Consistent representation of precipitation, cloud and radiative fluxes in GCMs

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ISU General Circulation Model (GCM):

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

1) Modified Zhang-McFarlane deep convection scheme

- Revised convection closure assumption consistent with CRM concept
- CRM-based trigger condition of deep convection
- CRM-validated convective momentum transport

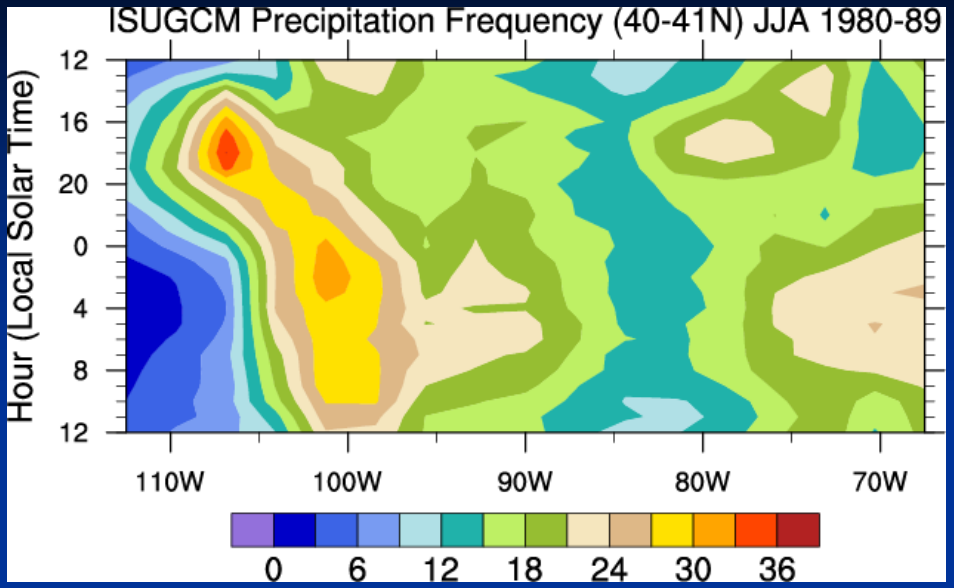
2) Modified cloud and radiation parameterization schemes

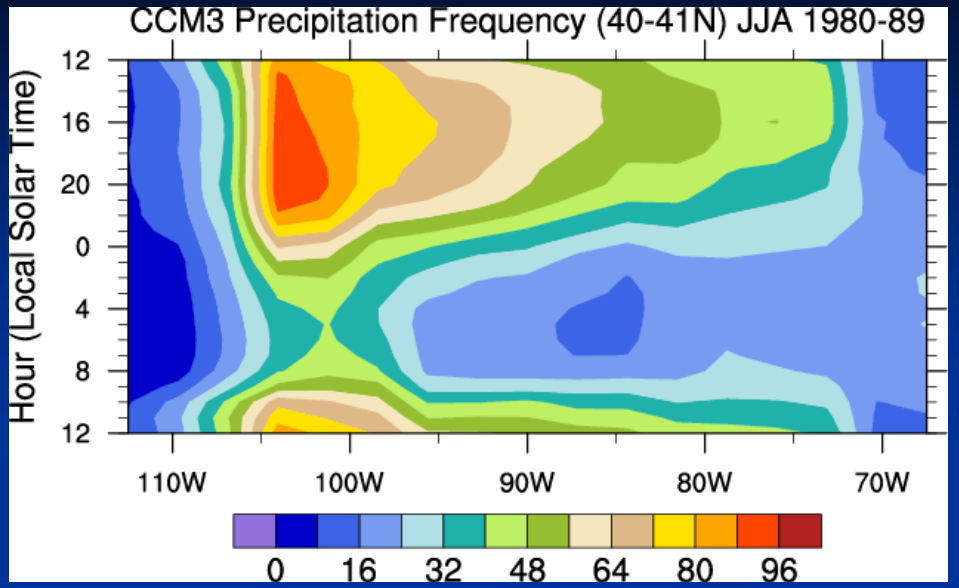
- CRM-validated mosaic treatment of subgrid cloud variability
- CRM-derived vertical scaling factor of in-cloud water content

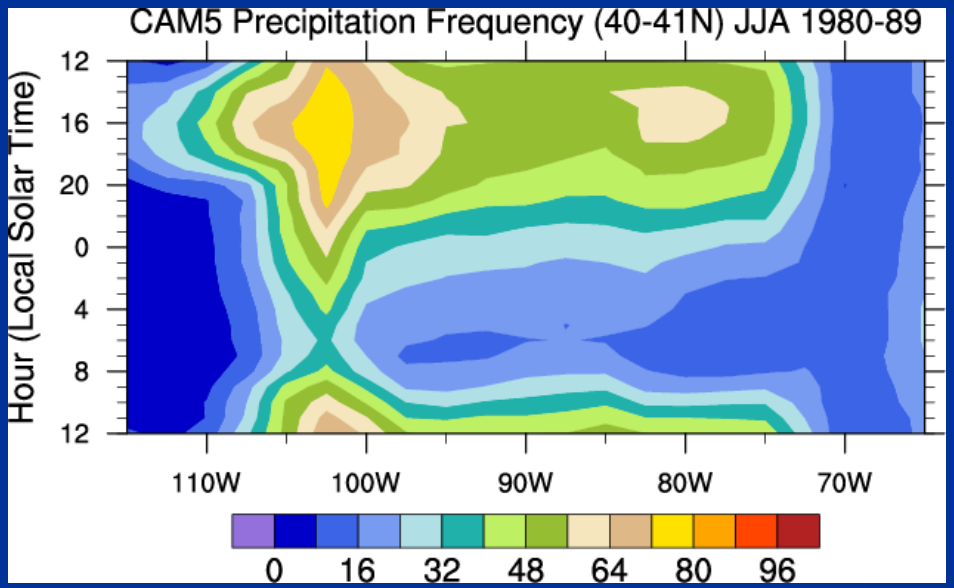
	Run	Runtime	Processor
ISUGCM	T42 AMIP 1979-	18h/10yrs	16
CAM4	2º AMIP 1979-	28h/10yrs	32
CAM5	2º AMIP 1979-	90h/10yrs	32

