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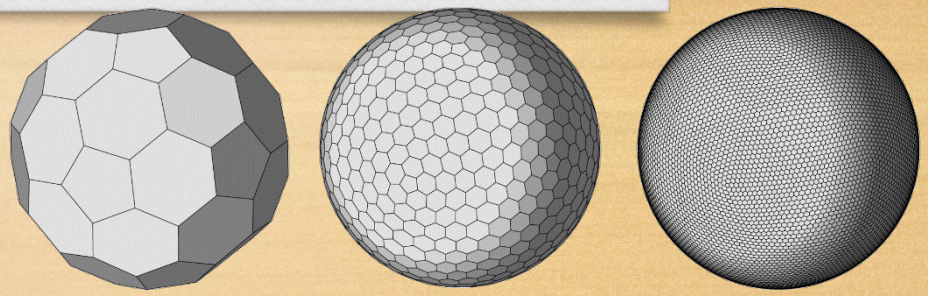
Cloud feedback parameters derived from NICAM AMIP-like simulations

C. Kodama[1], Y. Yamada[1], A. T. Noda[1], Y.-W. Chen[1], Y. Tsushima[2], and M. Satoh[3,1]

1: JAMSTEC 2: Met Office Hadley Centre 3:U Tokyo

NICAM: Non-hydrostatic icosahedral atmosphere model



Backgrounds

- NICAM vs. GCMs: different response of high cloud
  - Collins and Satoh [2009]: increase in cirrus
  - Tsushima et al. [2014]: using different parameters/schemes
    - Cirrus amount bias correlates with the LW cloud feedback.
    - Even if a good configuration for cirrus amount is used, NICAM still shows a greater LW cloud feedback.
  - <u>These were based on the seasonal-scale experiments.</u>
- My talk in CFMIP 2013:
  - 4-yr NICAM data: basically within the CMIP3/5 uncertainties

This study: cloud feedbacks using 20-yr NICAM data

NICAM AMIP-like simulations

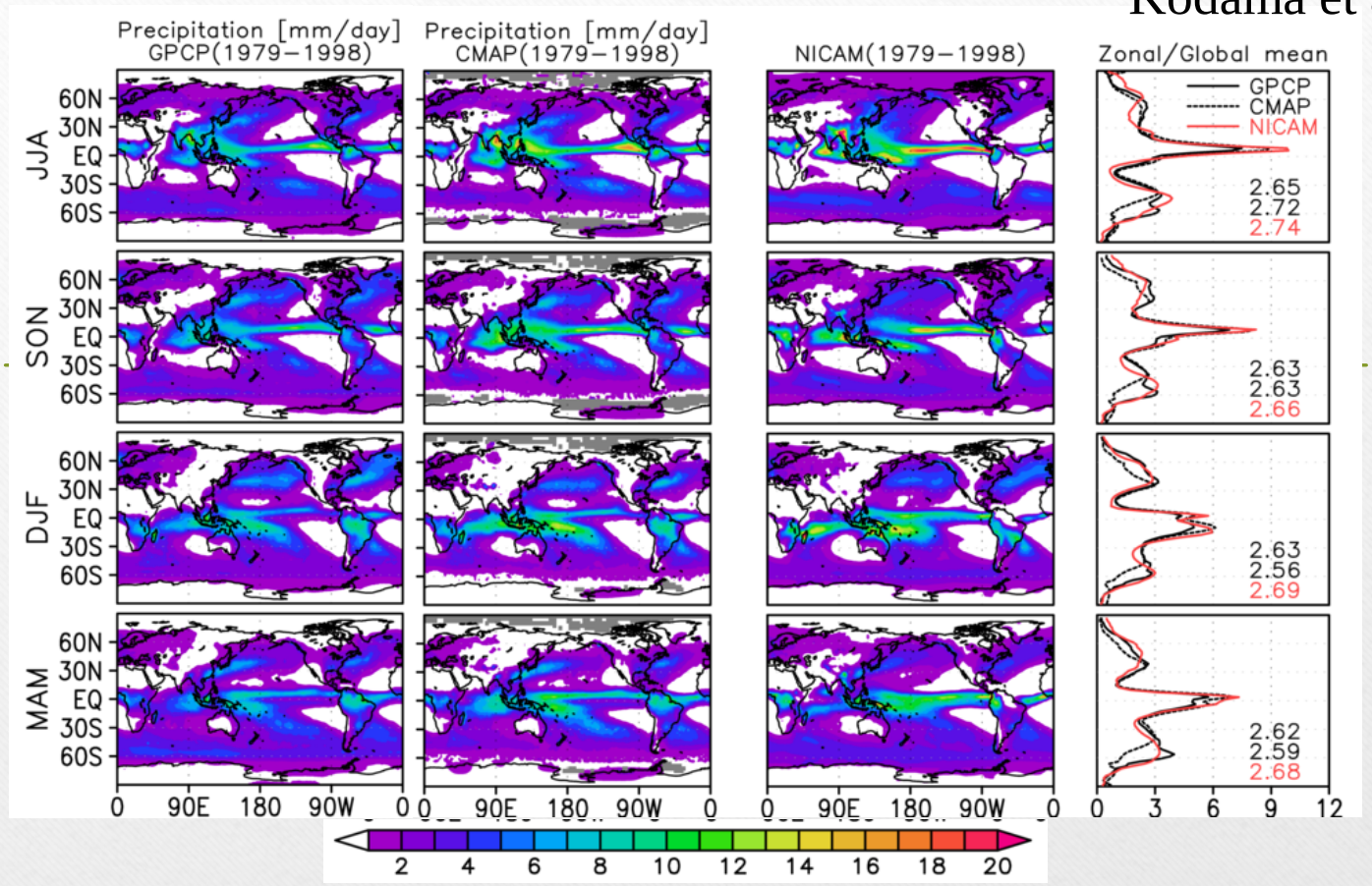
Kodama et al., in prep.

