National Aeronautics and Space Administration

The Vapor/Ice Profiling Radar (VIPR)

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What is it?

- Differential Absorption Radar (DAR)
  - Microwave analogue of DIAL

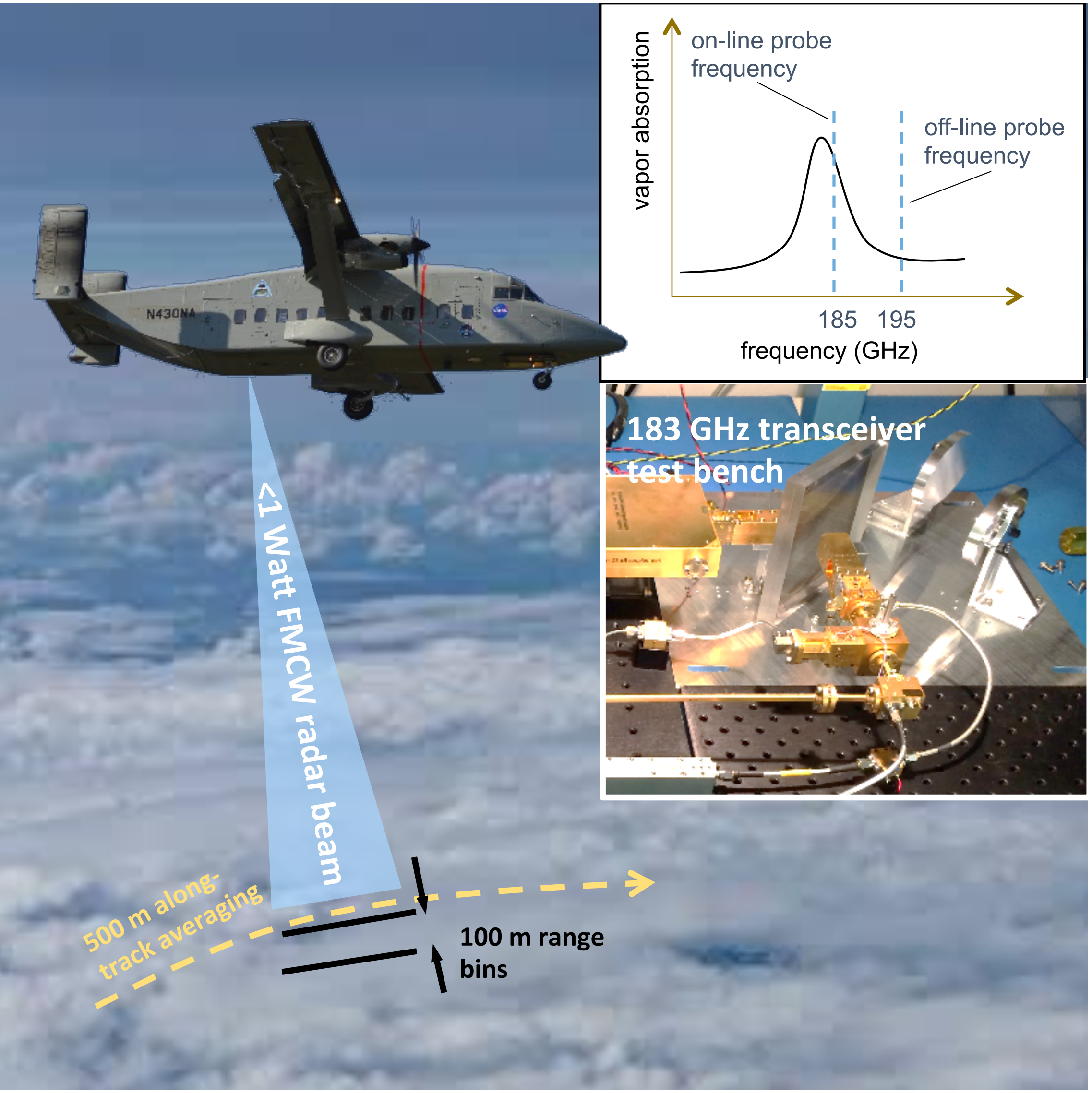
- An emerging concept to profile water vapor within the cloudy atmosphere.
  - Complements existing water vapor observations

Weather Measurement Need

One of the critical atmospheric variables that are **not adequately measured** by current or planned system is temperature and **humidity profiles** of adequate vertical resolution **in cloudy areas**.

[Andersson (2014) – Statement of guidance for numerical weather prediction, WMO report.]

Vapor / Ice Profiling Radar VIPR



Development supported by NASA ESTO

2013: ACT (Advanced Component Technology)

PI: Ken Cooper

-Develop a 183 GHz source

-Integrate into a transceiver

-Entry TRL = 2, Exit TRL = 4

2016: IIP (Instrument Incubator Program)

