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

ATMOSPHERE
ECHAM-4

COUPLER: OASIS

OCEAN
OPA

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

NO FLUX CORRECTIONS

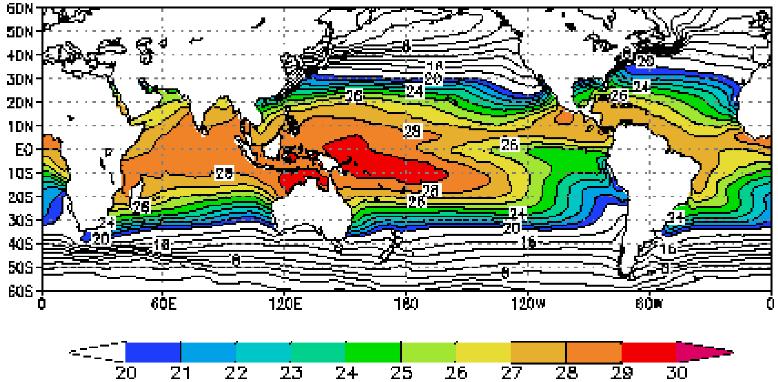
100 years

NORTHERN WINTER MEAN (ndjfm)

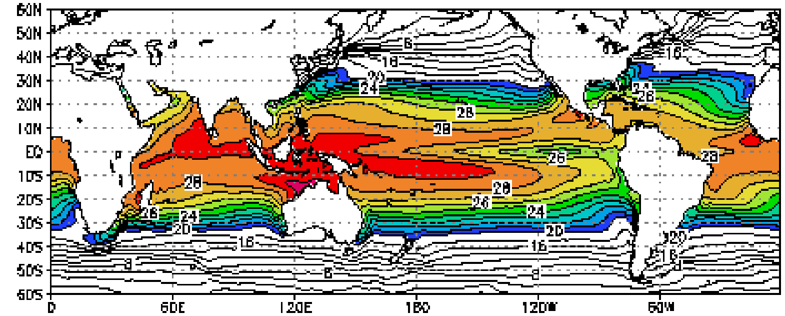
observations

model

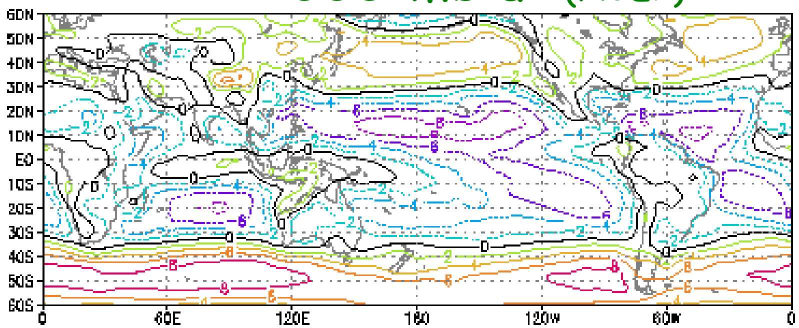
sst (HadISST)



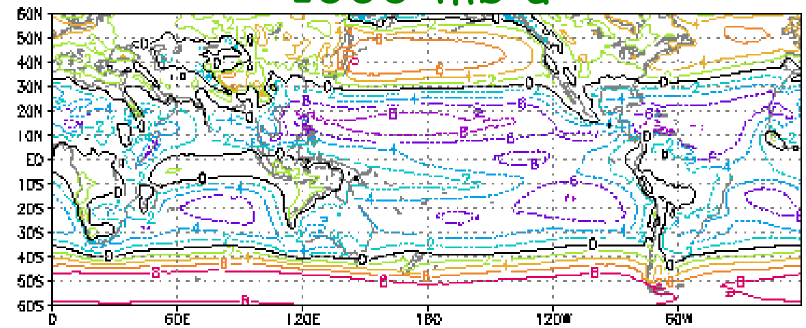
sst



1000-mb u (NCEP)



1000-mb u

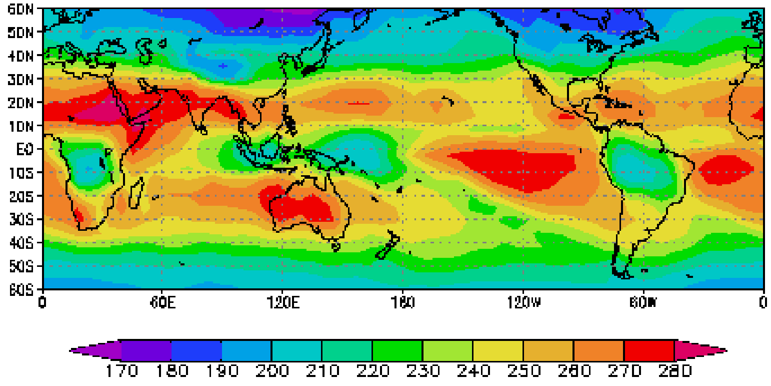


NORTHERN WINTER MEAN (ndjfm)

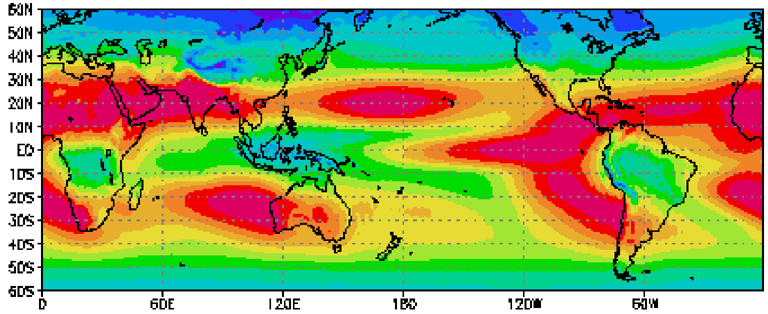
observations

model

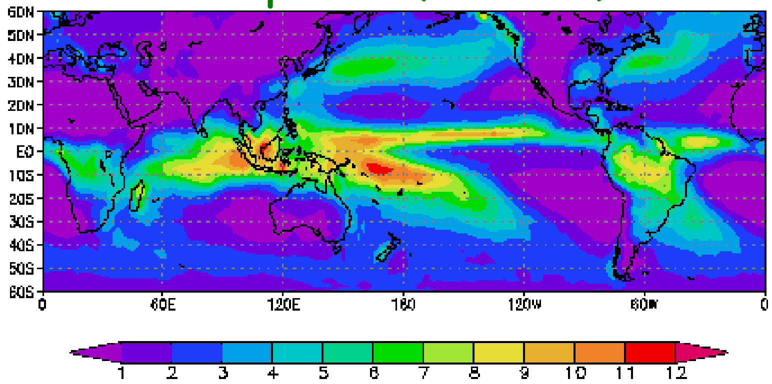
olr (NOAA)



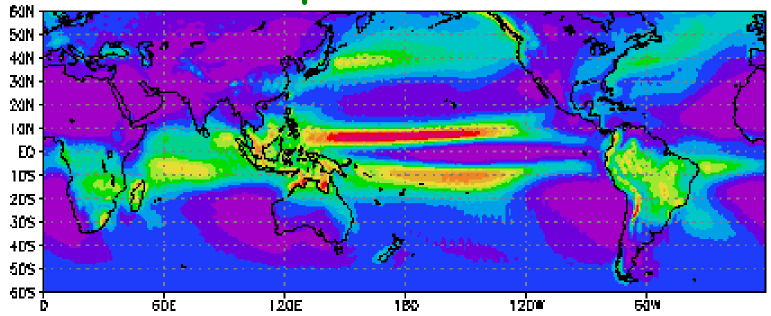
olr



prec (Xie-Arkin)



