Atmospheric System Research Program Update

Sally McFarlane
Ashley D. Williamson
ASR Program Managers

March 18, 2013

2013 ASR Science Team Meeting
Rockville, MD

Overarching ASR Priorities

- Use data and process modeling to reduce uncertainty in climate-critical atmospheric processes that impact the Earth's radiative balance and hydrological cycle

- Incorporate knowledge into improved representation of these processes in climate models, especially CESM

- Make strong use of DOE/CESD capabilities (e.g., ARM) and provide input to other CESD programs & activities
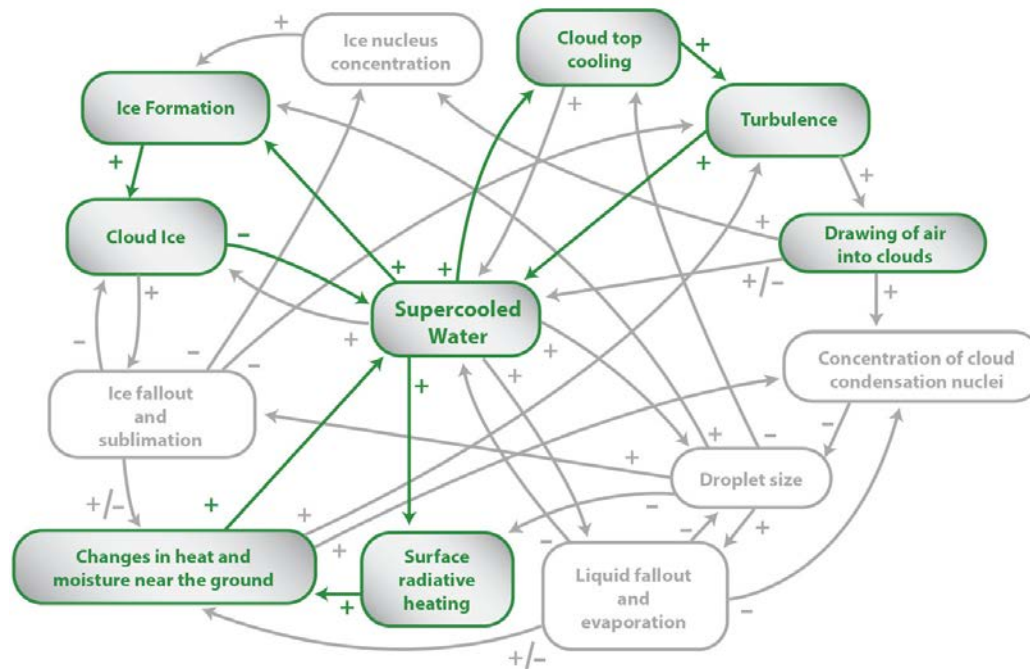
ASR Science Highlights

- Accomplishments brochure (available at registration table)

- Effects of black carbon in aerosols
  - Field and laboratory data significantly advanced understanding of absorption of particles containing black carbon mixed with other components
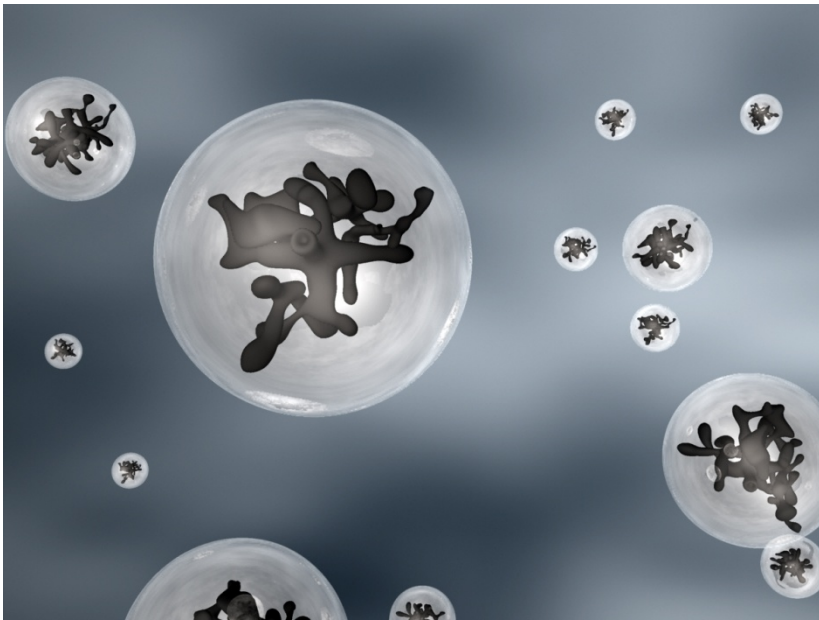
- Cappa, CD, et al. 2012. "Radiative absorption enhancements due to the mixing state of atmospheric black carbon." *Science.*
- Sedlacek AJ, et al., 2012. "Determination of and evidence for non-core-shell structure of particles containing black carbon using the Single-Particle Soot Photometer (SP2)." *Geophys. Res. Letts*
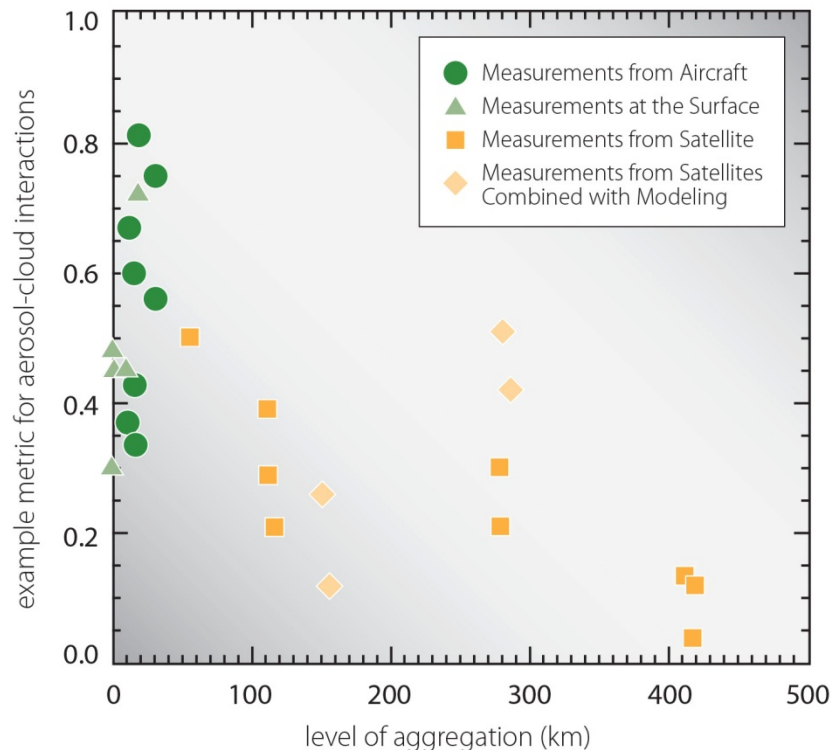
ASR Science Highlights

- ## Complexity of Arctic clouds
  - Identified complex interactions that allow Arctic mixed phase clouds to exist for long periods

• Morrison H, G de Boer, G Feingold, J Harrington, M Shupe, and K Sulia. 2011. "Resilience of persistent Arctic mixed-phase clouds." *Nature Geoscience*, 5, doi:10.1038/ngeo1332

ASR Science Highlights

- ## Scale shows true weight of aerosol effects on clouds
  - Identifies reasons for large range in estimates of observed impact of aerosol-cloud interactions; metrics from fine scale and aggregated data differ due to multiple processes operating at scales of aggregated data

McComiskey A and G Feingold. 2012. "The scale problem in quantifying aerosol indirect effects." *Atmospheric Chemistry and Physics*, 12, doi:10.5194/acp-12-1031-2012.

