The CGILS Project

CFMIP-GCSS Intercomparison of Large-Eddy and Single-Column Models

Minghua Zhang, Christopher Bretherton, Peter Blossey and Participants
(Lin, Zhang and Loeb, JCL 2010)
Idealized Experiments

Need to be relevant to observations and GCMs

(Zhang and Bretherton, 2008)
Purpose:
To understand the causes of cloud feedbacks, and thus climate sensitivities of climate models.

Objectives:
1. To understand the physical mechanisms of cloud feedbacks in SCMs
2. To interpret GCM cloud feedbacks by using SCM results
3. To Evaluate the SCM cloud feedbacks using LES simulations
SCM (16)

CAM4
CAM5
CCC
CSIRO
ECHAM5
ECHAM6
ECMWF
GFDL
GISS
GSFC
JMA
KNMI-RACMO
LMD
SNU
UKMO
UWM

LES (5)

KNMI
SAM
UCLA
UCLA/LaRC
UKMO
CGILS Participants

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Cloud Liquid Water in Control Simulation

CAM4 – s6
~6

CAM4 – s11
~15

CAM4 – s12
~18

GFDL – s6

GFDL – s11

GFDL – s12

UKMOL38 – s6

UKMOL38 – s11

UKMOL38 – s12

LaRC/UCLA – s6

LaRC/UCLA – s11

LaRC/UCLA – s12
SCM Results

Negative feedback: CAM4, ECMWF, JMA, UWM

Positive feedback: CAM5, CCC, CSIRO, ECHAM6, GFDL, LMD, UKMO

Mixed: GISS, GSFC, RACMO (positive at s6, negative at s11, s12).
CAM4 Cloud Water (CTL and PSST)
ECMWF Cloud Water (CTL and PSST)
CAM5 Cloud Water (CTL and PSST)
CCC Cloud Water (CTL and PSST)
Negative feedbacks

800mb

900mb

950mb

1000mb

1010mb
Positive feedbacks
(Explicit cloud top entrainment mixing)
(more decoupling)
S6: LES results (dx/dz = 100/40)

Fair agreement between LES models
Cloud layer deepens; transitions to a Cu-only layer in SAM and DALES
+2K changes are imperceptible
S6: No clear +2K change in SWCF, cldfrc, LWP for SAM, DALES
S11 control simulations \((dx/dz = \ldots)\)

Simulations split into thin-cloud and solid-Sc regimes
...but sensitive to finer dz

SAM at dz=5 m looks like DALES at dz = 25 m
S12: \( \frac{dx}{dz} = \frac{25}{5} \text{ m at} \)
Summary

1. The SCMs simulated a wide range of low clouds and cloud feedbacks at the three locations, consistent with what CGILS intended to achieve.

2. Interaction of parameterization components plays a major role in explaining the processes.

   The relative roles of PBL and convection for turbulent mixing, and their interaction with the stratiform cloud scheme need to be understood to explain the cloud feedbacks.

3. It appears that models with explicit cloud-top mixing have positive cloud feedbacks, while those without have negative feedbacks (related to moist flux in the PBL).

4. LES convergence experiments are still in progress.