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DOE/SC-ARM-25-005

# UMGVR_CAL
# Final Campaign Report

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ARM

## DISCLAIMER

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# Final Campaign Report

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# Acronyms and Abbreviations

| | |
|---|---|
| CAO | Cold-air outbreak |
| GVR | G-band Vapor Radiometer |
| MP | Mixed-phase |
| CAESAR | Cold Air outbreak Experiment in the Sub-Arctic Region |
| SGP | Southern Great Plains |

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# 1.0 Summary

Cold-air outbreak (CAO) clouds in the Arctic are commonly mixed-phase (MP); however, the partitioning of the amount of ice and water in CAO clouds and precipitation is not always well observed.

Understanding how cloud phases partition as a function of cloud lifecycle is important for predicting snowfall rates, convective lifecycle, and intensity at weather timescales. The partitioning into liquid versus ice also has radiative impacts that are consequential for climate. These concerns motivated the incorporation of an airborne G-band Vapor Radiometer (GVR) into an NSF-supported aircraft campaign named the Cold Air outbreak Experiment in the Sub-Arctic Region (CAESAR). The GVR is an upward-pointing passive microwave radiometer using four frequencies centered around the 183.31 GHz water vapor absorption line, displaced by +- 1, 3, 7, and 14 GHz. For context, DOE operates a surface-based GVR at its North Slope of Alaska site. The same GVR has been used previously for a field campaign in the southeast Pacific, where an offset was noticed between brightness temperatures (Tbs) measured under clear skies compared to those calculated from a radiative transfer model. To account for any calibration offsets to the Tbs, a request was made to DOE to allow the GVR to operate at the Southern Great Plains (SGP) site and enable comparisons between its measurements and those available at SGP. This request was granted, titled 'UMGVR_CAL', short for 'UMGVR_Calibration'.

From October 30 to November 10, 2023, the GVR was deployed to the DOE ARM SGP site to take advantage of their regular, nearby radiosonde launches under clear-sky conditions. The latter were determined using the SGP total sky imagery data. The GVR brightness temperatures in these clear-sky conditions were compared to those calculated by a radiative transfer code (PAMTRA) based on the SGP radiosondes. During the campaign, four suitable clear-sky episodes could be used for the GVR calibration. While few in number, these proved to be enough to satisfy our goal.

# 2.0 Results

Overall, the clear-sky GVR Tbs are warmer (higher) than those simulated by PAMTRA, especially under drier conditions and by the far-wing channels, as shown in the figure below. The PAMTRA simulations rely on the Rosenkranz (1998) water vapor emission model. A sensitivity test using the MonoRTM (Clough et al. 2005) emission model decreased the simulated Tb by 1-2K, increasing the bias further, but only slightly. The small difference between the radiative transfer models indicated that most of the discrepancy is from a miscalibration of the GVR.

The best estimate of the bias as a function of the measured Tb was used to post-process the GVR Tbs during the CAESAR campaign. The bias correction also improved a high bias noted in the real-time retrieved liquid water path estimates made during the campaign.

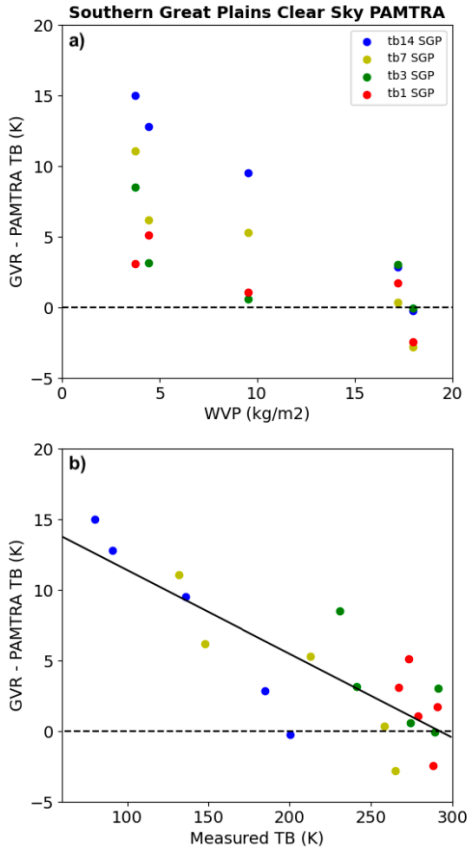


FIG. 4. Bias of GVR $T_b$s in clear sky conditions using radiosonde data with respect to PAMTRA simulated $T_b$s at the ARM SGP field site plotted with a) radiosonde observed WVP as the dependent variable, and b)measured $T_b$ as the dependent variable.

**Figure 1**. Figure reproduced from Ephraim et al., 2024.

# 3.0 Publications and References

The calibration results are included in a manuscript currently under review for publication within JAOT:

Ephraim, S, P Zuidema, TW. Juliano, C Grasmick, B Geerts, J French, M Cadeddu, A Pazmany, S Woods. 2024. "A New Neural Network Retrieval of Liquid Water Path Optimized for Mixed-Phase Cold Air Outbreaks Using Radiometer and Radar Observations." *Journal of Atmospheric and Oceanic Technology*, https://doi.org/10.31223/X5HQ56

# 4.0 Lessons Learned

The campaign was highly successful from my point of view. We did not fly under clear skies as part of CAESAR, and the comparison to the radiosondes and other measurements made at the well-controlled SGP site was absolutely critical for the success of our application of the GVR in the field. I wish we could have spent more time at the SGP site than two weeks, but the upload schedule for the NSF aircraft did not allow for that.


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