Characteristics of Precipitation across the Atlantic Inter-Tropical Convergence Zone from Shipborne Sea-Pol Radar Observations

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Background

- PICCOLO, the US component of the international field campaign ORCESTRA, is the **first ship-borne polarimetric radar deployment** along the Atlantic Intertropical Convergence Zone (ITCZ) (Fig. 1).
- During PICCOLO the **Colorado State University (CSU) Sea-Going and Land Deployable Polarimetric (Sea-Pol) radar**, an NSF CIF facility, was deployed on the German R/V Meteor, from August 16 to September 23, 2024 (40 days) (Fig. 1).
- Previous observational evidence from ship-borne radar over tropical oceans suggest that cumulus congestus constitute over half of the echo population [2] and found a lognormal distribution of echo height, peaking in the shallow cumulus regime [2 ,3].

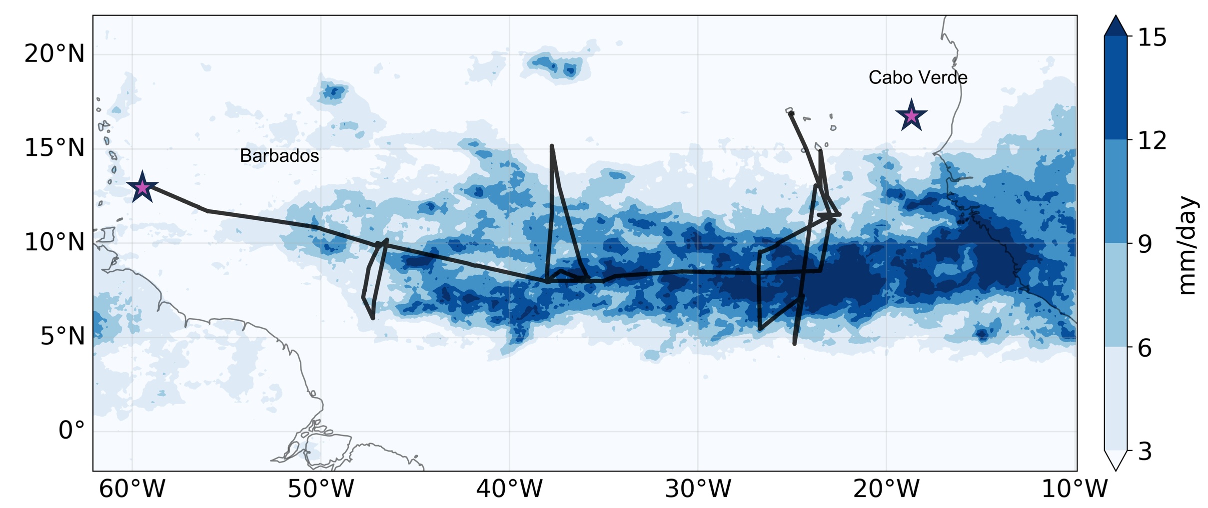


Figure 1. Mean precipitation from IMERG [1] during August 16- September 24, 2024 and track of the R/V Meteor during the PICCOLO campaign (black line), going from east to west.