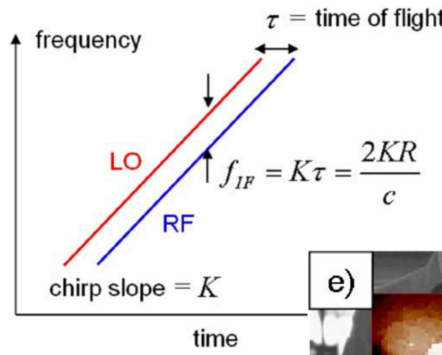
PI: Matt Lebsock

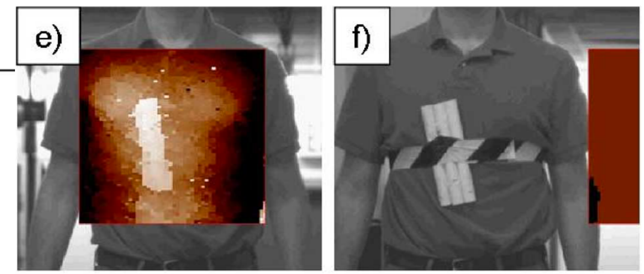
-Build airborne VIPR radar

-Demonstrate and validate

-Entry TRL = 3, Exit TRL = 6

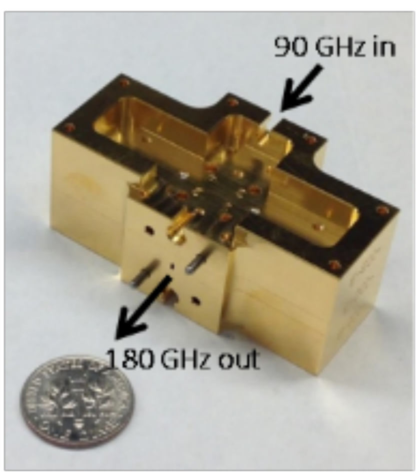
Technology Approach



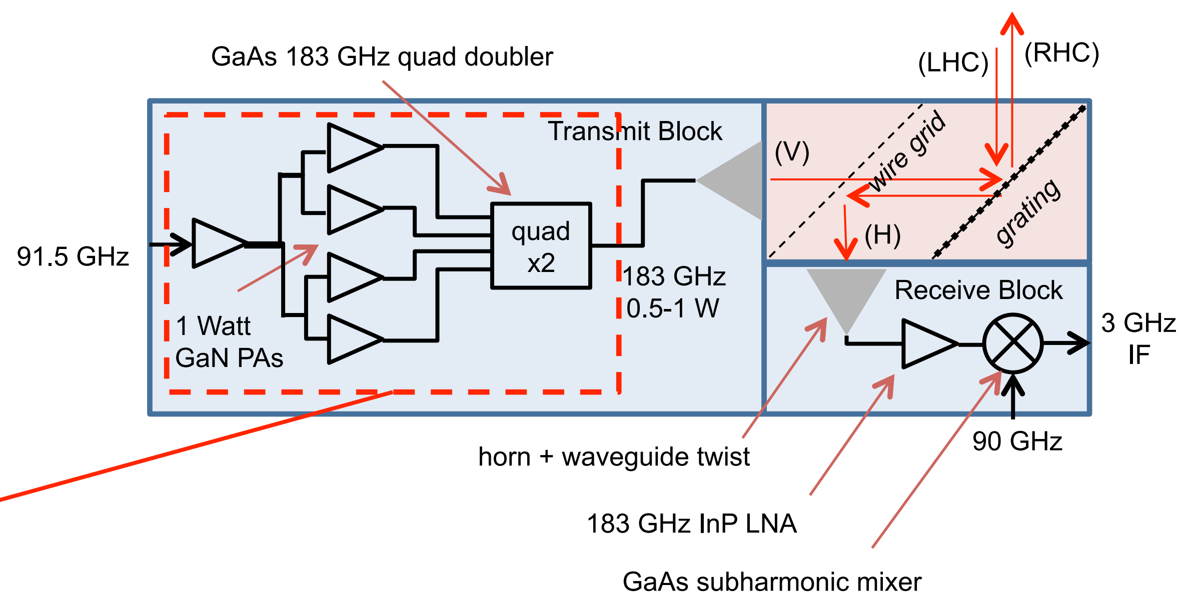


Frequency Modulated Continuous Wave (FMCW) radar.

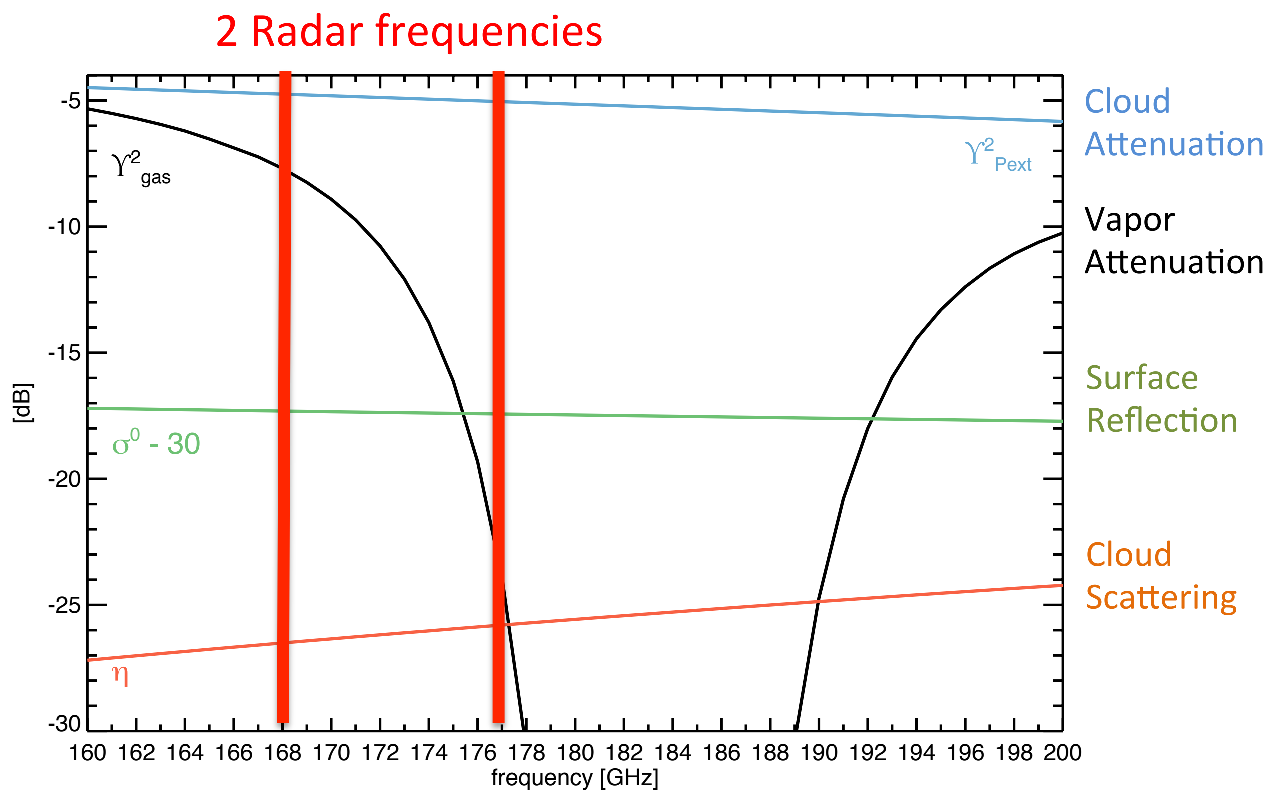
- 183 GHz with 10 GHz frequency sweep
- Heritage in high frequency radar development for security applications
- All solid state components are compact
- ~1W transmit power.



