

# Representing Cloud Processes in the Simulation of Climate

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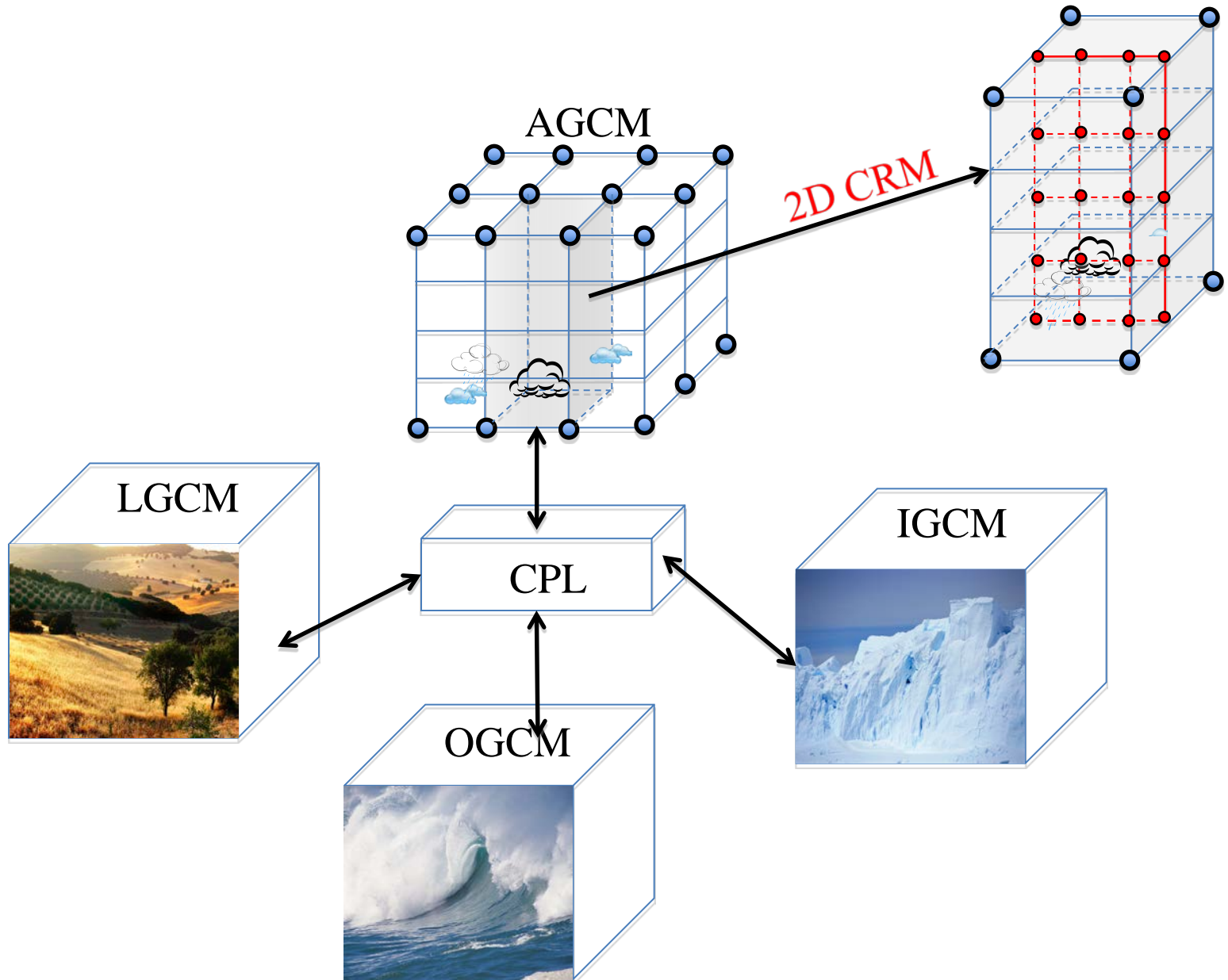
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# Common biases in current generation of CGCMs

- ***Errors in the precipitation distribution with***
  - Second spurious Inter-Tropical Convergence Zone (ITCZ) south of the equator in the eastern Pacific
  - Out of phase diurnal cycle
- ***Tropical Cyclone Activity with***
  - Unrealistic frequency
  - Weak intensity
- ***Misrepresentation of the Madden Julian Oscillation (MJO)***
  - Underestimation of the strength and coherence of convection and wind variability
  - Incomplete life cycle
- ***Misrepresentation of the Summer Indian Monsoon***
  - Deficit or excessive precipitation distribution over the Indo-Pacific Warm Pool
  - Underestimate subseasonal propagating variance
- ***ENSO with***
  - Unrealistic amplitude and regular occurrence
  - Period that is too long or too short

# Cloud Representation



# Models Configuration

		<b><i>SP-CCSM</i></b>	<b><i>Ctl-CCSM</i></b>
<b>Atmospheric GCM</b>	Horiz. Res.	T42 (sld <sup>1</sup> )	T42 (sld <sup>1</sup> )
	Vert. levels	30	26
	Deep conv.	CRM <sup>2</sup>	Zhang-McFarlan
	Shallow conv.	CRM <sup>2</sup>	Hack
<b>Ocean GCM</b>	Horiz. Res.	gx3v5	gx3v5
	Vert. levels	25	25
<b>Ice GCM</b>		CSIM4	CSIM4
<b>Land GCM</b>		CLM3.0	CLM3.0

<sup>1</sup> semi-Lagrangian dynamical core

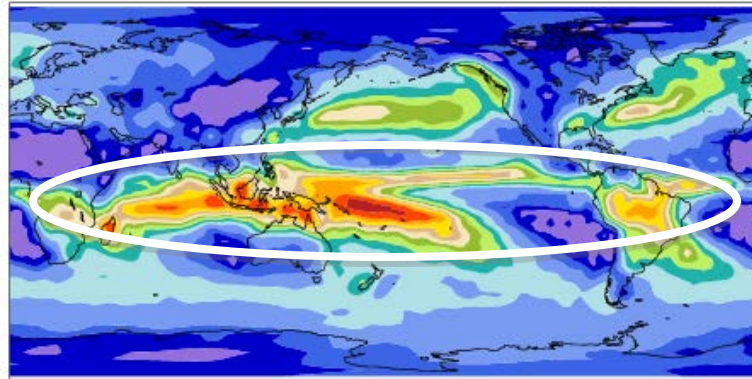
<sup>2</sup> M. Khairoutdinov and D. Randall

