

# ARM User Facility Products and Tools Supporting ACI and Climate Prediction Efforts

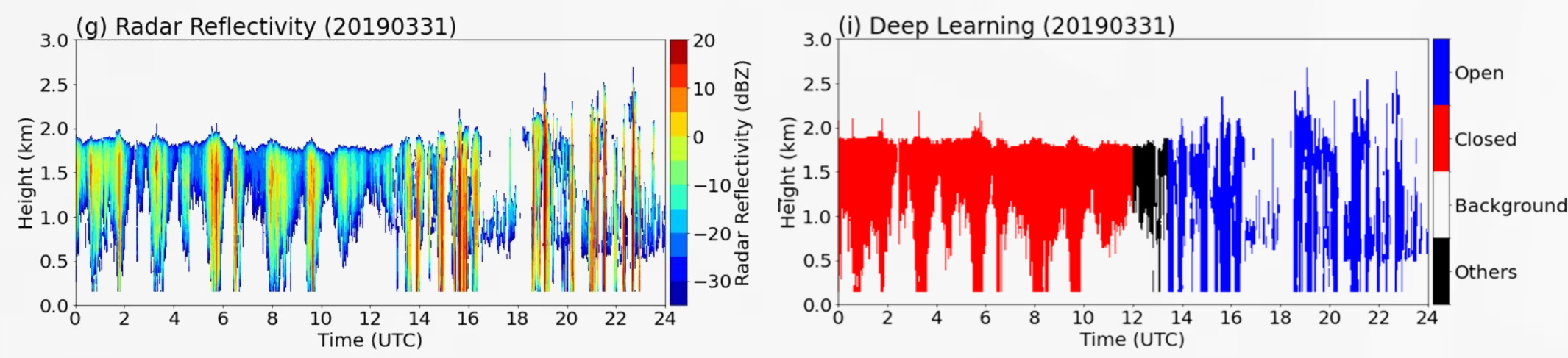
Israel Silber; John Shilling; Jingjing Tian; Damao Zhang; Jennifer Comstock | PNNL



## Mesoscale Cellular Convection Classification

An Insightful Application of Convolutional Neural Network (CNN) to Radar Data

This analysis describes the first application of a U-Net CNN algorithm to detect and classify mesoscale cellular convection (MCC) using 8 years of radar data from the ARM [ENA](#) site. This analysis (a [Data Discovery Epoch](#)) shows distinct differences between closed/open MCCs.

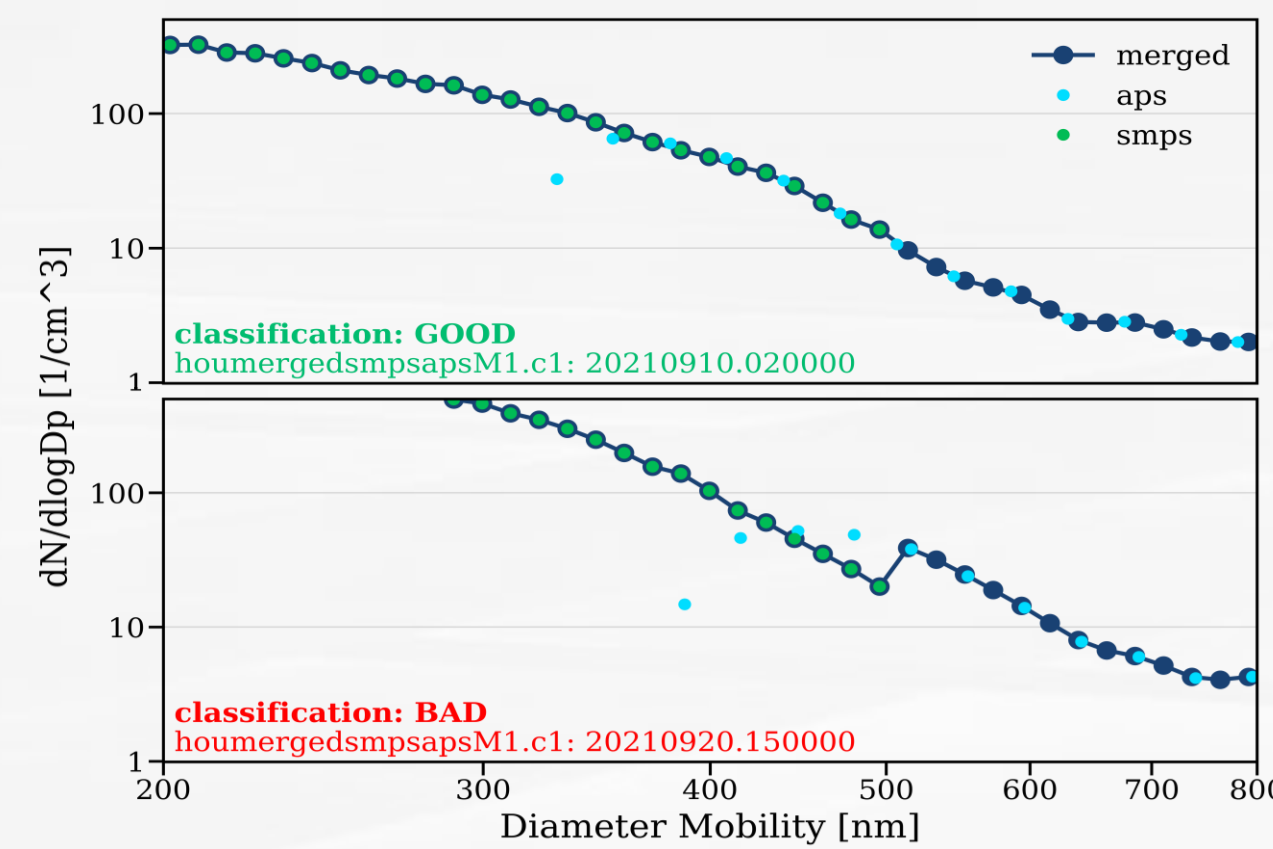


MCC case example (ARM ENA; March 31, 2019): KAZR reflectivity (left); CNN classification (right).

