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Atmospheric Radiation Measurement (ARM) Climate Research User Facility

Wanda R. Ferrell, Ph.D.
(Acting) Division Director
Climate & Environmental Research Division
Biological & Environmental Research
Office of Science
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(ARM) Climate Research User Facility

Mission:

To provide high-quality, long-term, continuous measurements needed to determine the effects of atmospheric water vapor, clouds and cloud properties, and aerosols on the radiation balance of the atmosphere across a range of climatic regimes.

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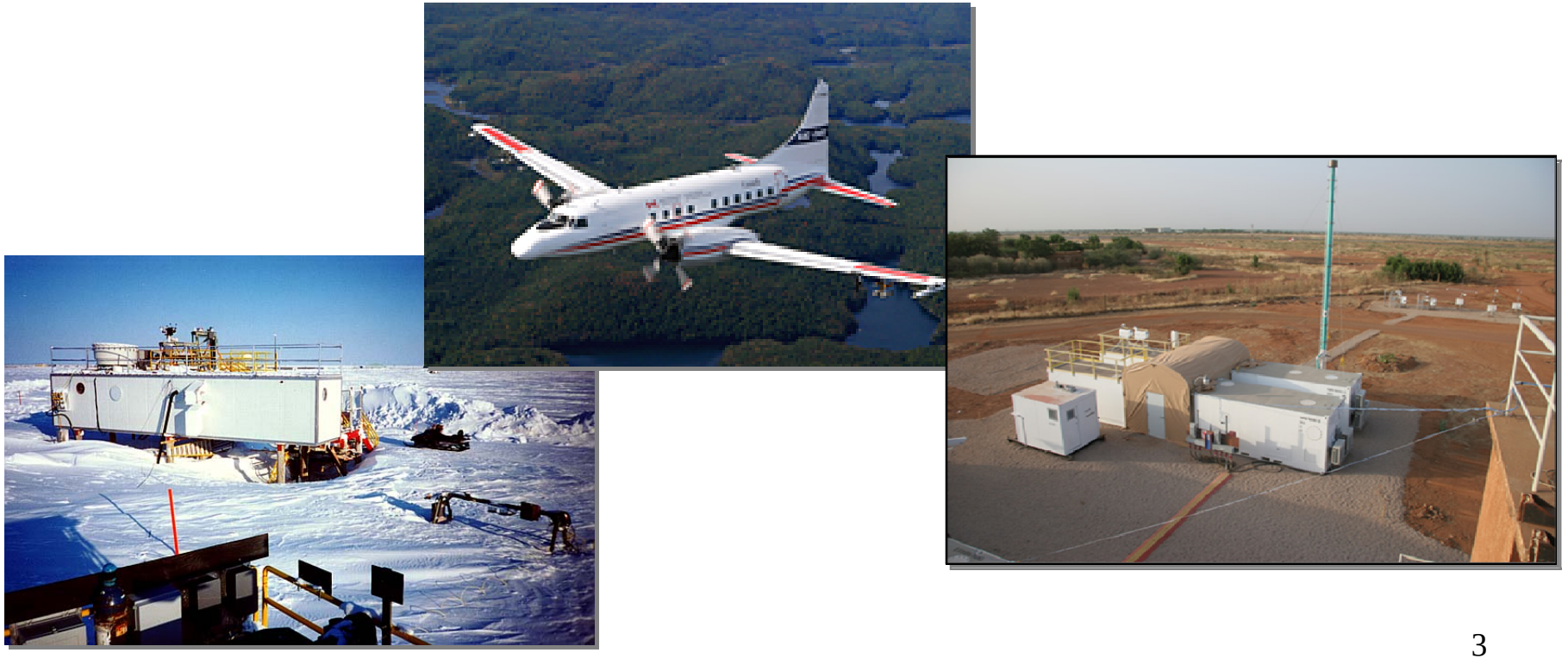
ARM Climate Research User Facility (ACRF)

Consists of Fixed and Mobile Sites
and Aerial Measurements



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ARM Climate Research User Facility (ACRF)

Shouxian instrument deployment, from left to right: microwave radiometer profiler, high-frequency microwave radiometer, and microwave radiometer.

