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DOE/SC-ARM-25-009

G-Band Radar Demonstration for Microphysics Final Campaign Report

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April 2025

ARM

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Work supported by the U.S. Department of Energy,
Office of Science, Office of Biological and Environmental Research

Acronyms and Abbreviations

DFR	Dual-Frequency Ratio
EPCAPE	Eastern Pacific Cloud Aerosol Precipitation Experiment
GRDM	G-Band Radar Demonstration for Microphysics
JPL	Jet Propulsion Laboratory

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1.0 Summary

The G-Band Radar Demonstration for Microphysics (GRDM) campaign took place at the Eastern Pacific Cloud Aerosol Precipitation Experiment (EPCAPE) from March 15 – April 30, 2024. This was a deployment of two of NASA's Jet Propulsion Laboratory (JPL) radars and one radar from Brookhaven National Laboratory to demonstrate the utility of high-frequency millimeter-wave radars for remote sensing of stratocumulus microphysical properties.

The radars were deployed on the Ellen Browning Scripps Memorial Pier alongside the AMF instruments (Figure 1). The radars include a Ka-band (35 GHz), W-band (94 GHz), and four G-band (158, 165, 174, and 240 GHz) channels. The 240 GHz and W-band channels provide complete Doppler spectra, which are useful for advanced analysis. The 158-175 GHz channels are sensitive to the water vapor profile and are useful for attenuation correction. These radars complement the high-sensitivity ARM KAZR. The goal of the deployment was to observe drizzling stratocumulus and demonstrate the capabilities of the multi-frequency radar data set to constrain profiles of liquid water content and drizzle drop characteristic size.

The data are still being analyzed. The methodology to derive the cloud and precipitation parameters will exploit differential attenuation and differential reflectivity between low-frequency (Ka-band) and high-frequency (G-band) channels. The method will also exploit the capability of the G-band observations to constrain the attenuation due to water vapor. These observations will quantify the capabilities and limitations of the emerging technology of G-band radars for constraint stratocumulus cloud microphysics, which are key to constraining aerosol-cloud-precipitation interactions and low-cloud climate feedback.

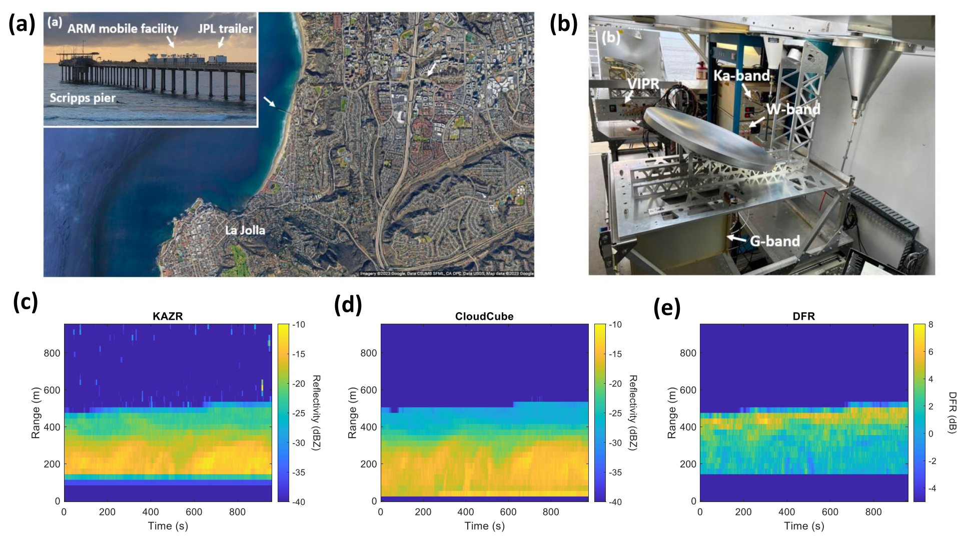

Figure 1. Images from the JPL cloud radar trailer operations at the EPCAPE deployment of the ARM Mobile Facility. (a) The Location and deployment of the CloudCube instrument during the EPCAPE field campaign. (b) Picture from inside the trailer where VIPR and CloudCube were installed and operated. (c) KAZR reflectivity. (d) CloudCube G-band radar reflectivity. (e) The Dual-Frequency Ratio (DFR: Ka-band/G-band). This figure hints at two useful ways the G-band complements the KAZR—specifically, the minimal blind zone in panel d and the DFR in panel e.

2.0 Results

The CloudCube Ka-band has been used to evaluate the ARM KAZR calibration (e.g., Figure 2). These results demonstrate calibration accuracy within 1.5 dB of the two radars during the spring 2024 months of EPCAPE.