## Merged SMPS-APS ML VAP

Quality-Controlled Aerosol Particle Size Distributions

The ARM [MERGEDSMPSAPS VAP](#) combines scanning mobility particle sizer (SMPS) and aerodynamic particle sizer (APS) samples onto a common mobility diameter grid. The [MERGEDSMPSAPSMML VAP](#) classifies these merged distributions as usable, unusable, or suspect.

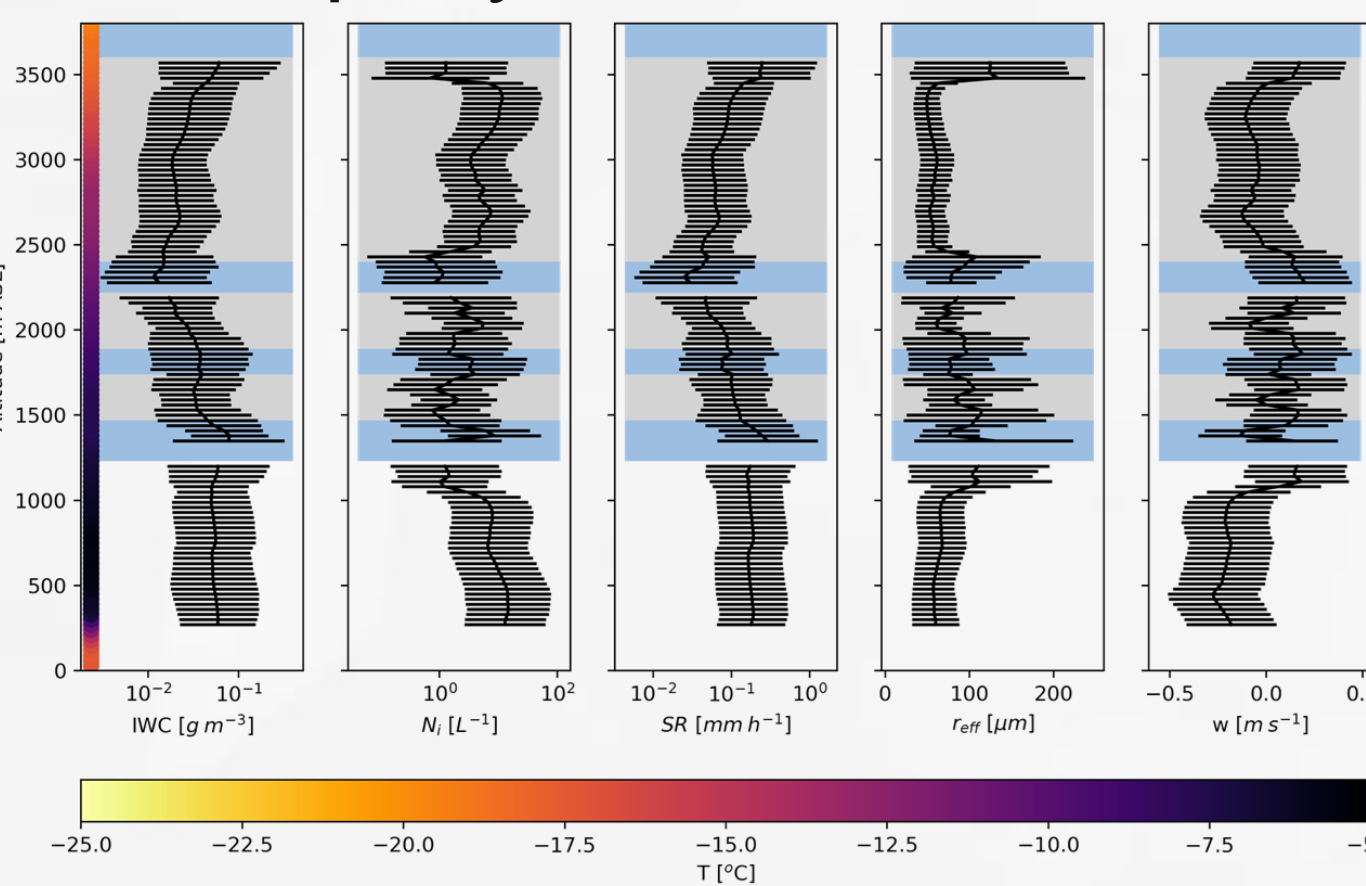


Example of merged size distributions with hand-labelled merge quality ("good" or "bad").