- As a user facility the goal is to provide support for broader climate research community
- Primary focus is long-term measurements needed for climate studies
- Short field campaigns complement these long-term measurements and validate critical processes

Implications of User Facility Designation

- Proposals for facility use are peer reviewed
- Science Board reviews all major resource requests for site use
- OMB tracks operations metrics on quarterly basis

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Program Planning

Climate Change Strategic Plan

- BER's **Climate Change Program Strategic Plan** is complete
- ACRF planning is underway
- Input from scientists key to the planning effort
- October 21-22, 2008 Workshop collected ~30 climate research scientists to discuss the role of ACRF in solving outstanding climate science issues

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Workshop Guidelines

- Developing strategies for use and structure of the ACRF to support future scientific investigations and addressing remaining scientific uncertainties
- Long-term measurements will continue to be the mission of ACRF
- Consideration of new site locations and the mix of appropriate mobile, fixed, and aerial facilities
- DOE will use workshop findings and other sources to develop programmatic strategies

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Workshop Role in Planning

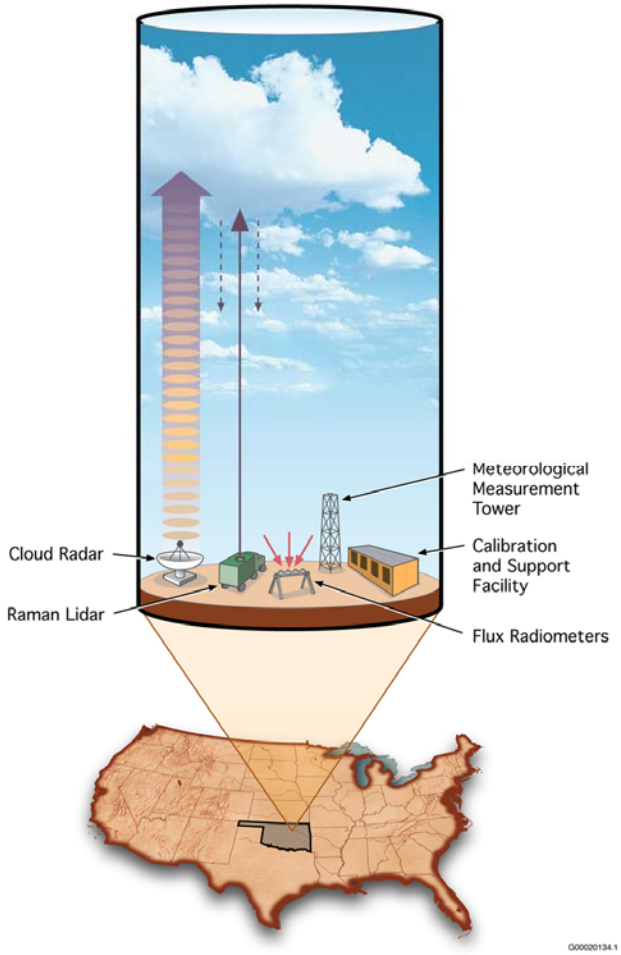
Questions to be considered by workshop participants:

1. What are the outstanding science questions for the next ten years?
2. What specific locations are appropriate to address science questions? How long an observational period will be required at each location?
3. What measurements, instruments, and data products are needed to address science questions?

Unique Scientific Leadership Capabilities

Workshop Conclusions:

- Data are continuously collected at sites with high temporal resolution. This makes ACRF observations ideal for studying the diurnal cycle, an important mode of climate variability that is not well sampled by most satellite sensors.
- ACRF is best suited to study processes at the local or cloud scale.
- Combination of spatial and temporal scales makes ACRF observations uniquely suited for studying local cloud processes, many aspects remain among the most poorly represented processes in climate models.



Outstanding Science Questions

1. How do aerosols influence ice-containing clouds?
2. How do aerosols influence liquid water clouds?
3. What is the relationship between aerosols and precipitation?
4. What controls the distribution of vertical velocity and how does it vary at spatial scales?
5. What is the relationship between dynamics and cloud properties?
6. How does precipitation evolve in clouds?

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Outstanding Science Questions
(continued)

7. What is the role of orography in cloud formation and precipitation?
8. What is the role of surface processes and properties in cloud formation (albedo, diurnal cycle, subsurface moisture, land cover)?
9. What is the profile of time-averaged radiative and latent heating and cloud properties?
10. How do we account for 3D radiative transfer in climate modeling and remote sensing?
11. What characterizes and controls the upper tropospheric humidity?

