

ARM/ASR High-Resolution Modeling Workshop & ARM Facility Updates

Presentation for BERAC

Sally McFarlane (ARM)

with

**Rick Petty (ARM), Ashley Williamson (ASR),
Shaima Nasiri (ASR)**



U.S. DEPARTMENT OF
ENERGY

Office
of Science

Office of Biological
and Environmental Research

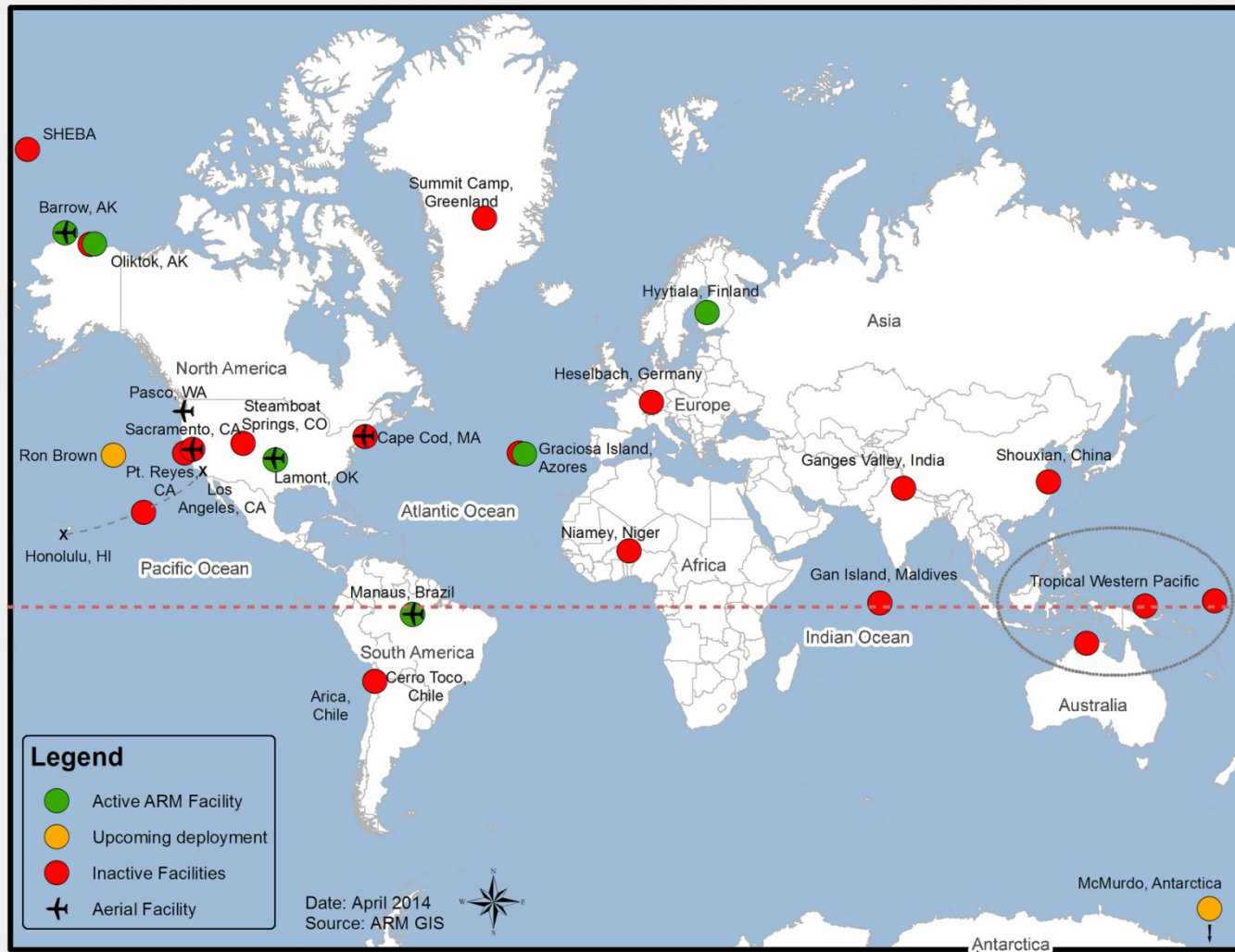
Outline

- ARM Facility Updates
 - Triennial Review
 - New Sites
 - Mobile facility deployments
- Planning process via community workshops
 - SGP ARM/ASR High-resolution Modeling Workshop (May, 2014)
 - North Slope of Alaska Workshop (September, 2014)
 - ARM airborne capabilities Workshop (spring, 2015)
- SGP ARM/ASR High-Resolution Modeling Workshop
 - Motivation
 - Goals and Agenda
 - Identified Measurement and Modeling Priorities
 - Next Steps

ARM Triennial Review – April 2014

- Findings:
 - ARM successfully met the criteria to strongly support the DOE's energy, climate and environmental mission and the goals of BER
 - ARM operations and management are at the highest level
 - ARM processes facilitate high impact climate research
 - ARM facility management needs to actively prepare and plan for the execution of the ARM Next Generation vision
- Outcomes:
 - Develop an ARM Decadal Vision white paper (Due Oct 31)
 - Establish a User Executive Committee to better engage the user community in facility planning and directions (Dec 31)
 - Complete Archive Data Discovery interface upgrade to include IOP data sets
 - Provide data backup strategy for ARM Archive to mitigate risk from catastrophic events

ARM Facility Sites - Updates



Tropical Western Pacific

- Nauru site officially closed Oct 1, 2013
