A Recap of the First Phase CGILS Results:

What Have We Learned?

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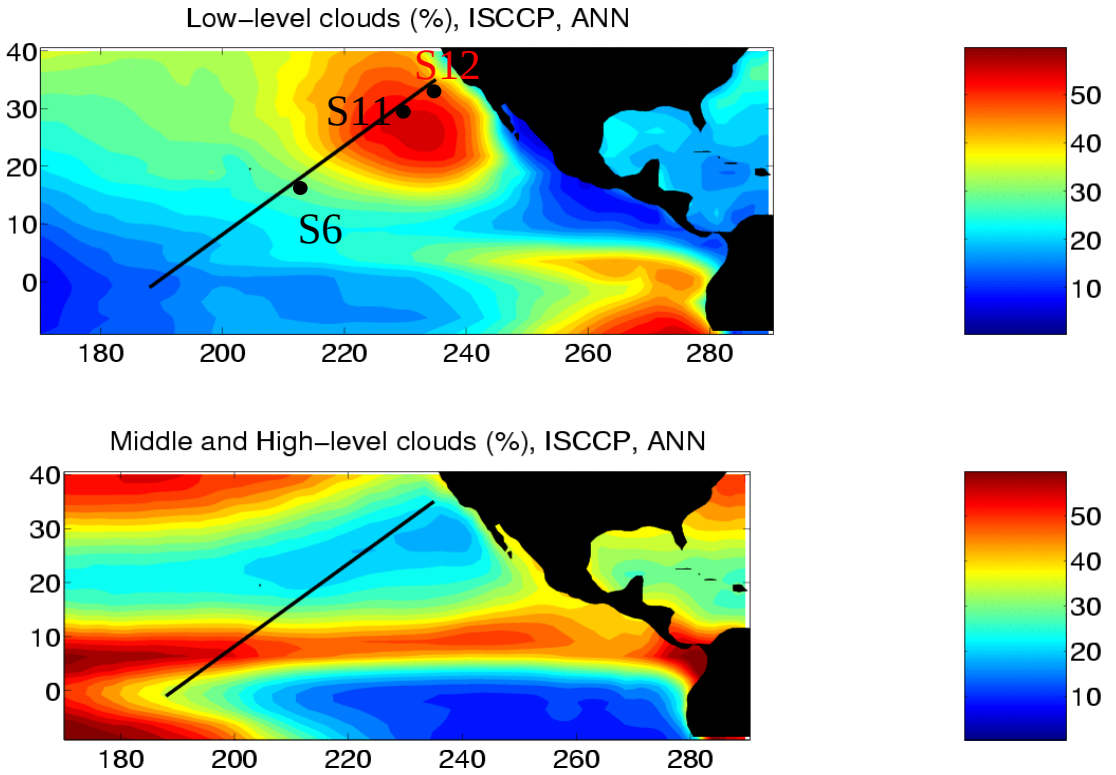
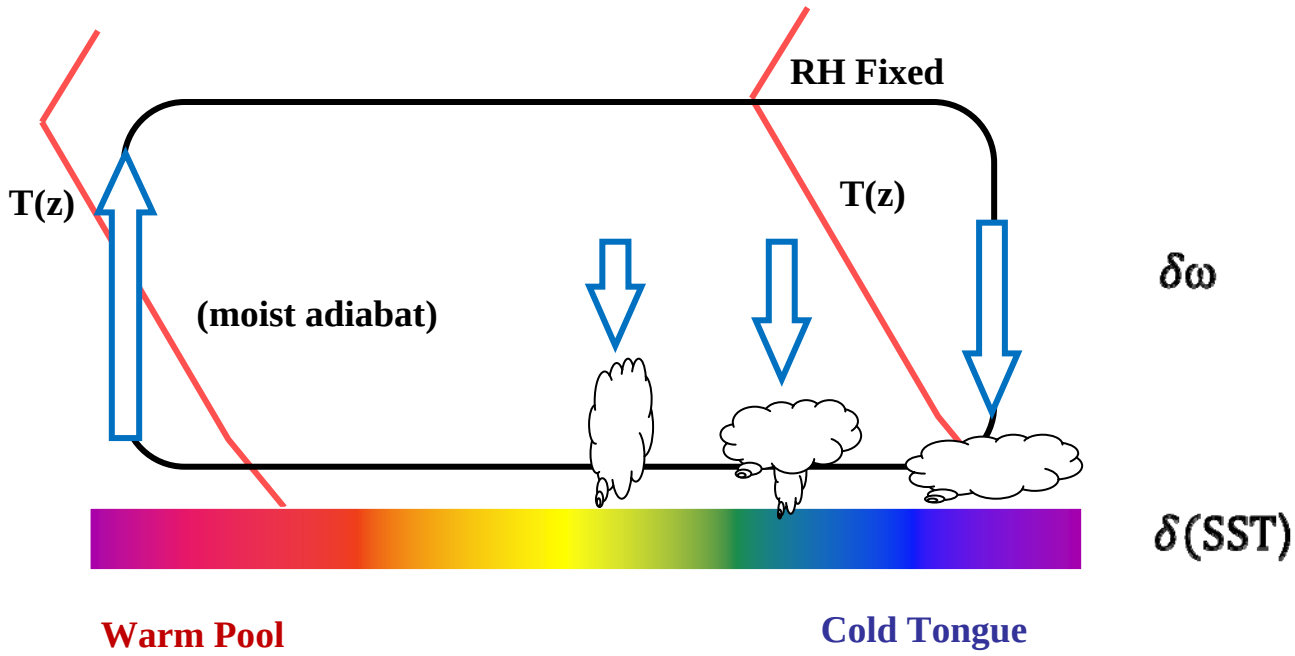
And CGILS Participants

