An Assessment of the Cloud Properties Simulated by NICAM Using ISCCP, CALIPSO and CloudSat Satellite Simulators

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1. Introduction

Cloud influences earth climate through long and short wave radiations. It is of great importance for model developers to appropriately assess how well one's model reproduces 3-D cloud .

In this study, we assess cloud and precipitation simulated by the global non-hydrostatic model with explicit cloud microphysics using ISCCP, CloudSat and CALIPSO satellite datasets. CloudSat and CALIPSO can observe vertical structure of the cloud and precipitation. We use satellite simulators to consistently compare model output with satellite observations.

2. 1. NICAM Configurations

Resolution	Hor. 14km Ver. Intervals 80m~2.9km, up to 40km
Integration	2004.06.01 - 2004.10.31 (5 months)
Cloud microphys.	NSW6 (6 cat, 1 moment; Tomita 2007)
Cumulus conv.	Not used
PBL	MYNN2.0 (Nakanishi & Niino 2006, Mellor & Yamada 1982)
Surface flux	Louis (1979)
Land model	MATSIRO (Takata et al. 2003)
Ocean	1 layer slab ocean with nudging (τ = 5dy)
Radiation	MSTRNX (Sekiguchi & Nakajima, 2008)

*NICAM: Nonhydrostatic ICosahedral Atmospheric Model Satoh et al. (2008); Tomita and Satoh (2004)

2. 2. Satellite Datasets

◇ ISCCP (Int'l Satellite Cloud Climatology Project; Rossow and Schiffer, 1999)
- IR and VIS images → Optical depth and cloud top pressure
- Δlat=Δlon=2.5°, 3-hourly, daytime, Jun-Jul-Aug 2004.

◇ CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation)
- GOCCP (GCM-Oriented CALIPSO Cloud Product; Chepfer et al. 2010)
- 532nm lidar → Cloud mask (sensitive to thin cirrus)
  # SR (lidar Scattering Ratio) SR～1: clear SR > 5: cloudy
- 3.5° × 2.5° × 40 layers (480m int.), all day, JJA 2006-2008

◇ CloudSat (Stephens et al. 2002)
- 94GHz radar → Cloud and precipitation mask
  # Ze > -30dBZe : cloud/precipitation
- 1° ×1° ×40 layers (480m int.), all day, JJA 2006-2007

2. 3. Satellite Simulator COSP

◇ Satellite simulator・・・estimates satellite signals from model output.
- COSP (CFMIP Observational Simulator Package; Bodas-Salcedo et al., 2008)

*CFMIP: Cloud Feedback Model Intercomparison Project

4. 1. Sensitivity Experiments

too much cloud ice !

○ autoconversion from q_i (cloud ice) to q_s (snow)

$$P_{SAUT} = \min[\beta_1(q_i - q_{icrt}), 0] \quad \text{[g/(kg s)]}$$

q_{icrt}= 0, 0.001, **0.005 (control)**, 0.01, 0.1 [g/kg]

○ fall process of cloud ice

off (control) or on

(q_{icrt} = 0)