- 14km horizontal mesh and 38 vertical levels up to 40km.
- 1-moment 6-category bulk cloud microphysics (Tomita 2007).
  - cloud parameterization is not used.
- slab ocean model with SST nudging and fixed sea ice.

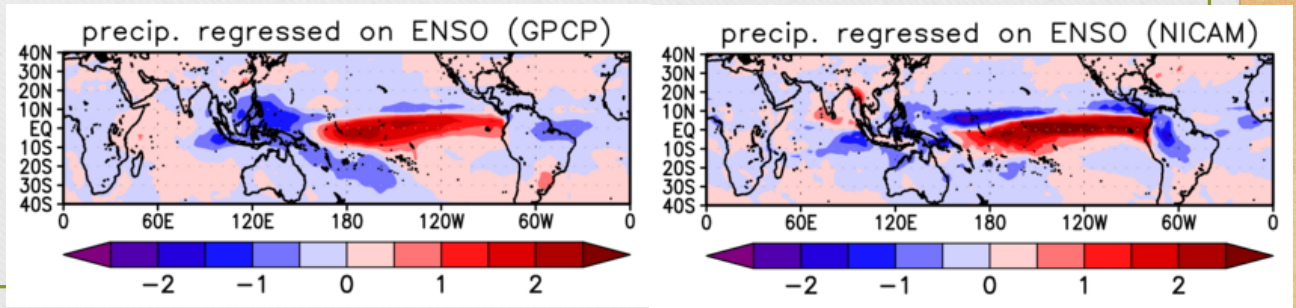
- CNTL run: 1979-2009
  - monthly mean AMIP2 SST/SSI.
- FUTURE run: 2075-2105 (A1B scenario)
  - CMIP3 model ensemble dSST = SST(2075-2099) – SST(1979-2003) including trend is added to AMIP2 SST. For sea ice, areal change is considered following Mizuta et al. [2008].

20-yr Precipitation [mm/day]: mean state and variability

Kodama et al., in prep.



