Simulation of Tropical Intraseasonal Variability in the CFS

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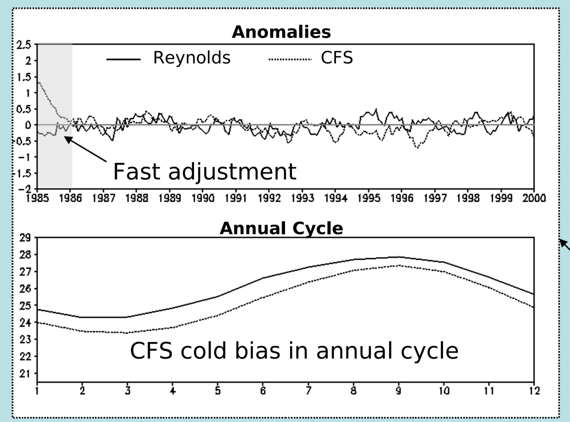
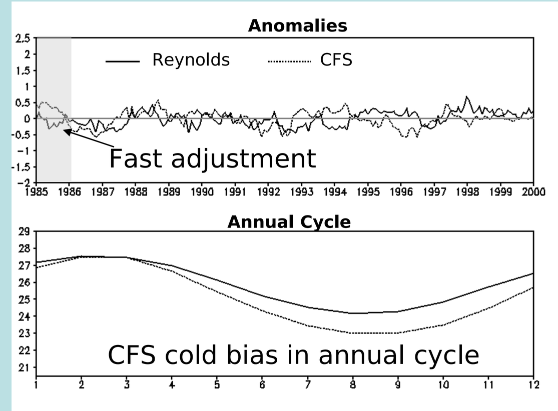
Introduction

The National Center for Environmental Prediction (NCEP) Climate Forecast System (CFS) has been integrated in a freely coupled simulation for 52 years. The model's ability to simulate the mean climate and intraseasonal variability is examined. Additionally, the atmosphere-only component of the model has been forced with daily SSTs from the coupled simulation and integrated for 18 years. The simulation of tropical intraseasonal variability in the coupled and uncoupled models is compared.