# Precipitation Simulation

## Boreal Winter Climatology

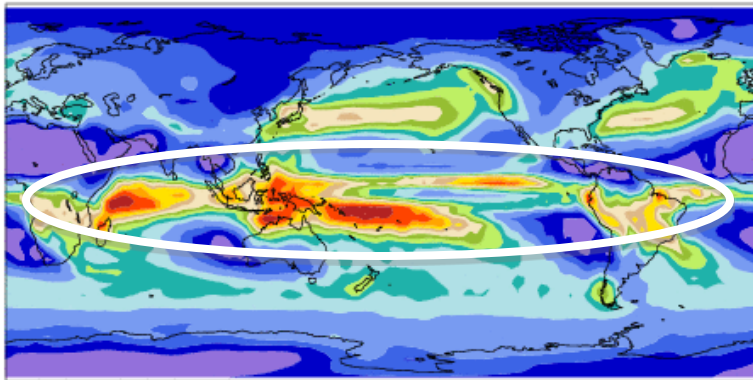
### **CMAP: 1979–1998**

Precipitation rate      mean= 2.64      mm/day



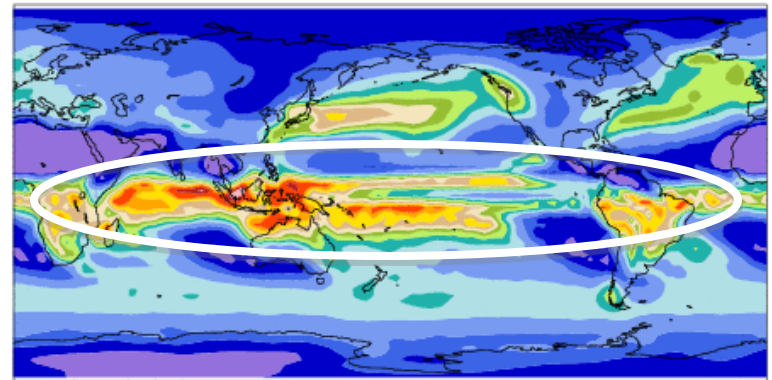
### **SP-CCSM: 0004–0023**

Precipitation rate      mean= 2.80      RMSE = 1.48



### **Ctl-CCSM: 0004–0023**

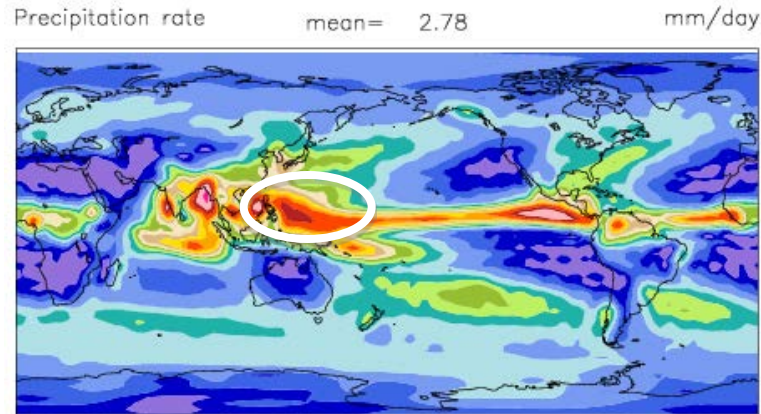
Precipitation rate      mean= 2.75      RMSE = 1.76



