An Overview of Cloud Modeling Efforts at NASA LaRC

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Motivation

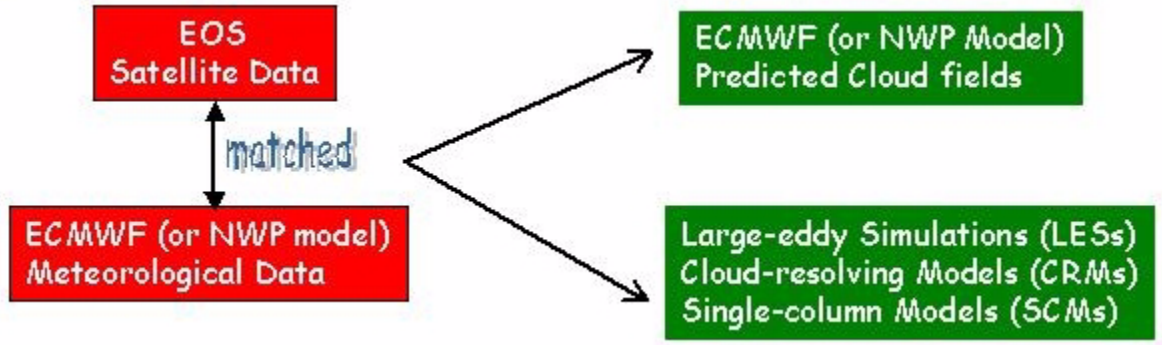
The evaluation of Cloud Resolving Models (CRMs) is an important task, if we wish to use them for tasks such as:

- Studies of cloud dynamics
- Development of cloud parameterizations for General Circulation Models (GCMs), including “super-parameterizations”

The manner in which we will evaluate our CRMs is by comparing the probability density functions (PDFs) of several variables within 29 large, deep convective cloud systems observed using the Single Scanner Foot-print (SSF) product from the CERES instrument during March 1998 to the PDFs of the same variables from the simulated cloud systems. We believe that:

- Using many cases will help us avoid excessive tuning of the models, while revealing areas of the models that need improvement
- Comparing PDFs of the observed and simulated fields will provide a more meaningful test for the CRMs to pass than comparing the mean values.

Cloud Object Approach



Cloud Object Selection Criteria

Category	Latitude Range	Effective Height	Cloud Fraction	Optical Depth
Tropical deep convection	25˚ S - 25˚ N	$z_{top} > 10$ km	1.0	$\tau > 10$
Trade cumulus	40˚ S - 40˚ N	$z_{top} < 3$ km	0.1-0.4	N/A
Transition stratocumulus	40˚ S - 40˚ N	$z_{top} < 3$ km	0.4-0.99	N/A
Stratus	40˚ S - 40˚ N	$z_{top} < 3$ km	0.99-1.0	N/A