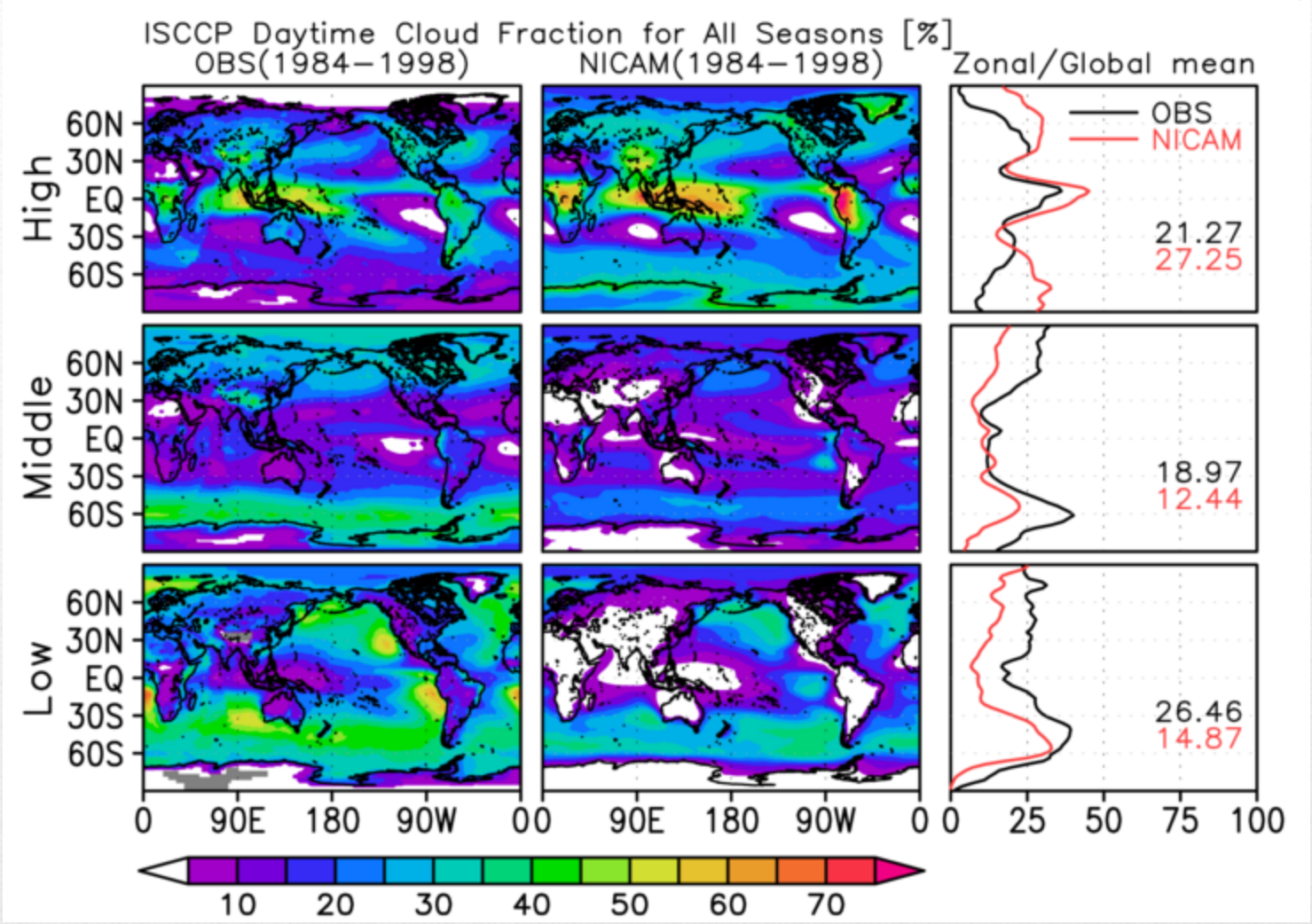
ENSO index = +1 anomaly ->



ISCCP cloud amount [%]

15-year mean

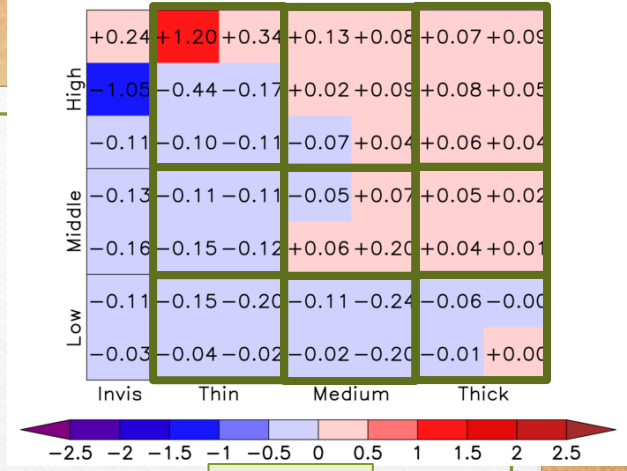
Kodama et al., in prep.



Note: Some of the cloud biases will be reduced by introducing double-moment cloud microphysics scheme (tomorrow's poster by T. Seiki)

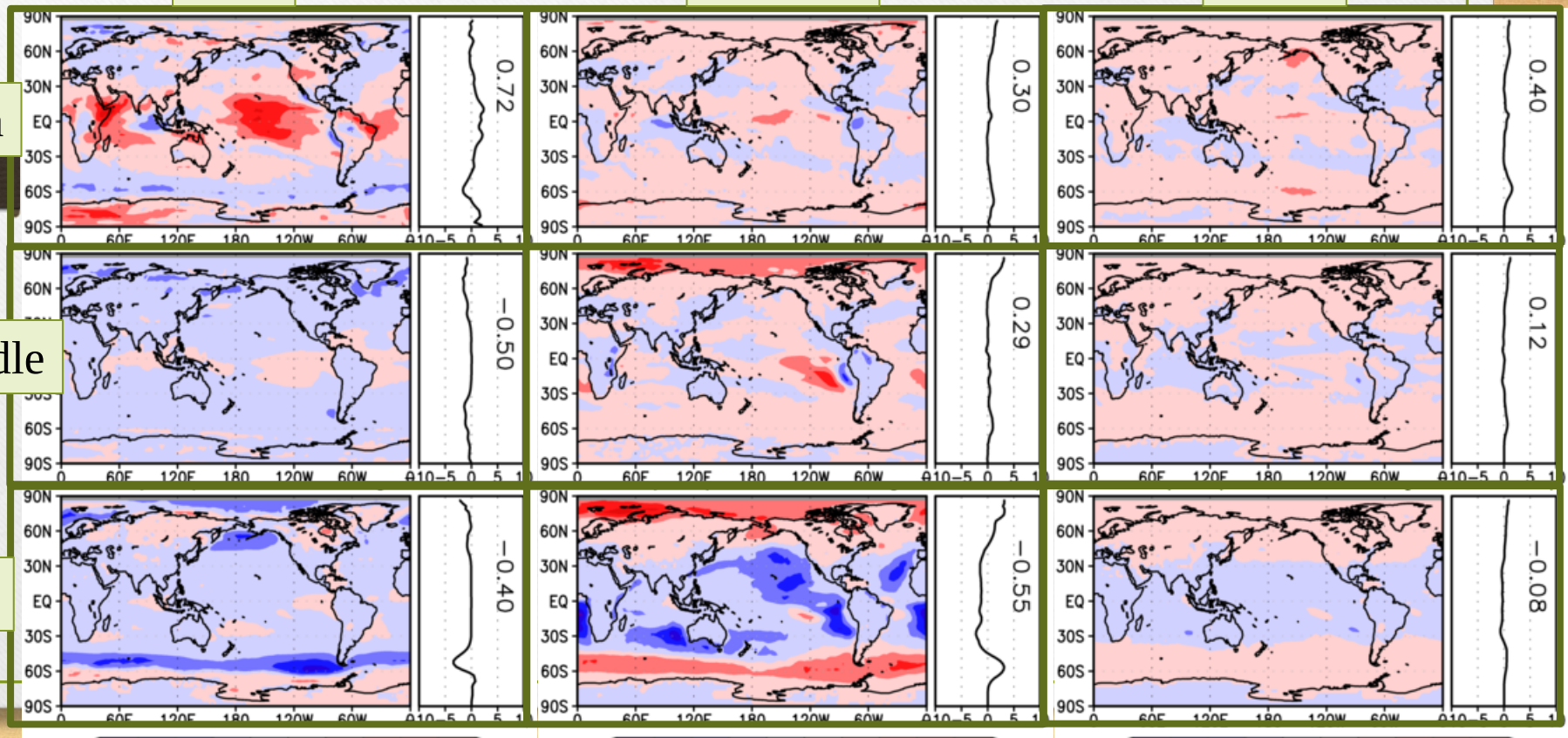
ISCCP cloud amount change [%]