ASR Science Highlights

- ## Probing the birth of new particles
  - Data from laboratory experiments and field studies used to develop computationally simple model of new particle formation
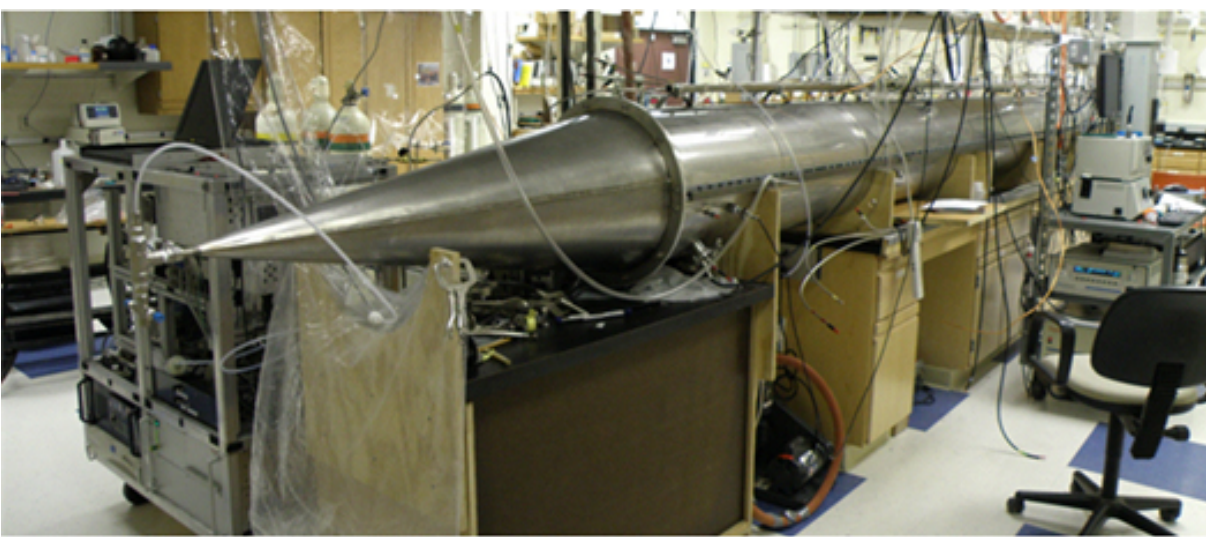
• Chen M, M Titcombe, J Jiang, C Jen, C Kuang, ML Fischer, FL Eisele, I Siepmann, DR Hanson, J Zhao, and PH McMurry. 2012. *Proceedings of the National Academy of Sciences*.

• Dawson ML, ME Varner, V Perraud, MJ Ezell, RB Gerbery, and BJ Finlayson-Pitts. 2012. *Proceedings of the National Academy of Sciences*.

ASR Science Highlights

- ## Looking at the full spectrum for water vapor
  - ### Data from RHUBC campaign used to improve radiative transfer modules in climate models
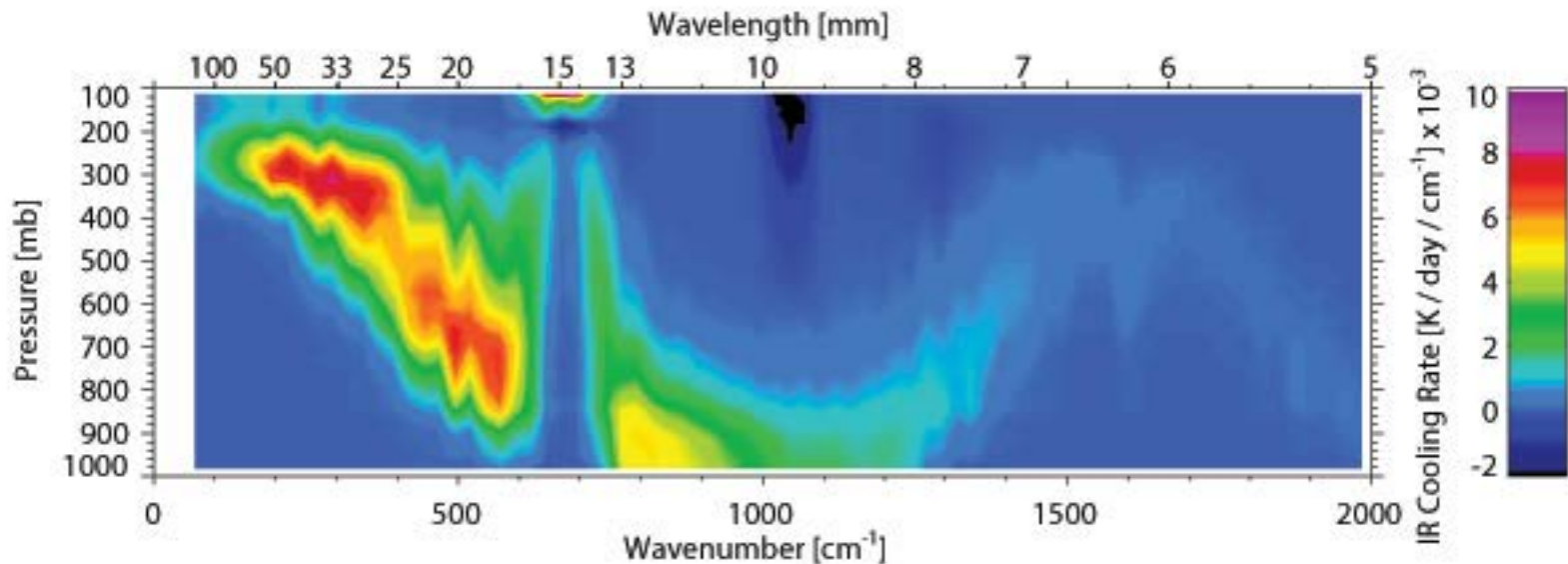
- Turner, D, A Merrelli, D Vimont, and E Mlawer. 2012. "Impact of modifying the longwave water vapor continuum absorption model on community Earth system model simulations." *Journal of Geophysical Research*.
- Mlawer EJ, VH Payne, J Moncet, JS Delamere, MJ Alvarado, and DD Tobin. 2012. "Development and recent evaluation of the MT_CKD model of continuum absorption". *Philosophical Trans. of the Royal Society.*

ASR Science Highlights

- Modeling from a tropical state of mind
    - Data from TWP-ICE, Darwin site, and cloud-resolving models used to identify key factors that impact simulation of tropical cloud systems in global climate models
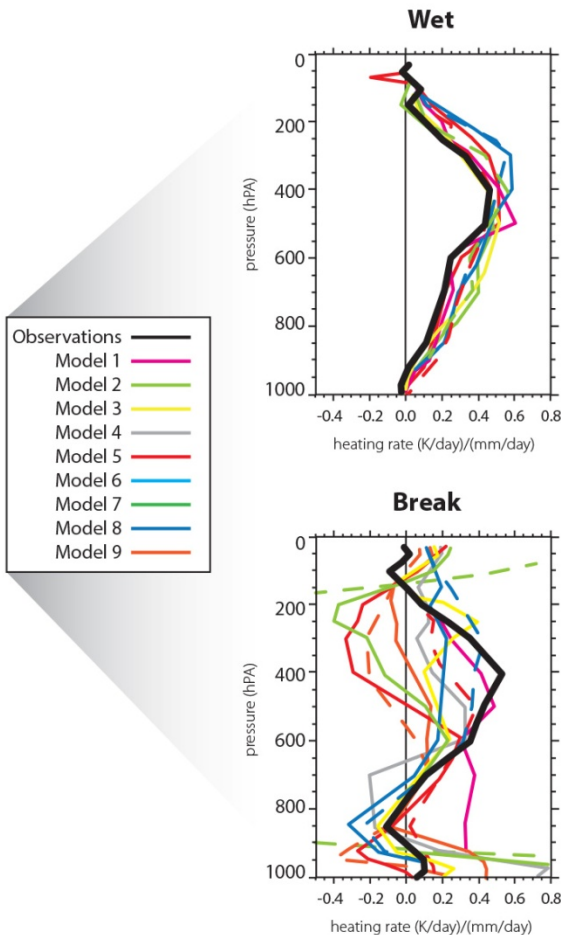
- Del Genio, AD, J Wu, and Y Chen. 2012. *J. Climate.*
- Evans, SM, RT Marchand, TP Ackerman, and N Beagley. 2012. *J. Geophys. Res.*
- Lin, Y, LJ Donner, J Petch, P Bechtold, J Boyle, SA Klein, T Komori, and C Schumacher. 2012. *J. Geophys. Res.*
- Mrowiec, AA, C Rio, AM Fridlind, AS Ackerman, AD Del Genio, OM Pauluis, AC Varble, and J Fan. 2012. *J. Geophys. Res.*