GPCI


Low–level clouds (%), ISCCP, ANN
S12
S11
S6
40
30
20
10
0
180
200
220
240
260
280
50
40
30
20
10
Middle and High–level clouds (%), ISCCP, ANN
40
30
20
10
0
180
200
220
240
260
280
50
40
30
20
10



2XCO$_2$ subtropical oceans

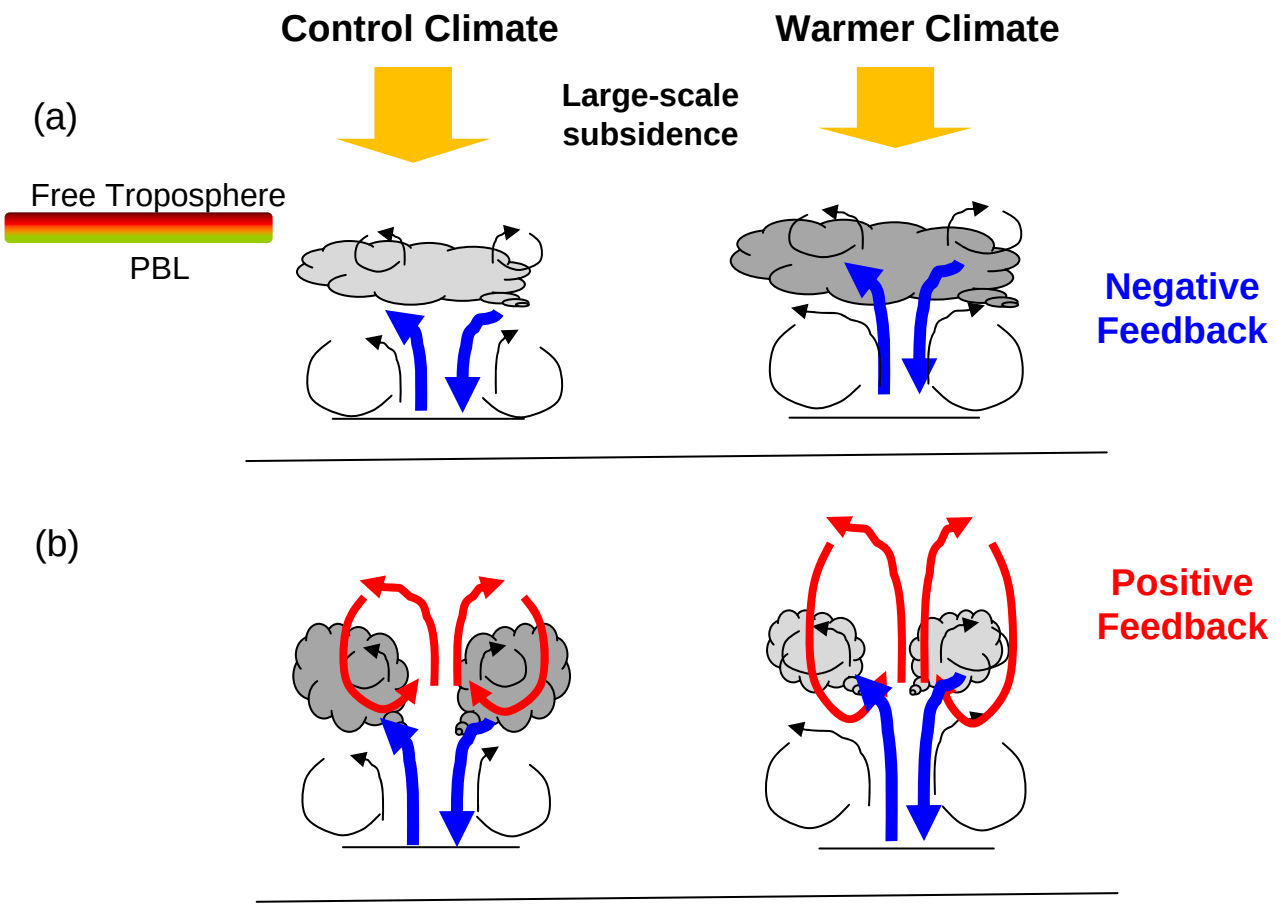
Perturbation	Description	Reference
δSST(15-35N)	2.5±0.5 K	*IPCC* [2007] Fig. 10.6 and Box 10.2
$\delta\omega$(500 hPa)	-5±3%	*Vecchi and Soden* [2007] Fig. 1; *Webb et al.* [2012] Fig. 7f/9f
δEIS	0.6±0.2 K	*Webb et al.* [2012] Fig. 7e/9e
δRH	-1.5±1%	*Richter and Xie* [2008] Fig. 10; *Sherwood et al.* [2010] Fig. 2
δWS	-1.5±1.5%	*Lu and Cai* [2009] Table 3 (Tropical)