20-year mean



Thin | Medium | Thick

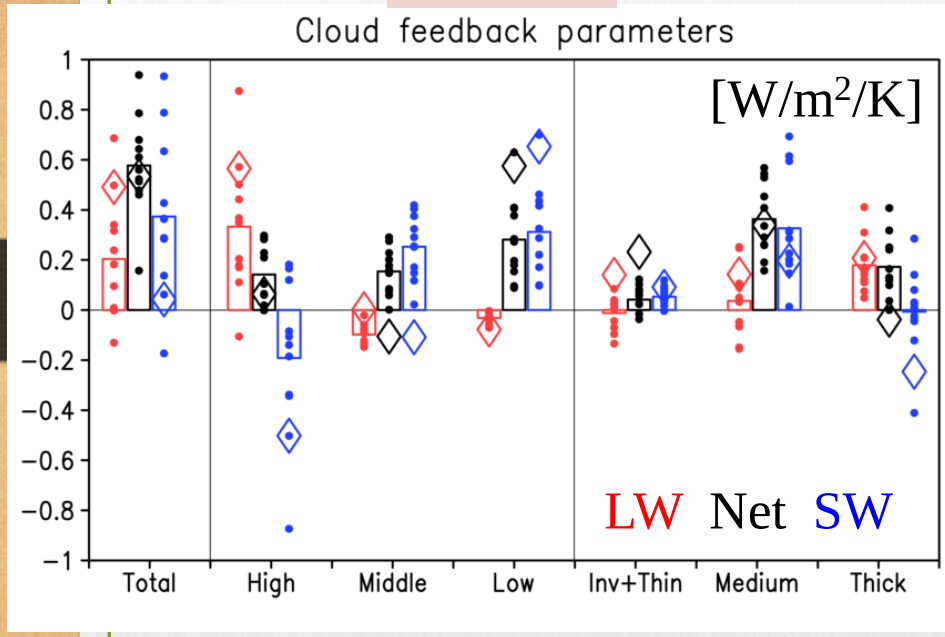
High | Middle | Low



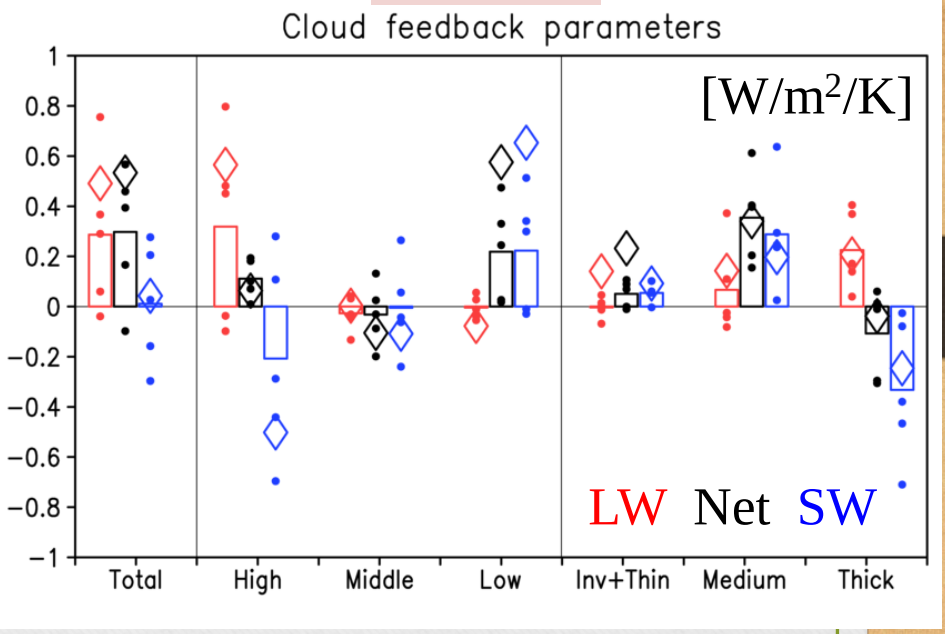
Cloud feedbacks [W/m^2/K]

using cloud radiative kernel provided by Mark Zelinka.

