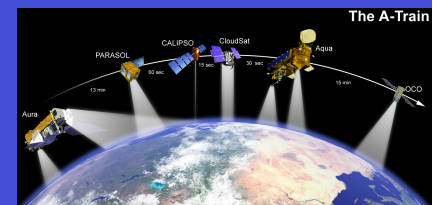
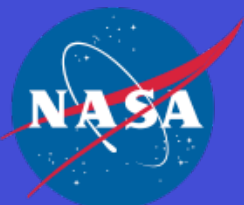


# Performance of SPCAM and SPCAM-IPHOC at High Vertical Resolution in the Low Troposphere

Kuan-Man Xu<sup>1</sup> and Anning Cheng<sup>2</sup>

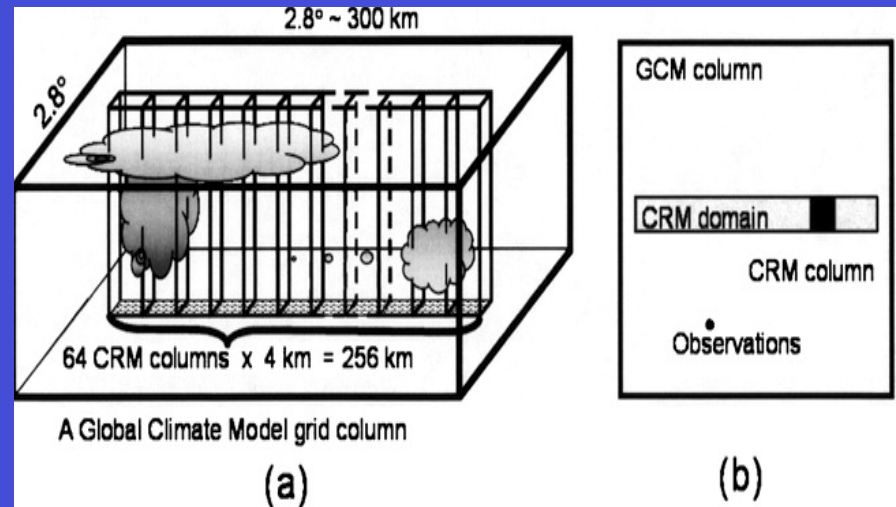
1. NASA Langley Research Center, Hampton, VA
2. Science Systems and Applications, Inc., Hampton, VA



# Multiscale Modeling Framework

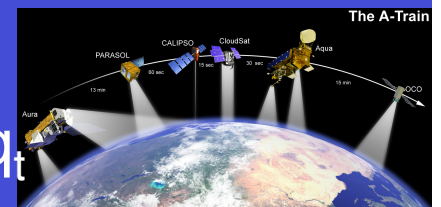
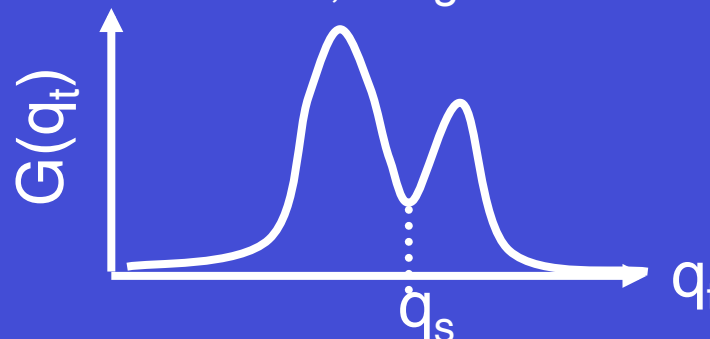
(Grabowski 2001; Khairoutdinov and Randall 2001)

- ✦ A CRM is embedded at each grid column ( $\sim 100\text{s km}$ ) of the host GCM to represent cloud physical processes
- ✦ The CRM explicitly simulates cloud-scale dynamics ( $\sim 1\text{s km}$ ) and processes
- ✦ Periodic lateral boundary condition for CRM (not extend to the edges)



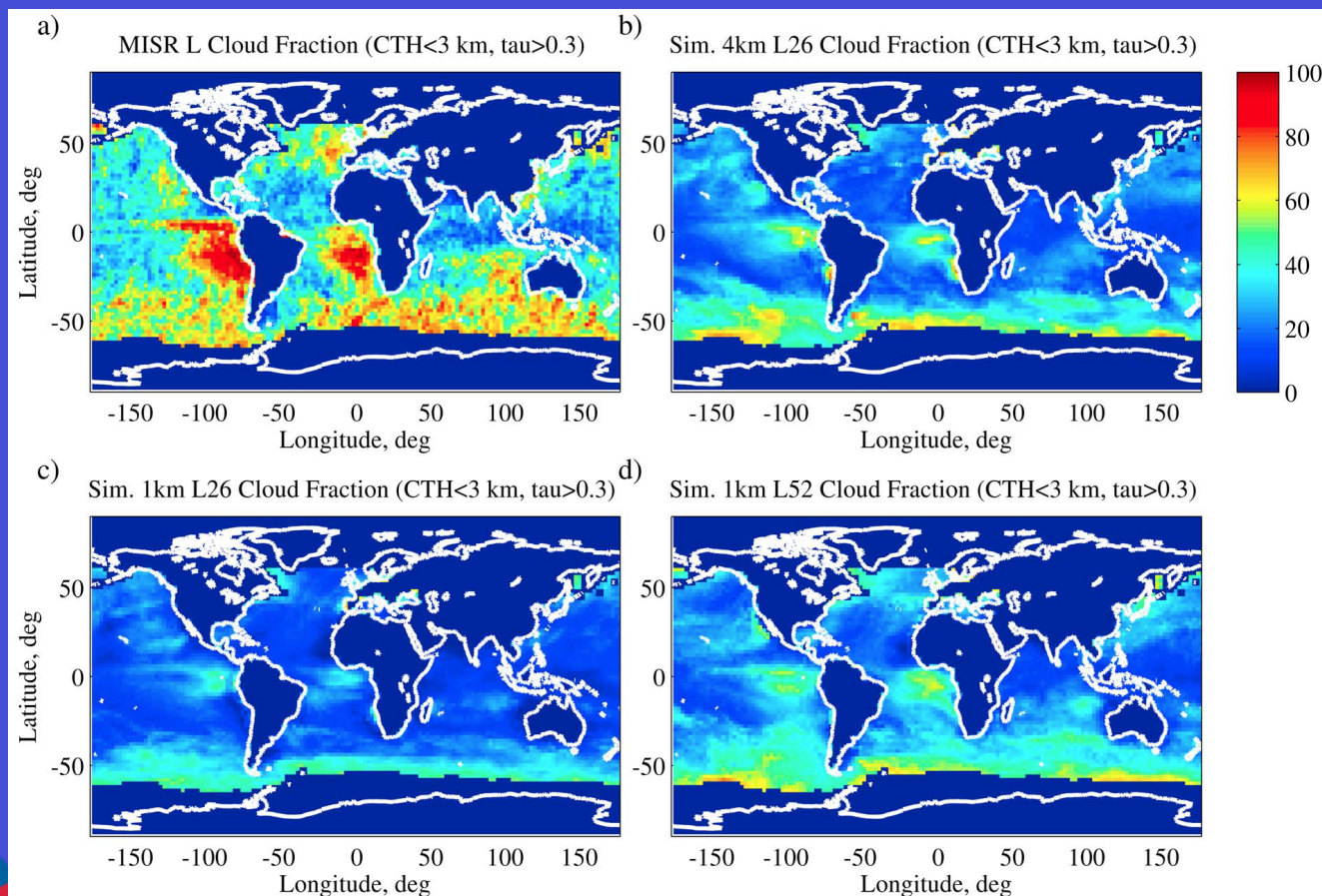
## Upgraded CRM with a third-order turbulence closure (IPHOC):

