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Importance of minor treatments in parameterizations in GCMs

for the cloud representations and the cloud feedbacks

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Point of this talk:

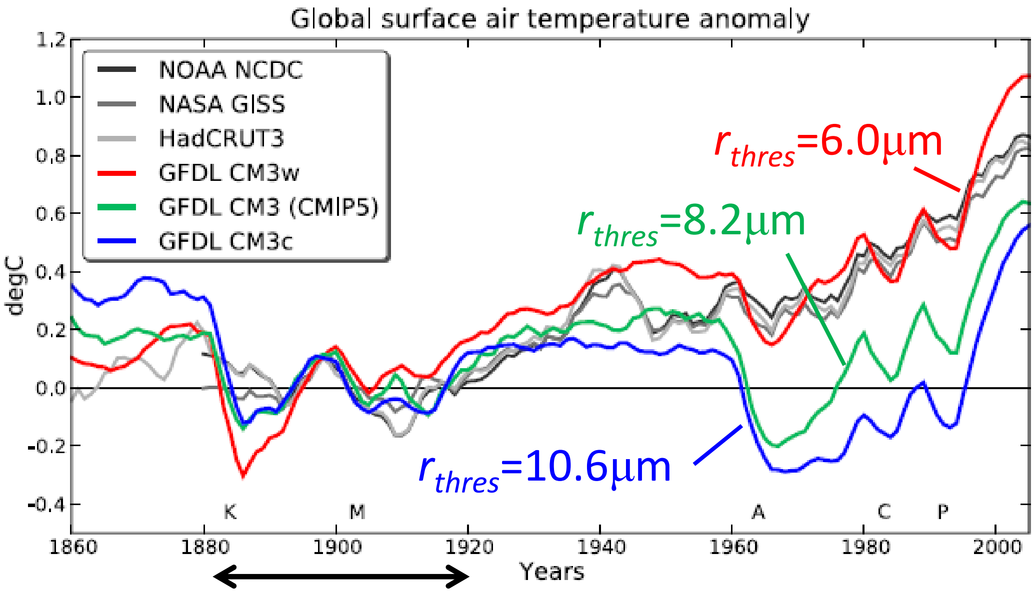
- Can we share the information related to minor treatments in parameterizations in GCMs more?

Cloud droplet radius threshold for autoconversion On CMIP5 historical runs

$$\left(\frac{\partial q_l}{\partial t}\right)_{AU} = -a\frac{0.104gE_{AU}\rho_{air}^{4/3}}{\mu(N_d\rho_l)^{1/3}}\left(\frac{q_l}{a}\right)^{7/3} H\left(\frac{q_l}{a}-q_{crit}\right)$$

Manton & Cotton (1977)

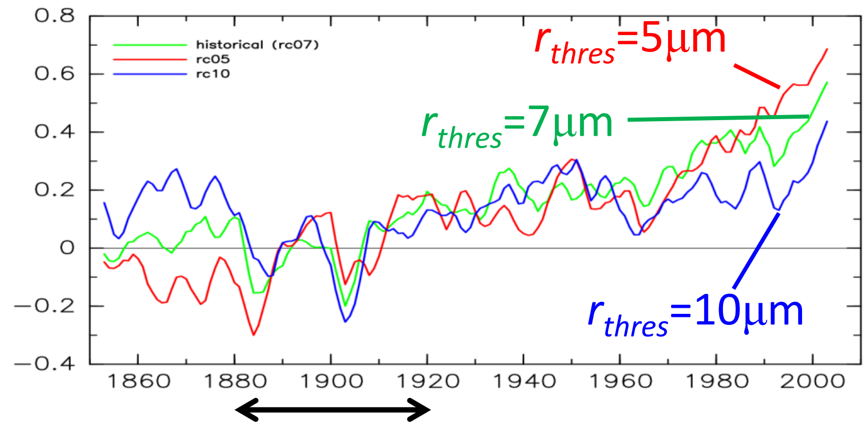
GFDL CM3



Copied from Golaz et al. (2013, GRL)

