# Madden-Julian Oscillation:
# Global impacts during boreal winter

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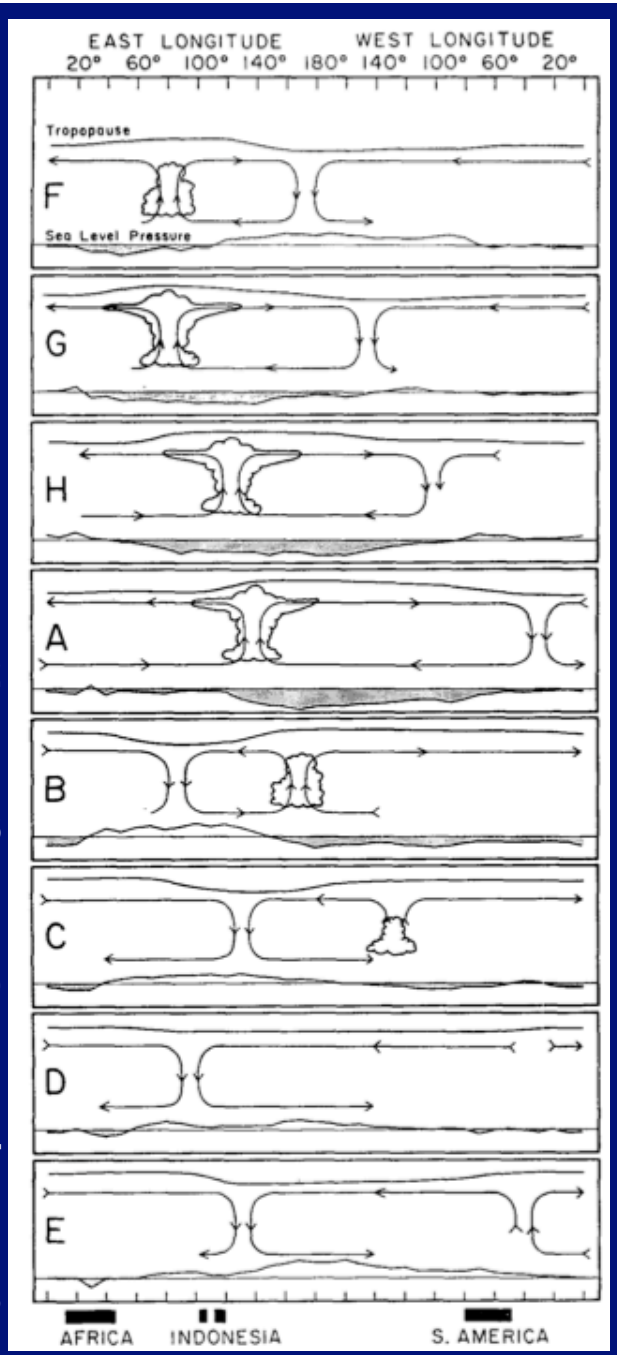
Trieste, 11 15 July 2011

# Review of MJO




*(Madden and Julian , 1972)*

- ✓ Oscillation that the tropical troposphere undergoes with a period of 30-60 days.
- ✓ The first baroclinic mode, equatorially trapped, convectively-coupled disturbance propagating at a phase speed of about 5m/s as it travels from the Indian Ocean eastward to the dateline, where the convective coupling diminishes and propagates at about 12m/s.
- ✓ Involves eastward moving of rainy and dry weather in the Indian and West Pacific Oceans.
- ✓ A region can expect on average 20 days of above normal rainfall followed by 20 days of below normal rainfall.
- ✓ In the convectively active phase is characterized by strong surface westerlies and high surface latent fluxes.
- ✓ In the convectively inactive phase is characterized by weak surface easterlies and high downward radiative fluxes.

# Identification of MJO and its phases

## Multivariate EOF analysis *(From Wheeler and Hendon, 2004)*

★ EOF analysis of 15ºS to 15ºN averaged OLR, u850 and u200

- each variable is normalized by its standard deviation
- first two combined EOF describe propagating MJO structure
- RMM = Realtime Multivariate MJO index: project OLR, u850, and u200 onto the first 2 combined EOFs

★ Includes both OLR and wind

★ Distinguish between the MJO events

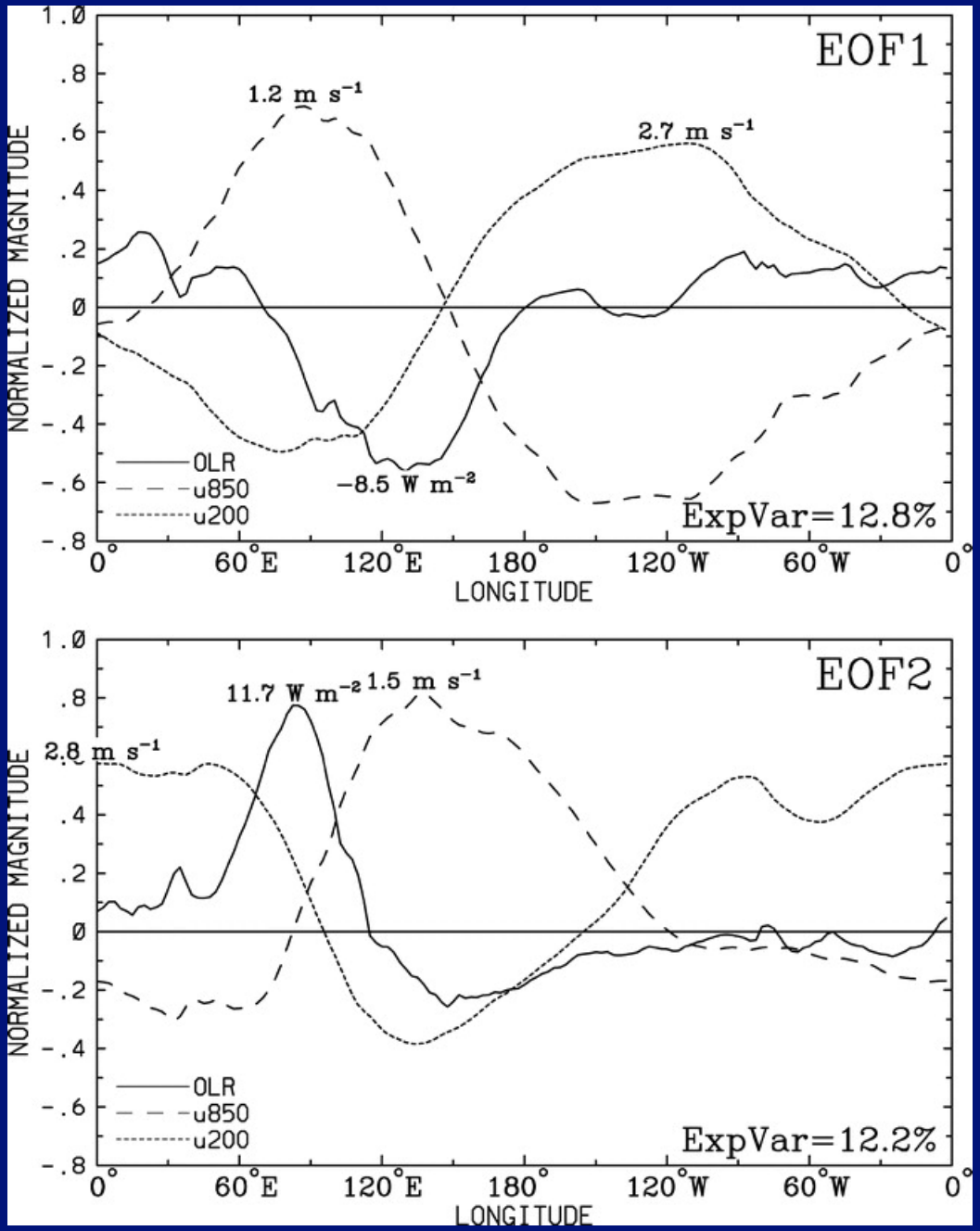
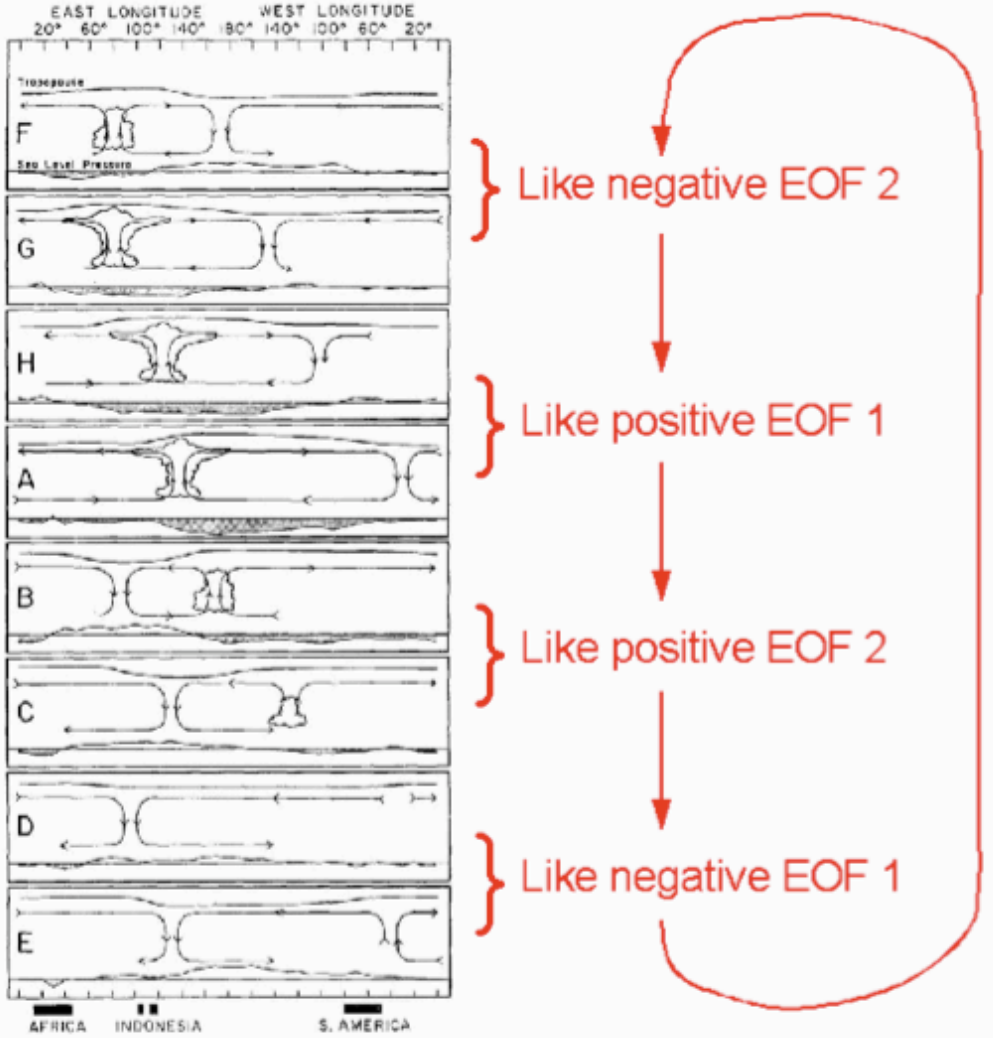


