Convection Trigger: A key to improving GCM MJO simulation?
CRM Contribution to DYNAMO and AMIE

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ISU Cloud-Resolving Model (CRM) (formally NCAR CRM)

Has been validated with:

- Week-long GATE observations over the Atlantic
  (Grabowski et al. 1996, JAS);
- Month-long TOGA COARE observations over the western Pacific
  (Wu et al. 1998, 1999, JAS; Wu and Moncrieff 2001 JAS)
- Year-long ARM observations over the central USA
  (Wu et al. 2008, JAS)

Long-term CRM simulations can be used to study/evaluate:

- Subgrid cloud variability and its impacts on radiative fluxes;
- Convective and mesoscale enhancement of surface heat fluxes;
- Convective momentum transport;
- Cloud-aerosol interaction;
- Convection trigger

Multi-year CRM simulations can be performed over climate sensitive regions using the ECMWF/NCEP and RUC reanalysis together with the measurements of precipitation, surface sensible and latent heat fluxes, shortwave and longwave fluxes at the surface and the top of the atmosphere (TOA).

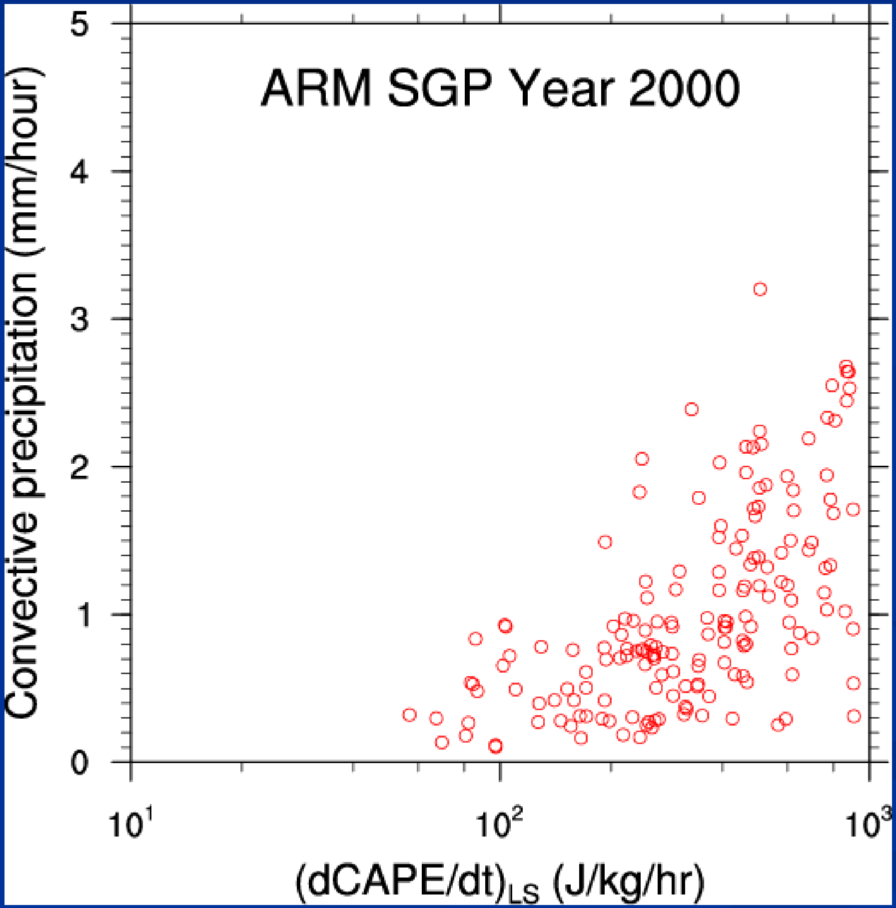
For DYNAMO and AMIE,

CRM will be forced with the observed forcing obtained during the intensive observation period (IOP) (Johnson, Long) and validated with the available measurements.

Long-term simulations over the Indian Ocean and western Pacific will then be performed using the ECMWF reanalysis constrained by RAMA and TWP precipitation, surface heat fluxes and radiation fluxes (McPhaden, Long) and TOA radiative fluxes (Pat Minnis), and used to evaluate GCM climate simulations and improve convection, cloud and radiation parameterization.

