CGILS-LES Phase 2

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CGILS Phase 2 Modelers:

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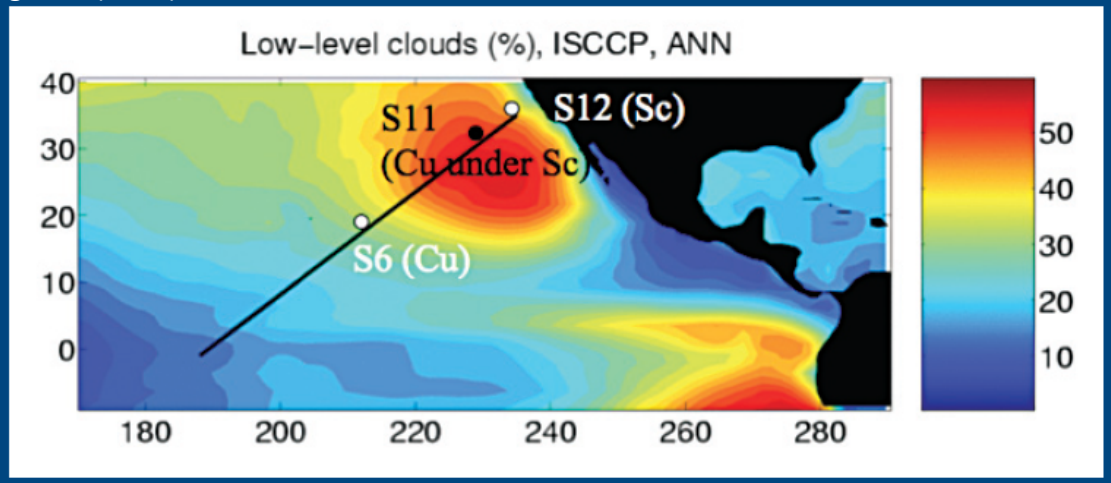
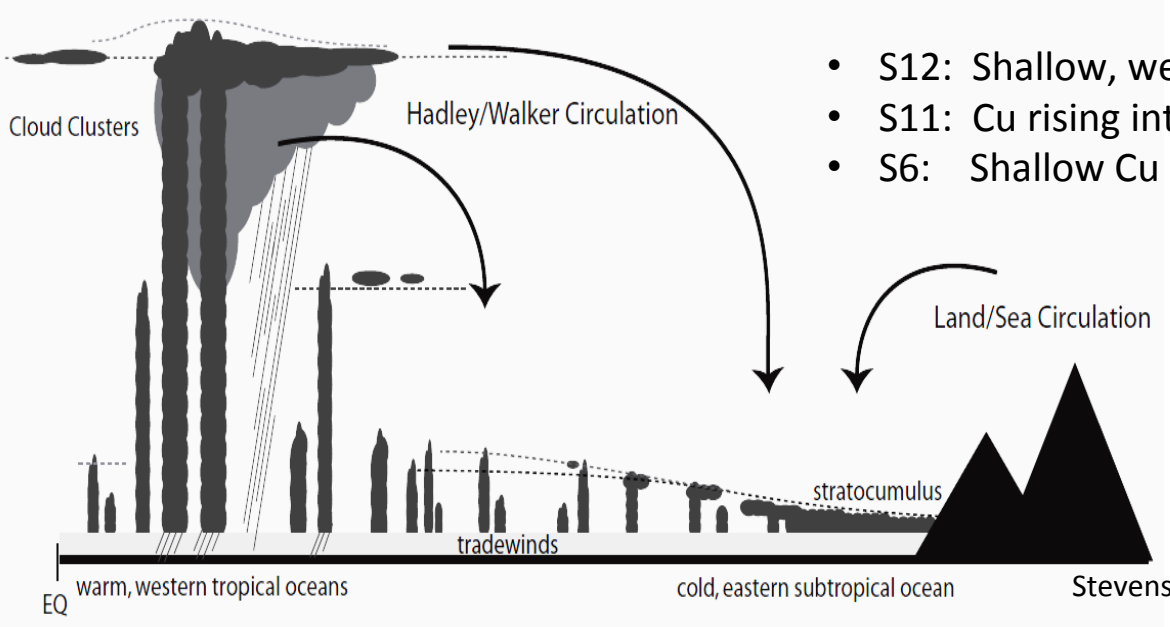
CGILS: CFMIP/GASS Intercomparison of Large-eddy and Single-column models

Zhang et al (2010)



The CGILS intercomparison transect overlaid on the Northeast Pacific annual-mean low cloud amount. Initially, CGILS focused on location S11 (32°N, 129°W) near the northern end of the GCSS Pacific Cross-Section Intercomparison study region. The other two locations are S6 and S12. S11 is near the climatological summertime maximum of low-level cloud cover. S6 is characterized by shallow cumuli, and S12 by shallow coastal stratocumulus.



Stevens 2006

- S12: Shallow, well-mixed stratocumulus (Sc)
- S11: Cu rising into Sc
- S6: Shallow Cu

CGILS Goal: Compare LES and SCM CTBL simulations of these locations under large-scale forcings representative of present and perturbed climates

