

# **Model study of Madden –Julian oscillation (MJO)**

Russian State Hydrometeorological University

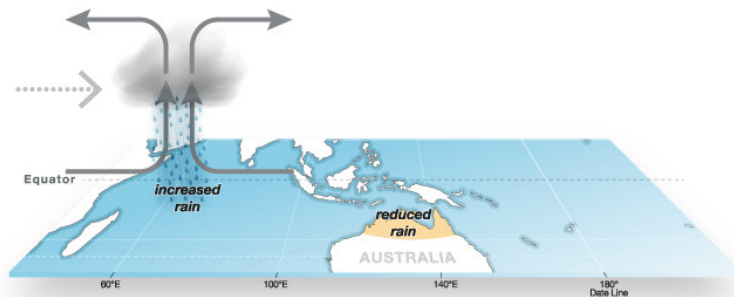
K. K. Kandieva, A.I. Pogoreltsev, O.G. Aniskina

Saint - Petersburg 2017

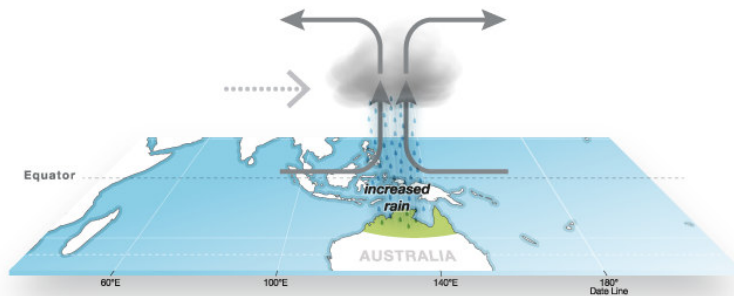
# Characteristics of tropical oscillation:

## Madden-Julian Oscillation (MJO)

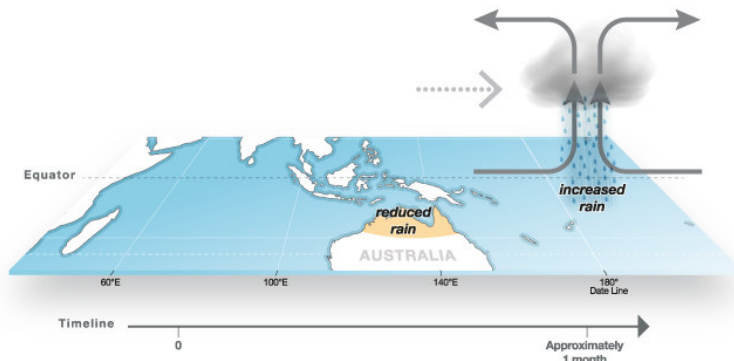
### Example cycle: Week 1



### Example cycle: Week 2-3



### Example cycle: Week 4-5



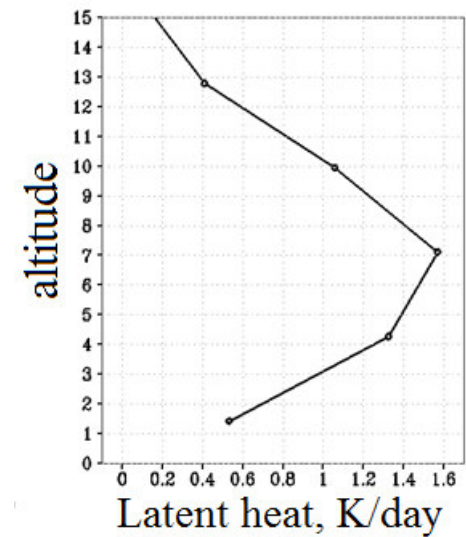
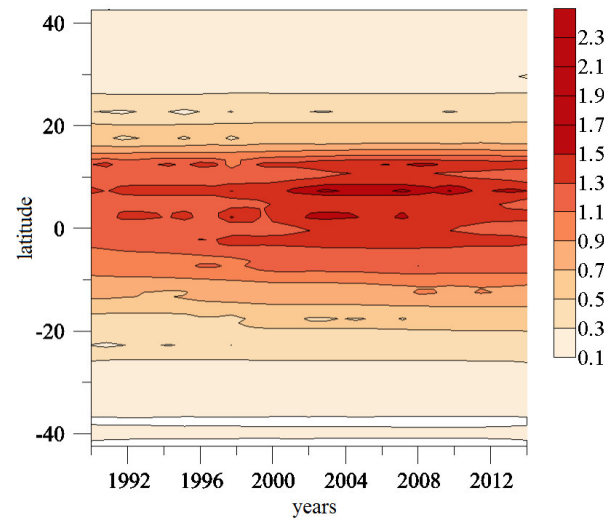
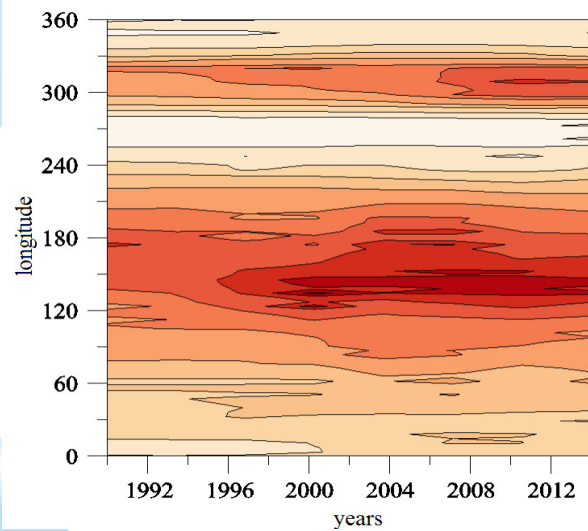
- Convection-wind coupling
- Eastward propagation
- Phase speed — 5 m/s
- Intraseasonal period — 30-60 days
- Zonal scale — 12 000-20 000 km
- Multiscale cloud structure
- Index MJO developed by Wheeler and Hendon 2004.