- Manus site officially closed July 1, 2014
- Darwin site closing Jan 1, 2015



Eastern North Atlantic (ENA) Site



Eastern North Atlantic (ENA) Site

- **Operational with baseline instrumentation Oct 1, 2013**
- **New Instrumentation installed in 2014:**
 - Profiling microwave radiometer (March)
 - Eddy flux correlation system & surface energy balance (June)
 - Radar wind profiler (Sept)
 - Ka/W Scanning Cloud Radar (Sept)
- **Upcoming Instrumentation:**
 - Video Disdrometer (Oct)
 - Doppler Lidar (Oct)
 - X-band Precipitation Radar (Nov)
 - Raman Lidar (May 2015)
- **Workshop planned – Dec 2014**
 - Local scientists & students from U. Azores



Third ARM Mobile Facility (AMF3) - Oliktok



AMF3 - Oliktok Point

- Operational Oct 2013
- New Instrumentation in 2014:
 - Radars (scanning Ka/W, vertical Ka)
 - Lidars (Doppler lidar, Raman lidar)
 - AERI, eddy correlation flux, surface energy balance
 - Snow flake camera
- Upcoming Instrumentation:
 - Aerosol Observing System (2015)
- Upcoming Activities
 - Engineering flights of tethered balloon and unmanned aerial systems (UAS) in October to plan ARM baseline UAS activities
 - ERASMUS field campaign – April 2015
 - Flights of Pilatus and Data Hawk UAS





ARM Mobile Facility Deployments




BAECC - Biogenic Aerosols – Effects on Clouds and Climate (Feb – Sep 2014)



- AMF-2 in a pine forest in southern Finland – site of U. of Helsinki' s Station for Measuring Ecosystem-Atmosphere Relations (SMEAR-II)
- Objective: study the links between biogenic aerosols and cloud formation
- Other projects: snowfall microphysics, instrument comparisons
- BAMS article in preparation

