The New Integrated Cloud Observation Capabilities of Wyoming King Air by Combing Remote Sensors and In Situ Probes

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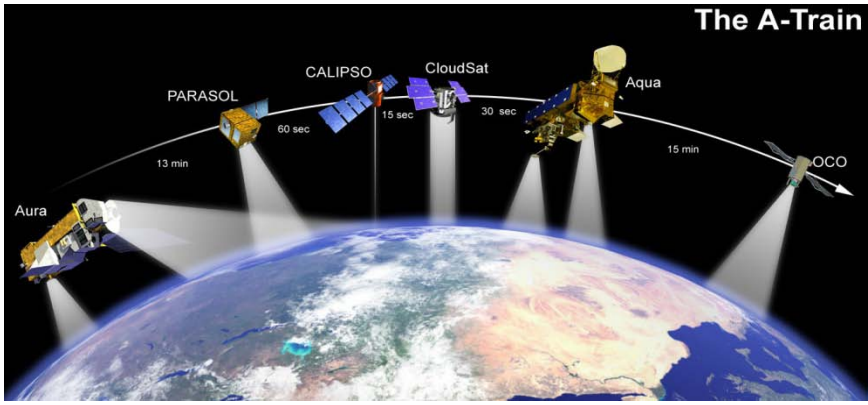
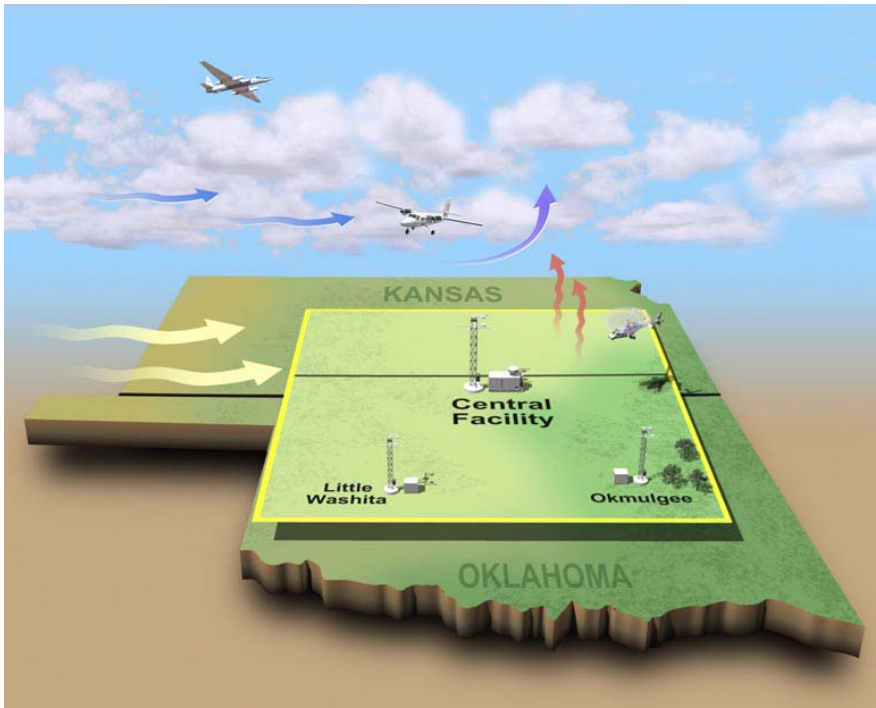
The General Goals of Cloud Observations

- Build a reliable cloud Climatology
- ***Understand cloud microphysical properties and processes***
- Understand cloud-dynamical-radiation feedbacks
- ***Improve cloud simulations in models***





Cloud Physics Processes In Numerical models

- Cloud physics processes are explicitly simulated or parameterized in models.
- Many cloud physics processes can't directly measured.

It is not easy to collect measurements to improve cloud physics !!

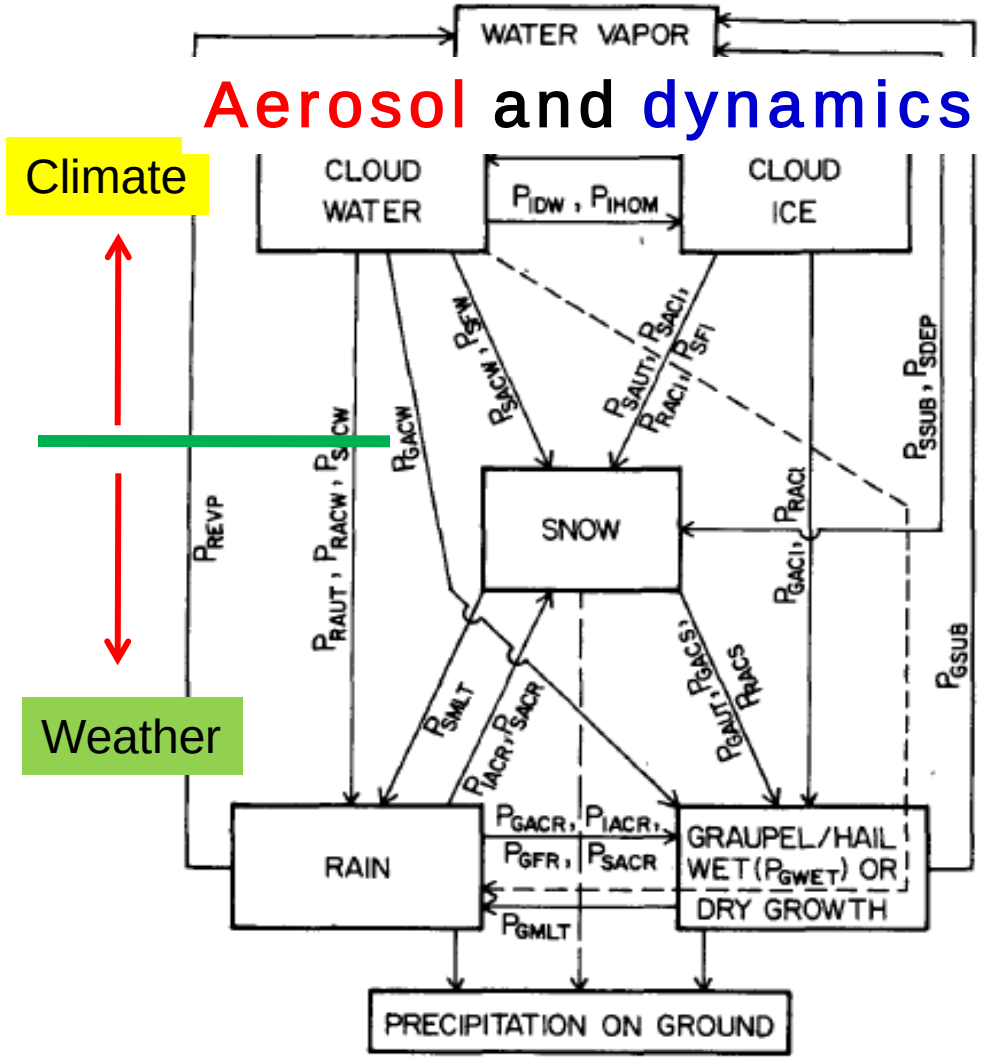


FIG. 1. Cloud physics processes simulated in the model with the snow field included. See Table 1 for an explanation of the symbols.

