CFMIP-GCSS Intercomparison of LES and SCMs (CGILS)

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AR4 GCM ΔCRF for CO_2 doubling.

- Tropical ΔSWCRF drives model spread in global ΔCRF

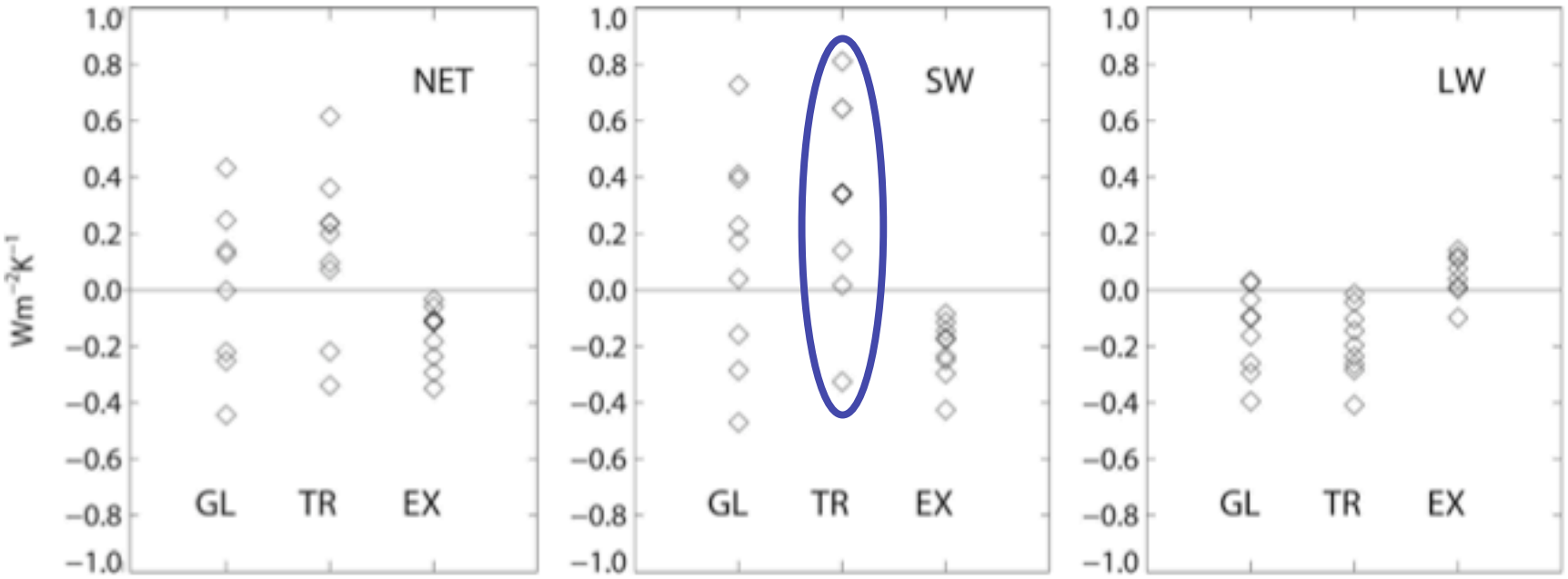


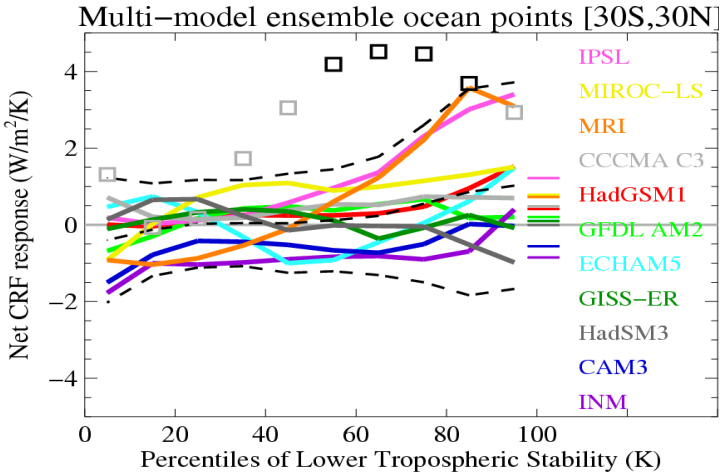
FIG. 10. Global change in the (left) NET, (middle) SW, and (right) LW CRF normalized by the change in global mean surface air temperature predicted by AR4 mixed layer ocean atmosphere models in 2xCO_2 equilibrium experiments. For each panel, results (in W