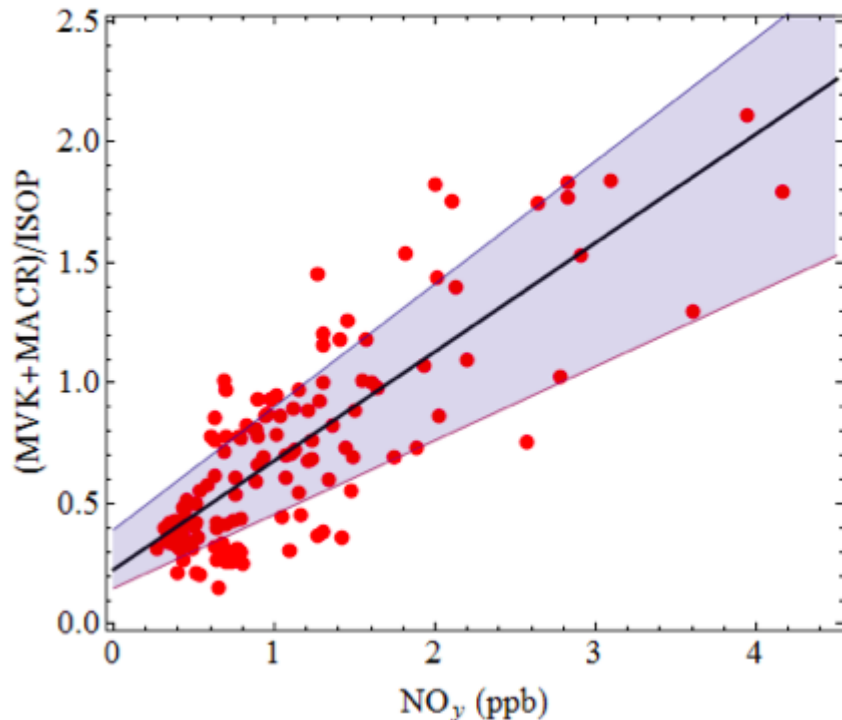
Green Ocean Amazon (GOAmazon)

Jan 2014 – Dec 2015

- Collaborative with two Brazilian organizations, TES, ASR, and RGCM
 - Second intensive observing period (IOP) ongoing
- 
- Woodrow Wilson Center Symposium on FAPESP-US Collaborative Research on the Amazon (Oct 28)
 - Visibility to research projects involving the Amazon that are collaborations between researchers in São Paulo and colleagues in the US
 - Followed by 1-day GOAmazon workshop
 - US/Brazilian Student workshop Oct 14-17 in Manaus

Initial GOAmazon Science Results

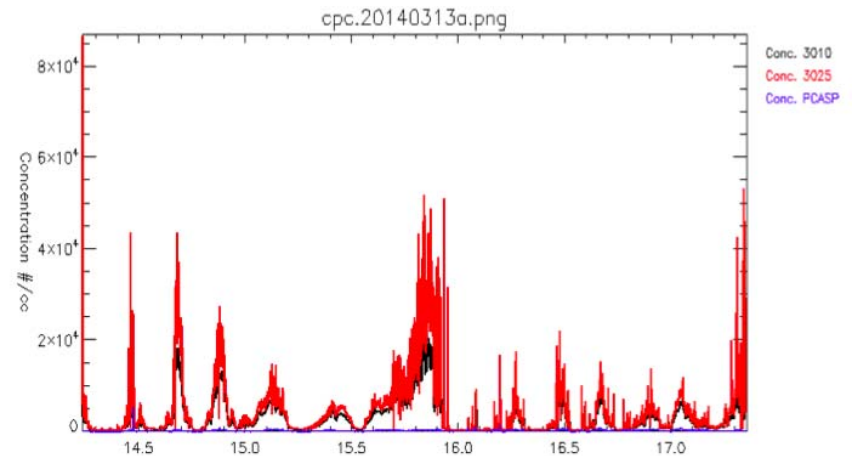
Data shows anthropogenic influence on Isoprene Chemistry



Acknowledgements : Yingjun Liu, Karena McKinney, Scot Martin, and partners

Acknowledgments: IARA G1 AAF Science and Technical Teams. Figure prepared by S. Springston and S. Martin.