Lowest TRL element



Measurement Theory



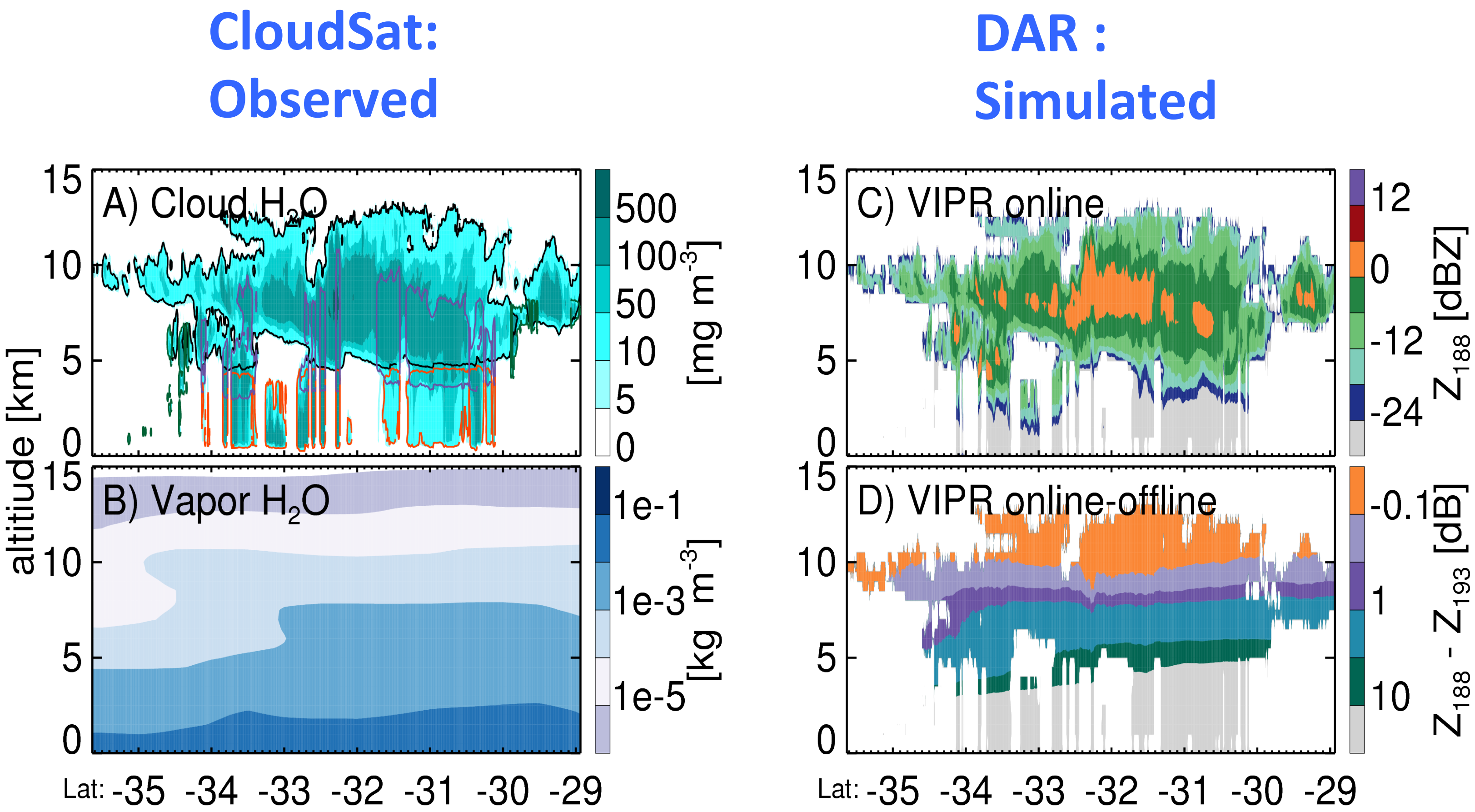
- Near the 183 GHz absorption line the difference in reflectivity between two frequencies is a linear function of the atmospheric water vapor content.