CMIP3



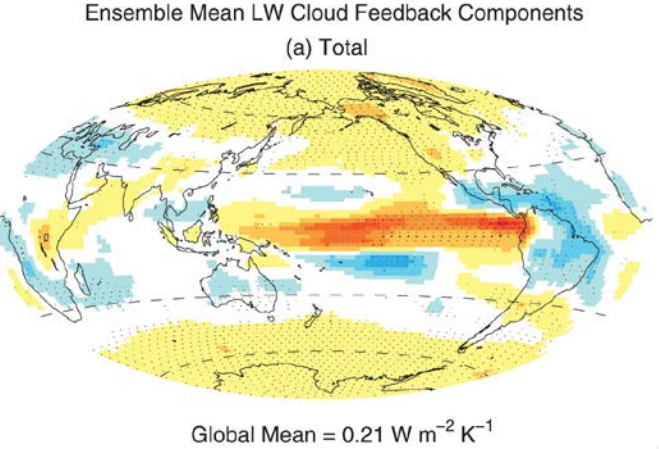
CMIP5

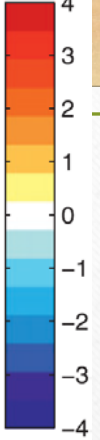


▪ : CMIP3/5 each model ☐: CMIP3/5 ens. means ◇: NICAM-AMIP

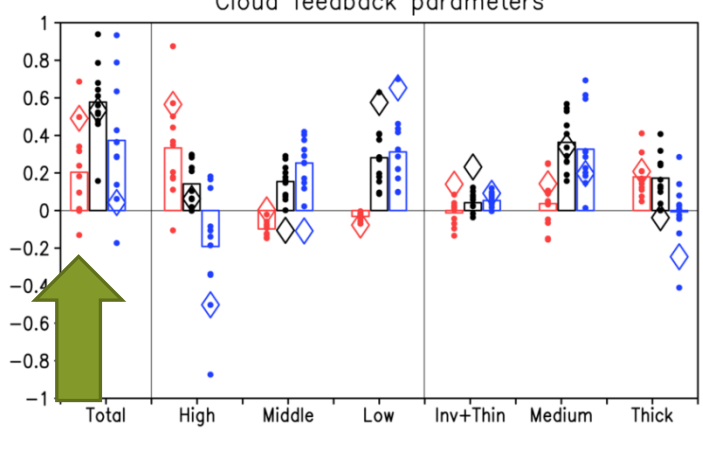
CMIP3/5 data courtesy of Mark Zelinka (same as Zelinka et al. 2012, 2013)

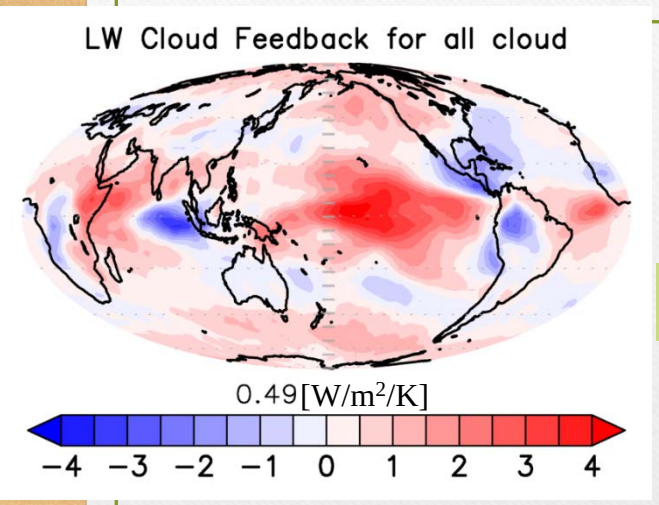
Note: CMIP3/5 models are coupled model, whereas NICAM is atmospheric model with slab ocean.



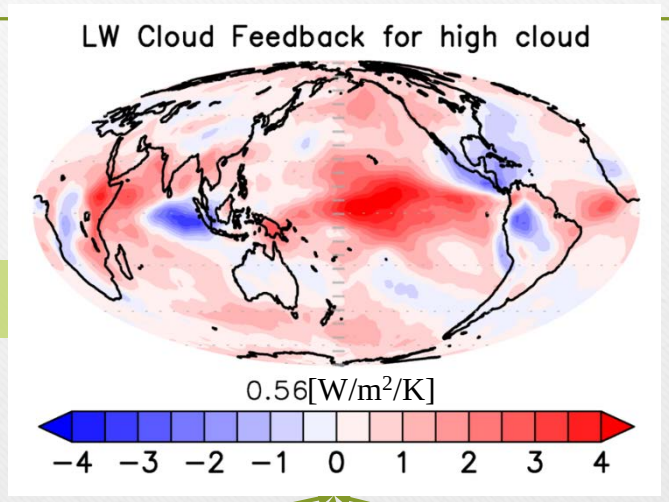


CMIP3 ens. mean
Zelinka et al. [2012]