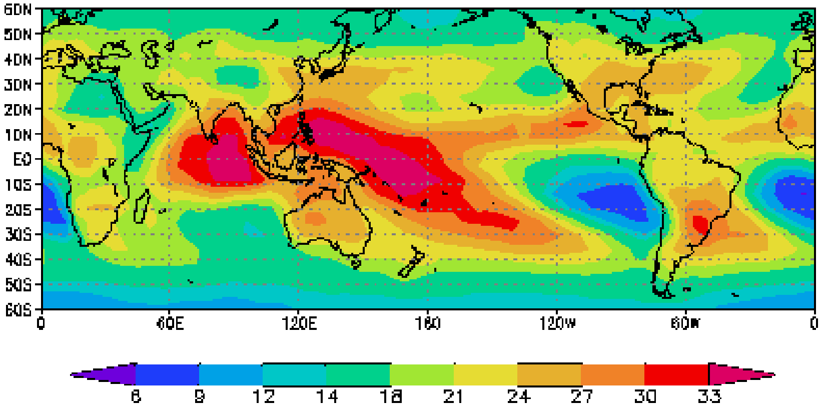
prec

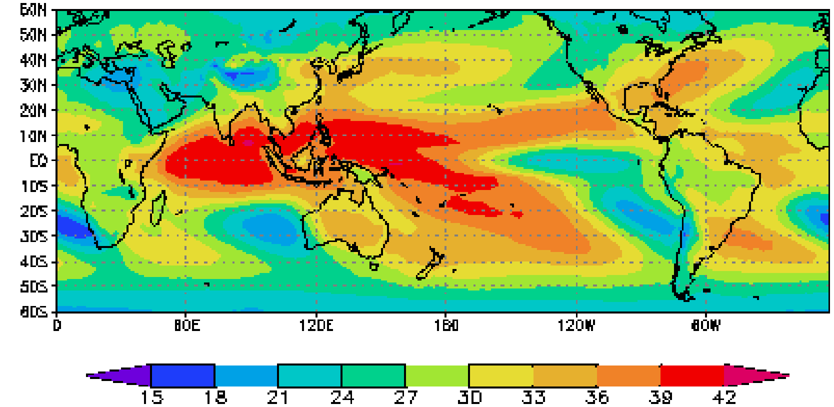


OLR STANDARD DEVIATION

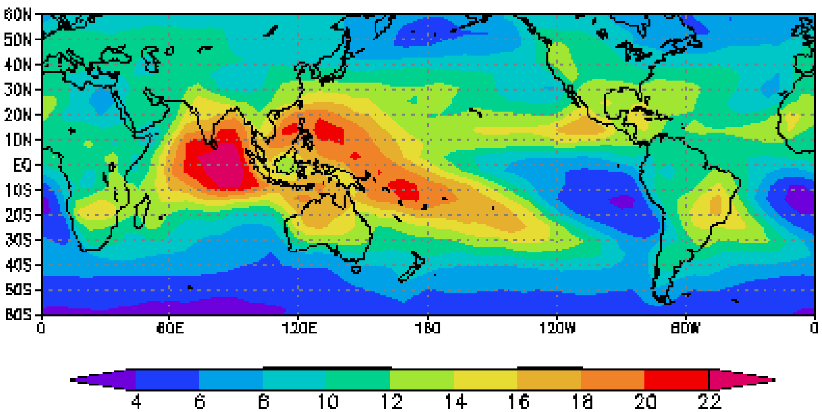
observations | model

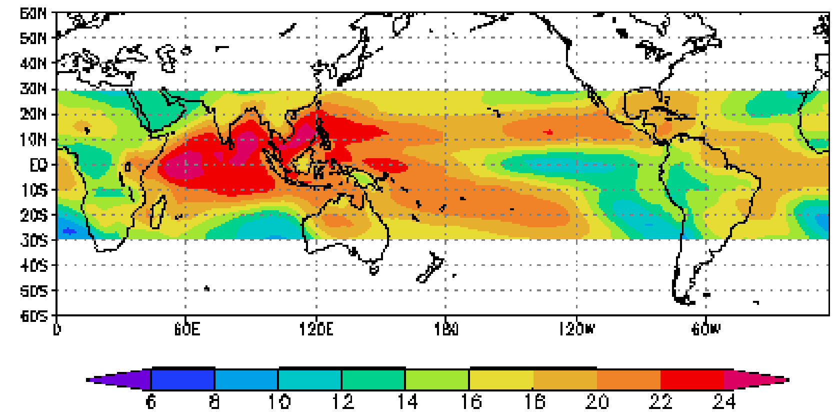
total anomalies





band-pass (20-100 days) anomalies



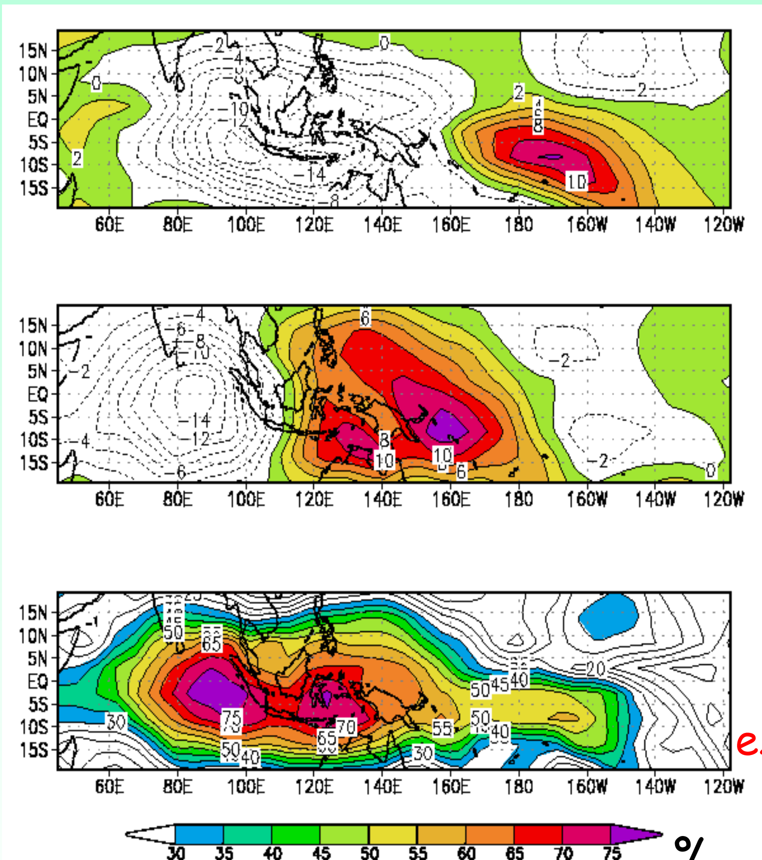


W/m^2

OLR EOF ANALYSIS

Nov –Mar intraseasonal (20-100 day) anomalies

OBSERVATIONS

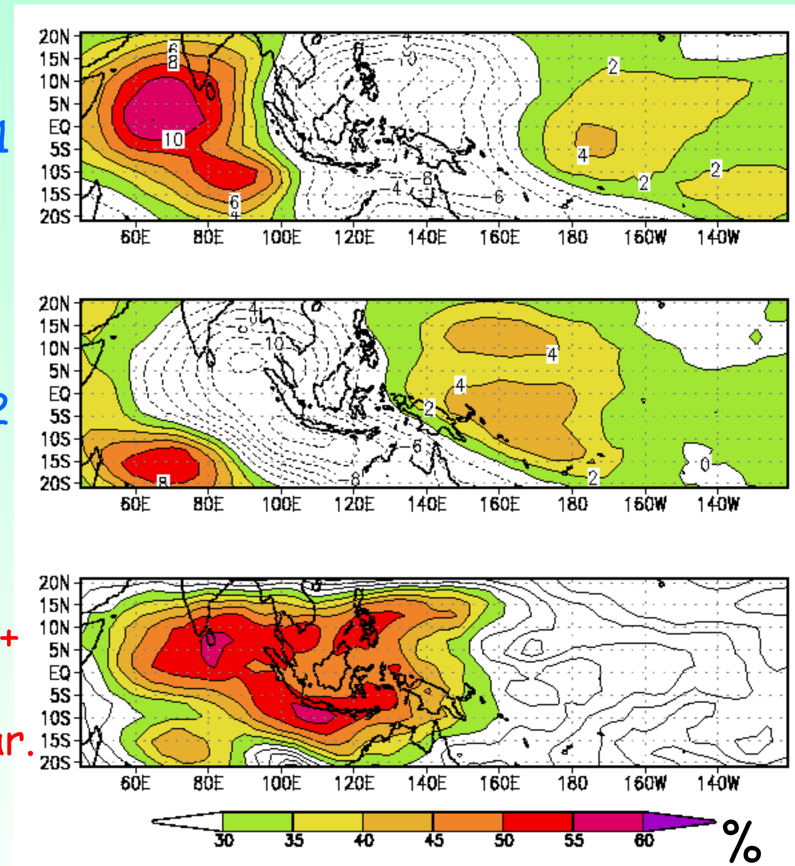


EOF 1

EOF 2

EOF1 + EOF2 expl. var.