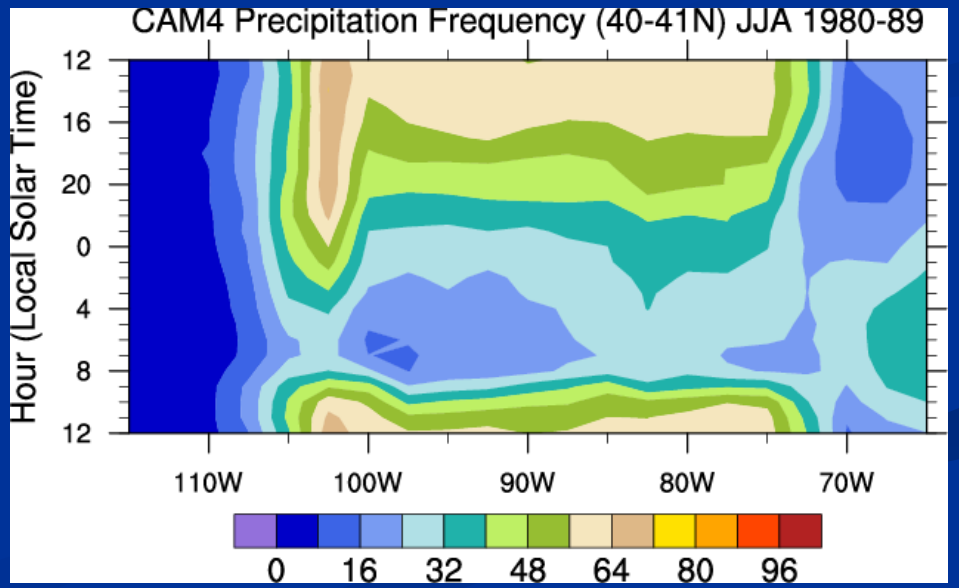
Precipitation Characteristics

Diurnal cycle of summer precipitation over US

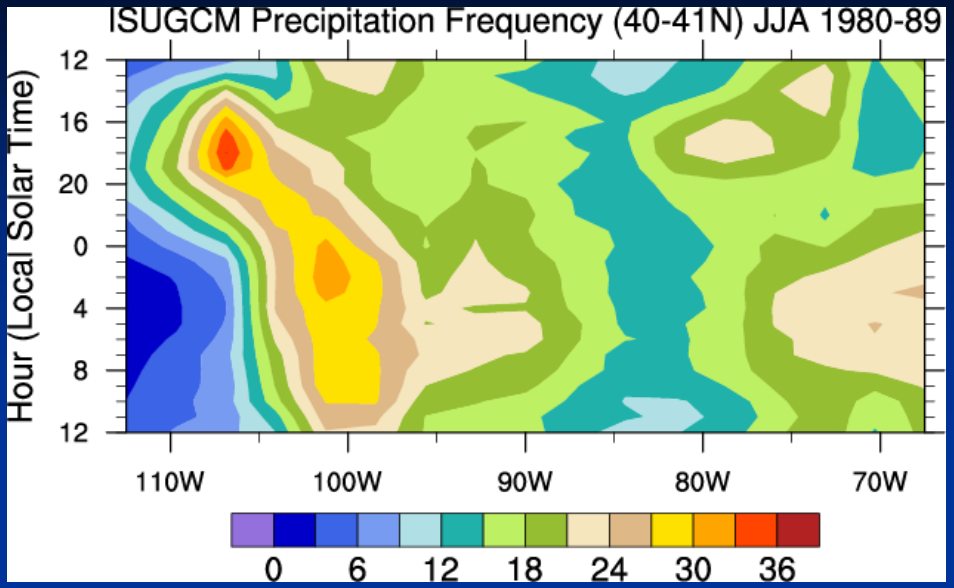


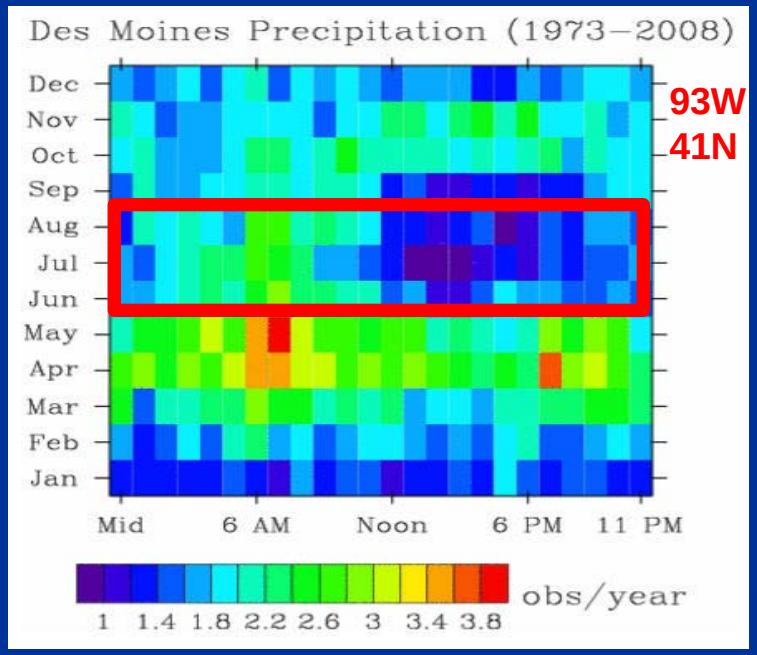




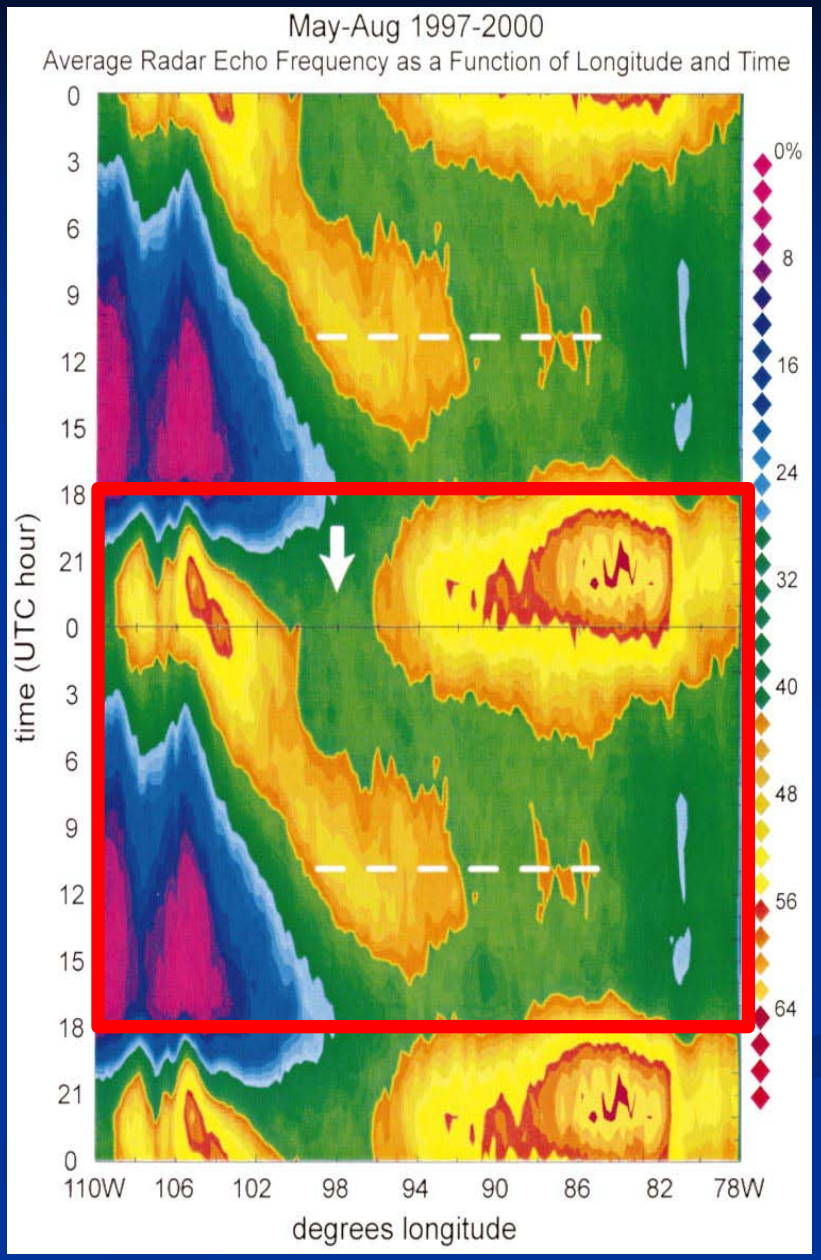


Diurnal cycle of summer precipitation over US



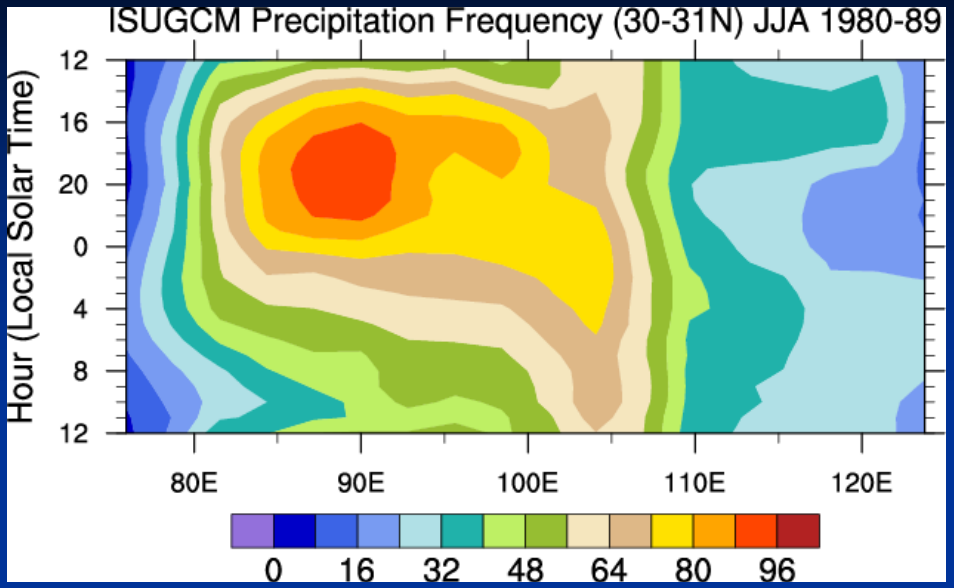


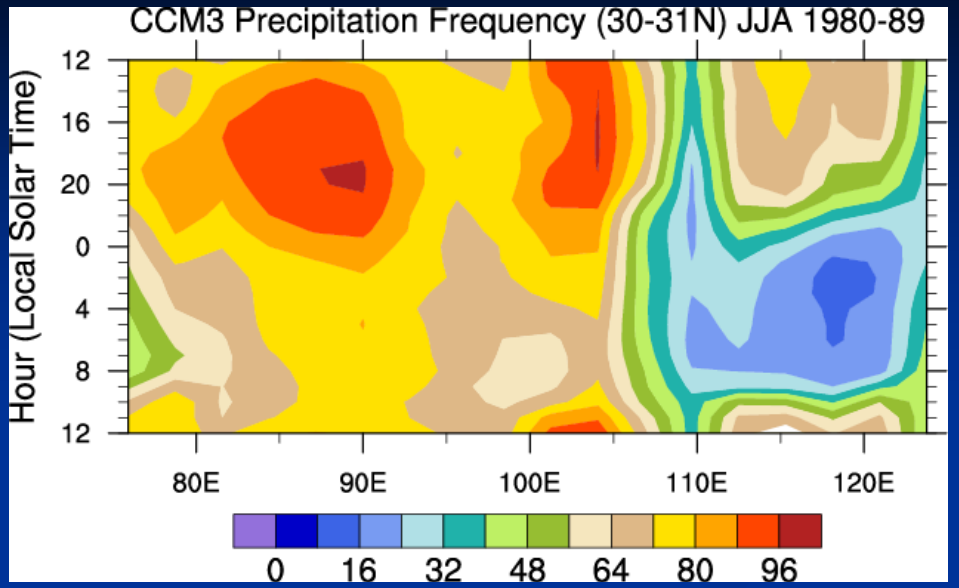
