Two year simulations of Super-CAM with a third-order turbulence closure in the embedded CRM

Anning Cheng[1] and Kuan-Man Xu [2]

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

Thank Marat Khairoutdinov for providing SPCAM, initial condition, and forcing data

Outline

- A short introduction of intermediate prognostic higher-order turbulence closure (IPHOC)
- Experiment design: application of IPHOC to MMF
- Expected improvements and results

Intermediately Prognostic Higher-Order Closure Model

- Double-Gaussian distribution of liquid-water potential temperature, total water mixing ratio and vertical velocity
- Skewnesses of these three third-order moments predicted
- All first-, second-, third- and fourth-order moments, subgrid-scale condensation and buoyancy based on the same probability distribution function
- Extensively tested with GCSS and ARM cases

Application of IPHOC to Climate Models

Used in MMF and CRM to compare against observations

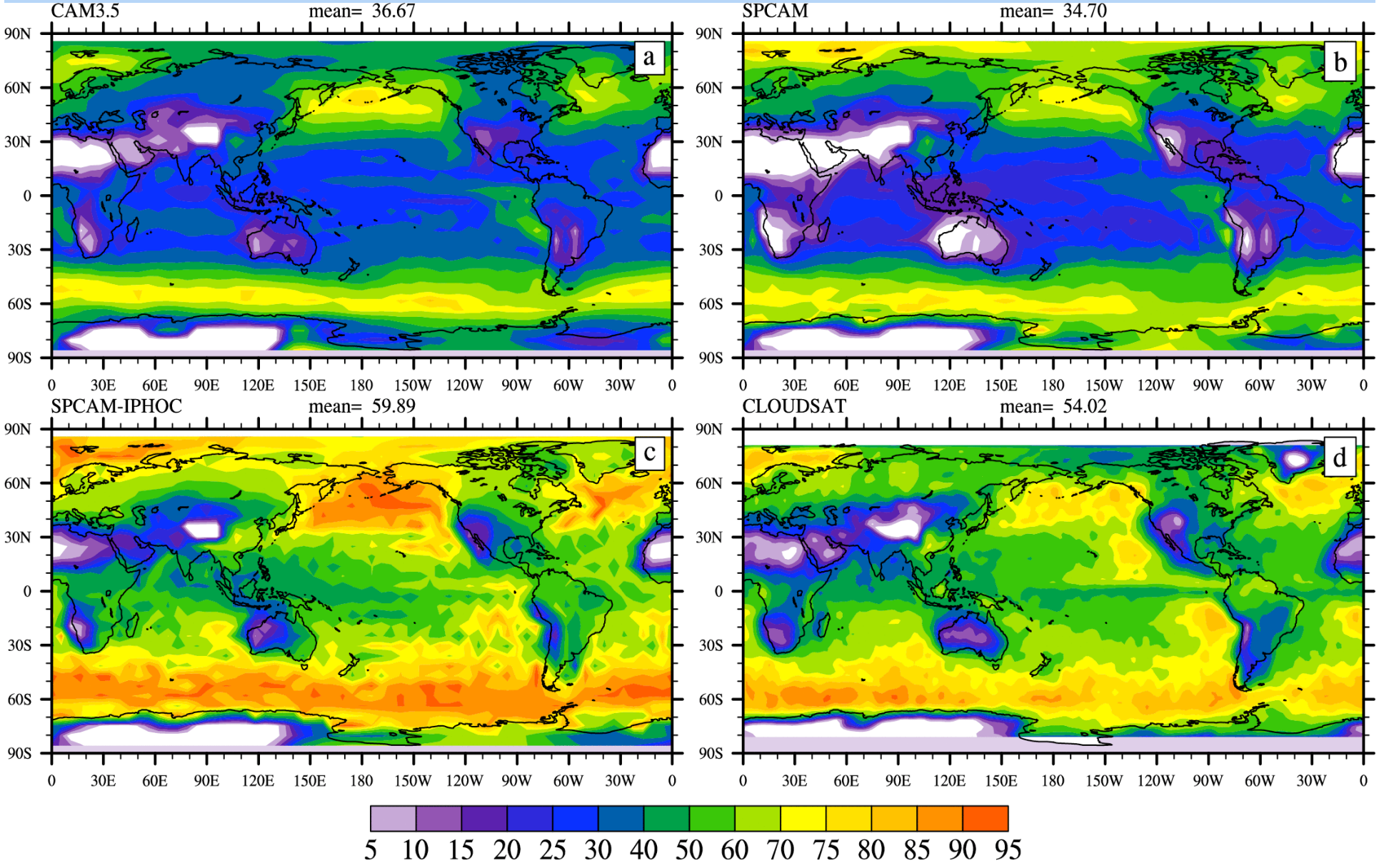
Expected improvements:

1) BL cloud amount and global distribution
2) Diurnal cycle
3) Low cloud and radiation feedbacks
4) Microphysics and turbulence
5) Surface fluxes --> MJO

