A CFMIP-GCSS Project to Study Cloud Feedbacks in Climate Models and the Role of ARM Data

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With contributions from
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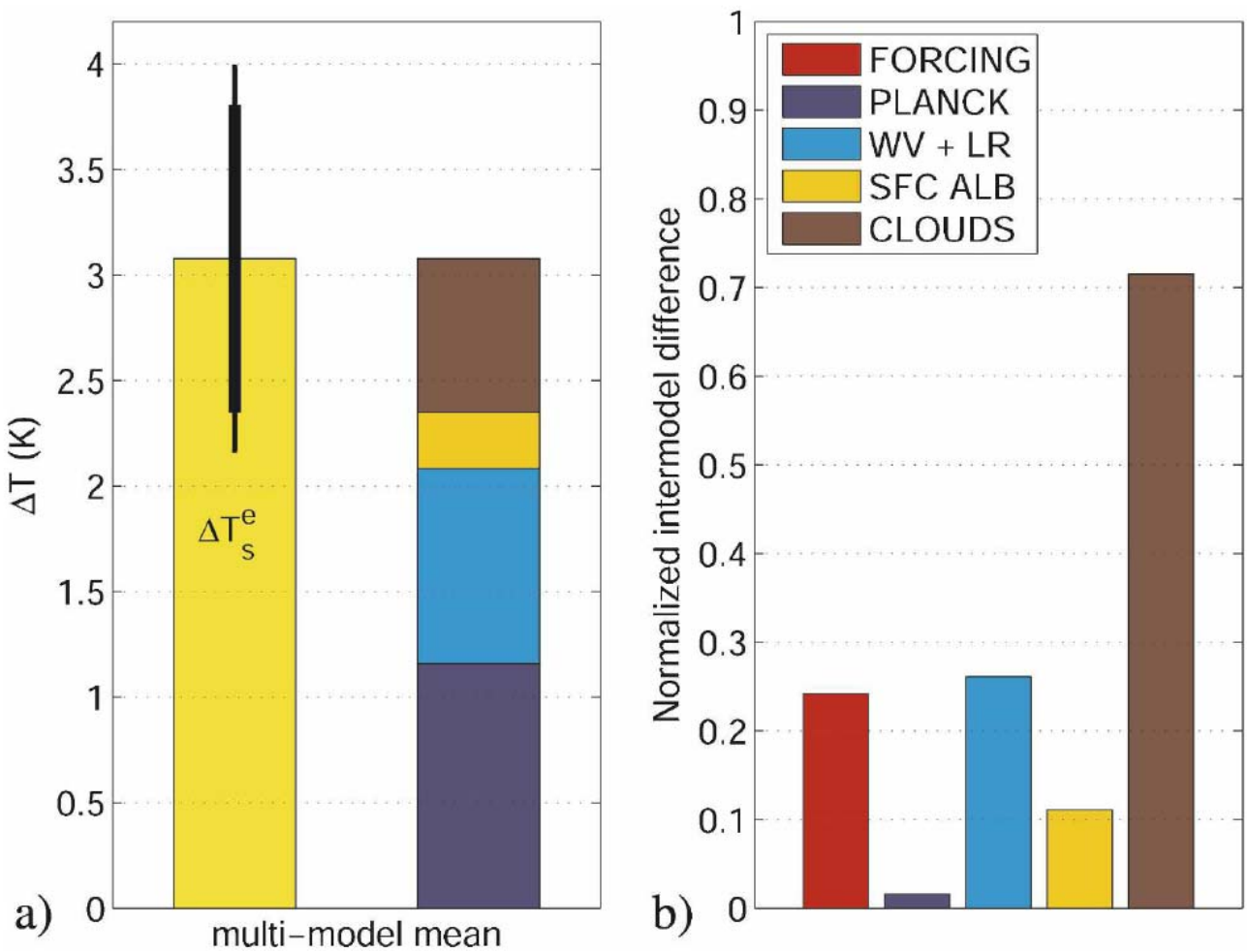
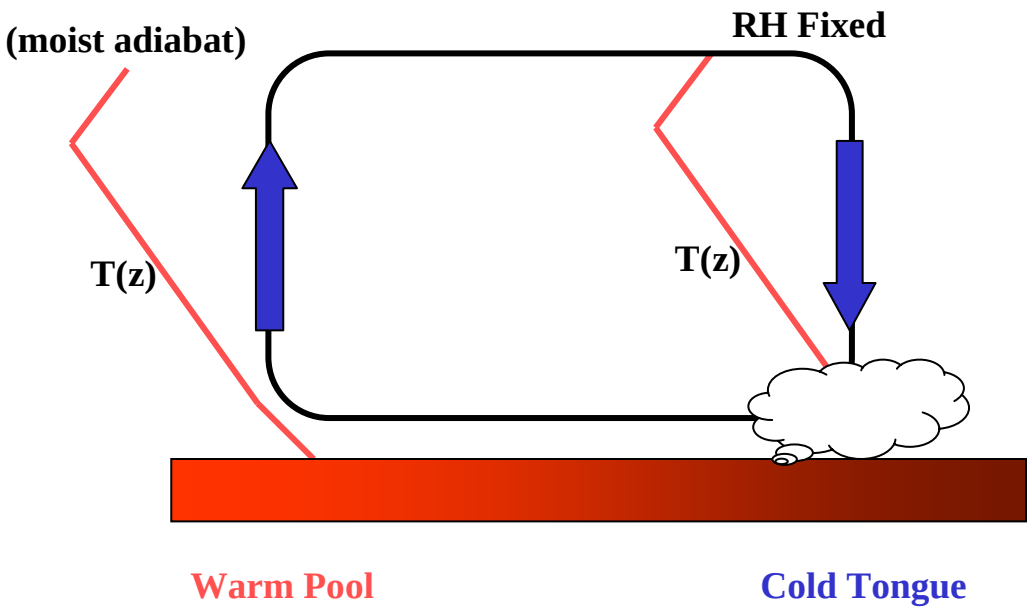
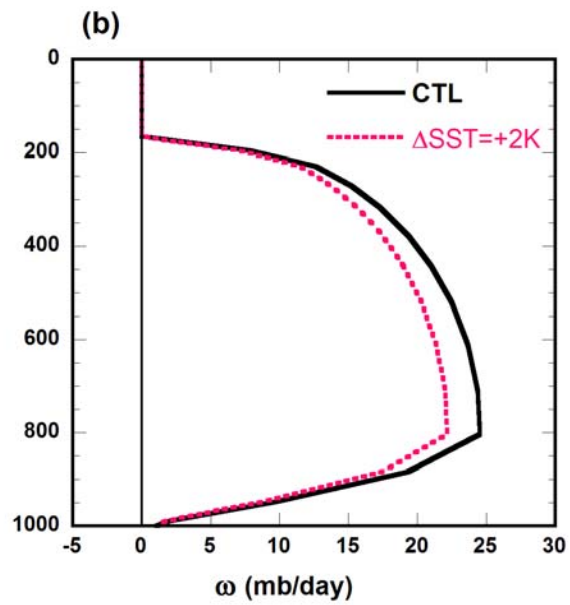
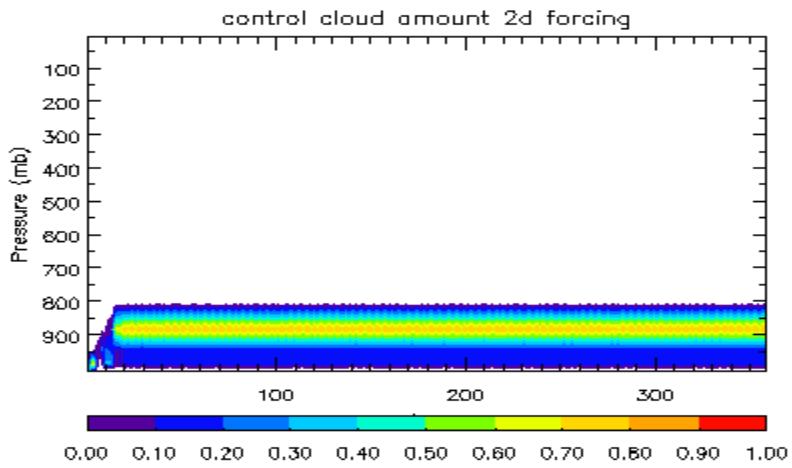