Provided by Daryl Herzmann, IEM/ISU

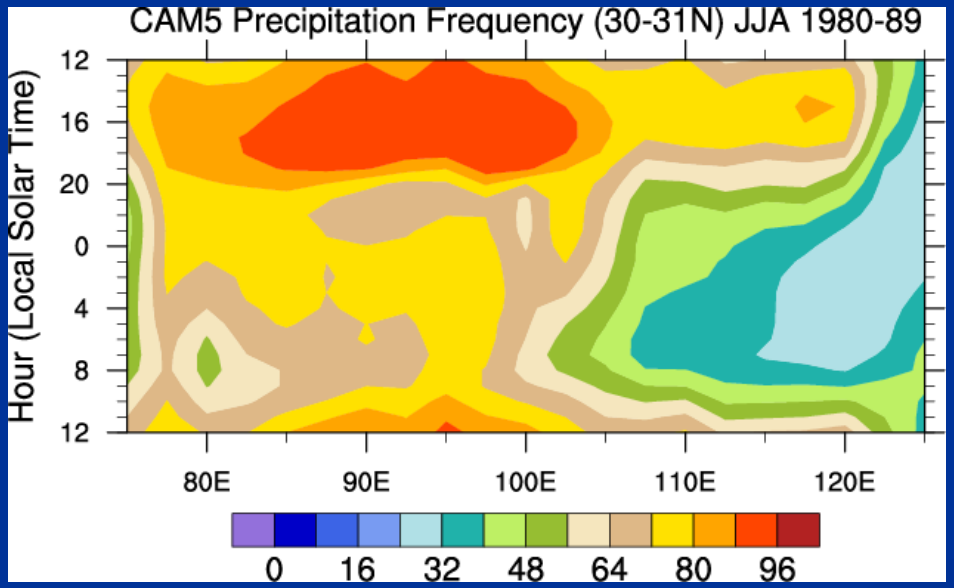


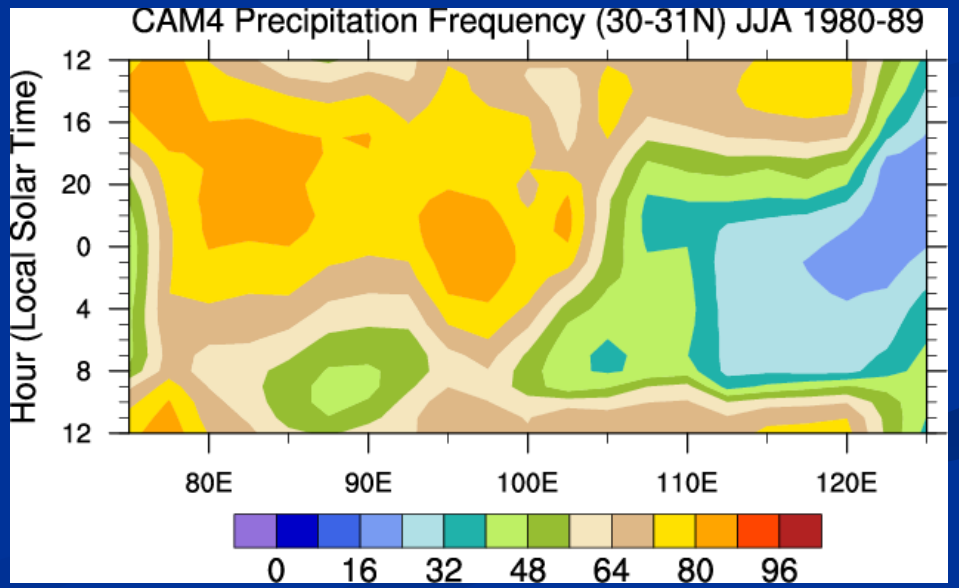
Carbone et al. (2002 JAS)

Diurnal cycle of summer precipitation over China

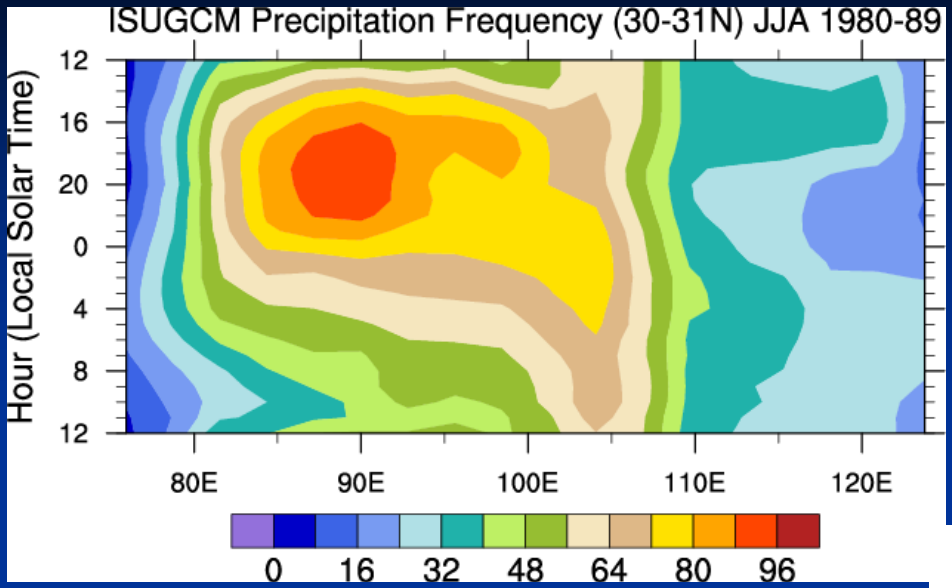




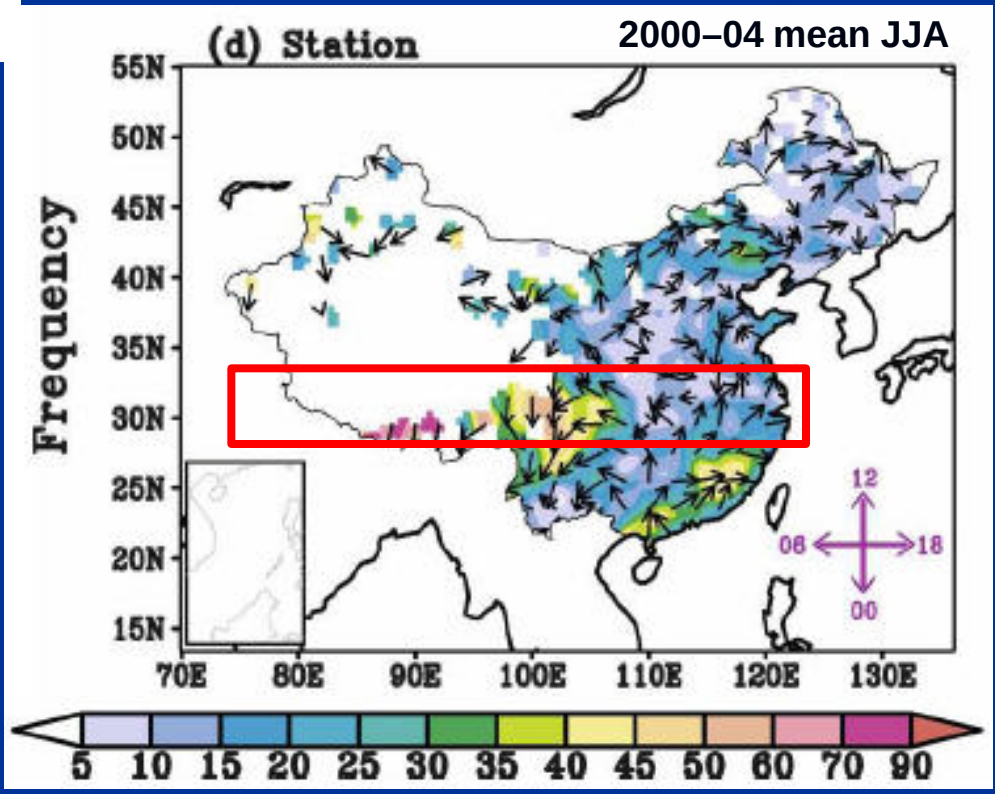




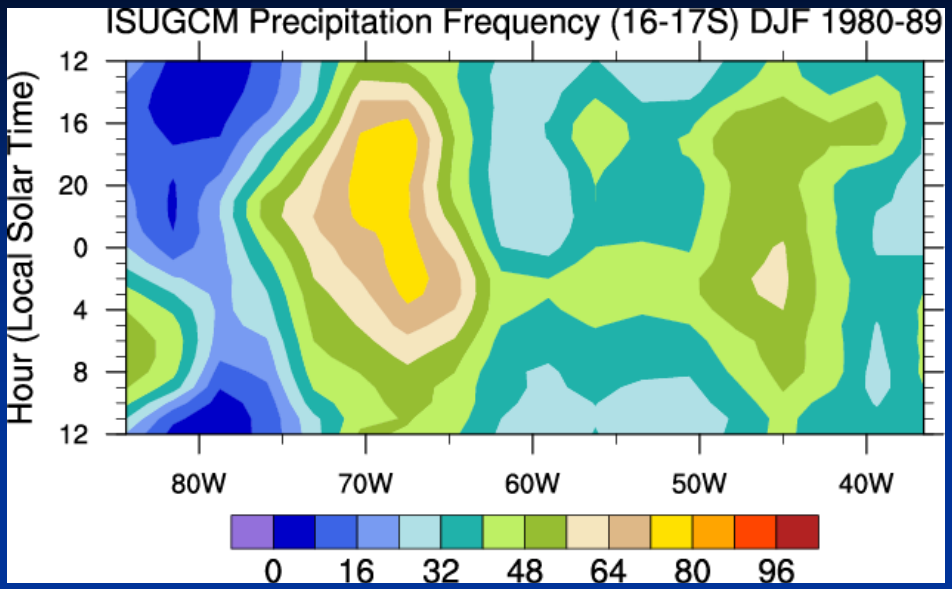
Diurnal cycle of summer precipitation over China

