CGILS LES intercomparison update

Peter Blossey and Chris Bretherton, U. Washington
Minghua Zhang, Stony Brook

With results from participating LES modeling groups:

SAM: Peter Blossey (UW)/Marat Khairoutdinov (Stony Brook)

MOLEM: Adrian Lock (UKMO)

UCLA: Irina Sandu (ECMWF)/Thijs Heus (MPI)

LARC: Anning Cheng (LaRC)

DALES: Stephan De Roode (TU Delft)

GCSS-CFMIP column cloud feedback intercomparison

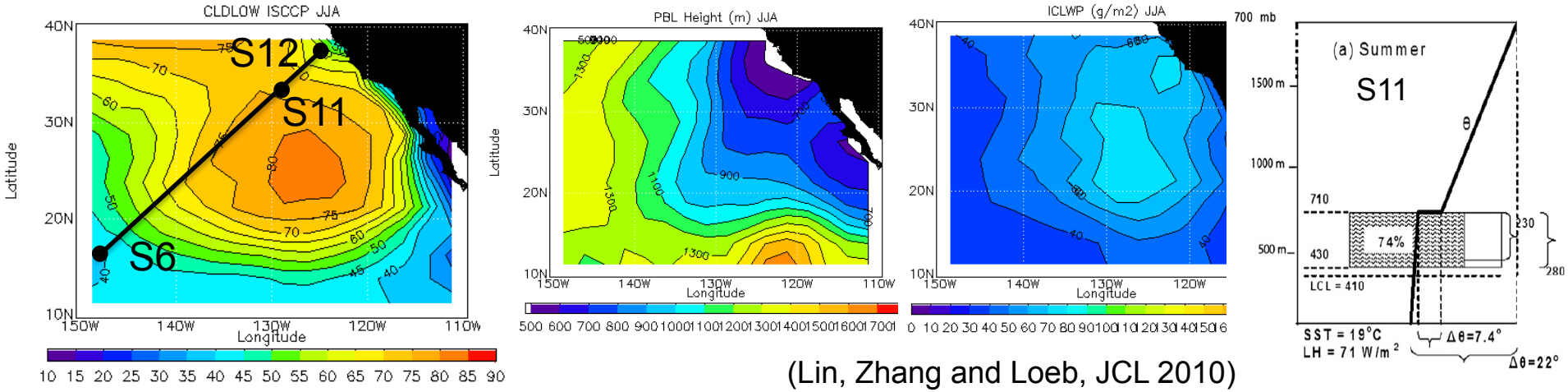
Objectives:

1. To test whether a column analogue to a climate change (+2K SST) reproduces the intermodel variability in AGCM subtropical cloud response.

2. To understand the low cloud response mechanisms in the column models.

3. To compare SCM with LES/CRM column simulations

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, .
~same horizontal T,q advection profiles, subsidence reduced ~10%,.
Run models to steady state with diurnally averaged insolation, RRTM radiation.



(Lin, Zhang and Loeb, JCL 2010)

Forcing changes from February:

(1) Reference T/q profiles from ERA40 climo instead of idealized moist adiabats above. Relax profiles above 4000/2500/1200 m for S6/S11/S12

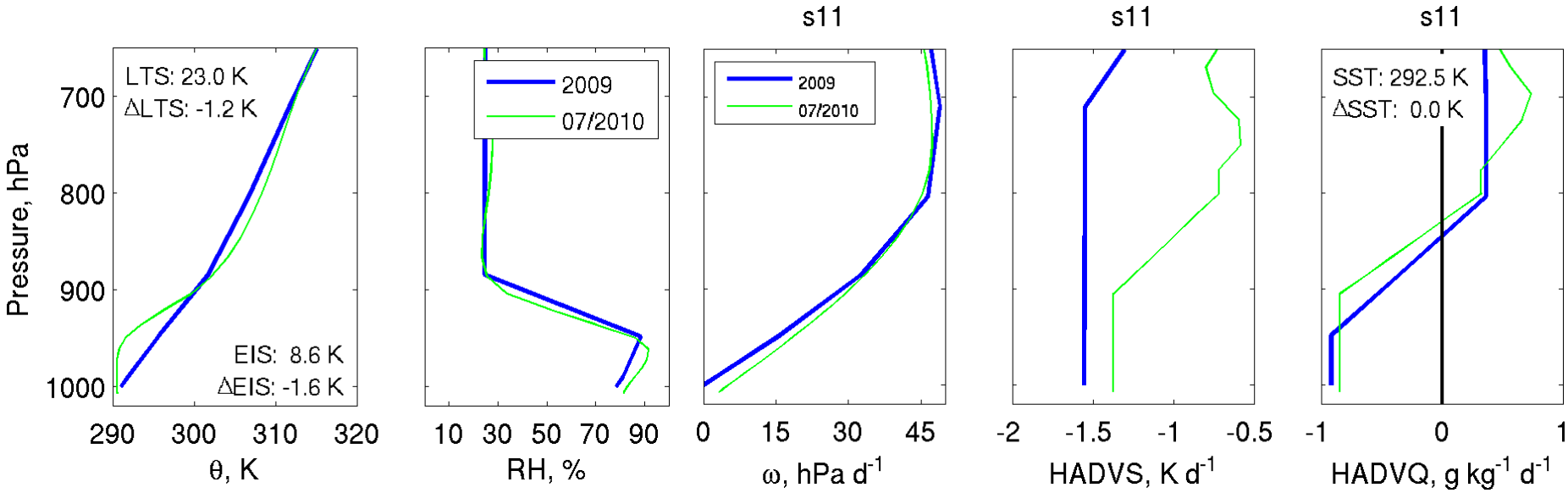
(2) Bulk T,q surface flux relationships with 10 m transfer coefficient 1.2×10^{-3}, specified 10 m wind, adjusted to lowest model level using log-layer scaling.

(3) 'Local' moist adiabat with ERA LCL for reference +2K T, q at each level.

Unfinished business:

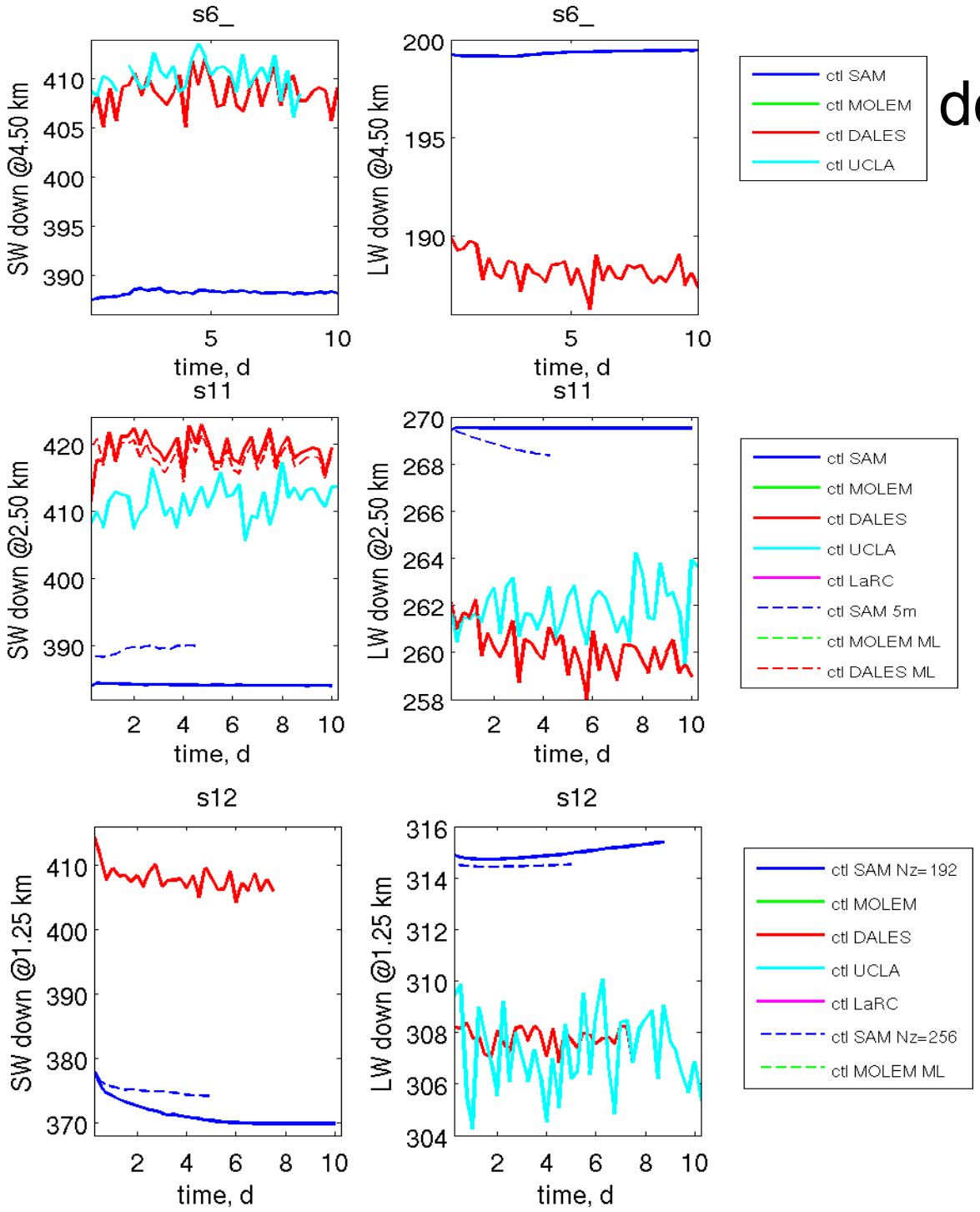
Advective forcings computed at eta levels, but used at pressure levels (p_s=1008)

