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

Presentation for BERAC

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with

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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

Aircraft data show increase in aerosol concentration downwind of Manaus

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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

• 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”)
  • Site Visit Nov 2014

Observations of cloud, upper air and surface energy budget
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