



ARM Data Products for Climate Model Evaluation

Jim Mather

Technical Director, ARM Climate Research Facility

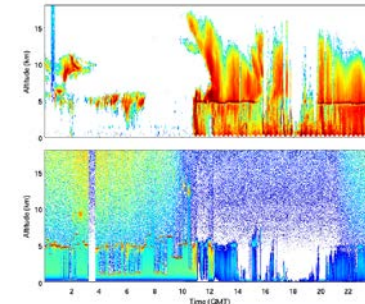
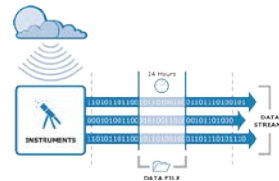
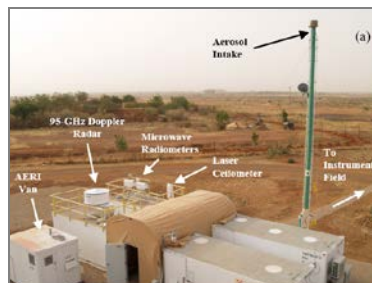
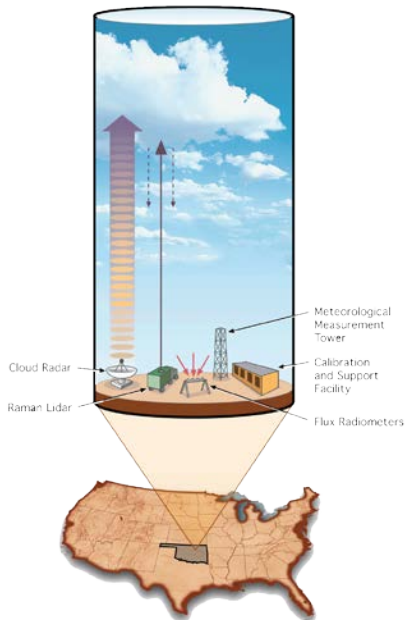


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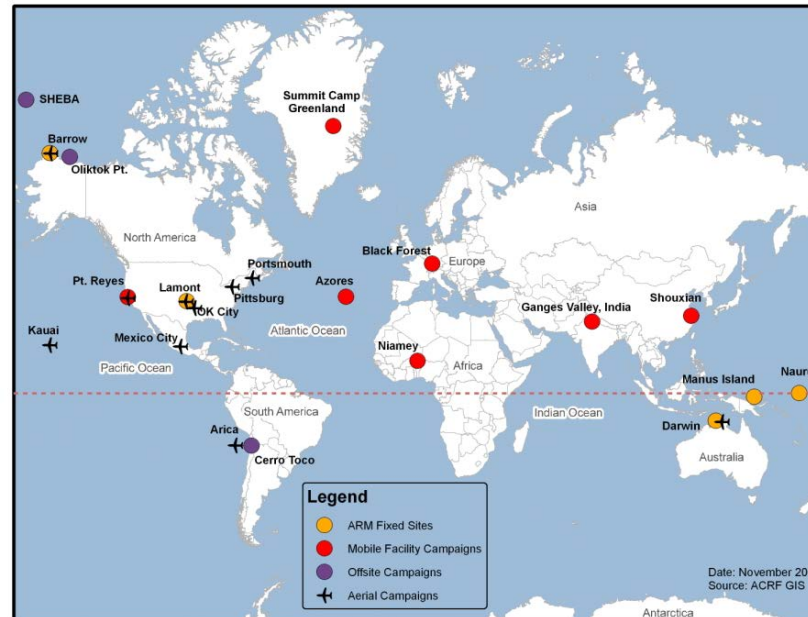
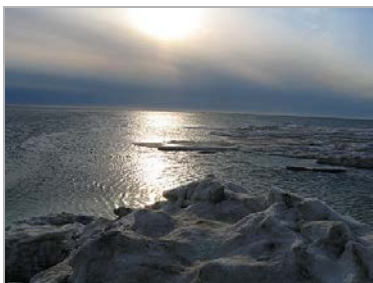
The ARM Climate Research Facility

The Atmospheric Radiation Measurement (ARM) Climate Research user facility collects and delivers ground-based observational data for the climate research community to improve understanding of atmospheric processes and support the improvement of climate models.