S11 reference profile changes



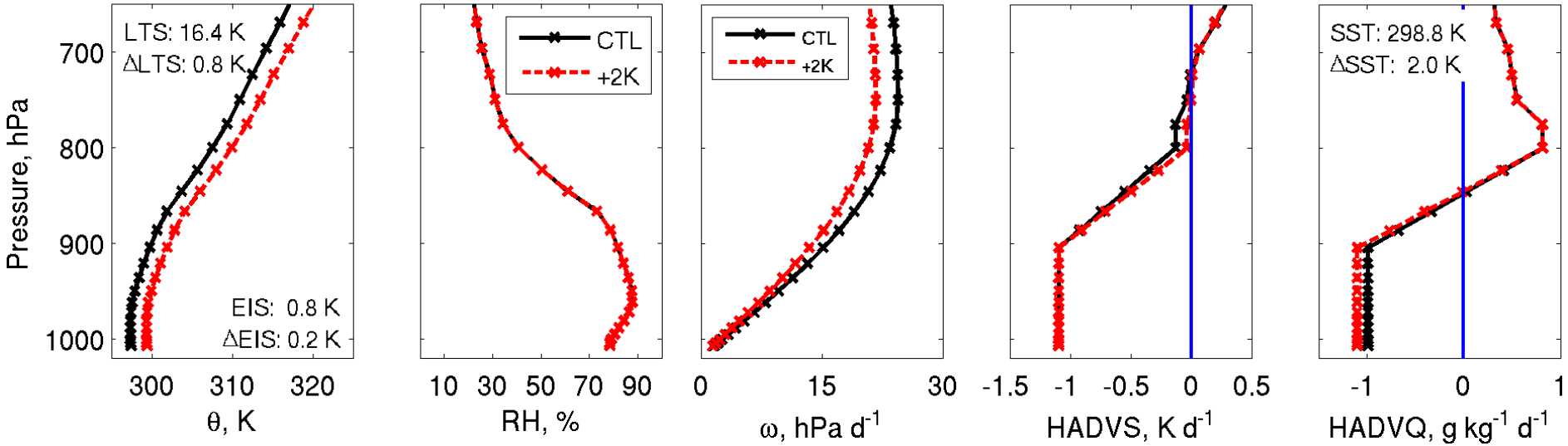
- Horizontal advection keeps new T, q, ω reference profiles in steady-state above PBL.
- ω = 0 at surface pressure of 1008 hPa (should be ~1022 hPa)
- This approach cannot capture inversion height advection (Lagrangian PBL deepening) very well without modification, resulting in simulated boundary layers that are deeper than observed at S6 and S11.

Free-tropospheric downwelling radiation

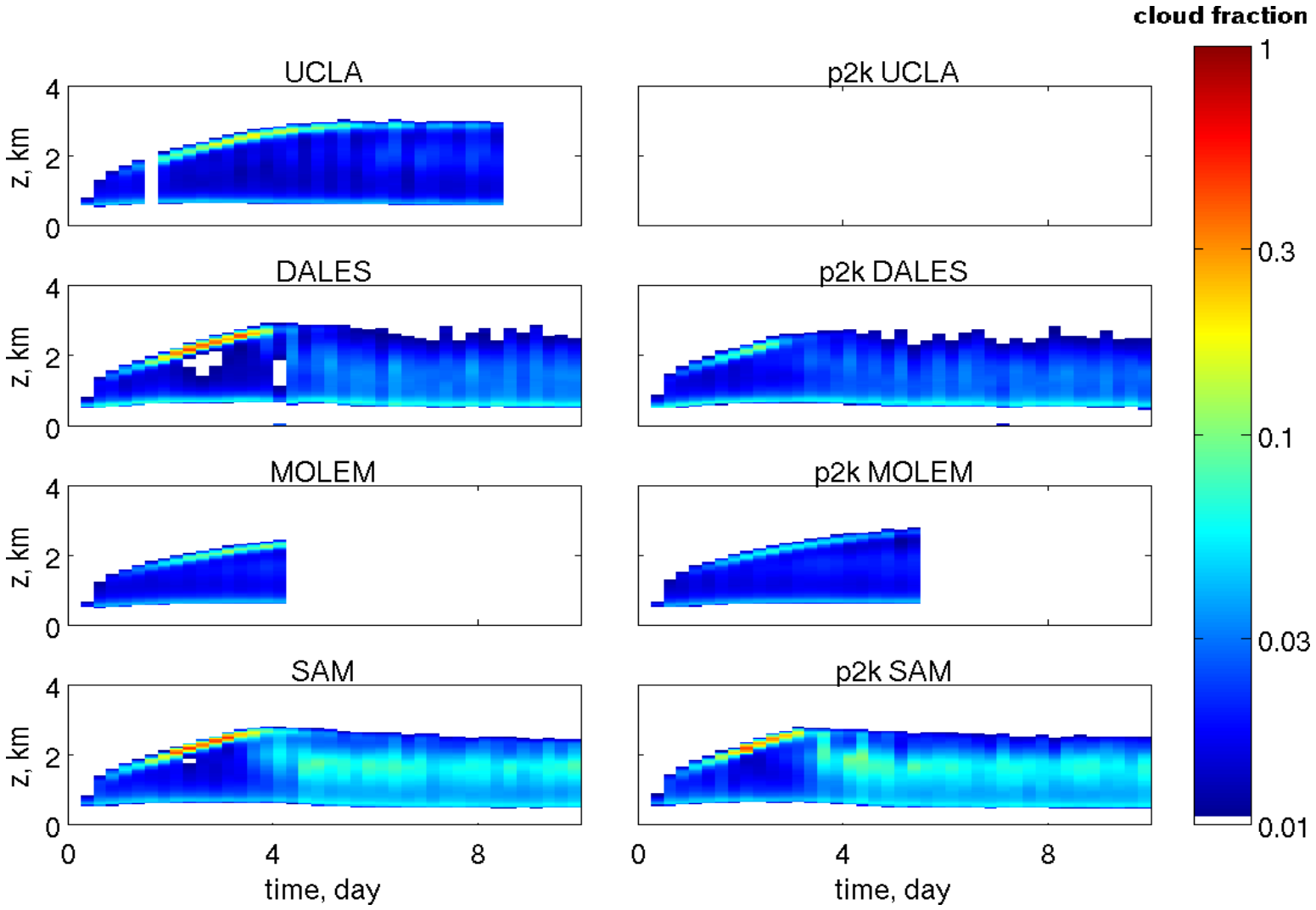


- Should be almost the same between models…
- Nontrivial differences still exist between DALES/ UCLA and SAM.
- Would be nice to get closer agreement.