Aircraft data show increase in aerosol concentration downwind of Manaus



ACAPEX – ARM Cloud Aerosol Precipitation Experiment – Jan-Feb, 2015

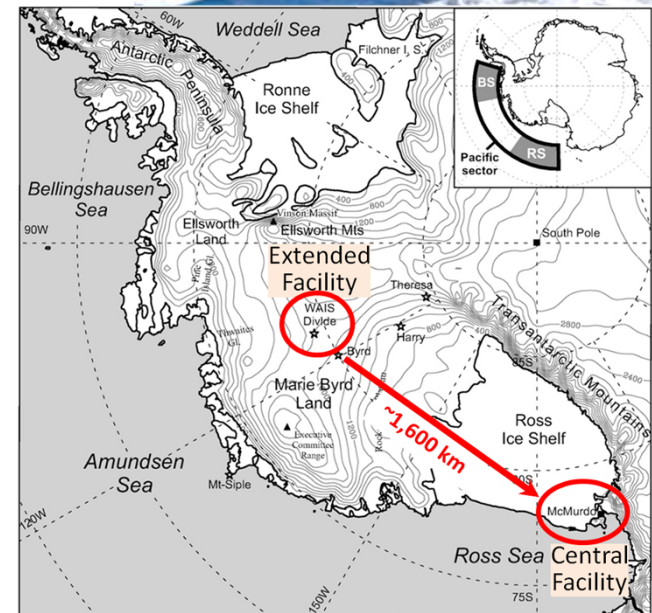
- Collaboration with NOAA CalWater2 field campaign
- AMF2 on R/V Ron Brown and deployment of G1 for aerial measurements
- Objectives:
 - Observe the evolution and structure of atmospheric rivers
 - Observe the long-range transport of aerosols and potential interactions with atmospheric rivers
 - Examine how aerosols from long-range transport and local sources influence cloud and precipitation on the U.S. West Coast



AWARE – ARM West Antarctic Radiation Experiment – Oct 2015 – Sep 2016



- Joint DOE-NSF campaign
- **Objectives**
 1. Improve understanding of mechanisms governing West Antarctic energy balance and climate change
 2. Assessment and improvement of cloud physical parameterization in climate model simulations for the coldest climate regime
- **Deployment Plan**
 - October 2015 – September 2016
AMF2 at McMurdo Station (“Central Facility”)
 - October 2015 – 15 January 2015 (Summer)
West Antarctic Ice Sheet (WAIS) Divide (“Extended Facility”)
Observations of cloud, upper air and surface energy budget
- **Site Visit Nov 2014**



Other recent supported field campaigns:

- SGP:

- Radar Scanning IOP for Boundary Layer Clouds
- Full-Column Greenhouse Sampling
- Measuring Clouds at SGP with Stereo Photogrammetry
- Stable Boundary Layer Education (StaBLE)
- Evaluation of the Marine Profiling Radiometer



- ENA:

- Atmospheric Electric Field-Mill Sensor at ENA

- NSA:

- TICFIRE Measurements in the Arctic
- Summertime Aerosol across North Slope of Alaska
- Arctic Methane, Carbon Aerosols, and Tracers Study