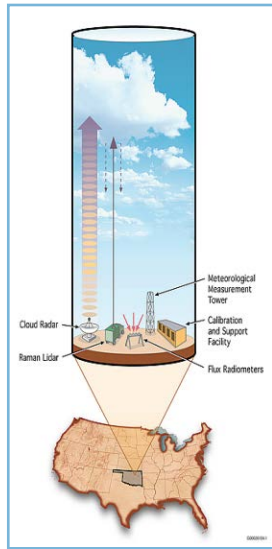
- Research sites – permanent, mobile, and aerial
- Instruments and measurements (clouds, aerosols, atmospheric state)
- Data processing, data quality, Data Archive
- Field campaigns – ground-based and airborne
- The ARM facility is managed and operated through 9 DOE laboratories

Research Sites

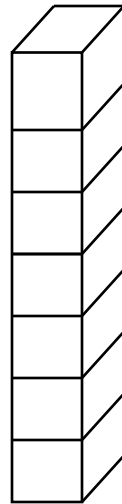
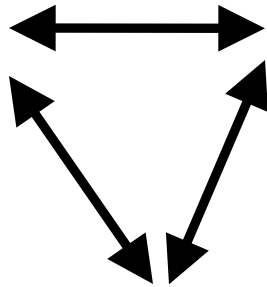


- Permanent sites in the US Southern Great Plains, the North Slope of Alaska and the Tropical Western Pacific
- Mobile facility deployments have included coastal California, Niger, Germany, China, Portugal (the Azores), Colorado, India and The Maldives
- The ARM Aerial Facility includes support for a Gulfstream G1 and a Cessna 206

The ARM integrated modeling approach



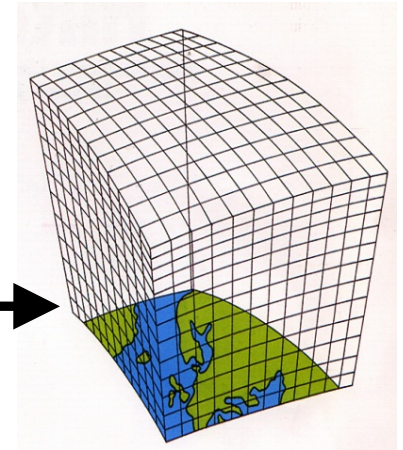
ARM Data



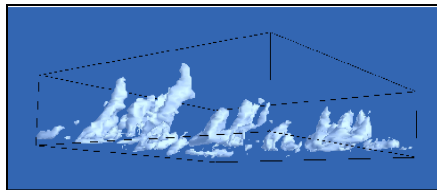
SCM



CAPT



GCM

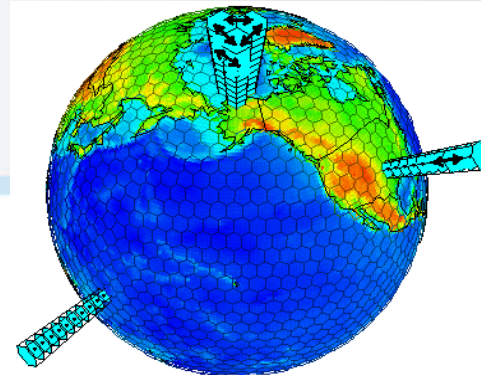


CRM/LES

- Special ARM Datasets for Modelers**
 - Forcing dataset/variational analysis
 - Composite best estimates

Courtesy Shaocheng Xie

Forcing data for model simulations over ARM sites



“Advective Forcing” computed from observations

“Physics” computed from:

- CRM explicitly
- SCM parameterizations

$$\frac{\partial s}{\partial t} = -V \cdot \nabla s - \omega \frac{\partial s}{\partial p} + L(c - e) - \frac{\partial \overline{\omega' s'}}{\partial p} + Q_{rad}$$