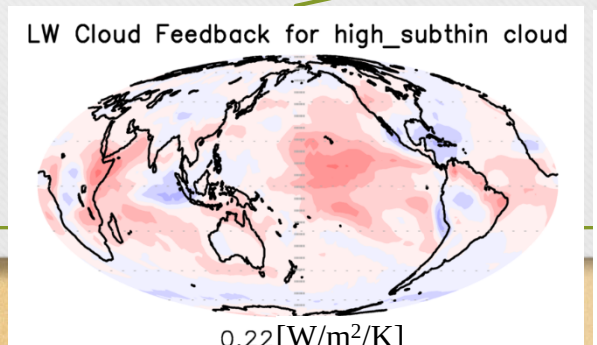
High

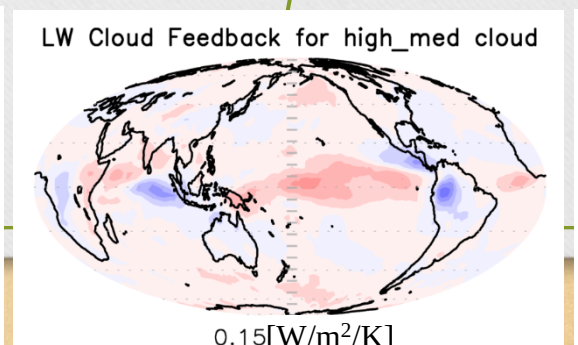


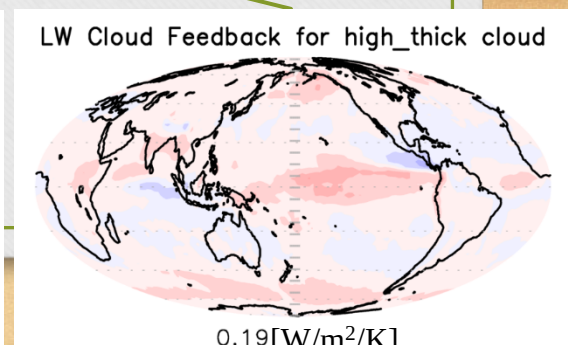
Inv+Thin

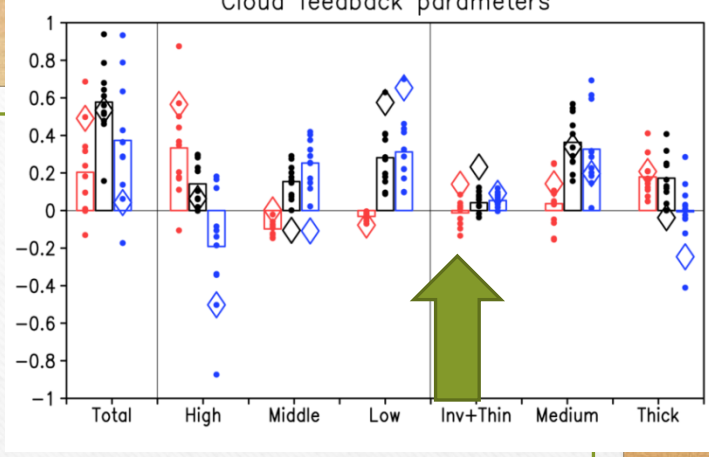
Medium

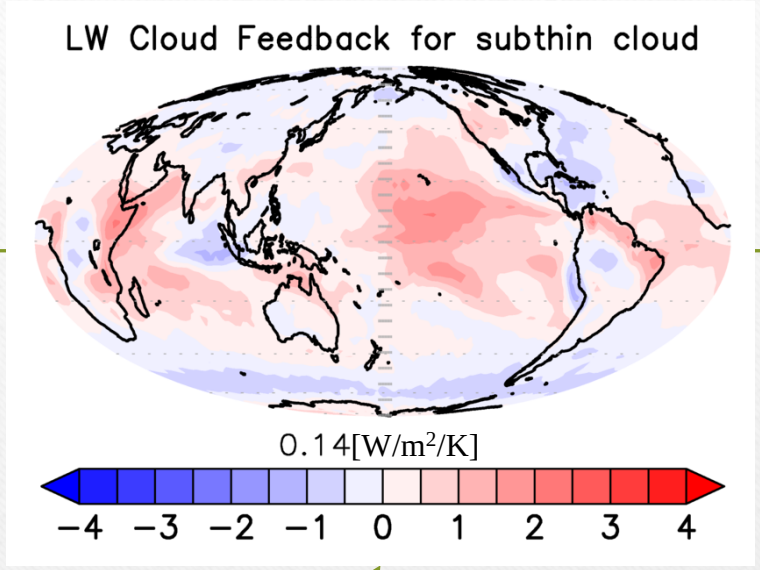
Thick



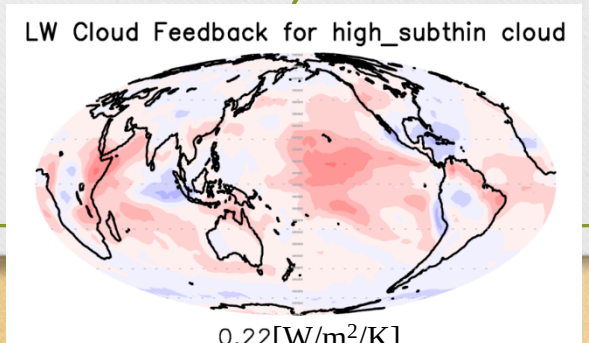


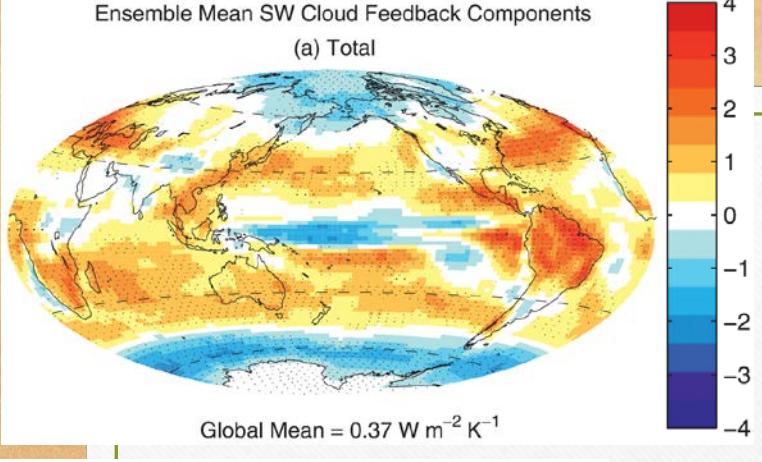



Cloud feedback parameters
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
Total
High
Middle
Low
Inv+Thin
Medium
Thick