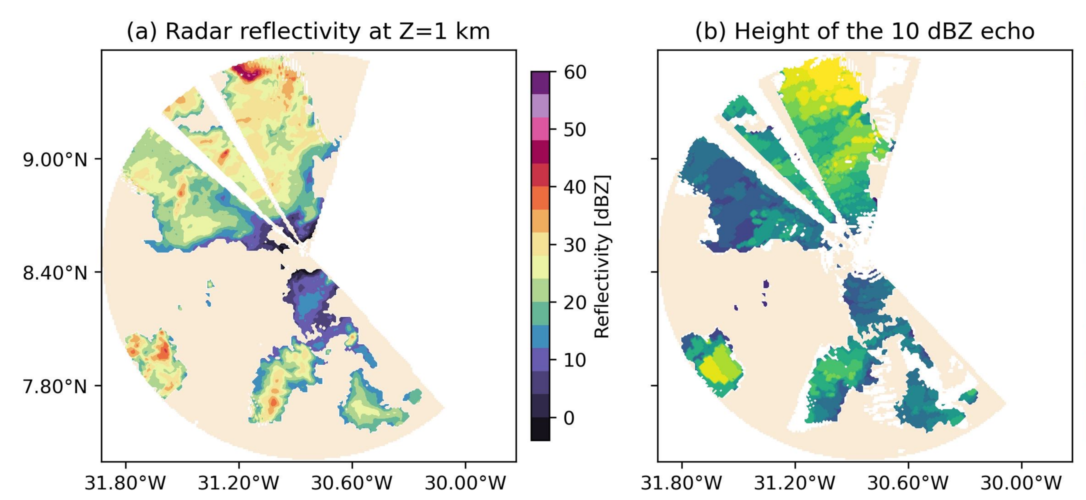
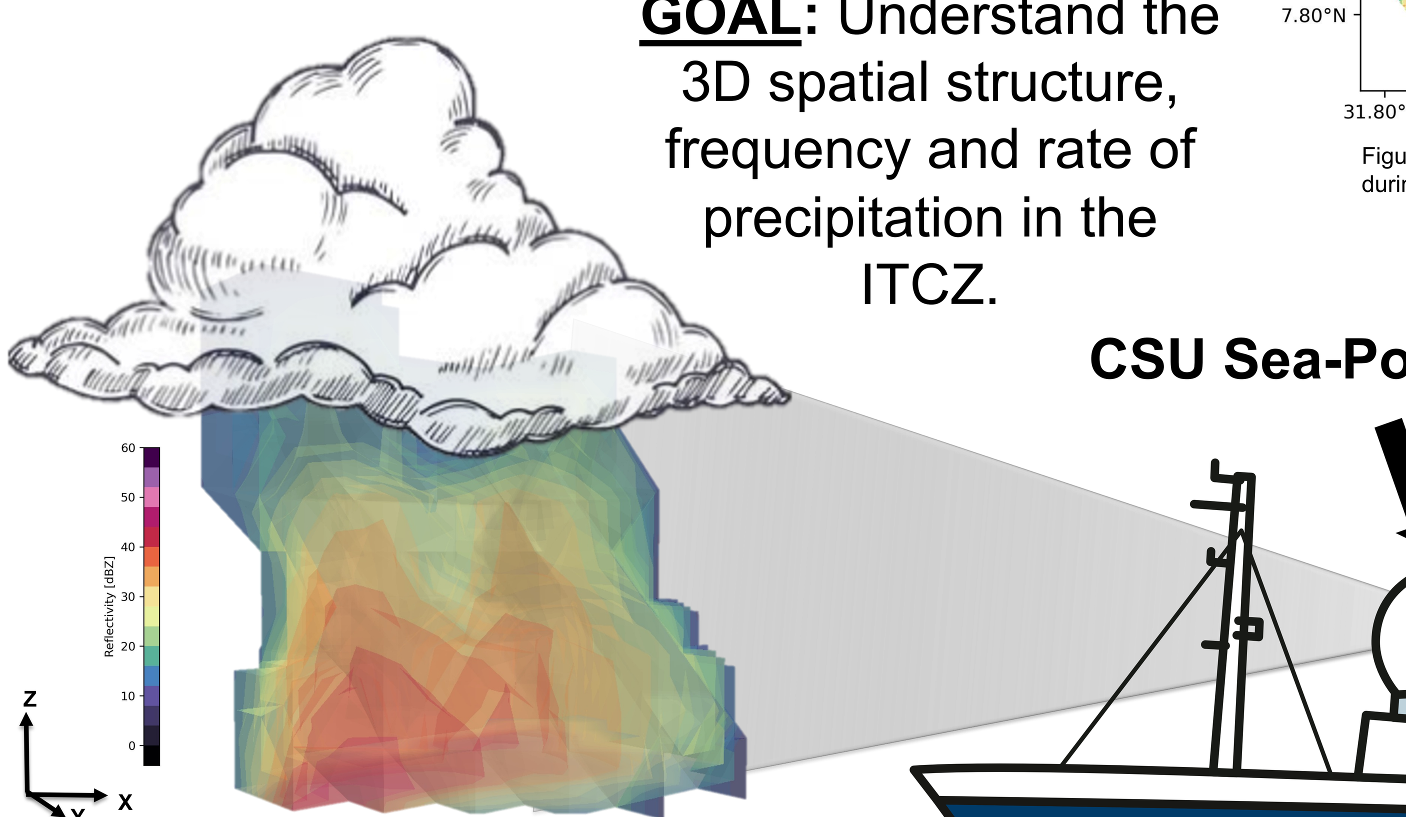