S6: New forcings



S6: LES results (dx/dz = 100/40 m)

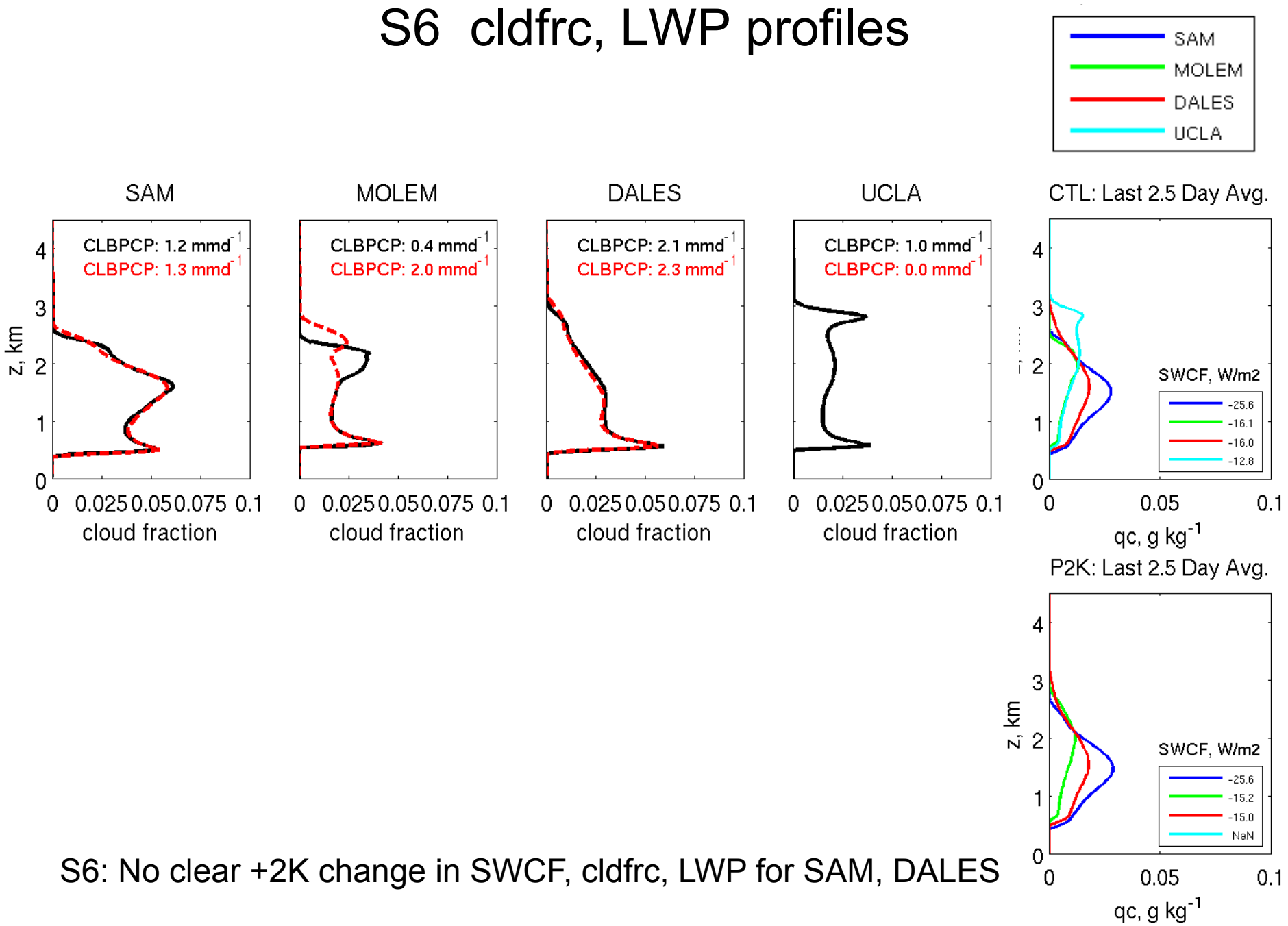


Fair agreement between LES models

Cloud layer deepens; transitions to a Cu-only layer in SAM and DALES

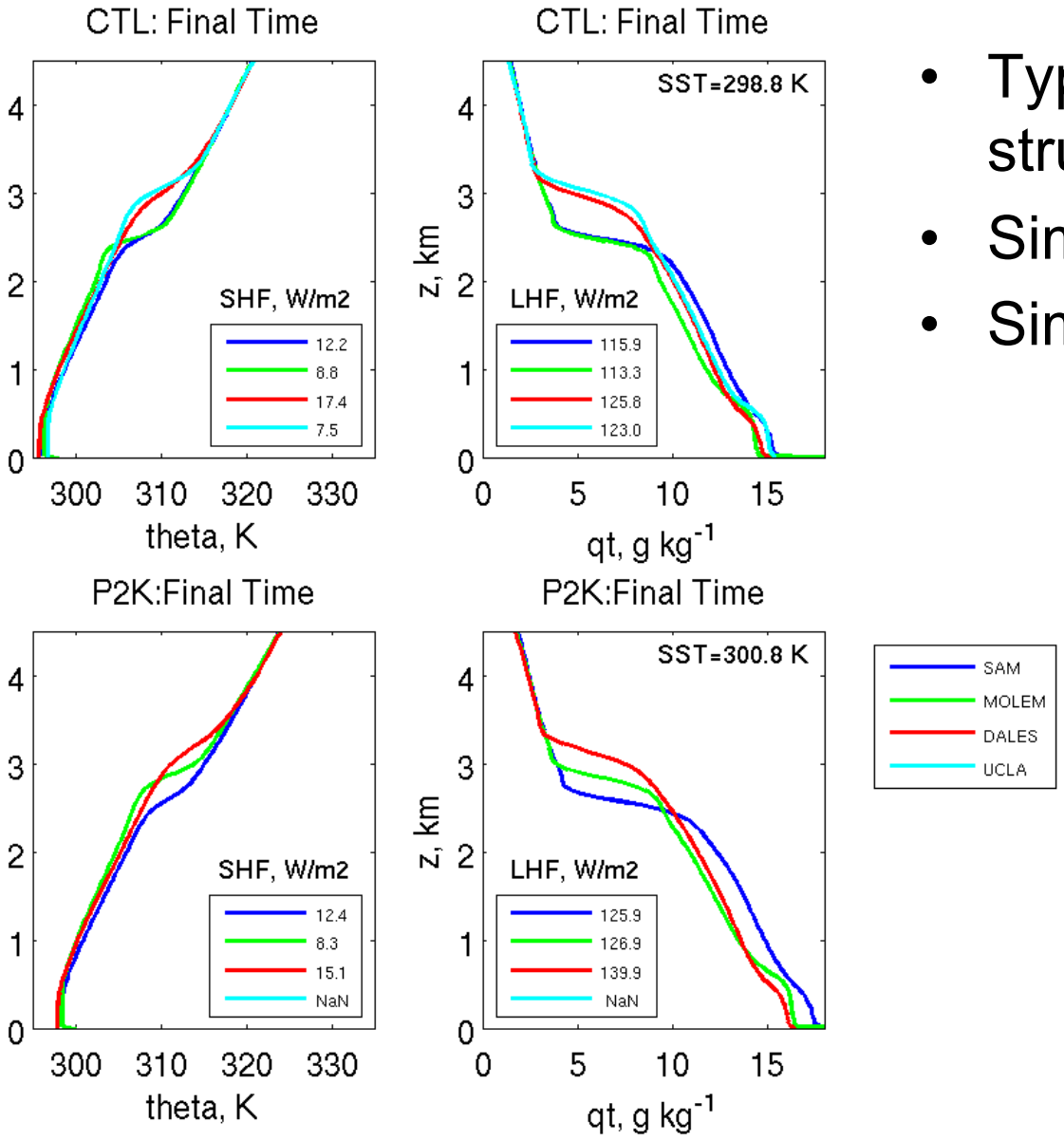
+2K changes are imperceptible

S6 cldfrc, LWP profiles



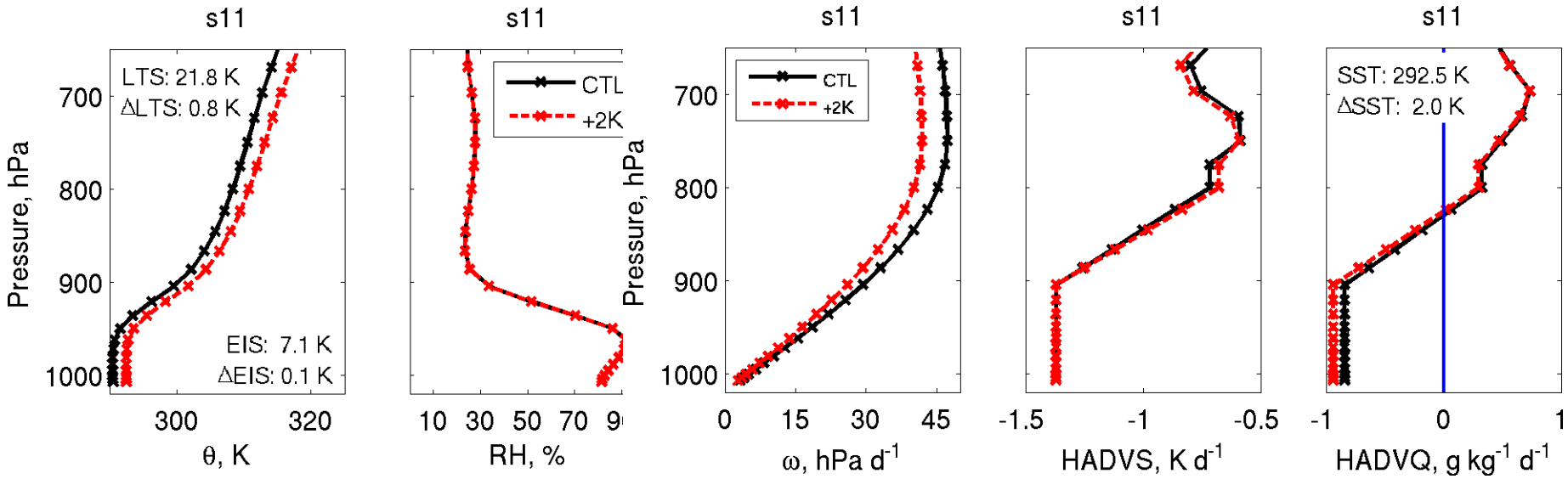
S6: No clear +2K change in SWCF, cldfrc, LWP for SAM, DALES

