# Impact of a shallow convection parameterization to the cloud feedback in MIROC5

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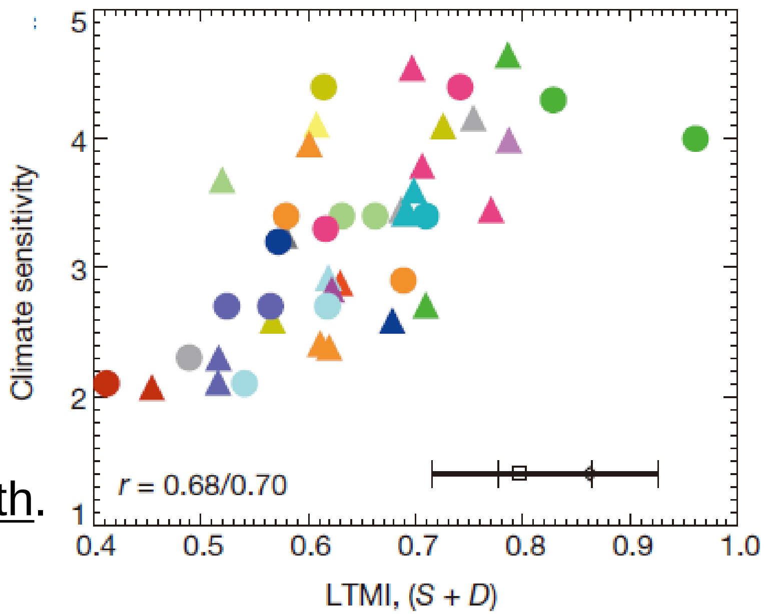
# Lower tropospheric mixing and cloud feedback

- CS related to strength of conv. mixing in tropical lower troposphere.




Sherwood et al. (2014)

- Mechanism:

  1) mixing dries low-cloud layer at a rate that increases with warming

  2) rate of increase depends on <u>init. mixing strength</u>.

- **If <u>init. mixing strength</u> increased in one model, does it lead to more positive cloud feedback, due to low cloud decrease ?**

- Single Column Model results consistent with the idea (Zhang et al. 2013)

# Experiments

- MIROC5-AGCM-T42
- AMIP-type (pre-industrial control, climatological AMIP SST & sea ice)

| | Control | SST+4K |
|---|---|---|
| Shallow Conv OFF | *Cloud feedback with "OFF"* ⟷ | |
| Shallow Conv ON + tuning | *Cloud feedback with "ON"* ⟷ | |

- Cloud feedback evaluated with CRE and Cloud Radiative Kernel, following Zelinka et al. (2012)
- 30 years annual mean discussed (unless stated otherwise)

# Issues to be discussed

Q1. Is cloud feedback more positive when Shallow Convection is turned on ?

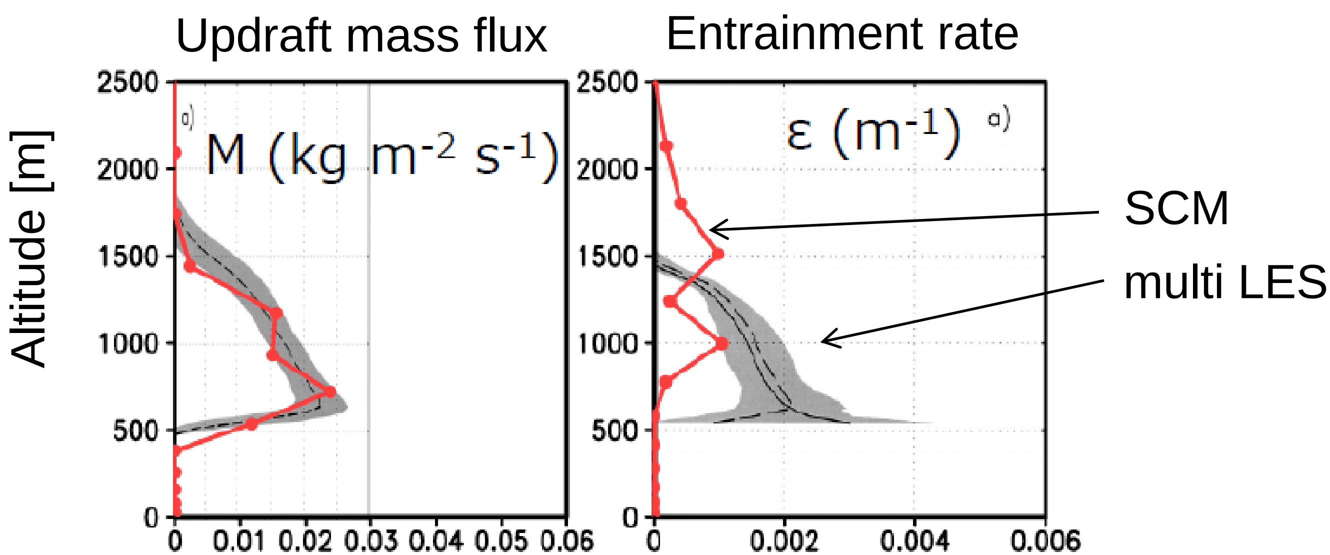
Q2. If so, what is the mechanism ?