Filling an Observation Gap

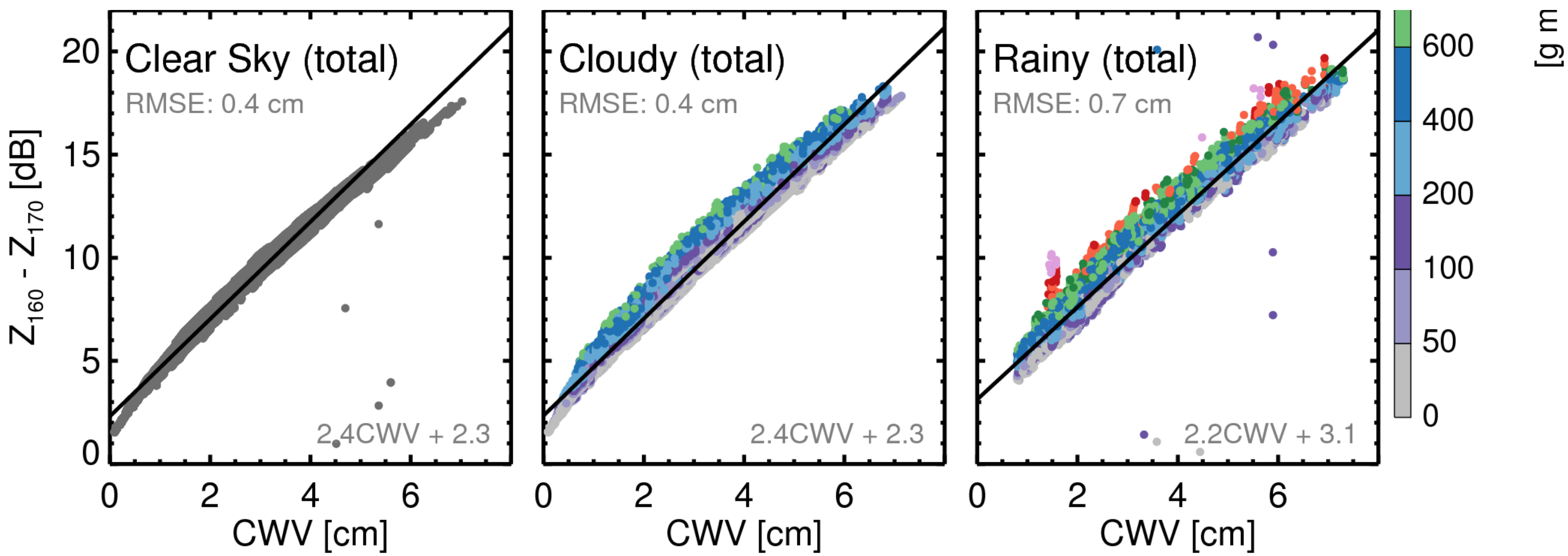
Existing Sounding Techniques	DAR Provides
IR Sounding	• In cloud sounding • High resolution (~500 m x 2 km^2)
Microwave Sounding	
Radio Occultation	
Limb Sounding	
Differential Absorption Lidar	

Existing Column Integral Techniques	DAR Provides
Microwave imagery	• All surface types • All weather conditions • High resolution (~2 km^2) • Improved precision
Near-IR imagery	

Instrument Simulations



Total Column Water Vapor



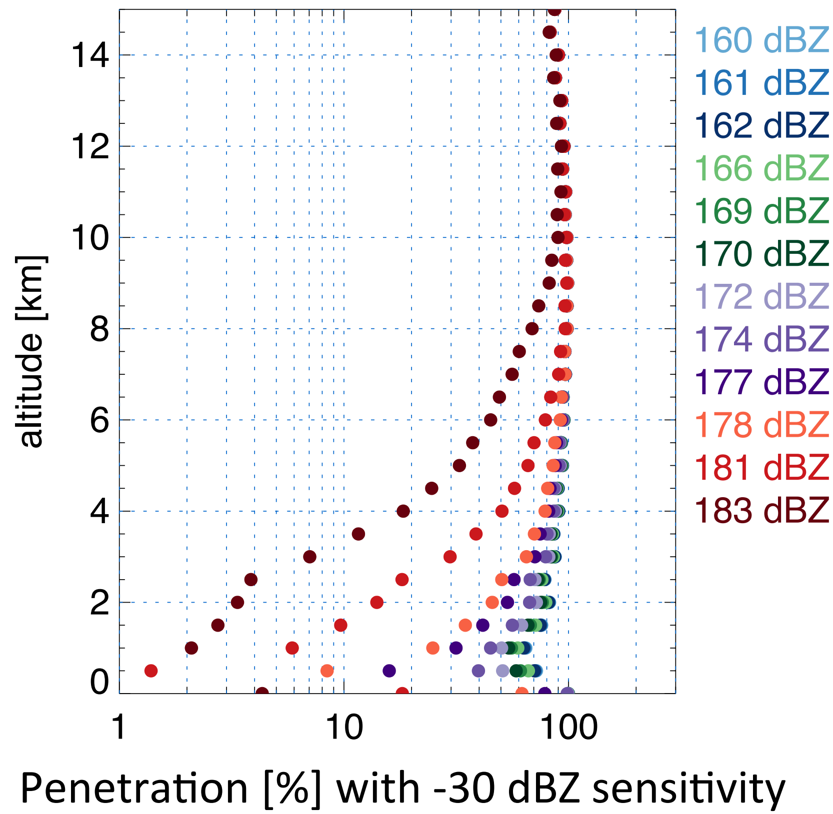
- DAR can provide CWV over all surfaces and cloud conditions with high accuracy

Penetration Depth

- Attenuation provides the differential radar signal

BUT

- Attenuation limits penetration depth (sampling)



Analysis guides frequency selection considerations. Probing high-altitude clouds requires different frequency-pairs than does low-altitude clouds.