S6 θ, q profiles

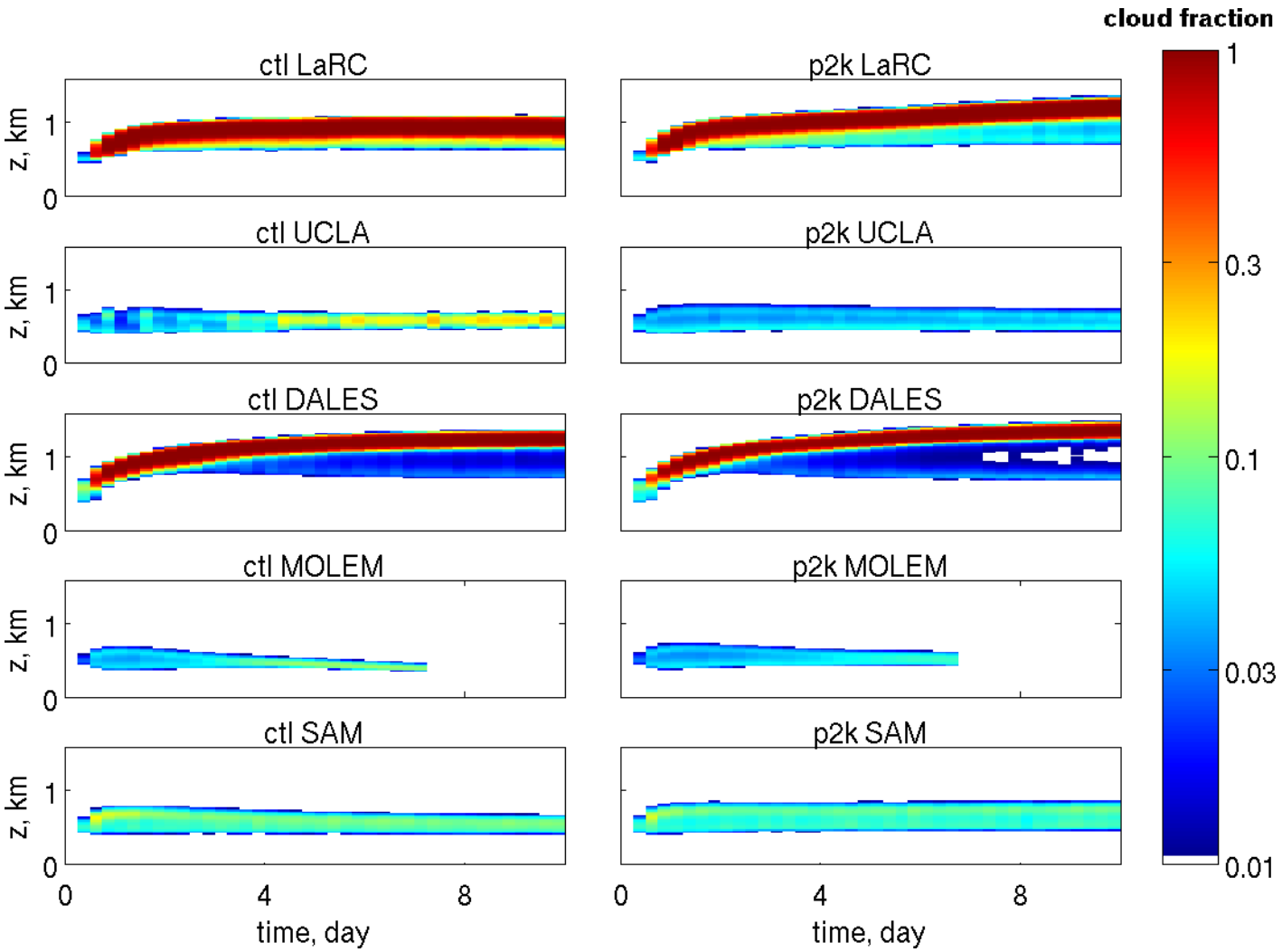


- Typical shallow Cu structure
- Similar between models
- Similar for +2K vs. ctrl

S11 forcings

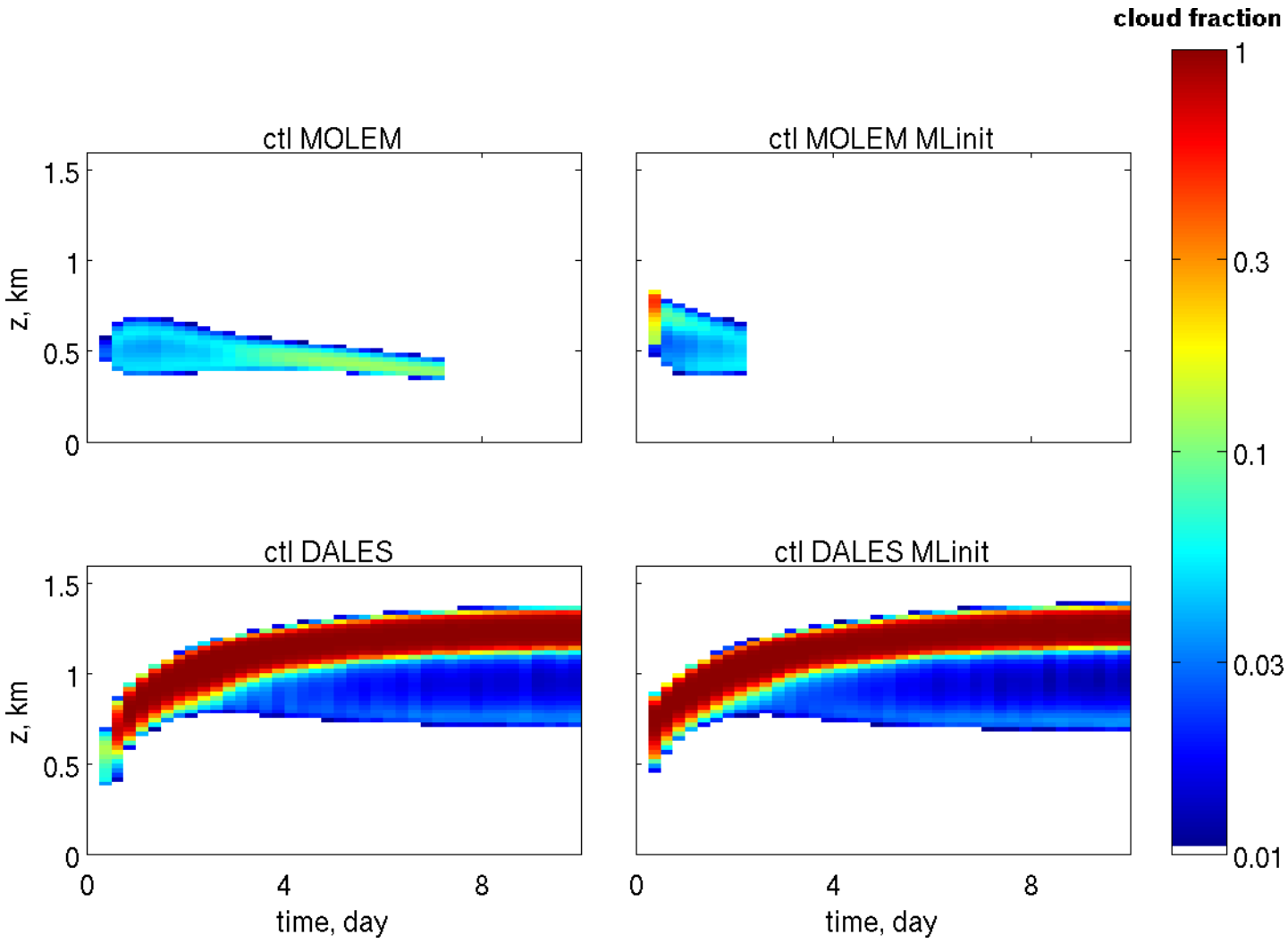


S11 control simulations (dx/dz = 50/25 m)