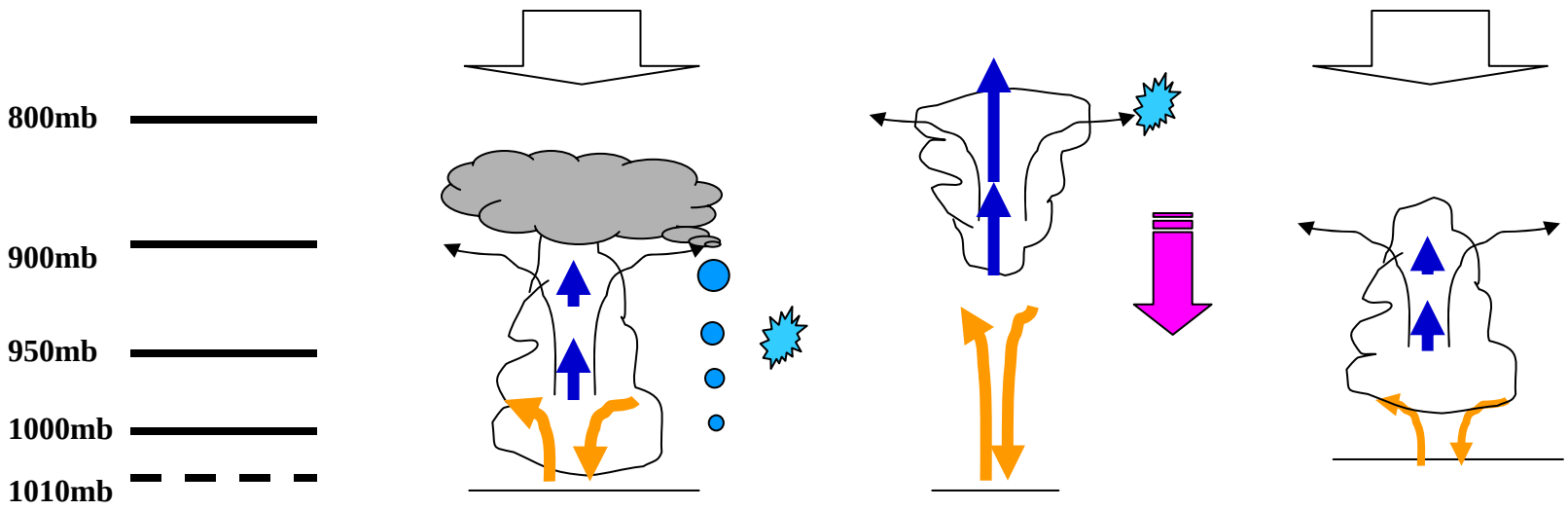
(Dufresne and Bony 2008)





(Zhang and Bretherton, 2008)


control cloud amount 2d forcing
Pressure (mb)
100
200
300
400
500
600
700
800
900
100
200
300
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00


800mb
900mb
950mb
1000mb
1010mb

The CFMIP-GCSS Project:

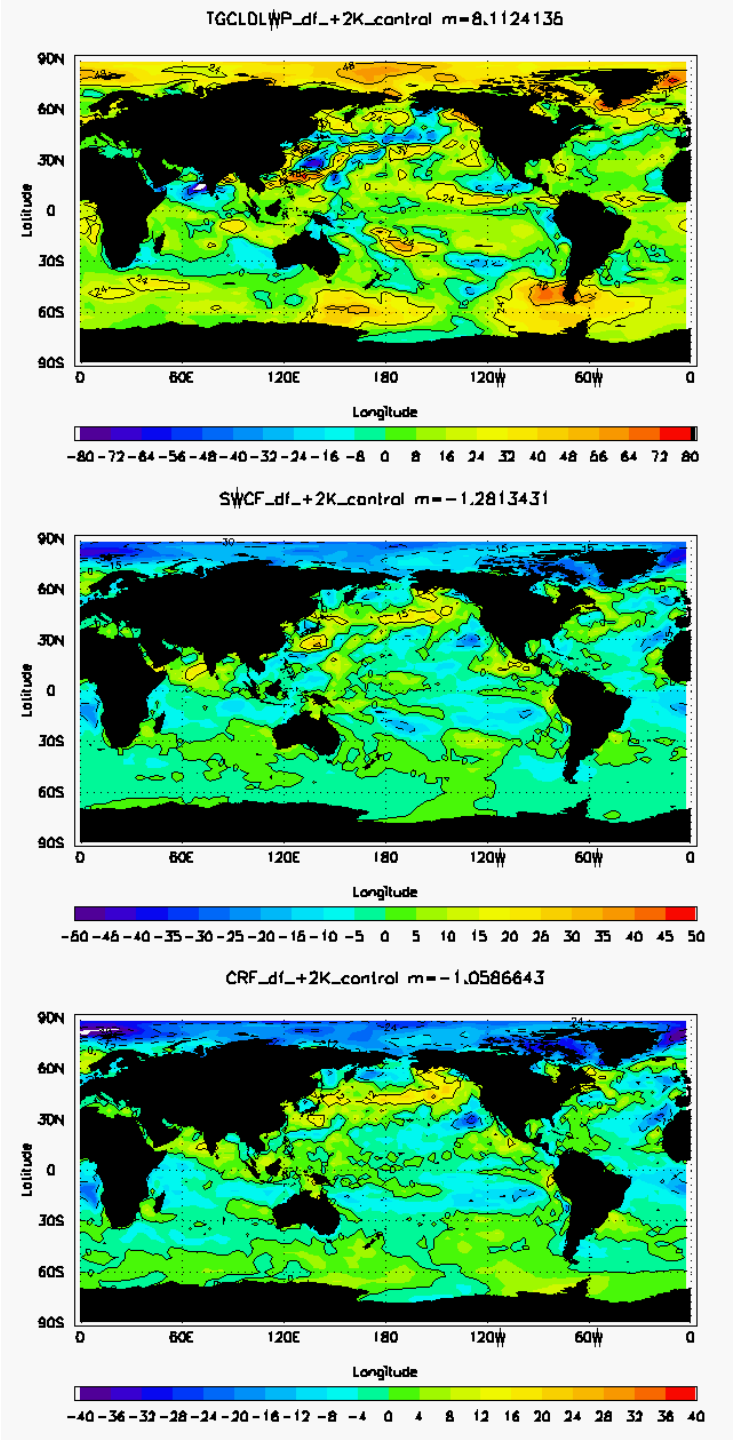
1. Use similar idealized SCM simulations to interpret cloud climate feedbacks in GCMs.