DAR Capabilities

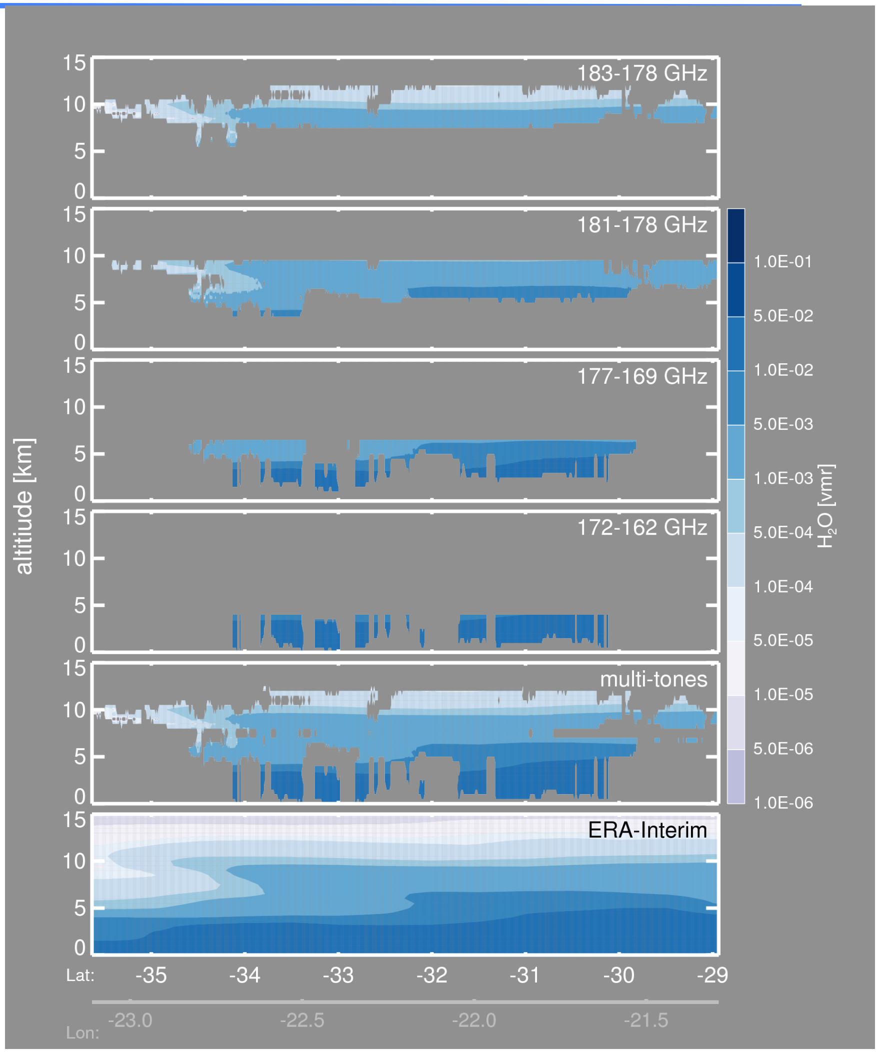
DAR water vapor measurements can provide:

In-cloud water vapor profiles

- Resolution possible at cloud scale (~500 m by 2 km)

Continuous column water vapor

- ~2 km horizontal resolution
- All surface types
- All weather conditions



Cross section of simulated retrievals

Publications:

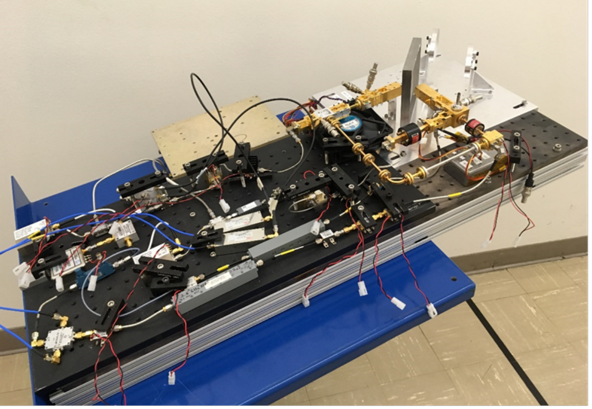
Millán (2014) – 10.5194/amt-7-3959-2014

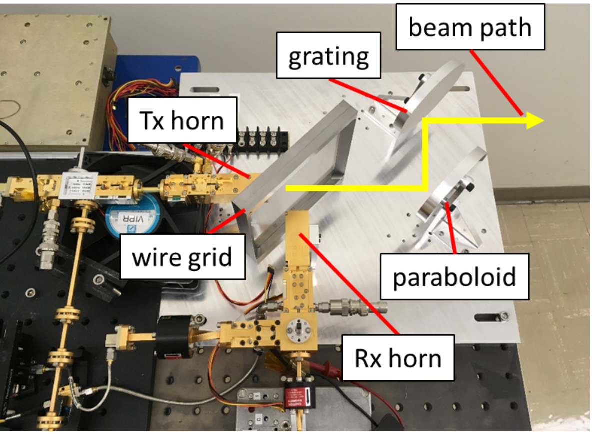
Lebsock (2015) – 10.5194/amt-8-3631-2015

