The Structure and Annual Cycle of the MJO

Chidong Zhang

University of Miami, RSMAS

In collaboration with

Ken Sperber and Wanqui Wang

Purpose:

Through discussing recent observations of the MJO, to motivate further understanding of the MJO dynamics and to set a higher standard for model validation

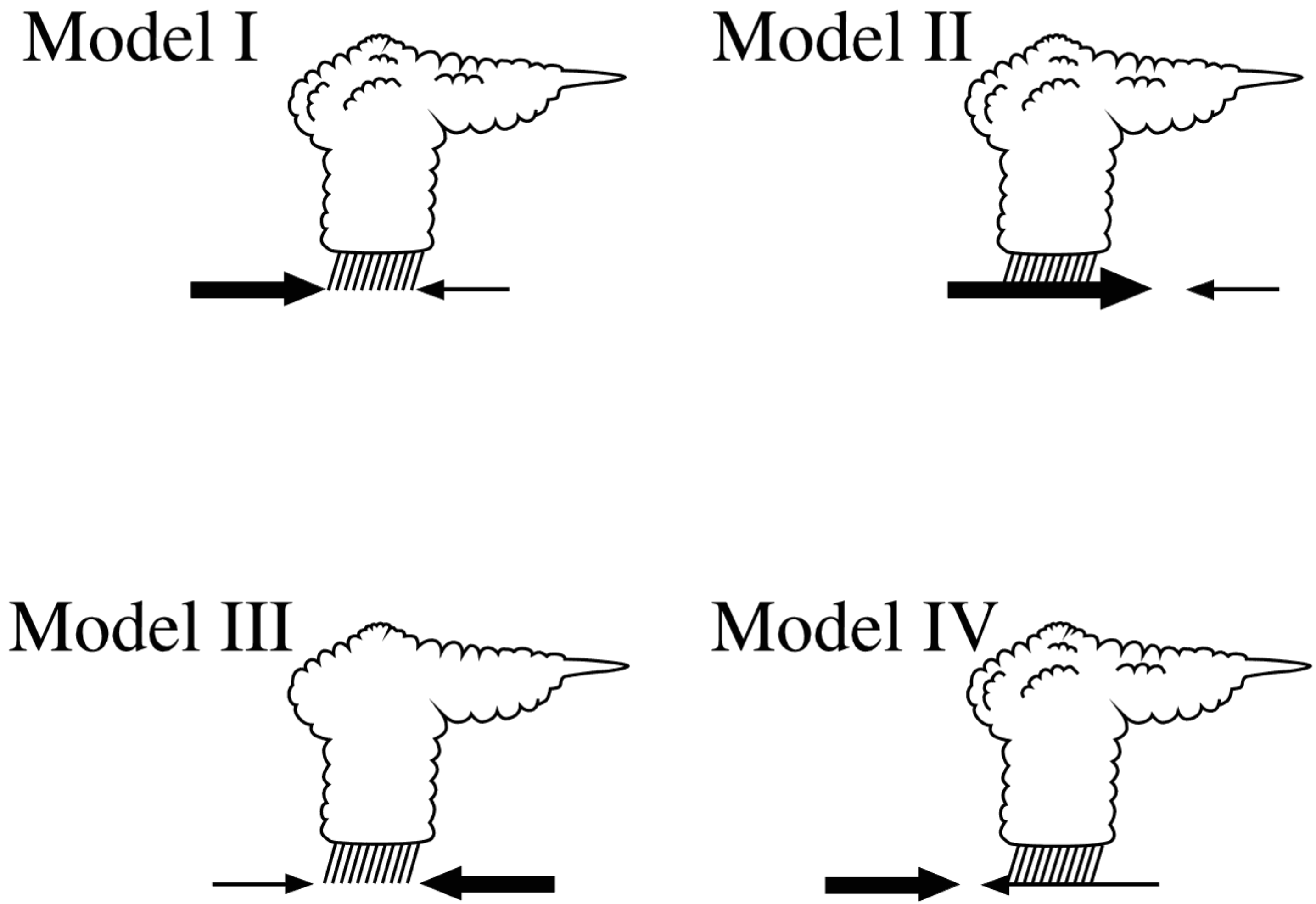
Outline:

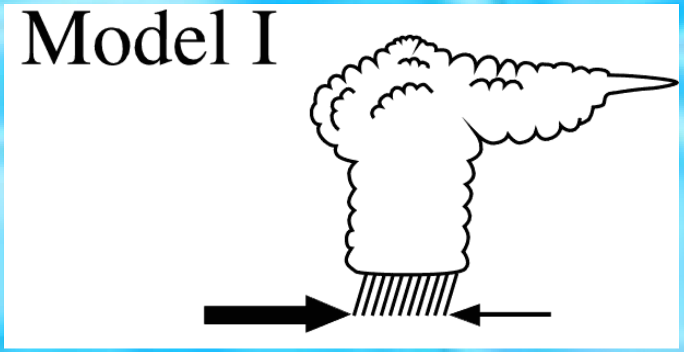
1. **The structure: Air-sea interaction and the dynamics**
2. **The annual cycle: Effects of the mean background**

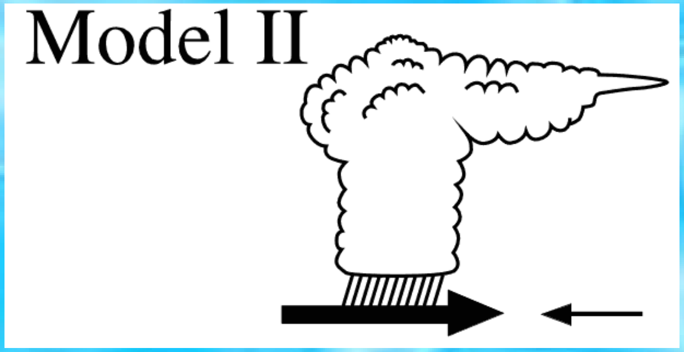
Zhang, C., and S.P. Anderson, 2003: Sensitivity of intraseasonal perturbations in SST to the structure of the MJO. *J. Atmos. Sci.*, 60, 2196-2207.