- ✦ Double-Gaussian distribution of liquid-water potential temperature, total water mixing ratio and vertical velocity
- ✦ Skewnesses, i.e., the three third-order moments, predicted
- ✦ All first-, second-, third- and fourth-order moments, subgrid-scale condensation and buoyancy based on the same PDF

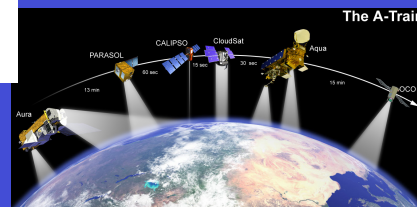
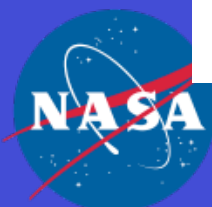


# Motivation

- SPCAM with higher vertical resolution in the low troposphere or SPCAM with IPHOC (SPCAM-IPHOC) at coarser resolution?



Marchand &  
Ackerman 2010



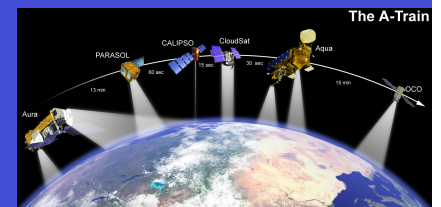
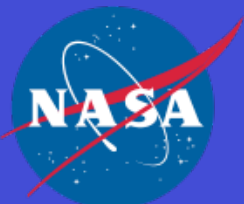
# Simulations

- ✦ SP-12L: 12 levels below 700 hPa (enhanced) with SPCAM model.
- ✦ IP-6L: 6 levels below 700 hPa (standard vertical resolution) with SPCAM-IPHOC model;
- ✦ IP-12L: 12 levels below 700 hPa (enhanced) with SPCAM-IPHOC;

All simulations were performed for 2 years and 3 months. The last two years are analyzed.

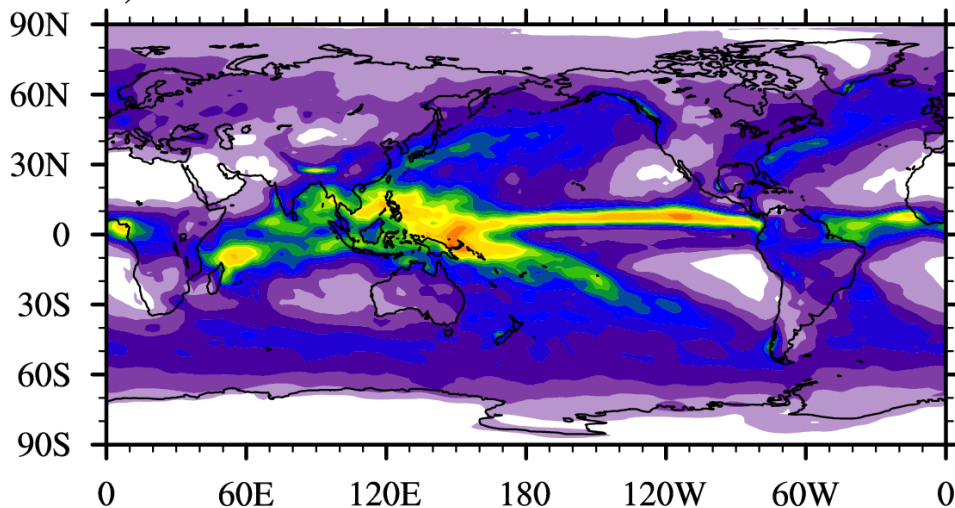
The following slides, except for zonal means, are arranged as:

SP-12L	IP-6L
IP-12L	Observation

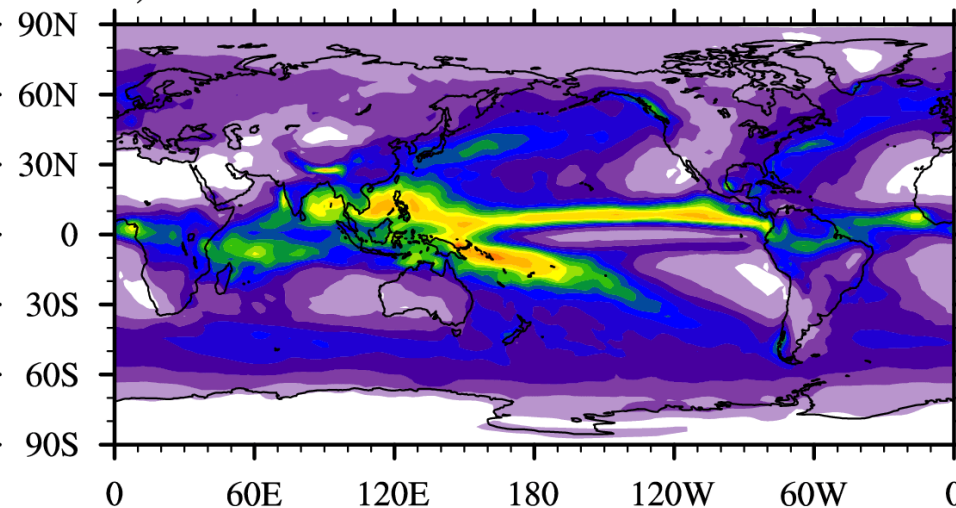


# Annual-mean surface precipitation

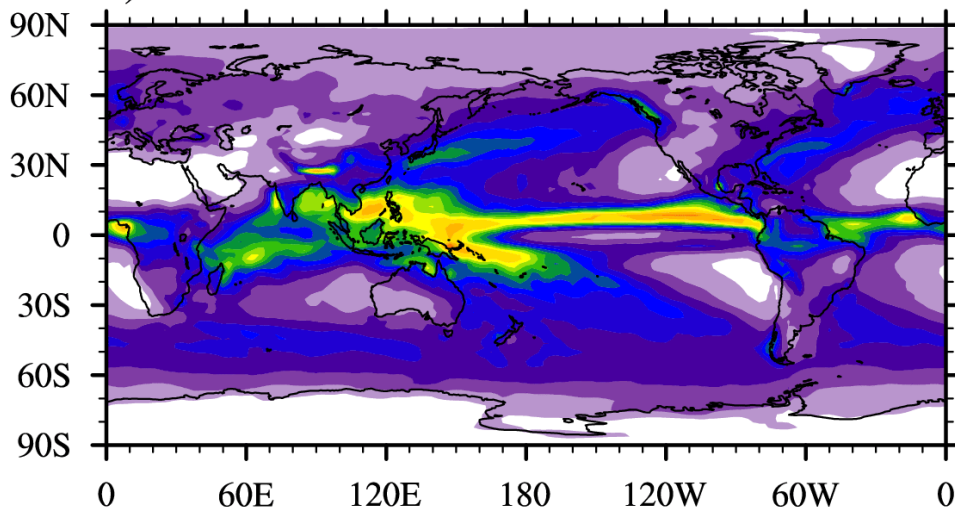
a) mean= 2.84 rms=1.4259 corr= 0.8596



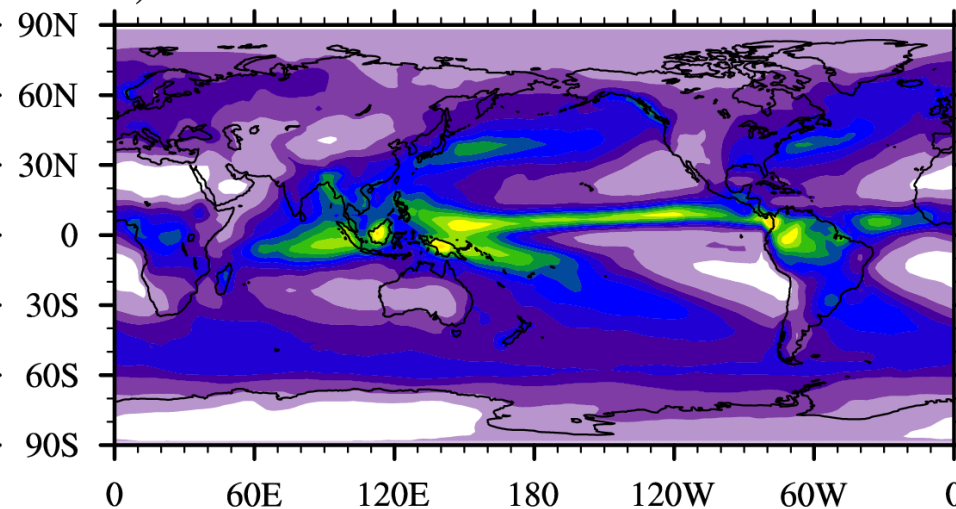
b) mean= 2.88 rms=1.4074 corr= 0.8609



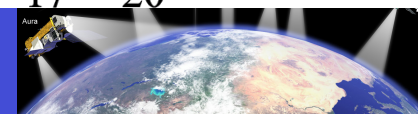
c) mean= 2.86 rms=1.3263 corr= 0.8738



d) mean= 2.68

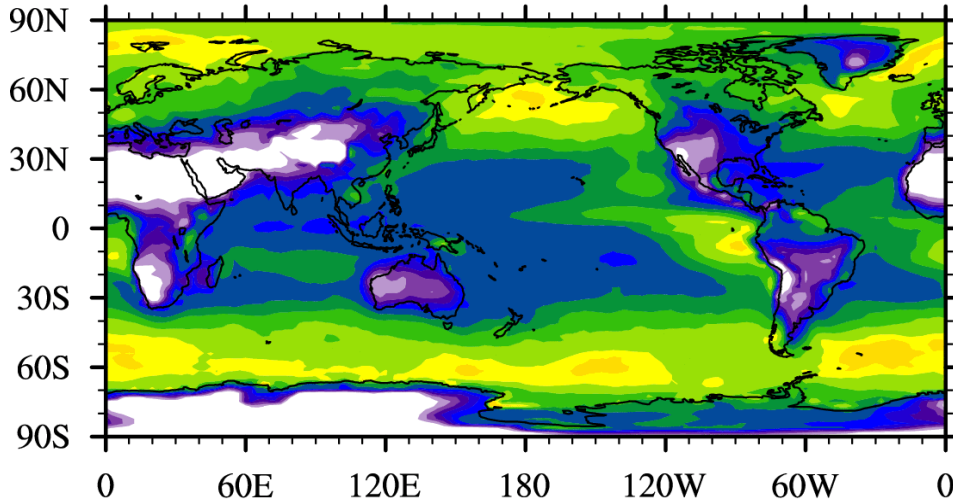


(mm/day)