# Latent heat distribution

$$I(z, \varphi) = I_z(z)I_\varphi(\varphi)$$

Empirical formula of Hong and Wang 1980:

$$I_z(z) = A \left\{ \exp \left[ - \left( \frac{z - 6,5}{5,39} \right)^2 \right] - 0.23 \exp \left( - \frac{z}{1,31} \right) \right\}$$



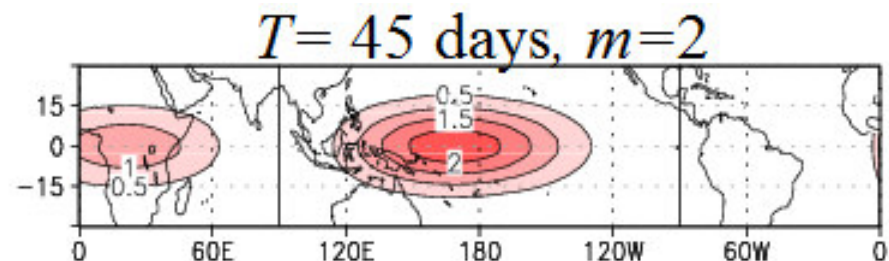
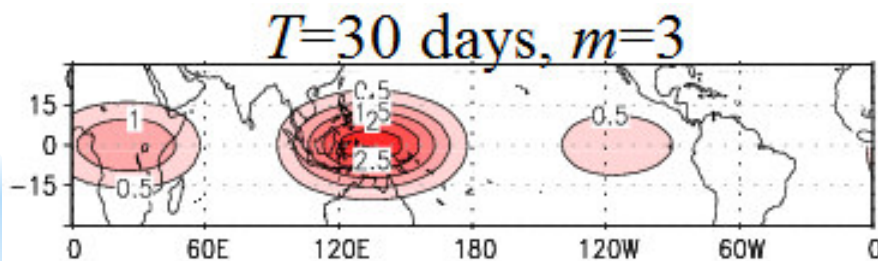
# Identification of the Madden –Julian oscillation model

$$Q(x, y, z, t) = A[1 + \cos(m\lambda - \omega t)] \exp \left( - \left( \frac{x - x_0}{x_0} \right)^2 - \left( \frac{y}{y_0} \right)^2 - \left( \frac{(z - z_0)}{z_0} \right)^2 \right)$$

where  $A$  — the amplitude of heat 1,5 K/day;

$m$  — zonal wave number;

