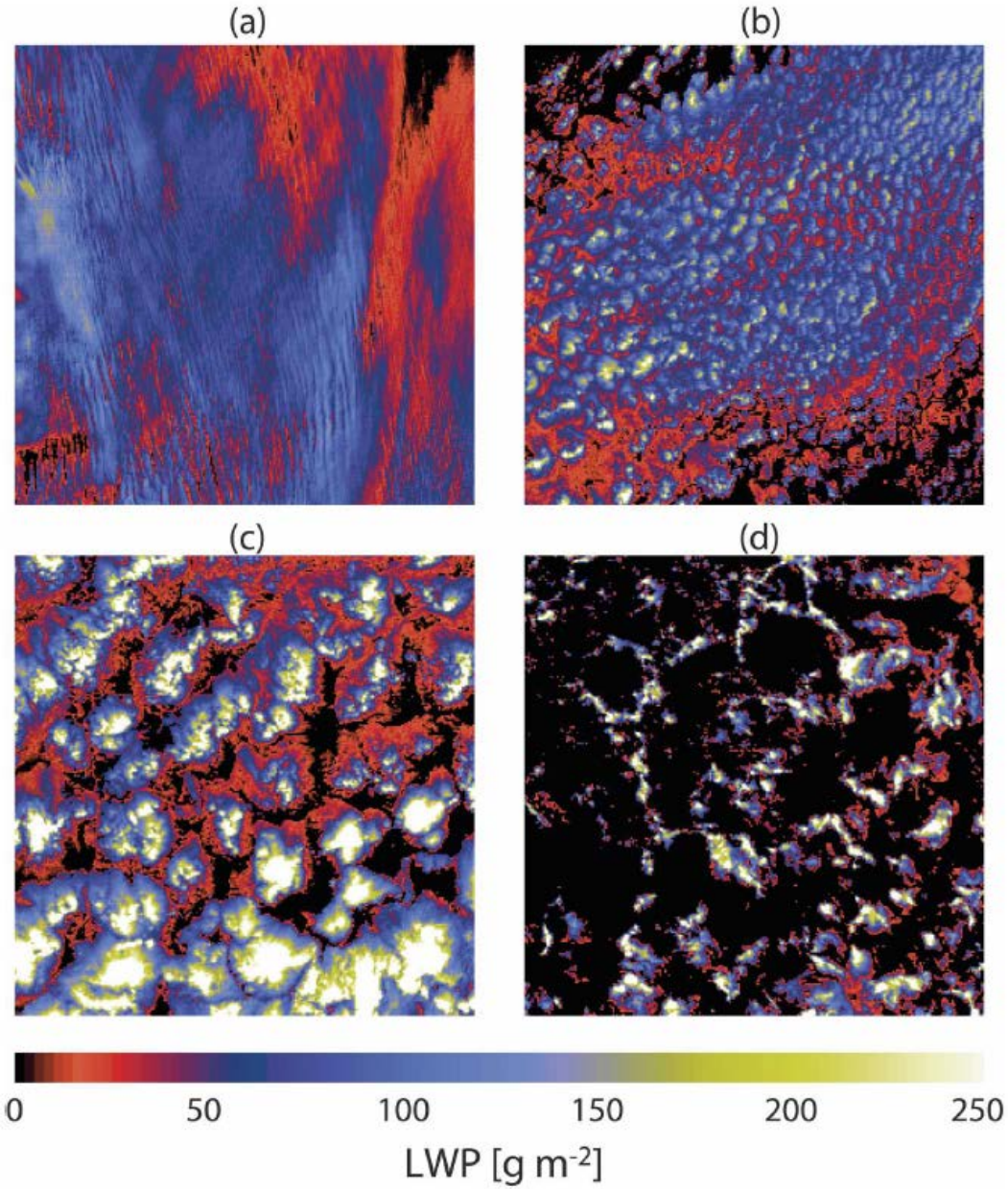
Modeling Perspective on Low Clouds

Minghua Zhang

Stony Brook University



(Wood and Hartmann 2006)

