Examining Cloud Phase in Convective Conditions at Darwin with Active Sensors

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Motivation

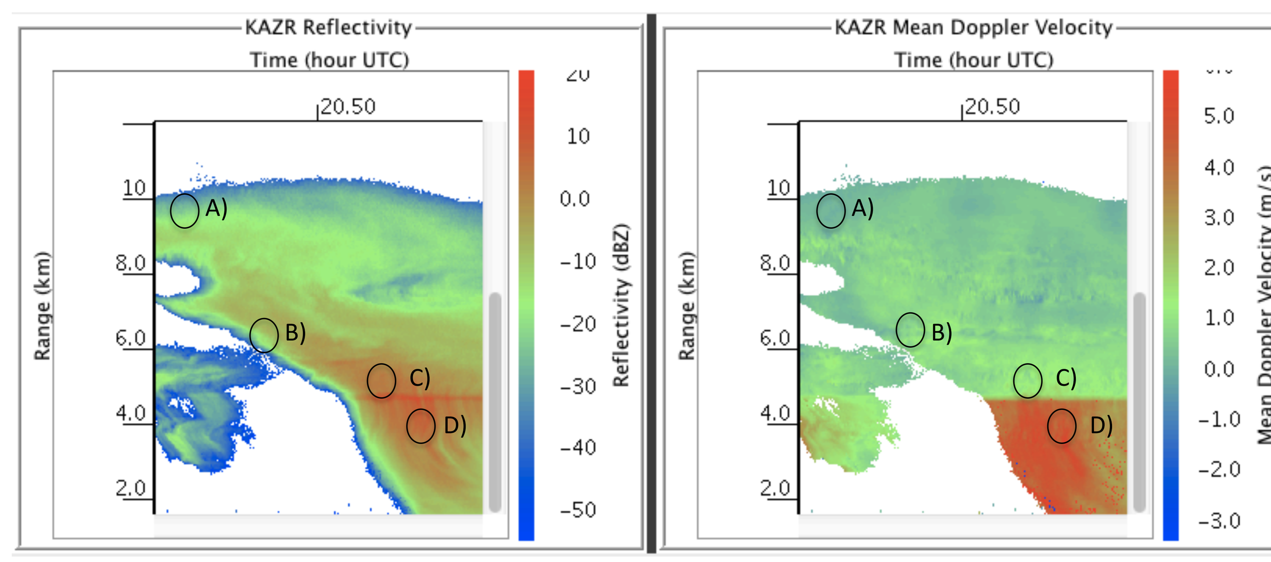
Knowledge of cloud phase allows us to better understand cloud radiative effects as well as processes that impact cloud lifecycle, yet phase can be quite challenging to observe and model correctly. Observing cloud particle phase in convective clouds is particularly challenging. Vertically pointing active instruments have a lot of potential to observe cloud phase. While most previous ARM studies on cloud phase have been done at the Arctic sites, here we examine active sensor data at Darwin, Australia for its potential to describe cloud phase in convective conditions.

Conclusions

- Convective cloud at Darwin contains mixed-phase regions with both super-cooled liquid water layers and ice hydrometeors
- Examination of Doppler spectra shows presence of liquid water drops in updrafts, in either a secondary peak in the spectra or a broadened peak.
- K-means clustering on parameters describing KAZR Doppler spectra shape (from MicroARSCL) identifies liquid water layers seen in Raman Lidar data, showing multiple distinct mixed-phase layers within the cloud