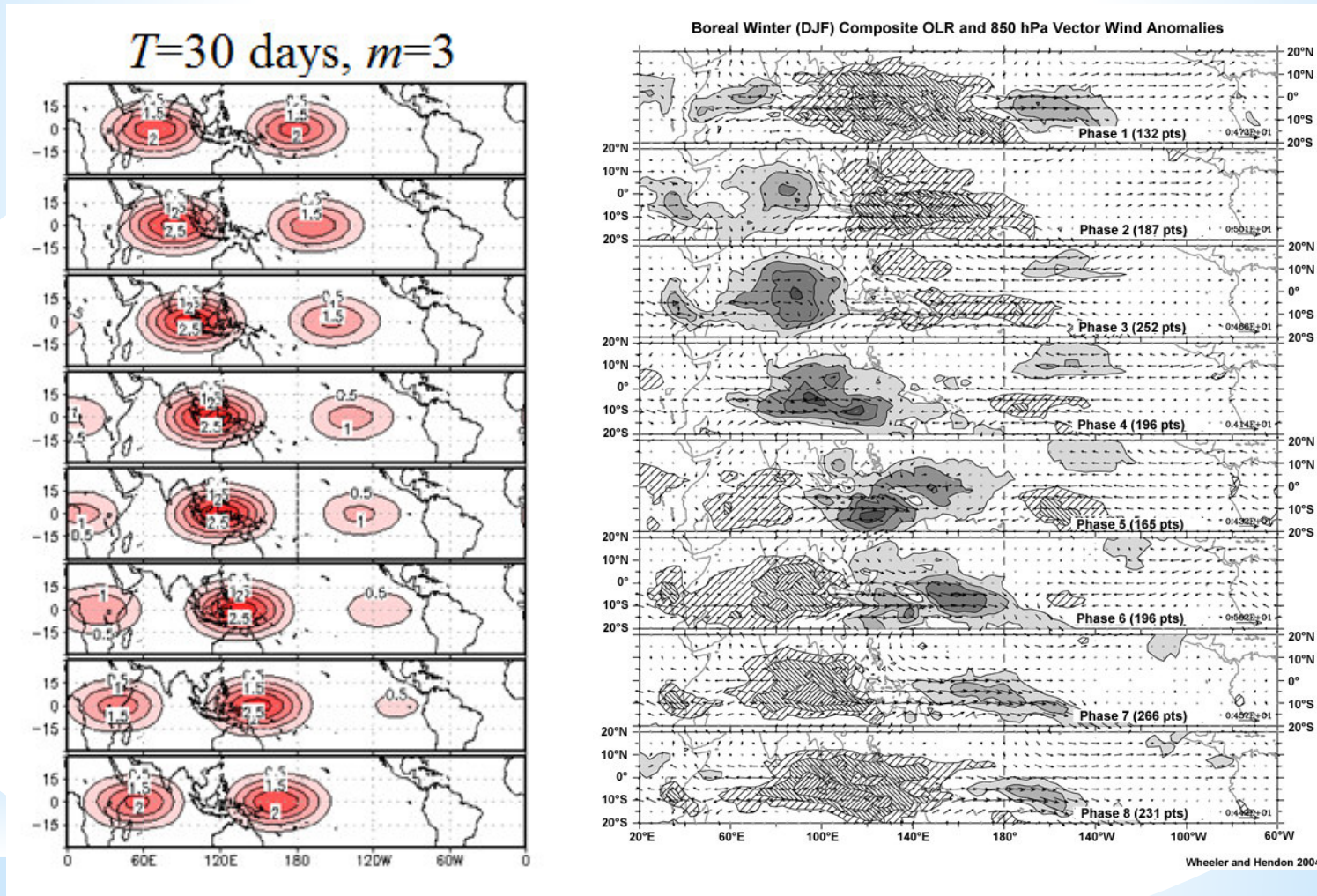
$x_0 = 120$  ,  $y_0 = 15$  ,  $z_0 = 7$  km.





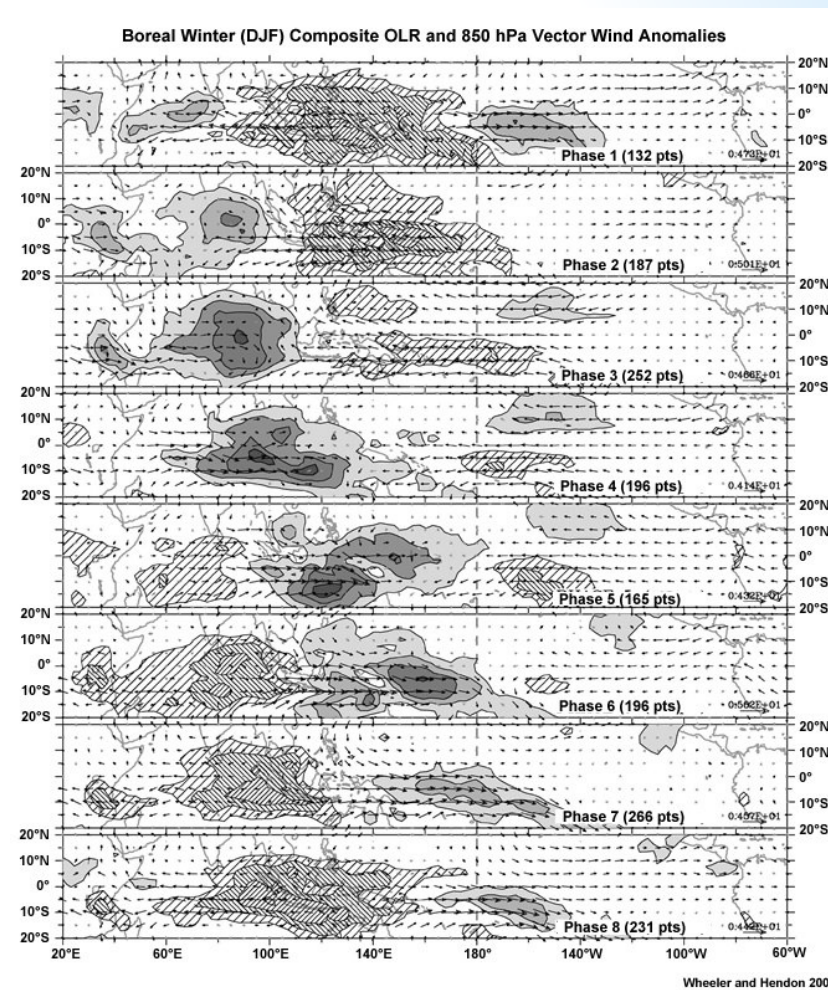
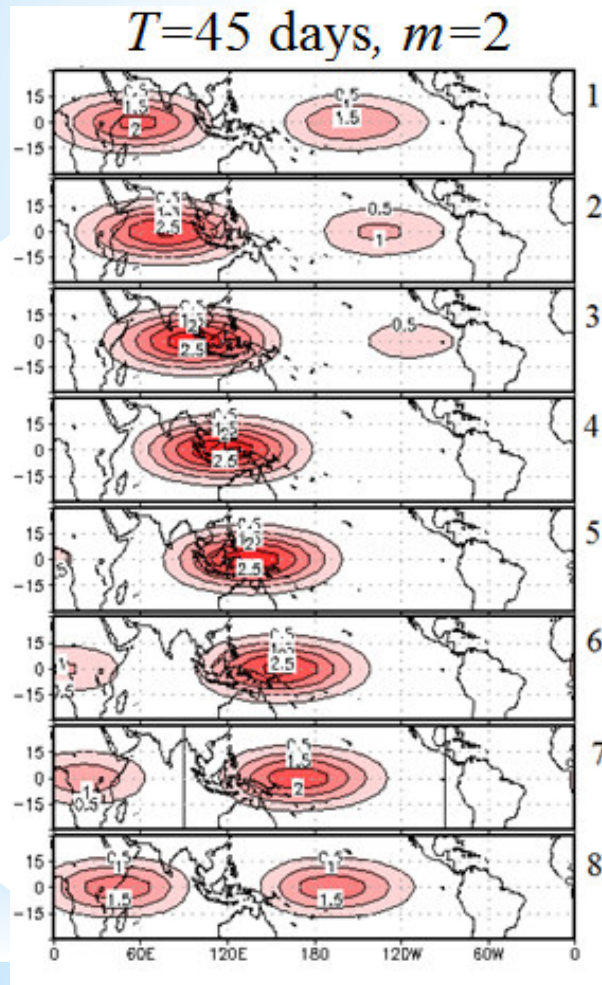
# Verification of the MJO model

