# Use of a Cloud Ensemble Model to Develop Cloudiness Parameterizations

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The objective of this project is to use a cloud ensemble model (CEM) as a tool for developing a cloudiness parameterization for use in climate models. CEM is a cloud-resolving model that is able to simulate an ensemble of clouds under given large-scale conditions. It can also provide detailed, statistical properties of clouds, information that cannot be obtained from observations.

Several simulations have been performed with 1) typically observed large-scale conditions (e.g., large-scale advective cooling and moistening rates and large-scale pressure gradient forces) in the tropics and 2) during the Atlantic Stratocumulus Transition EXperiment (ASTEX), using the University of California at Los Angeles CEM (Krueger 1988; Xu and Krueger 1991). Xu and Randall (1994) provide details of the simulations of tropical cloud clusters. The results from the ASTEX simulation are very preliminary.

The main finding is that the amounts of stratiform cloud are highly correlated with cloud water+ice mixing ratio in both cloud regimes. The stratiform cloud amounts are somewhat correlated with the relative humidity (RH), too. The relationship between stratiform cloud amount and cloud water+ice mixing ratio does not depend upon the grid size of climate models. The scatter around the regression line is, however, slightly larger for smaller grid size. The large variation of relative humidity in smaller grid sizes is responsible for the scatter. Thus, a more accurate estimate of stratiform cloud amount must also include its dependency on RH.

Based on these results, we can propose a cloudiness parameterization for both cloud regimes as follows:

$$C_S = 1 - \exp\left(-\alpha \frac{q_c}{(1 - RH)^p}\right)$$

where $\alpha$ and p are to be determined. Ideally, these two parameters should be quasi-constants. Based on data used in this study, we can determine the value of p to be 0.5, but $\alpha$ is more difficult to determine. It is possible that $\alpha$ is related to the phase of clouds, i.e., it is slightly different for ice and warm clouds.

Data from the Atmospheric Radiation Measurement Program will be used to further verify such an approach.

## References

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