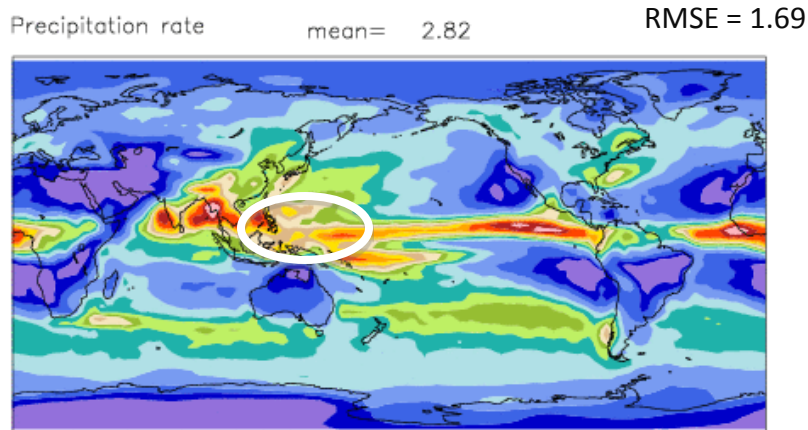
# Precipitation Simulation

## Boreal Summer Climatology

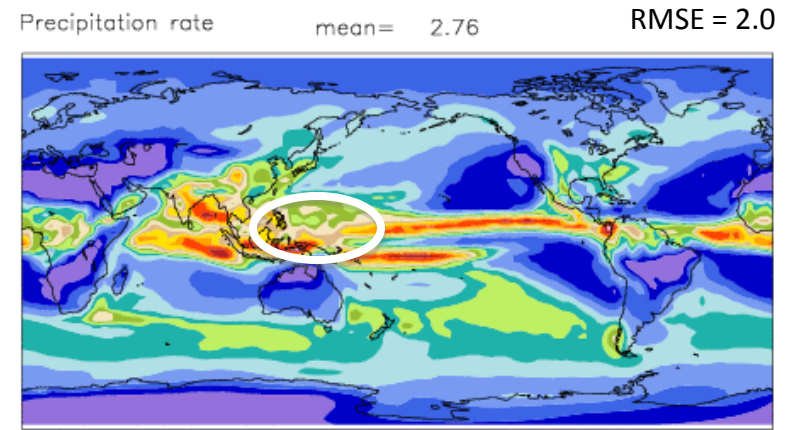
***CMAP: 1979–1998***



***SP-CCSM: 0004–0023***



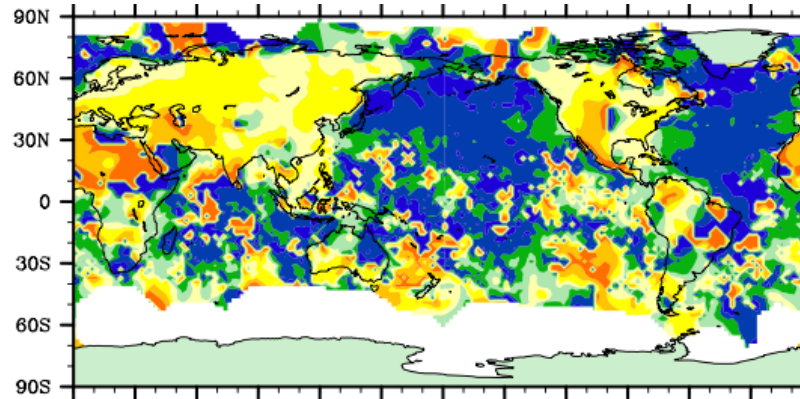
***Ctl-CCSM: 0004–0023***



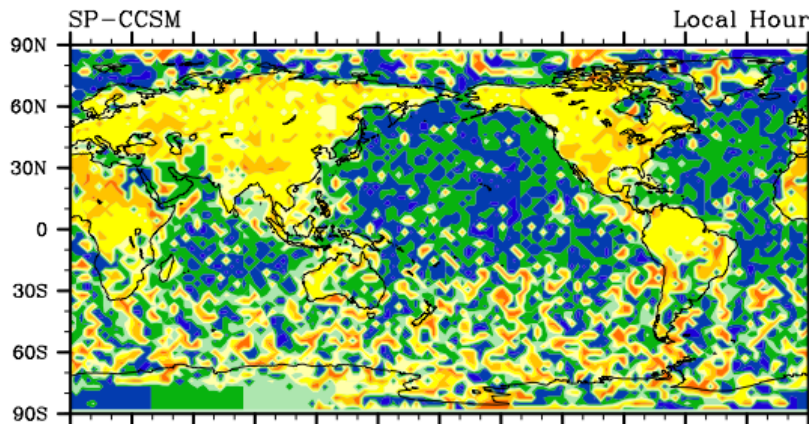


# Diurnal Cycle of Precipitation (Boreal Summer)

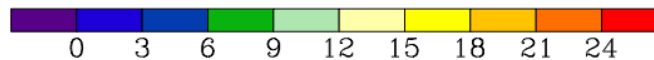
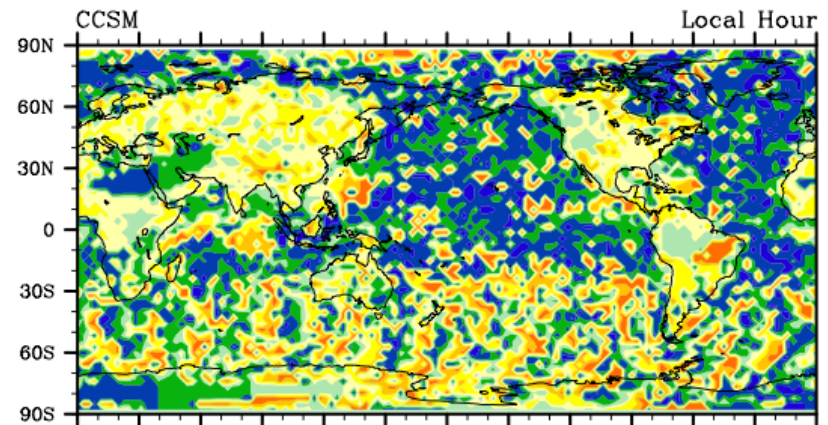
*Dai: 1975–1997*