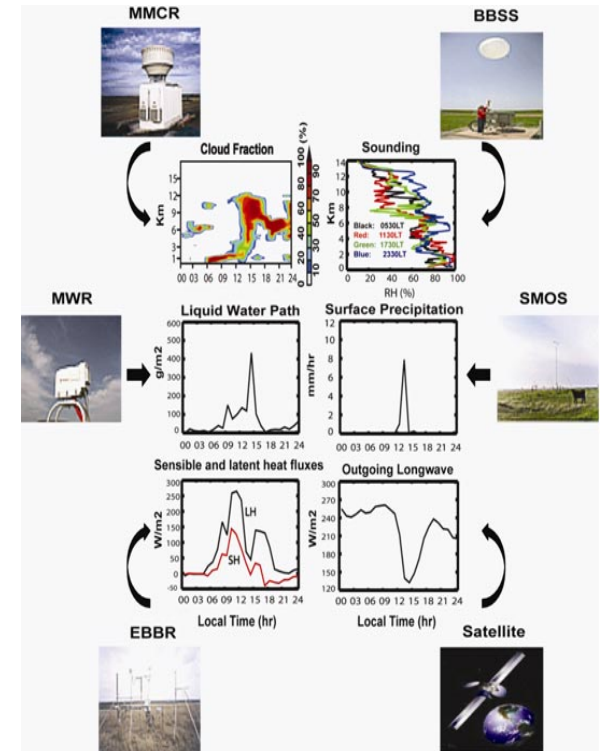
$$\frac{\partial q}{\partial t} = -V \cdot \nabla q - \omega \frac{\partial q}{\partial p} + (e - c) - \frac{\partial \overline{\omega' q'}}{\partial p}$$

The Climate Modeling Best Estimate Data Product (CMBE)

Assembling those fields that are often used in climate model evaluations from the highest quality of data ARM has available for many years into one single data file with a temporal resolution (one hour) comparable to climate model output.

Xie et al. 2010, BAMS

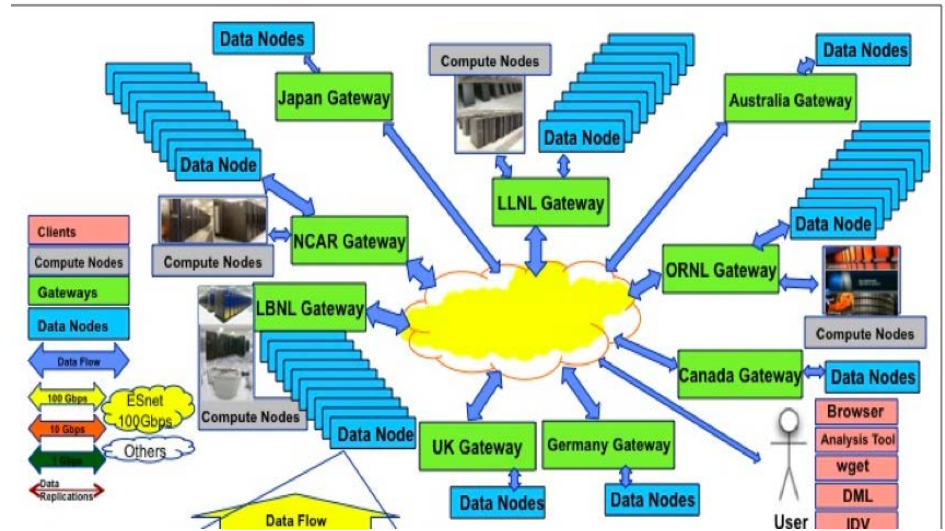
- **CMBE-CLDRAD**
 - Cloud fraction profiles
 - Total clouds
 - Liquid Water Path/Precipitable Water
 - Surface radiative fluxes
 - TOA radiative fluxes
 - Satellite retrieved clouds
- **CMBE-ATM**
 - Soundings
 - NWP analysis data
 - Surface heat fluxes
 - Surface precipitation
 - Surface temp, RH, and winds