Lin et al. (1983)

Combining airborne in situ sampling and remote sensing for cloud study

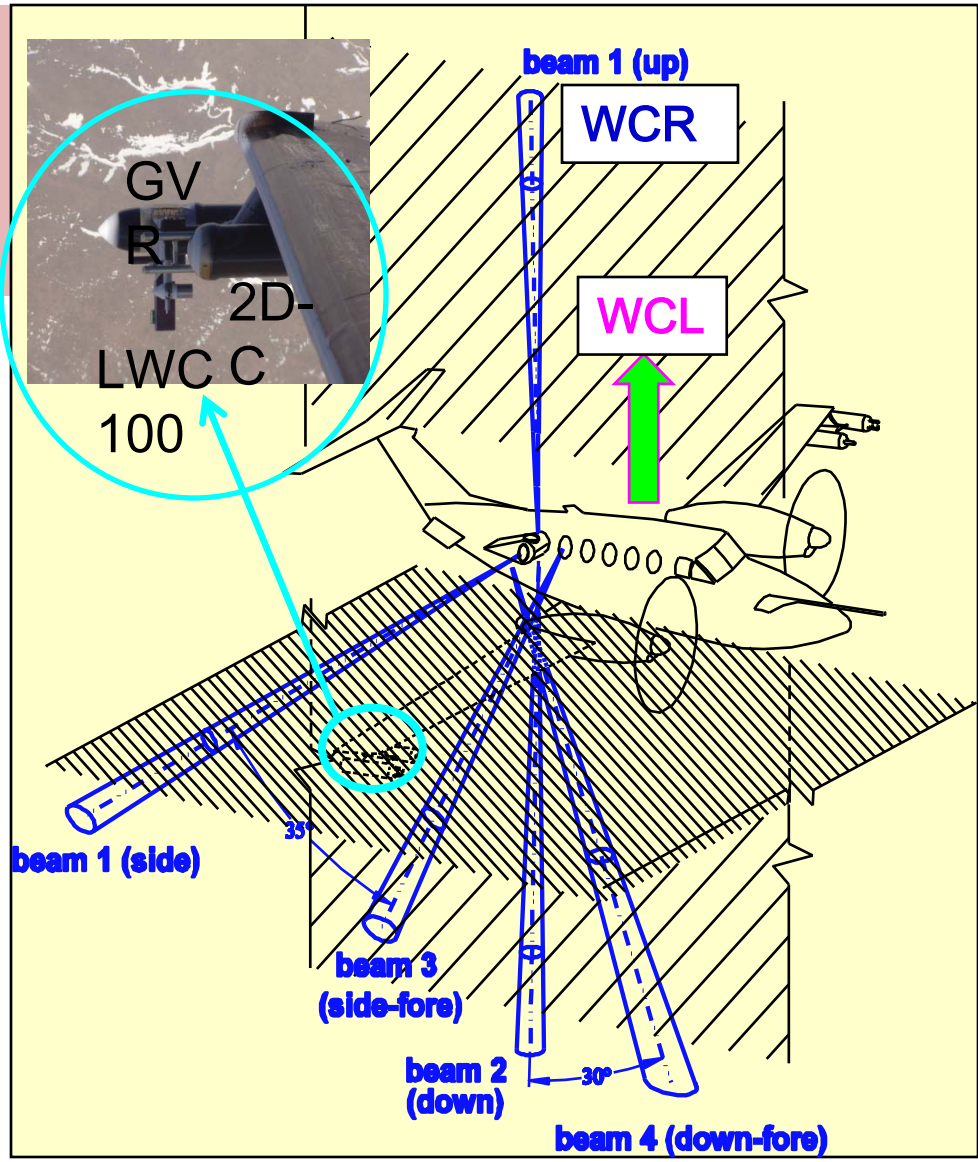
- Multi-aircraft approach
- Single aircraft
  - Wyoming King Air
  - …

University Wyoming King Air

A part of NSF low atmospheric facility

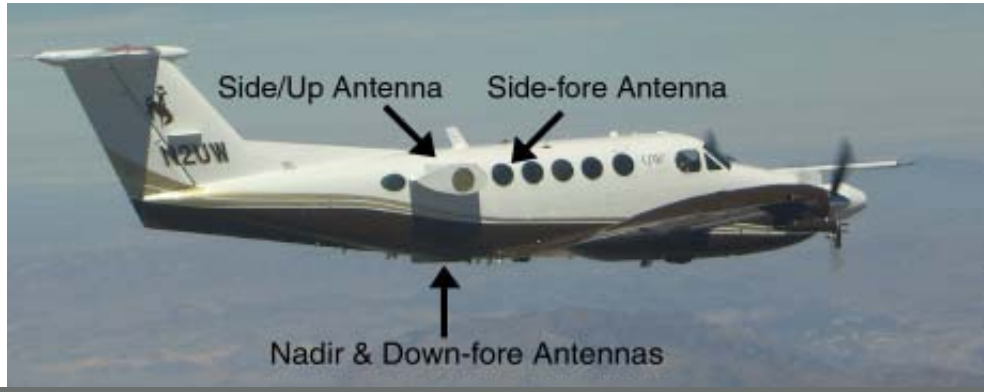
Provide extended cloud microphysical properties for cloud physics study