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Target Issues

1. Focus on the diurnal cycle, a time scale that ACRF is uniquely qualified to address.
2. Improve measurements of cloud properties and enable measurements during precipitation.
3. Determine the impact of aerosols on cloud properties.
4. Obtain measurements of trade cumulus, a key cloud type for climate processes
5. Increase emphasis on surface process measurements

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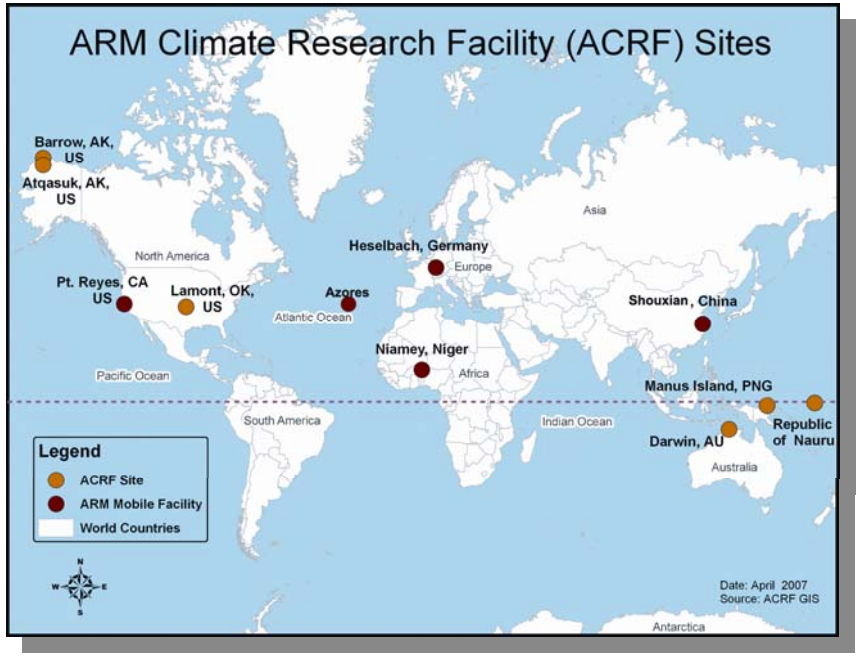
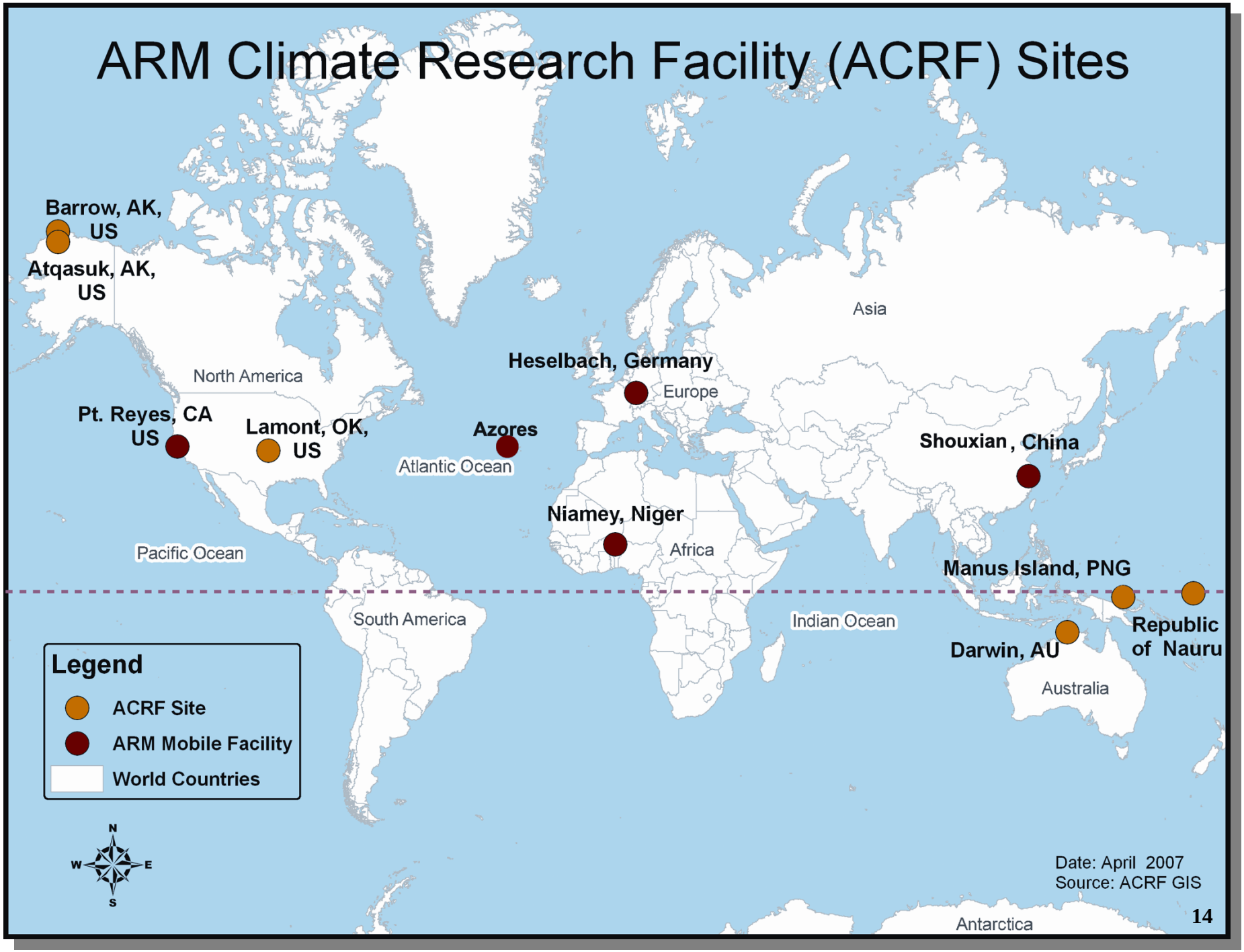
Site Location Discussions