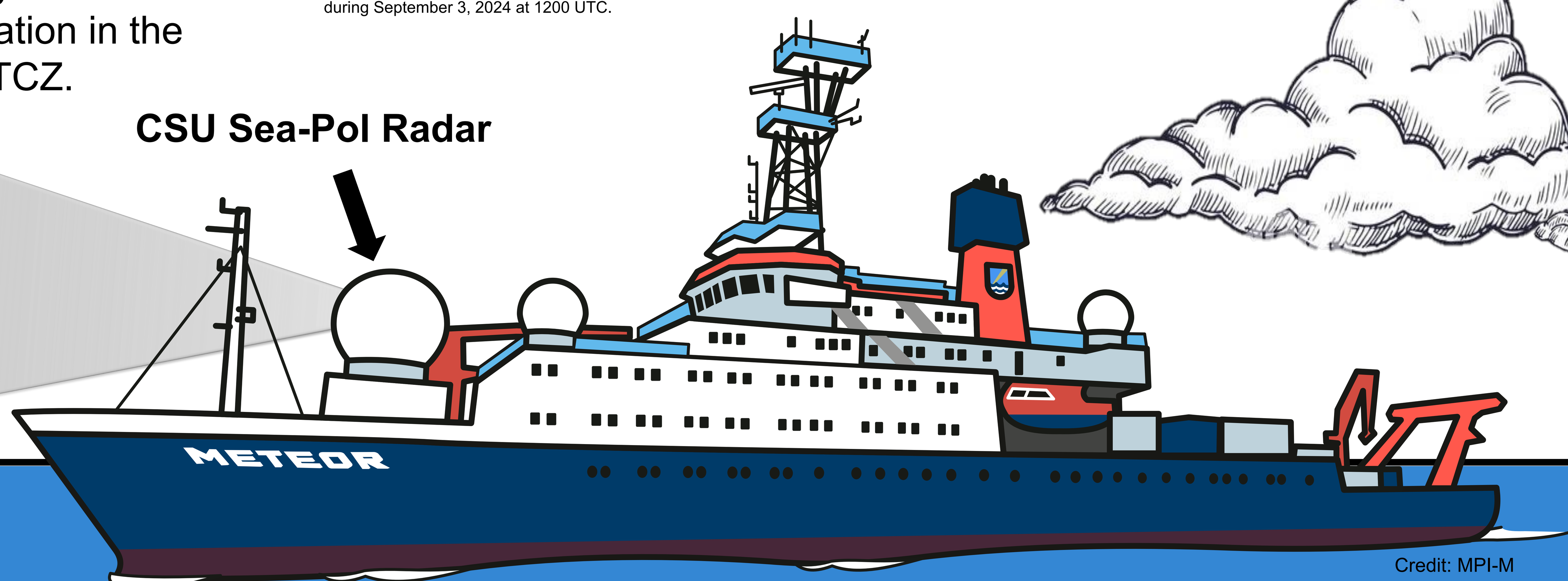