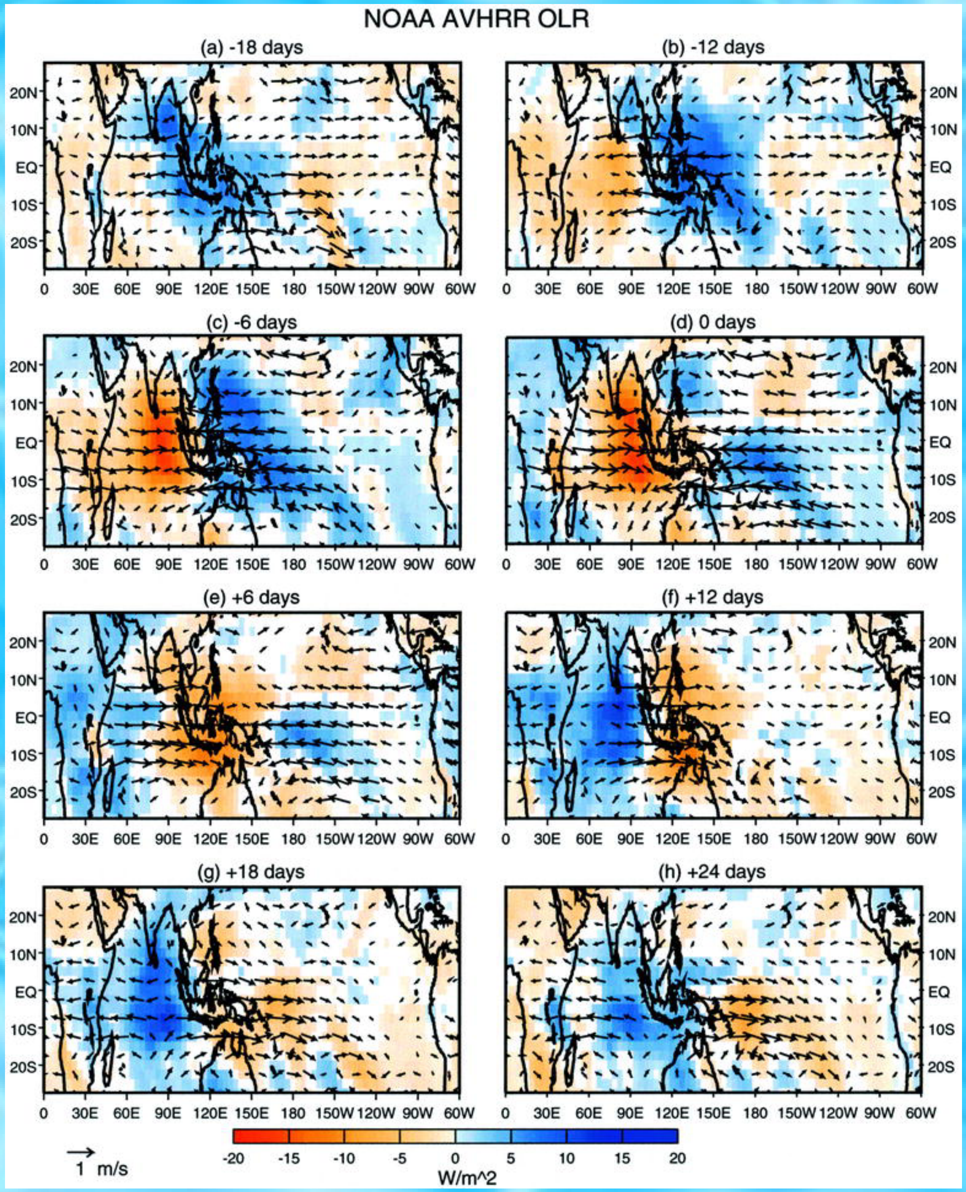
Zhang, C., and M. Dong, 2003: Seasonality of the MJO. *J. Climate*, submitted.
(http://orca.rsmas.miami.edu/~czhang/publications/smjo.pdf)

Zhang, C., 2003: Structures of the MJO: Implications to its air-sea interaction and dynamics. Manuscript for this workshop.