Year-long CRM simulations of ARM Cloud Systems

Trigger condition of deep convection: Convection is activated when the increase of CAPE due to the large-scale processes exceeds certain threshold (70 J kg^{-1} hr^{-1}).



Wu et al. (2007, GRL)

ISU General Circulation Model (GCM)

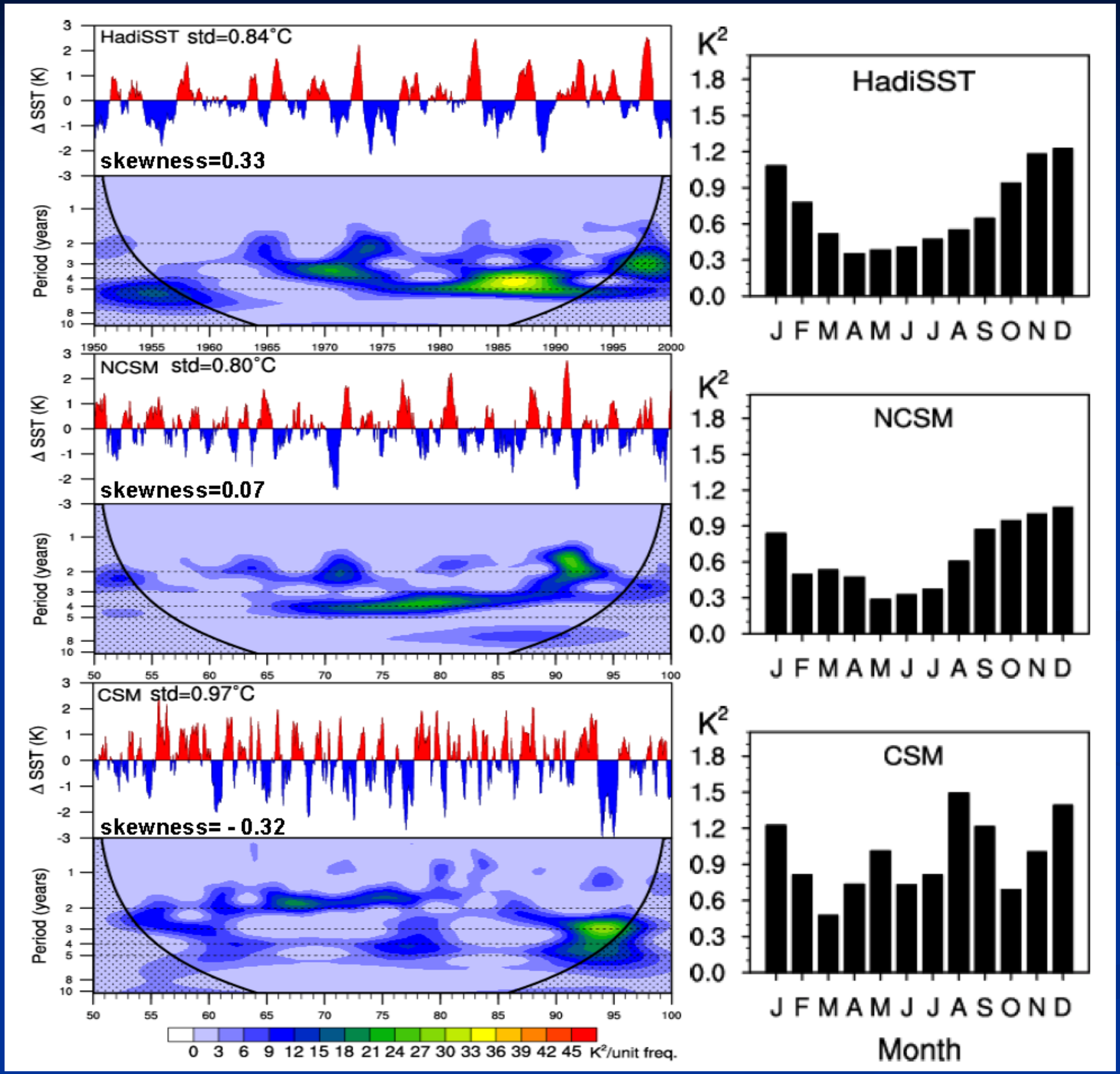
Based on a version of NCAR CCSM (CCM3, CSM), but with

