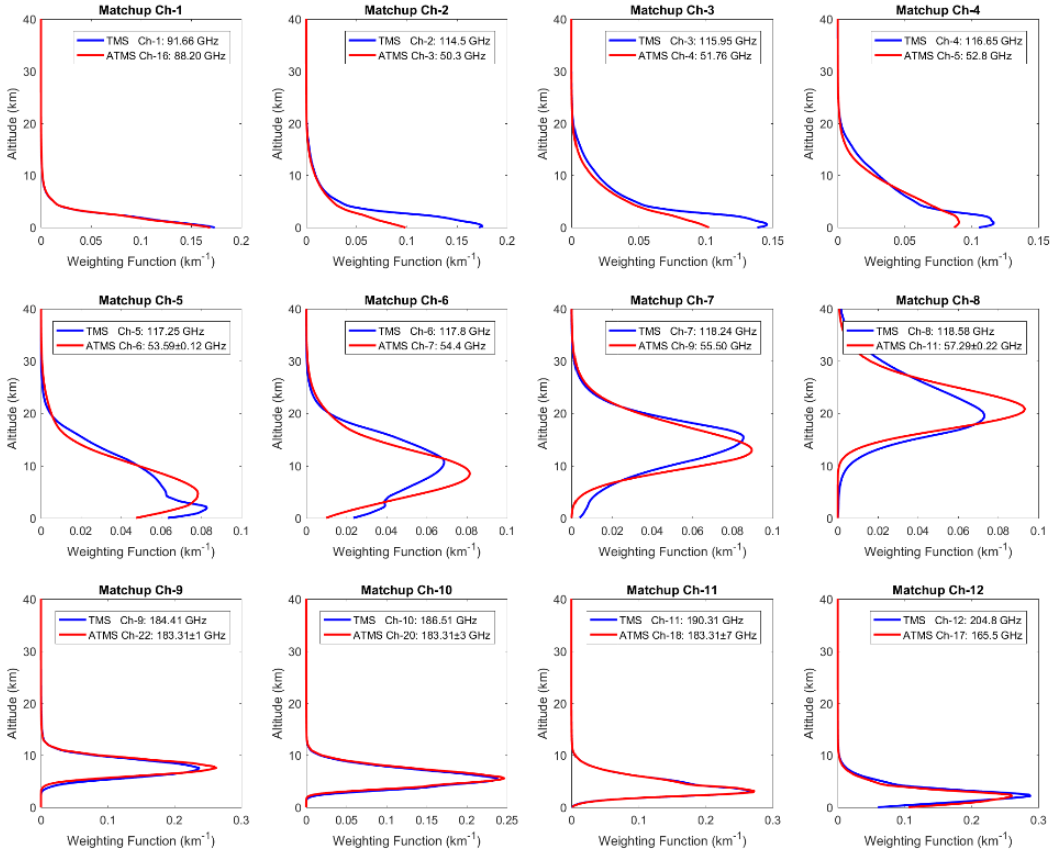
Low noise of N21 water vapor channels improved water vapor retrieval (red line for N21 vs black line for NPP).