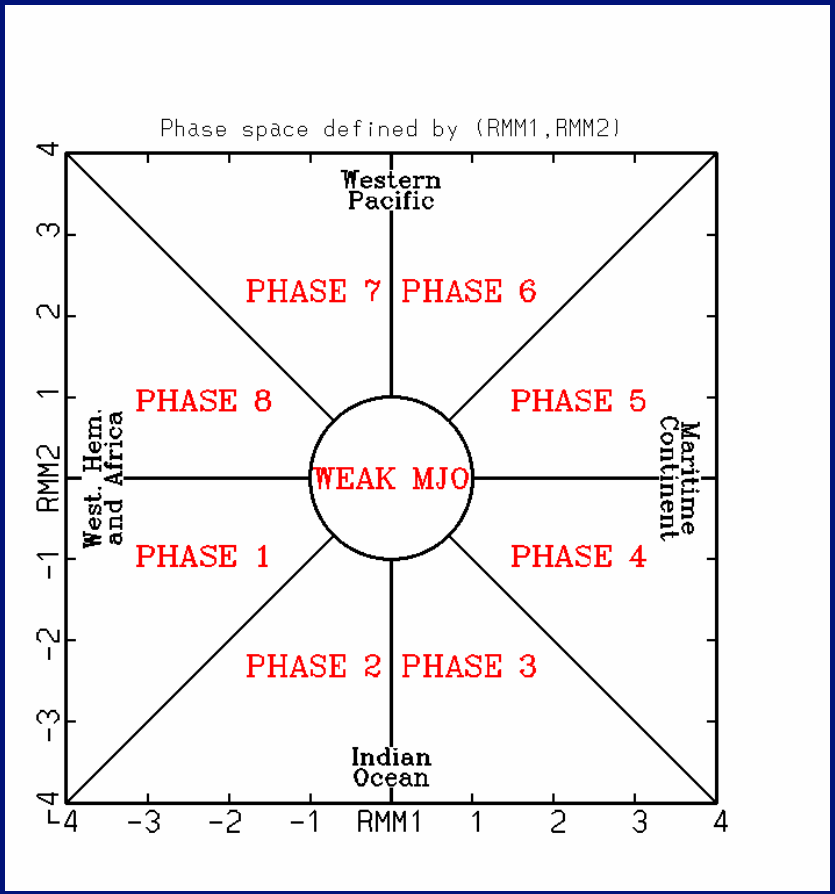

**FIG. 1. Spatial structures of EOFs 1 and 2 of the combined analysis of OLR, u850, and u200.**

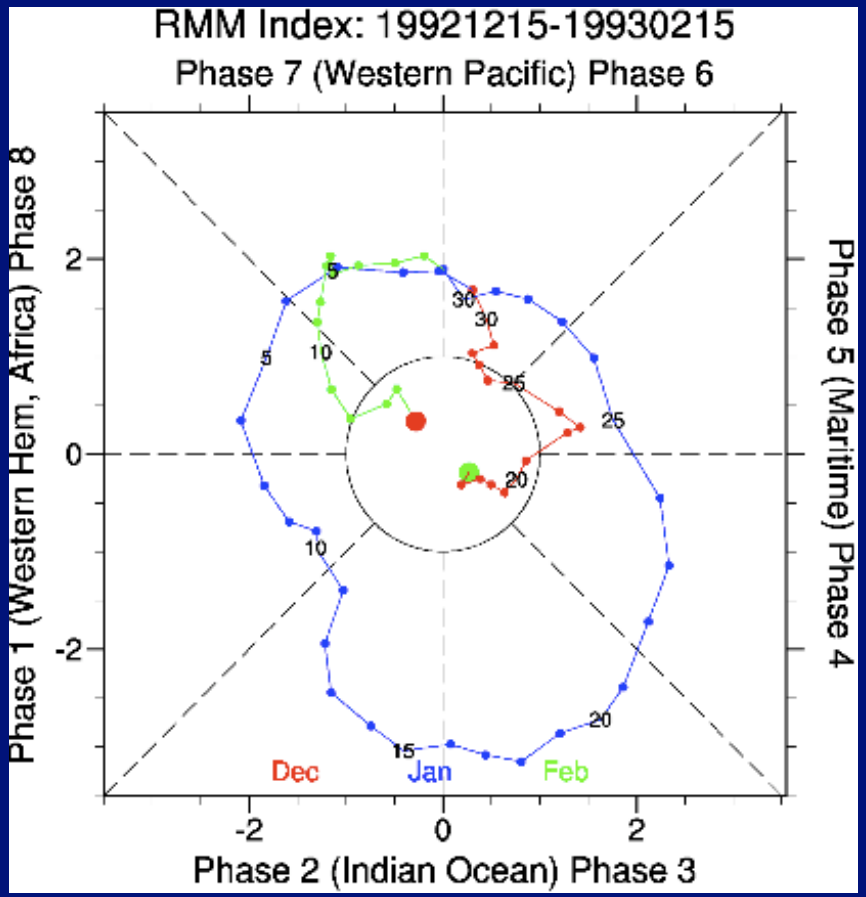
***(From Wheeler and Hendon, 2004)***

## Madden and Julian's (1972) schematic




*From http://cawcr.gov.au/staff/mwheeler/maproom/RMM/eof1and2.htm*



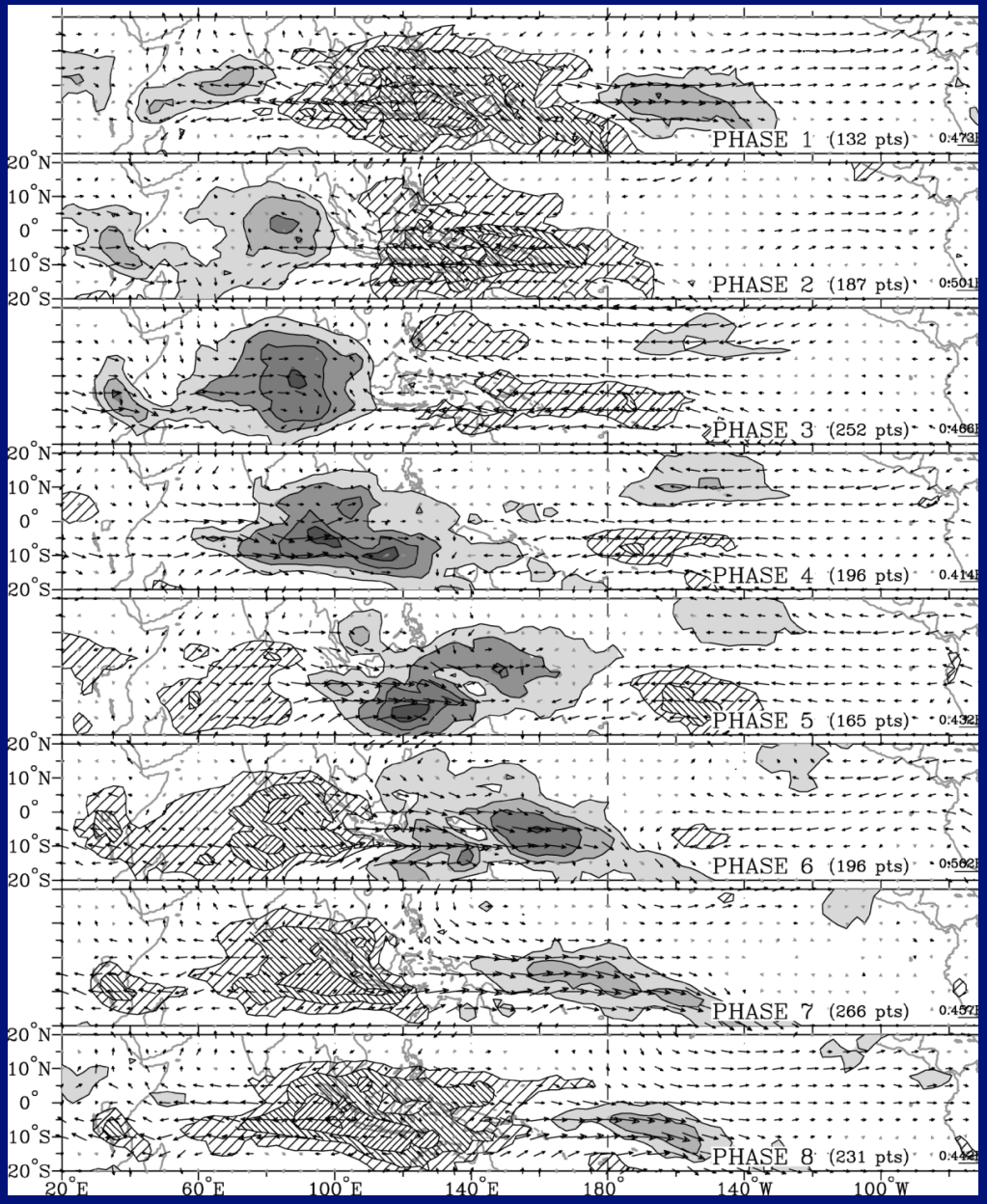

The resulting pair of PC time series that form the desired index is called the Real-time Multivariate MJO series 1 (RMM1) and 2 (RMM2).

# Data and Methodology

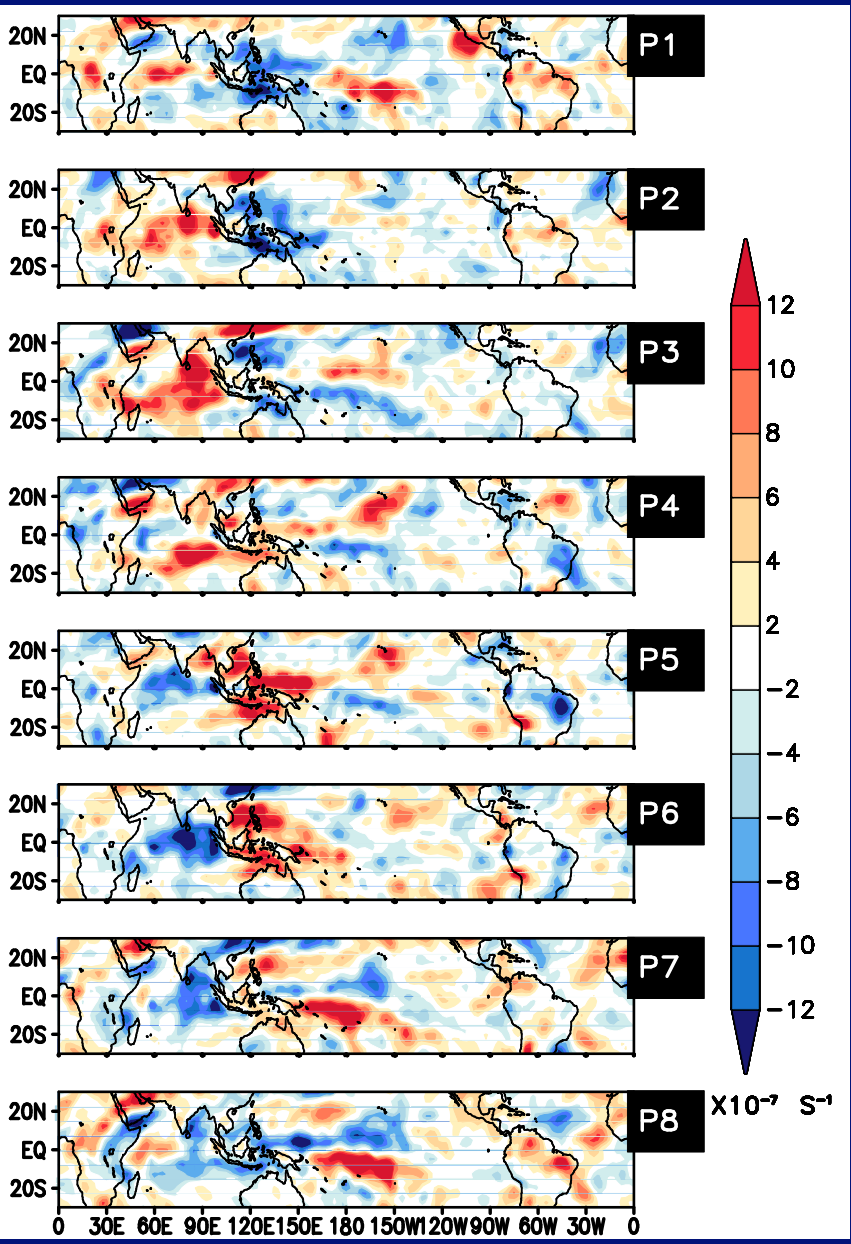
1. Data: ERA40 $div_{200}$, $u_{850}$, $v_{850}$, $v_{200}$; OLR; observed daily precipitation from more than 10,000 stations in South America, gridded to 1º.
   Period of analysis: October-March during1979-2010.
2. For each variable and each grid point of the data, the annual cycle of daily climatology is calculated. For instance, the average of $div_{200}$ is calculated over all 1st January, all 2nd January, ..., all 31st December.
3. This annual cycle has much spurious variance, due to the small size of the sample (32 years). Therefore, it was smoothed by a 31 day moving average.
4. The daily anomalies are calculated with respect to this smoothed daily climatology.
5. The daily anomalies are filtered with a bandpass Lanczos filter, to retain periods of 20-90 days.
6. A list of dates for each phase of the MJO is organized
7. The anomalies are composited for the dates of each phase, in order to characterize the corresponding convection anomalies and atmospheric circulation anomalies associated with each phase.

