An Observational Framework to Aid Large Scale Modeling of Clouds

BOG Report

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1. INTRODUCTION

To the extent that uncertain parameterizations of cloud and precipitation processes in large-scale models are important, there is a need to test them. This need becomes more urgent when one realizes that the empirical basis for some parameterizations has become virtual, i.e., based on synthetic data-sets produced by fine-scale process oriented models such as LES (large eddy simulation) or CRMs (cloud resolving simulations). Cloud-resolving models are powerful tools for illuminating the cloud-scale circulations associated with turbulent or convective processes that lead to clouds. However, they also parameterize the cloud, radiation, and surface processes, and may not adequately represent the turbulent processes either. Furthermore, they usually require initialization, boundary conditions, or forcing that may either not be perfectly known or may remove feedbacks present in the real world. Hence, such models aid our interpretation of observations and help frame observationally testable hypotheses, but cannot substitute for observations.

Observational tests can take many forms. One baseline is comparison of global datasets such as ISCCP with model predictions of the global and seasonal distribution of different cloud types and their radiative impact. However, there are many ways to tune cloud parameterizations, and global datasets are a very indirect constraint that does not always pinpoint the reasons for shortcomings in a parameterization. Moreover, failures of a parameterization in a large-scale model, need not reflect failures of the parameterization itself, but rather failures in the forcing which it is fed. Composite studies, using global datasets but with a focus on the clouds associated with a particular type of circulation such as a midlatitude cyclone or ENSO, can often isolate more specific problems, but for similar reasons, still can be difficult to interpret. Field experiments can explore some physical process in a cloud regime in which it has not been observed, or focus on particular types of physical processes that affect cloud and precipitation development, or collect an integrated suite of special observations in a particular climatic regime. Lastly laboratory experiments have an important niche for studying certain types of turbulent processes (e.g. stratocumulus and cumulus entrainment) or cloud microphysics (ice crystal habits, cloud electrification). The interplay of these diverse observational perspectives is required for continued progress, and should be fostered within GCSS. We should promote small, focussed efforts as well as large ones.

2. PARADIGMS FOR FUTURE OBSERVATIONS

Figure 1 diagrams our perspective. A selection of areas in which we judge ripe for further progress with particular types of observations are listed at the bottom; this list is not meant to be complete and reflects biases of BOG participants. The perspective is not revolutionary, but opportunities exist on many fronts. This is due primarily (1) to a multitude of new ground and satellite
Based on remote sensing techniques, many of which provide information over an entire volume of space, either routinely or in support of a special field campaign, and (2) to the increasing level of physically-motivated detail incorporated in parameterizations in both global models and cloud-resolving models. For both reasons, it may be valuable to revisit some previously trodden ground (such as stratocumulus entrainment or shallow cumulus dynamics) using new technology (such as mm-wavelength Doppler radar) in combination with traditional types of aircraft and surface observations. Another parameterization bugaboo, ice microphysics, especially in association with deep convection, has seen less prior study due to the technical difficulties of making in-situ observations. Again, new aircraft, new particle imaging systems, and new remote sensing devices (SSM/I, TRMM, CIRES) make this an area that also may be ripe for progress.

A problem for modelers is keeping up with the diverse range of observational studies being made. The case studies formulated by different GCSS working groups need, as much as possible, to bring all of the relevant types of observations together to test model results. GCSS WG2 has perhaps worked the hardest to do this (for their TOGA COARE Case 2 intercomparison). This is an iterative processes, as more investigators become aware of a specific interesting case. GCSS working groups should develop WWW sites from which the data (and literature) relevant to particular cases are accessible or contacts are mentioned. This needs to continue for some time after the first model intercomparison.

**Figure 1. Observational framework for cloud modeling**

<table>
<thead>
<tr>
<th>Models (of all shapes and sizes)</th>
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<tbody>
<tr>
<td>Existing datasets (field, global)</td>
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<tr>
<td>Plausibility analysis</td>
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<tr>
<td>Exploratory analysis</td>
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- Arctic clouds
- Stable PBL
- Continental PBL clouds
- Precipitation from shallow clouds and aerosol feedback
- Cirrus and synoptic systems

- Tropical cirrus microphysics
- Warm advection PBL clouds

- Sc entrainment—roles of thermo, shear
- Trade Cu entrain, detrainment

- Tropical cirrus feedbacks with deep convection
- Trade cumulus (BOMEX with remote sensing)