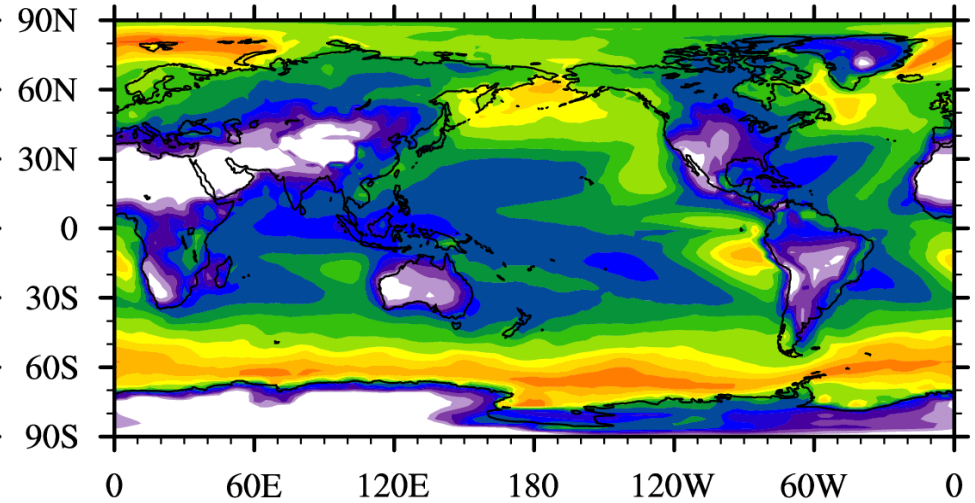


# Annual-mean low-level cloud amount

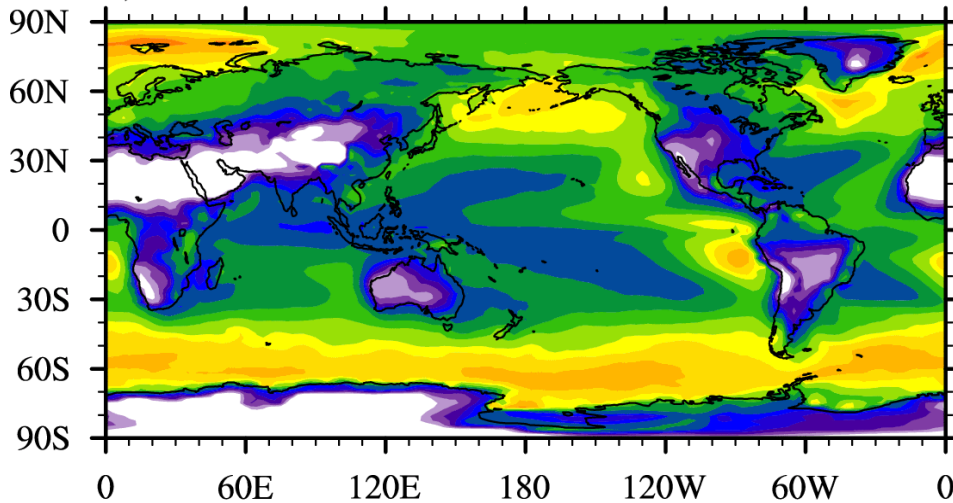
a) mean= 41.4 rms=13.1169 corr= 0.7506



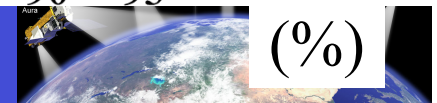
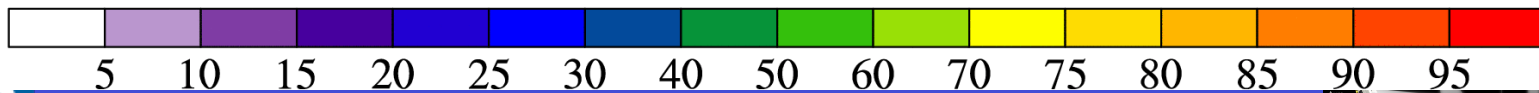
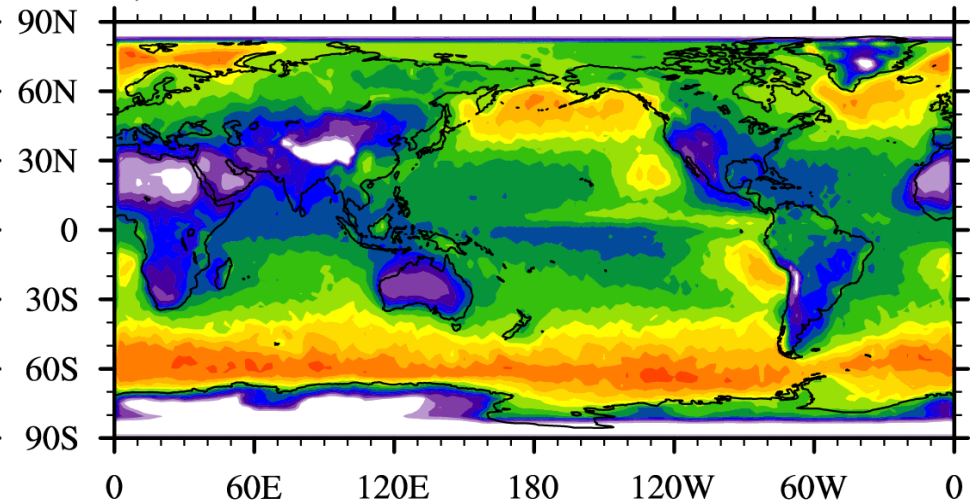
b) mean= 41.5 rms=13.1957 corr= 0.7650