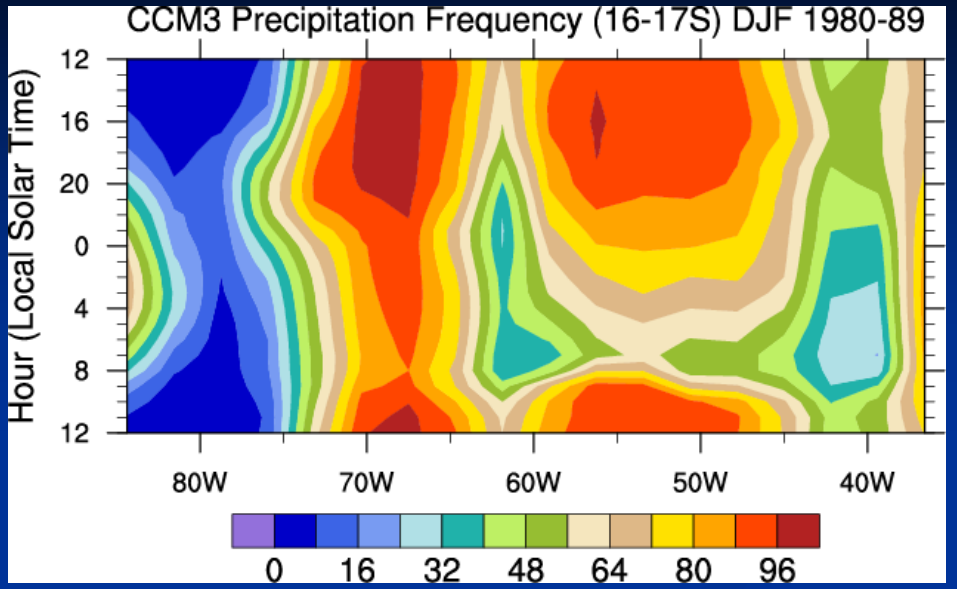


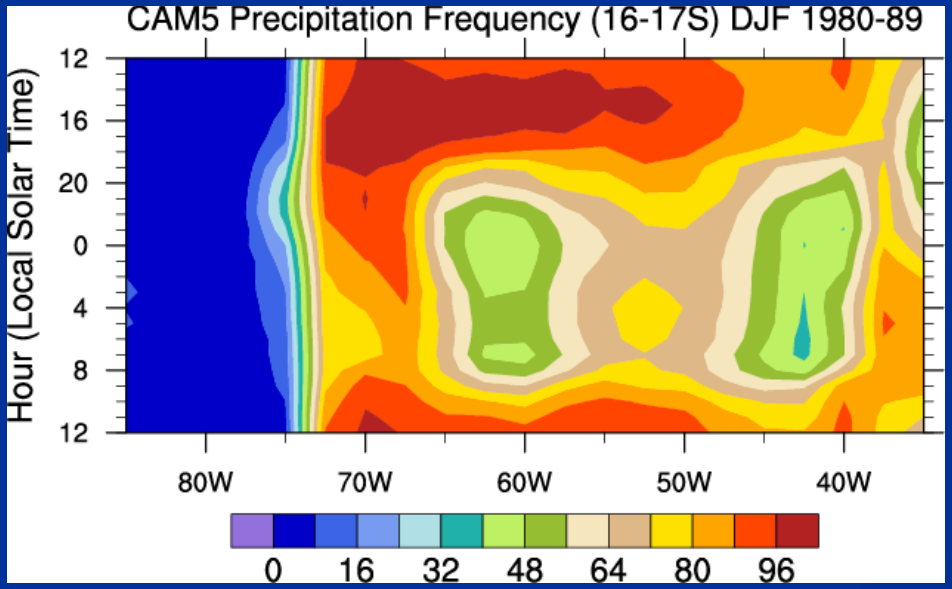
Zhou et al. (2008 JC)

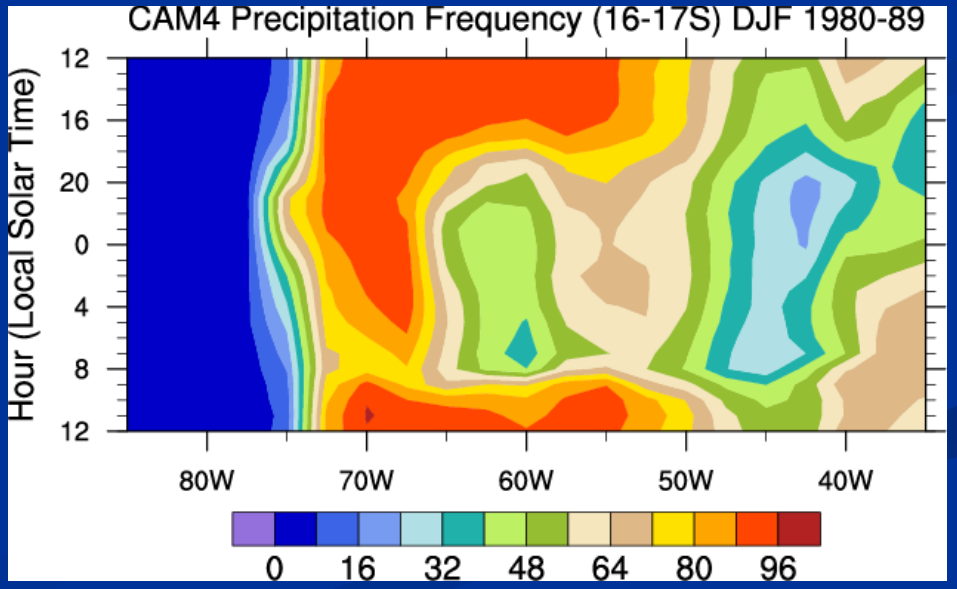


Diurnal cycle of summer precipitation over South America

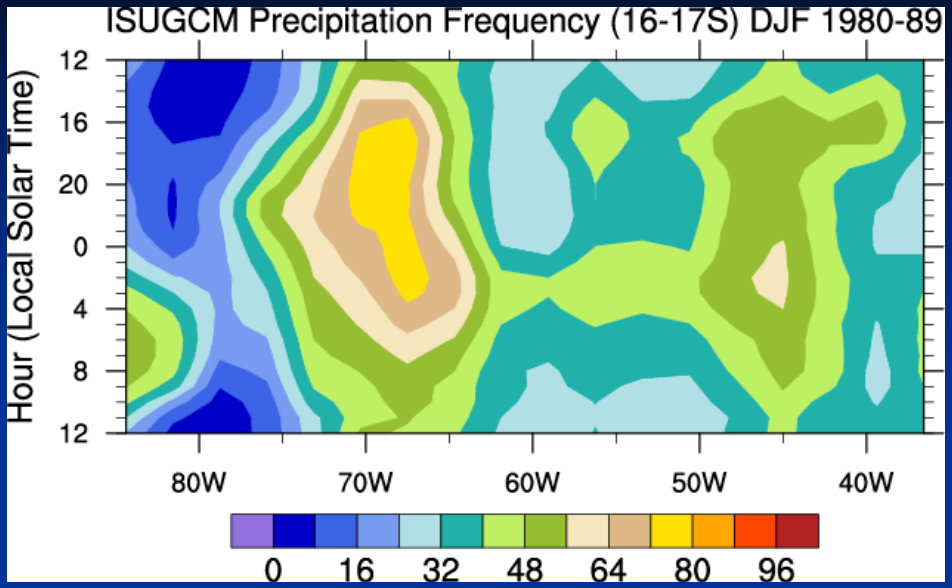




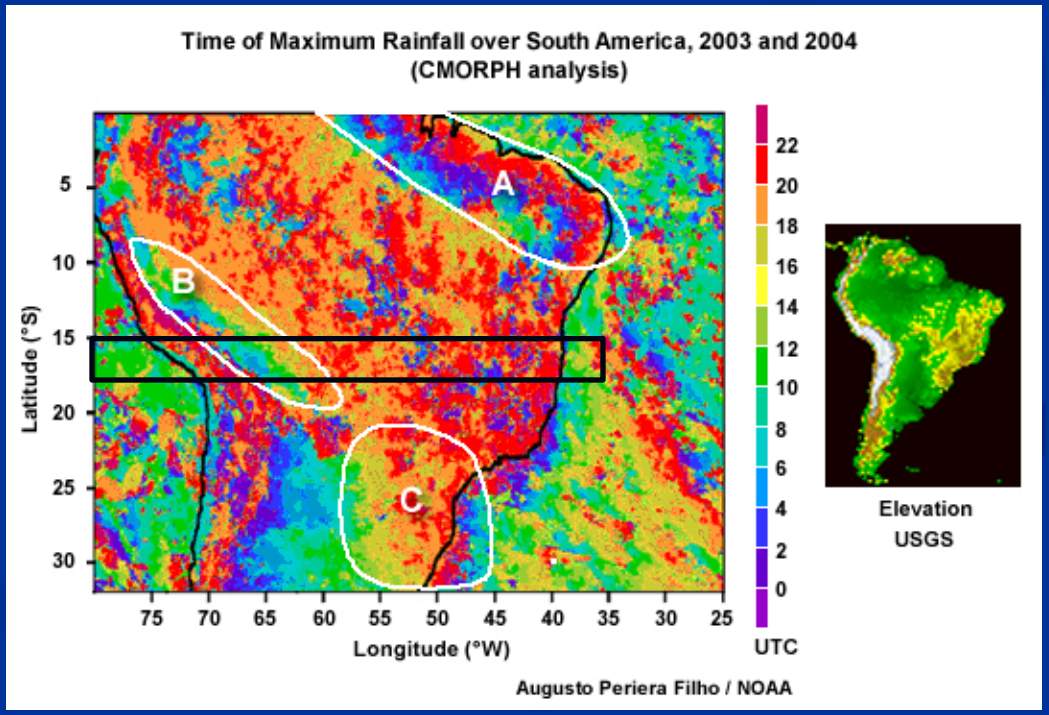




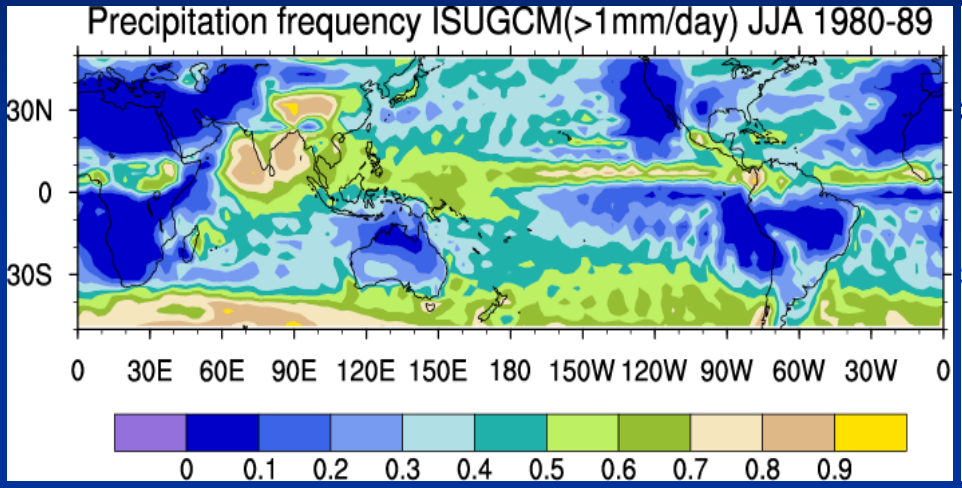
Diurnal cycle of summer precipitation over South America

