The Synergy of WCR and WCL for Better Measurements of Cloud Microphysical and Dynamical Properties

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1. Motivation

- Provide co-located multi-sensor measurements to improve WCR's capabilities to provide cloud microphysical and dynamical properties;
- Provide integrated observations connecting aerosols, water vapor, cloud, precipitation and dynamics to better understand cloud physical processes and to improve their parameterizations in models.

2. Instrumentation

*a. **Wyoming Cloud Lidar (WCL)***

- Newly built compact elastic polarization lidar (up and down)
- Provide cloud boundary as well as backscattering and depolarization ratio profiles

*b. **Wyoming Cloud Radar (WCR 95 GHz)***

- Multiple-beam radar reflectivity and Doppler velocity measurements
- Single beam Doppler spectrum measurements
- 20-year and over 35 field deployments

*c. **G-band water vapor radiometer (GVR)***

- Four double-sideband receiver channels
- High sensitivity to water vapor and liquid water – Water vapor path and LWP

*d. **In situ cloud probes***

- Traditional probes for aerosol, clouds, and trace-gases measurements
- Capable to carry new probes (2D-S,…)

3. Instrumentation layout and cloud dynamics measurement examples

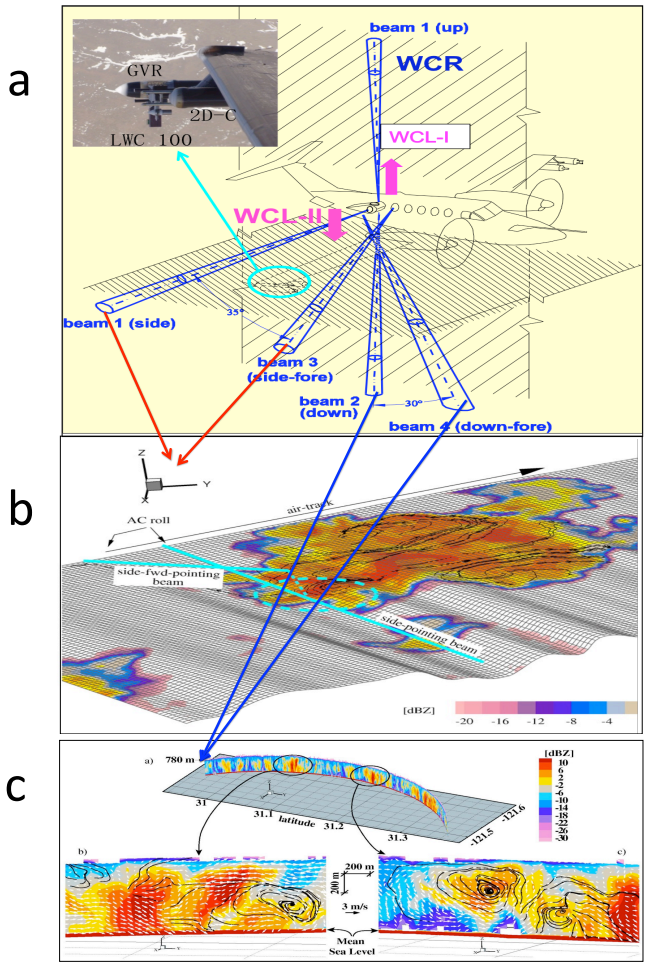

Figure 1: The beam configuration of the WCR and the installation of WCL and GVR on the UWKA (a). The multi-beam configuration of WCR provides vertical (b) and horizontal (c) 2D wind measurements in clouds.

4. Examples of integrated measurements—Wave cloud and ice generation

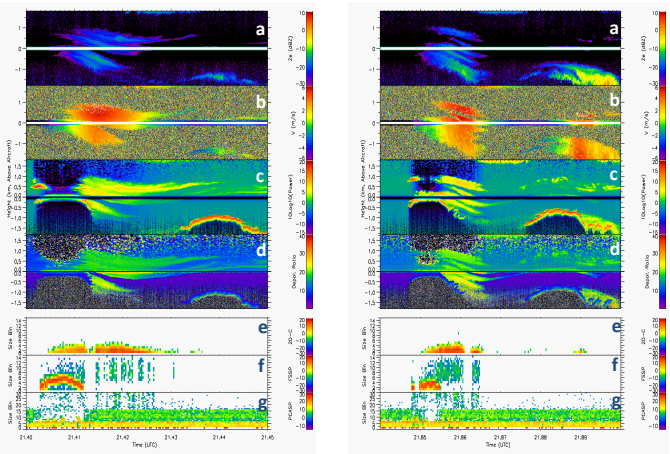

Figure 2: a) WCR radar reflectivity, b) WCR vertical Doppler velocity, c) WCL returned power, d) WCL linear depolarization ratio (uncalibrated), e) 2D-C number concentration (N) per bin in 10log(N)), f) FSSP number concentration (N) per bin in 10log(N)), g) PCASP aerosol number concentration (N) per bin in 10log(N)).

5. Cloud microphysical property retrievals

Table 1: A list of measurements needed to retrieve ice, water, and mixed-phase cloud microphysical properties

Measurements	Ice clouds	Water Clouds	Mixed-phase clouds
	Ice water content (IWC) and General effective radius (D_{ge})	Liquid water content (LWC), effective radius (r_{eff}), and drizzle flux	IWC and D_{ge} for ice phase LWC and r_{eff} for water phase
WCL	Extinction	Extinction	Extinction Depolarization ratio
WCR	Radar reflectivity	Radar reflectivity and Doppler velocity	Radar reflectivity or spectrum
GVR		LWP	LWP

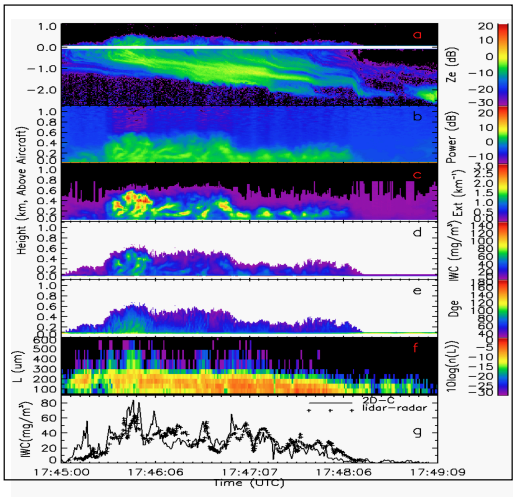

Figure 3: Combined WCR and WCL measurements of ice clouds and microphysical properties retrievals: a) up and down WCR reflectivity factor, b) upward WCL attenuated backscattering power, c) WCL retrieved cloud extinction coefficient, d) retrieved IWC profile, f) retrieved D_{ge} profile, f) 2D-C measured ice crystal size distribution in terms of maximum length (number/L/um), and g) comparison of 2D-C estimated IWC with retrieved IWC at ~100m above the King Air.

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