A Regional Atmospheric Inter-Model Evaluation Project (RAIMEP) with the Focus on Sub-daily Variation of Clouds and Precipitation

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Outline

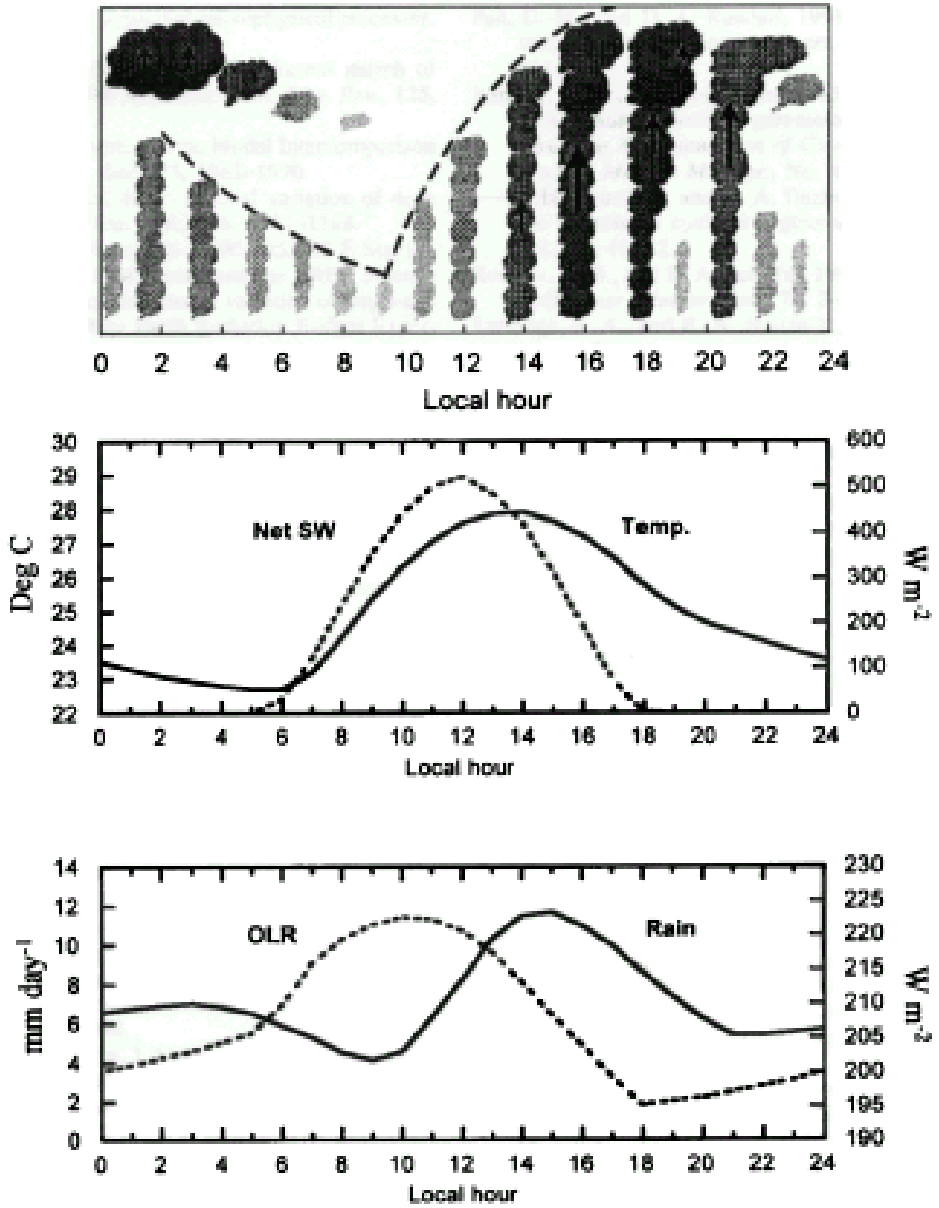
- Motivation
- Observed diurnal variations of clouds and precipitation
- Mechanisms
- Performance of current atmospheric models
- Some issues and the RAIMEP project

Motivation

- Diurnal cycle is a fundamental component of variability of the global climate system;
- Diurnal cycle of clouds and precipitation is important to both weather and climate;
- Diurnal cycle of clouds and precipitation affects the partitioning of precipitation between convective and stratiform, and between the land and the ocean;
- An accurate representation of the amplitude and phase of diurnal cycle provides a key test of many aspects of the physical parameterizations in an atmospheric model;
- Current AGCMs have deficiencies in simulating the diurnal cycle of clouds and precipitation.

Observed diurnal variations of clouds and precipitation

- Over the open ocean, maximum rainfall occurs in the early morning; over the land, a late afternoon/early evening maximum is prevalent;
- Diurnal variations are generally believed to have striking geographic patterns due to prevailing local circulations, topography, land-sea contrast, etc.;
- There are coherent propagating signals of diurnal cycle, related to the convectively generated gravity waves.



A descriptive model showing the diurnal cycle of convection over land

From Lin et al. (2000)

Mechanisms over ocean

- Direct radiation-convection interactions;
- Radiation-dynamics interactions;
- Diurnal cycle of SST;
- Atmospheric thermodynamics;
- Remote control of continents;
- Large-scale thermally driven atmospheric tides.

Models being checked

- GCMs

  Canadian Climate Center's AGCM (Zwiers and Hamilton 1986);

  Japanese MRI GCM (Yagai 1987; 1989);

  CSU GCM (Randall et al. 1991; Lin et al. 2000);

  NCAR CCM2 (Lieberman et al. 1994; Chen et al. 1996); CCM3 (Dai 2002); CCSM (Dai and Trenberth 2003);

  UK UM HadAM3 (Yang and Slingo 2001; Neale and Slingo 2003).

- Global NWP models

  ECMWF model (Betts and Jakob 2002).