Model I
Model II
Model III
Model IV

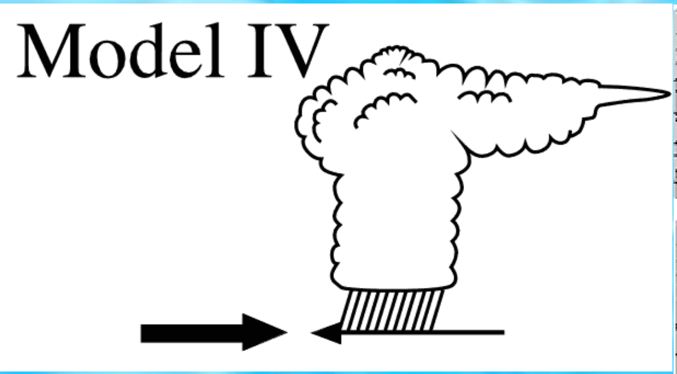


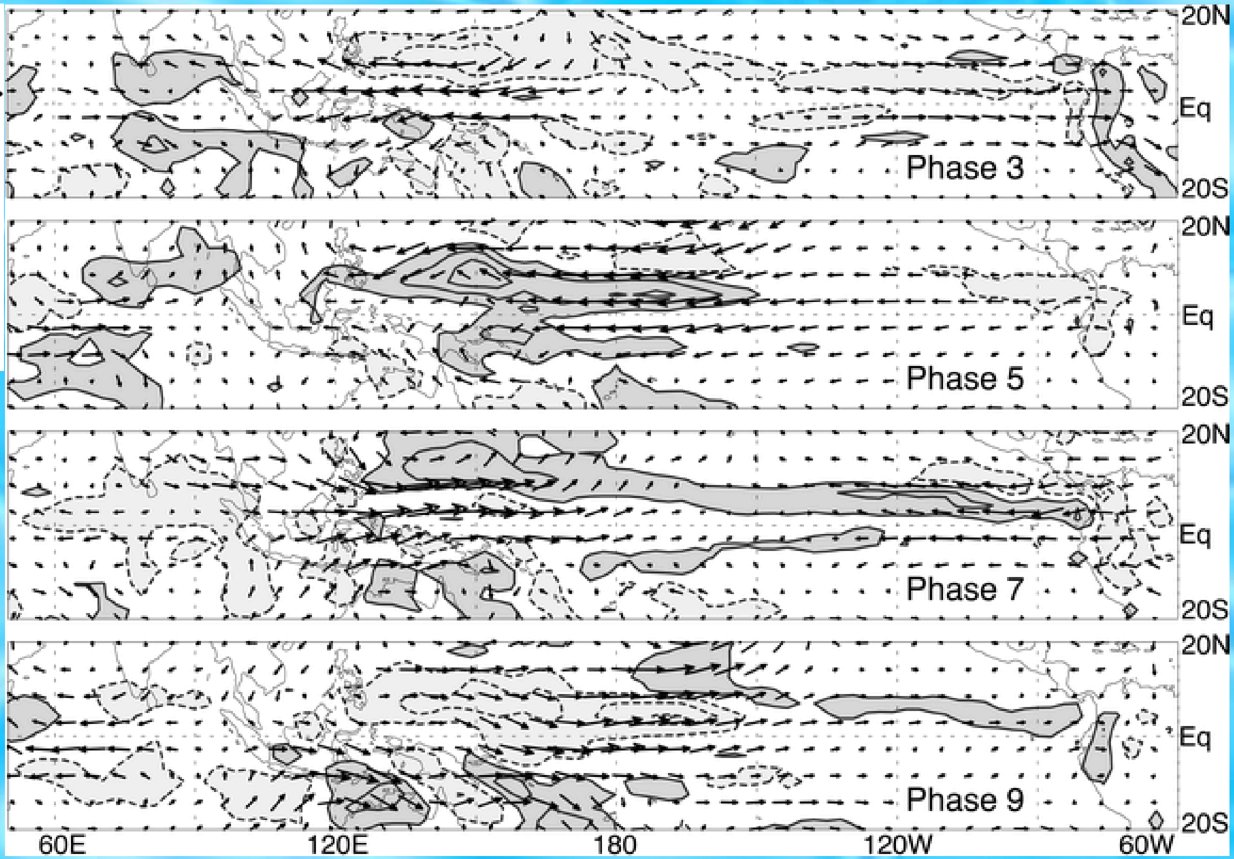




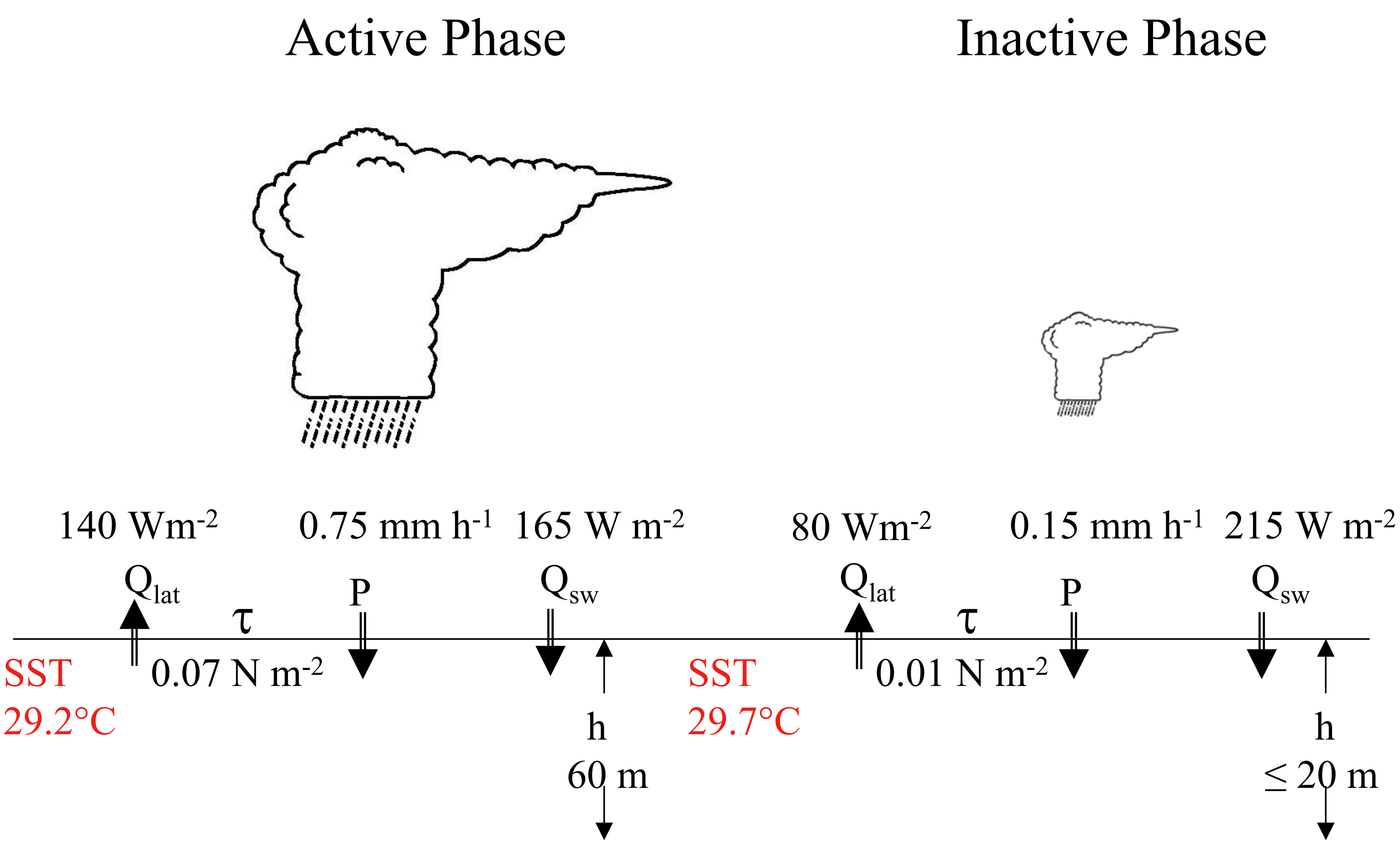
Inness and Slingo (2003)

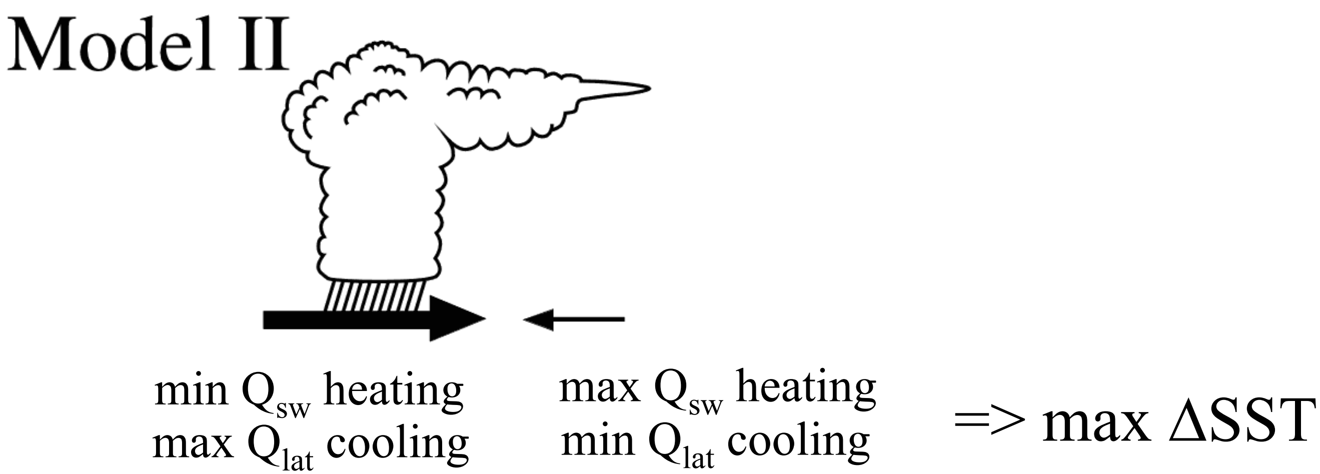
850 hPa wind and convective precipitation in CCM3/McRAS (from Maloney and Hartmann 2001)