2. Use LES/CRM simulations to evaluate the SCMs.

1. Can cloud variation at a single point represent area-averages in GCMs?

2. Can SCMs reproduce cloud feedbacks in the GCMs?

CAM-SP

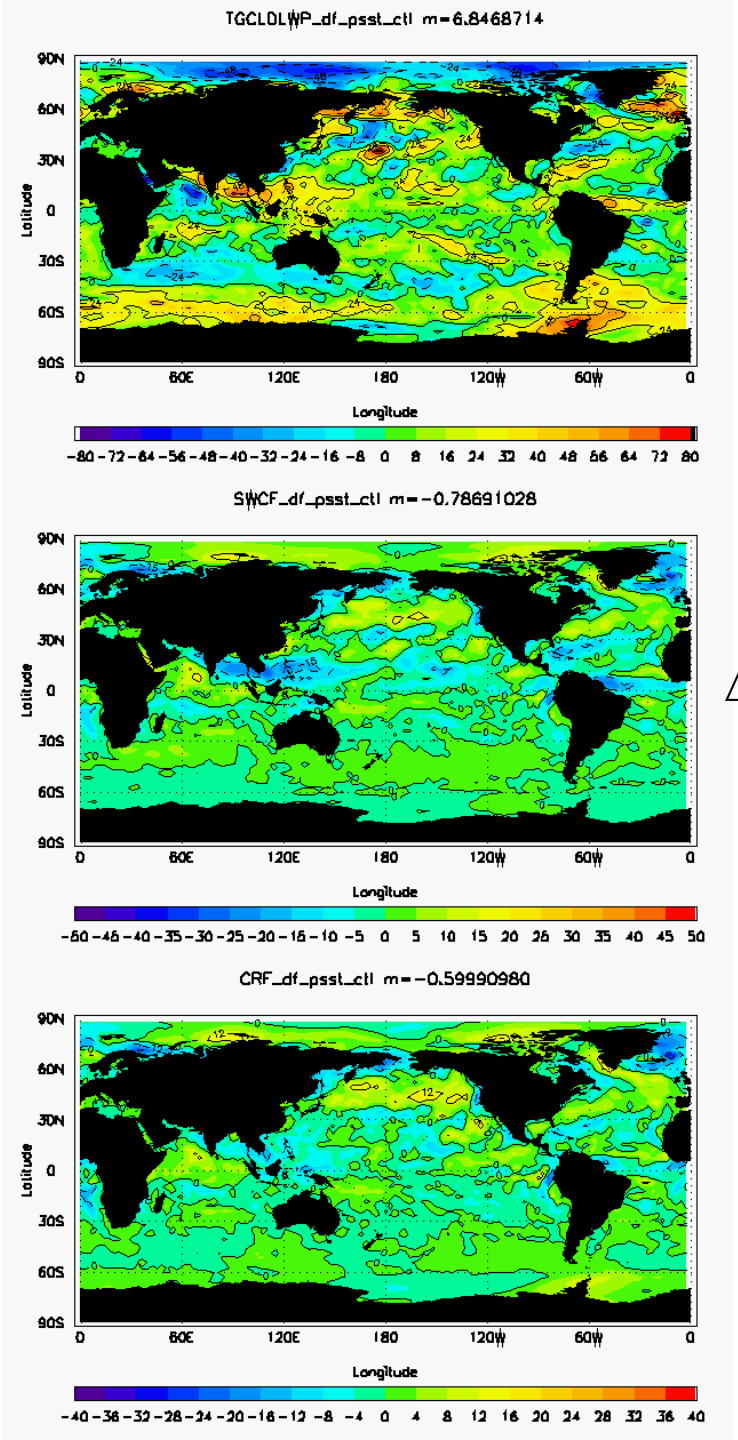


ΔLWP

ΔSWCF

ΔCRF

CAM3.5

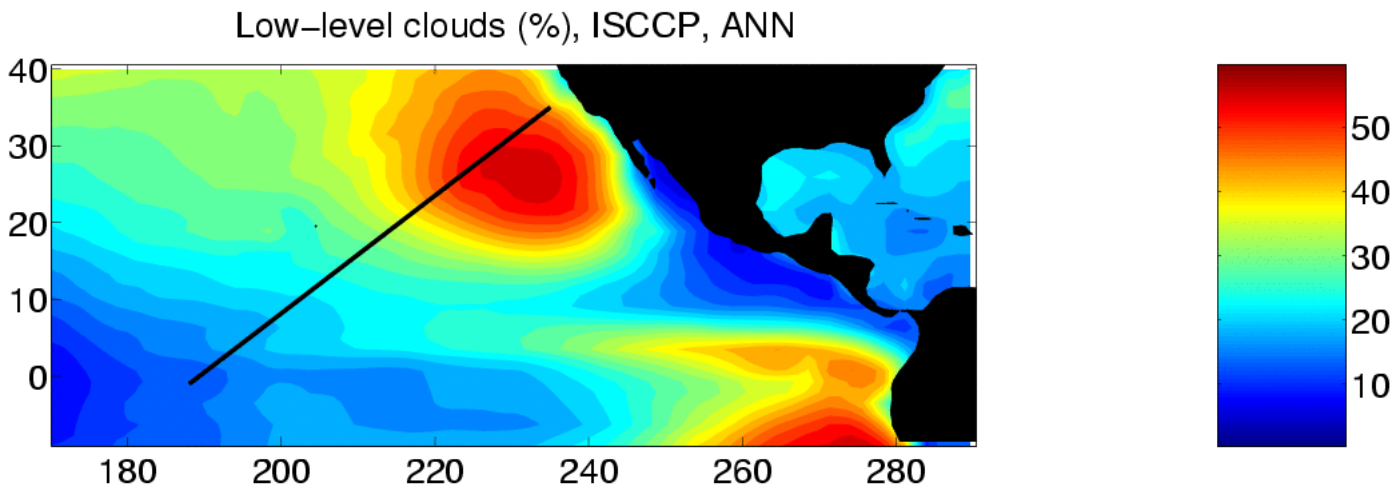


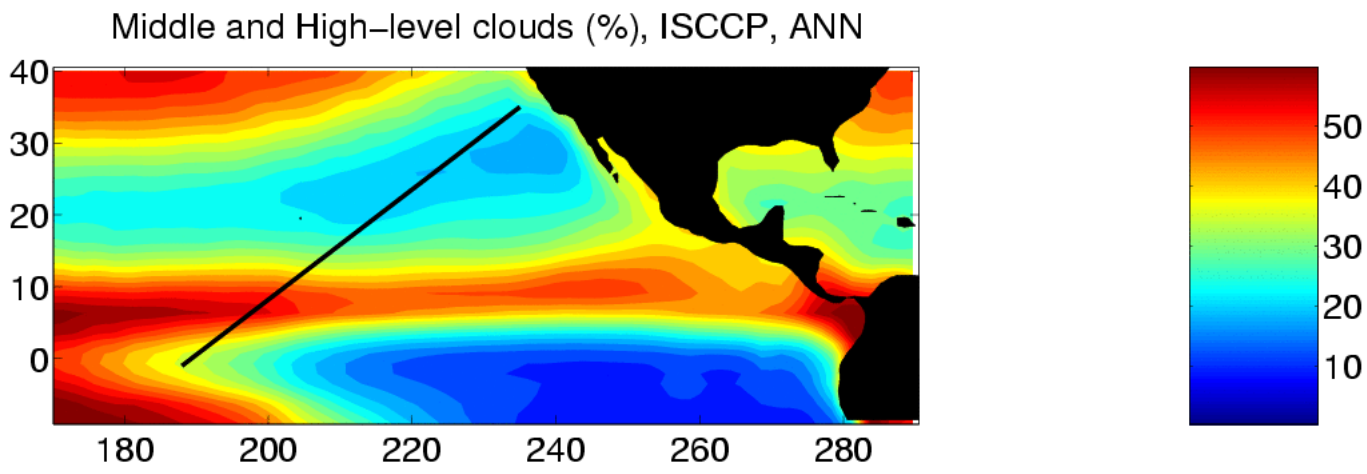
ΔLWP

ΔSWCF

ΔCRF

GPCI





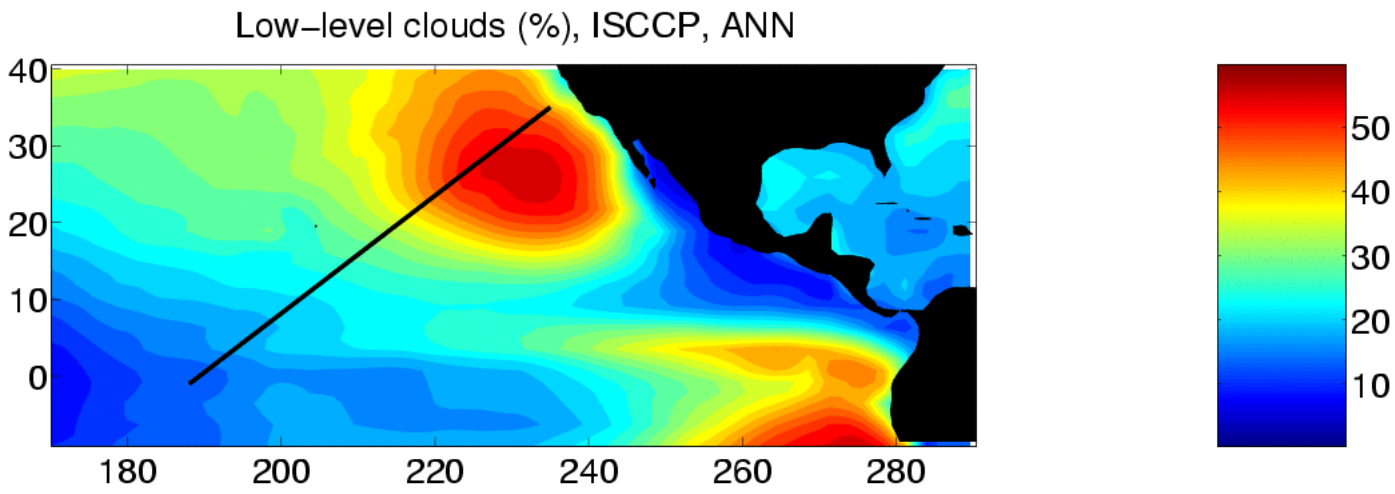
(Teixeira et al. 2008)

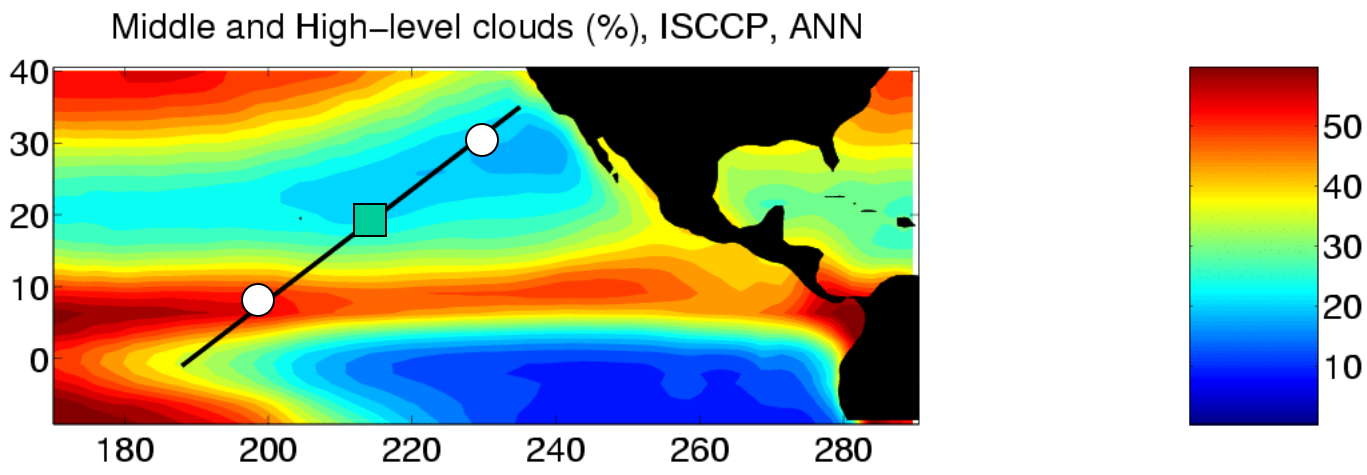
Forcing Data:

1. Independent of parameterization of any model.

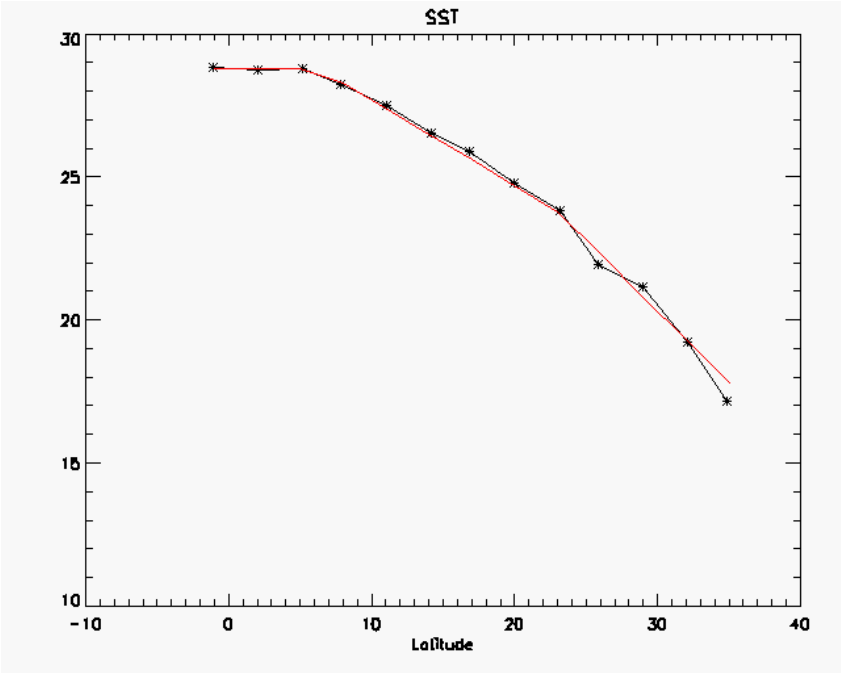
2. Both control and perturbed climate.

