

# DOE ARM Climate Research Facility – Providing Research Quality Data Products for Climate Model Evaluation and Enhancement

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## 1. The ARM Climate Research Facility

DOE Office of Science National Scientific User Facility

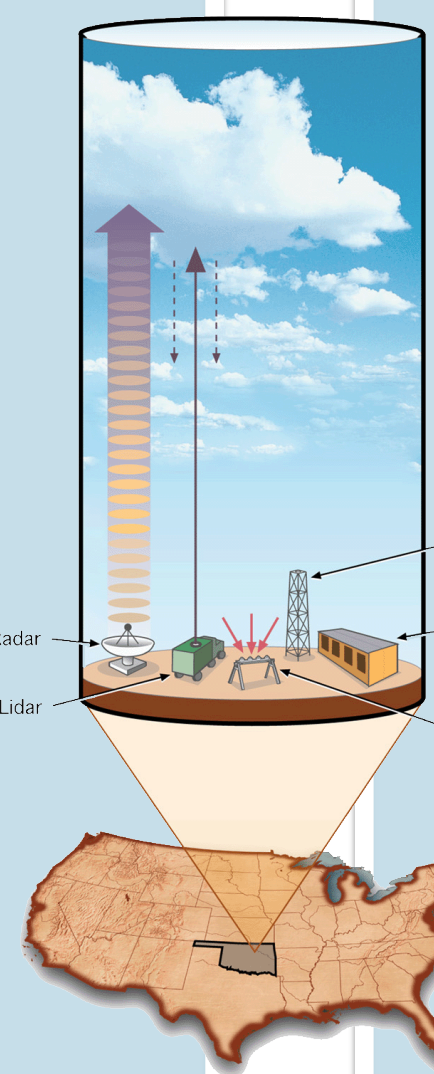
High quality, research data products for atmospheric and climate sciences

National and international research sites spanning the tropics to the arctic and including mobile and aerial facilities

Primary focus on measurements needed to advance the understanding of clouds and radiative feedbacks

To use this understanding to improve the performance of climate models

Learn more by visiting our Webpage:  
<http://www.arm.gov>



## 2. ARM Measurements

Each ARM Site Includes an array of instruments for measuring cloud and aerosol properties along with profiles of temperature and humidity and the surface radiation budget.

- Cloud profiles: millimeter radar and lidar
- Temperature/relative humidity/wind profiles: radiosondes
- Column water: microwave radiometer
- Column aerosol: solar spectral radiometer
- In situ aerosol optical and cloud nucleation properties
- Surface radiation budget: solar and terrestrial IR radiometers
- Surface meteorology: T/RH/wind

## 3. Recovery Act Enhancements

Through the Recovery Act, ARM has significantly expanded its measurement capabilities.

These measurements will:

- Provide 3-dimensional measurements of cloud scale dynamics, microphysics, and precipitation
- Provide enhanced measurements of atmospheric aerosol composition and chemistry
- Develop an in-house an in-house capability for airborne measurements of clouds and aerosols
- Expand capabilities for measuring parameters including vertical motion and humidity profiles



### Instrument Types

- Scanning Dual-Frequency Cloud Radars
- Scanning Precipitation Radars
- Reference Rain Network
- Lidars for Clouds, Aerosols, Water Vapor, and Vertical Motion
- Multi-frequency Microwave Radiometers
- Infrared and Solar Spectroradiometers
- Expanded Surface Flux Network
- Atmospheric Aerosols and Chemistry
- Airborne probes for cloud, aerosol, and atmospheric state properties
- Research Site Infrastructure, Computing, and Networking

A list of instruments being purchased is available here: <http://www.arm.gov/about/recovery-act>