CGILS LES cases

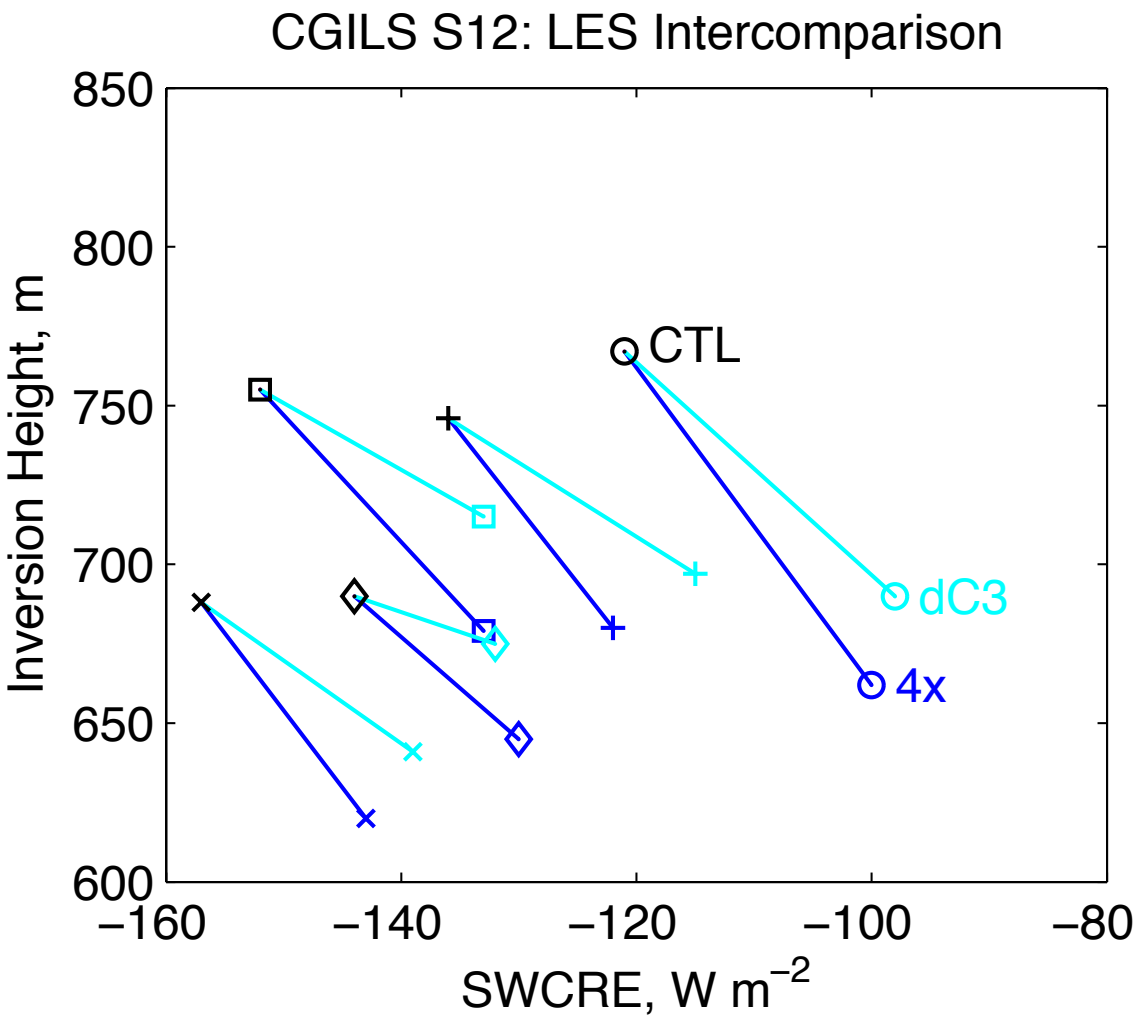
Phase 2 (updated results)

- **4xCO_2 fixed SST**
- **dCMIP3** (CMIP3 multimodel-mean forcing change)

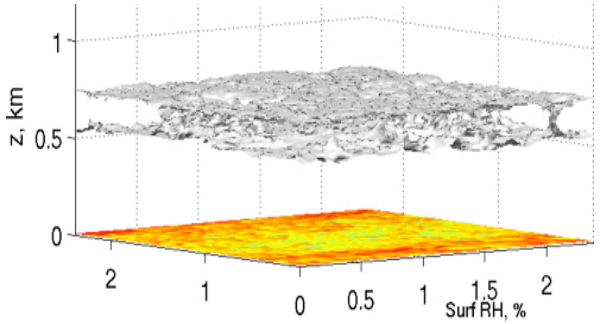
Transient forcing

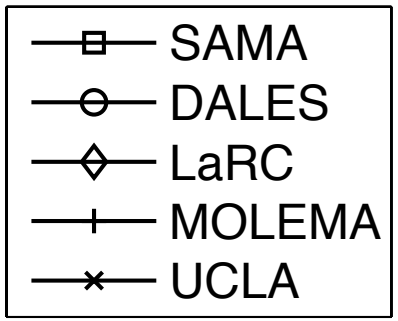
- **S6 SAM pilot study**
- **S11 SAM pilot study**

Perturbation	dCMIP3
δCO_2	2x
δSST	2.2–2.5K, S12→S6
δω(500 hPa)	-5 %
δEIS	0.8-0.6K, S12→S6
δRH	-1.5%
δ(wind speed)	-1.5%