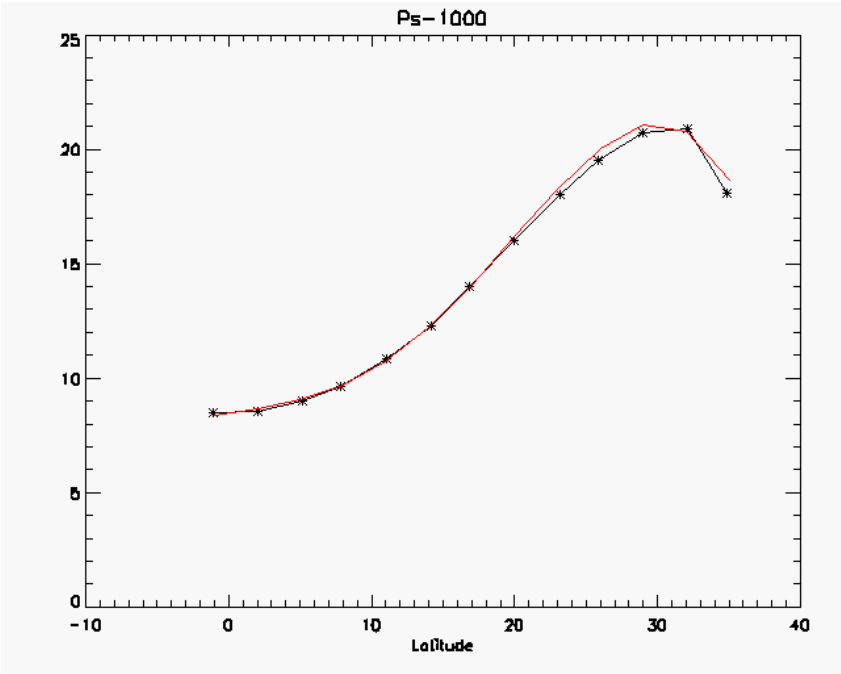
GPCI

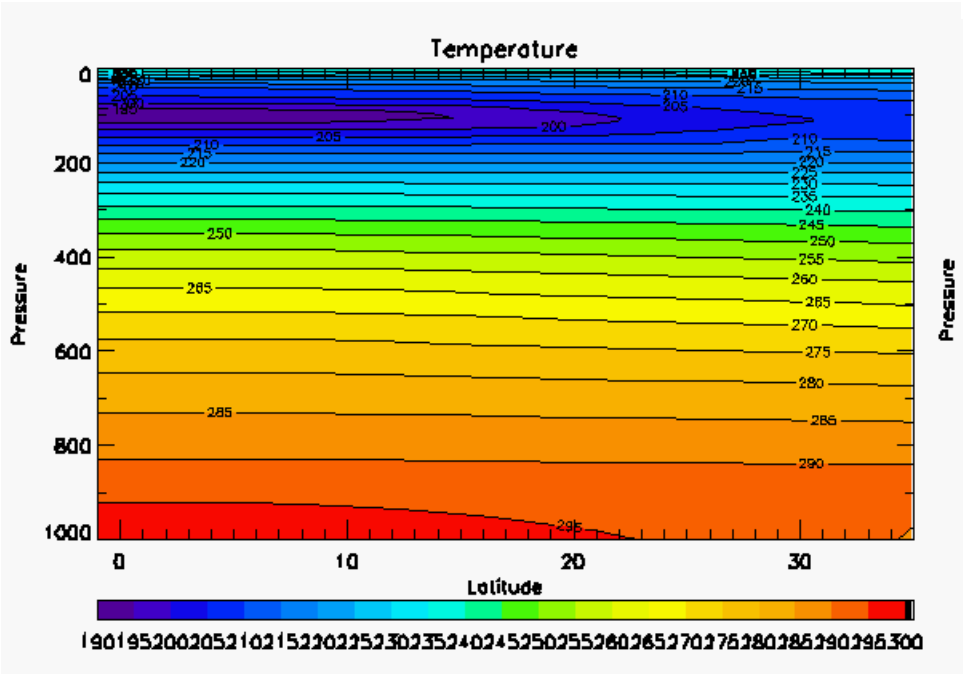


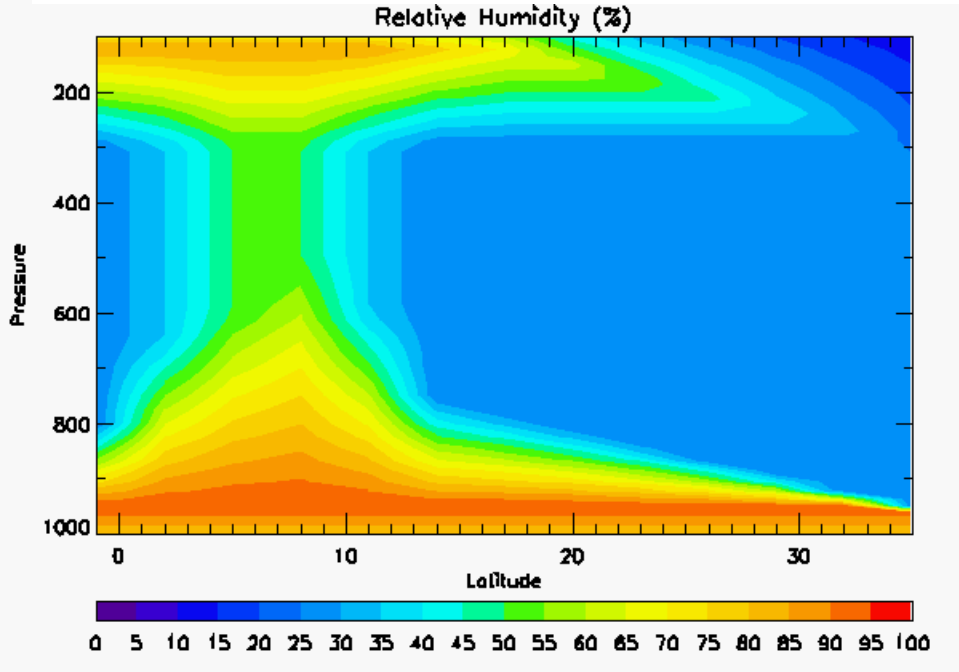


(Teixeira et al. 2008)


