High-frequency rainfall variability reveals nature of simulated climates.

Precipitation processes in general circulation models (GCMs) have historically been parameterized, that is, represented by code that generates the typical effects of rain systems for a given set of atmospheric conditions, rather than explicitly representing the rain systems themselves. Ongoing advances in computational capacities and recent developments in modeling techniques have resulted in a Multiscale Modeling Framework (MMF), in which rain systems are explicitly modeled in GCMs. The MMF approach is attractive because it provides a direct, physical link between small, cloud-scale processes (i.e., chemical transports, lightning production) and global-scale circulations.

Evaluating the realism of MMF simulations is one component of early research efforts involving this cutting-edge modeling approach. A recent study compared the effects of rainfall variability on precipitation climatology in two versions of a GCM, the Community Atmospheric Model (CAM), v3. It is possible (and rather common) for GCMs to simulate a realistic precipitation climatology while at the same time incorrectly simulating the daily timing and intensity of rainfall. Day-to-day rainfall simulation becomes important when one attempts to use GCMs to study the impact of climate change on watersheds, plant cover, flood control, and other problems that are impacted primarily by extreme events, rather than long-term averages.

Our comparison of rainfall intensity in the CAM and MMF revealed that, over the entire globe, the CAM generally produces rainfall too frequently, with too little intensity, and too close to local noon when compared to observations. MMF precipitation fidelity varied over the globe, but was generally less frequent, more intense, and not as likely to occur at local noon. It was also characterized by more realistic interactions with environmental humidity.

Our analysis also revealed some unintended interactions between parameterized precipitation and surface vegetation in the CAM. The unrealistically light rainfall in the CAM resulted in too much precipitation "resting" on leaf surfaces, and not enough soaking into the ground. As a result, surface water was too readily available for re-evaporation the following day, which led to nearly daily rainfall events over North America in the summertime, despite what should have been prohibitively dry conditions. These results have been published, and efforts are already underway among CAM developers to mitigate some of these issues with the precipitation parameterization. The ability to analyze precipitation behavior in the MMF framework, and then use that knowledge to improve the CAM benefits a broad scientific community, since computational limitations dictate that traditionally parameterized GCMs will remain primary tools for climate researchers and forecasters for many years.

Figure 1 Rainshafts of varying intensity are observed in a Colorado summertime thunderstorm. Photo credit: Ian Wittmeyer. Permission granted.