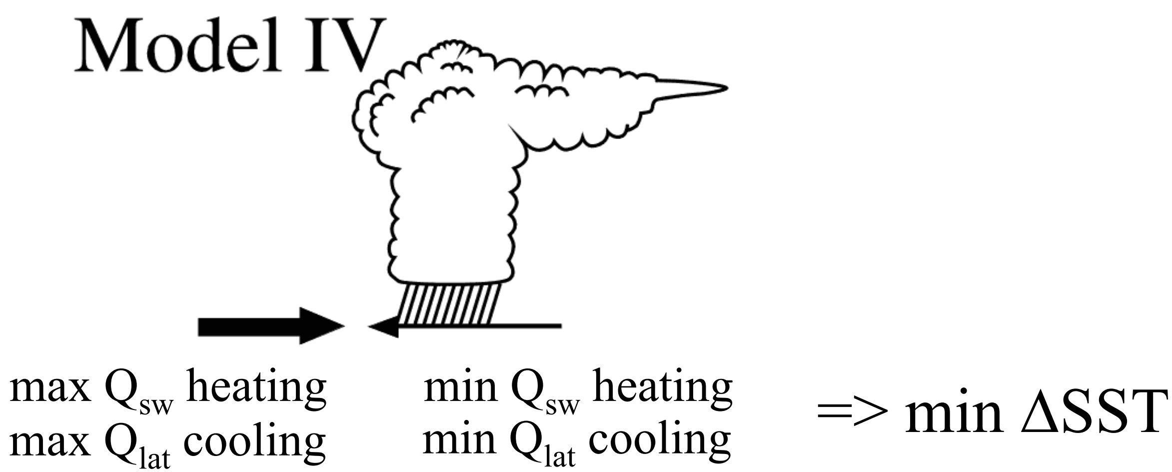


Surface Fluxes During the Two Extreme Phases of the MJO





Model II
min Q_{sw} heating
max Q_{lat} cooling
max Q_{sw} heating
min Q_{lat} cooling
=> max ΔSST

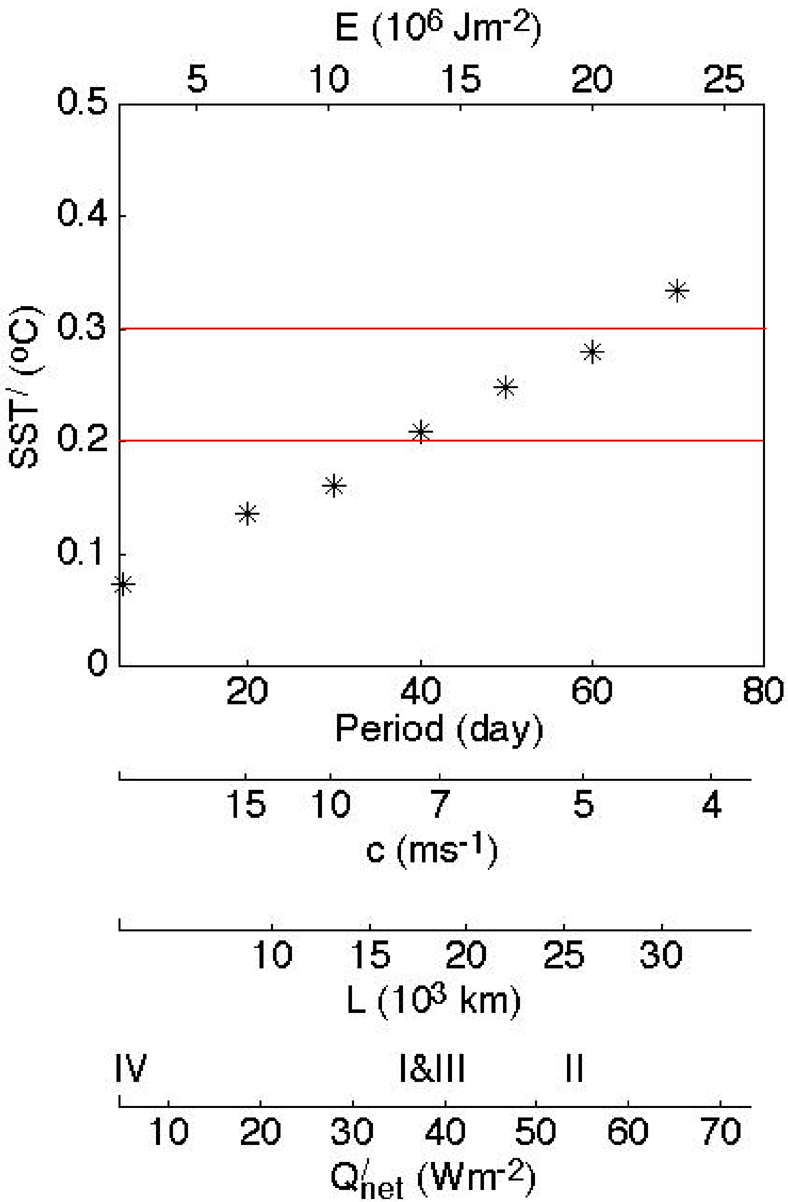


Model IV
max Q_{sw} heating
max Q_{lat} cooling
min Q_{sw} heating
min Q_{lat} cooling
=> min ΔSST

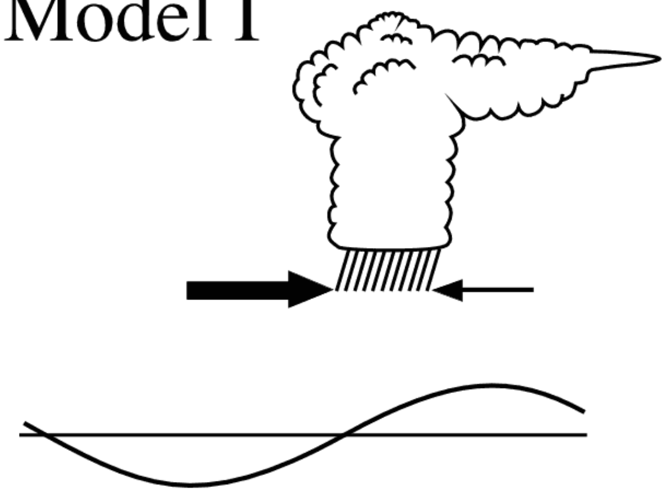
Default parameter:

Period = 50 days
c = 5 m s^{-1}
L = 26 x 10^3 km
Q'$_{net}$ = 55 W m^{-2}
MJO Model II

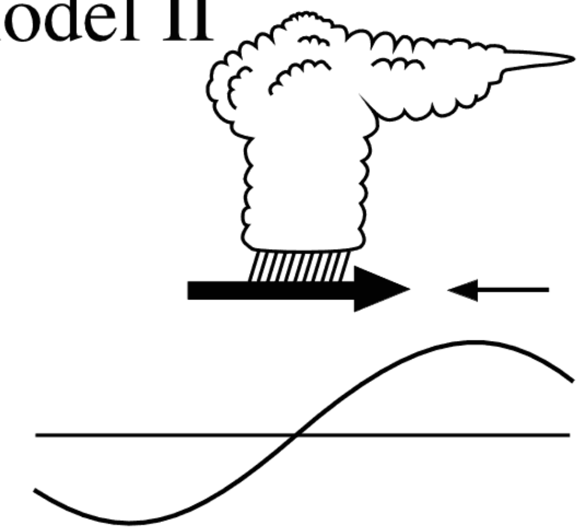
SST perturbations simulated by a 1-D mixed layer model