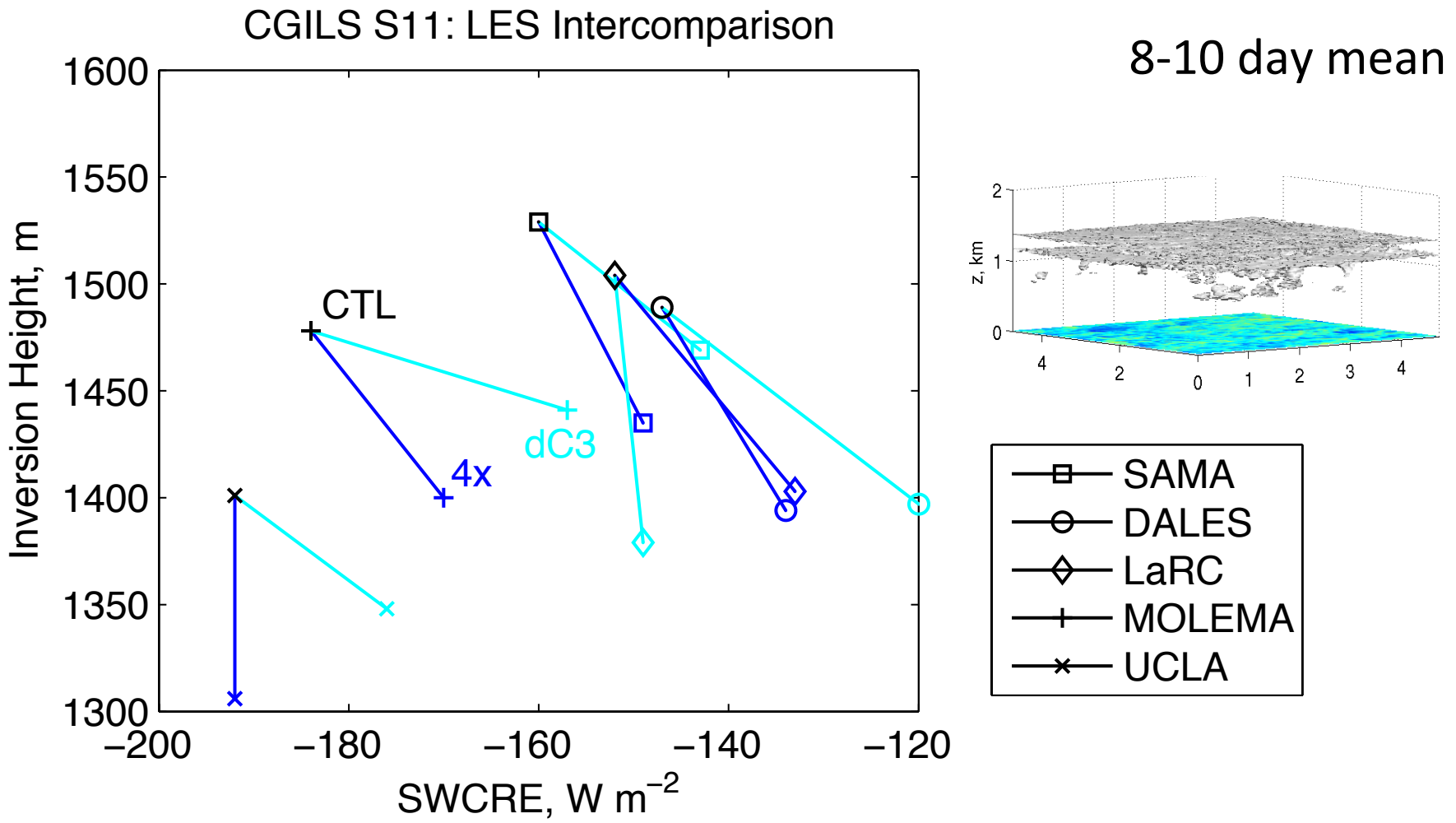


8-10 day mean

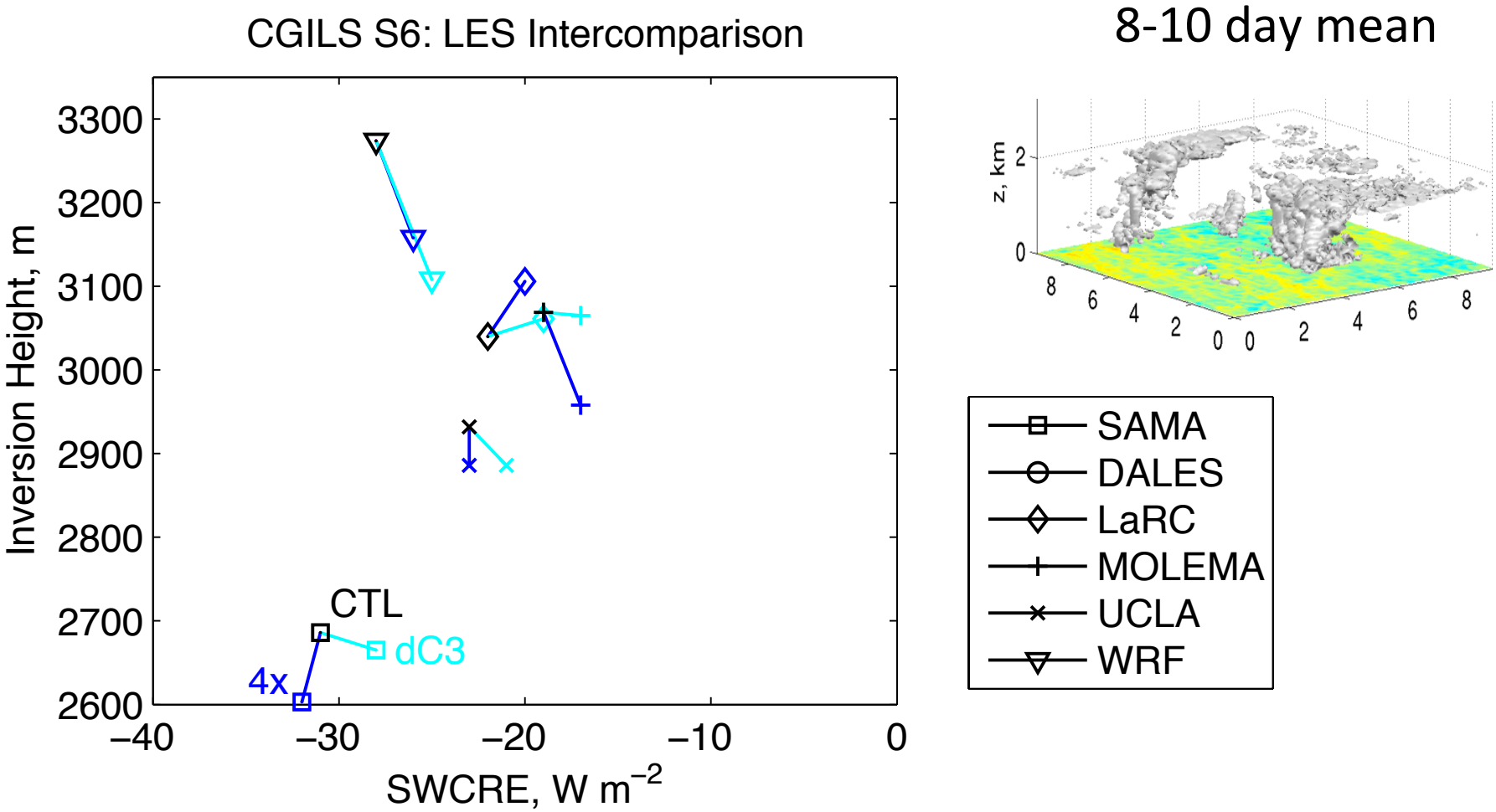




- LES all show cloud thinning and inversion shallowing for 4x, dC3



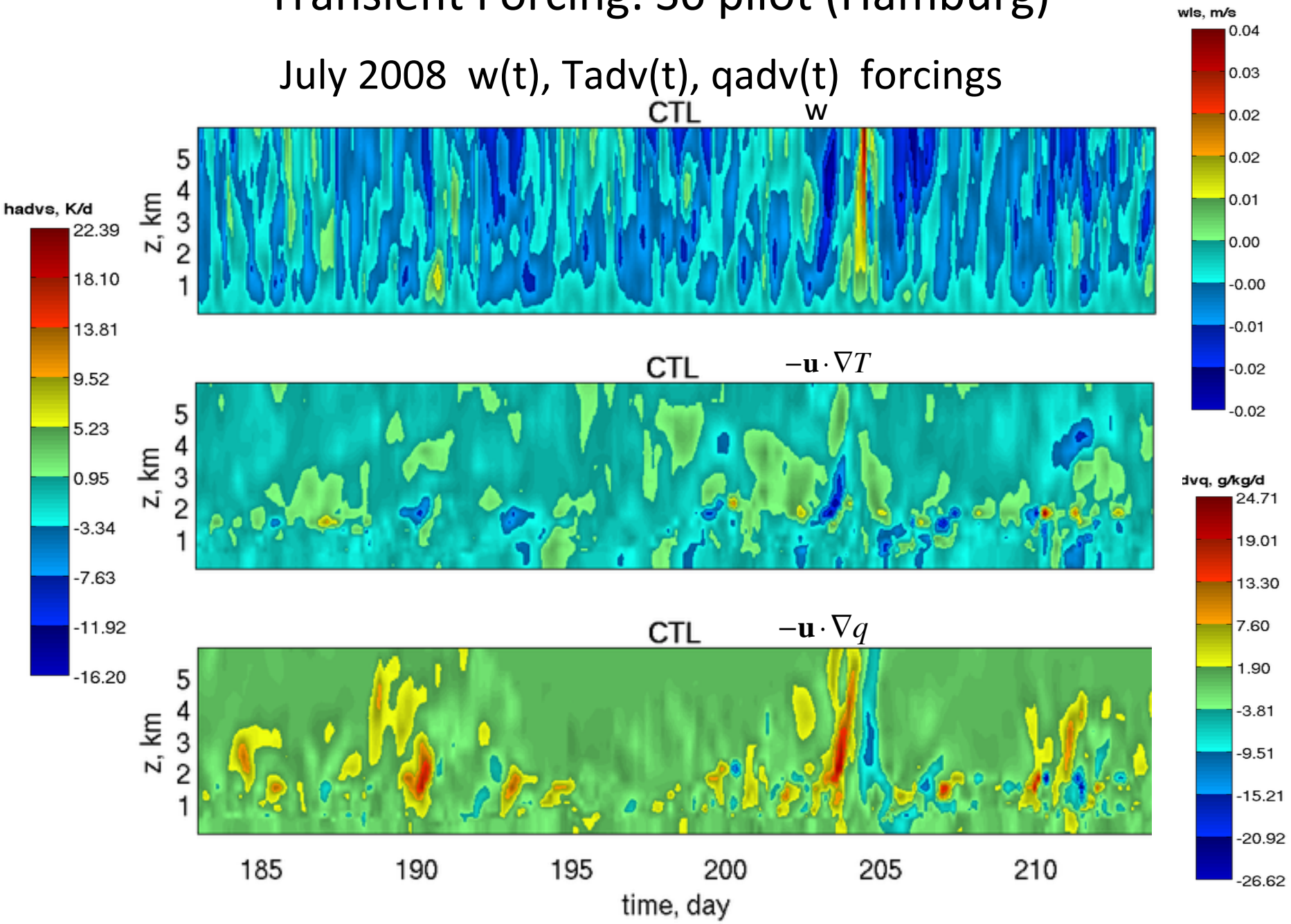
