

Precipitation Ice water path (PIWP) retrievals from the TROPICS mission

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Overview

- Combining GPM-DPR radar and TROPICS data (TROPICS 01 shown here as an example)
- KD-tree model development
- Accuracy based on test dataset
- Global retrievals

Data Source

- TROPICS data (2022 & 2023)
- GPM-DPR data (2022 & 2023)
 - Combined Precipitation L2B 1.5 hour 5 km V07 (GPM_2BCMB)
- T, q from GEOS5
 - CRTM model used to generate simulated TBs

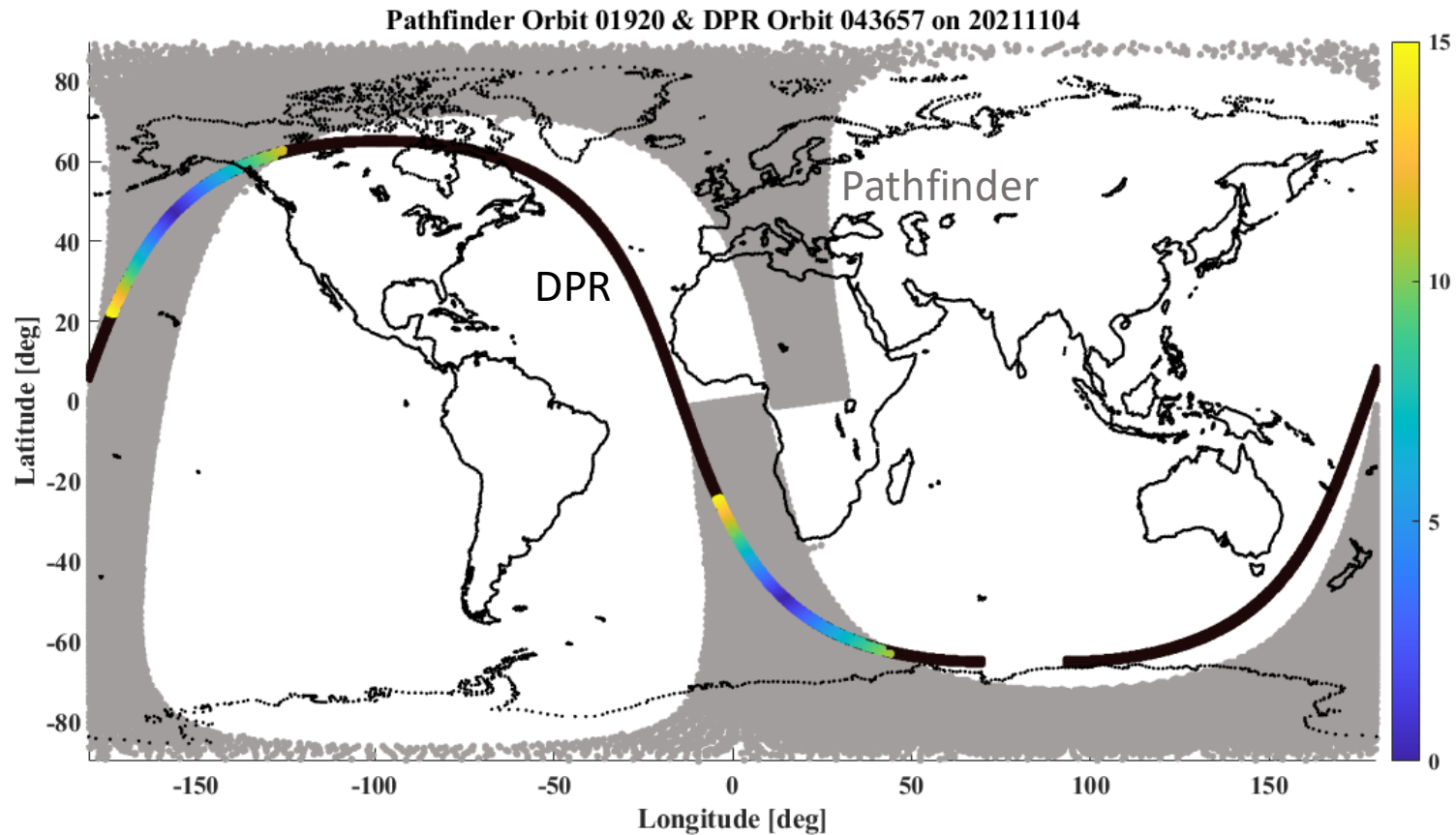
TABLE 2 Description of the TROPICS radiometer channels