Cloud Schemes

Subgrid-scale variability:

$$C = \int_{q_s}^{\infty} P(q_t)\,dq_t,$$

$$P(q_t)$$

OR

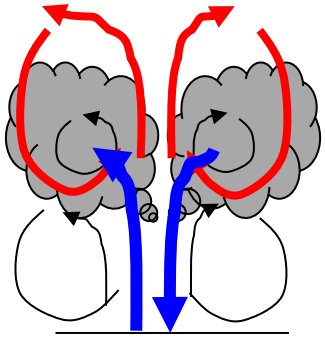
$$C = C(\overline{RH})$$

Mean condition:

$$\overline{RH}$$

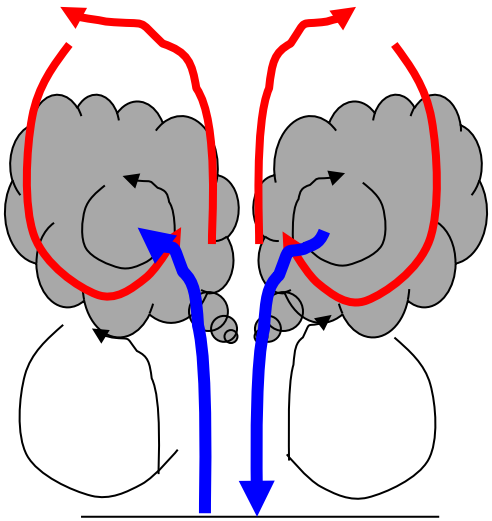
Large-scale forcing

Mixing



Cloud Schemes

Mixing

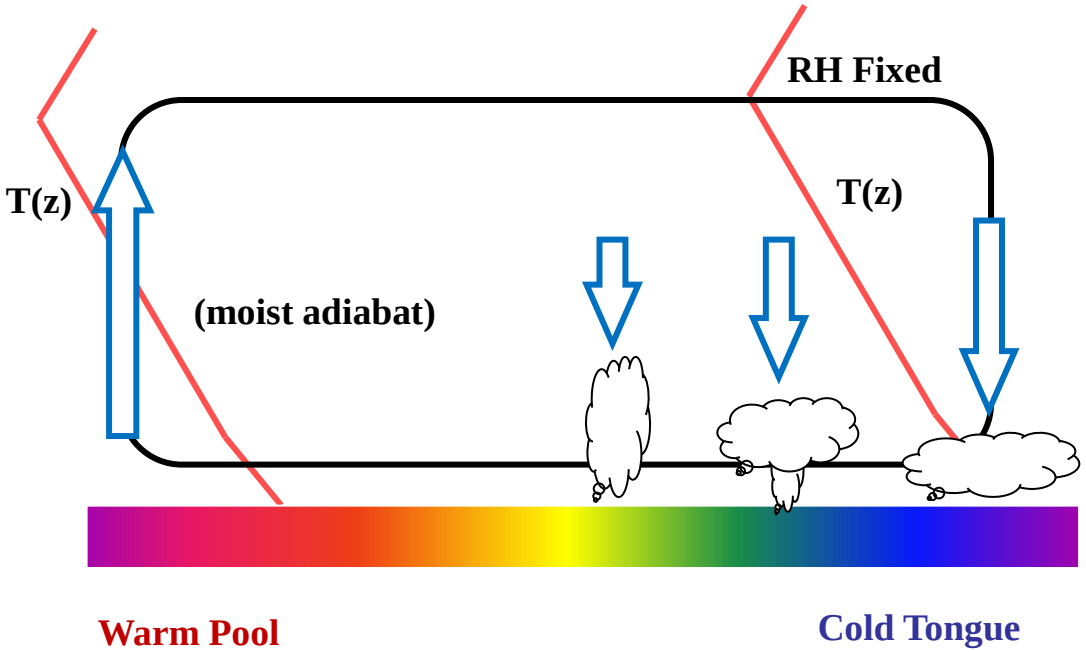