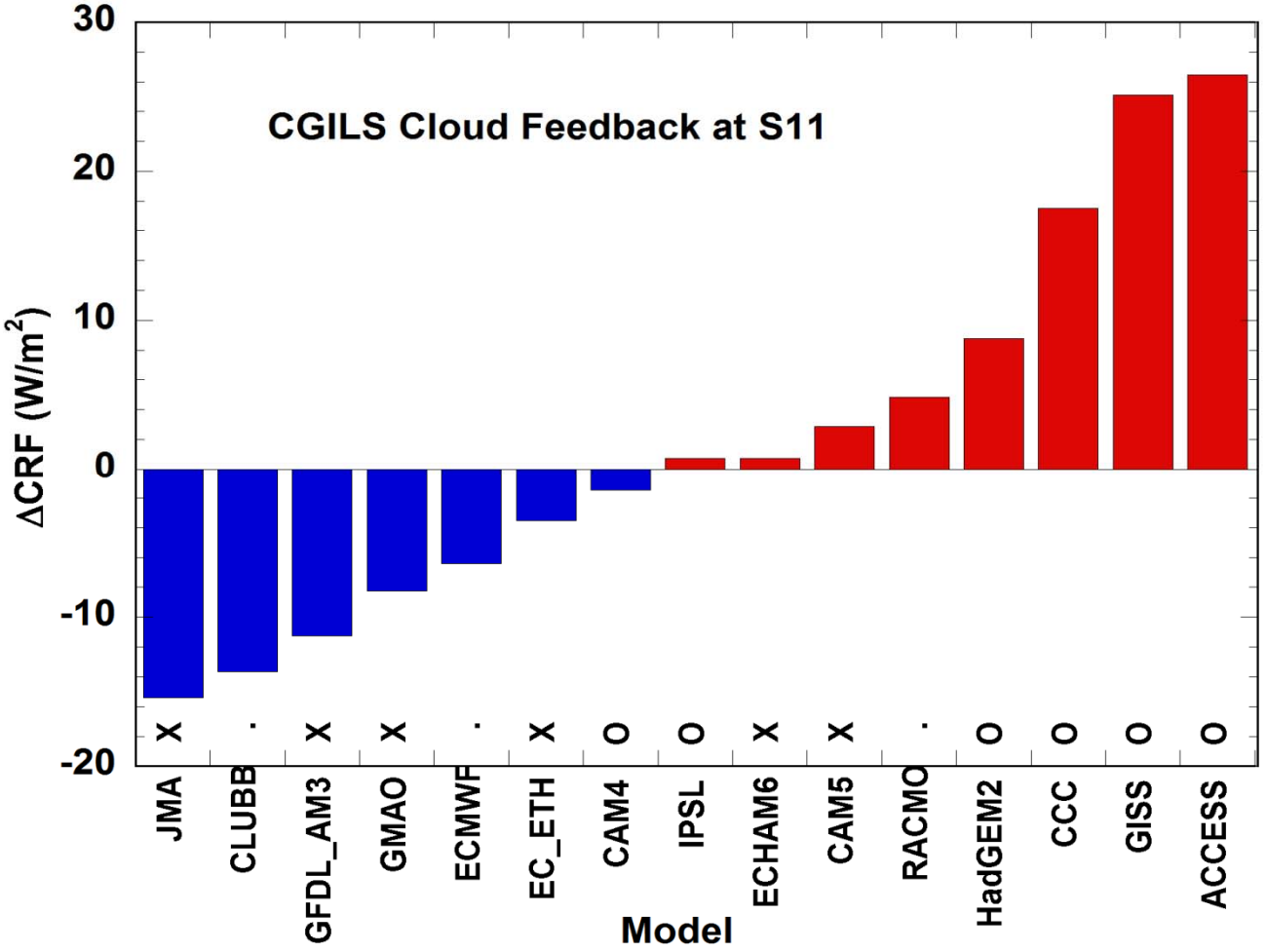
Bretherton et al. (2013,JAMES)

What have we learned from the first phase of CGILS?