- Two of the target issues: "aerosol measurements at an elevated site" and "measurements of trade cumulus" would require observations in a new location

- The remaining three could be carried out at the existing ACRF locales. In general, for the science issues put forward at the workshop, the majority could be addressed at the existing sites



ARM Climate Research Facility (ACRF) Sites



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New Instruments Needed

Focus on the diurnal cycle - Potential improvements include:

- Better temporal sampling of upper tropospheric water vapor
- Measurement of nighttime aerosol (e.g., with star photometry), and nighttime sky imaging (using an IR imager).

New Instruments Needed

Improve measurements of cloud properties and significantly improve ability to measure cloud properties during precipitation

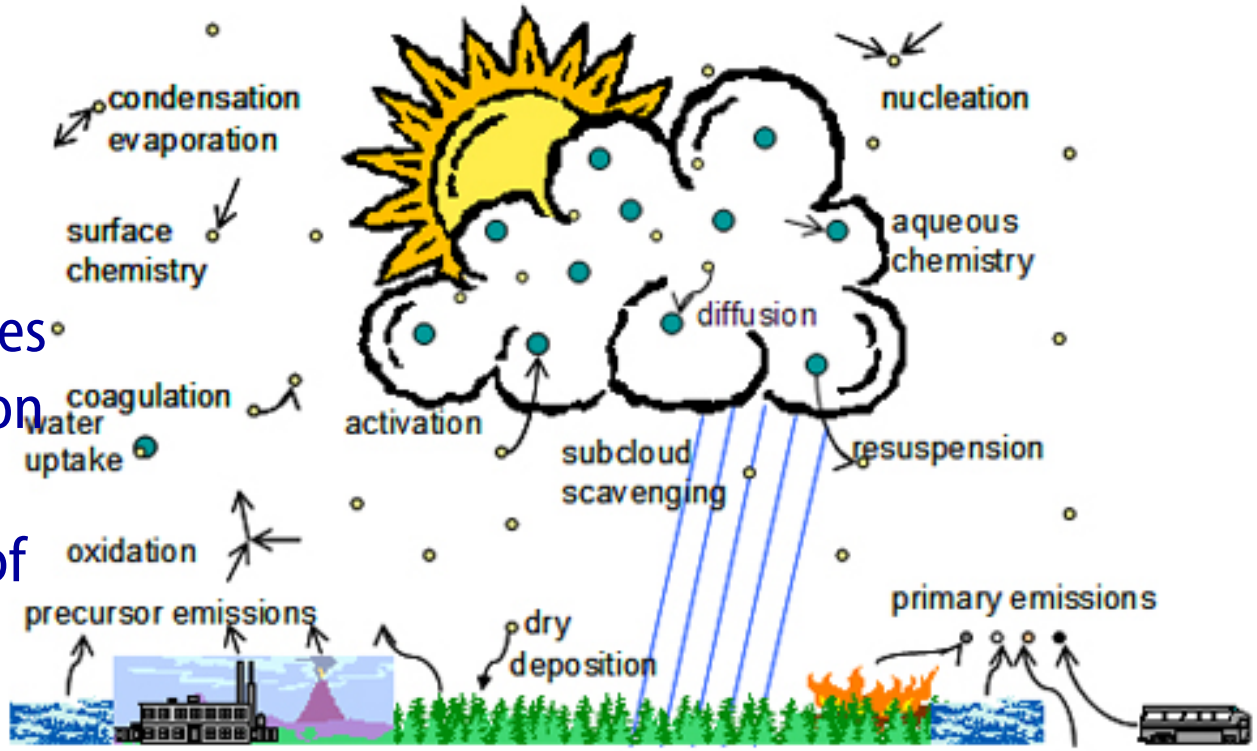
- Dual frequency scanning radars plus a precipitation radar
- Raman or differential absorption lidar