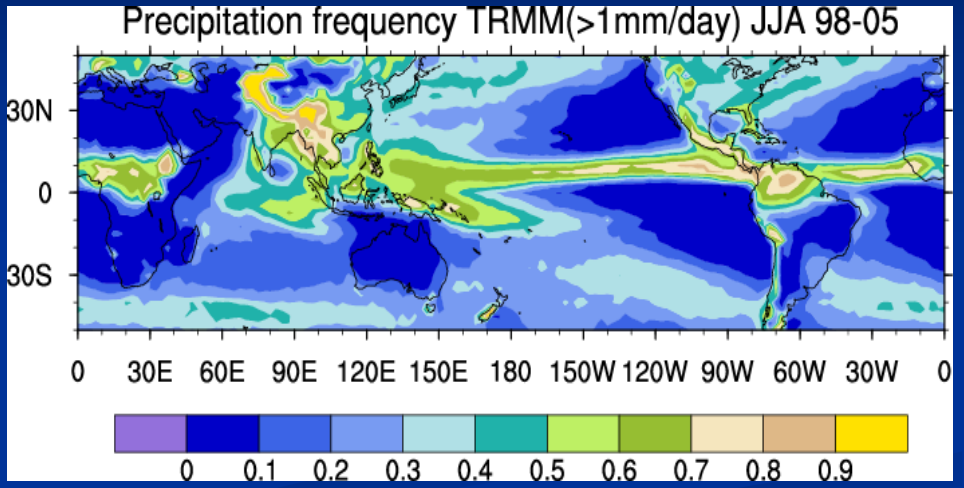


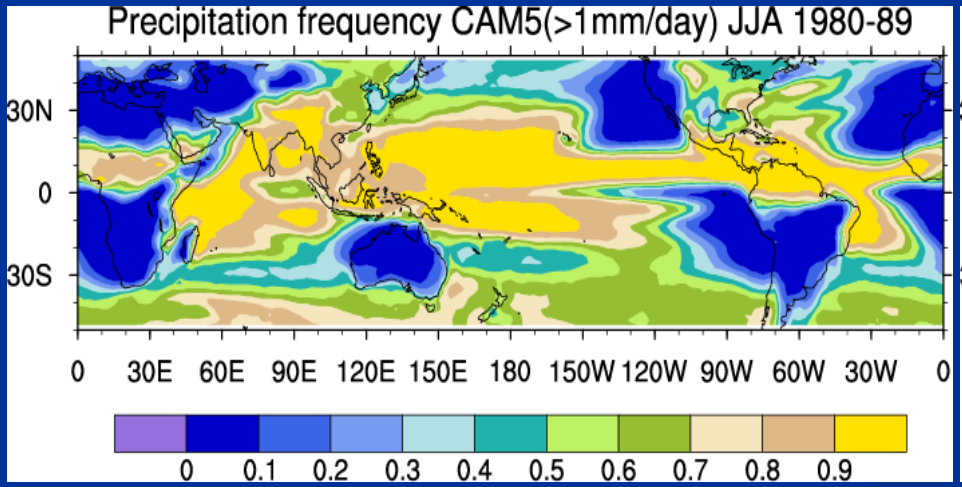
Courtesy of Augusto Periera Filho, NOAA

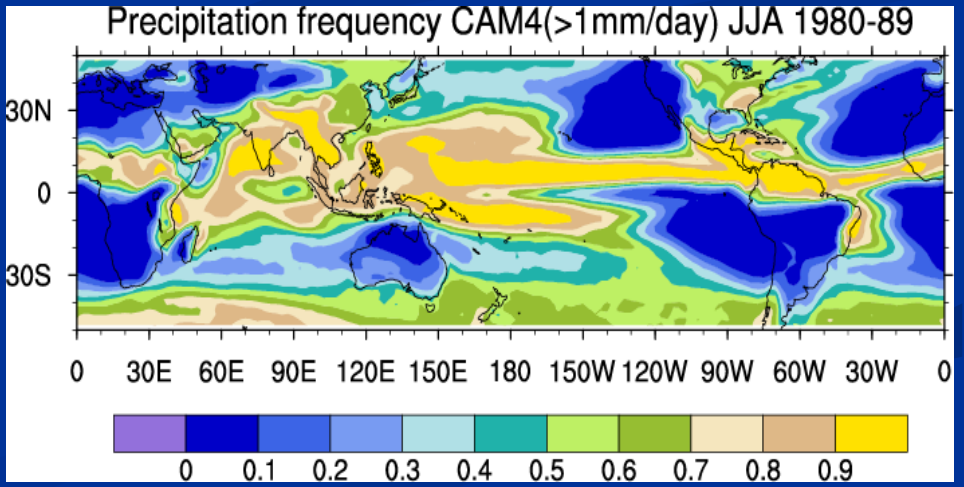


Precipitation frequency of rainfall > 1 mm/day

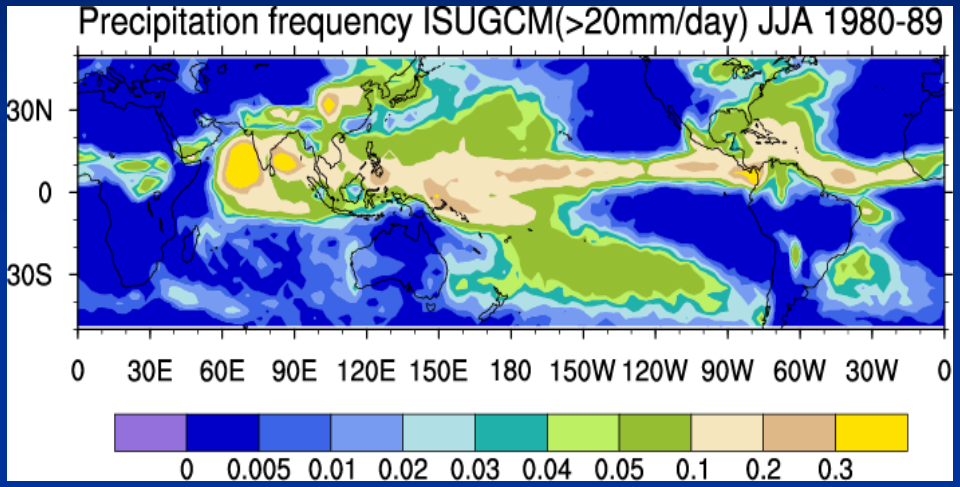


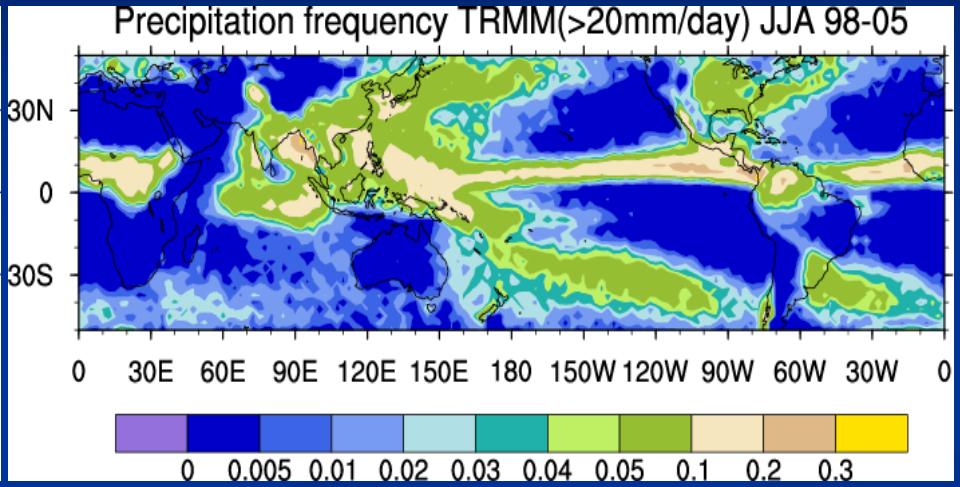


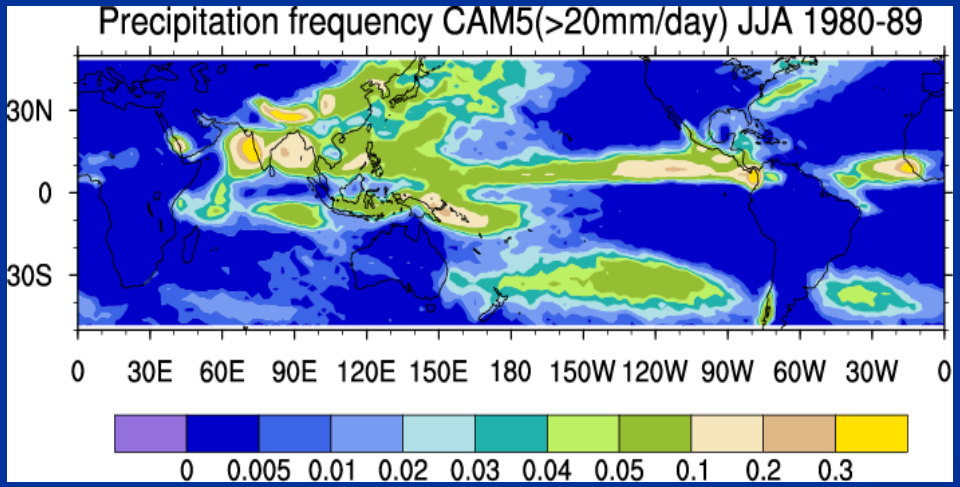


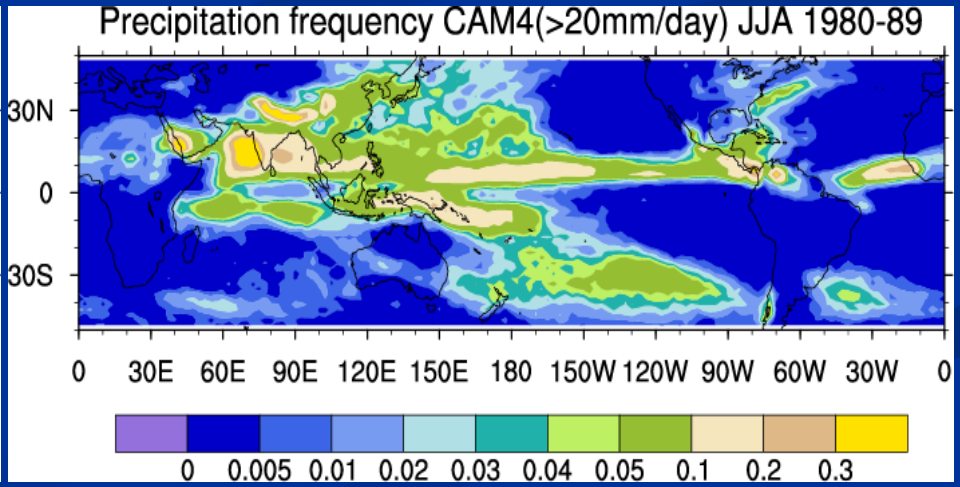


Precipitation frequency of rainfall > 20 mm/day