## 1. Comparison with the empirical MJO index



# Verification of the MJO model

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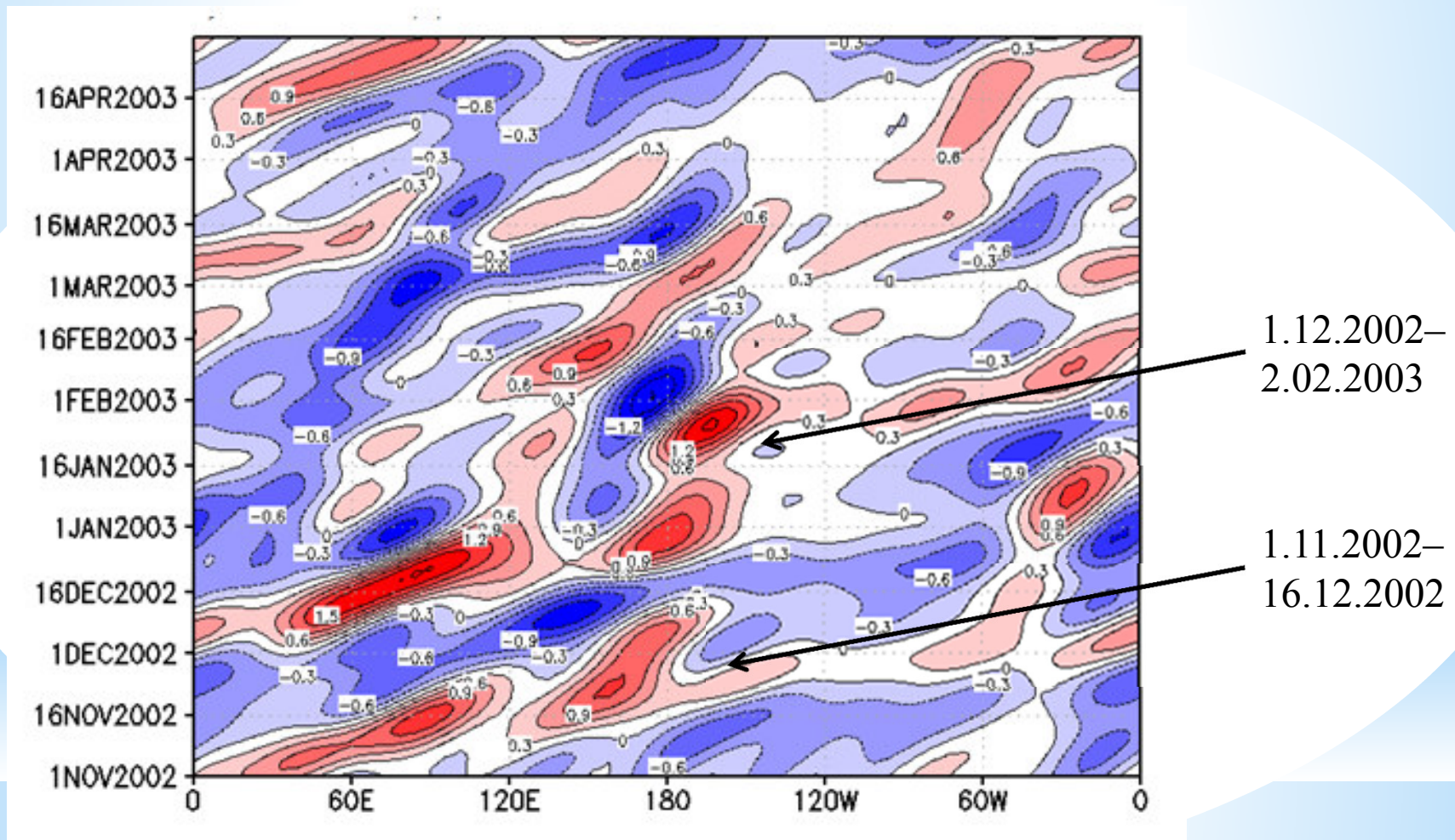