1. Modified Zhang-McFarlane (ZM) Convection Scheme
   - Revised convection closure assumption
   - Trigger condition of deep convection
   - Convective momentum transport

2. Modified Radiation parameterization Scheme
   - Mosaic approach (MOS) of treating subgrid cloud variability

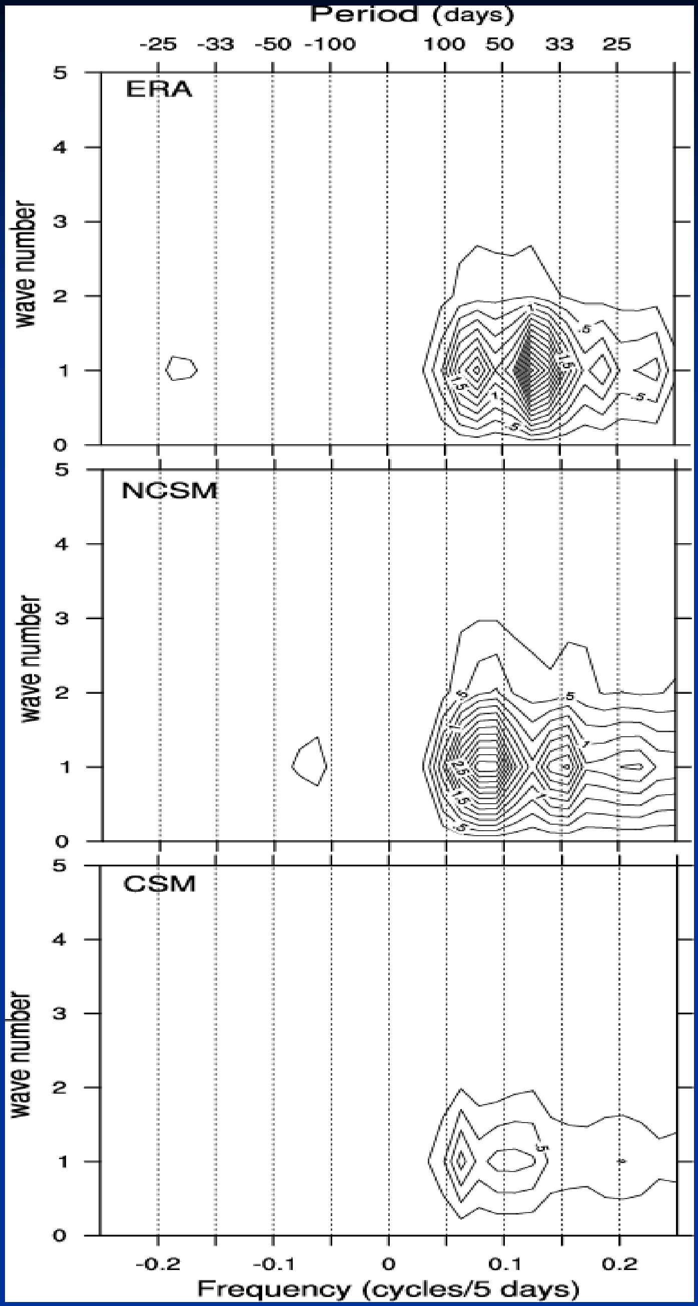
3. Modified cloud parameterization Scheme
   - CRM-derived vertical distribution of in-cloud water content

El Niño/Southern Oscillation (ENSO)



Monthly time series of the Niño-3.4 (5°N-5°S, 170-120°W) Sea Surface Temperature (SST) anomalies and wavelet power spectrum analysis (left) and monthly averaged variances (right) from observations of the Hadley Centre Sea Ice and SST dataset (HadISST,1950-1999), NCSM and CSM (years 50-99).