Convective Case Description: Darwin, Australia, May 17, 2013

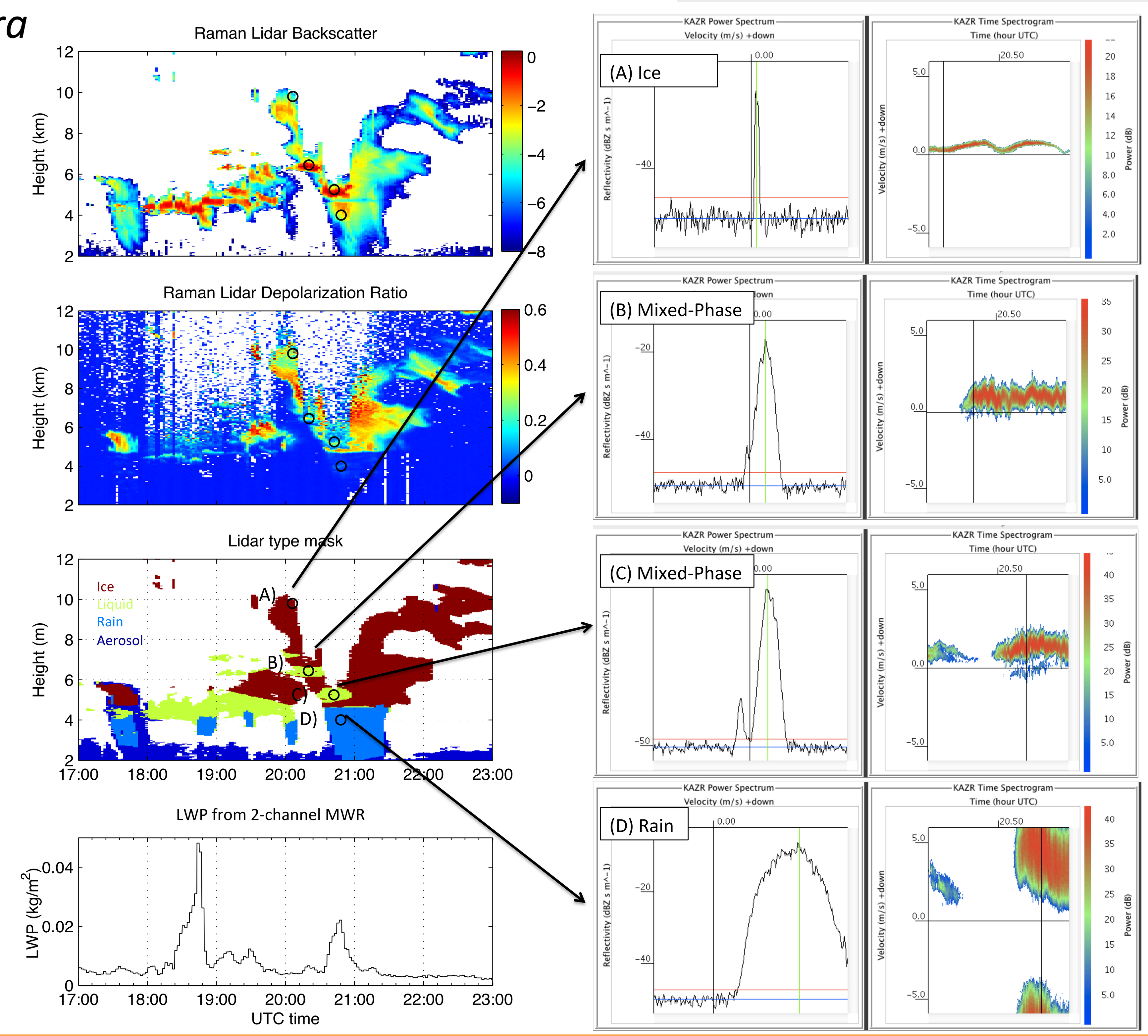
Raman Lidar & Microwave Radiometer confirm existence of super-cooled liquid water layers in deep convective cloud that is not obvious from KAZR Reflectivity, but can be seen in KAZR spectra



Raman Lidar high backscatter and low depolarization ratio show liquid water above the melting layer. This is further confirmed by attenuation of lidar.

A target classification scheme using Raman Lidar according to *Thorsen et al.* (2015) JTECH.