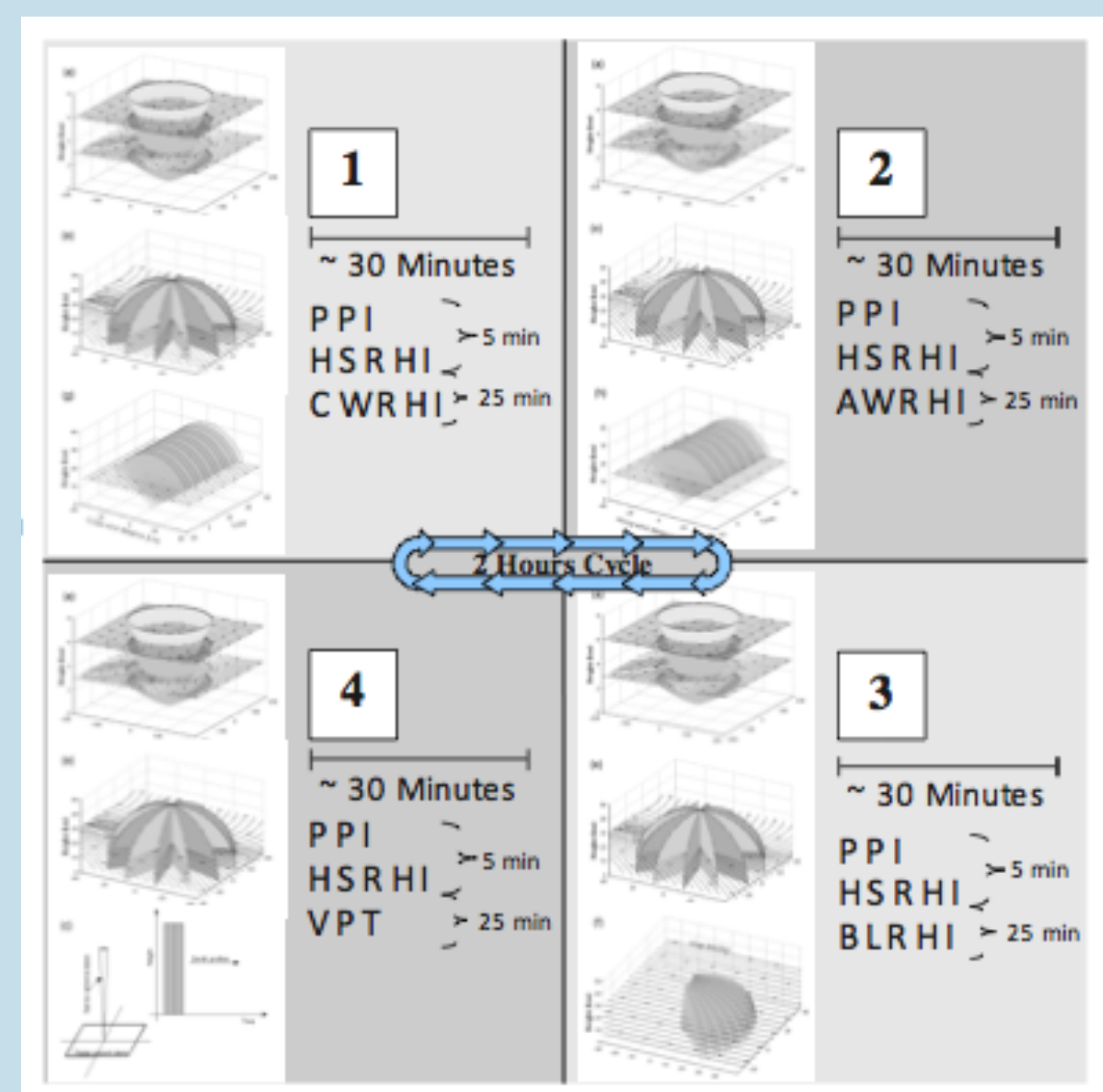
## 4. Cloud Properties and Life Cycle

### Advanced Radars for Cloud Research

ARM is deploying an assortment of radars that span a range of frequencies for sampling both clouds and precipitation.

Many of these radars will scan to provide 3-D cloud structures. We are currently exploring scanning strategies to optimize the study of cloud evolution.

Some radars will have dual-polarization which combined with multiple frequencies will provide improved microphysical retrievals including better discrimination of liquid from ice.