Models

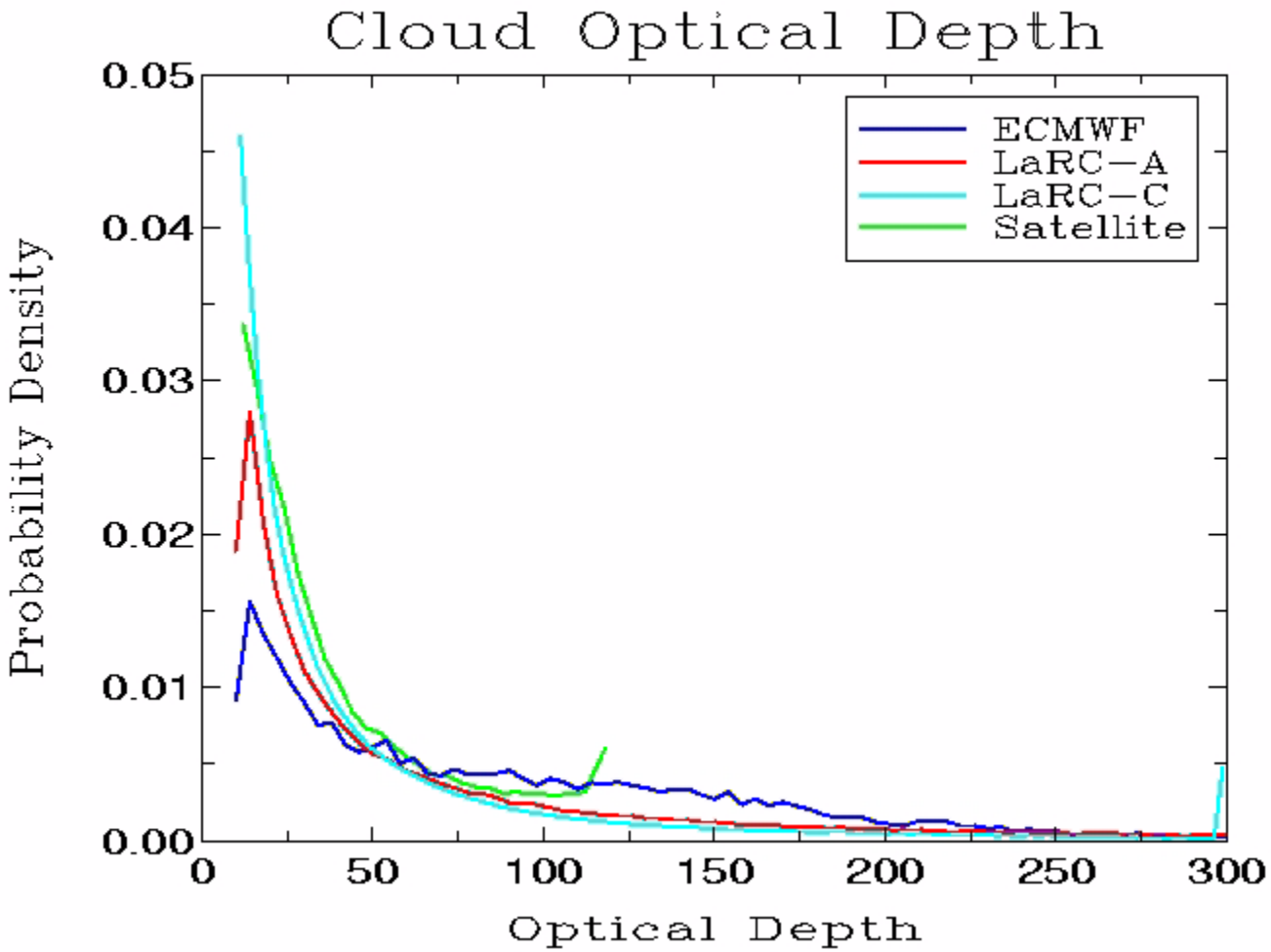
The models that were employed in this study are LaRC-A (Krueger 1988; Xu and Randall 1995) and LaRC-C, based on the Advanced Regional Prediction System (ARPS; Xue et al. 2000, 2001), which include the following features:

Table 1: Models Used

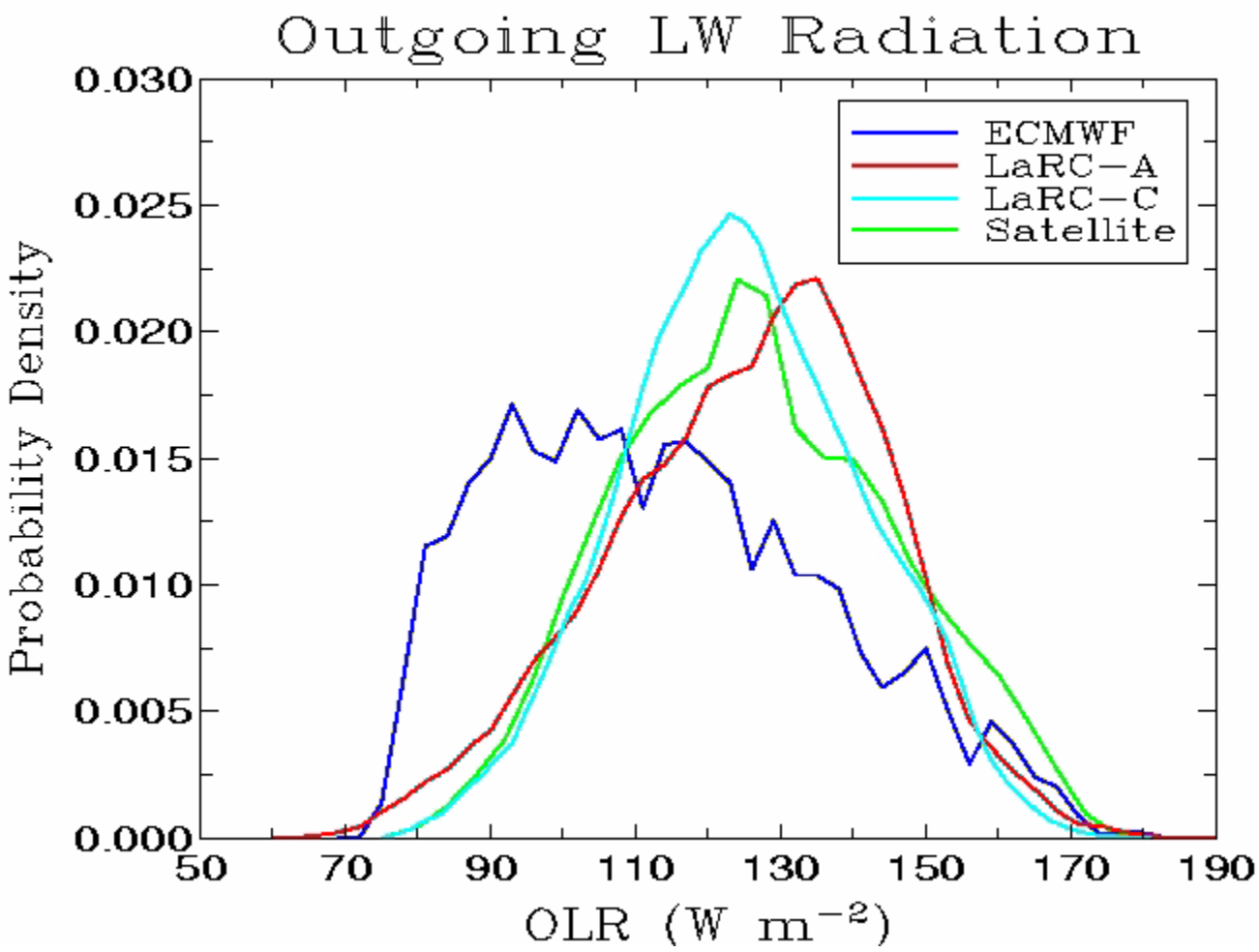
	LaRC-A	LaRC-C
Dynamics	anelastic	fully compressible
Microphysics	Lin et al. (1985); Krueger et al. (1995)	Lin et al. (1983); Krueger et al. (1995)
Turbulence	Prognostic third-order scheme	1.5-order TKE equation
Radiation	Fu-Liou (1998)	ARPS code, Fu-Liou

Green text denotes new additions to LaRC-C model after identifying problems comparing its results to CERES observations.