3. 1. ISCCP Cloud Fraction

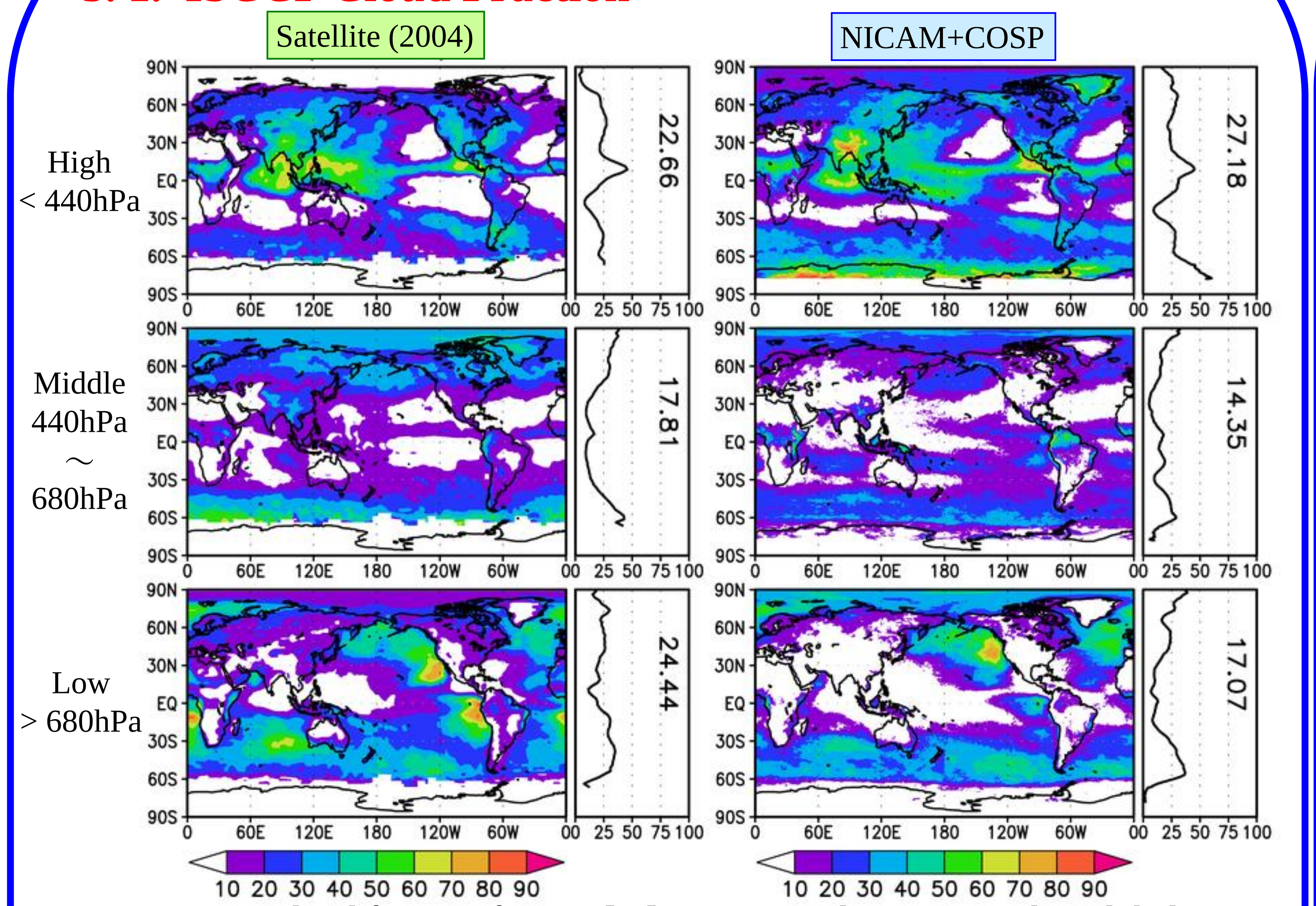

Fig. 1: ISCCP cloud fraction for JJA [%]. Lines & values are zonal & global means.

◇NICAM
- reproduces ISCCP cloud patterns, qualitatively
- slightly overestimates high cloud and slightly underestimates middle and low clouds.

