Evaluation of Cloud Fraction Simulated by 7 SCMs against ARM Observation at the SGP Site

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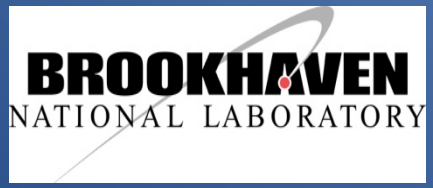
1. ASD/BNL 2. NOAA/GFDL 3. CU 4. KNMI 5. NASA GISS



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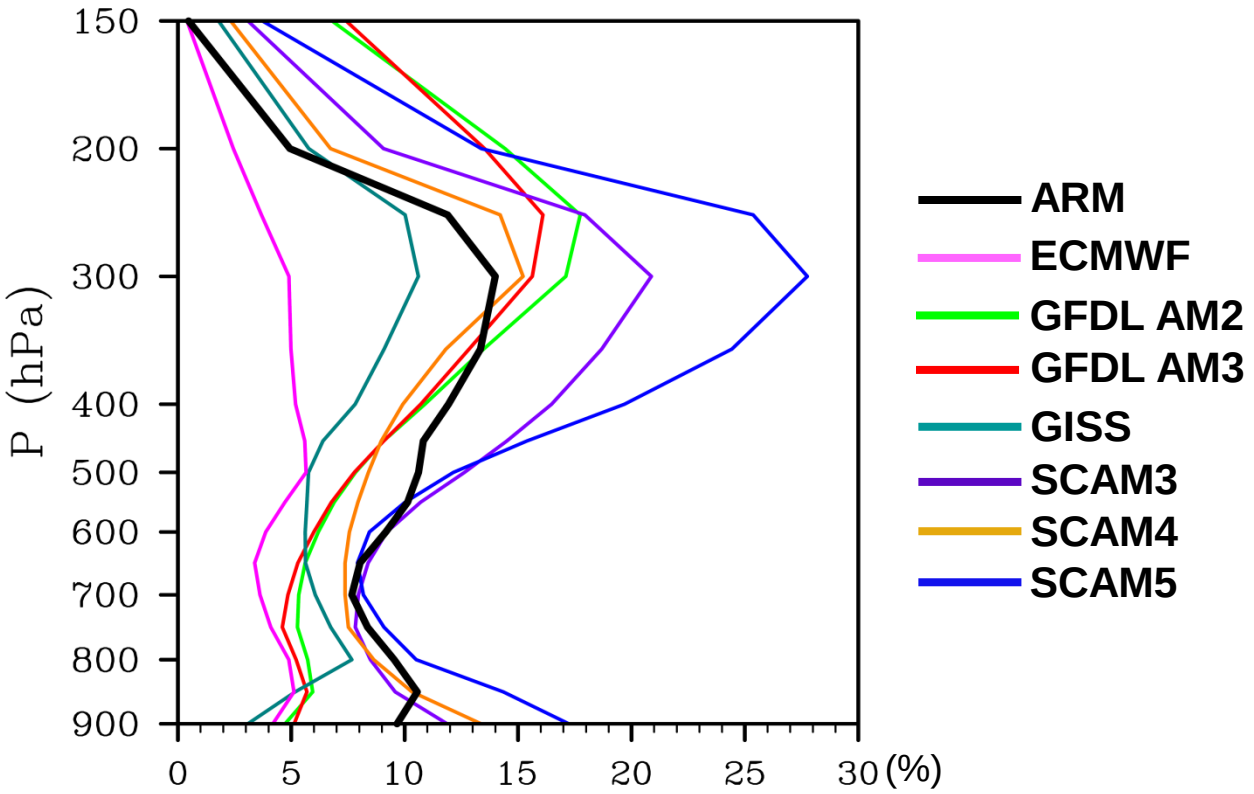
Introduction

- Evaluation of **vertical profile, mean cloud amount and frequency** of cloud fraction in 7 SCMs by comparison with ARM observation at SGP site
- Statistical analysis with 3-year hourly data (Jan1999-Dec2001)
- Observation: CMBE ARSCL cloud fraction (Xie et al. 2010)
- 7-SCM simulations driven by same surface and large-scale forcing plus a relaxation term, and run in the FASTER SCM Testbed