# Shallow convection

- A parameterization based on Park and Bretherton (2009) implemented to MIROC5

$$\psi = \{\theta_l, q_t, u, v\}, \qquad \rho\overline{w'\psi'} \approx M_u(z) \times \left\{\psi_u(z) - \overline{\psi(z)}\right\}$$

- Single column test for BOMEX case
- Results being compared with multi-LES output by Siebesma et al. (2003)

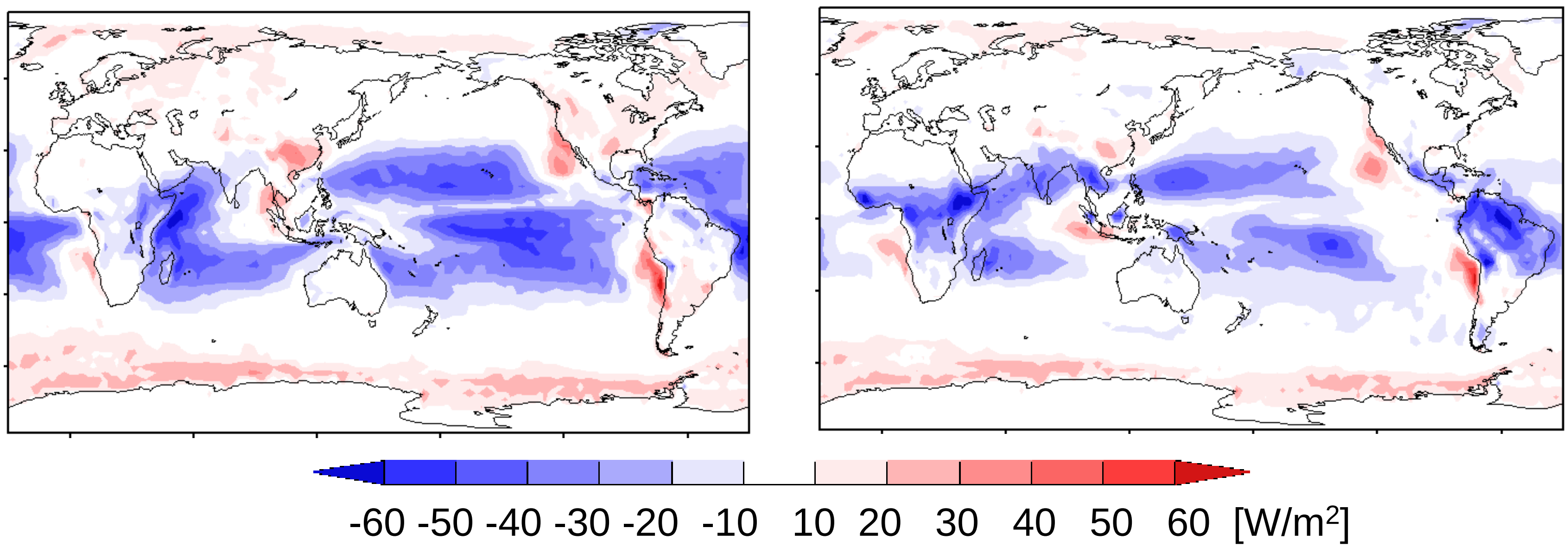


# Shallow convection

Bias of SCRE (MIROC5-T42-AGCM minus CERES-EBAF, annual mean)