2022-12-06

NOAA-21 Preliminary, Non-Operational Data

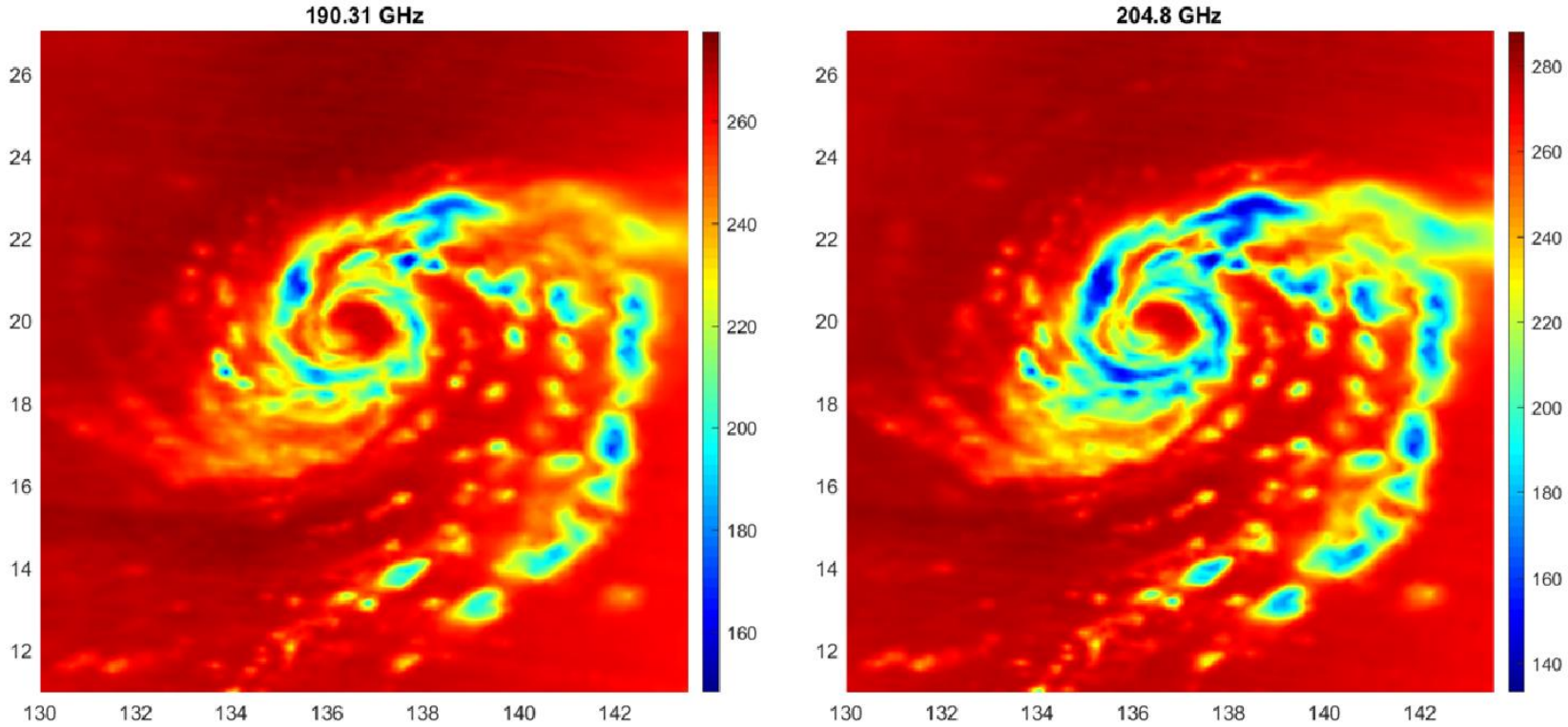
TROPICS PATHFINDER Specification

Channel	Center Freq. (GHz)	Pol.	Bandwidth (GHz)	Footprint Nadir (km)	NEDT in-orbit(K)	ATMS Channel (GHz)	ATMS NEDT (K)
1	91.655±1.4	H	1	29.6	0.94	88	0.21
2	114.5	H	1	24.1	0.64	50.3	0.32
3	115.95	H	0.8	24.1	0.60	51.76	0.22
4	116.65	H	0.6	24.1	0.68	52.8	0.22
5	117.25	H	0.6	24.1	0.61	53.596±0.115	0.24
6	117.8	H	0.5	24.1	0.64	54.4	0.22
7	118.24	H	0.38	24.1	0.70	55.5	0.24
8	118.58	H	0.3	24.1	0.83	57.2903±0.217	0.46
9	184.41	V	2	16.1	0.55	183±1	0.58
10	186.51	V	2	16.1	0.57	183±3	0.40
11	190.31	V	2	16.1	0.51	183±7	0.35
12	204.8	V	2	15.6	0.59	165.5	0.32