1. **An idealized case to do sanity checks of SCMs, to understand how PBL and shallow convection parameterizations respond to perturbations of large-scale fields.**

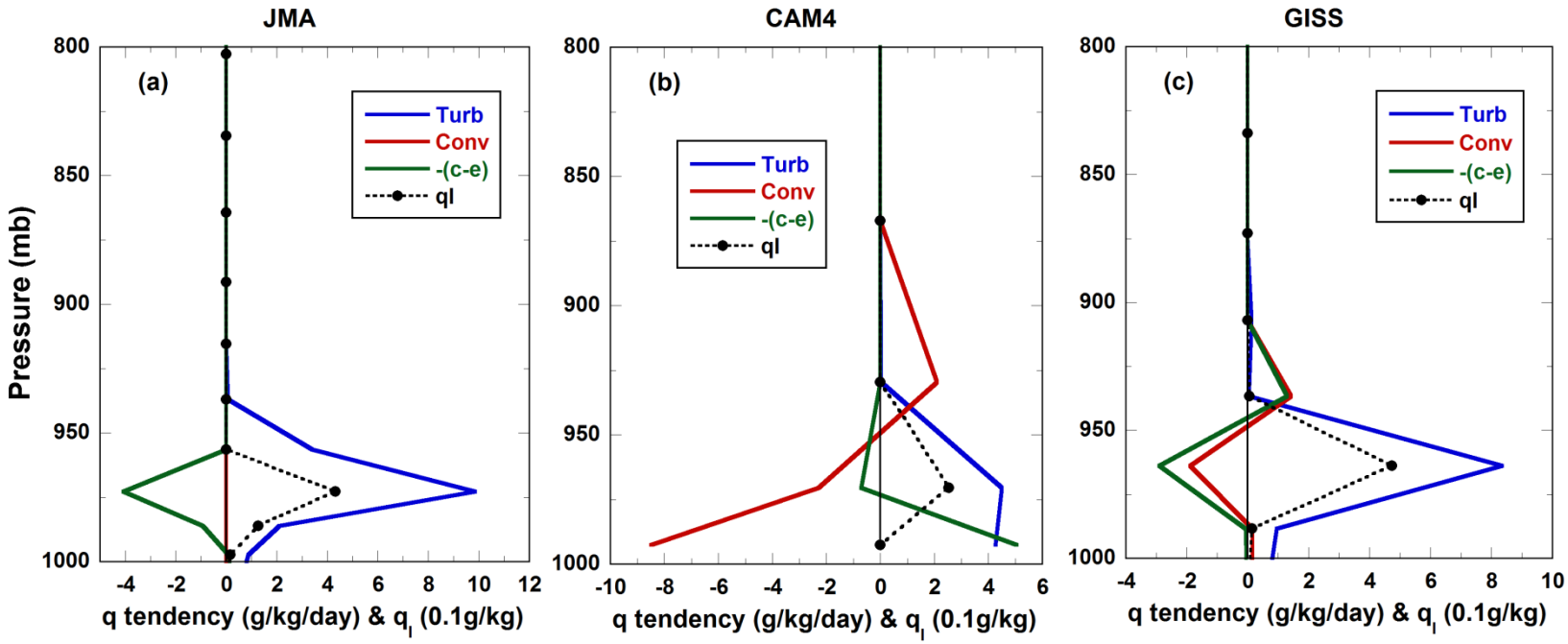
2. **Physical processes of low cloud feedbacks in SCMs.**


Control Climate
Warmer Climate
(a)
Large-scale subsidence
Free Troposphere
PBL
Negative Feedback
(b)
Positive Feedback



X
Without convection

O
With convection



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

What have we learned from the first phase of CGILS?

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Negative cloud feedback from mixing by the PBL schemes

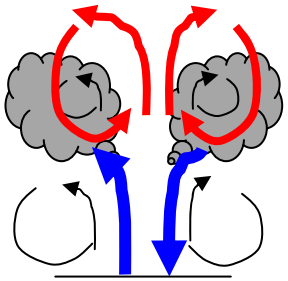
Positive feedback from mixing by the shallow convection schemes

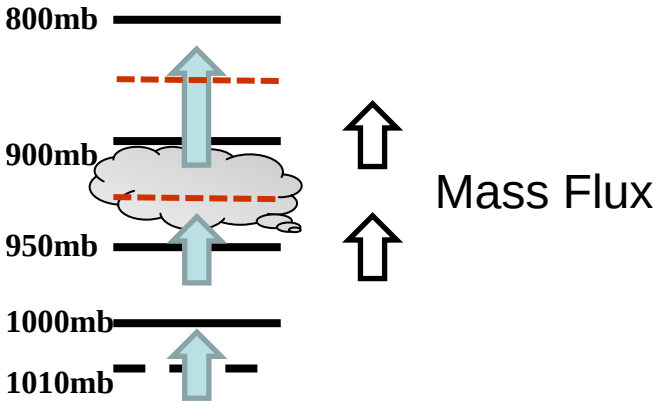
Convection dominates when it occurs

Why does convection dominate for shallow cu?