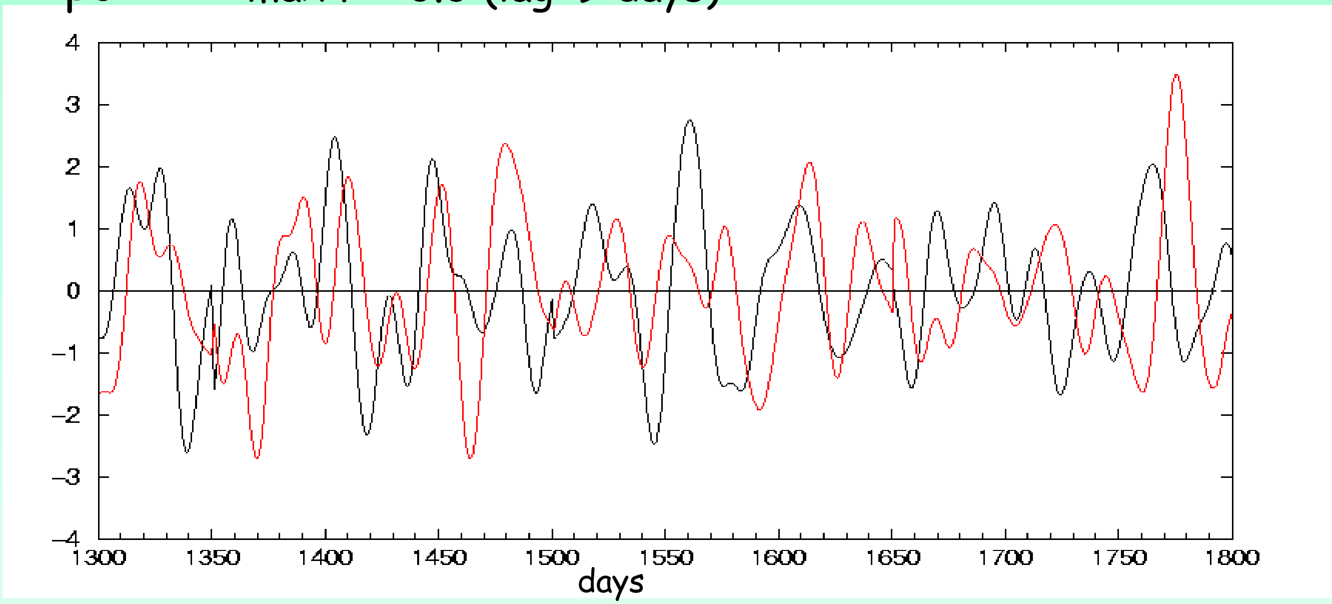
MODEL



MODEL OLR EOF ANALYSIS

pc1

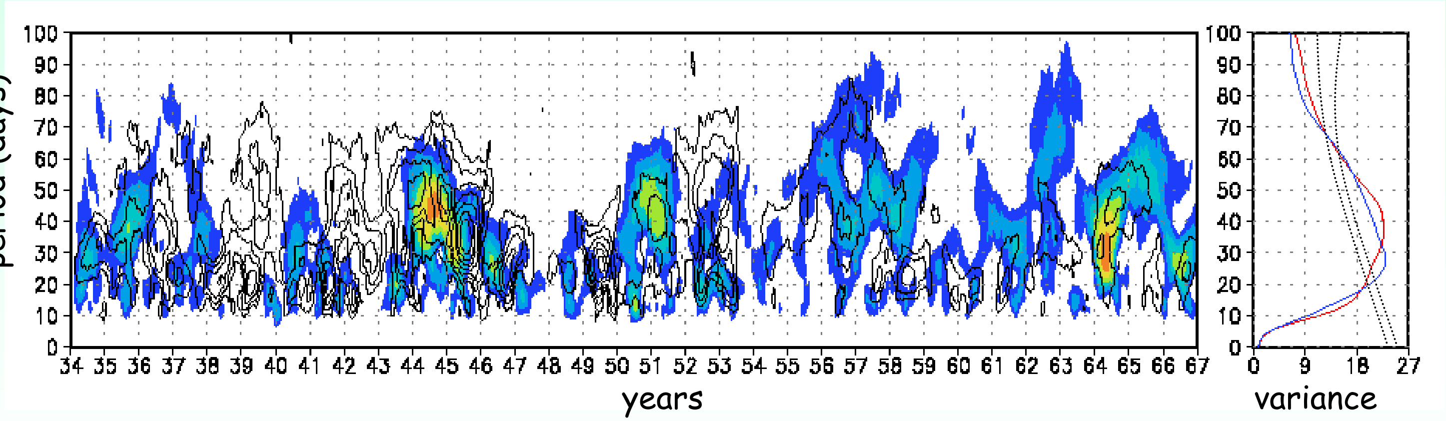
pc2 max r = 0.3 (lag=9 days)



(Morlet) wavelet analysis

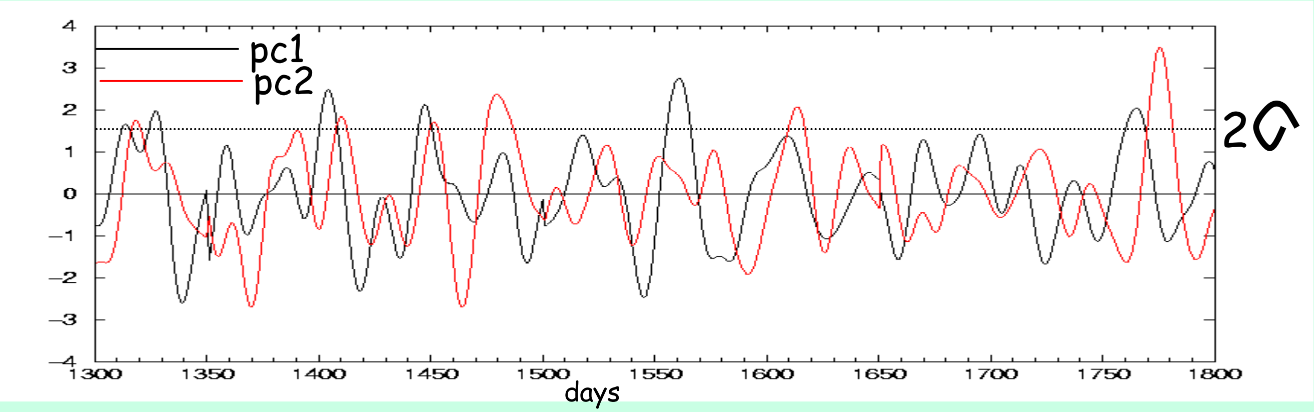
pc1 (shaded)

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)

OLR < 0.
convection

- 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

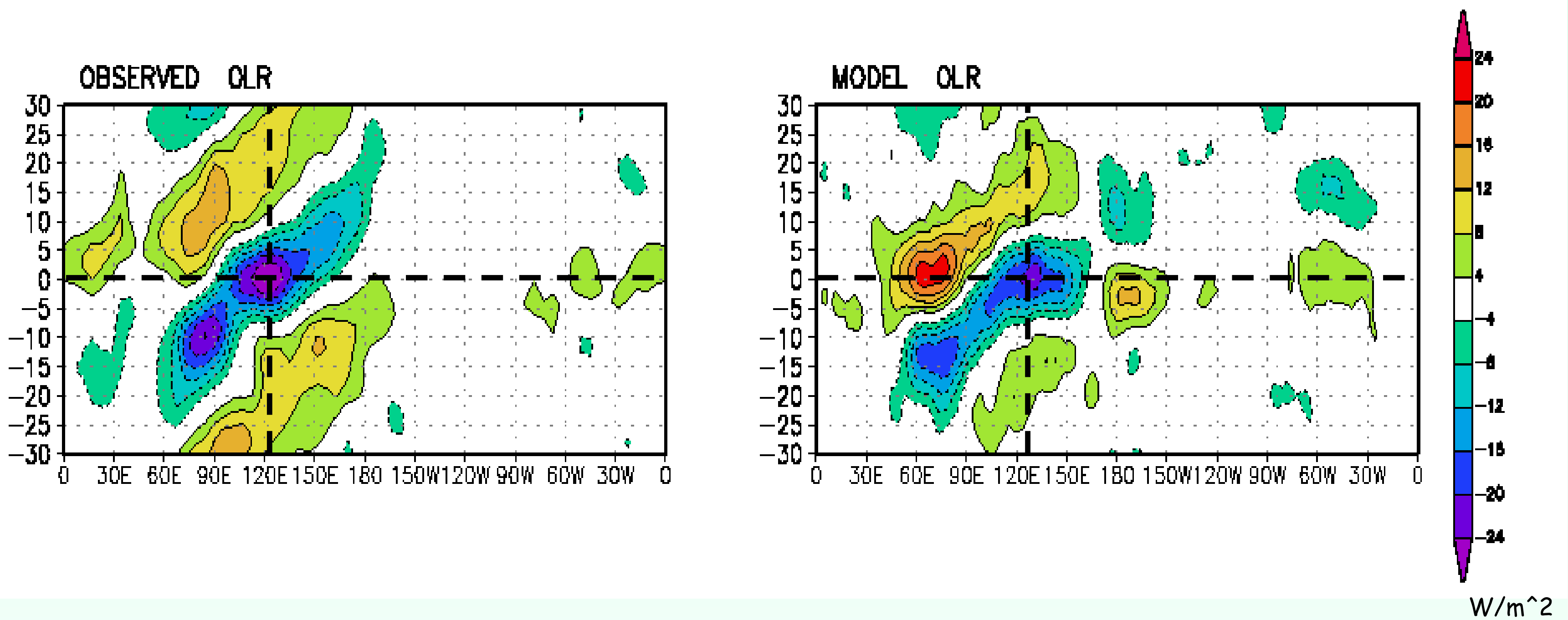
MODEL RUN: 42 MJO EVENTS IN 100 SIMULATED WINTERS