# Convection anomalies in different phases of the MJO

DJF composite OLRA and 850-hPa wind vector anomalies



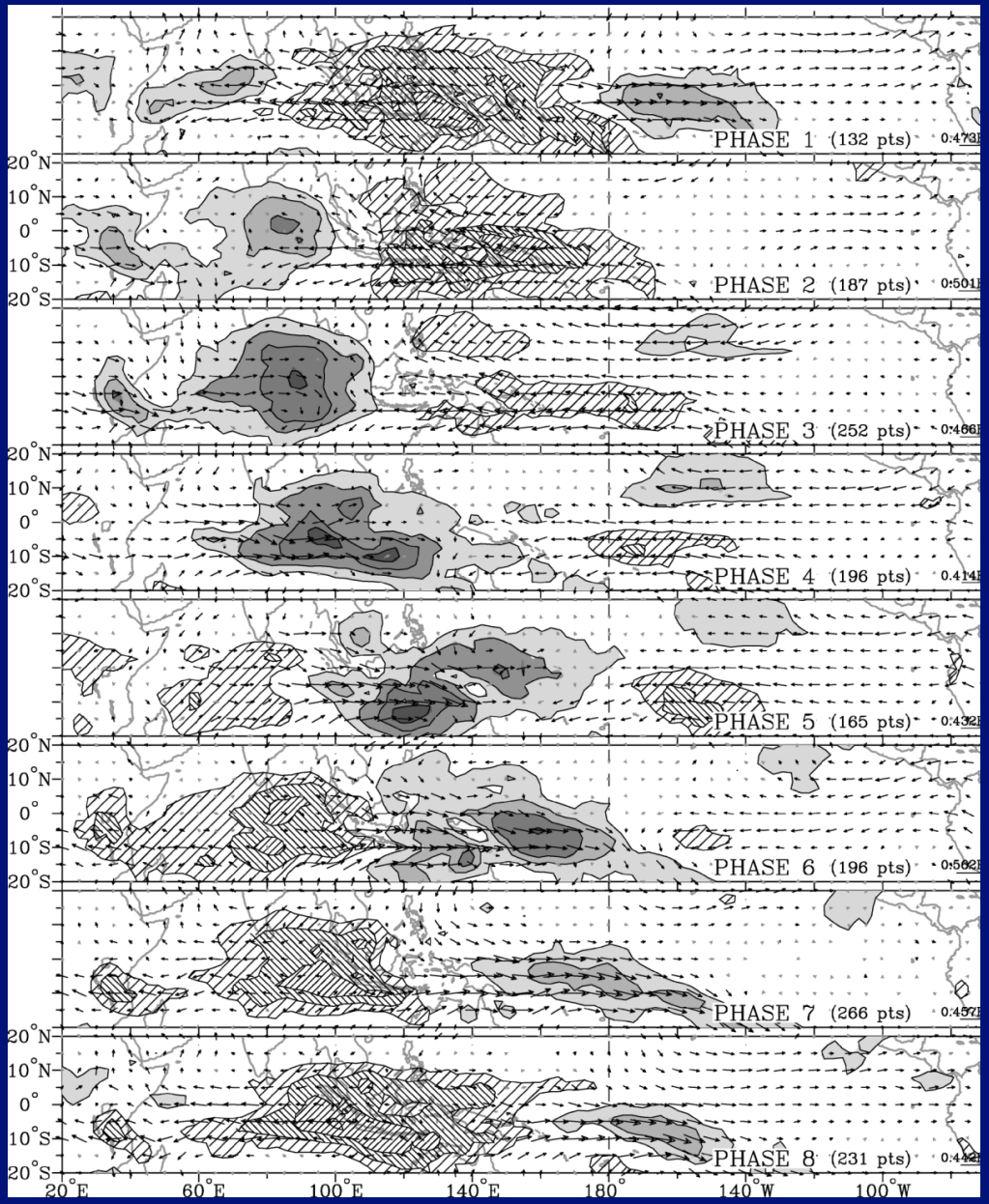

200-hPa divergence anomalies



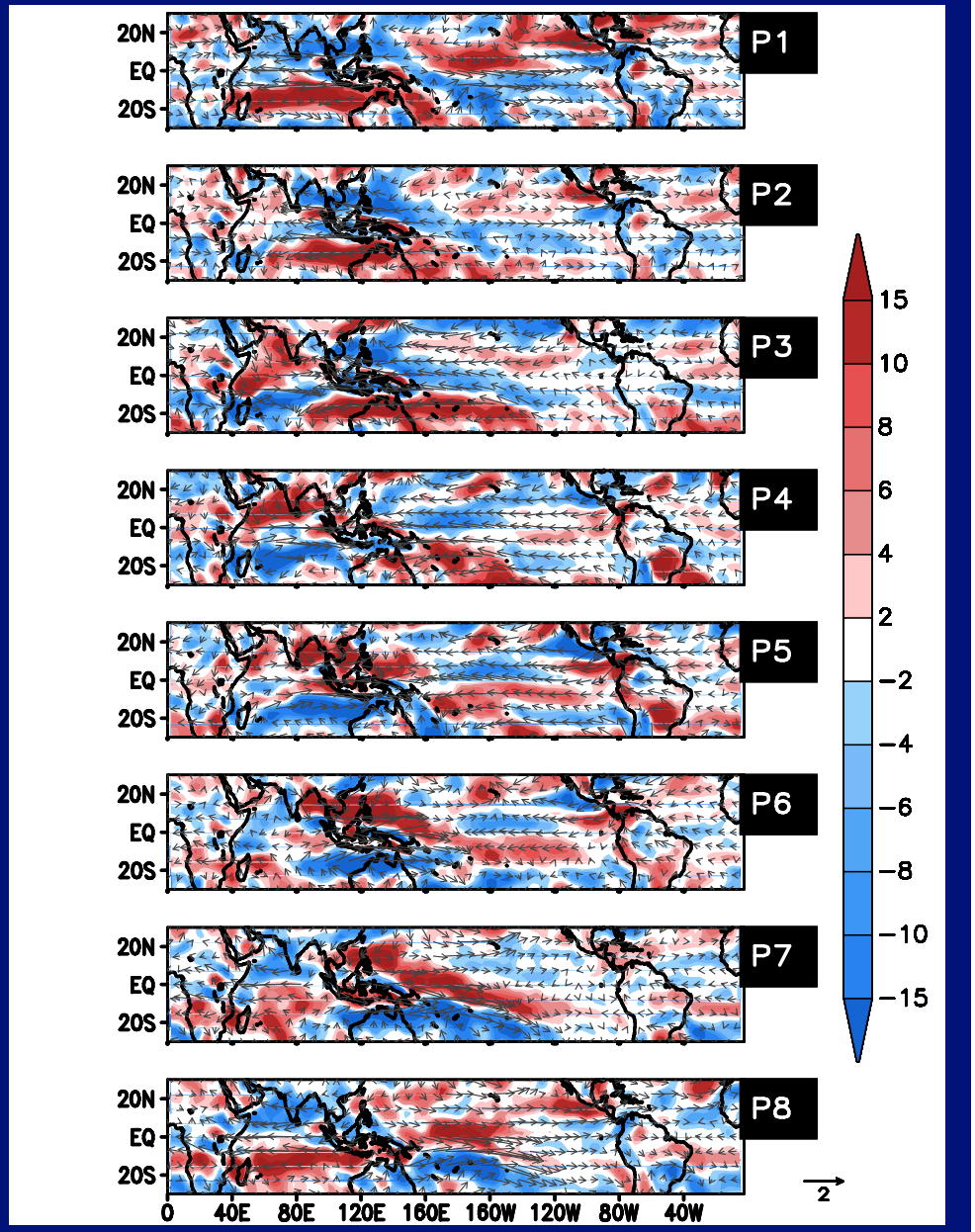

*(From Wheeler and Hendon, 2004)*

# Circulation anomalies in different phases of the MJO

DJF composite OLRA and 850-hPa wind vector anomalies