*SP-CCSM*

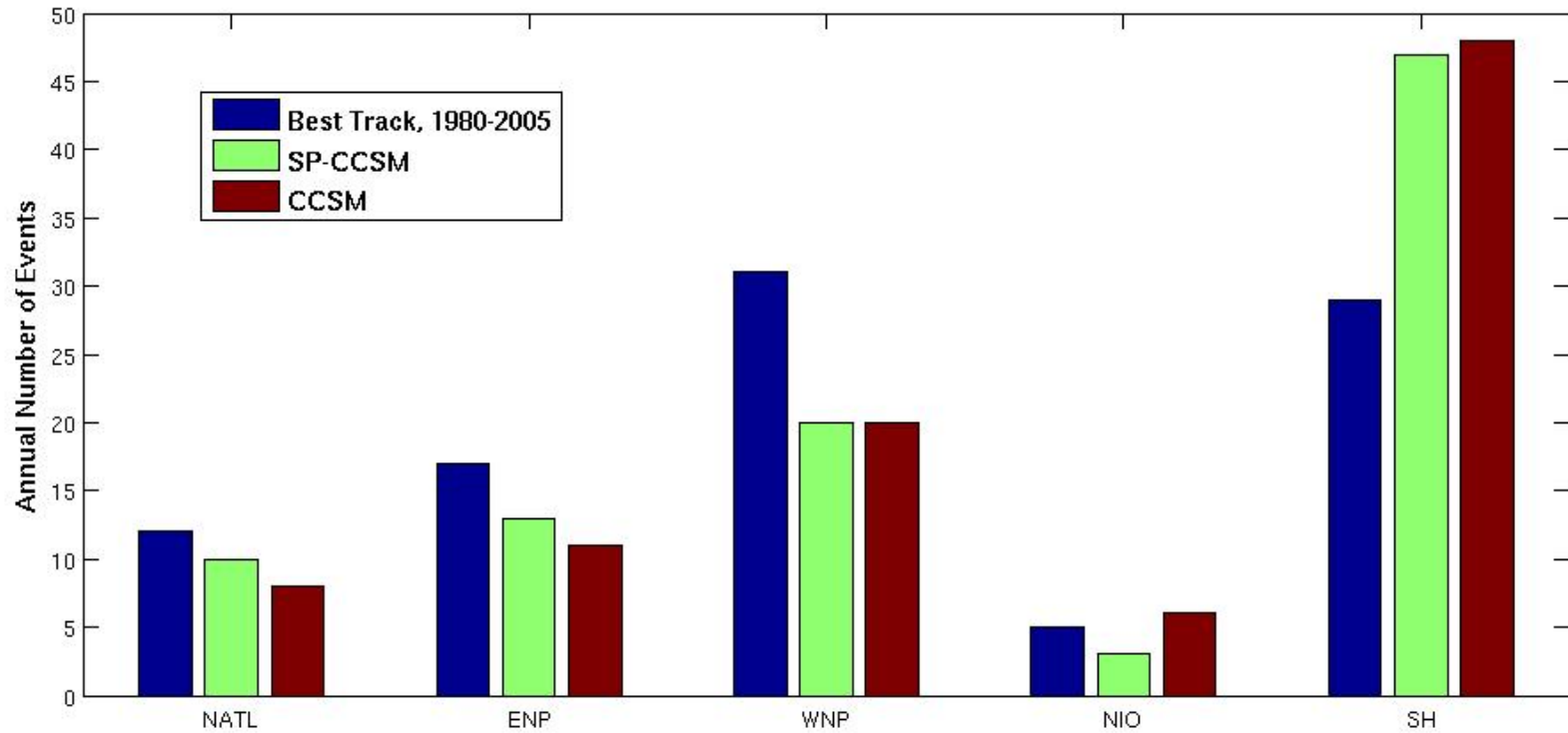


*Ctl-CCSM*



# Tropical Cyclone Activity

(models: 0004-0023, Obs:1980-2005)



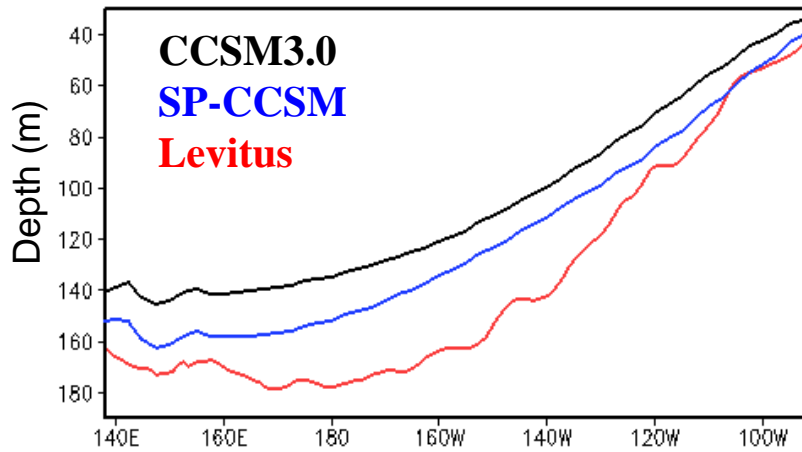


# 20-degree Isotherm, 5S-5N

(models: 0004-0023, Levitus: WAO 1998)