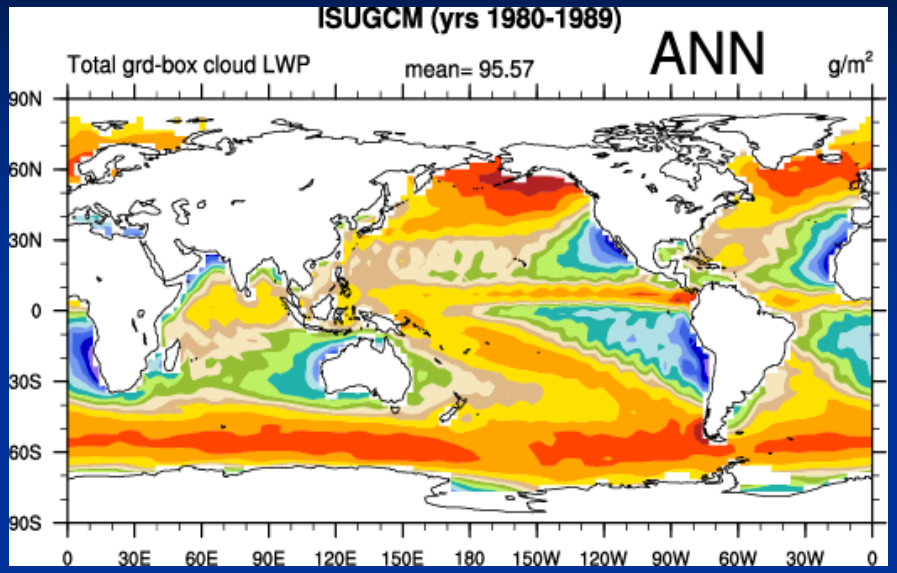


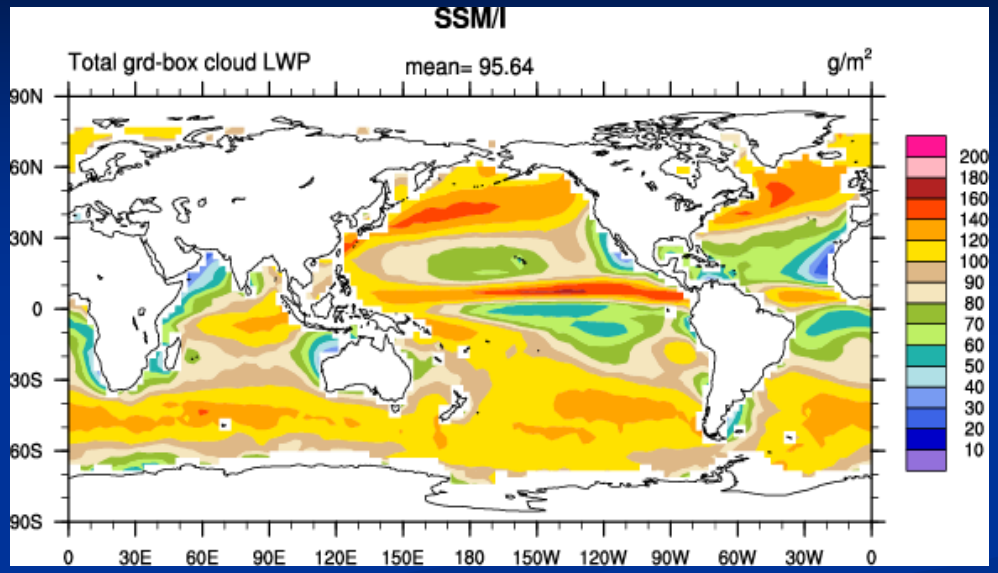
Clouds and Radiation

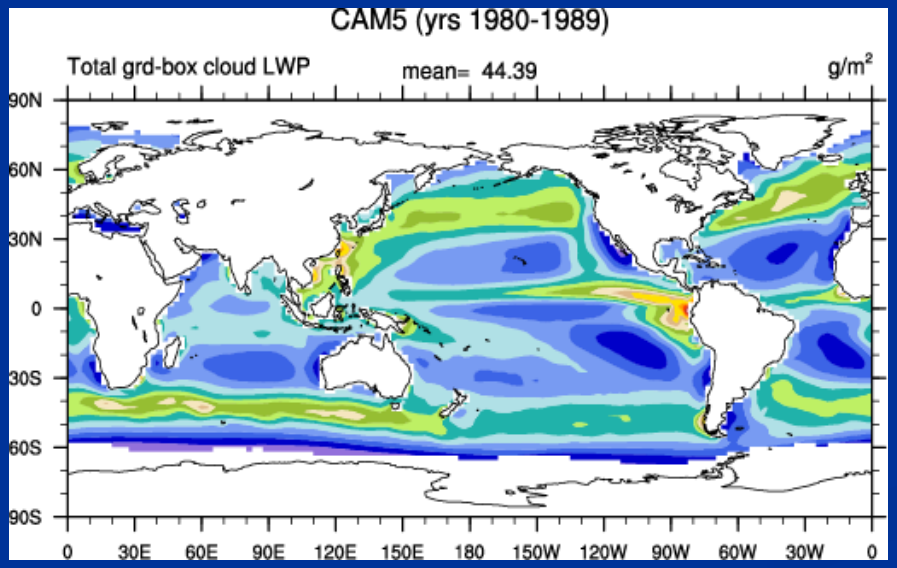
Longwave (LW) and shortwave (SW) radiative fluxes at the top of the atmosphere (TOA) from GCMs (1980-1989 mean) and observation (ERBE)

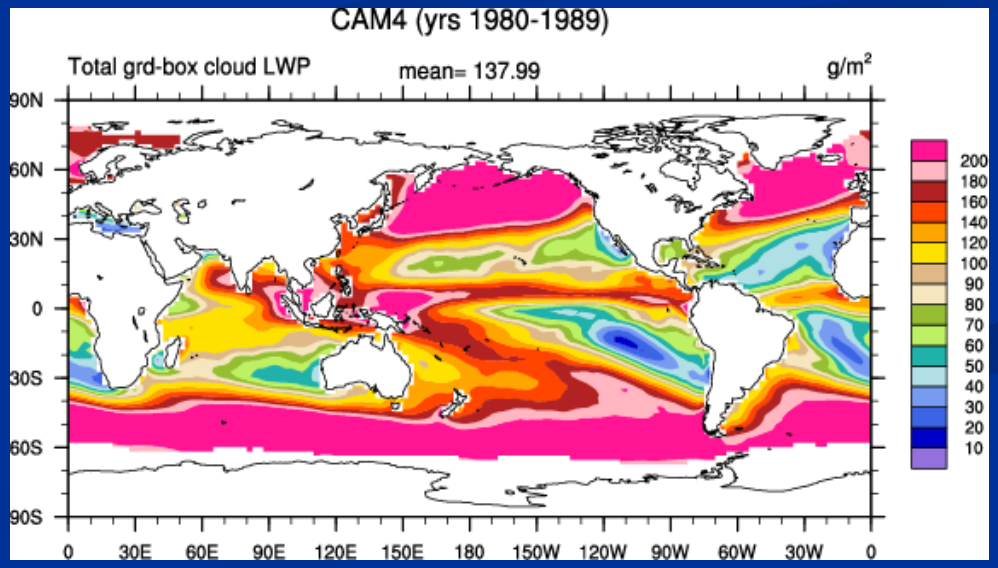
Flux(Wm^{-2})	F_{LW}(TOA)	F_{SW}(TOA)
ISUGCM	233.5	236.4
ERBE	233.9	234.0
CAM5	236.9	239.4
CAM4	233.5	236.6

Cloud liquid water path (g m^{-2})