Channel	Centre frequency (Ghz)	Bandwidth (MHz)	Beamwidth (°) Down/Cross	ΔT_{rms} (K)	Calibration accuracy (K)
1	91.655 \pm 1.4	1000	3.0/3.17	0.7	2.0
2	114.50	1000	2.4/2.62	1.0	1.5
3	115.95	800	2.4/2.62	0.9	1.5
4	116.65	600	2.4/2.62	0.9	1.5
5	117.25	600	2.4/2.62	0.9	1.5
6	117.80	500	2.4/2.62	0.9	1.5
7	118.24	380	2.4/2.62	0.9	1.5
8	118.58	300	2.4/2.62	1.0	1.5
9	184.41	2000	1.5/1.87	1.0	1.0
10	186.51	2000	1.5/1.87	0.6	1.0
11	190.31	2000	1.5/1.87	0.6	1.0
12	204.80	2000	1.4/1.83	0.6	1.0

DPR / TROPICS Match Database

- Matching data
 - 0.25 x 0.25 deg, 15 min
 - Averaging all DPR measurement in that quarter deg box
 - Using single L1 observations from TROPICS (no averaging)
 - Quantities we use from DPR:
 - Precipitation Ice Water Path (vertically integrated ice water content derived from DPR)
 - Hydrometeor Water Path (vertically integrated ice +rain water content derived from DPR)
 - Surface rain rate
 - Note: Since DPR is not sensitive to cloud ice with small suspended ice particles, e.g. cirrus, we cannot derive cloud ice water path (TROPICS is also not sensitive to those)

An example of single orbit collocations between TROPICS 01 & DPR within 15 mins time window



Calculating ΔTB

- In addition to using the 12 TROPICS TBs, we use ΔTB , defined as observed minus simulated cloud-free TBs

$$\Delta TB = TB_{obs} - TB_{sim}$$

- Cloud-free simulations based on GESO5 and CRTM
- Observed TBs are bias-corrected
- Follow paper (Chen & Bennartz 2020)