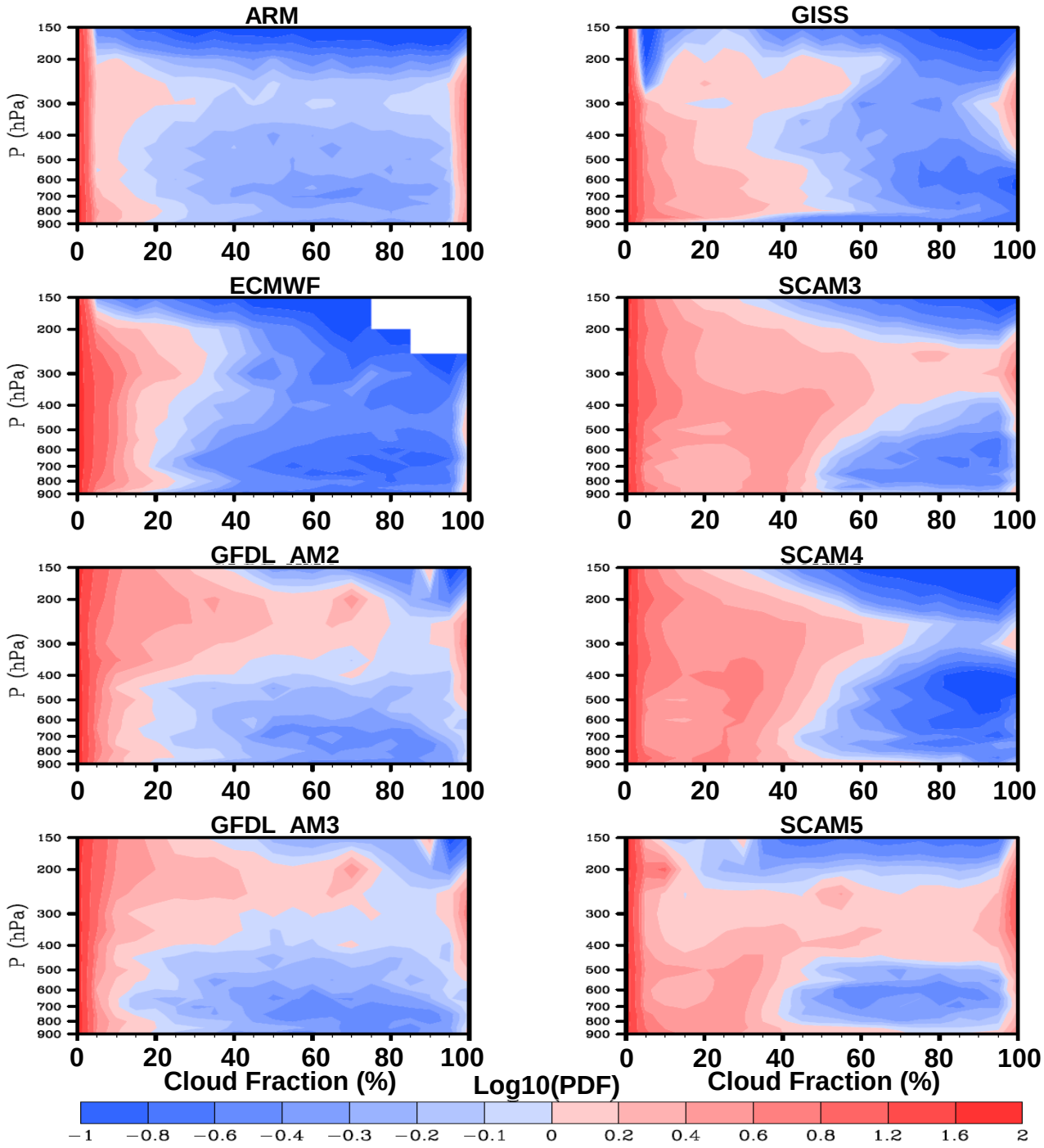
  ECMWF IFS, GFDL AM2 and AM3 (**prognostic** cloud fraction schemes)