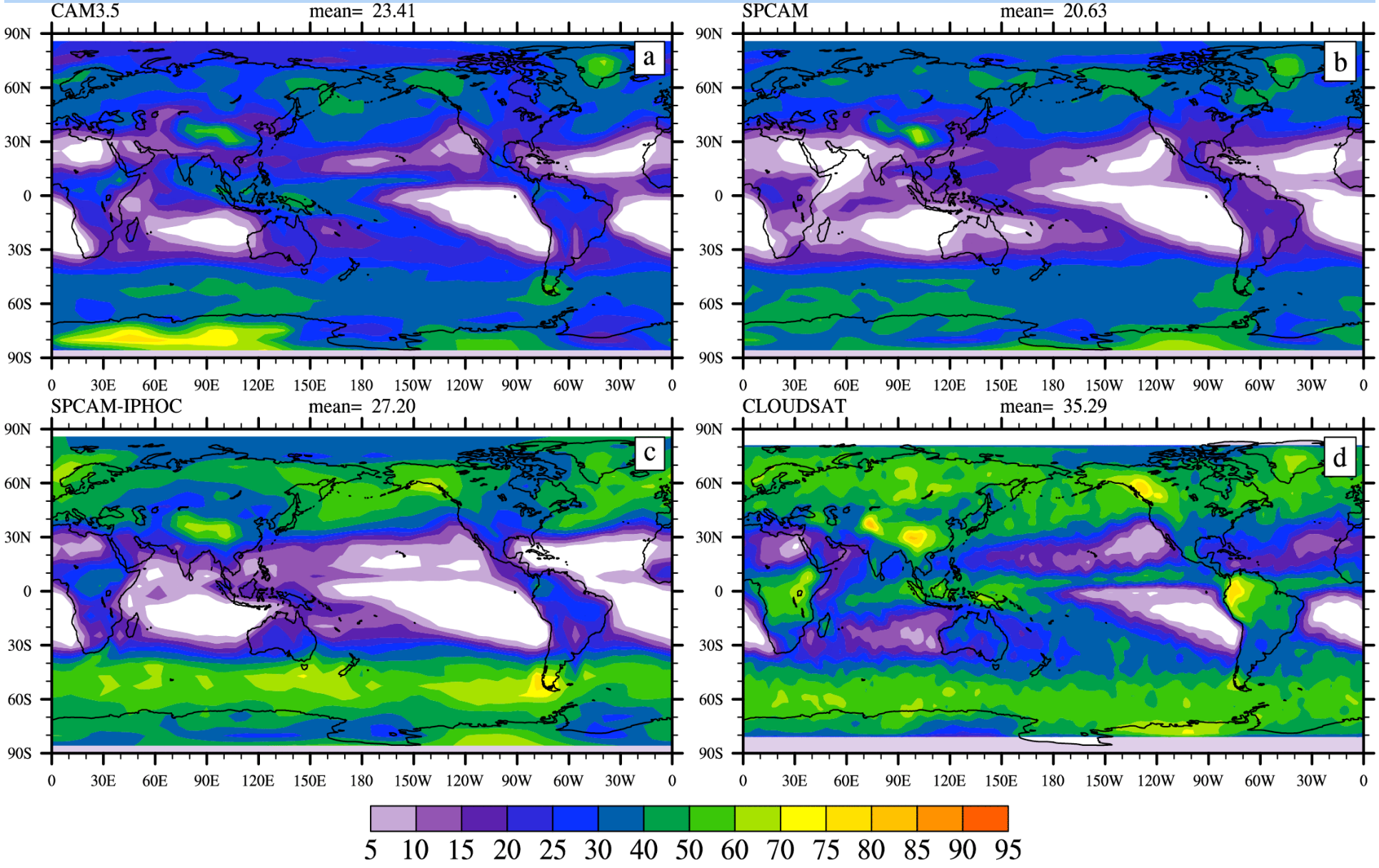
Experiment Design

- Standard initial condition and forcing for CAM3.5, beginning at September 1, 1990
- T21 with 26 levels in vertical direction
- Integration time: 2 years for CAM3.5, SPCAM with a first-order closure, and SPCAM with IPHOC, respectively
- Computation cost: 200,000 service units from NCAR BlueGene