# Verification of the MJO model

## 2. Identification of the MJO signal in data of latent heat

$m=1-9$ ,

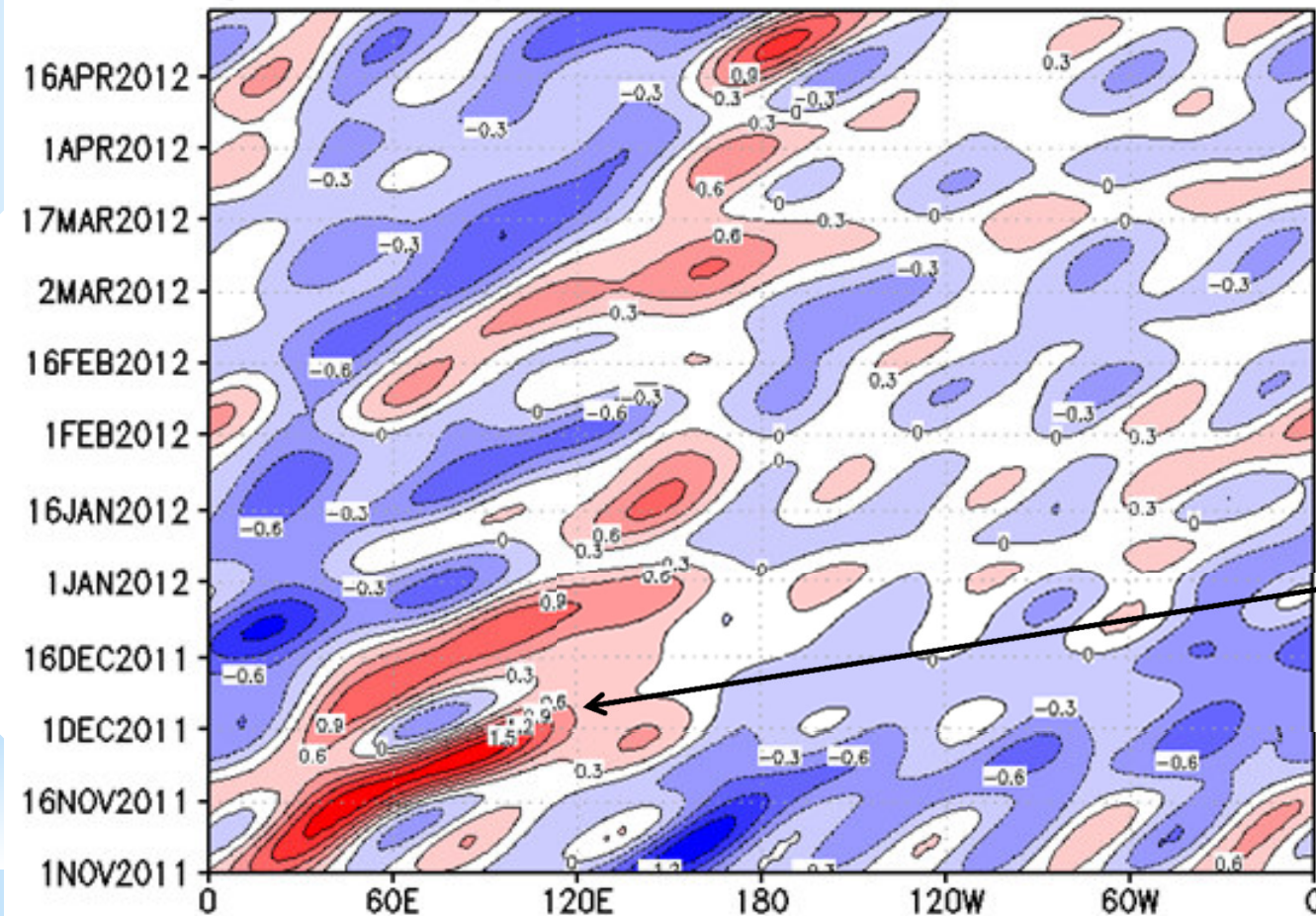
Nov/2002-May/2003



# Verification of the MJO model

## 2. Identification of the MJO signal in data of latent heat

Nov/2011-May/2012

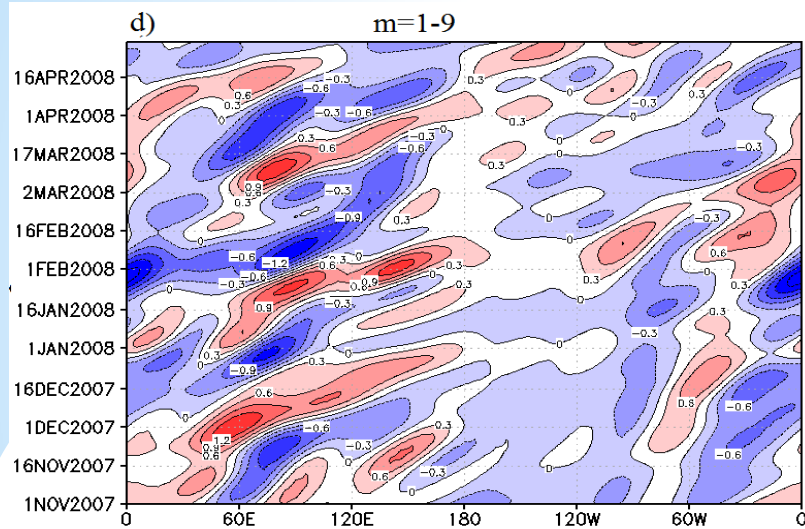


1.11.2011-  
8.12.2012



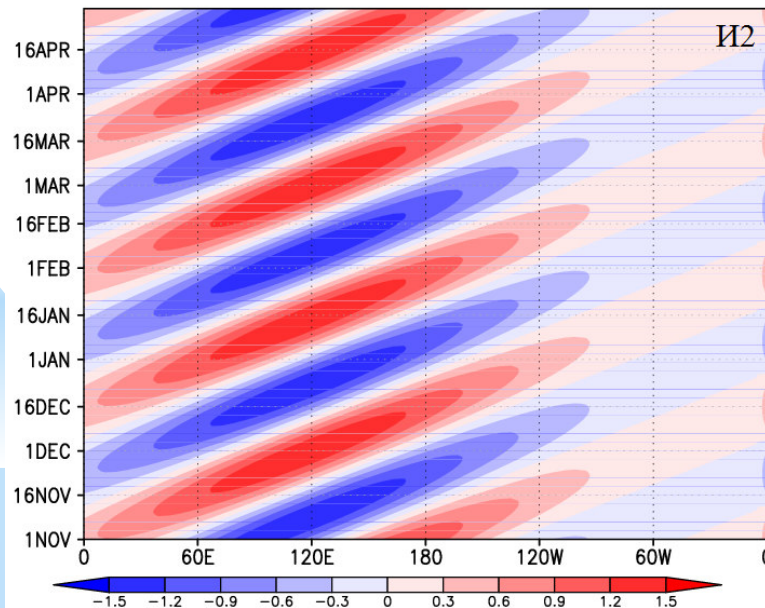
# Verification of the MJO model

## 2. Identification of the MJO signal in data of latent heat



### Characteristics of the MJO signal:

- mean phase speed — 5 m/s
- mean amplitude — 1,5 K/day
- mean period — 46 days



### Characteristics of the MJO model with zonal wavenumber 2:

- mean phase speed — 5 m/s