(click for tropical convective cloud animation)

New Instruments Needed

Determine the impact of aerosols on cloud properties:

- Instruments to determine detailed composition of the aerosol
- New site that includes a significant elevation change to gather a long-term data set of aerosol/cloud properties



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Scanning W-band ARM Cloud Radar

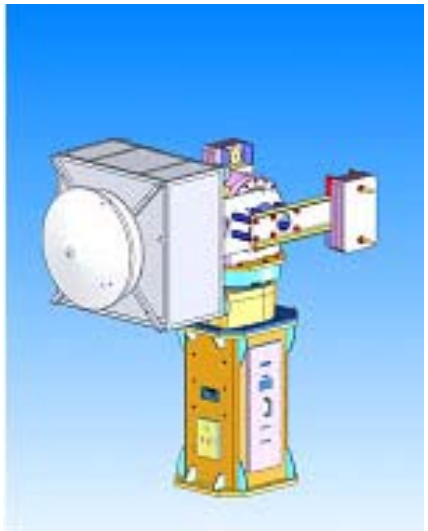
Same radar frequency as NASA's CloudSat

Capable of detecting all radiatively significant clouds in a radius of 5-10* km

Scanning capabilities:

1. Horizon to Horizon (fixed azimuth)
2. 360° revolution (fixed elevation)
3. Sector scan (for cloud tracking)
4. Staring mode