OBSERVED OLR: 16 MJO EVENTS IN 24 WINTERS

MODEL MJO CYCLE PC1-INDEX COMPOSITE

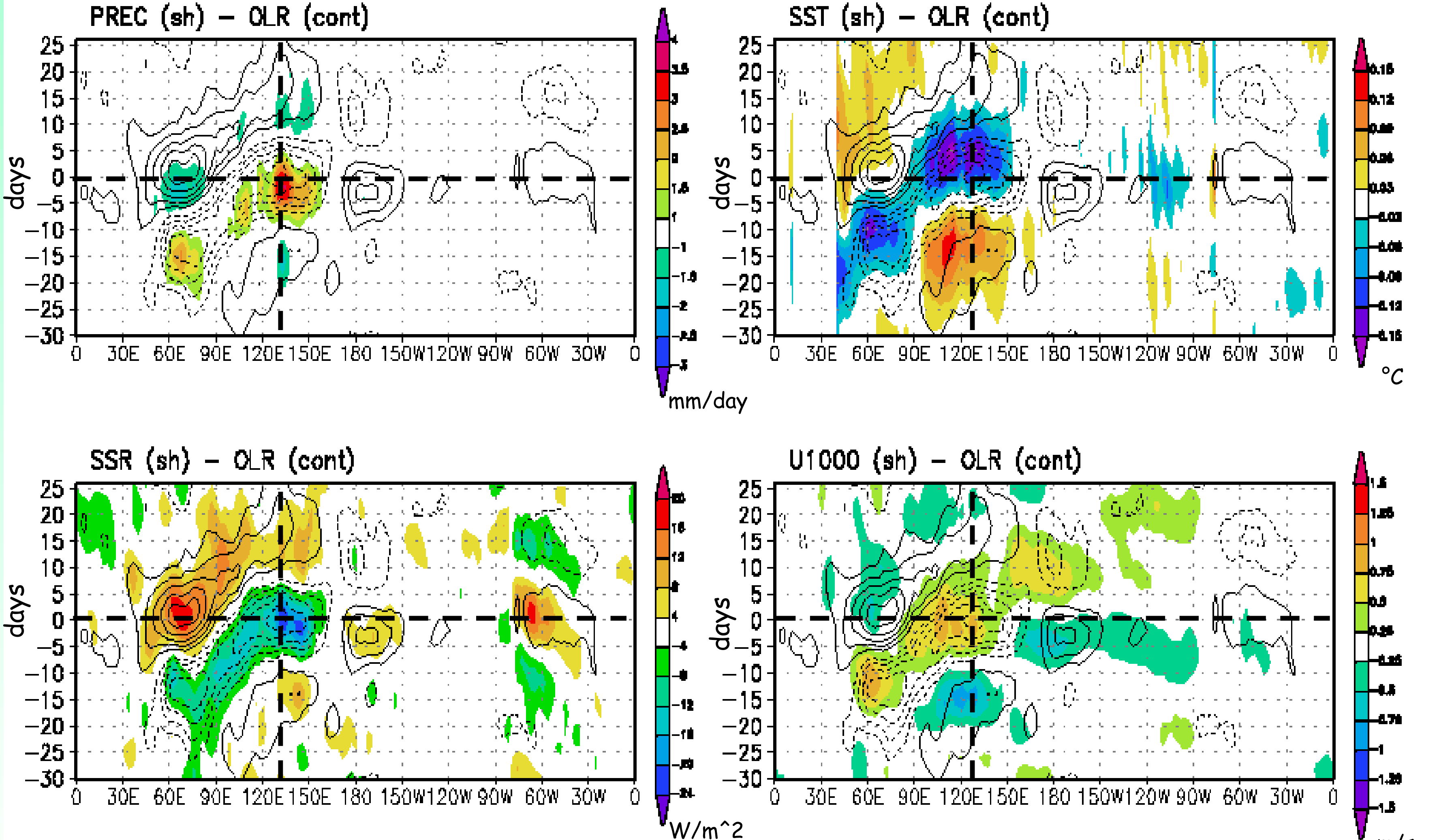
Equatorial anomalies (10N - 10S)

Propagation of the convective signal



MODEL MJO CYCLE PC1-INDEX COMPOSITE

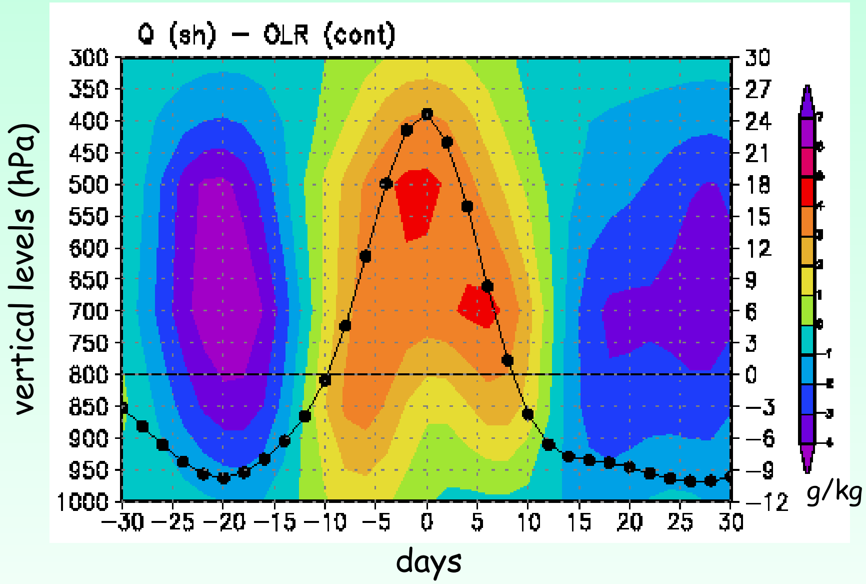
Equatorial anomalies (10N - 10S)



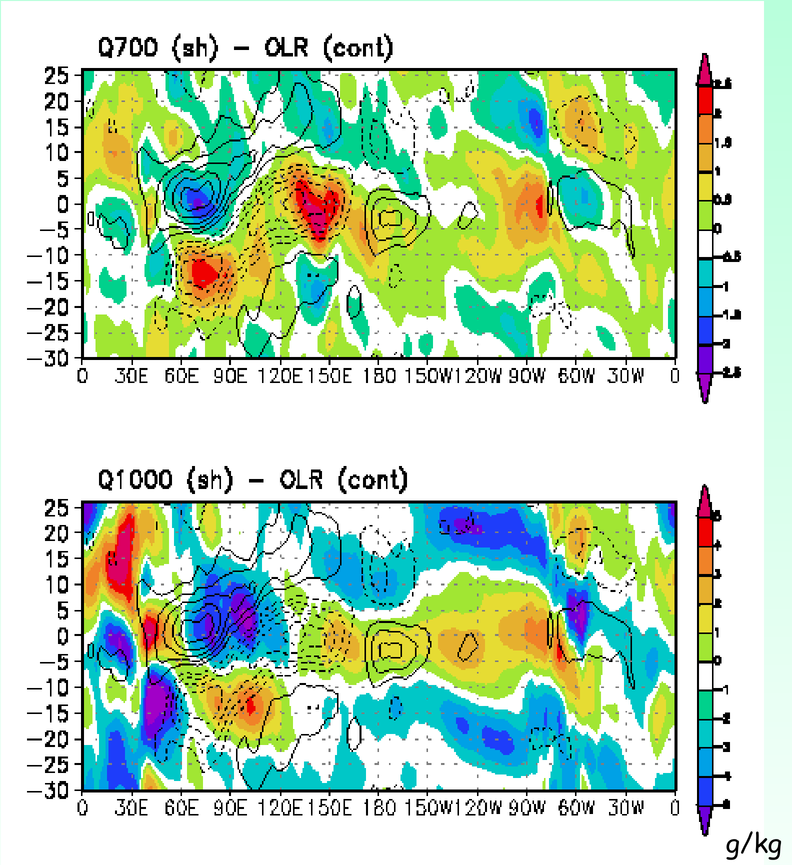
MODEL MJO CYCLE PC1-INDEX COMPOSITE

Equatorial anomalies (10N – 10S)

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



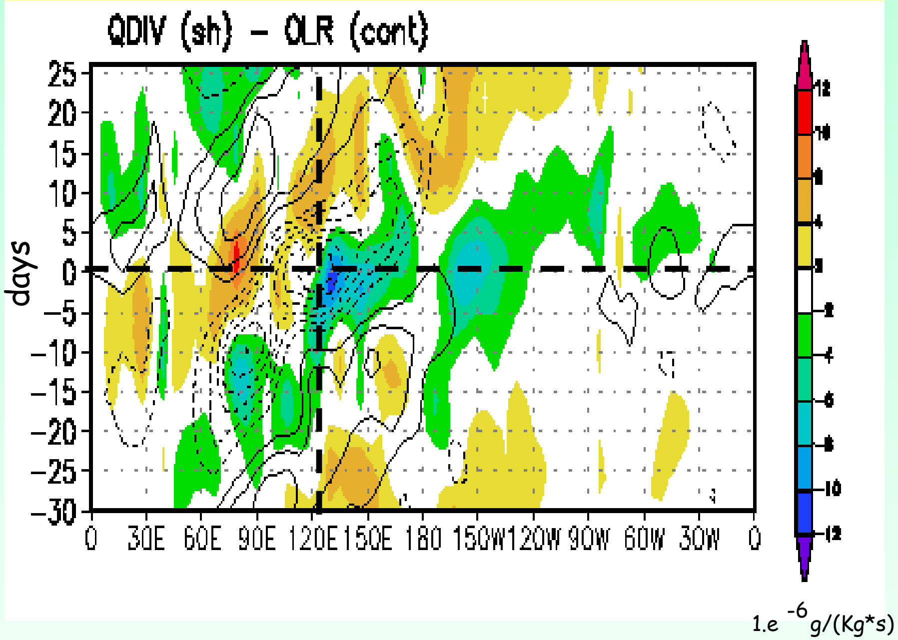
Q anomaly



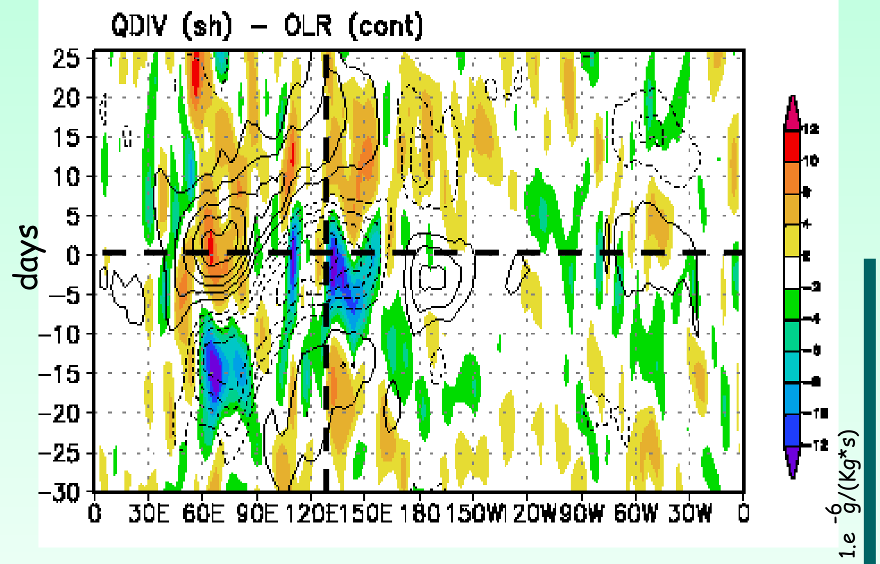
MODEL MJO CYCLE PC1-INDEX COMPOSITE

Equatorial anomalies (10N – 10S)