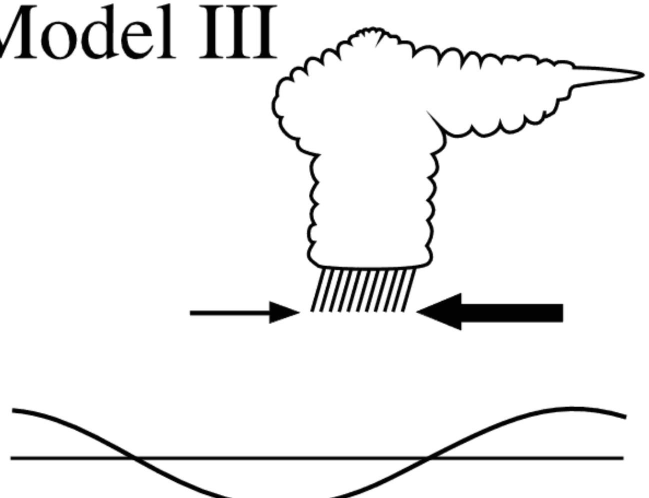
Model I



Model II



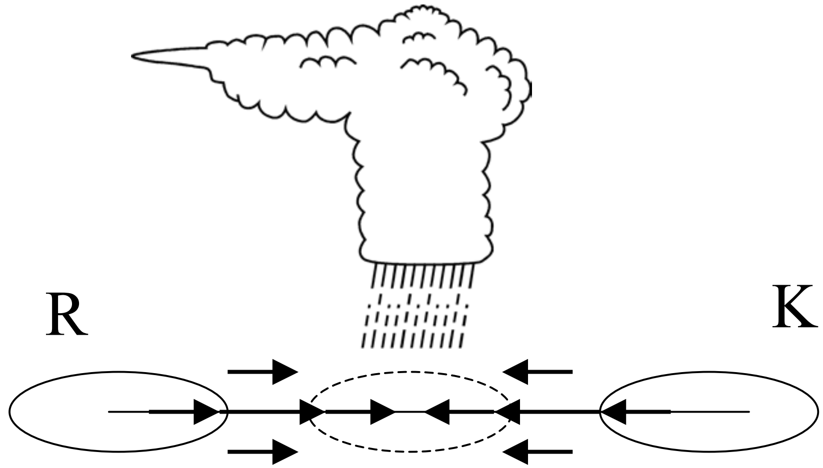
Model III



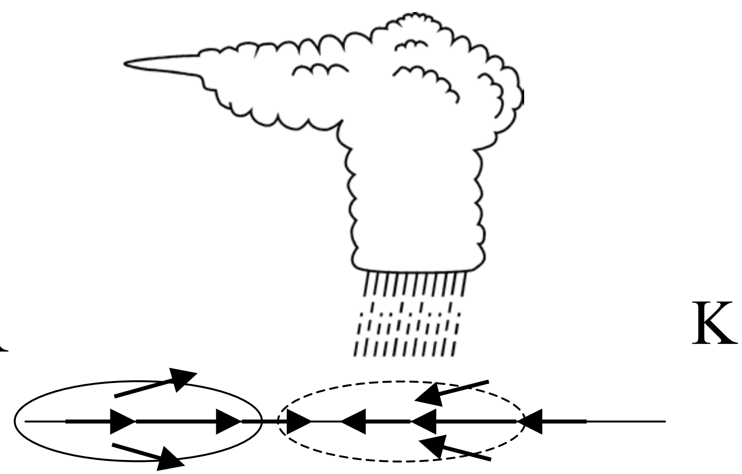
$$\frac{\partial Q}{\partial T} = Q\frac{L}{R_v T^2} = 6.5 W m^{-2} K^{-1}$$

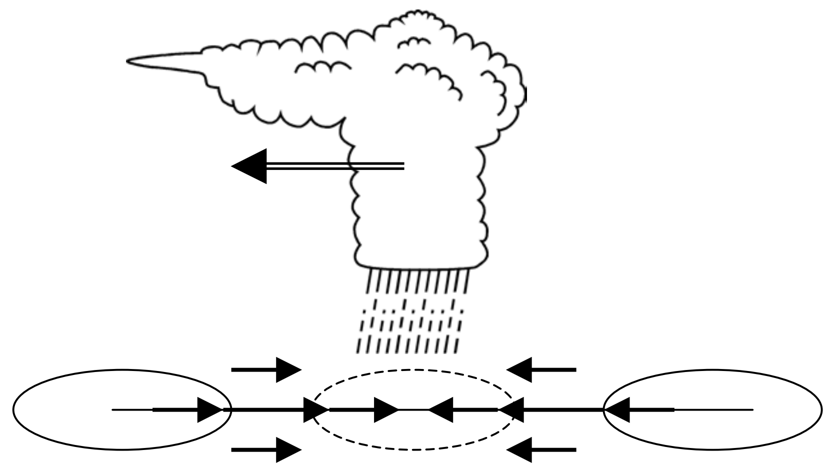
$$\Delta Q = Q\frac{L}{R_v T^2}\Delta T < 2 W m^{-2}$$