Wu et al. (2007, GRL)

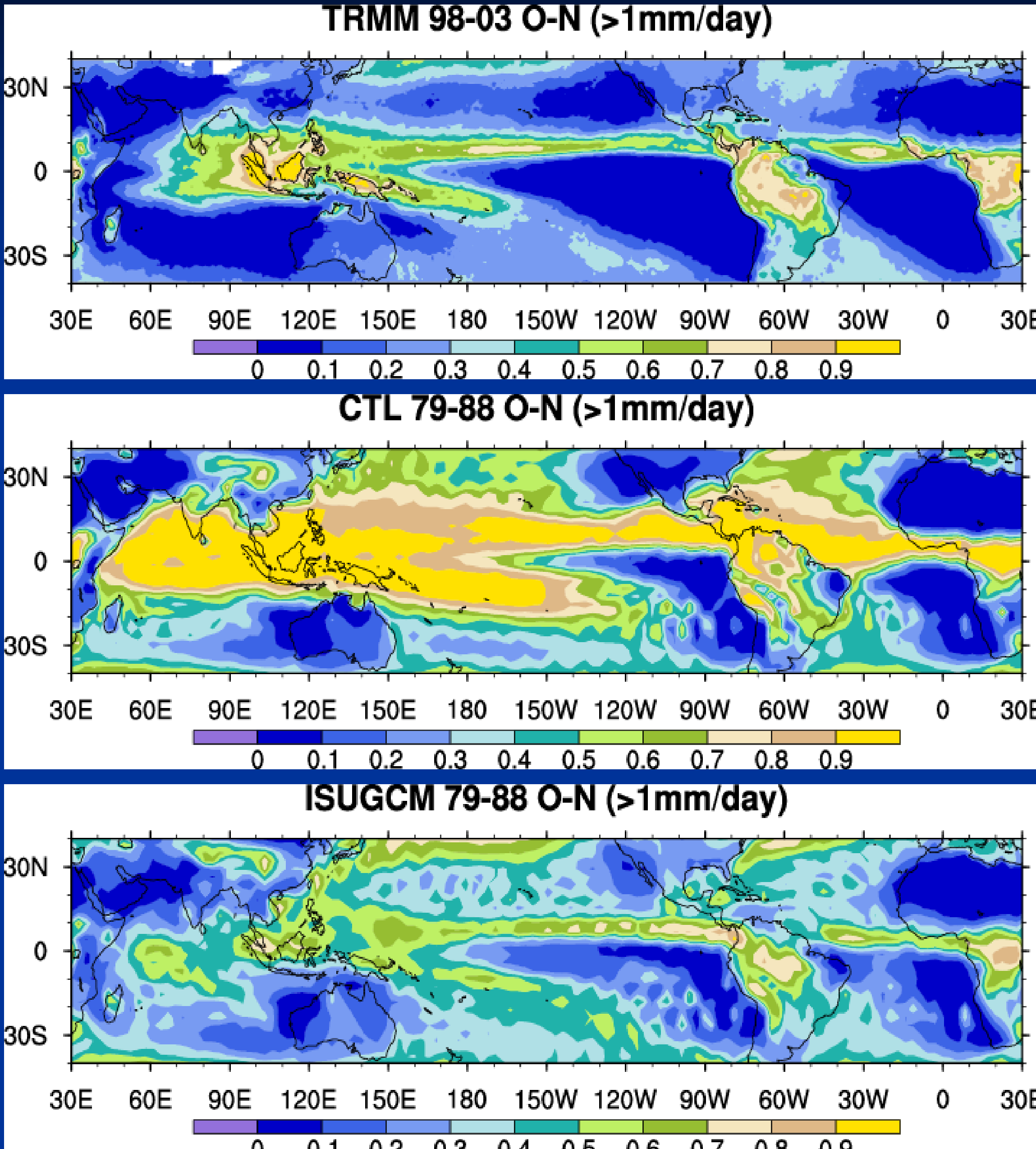


Madden-Julian Oscillation (MJO)

Wavenumber–frequency spectra of 200-hPa velocity potential averaged between 10 °N and 10°S for ERA (ECMWF Re-Analysis)-40 reanalysis (years 1989-1998), the NCSM (years 80-89) and the CSM (years 80-89). Positive (negative) frequency and period represent the eastward (westward) propagation. A 20-100-day band-pass filter is applied to remove the annual cycle and lower frequencies in the pentad (5-day mean) time series (following Maloney and Hartmann 2001, JC).