SGP ARM/ASR High-Resolution Modeling Workshop

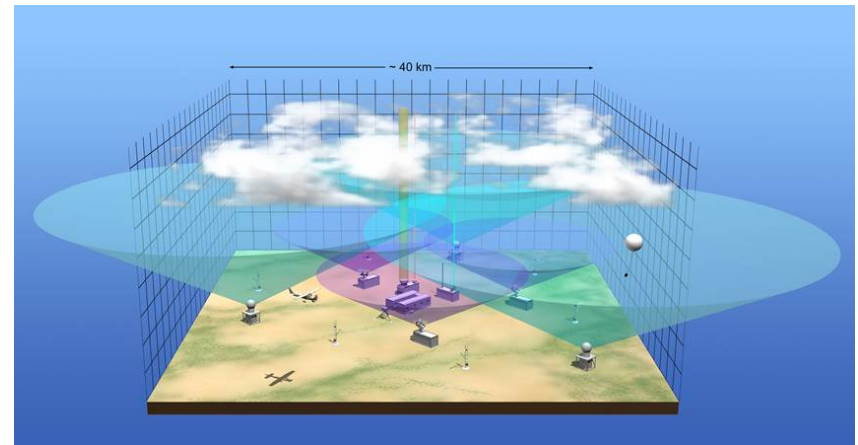
May 19-20, 2014

Bethesda, MD

Key findings

Workshop Motivation

- Next generation climate models with higher and/or variable spatial resolution require updated parameterizations of physical processes
- High-density observations needed to provide information on spatial variability within next generation climate model domains → ARM “mega-site” reconfiguration
- Dense observations should be coupled with high-resolution process models to provide “4-dimensional data cubes” for parameterization development and process understanding
- Long-term, routine high-resolution modeling, rather than case studies will take advantage of ARM observational strengths
- What are the measurement, modeling, data, and computational challenges that need to be addressed for routine high-resolution modeling at ARM sites?



Workshop Goals:

- Identify high priority scientific questions that could be addressed with routine high-resolution model simulations at the ARM sites
- Discuss challenges to integrating high-resolution models and observations
- Identify key measurement needs to improve observational constraints on high resolution models
- Identify scientific priorities in choosing model configurations/frameworks
- Identify the computational challenges in running, storing, and processing the model simulations

Workshop Details:

- Co-chairs:
 - Jim Mather, PNNL, ARM representative
 - Graham Feingold, NOAA, ASR representative
- Timing/Venue:
 - May 19-20, 2014; Bethesda, MD
- Attendees:
 - 22 scientists from university, national labs with expertise in climate modeling, high resolution modeling, measurements, cloud, aerosol, radiation, and land-atmosphere processes
 - 6 observers from ARM infrastructure operations
 - DOE program managers
- Pre-workshop homework
 - Attendees (and ARM community) were invited to submit white papers addressing the workshop goals
 - Co-chairs synthesized white paper responses at workshop

Workshop Agenda

- Day 1 - Morning Session - Plenary
 - Introductions and workshop charge
 - Overview of homework responses
 - Identification and discussion of key science goals
- Day 1 - Afternoon Session – Breakout Groups
 - Discussion of measurement & modeling needs and priorities to address each of the identified science goals
- Day 2 - Morning Session
 - Breakout Groups:
 - Computational challenges
 - Data products & tools needed to integrate models and observations
 - Plenary:
 - Wrap up and final group discussion

Workshop – Discussion

- Science themes/priorities:

- **Shallow convection**
- **Deep convection**
- Aerosol
- Radiation
- Land surface and carbon cycle



- **Shallow convection:**

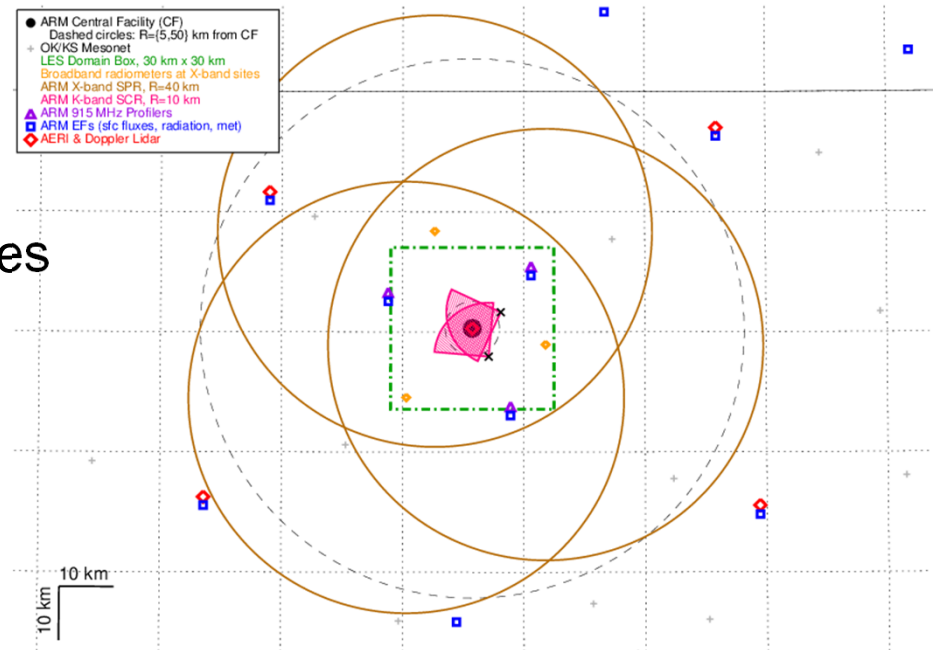
- representation of sub-grid convection is a challenge for climate models & linked to climate sensitivity
- Weakly forced shallow clouds sensitive to small perturbations in atmospheric conditions, land surface forcing, aerosol properties, and entrainment rate