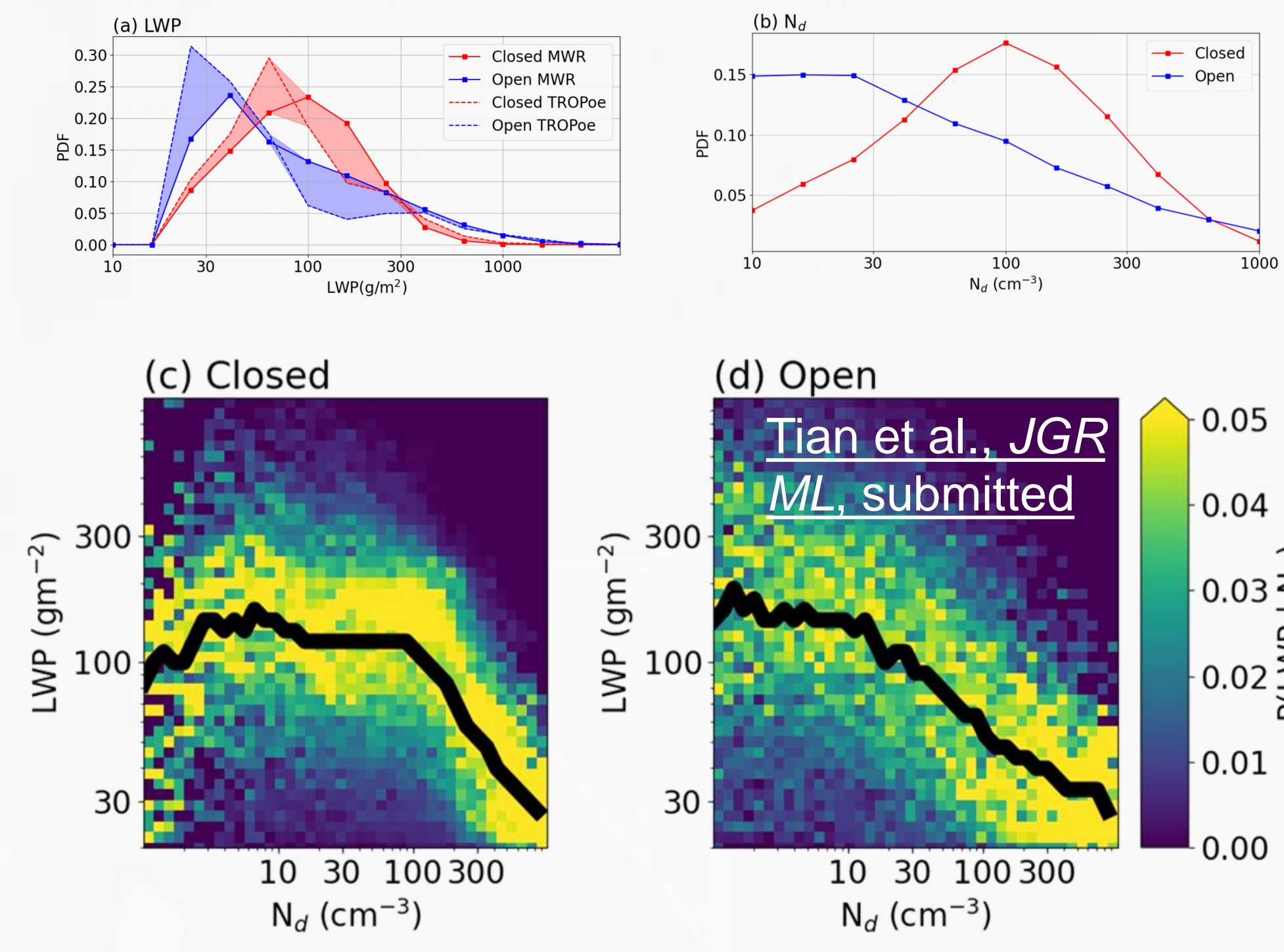
## ARM Machine Learning Ice Profiles (AMLIP) VAP

Sub-Mixed Phase Cloud Ice Particle Microphysical Property Profiles

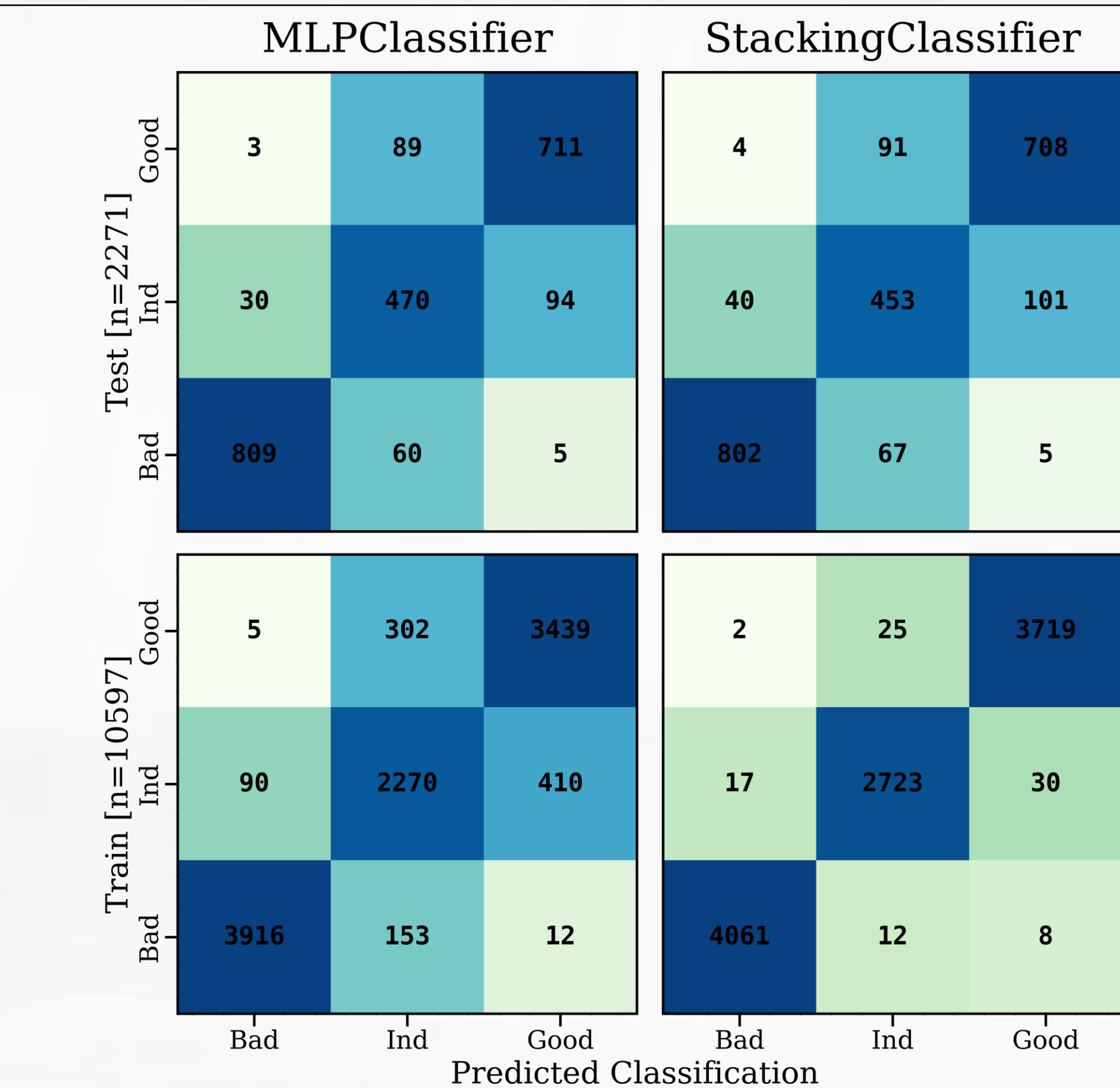
The AMLIP VAP synthesizes radar ([KAZR](#)), lidar ([HSRL](#)), and sounding data to retrieve ice precipitation profiles (with their uncertainties) underlying mixed-phase clouds. The retrieved variables include, among other parameters, the IWC, number concentration, effective radius, and vertical air motion. The retrieval implements a deep neural network (DNN) model ensemble emulating [MCMC](#) inference ([Silber, 2023](#)). Numerous fields, e.g., phase classifications, accompany AMLIP datasets.