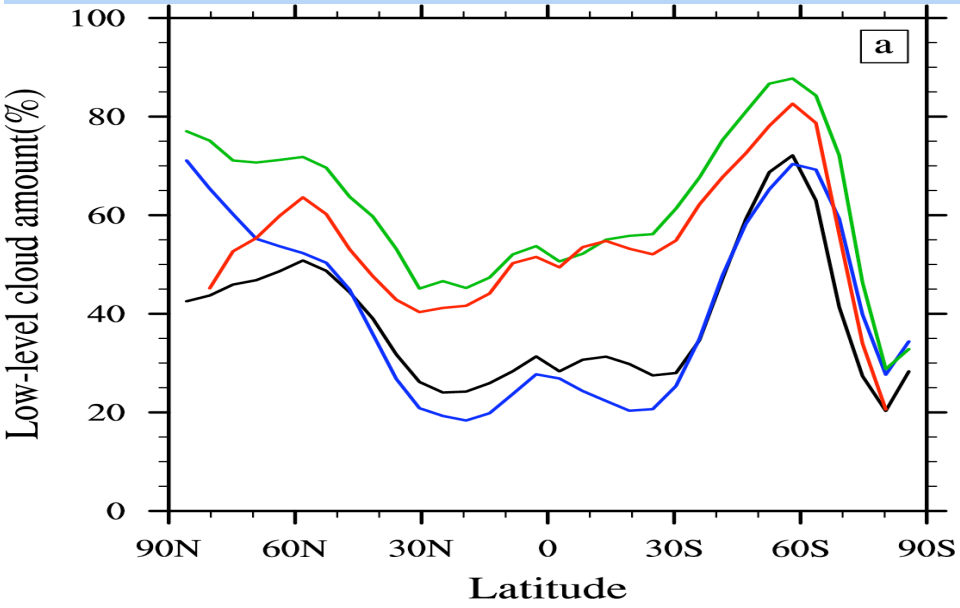
Global Annual-Mean Low Clouds

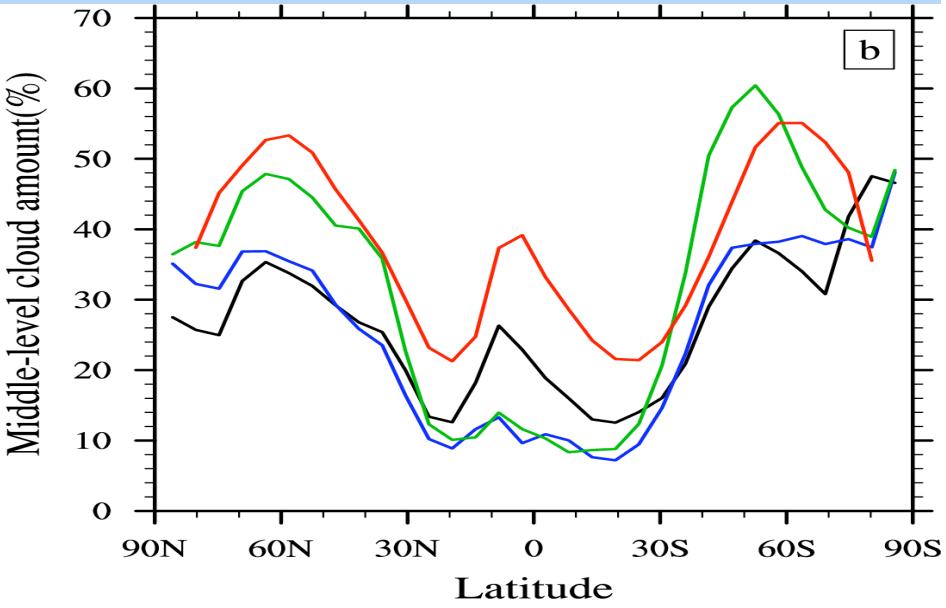


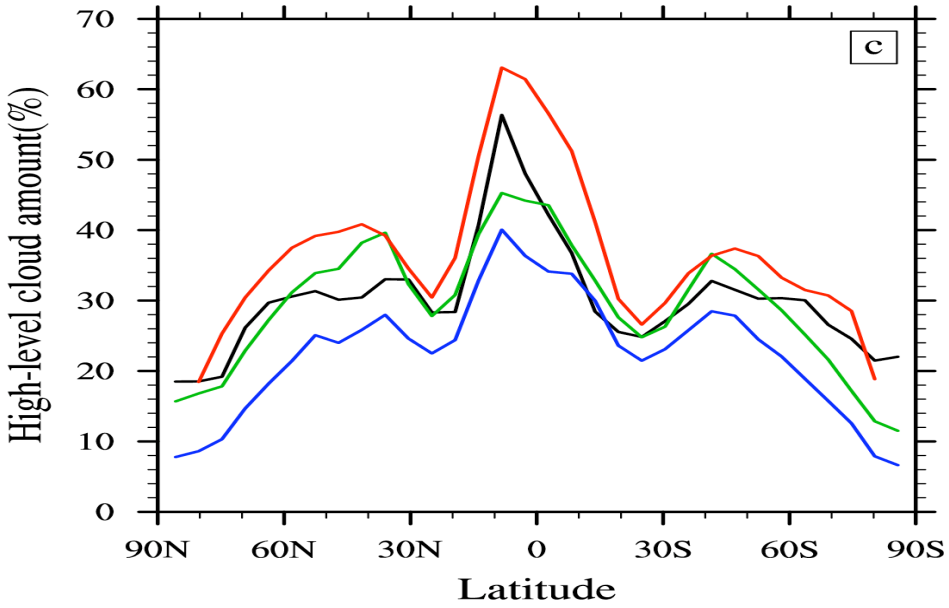
Global Annual-Mean Middle Clouds

