"The Future of ARM Science and Observations"

Minutes of Plenary Discussion on Friday, November 21, 2008 from the
U.S. Department of Energy Atmospheric Radiation Measurement (DOE ARM) Program
Joint Meeting of Radiative Processes and Cloud Modeling Working Groups

Introduction

During the final session of the 2008 Cloud Modeling Working Group Meeting in Princeton, NJ, attendees were asked to arbitrarily break into sub-groups to facilitate discussion of several questions recently posed to each working group. The questions and their responses follow. This material will serve as an input to a new ARM science plan that is intended to be complete in draft form for circulation to the greater climate science community by early April 2009.

Questions

1. What are the outstanding aerosol, cloud, radiation and precipitation questions for ARM science in the next five years?
2. What ARM observations and data products are needed to address these questions? Are current ARM locations sufficient?
3. How can ARM be more effective in improving aerosol, cloud, radiation and precipitation parameterizations in global climate models?
4. How can ARM science be more effective in addressing the outstanding science questions identified by organizations such as the Intergovernmental Panel on Climate Change and the National Academy of Sciences?

Responses Reported by Christian Jakob's Group

General comments and science questions (Q1+Q2)

ARM should continue fostering the links between the observational and modelling communities. This has been a strength of the program and it needs to be maintained/expanded.

We need to better understand the interactions and feedbacks between cloud dynamics and cloud microphysics, including but not limited to the role of aerosols. -> This requires collocated measurements of cloud properties, aerosols and cloud-scale vertical velocity as well as the large-scale conditions the cloud fields are embedded in.

More work is required to better evaluate LES models and CRMs. ARM is perfectly placed to support such an evaluation. For the triangle of observations - process models (LES/CRM) - GCMs to work effectively in improving climate models, is is crucial that we know the quality of the process models.

Tropical deep convection remains on of the most critical and poorly simulated phenomena in climate models. We encourage ARM to keep contributing to solutions. This requires that ARM maintain a strong presence in the tropics.

Some continued focus on the radiative impact of various cloud types is required. It might be wise to use findings from cloud-climate feedback studies to provide this focus.

An underused strength of the ARM program is its long data record. More emphasis should be given to using this long record in the evaluation of models with the aim to identify problem areas and regimes that can then be studied in more detailed process studies. The long-term evaluation may also highlight needs for AMF deployment or field studies/IOPs.

Some "technical" comments

The data base is still hard to use for modellers. There is simply too much information and too detailed a level for a first cursory look. It literally "scares" people off. The VAPs in particular the climate best estimate do help in this respect and need to be supported and expanded.

The PI data sets are only poorly advertised and many people only know about them through here-say. People outside the program have usually no idea of their existence. This needs to be improved.

Q2b Are the current sites sufficient?

Of course not. However, given the budget constraints it is crucial that the existing ones are well supported and useful to the community. We feel that the SGP, NSA and Darwin locations do well and that thought should be given to establishing a site similar to Darwin in capability (i.e., including a weather radar) somewhere in the TWP (e.g., Kwajalein?).

Q3

ARM is very effective in influencing climate model improvements. The ARM fellow program works well. As shown by several talks during the meeting model development is a long and slow process that makes use of many tools, including but hardly ever restricted to ARM data and programmatic support. The complexity of the process is such that no single program will ever be able to claim sole ownership of an improved model component. ARM should keep doing what it is by bringing together different communities to address some of the crucial parameterization issues.

Q4

The program management should encourage ARM scientists to participate in the national and international assessment processes with the recognition that this will somewhat reduce their capability to deliver on ARM projects. Maybe this needs to be somehow built into the funding mechanism (built-in no-cost extensions etc.).

Our group especially favored more effort to use ground-based cloud radars to measure/retrieve the properties of precipitating clouds, and to measure vertical velocities in clouds, preferably both non-precipitating and precipitating clouds. Both of these would provide more cloud-scale measurements, which are of course necessary for evaluating microphysics parameterizations. They would provide additional long-term relationships for both non-precipitating and precipitating clouds that would be valuable for all kinds of models: GCMs, mesoscale NWP, cloud-resolving, and LES models.