m^{-2} K^{-1}) are shown for global (GL), tropical (TR, 30°S–30°N) and extratropical (EX) areas. The intermodel spread of the global CRF response to climate warming primarily arises from different model predictions of the change in tropical SW CRF. (Adapted from WEBB.)

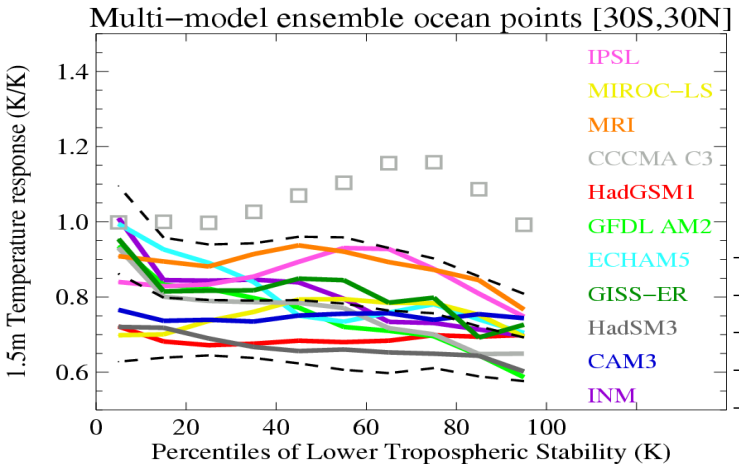
Bony et al. 2006

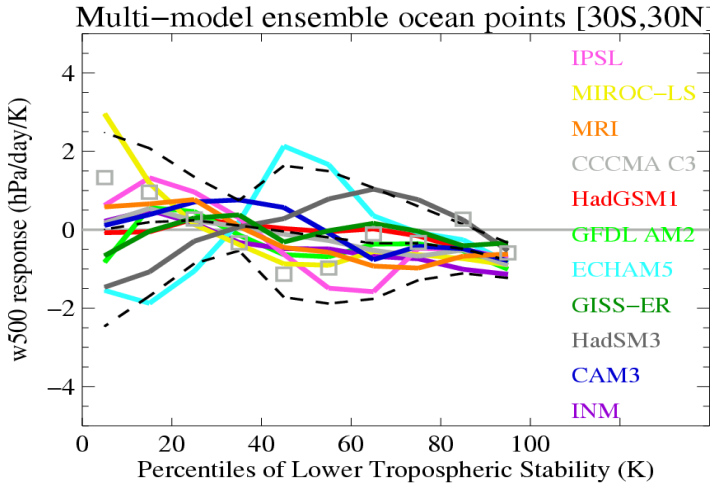
⇒ Low-latitude boundary layer cloud drives model spread in climate sensitivity.

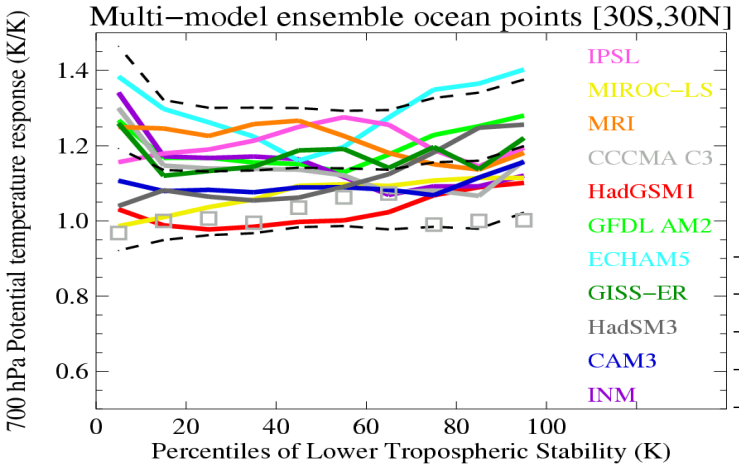
LTS-binned response of AR4 slab GCMs to 2xCO_2