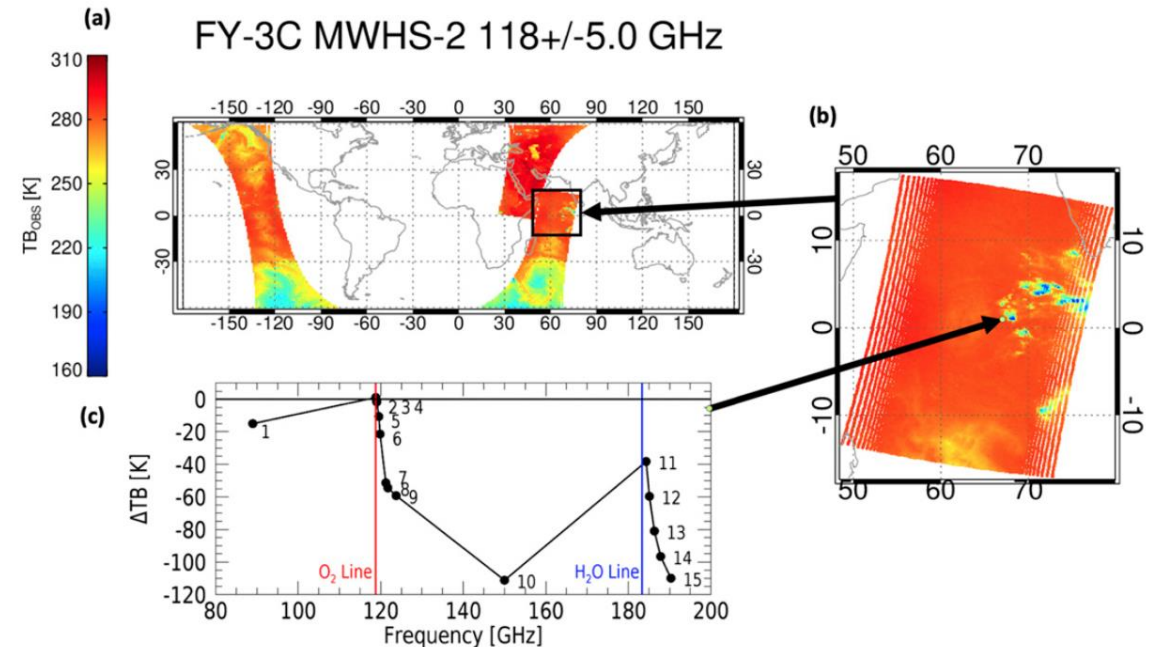
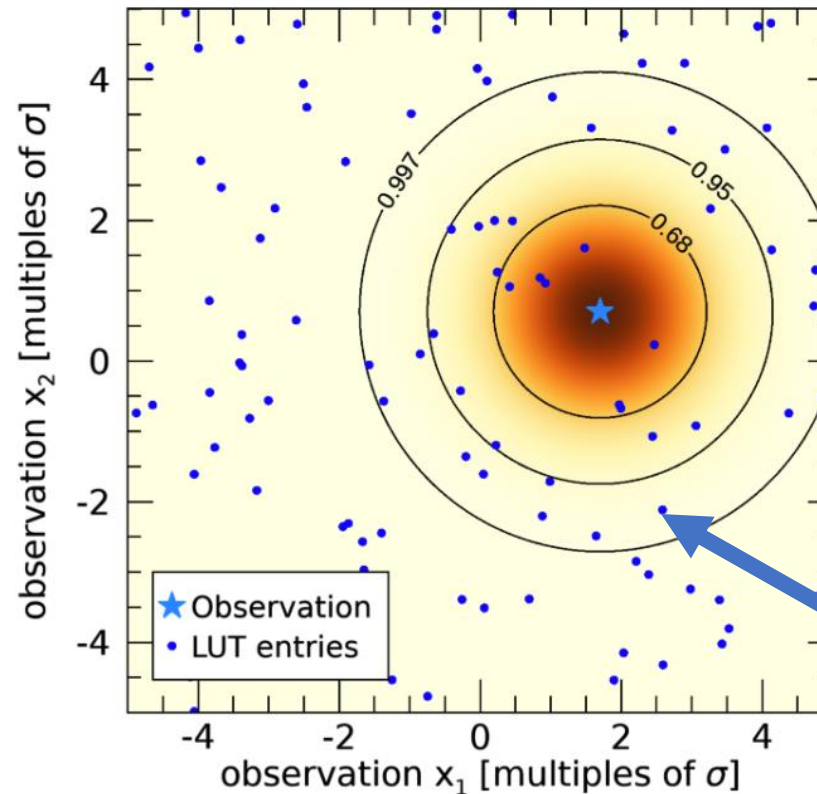


FIG. 4. Example of the scattering signature of deep convective clouds observed by MWHS-2. (a) One full orbit of MWHS-2 data (channel 9; 22 Aug 2016, with start time 0554 UTC). (b) The same data as in (a), enlarged around an area in the Indian Ocean that contains isolated deep convection, visible as the blue and green dots in the center-right of the panel. (c) The spectral variation of ΔTB for the center of one of the convective cells, as highlighted by the arrow to (b); the plot in (c) also shows the location of the 118.75-GHz oxygen absorption line, the 183.31-GHz water vapor absorption line, and the MWHS-2 channel numbers corresponding to Table 1. Note that MWHS-2 sounding channels 2–9 and 11–15 are all double sideband (e.g., channel 9 is 118.75 ± 5 GHz). In (b), their corresponding ΔTB are only shown at the location of the upper subband (e.g., $118.75 + 5$ GHz).

Chen & Bennartz 2020

KD-Tree

- Enables finding the nearest neighbor in a lookup table (LUT) within a multi-dimensional space
- Allows finding all points in a LUT in a hyper-sphere around a given point
- Allows for various parameters to be retrieved beyond just the values of the nearest neighbor



Each LUT entry has DPR IWP

Retrieval:

- For each new observation find all LUT entries that fit into e.g. 0.65 likelihood hyper-sphere and average

KD-Tree Model Development

- After screening the data, ~10 million valid matchups were identified over a 2-year period
 - 70% used for training and 30% for testing
- Features used to build K-D trees:
 - TROPICS TBs & Δ TBs at 12 channels
- Build four K-D trees evenly distributed along the scanline, using relative airmass as the basis for distribution