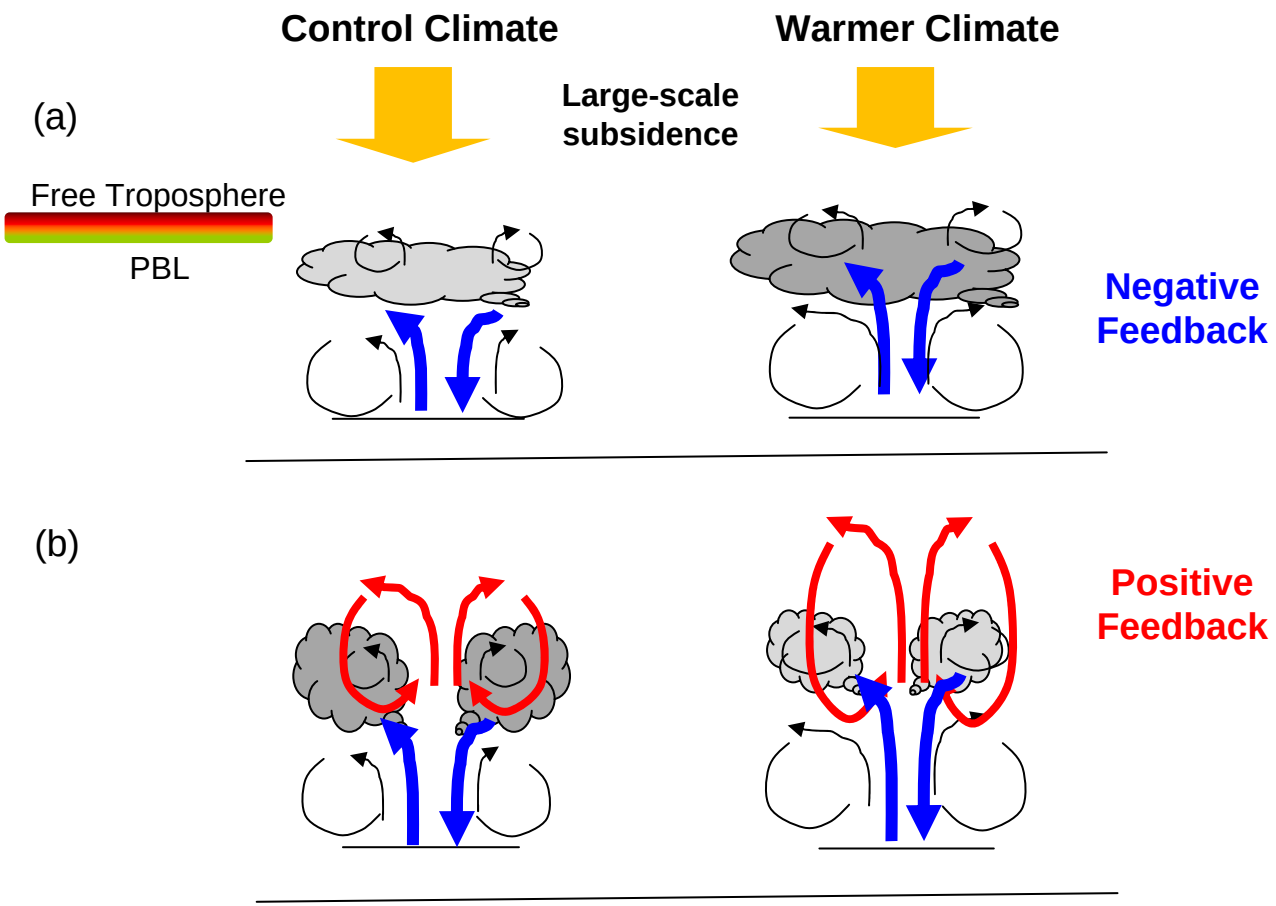
$$\overline{w'q'}\Big|_{Turb} = -K_c\left(\frac{\partial q}{\partial z} - \gamma_c\right), \qquad \overline{w'q'}\Big|_{Turb} \approx LH \propto (q_s - q_c)$$