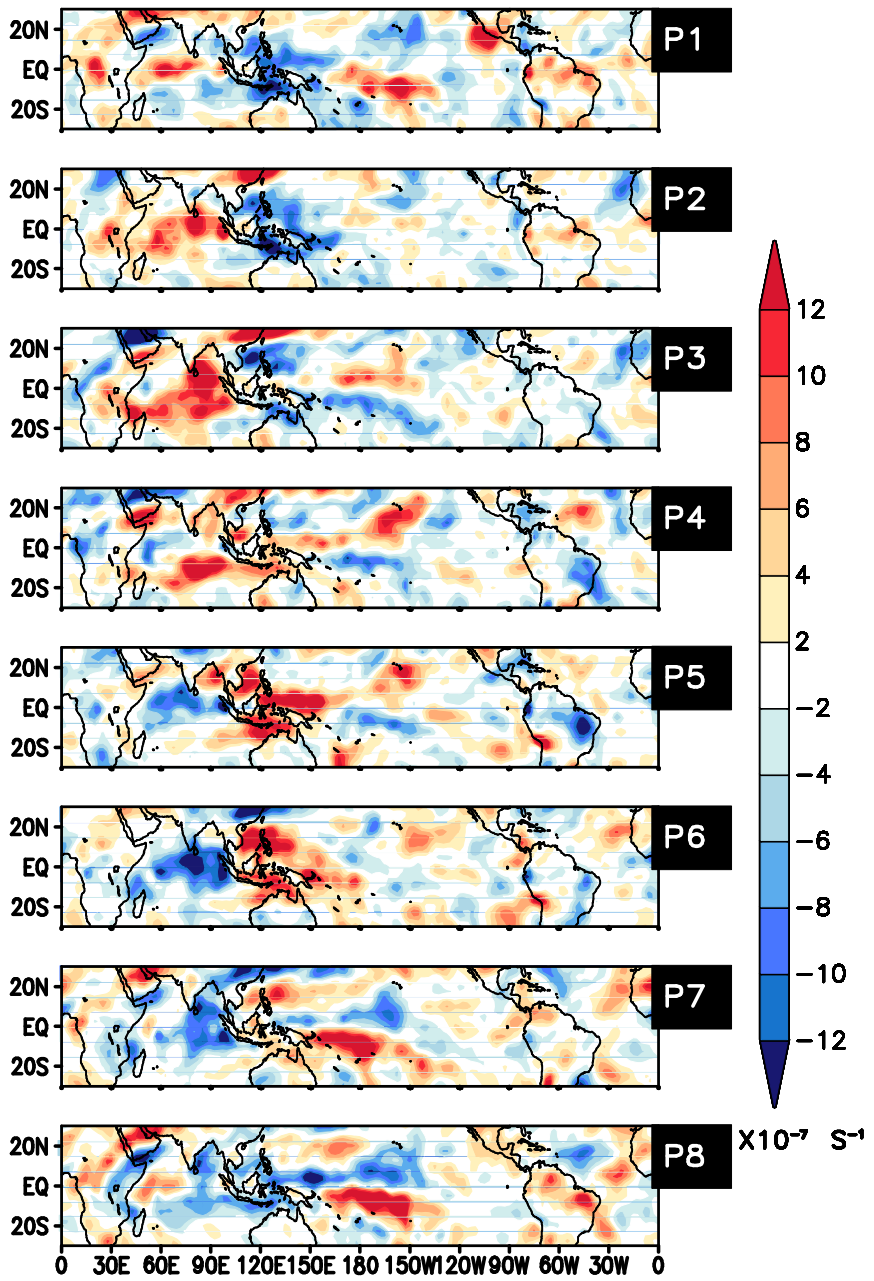

850-hPa vorticity and wind anomalies



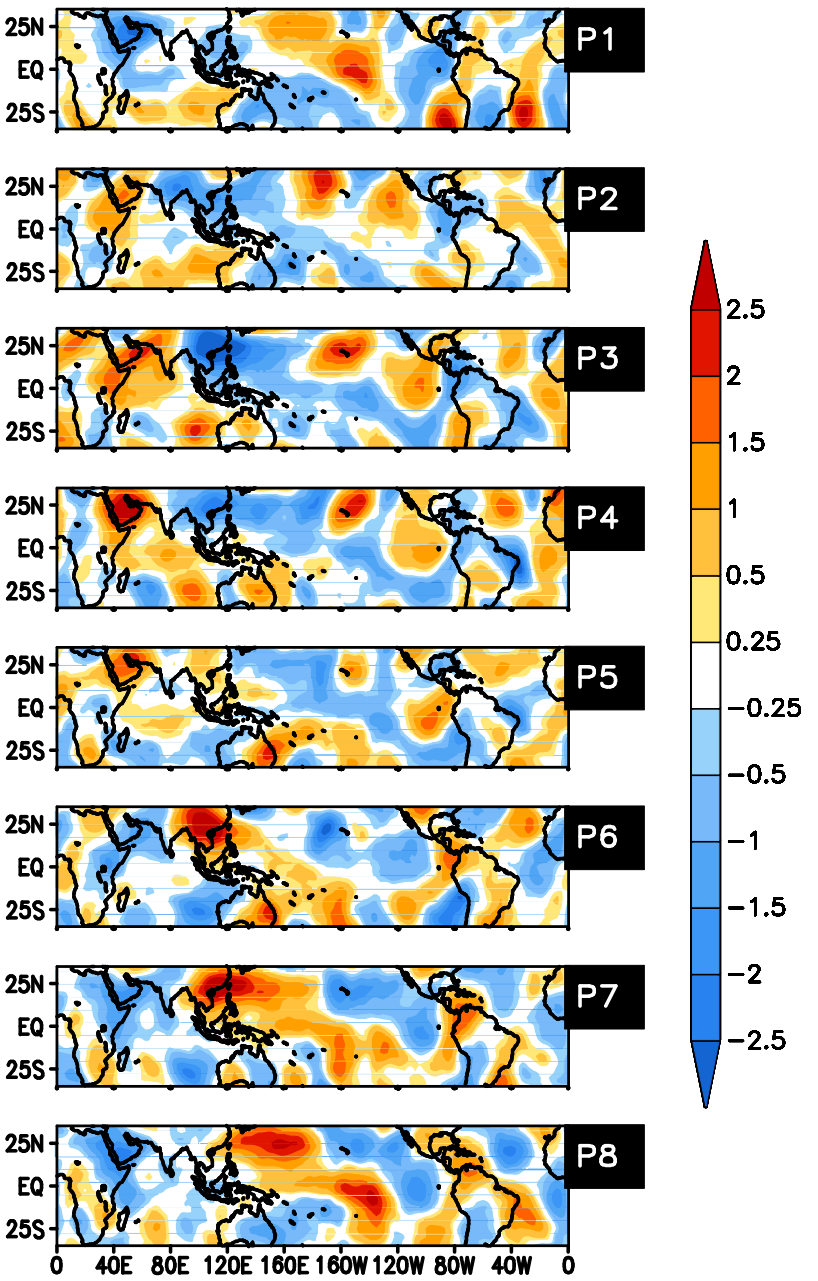

*(From Wheeler and Hendon, 2004)*

# Circulation anomalies in different phases of the MJO

200-hPa divergence anomalies

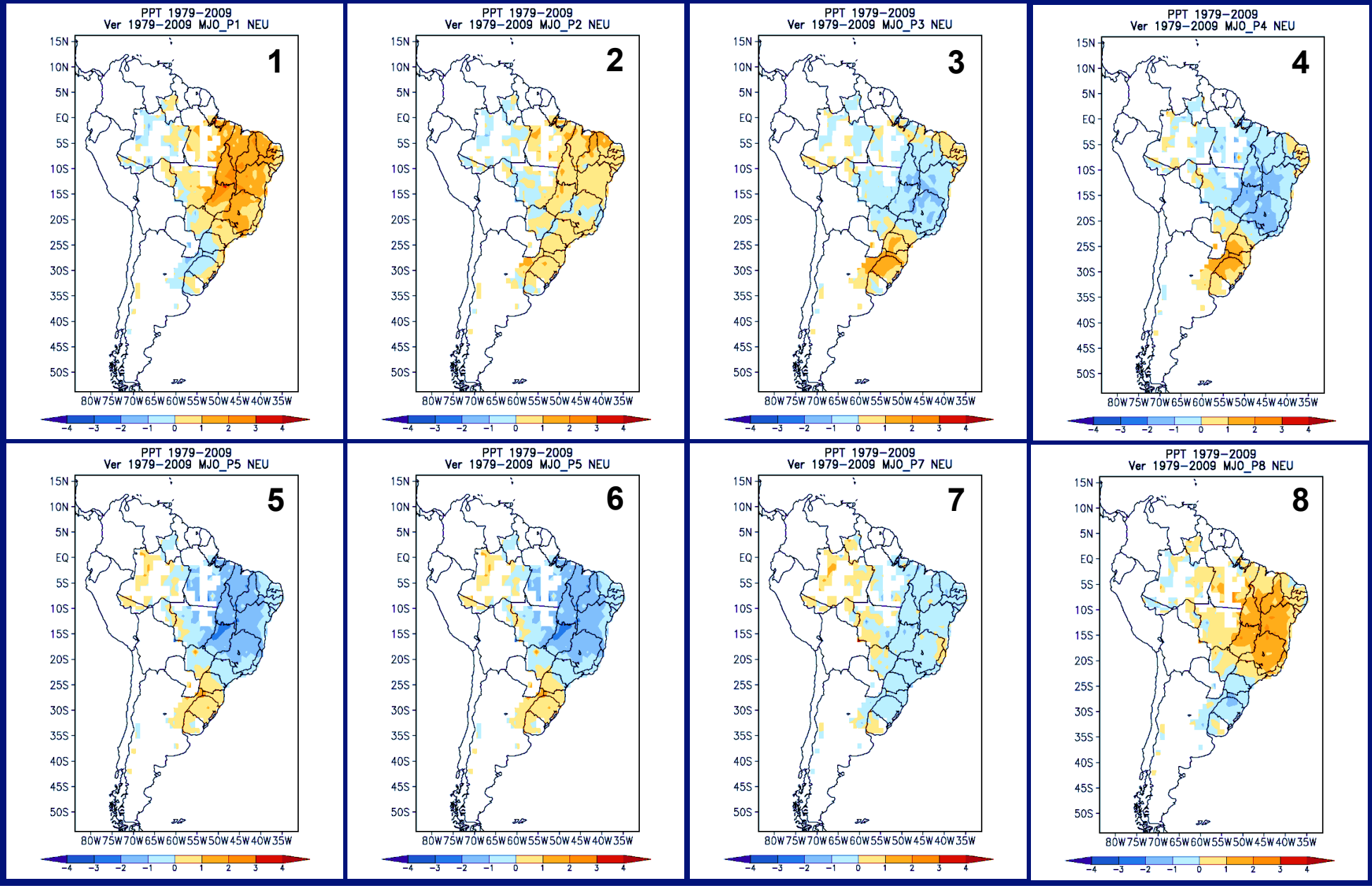



200-hPa meridional wind anomalies