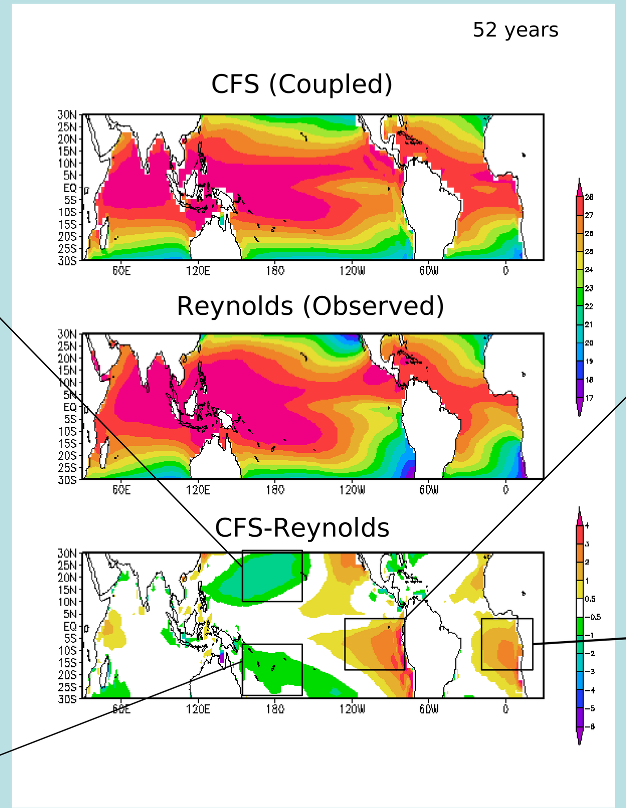
Model Climatology

Cold Bias

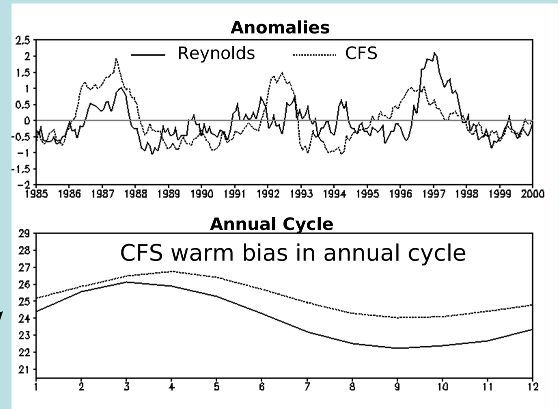


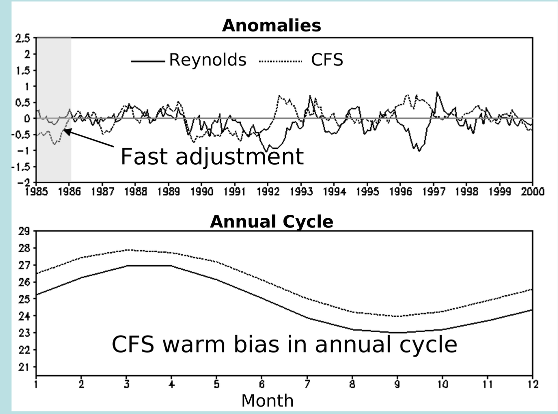


Sea Surface Temperature (^oC)



Warm Bias



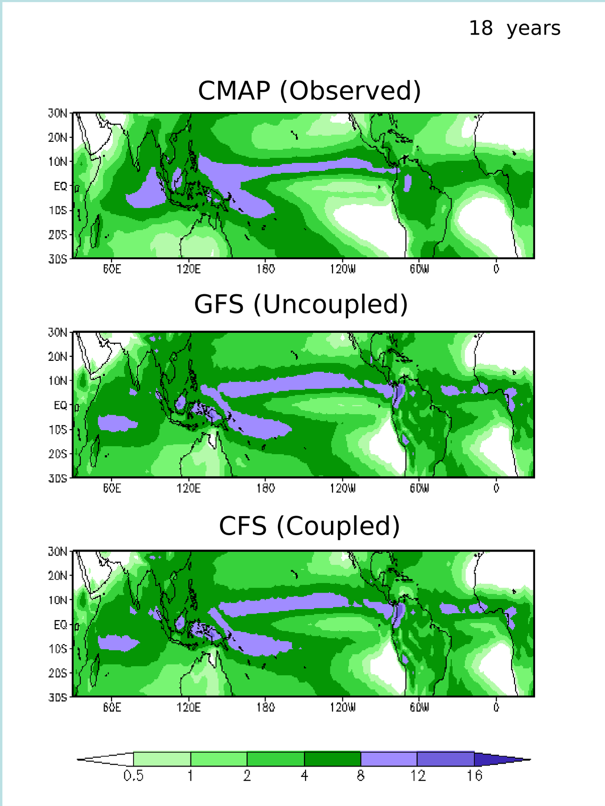


GFS & CFS have similar mean

Both have problem with double ITCZ

Primary difference between GFS & CFS is Pacific cold tongue

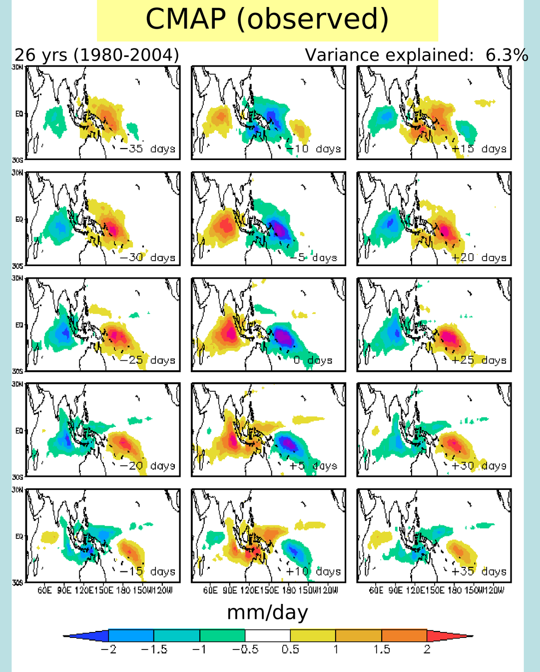
Precipitation (mm/day)



Intraseasonal Variability

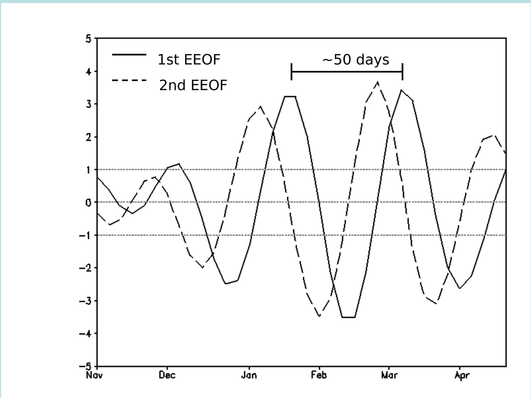
An Extended EOF (EEOF) analysis from -35 to 35 days has been performed on pentads of 30-100 day, winter (Nov-Apr) precipitation for CMAP, the uncoupled, and the coupled simulation. The spatial pattern of the 1st EEOF for each is shown along with the time series amplitude for a large single MJO event in each case.