There are many important applications of such measurements, such as:

- Evaluation of Leo Donner's GCM microphysics parameterization which needs vertical velocity variance
- Evaluation of assumed PDF cloud parameterizations, which attempt to predict vertical fluxes of liquid water, which is an important term in the buoyancy flux and perhaps could be retrieved by cloud radar if vertical velocity can be measured
- Improved fall speed parameterizations
- Produce a climatology of vertical velocities in different types of cloud systems; relating the vertical velocities to cloud macro and microphysics

A few more points:

- Our group expressed a strong interest in the ensemble forcing dataset produced by Christian Jakob and collaborators
- Vertical velocity measurements in clear-air (perhaps from doppler lidar just beneath cloud base) would also be welcome
- The new instruments necessary for the desired measurements (e.g. 2+ wavelength cloud radars to separate cloud and precipitation, scanning cloud radar, doppler lidar, etc.) are very expensive and complicated to operate, use, and produce data products from. A careful evaluation of the gains and losses for each system needs to be done at the outset. Particularly important are Observation Simulation System Experiments (OSSE) that demonstrate the viability and utility of the new measurements. Important considerations for each new system is whether the spatial and temporal resolution or accuracy of the data collected will be sufficient to meet modeling needs. Because the requirements differ with cloud-type and model-type, it is important to carefully consider this question before investing resources.
- Our group expressed a strong interest in the development of model simulators. There are two purposes for simulators: 1. for OSSEs and 2. comparison of models (e.g. climate models) to observational data products (e.g. ISCCP simulator). The makeup of simulators are different for each type of simulator; nonetheless there is utility and interest from the group in these tools.
- A number of science questions that the group felt were important to address include: almost every aspect of convection (closure, trigger, entrainment effects), ice nucleation, ice microphysics, and ice fall speeds, and precipitation overlap. Also an important point is that many of the new insights come from working at the boundaries of subjects, for example, combining analysis of latent heating with radiative heating in cloud systems.

Measurement desires

- Vertical velocities
- Better mixed phase detection
- Retrievals that are integrated, time continuous, and have adaptive error bars
  - Some like CloudNet
    - LWP retrieval that's continuous through rainy periods
    - Error bars and flags
  - Integrated means information from a range of instruments
  - Could there be metrics for retrievals?
    - This is how CPWG is planning to use BBHRP
    - But BBHRP is only useful in some circumstances
  - We've been talking about how to do this, and maybe we need a deadline
  - Jay Mace's work evaluating the ISCCP simulator could be a model
  - Or maybe data intercomparisons
  - "We like data intercomparisons, and we need deadlines"

Organizational issues

- Modelers should not be only target for ARM - science stimulates model development
- "What do the modelers want" isn't a helpful question
  - We want different things depending on application, scale, etc.
  - This applies to how we set priorities
- Great instruments but limited funding/people power to produce data product
  - This applies to operations and to development of new products
  - Instrument and science product decisions seem decoupled
  - Users aren't interested in instruments, they're interested in products
- How important is going 3D?
  - Some want vertical velocities more than 3D wind vectors
- There's some question about how well we've communicated our priorities
  - Some think well, others think not
  - Maybe it'll help to figure out who might want to fill those needs on the data side
- And how about all the money we're spending on IOPs and field campaigns?
  - Maybe we can assess what we've learned from each IOP after a few years
  - The same could be said about the AMF
  - Maybe the best use of the AMF is in helping with retrievals
- "No good science program can have, as its first order goal, the idea of improving models"
- To address IPCC concerns about low-level clouds we could deploy in trade Cu
  - Just taking the obs isn't going to address that question

Responses Reported by Minghua Zhang's Group

Q1: Outstanding science questions

- Understanding the interactions among cirrus, stratiform anvils, convective updrafts and downdrafts, entrainment, and PBL inhomogeneities that trigger convection
- Better understand of the entrainment at the PBL top for shallow cumulus clouds
- Evaluations of the above processes in CRM/LES and parameterization in GCMs
- Characterization of the upper tropospheric water vapor and processes at the TTL
- Understanding of the cause of oceanic and land convections

Q2: What data are needed

- Coordinated measurements of the processes and variables listed above, rather than in isolation

Q3: How can ARM do better

- Put more emphasis on how to make the best use of existing data
- Provide first order variables for convenient use by the modeling community, such as cloudiness and aerosol optical depth (near real-time processing of data is desirable)
- Work and leverage with other programs such as DOE ASP, NASA to obtain the coordinated measurements
- Organize campaigns in which people with interests in observations, process understanding, and modeling truly work together

Q4: ARM to IPCC and NAS

- Reduce uncertainties and understand cloud-climate feedbacks
- Understand aerosol indirect effects in climate models