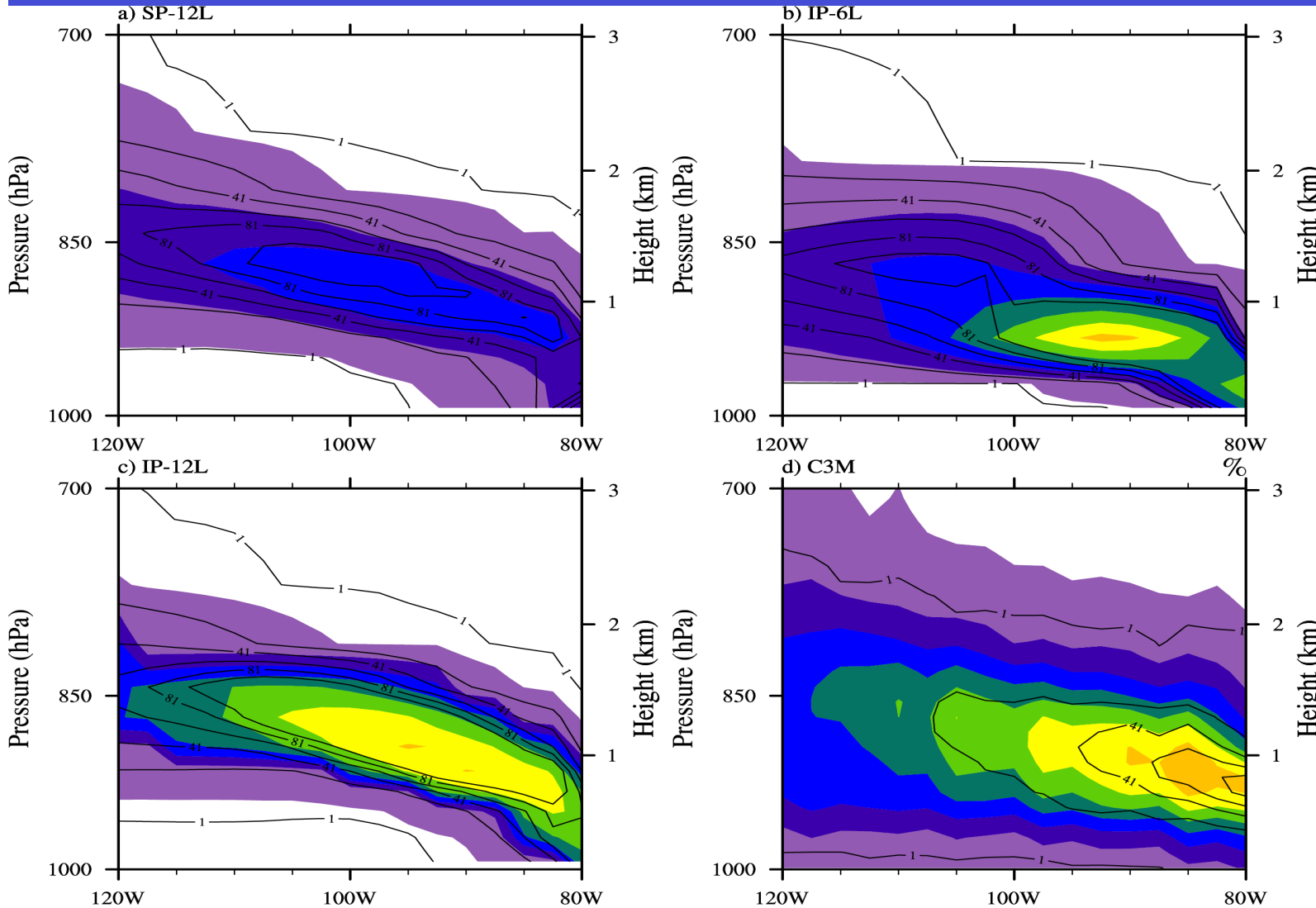
c) mean= 45.1 rms=10.3306 corr= 0.8037



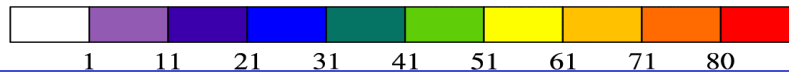
d) mean= 50.3



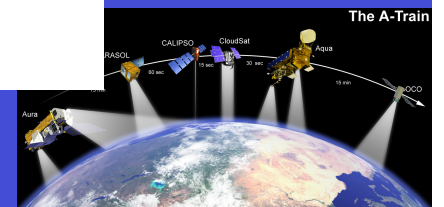
# Vertical cross section at 15° S, MMF vs. C3M



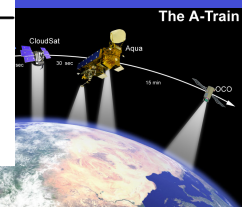
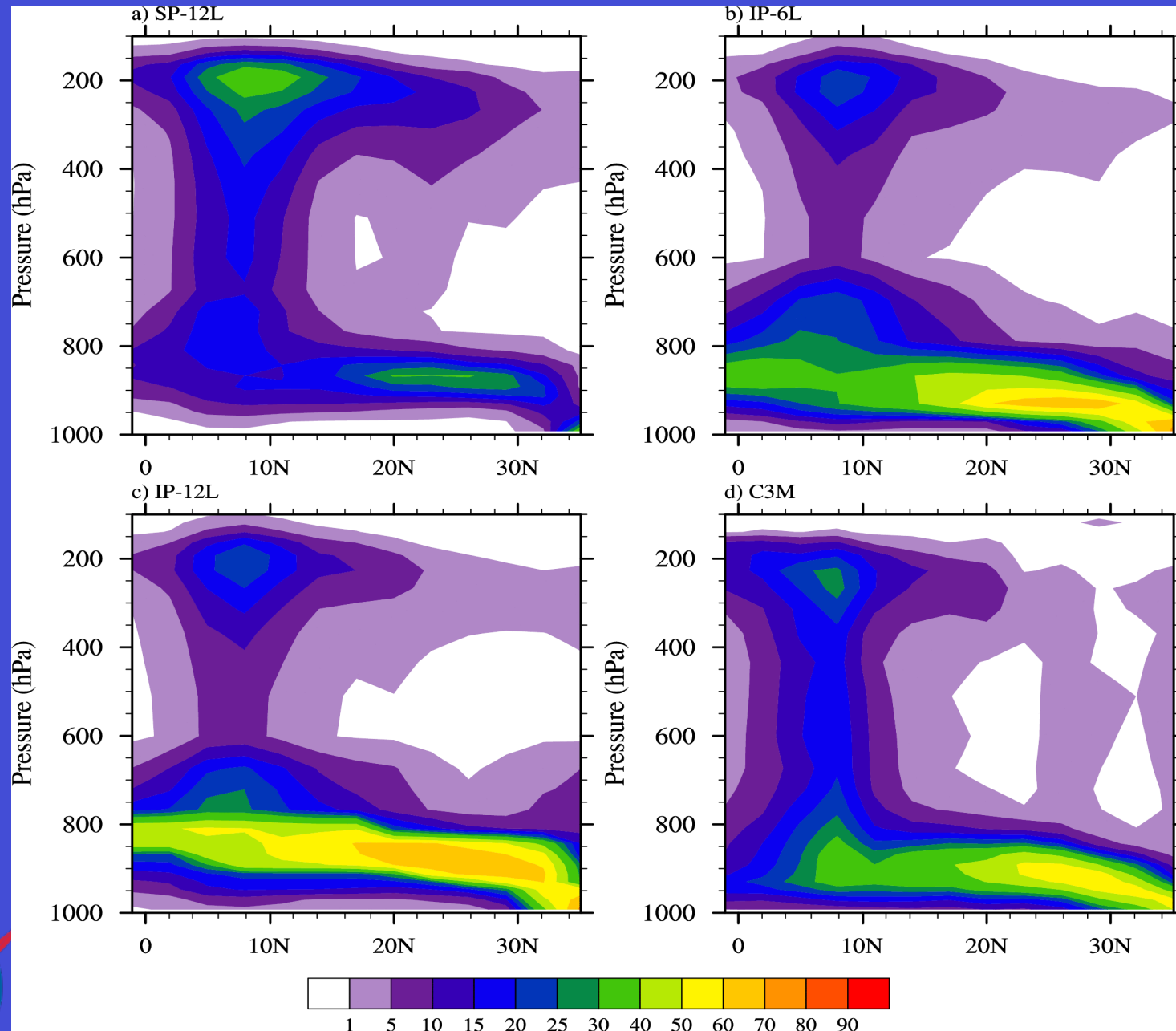
Color:  
cloud fraction  
(%)  
  