SST
Latitude

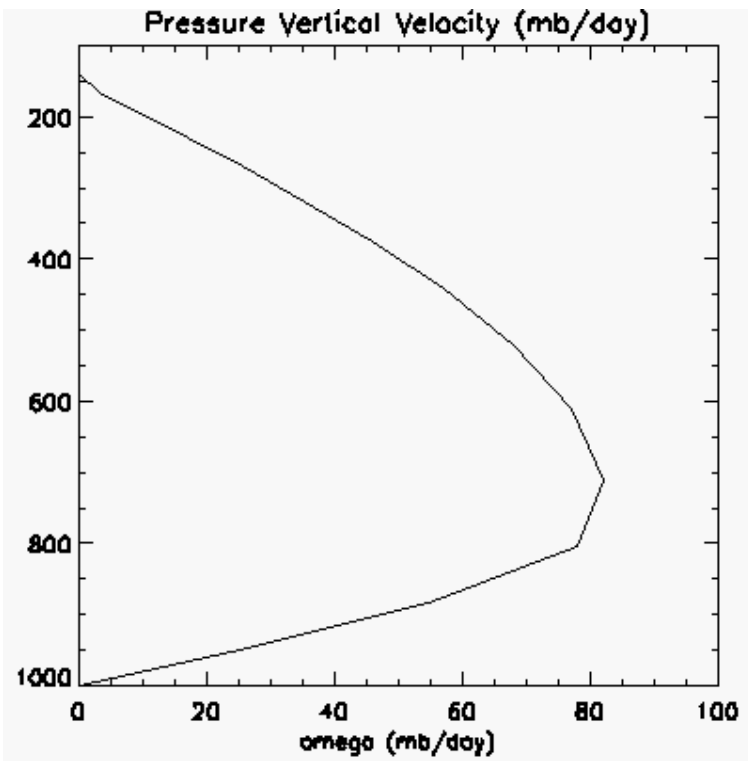

Ps-1000
Latitude

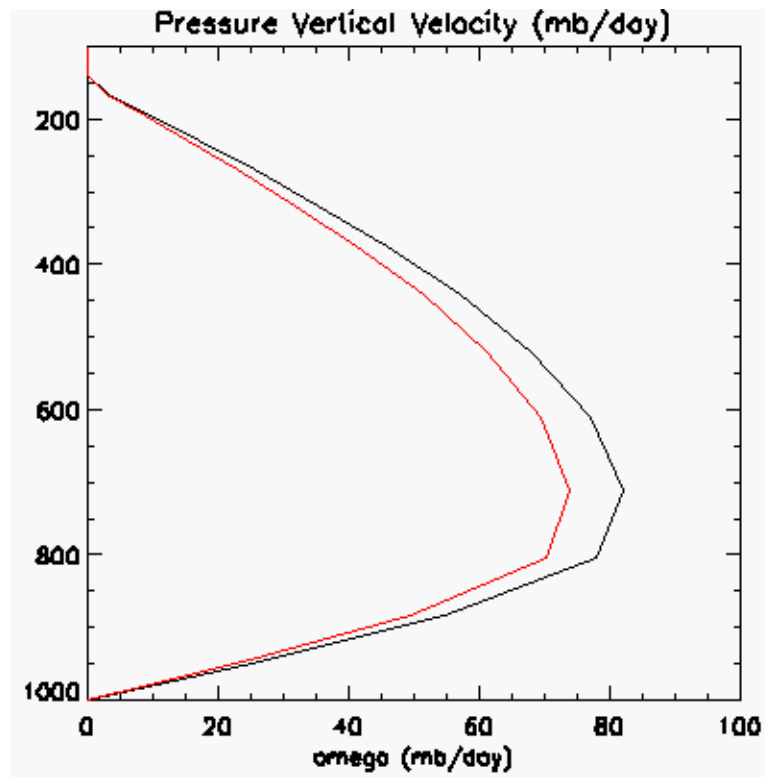

Temperature
Pressure
Latitude

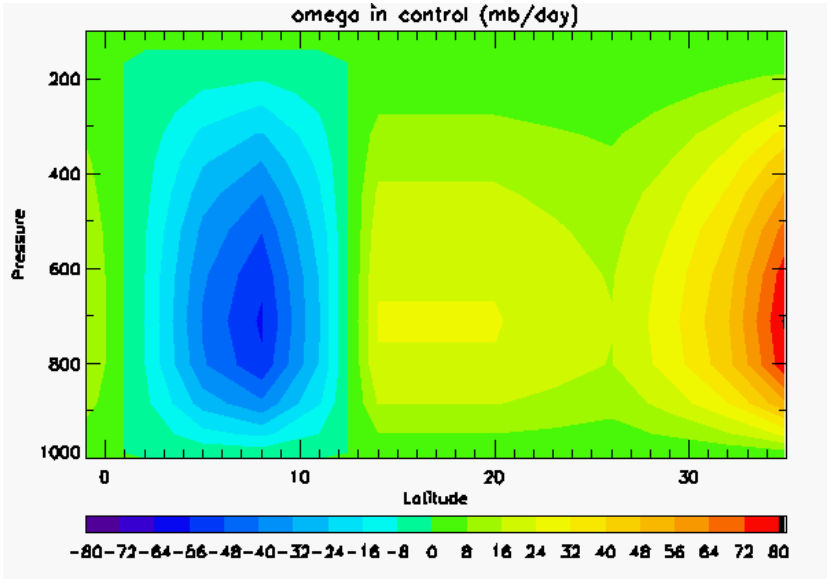

Relative Humidity (%)
Pressure
Latitude

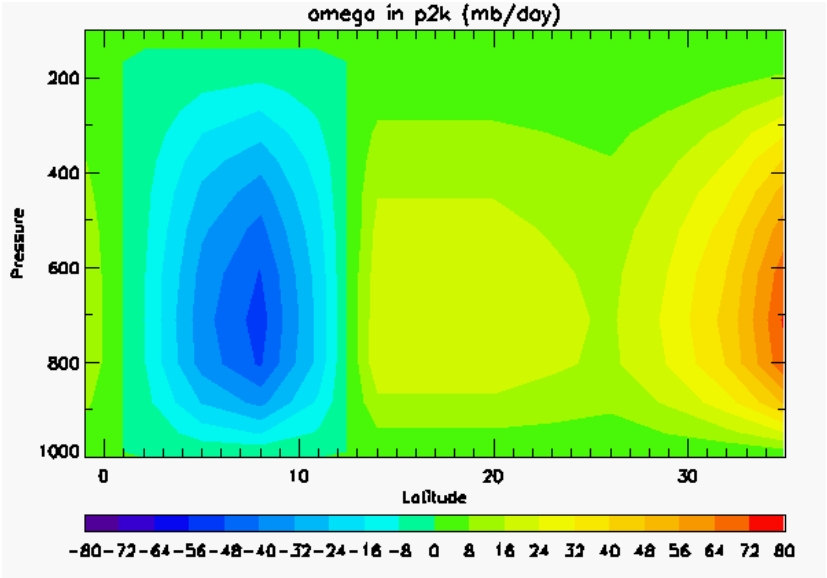
$$\omega \frac{\partial \theta}{\partial p} = Q_R - (\vec{V} \cdot \nabla \theta)_{LS}$$

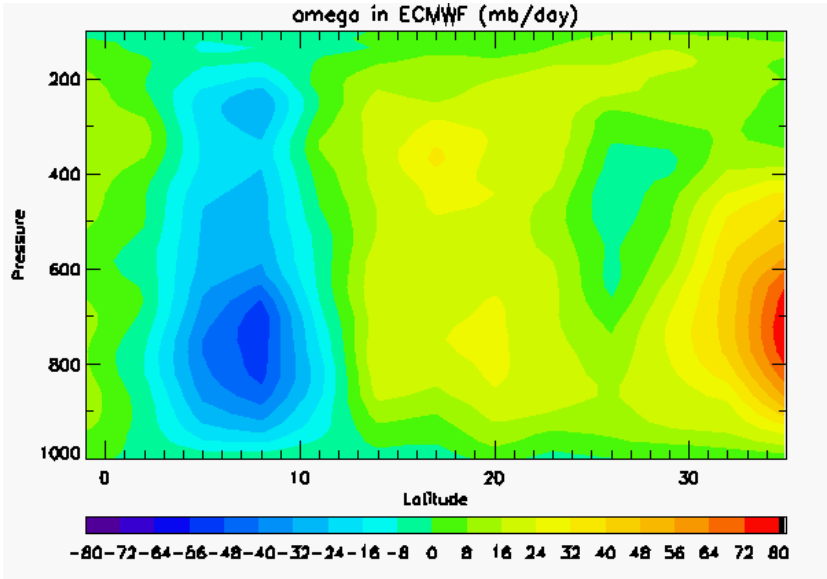
$$\int_{p_1}^{p_2} \omega \frac{\partial \theta}{\partial p} dp = \int_{p_1}^{p_2} Q_R dp - \int_{p_1}^{p_2} (\vec{V} \cdot \nabla \theta)_{LS} dp$$

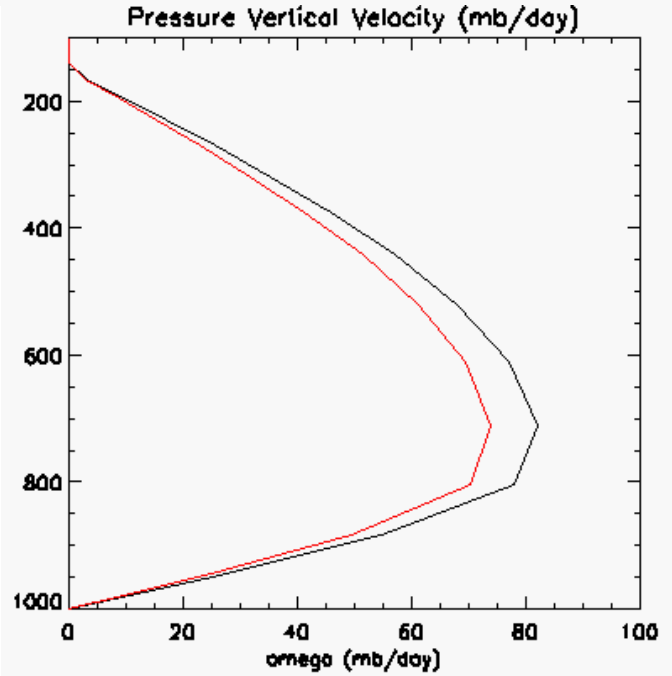




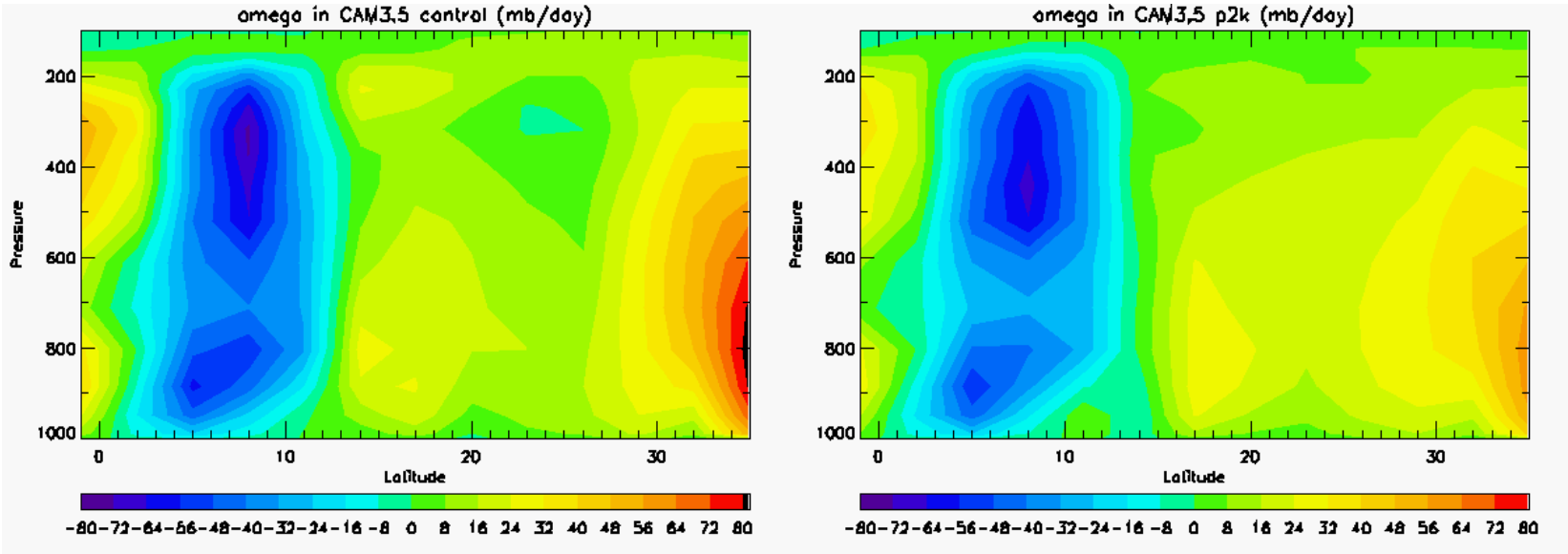








Omega in control climate and ECMWF



Omega in control climate and P2K climate, CAM3.5

In the free atmosphere with downward motion:

$$-(\vec{V}\cdot\nabla\theta)_{LS} = \omega\,\frac{\partial\theta}{\partial p} - Q_R$$