Model I

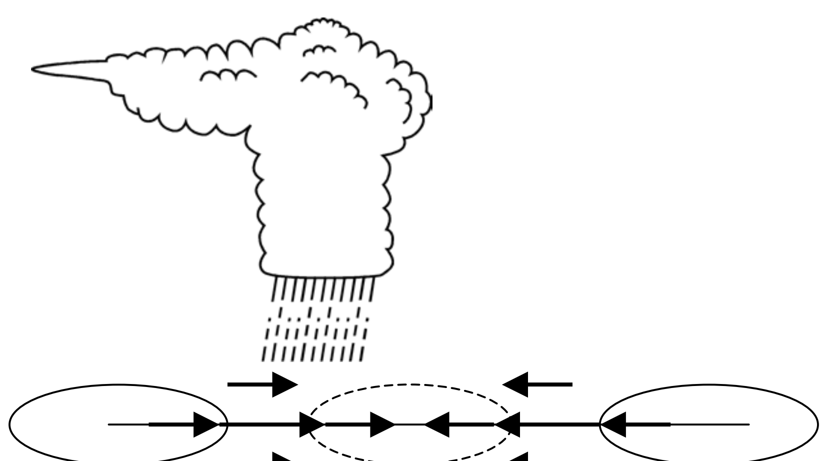


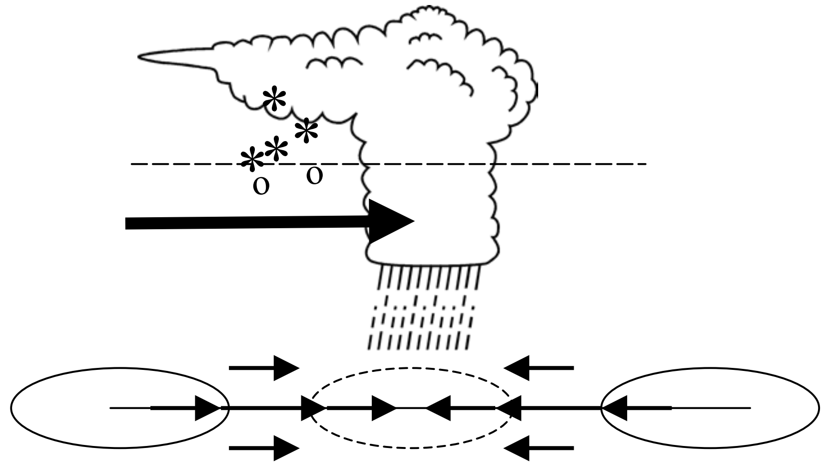
Model IV



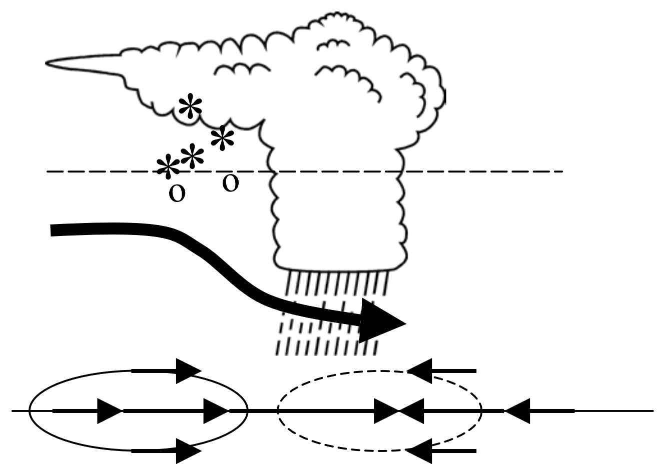


Model II





Model II

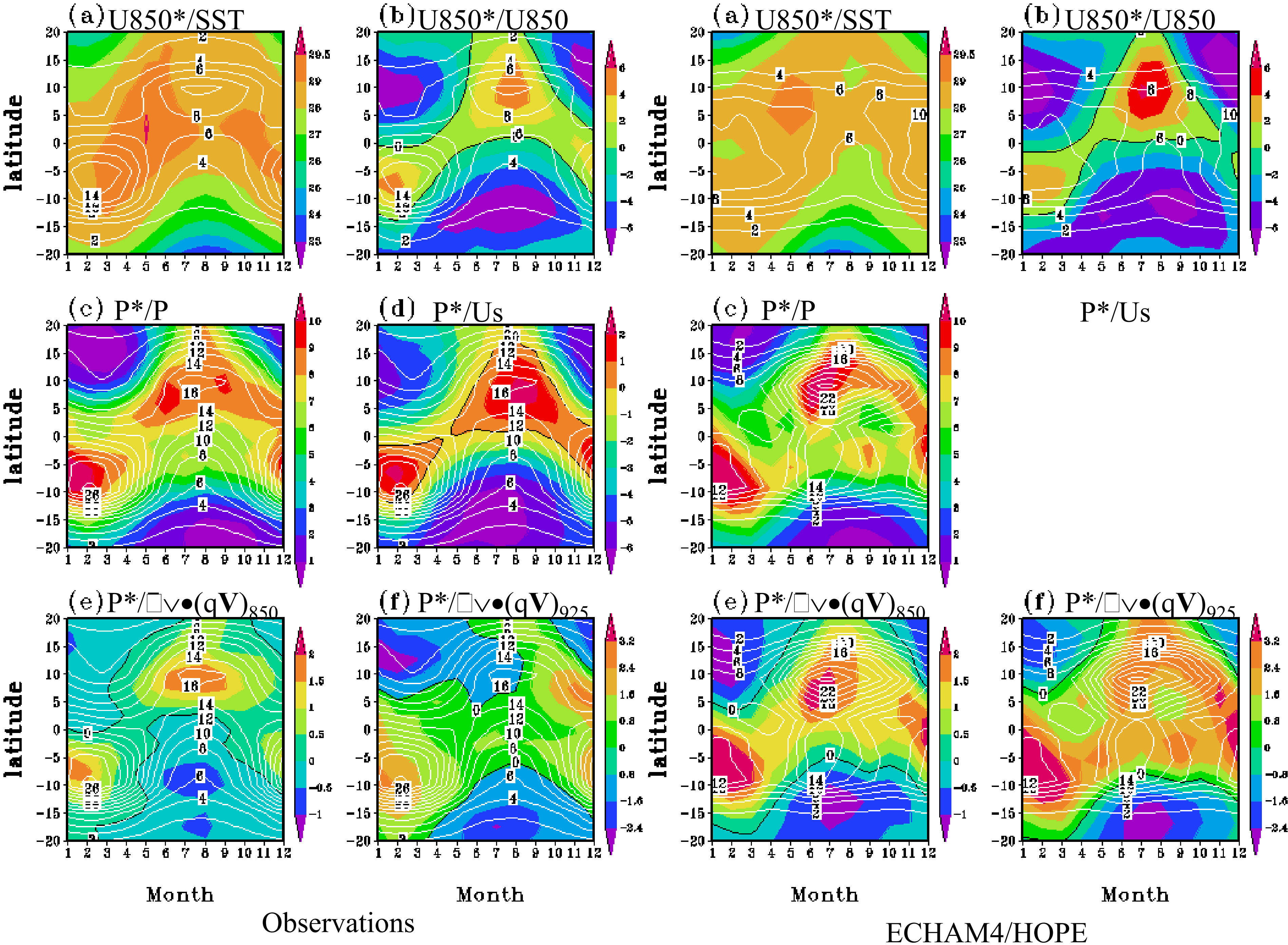


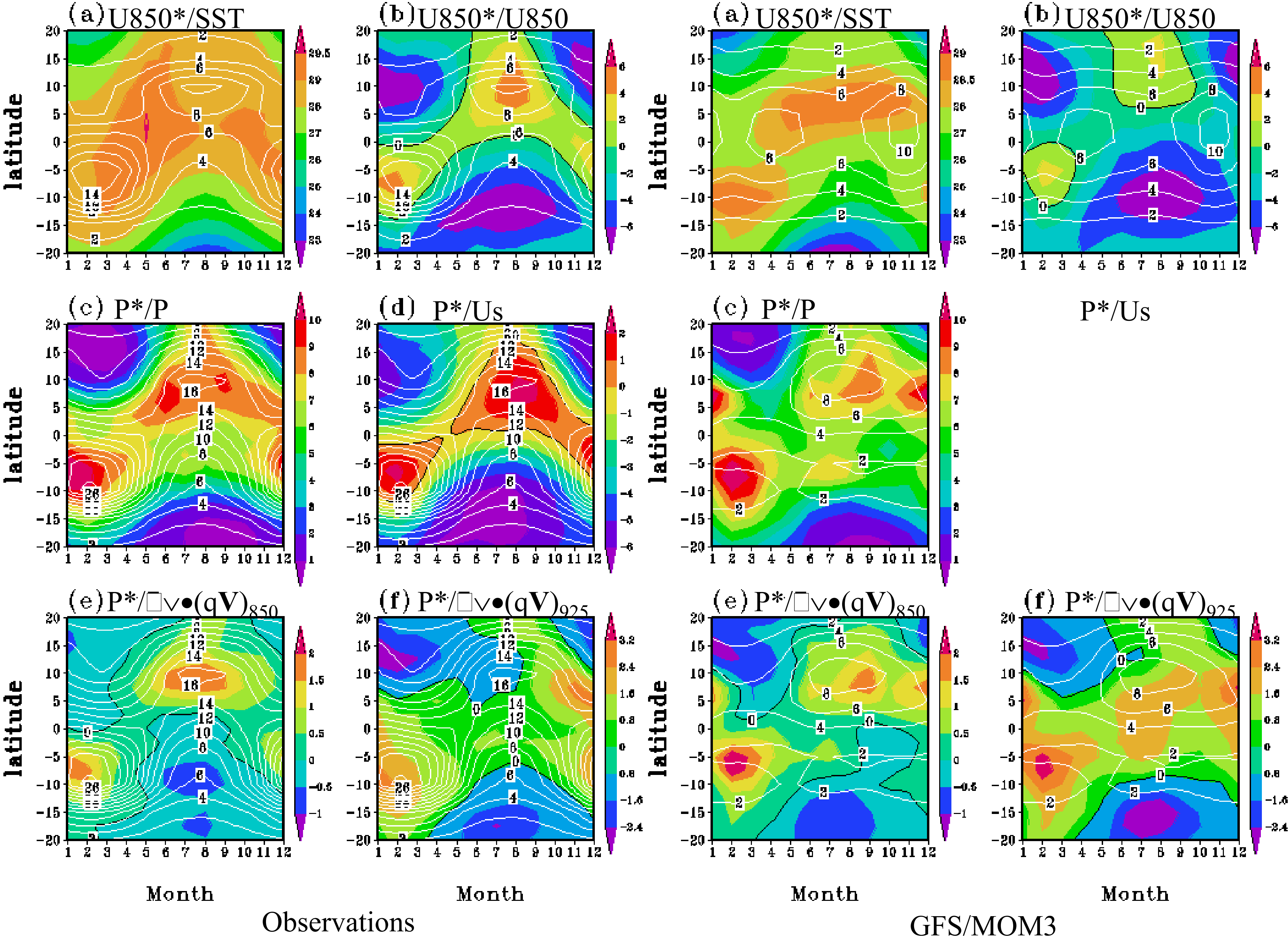
(Houze et al. 2001)

The Annual cycle of the MJO:

- The MJO peaks during boreal winter/spring.
- The MJO migrates in latitude.

• Observations
• GCM simulations


(a) U850*/SST
(b) U850*/U850
(c) P*/P
(d) P*/Us
(e) P*/□∨•(qV)850