- AR4 GCMs show quite similar stratification and vertical motion changes across all tropical ocean regimes, but diverse cloud response.

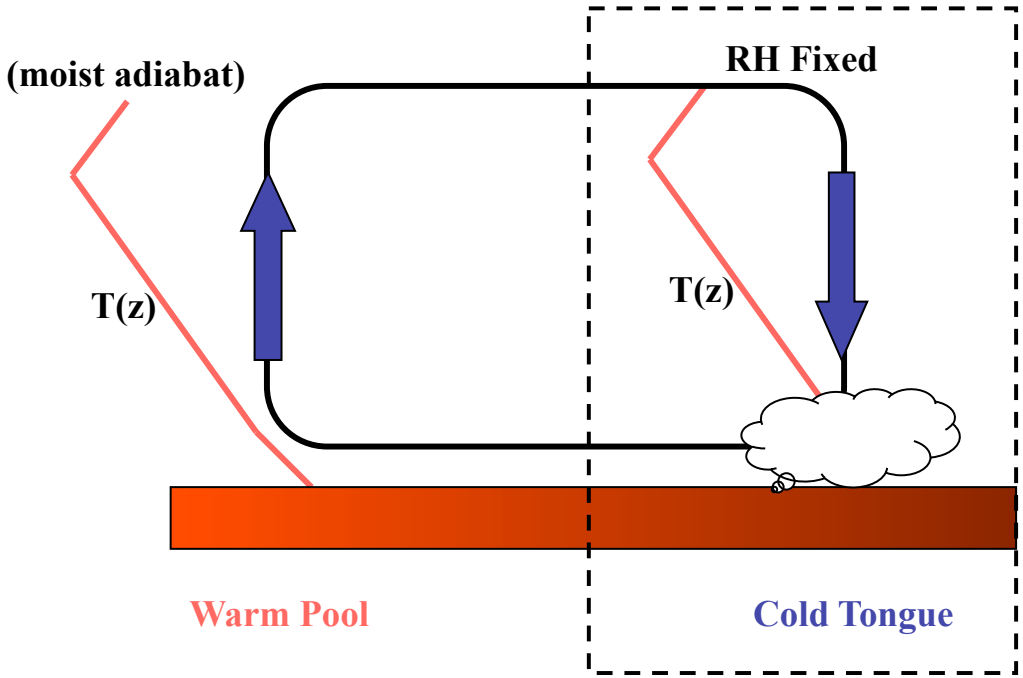








...suggests a column framework with specified control and perturbed-climate large-scale forcings might be useful for assessing subtropical low cloud response.



(Zhang and Bretherton, 2008)