- LES again show cloud thinning and inversion shallowing for 4x and dC3, but magnitudes vary.



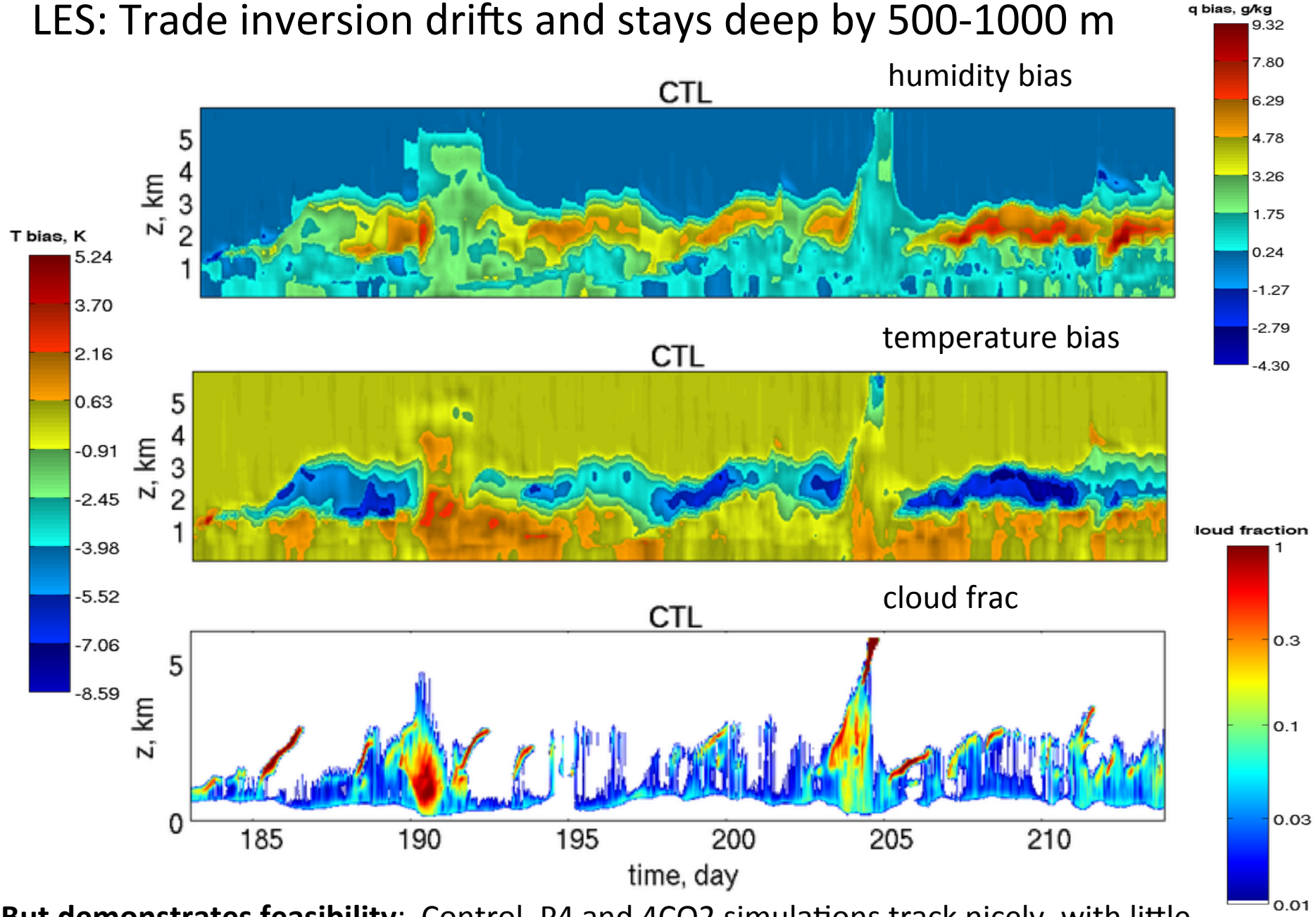
- dC3: LES all show slightly less cloud
- 4CO2: 4 of 5 models shallow the inversion, little CRE change