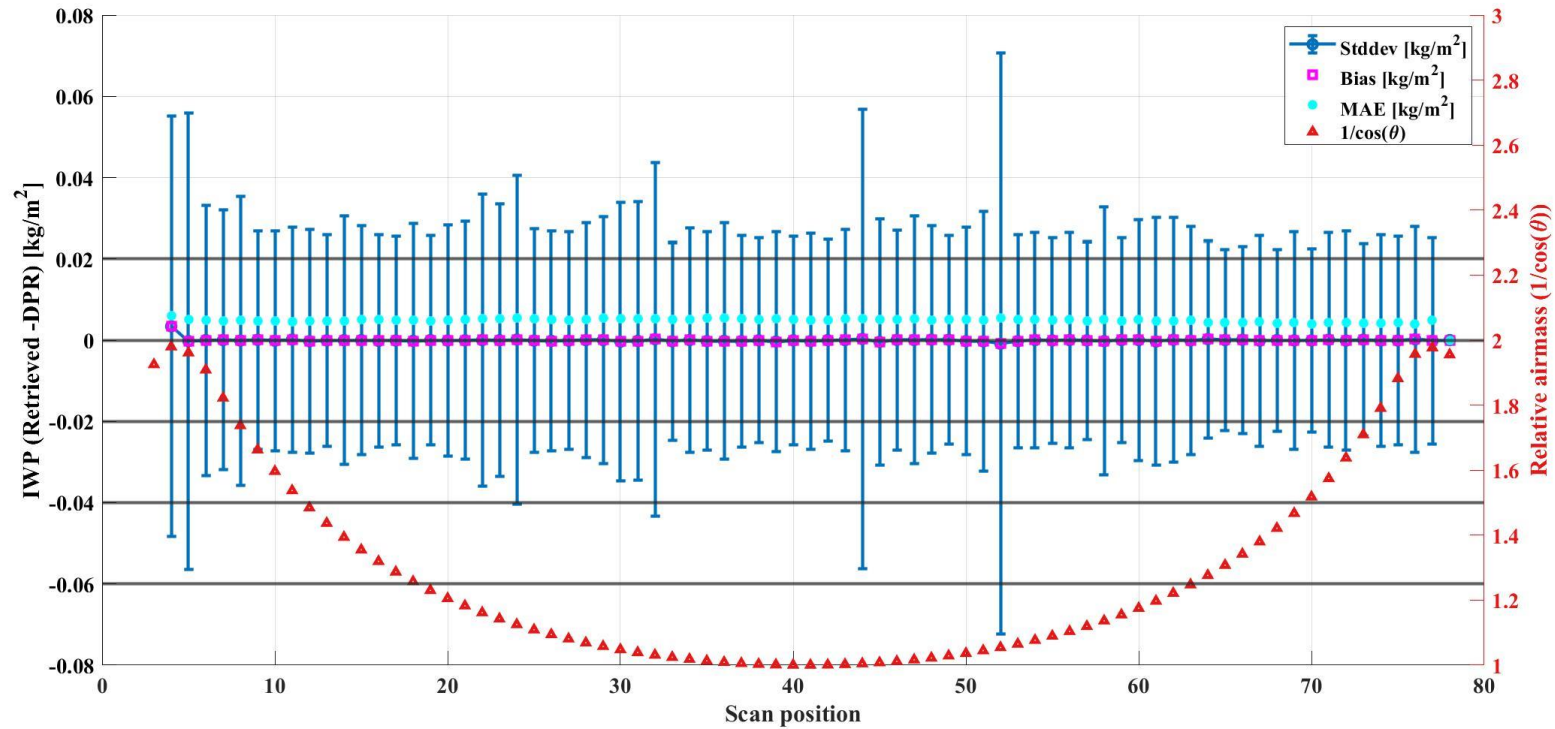
$$f(\theta) = \frac{1}{\cos(\theta)}$$

Summary of Performance

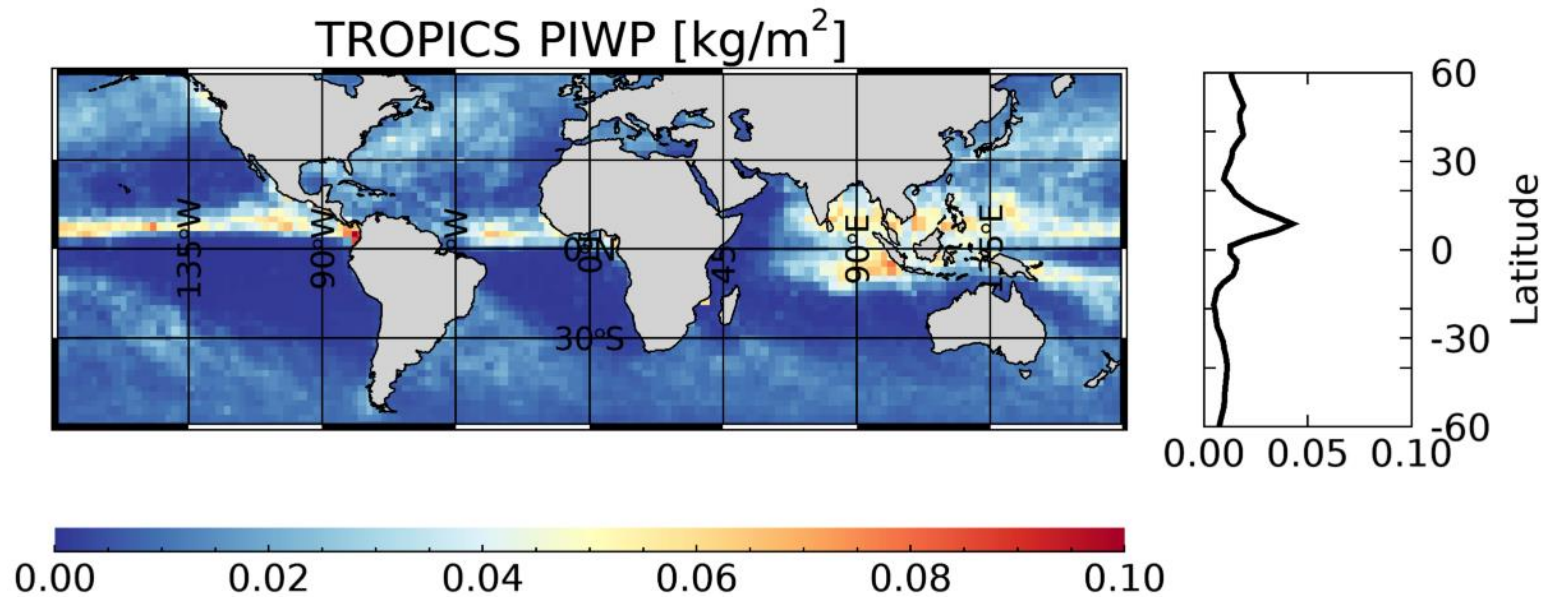
PIWP retrieval statistics against DPR for the three different kd-tree setups

	Bias [g/m ²]	RMSE [g/m ²]
Δ TB-only (12-dim)	0.09	35.9
TB-only (12-dim)	0.11	37.5
TB+ Δ TB (24-dim)	0.00	30.1