- **Deep convection:**

- Key component of atmospheric circulation and cloud systems on local and large-scales
- Challenges are representation of interacting scales; timing of convection; system organization; impact of aerosol processes; links to land surface

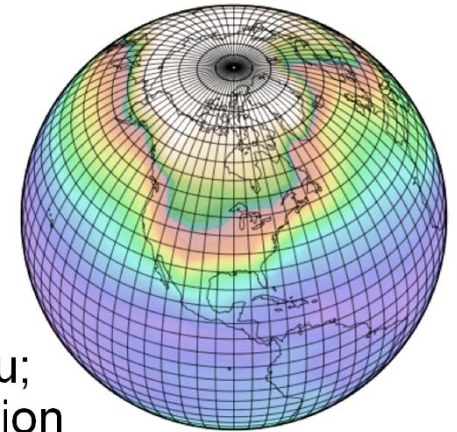
Workshop – Discussion

- Measurement gaps/needs:
 - Continuous profiles of temperature, humidity and wind using remote sensors
 - Characterization of the spatial heterogeneity of soil moisture and temperature and surface heat fluxes
 - 3-D cloud and precipitation properties (microphysics and dynamics)
 - Aerosol properties both at the surface and in vertical profile



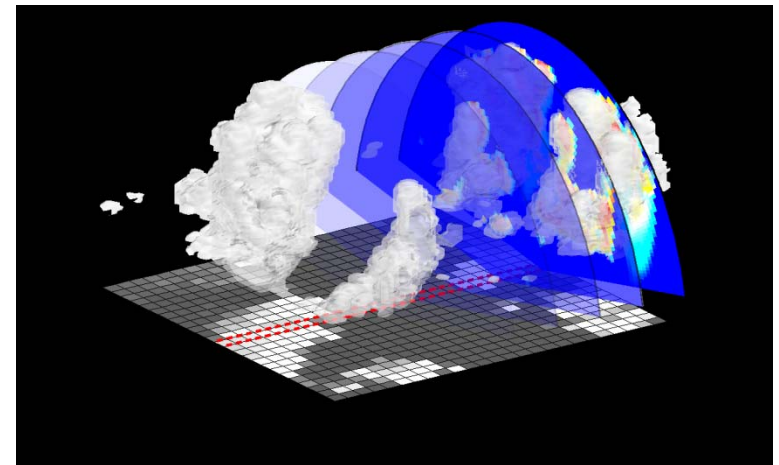
Workshop – Discussion

- Modeling gaps/needs:
 - Datasets & methodologies for forcing model simulations depend on question of interest
 - Spatially homogeneous may be appropriate for shallow cu; more advanced methodologies required for deep convection
 - Should explore data assimilation
 - Large eddy simulation models are most appropriate tool
 - Grid spacing/domain size varies with question
 - Process representation priorities:
 - Model must have some level of aerosol process representation; simple prognostic aerosol appropriate for some questions while detailed aerosol chemistry needed for others
 - Microphysical schemes should be two-moment (predicting number and mass of hydrometeor); bin schemes too expensive for routine modeling
 - Coupling with land surface model needed to study impact of surface heterogeneity on convection