(f) P*/□∨•(qV)925
(a) U850*/SST
(b) U850*/U850
(c) P*/P
P*/Us
(e) P*/□∨•(qV)850
(f) P*/□∨•(qV)925
latitude
Month
Observations
ECHAM4/HOPE



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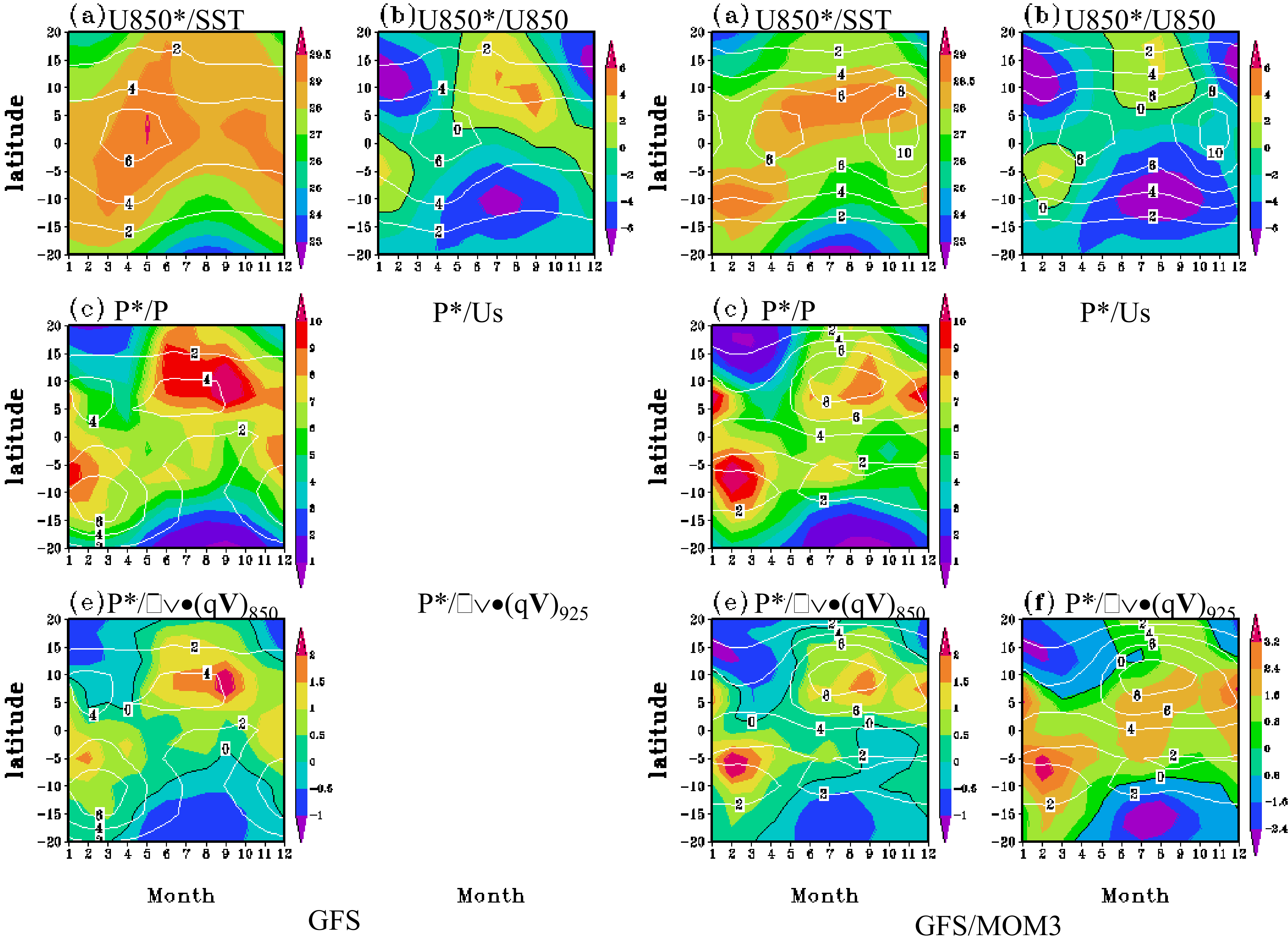
(f) P*/□∨•(qV)925
latitude
Month
Observations
GFS/MOM3



(a) U850*/SST
(b) U850*/U850
(c) P*/P
P*/Us
(e) P*/▯∨•(qV)850
P*/▯∨•(qV)925
latitude
Month
GFS
(a) U850*/SST
(b) U850*/U850
(c) P*/P
P*/Us
(e) P*/▯∨•(qV)850
(f) P*/▯∨•(qV)925
latitude
Month
GFS/MOM3