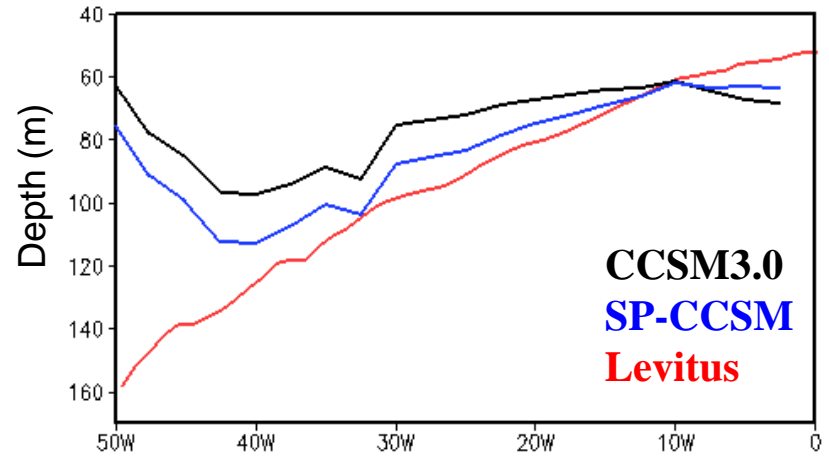
**Pacific**

DJF

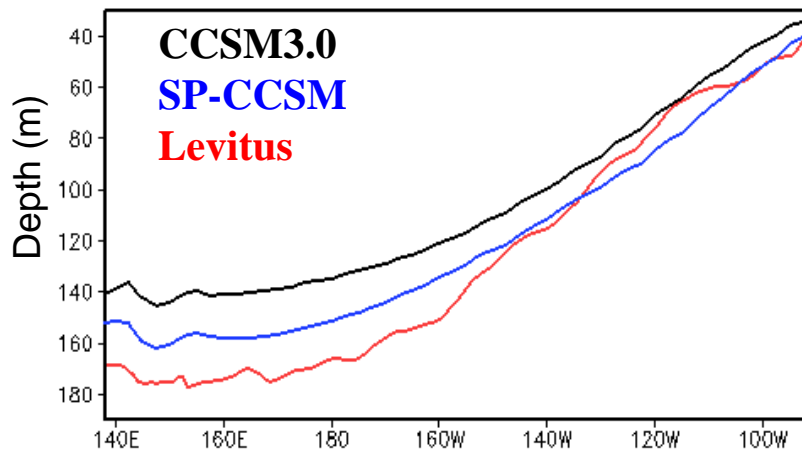


**Atlantic**

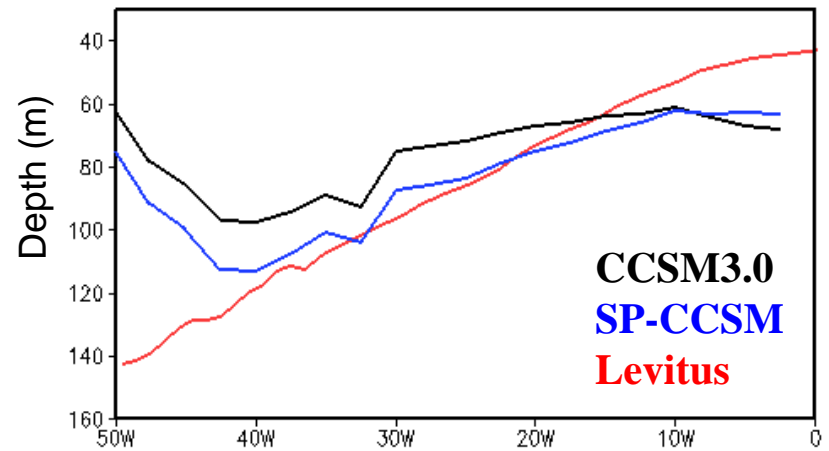
DJF



JJA



JJA



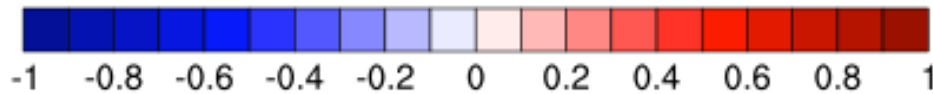
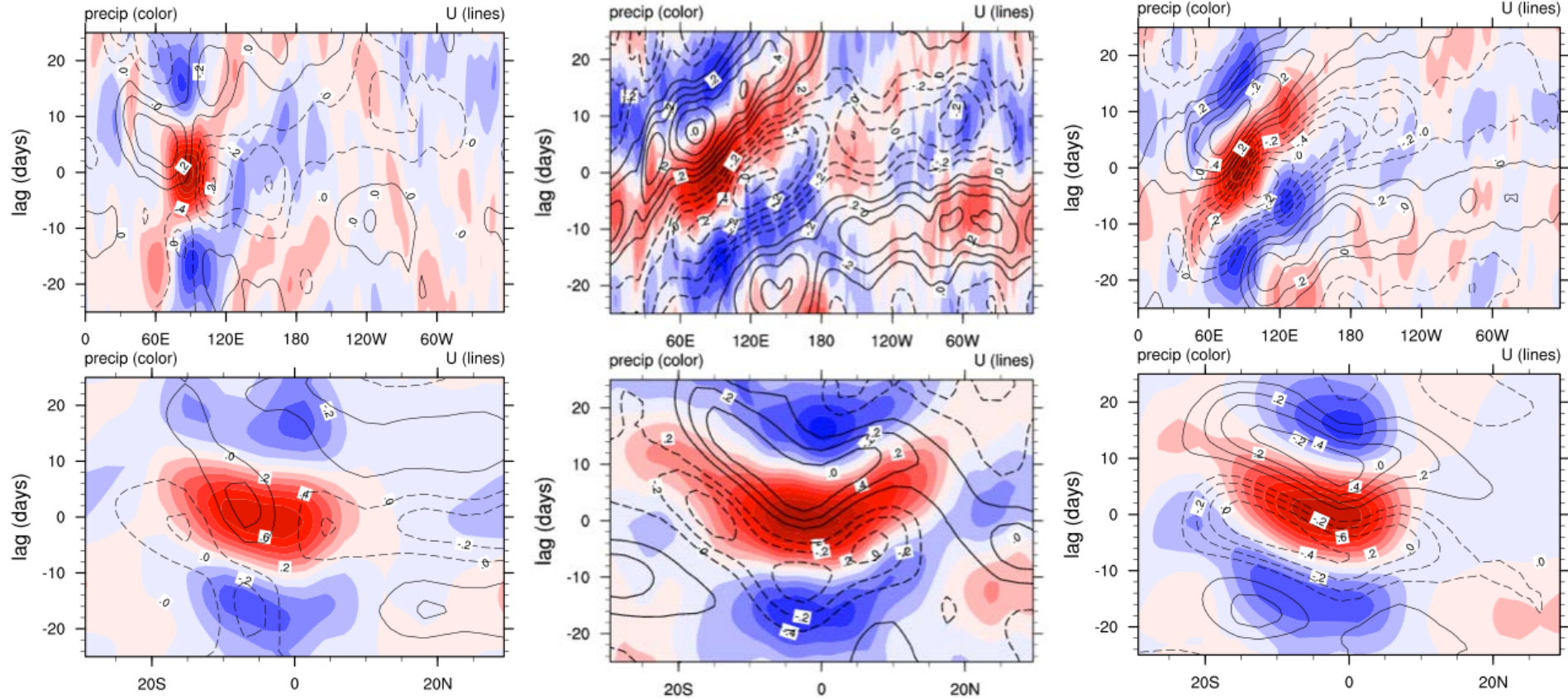
# MJO, Boreal Winter Variability

