# The dynamical composition of the Madden-Julian Oscillation

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# Outline

# Problem

- What are the modes more excited by the convection associated with the MJO, and in which modes is the energy generated?

# The energy balance equation

- The balance of the total energy (the kinetic plus the available potential energy), $E_{nlk}$, of the atmospheric circulation is given by

$$\frac{\mathrm{d}}{\mathrm{d}t} E_{nlk} = C_{nlk} + S_{nlk}, \tag{1}$$

$n$, $l$, $k$ stand for zonal wavenumber, meridional and vertical mode indexes, respectively. Terms $C_{nlk}$ and $S_{nlk}$ represent the nonlinear energy interactions and the energy source/sink due to diabatic heating and dissipation.
(See, Marques et al, 2020,
https://doi.org/10.5194/gmd-2019-340, for more details).

# Data & Method

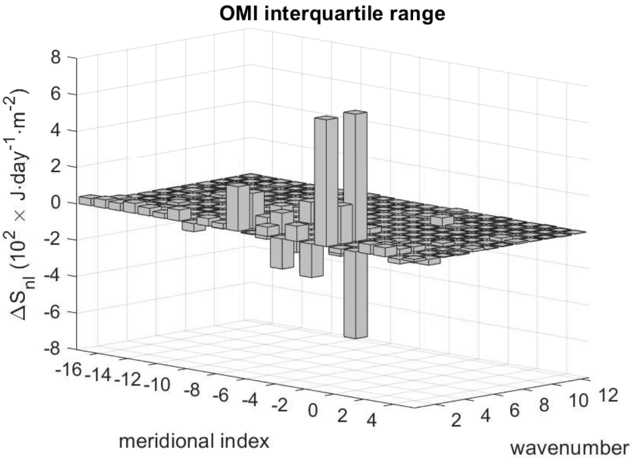
- Horizontal wind field and geopotential from ERA-Interim reanalysis (1979-2016), and the outgoing longwave radiation (OLR)-based MJO index (OMI – https://www.esrl.noaa.gov/psd/mjo/mjoindex/).
- Energy spectra for the composite differences between strong and weak convection were calculated.
- The composite were calculated finding the days when the MJO index strength falls in the first quartil or forth quartil of each phase.

# Index Convention for Figures

- In the next figures the following convention for the meridional index, $l$, was followed. Negative indexes denote Rossby waves with $l = -1$ representing the first equatorial Rossby mode. The index $l = 0$ denotes the mixed Rossby-gravity mode.

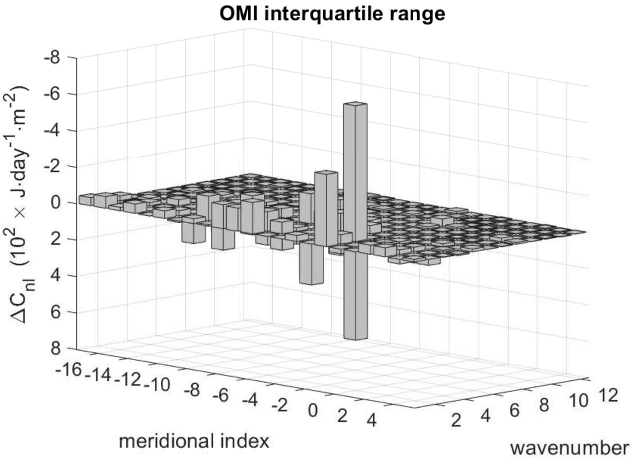
  Positive indexes denote gravity mode with $l = 1$ denoting the Kelvin waves.

# Generation & Dissipation



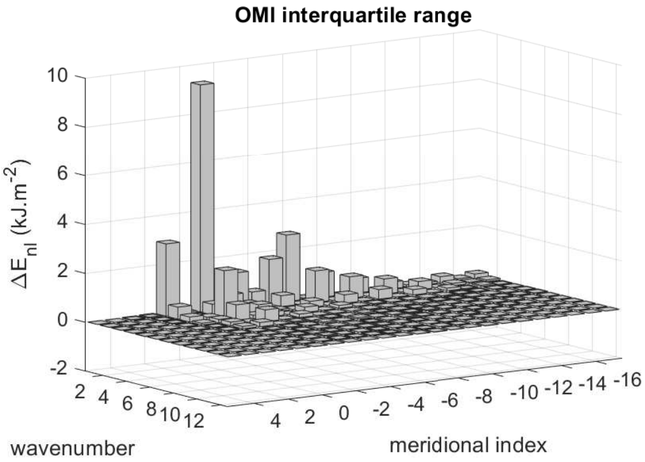

composite difference (strong - weak convection)

# Nonlinear Interaction



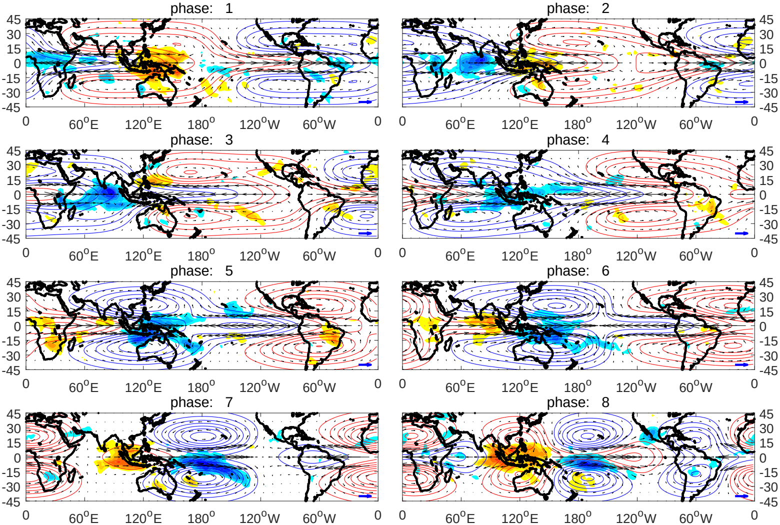

composite difference (strong - weak convection)

# Total Energy




composite difference (strong - weak convection)

# Horizontal Circulation and Geopotential Fields




strong - weak convection: shading represents the OLR anomalies; the thick blue vector in lower right corner of which panel represents a wind speed difference of $5\,\mathrm{m}\cdot\mathrm{s}^{-1}$.

# Conclusions

- The MJO is characterised by:
  1. Strong generation of energy in the equatorial Rossby waves of wavenumbers 1, 2 and 3;
  2. Energy transfer from the Rossby waves to the Kelvin waves of wavenumber 1;
  3. Strong dissipation of energy in the Kelvin waves of wavenumber 1;
  4. Compared to the case of weak convection, during strong convection the energy in the equatorial Rossby waves and in the Kelvin waves of wavenumber 1 is 1.5 and 1.9 times higher, respectively.