  GISS ModelE2, CAM3, CAM4 and CAM5 (**diagnostic** cloud fraction schemes)

3-year Mean Cloud Fraction



- The **ECMWF** SCM underestimates all-level cloud fraction.
- The **GFDL** SCMs overestimate high-level cloud fraction while underestimate low-to-middle-level cloud fraction.
- The **GISS** SCM underestimates cloud fraction below 200-hPa level.
- The **SCAM**s overestimate high-level cloud fraction while have similar low-level (800hPa-600hPa) cloud fraction to the observation.



Vertical Profiles of Frequency Distribution of Cloud Fraction

- U-shaped distribution of cloud occurrences in the observation.
- More frequent cloud occurrences on moderately cloudy ranges at high levels or low levels in SCMs.

For ECMWF and GFDL SCMs

$$\frac{\partial a}{\partial t} = A(a) + S(a)_{conv} + S(a)_{strat} - E(a)$$

$$S(a)_{conv} = f(D_u)$$

$$S(a)_{strat} = f(RH, RH_{\min}) \qquad E(a) = f(RH)$$

- Pick out the **events with convection source**: **Convective Precip>0.1mm/day and RH<80%**

For GISS and CAM SCMs

$$a = sum(a_c, a_s) \quad or \quad a = \max(a_c, a_s)$$

$$a_c = f(M_u)$$

$$a_s = f(RH, RH_{\min})$$

- Pick out the **events with convection source**: **Convective Precip>0.1mm/day and RH<80%**

- In SCM, no horizontal advection of cloud fraction:

$$\delta a_t = (\omega \frac{\partial a}{\partial p} + S(a)_{conv} + S(a)_{strat} - E(a)) \times \Delta t$$