## Precipitation, 850mb zonal wind

**Ctl-CCSM**

**OBS**

**SP-CCSM**



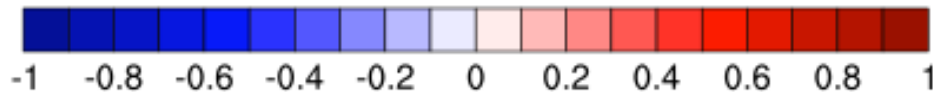
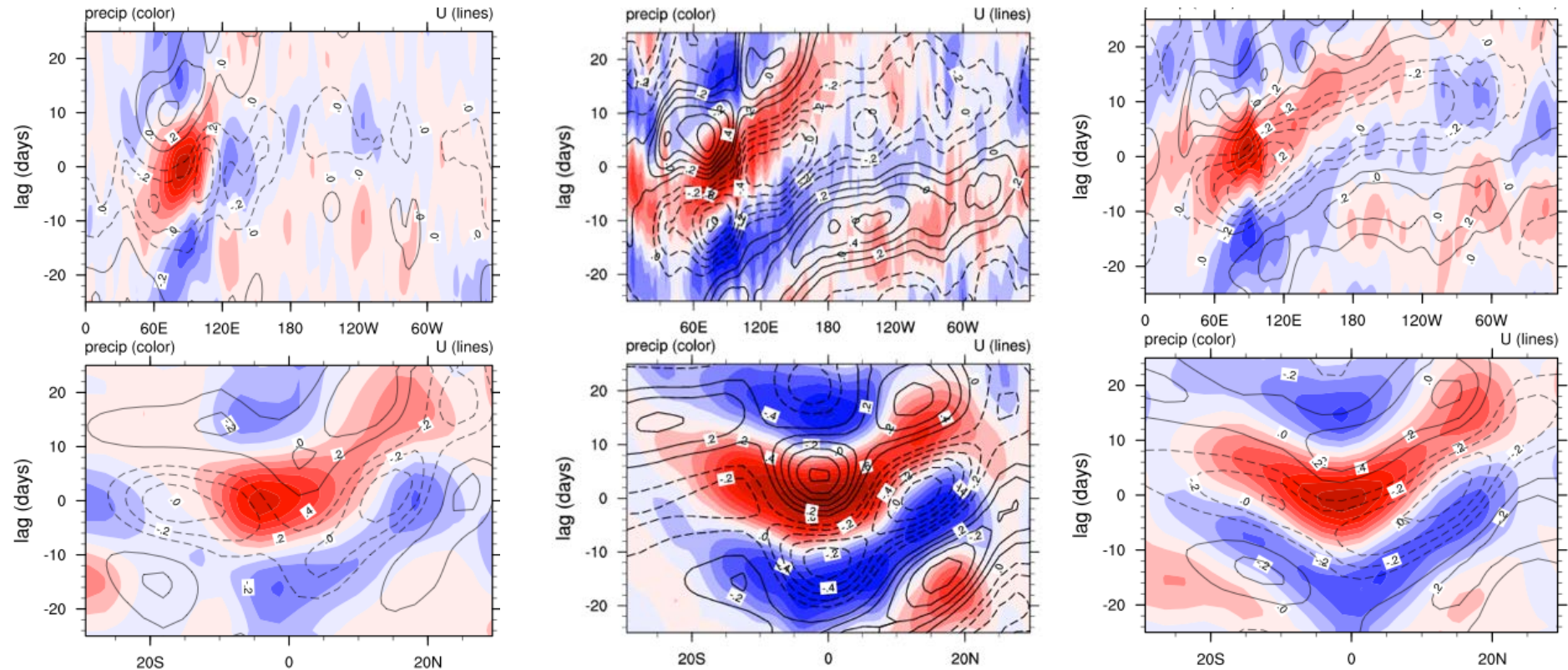
# MJO, Boreal Summer Variability