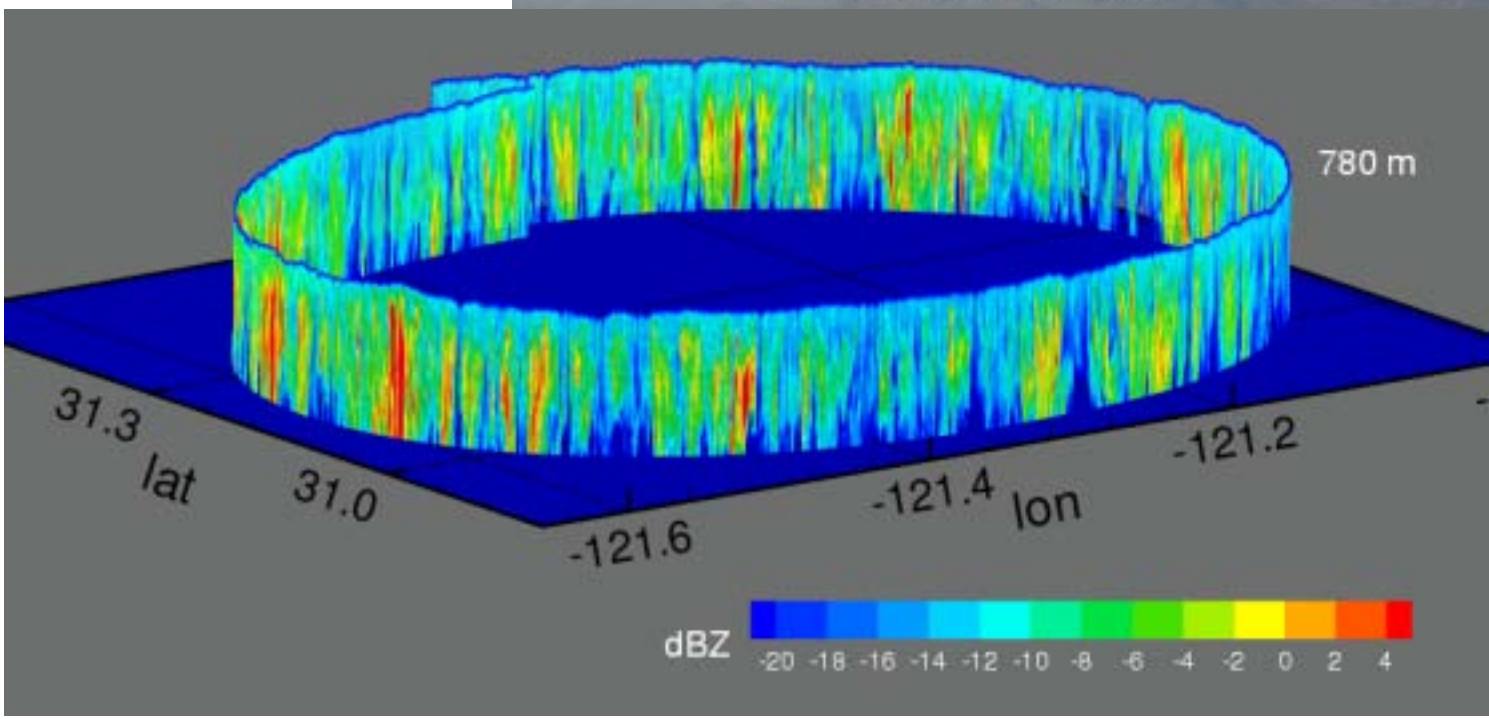
- Remote sensors
  - Cloud radar
  - Cloud lidar
  - Microwave radiometer
- In situ sensors
  - Aerosol
  - Cloud



Wyoming Cloud Radar (WCR)

- 94 GHz Doppler radar, -30 dBZ at 1 km.
- Multi-beam operation (4-simulataneously).
- 28 field deployments since 1996 including ARM 1997 Cloud IOP.