Figure 2. SEA-POL (a) radar reflectivity at 1 km and (b) calculated height of the 10 dBZ echo during September 3, 2024 at 1200 UTC.

GOAL: Understand the 3D spatial structure, frequency and rate of precipitation in the ITCZ.



CSU Sea-Pol Radar



Credit: MPI-M

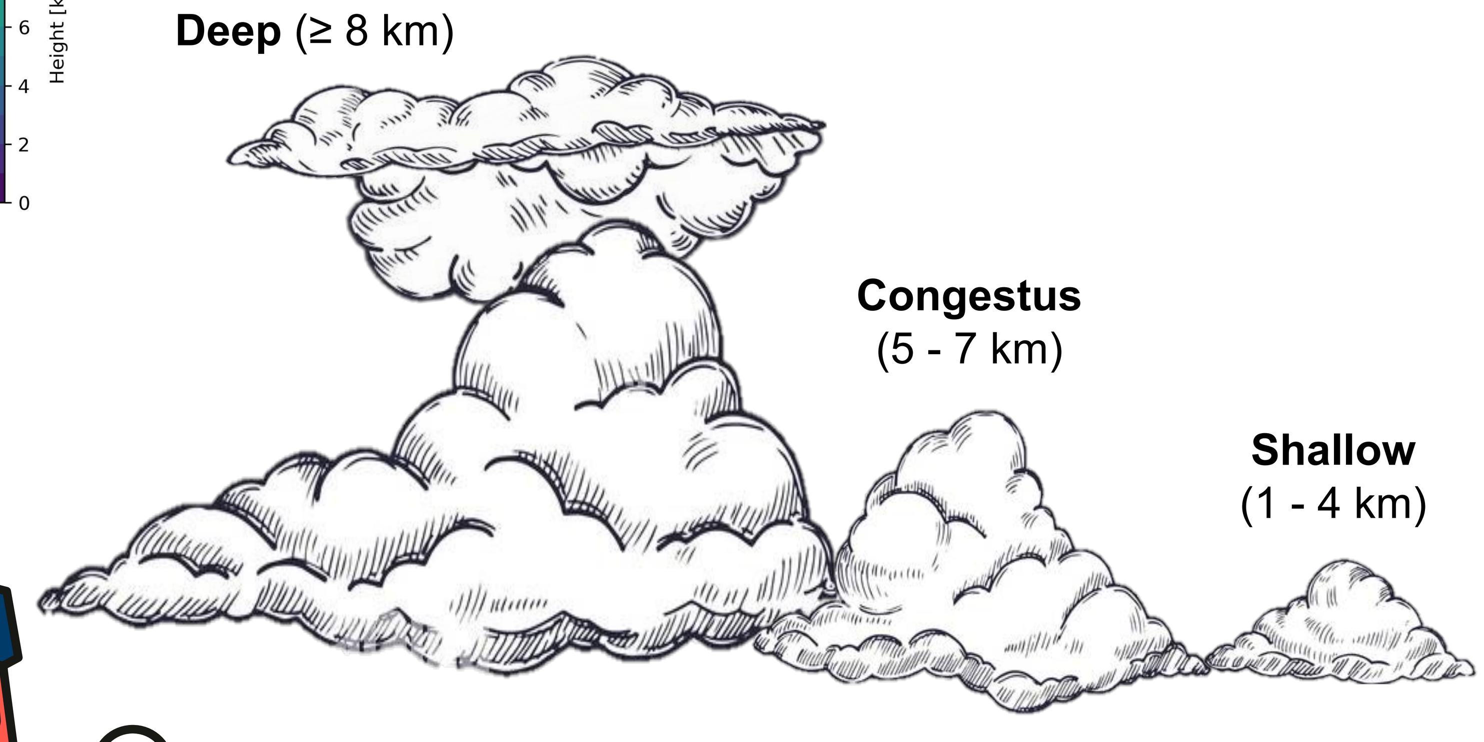
Data and Methods

- 10 dBZ echo top height was selected as the representative level of the height of the precipitating echo.
- Calculated the height of the 10 dBZ echo during the campaign (Fig. 2) from the 120 km range 3D volume scans gridded on a 1-km spatial grid and 5-minute time resolution.
- Found three convection groups based on a trimodal division of frequency: shallow (1- 4 km), congestus (5- 7 km), and deep (8 km+).
- The data were also gridded at 0.02 degree resolution to match with satellite brightness temperatures [4, 5].

Deep (≥ 8 km)

Congestus (5 - 7 km)

Shallow (1 - 4 km)