## Precipitation, 850mb zonal wind

**Ctl-CCSM**

**OBS**

**SP-CCSM**

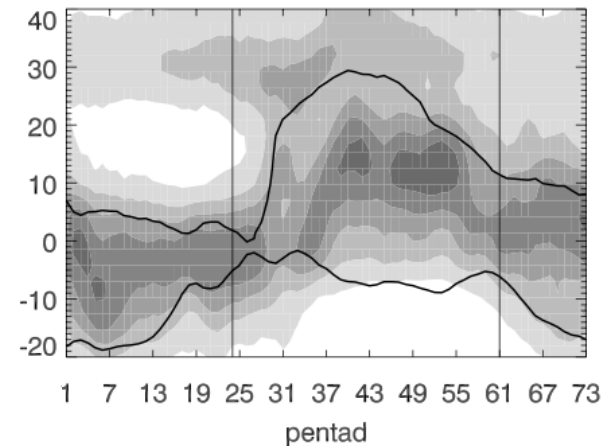
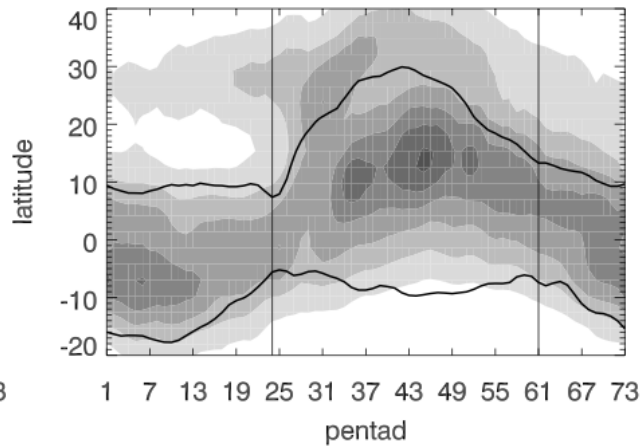
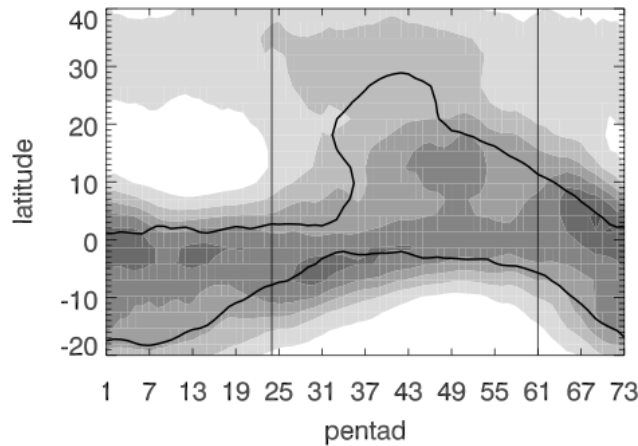
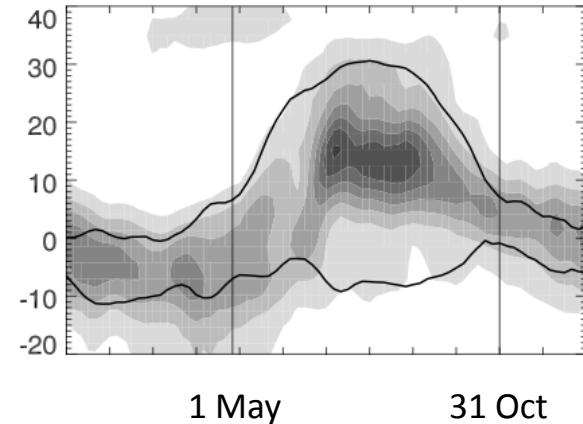
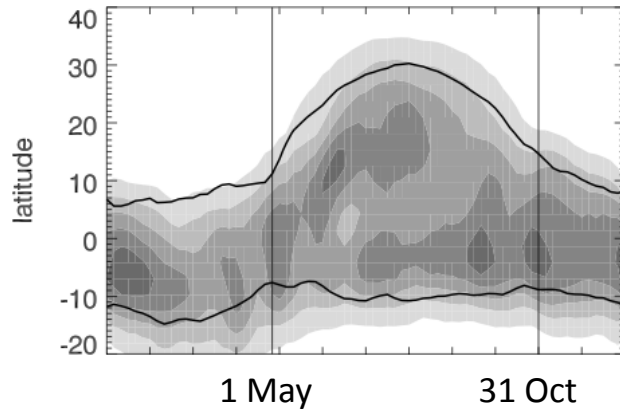
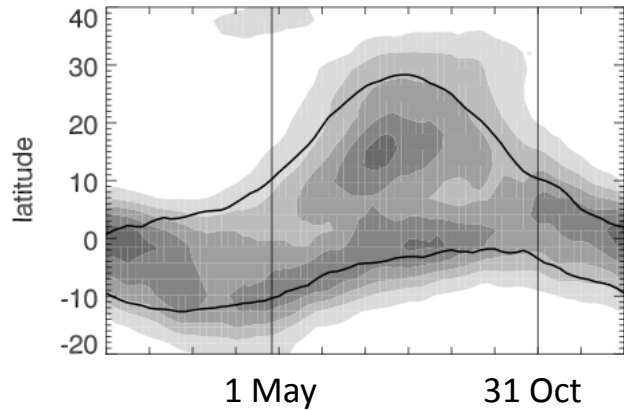


# Indian Monsoon Variability

**Ctl-CCSM**  
(0004–0023)

**GPCP/Rean**  
(1998-2008)

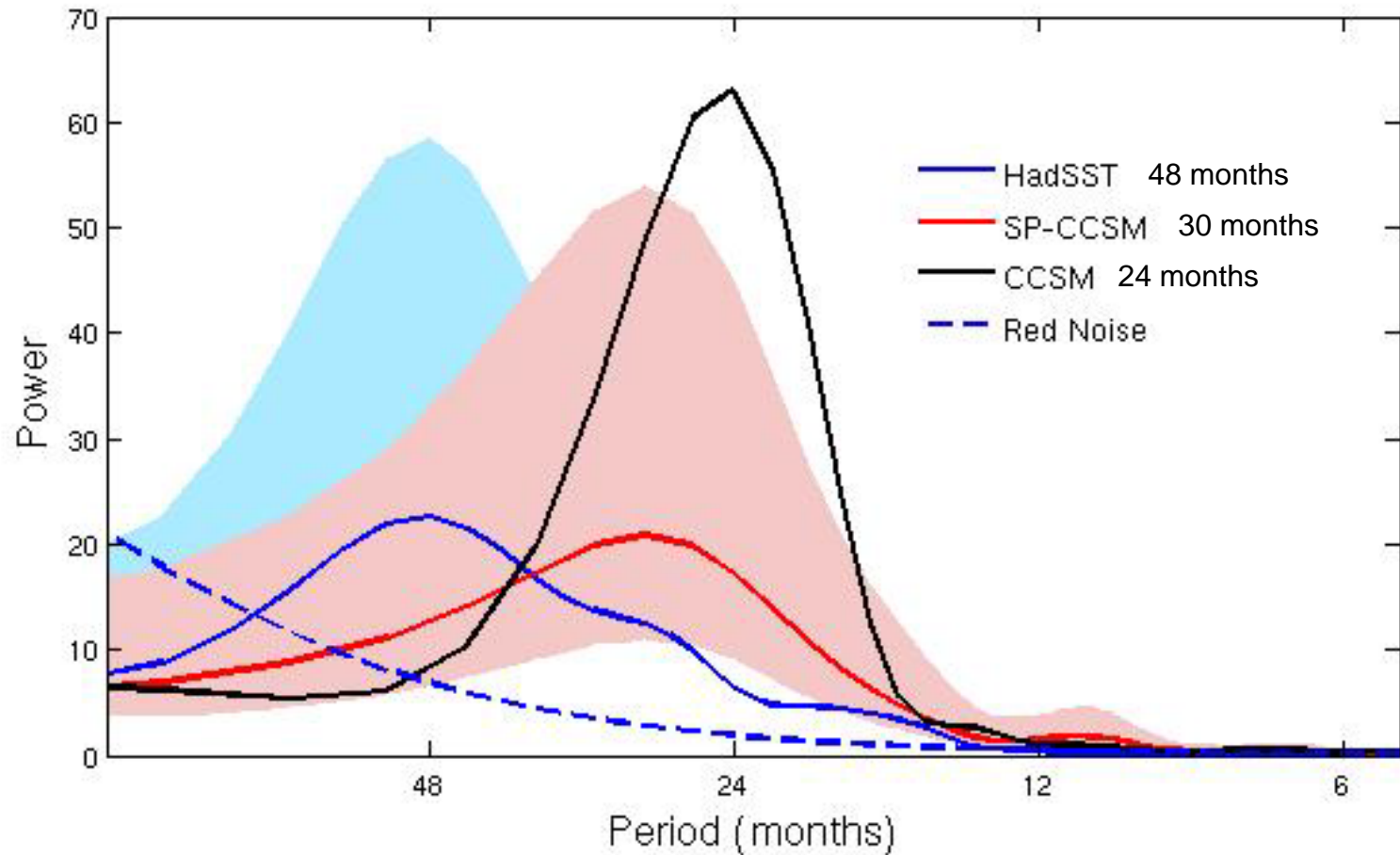
**SP-CCSM**  
(0004–0023)





