Feedbacks between Low Clouds and Radiation for the Climate Process Team Cases

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Thank Professor Minghua Zhang for providing the initial condition and forcing data and case setups
Introduction

• There are large uncertainties in the simulation of climate response to global warming by GCMs, due primarily to the parameterizations of low-level clouds
• The magnitude of the feedback of low-level clouds to global warming is unknown
• Large-eddy simulation (LES) is a promising tool to study such feedbacks, since low-level clouds are explicitly resolved
Model Description

- A directional-split monotone upwinding method for scalar advection and a fourth-order centered differences for momentum advection
- TKE-based subrange (small turbulence) closure
- Two-moment microphysics, with predicted rainwater and specified cloud droplet concentrations
- CAM3 radiation scheme
CPT Experiment Design

• Control experiments: specify the SST difference between two reference points in the warm and cold pools; ctls6K, ctls11K, ctls12K
• Sensitivity tests: increase SST by 2K from the control experiment: p2ks6K, p2ks11K, p2ks12K
• Domain: 6 km X 6 km X 20 km
• Grid-spacing: 200 m X 200 m X (stretched from 30 m to 360 m)
• Prescribed SST and large-scale forcing
Cloud Evolution

- ctlsl6 cloud fraction (%)
- ctlsl11 cloud fraction (%)
- ctlsl12 cloud fraction (%)
- p2ks6 cloud fraction (%)
- p2ks11 cloud fraction (%)
- p2ks12 cloud fraction (%)

Legend: 1 4 6 10 20 40 60 80 90 100
CRF at the Steady State

(a) LW CRF
(b) SW CRF
(c) Net CRF
Time series of surface LH, SH and TOA radiative fluxes
Times series of selected cloud-related fields
Mean Profiles of thermodynamic and cloud variables
Mean profiles of eddy transports
Summary and Discussions

• How low cloud amount and LWP change with the increased SST is the key result
• Negative feedback cycle:
  Increased SST $\rightarrow$ Increased moisture transport $\rightarrow$ Increased low cloud amount and LWP $\rightarrow$ more SW cooling $\rightarrow$ decreased SST
• The effects of the change of cloud height and LW CRF on the feedback are relatively weak
• The magnitude of CRF from Stratocumuli is larger than that from shallow cumuli
Thank You!
Large-scale forcing