Transient Forcing: S6 pilot (Hamburg)

July 2008 w(t), Tadv(t), qadv(t) forcings



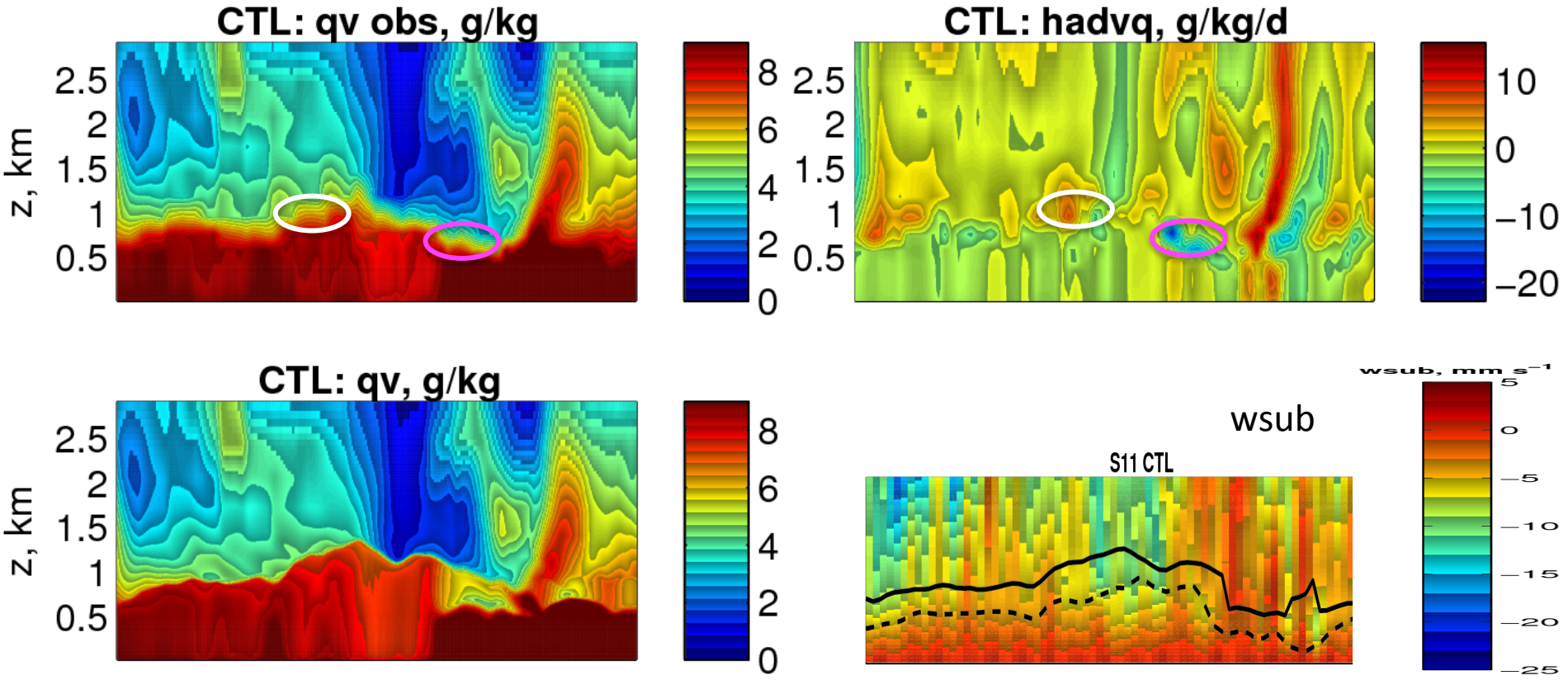
LES: Trade inversion drifts and stays deep by 500-1000 m



