Simulation of the tropical intraseasonal oscillation with a coupled GCM

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OBJECTIVE

- assess and document the ability of a CGCM to simulate the MJO

DATA USED

- daily data from a 100-year coupled run
- NCEP/NCAR reanalysis and observed OLR (AVHRR-NOAA)
- northern extended winter (November-March)

ANALYSIS PERFORMED

- EOF analysis of intraseasonal (20-100 day) OLR anomaly
- EOF PCs used to define a MJO index
- composites of intraseasonal anomalies
PLANE OF THE TALK

• the model and its climatology

• the simulated MJO:
  - main features
  - propagation mechanism
  - T30 vs T106

• summary
The model (SINTEX)

**ECHAM-4**: MPI - Hamburg (Roeckner et al. 1996)
- global
- T106 (320x 160 GG) ~ 1.1°
- 19 vertical levels

**OPA 8.1**: Lodyc - Paris (Madec et al. 1998)
- global
- 2° longitude; 0.5 - 2° latitude
- 31 vertical levels
- climatological sea-ice

**FLUXES and SST exchanged every 3 hours**

**ATMOSPHERE**
**ECHAM-4**

**COUPLER**: OASIS

**OCEAN**
**OPA**

**NO FLUX CORRECTIONS**

100 years
NORTHERN WINTER MEAN (ndjfm)

observations

model

SST† (HadISST)

1000-mb u (NCEP)

sst†

1000-mb u
NORTHERN WINTER MEAN (ndjfm)

observations

olr (NOAA) vs. model

prec (Xie-Arkin) vs. prec
OLR STANDARD DEVIATION

observations

model

total anomalies

band-pass (20-100 days) anomalies

W/m^2
Nov - Mar intraseasonal (20-100 day) anomalies

**OBSERVATIONS**

- **EOF 1**
- **EOF 2**
- **EOF 1 + EOF 2 expl. var.**

**MODEL**

- Expl. var. %

MODEL | OLR | EOF ANALYSIS

- pc1
- pc2  max $r = 0.3$ (lag=9 days)

(Morlet) wavelet analysis
pc1 (shaded)
pc2 (contour)
**A MJO INDEX BASED ON THE EOF PCs**

**strong events: pc > 2σ**

- **eastward propagation criteria** as in Woolnough et al. (2000) and Innes and Slingo (2003)
  - 45° to the east of the reference location for 10-19 days before
    - OR
  - 45° to the west of the reference location for 10-19 days after
    - OR
  - 25° to the west 3-14 days before AND 25° to the east 3-14 days after

**MODEL RUN:** 42 MJO EVENTS IN 100 SIMULATED WINTERS

**OBSERVED OLR:** 16 MJO EVENTS IN 24 WINTERS
Equatorial anomalies (10N - 10S)

Propagation of the convective signal
MODEL MJO CYCLE PC1-INDEX COMPOSITE

Equatorial anomalies (10N - 10S)
Equatorial anomalies (10N - 10S)

Vertical structure of the Q anomaly at the reference location 125E

MODEL  MJO CYCLE  PC1-INDEX  COMPOSITE
Equatorial anomalies (10N - 10S)

\[ \text{QDIV} = \text{DIV}(uq,vq) \]
MODEL  MJO CYCLE  .  PC1  COMPOSITE

---  convection (OLR<0.)

(\text{qu}, \text{qv})

shaded patterns  \text{DIV}(\text{qu}, \text{qv})
MODEL MJO CYCLE PC1 COMPOSITE

---

convection (OLR<0.)

(\(qu,qv\))

shaded patterns DIV(\(qu,qv\))
MJO CYCLE  T106 vs T30

observations

model T30

model T106

(Sperber et al. 2003)
MJO CYCLE T106 vs T30

(Sperber et al. 2003)
SUMMARY

The model reproduces many aspects of the observed MJO, especially over the Indian Ocean-Indonesian region.

Low-level moisture convergence mechanism for eastward propagation seems to be active across the Indian Ocean, consistent with observational results.

Propagation into the West Pacific appears to be problematic.

Increased horizontal resolution (T30 → T106) does not appear to have substantial beneficial impacts on the simulated MJO.
Equatorial anomalies (10N - 10S)
MODEL MJO CYCLE PC2 COMPOSITE

Equatorial anomalies (10N - 10S)
MODEL MJO CYCLE PC2 COMPOSITE

Equatorial anomalies (10N - 10S)
MODEL  MJO CYCLE  PC1 COMPOSITE

Equatorial anomalies (10N - 10S)

Vertical structure of the Q anomaly at the reference location 120E

moisture convergence

Vertical levels (hPa)

Q (sh) - OLR (cont)

g/kg

days

QDIV (sh) - OLR (cont)

1e-6 g/(Kg*s)

days
MODEL MJO ACTIVITY INDEX

Variance in 101-day sliding window U 200-hPa zonal mean (10S-10N)

(Slingo et al. 1999)
MODEL  OLR  EOF ANALYSIS

Nov–Mar intraseasonal (20-100 day) anomalies

EOF 1

EOF 2

EOF1+EOF2 expl. variance