$$\overline{w'q'}\Big|_{Conv} = M(z)(q_c - q_e)$$



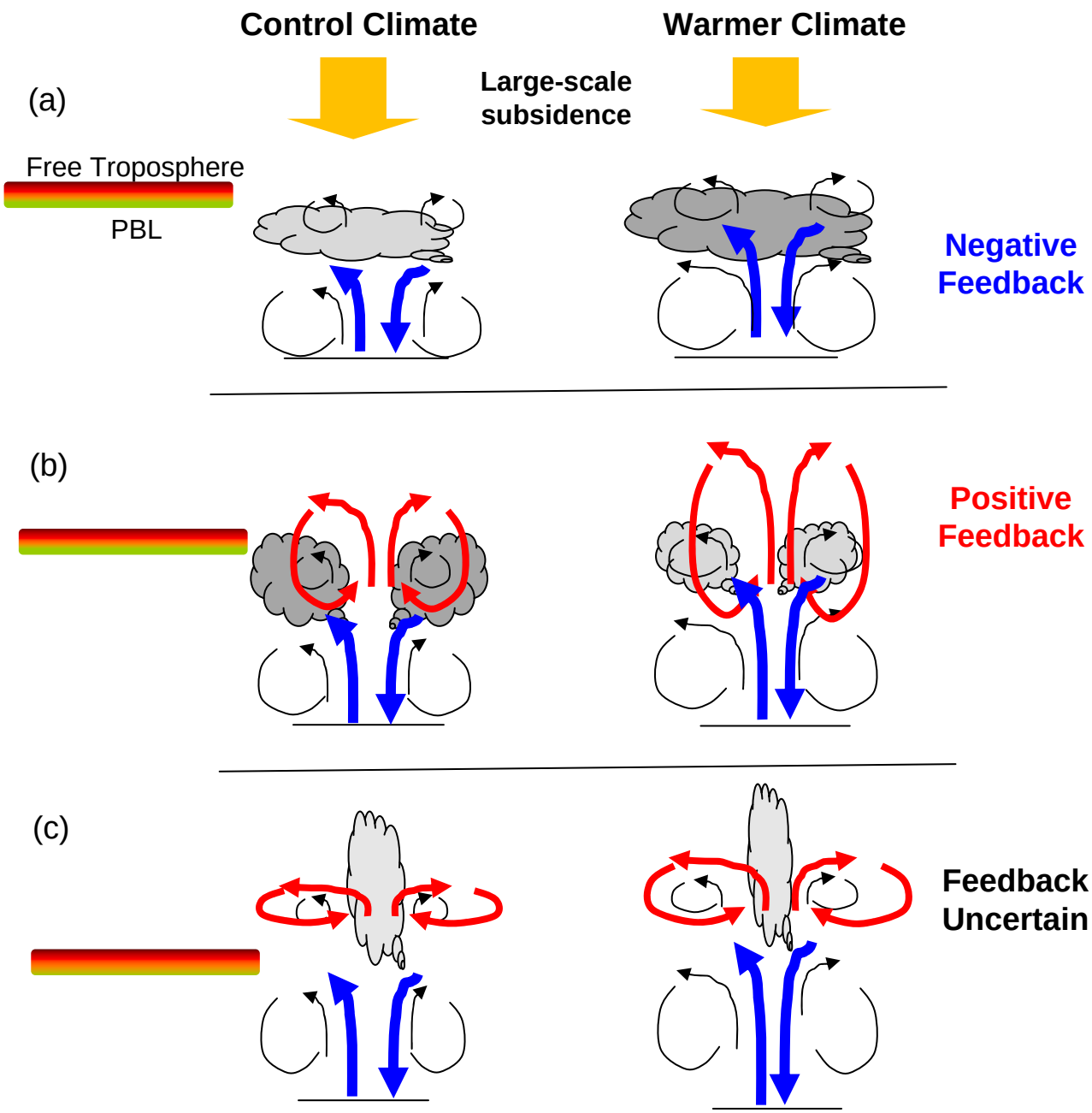


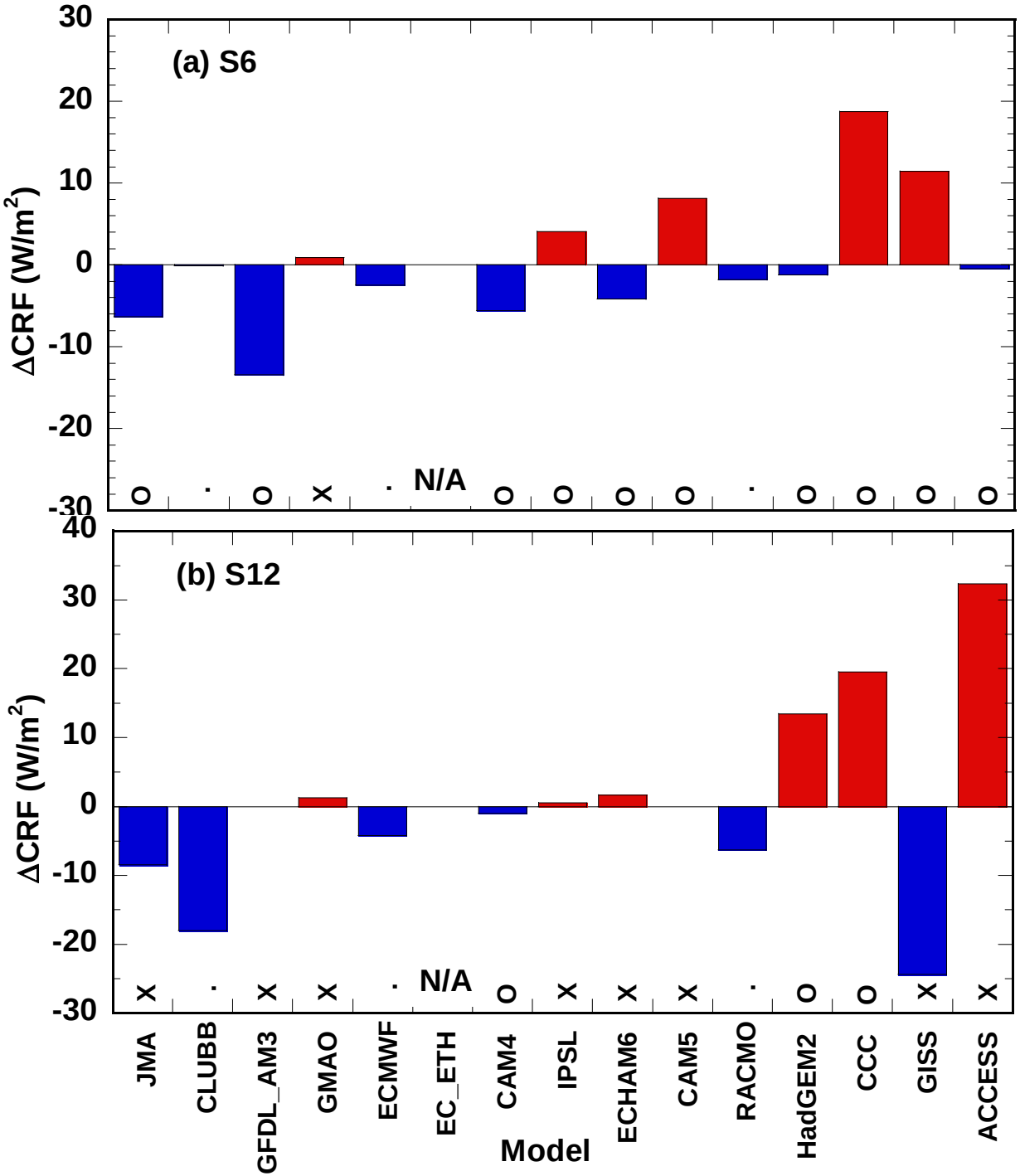
Change of Moisture Flux



Shallow Cumulus Dilution – Surface Turbulence Moistening

CGILS "SCuD-STeM" Competition Mechanism


Control Climate
Warmer Climate
(a)
Large-scale subsidence
Free Troposphere
PBL
Negative Feedback
(b)
Positive Feedback
(c)
Feedback Uncertain



X
Without convection

O
With convection

What have we learned from the first phase of CGILS?