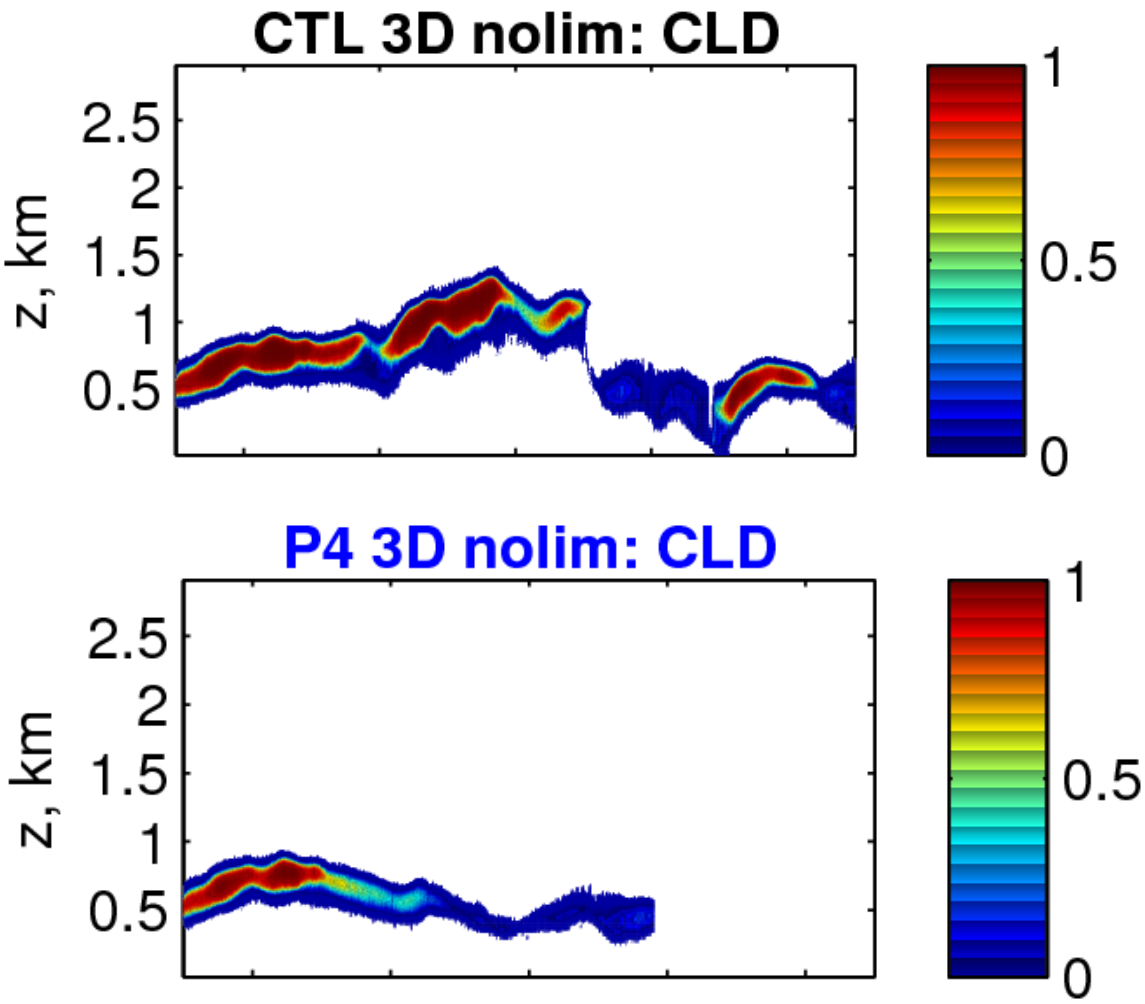
But demonstrates feasibility: Control, P4 and 4CO2 simulations track nicely, with little systematic response of cloud or CRE to climate perturbations, like in steadily-forced S6

Autumn 2013: S11 pilot using July 2006 transient forcings (more Sc)

- Motivation: (1) stronger cloud feedbacks in steadily-forced S11 case (thinner cloud for P2 than CTL); (2) challenge of strong inversions?
- As in S6 case, horizontal advective forcings strongly reflect ECMWF inversion gradients
- After 6 days, CTL inversion collapses below reference level during strong subsidence and stays too low for several days, during which horizontal advective forcings incompatible with simulated z_{inv}.



CTL cloud hangs on, P4 cloud goes away as inversion collapses



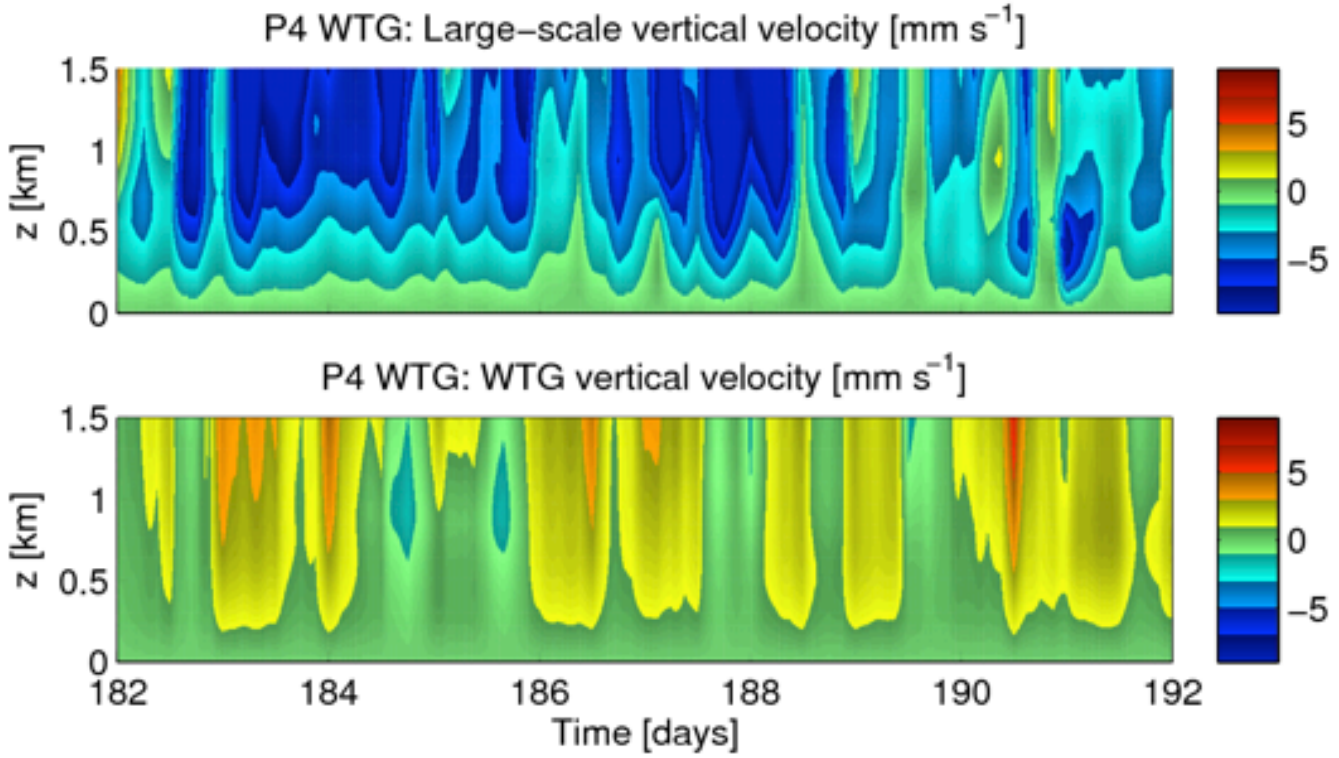
…maybe not a quantitatively useful cloud response to P4 perturbation
Note only reference SST and T profile changed in P4, w(t) unchanged.