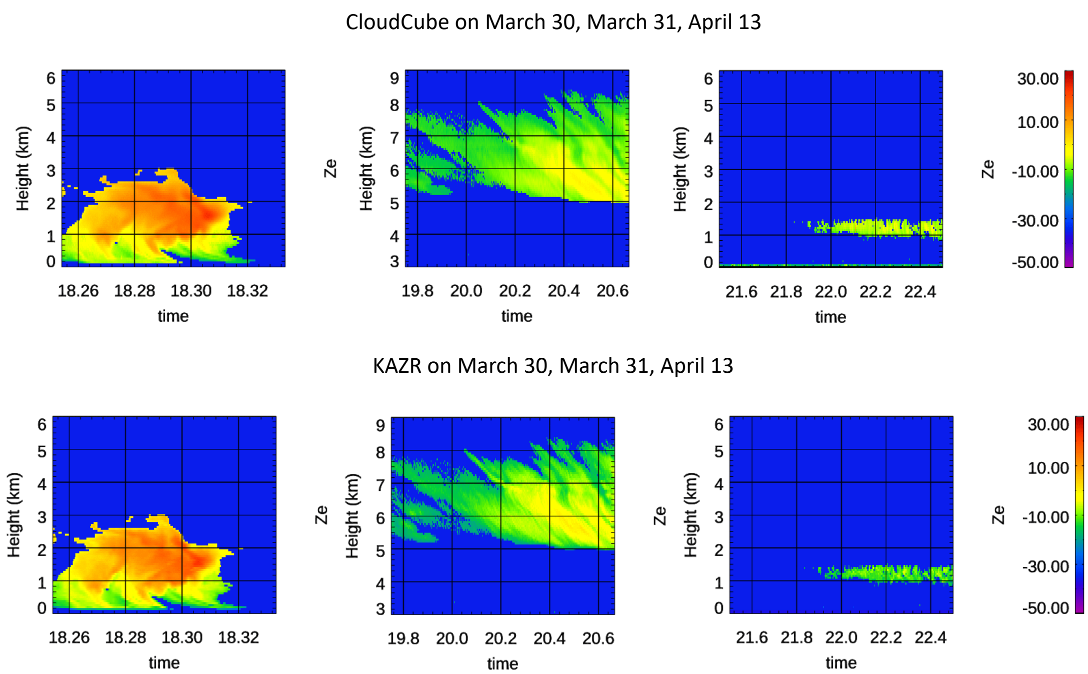

Figure 2. Images from previous operations of the JPL cloud radar trailer at the EPCAPE deployment of the ARM Mobile Facility. (a) The Location and deployment of the CloudCube instrument during the EPCAPE field campaign. (b) Picture from inside the trailer where VIPR and CloudCube were installed and operated. (c) KAZR reflectivity. (d) CloudCube G-band radar reflectivity. (e) The Dual-Frequency Ratio (DFR: Ka-band/G-band). This figure hints at two useful ways the G-band complements the KAZR—specifically, the minimal blind zone in panel d and the DFR in panel e.

CloudCube G-band reflectivity data is combined with the KAZR reflectivity to derive the Dual-Frequency Ratio (DFR). Previous studies have demonstrated the Ka/W-band DFR can be used to derive profiles of liquid water content in stratocumulus clouds. Theory indicates that the approach should be 3 to 4 times more accurate when using the Ka/G-band pair. The initial analysis shown in Figure 3 indicates qualitatively good results that compare well with the integrated liquid water path derived from the microwave radiometer.