3. 2. CALIPSO Cloud Fraction

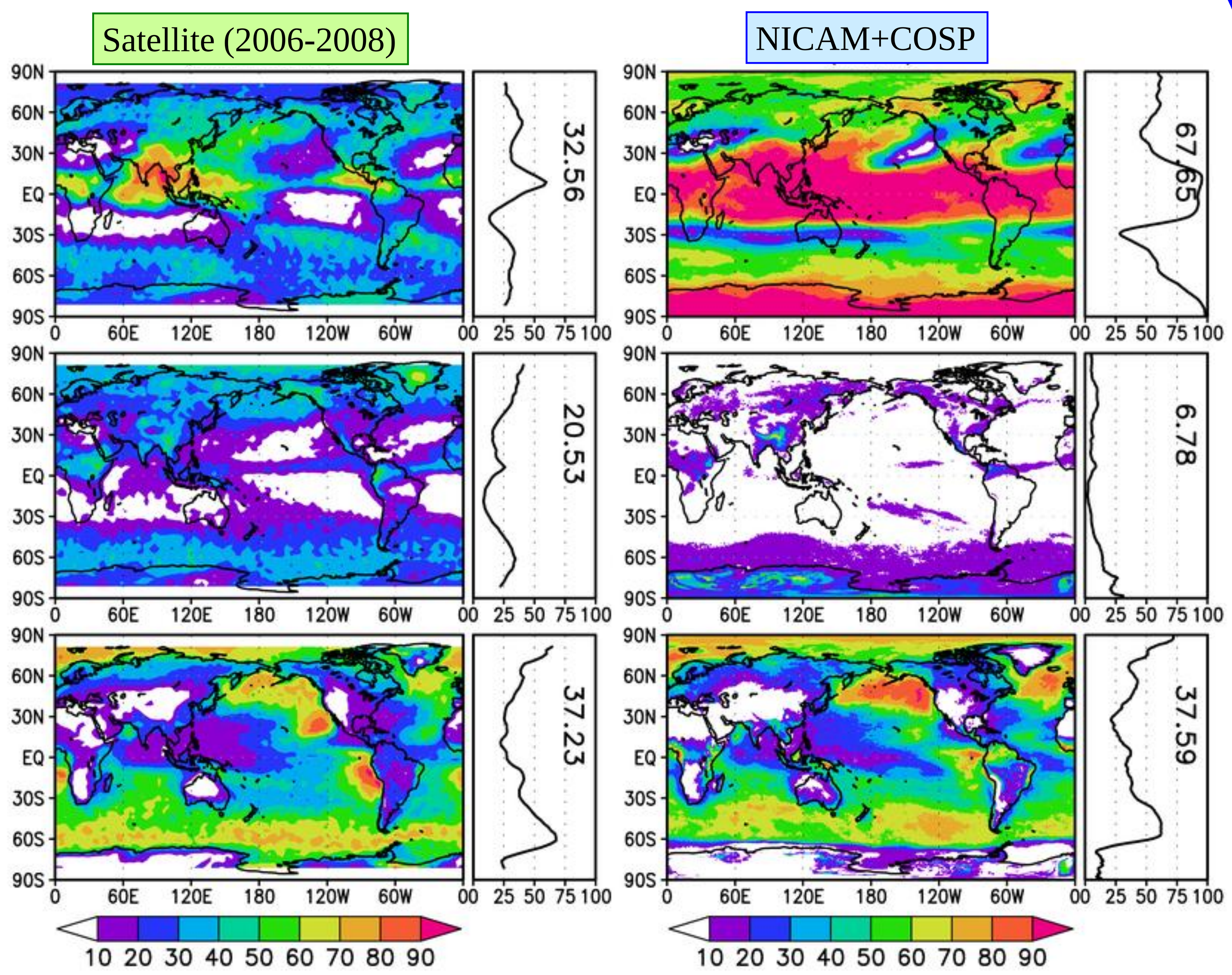

Fig. 2: Same as Fig. 1 but for using CALIPSO.

◇NICAM
- reproduces CALIPSO cloud patterns, qualitatively.
- overestimates high cloud
  -- (too much cloud ice)
  -- (especially, thin cirrus)
- underestimates middle cloud
- well reproduces low cloud
- overestimates cloud top height.