# Example of importance of the MJO outside the Indian/Pacific:

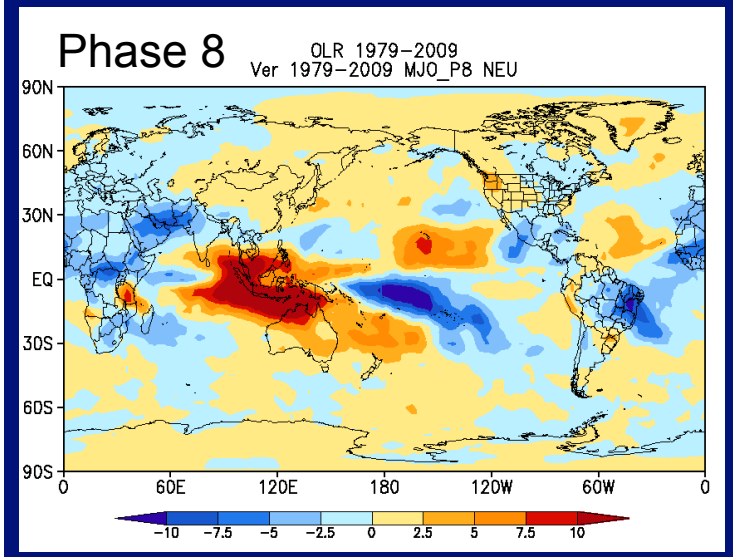
## South America DJF precipitation anomalies

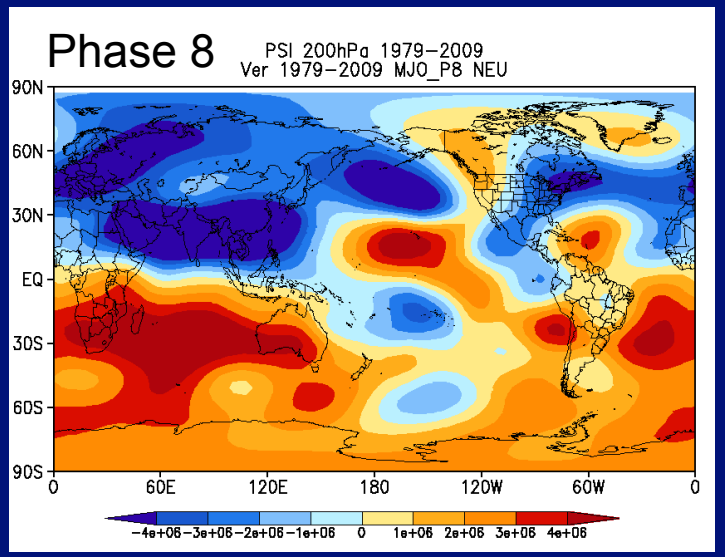


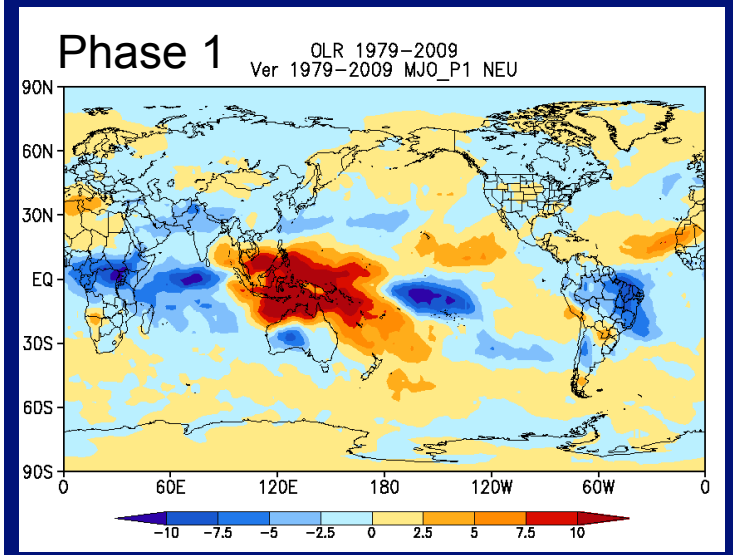
# Example of importance of the MJO outside the Indian/Pacific:
# Teleconnection to South America in DJF