OBS. moisture convergence



MODEL moisture convergence



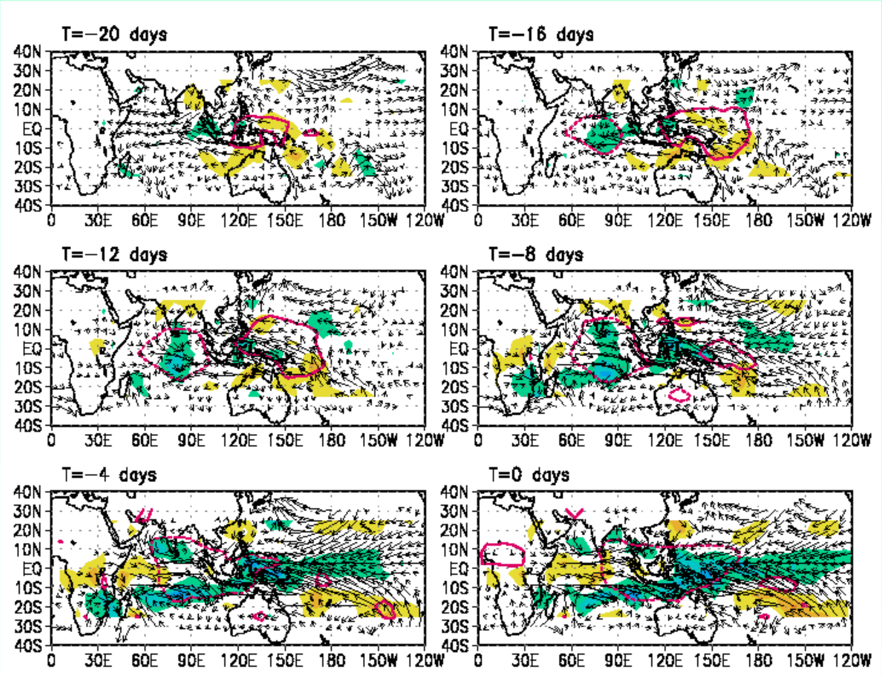
QDIV = DIV(uq,vq)

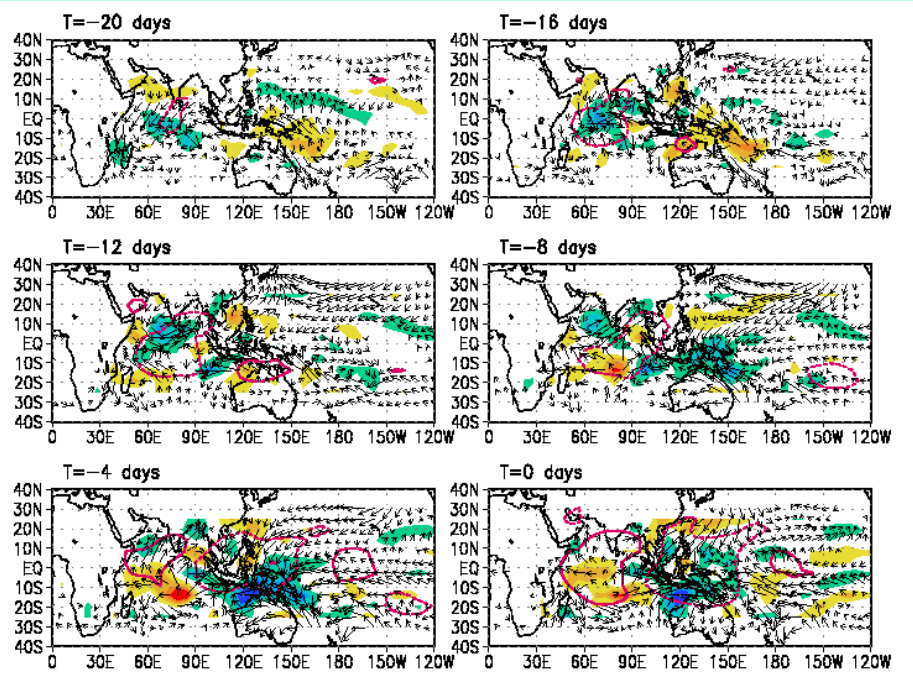
MODEL MJO CYCLE PC1 COMPOSITE

- - - - - convection (OLR<0.)

→ (qu,qv)

shaded patters DIV(qu,qv)



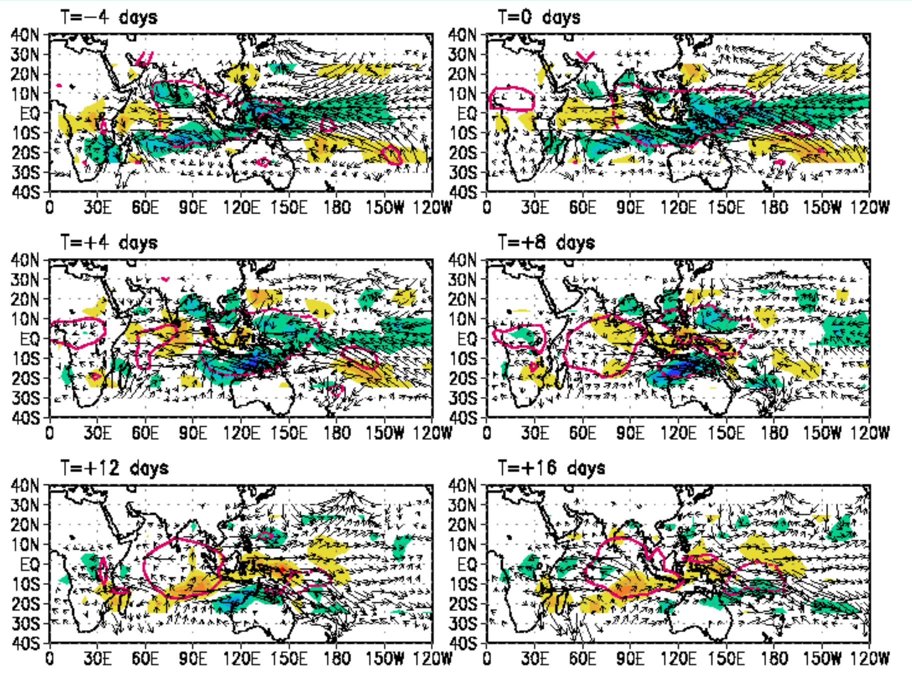


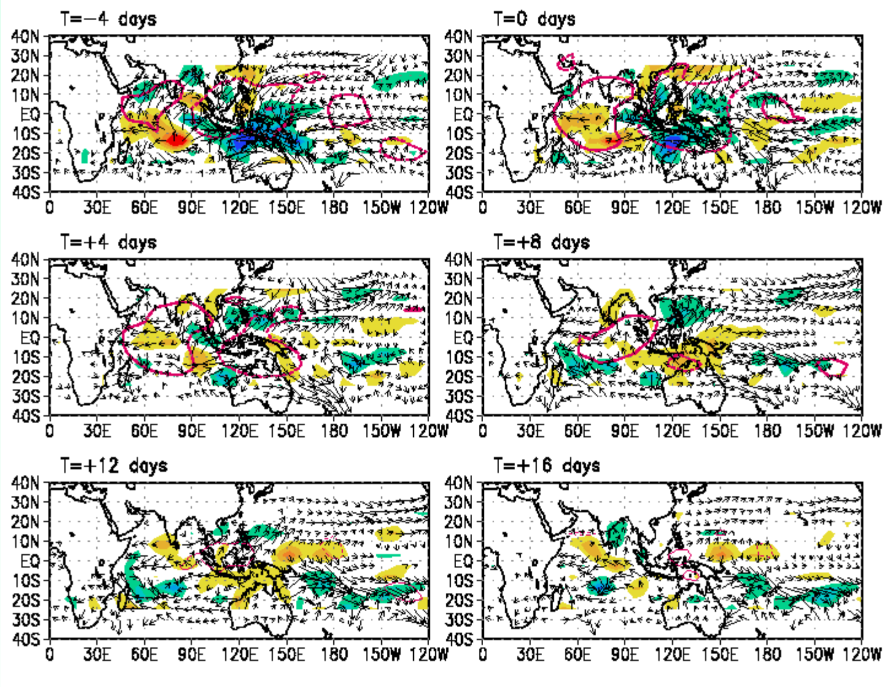
MODEL MJO CYCLE PC1 COMPOSITE

- - - - - convection (OLR<0.)