New strategy: Nudge subsidence to control inversion height

- WTG (Kuang 2008. Blossey et al. 2009):

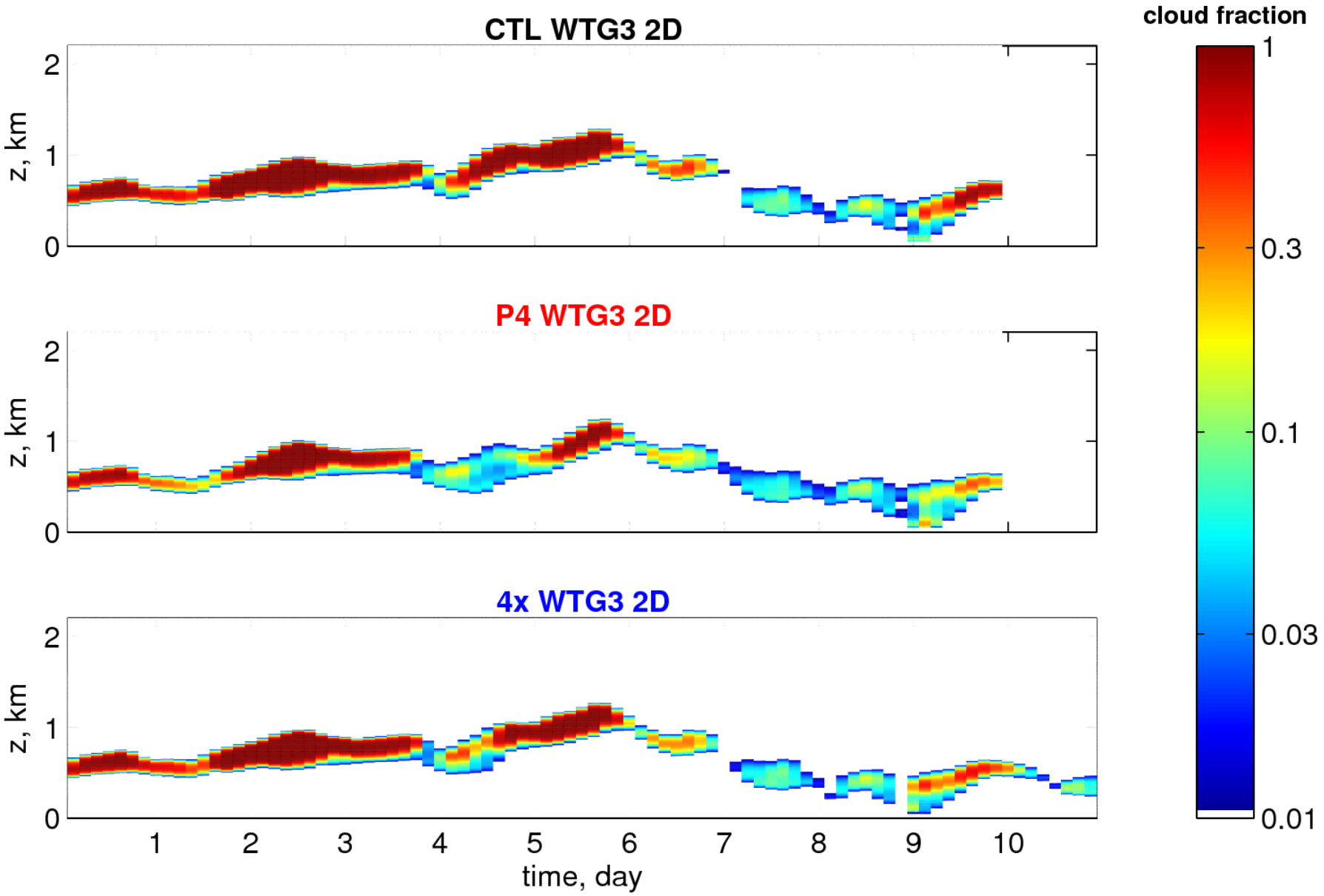
$$\frac{\partial^2 \omega'}{\partial p^2} = rT_v', \quad \omega'(p_s) = \omega'(p_t) = 0, \quad r = 3\times10^{-5}\ \mathrm{bar}^{-1}\,\mathrm{K}^{-1}\mathrm{s}^{-1}$$

- Required w' = -ω'/ρg is fairly small, even for P4 case:



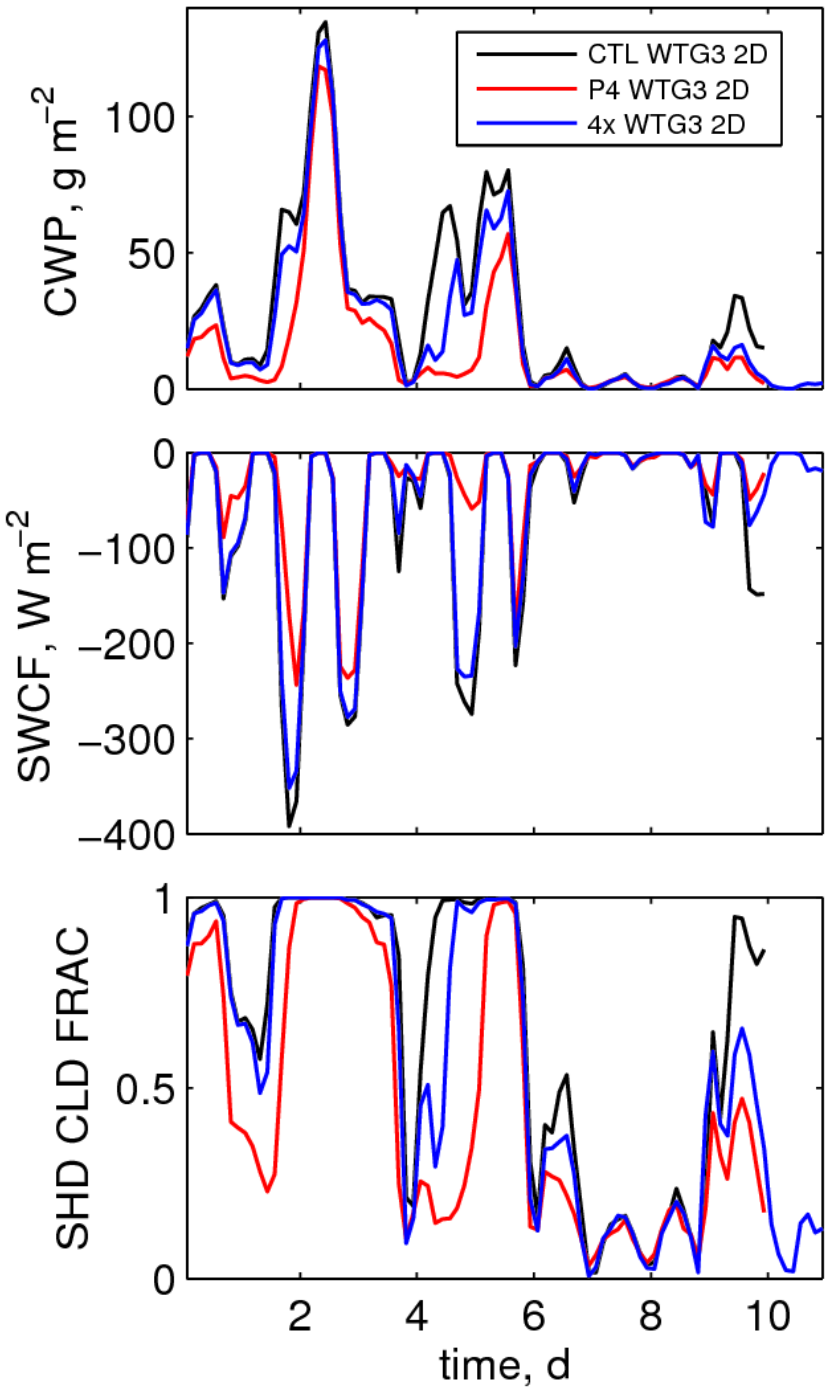
w' is mostly positive, counteracting inversion collapse