ASR Priorities – Making use of ARM ARRA investments to produce science outcomes

- New Radar Science group
  - Goal is robust, well documented radar data and products useful for ASR science goals
  - Work with operations to develop science-driven operational goals for existing and new radars
  - Radar Science Workshop held in Feb
  - Update this morning; radar science breakout session this afternoon

- Funded several proposals to support use of the new SAS (shortwave array spectroradiometer) measurements for aerosol/cloud retrievals

- Encourage more use of new aerosol & lidar technology

ASR Priorities – Improve Process Understanding in Key Geographic Regions

- **Tropics**
  - AMIE/DYNAMO campaign and associated science studies
  - Invested in joint projects to reduce tropical biases with Regional and Global Climate Modeling program
  - Upcoming investments in GoAmazon campaign

- **Marine**
  - Marine boundary layer clouds and aerosol effects in warm clouds are large sources of uncertainties in climate models
  - MAGIC campaign is ongoing
  - New Azores site on the horizon

- **Arctic**
  - Experiencing rapid changes due to global warming
  - Upcoming AMF3 multi-year deployment at Oliktok
  - Role of clouds and aerosol on surface energy budget; local aerosol sources vs long-range aerosol transport; vertical structure of atmospheric components

ASR/ARM Collaborations w/ CESD Programs

- Earth System Modeling (ESM)
  - CSSEF (Climate Science for a Sustainable Energy Future)
    - Developing testbeds for atmosphere/land/ocean components of CESM to accelerate model prototyping and evaluation process
    - ARM datasets included in atmospheric testbed
  - FASTER (Fast physics system testbed and research)
    - Evaluate and improve fast physics in GCMs by comparing models to continuous ARM observations
    - Breakout sessions Tues & Thurs; posters on Mon evening
  - Process-level understanding in ASR → parameterizations incorporated in CAM and CESM

- Regional and Global Climate Modeling (RGCM)
  - Renu Joseph will highlight joint projects
  - RGCM analysis → key processes/regions that need further study

- Upcoming GoAmazon FOA with RGCM and Terrestrial Ecosystem Science (TES) programs and Brazilian agencies

Meeting Goals/Overview

- Meeting Goals
  - Present and discuss scientific results and findings
  - Identify concrete steps to make progress on key scientific issues in each working group area

- Meeting format
  - Mon & Tues - plenary talks, breakout sessions, posters, evening breakout sessions
  - Wed & Thurs – extended Working Group time to discuss WG science priorities and actions toward meeting them
  - Please participate in the discussions! Make it an interactive and productive meeting

- Poster sessions
  - Posters are up all week - in 4 different rooms
  - Day to "present" your poster is on printed abstract list

Budget/FOAs/SFAs - anyone for acronyms?

- Budget (old slide)

- Two FOAs planned for FY14 funds
  - General ASR (**DE-FOA-0000885)**
    - http://science.doe.gov/grants/pdf/SC_FOA_0000885.pdf
  - GoAmazon
    - Collaborative solicitation with Brazilian agencies
    - Joint call with RGCM and TES

- ASR portfolio at DOE National Labs

ASR/ARM Budget Update:

- **FY2013(president's request): ASR $26.4M (~flat) ; ARM $70.6M (allowing for rampup for new sites)**

- **In absence of FY13 appropriation, government is operating on 6-month Continuing Resolution generally at FY 2012 levels:**

  - **Some uncertainty due to difference between House and Senate language, and contingency planning for "fiscal cliff" cuts**

  - **Half-year funding allows some advance spending, but new starts are difficult for ASR, and ARM forced to delay some acquisitions for new sites**

- **ASR FOA0885 issued for research to begin in early FY2014; another GOAmazon-related FOA in the works.**

- **ARM continuing work to establish new site in Azores, facility at Oliktok**

Research Funding Opportunities
DE-FOA-0000885

- Released Friday 3/15/2013
  - Mandatory Preapplications due 4/15/2013; response by 4/29/2013
    - Preapps submitted via PAMS system; registration required (read FOA)
  - Application Due date 5/29/2013
    - Applications via grants.gov
  - Review panel targeted for mid-July, selections by 9/30
  - Awards as early in FY2014 as feasible (~$6M/yr total contingent)

- Technical topics (read FOA)
  - "General ASR call" – covers topics in all working group areas
  - Priority research topics listed which cover areas of programmatic importance (**READ FOA**)
  - GoAmazon proposals to be considered only under upcoming FOA, (be patient it won't be too long)
  - Other requirements and exclusions typical for ASR calls (ARM data, no new campaigns, no instrument development, …)

Research Funding Opportunities
DE-FOA-0000885

- Collaborations encouraged as they make sense
  - Added expertise and resources not available to single PI
  - Science Team Meeting, Working Groups a pretty good place to explore potential collaborations
  - DOE lab scientists not eligible to apply, unfunded collaborations only

- Things you might miss (did I mention to read the FOA?)
  - Data Sharing/Data Management Plan (BER requirement)
  - Progress under previous DOE funding (appendix – right after narrative; specific review evaluation criterion)

- Technical questions can be addressed by Sally or me, preferably after Science Team Meeting

- Procedural questions to contacts in FOA

Research Funding Opportunities

GOAmazon: DE-FOA-0000???

- Joint call with RGCM (PM: Renu Joseph) and TES (PM: Dan Stover) Programs

- Collaborative with two Brazilian State agencies which are issuing their own funding calls for researchers in their respective States
  - FAPEAM: Amazonas Research Foundation
  - FAPESP: Sao Paulo Research Foundation

- Research to be coordinated with ARM GOAmazon 2014 (and 2015) campaign

- FY 2014 funding

ASR Research Portfolio: National Labs

ASR Program Distribution

- Grants 42%
- Federal Agencies 9%
- DOE Labs 49%
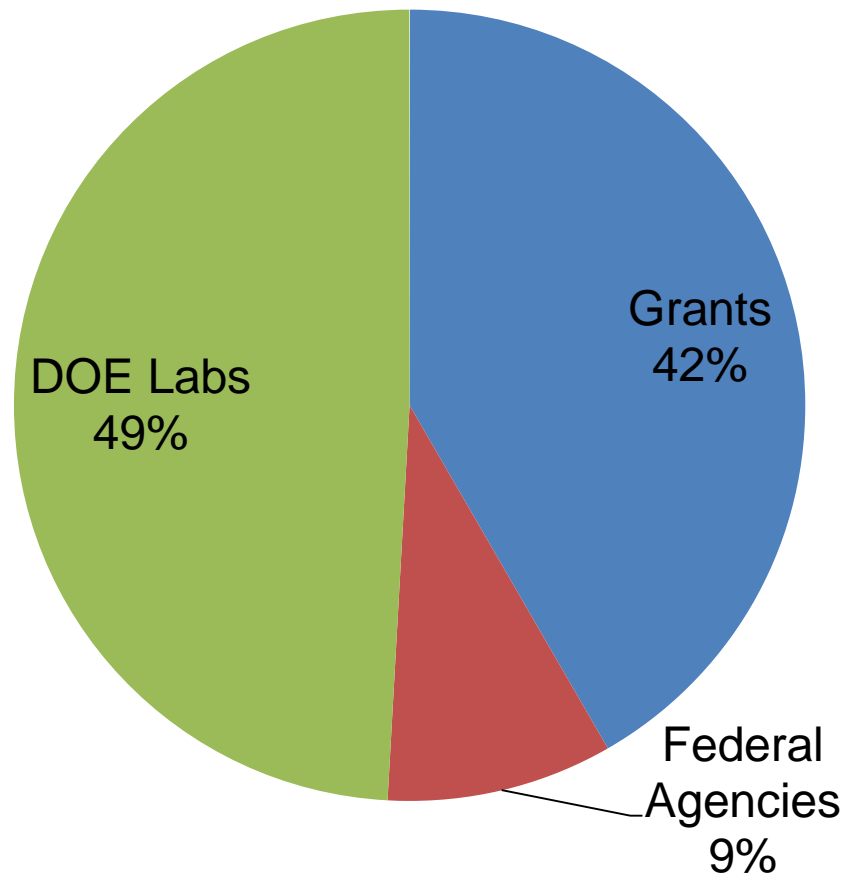
ASR Research Portfolio: National Labs