- mean amplitude — 1,5 K/day
- mean period — 45 days

# Numerical experiments

## Model of Upper and Middle Atmosphere (MUAM)

4 numerical experiments

1. easterly QBO
2. westerly QBO
3. QBO easterly with MJO model
4. QBO westerly with MJO model

Comparison with observation data:

**Weak MJO period** – mean amplitude of index  $MJO < 1$  (January-February)

**Strong MJO period** – mean amplitude of index  $> 1$  (January-February)

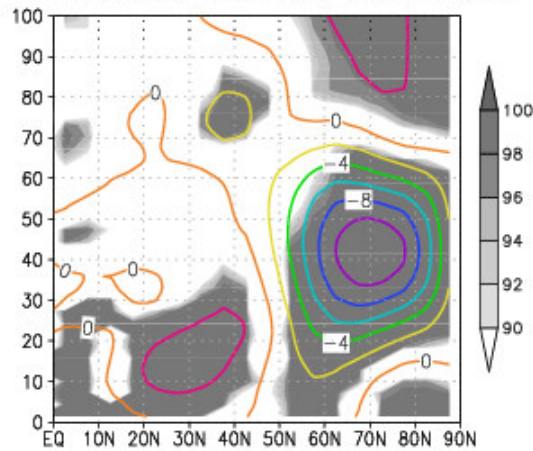
easterly QBO	
weak MJO	strong MJO
1982	1989
1984	1994
1996	2001
1998	2005
2000	2010
2003	2012
	1987
	2007

westerly QBO		
weak MJO	strong MJO	
1980	1983	1999
2011	1985	2002
	1990	2004
	1993	2006
	1995	2008
	1997	2013