1. **An idealized case to do sanity checks of SCMs, to understand how physical parameterizations respond to perturbations of large-scale fields.**

2. **Physical processes leading to low cloud feedbacks in SCMs.**

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Positive feedback from mixing by the shallow convection schemes

In the GCM world, the frequency and type of convection matter.

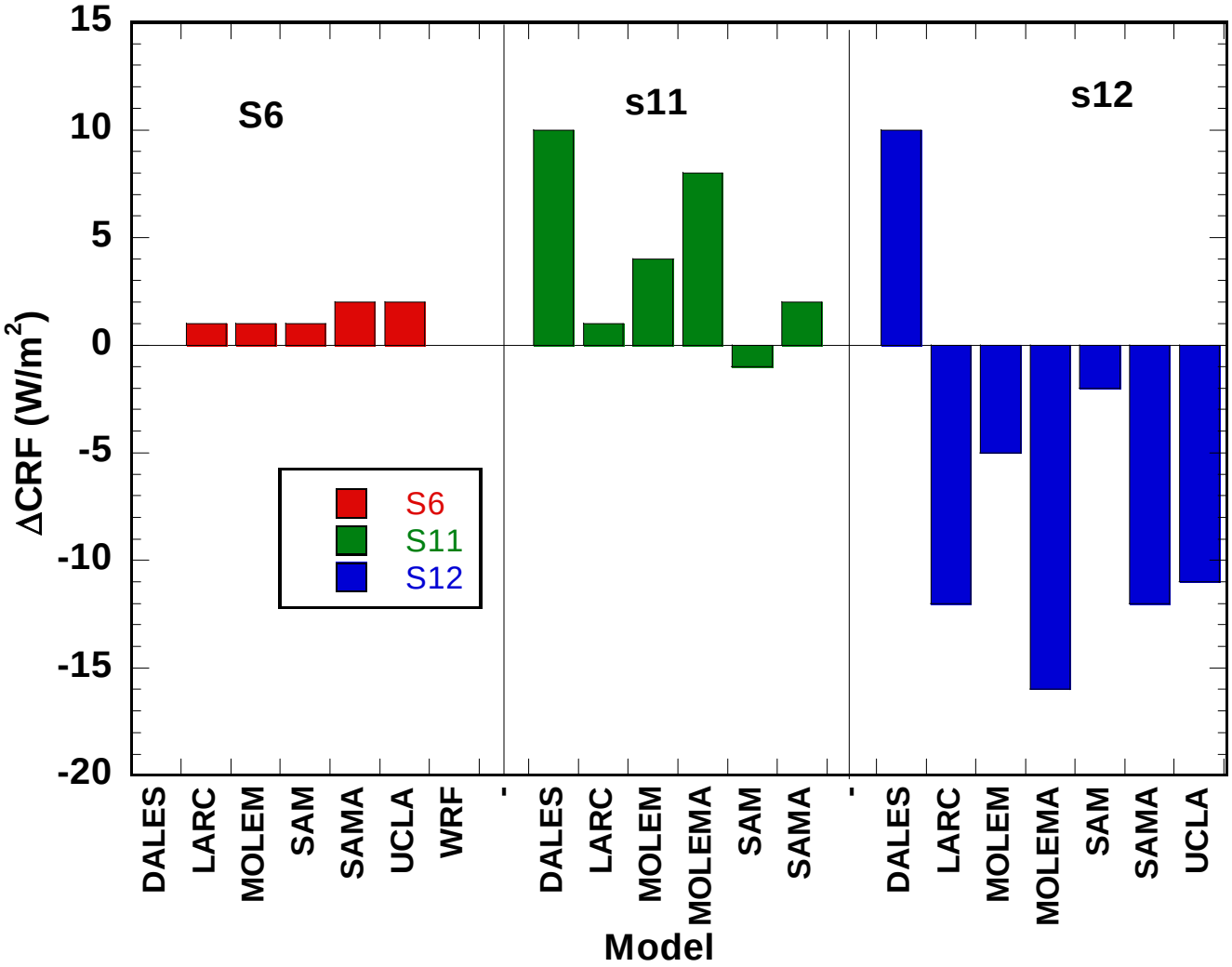
What have we learned from the first phase of CGILS?