- Lab activities under ASR Science Focus Area
  - Brookhaven National Lab
  - Pacific Northwest National Lab
  - Lawrence Berkeley National Lab
  - Lawrence Livermore National Lab

  Each of these labs has a distinctive multi-investigator SFA covering one or more topic of ASR research interest; may also have some smaller "boutique" activities involving special expertise or facilities.

- Smaller portfolios also funded at Argonne National Lab (management of GVAX campaign, Black/Brown Carbon aerosol impacts) and at Los Alamos National Lab (absorbing aerosol optical properties, FTIR solar spectrometer)

- These ASR portfolios are in addition to substantial ARM activities at all these and other labs.

NEW PARTICLE FORMATION AND GROWTH

Objective

- Develop a predictive understanding of the role that aerosols play in the climate system

Focus themes

- Laboratory and field measurements of particles down to 1nm diameter

- Theory and modeling studies of nucleation and particle growth

- Aerosol properties, dynamics, and mixing state simulation using QMOM, and novel "sparse particle" methods

Model fluxes for early particle growth
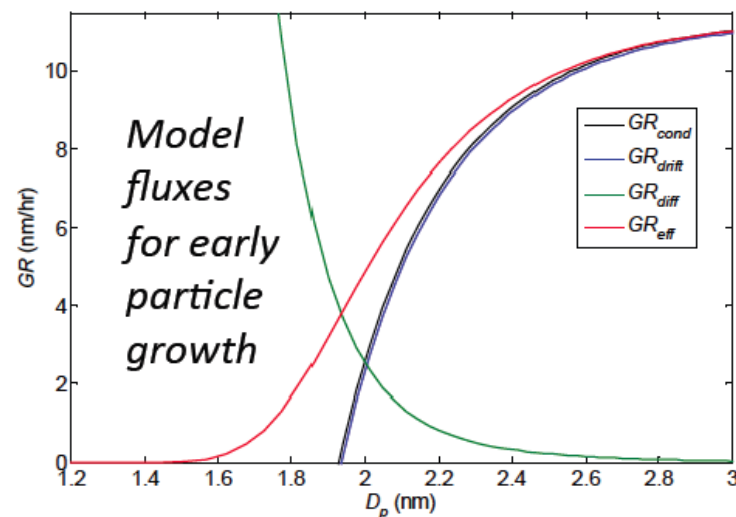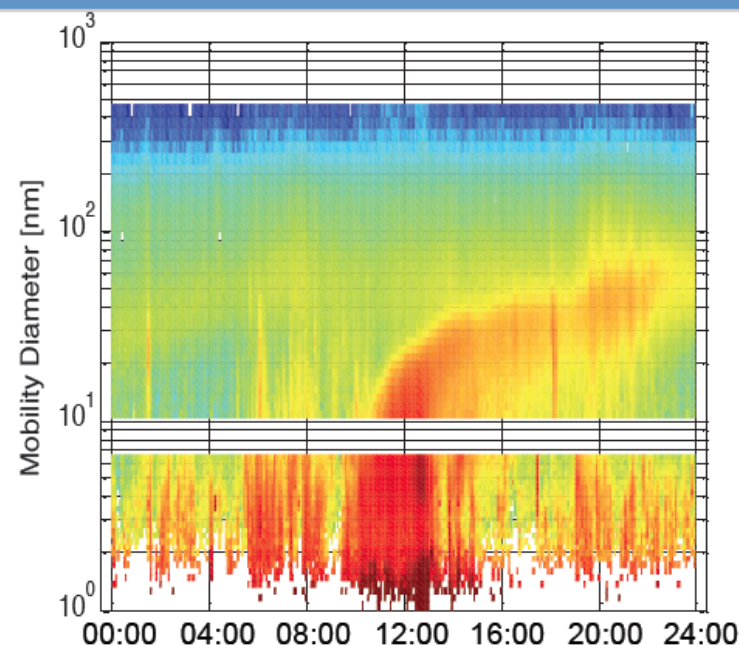
Evolution of Absorbing Aerosol Properties

We investigate the morphology and radiative forcing of absorbing aerosol particles through laboratory studies, modeling efforts, and field programs.

Uncoated Black Carbon (BC)
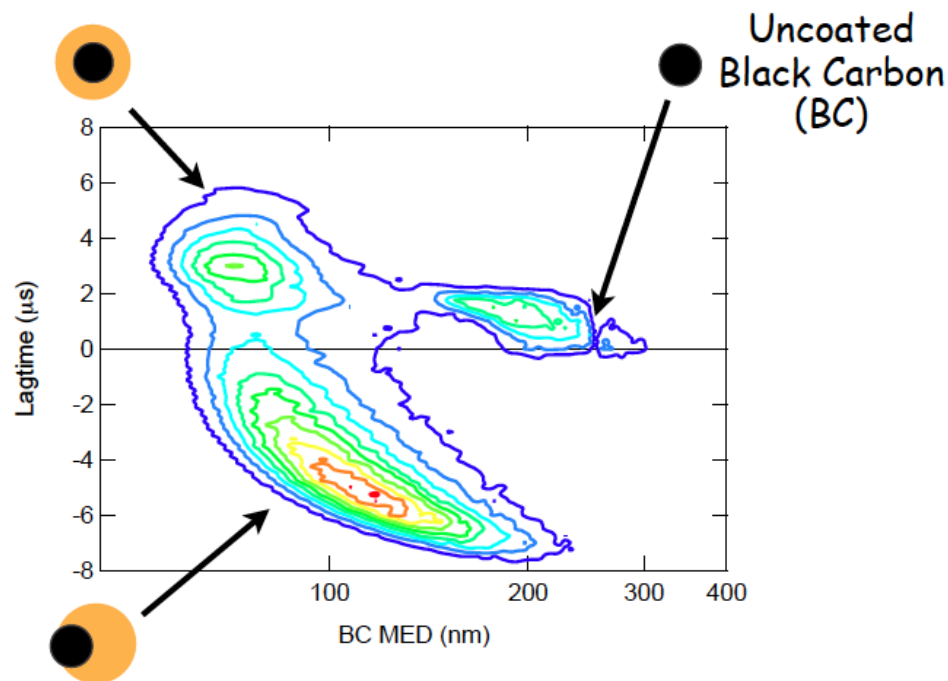
Lagtime analysis with Single Particle Soot Photometer (SP2) yields insight into individual BC-particle morphology: Each type expected to exert a different radiative effect

Biomass Burn Observation Project (BBOP) field campaign in 2013 will investigate evolution of morphology of ambient aerosol particles and effects on radiative forcing

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BNL Advanced TArgeted Cloud Science (ATACS)

Objective & Opportunity

- Target cloud-related processes that are essential to improve model representations of cloud feedbacks and aerosol-cloud interactions.