Comparison of the seasonal cycle of the MJO in observations and GCM simulations:

NCAR Community Atmospheric Model (CAM/SOM) - Maloney

NCEP Global Forecast System (GFS/MOM) - Wang

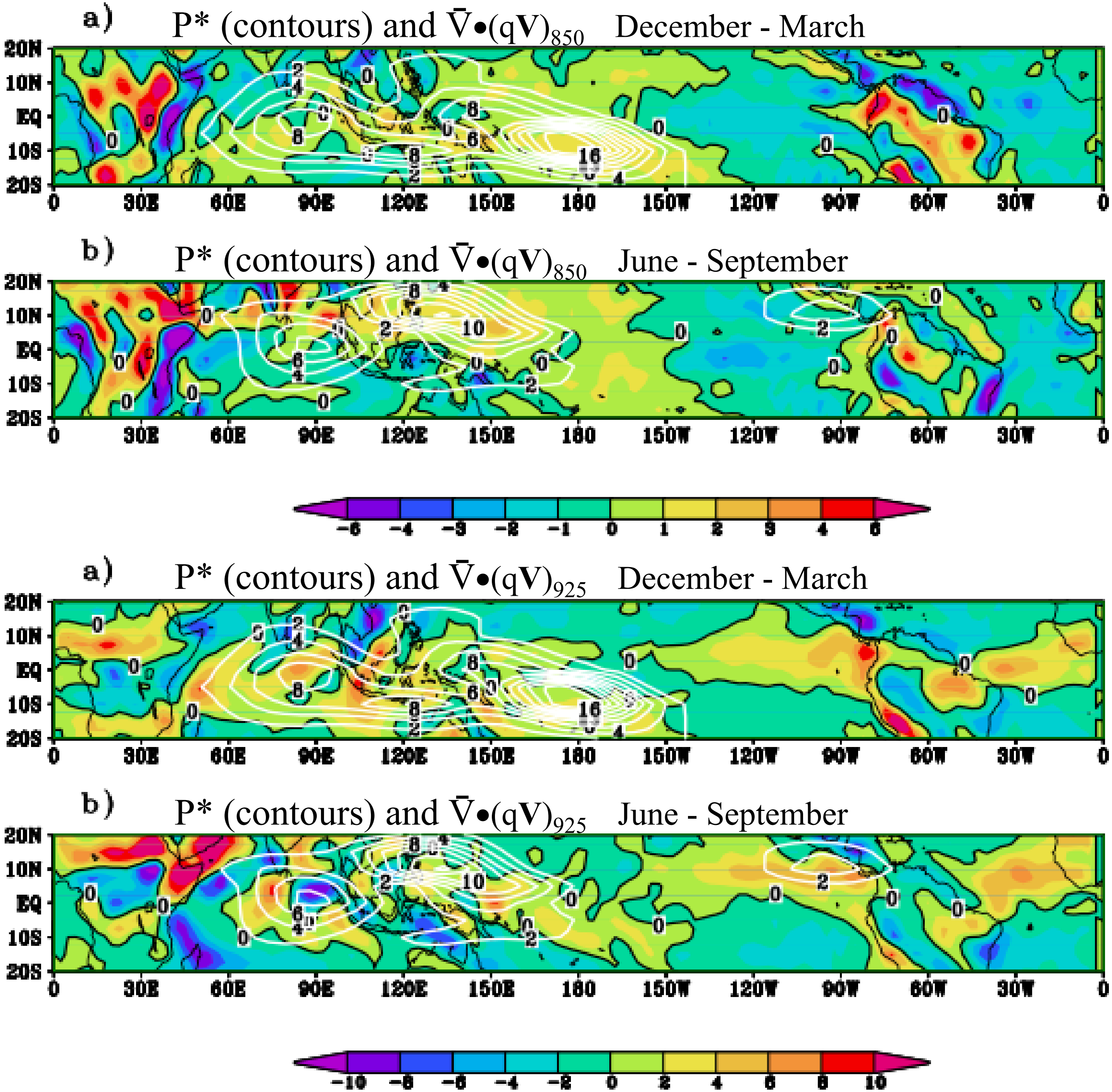
BOM Atmospheric Model (BAM) - Hendon

MPI ECHAM4/HOPE Model (ECHAM4/HOPE) - Sperber

Conclusions:

- The MJO must be highly sensitive to changes in latent heat flux, if SST feedback is important. But the mechanism for this sensitivity is unknown.
- It is important to simulate correctly the MJO structure when air-sea interaction is allowed.
- The structure of the MJO must be understood in terms of scale interactions between its large-scale circulation and mesoscale convective systems.

- **The seasonal cycle of the MJO poses another challenge to understanding the MJO dynamics.**
- **The structure and seasonal cycle of the MJO set higher standards for the evaluation of model simulations.**



a) P* (contours) and $\bar{\nabla}\bullet(q\mathbf{V})_{850}$ December - March
b) P* (contours) and $\bar{\nabla}\bullet(q\mathbf{V})_{850}$ June - September
-5 -4 -3 -2 -1 0 1 2 3 4 5
a) P* (contours) and $\bar{\nabla}\bullet(q\mathbf{V})_{925}$ December - March
b) P* (contours) and $\bar{\nabla}\bullet(q\mathbf{V})_{925}$ June - September
-10 -8 -6 -4 -2 0 2 4 6 8 10

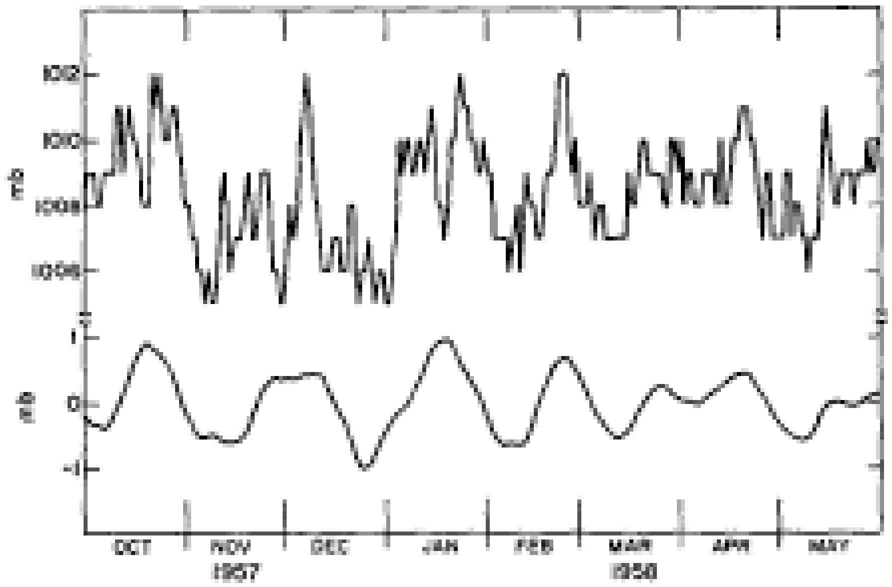


FIG. 9. Actual station pressures at Canton (top) and the corresponding pressures treated with a 45-day band-pass filter (bottom).