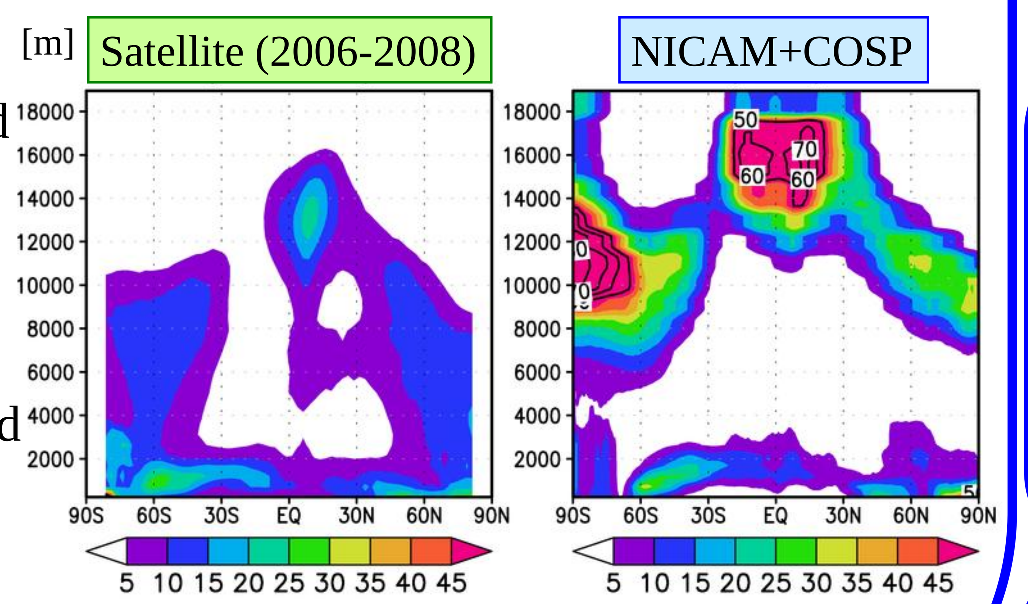

Fig. 3: Zonal mean CALIPSO cloud fraction [%].

3. 3. CloudSat Results

◇ NICAM
- reproduces pattern of the cloud and precipitation, qualitatively.
- slightly overestimates high cloud
- slightly underestimates middle cloud.
- slightly overestimates cloud top height.

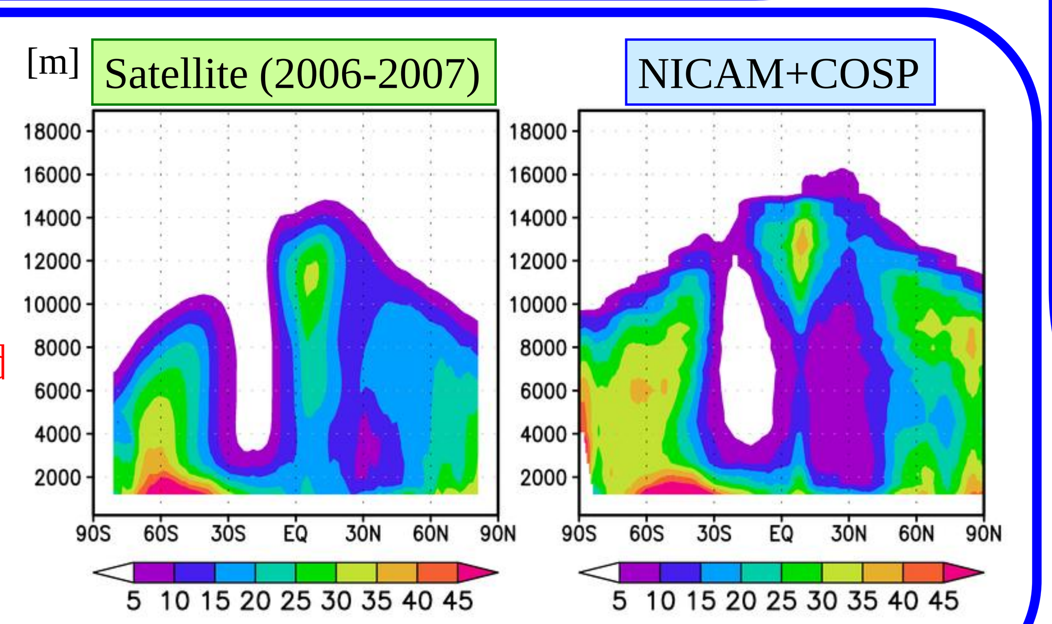

Fig. 4: Same as Fig. 3 but for using CloudSat.