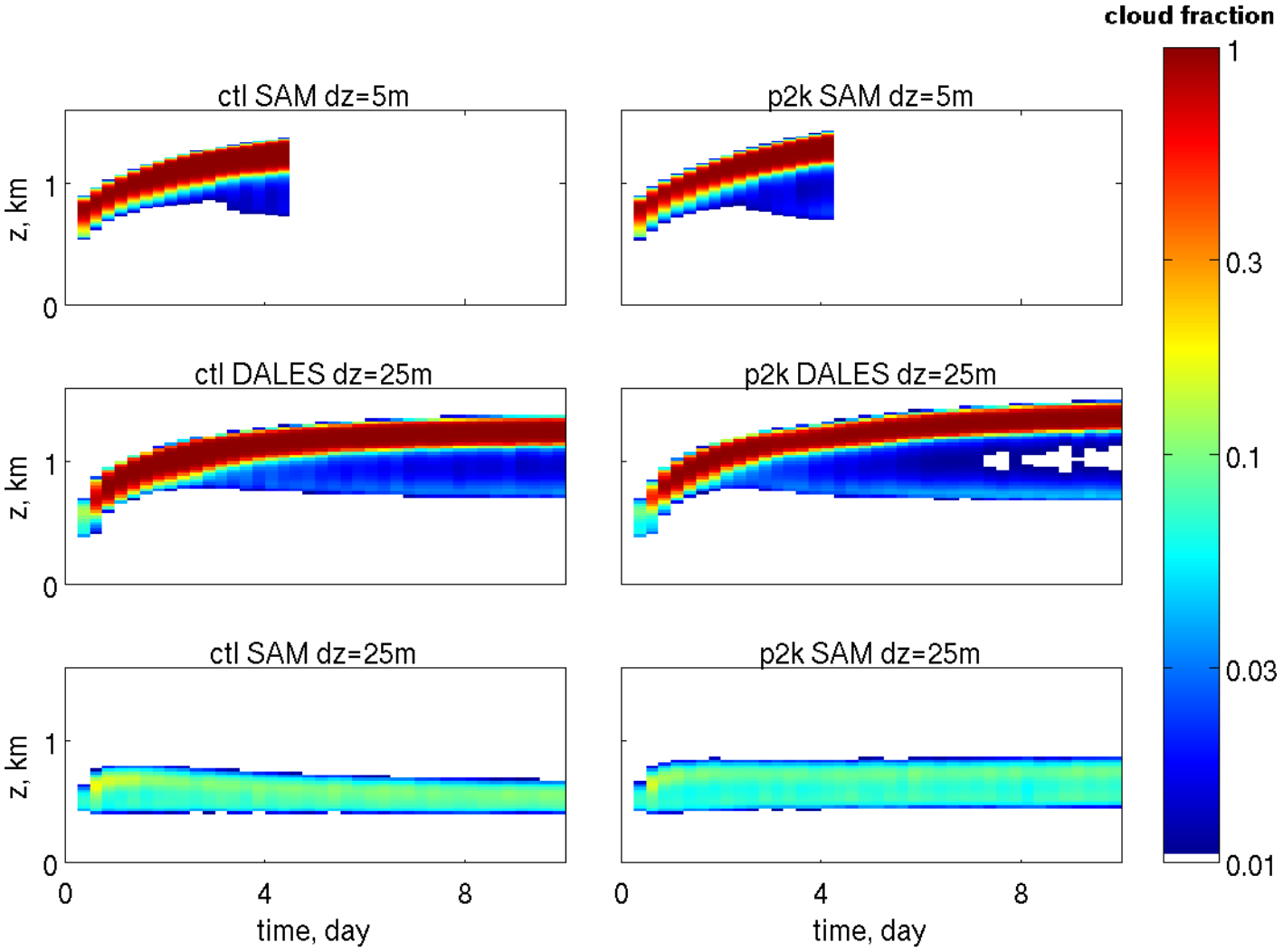


Simulations split into thin-cloud and solid-Sc regimes

Insensitive to use of mixed-layer initial condition



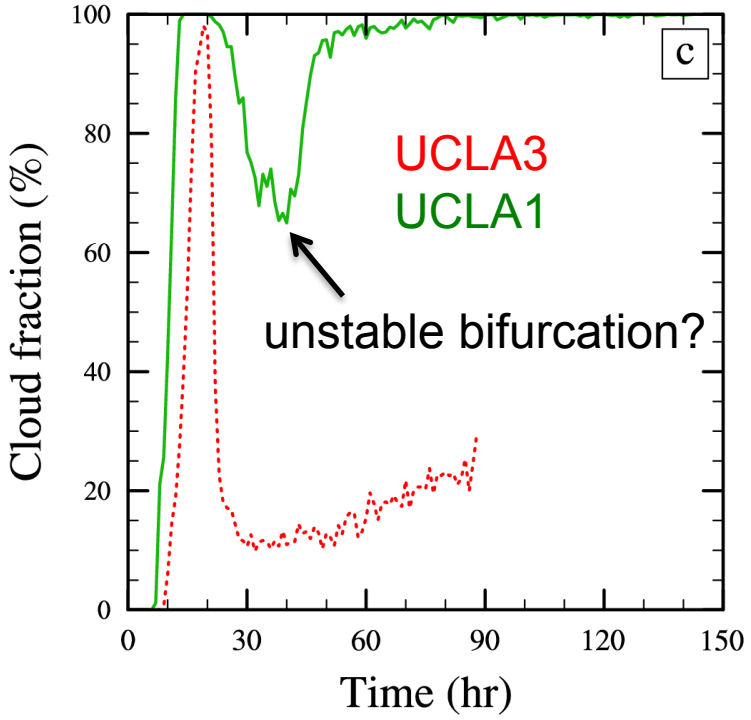
…but sensitive to finer dz



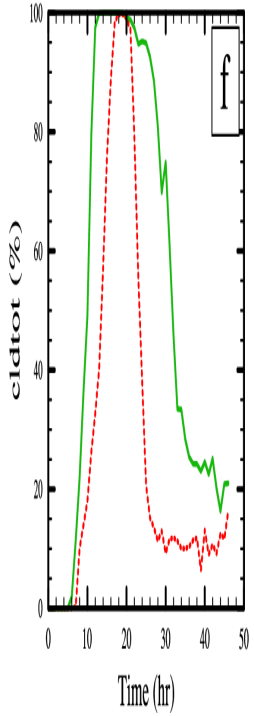
SAM at dz=5 m looks like DALES at dz = 25 m

…and sensitive to surface flux formulation (LaRC)