$$a_t = a_{t-1} + \delta a_t$$

When δa_t is very small with Pr.conv<0.1mm/day and RH<80%,

$$a_t \approx a_{t-1}$$

- Pick out the **events with**

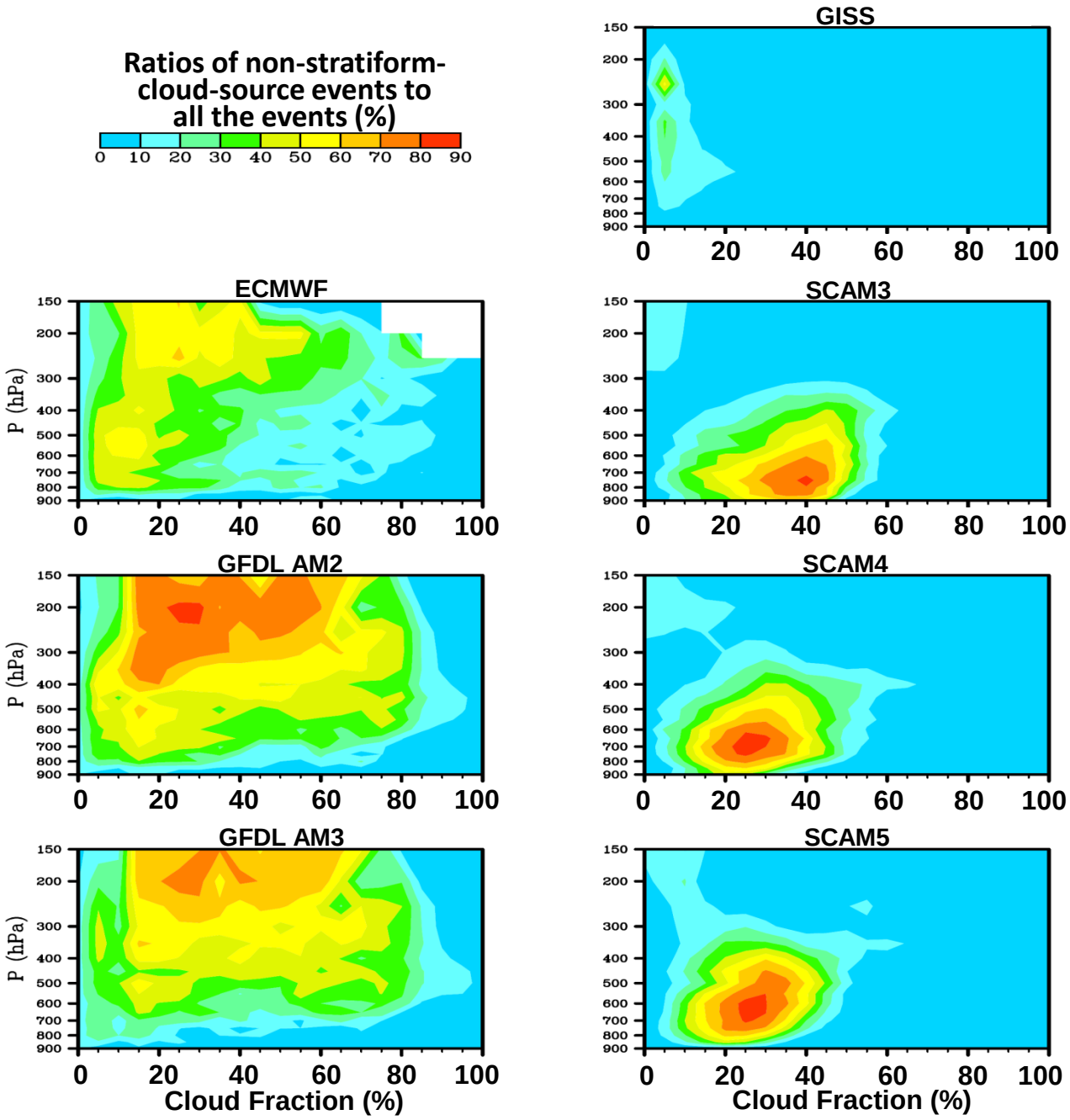
$$\left|Bias(a_{t-1})\right| > 20\% \quad and$$

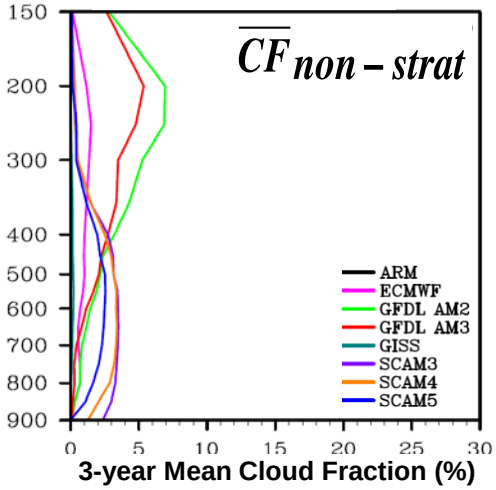
$$\left|\delta a_t\right| < 4\%, \Pr.conv < 0.1, RH < 80\%$$

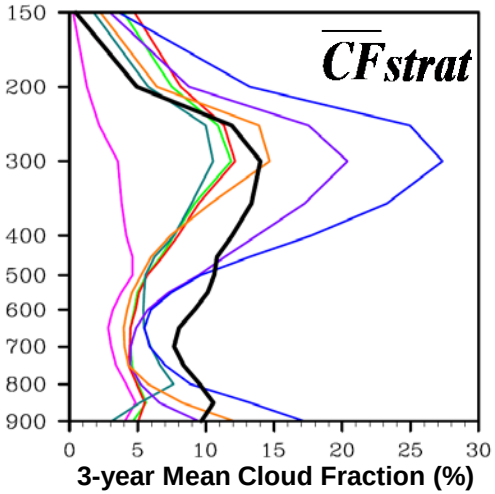
The cloudy events are roughly partitioned to two types:

Non-stratiform-cloud-source

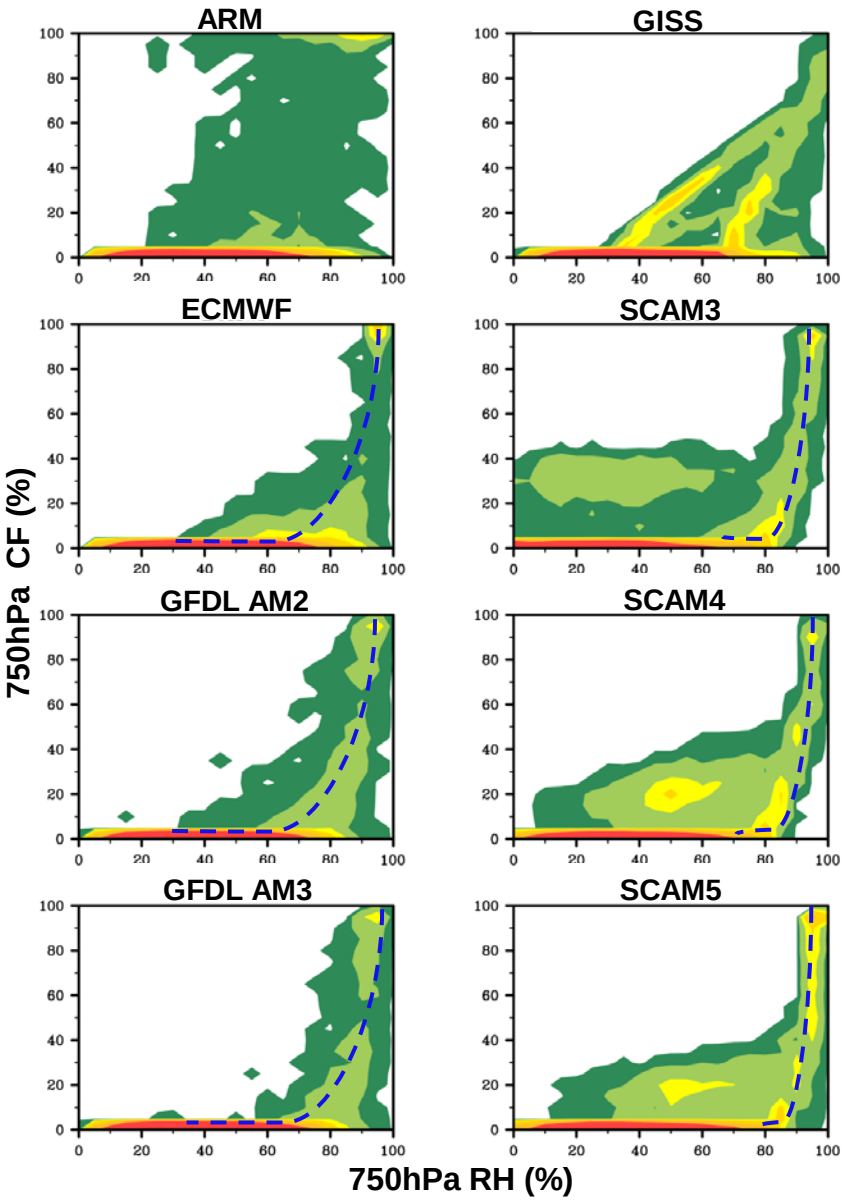
Stratiform-cloud-source


Ratios of non-stratiform-cloud-source events to all the events (%)
0 10 20 30 40 50 60 70 80 90
GISS
ECMWF
SCAM3
GFDL AM2
SCAM4
GFDL AM3
SCAM5
P (hPa)
Cloud Fraction (%)

