Differential Absorption Radar Humidity Sounding

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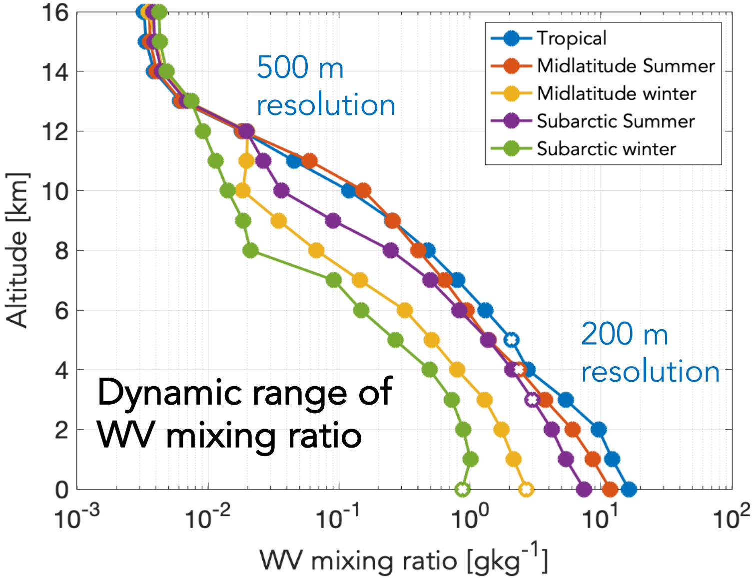
Humidity sounding

Water is almost entirely distributed in the atmosphere in the form of vapor (99.5%).

Current humidity remote sensing technology (e.g., passive microwave/infrared, lidar) is often confounded by clouds, and/or does not provide the desired spatial resolution within PBL.



Accuracy ~ 0.01 g/Kg

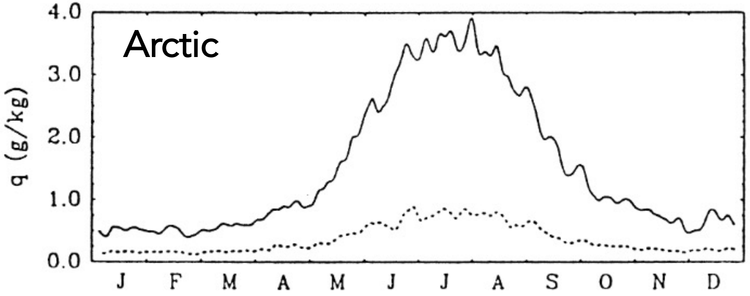


FIG. 3. Ten-day running mean of water vapor mixing ratio using radiosonde data from the Russian drifting ice island stations in the Arctic Ocean. Solid line is an average over the 1000–850-mb layer and dashed line is the 500-mb level. From Curry et al. (1995).