CMAP (observed)

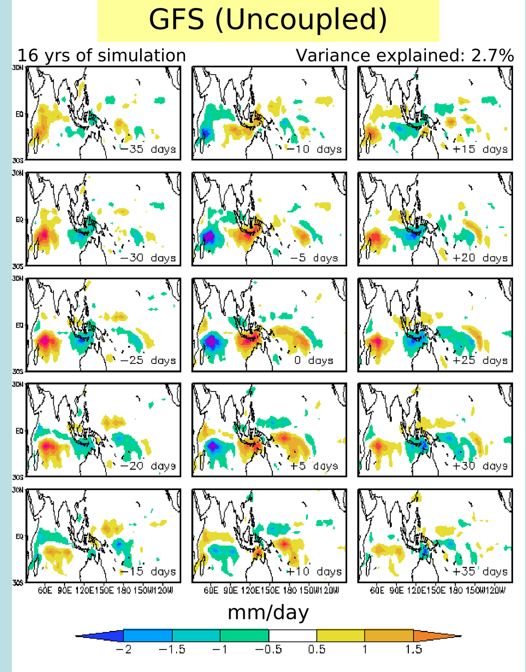


Eastward propagation from Indian Ocean, across Maritime Continent, into Western Pacific

Timescale of ~50 days



GFS (Uncoupled)

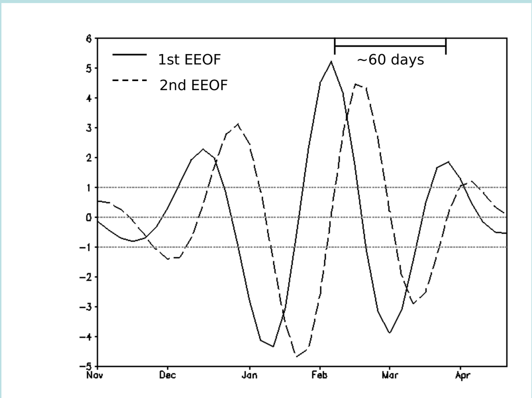


Standing oscillation

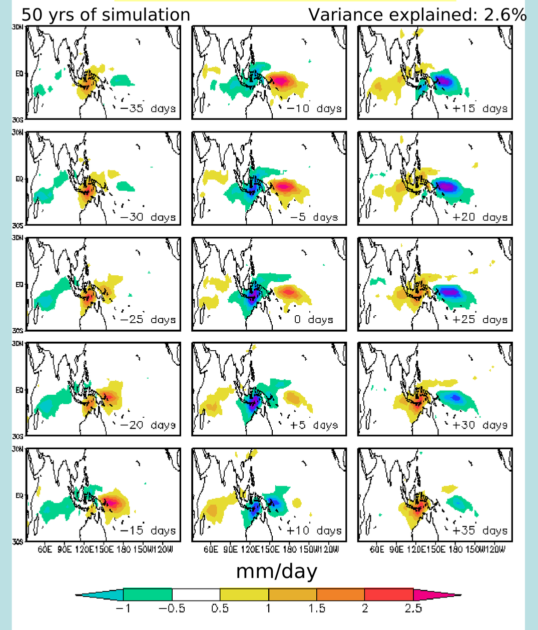
Weaker amplitude than observed

Largest amplitudes in Indian Ocean

No max/min in Western Pacific



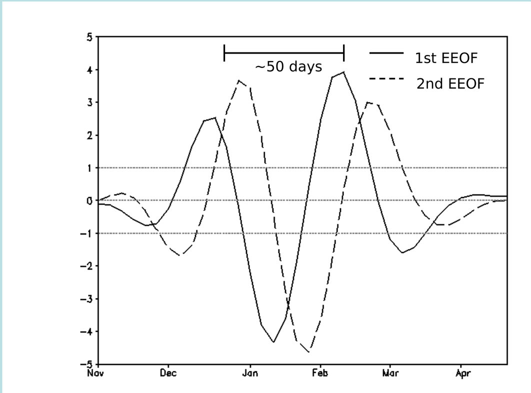
CFS (Coupled)