Shallow convection OFF

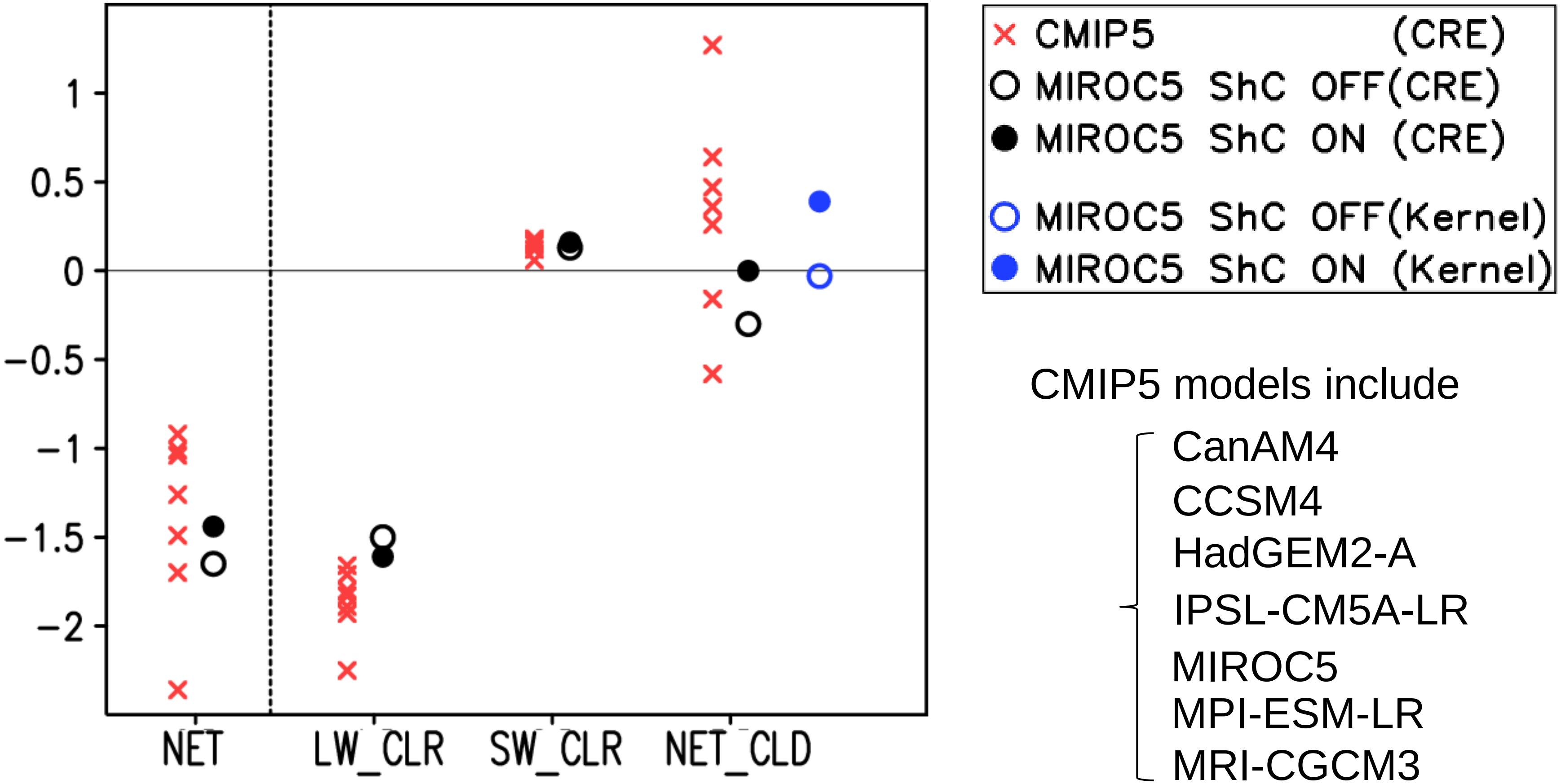
Shallow convection ON (after tuning)




- SCRE bias alleviated over ocean, but worsened over land
- Shallow convection causes decrease in low cloud

# Cloud Feedback: Shallow convection OFF vs ON

Feedback parameter (30S-30N) [W/m$^2$/K]




CMIP5 models include

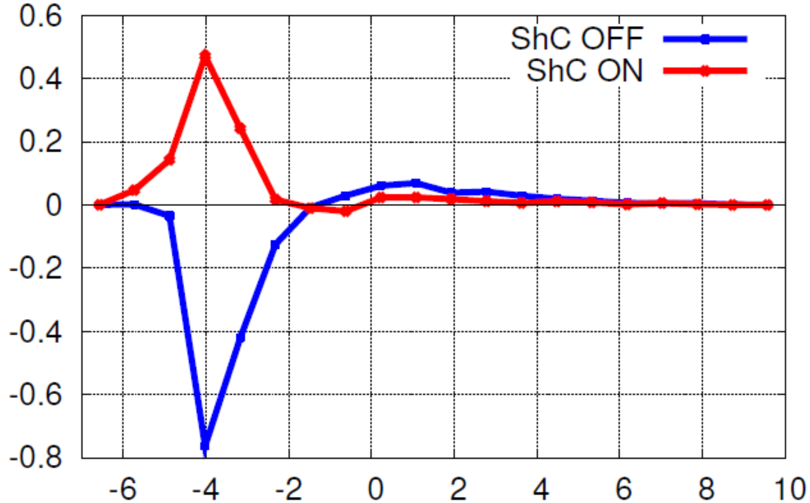
- CanAM4
- CCSM4
- HadGEM2-A
- IPSL-CM5A-LR
- MIROC5
- MPI-ESM-LR
- MRI-CGCM3

Climate feedback more positive when ShC is turned on, due to net cloud component.