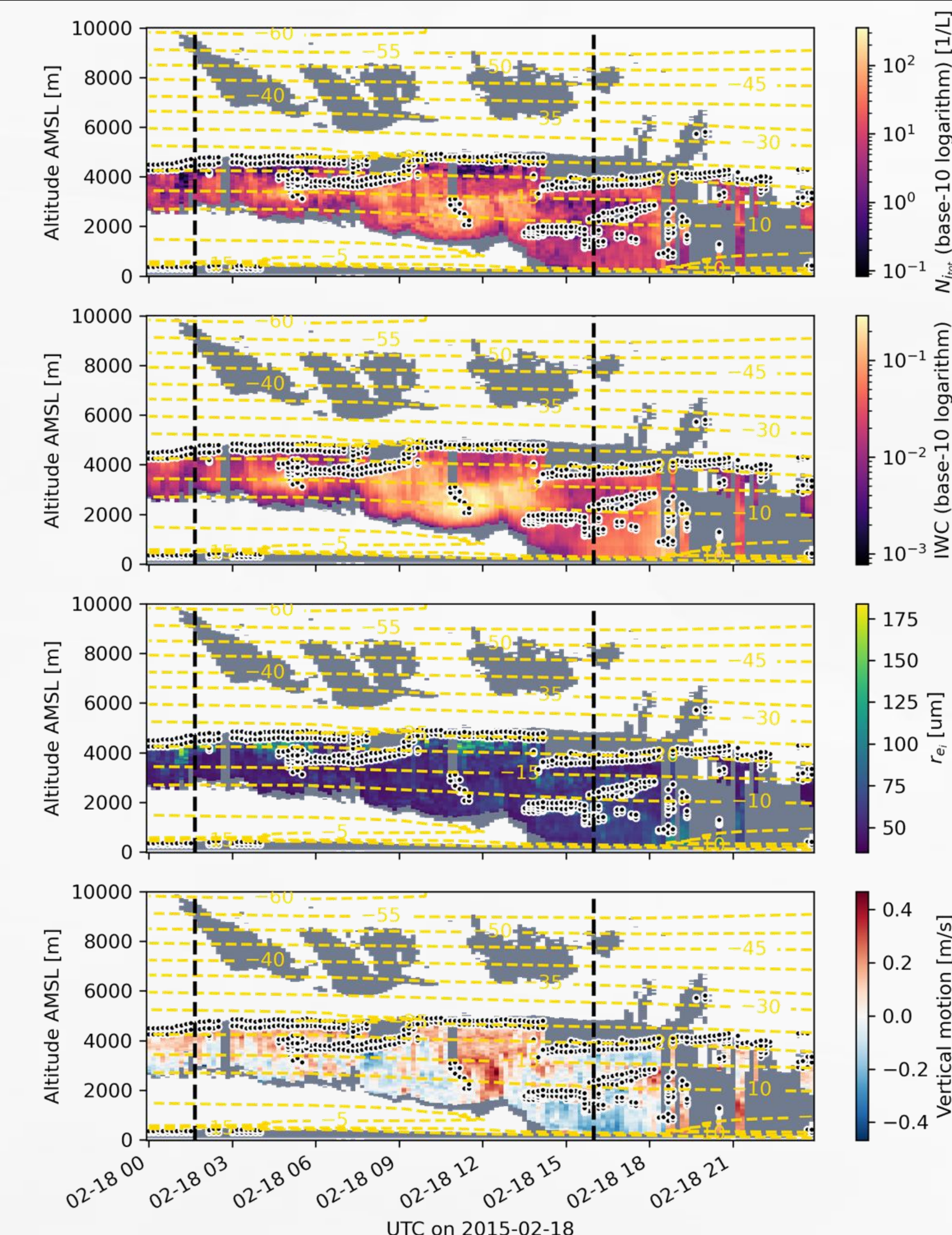
AMLIP-derived ice properties over the NSA site on February 18, 2015 at 16:00 UTC (blue – liquid layers, light gray – cloud deck).