*depends on the presence of rain



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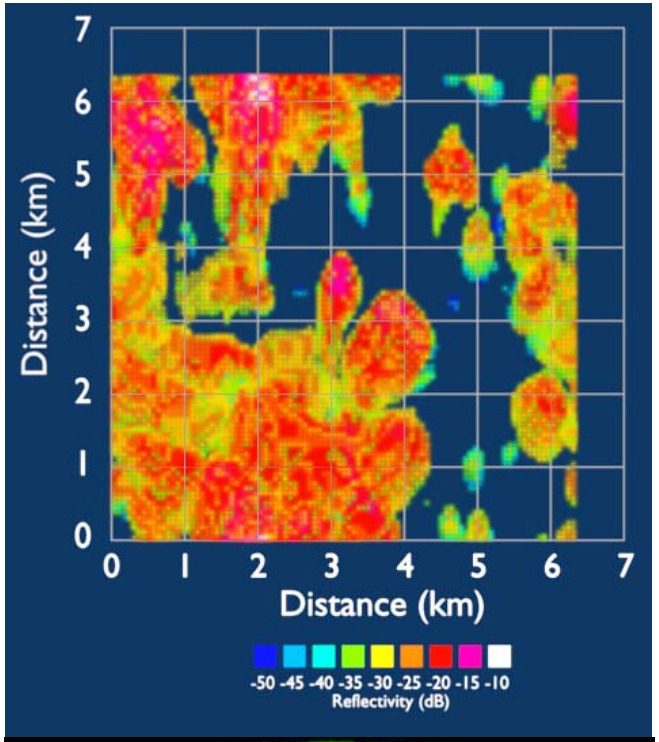
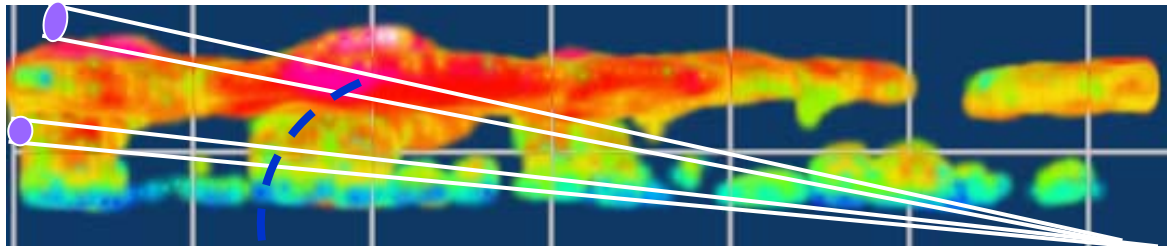
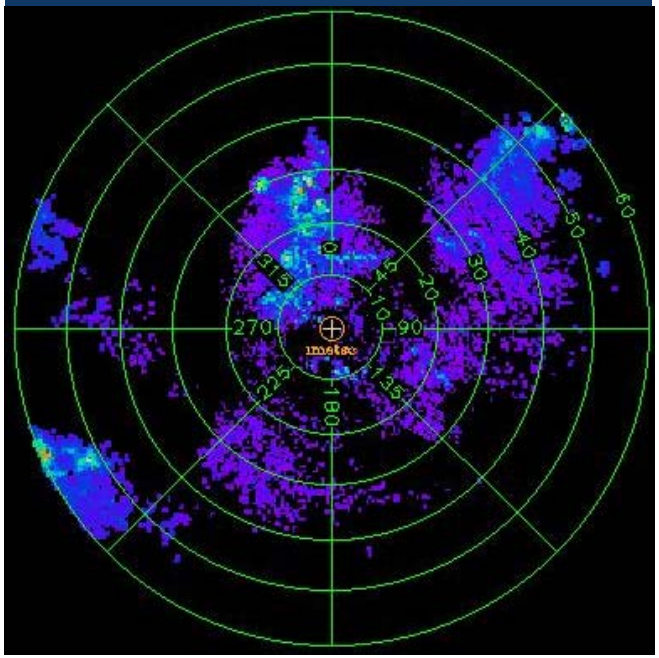
3D-Cloud Products
Case Study - Marine BL clouds