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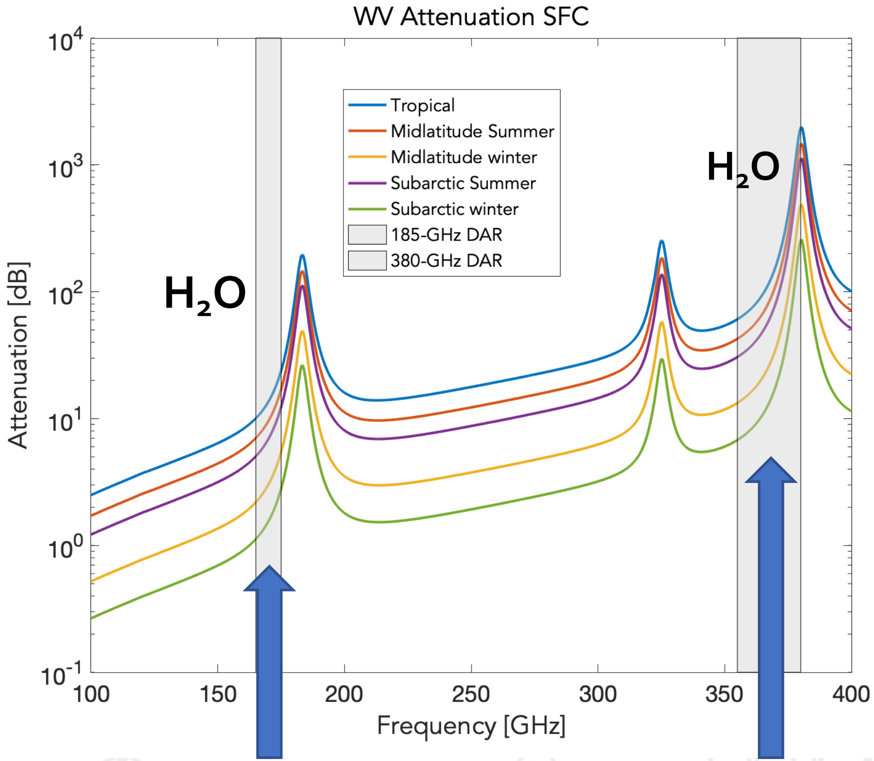
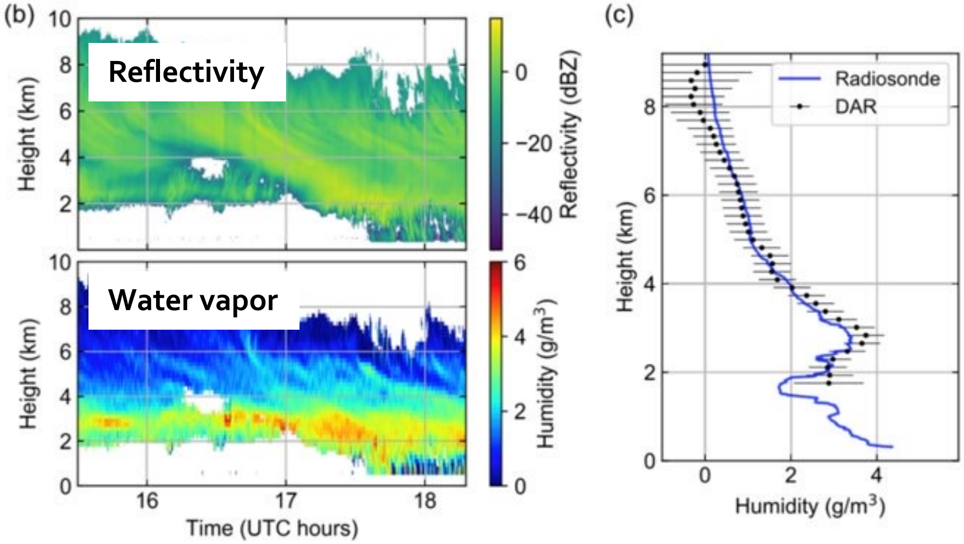
Differential Absorption Radar



Transmission restrictions
More penetration,
weaker signal

No restrictions, Less penetration, stronger signal

WV Retrievals



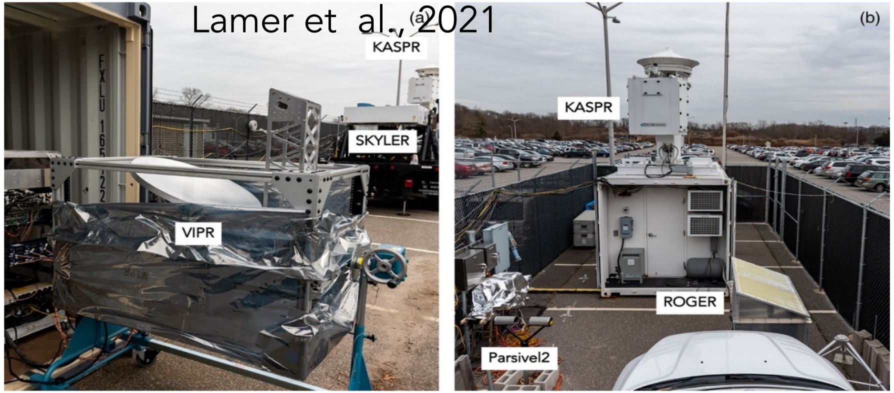
Ken B. Cooper, et al., "A G-Band Radar for Cloud and Humidity Remote Sensing," *IEEE Transactions on Geoscience and Remote Sensing*, 2020.

Richard J. Roy, et al., "Validation of a G-band differential absorption radar for humidity remote sensing," *J. Ocean. and Atmos. Tech.*, 2020.