Contours:  
liquid water  
content (mg/kg)



(%)

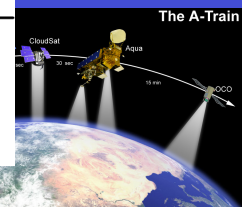
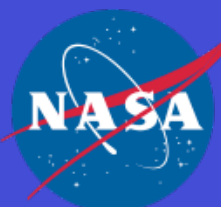
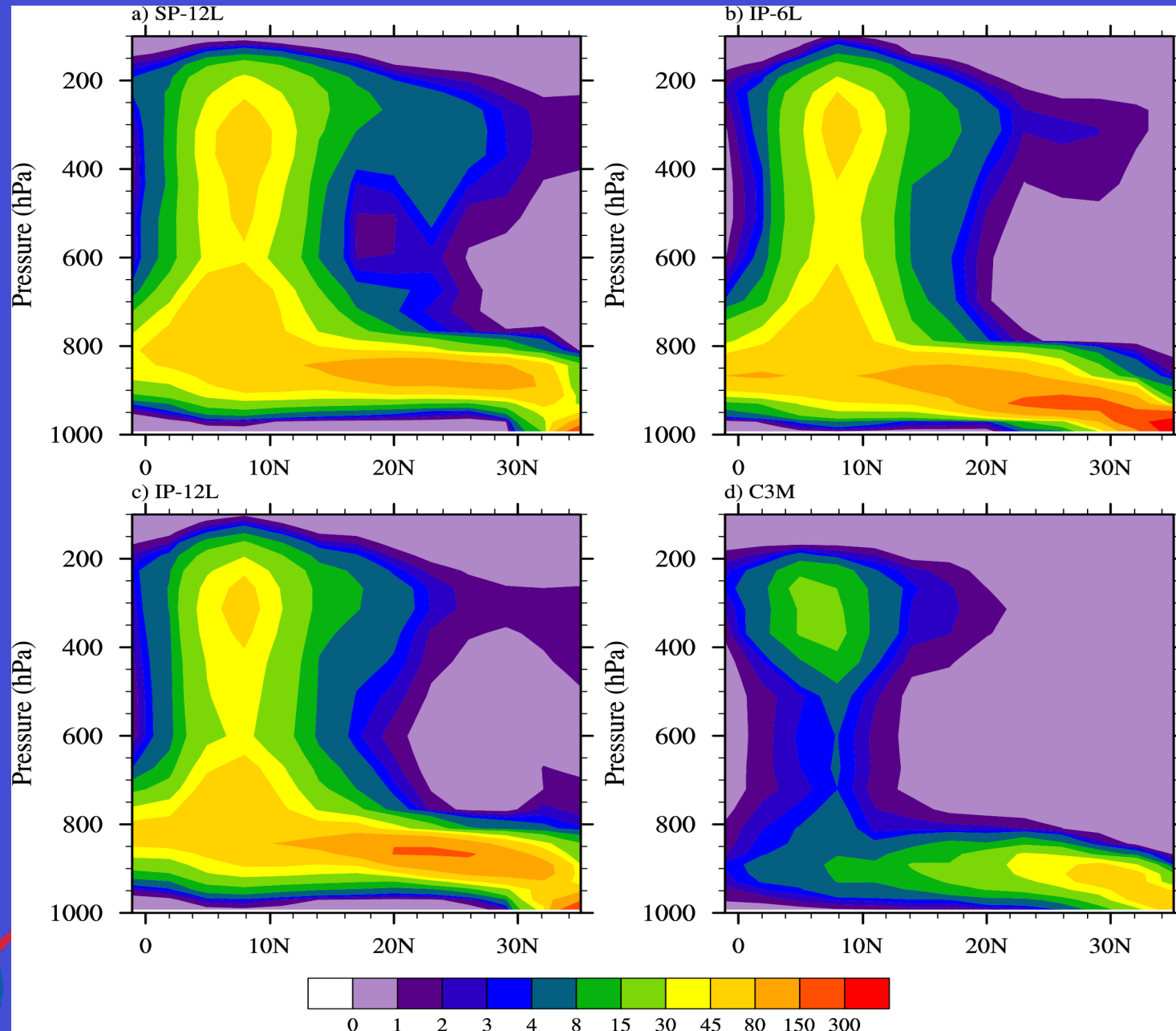