Control



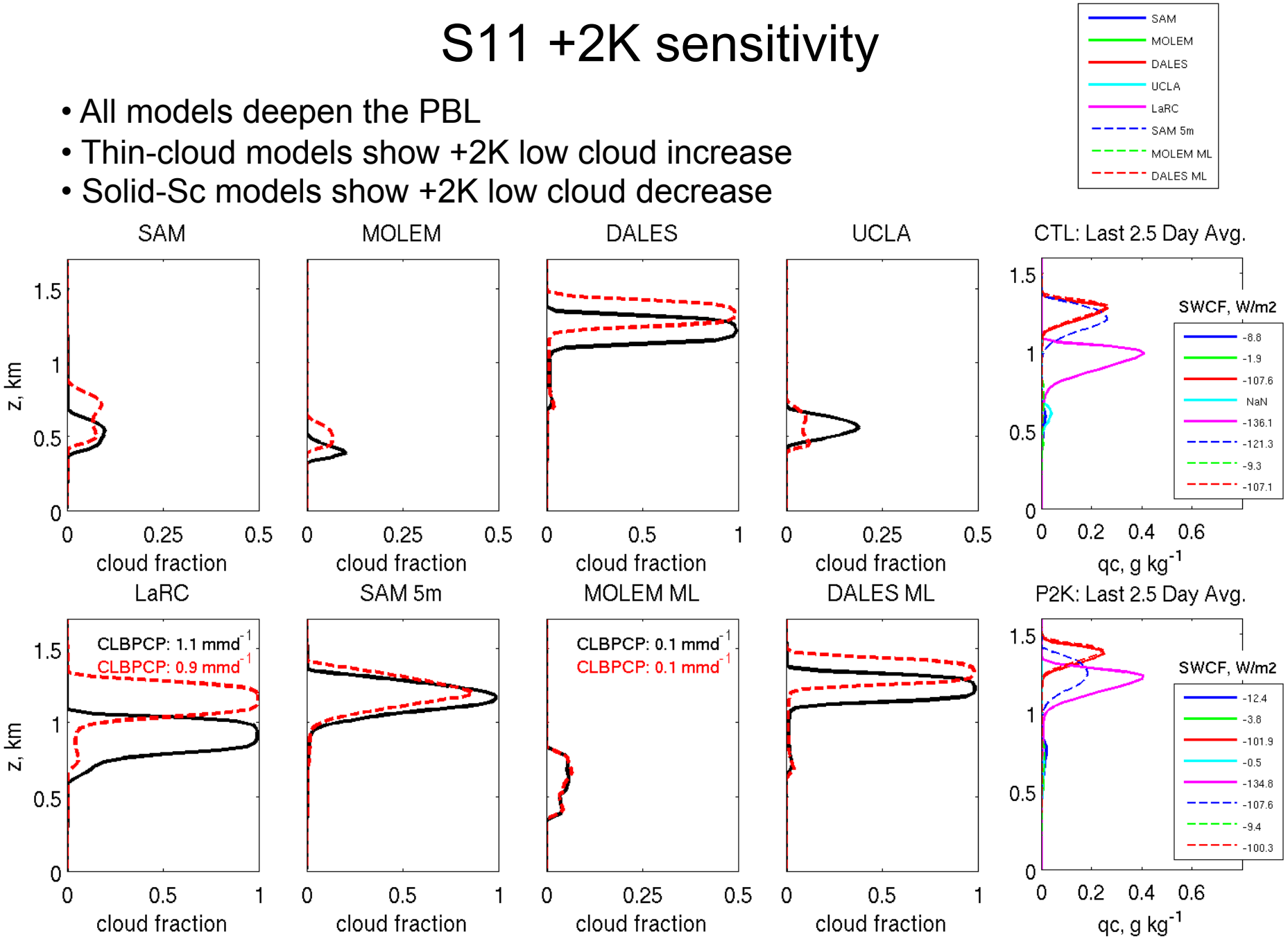
UCLA3 surface flux scheme in UCLA1



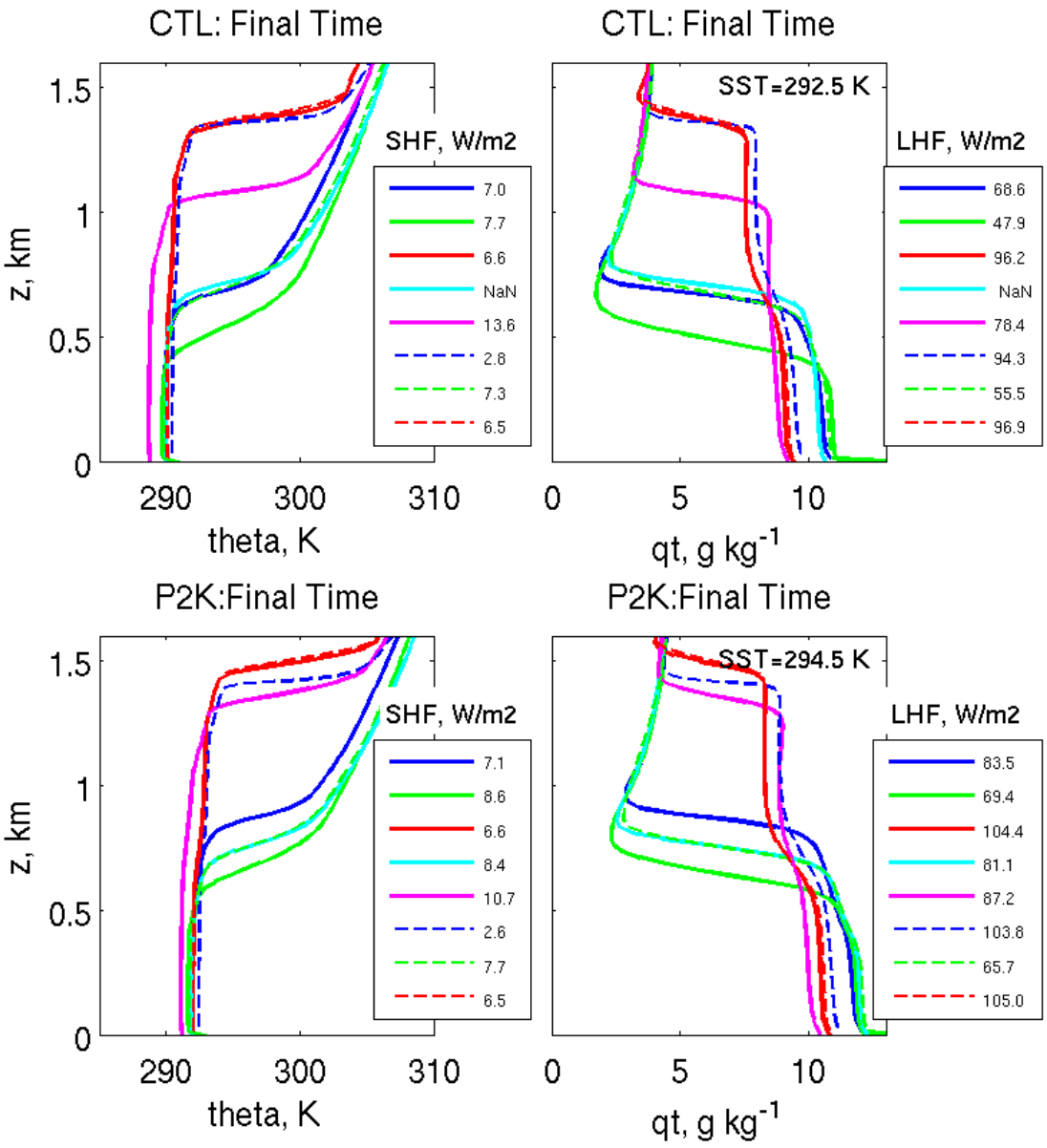
General conclusion: We should all consider running this case with dx/dz = 25/5 m to see if everyone ends up in the solid-Sc regime.

S11 +2K sensitivity

- All models deepen the PBL
- Thin-cloud models show +2K low cloud increase
- Solid-Sc models show +2K low cloud decrease