CMBE and Model Evaluation

- Included in the CESM diagnostics package
- Now included in the Earth System Grid for broader model applications
- Currently available through the ORNL Gateway

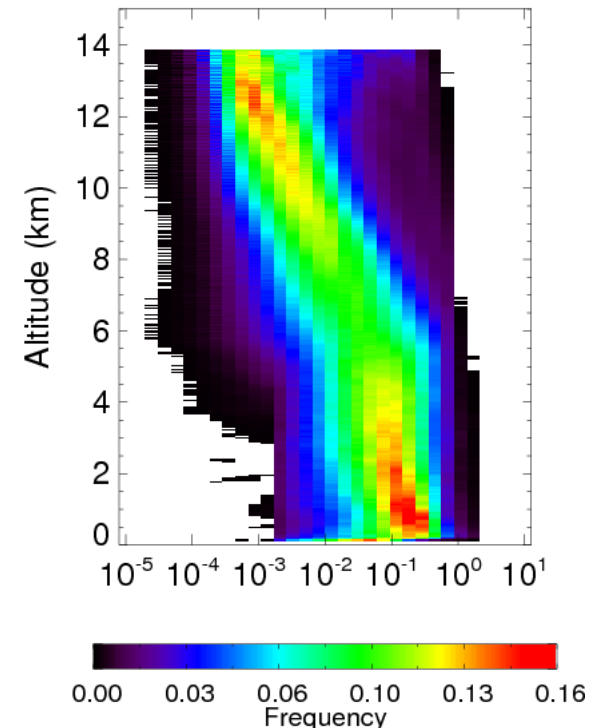
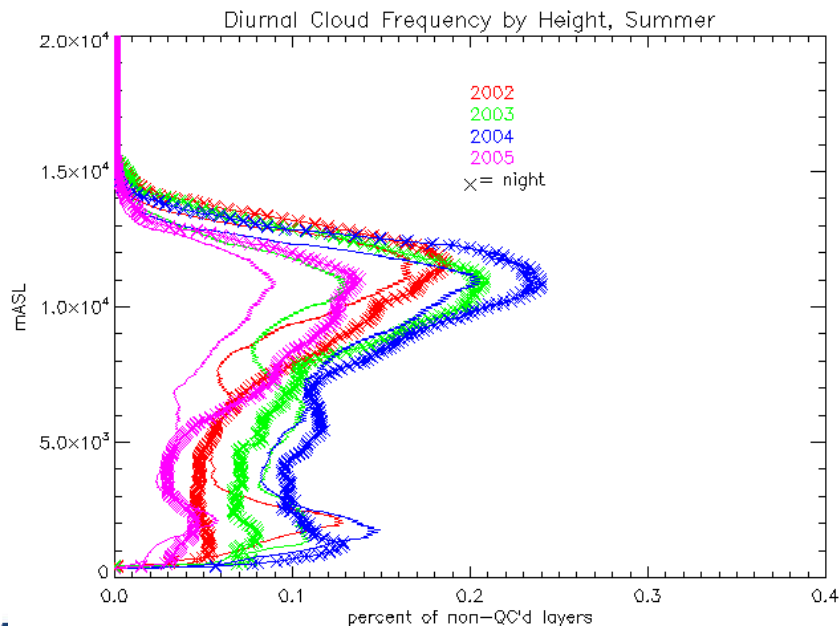
ESG: Earth System Grid



The ESG is the next generation infrastructure that enables distributed data analysis through sharing of climate model output data (IPCC and other) and observational data sets

Radiatively Important Parameters Best Estimate (RIPBE)

- Combines all radiatively important parameters (cloud and aerosol properties, water vapor, temperature, ozone, surface albedo) required to calculate radiative fluxes and heating rates on a uniform vertical and temporal grid



Frequency distribution of cloud condensed water (liquid+ice) content over Oklahoma.