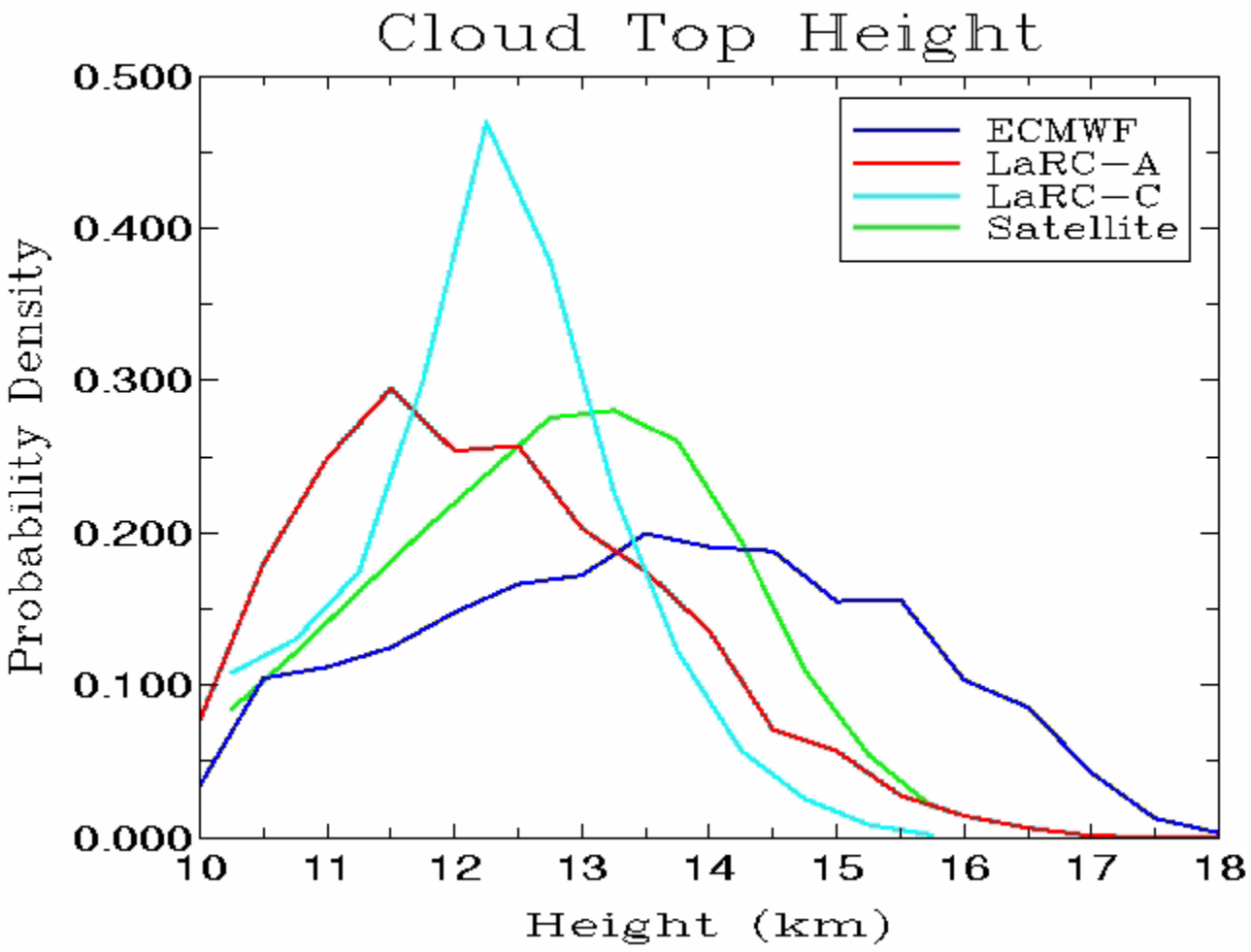
Results - Cloud Optical Depth



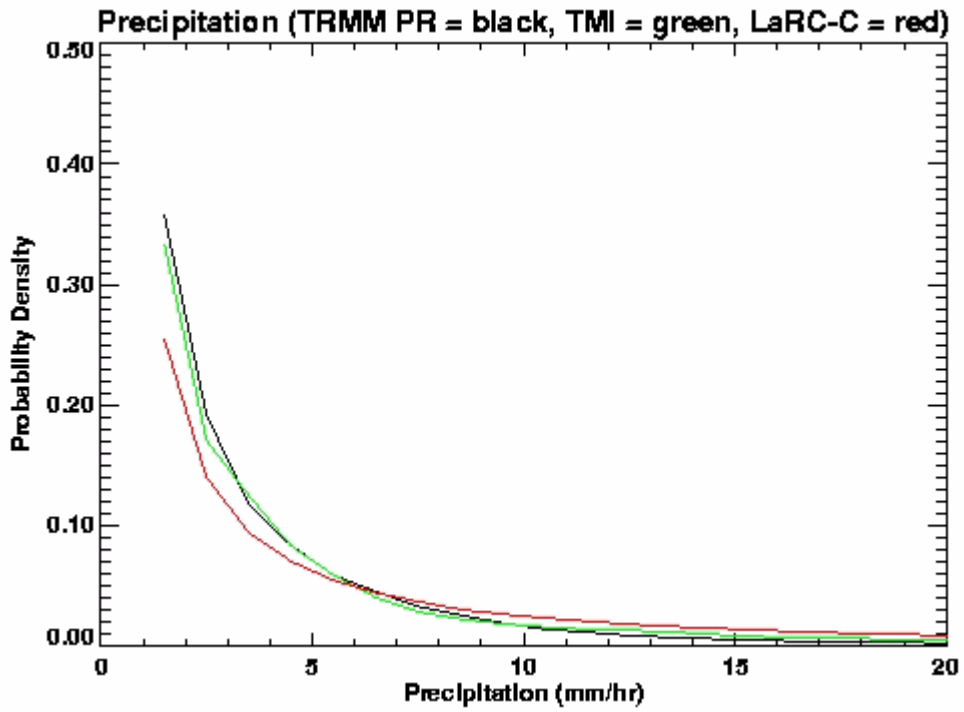
Results - OLR


Outgoing LW Radiation
ECMWF
LaRC—A
LaRC—C
Satellite
Probability Density
0.030
0.025
0.020
0.015
0.010
0.005
0.000
50
70
90
110
130
150
170
190
OLR (W m^{-2})