1. **An idealized case to do sanity checks of SCMs, to understand how physical parameterizations respond to perturbations of large-scale fields.**

2. **Physical processes of low cloud feedbacks in SCMs.**

3. **LES models as benchmarks**

LES models simulated negative cloud feedback at the coastal stratus location S12, positive feedback at the stratocumulus and shallow cumulus locations S11 and S6.


15
10
5
0
-5
-10
-15
-20
ΔCRF (W/m2)
S6
s11
s12
S6
S11
S12
DALES
LARC
MOLEM
SAM
SAMA
UCLA
WRF
-
DALES
LARC
MOLEM
MOLEMA
SAM
SAMA
-
DALES
LARC
MOLEM
MOLEMA
SAM
SAMA
UCLA
Model

What have we learned from the first phase of CGILS?

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2. **Physical processes of low cloud feedbacks in SCMs.**

3. **LES models as benchmarks**

LES models simulated negative cloud feedback at the coastal stratus location S12, positive feedback at the stratocumulus and shallow cumulus locations S11 and S6.

The SCMs are generally consistent at S11 and S12 if the occurrences of convection are correct, but not at S6

What have we learned from the first phase of CGILS? – The Take Home Message

1. **An idealized case to test PBL and shallow convection schemes**

2. **Physical processes of low cloud feedbacks in SCMs: the two competing mechanisms.**

SCuD-STeM

CGILS first-phase results may not give the same cloud feedbacks as in GCMs, but the interpretation framework should be relevant.

3. **LES results available as benchmarks**

And …

CGILS: Results from the First Phase of an International Project to Understand the Physical Mechanisms of Low Cloud Feedbacks in General Circulation Models

Minghua Zhang[1], Christopher S. Bretherton[2], Peter N. Blossey[2], Phillip H. Austin[3], Julio T. Bacmeister[4], Sandrine Bony[5], Florent Brient[5], Suvarchal K. Cheedela[6], Anning Cheng[7], Anthony D. Del Genio[8], Stephan R. De Roode[9], Satoshi Endo[10], Charmaine N. Franklin[11], Jean-Christophe Golaz[12], Cecile Hannay[4], Thijs Heus[6], Francesco Alessandro Isotta[13], Dufresne Jean-Louis[5], In-Sik Kang[14], Hideaki Kawai[15], Martin Koehler[16], Vincent E. Larson[17], Yangang Liu[10], Adrian P. Lock[18], Ulrike Lohman[13], Marat F. Khairoutdinov[1], Andrea M. Molod[19], Roel A.J. Neggers[20], Philip Rasch[21], Irina Sandu[6,16], Ryan Senkbeil[17], A. Pier Siebesma[20], Colombe Siegenthaler-Le Drian[13], Bjorn Stevens[6], Max J. Suarez[19], Kuan-Man Xu[7], Knut von Salzen[22], Mark J. Webb[18], Audrey Wolf[23], Ming Zhao[12]

JAMES, Under Review

Co-Authors: Please check Tables 2-3 of the revised paper (PBL and cu)

CGILS Paper Status:

Zhang et al. 2012: CGILS Experimental Design, JAMES

Blossey et al. 2013: CGILS LES Results, JAMES

Bretherton et al. 2013: CGILS LES Analysis, JAMES

Zhang et al. 2013: CGILS SCM and Overview Results, JAMES, submitted

Brent and Bony 2012: IPSL

Kawai 2012: SOLA

Webb and Lock (2012)

??? (let us know)

The first 4 are available at http://www.atmos.washington.edu/~bloss/

CGILS Case Plots: http://atmgcm.msrc.sunysb.edu/cfmip

Next phases of CGILS for Discussion

$4XCO_2$

- **Fast response**

  To evaluate SCM results against LES?

  To compare SCM results with GCMs?

- **To compare the radiative forcing of $4XCO_2$?**

Other control variables DCMIP3 (RH, WS, Cd, EIS in addition to SST and ω)

- **Are the changes similar among GCMs?**
- **Should different models do the same perturbation experiments?**

Next phases of CGILS for Discussion

Seasonal Variations

- **Cloud response to large-scale forcing, January and July**
- **Observations to compare (MAGIC)**

Connection with GCM output at cfsites.

- **Stratify data and link with processes**
- **Hypothesis testing (CGILS – cfsites – SCM – GCM)**

Need Champions!