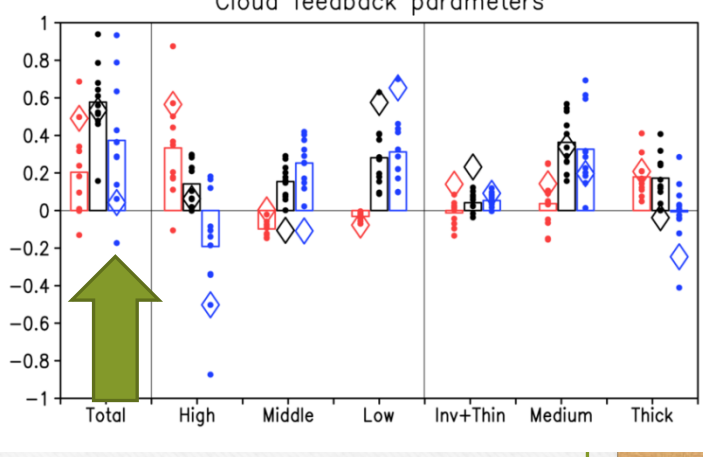

LW Cloud Feedback for subthin cloud
0.14[W/m2/K]
−4 −3 −2 −1 0 1 2 3 4

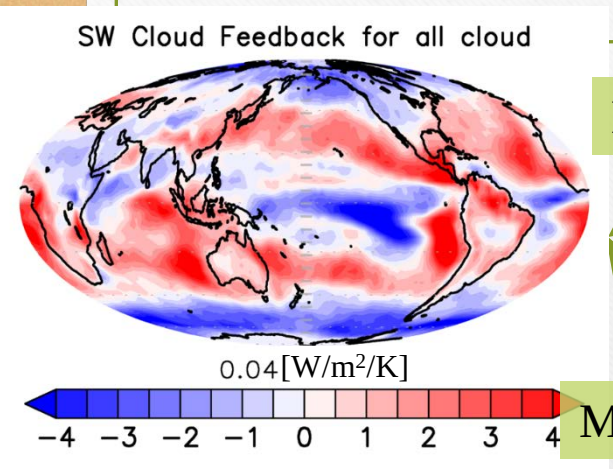
High


LW Cloud Feedback for high_subthin cloud
0.22[W/m2/K]

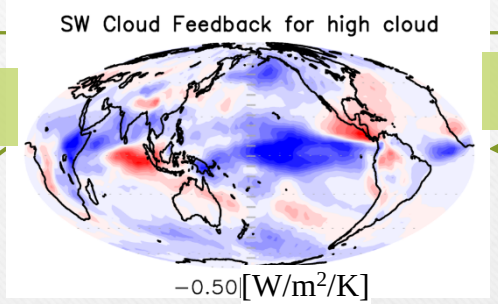


Zelinka et al. [2012]