+ **Airborne demonstrator**

DAR development efforts

Lamer et al., 2021

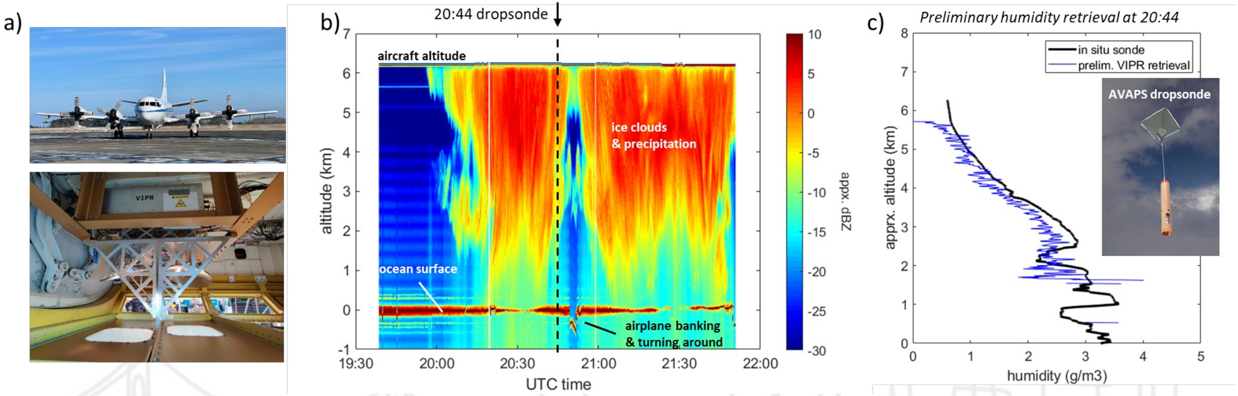


The Vapor In-clouds Profiling Radar (VIPR, JPL) – Tested at SBU/BNL

The UK-CEOI G-band Radar for Cloud Experiment (GRACE)

The U. of Cologne airborne G-band DAR

The NOA (Greece) airborne/ground G-band DAR - will be tested at SBU/BNL



DFG Deutsche Forschungsgemeinschaft

UK SPACE AGENCY

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JPL Jet Propulsion Laboratory
California Institute of Technology

Stony Brook University

Brookhaven National Laboratory

High resolution cloud radar

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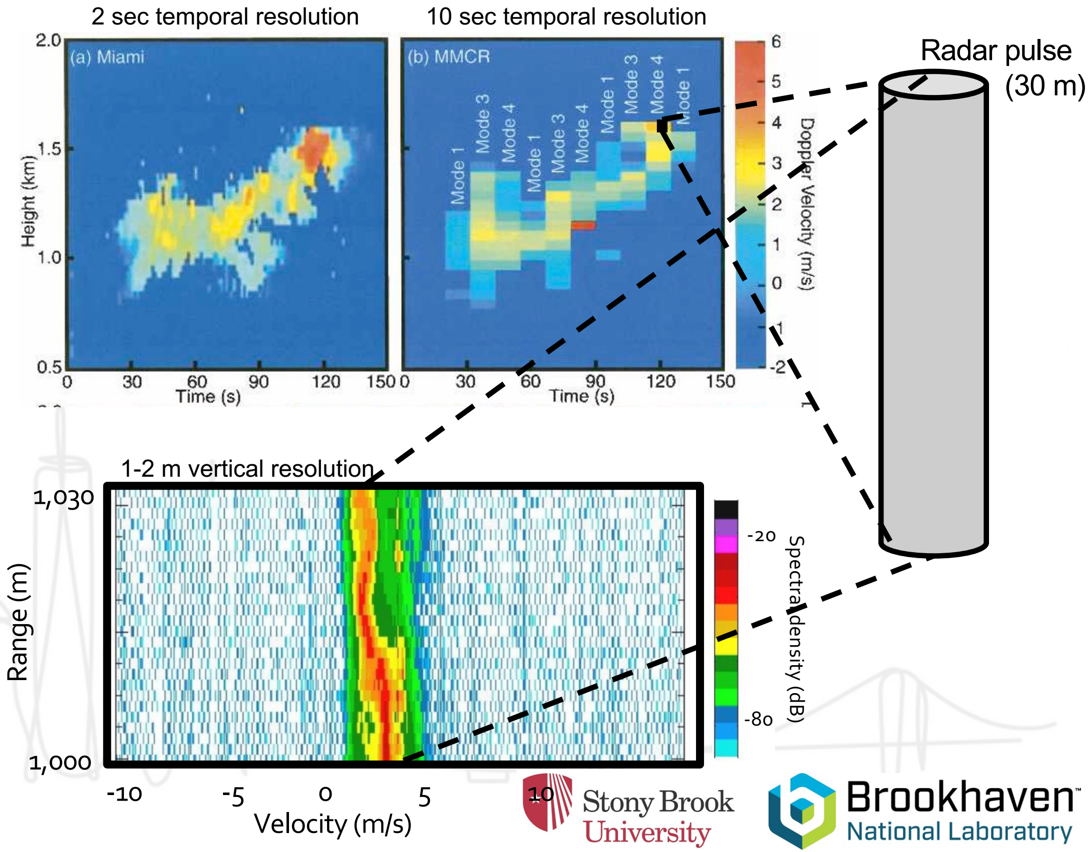
High-resolution radar resolving small-scale processes