- Mesoscale regional models

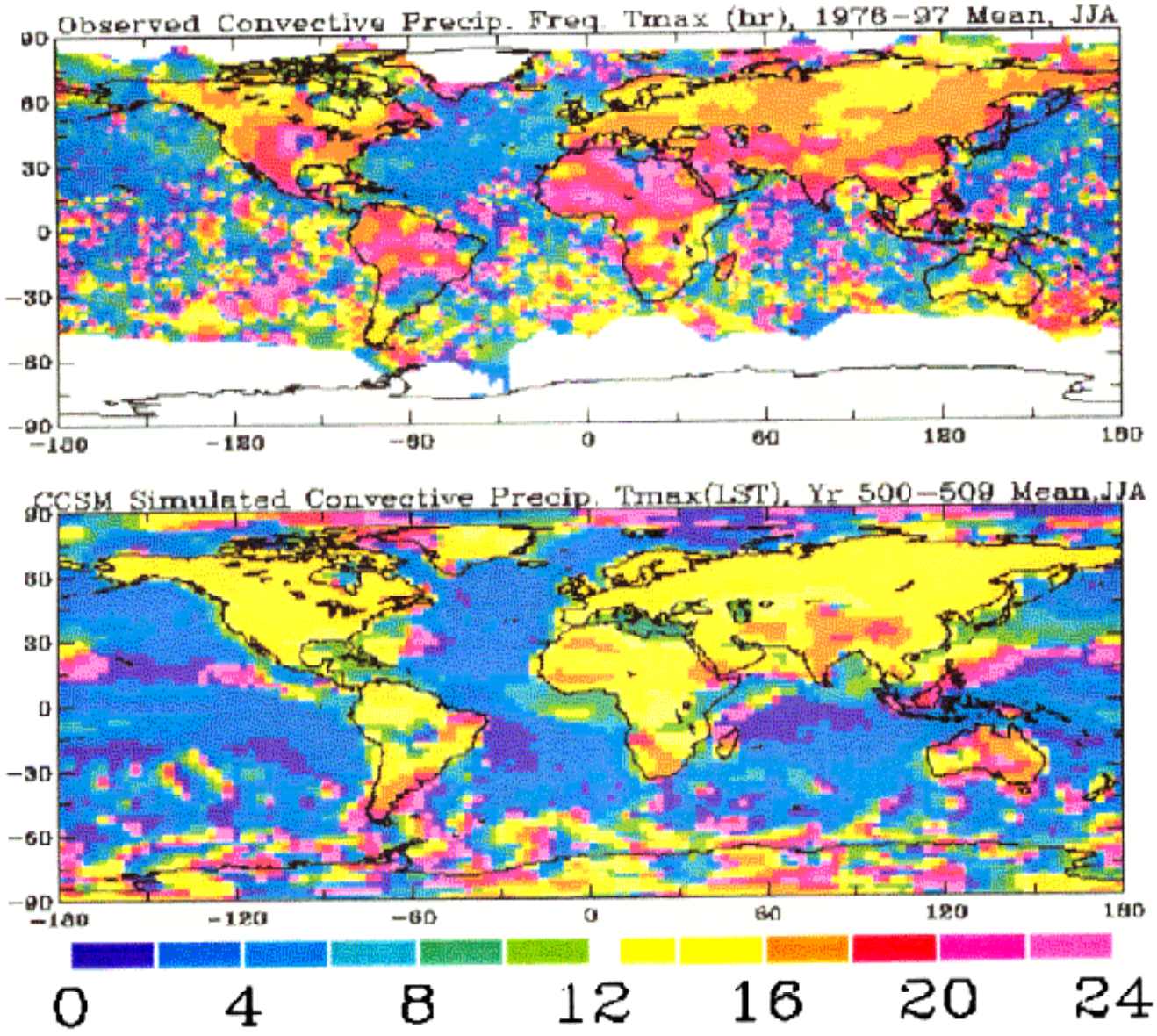
  NCAR RegCM2 (Dai et al. 1999), WRF and NCEP Eta models (Davis 2003); IPRC-RegCM (in this talk).

A summary of current model performance

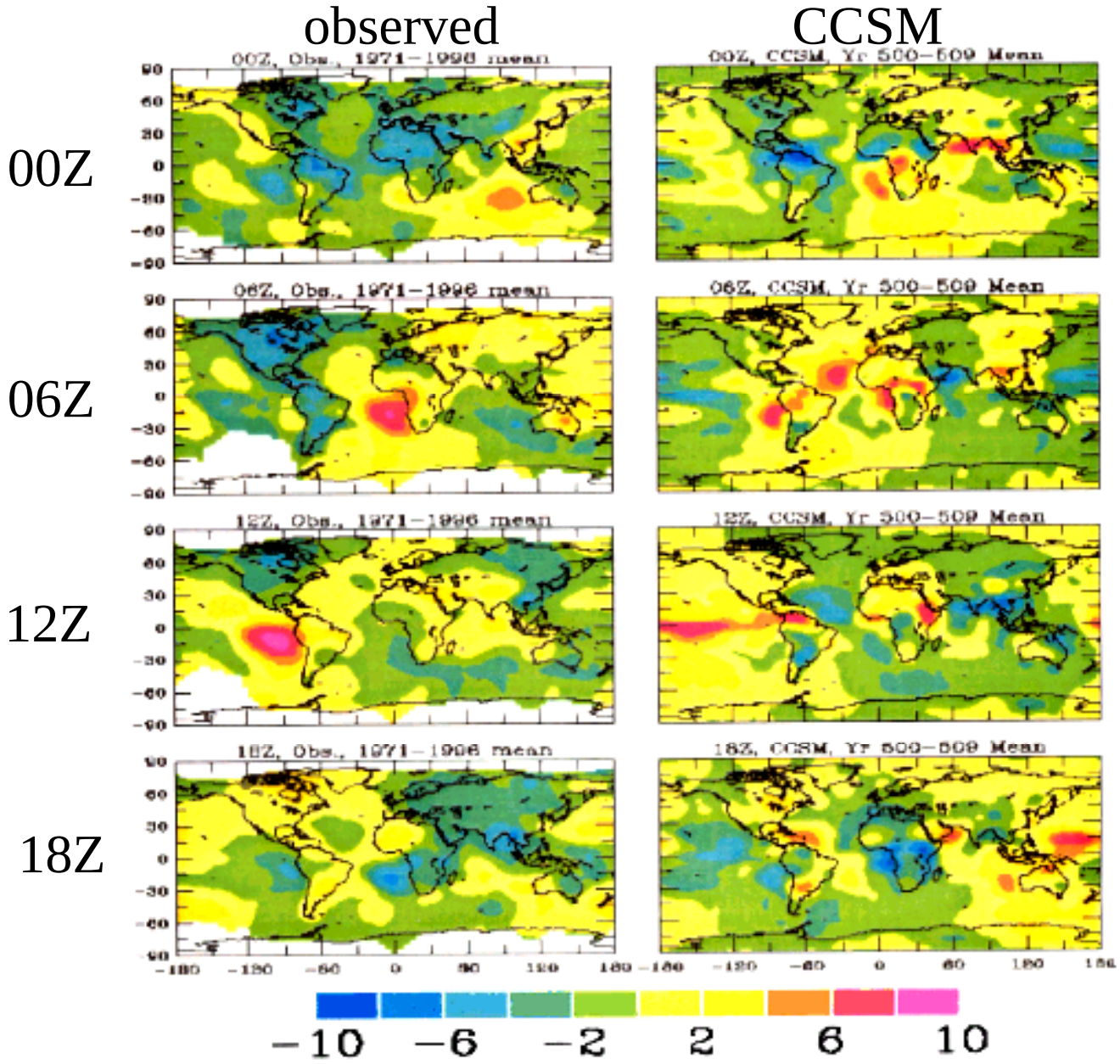
- All models can simulate the diurnal variation of clouds and precipitation to some degree, but with considerable discrepancies;
- Most of the models produce too early convective precipitation maximum both over land and over ocean by 2-3 hours, except for the CSU GCM, which gives lagged precipitation maximum by 2-3 hours;
- The amplitude of diurnal variation is too large over the land, but too small over the ocean;
- So far, no insights into the discrepancies have been elucidated although some efforts are being started.