(a) LWP PDF for classified open and closed cells; (b) same, but for retrieved cloud number concentration ( $N_d$ ); (c) the probability of LWP given  $N_d$  for closed cells; (d) same, but for open cells.



Confusion matrices for selected models on the test and training sets ( $N=15,000$ ). Both classifiers have low rates of bad as good or good as bad.

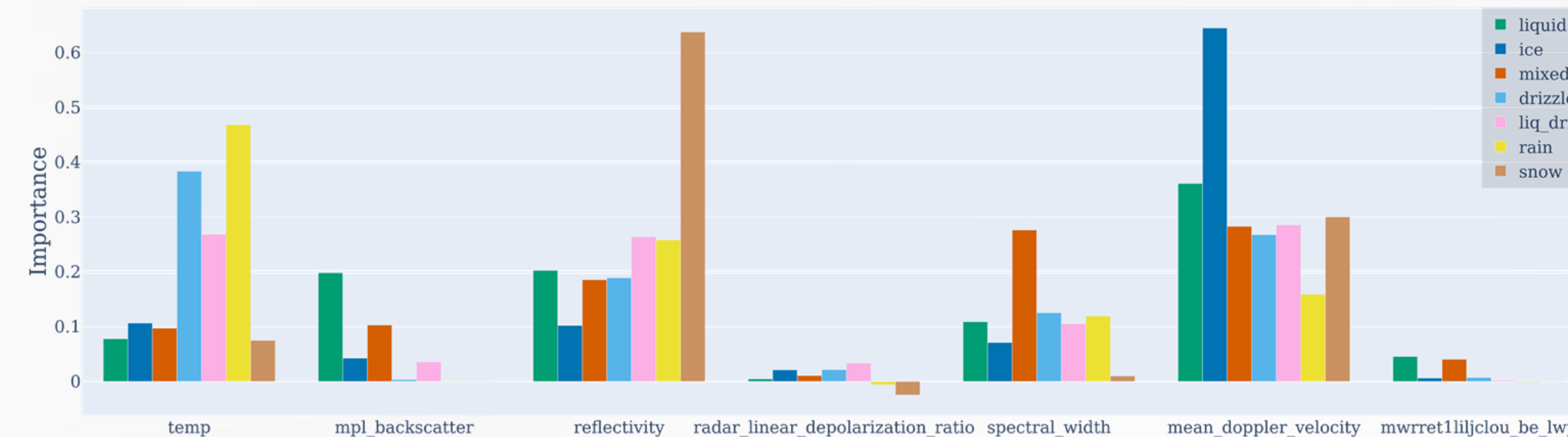


Ice properties and vertical motion over the NSA site on February 18, 2015 derived by AMLIP (yellow contours – temperature).