# Cloud Feedback: Shallow convection OFF vs ON

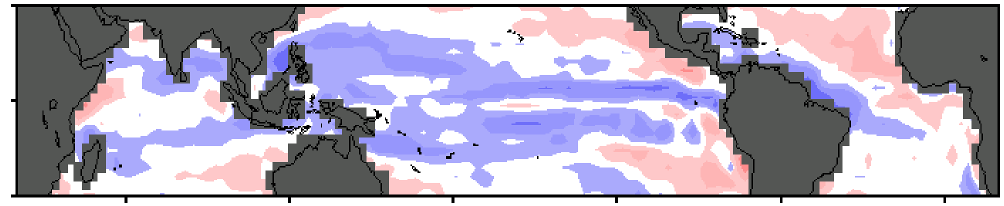
Net Cloud Feedback to SST+4K, 30S-30N ocean ( in W/m$^2$)

Composite with EIS, area-weighted

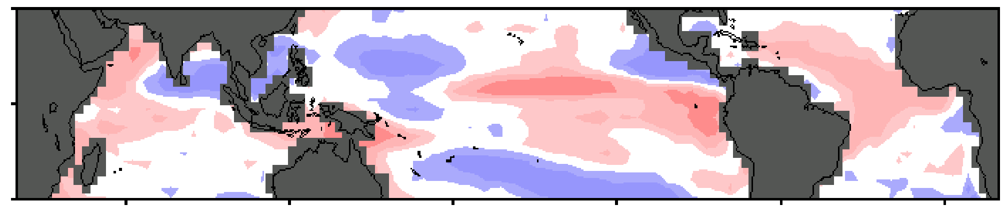



Estimated Inversion Strength (EIS) [K]