4. 2. Results

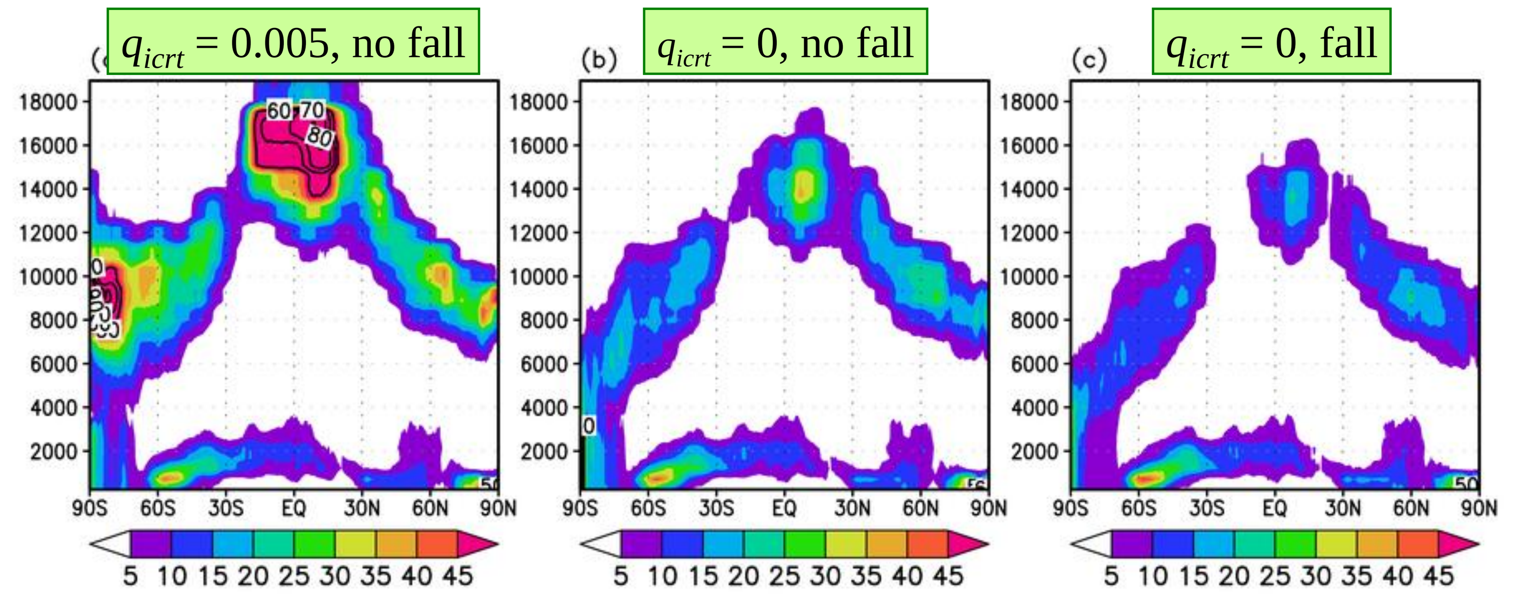

Fig. 5: Zonal mean CALIPSO cloud fraction for 6-10th day [%].

◇ Impacts of decrease in q_{icrt} and/or introduction of cloud ice fall process
- to decrease high cloud without changing middle and low clouds
- to lower cloud top height

◇ Upper Invisible and thin clouds mainly contribute to the changes in the LWCRF as q_{icrt} changes from 0.005 to 0.

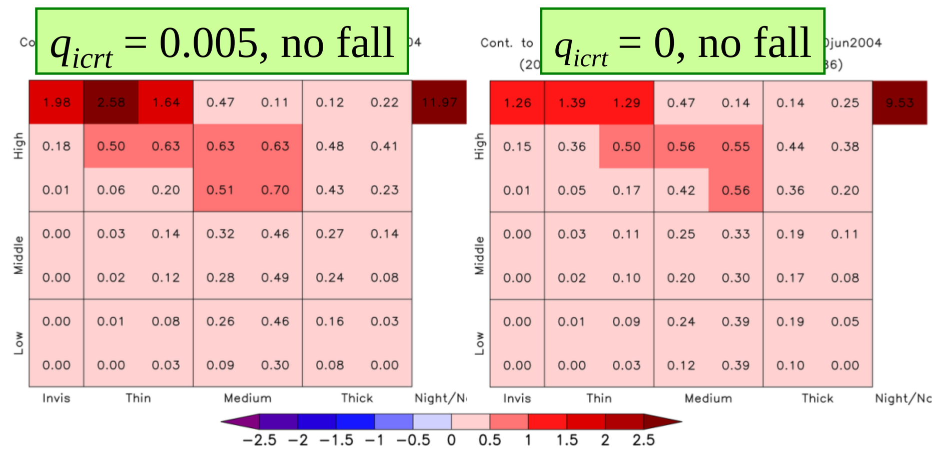

Fig. 6: Global mean LWCRF contributed from each ISCCP cloud

5. Summary

◇ Assessments of NICAM (vs. satellite observations)
- high cloud: too much (especially thin cirrus), higher cloud top height
- middle cloud: smaller
- low cloud: good

◇ Sens. exps. : (1) accelerate cloud ice → snow, (2) introduce cloud ice fall process
- both reduce high cloud and lower high cloud top height.

6. Acknowledgements

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