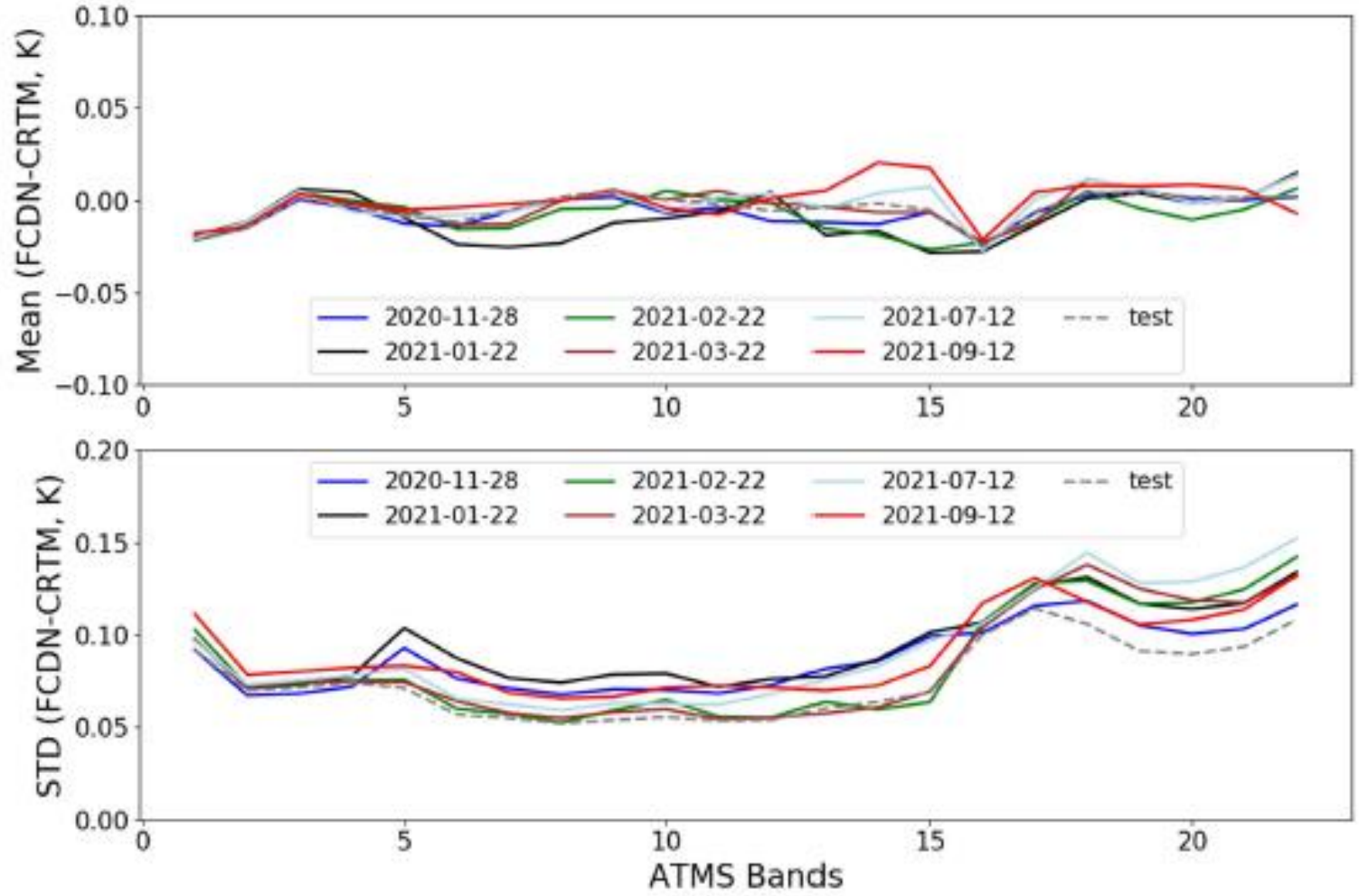
- A subset of ATMS channels that match up with TMS is used in retrieval, which permits a more direct comparison of the information content available between the V-band and F-band

Typhoon Mindulle seen by TROPICS



- 190.31 GHz (left) and 204.8 GHz (right) of TROPICS for Typhoon Mindulle on 27 September 2021
- The new 204.8 GHz resolves fine structures about typhoon eye and rainbands
- Colder brightness temperature in rainband at 204.8 GHz, with larger dynamical range of 155 K, compared to 129 K at 190 GHz