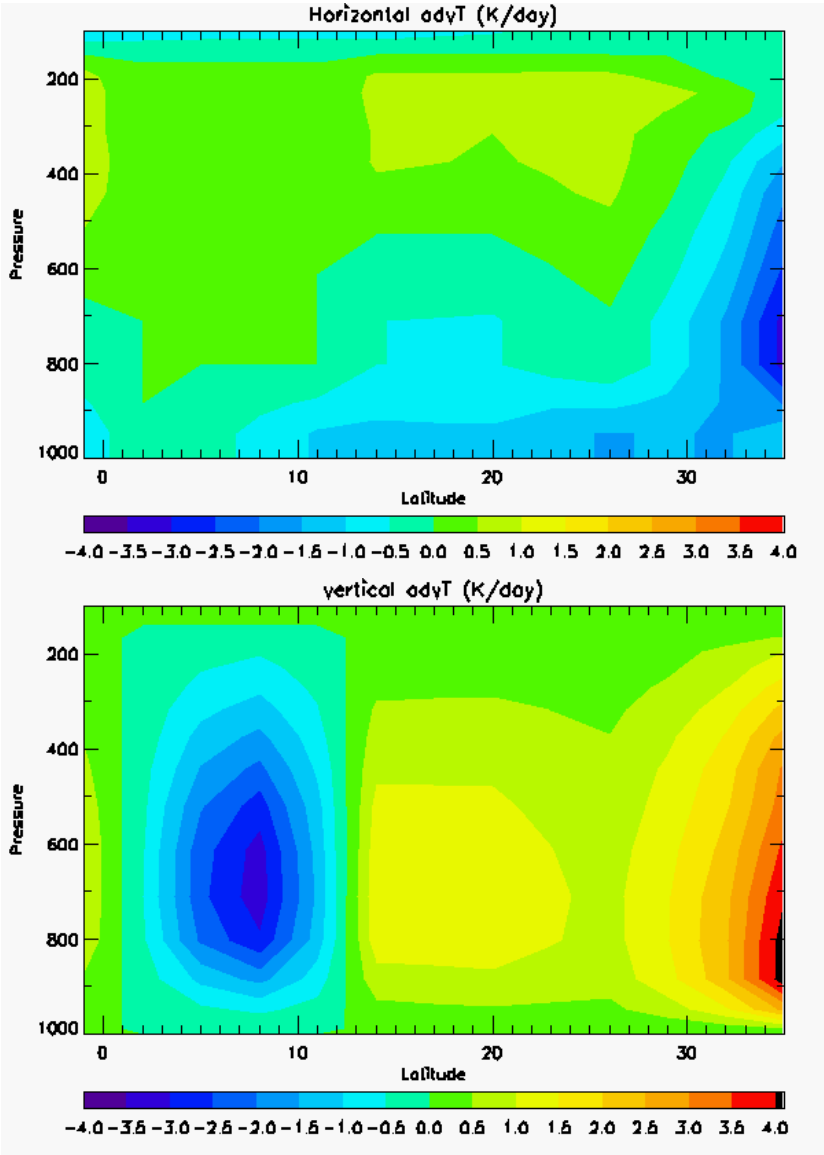
$$-(\vec{V}\cdot\nabla q)_{LS} = \omega\,\frac{\partial q}{\partial p}$$

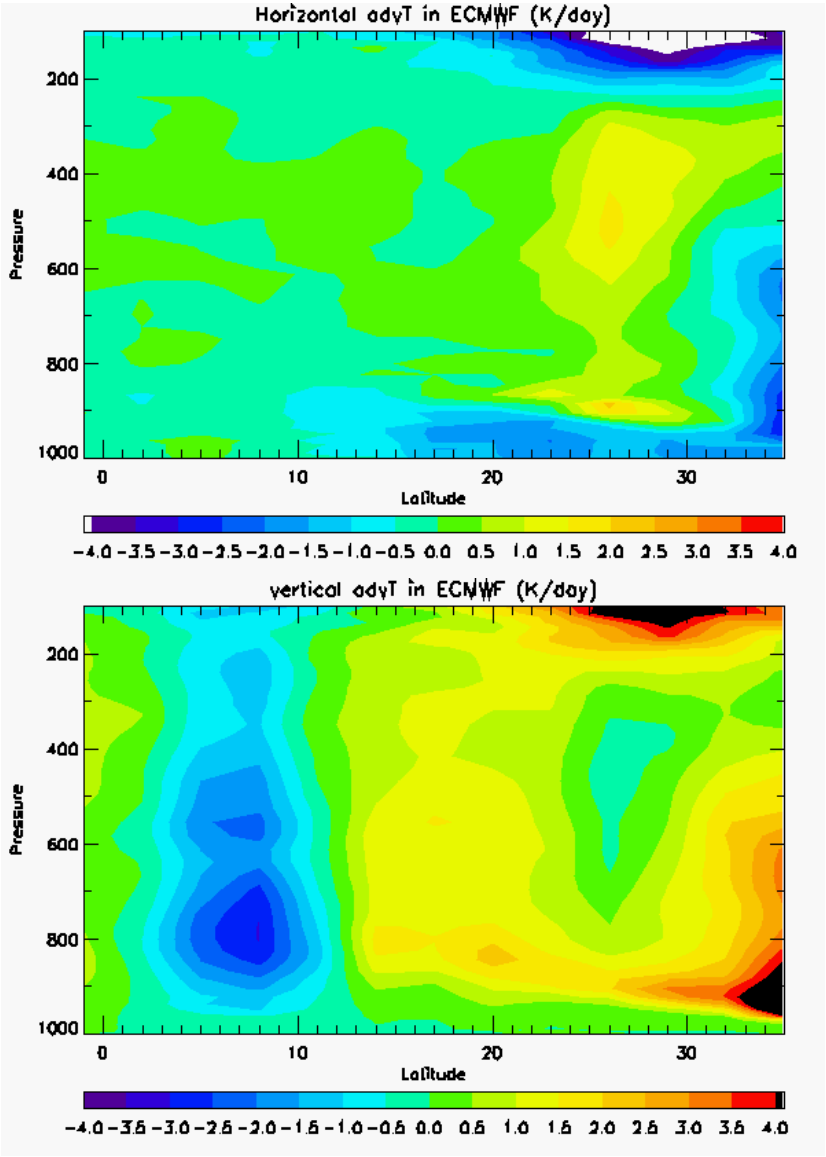
In the free atmosphere with upward motion:
horizontal advection set to zero

Below 950 mb:

$$-(\vec{V}\cdot\nabla T)_s = -\left|\vec{V}_s\right|\cdot\left|\nabla T_s\right|\cos(\vec{V},\nabla T) = -\left|\vec{V}_s\right|\frac{\partial SST}{\partial l}\frac{\cos(\vec{V},\nabla T)}{\cos(\vec{l},\nabla T)}$$

