

PROGRESS REPORT ON ARM EFFORTS JULY 14, 2000

Title: Accounting for the sub-grid scale variability of clouds and water vapor in large scale models based on ARM observations
Grant: DE-FG02-00ER62933
P.I.s: Robert Pincus, University of Wisconsin, Madison;
Stephen A. Klein, NOAA/GFDL, Princeton, New Jersey

GOALS OF INVESTIGATION

Our goal is to assess and mitigate the impact of unresolved spatial variability on large-scale model simulations of the atmosphere, focusing initially on water vapor and cloud condensate. We use observations taken at ARM facilities and cloud-resolving model simulations to characterize the distribution of cloud water with large-scale model grid-cell sized domains. We then use the distributions to evaluate the difference between process rates computed from the average condensate concentration and process rates computed at full spatial resolution and then averaged.

We intend to use these observations and model results as the basis of a scheme to diagnose or predict the sub-grid scale variability of water vapor and condensate in a large scale model, and to correctly compute microphysical process rates based on the distribution. We plan to implement this scheme in the GFDL atmospheric model.

This investigation began in April 2000.

ACCOMPLISHMENTS

- 1) Established collaboration with members of the ARM Single Column Modeling group (Kuan-man Xu and Steven Krueger) and obtained cloud resolving model simulations of a 17-day intensive operational period at the SGP site.
- 2) Used one simulation day to examine the sub-grid scale distribution of cloud water mixing ratio, and to evaluate the bias in autoconversion rate.

PROGRESS REPORT (APRIL-JULY 2000)

We began the characterization of sub-grid scale distributions of cloud condensate by obtaining output from a cloud resolving model (CRM) run for a 17-day intensive operational period at the ARM SGP CART site. The CRM has a temporal resolution of 5 minutes and a horizontal resolution of 2 km, so that CRM output aggregated to the nominal spatial and temporal resolution of the GFDL large scale model (256 km and 30 min) provides as many as 768 points in each sub-grid scale distribution. Cloud condensate is partitioned into stratiform and convective components based on vertical velocity and cloud fraction criteria, providing distributions of stratiform cloud condensate in each GCM grid cell. An example distribution is shown in Figure 1.

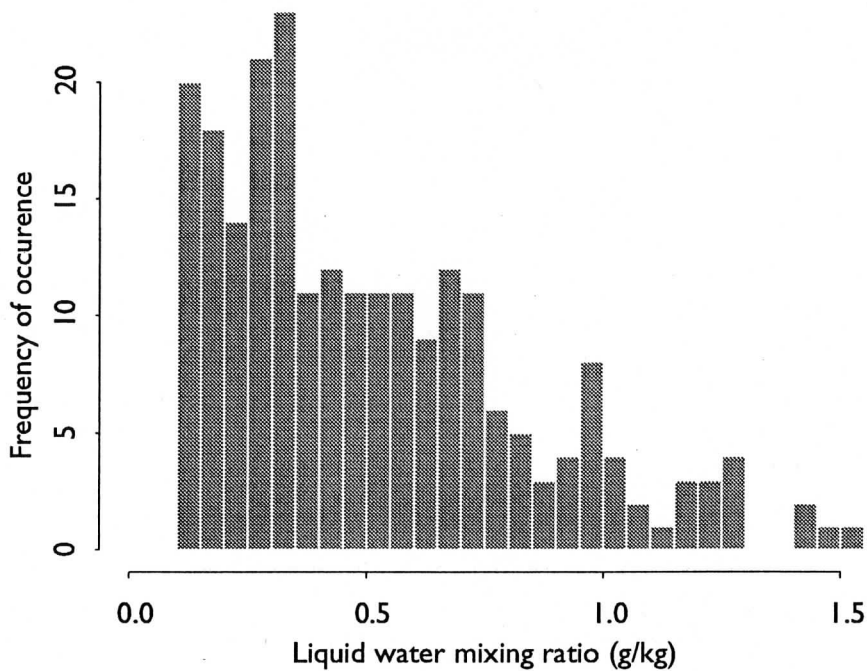


Figure 1: Distribution of cloud liquid water mixing ratio with a large scale model grid cell as predicted by a cloud resolving model. The cloud resolving model was forced by observations during an IOP at the ARM CART site. Model output has been aggregated to 256 km, 30-min scales, as would be typical of a climate model.

We used the distributions obtained from the CRM to explore the impact of unresolved variability on average process rates, especially autoconversion. For each distribution of cloud condensate obtained for a GCM grid cell, we compare the average autoconversion rate (as integrated across the distribution) and the autoconversion rate computed from the average condensate concentration. An example comparison for one day of simulated time is shown in Figure 2. The GFDL autoconversion parameterization produces no rain until the diagnosed drop size exceeds some value r_0 . In the comparison a physically realistic value of $r_0 = 10 \mu\text{m}$ is used for the spatially integrated computations. If this same value of r_0 is applied to the grid-cell averaged condensate concentration, however, no autoconversion is ever predicted on this day. Instead, we use an arbitrarily reduced value of $r_0 = 7 \mu\text{m}$, in accordance with current practice in the GFDL GCM. We intend to characterize these distributions as functions of atmospheric state as it is predicted by the model.

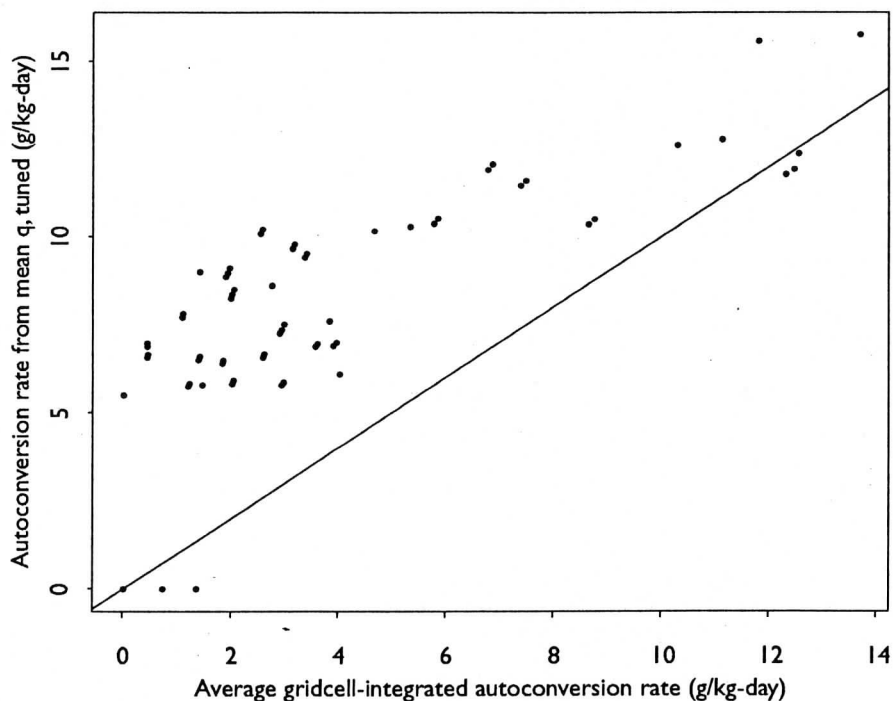


Figure 2: Comparison of autoconversion rates averaged across a large scale model domain and computed directly from the average condensate concentration in the domain, as would be inferred by a large scale model. Parameters in the latter calculation have been arbitrarily reduced to provide non-zero values of autoconversion.