Strong amplitude over Maritime Continent and Western Pacific

Weak amplitude in Indian Ocean

Eastward propagation

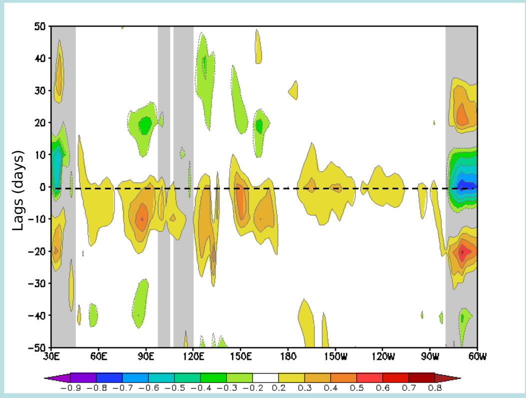


Air-Sea Coupling

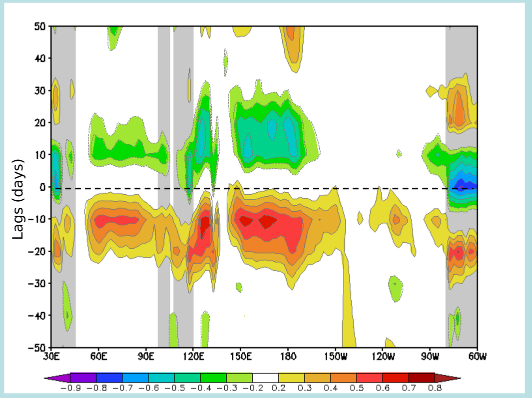
The differences between the coupled and uncoupled simulation of intraseasonal variability are evaluated by comparing lag correlations of intraseasonal (30-100 days), equatorial (5ºN-5ºS) precipitation with surface variables along the equator (5ºN-5ºS). The correlations are made using the 10 largest MJO events from each of the simulations. These events are identified using the EEOF analysis. Correlations plotted are statistically significant from zero at the 95% level based on 58 degrees of freedom

GFS (Uncoupled) | CFS (Coupled)

Precip & SST
+lag: SST lags Precip
-lag: SST leads Precip



Positive SST anomalies lag precipitation by ~10 days in the Indian Ocean, ~5 days in the Western Pacific, and is coincident in the Central Pacific

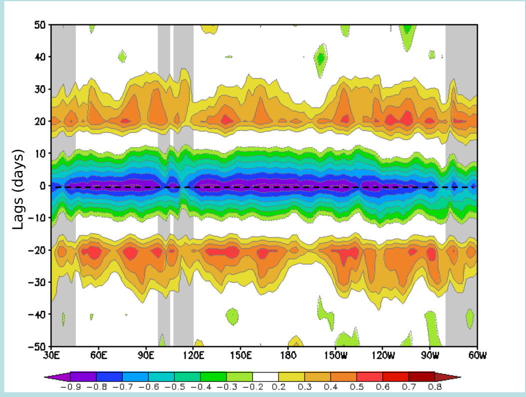


Positive SST anomalies lead precipitation by ~10 days in the Indian Ocean & Central Pacific & ~5 days in the Western Pacific

Negative SST anomalies lag precipitation by ~10-20 days

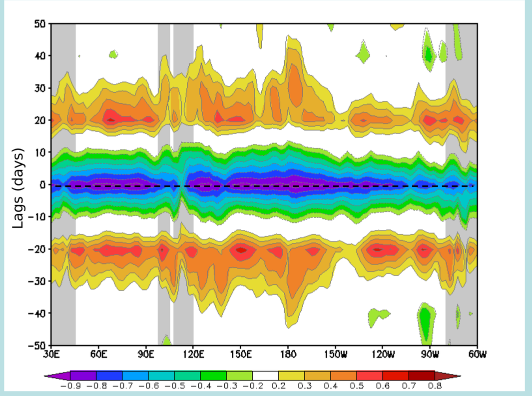
This relationship is not present in the uncoupled simulation

Precip & Shortwave Flux
+ lag: SWF lags Precip
- lag: SWF leads Precip



Reduced shortwave flux is coincident with precipitation, as is expected due to increased cloudiness

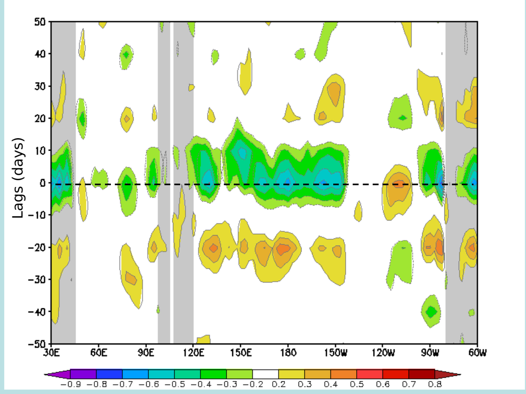
Increased shortwave flux both leads and lags precipitation by about 20 days.