- 5 ensemble members

MRI CGCM3



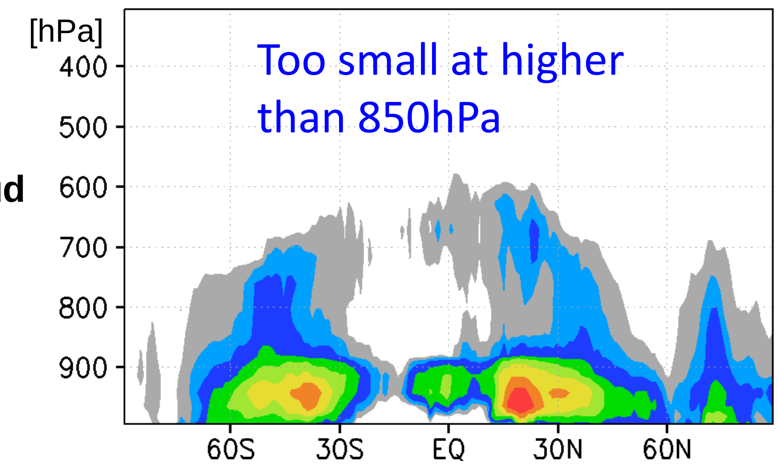
Courtesy of T. Koshiro (MRI)

- 1 member

Lower Limit for Number Concentration of Cloud Droplets

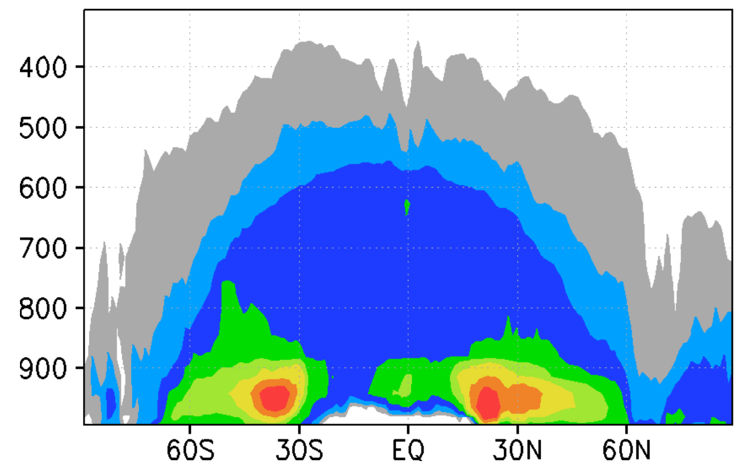
No Lower Limit for in-cloud N_l

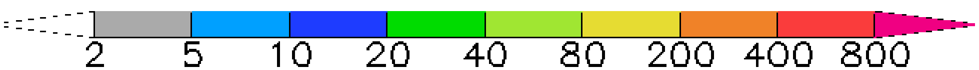
in-cloud N_l



(Similar to the MRI-CGCM3 CMIP5 version)

in-cloud N_l Lower Limit : 20[#/cm^3]





180W-120W Mean

Weighted by cloud fraction

Jan

Typical values： **50** [#/cm^3] (**clean**)
300 [#/cm^3] (**polluted**)

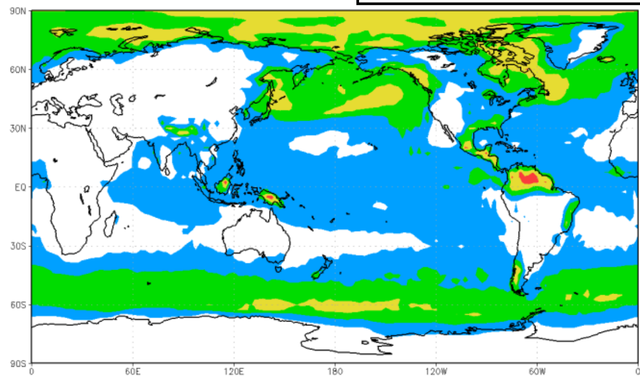
Lohmann et al (2007)： **Lower limit: 40** [#/cm^3]