- Develop observational capabilities as directed by theoretical and parameterization needs, particularly involving ARRA investments.

- Focus on:
  - Interfacial studies
  - Transitional studies
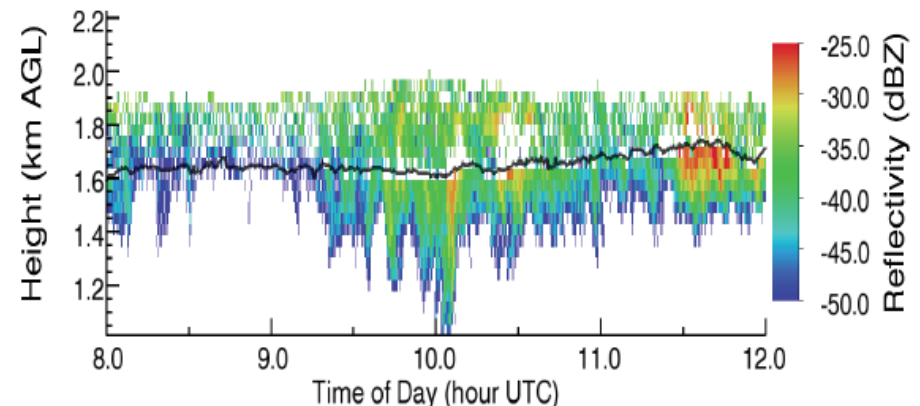 - Multi-scale interactions

Targeted Cloud Processes

- Phase Transitions
- Entrainment Studies
- Cloud-Drizzle Transitions

Ice
Supercooled Liquid
0°C
Liquid
Cloud
Drizzle/Rain
Aerosols   Evaporation
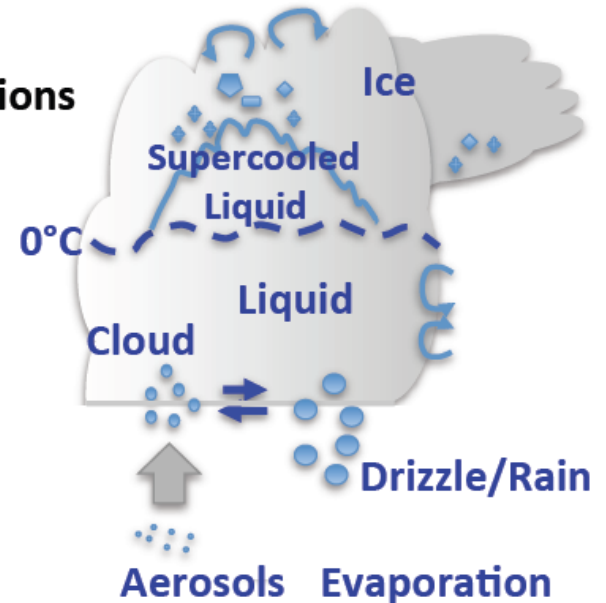
Separated Cloud/Drizzle Reflectivity

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NATIONAL LABORATORY

Aerosol-Cloud-Precipitation Interactions

- Using long term ARM datasets to isolate the effects of aerosol on cloud properties and processes from those due to meteorology.

- Characterization and parameterization of aerosol cloud nucleating properties under both pristine and polluted conditions.

Correlation between organic hygroscopicity and oxidation level
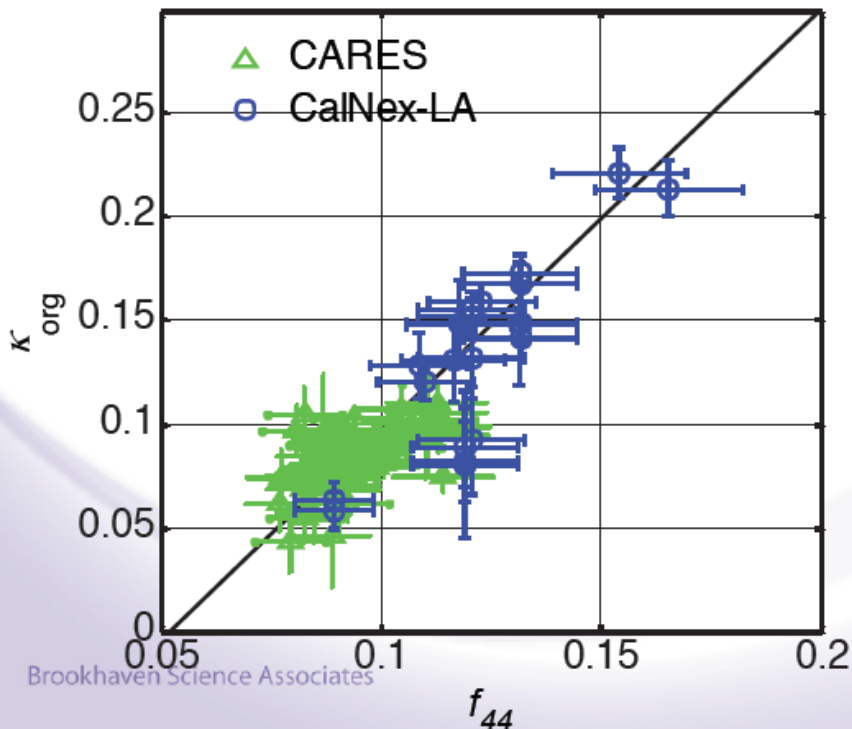
*GoAmazon: Impact of megacity plume on aerosol and cloud*

BROOKHAVEN
NATIONAL LABORATORY
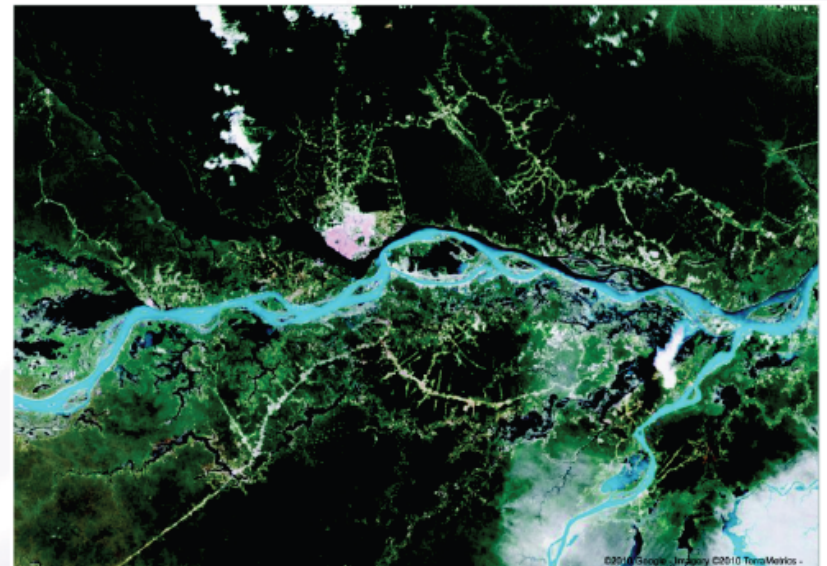
PNNL's Research for the ASR Program
## Point-of-Contact: Jerome Fast

Goal: Develop representations of radiatively important cloud, aerosol, and cloud-aerosol interaction processes suitable for global climate models.

Approach: Use a "measurements-to-models" approach in which Atmospheric Radiation Measurement Program (ARM) data are used to improve the understanding of important cloud and aerosol physical processes and their sub-grid variability, test and evaluate cloud and aerosol process modules, and develop parameterizations that will be applied within CAM5.