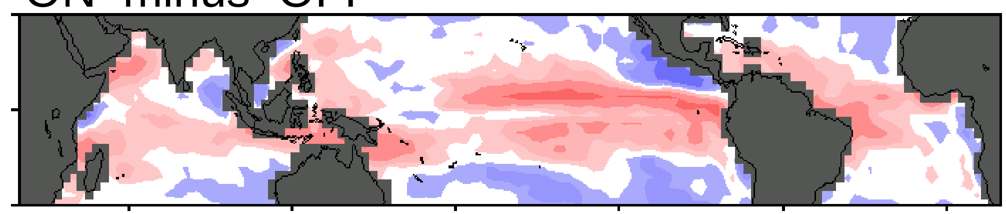
Shallow Convection OFF

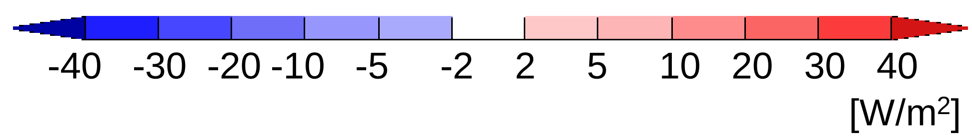


Shallow Convection ON



ON minus OFF



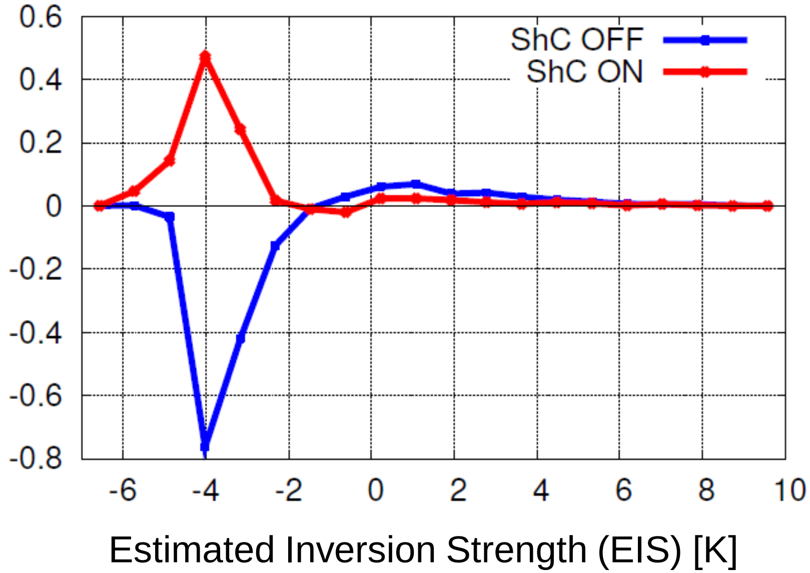


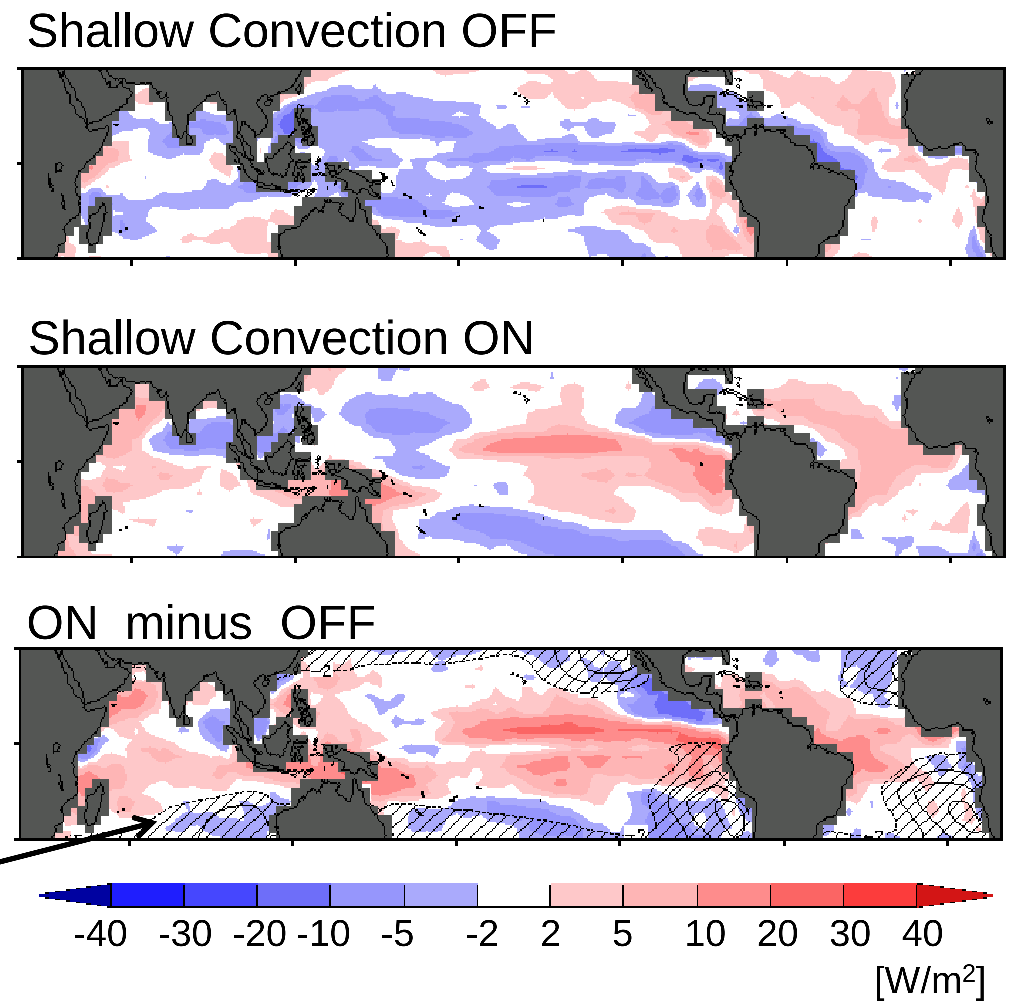

Net cloud feedback changes from negative to positive in unstable regimes.