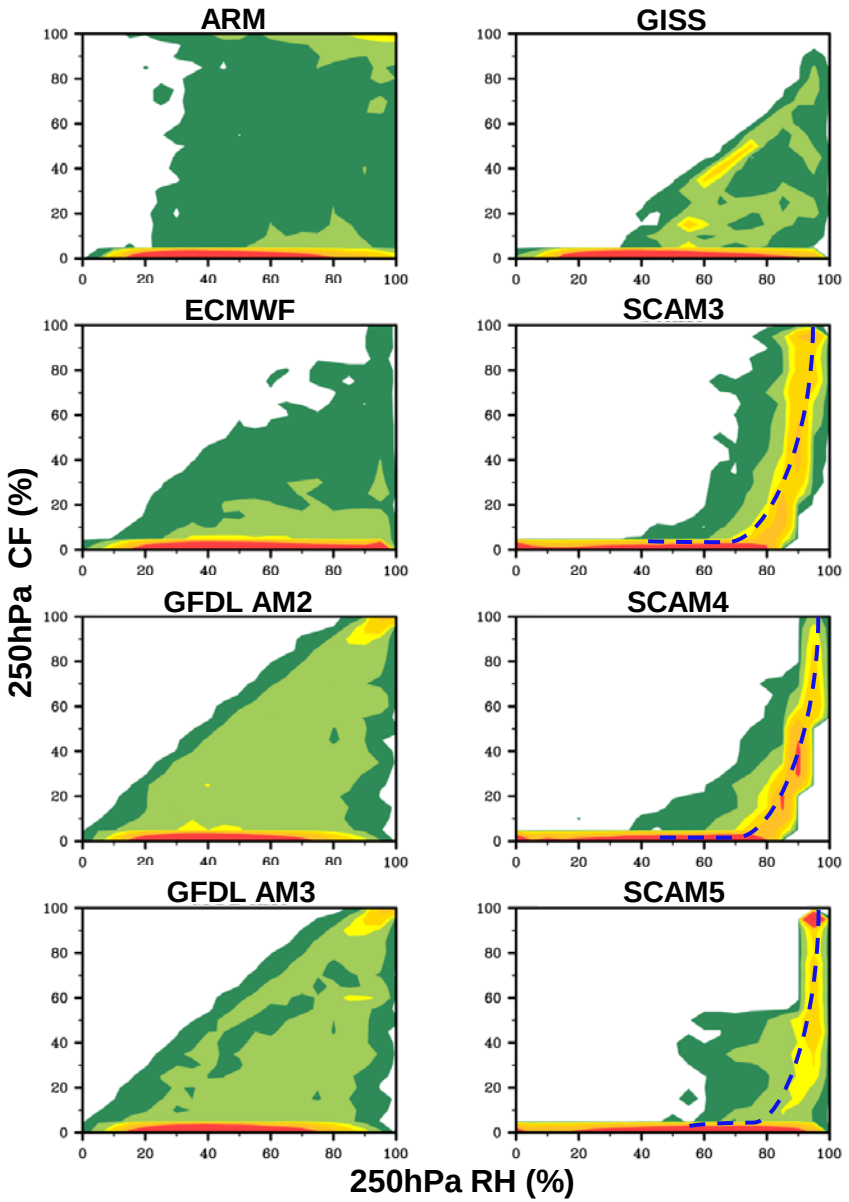

$\overline{CF}_{non-strat}$
ARM
ECMWF
GFDL AM2
GFDL AM3
GISS
SCAM3
SCAM4
SCAM5
3-year Mean Cloud Fraction (%)


$\overline{CF}_{strat}$
3-year Mean Cloud Fraction (%)