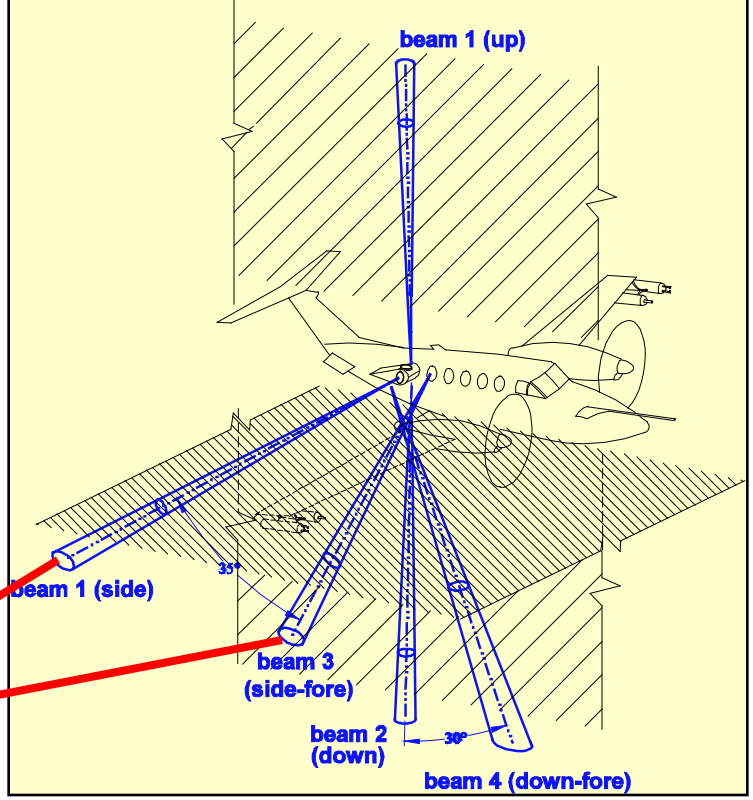


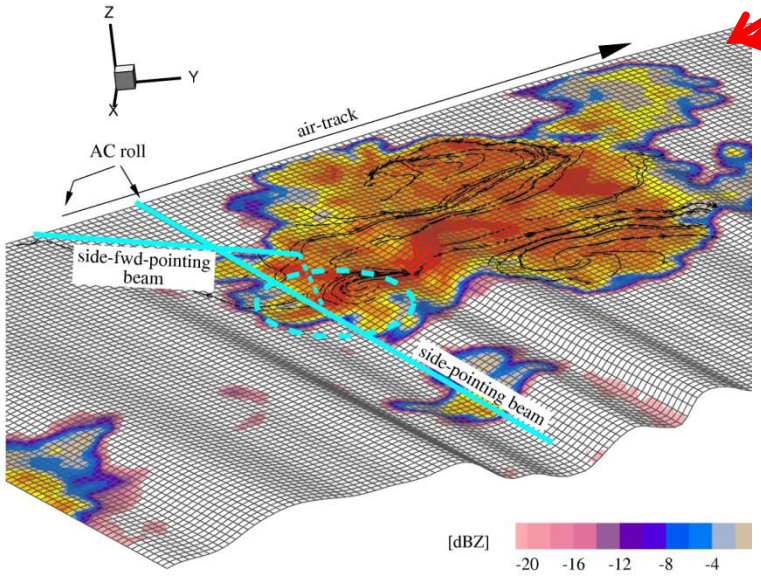


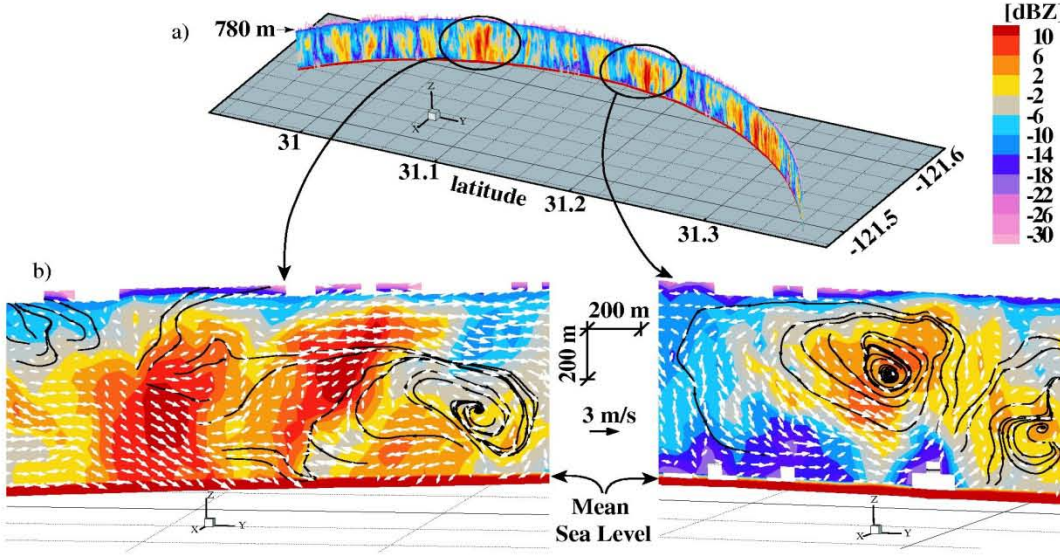
http://www.atmos.uwyo.edu/wcr/

WCR

- "3"-D cloud structure
- Cloud scale dynamics

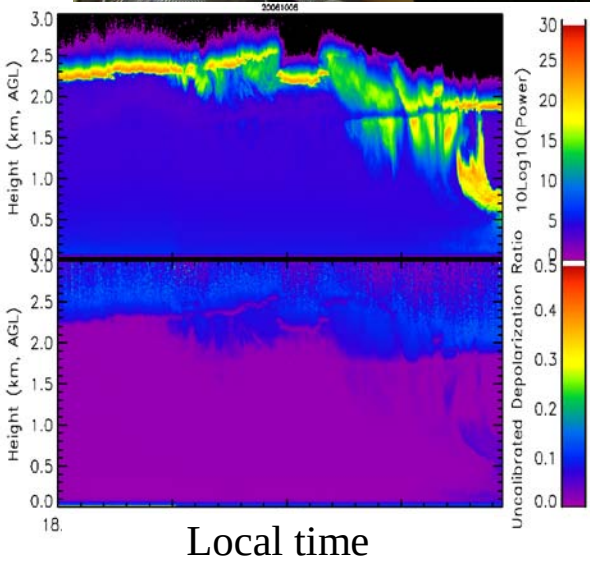






Wyoming Cloud Lidar (WCL)

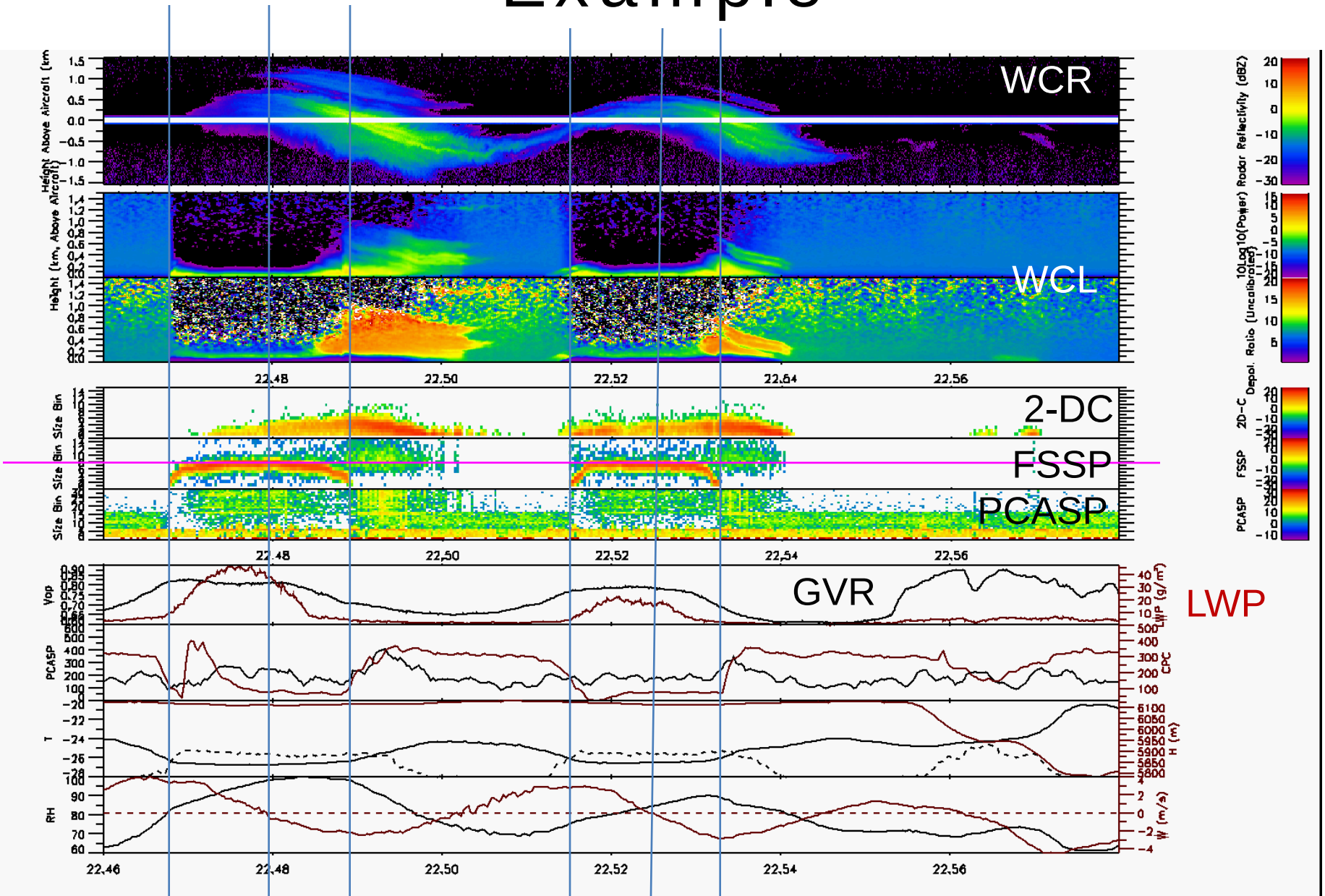
- A *simple* elastic lidar with depolarization measurements
- Working together with the WCR to improved cloud microphysical property profiles
- 355 nm laser– eye safe
- The nearest usable bin: ~15 m
- Two-year old; 4 field deployments
- On NCAR C-130 in VOCALS now