# Northern Pac. transect (GPCI) cloud fraction (%)

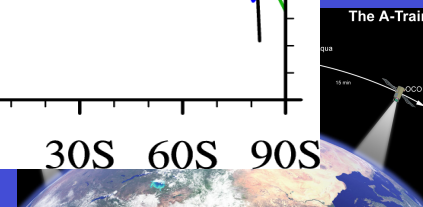
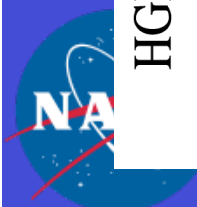
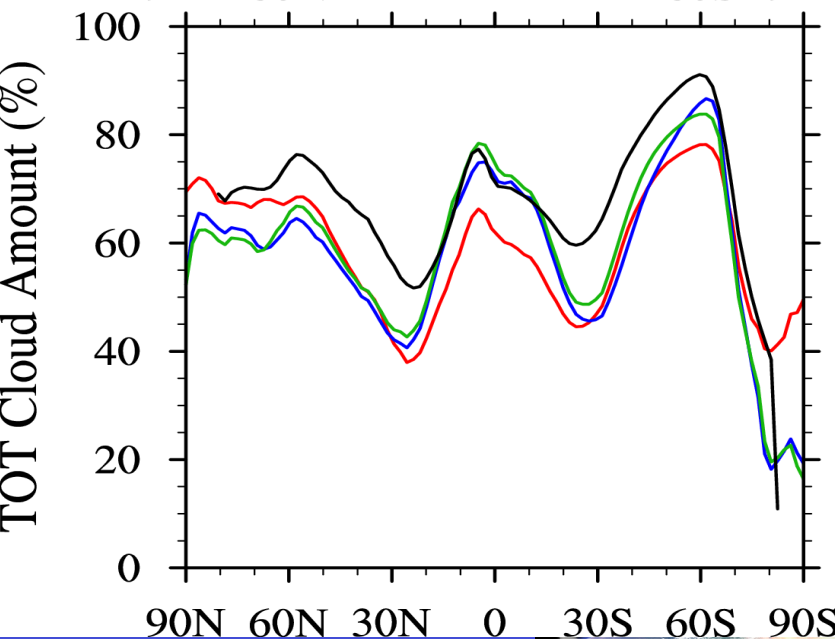
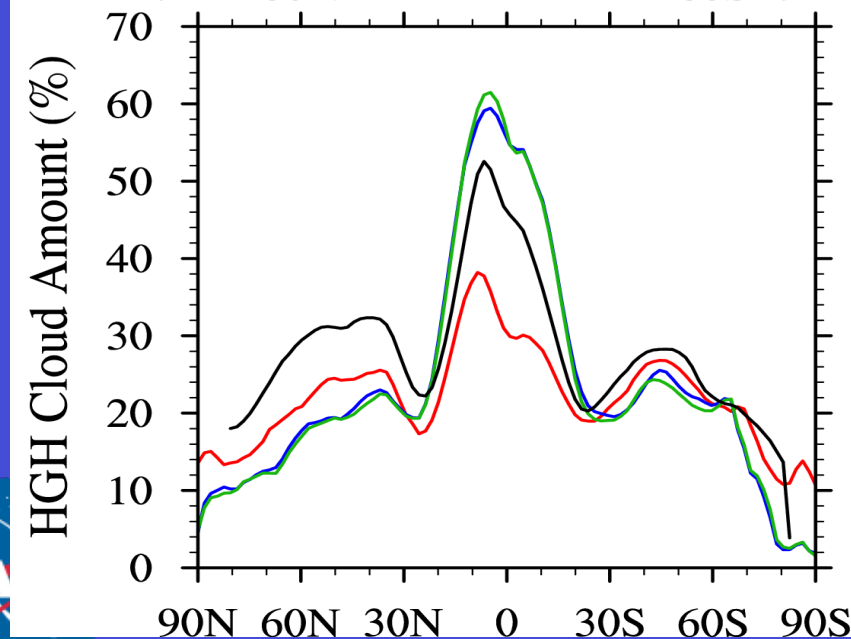
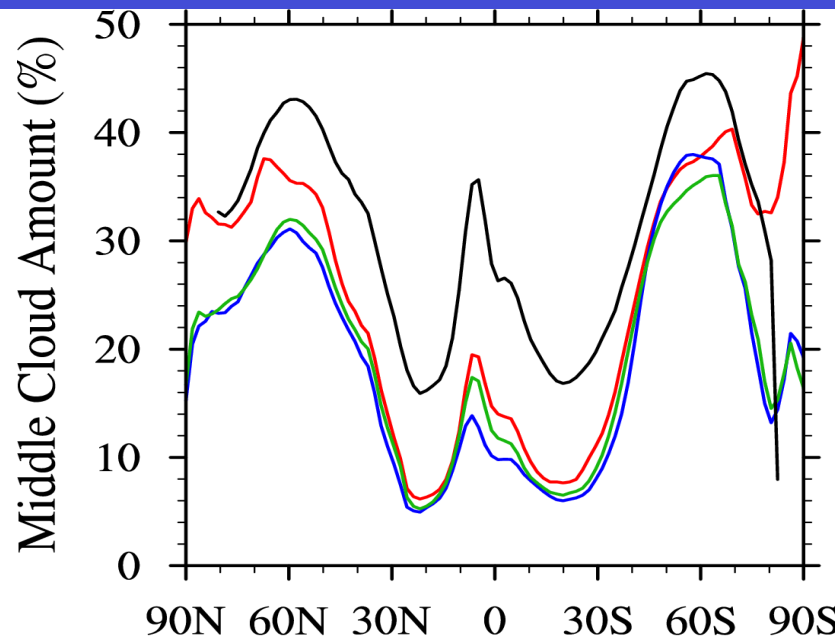
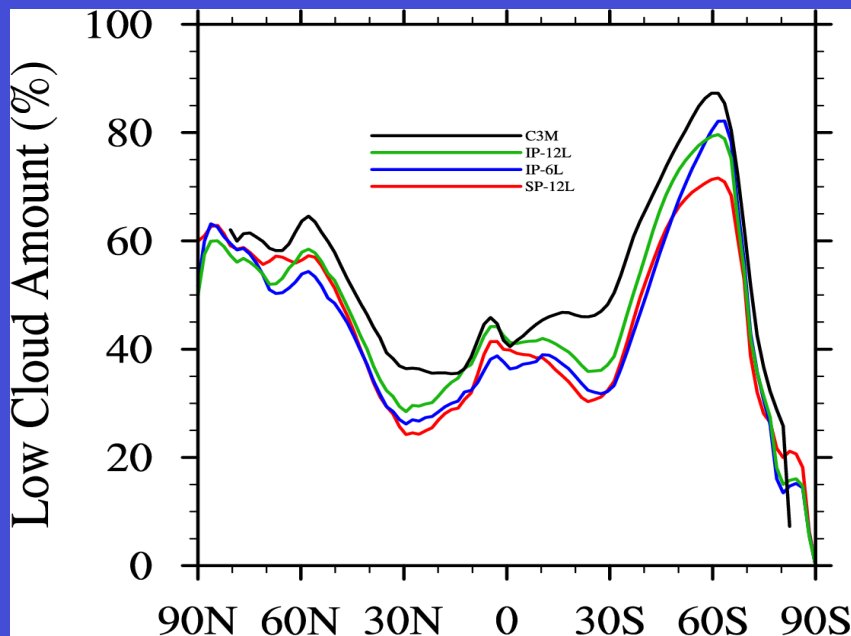