Current scan sequence for the Scanning ARM Cloud Radars (Nitin Bharadwaj)

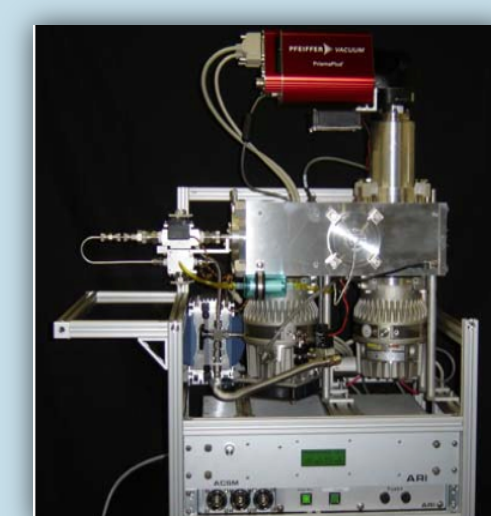
## 5. Aerosol and Chemistry Observations

### Aerosol Measurement Enhancements

Two additional sites (Darwin and the second mobile facility) will have Aerosol Observing Systems measuring aerosol optical properties and cloud nuclei. Four Aerosol Observing Systems will be co-located with an advanced lidar (Raman or HSRL) capable of measuring vertical profiles of aerosol extinction

A new mobile aerosol system will provide additional capabilities for determining aerosol composition. Many of these instruments will also be available for aerial deployments.

Goals of this new array of aerosol and chemistry instruments are to study the life cycle of aerosols, to characterize aerosols through the vertical column, and study interactions between aerosols and clouds.



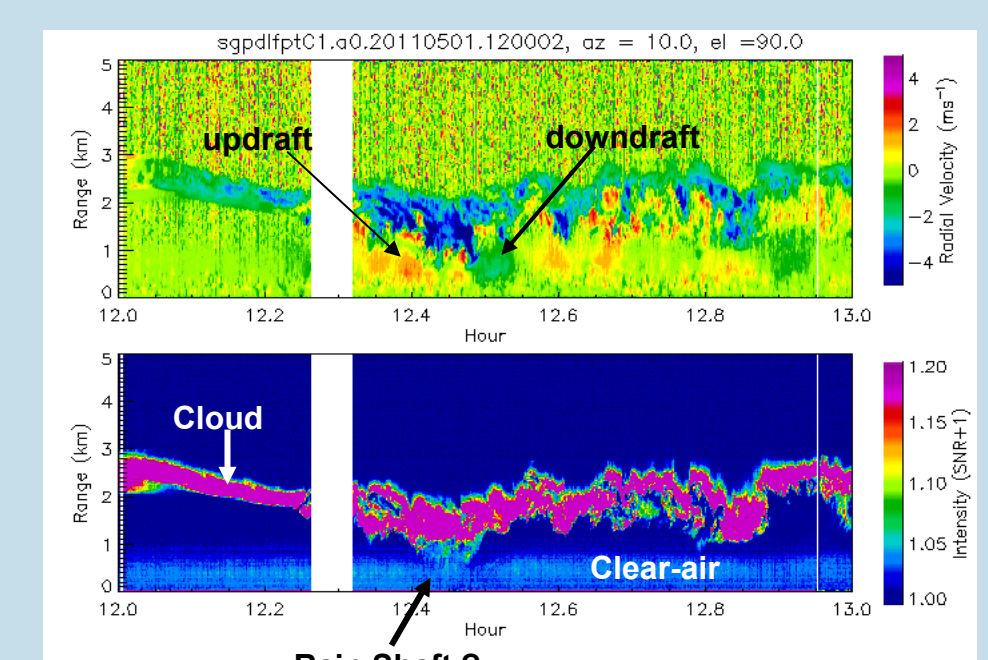
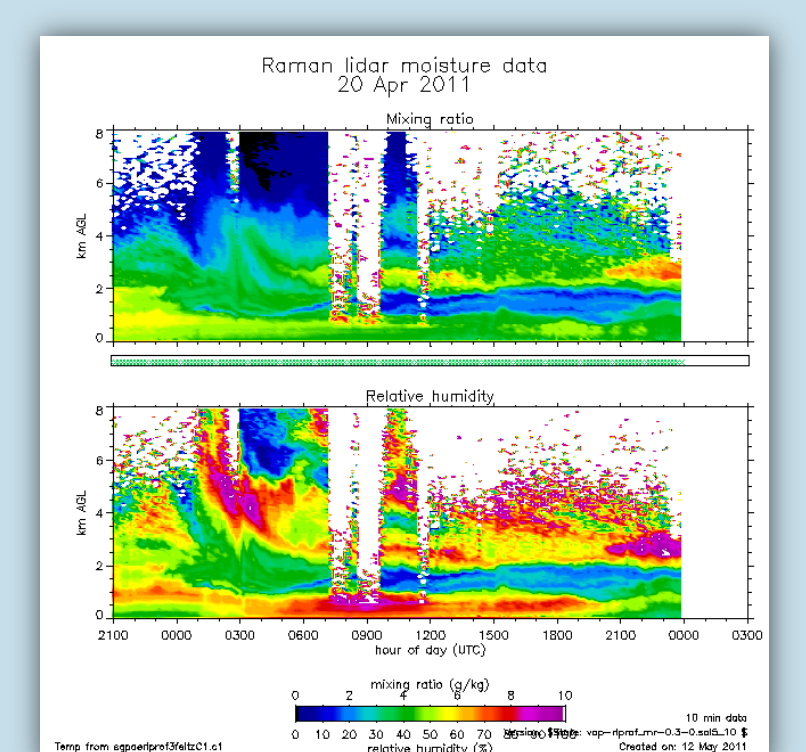
## 6. Atmospheric State Observations