Low-level Cloud Fraction and RH



High-level Cloud Fraction and RH



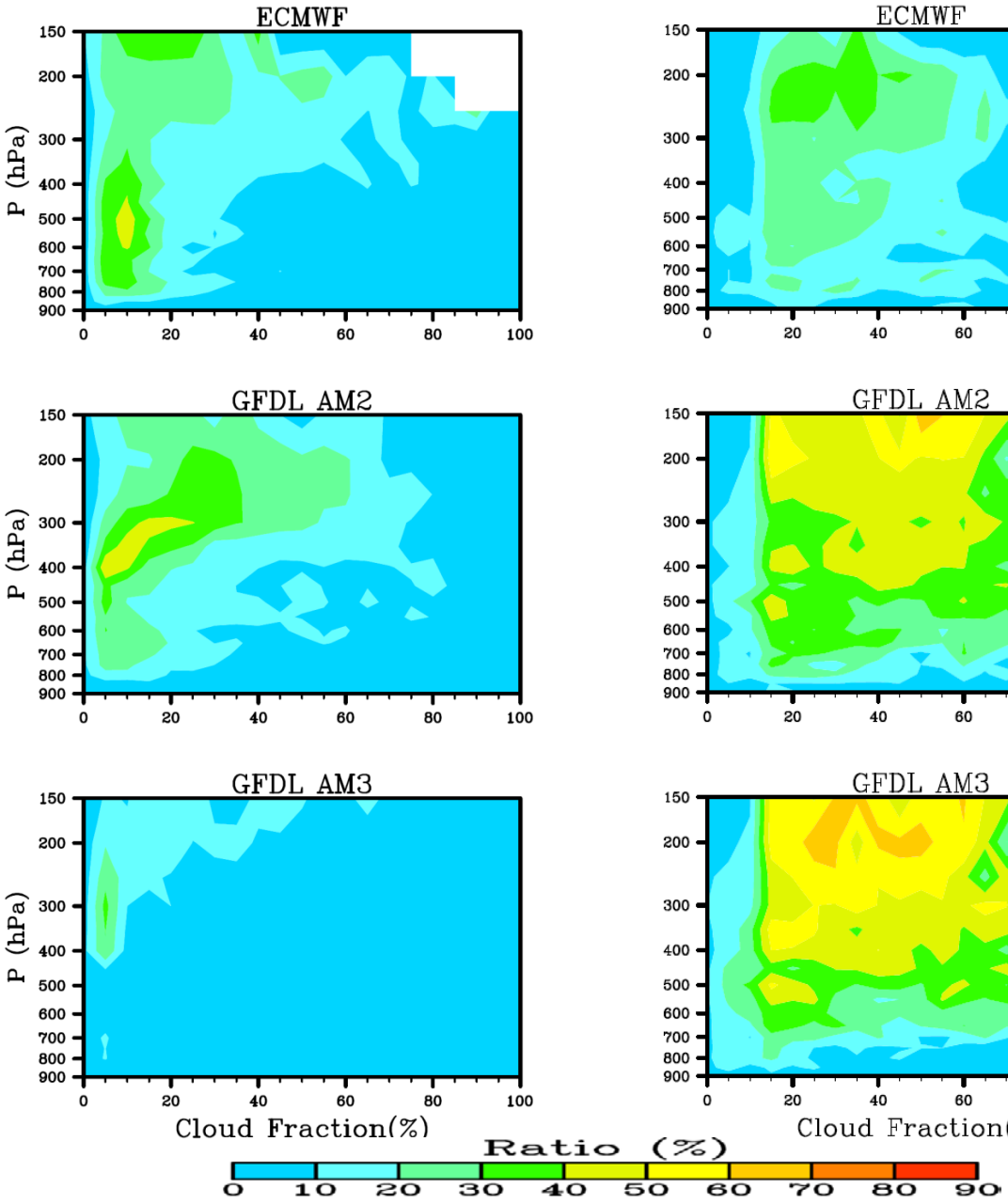
Joint Frequency Distribution (%)