# Cloud Feedback: Shallow convection OFF vs ON

Net Cloud Feedback to SST+4K, 30S-30N ocean ( in W/m$^2$)

Composite with EIS, area-weighted

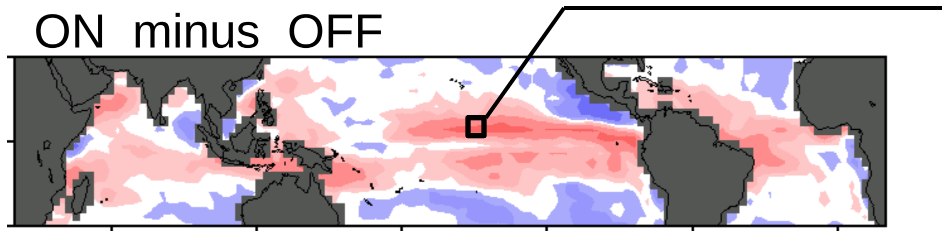



Hatched where EIS > -2 K

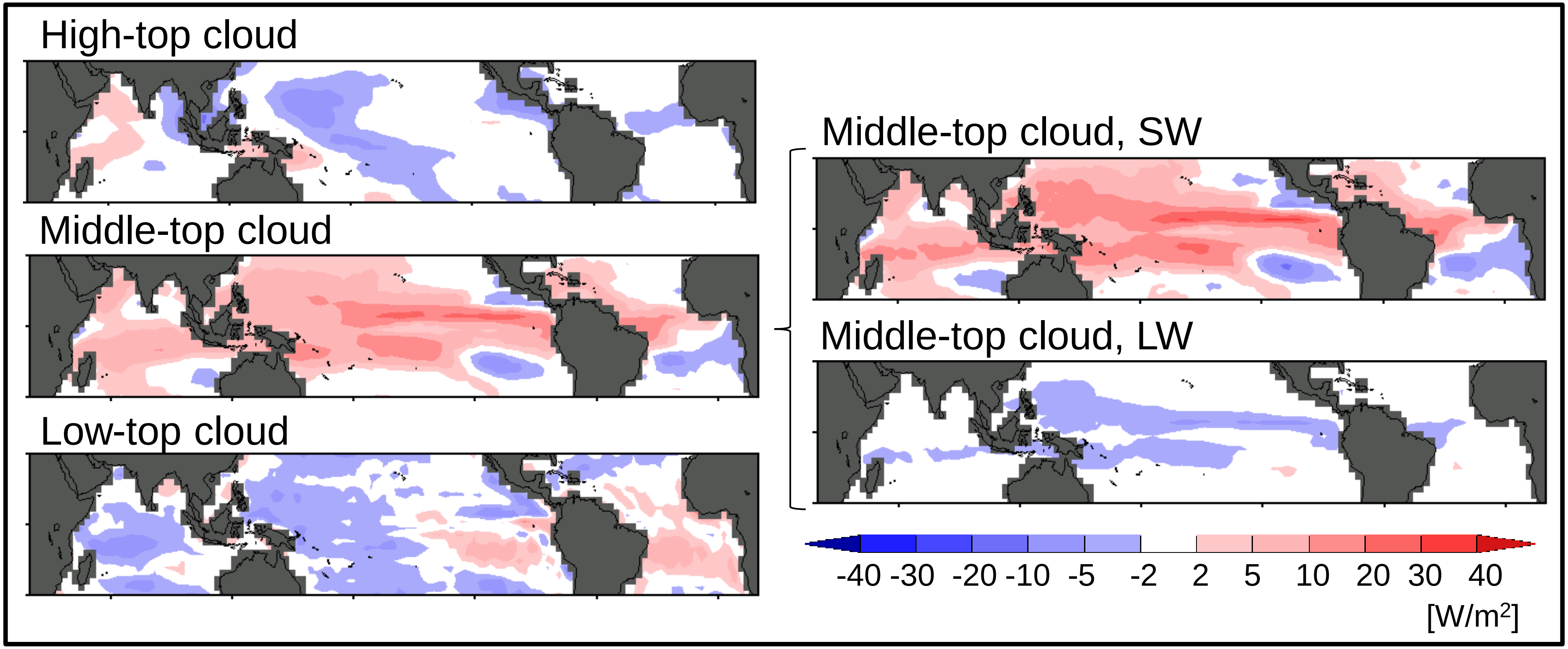
Net cloud feedback changes from negative to positive in unstable regimes.
, but to opposite direction in stable regimes.