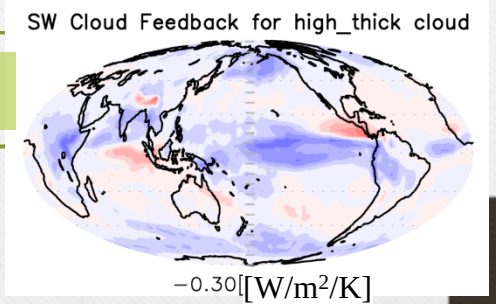




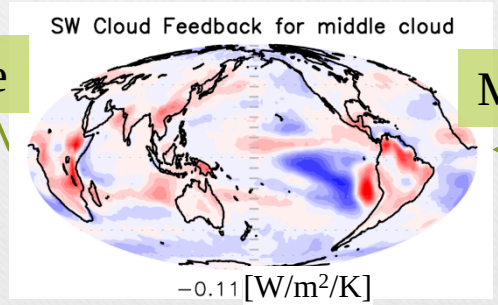
High



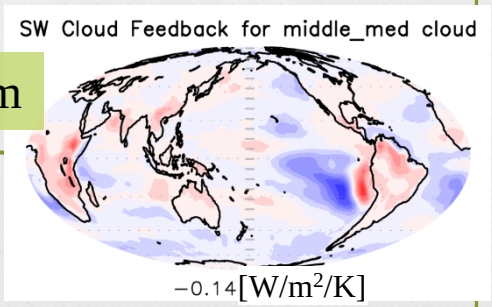
Thick



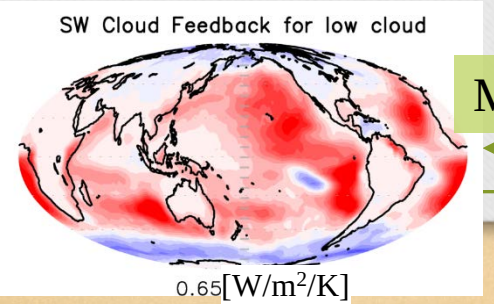
Middle



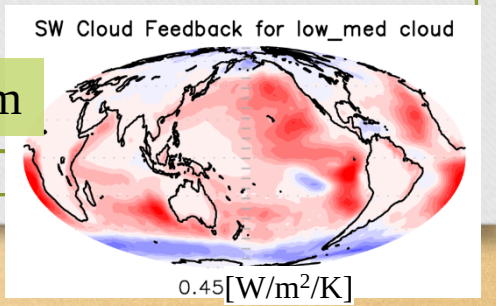
Medium



Low



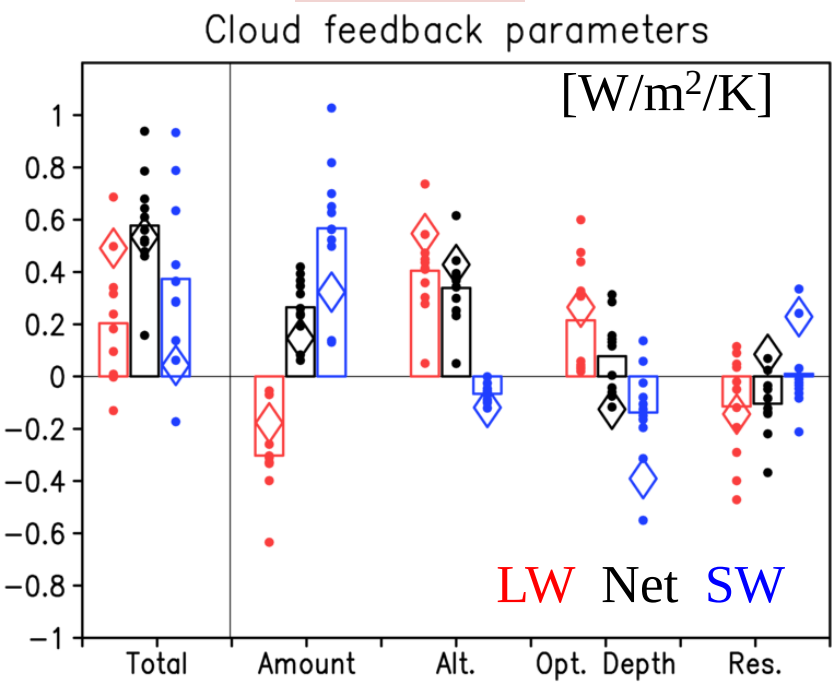
Medium



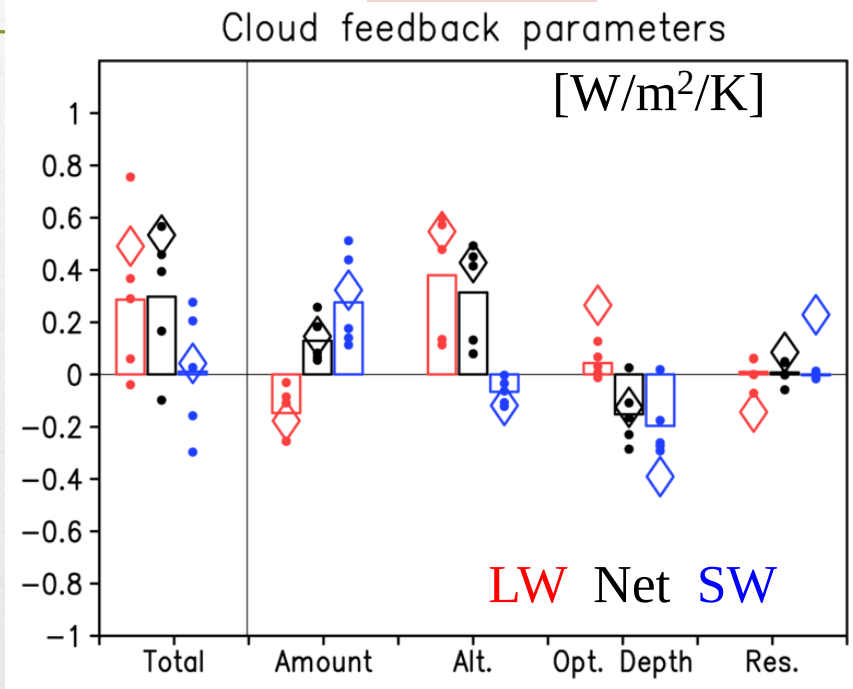
Cloud feedbacks by factors [W/m^2/K]

contributions from changes in total cloud amount, cloud top altitude, and cloud optical depth following Zelinka et al. [2012].

CMIP3



CMIP5



▪ : CMIP3/5 each model ☐: CMIP3/5 ens. means ◇: NICAM-AMIP

CMIP3/5 data courtesy of M. Zelinka (same as Zelinka et al. 2012, 2013)

Note: CMIP3/5 models are coupled model, whereas NICAM is atmospheric model with slab ocean.

Summary

- Cloud feedbacks in 20-yr AMIP-like NICAM simulations
  - In general, results from NICAM are within the uncertainties of the CMIP3/5 results.
    - positive LW feedback contributed from increased high clouds (by altitude feedback)
    - slightly positive SW feedback as a result from the compensation between the effect of decreased low cloud and increased high cloud.
  - LW cloud feedback by thin cloud (~cirrus): NICAM > CMIP3/5 models, consistent with the previous NICAM studies (Collins and Satoh 2009; Tsushima et al. 2014)

NICAM posters

- Poster by Tatsuya Seiki (tomorrow)
  - performance of the double moment cloud microphysics scheme
  - contact person of NICAM-COOKIE
- Poster by Ying-Wen Chen (today!)
  - cloud feedbacks: single vs. double moment cloud microphysics scheme

COOKIE/NICAM Planning (Seiki, Kodama)

Name	SST	Clouds	Resolution-Period
Aqua	APE	On	56km-1year 28km-3month 14km-3month
Aqua 4K	APE+4K	On	56km-1year 28km-3month 14km-3month
offAqua	APE	Off	56km-1year 28km-3month 14km-3month
offAqua 4K	APE+4K	Off	56km-1year 28km-3month 14km-3month

Objectives: Radiative Effect on Convective Organizations over the tropics

Framework

- Non-Hydrostatics
- No Cumulus Parameterization
- Double Moment Bulk Cloud Microphysics with Precipitating Hydrometeors

Thank you!