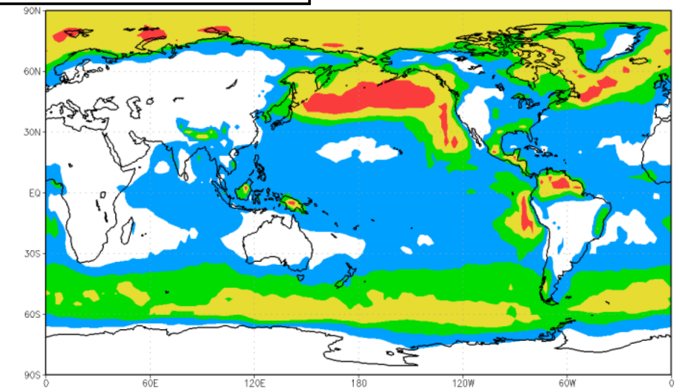
Impact of treatments of vertical diffusivity (at cloud top)

Without Simple Sc scheme

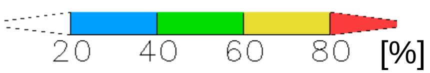
With Simple Sc scheme

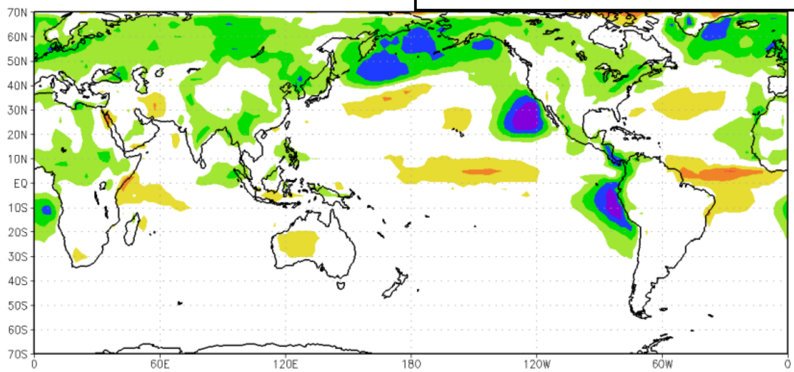
Low Cloud Fraction

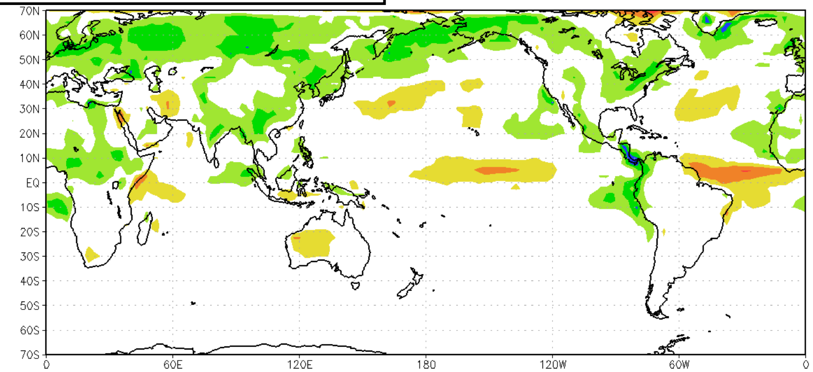


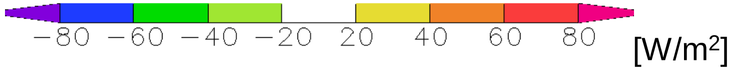


Bias of TOA upward shortwave flux









July

3 years average (1987-1989)

Model Physics (in the JMA-GSM)

Clouds: PDF scheme by Smith (1990)

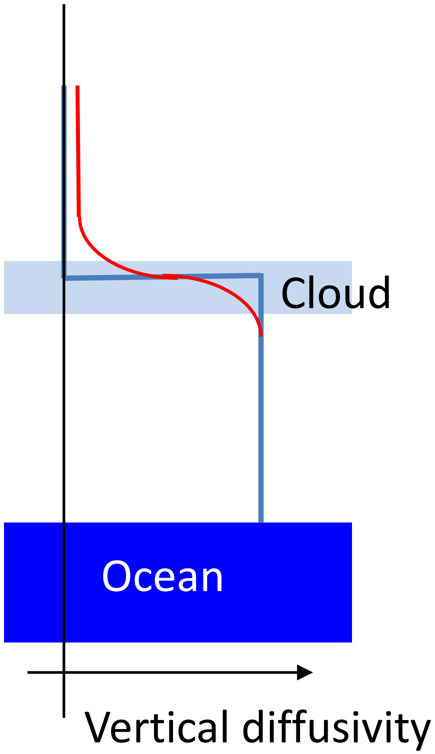
Convection: Arakawa-Schubert scheme (Pan and Randall 1998)