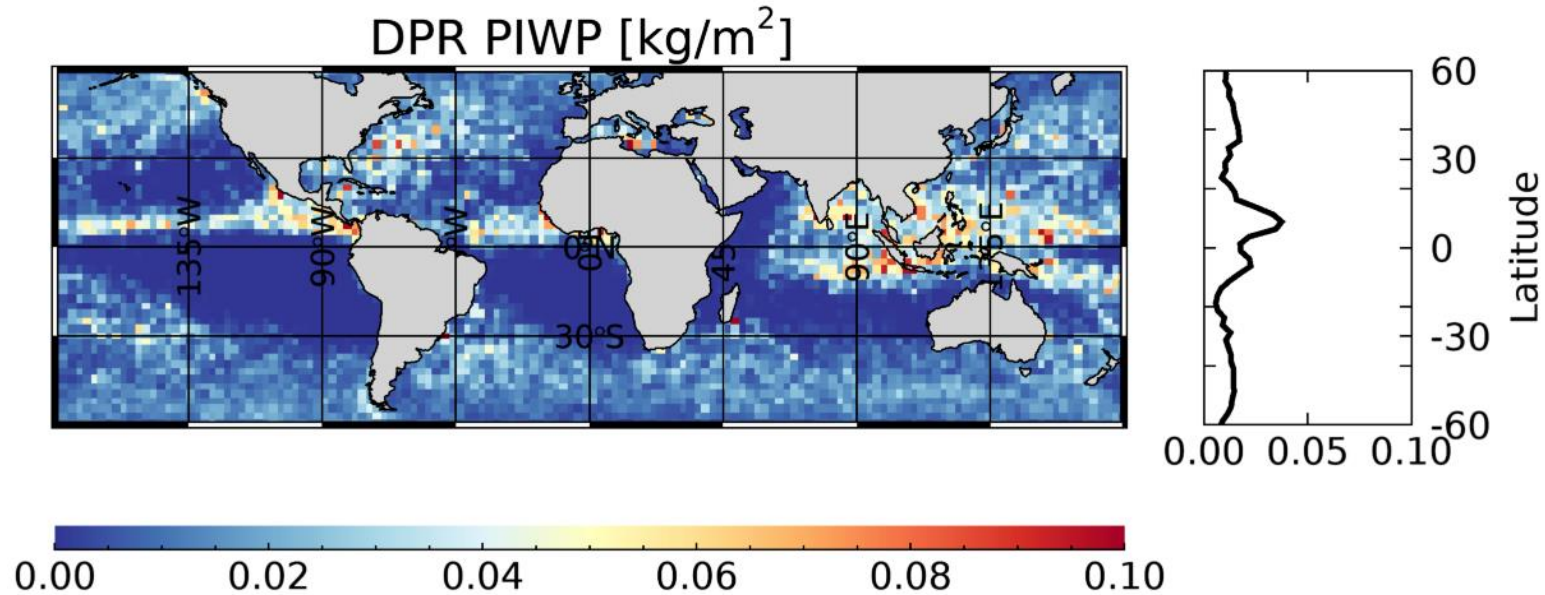
PIWP Bias/Error across Scanline



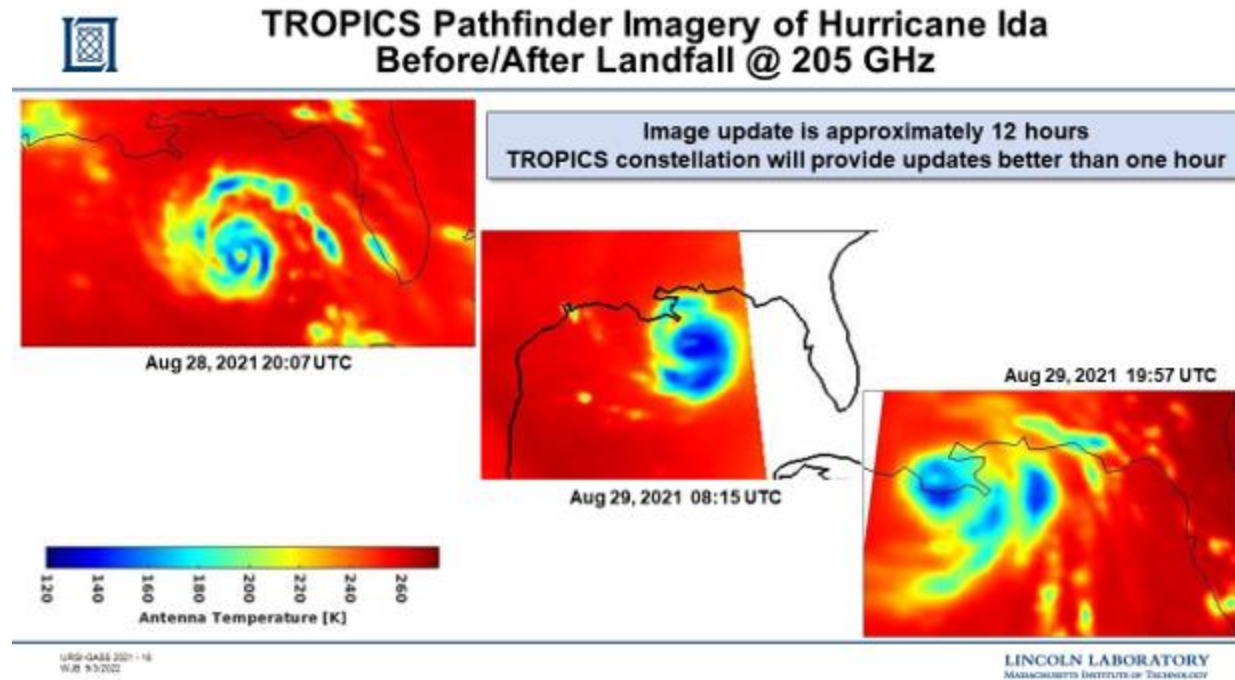
TROPICS Precip. Ice Water Path



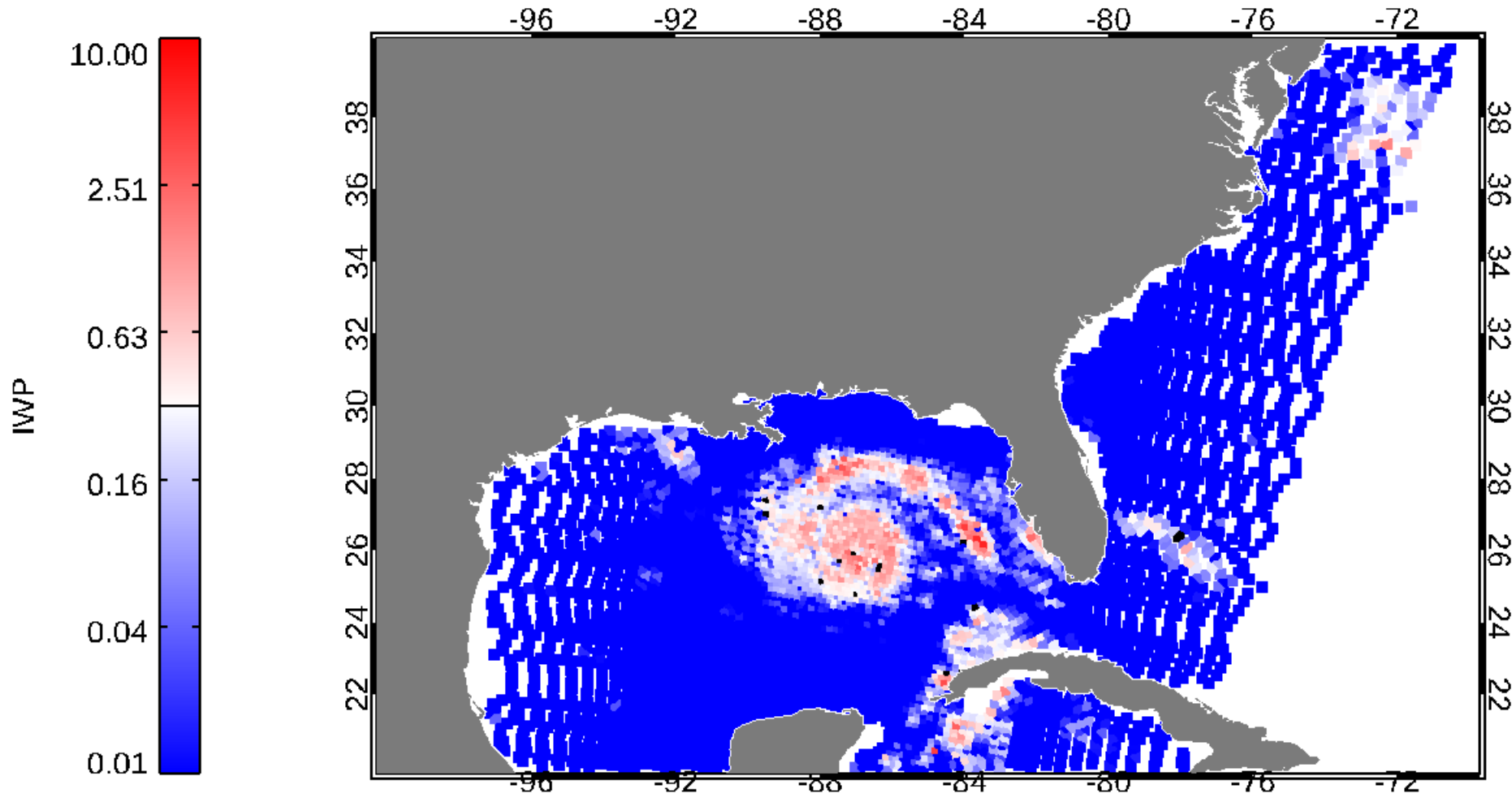
DPR Precip. Ice Water Path



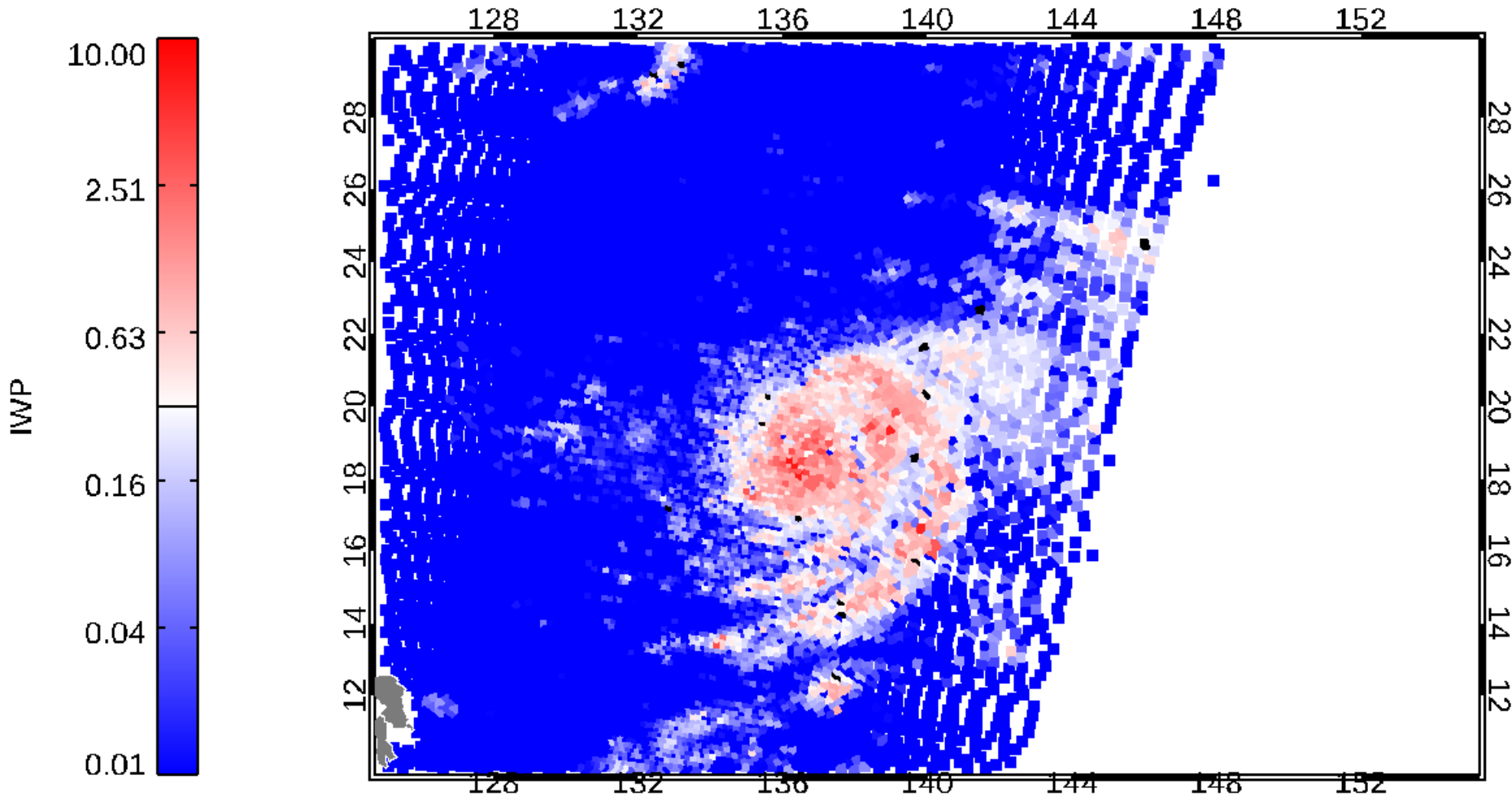
Hurricane Ida 8/28/21c 20:07 UTC



Hurricane Ida 8/28/21c 20:07 UTC – PIWP [kg/m²]



Hurricane Mindulle 9/26/21 5:45 UTC – PIWP [kg/m²]



Conclusions

- TROPICS PIWP retrievals align well with DPR, demonstrating high accuracy
- The KD-tree shows significant potential for efficient PIWP retrievals
- Interesting features have been identified in the Kd-tree LUTs, such as the likelihood of precipitation
- An algorithm package is being developed for DPC at Wisconsin, designed to process the entire lifetime of TROPICS 01 data
 - March 2025 targeted for initial data product release
- Similar algorithm development will be extended to other TROPICS satellites (03, 05, & 06)