Enhancements are being made to measurements of the atmospheric state. These will include:

Profiles of water vapor from a Raman lidar in Darwin.

Profiles of clear air vertical velocity from Doppler lidars in Oklahoma, Darwin, and the 2<sup>nd</sup> Mobile Facility.

These observations will be important for studying life cycle processes of clouds and aerosols and will provide a more complete description of the atmospheric column.

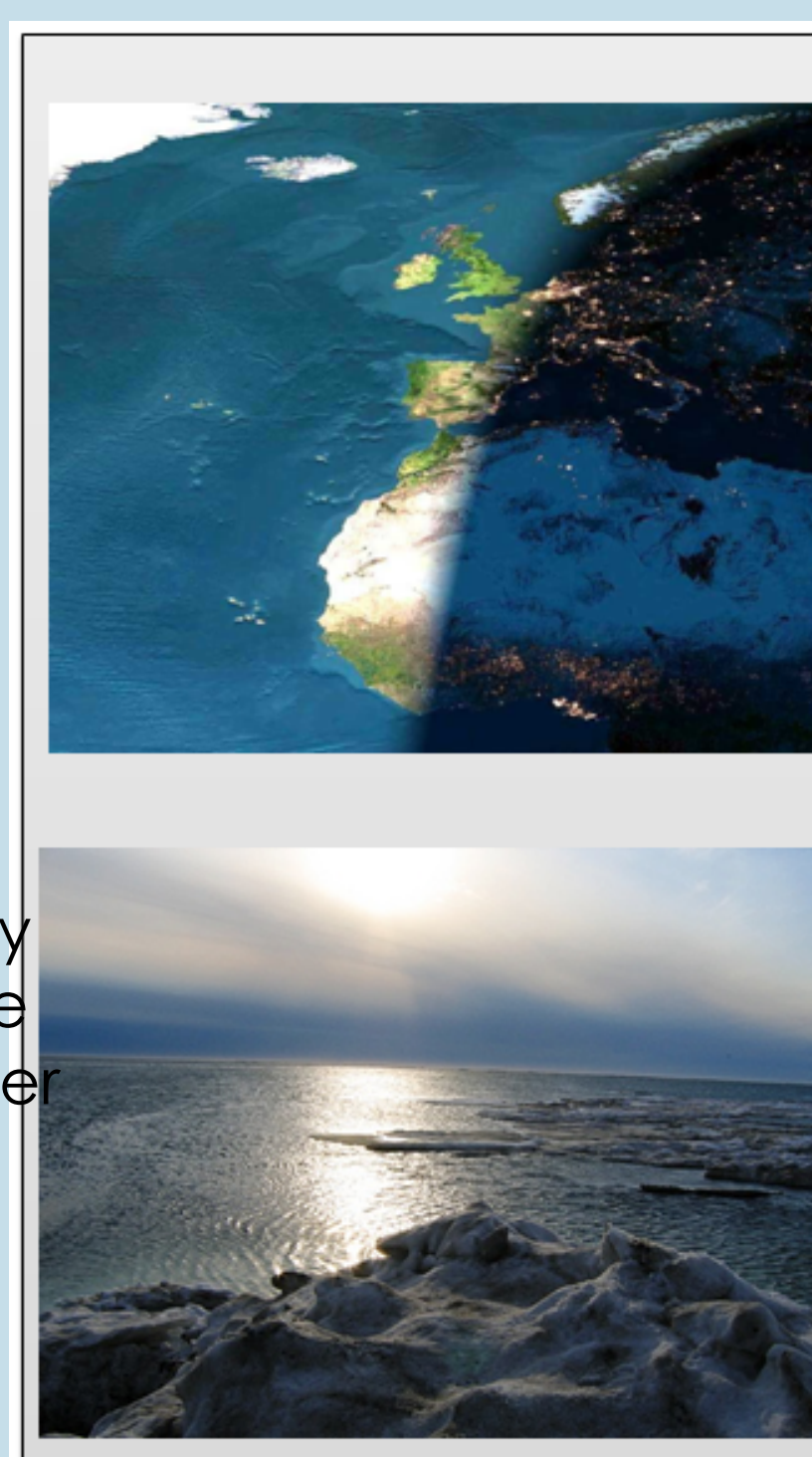


Courtesy: Rob Newsom

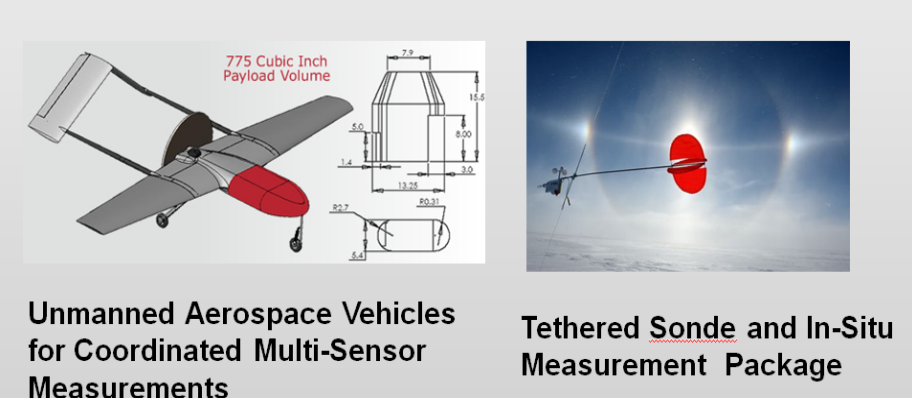