Reduced shortwave flux is coincident with precipitation, as is expected due to increased cloudiness

Increased shortwave flux both leads and lags precipitation by about 20 days.

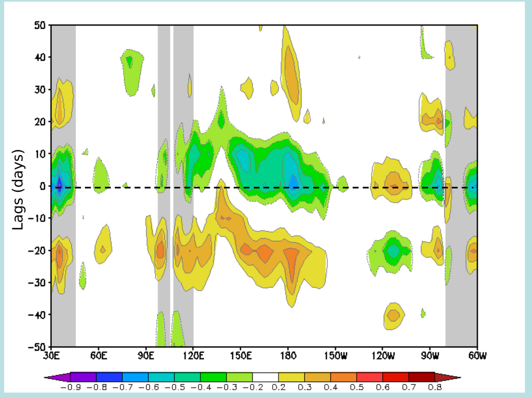
Precip & Taux
+ lag: Taux lags Precip
- lag: Taux leads Precip



Increased westerlies lead precipitation by ~20 days

Increased easterlies lag precipitation by ~0-5 days

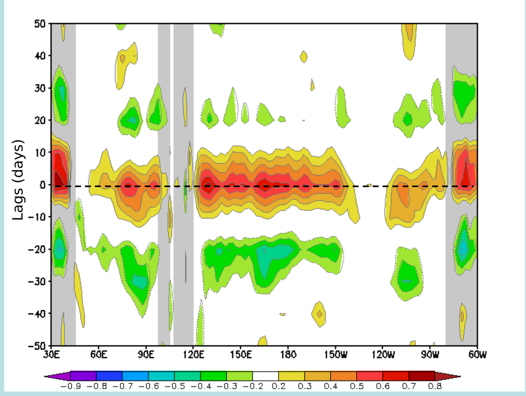
The increased easterlies take longer to develop near 160E



Increased westerlies lead precipitation by about 20 days in the Pacific Ocean with the exception of a region between 140E-150E where the lead is only ~5-10 days

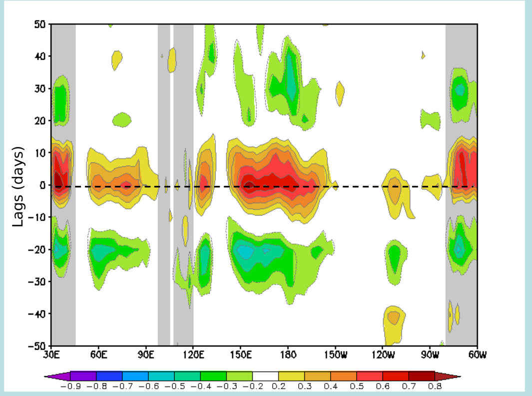
Increased easterlies lag precipitation by ~5 days in the Pacific Ocean with the exception of an area between 140E-150E where the increased easterly anomalies take longer to develop

Precip & LHF
+ lag: LHF lags Precip
- lag: LHF leads Precip



Decreased latent heat flux leads precipitation by ~30 days in the Indian Ocean & ~20 days in the Pacific Ocean

Increased latent heat flux is coincident with precipitation across the Indian and Pacific Oceans to about 140W.



Decreased latent heat flux leads precipitation by ~20 days in the Pacific Ocean

Increased latent heat flux lags precipitation by ~5 days in the Pacific Ocean to about 160W.

Conclusions

1. CFS has a small bias in SST. Biases are due to problems with annual cycle.
2. CFS & GFS have almost identical mean climate in precipitation.
3. The CFS (coupled) has stronger amplitude and better propagation of tropical intraseasonal variability than the GFS (uncoupled), and more closely matches nature.
4. The lagged-relationship between SST and precipitation is different in the coupled and uncoupled simulations
5. This relationship between SST & precipitation may be related to the improved simulation of tropical intraseasonal variability in the coupled model. Future studies will investigate this.

References

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