→ (qu,qv)

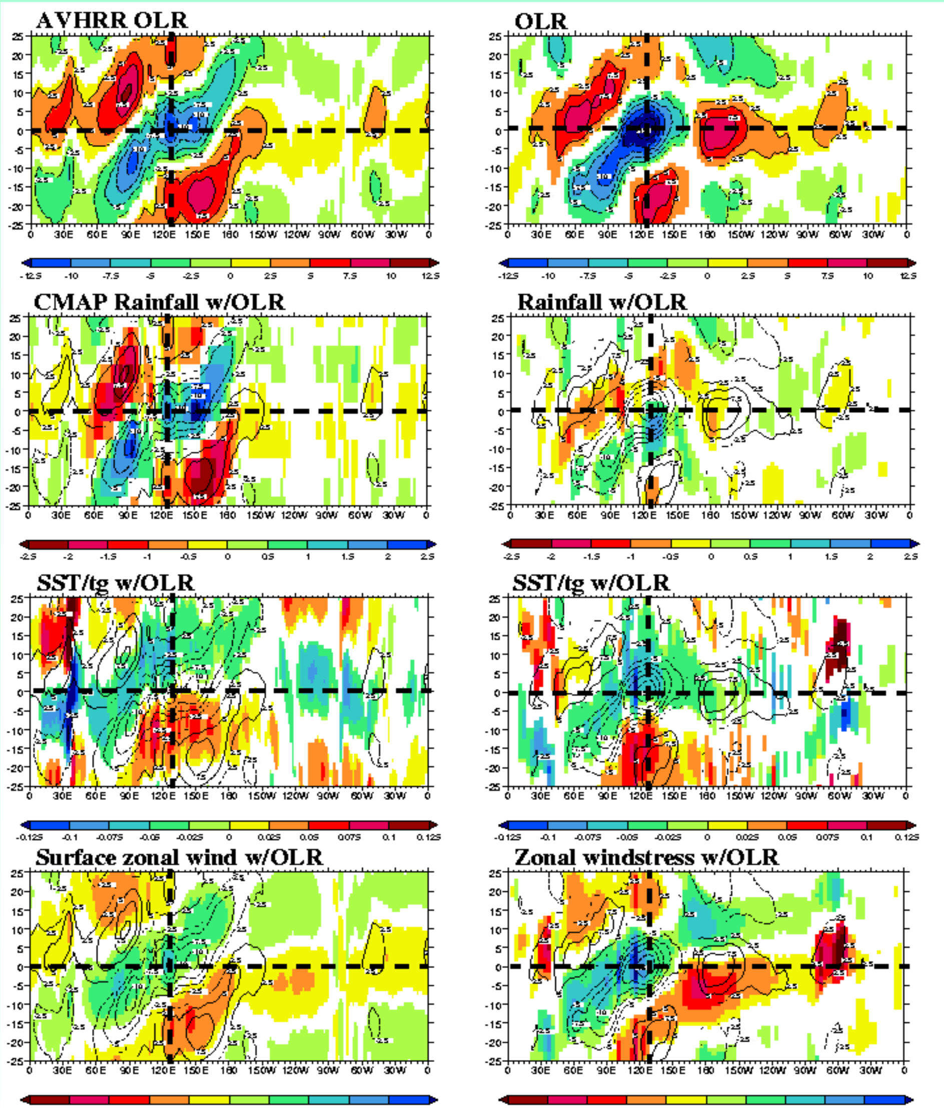
shaded patters DIV(qu,qv)

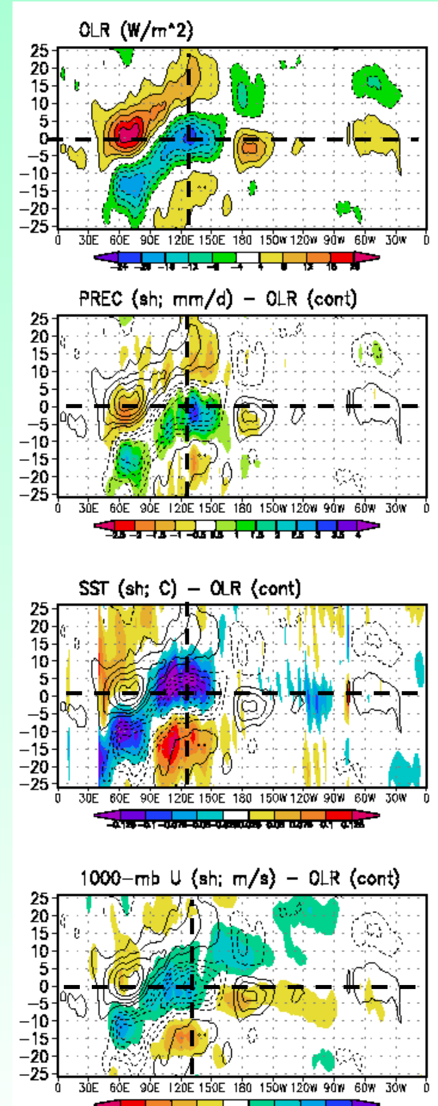




MJO CYCLE T106 vs T30

observations | model T30 | model T106

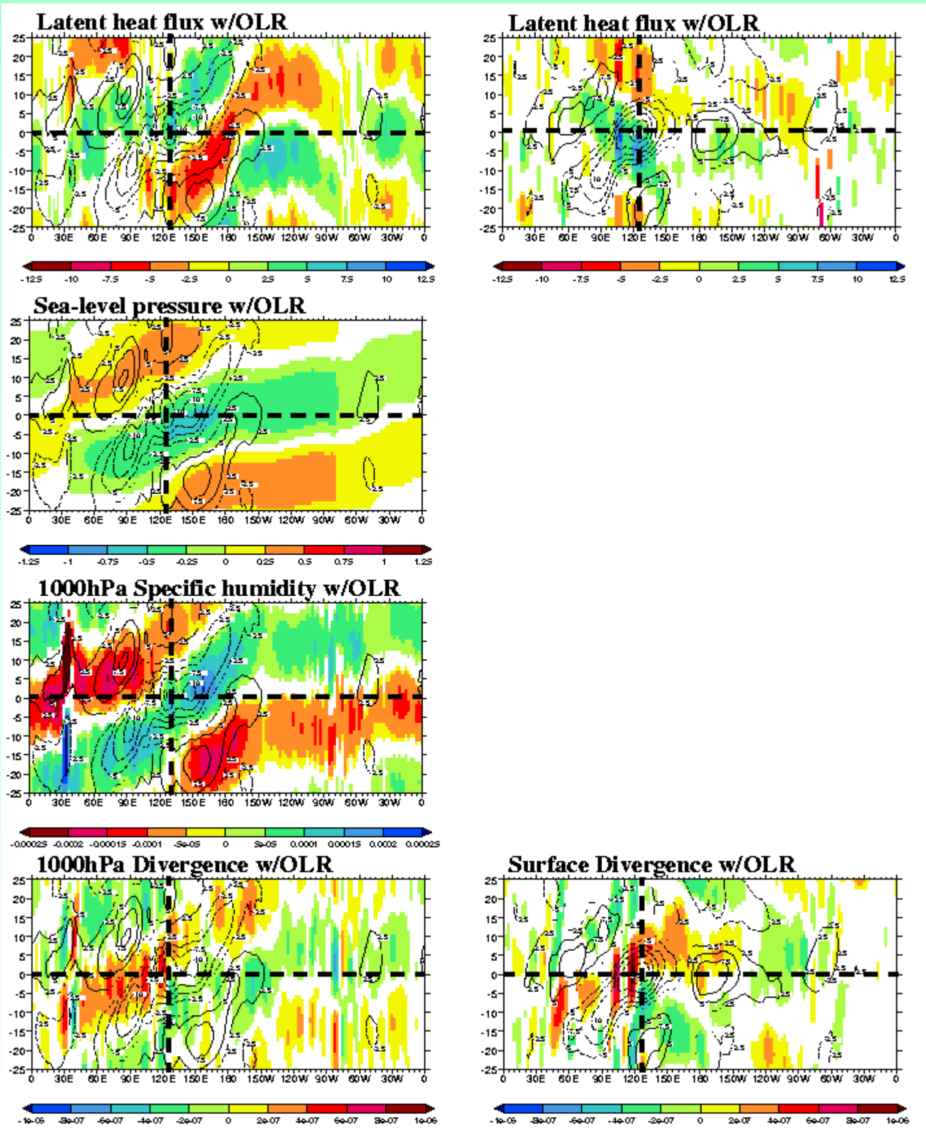


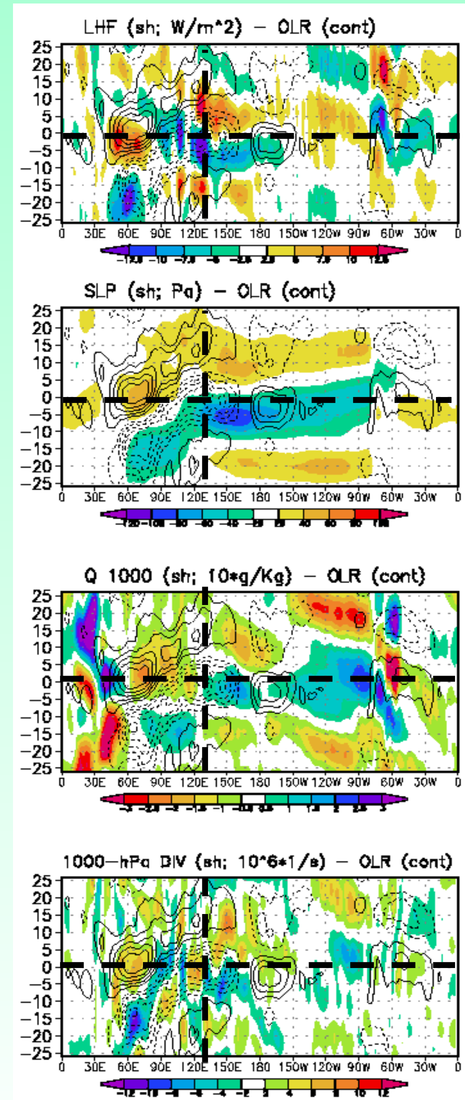


(Sperber et al. 2003)

MJO CYCLE T106 vs T30

observations | model T30 | model T106





(Sperber et al. 2003)