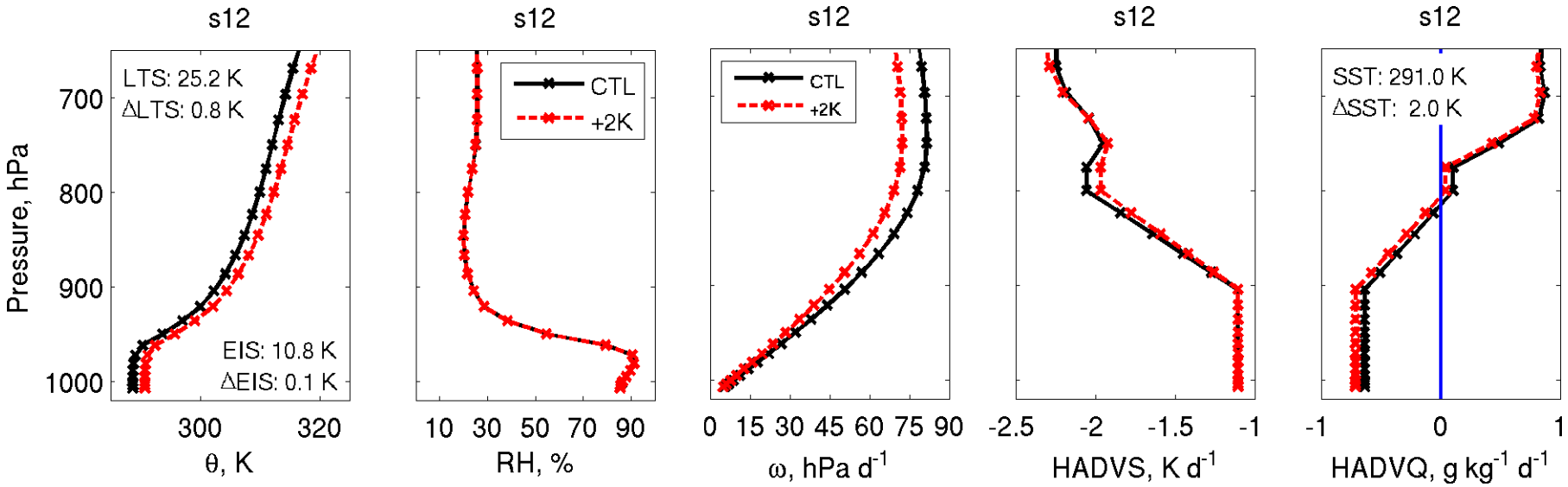


S11 θ and q profiles

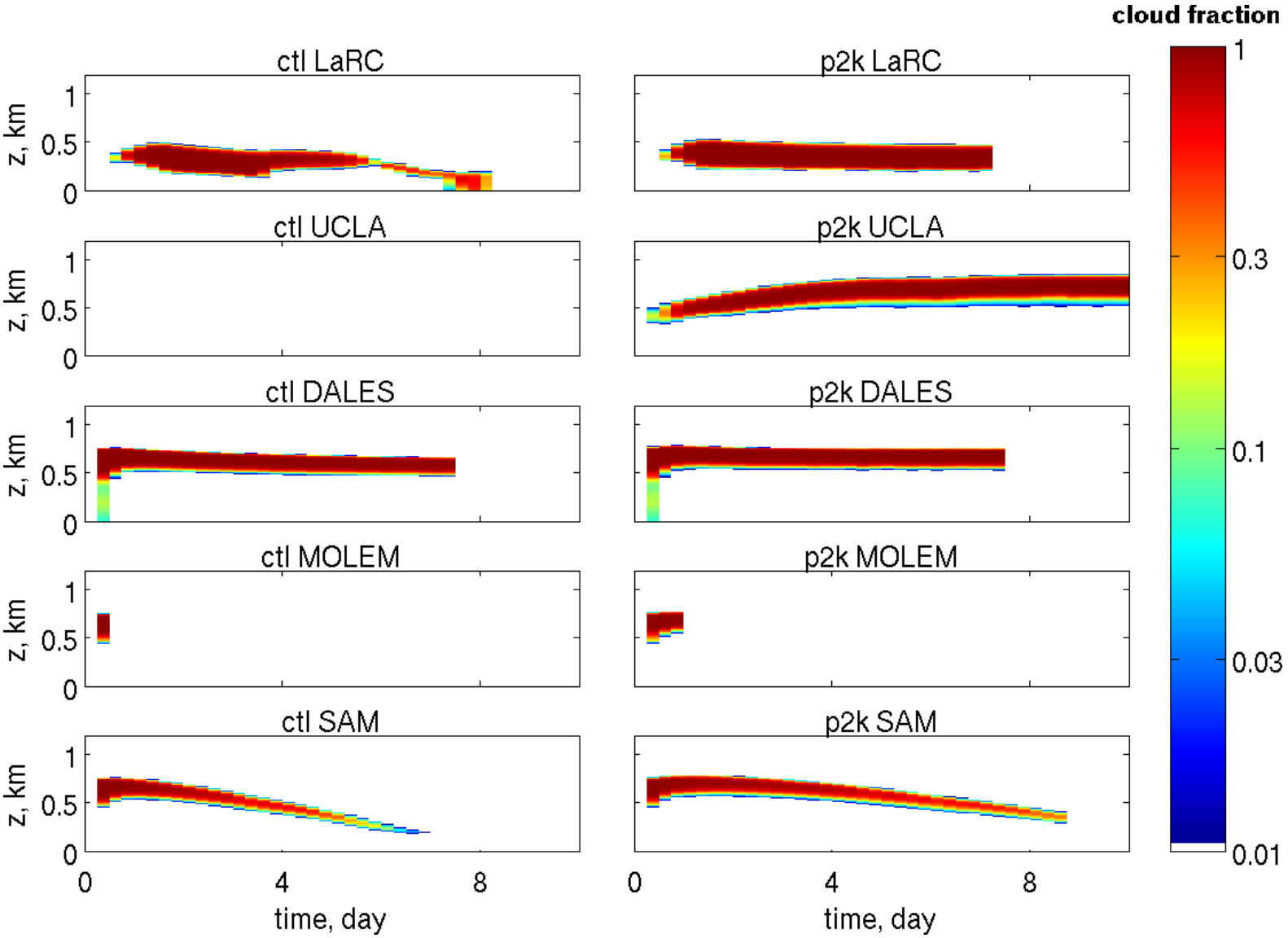


- All models show decoupling
- Undesirably dry free troposphere when PBL shallows due to dry advection+subsidence
- This leads to strong evaporative cooling efficiency κ for low zinv