Shallow Convection

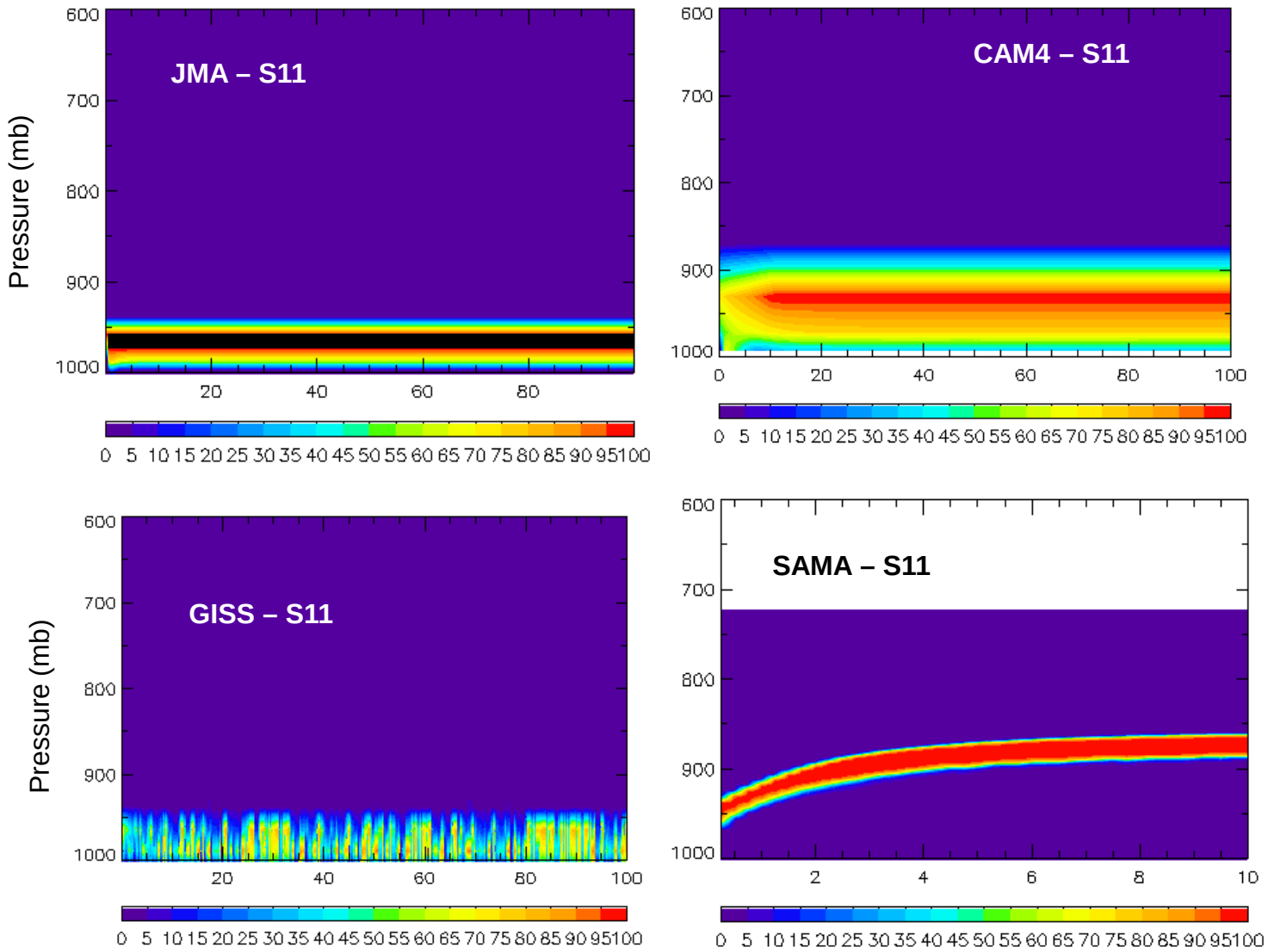
Cloud-top Entrainment

PBL scheme

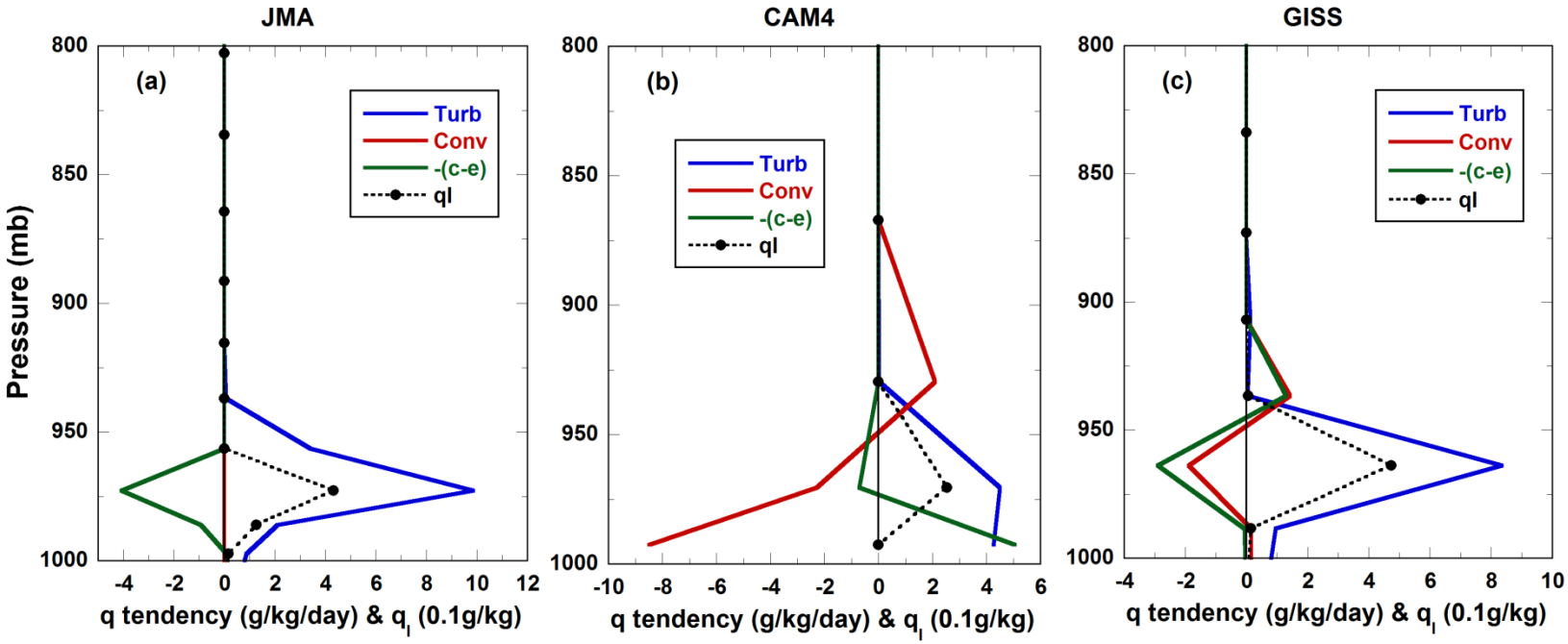
Surface Fluxes



(Zhang et al. 2013, JAMES)