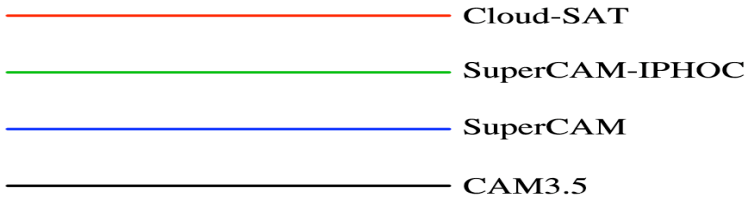


Annual-Zonal-Mean Clouds

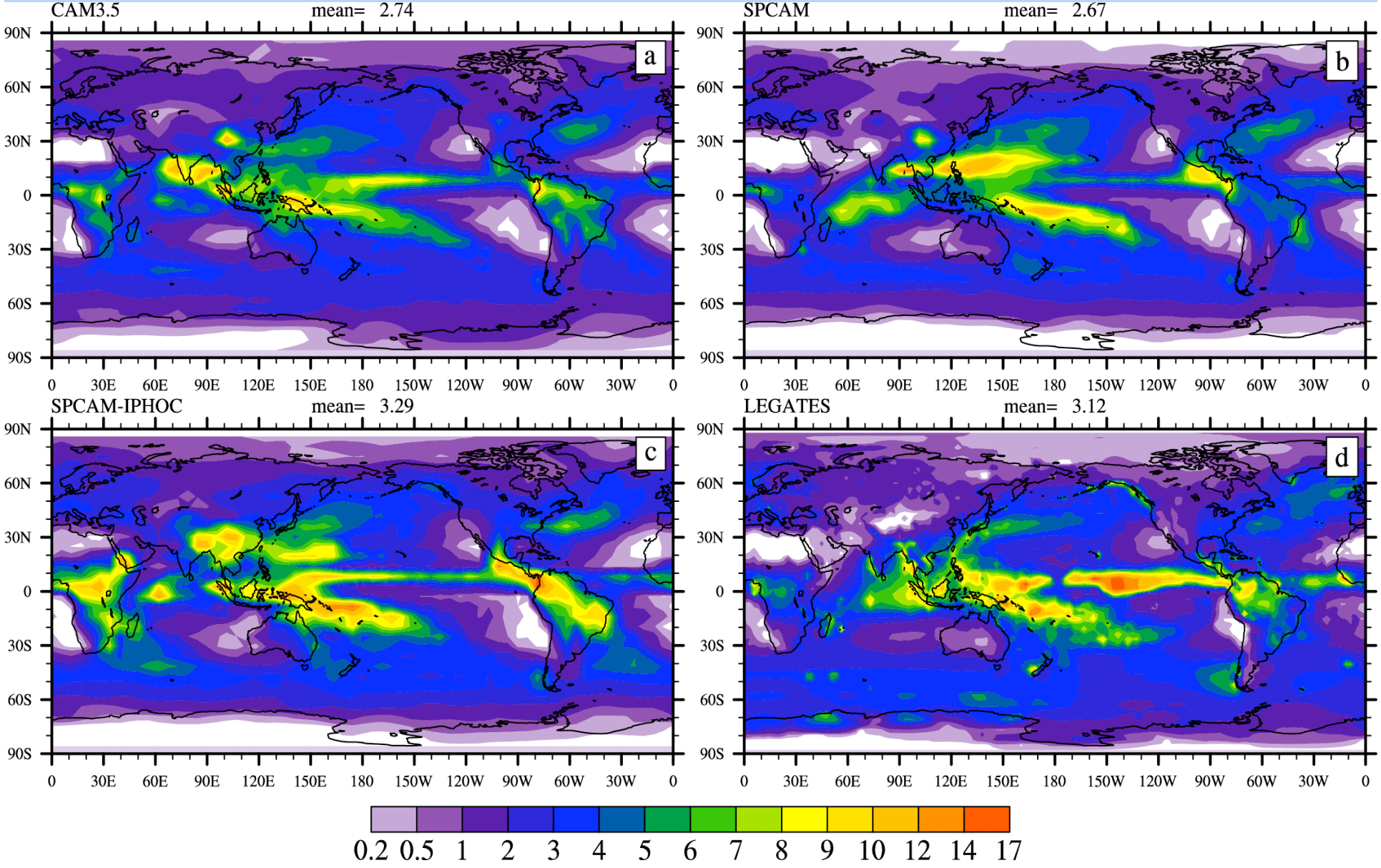




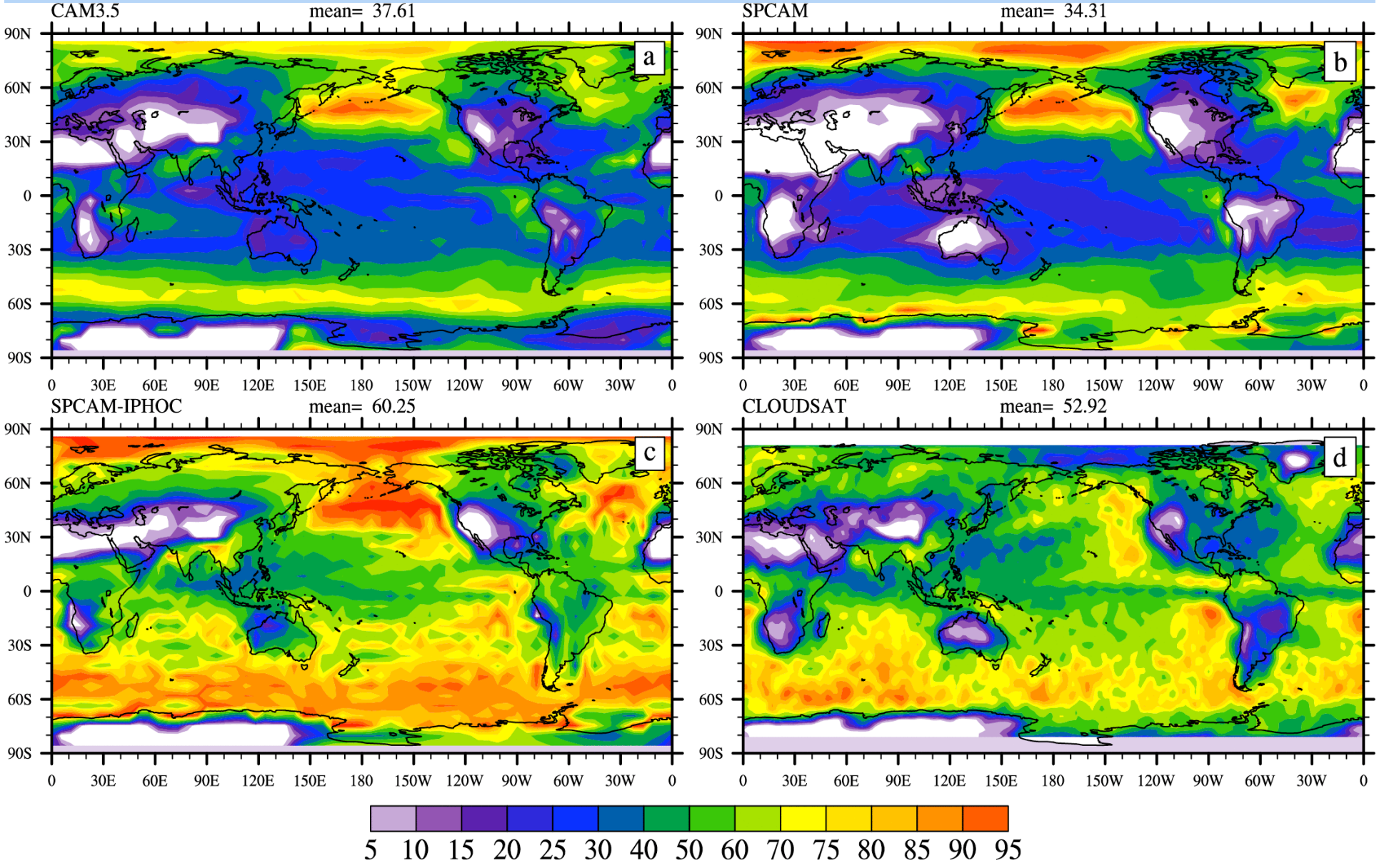