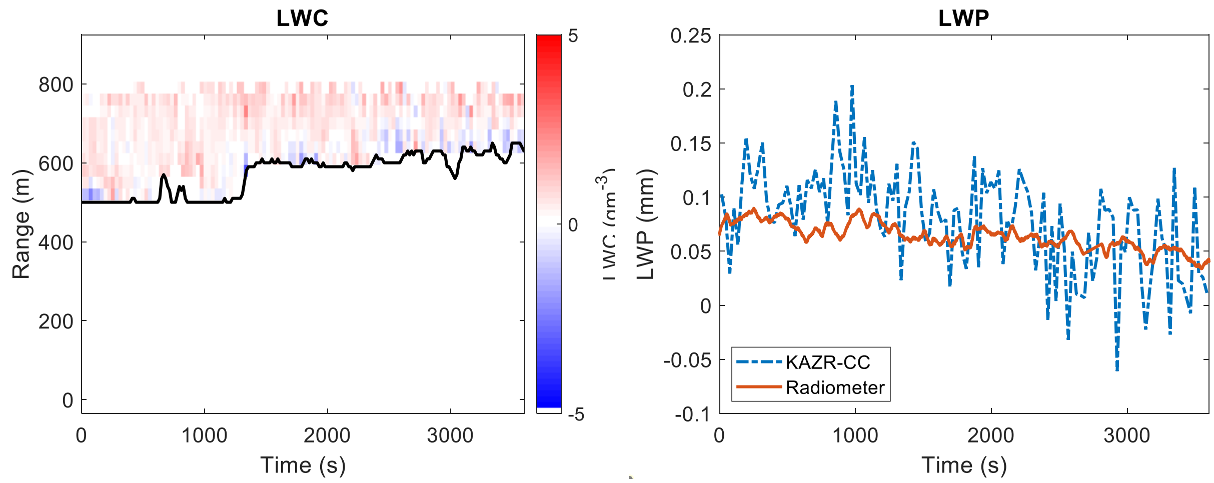

Figure 3. Retrieved profiles of liquid water content from the Dual-Frequency Ratio (Ka/G) derived from combining KAZR and CloudCube observations (left). A comparison of the Integrated liquid water path from the radar DFR retrieval and the independent measurement from the microwave radiometer.

Finally, the Doppler spectra at the G-band are very useful for deriving the vertical air motion using the Mie-notch technique that identifies the resonant minimum in a Doppler spectrum, which corresponds to drops of a known sedimentation velocity. The technique has previously been used in W-band but is much more accurate and has a significantly larger G-band application range. Results in Figure 4 show how early the derived motions were analyzed using this technique.

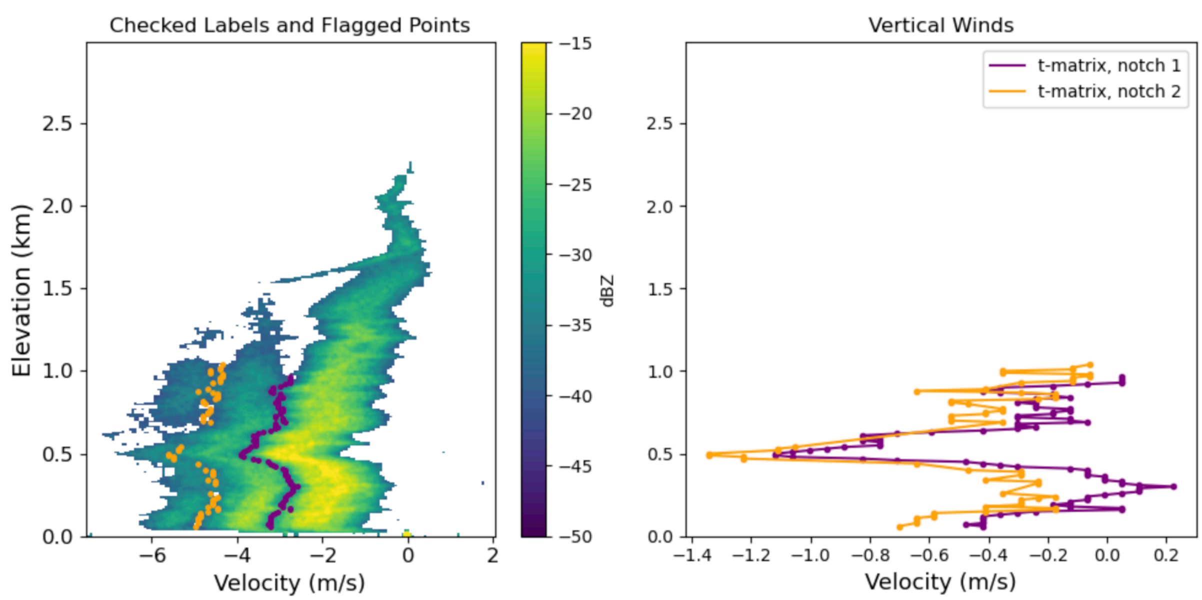

Figure 4. A profile of G-band Doppler spectra during shallow cumulus showers with purple and orange dots showing the locations of the first and second Mie-notches (left) and derived vertical air motion from the area of each notch (right).

3.0 Publications and References

The following manuscript is currently under review, which describes the CloudCube dataset collected as part of GRDM:

Socuellamos, JM, R Rodriguez Monje, MD Lebsock, KB Cooper, RM Beauchamp, and A Umeyama. 2024. "Multifrequency radar observations of marine clouds during the EPCAPE campaign." Earth System Science Data Discussion [preprint], https://doi.org/10.5194/essd-2023-454, in review

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