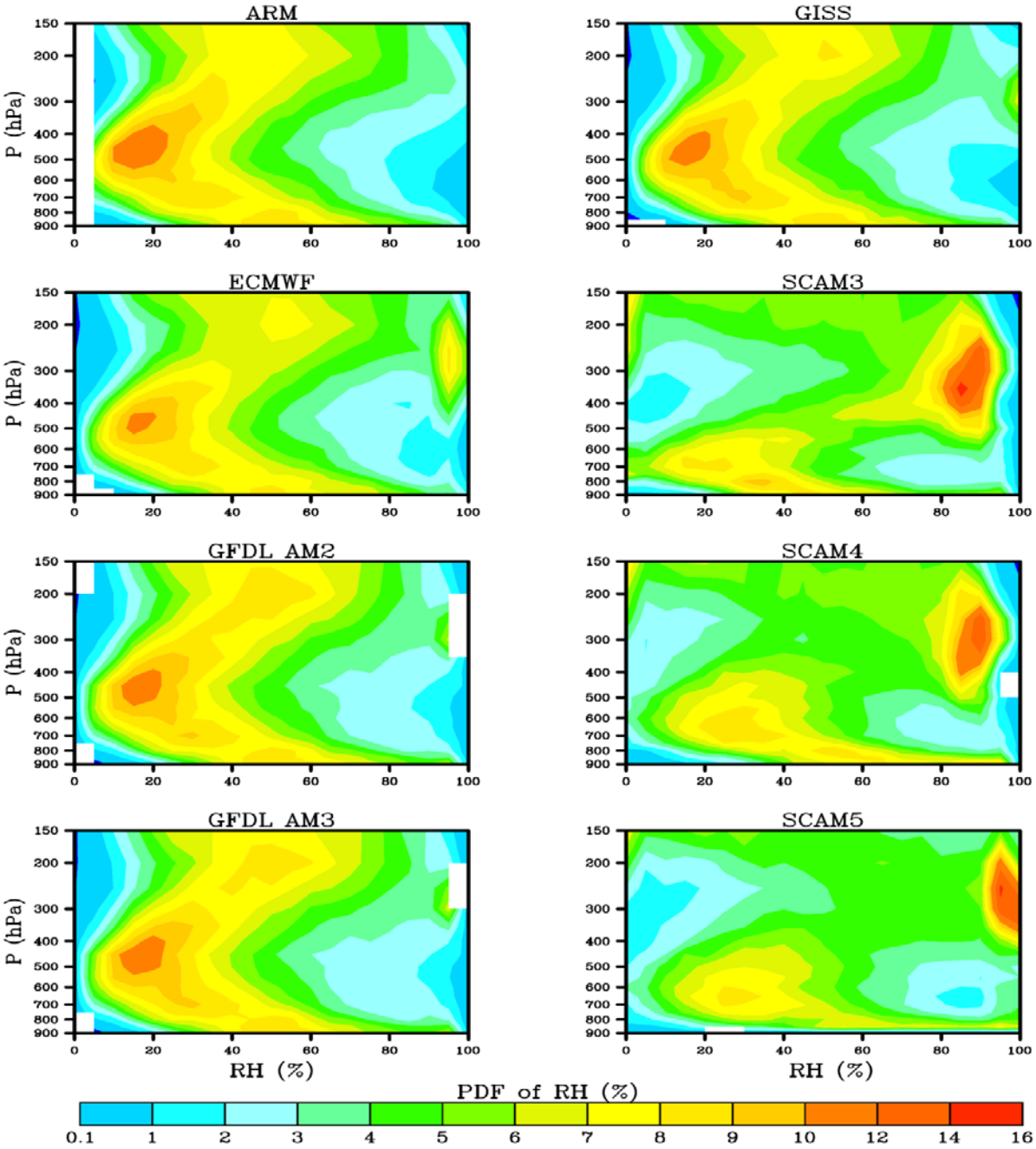
Summary

- Compared with observation, the ECMWF SCM underestimates all-level clouds and GISS SCM underestimates clouds below 200 hPa.
- The two GFDL SCMs overestimate high-level cloud fraction but underestimate low-level cloud fraction.
- The three SCAMs overestimate high-level cloud fraction, but have low-level cloud fraction similar to the observation, due to the compensation between the overproduction of convective clouds and underproduction of stratiform clouds.
- The frequency distribution of cloud fraction shows a large discrepancy between the observation and SCMs.
- The contribution of non-stratiform-cloud sources is mainly on the moderately cloudy range, at high levels for ECMWF and two GFDL SCMs and at low levels for three SCAMs.
- Further analysis will be focused on relationship between cloud fraction (non-convective) and relative humidity in SCMs and observation.

Events with Pr.conv>0.1mm/d and RH<80%

Events with large model CF bias in previous time-step





Vertical Profiles of Frequency Distribution of RH