Recovery Act: Introduction

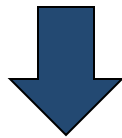
- DOE Office of Science investments in instrumentation and research infrastructure to support the instrumentation and the associated increase in data volume and complexity
- 3-dimensional measurements of cloud scale dynamics, microphysics, and precipitation
- Enhanced measurements of atmospheric aerosol composition and chemistry
- Deploying over 100 new instruments plus enhancements to facility infrastructure
- Enhance measurement base to bridge new knowledge into climate models

<http://www.arm.gov/about/recovery-act>

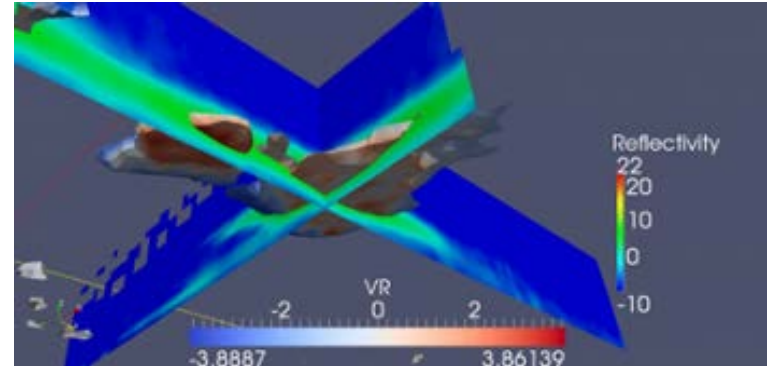


Cloud and Precipitation Products

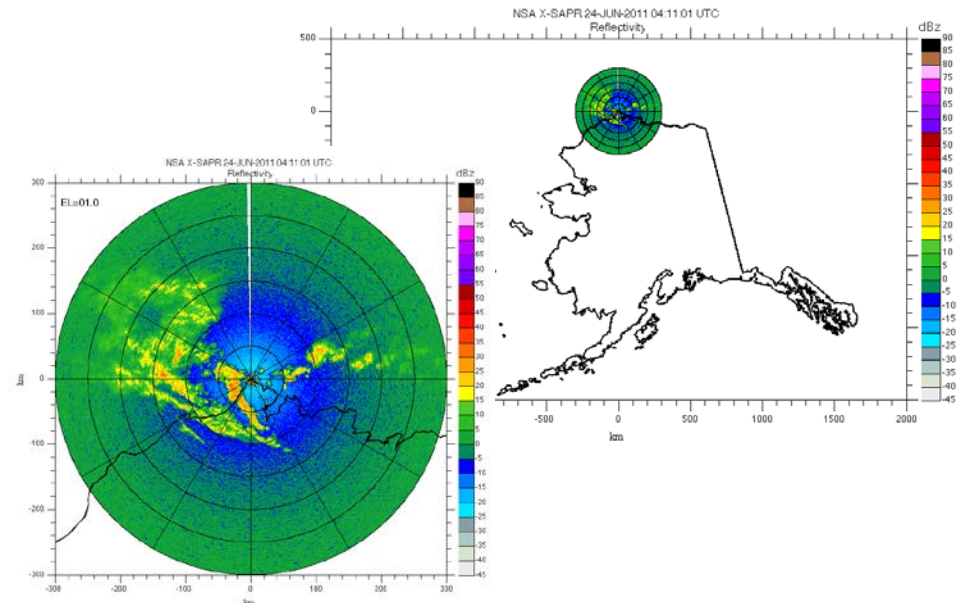
Millimeter Wavelength Radar
Centimeter Wavelength Radar
Raman and Extinction Lidar
Spectral Radiometers
In Situ Aircraft Probes



Cloud Boundaries (1-3D), phase,
particle sizes and shapes,
Liquid and Ice water content, 2-D
precipitation rates