Obs.

CCSM



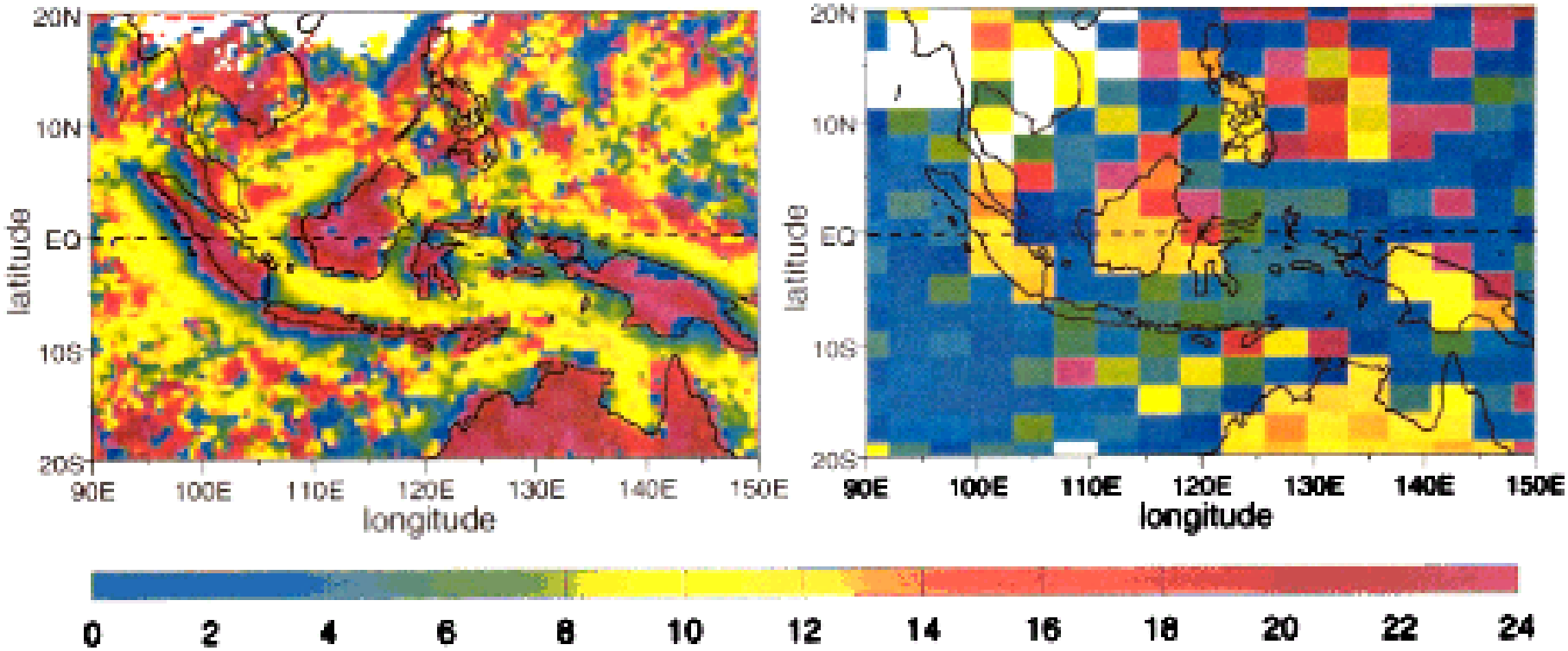
The local solar time of the maximum of diurnal harmonic of JJA convective precipitation frequency based on weather report and of that from CCSM (Dai and Trenberth 2003)



Mean DJF diurnal anomalies of observed (left) and CCSM simulated (right) Total cloud amount (10%) at 00, 06, 12, 18 UTC. (Dai and Trenberth 2003).