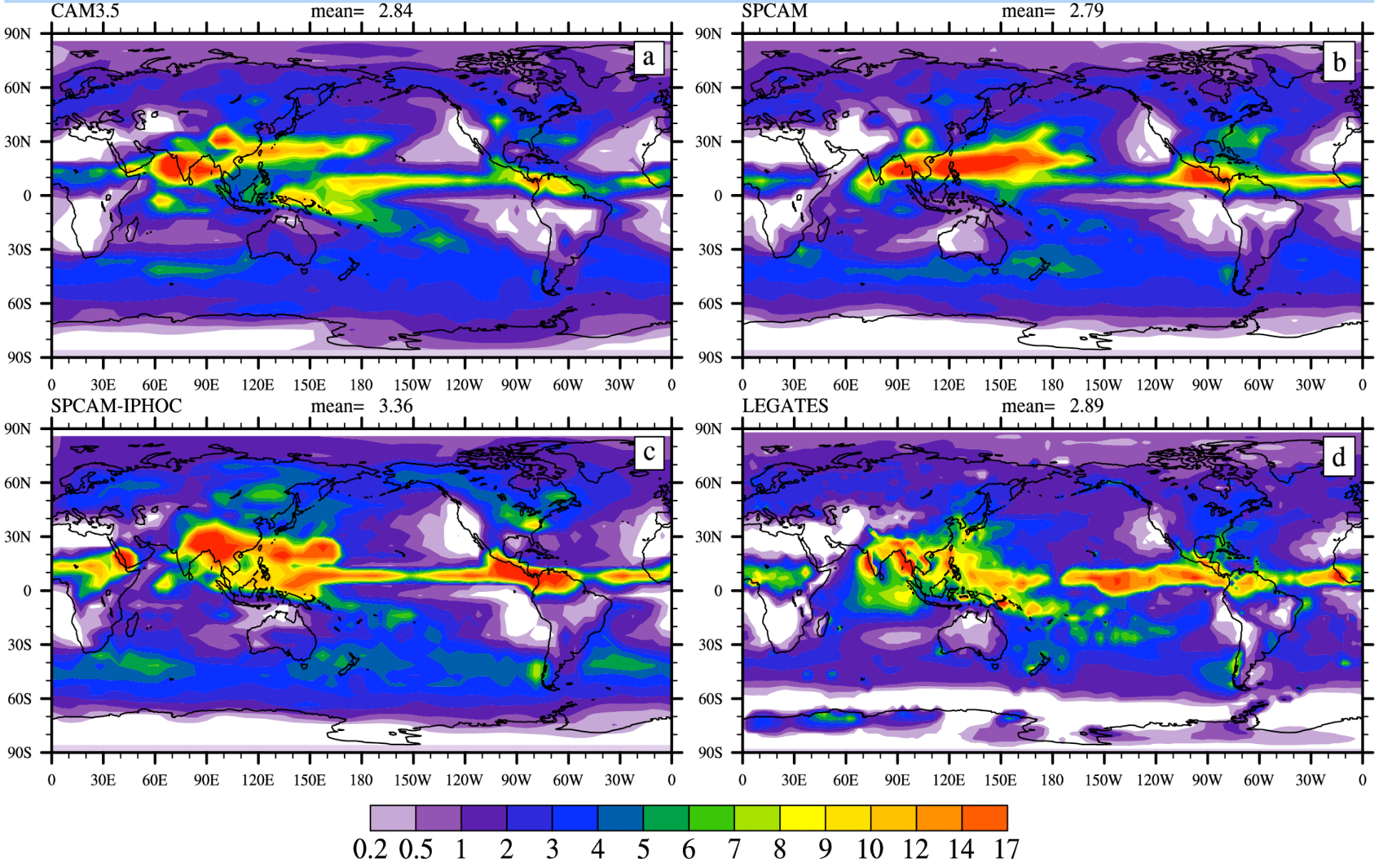
Annual-Mean Precipitation



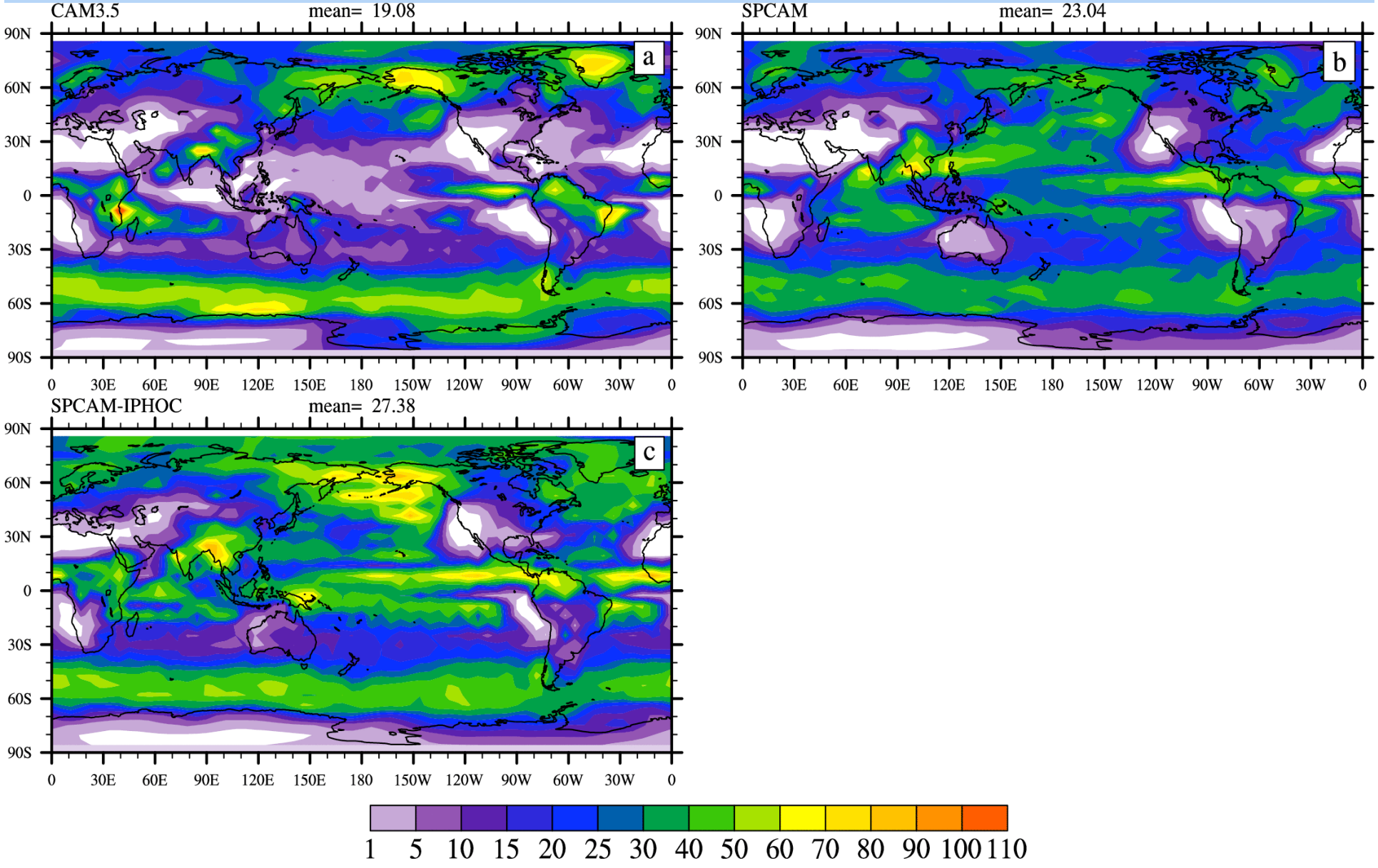
JJA Low Clouds



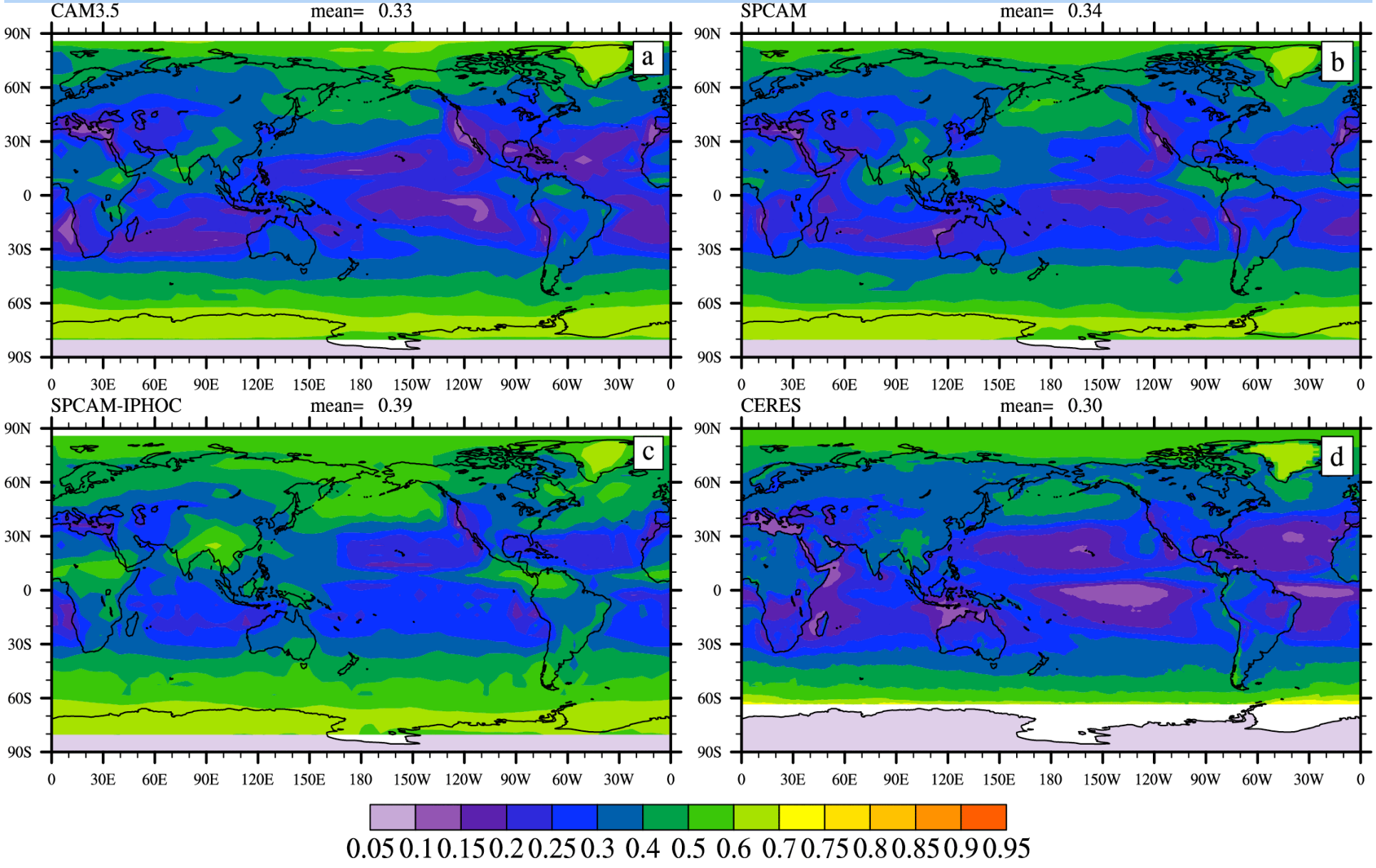
JJA Precipitation