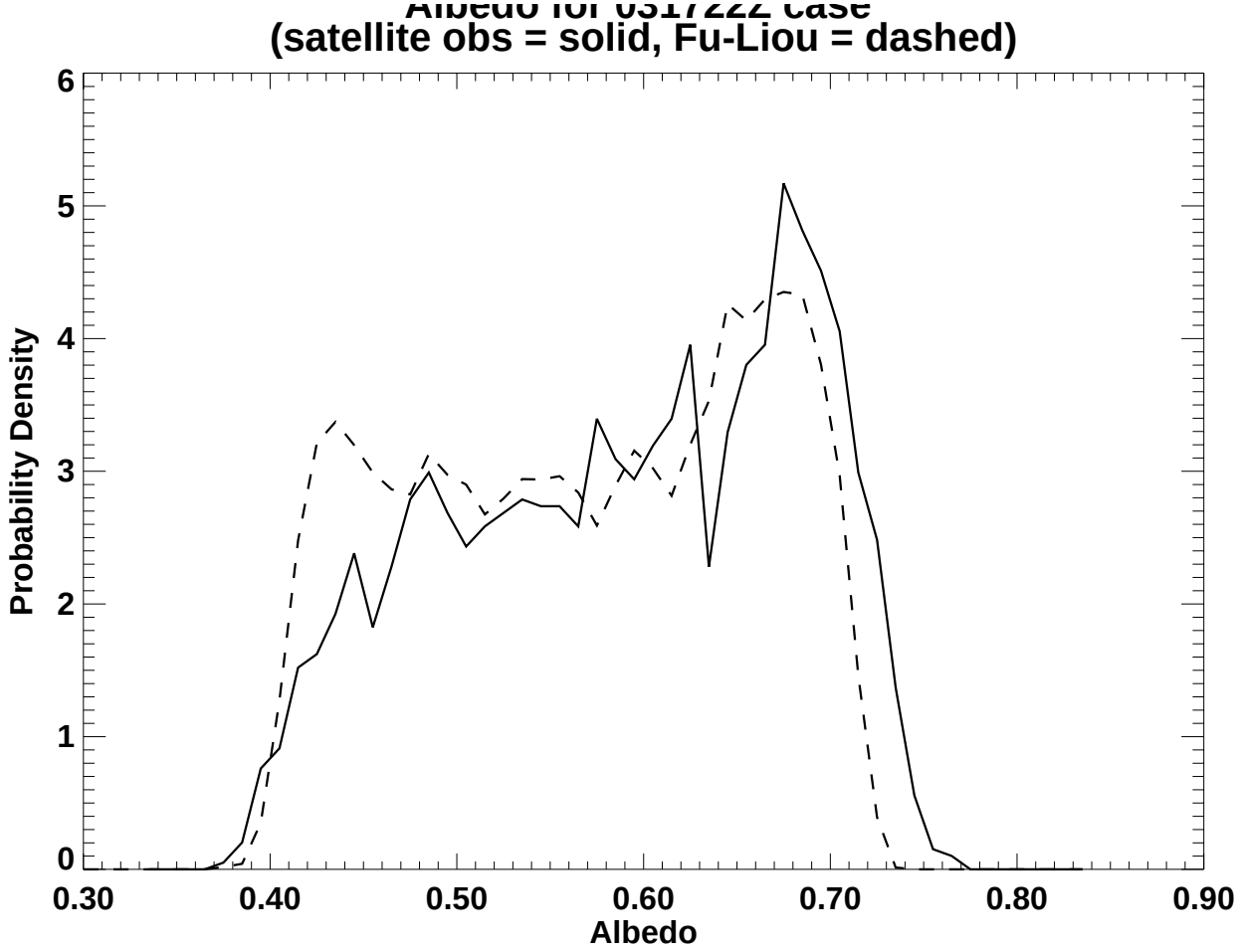
Results - Cloud Top Height



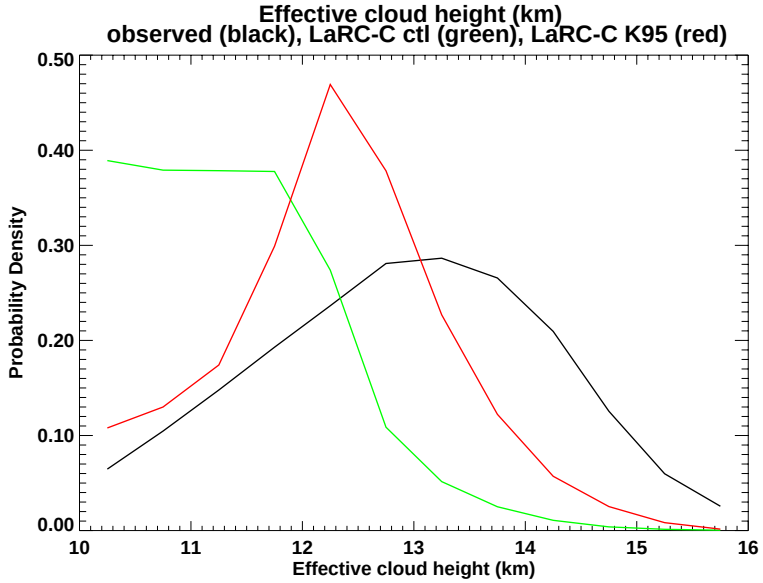
Results - Comparison with TRMM Precipitation Data