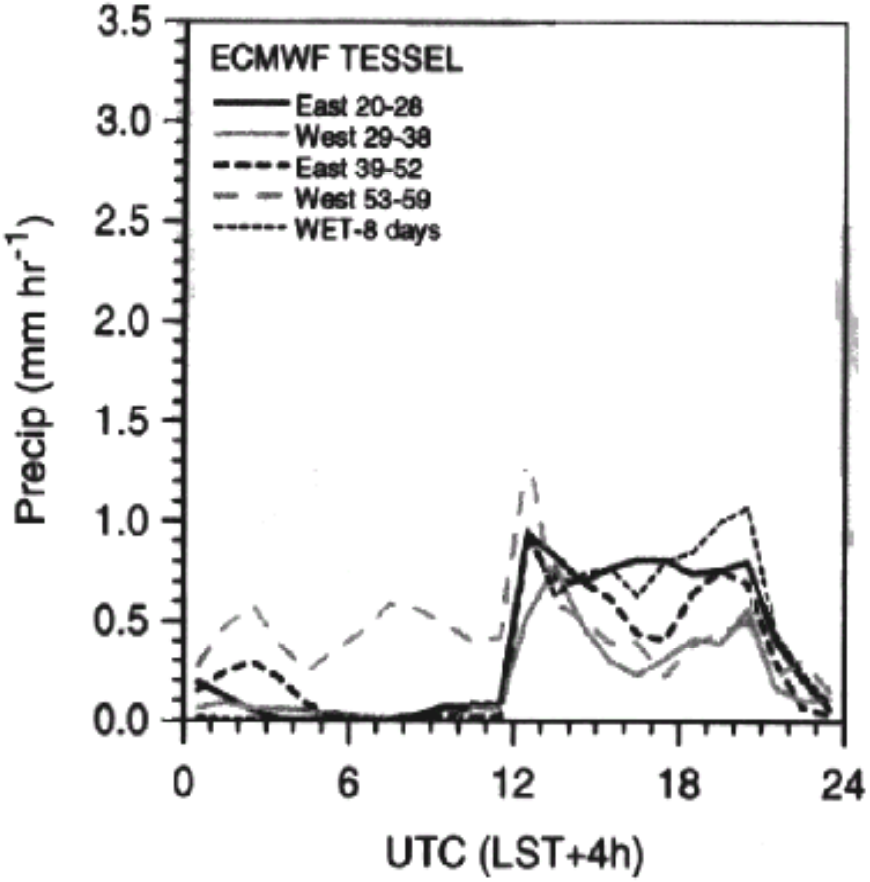
(a) Observed

(b) AMIP II

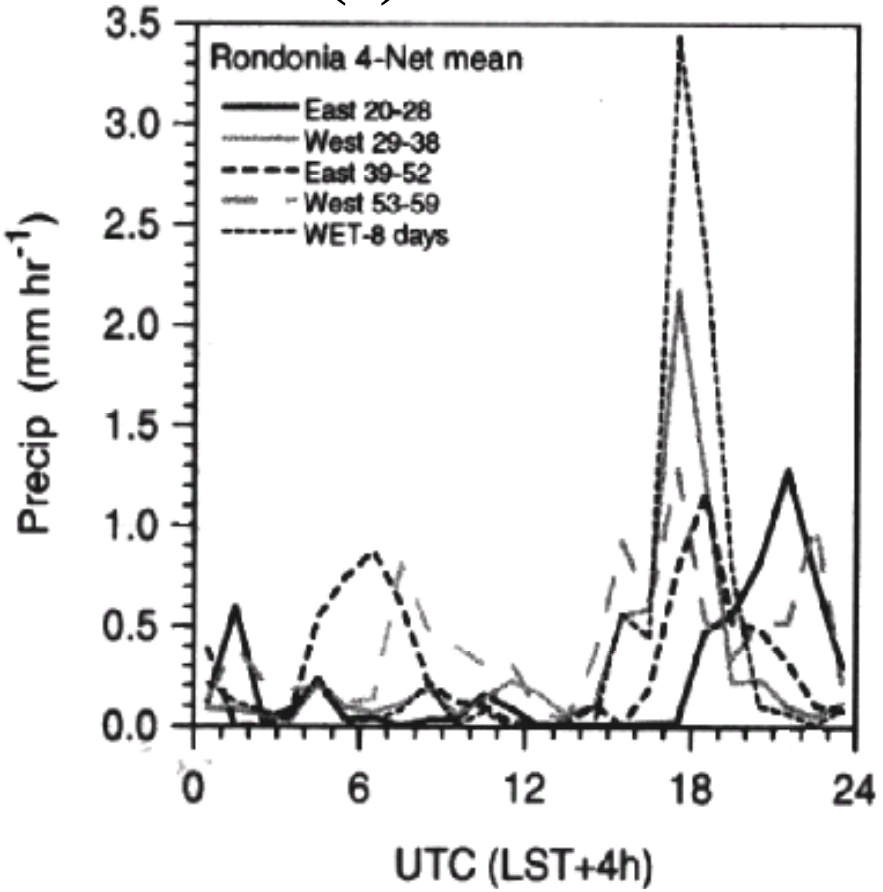


Local time of the maximum in the diurnal cycle of precipitation over the Maritime Continent: (a) observed and (b) AMIP II simulated, from Neale and Slingo 2003

(a) ECMWF Model



(b) Observed

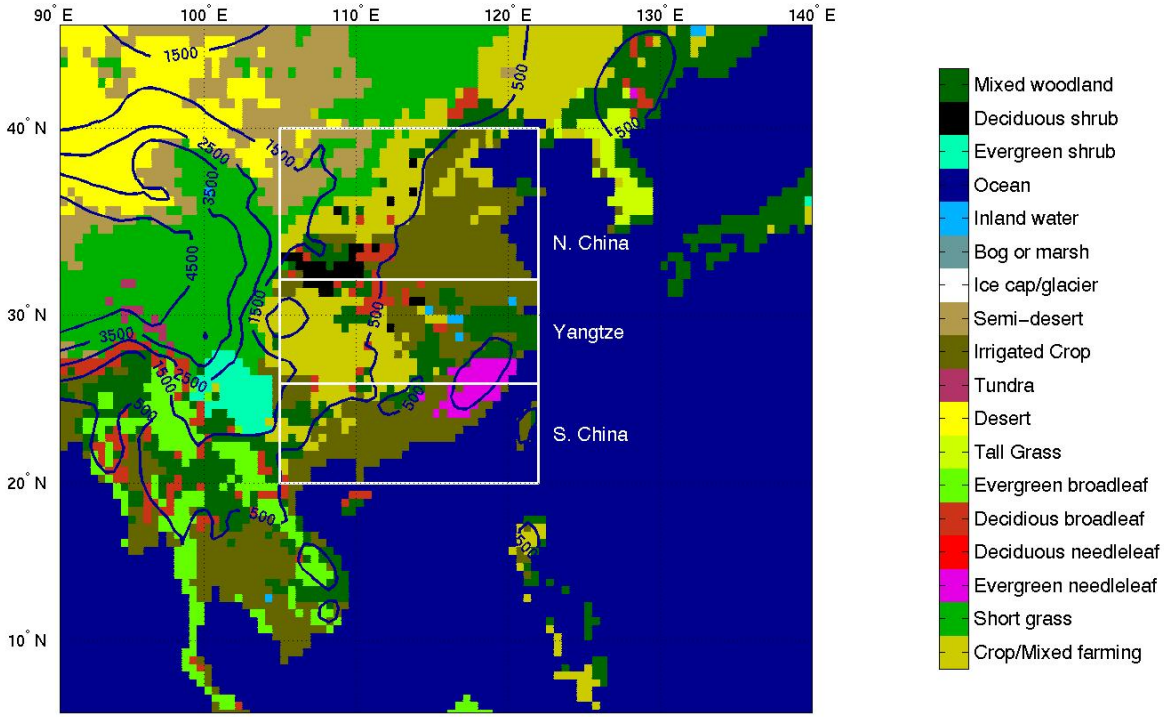


Mean diurnal cycle of precipitation over Rondonia for five convective Classifications for current ECMWF model (a) and observed (b).

From Betts and Jakob (2002).

RCM simulation from IPRC-RegCM

Model Topography and vegetation types



Time integration: 00Z 26 April through 31 August 1998

Model resolution: 0.5^{o} by 0.5^{o} with 28 vertical levels

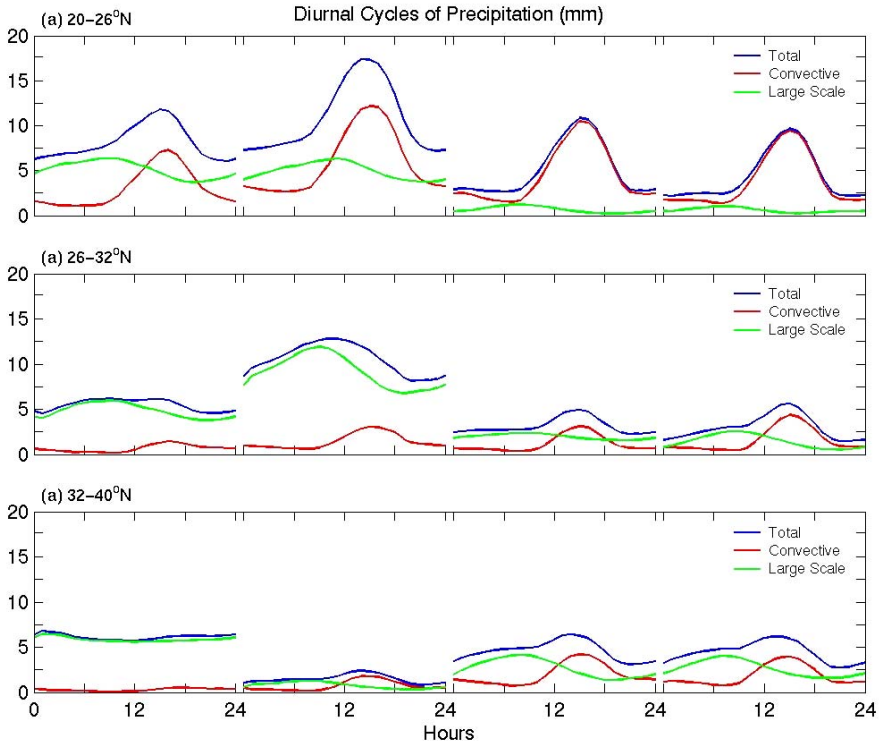
Initial condition: ECMWF analysis (2.5^{o} by 2.5^{o} with 14 p-levels, twice daily)