# Cloud Feedback: Shallow convection OFF vs ON




(208E, 4.2N) examined in next slide …

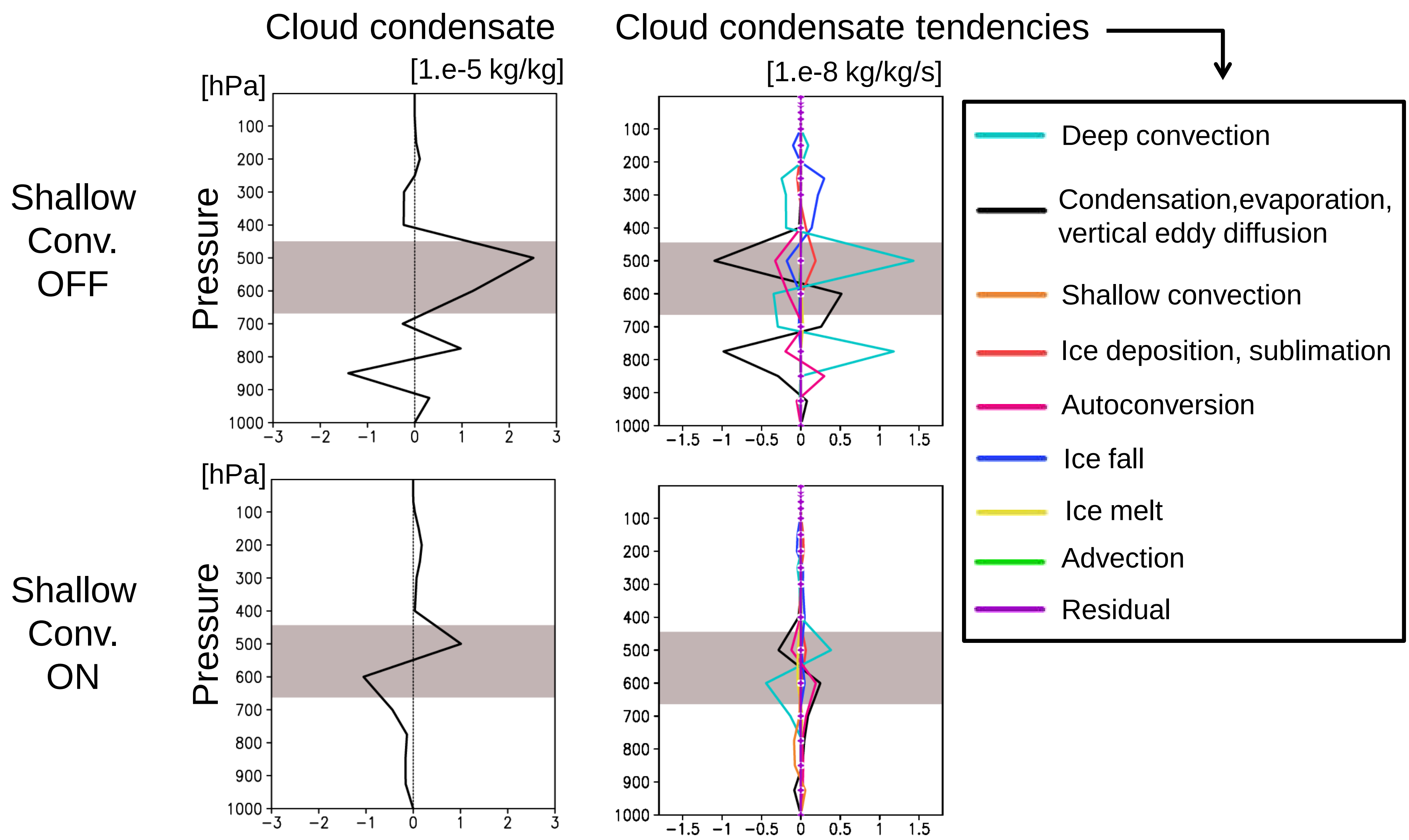
**Contributions from different categories**




Positive changes come mostly from middle-top cloud, Shortwave component.

# Response to SST+4K at (208E, 4.2N)

10 year average




Increase in middle-cloud suppressed when ShC is turned on, through Deep convection.

# Discussion

Q1. Is cloud feedback more positive when Shallow Convection is turned on ?

→ Yes.

Q2. If so, what is the mechanism ?

→ Not consistent with the one suggested by Sherwood et al. (2014).

middle top cloud
deep convection and detrained anvil cloud

Q3. What can we learn from the results ?

→ Model error ? Experiment not appropriate ?

Plausible physics in nature (which requires further testing) ?

Q4. What to do next ?

