Structure and Persistence of Post-frontal Stratus in Numerical Models

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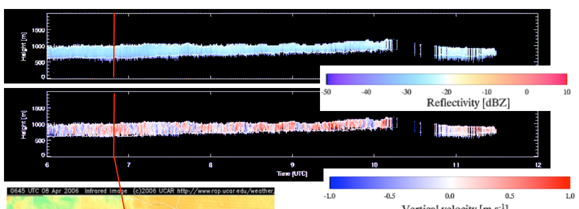
Introduction

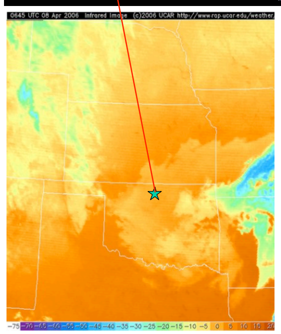
Mid-latitude synoptic systems are frequently accompanied by broad areas of low-altitude cloudiness located behind the cold front. Field and Wood (J. Clim. 2007) show that these clouds constitute a significant climatological signal.

How different are postfrontal continental stratus from marine stratocumulus? Does buoyancy reversal (CTEI-like mechanism) play the same role as in marine clouds?

This study explores the sensitivity of continental boundary layer clouds to uncertainty (errors) in advective forcing, large-scale vertical velocity, and latent and sensible heat flux.

SGP ACRF stratus as represented by MMCR, rawinsonde, and the RUC.





MMCR samples turbulent structures that are coherent in time and in the vertical. Radar structures look similar to marine stratocumulus.

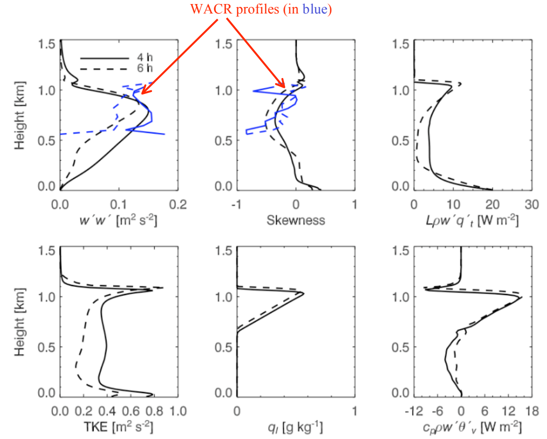
Soundings show large temperature jumps with small, nonexistent, or even negative (!) moisture jumps — classical buoyancy reversal mechanism does not apply. The cloud layer is unstable if

$$\kappa \equiv 1 + \frac{\Delta s_l}{L \Delta q_t} > 0.45$$

κ is negative for small total water jump conditions, unbounded at zero, and meaningless for positive values.

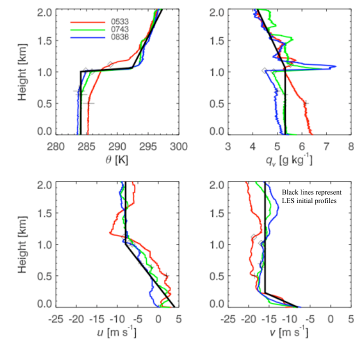
RUC forcings and vertical cross sections indicate complicated vertical structures that vary rapidly in time. Indications exist of upward vertical motion, even in the "subsidence" region of the system behind the cold front.

LES (SAMEX) baseline

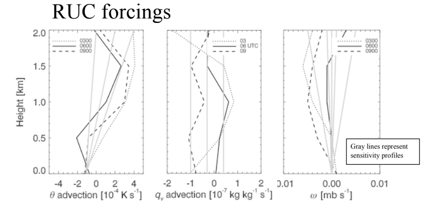


LES statistics for the SGP stratus control simulation. Variance and skewness statistics calculated from the WACR data are overlaid on the LES profiles.

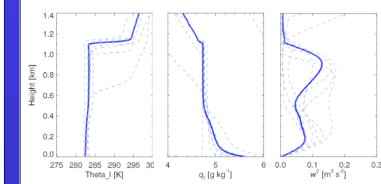
Soundings from the SGP ACRF and RUC model analyses supply initial conditions and forcings for the LES



RUC forcings

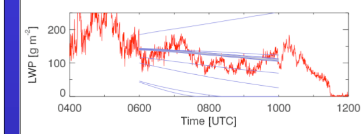


Cloud sensitivity

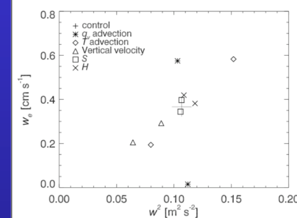


Different simulation series varying…

- •Moisture advection
- •Temperature advection
- •Vertical velocity
- •Sensible heat flux
- •Latent heat flux



LWP from the MWR (red) and the simulation ensemble (blue). Thick blue line is control run.



•Most of the sensitivity simulations follow a simple scaling law, where the turbulent intensity sets the entrainment rate.

•This result implies that entrainment efficiency is relatively constant between most of the runs.

Summary

•This stratus case was *not* accompanied by consistent subsidence and slowly varying advective forcings typical of a marine barotropic atmosphere. Instead, subtle baroclinic structures complicate the forcing, even on the back side of the system.

•Cloud top gradients are generally smaller than over the marine layer.

•Cloud evolution is governed by advective forcing rather than the buoyancy reversal mechanisms associated with entrainment.

•This is a "nice" result for mesoscale/NWP/climate models, since they resolve advection and large-scale vertical motion better than they represent entrainment.

•A simple observational climatology of these jump conditions for SGP ACRF stratus would generalize these results.