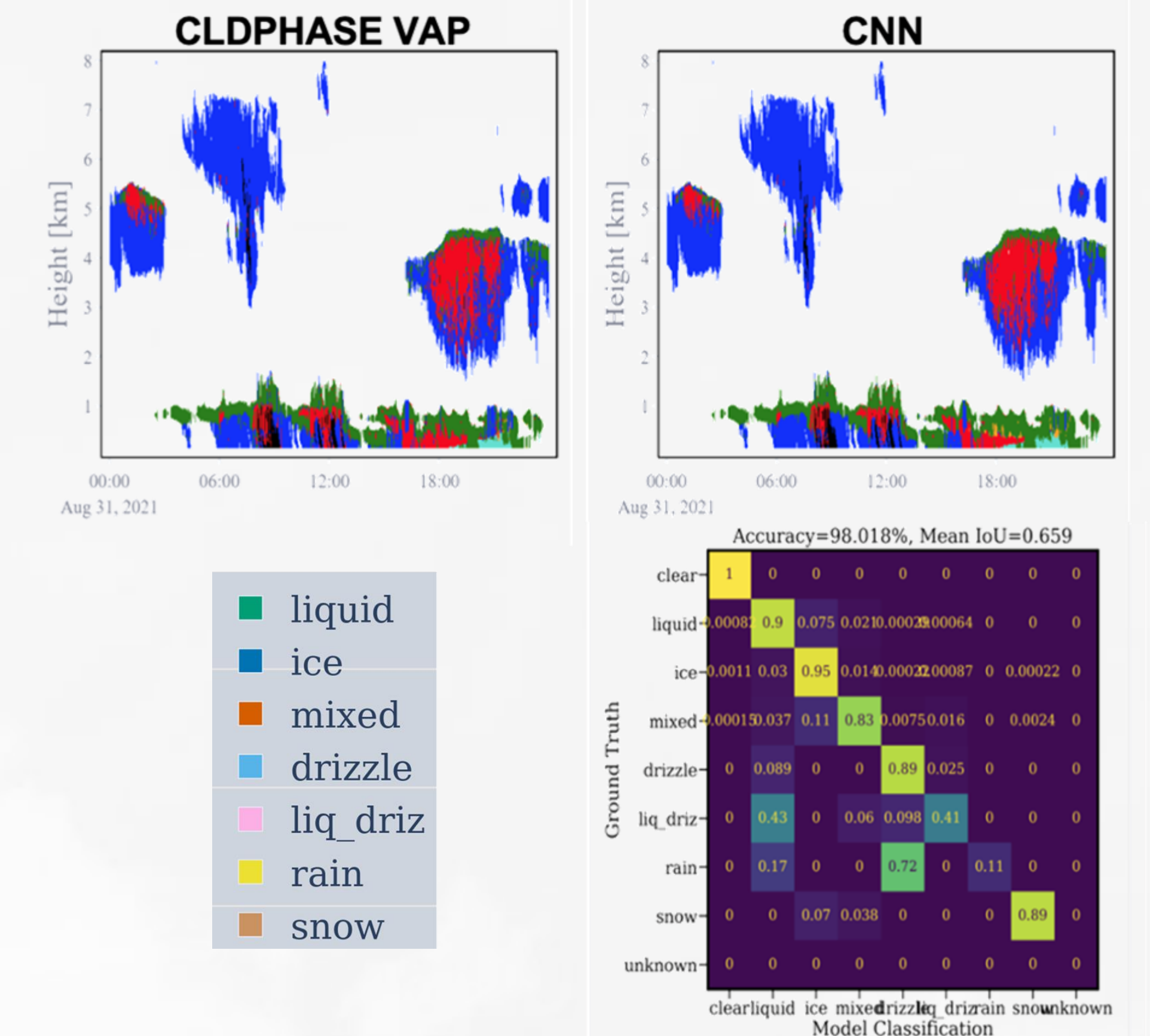
## Cloud ML Phase Classification

An Adaptive ML-Powered Phase Classification Prototype

By using 3 years of ARM [THERMOCLDPHASE](#) hydrometeor phase classification VAP [NSA](#) data as a reference, applications of different ML algorithms were tested as potential alternatives for instrument downtimes or lack of certain instruments in given deployments.



Feature Importance Analysis. Reflectivity, mean Doppler velocity, and temperature are crucial for classification.



(Top left) THERMOCLDPHASE data for ARM NSA on Aug 31, 2021 (see legend); (Top right) CNN output; (Bottom right) Confusion matrix for CNN application.



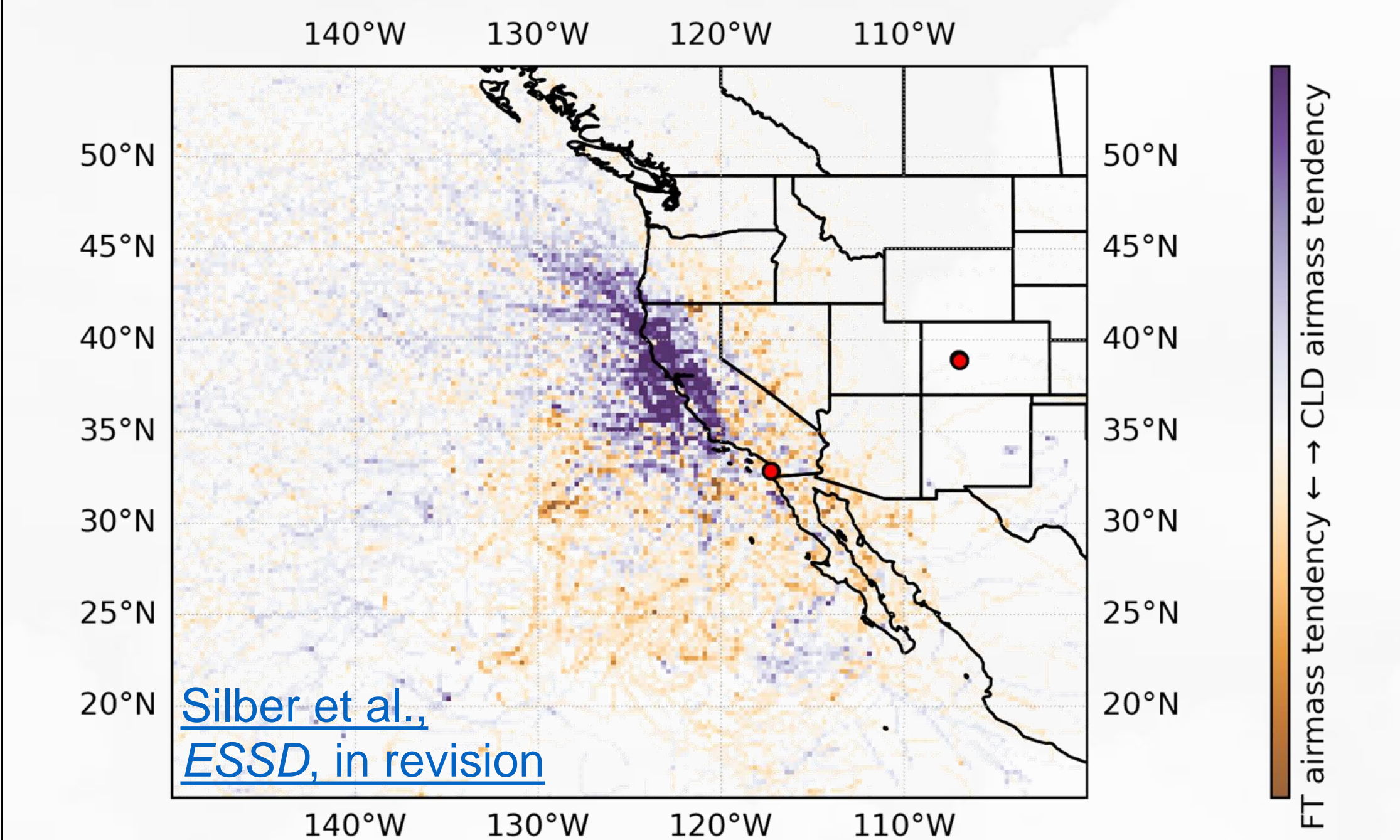
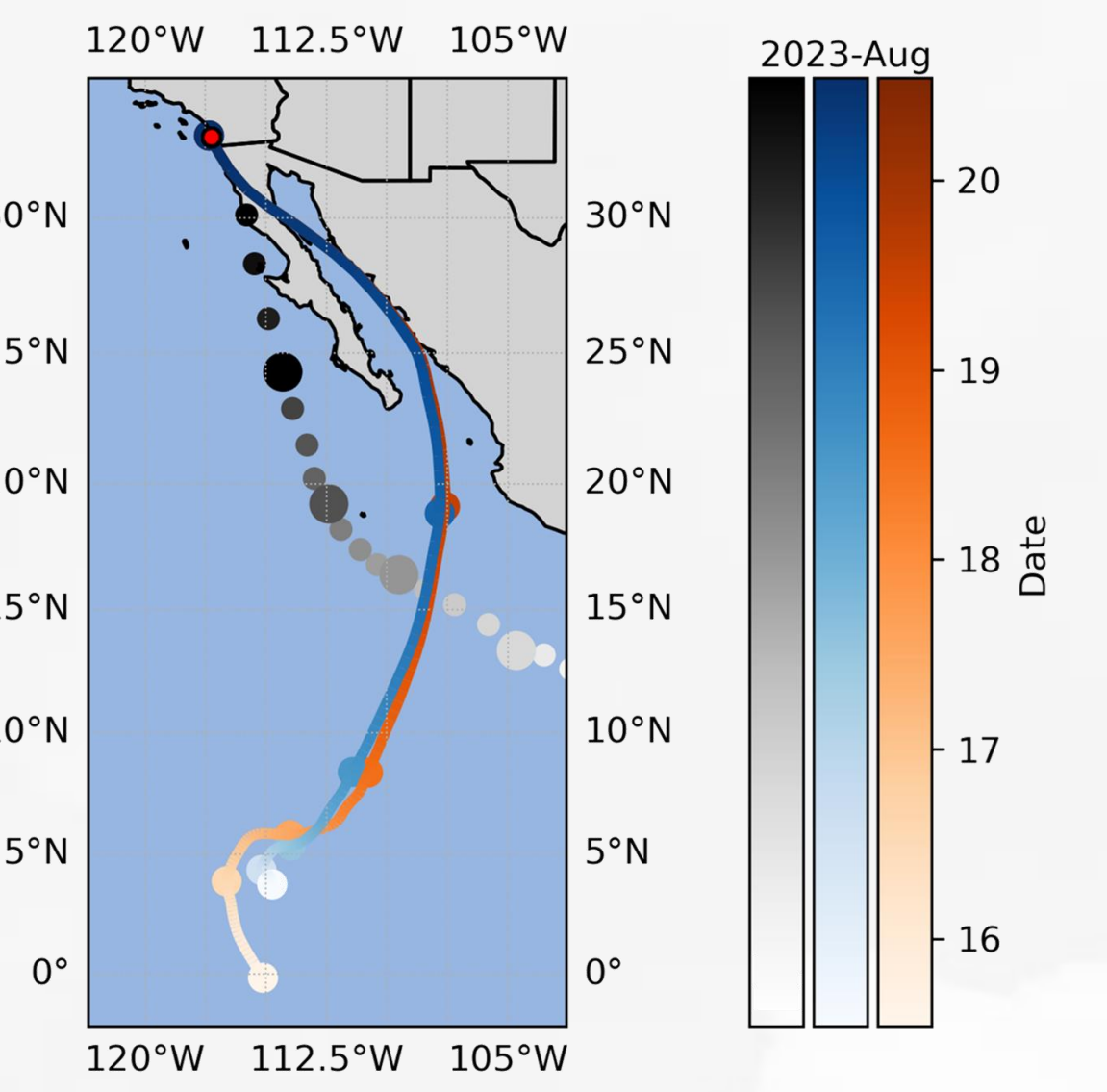
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## ARMTRAJ VAP