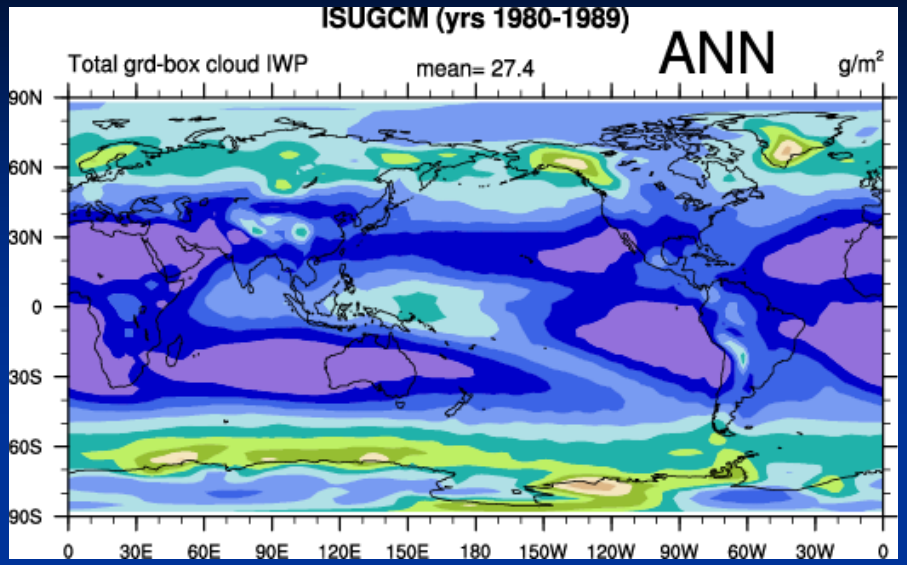


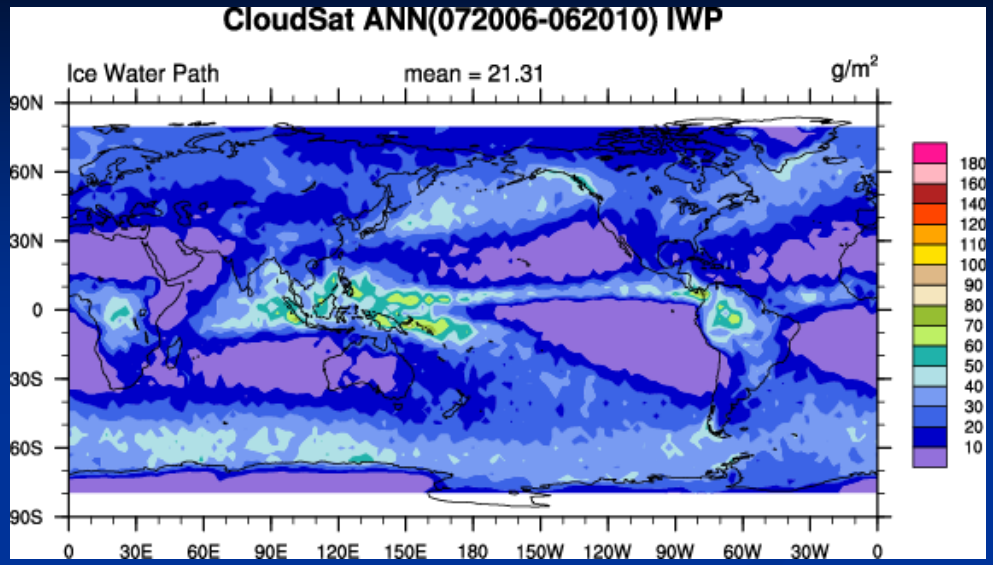


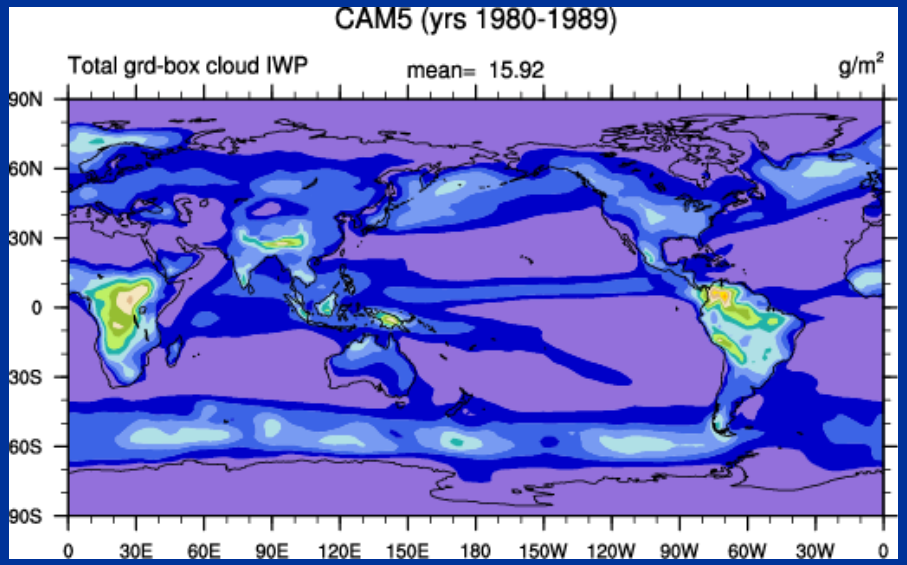


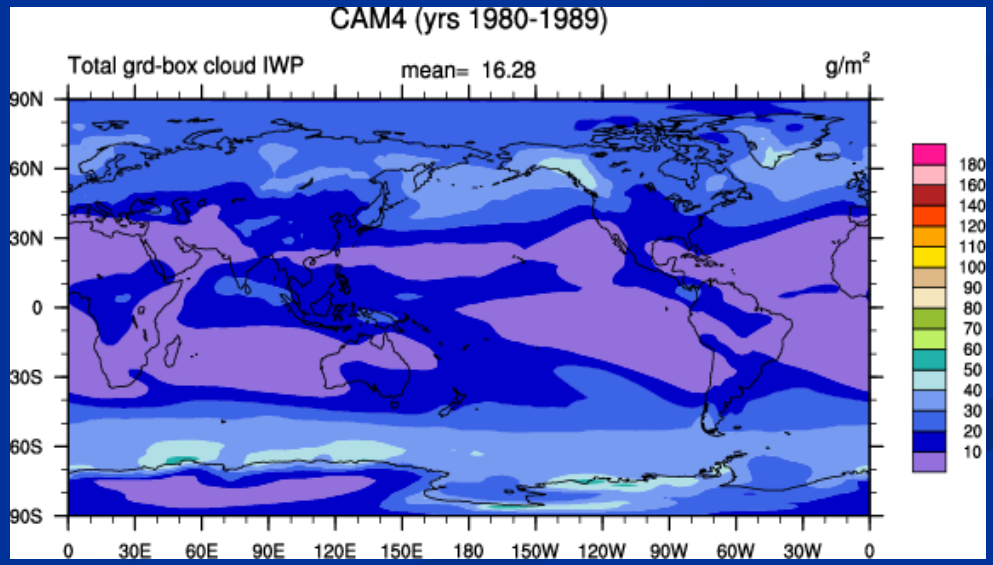


Cloud ice water path (g m^{-2})







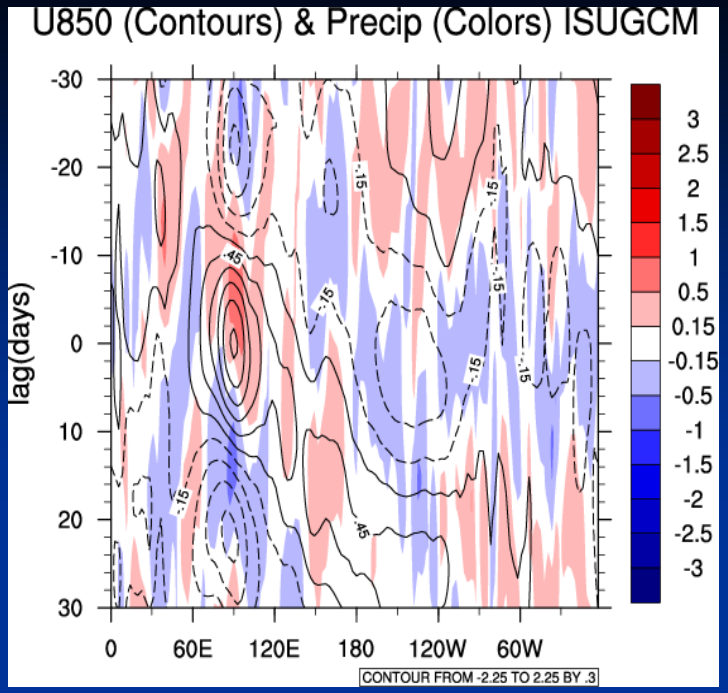


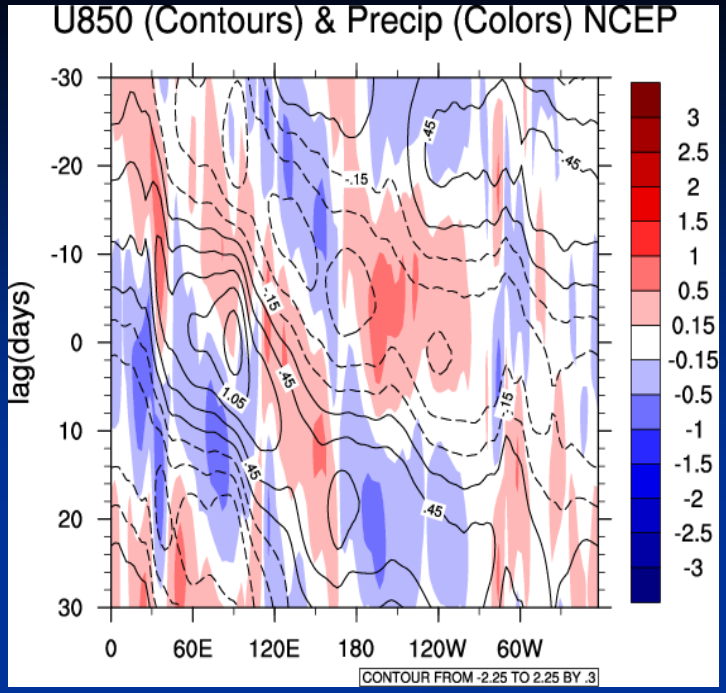
CloudSat 4-year mean IWP data provided by Jui-Lin Li (Waliser et al. 2009 JGR)

