CGILS: A Project to Understand Climate Feedbacks of Low Clouds in GCMs

Minghua Zhang
Stony Brook University, State University of New York
And CGILS Participants

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(Cess et al. 1990)
Sensitivity of the Tropical NET Cloud Radiative Forcing (CRF) to surface temperature change (W/m²/K)

\[ \Delta \text{SST} = 1.2 \pm 0.2 \text{ K} \]
(low-sensitivity models)

\[ \Delta \text{SST} = 1.7 \pm 0.3 \text{ K} \]
(high-sensitivity models)

Reduced cooling effect of clouds
Enhanced cooling effect of clouds

(Bony and Dufresne, GRL, 2005)
The Idea:

- Simplify the problem by isolating physics from dynamics
- Use idealized dynamics - GCM independent, interactive with SST, can do climate change experiments

Relevant to GCM clouds and observations
Synthesis of Observations

(Lin, Zhang and Loeb, JCL 2009)
Clouds in CAM3
A Time Segment

Total and Convective Cloud Amount
The penetrative convection and shallow convection
Interaction of Parameterizations!

(Zhang and Bretherton 2008)
Cloud Feedback: Change of Cloud Amount (Solid to Dashed)

Convective mass flux increased. $h_0 - h_z^* = (s_0 - s_z) + L(q_0 - q_z^*)$
1. Are they correct?

2. What are the mechanisms in other models?
CGILS

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

CFMIP: Cloud Feedback Model Intercomparison Project

GCSS: GEWEX Cloud System Study
(Zhang and Bretherton, 2008)
The objectives:

1. To understand the models and their cloud feedbacks
2. To compare with LES/CRM simulations
3. To compare with observations
**SCM (16)**

CAM3  
CAM4  
CCC  
CSIRO  
ECHAM5  
ECHAM6  
ECMWF  
GFDL  
GISS  
GSFC  
JMA  
KNMI  
LMD  
SNU  
UKMO  
UWM

**LES (5)**

UCLA/LaRC  
SAM  
KNMI  
UCLA/MPI  
UKMO

Results submitted to date
Cloud Liquid Water in Control Simulation

~6
~15
~18
Negative Feedback in CAM4

ctl

p2k
Negative Feedback in CSIRO

ctl

csiro (ctl_s11) Cloud Amount

p2k

csiro (p2k_s11) Cloud Amount

Days

0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Positive Feedback in GISS

ctl

p2k
Positive Feedback in UKMO L38

ctl  p2k
Negative Feedback in the LES

LES has not converged yet
Summary

1. The models simulated the intended types of low clouds and the range of cloud feedbacks.

2. The negative feedbacks are due to larger turbulent water transport to the upper boundary layer; the positive feedbacks are due to break-up of clouds.

3. Vertical resolution in current models is insufficient for low clouds; they require new ways of parameterizations.

4. Interaction of PBL turbulence, convection, stratiform clouds, and radiation needs to be understood.
Next Steps

1. LES equilibrium and convergence tests
2. Use seasonal variation as a test
3. Connecting to GCM climate sensitivity
4. Evaluate against observations

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http://somas.stonybrook.edu/cgils