Results

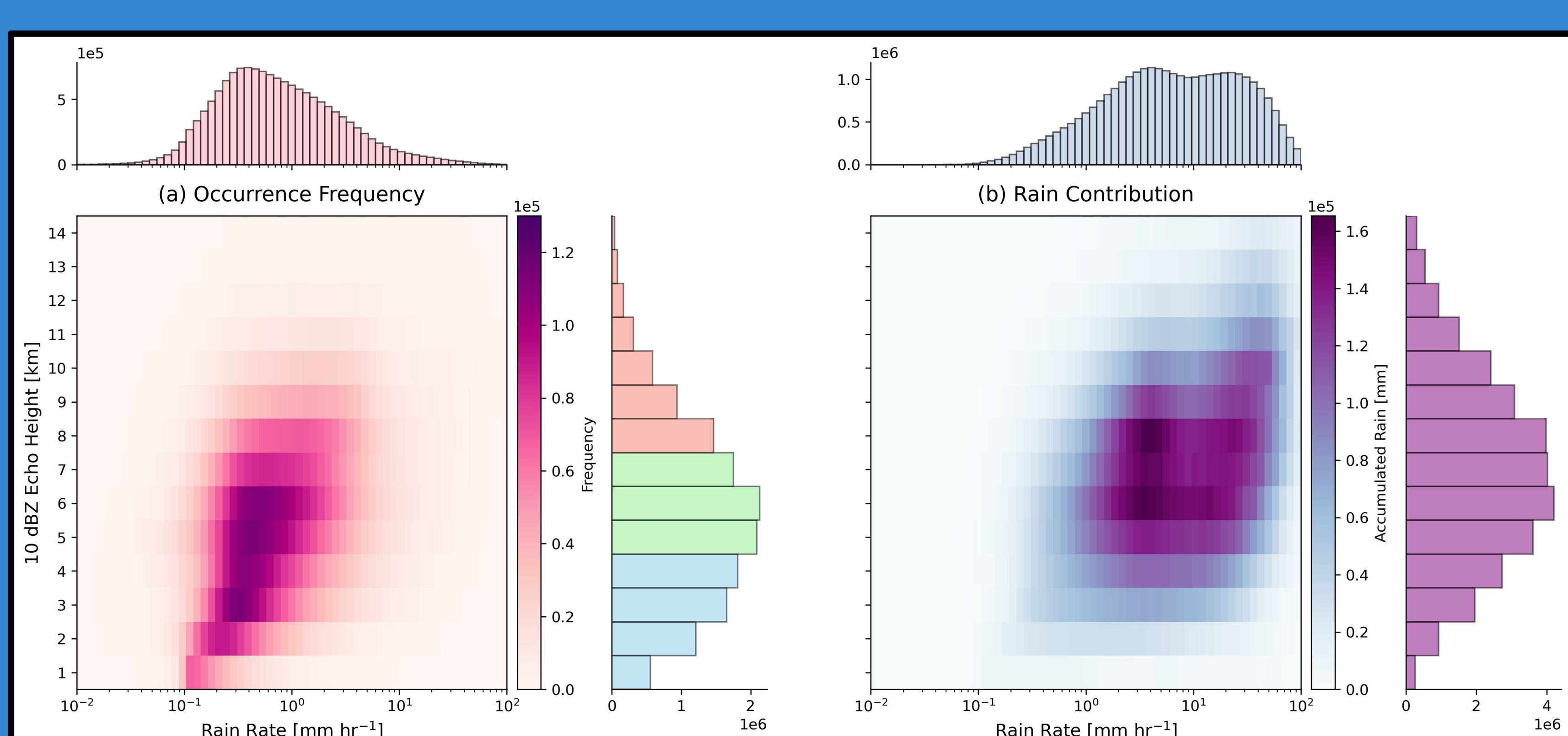


Figure 3. (a) Joint PDF of frequency of occurrence of rain rate (log) per height of the 10 dBZ echo. On the top the PDF of rain rate (count) and on the side the PDF of height of the 10 dBZ echo (count). (b) Joint PDF of accumulated rain of per rain rate and height of the 10 dBZ echo. On the top the PDF of rain contribution per rain rate, and on the side the PDF of total accumulated rain per height of the 10 dBZ echo.