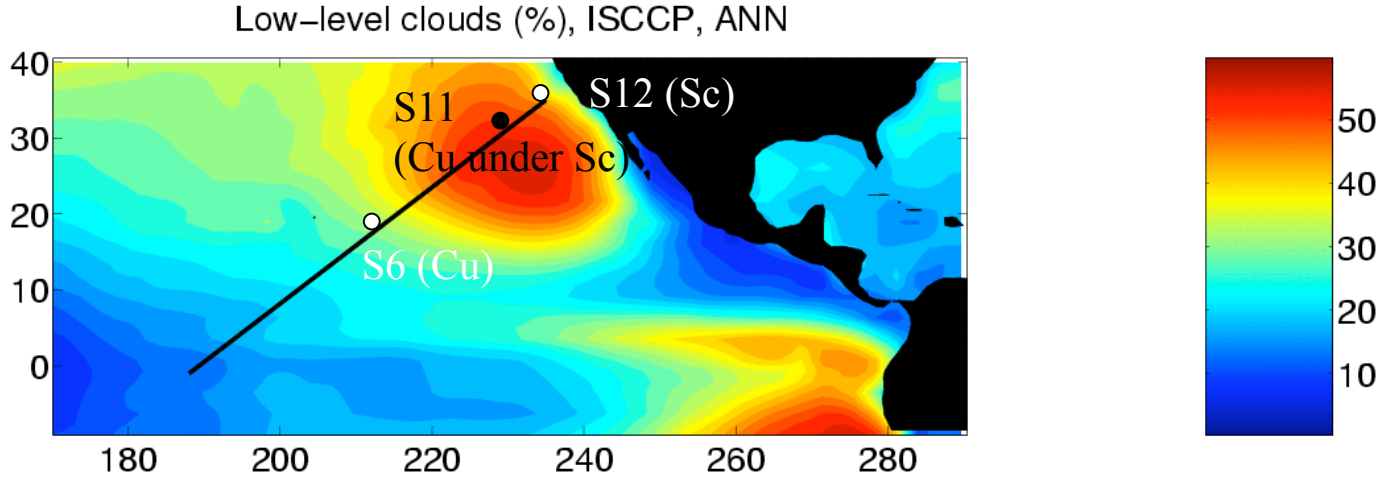
CFMIP-GCSS Intercomparison of LES and SCMs (CGILS)

Led by M. Zhang and C. Bretherton
First submission of results: June 2009

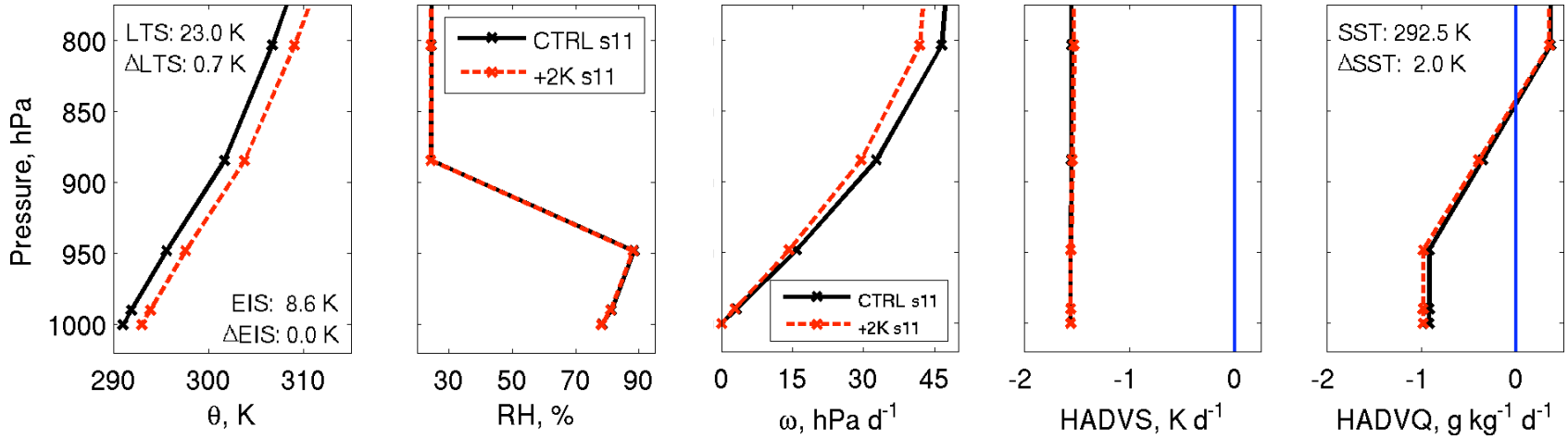
Objectives:

- To compare SCM and LES/CRM column simulations
- To understand low cloud response mechanisms to a climate perturbation in LES and SCM column models.
- To test whether a column analogue to a climate change (+2K SST) reproduces the intermodel variability in AGCM subtropical cloud response.