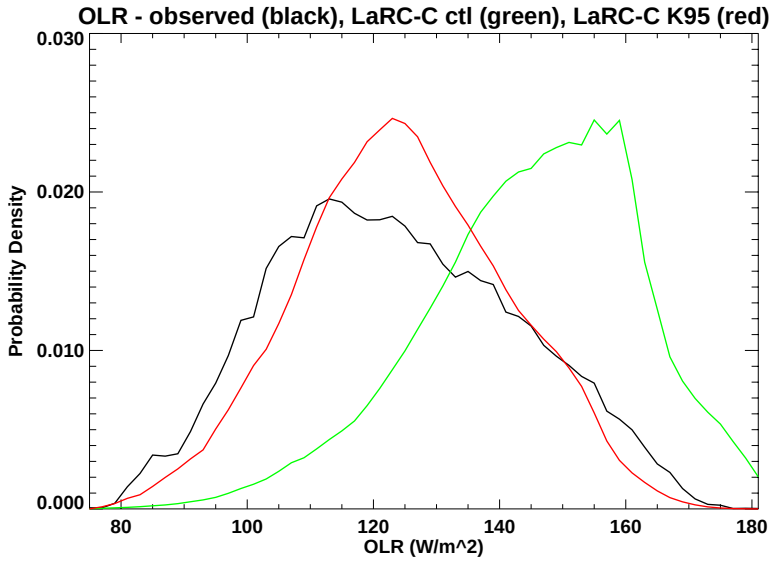


Results - Albedo with Fu-Liou Parameterization



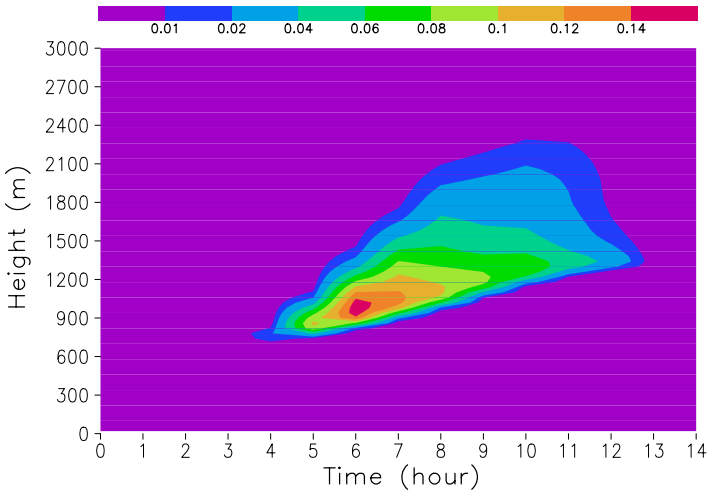
Example of Model Improvement- Change in Cloud Microphysics



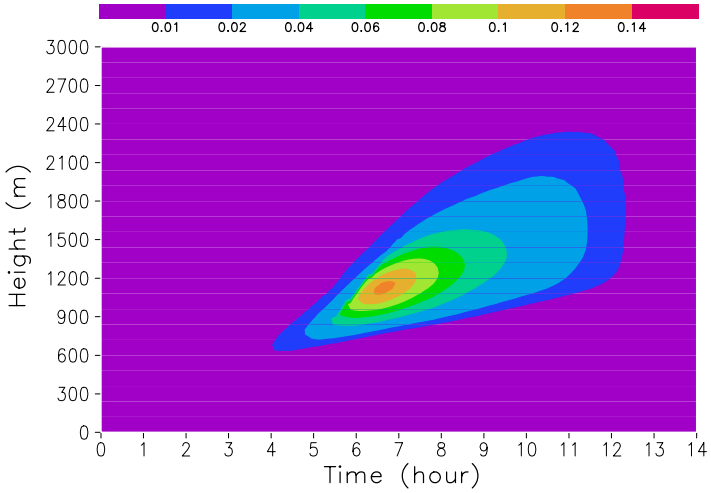


Boundary Layer Simulations

Here, we compare the cloud fraction (shaded) from a LaRC-A simulation of a shallow cumulus case observed at the ARM SGP site to a high-resolution LES simulation of the same case:



LES simulation



LaRC-A simulation

We look forward to using the boundary layer cloud systems identified by CERES to allow us to evaluate the model's strengths and weaknesses in simulating the different boundary layer cloud regimes.

Conclusions and Future Work

- The LaRC CRMs seem to do a good job at producing realistic PDFs of several observed variables in an ensemble of 29 simulations of tropical deep convective cloud systems observed in March 1998.
- We have already made some improvements to the LaRC-C model based on the technique outlined here, and look forward to the possibility of making further improvements with additional simulations.
- Preliminary results indicate that the LaRC-A model can do a good job simulating a shallow cumulus case - but this is only a single case. We look forward to using the boundary layer cloud systems identified by CERES to allow us to evaluate the model's strengths and weaknesses in simulating the different boundary layer cloud regimes.
- We want to use the "super parameterization" approach by embedding a LaRC CRM into a GCM. Using the cloud object selection criteria on the results, we hope to gain valuable insight about cloud-climate feedback for each system type. The super parameterization's results could also be used to improve conventional cloud parameterizations, which are much cheaper to use in general.