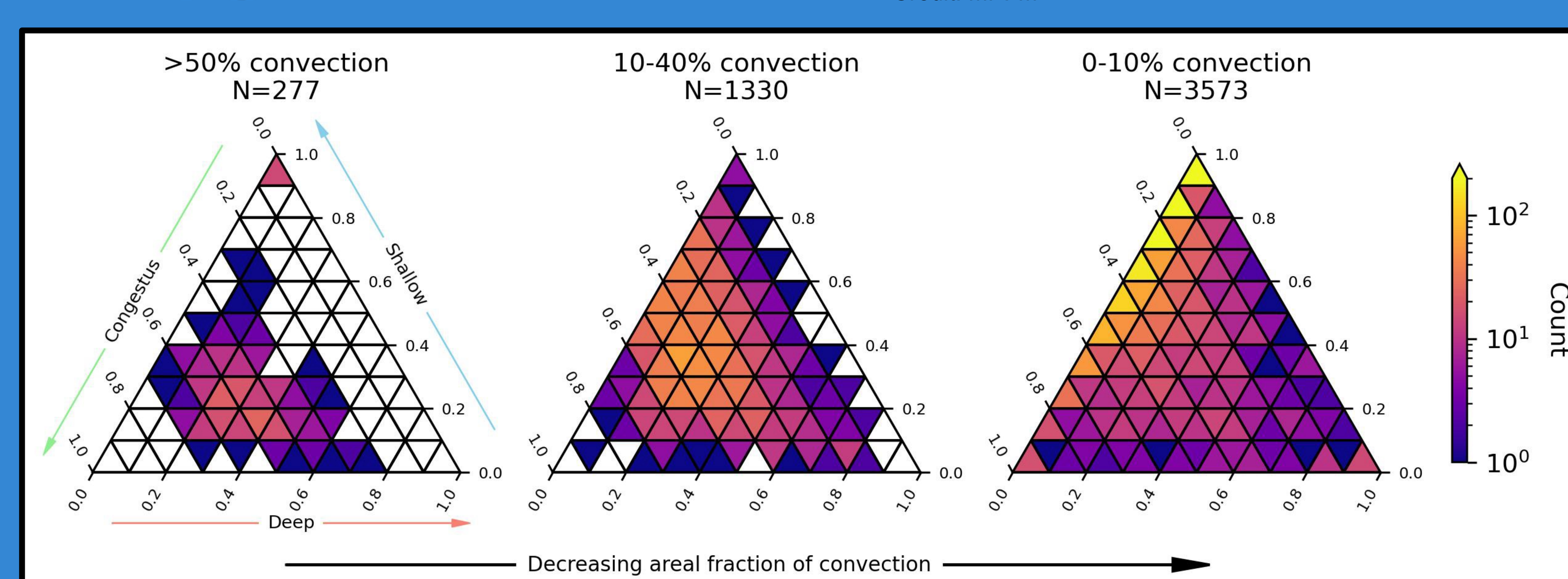


Figure 6. Ternary plot of the frequency of the three convection groups per scan conditioned by the amount of the clear air in the scan. N refers to the number of scans included in each ternary plot.

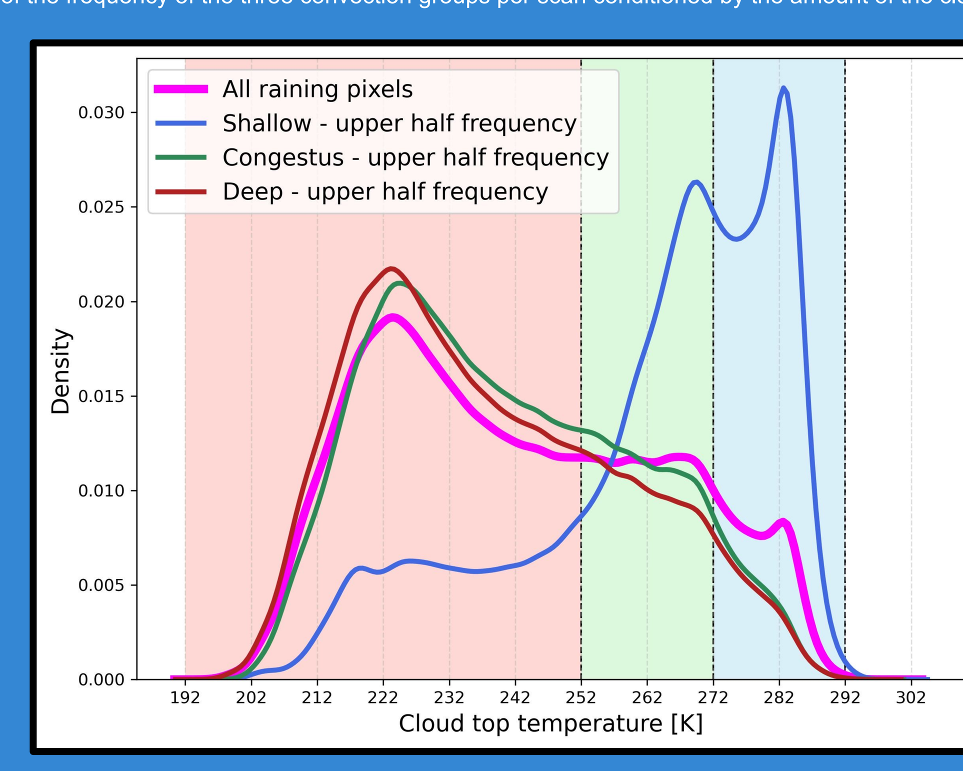


Figure 5. Distribution of brightness temperature for raining pixels at 1 km shown for times in the top half of frequency of each convection group.