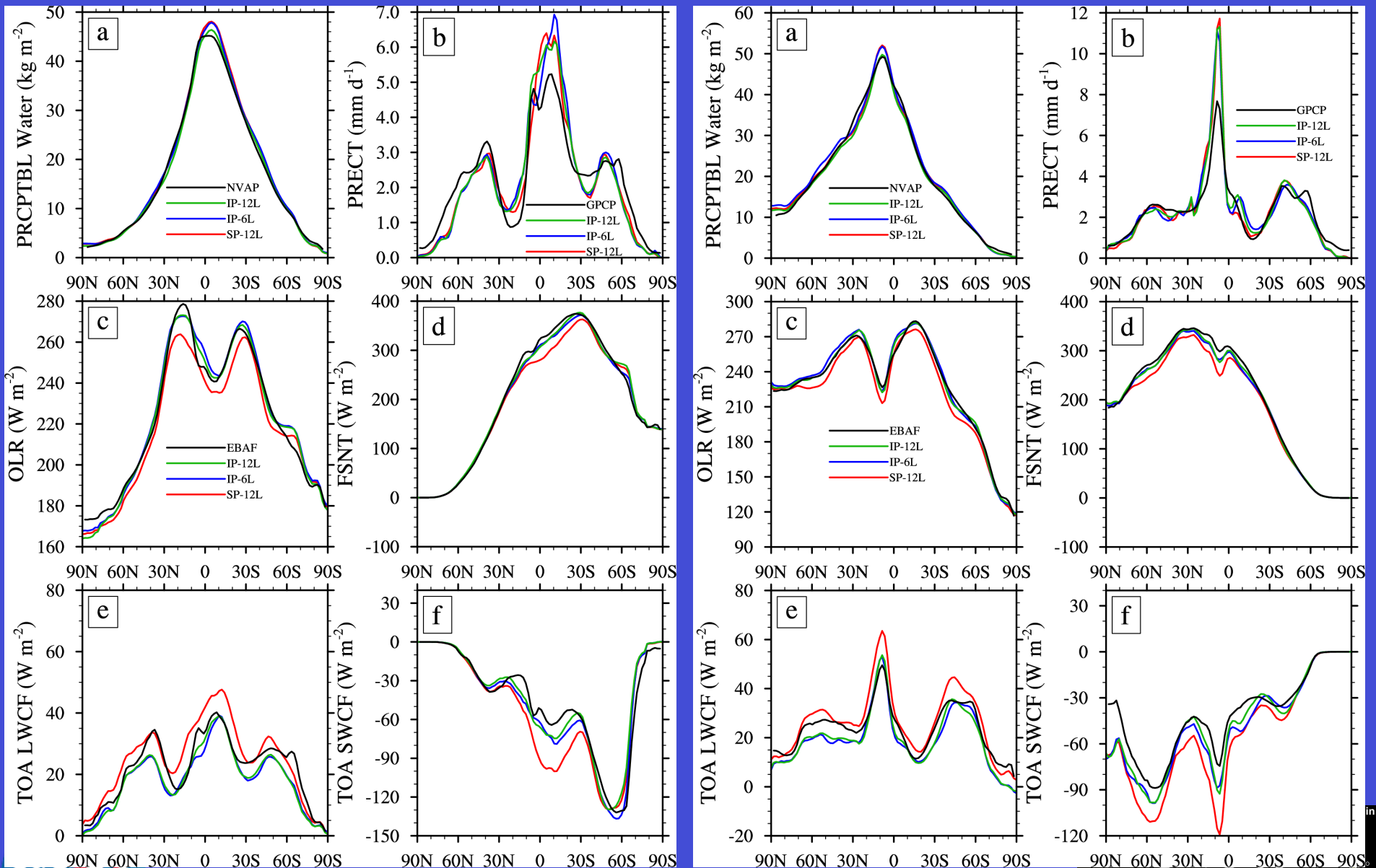
# Northern Pac. transect (GPCI) liquid+ice content



# Zonal-mean cloud amounts, MMFs vs. C3M

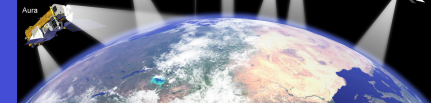


# Zonal and seasonal means, MMFs vs. C3M



DJF

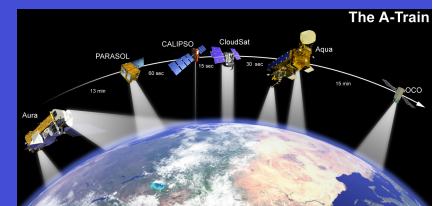
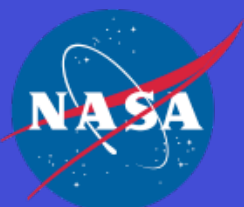
JJA



# TOA and surface energy imbalances

Experiment	SW	LW	Imbalance
SP-12L	230.4	234.5	-4.1
IP-6L	238.4	241.5	-3.1
IP-12L	240.6	240.4	+0.2
CERES Obs.	240.2	239.6	+0.6

Experiment	SW	LW	SH	LH	Imbalance
SP-12L	150.7	53.0	20.0	83.6	5.7
IP-6L	158.6	55.5	22.5	85.6	5.0
IP-12L	162.0	57.7	23.5	88.3	7.5
Observations	163.0	54.5	19.4	87.9	1.2



# Summary and conclusions

- SPCAM with 12 level below 700 hPa (SP-12L) produces a global low-cloud amount nearly identical to that of SPCAM-IPHOC with 6 level below 700 hPa (IP-6L), but smaller than IP-12L and C3M observations.
- Vertical structures of low-level clouds are improved with higher vertical resolution for both SP-12L and IP-12L.
- Similar to conventional GCMs, SPCAM produces optically thicker clouds to compensate for the lack of cloud areas (low, high and total); cloud radiative forcings are overestimated, but both TOA SW and LW fluxes are underestimated.
- All simulations have various amounts of energy imbalances at TOA and surface, which should be fixed for long-term and/or coupled model simulations.
- SP-12L would be ideal for coupled model simulations due to its improvement in low cloud simulations, compared to the standard resolution SPCAM.