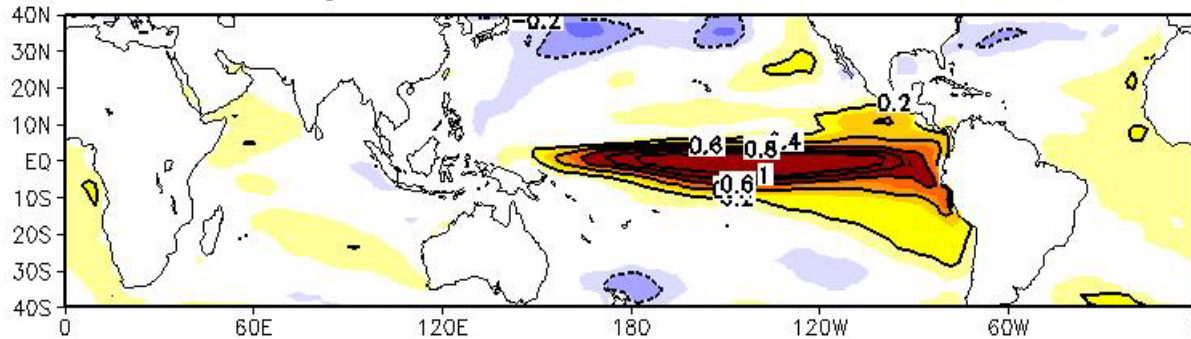
# ENSO Simulation

## Niño-3.4 (5S-5N, 150W-90W)

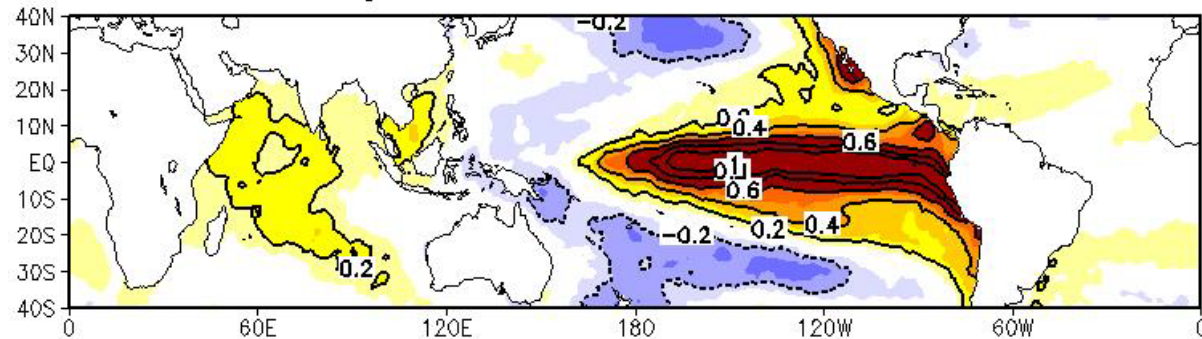


# SSTA Regression with Niño3.4

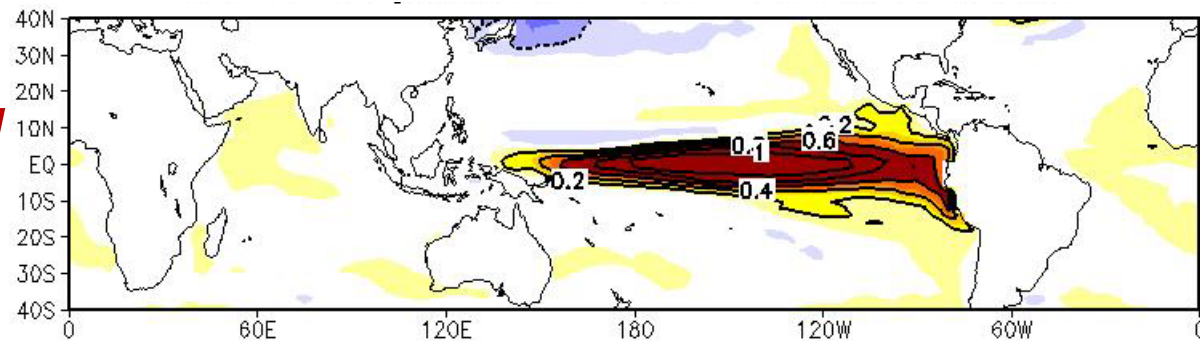
**SP-CCSM**  
(0002–0023)



**HadISST**  
(1948–1998)



**Ctl-CCSM**  
(0002–0023)





# Current Development

- Implementation of Super-Parameterization in CCSM4 – completed

	low	medium	high
CAM/CLM	1.9 <sup>0</sup> x2.5 <sup>0</sup>	0.9 <sup>0</sup> x1.25 <sup>0</sup>	0.47 <sup>0</sup> x0.63 <sup>0</sup>
crm_nx	32	24	16
crm_dx	4 km	4 km	3 km
POP/CICE	1 <sup>0</sup>	1 <sup>0</sup>	0.1 <sup>0</sup>

- Control & RCP8.5 run using the high resolution configuration – pending computational resources from INCITE program.
- Porting SP-CAM code into CAM5 for SP-CESM