Lateral boundary condition: ECMWF analysis (interpolated in space and time)

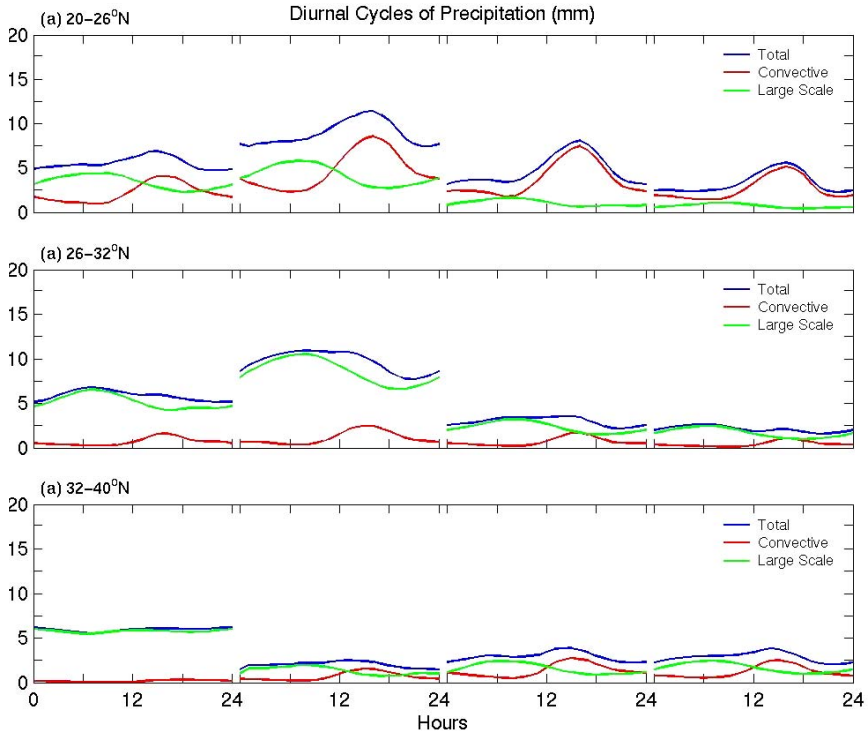
SST: Reynolds weekly SST (1^{o} by 1^{o})

Buffer zone: 5^{o} exponential function

Control experiment



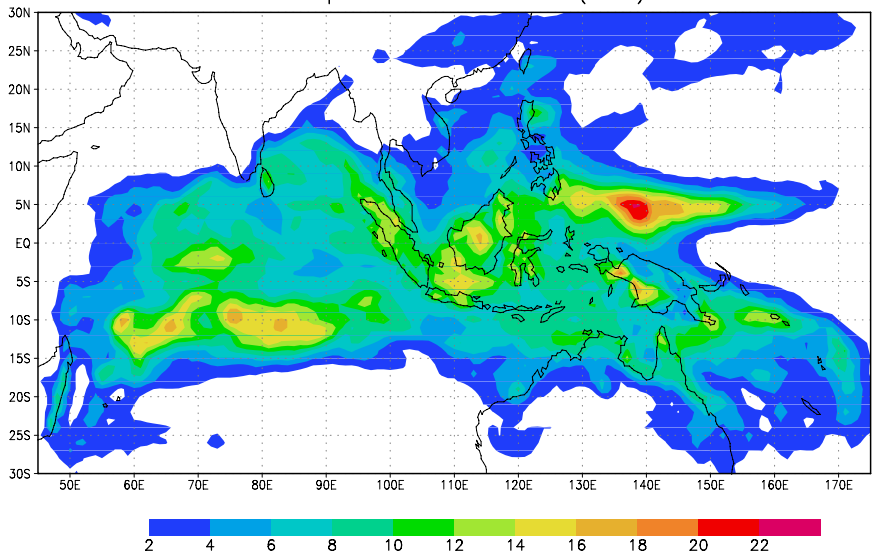
With no shallow convection



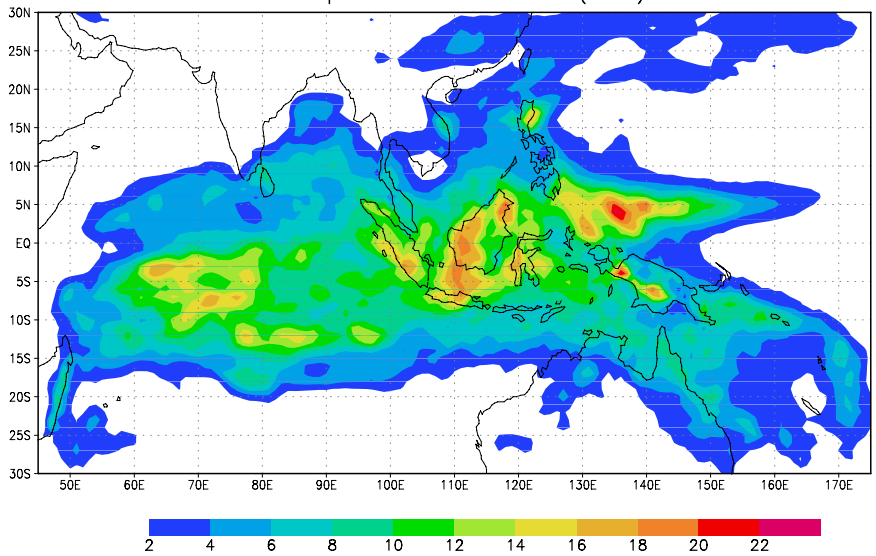
Some Issues

- How can the convective and stratiform precipitation be defined accurately from observations and models?
- What are the dominant mechanisms responsible for the diurnal cycle of clouds and precipitation?
- What causes discrepancies in simulating the diurnal cycle in atmospheric models?
- How can we improve the simulation of diurnal cycle by atmospheric models?
- How important is the diurnal cycle of clouds and precipitation in determining the mean climate and climate variability?
- Can our RCM community help address these issues?