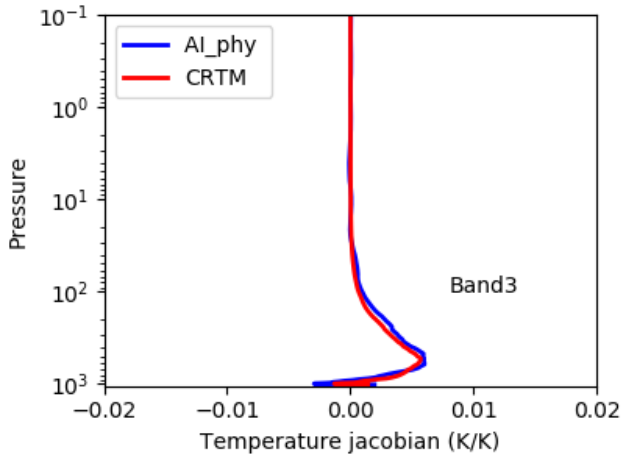
AI Forward RTM vs CRTM for ATMS

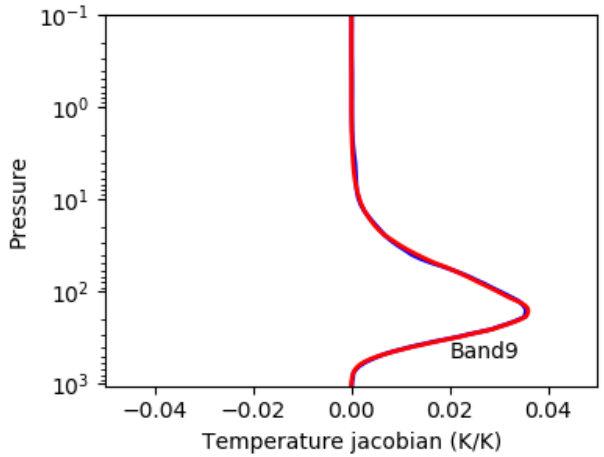


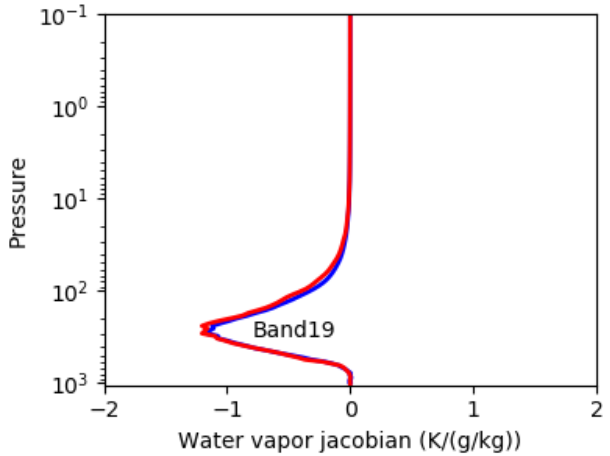
The difference is smaller than ATMS instrumental noise.