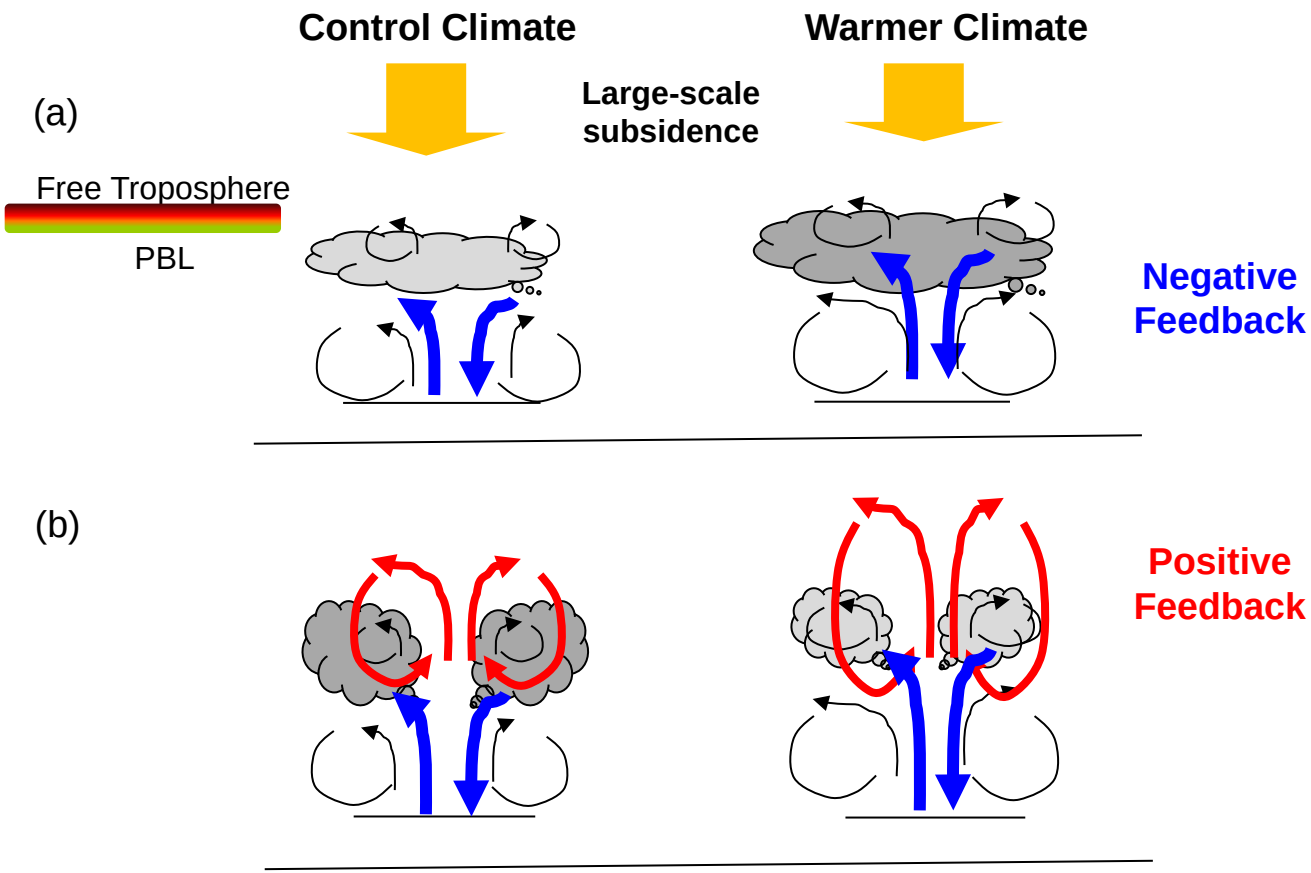

JMA – S11
CAM4 – S11
GISS – S11
SAMA – S11
Pressure (mb)
600
700
800
900
1000
20
40
60
80
100
2
4
6
8
10
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