Workshop – Discussion

- High priority data products/tools:
 - Methods to produce comparable statistical output of key properties from models and observations
 - Higher order products – joint PDFs of variables, vertical profiles, variable covariances
 - Instrument simulators to produce radar Doppler moments, radar spectra, lidar backscatter, spectral radiance
 - Integrated data products on a common spatial/temporal grid
 - “4D data cube” – model output that meets clear criteria with respect to the model’s ability to reproduce observations
 - Visualization tools for quick comparison of model/obs data
 - Data assimilation to constrain models with observations



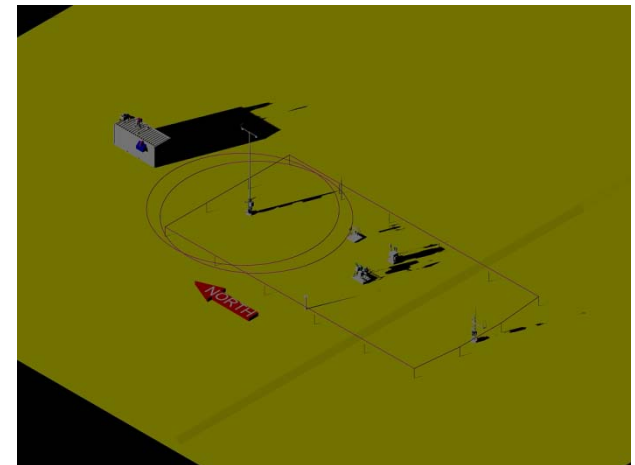
Mark Fielding, U. Reading

Workshop – Summary

- Short term priorities:
 - Initial focus of ARM routine modeling should be shallow convection, with a longer-term focus on deep convection
 - Additional profiling sites within ~50 km of the SGP central facility are critical to provide boundary layer profiles for model forcing
 - Optimization of existing land-atmosphere coupling sites & addition of new sites are critical for studying land-atmosphere interactions
 - Perform a pilot study to optimize design of the modeling framework
 - Deploy additional scanning radars for 3D cloud properties
- Longer-term priorities:
 - Exploration of data assimilation to provide improved model forcing and local-scale reanalysis
 - Deploy profiling sites at ~200 km radius from SGP to support deep convection modeling
 - Additional capabilities for aerosol profiling

Post-workshop Actions

- Workshop Report
 - Available online at <http://science.energy.gov/ber/news-and-resources/>
- ARM Infrastructure planning:
 - Identifying computational needs and resources
 - Annual ARM data developer's meeting (Aug) discussed ARM Engineering needs associated with next generation ARM activities
 - Data products meeting (Oct) will discuss plans for optimizing development of higher order data products for LES
- Measurement activities:
 - Discussion with land surface experts on improving existing measurements
 - Planning deployment of 4 profiling sites and 3 land-atmosphere sites at SGP
- Modeling activities:
 - ARM plans to request white papers for a modeling pilot study
 - Conversations within CESD on integrating ARM activities with other modeling activities



Nicki Hickmon, ANL

Additional Workshops (to be outbriefed at future BERAC meetings)

- North Slope of Alaska Workshop
 - Co-organized by ARM and ASR
 - Held Sep 10-11, 2014
 - Focus on NSA mega-site
 - Linking Barrow/Oliktok
 - Measurement needs
 - Potential links to modeling and TES programs
 - Workshop Report and outcomes to follow
- CESD Aerial Measurements Workshop
 - Recent workshops/activities/discussions have indicated scientific interests in aerial & satellite measurements across CESD
 - Developing initial plans for a spring workshop