Low Elevation 360° revolution

Product: 3D cloud fraction

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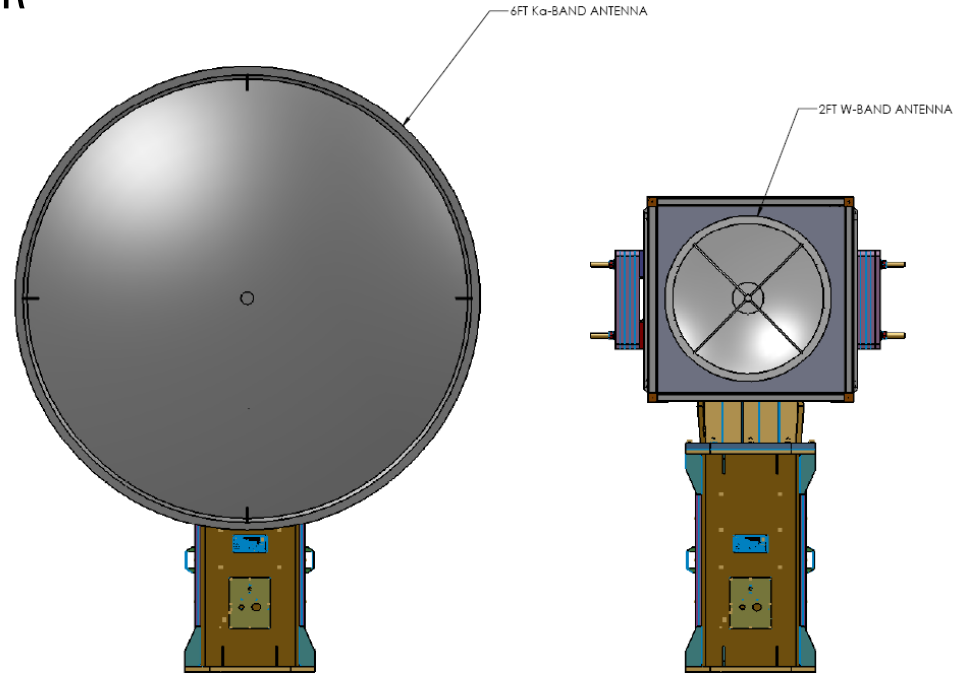
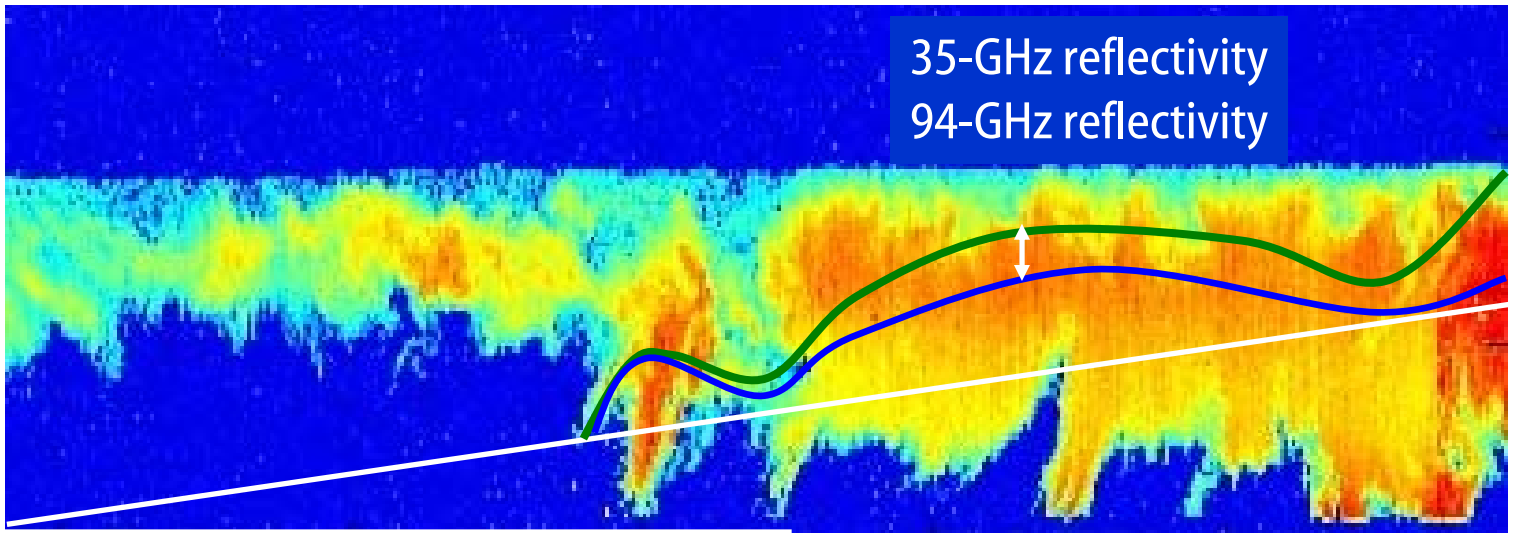
Scanning Dual-Frequency Radar

- Scanning dual frequency, dual polarization millimeter-wave cloud radar (35/95 GHz)
- Auxiliary radiometer channels at 35 and 95 GHz
- Matched beam widths
- Implementation will be similar to SWACR

- Two independent radars mounted on separate pedestals
- Allows re-use of SWACR
  - RF unit could be slightly modified to add radiometer channel
- Phase II SBIR funds sufficient to build Ka-band system

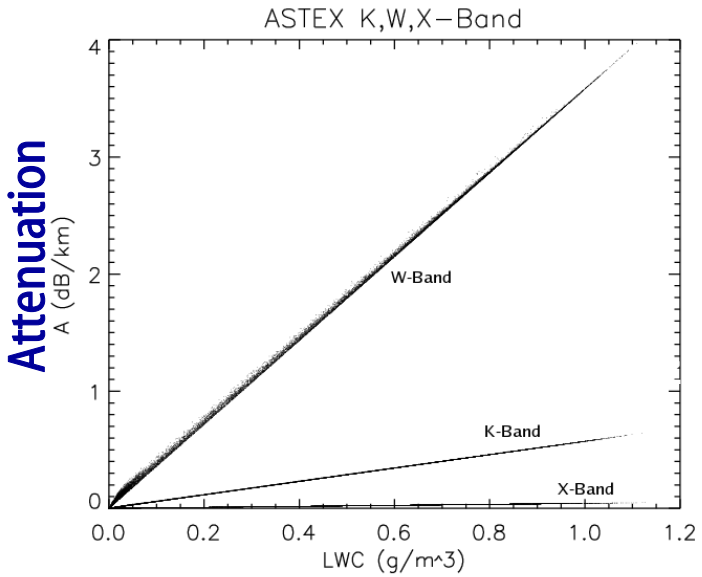


Scanning Dual-Frequency Radar



The second frequency:

- Extends the range of the system into drizzle and shallow precipitation
- Allows the retrieval of LWC and particle size using the differential reflectivity that is proportional to cloud LWC



Liquid Water Content

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New Instruments Needed

Obtain measurements of trade cumulus, a key cloud type for climate processes:

A new site in a subtropical region away from significant orographic effects

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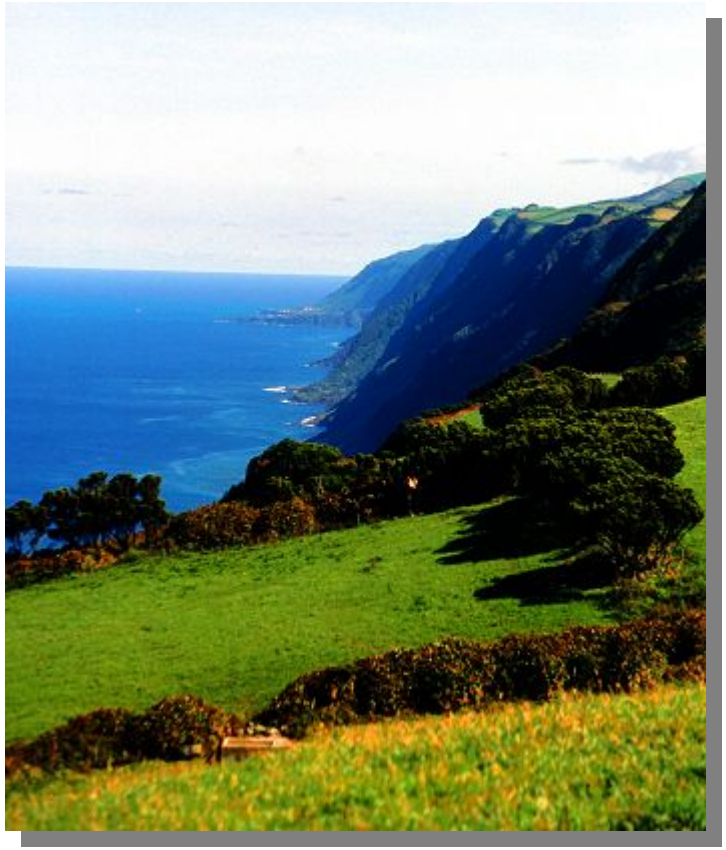
New Instruments Needed

Increase emphasis on surface process measurements:

- Duplicate measurement currently taken only at Southern Great Plains site to other fixed and mobile locations
- Important surface properties that impact the energy budget include the spectral albedo (solar surface reflectance), vegetation cover, subsurface moisture, and the measurement of the surface heat fluxes themselves.



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Participants

Thomas Ackerman, U. Washington
Mark Boslough, SNL
Larry Carey, U. Alabama Huntsville
Manvendra Dubey, LANL
Ann Fridlind NASA, GISS
Steve Ghan, PNNL
Anthony Janetos, PNNL
Rich Ferrare, NASA Langley
Jean-Christophe Golaz, GFDL
Jim Hack, ORNL
Everette Joseph, Howard University
Rao Kotamarthi, ANL
Henry Loescher, NEON Inc.

Gerald Mace, U. Utah
Greg Mcfarquhar, U. Illinois
Mark Miller, Rutgers University
Dave Randall, Colorado State Univ.
Courtney Schumacher, Texas A&M
Peter Thorne, Hadley Centre
Margaret Torn, LBNL
David Turner, U. Wisconsin
Taneil Uttal, NOAA
Sandra Yuter, North Carolina State
Warren Wiscombe, BNL
Robert Ellingson, Florida State
Steve Klein, LLNL

Next Steps

- Developed spending plans for new instruments and measurements
- New capabilities will be added as the budget allows