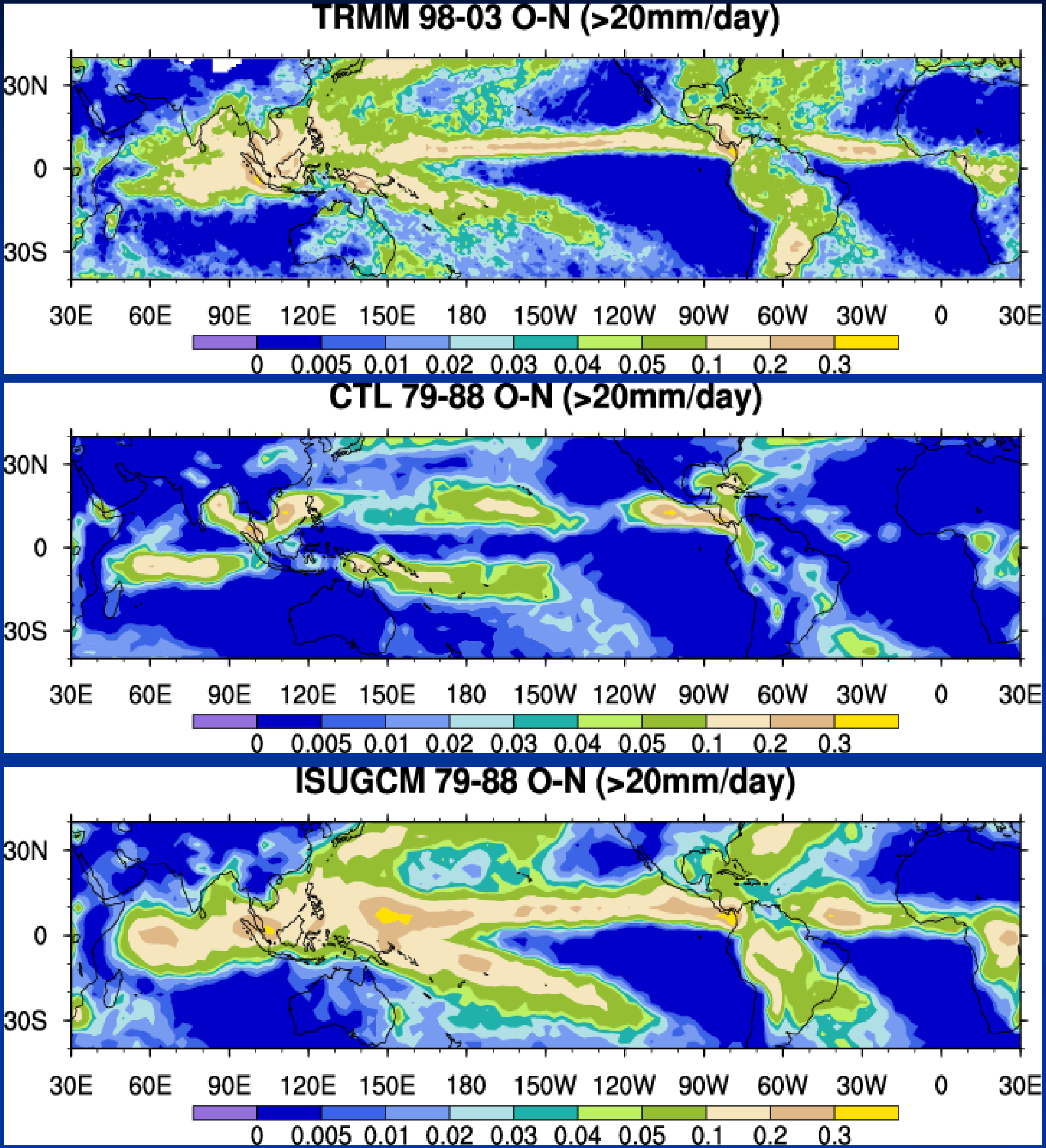
Wu et al. (2007, GRL)

Daily Precipitation Frequency (>1 mm day^{-1})