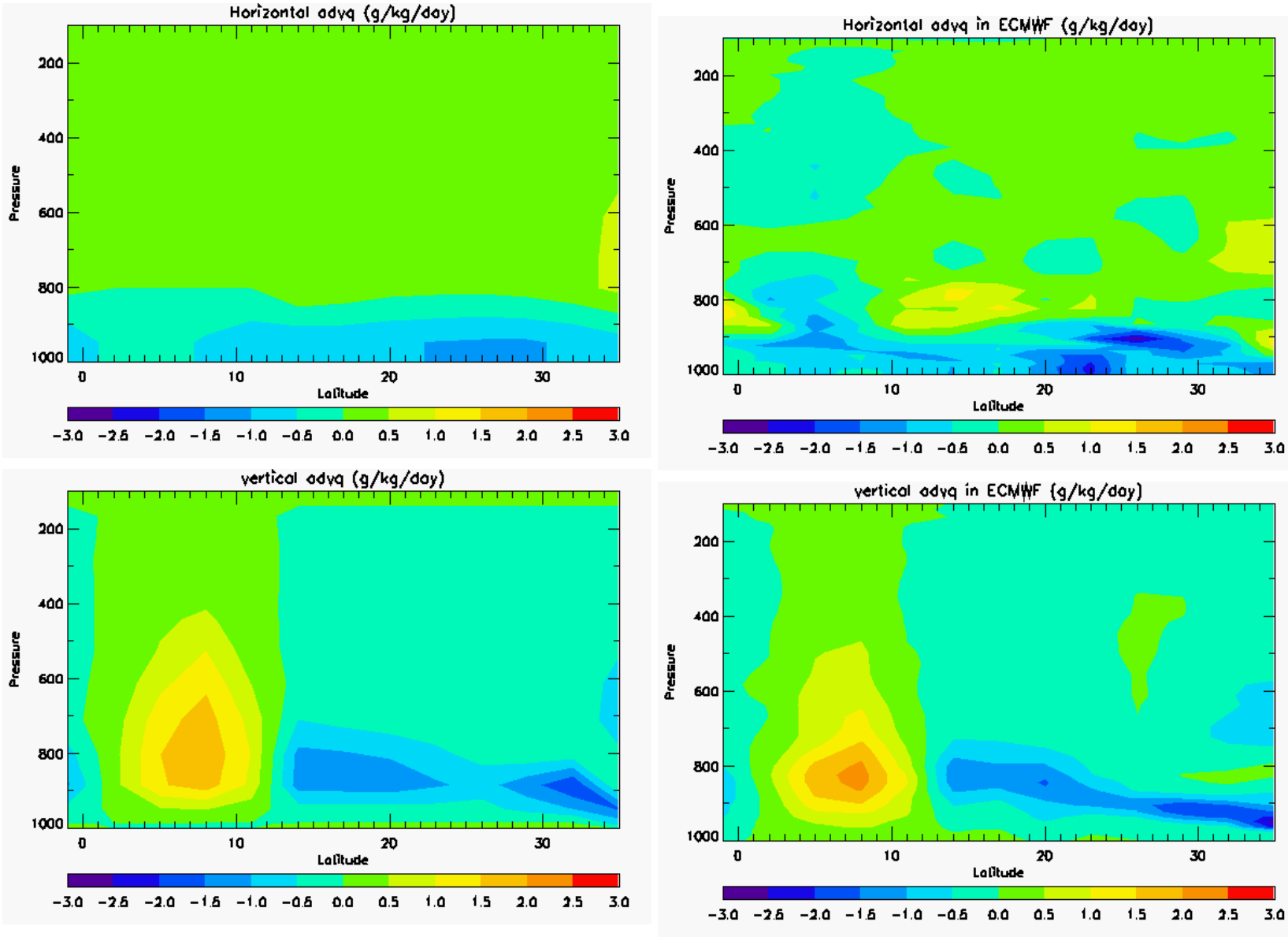
$$-(\vec{V}\cdot\nabla q)_s = -(\vec{V}\cdot\nabla T)_s\left(RH_s\frac{\partial q_s}{\partial T}\right)$$





Horizontal and Vertical T advection.

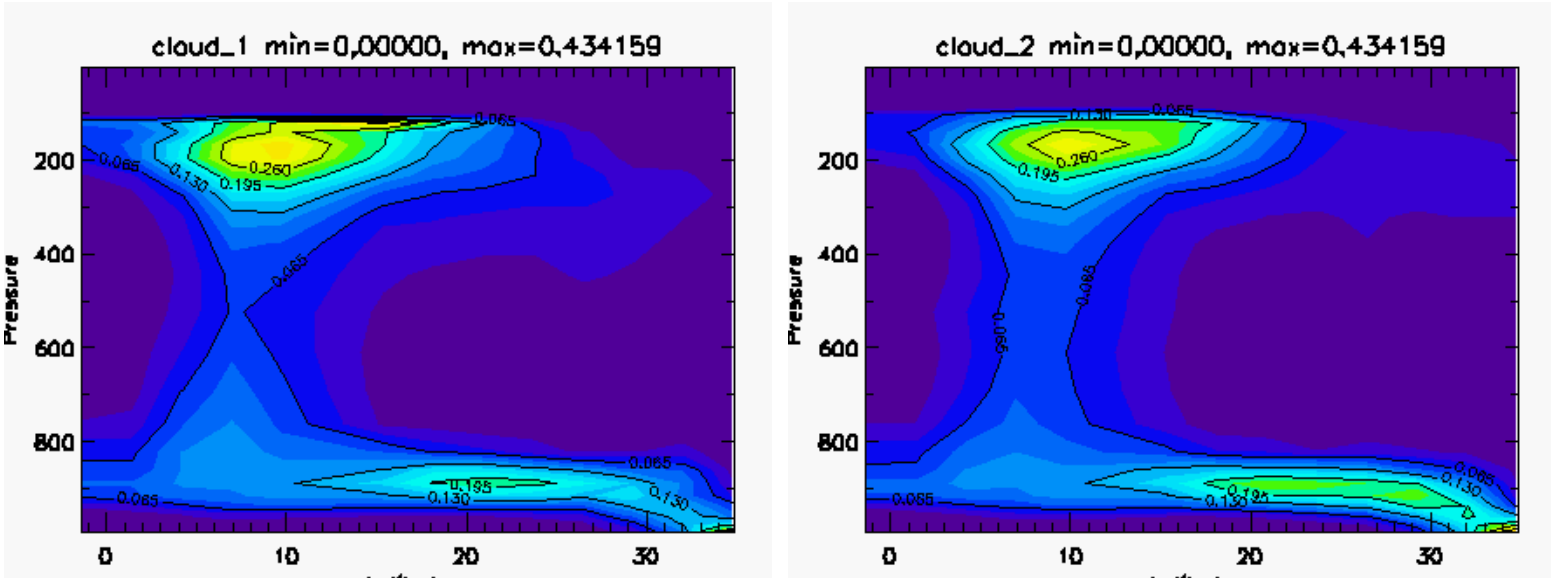
Same but in ECMWF analysis



Horizontal and Vertical q advection.

ame but in ECMWF analysis

CAM-SP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cloud_2 min=0.00000, max=0.434159
Pressure
200
400
600
800
0
10
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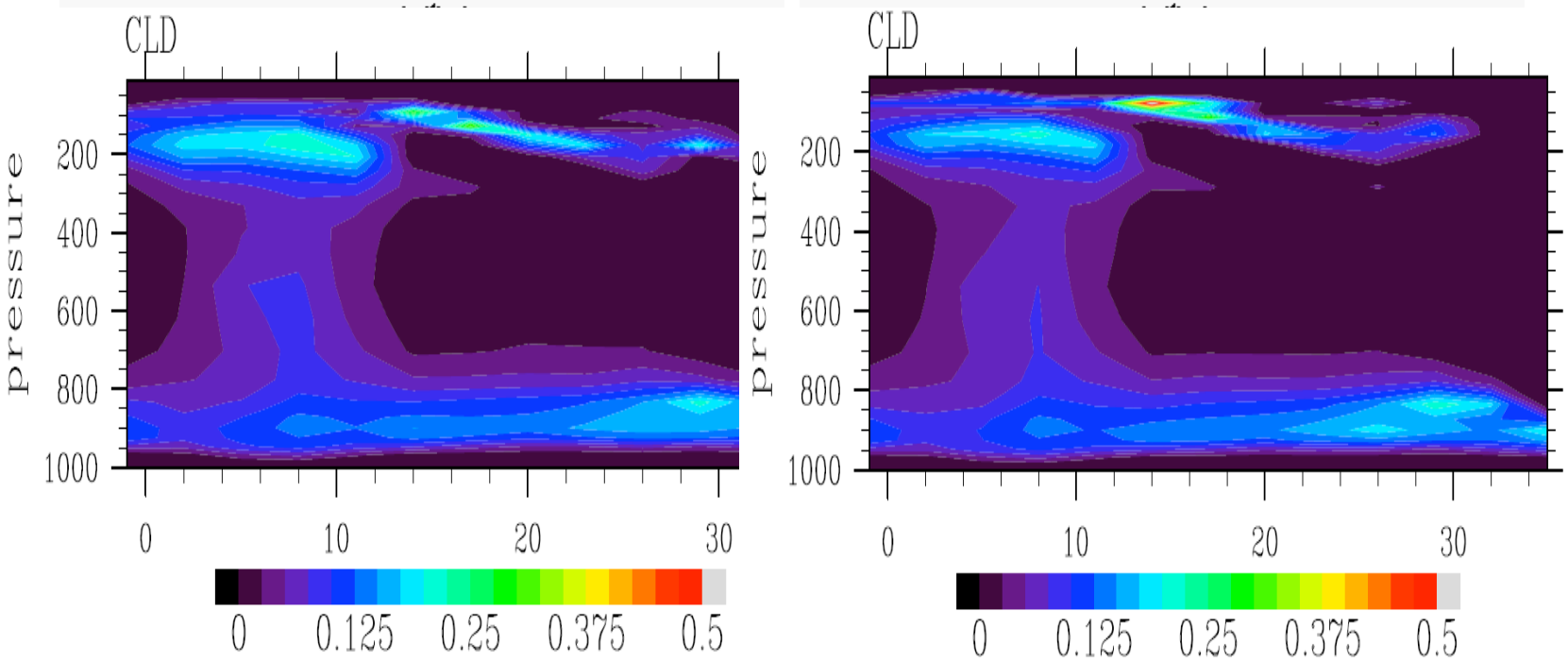
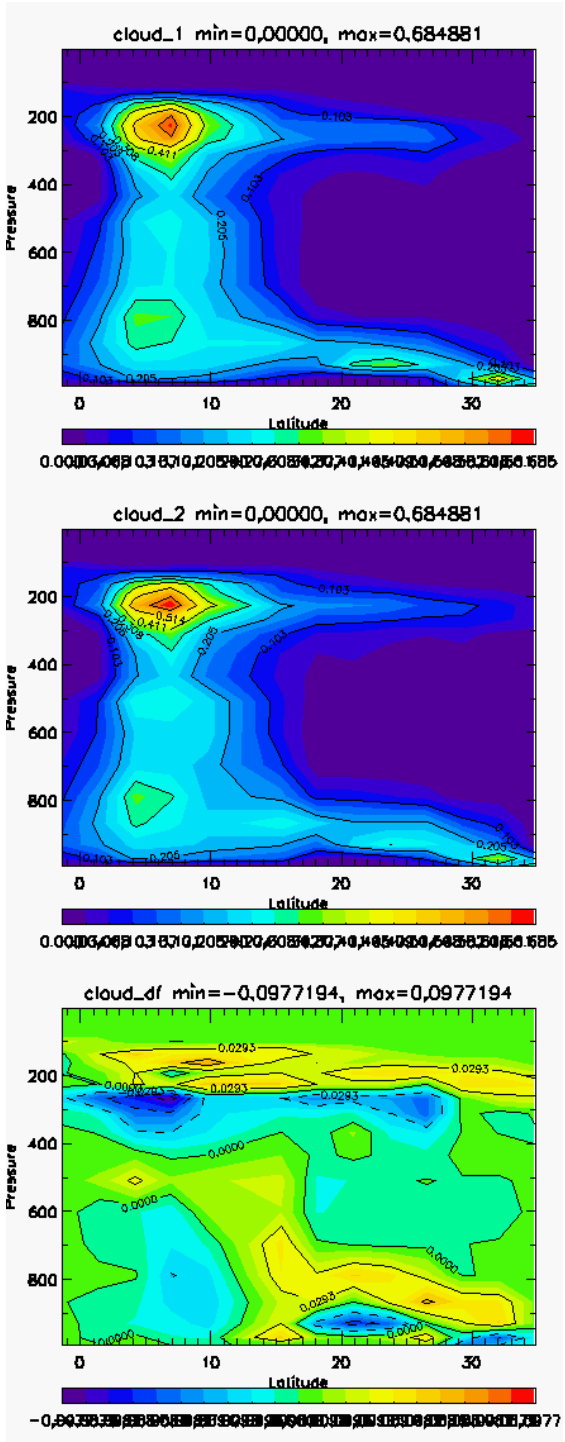
0.065
0.130
0.195
0.260