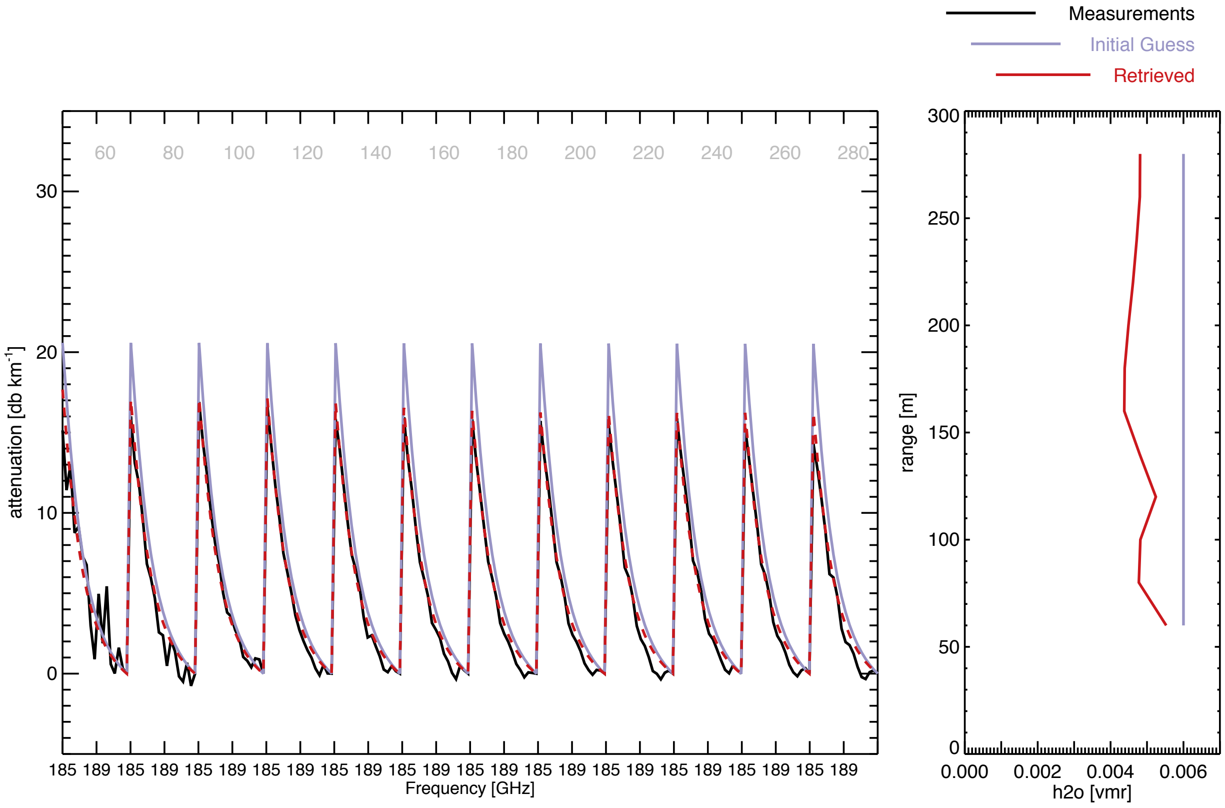
Millán (2016) – 10.5194/amt-9-2633-2016

Cooper (in preparation)