## 6. Two New Sites

**Eastern North Atlantic:** Long-term deployment in the Azores, returning to the site of the 2009-2010 Mobile Facility deployment. New observations relative to the AMF deployment include 3D clouds, precipitation, and vertical velocity.

**North Slope of Alaska:** Extended deployment of a new Mobile Facility at Oliktok near Prudhoe Bay. The site features the potential to fly UAVs over the arctic sea ice.



### Fundamentally New Arctic Measurements



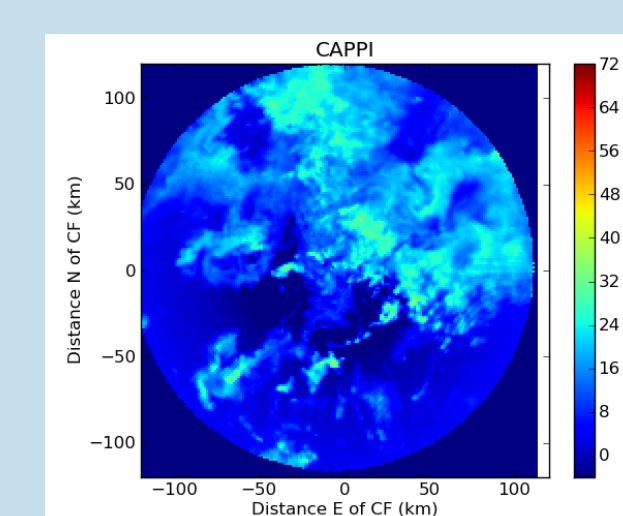
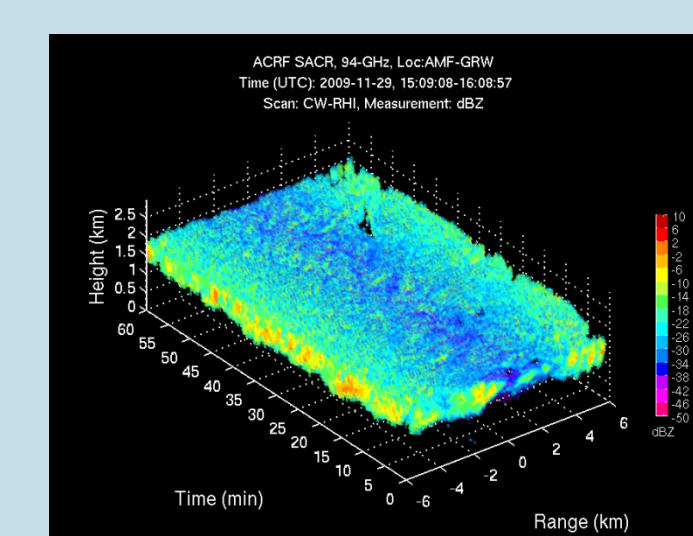
## 7. Value Added Data Products