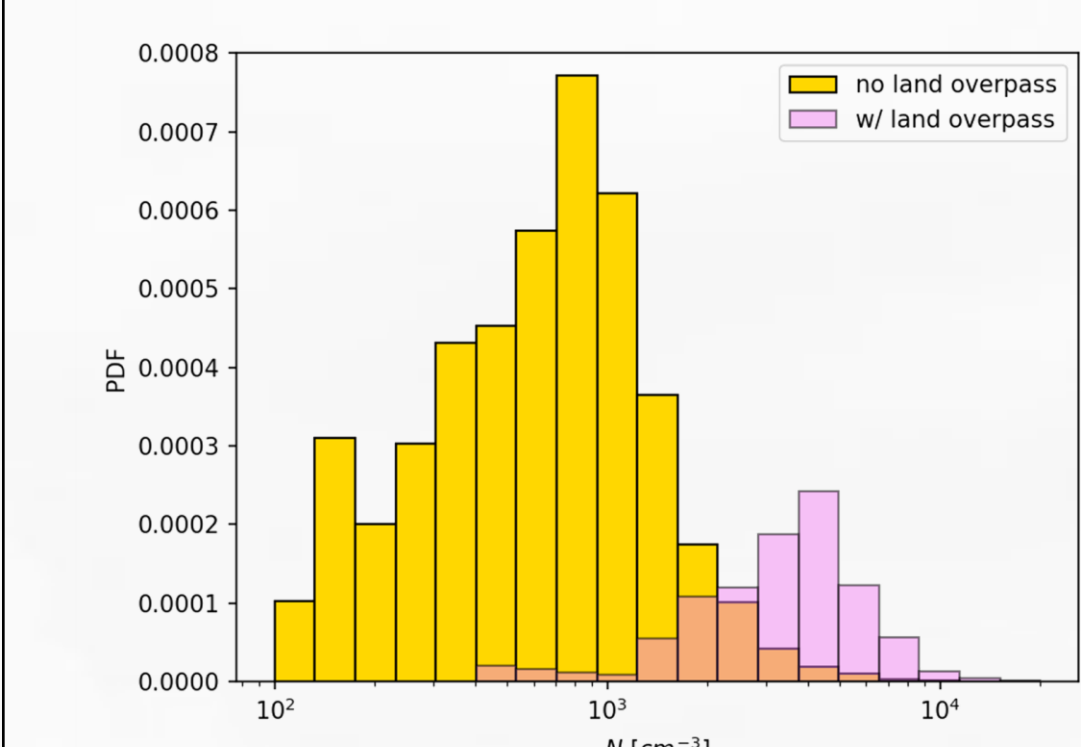
A Multi-Purpose Trajectory VAP Augmenting ARM Measurements

The [ARMTRAJ VAP](#) provides trajectory datasets with ensemble run statistics (uncertainties) initialized at ARM sites and configured using ARM datasets. These trajectory datasets support aerosol, cloud, boundary layer, and related research (ACI, etc.). Near real-time datasets for ARM deployments will be released soon.