Specific Processes to be Addressed
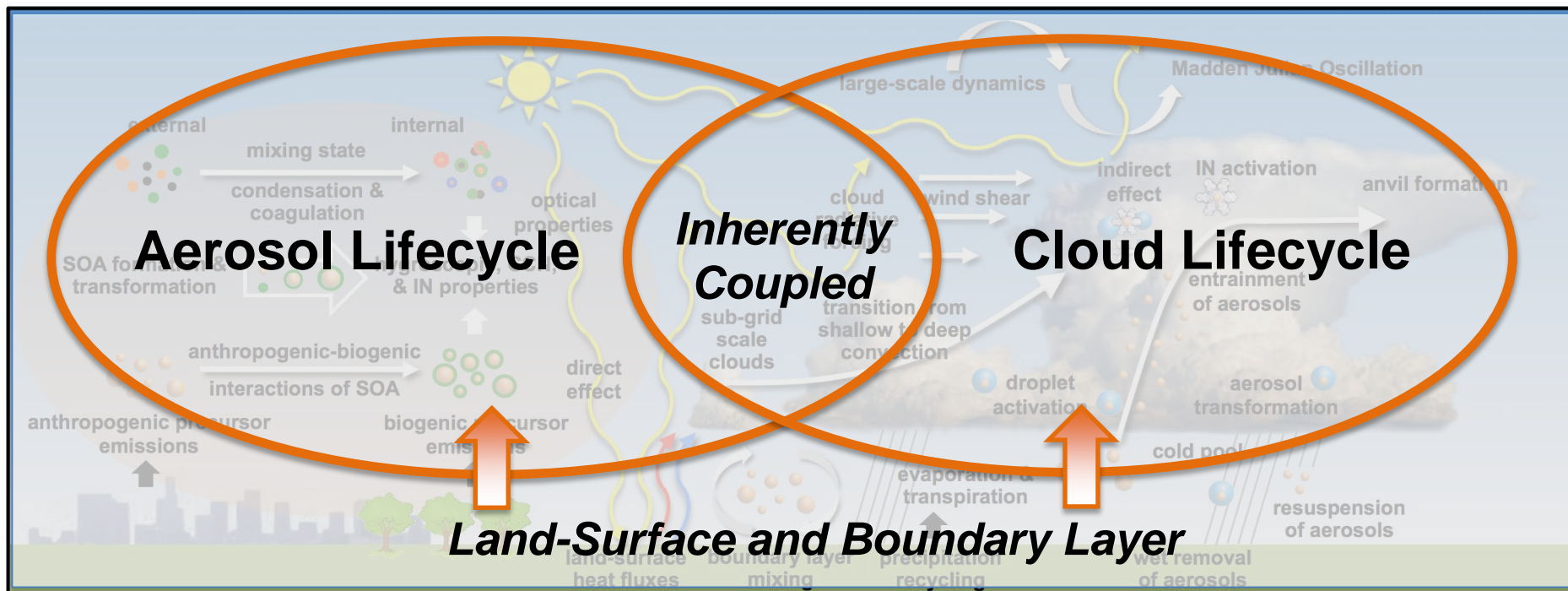
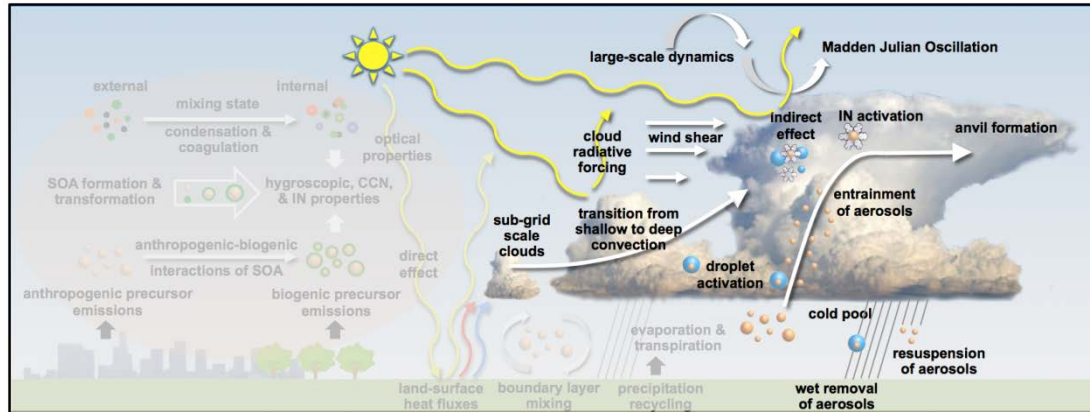# 1) Linking Land-Surface, Boundary Layer, Aerosol, and Shallow Clouds
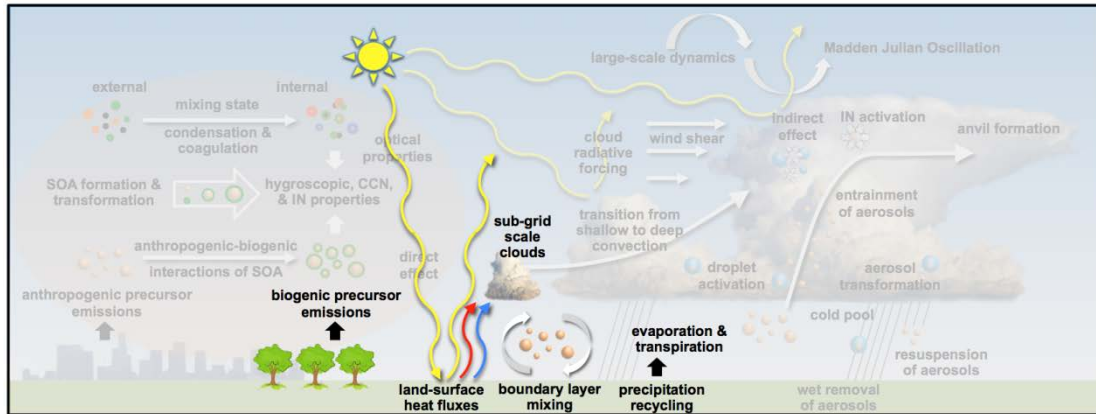
Primary Science Questions:

► What is the relative role of **resolved and sub-grid vertical motions** on the initiation of convective clouds?

► What physical processes are critical for generating **sub-grid scale variability** that triggers convection?

► How does the effect of **local evapotranspiration on precipitation** in the mid-latitudes and tropics differ and what is the impact of aerosol loading on precipitation recycling?

Evaluate the next generation of cloud parameterizations in predicting the initiation of convection and examine how that skill depends upon the treatment of land-atmosphere interactions and turbulent mixing:

► **SGP long-term data**

► **CARES, TCAP, AMIE, and GOAMAZON datasets**

► **Regional modeling studies with WRF using CLM and CAM5 physics**

► **Testing CuP and CLUBB cloud parameterizations**

2) Environmental Conditions, Wind Shear, and Aerosol Effects in the Lifecycle of Deep Convection

Primary Science Questions:

► How does the coupled moisture field and cloud population evolve during **MJO development**?

► What is the role of **wind shear** and **cold-pool** dynamics on convective organization?

► What are the key factors that enable **aerosols to affect** cloud updraft intensity, cloud-top height, and detrainment in **deep convective clouds**?

► What measurements are needed to better constrain the representation of **wet removal** in models?