With the majority of Recovery Act instruments now operating in the field, the focus is now turning to develop new data products. ARM Value Added Products provide derived physical parameters, refined quality assessments, and parameters merged onto common grids from multiple sources.

Products currently under development for the Recovery Act instruments include a cloud mask for the scanning radars and quantitative precipitation estimates from the cm-wavelength radars.

All ARM data are available through the ARM data archive:  
<http://www.archive.arm.gov>

A new user interface is also now available for evaluation. This interface provides enhanced searching capability and access to other metadata:  
<http://www.archive.arm.gov/discovery/#v/home/s/>



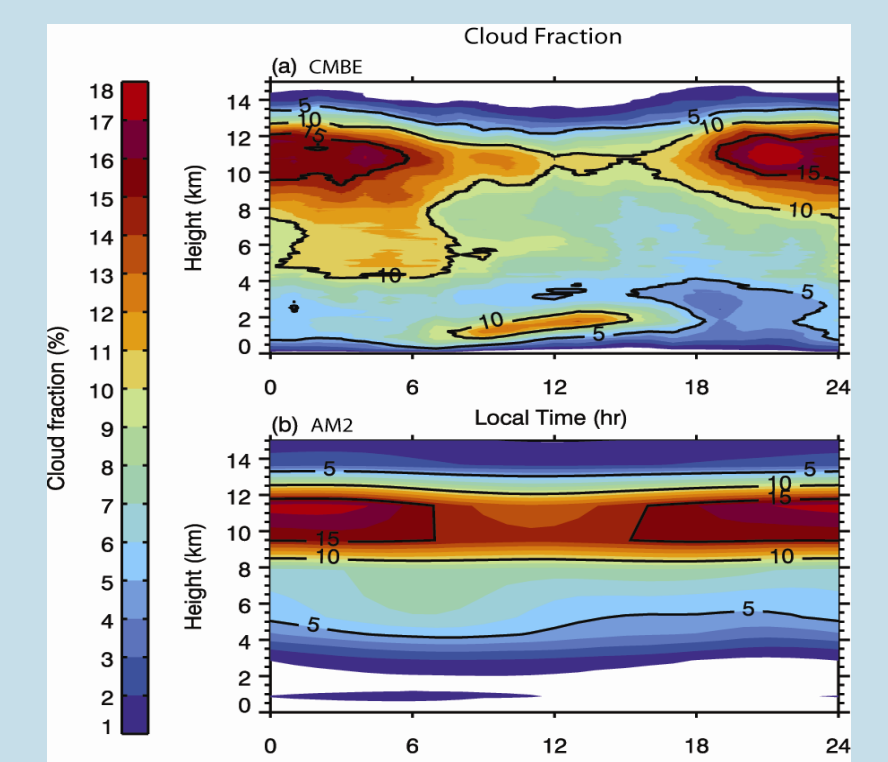
## 8. Data Products for Model Development

ARM measurements provide data at high temporal and spatial resolution and are well-suited for directly applying to process studies. For direct application to model evaluation, several products have been developed that are better suited to a coarser scales, and aggregated parameter sets.

- The suite of ARM Best Estimate (ARMBE) products merge parameters from multiple sources onto a uniform time/height grid.
- The Variational Analysis Product provides dynamical forcing to drive cloud resolving or single column models
- The ARM Cloud Retrieval Ensemble Dataset (ACRED) combines multiple cloud retrievals with the object of assessing retrieval uncertainties.

These products are now being widely applied for model evaluation.

ACRED is part of a larger effort – the Quantification of Uncertainties in Cloud Retrievals (QUICR). The QUICR group led by Shaocheng Xie is bringing together multiple retrievals, in situ observations, and analyses to characterize cloud retrievals.



Comparison of ARMBE with the AM2 GCM (Xie et al., 2010)

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