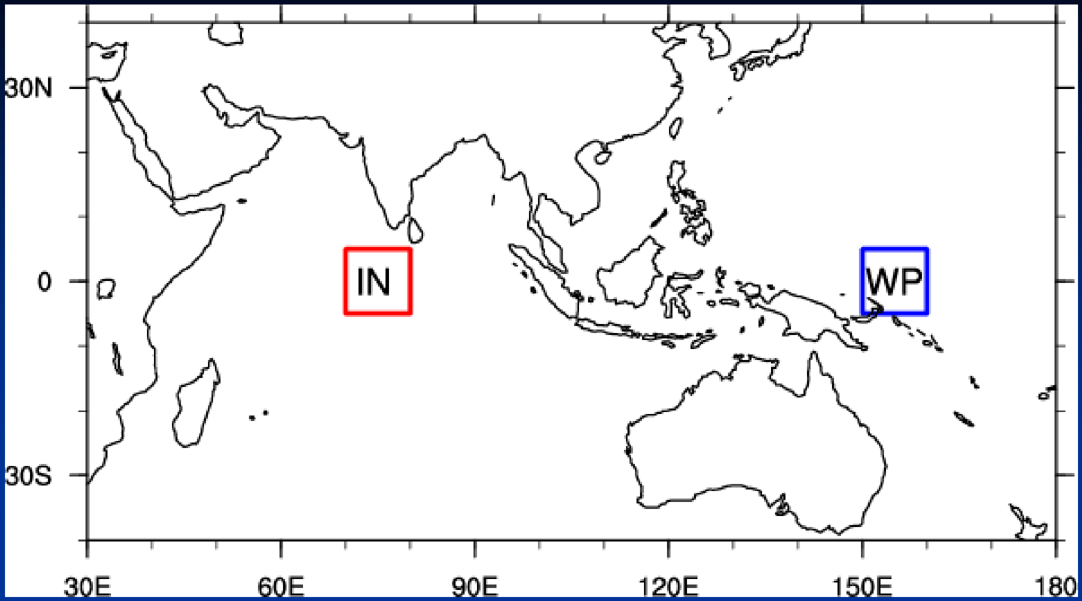


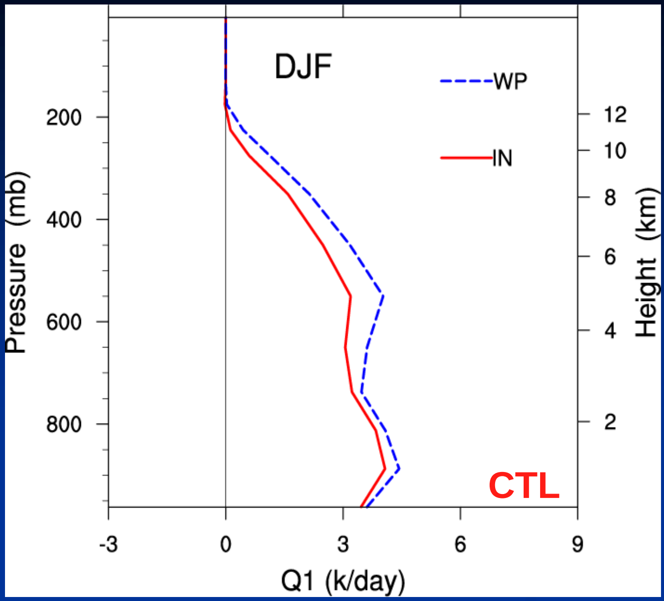
TRMM 3B42 satellite observations (1998-2003) and coupled models (CTL, ISUGCM).