Better represent how environmental conditions and aerosol affect convection in models, including the transition from shallow to deep convection, cloud and precipitation microphysics, and anvil formation:

► **TWP and SGP long-term data**

► **AMIE, MC3E, GOAMAZON datasets**

► **Advanced radar products**

► **Cloud-resolving, regional (WRF), and global (CAM5) modeling studies, with and without aerosol effects**

► **Extend CLUBB to handle processes associated with deep convection**

3) Aerosol Aging and Its Impact on Optical and Cloud Nucleating Properties
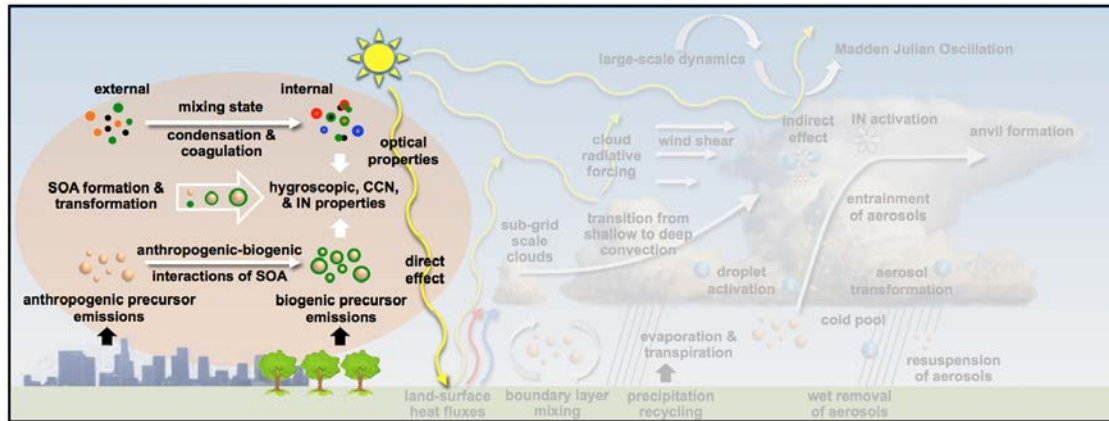
Primary Science Questions:

► What is the nature of **SOA** formation, transformation, phase, morphology, volatility, and the chemical interactions of anthropogenic and biogenic precursors?

► How does the **mixing state** of BC particles evolve as a result of condensation and coagulation?

► How does the **IN activity** of dust and biological particles change as they age?

► What is the significance of **regional-scale variations in aerosol properties** on radiative forcing?

Improve treatments of aerosol aging to better represent the mass, composition, size, and optical properties as well as the capacity of aerosols to serve as CCN and IN:

► **CARES, TCAP, GOAMAZON datasets**

► **Laboratory experiments**

► **Single particle instruments, scanning microscopy imaging**

► **Lagrangian process studies that use bulk and particle-resolved version of MOSAIC**

► **Regional (WRF) and global (CAM5) studies with MOSAIC and MAM aerosol models**

ASR – Sponsored Science at LLNL

1. Cloud-Associated Parameterizations Testbed (CAPT)

Are "forecast" errors "climate" errors? How can ARM observations be brought to bear on new parameterizations being developed for the Community Atmosphere Model?

CAM5 Precipitation Errors

" Climate Error"   "Forecast Error"
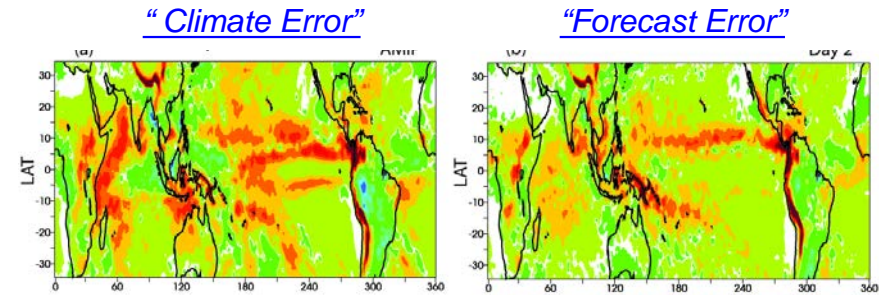
Xie, Ma, Boyle, Klein and Zhang (JCLIM 2012)

Observed early morning relative humidity @ SGP for days of thin and thick shallow and deep convection

Height (km)

Deep
Thick
Thin

RH (%) at 0530 LST

Zhang and Klein (JAS 2010, 2013)
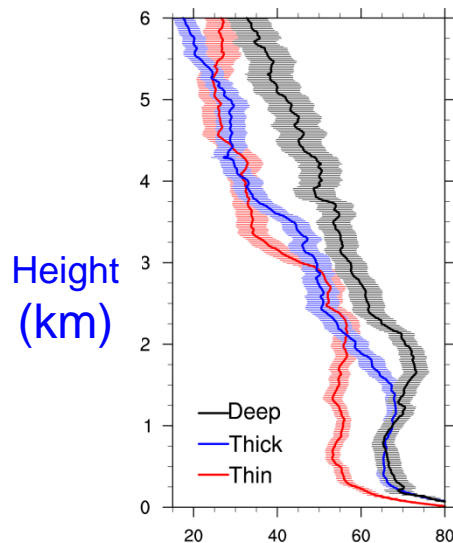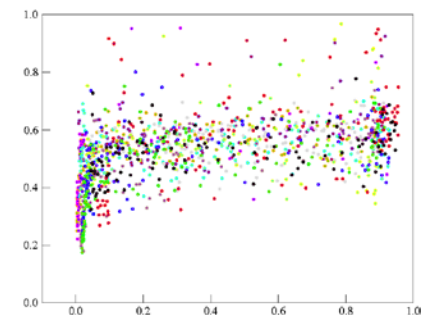
2. Lifecycle of Convective Clouds over Land

What determines whether shallow convection remains shallow or transitions to late-afternoon deep convection?

3. Land-Atmosphere Interactions

How do land-surface properties influence surface fluxes, clouds precipitation?

ARM Observations at SGP

Evaporative Fraction
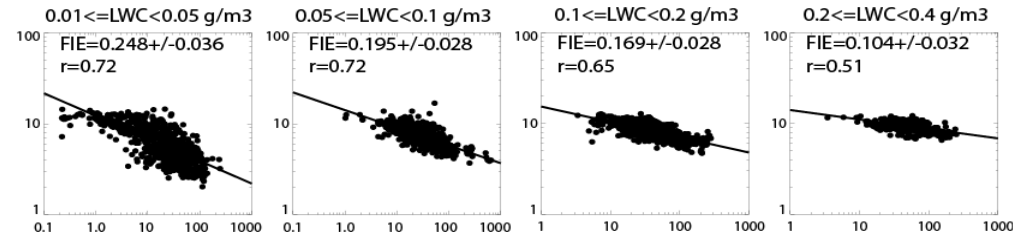

Soil Moisture Index

Phillips and Klein (2013)

ASR – Sponsored Science at LLNL

4. Aerosol-Cloud Interactions

How are aerosol and cloud properties related in climate models and observations?

CAM5 at ARM NSA site

Effective Radius

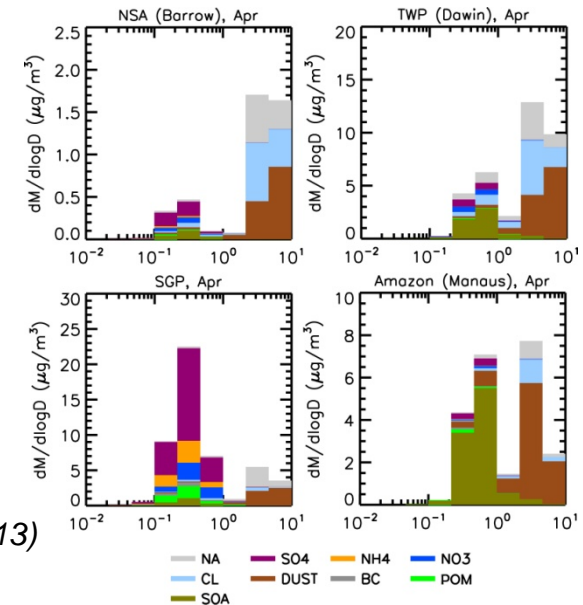| 0.01<=LWC<0.05 g/m3	0.05<=LWC<0.1 g/m3	0.1<=LWC<0.2 g/m3	0.2<=LWC<0.4 g/m3
FIE=0.248+/-0.036 r=0.72	FIE=0.195+/-0.028 r=0.72	FIE=0.169+/-0.028 r=0.65	FIE=0.104+/-0.032 r=0.51

CCN

Zhao, Klein, Xie, Liu, Boyle, and Zhang (GRL, 2012)

5. Sectional Aerosol Modeling

What effects are missed by the simplifications used in typical climate model representations of aerosols?