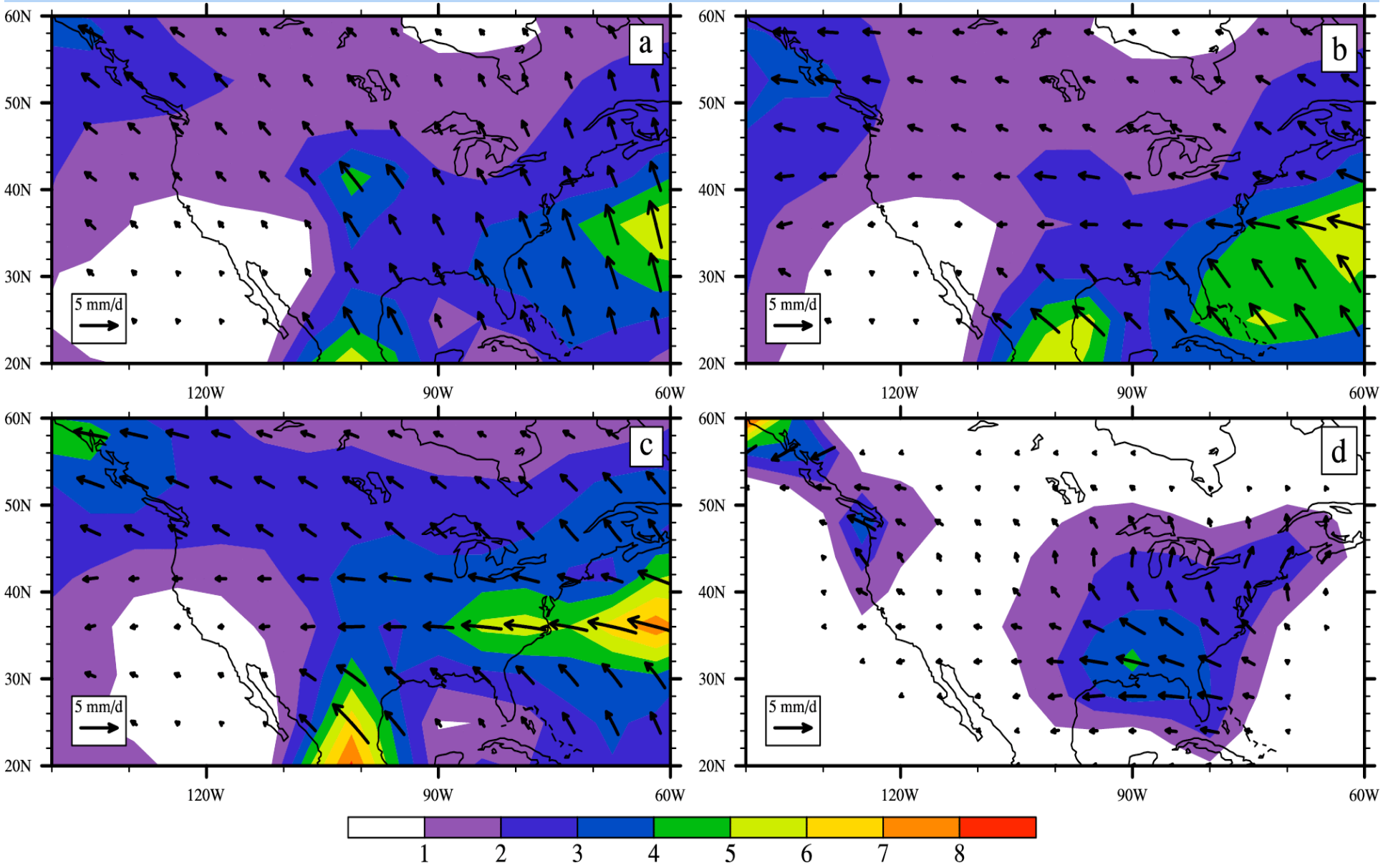
JJA Low Cloud LWP



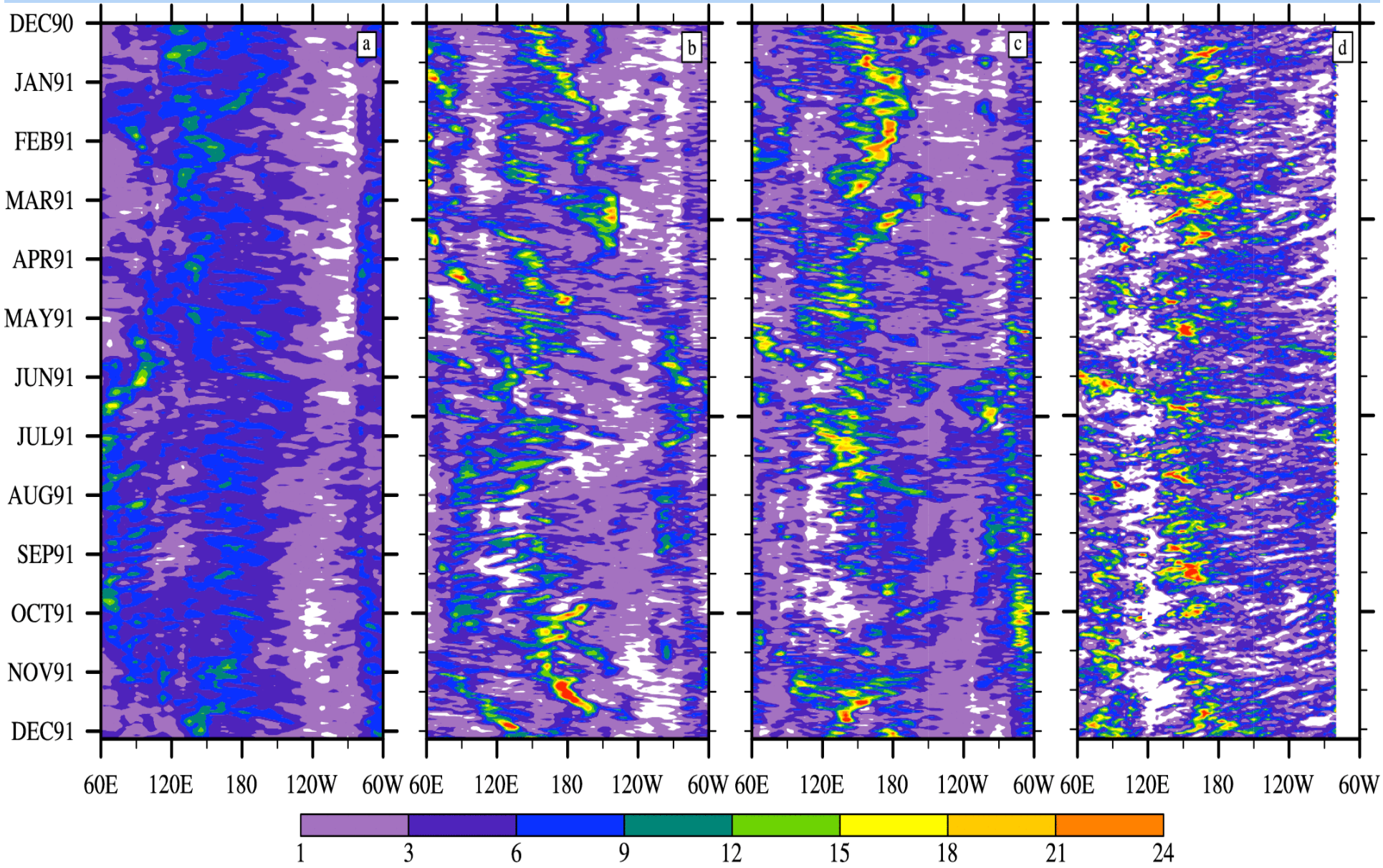
JJA Albedo


CAM3.5
mean= 0.33
a
SPCAM
mean= 0.34
b
SPCAM-IPHOC
mean= 0.39
c
CERES
mean= 0.30
d
90N
60N
30N
0
30S
60S
90S
0 30E 60E 90E 120E 150E 180 150W 120W 90W 60W 30W 0
0.05 0.1 0.15 0.2 0.25 0.3 0.4 0.5 0.6 0.7 0.75 0.8 0.85 0.9 0.95