First VIPR Observations

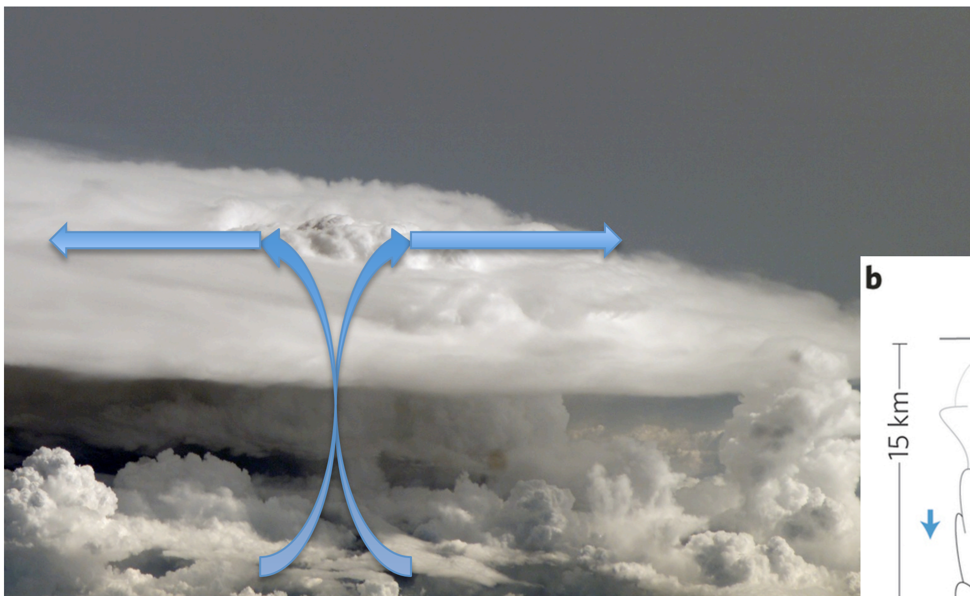


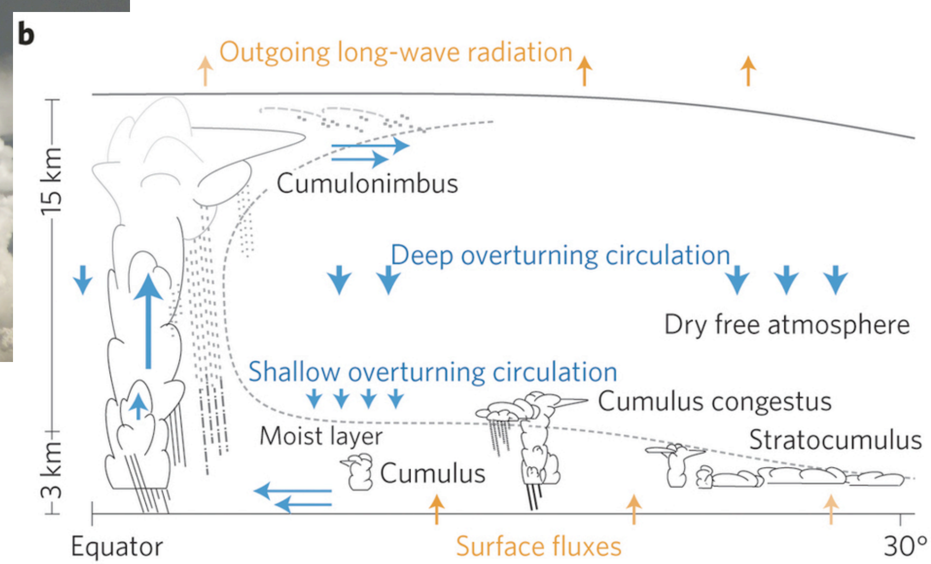




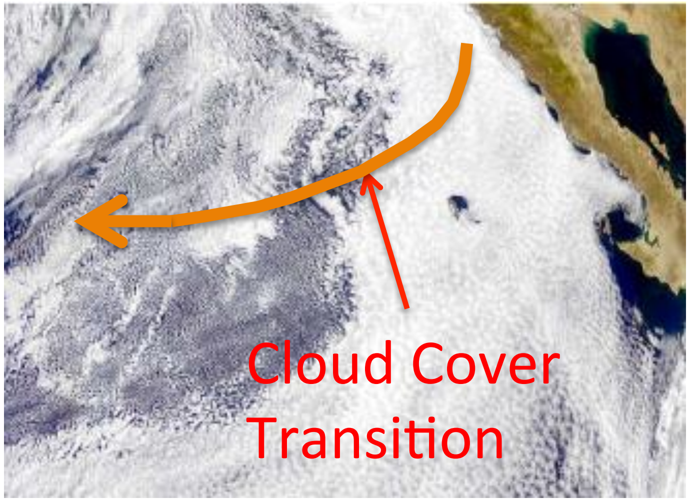
Science Scenario 1: Convective Mixing

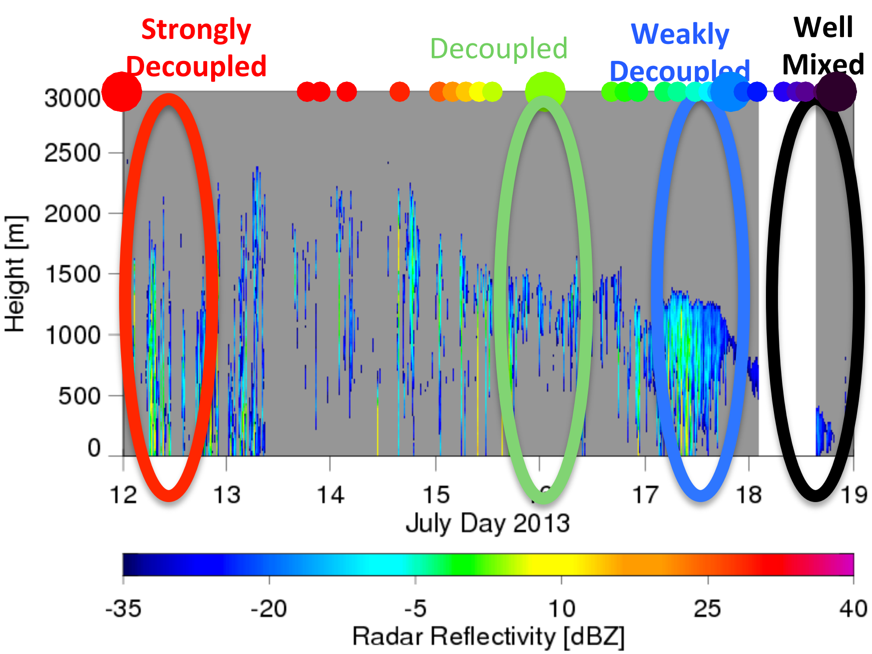
- How efficiently does moist convection transport moisture to the upper troposphere?