No specific treatment for shallow convections

Turbulence: Mellor & Yamada (1974, 1982) Level 2

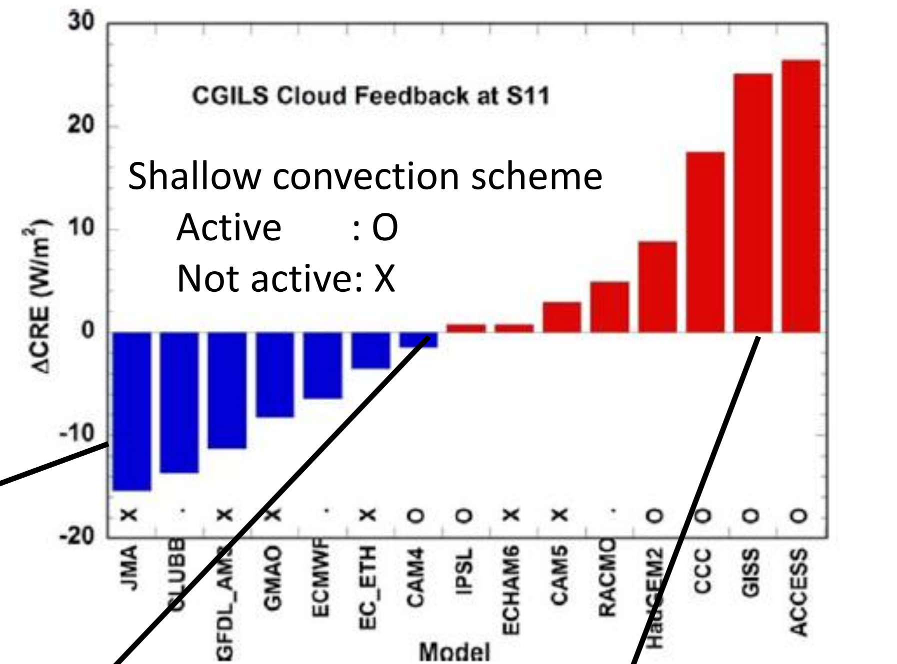
No Non-local effect
No cloud top entrainment