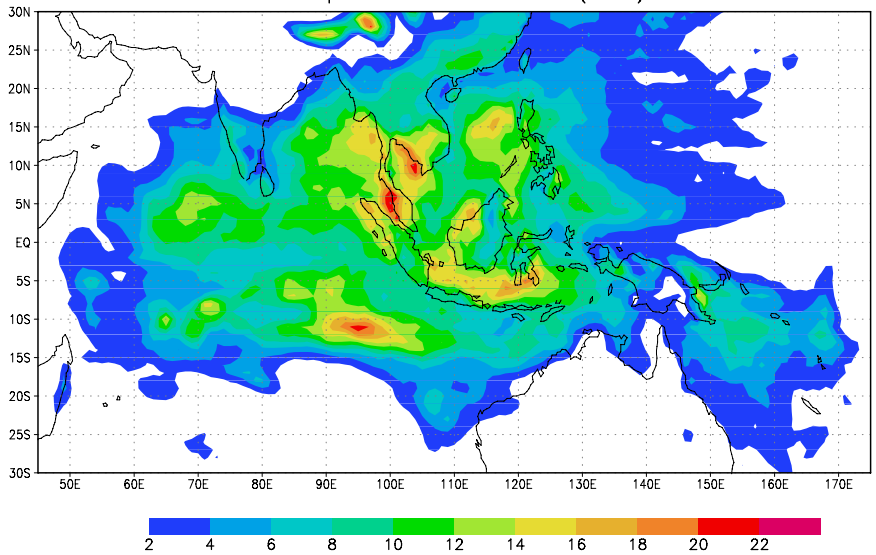
Precipitation for RCM1 (JFM)



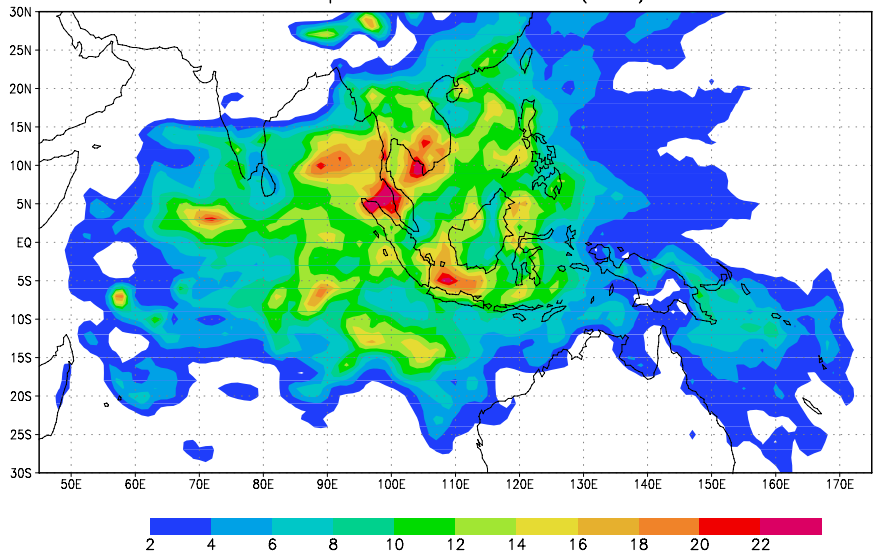
Precipitation for RCM2 (JFM)



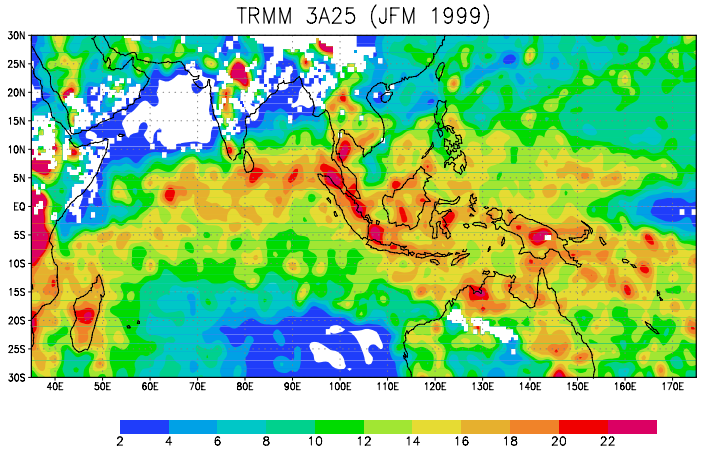
Precipitation for RCM1 (AMJ)

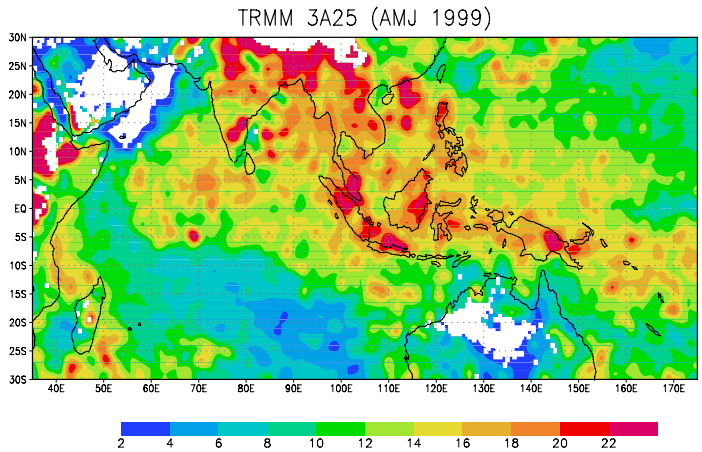


Precipitation for RCM2 (AMJ)