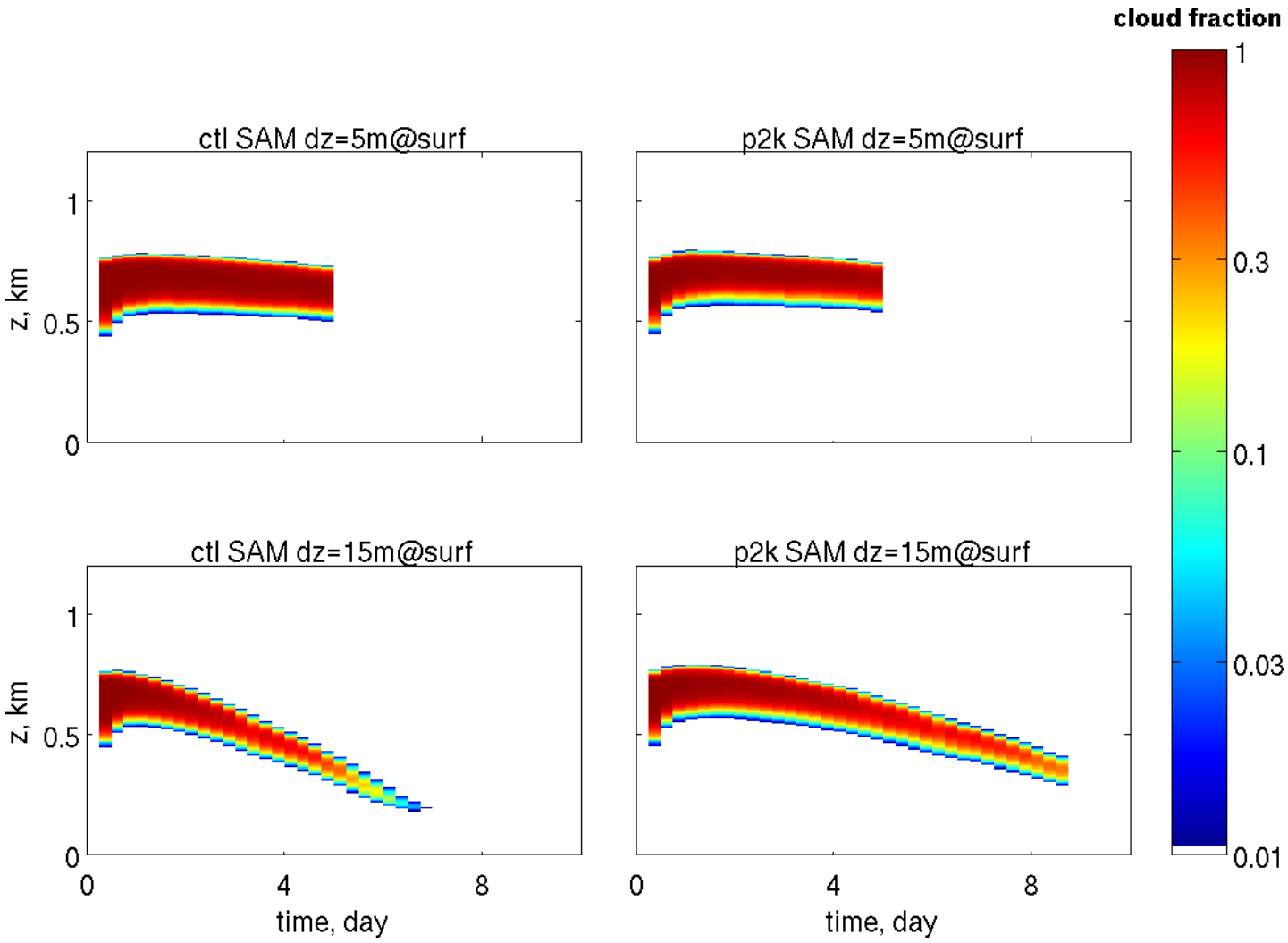
S12 forcings



S12: dx/dz = 25/5 m at inversion



Sensitivity of SAM to near-surface dz

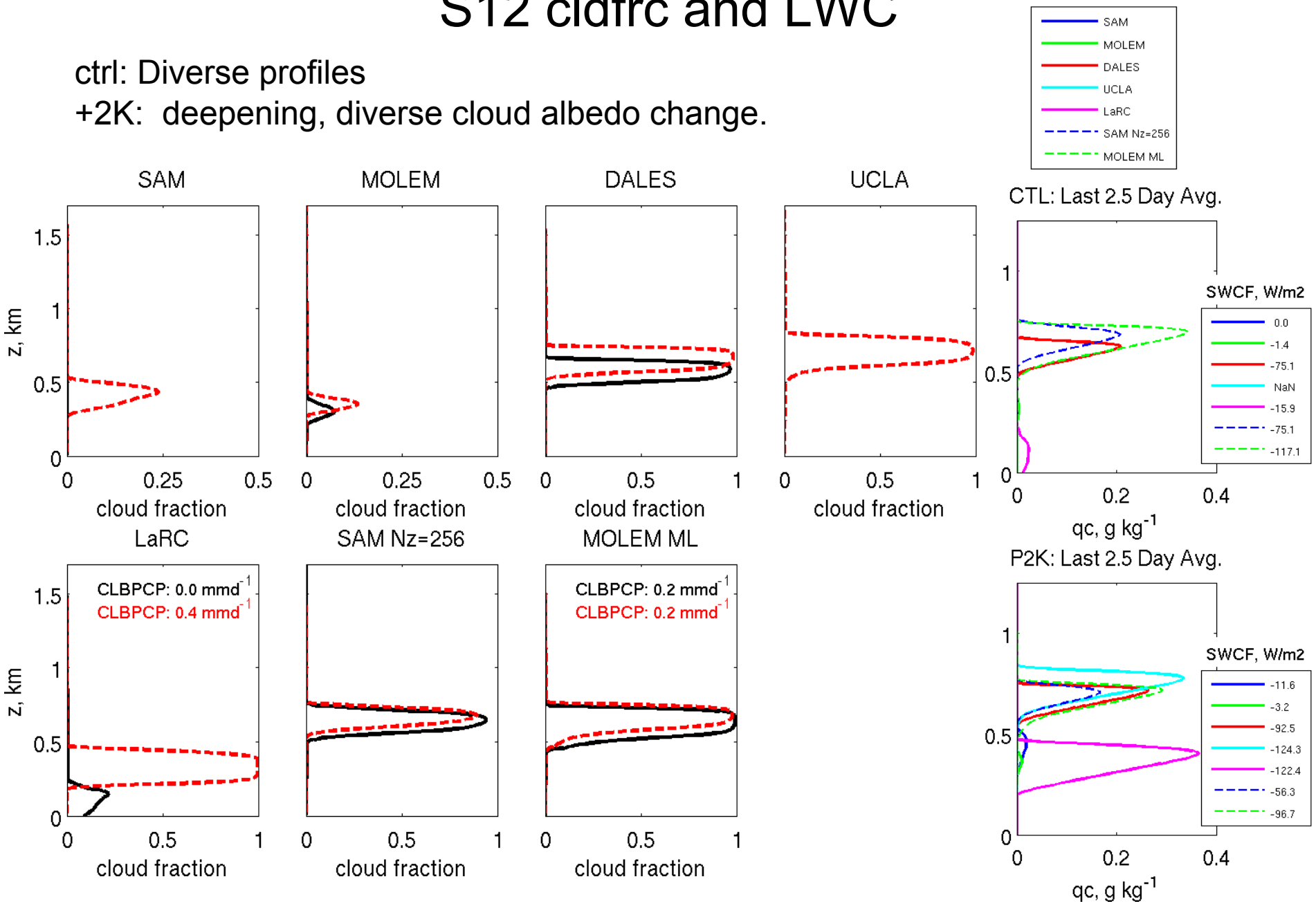


- Finer dz near surface helps too!

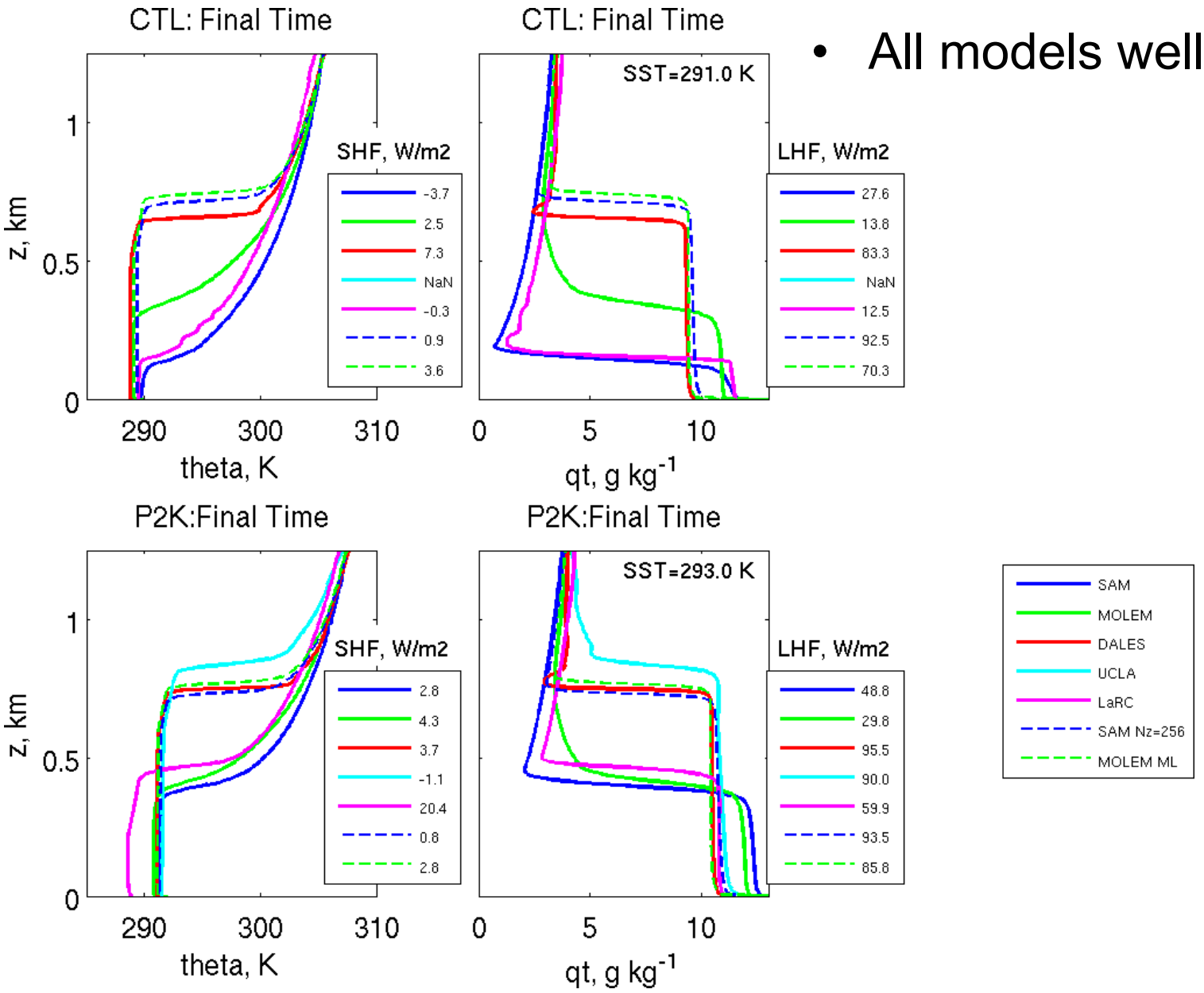
S12 cldfrc and LWC

ctrl: Diverse profiles

+2K: deepening, diverse cloud albedo change.



S12 θ and q profiles



- All models well-mixed

Summary of CGILS LES results

CGILS is promising but challenging

Forcing problems: Almost sorted out, except

surface pressure and qv drying at S11/12 below 1.5 km

S6 (trade Cu): LES ~ agree at dz/dx = 100/40 m

control PBL is deeper than climo,

+2K cloud response is in the noise

S11 (decoupled Sc):

Some LES make solid Sc with dz = 25m; others require finer dz to do so. Shallowing/FT drying feedback may hinder solid Sc.

+2K cloud thinning in solid Sc models – working on why.

+2K PBL deepening in all models

S12 (well-mixed Sc):

Some LES collapse, some don't.

+2K response not yet robust enough to take seriously

Plans: Maybe one more case rerun, then write up results by early 2010.