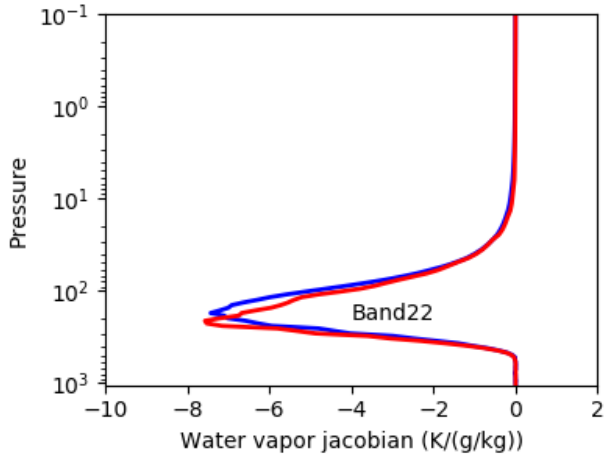
Radiance Jacobian Comparisons

AI_phy RT

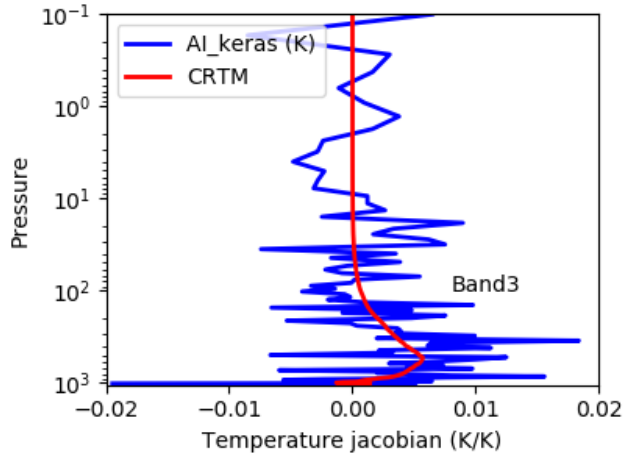


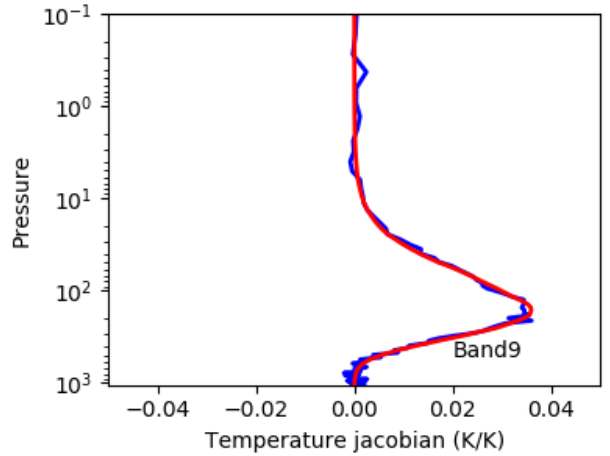


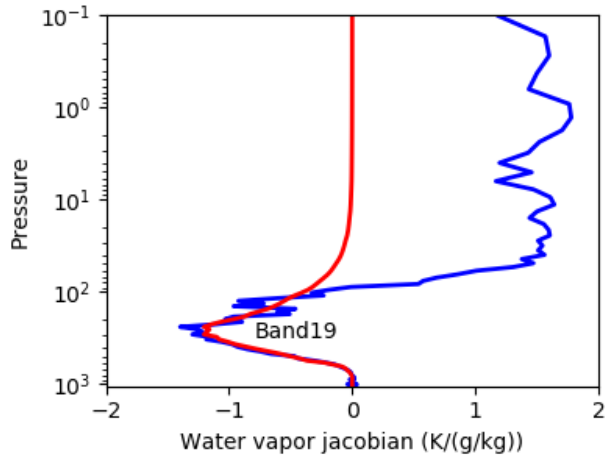


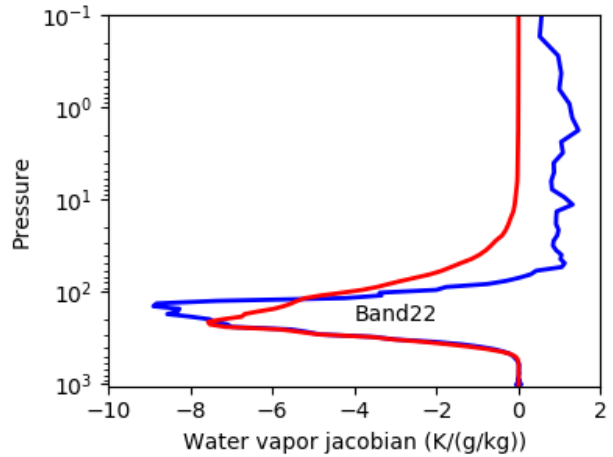


AI_keras RT









AI_phy_rt and AI_keras_rt use the same AI model configuration. AI_phy_rt is trained with physics constraint and its forward model accuracy is comparable to AI_keras, better than ATMS instrumental noise. AI_phy_rt jacobian agrees with the CRTM, much better than AI_keras_rt.

Summary

- ✓ On orbit channel-to-channels noise correlations among S-NPP, NOAA-20, and NOAA-21 are analyzed. NOAA-21 ATMS is the best;
- ✓ NOAA-21 ATMS channel NEΔTs are stable and comparable to NOAA-20;
- ✓ Good agreement between nearly simultaneous NOAA-21 and NOAA-20 ATMS measurements;
- ✓ Good agreement between nearly simultaneous NOAA-21 and S-NPP ATMS measurements;
- ✓ Low noise of NOAA-21 ATMS water vapor channels improves MiRS water vapor EDR performance;
- ✓ Details are referred to https://www.star.nesdis.noaa.gov/icvs-beta/status_J02_ATMS.php
- ✓ TROPICS Pathfinder imagery at 204 GHz has better contrast for hurricanes
- ✓ AI-based radiative transfer calculations are 100 times faster for clear-sky and 400-1,000 time faster than the CRTM, achieved high accuracy