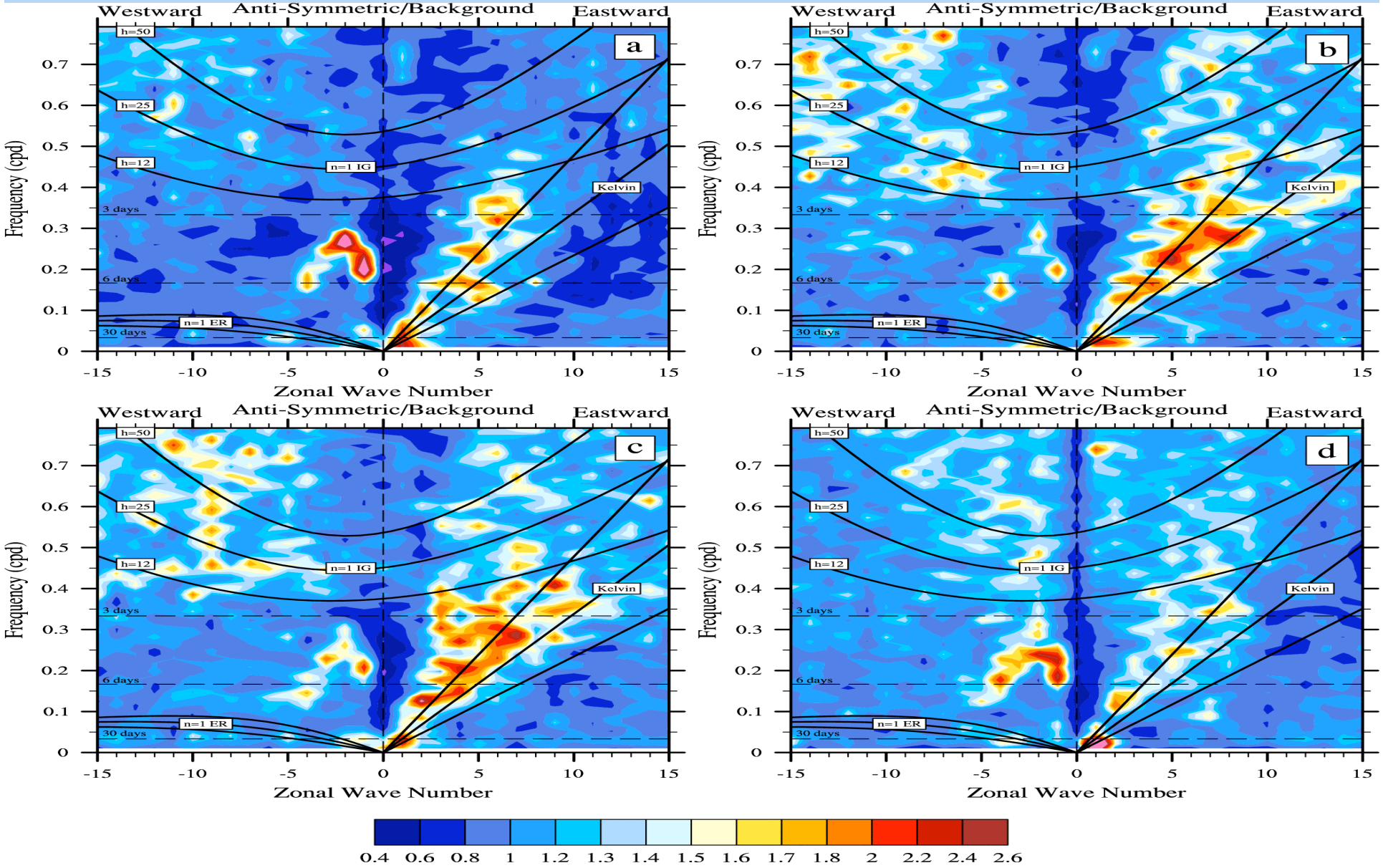
Diurnal Cycle in North America



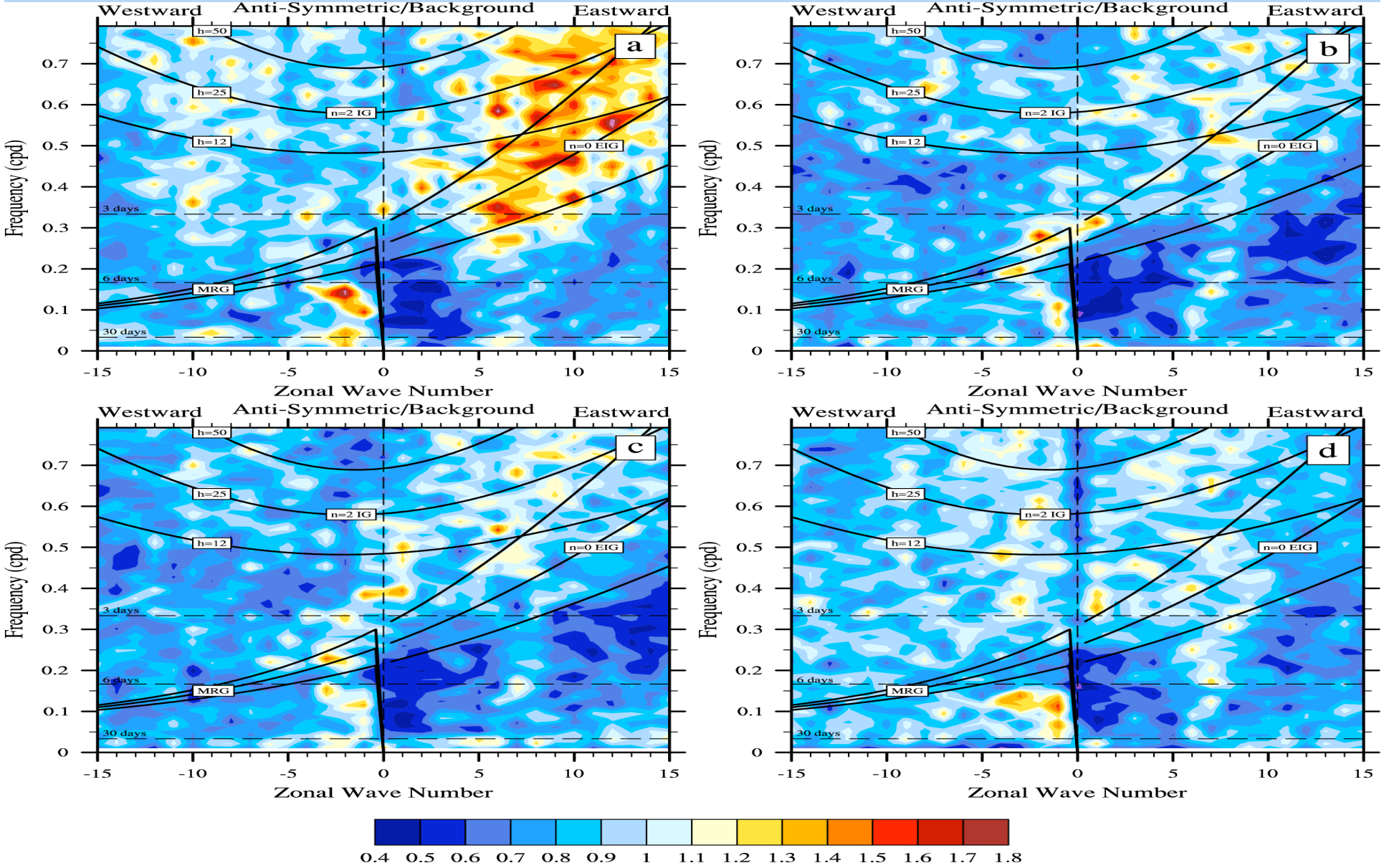
Hovmöller Diagrams for Tropical Daily Precipitation



Symmetric Power Spectra of U Wind at 850 hPa



Antisymmetric Power Spectra of U Wind at 850 hPa



Summary

- CRM with IPHOC was embedded in CAM3.5 and integration for two years. The results were compared with those from SPCAM with a first-order turbulence closure, and those from CAM3.5
- Representation of low-cloud amount shows substantial improvement compared with CloudSat
- Some improvements can also be seen from the representation of middle latitude storm track, diurnal cycle, and MJO.