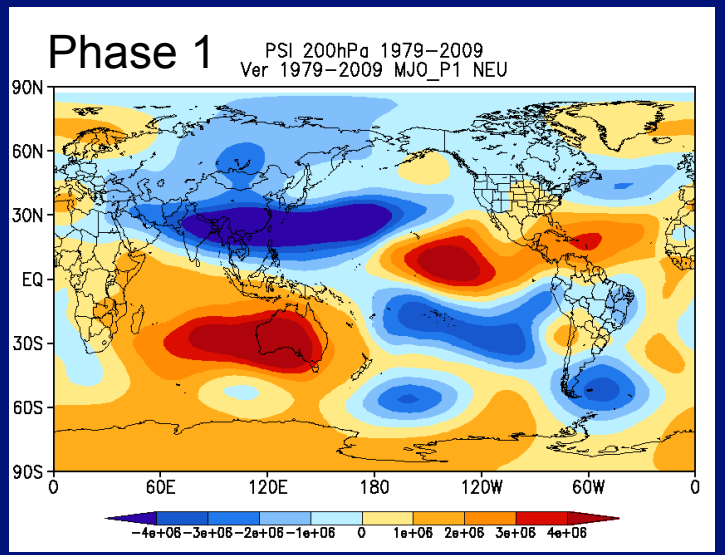
OLR anomalies

$\psi_{200}$ anomalies

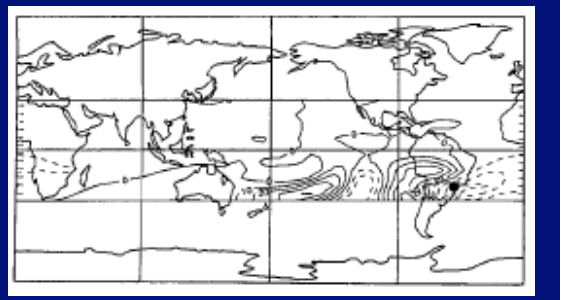


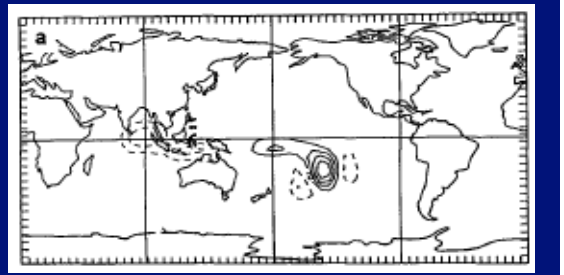



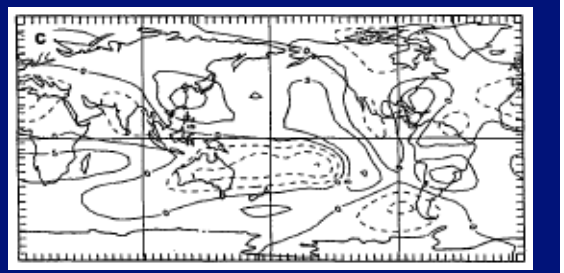




Influence Function



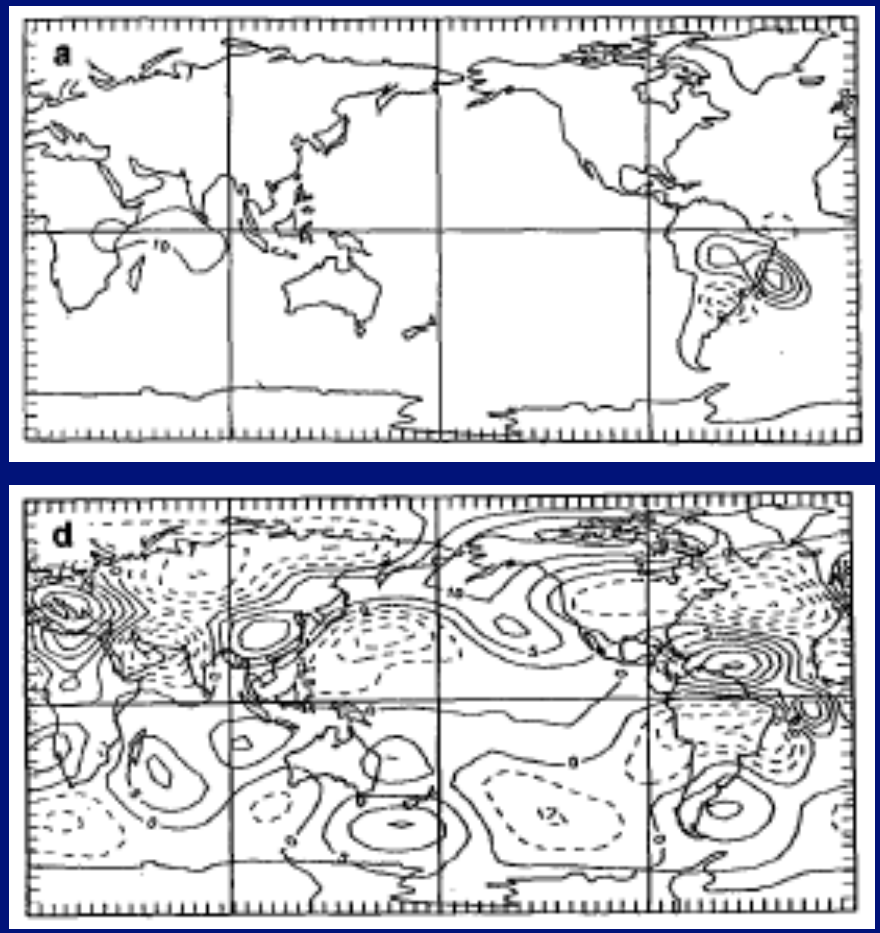
Simulation




From (Grimm and Silva Dias, 1995)

# Example of importance of the MJO outside the Indian/Pacific:
# Possible teleconnection South America-Eurasia




Grimm, A. M., e P. L. Silva Dias, 1995: Analysis of tropical-extratropical interactions with influence functions of a barotropic model. Journal of the Atmospheric Sciences, 52, 3538-3555.

# Precipitation regimes in SA

## 1950-2005

Precipitation maxima (SH seasons):

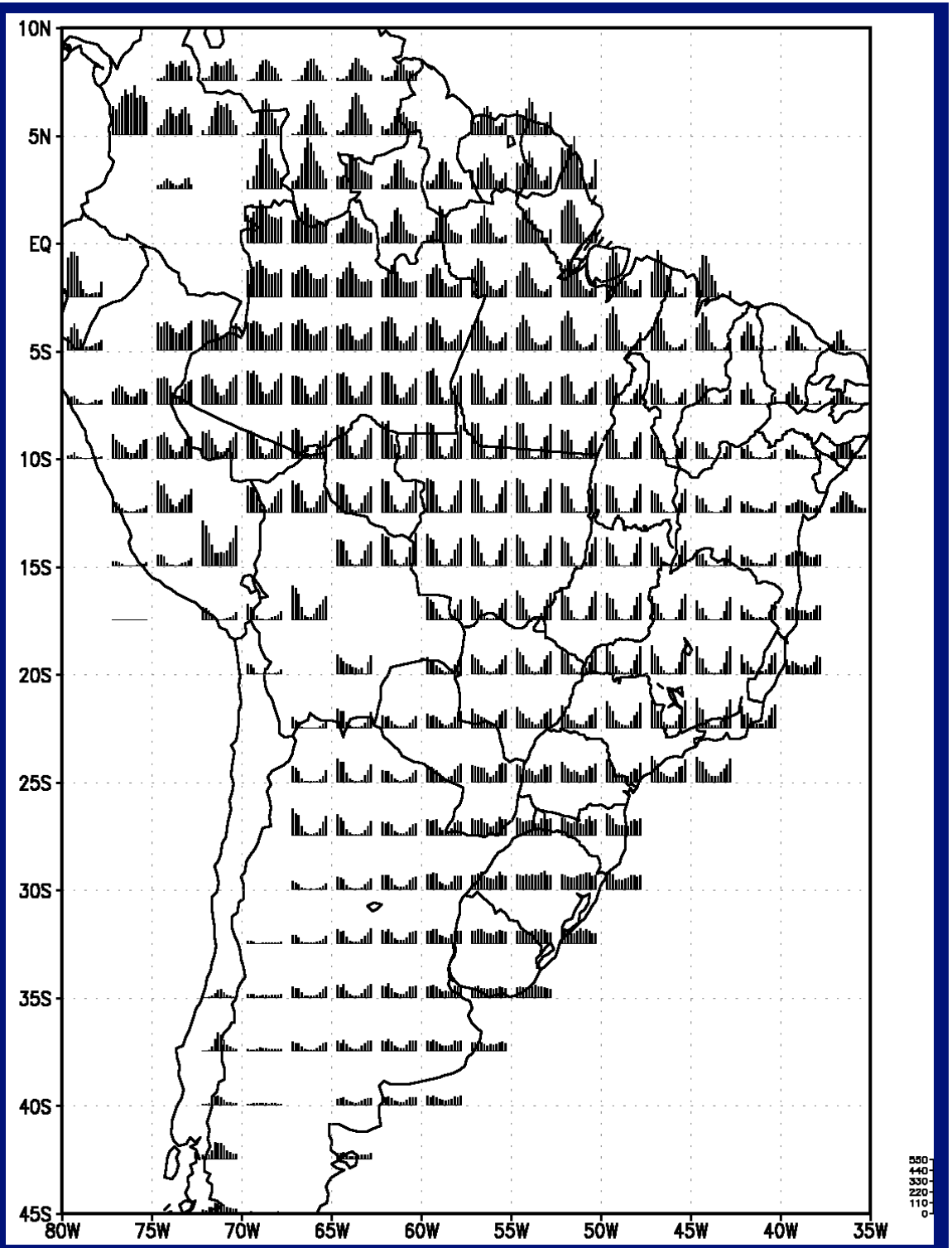
Most of South America: summer, with dry season in the winter, due to the South American monsoon system.

