Simulation and prediction of the MJO with the NCEP coupled model

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What is the impact of ocean surface on MJO simulation and prediction?
What is the role of ocean surface on MJO simulation by NCEP atmospheric global forecast system (GFS)?

How should we treat the ocean surface for MJO prediction with NCEP GFS?

- Use climatological SSTs
- Damp initial SST anomalies
- Couple GFS to an ocean model
Objective

• Investigate the impact of the treatment of SSTs on MJO simulation and forecast by NCEP models

Approach

• Simulating and forecasting the MJO with specified and interactive ocean surface
Outline

- Models
- Simulations
- Forecasts
- Conclusions
The models

1. Atmospheric model (GFS03)
   - NCEP Global Forecast System 2003
   - T62; L64

2. Oceanic model (MOM3)
   - GFDL Modular Ocean Model V.3
   - $1/3^\circ \times 1^\circ$ in tropics; $1^\circ \times 1^\circ$ in extratropics; 40 layers
   - Quasi-global domain (74$^\circ$S to 64$^\circ$N)
   - Free surface

3. Coupled model (CFS03)
   - Once-a-day coupling
   - No flux adjustment
   - Sea ice extent taken as observed climatology
**Simulations**

- **GFS03** AMIP with monthly-SSTs for 1982-2002
- **CFS03** 21-year coupled free run

**Observations**

- **R2** NCEP/DOE reanalysis 2 (Kanamitsu et al., 2002)
- **CMAP** CPC merged analysis of precipitation (Xie & Arkin, 1997)
SST bias from CFSv3 (K)

Annual mean

5S–5N average

[Map showing SST bias from CFSv3 (K) with color-coded areas indicating temperature deviations.]
Diagnoses for the simulations

- Wavenumber-frequency spectra
- EOF modes of Precipitation, U850, and U200
- Lag correlation between EOF PCs and individual fields
Spectra of 10S–10N u850 (m²s⁻²day)
EOFs of combined fields (10S–10N average) for Nov to Mar

**R2/CMAP**

- **EOF1**: 17.96%
- **EOF2**: 14.16%

**GFS03**

- **EOF1**: 12.42%
- **EOF2**: 10.35%

**CFS03**

- **EOF1**: 13.01%
- **EOF2**: 11.43%
Lag correlation with PC1
Lag correlation with PC2

R2/CMAP

GFS03

CFS03

U850

Prec

LH

SW

SST

0 60E 120E 180 120W

0 60E 120E 180 120W

0 60E 120E 180 120W

0 60E 120E 180 120W

-0.8 -0.8 -0.4 -0.2 0 0.2 0.4 0.6 0.8 0.8

-40 -20 0 20 40
Spectra of 10S–10N u850 (m²s⁻²day)
Lag correlation with PC1

GFS03 climSST

GFS03 amipSST

CFS03

U850

Prec

LH

SW

SST

0 60E 120E 180 120W

0 60E 120E 180 120W

0 60E 120E 180 120W

-40 -20 0 20 40

-40 -20 0 20 40

-40 -20 0 20 40

-40 -20 0 20 40

-40 -20 0 20 40

-40 -20 0 20 40

-0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8
Conclusions from simulations

- Improvements due to air-sea coupling
  - convection and circulation is more coherent
  - propagation is more clear
  - strong intraseasonal variance band is more narrow
- The MJO simulated by CFS03 is too strong and a little too slow
- Latent heat flux pattern in CFS03 is not consistent with that in reanalysis, possibly due to that the mean surface westerly in the Indian ocean and western Pacific is too weak
- The MJO in AMIP run may contain response to SST anomalies
Forecasts

Models
- GFS03
- CFS03

Initial dates
- November 1 to February 28
Forecasts

Experiments

- **damp**: GFS03 with decaying SST anomalies
- **clim**: GFS03 with climatological SSTs
- **amip**: GFS03 with observed weekly SSTs
- **coup**: CFS03 with initial ocean state from NCEP GODAS
10–100-day filtered 10S–10N average

2000/2001

prec  u850  u200

2002/2003

prec  u850  u200

Phase 1  Phase 2  Phase 3  Phase 4
Conclusions from forecast experiments

- Air-sea coupling is necessary for MJO forecast beyond week two
- The forecast MJO by CFS03 from peak phase of EOF1 propagates too slowly
- MJO Forecast by CFS03 from other phases is encouraging
10–100-day filtered 10S–10N average