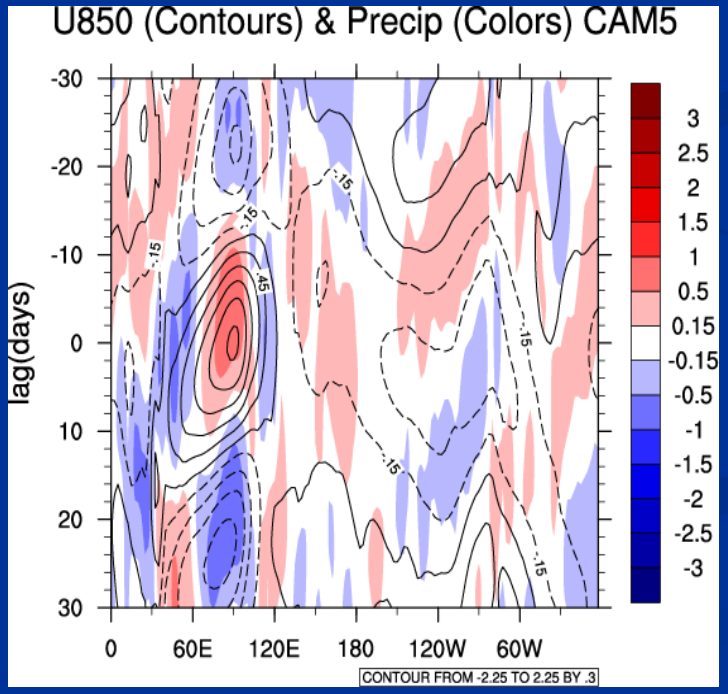
Madden-Julian Oscillation (MJO)

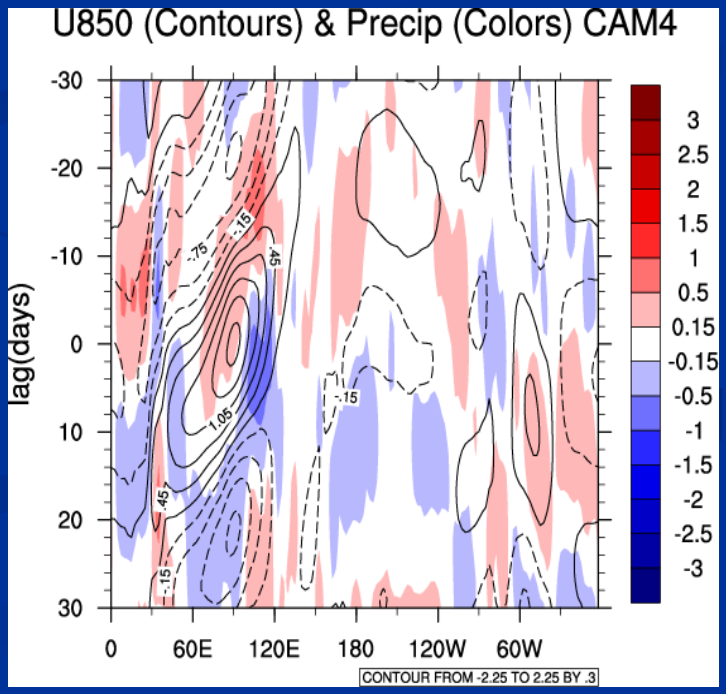
MJO
Indian Ocean

Ten-years (1980-89 October-April) lag correlations of 30-90-day band-passed daily equatorial (5S-5N averaged) 850-hPa zonal wind (contours) and precipitation (colors) onto the daily equatorial 850-hPa zonal wind time series at 90˚E





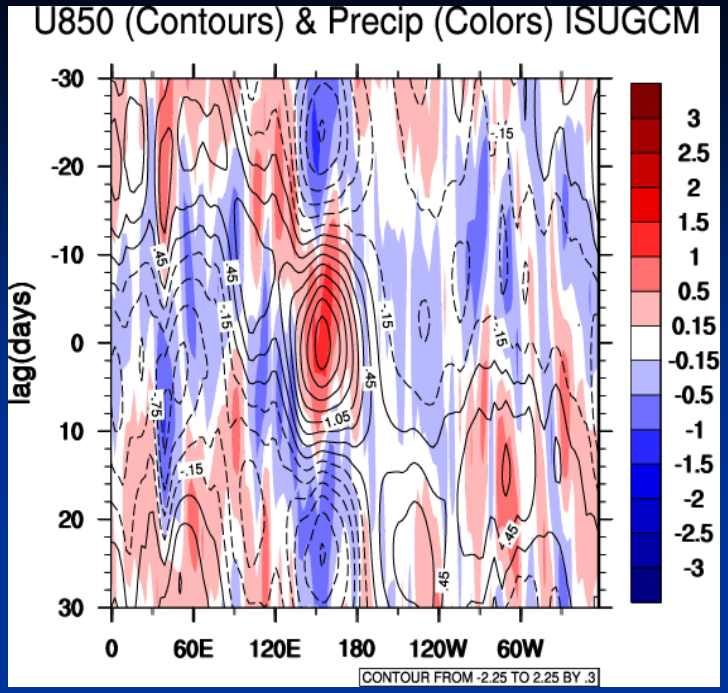


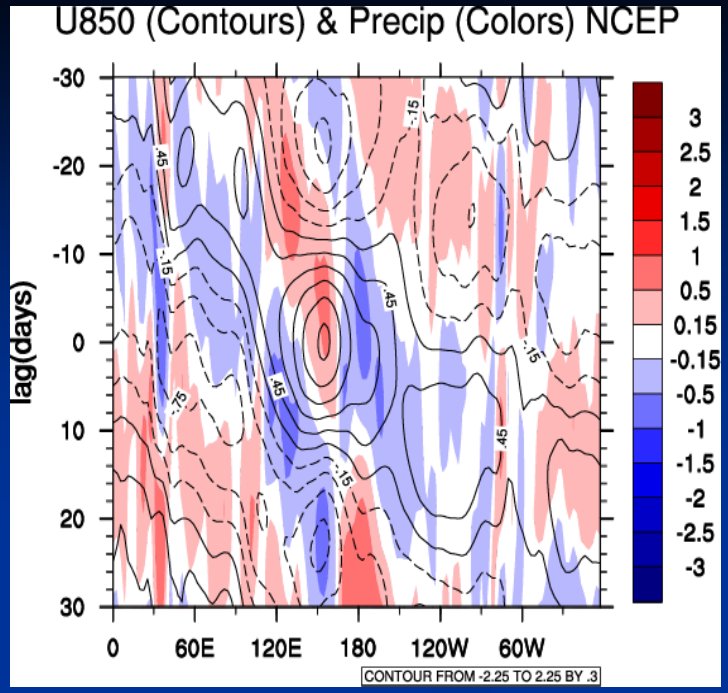


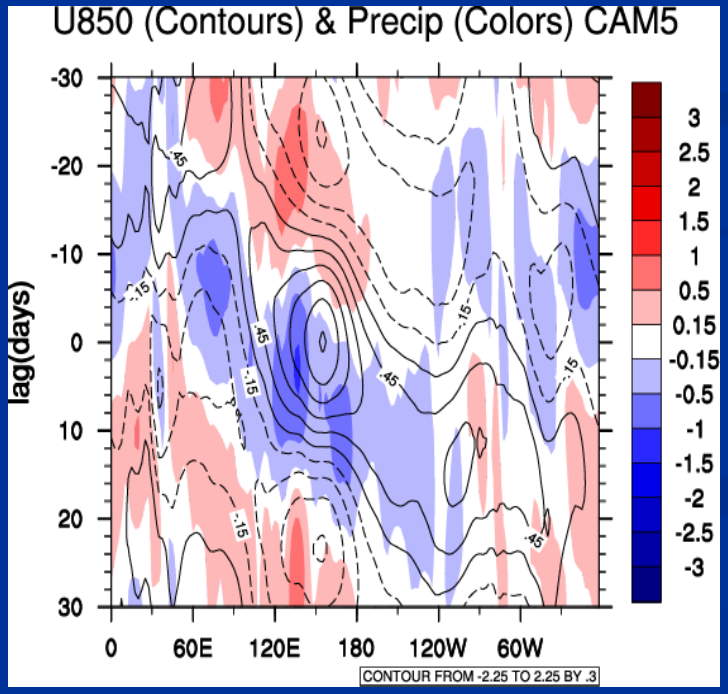
MJO

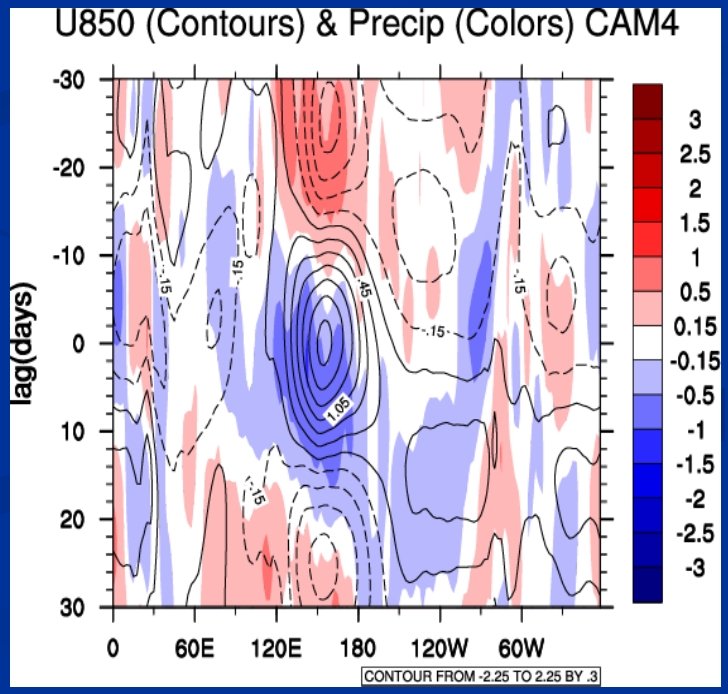
Western Pacific

Ten-years (1980-89 October-April) lag correlations of 30-90-day band-passed daily equatorial (5S-5N averaged) 850-hPa zonal wind (contours) and precipitation (colors) onto the daily equatorial 850-hPa zonal wind time series at 155˚E









Summary

- **Diurnal cycle of precipitation is largely affected by the convection closure assumption.**
- **Precipitation frequency is closely controlled by the trigger condition of deep convection.**
- **Inclusion of subgrid cloud variability in the radiation calculation holds the key to obtain consistent clouds and radiative fluxes.**
- **Moist convection is tied to the large-scale advection, occurs less frequent but more vigorous, and redistributes the momentum, which lead to improved MJO simulations .**