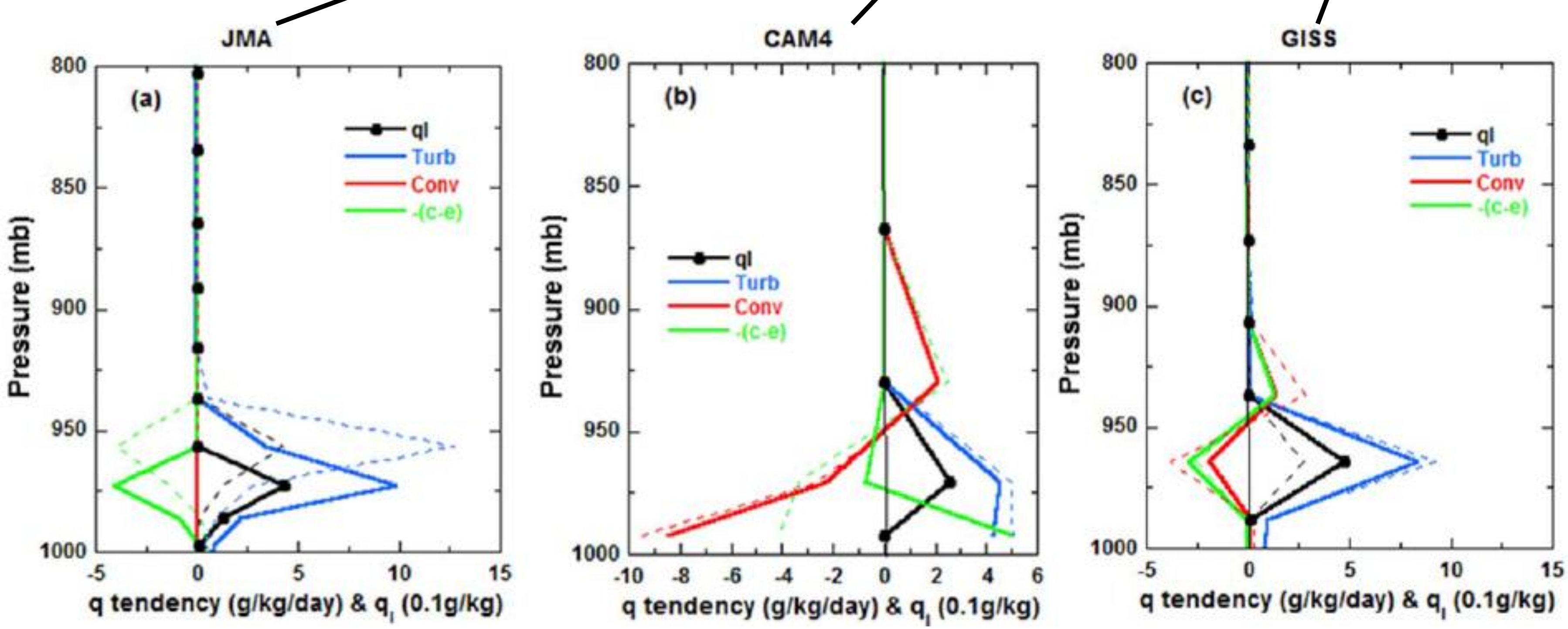
- Vertical smoothing of vertical diffusivity
- Background vertical diffusivity



Simple Stratocumulus Scheme: Kawai (2013, WGNE Blue Book)
These treatments are just turned off when the stability is large.

Cloud Feedback in CGILS
M. Zhang et al. (2013, JAMES)





Does this depend on difference of types of (shallow) convection scheme?

For the JMA-GSM,
the reason could be simpler in this case.

In the JMA Arakawa-Schubert scheme, cloud base is fixed at 900hPa.

A lot of Important Minor Treatments...

Mentioned:

- Threshold cloud droplet radius for autoconversion
- Lower limit of in-cloud N_l (number concentration of cloud droplet)
- Lower limit of vertical diffusivity (& minor treatment of vertical diffusivity)
- Fixed cloud base height in a convection scheme

Others:

- Threshold RH for cloud formation
- Lower limit of in-cloud N_i (number concentration of cloud ice)
- Lower limit of sub-grid scale *w* for CCN activation
- Detailed treatment in cloud ice fall scheme
- .....

- In convection schemes, really a lot...

We also know that a lot of parameters in physics dramatically influences the model performance.

Points of this talk:

- Can we share the information related to minor treatments (and parameters) in parameterizations in GCMs more?

  Can we encourage and promote publications of detailed model documents for GCMs (ideally, like ECMWF IFS document)?

- Can we share more the importance of such minor treatments with non-modelers in the climate change community?

In addition,

Can we have opportunities of more honestly sharing the information of

* effects of minor treatments (including lower limits)
* bothersome parameter tuning
* reluctantly chosen parameters
* inconvenient truth
* dilemmas
* compromises

in GCM development?

⇨
- They will give us more hints for solving problems common among GCMs.
- They can be a shorter route to improve model performance.

For example...,

Workshop not for presenting excellent results but for sharing bothers

Backup Slides

CTE Sc scheme (Kawai 2013)

(1). Lower troposphere is stable (considering the effect of CTEI).

$$EIS_{CTE} = EIS - (1-k)\frac{L}{c_p}(q_{surf} - q_{700})C_{\Delta q} > 0.$$

and two minor conditions $EIS > 3[K]$ $RH_{surf} > 60[\%]$

(2). Layer near surface is not stable. (To guarantee the existence of a mixed layer.)

↓

Cloud top mixing is completely suppressed.

- Stop vertical smoothing of vertical diffusivity.
- Background vertical diffusivity is almost zero.

→ The intrusion of dry air from the cloud top is prevented.

→ BL is moister, and clouds are formed and not destroyed.