CGILS Case

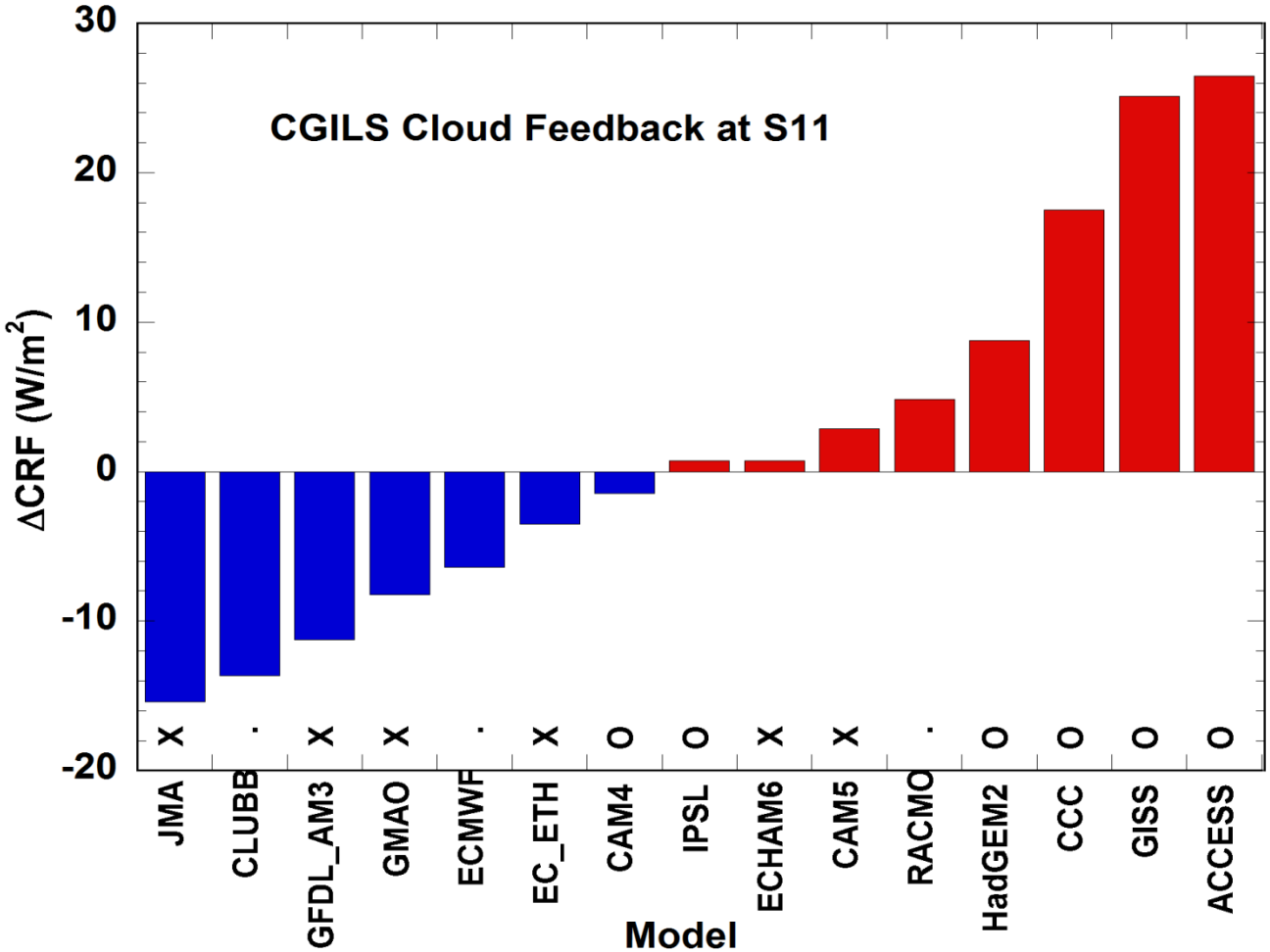


$$\frac{\partial q_v}{\partial t} = \left(\frac{\partial q_v}{\partial t}\right)_{turb} + \left(\frac{\partial q_v}{\partial t}\right)_{conv} - c_{stra} - \left(\frac{\partial q_v}{\partial t}\right)_{LS}$$

Low Cloud Feedback



(Zhang et al. 2013)



X
Without convection

O
With convection

CGILS: The “NESTS-SCOPE” Mechanism of Low-Cloud Feedbacks in Models

NESTS - NEgative feedback from Surface Turbulence under weaker Subsidence

SCOPE - Shallow COnvection PositivE feedback

(Zhang et al. 2013)

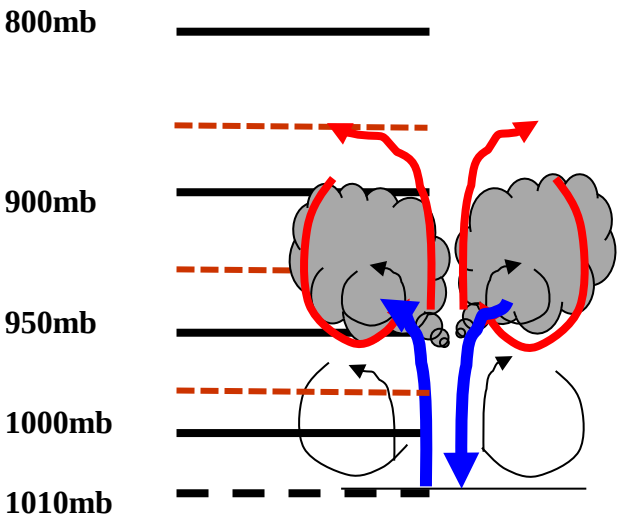
Low-cloud in climate models:

Shallow convection

Cloud-top entrainment
Aerosol

PBL scheme

Surface fluxes
at coarse vertical resolutions



All these processes play a role in determining the grid-scale low clouds in models

It would be useful to isolate some of these processes to understand and improve the models.