Now all simulations keep inversion cloud…

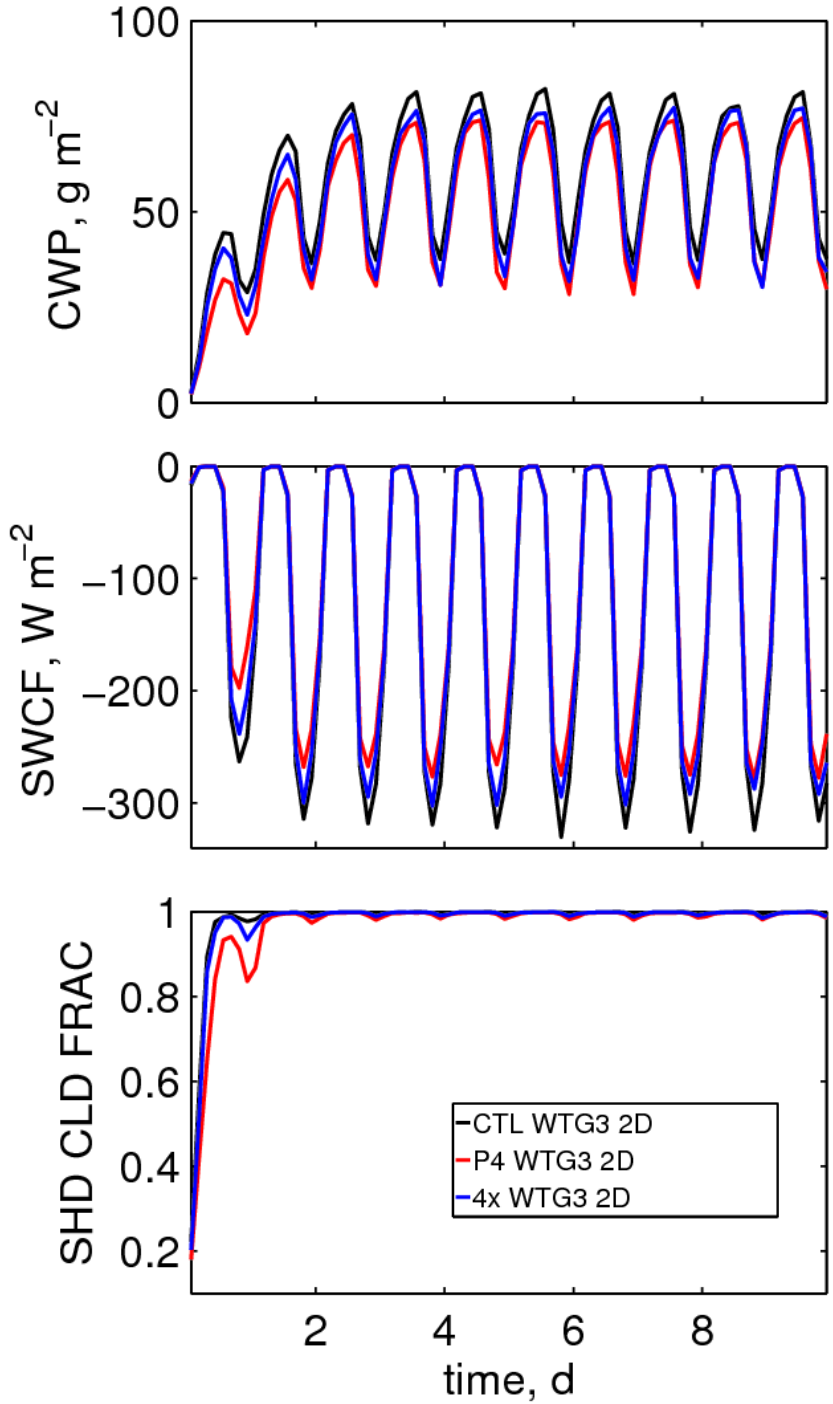


…and the cloud response is quite consistent

- Cloud thinning with 4CO2
- More thinning with P4



Behavior is similar with 10 day time-mean forcing



Conclusions

- CGILS Phase 2 4xCO2 and dCMIP3 results complete, will be written up for JAMES by Blossey later this summer.
- A 'WTG' protocol for transient-forcing cases in which nudges the subsidence profile to keep simulated temperature profiles close to time-varying reference profile, keeping inversion height consistent with horizontal forcings.
- This protocol is effective for LES, but only simulates cloud responses to climate perturbations that do not depend on inversion height change.
- When applied to S11, it shows cloud thinning from a 4 K temperature increase and from $4xCO_2$, like other CGILS cases.
- Moving forward, Brian Medeiros has agreed to coordinate further SCM simulations, but no clear plan for further CGILS LES phases, due to lack of available people-power.