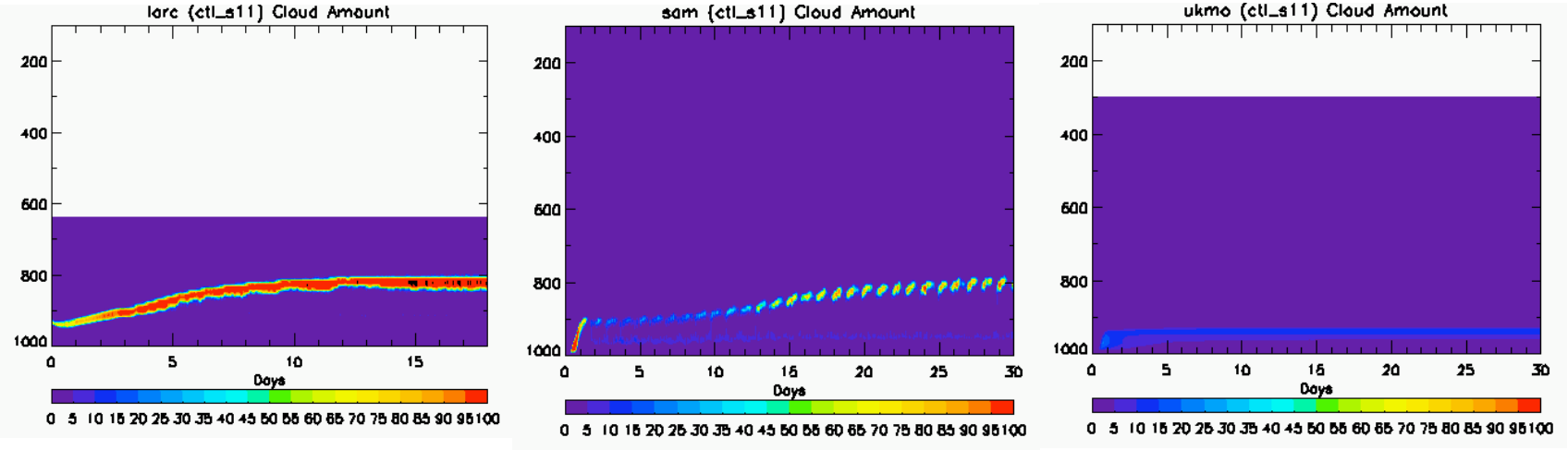
Control: Force column models with JJA climo from 3 GPCI points (focus on S11)
SST+2K: Start with warmer free-trop moist adiabat, same free-trop RH=25%.
Subsidence reduced ~10%, same horizontal T,q advection profiles.
Run models to steady state with diurnally averaged insolation.



S11 Free-trop T, vertical motion, hadv profiles (SST=292.5 [+2K])