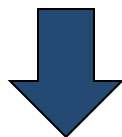
3-D cloud field Courtesy Scott Collis



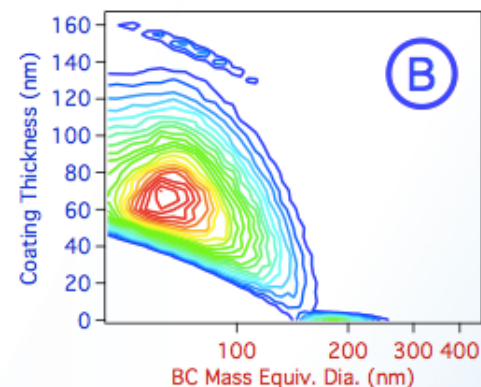
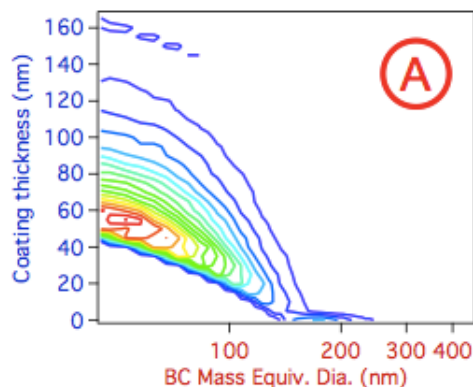
2-D Precipitation map from Barrow, AK
Courtesy Nitin Bharadwaj¹⁰

Aerosol Products

Nephelometers, Particle Counters, Cloud Condensation Nuclei Counters, Particle Size Probes, Chemical Speciation Monitor, Soot Photometers, Solar Spectrometers



Optical properties, Size distributions, bulk composition, Optical extinction profiles, Cloud nuclei concentrations



Aerosol coating thickness as a function of particle size for clean (A) and polluted (B) conditions.

Courtesy Art Sedlacek

Other Measurements and Proposed Data Products

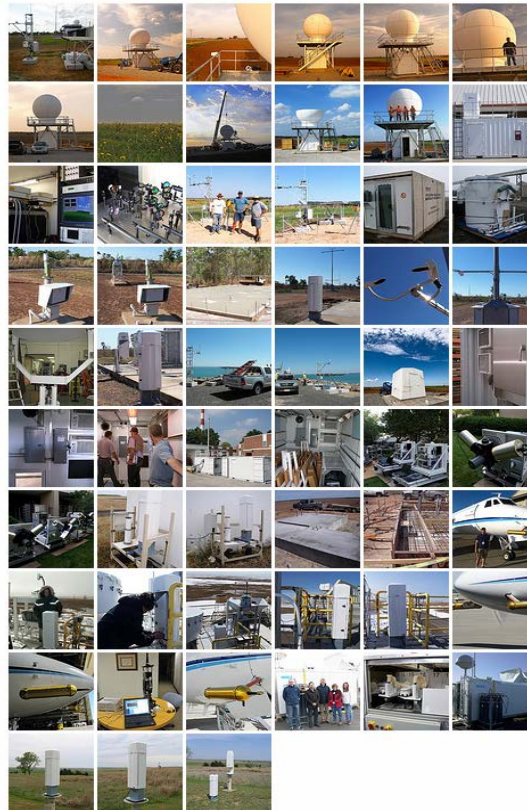
Vertical Velocity in
Clouds and Clear Air