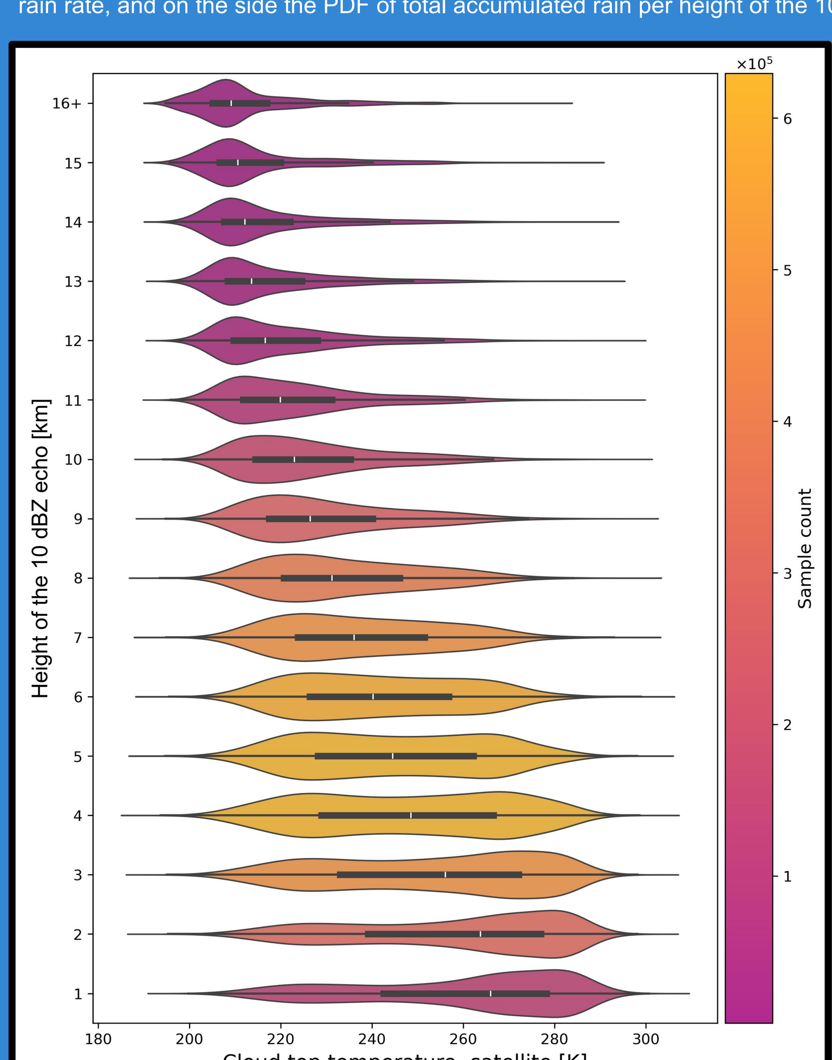


Figure 4. Brightness temperature distribution per height of the 10 dBZ echo. White line in the violins represent the median of the distribution, and the box the interquartile range. The color of the violins is based on the sample count in each convection group.

Conclusions

- Radar observations show a prevalence of the congestus mode (5-7 km). This group was the greatest contributor to the overall rainfall (40%), although deeper clouds are responsible for the more extreme rain rates (Fig. 3).
- Results show the potential shortcomings of using satellite cloud top temperatures alone to estimate height, particularly for congestus (Fig. 4).
- Higher populations of deep and congestus clouds are often found in proximity, while the remaining cloud population of shallow convection is found to be more distinct spatially, from the satellite brightness temperature analysis (Fig. 5).
- Spatial analysis conditioned on the amount of clear air show that scans >50% covered by convection are rare and are deep and congestus dominated. As the areal fraction of convection decreases, shallow and congestus dominate in space, and this pairing is the most common (Fig. 6).
- **Future work:** Perform convective/stratiform rain partitioning and analyzing effects on statistics and train a machine learning model using the SEA-POL volume scans, to retrieve height of raining cores and rain rates across the Atlantic from satellite retrievals.

Acknowledgements

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