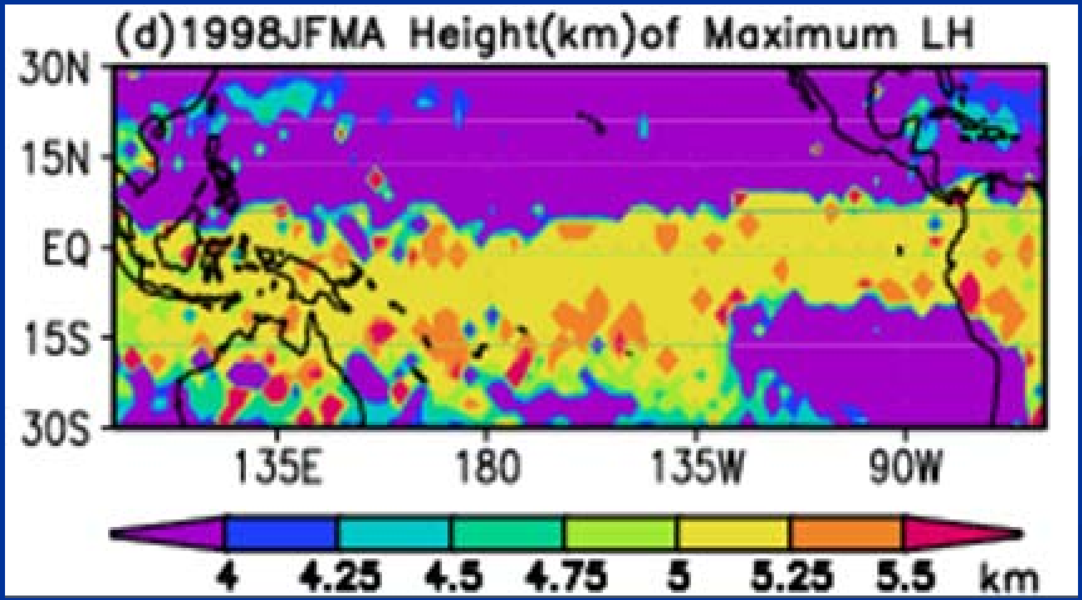
Daily Precipitation Frequency (>20 mm day^{-1})

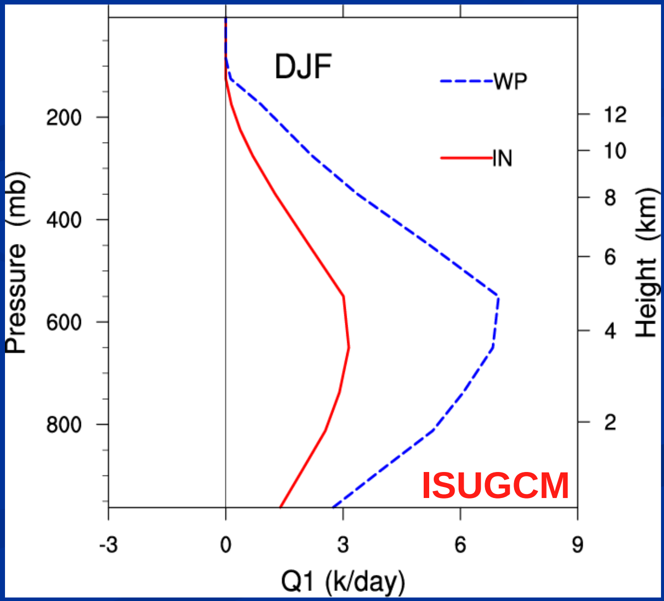


TRMM 3B42 satellite observations (1998-2003) and coupled models (CTL, ISUGCM).







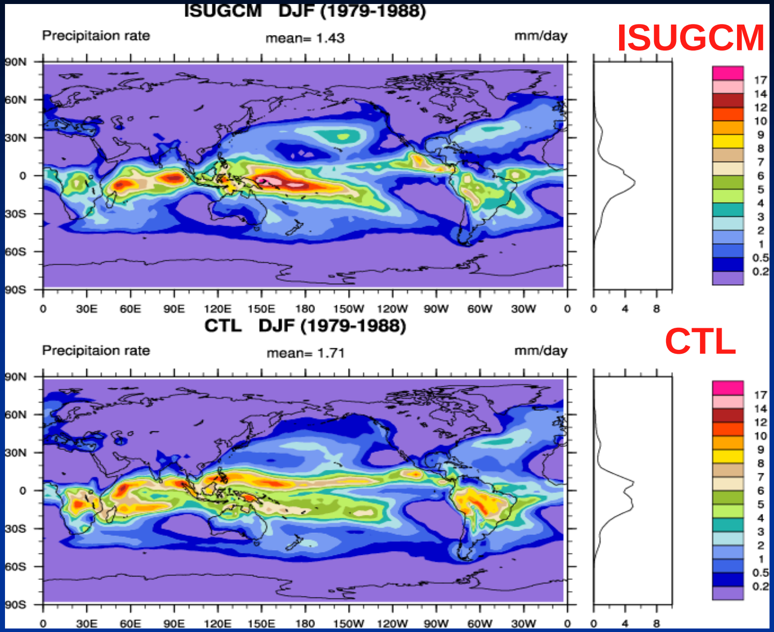


(Courtesy of Qilong Min)