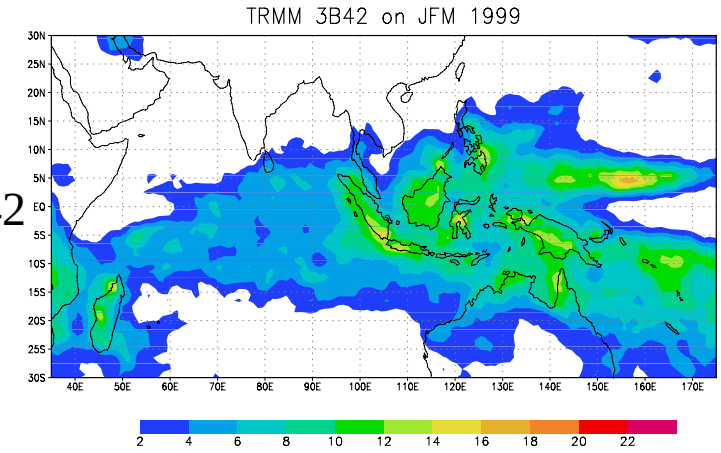


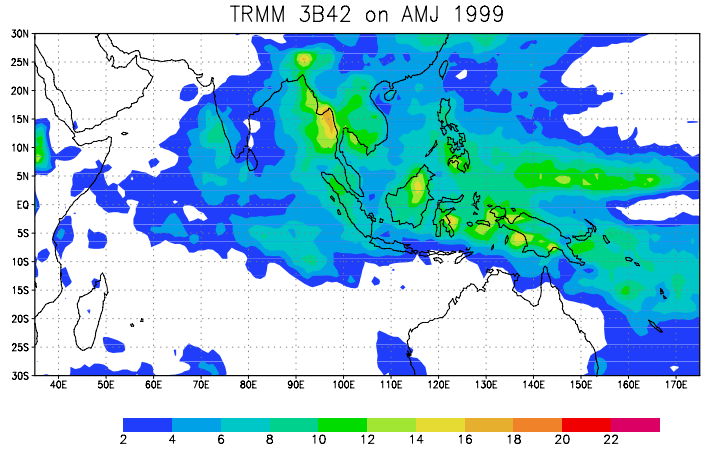
TRMM 3A35



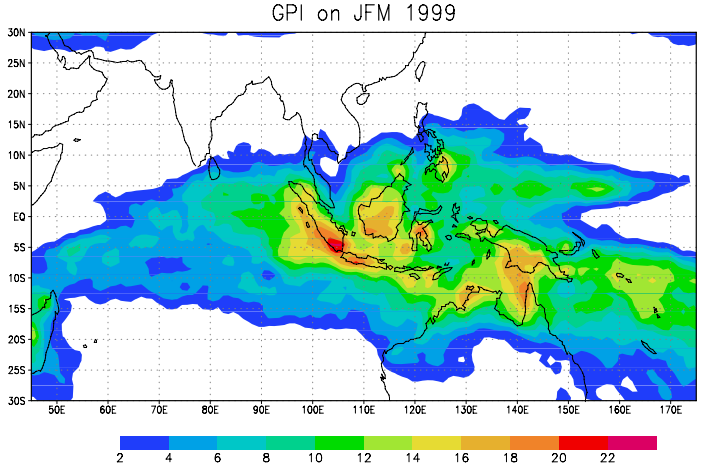


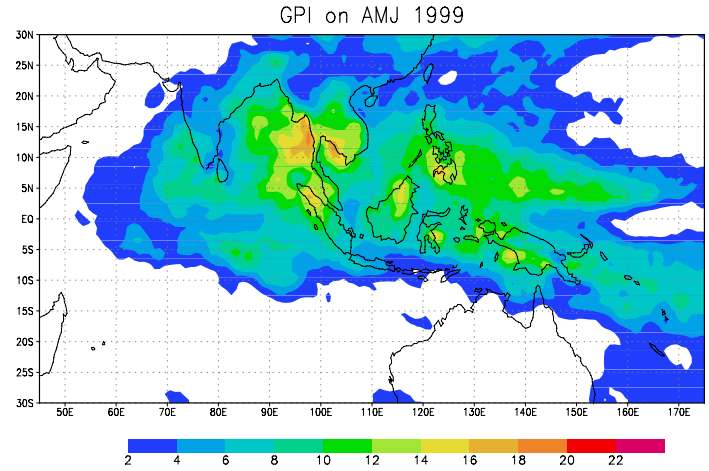
TRMM 3B42



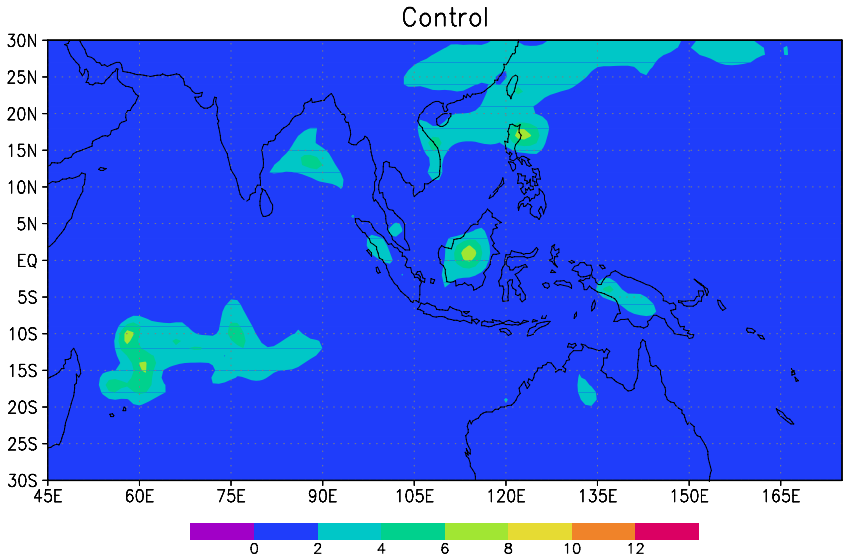


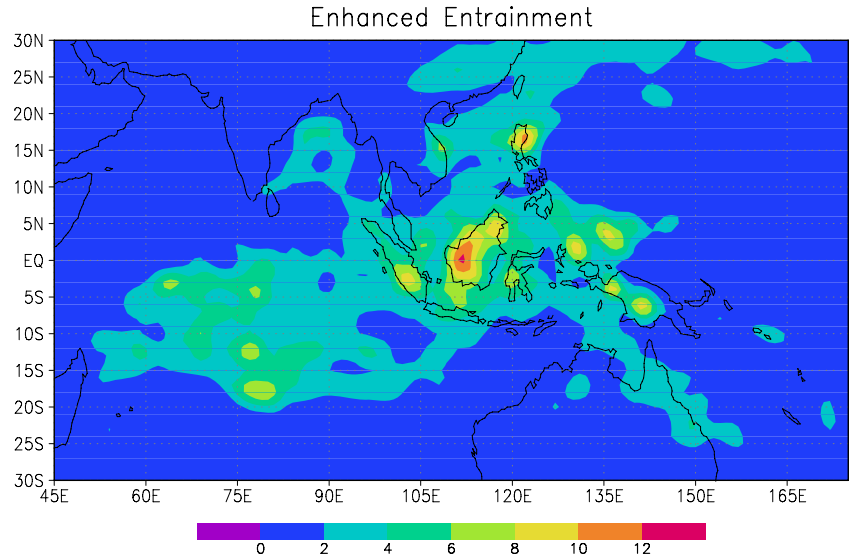
GPI

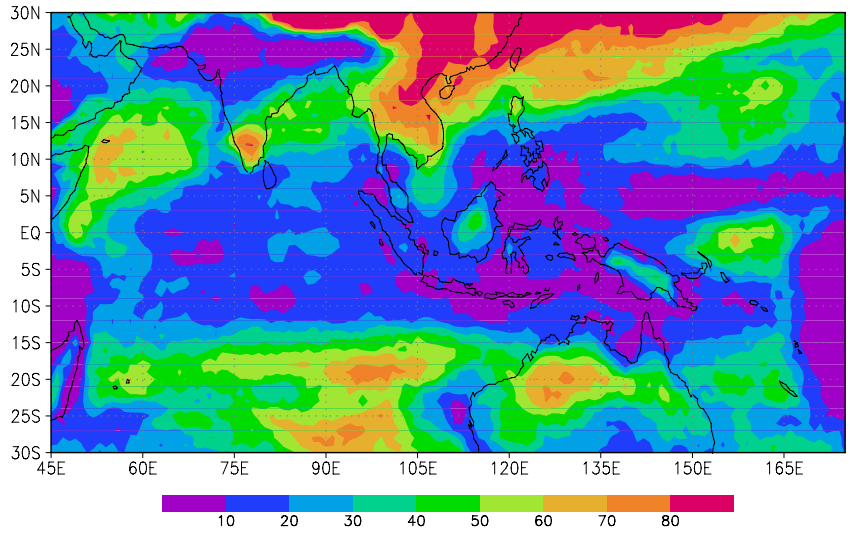


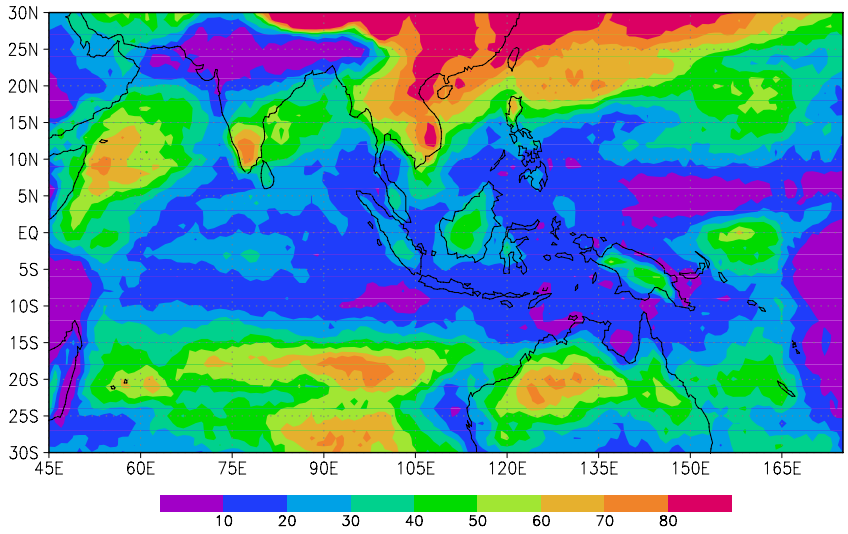


Large-Scale precipitation and its percentage



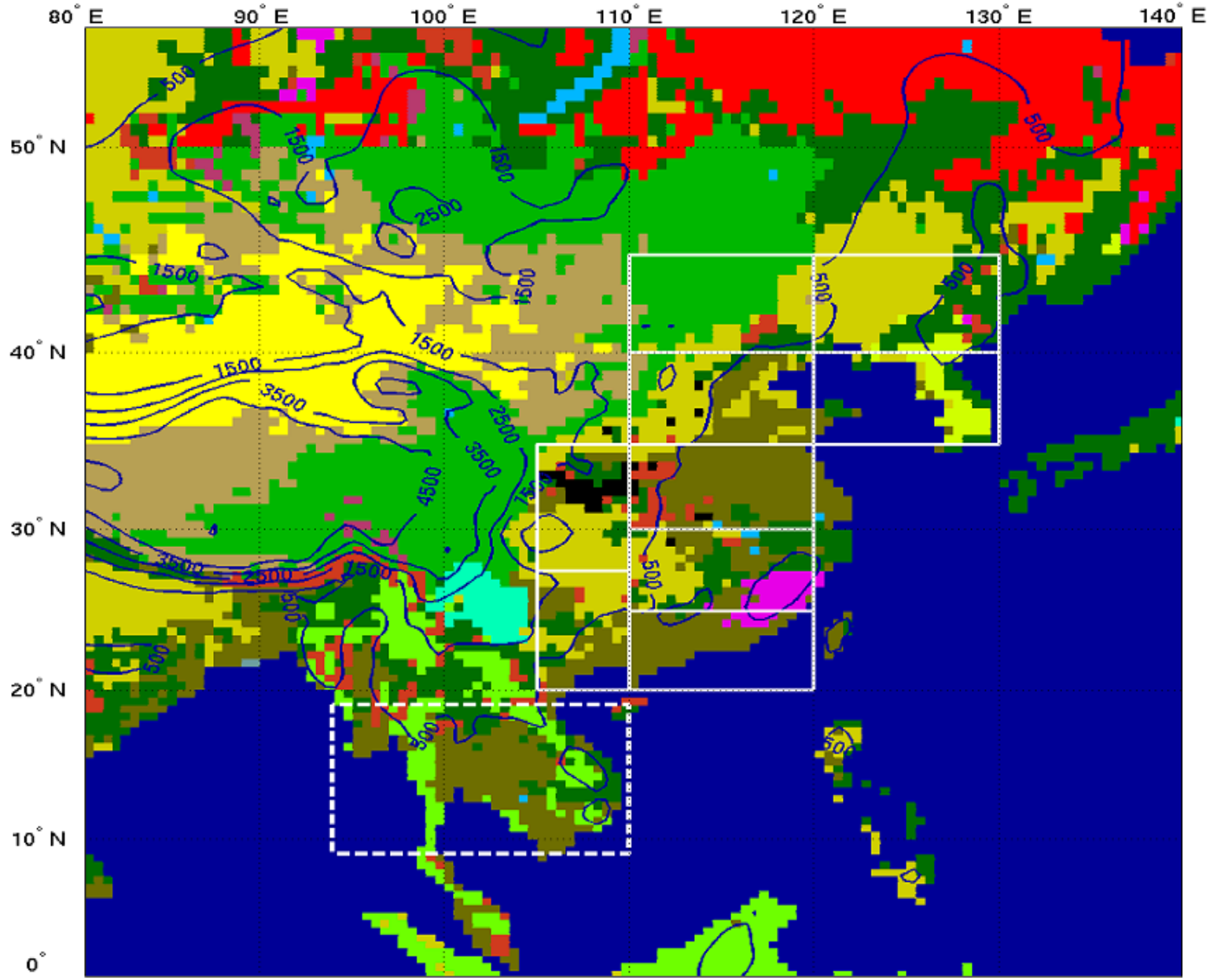






A Regional Atmospheric Inter-Model Evaluation Project

- To examine the performance of current RCMs in simulating the diurnal cycle of clouds and precipitation with the use of CEOP dataset;
- To identify the common discrepancies and the key factors that result in the bias and find the way to improve the simulation;
- We have 10 independently developed RCMs to participate in the project and plan to complete the whole project in three years (3 phases);
- We will focus on the East Asian monsoon region during summer seasons.


80° E
90° E
100° E
110° E
120° E
130° E
140° E
50° N
40° N
30° N
20° N
10° N
0°
500
1500
2500
3500
4500

Participating RCMs

- IPRC-RegCM (Y. Wang)
- SUNYA-RCM (W.-C. Wang)
- RegCM_NCC (Y. Ding)
- NTU-RCM (H.-H. Hsu)
- SNU-RCM (D.-K. Lee)
- MM5 (T. Satomura)
- RAMS (F. Kimura)
- C-CAM (J. McGregor)
- RSM_NCU (L.-P. Lin)
- WRF (R. Leung)

3 Phases

- Phase I: To examine the performance of these selected RCMs in simulating the diurnal cycle of clouds and precipitation for one summer season;
- Phase II: To identify the discrepancies and sensitivity to model parameters and to study the physical mechanisms that control the diurnal cyclone of clouds and precipitation;
- Phase III: To improve the simulation by improving the model physics, especially the PBL and CPS.