Small peaks in MWR measured LWP correspond to times when the lidar attenuates



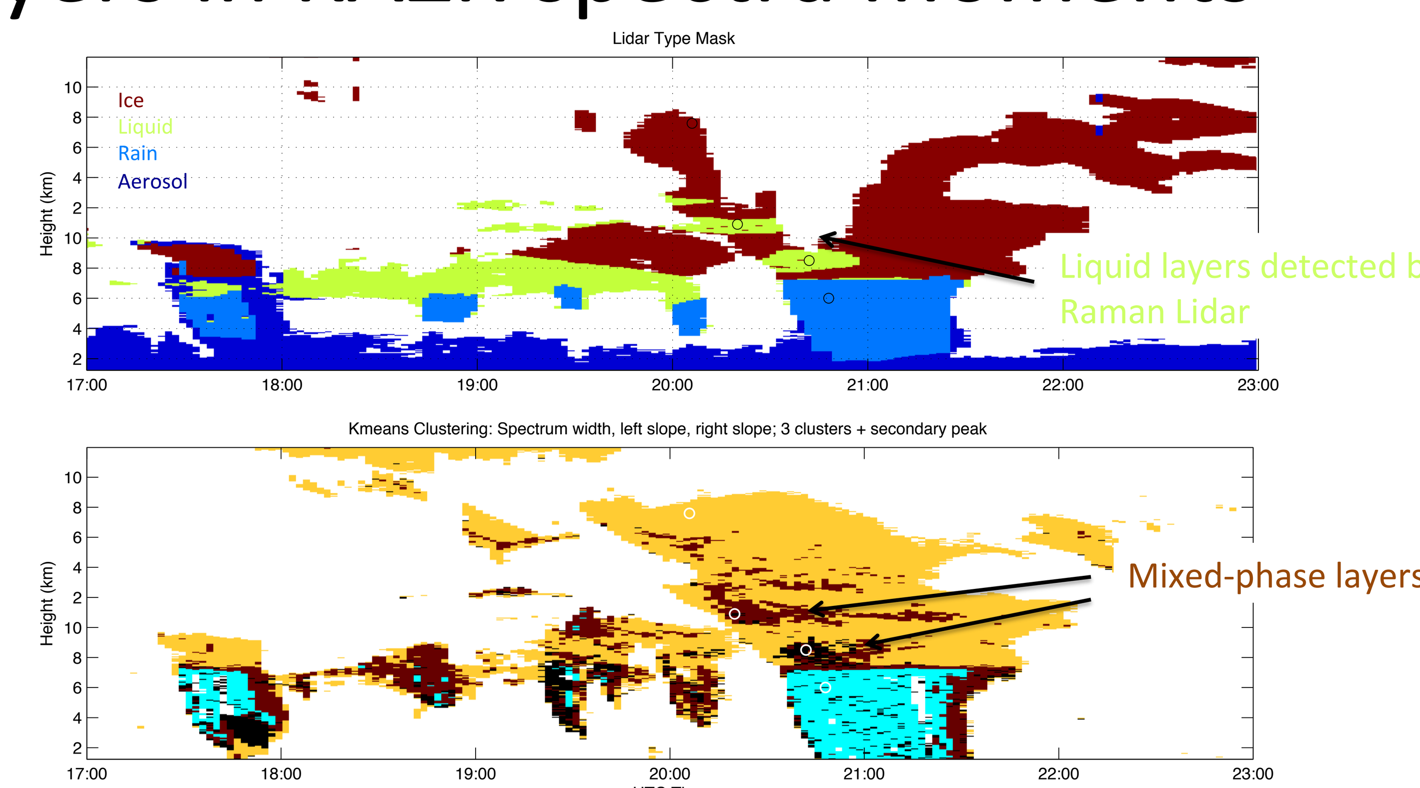
A) Narrow peak indicator of small, newly formed ice.

B-C) liquid signal shows up as a small peak to left—updraft. This is a distinct peak in C) but merged with the ice peak in B). Broadening of ice peak due to turbulence and/or particle growth from riming.