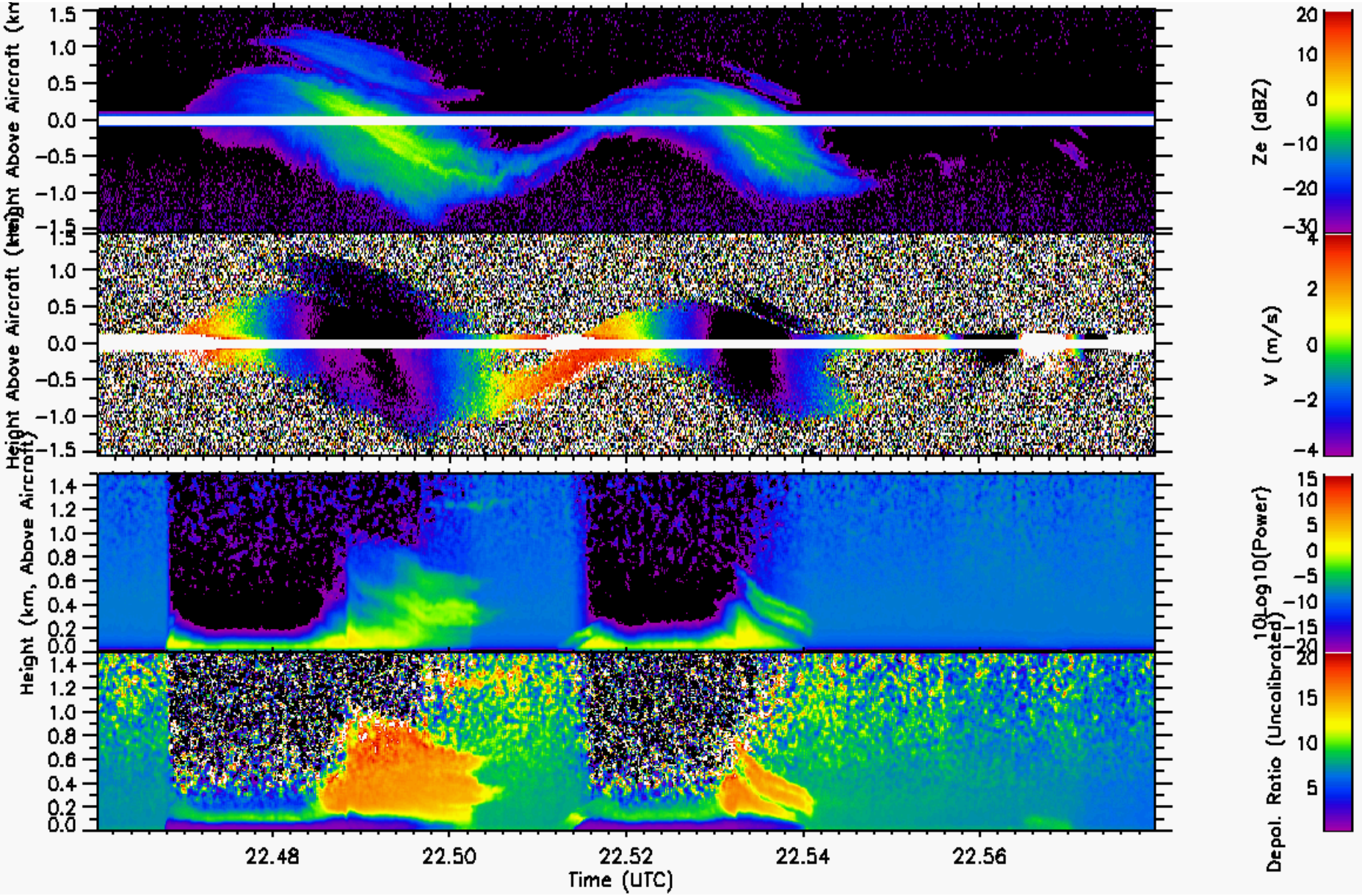


GVR

- A G-band (183 GHz) water Vapor Radiometer (GVR) from ProSensing Inc.
- Four double-sideband receiver channels, centered at 183.31 1, 3 and 7, and 14 GHz
- Operate from a standard 2-D PMS probe canister
- Provide precipitable Water Vapor (PWV) and Liquid Water Path (LWP) up to 20 Hz

Wyoming King Air Observation Example




Height Above Aircraft (km)
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Height (km, Above Aircraft)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
22.48
22.50
22.52
22.54
22.56
Time (UTC)
Ze (dBZ)
20
10
0
−10
−20
−30
V (m/s)
4
2
0
−2
−4
10*Log10(Power)
15
10
5
0
−5
−10
−15
−20
Depol. Ratio (Uncalibrated)
20
15
10
5