Resolving small-scale processes such as mixing at the cloud-air interface in a cloud chamber and in the natural environment will be enabled by next generation radars with:

- Increased temporal resolution
  10 sec --> 1 sec
  Kollias et al. (2005)

- Increased vertical resolution
  30 m --> 2 m



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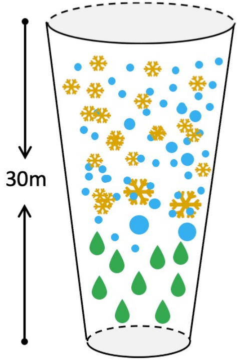
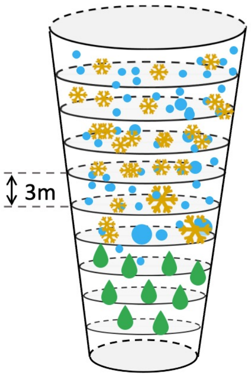
30 m



3 m



Requires a wide bandwidth transmitter (chirp), easier to do at cloud radars

Advantages:

- Minimizes the influence of turbulence and reduces non-uniform beam filling effects
- Improve microphysical signatures on radar Doppler spectra (e.g., SIP, SLW)
- Improve the representation of cloud edges
- Capture small-scale, high-magnitude, dynamical features

Disadvantages:

- Larger data files
- Lower sensitivity

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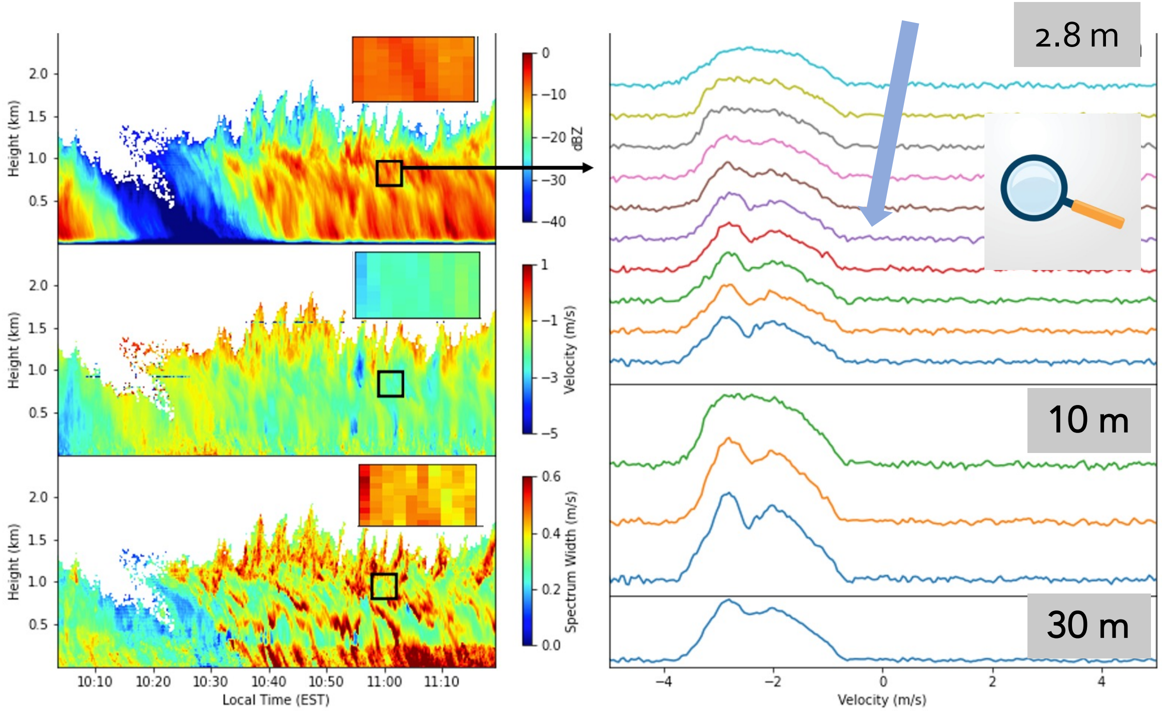
High resolution radar

Accretion Process(Rain droplets Development)

The development of the Mie notch indicates the gradual growth of larger raindrops



BNL WCR-QPC

94-GHz FMCW
1 w SSPA
2.8 – 200 m range resolution
Quadratic phase coding (QPC)
100% duty cycle
Variable NFFT length

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