ARMTRAJ-CLD 5-day back trajectory for a cloudy layer detected over ECAPE on August 20, 2023 during [Hurricane Hillary's landfall](#) (orange – center coordinates, blue – ensemble mean, gray – Hillary).



Qualitatively-demonstrated cloudy and free-tropospheric air mass source origin tendencies (ARMTRAJ-ARSC1; 1-4 days; Full ECAPE deployment).

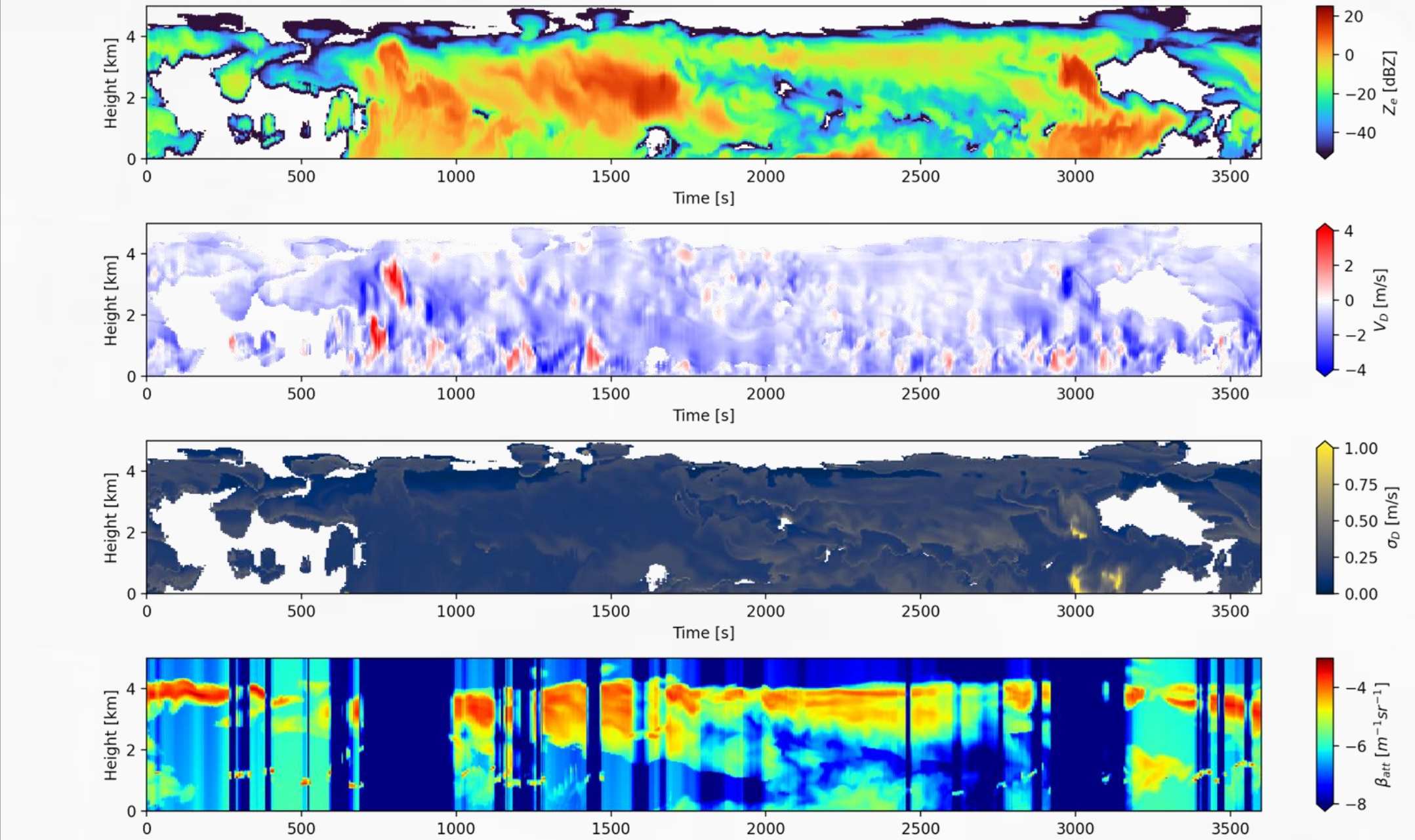


SMPS sub-micron total aerosol number concentration during ECAPE partitioned based on 12-36-hour surface back-trajectories land overpass.

## The Earth Model Column Collaboratory (EMC<sup>2</sup>)

Instrument Simulator and Subcolumn Generator Faithful to Model Physics

Upcoming expansions of [EMC<sup>2</sup>](#) include the implementation of the [P3](#) microphysics scheme physics and assumptions (including some SGS features resolved by [CLUBB/SHOC](#)) as used in [E3SM](#), and a robust and flexible statistics module.



Doppler radar and lidar fields calculated from an LES model output (a [COMBLE MIP](#) case) using [EMC<sup>2</sup>](#); LES microphysics (MG2) faithfully represented by [EMC<sup>2</sup>](#).

**Acknowledgments:** This research was supported by and data were obtained from the ARM user facility, a U.S. DOE Office of Science user facility managed by the BER program.

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