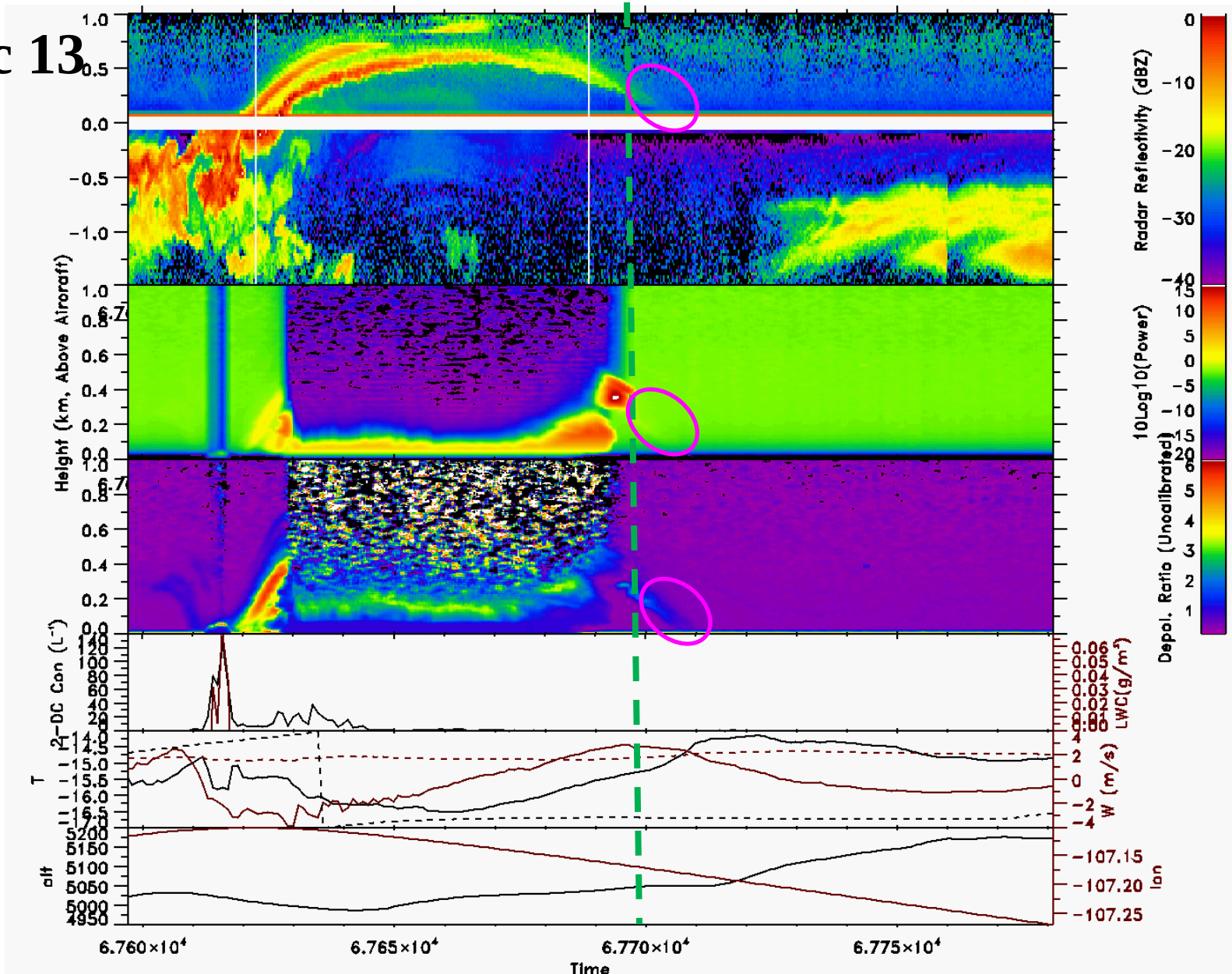
WCR and WCL Observations from C-130

ICE-L

RF11, Dec 13

WCR

WCL



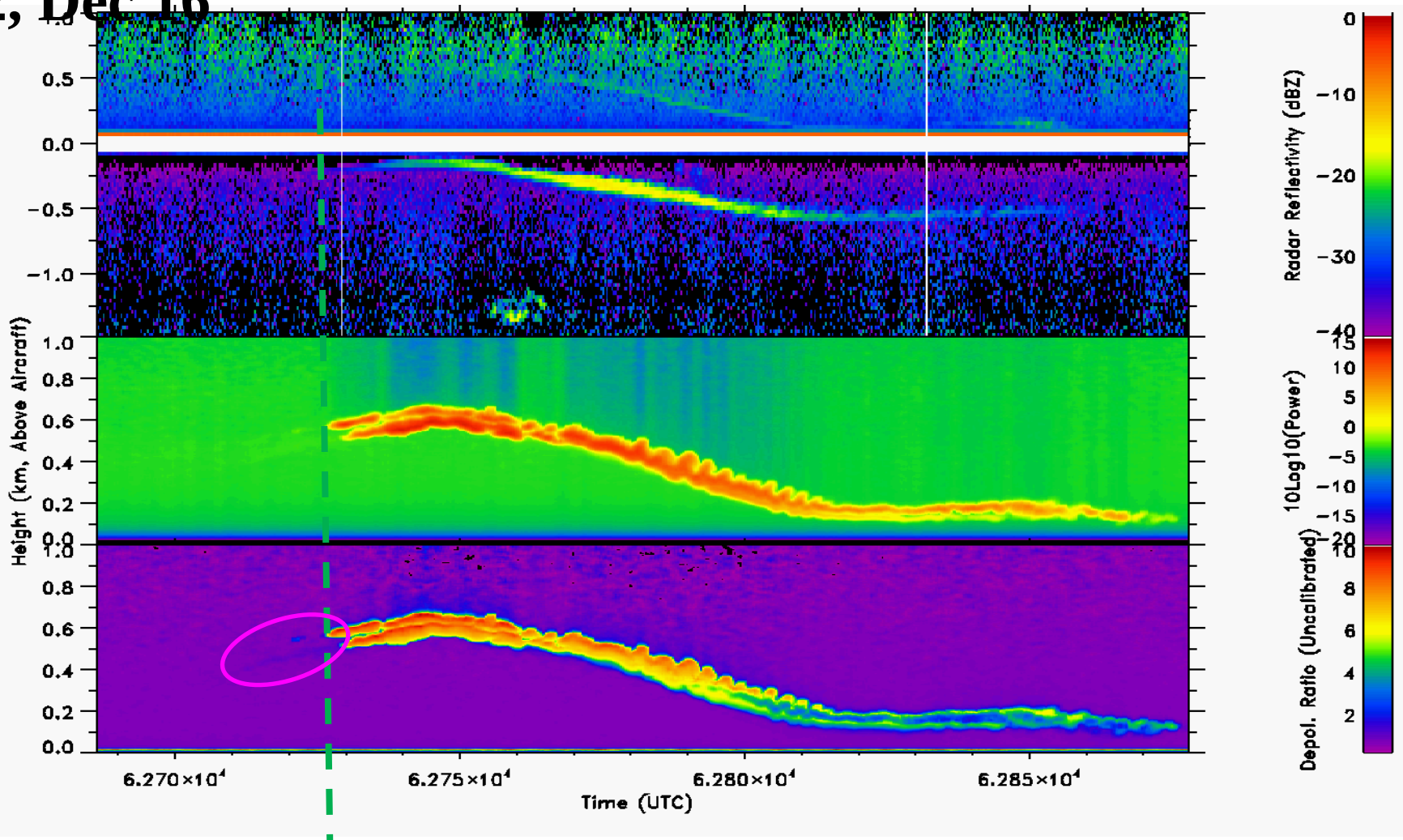
Homogeneous Ice Nucleation

ICE-L

RF12, Dec 16

WCR

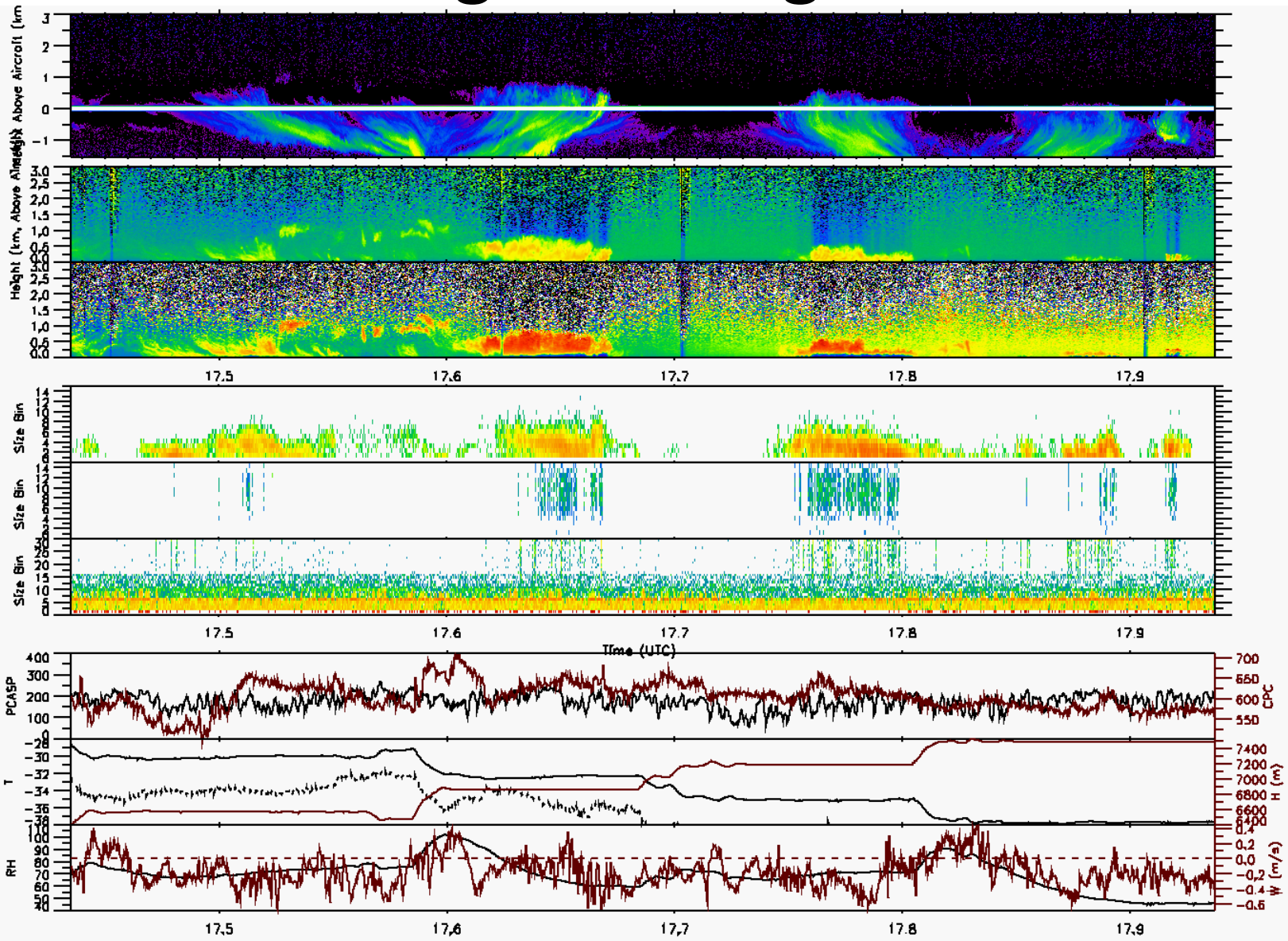
WCL



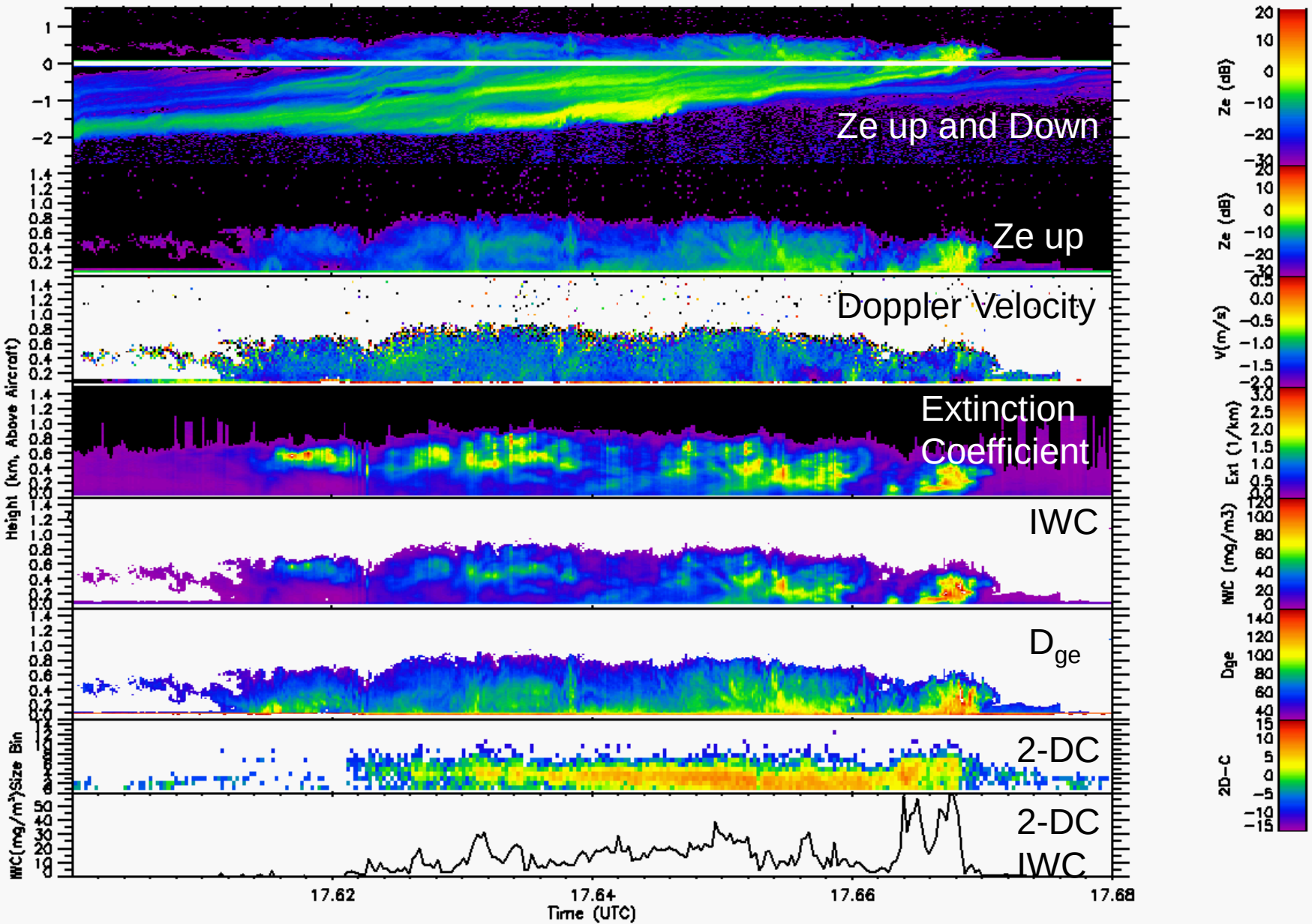
Microphysical Retrievals