Aerosol size-distributions by chemical species simulated by CAM-Sect over ARM sites

Chuang (2013)

NSA (Barrow), Apr   TWP (Darwin), Apr
SGP, Apr   Amazon (Manaus), Apr

NA   SO4   NH4   NO3
CL   DUST   BC   POM
SOA

6. Community Leadership

Stephen Klein is a co-Chair of the Global Atmospheric System Study, the follow-on project to the GEWEX Cloud System Study that uses SCM and CRMs to compare to observations of cloud processes from many ARM field campaigns

BERKELEY LAB
LAWRENCE BERKELEY NATIONAL LABORATORY

Carbon Cycle Observations
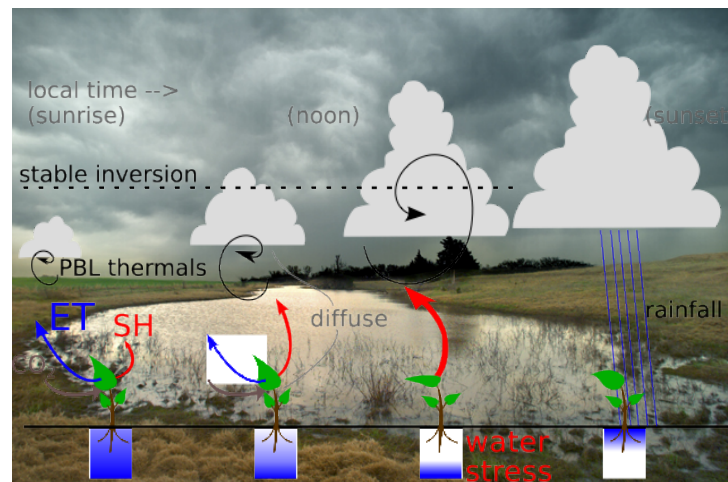
Measurement and analysis of:
- Ecosystem carbon, water fluxes
- Atmospheric composition
- Validation of satellite CO_2
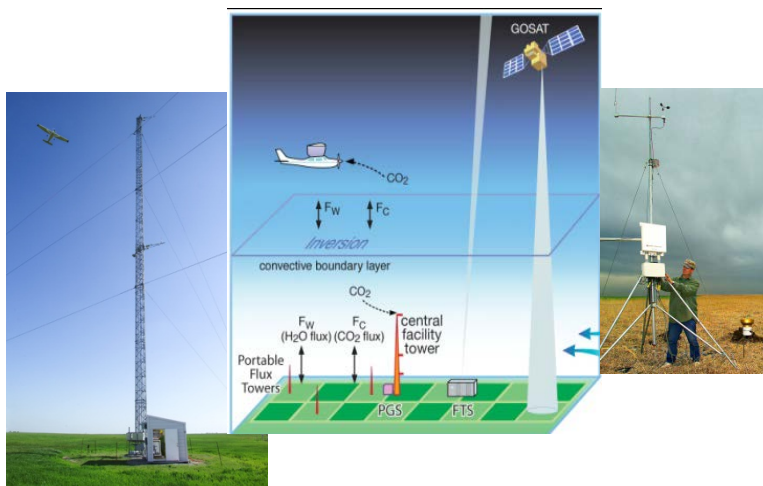
*Observations also supported by
TES, AAF, ARM, NOAA*

Land-Atmosphere Coupling

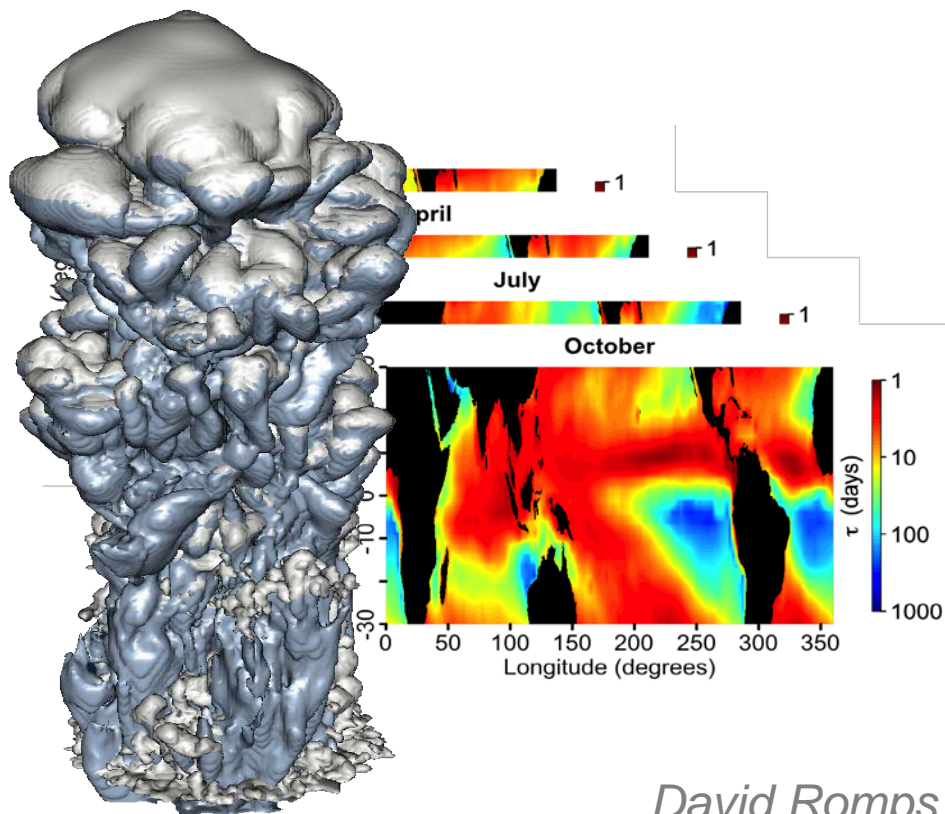Combining models and data to investigate regional carbon fluxes and the strength of land-convection-radiation feedbacks
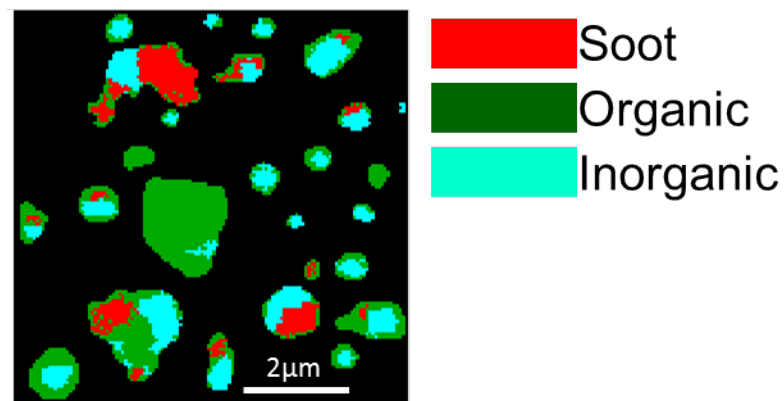

SGP and GoAmazon - Geco

Margaret Torn

Cloud dynamics

Convective entrainment
and transport of water,
momentum, and trace gases

Single Particle Imaging

Soot
Organic
Inorganic

2µm

Soft X-ray imaging of field collected samples provides

- chemical speciation
  (C, N, O, S, metals),
- morphology
- mixing states & their evolution
- correlate carbon bonding with optical properties
- phase state
- in situ reactive processing

David Romps

Mary K. Gilles

ASR Research Portfolio: National Labs

- This year we will complete first full three-year cycle of ASR SFA plans and reviews; SFA paradigm still a work in progress, but was constructed to take advantage of the considerable strengths of our lab portfolio.

- In 2013 we plan to enhance communication and coordination among lab research programs

- Lab Science Focus Area activities as centers of research collaboration – resource for other investigators in program.

Finally …

- Do enjoy the meeting. The agenda is full as always, but there is always something for everyone – usually at the same time as something else that is equally fascinating!

- We will of course entertain questions …