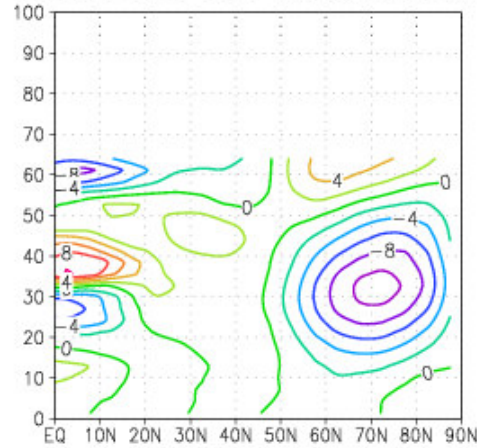
# Results of numerical experiments

## Change of zonal mean zonal wind caused by the MJO

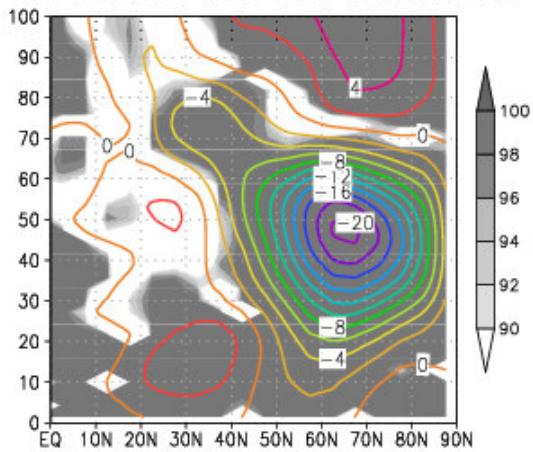
Diff. MJO\_eQBO-eQBO zonal wind, JF, MUAM



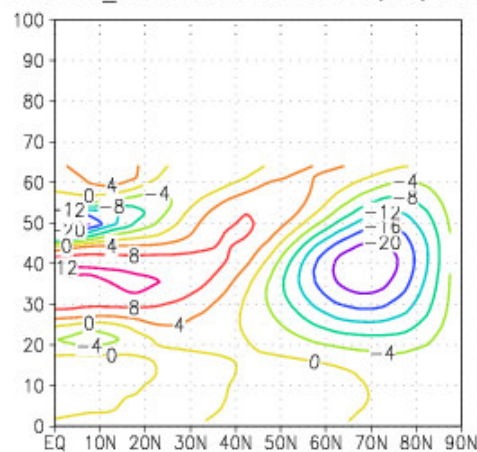
Diff. MJO\_eQBO-eQBO zonal wind, JF, MERRA



Diff. MJO\_wQBO-wQBO zonal wind, JF, MUAM



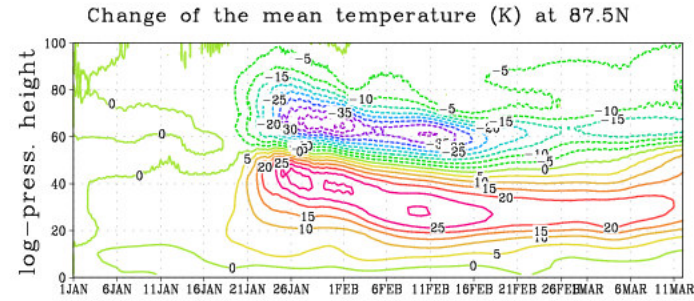
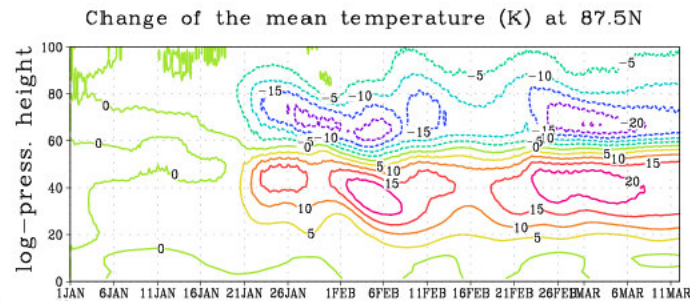
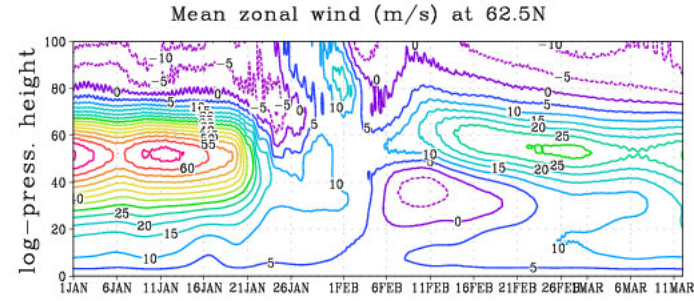
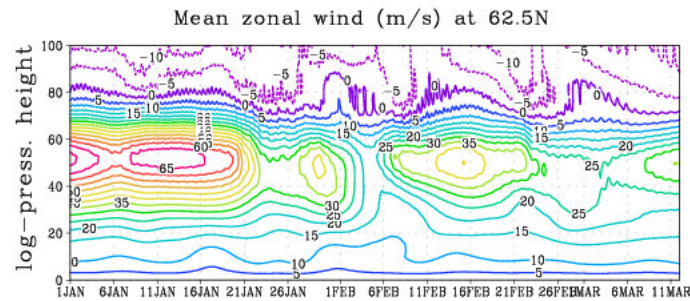
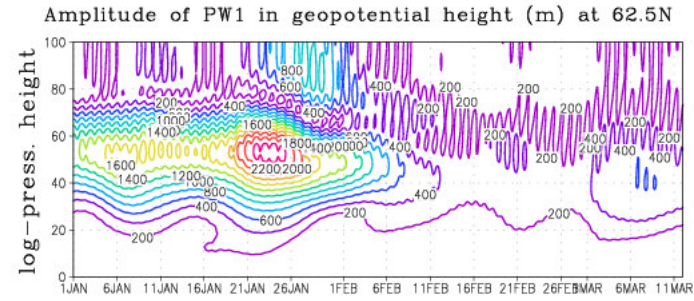
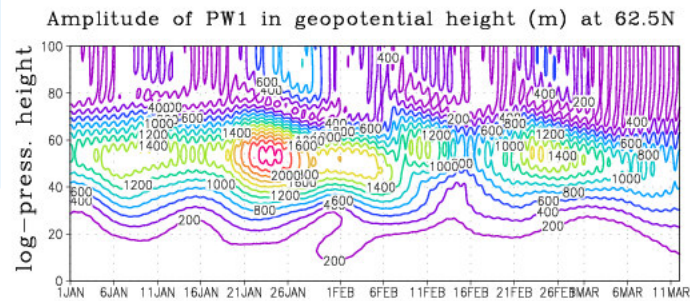
Diff. MJO\_wQBO-wQBO zonal wind, JF, MERRA