	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

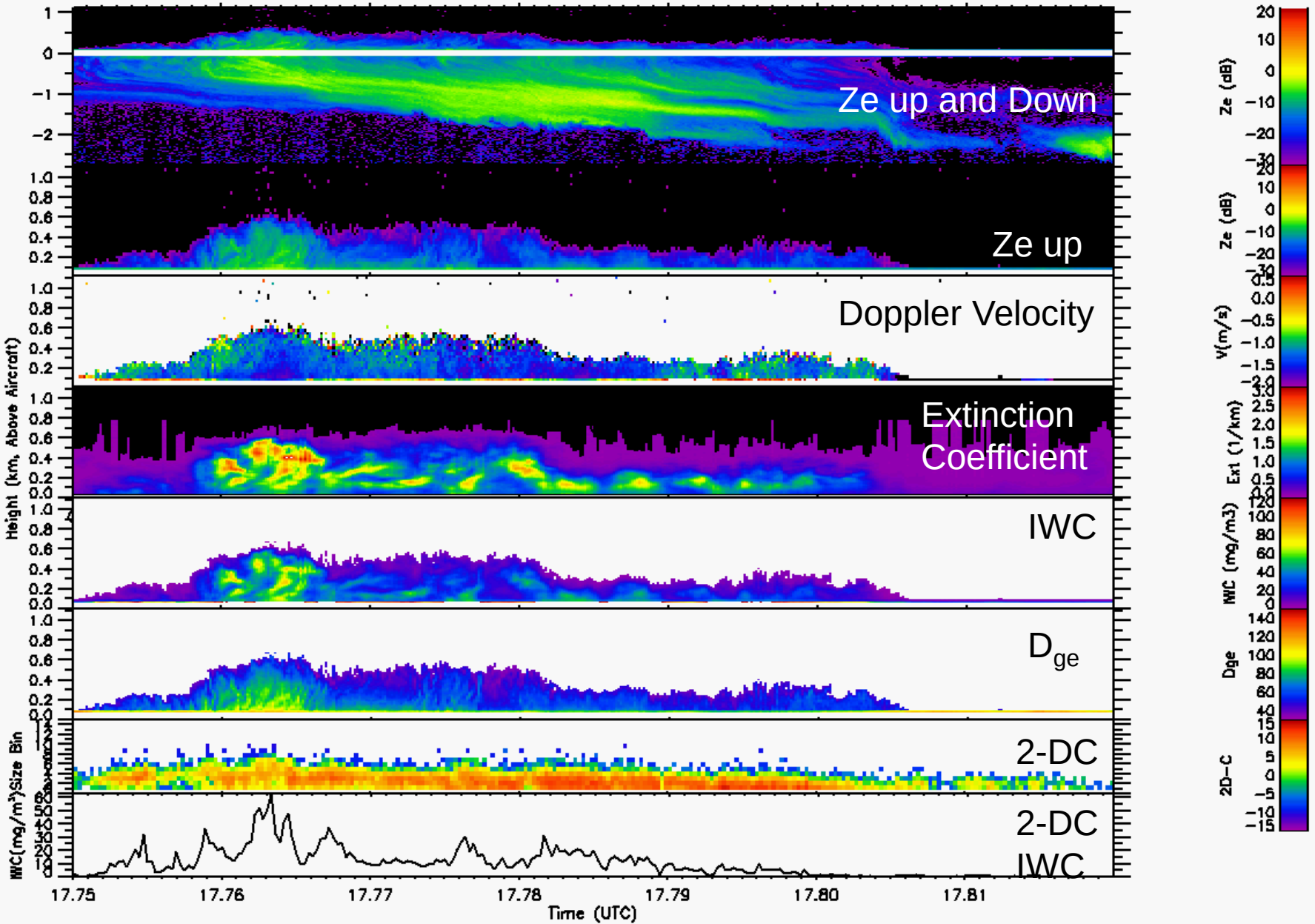
Ice cloud microphysical property evolution in generating cells



Microphysical retrievals



Microphysical retrievals



Summary

- The state-of-art remote sensors and in situ probes can be effectively combined in a small aircraft to provide better measurements for cloud physics study.

- More efforts are needed in retrieval algorithm development and validation.

Near Future

- **WCR-II** (testing on ground now)
- **Downward WCL** (flight test in spring 2009)—up and down lidar and radar observations
- In situ **cloud and aerosol** probe upgrade