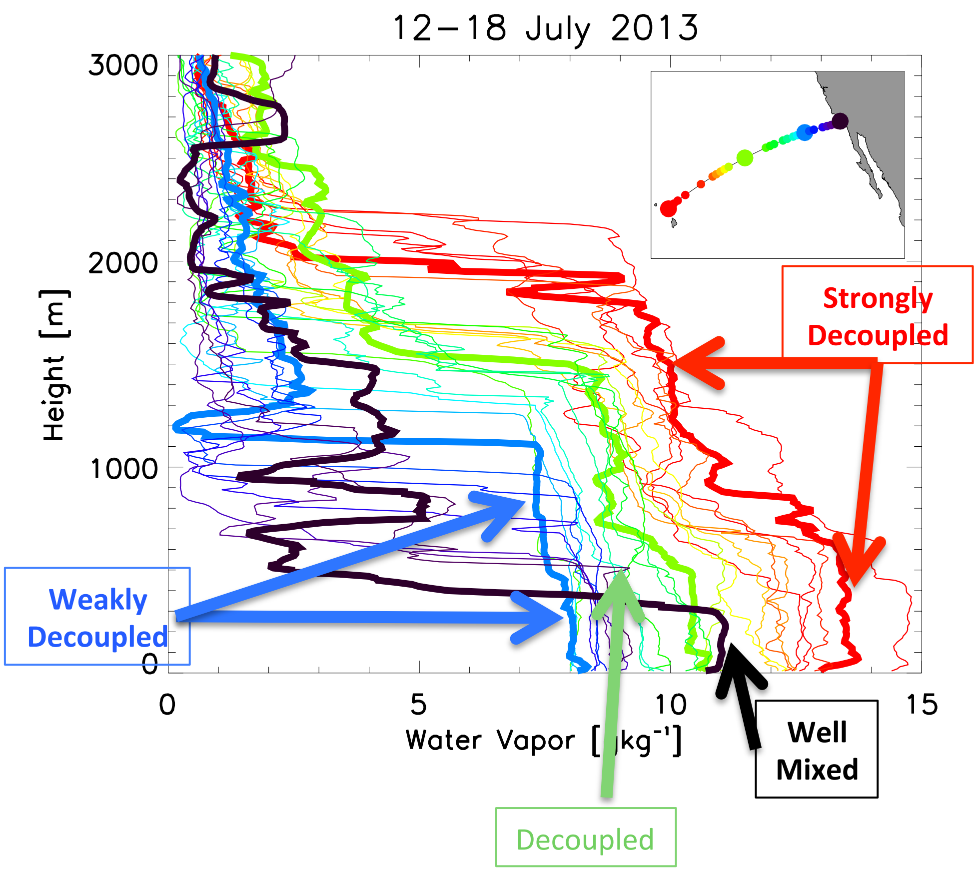




Science Scenario 2: Shallow Cloud Cover







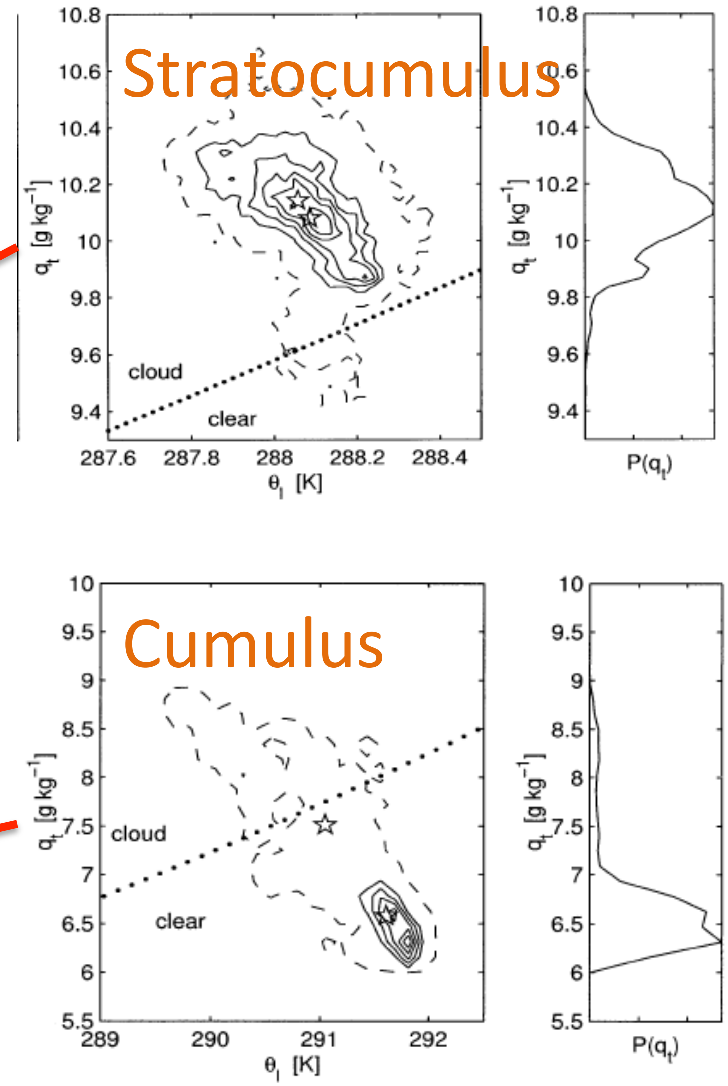
Science Scenario 3: Water Vapor Variance

-Cell width ~ 15-25 km (Order~microwave imagers).

-High resolution CWV would enable quantifying the variance.

Terra - MISR

Different cloud regimes have very different water vapor variability



Larson et al., 2002