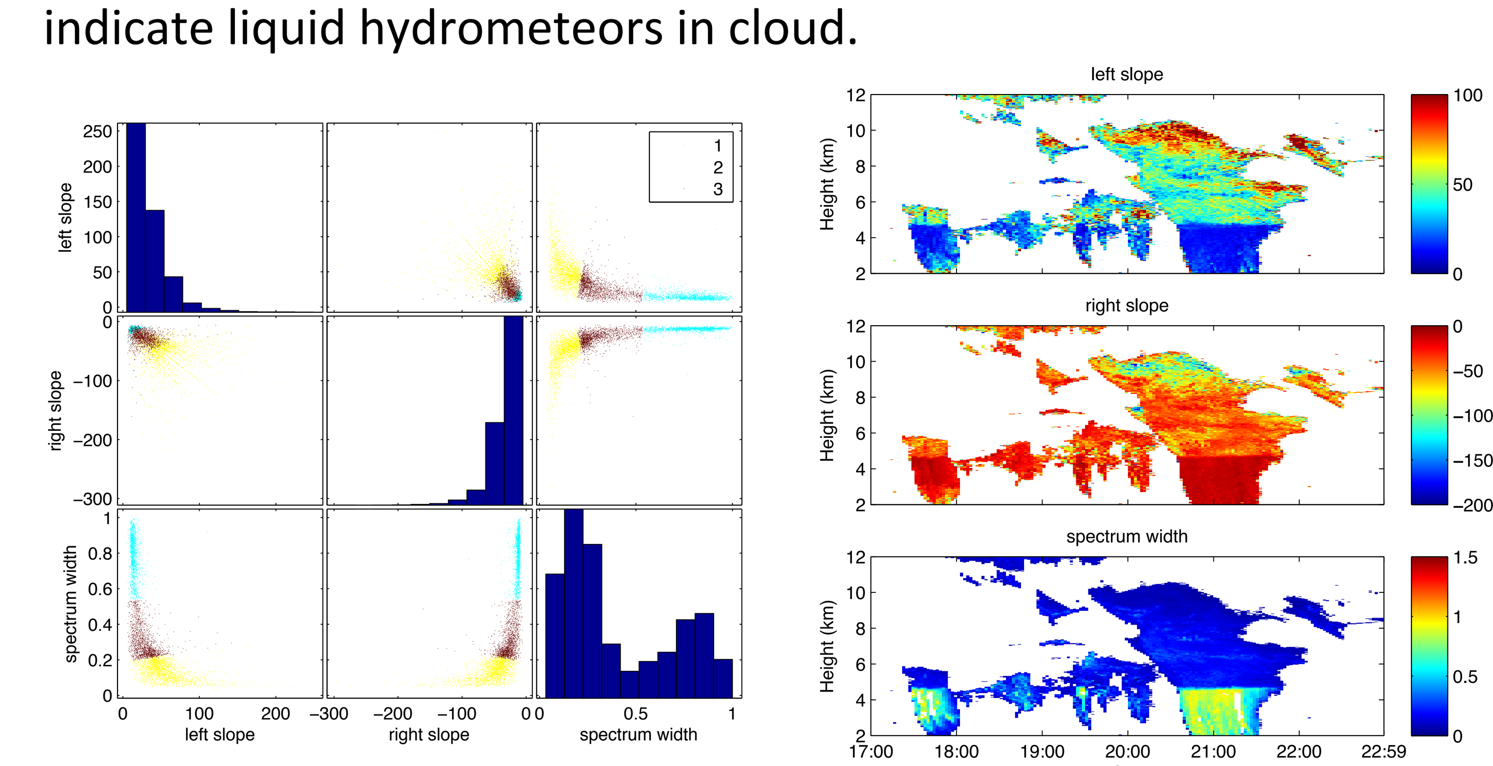
D) Precipitation shows up as a broad peak with higher fall speeds.

Time spectrograms show spectra for a given height slice over the hour 20:00 UTC, showing liquid layers extend over periods of 20-30 min.

K-means clustering finds liquid layers in KAZR spectra moments



K-means clustering is performed on 3 variables (spectrum width, left slope and right slope) describing the primary peak in the Doppler spectra. Additional points containing secondary peaks are also identified in black (above). Secondary peaks in the spectra indicate liquid hydrometeors in cloud.



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Thorsen, T. J., Q. Fu, R. K. Newsom, D. D. Turner, and J. M. Comstock, 2015: Automated Retrieval of Cloud and Aerosol Properties from the ARM Raman Lidar. Part I: Feature Detection. *Journal of Atmospheric and Oceanic Technology*, **32,** 1977-1998.

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