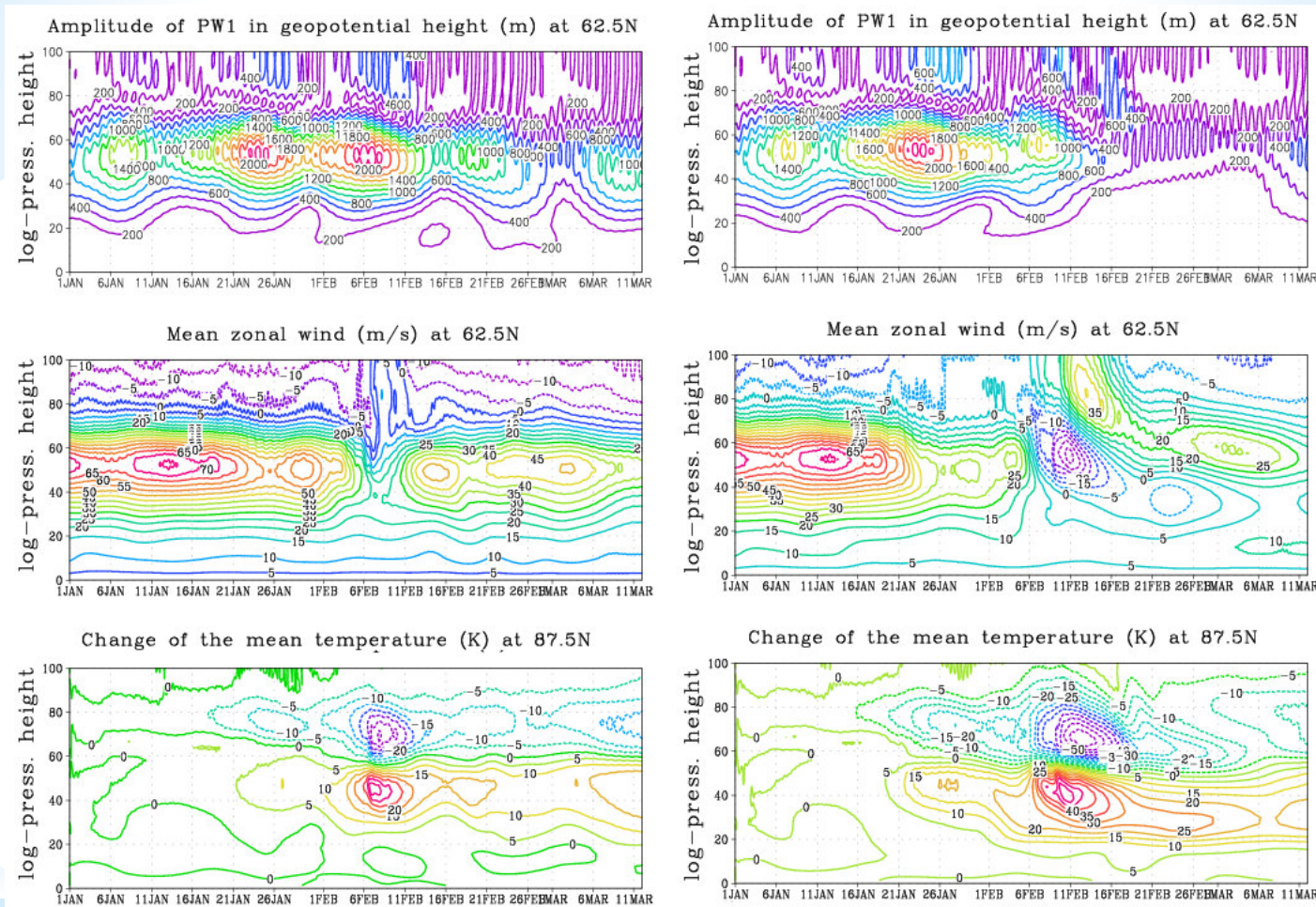
# Results of numerical experiments

## Change caused by the MJO during easterly QBO



# Results of numerical experiments

## Change caused by the MJO during westerly QBO



Thank you.