→ Check robustness (different tuning, different GCMs)

Further understanding (ShC → ?? CAPE? → Deep convection)

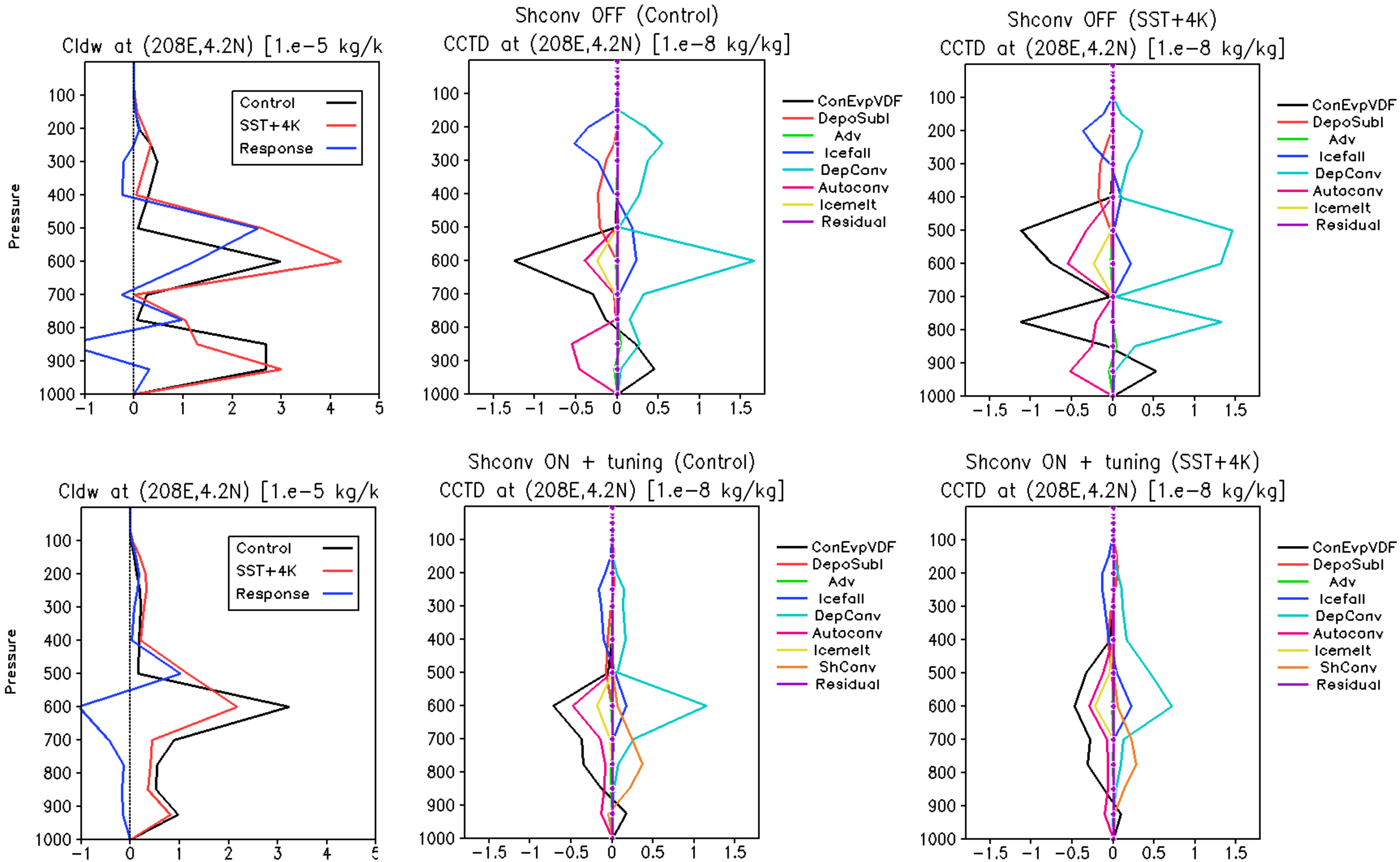
Look for observational constraint

# Summary

- We studied impact of a shallow convection parameterization on cloud feedback with AMIP-type experiments using MIROC5-AGCM.

- Implementing a shallow convection scheme and tuning resulted in more positive cloud feedback over low latitude oceans, by suppressing increase in middle cloud through deep convection.

- Lower tropospheric mixing may be related not only to low cloud feedback, but also to middle cloud feedback.


Cldw at (208E,4.2N) [1.e−5 kg/k
Control
SST+4K
Response
Pressure
Shconv OFF (Control)
CCTD at (208E,4.2N) [1.e−8 kg/kg]
ConEvpVDF
DepoSubl
Adv
Icefall
DepConv
Autoconv
Icemelt
Residual
Shconv OFF (SST+4K)
CCTD at (208E,4.2N) [1.e−8 kg/kg]
Cldw at (208E,4.2N) [1.e−5 kg/k
Shconv ON + tuning (Control)
CCTD at (208E,4.2N) [1.e−8 kg/kg]
ShConv
Shconv ON + tuning (SST+4K)
CCTD at (208E,4.2N) [1.e−8 kg/kg]