Cloud Amount in Control Simulation at s11: LES results profoundly disagree



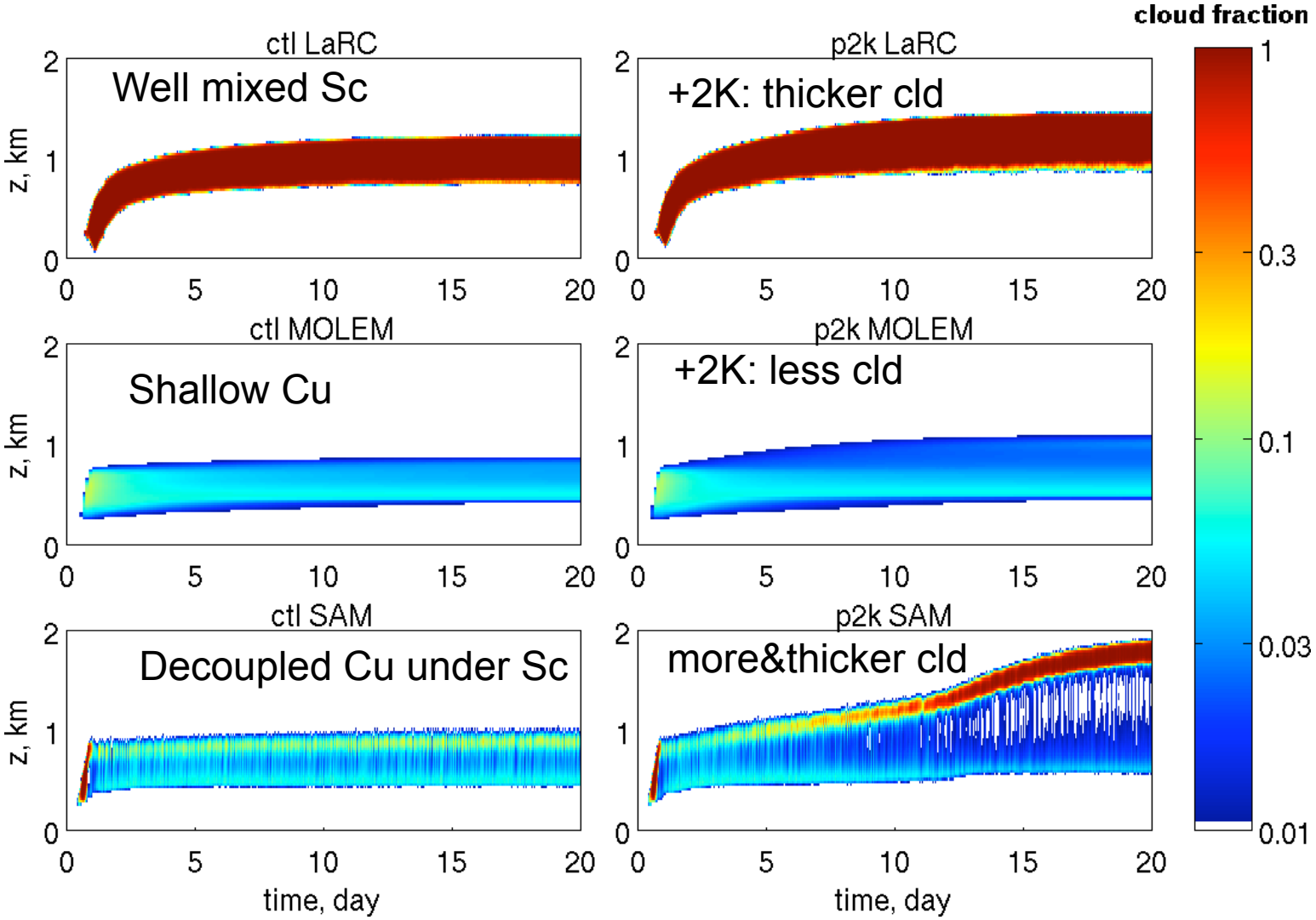
...why? Not resolution, since all LES have $\Delta x = \Delta y = 50$ m, $\Delta z = 25$ m.

This is an issue for CMMAP, which is founded on the assumption that LES/CRM can lead to more reliable modeling of cloud/climate interactions.

This fall LES modelers tried to understand discrepancies:

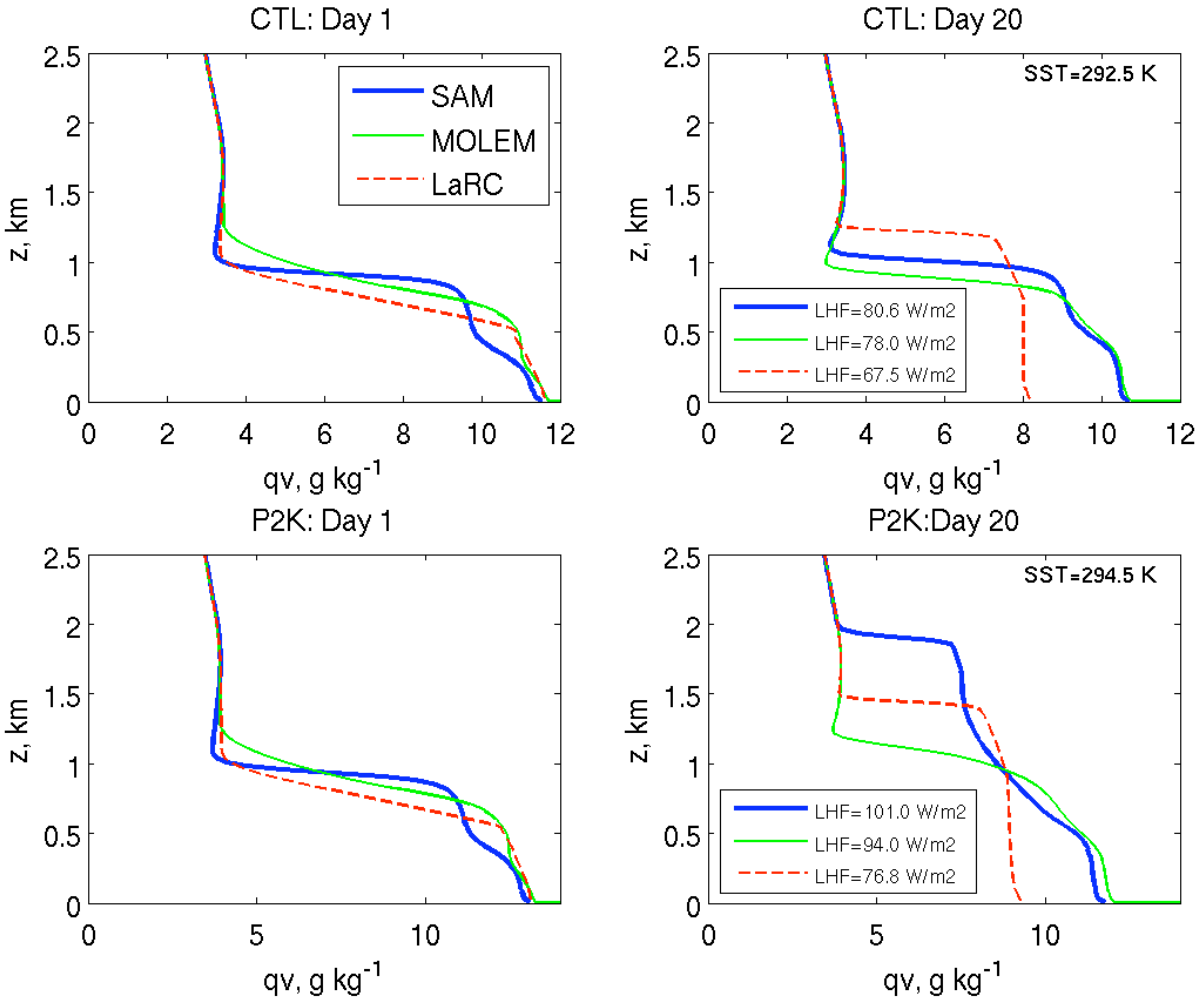
- Used consistent, stronger relaxation of T, q to reference profiles in free trop.
- Implemented the same RRTM radiation scheme in all LES, using an interface designed by Peter Blossey and Robert Pincus.

This has not reduced the model differences!



- Likely explanation for ctrl CTBL differences: Differences in model entrainment efficiency; multiple equilibria; residual setup issues?
- The LES do not agree on the sign of the predicted low cloud response

Differences also clear in vertical q_v structure



Caveat: LaRC surface fluxes too weak?

Formulation weakness: +2K PBL deepening exaggerated by artificially large low-level ω decrease.

What's Next?

- Must better understand why the control cloud response is very different between LESs.
- The self-similar +2K ω change seems unrepresentative of a real subtropical climate perturbation.
- Add ω -feedback (deeper, colder PBL drives more low-level subsidence) to prevent inversion height runaway?
- Workshop at Stony Brook at the beginning of March.