Single Column Simulation of Low-cloud Feedbacks to 2K SST Change with GPCI configurations

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Thank Minghua Zhang for providing initial condition and forcing data
Introduction

• Representing low clouds contributes a large part of uncertainty of GCM to simulate climate response to global warming
• The feedback of low clouds to global warming could be either positive or negative
• This study compares a single column model (SCM) with UCLA-LES to simulate low-cloud feedbacks
Model Description (IPHOC-SCM)

- Double-Gaussian distribution of liquid-water potential temperature, total water mixing ratio and vertical velocity
- Skewnesses of these three third-order moments predicted
- All first-, second-, third- and fourth-order moments, subgrid-scale condensation and buoyancy based on the same probability distribution function
- Bulk microphysics considering subgrid-scale variabilities
- Four stream Fu-Liou radiation integrated through 18 bands
Model Description (UCLA-LES)

• A directional-split monotone upwinding method for scalar advection and a fourth-order centered differences for momentum advection
• First-order turbulence closure
• Microphysics with forecasted rain and specified cloud drops concentration
• Radiation scheme adopted from CAM3
Experiment Design

• Control experiments (three points in cold pool): ctls6 (case 1), ctls11 (case 2), and ctls12 (case 3)
• Sensitivity tests (increasing SST of 2K): p2ks6, p2ks11, and p2ks12
• Domain for CRM: 6 km x 6 km x 14 km
• Grid-spacing: 200 m x 200 m x (30 m ~550 m in vertical for both SCM and CRM)
• Prescribed SST and large-scale forcing
Cloud Radiation Forcing (p2k – ctl)

- LW-CRF
- SW-CRF
- Net-CRF
Cloud Evolution for s6
Cloud Evolution for s11 and s12
Mean Profiles Averaged over Last Ten Days for s12
LHF and SHF

Differences of surface LHF (p2k - ctl)

Differences of surface SHF (p2k -ctl)
CF, LWP, and ODP

Differences of LWP (p2k - ctl)

Differences of optical depth (p2k - ctl)

Differences of CF (p2k-ctl)
Summary and Discussions

• Despite different radiation schemes and models, the low-cloud feedbacks are similar
• Negative feedback cycle. Increased SST -> Increased latent heat fluxes -> larger LWP and ODP -> more outgoing SW forcing.
• The effects of the change of cloud height and cloud amount, sensible heating flux, LW CRF on the feedback are relatively weak.
Thank You!
Extra slides
Mean Profiles Averaged over Last Ten Days for s11
Mean Profiles Averaged over Last Ten Days for s6