Lidar-based water
vapor profiles from
Darwin, Australia

Surface heat fluxes in
the tropics and the arctic

Boundary layer height
from lidar and radar
observations

Airborne measurements
of cloud and aerosol
properties



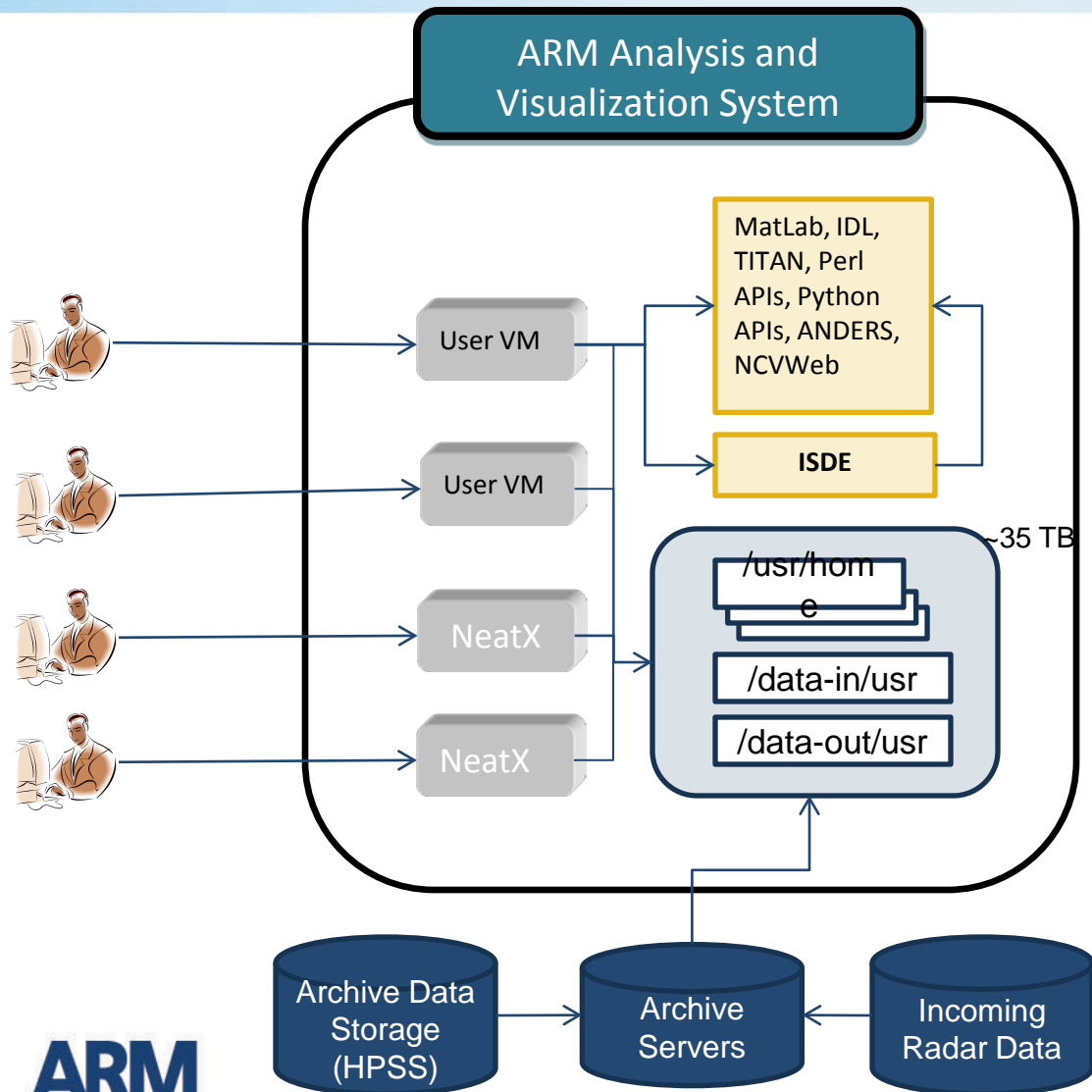
Liquid Water Path in
thin clouds from a 3-
channel microwave
radiometer

ARM

CLIMATE RESEARCH FACILITY

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Data Infrastructure Enhancements: Interactive Analysis System



- **Interactive visualization**
 - Users request access to the cluster
 - Almost instance access to the Archive users
 - need to create one more account (can use the same archive user id)
 - User-saved “views” and data extractions can be made available via web services
- **Software Development**
 - Access to local copy of Integrated Software Development Environment (ISDE)
 - Users develop scripts using ISDE, test it with locally available data.

Courtesy Giri Palanisamy

Engaging with ARM Data

Order data from the ARM archive at:

<http://www.arm.gov/data>

Information about special products is found on the Value Added Product (VAP) page:

<http://www.arm.gov/data/vaps>

The ARM Mobile Facility or Aerial Facility is deployed in response to an open call. Pre-proposals will be due in January. Information will be coming at in November:

<http://www.arm.gov/campaigns>



Questions about data or instruments? Or suggestions? Let us know! Links to submit comments are available on most www.arm.gov pages.

Or Contact me:

Jim.Mather@pnnl.gov