SUMMARY

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

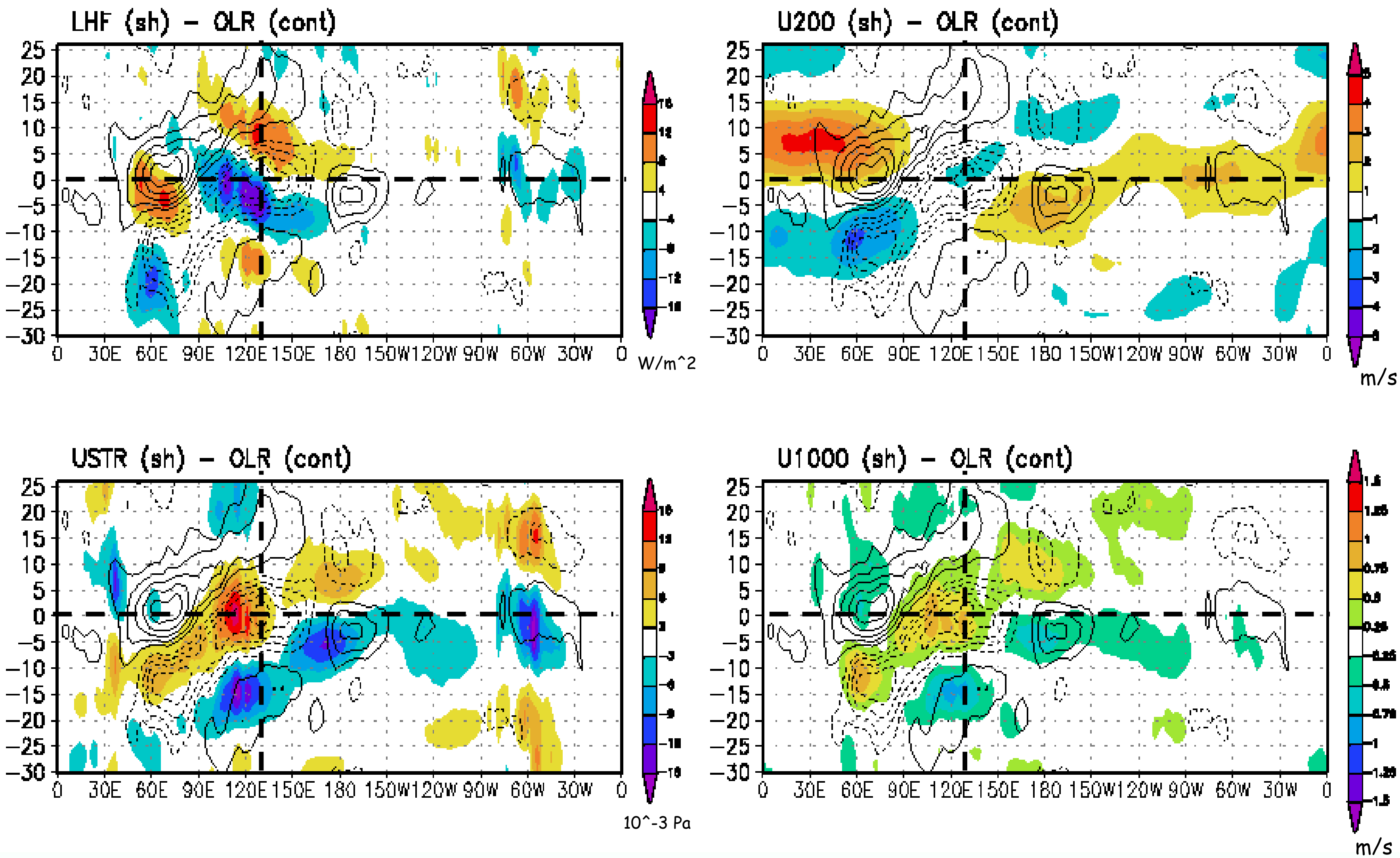
- Low-level moisture convergence mechanism for eastward propagation seems to be active across the Indian Ocean, consistent with observational results.

- 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

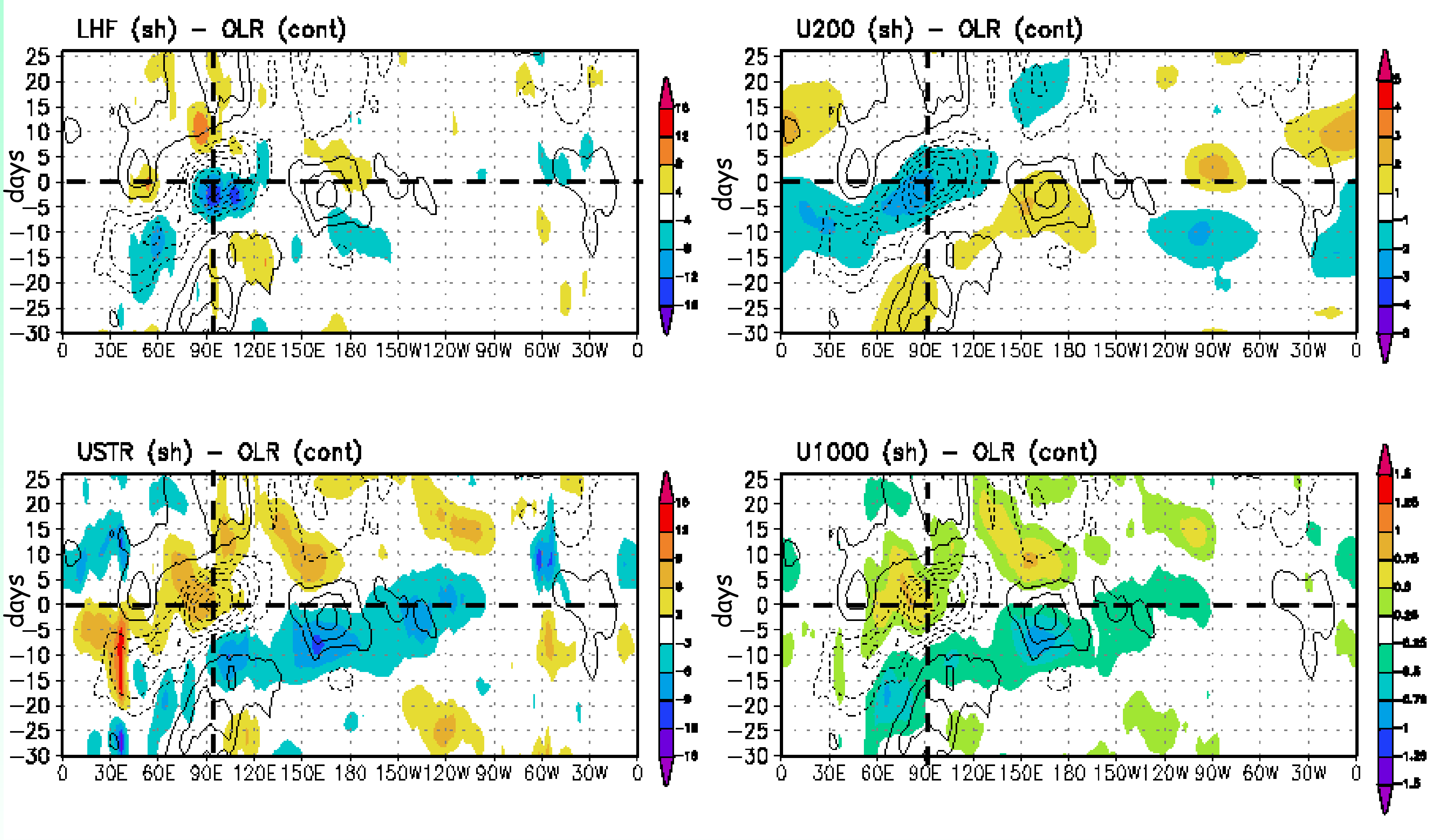
MODEL MJO CYCLE PC1 COMPOSITE

Equatorial anomalies (10N - 10S)