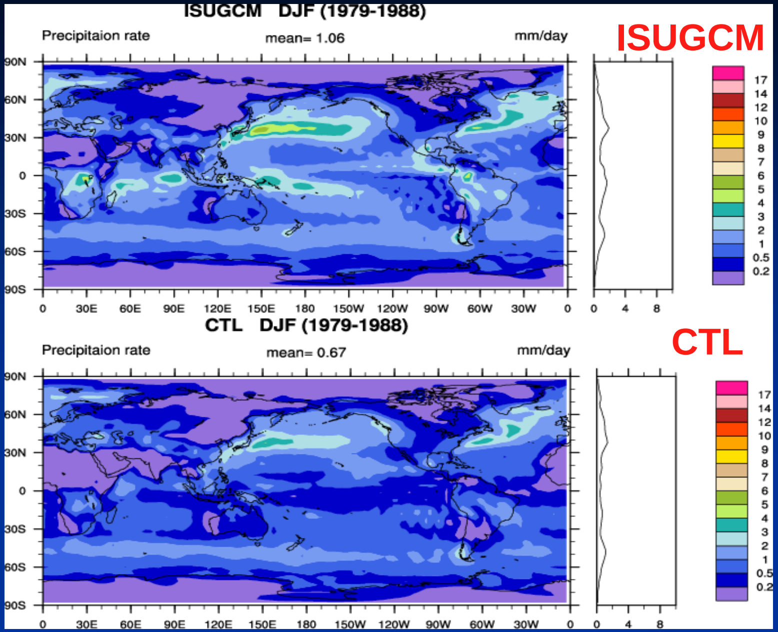
Hypothesis based on previous studies:

Moist convection simulated by the GCM with the improved convection scheme especially convection trigger occurs less frequent but more vigorous and is more consistent with observations, which results in increased MJO activity. The organized convection and clouds within the MJO affects ENSO events and associated extreme floods and droughts through the influence on the Hadley and Walker circulations, tropical surface energy budget, air-sea interaction and teleconnection.

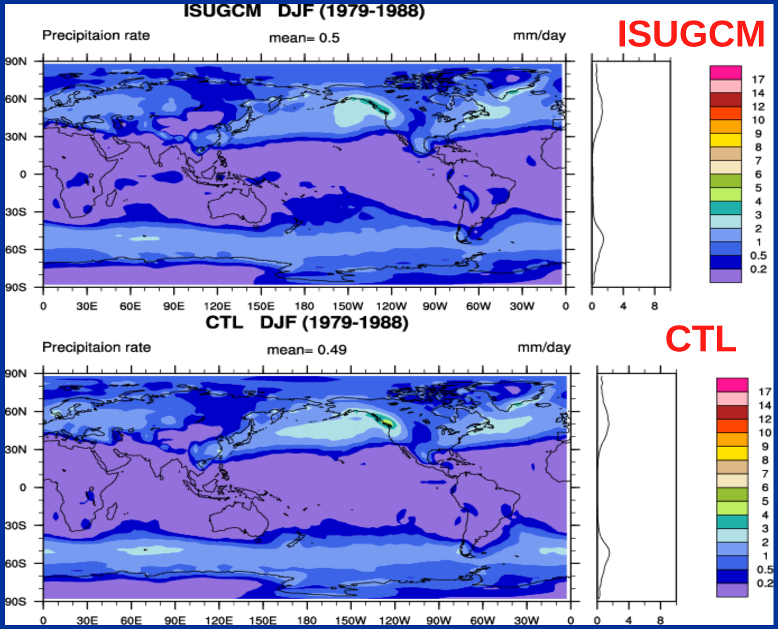
Deep convective precipi.



Shallow convective precipi.



Large-scale precipi.



Total precipitation rate