CLD
CLD
pressure
pressure
200
400
600
800
1000
0
10
20
30
0
0.125
0.25
0.375
0.5

CAM3.5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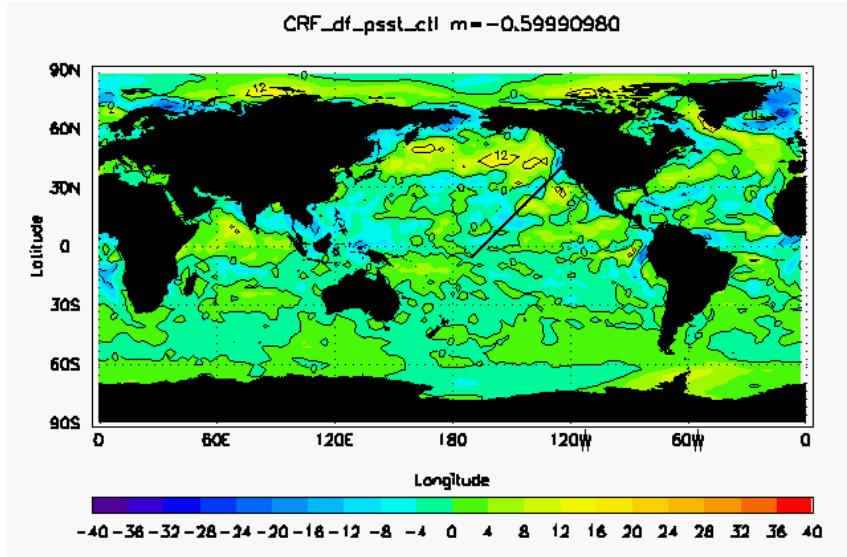
Pressure
Latitude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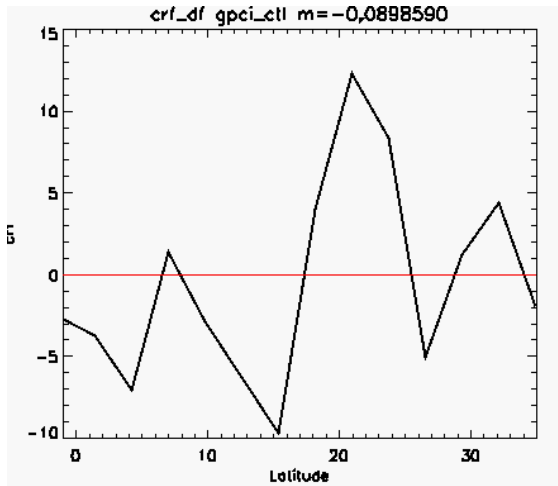
Latitude
Longitude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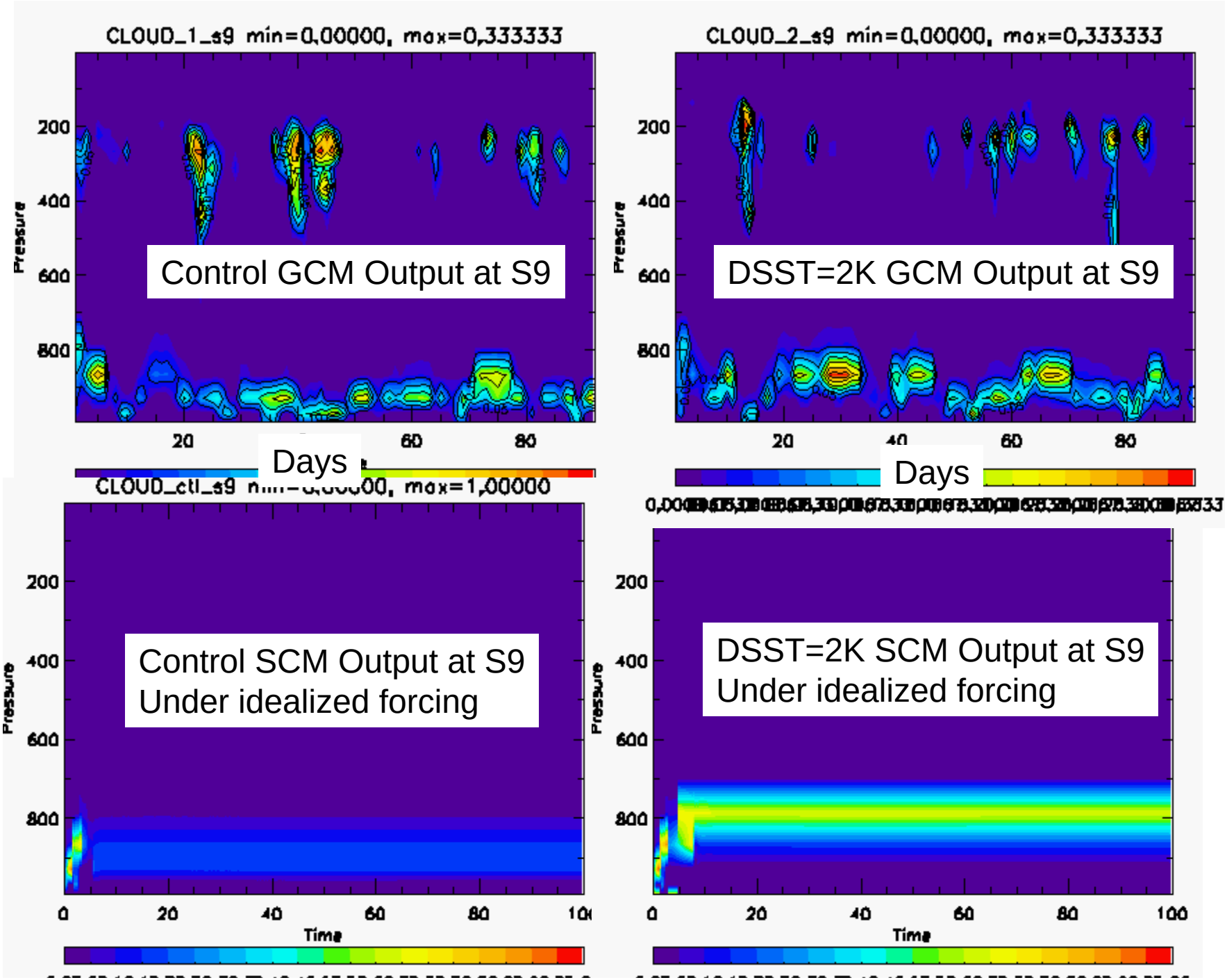
Latitude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Control GCM Output at S9
Pressure
Days
CLOUD_2_s9 min=0.00000, max=0.333333
DSST=2K GCM Output at S9
Pressure
Days
CLOUD_ctl_s9 max=1.00000
Control SCM Output at S9
Under idealized forcing
Pressure
Time
DSST=2K SCM Output at S9
Under idealized forcing
Pressure
Time

Summary

1. Use forcing data for a cross section rather than a single grid to sample cloud feedbacks in a GCM

2. This increases the likelihood that an SCM or CRM captures the cloud feedback processes in the GCMs.

ARM data

Composite ARM data for various forcing regimes to evaluate SCM clouds against ARM measurements.