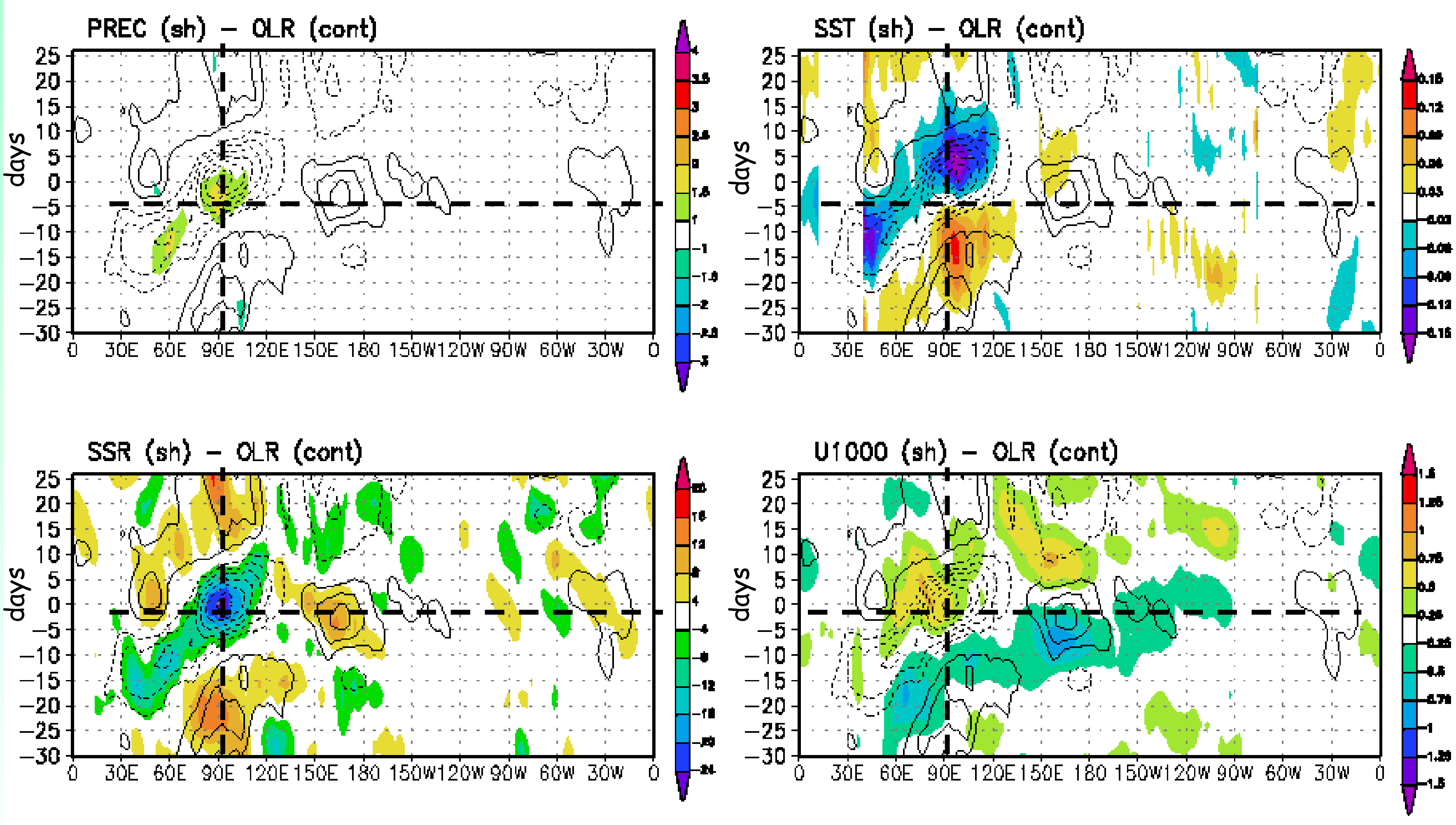
MODEL MJO CYCLE PC2 COMPOSITE

Equatorial anomalies (10N - 10S)



MODEL MJO CYCLE PC2 COMPOSITE

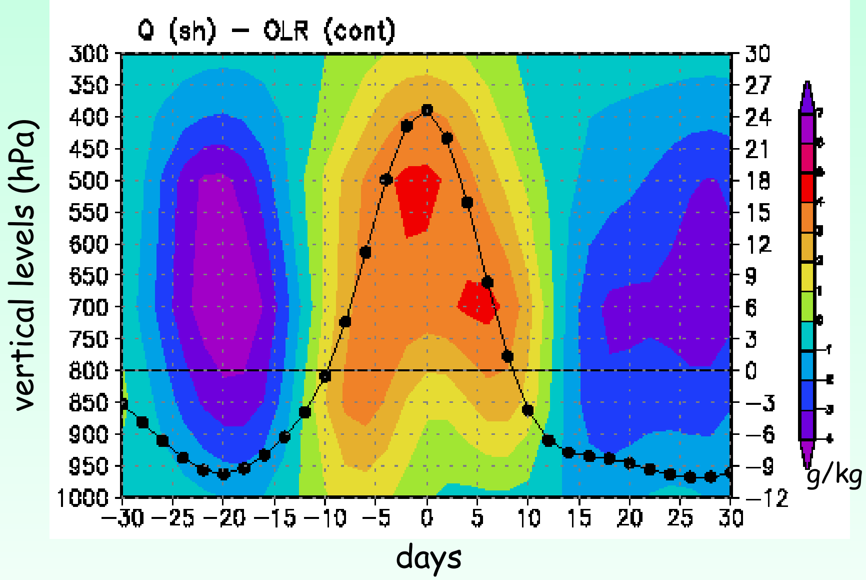
Equatorial anomalies (10N - 10S)



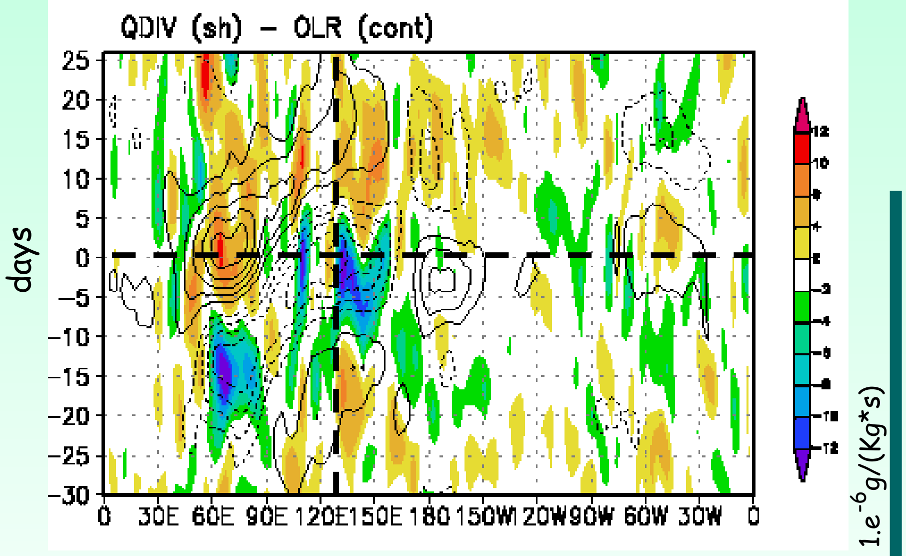
MODEL MJO CYCLE PC1 COMPOSITE

Equatorial anomalies (10N – 10S)

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



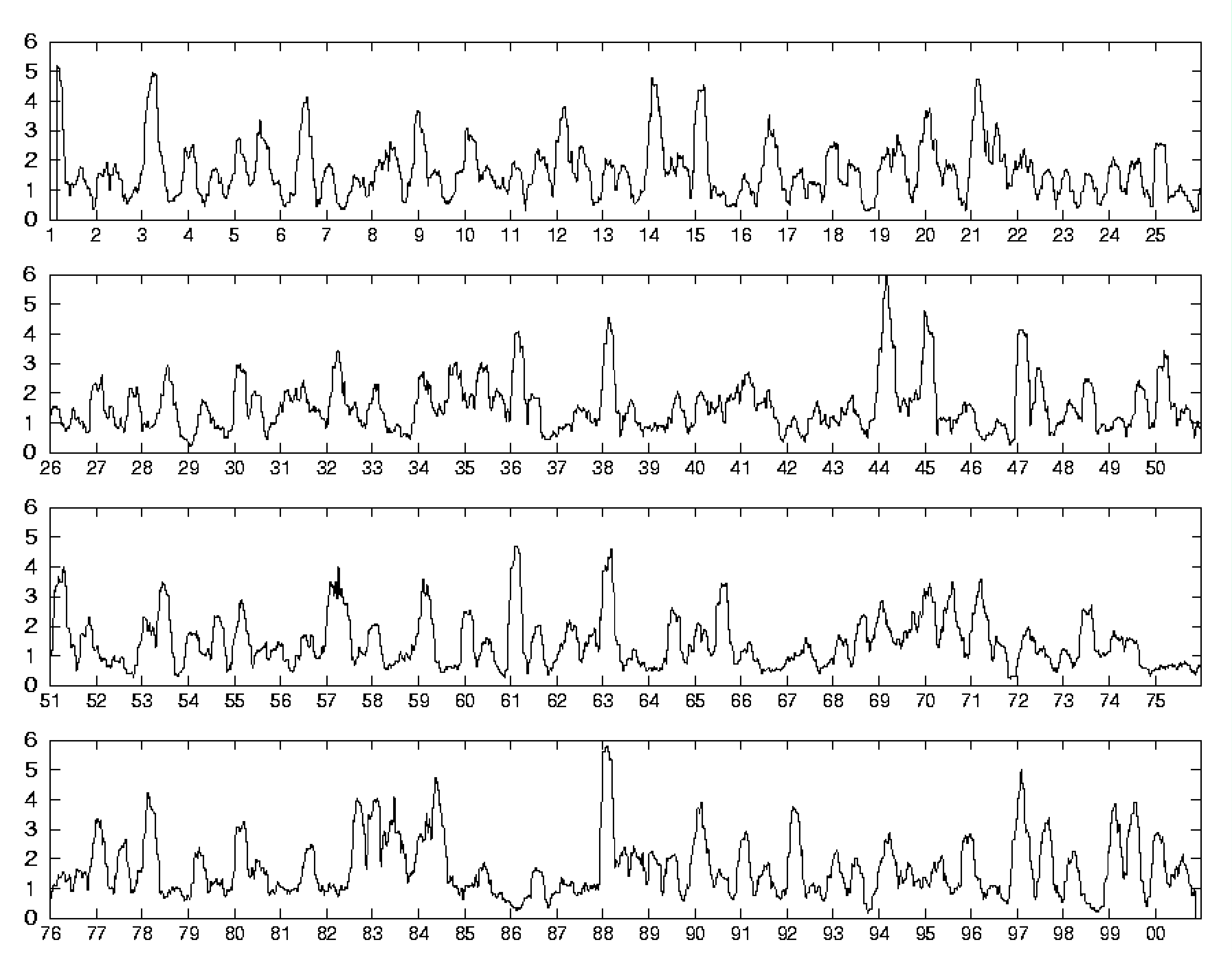
moisture convergence



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