North: autumn and winter, in connection with the annual migration of the deep tropical convection.

Northeast Brazil: autumn, in connection with the southward shift of the Atlantic ITCZ.

South Brazil: region of transition, where the maximum changes from summer to spring and to winter. The southernsmost region has uniform rainfall distribution because is subjected also to the midlatitude regime in which rainfall is due to frontal incursions associated with extratropical cyclones.

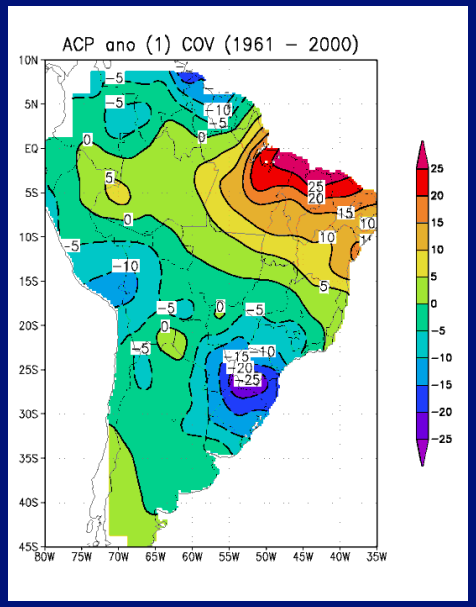
(Grimm, 2003, J. Climate; Grimm, 2009, SERRA)



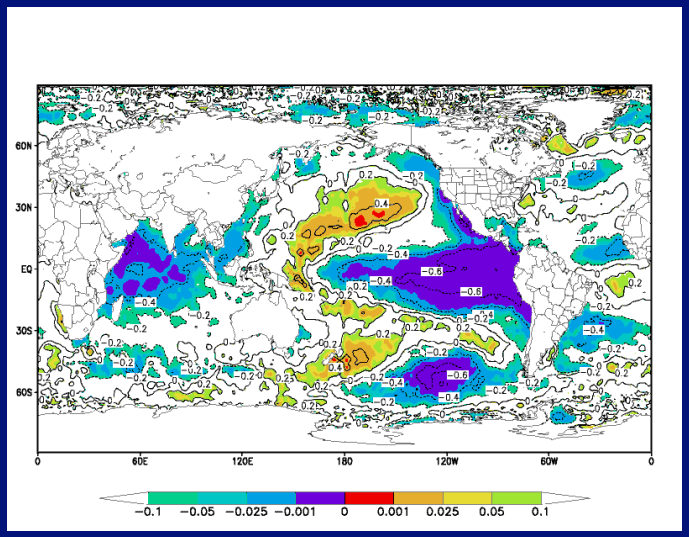
# Interannual Variability

## Annual precipitation modes

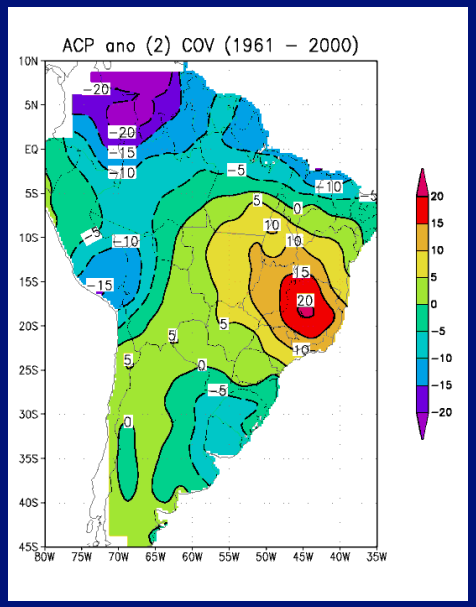
1



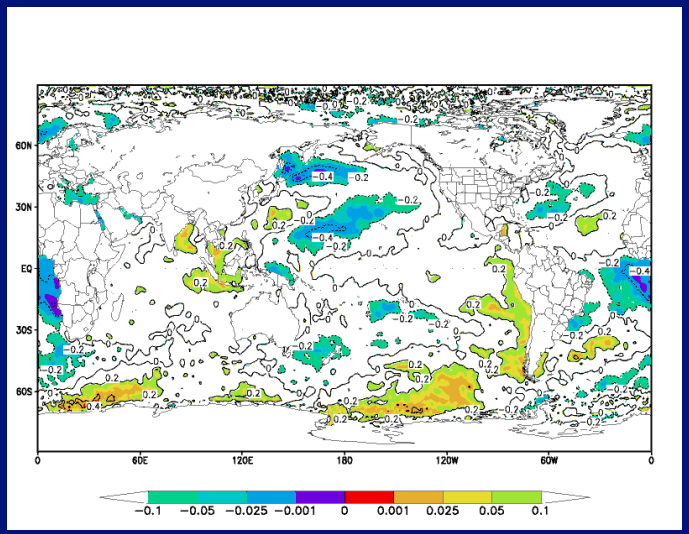

23,6%



2




14,0%

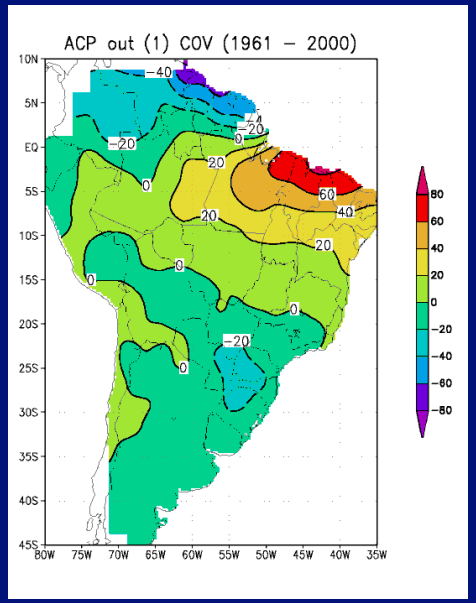


## Seasonal precipitation modes

### Autumn

1

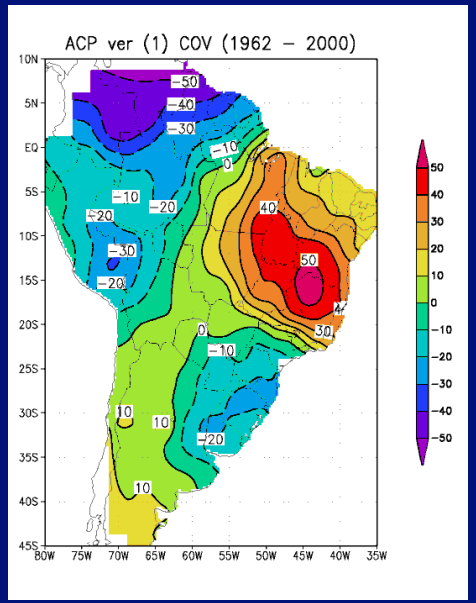
29,2%




### Summer

1

26,5%



# Conclusions

- The Madden-Julian Oscillation presents strong impacts in regions far from the Indian/Pacific Ocean, where its equatorial convection anomalies are strongest.
- Its impacts in subtropical and extratropical regions are produced by tropical-extratropical Rossby wave propagation.