MJO and influence on the South American Climate

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MJO Characteristics

- The MJO is an intraseasonal or subseasonal fluctuation originating in the tropics

- Typical period of the MJO cycle is approximately 30-60 days

- The MJO results in changes in atmospheric and oceanic variables
  - Lower- and upper-level wind
  - Cloudiness and tropical rainfall
  - Sea level Pressure
  - Sea surface temperature (SST)
  - Ocean surface evaporation
  - Ocean chlorophyll

- Acts on a global spatial scale

- Coherent eastward propagation (Eastern Hemisphere: 5 m/s and Western Hemisphere 15 m/s)

Madden and Julian, 1971; 1972; Zhang, 2005; Hendon and Salby, 1994
MJO Characteristics

Madden-Julian Oscillation
The MJO is most active during the austral late spring, summer and early fall periods.

The MJO tends to be most active during ENSO neutral years. Often absent during strong El Niño events.

Outgoing Longwave Radiation (OLR)

Matthews, 2000
200-hPa Velocity Potential (~-Div)

Spring 2005 MJO Event

22 FEB 2005
MJO Structure

8 phases altering patterns of:

Tropical Rainfall (cloud)
Winds (green arrows)
Sea level pressure (red/blue shading)

- Convective signal strongest across the Indian Ocean, Indonesia and Western Pacific
- Circulation signal transverses the globe
Schematic of Three-Dimensional MJO Structure
Monitoring the MJO -- OLR Anomalies

MJO activity
December 2009 – January 2010

Blue shades
Enhanced convection
Increased rainfall

Red/Yellow shades
Suppressed convection
Decreased rainfall
Monitoring the MJO -- Time-Longitude Sections

Eastward Propagation
Monitoring the MJO – 850-hPa Zonal Wind

MJO event during late 2007

Boxes indicate enhanced westerly (red) and easterly (blue) anomalies and low-level convergence (black circle) when the enhanced convective phase of the MJO is centered over the eastern Indian Ocean.
Monitoring the MJO – 200-hPa Zonal Wind

Anticyclonic (A) and cyclonic (C) circulations straddling anomalous tropical convection

Westerly anomalies across the eastern equatorial Pacific Ocean

Enhanced phase of the MJO (black circle) centered across Indonesia
The axes (RMM1 and RMM2) represent daily values of the PCs from two leading modes.

The triangular areas indicate the location of the MJO enhanced convective phase.

Counter-clockwise motion is indicative of eastward propagation. Large dot is the most recent day.

Distance from center indicates strength.

--based on combined EOF analysis (OLR, 850 and 200 hPa zonal wind)
Interannual Variability of the MJO

There is strong year to year variability in MJO activity.

Grey areas “active” MJO periods.
Global MJO Impacts

The MJO affects both tropical and extratropical areas

• The MJO substantially impacts tropical rainfall patterns

• MJO also influences tropical cyclone activity in all ocean basins, monsoon systems, and can affect the evolution of the ENSO cycle.
MJO influence on climate in South America

MJO influences both divergent and rotational component of the atmospheric circulation
MJO influence on SH circulation in DJF

Anomalies of 200 hPa Geopotential Heights (contours; significant values are shaded) and $\chi$ (thick contours) as a function of MJO phase during DJF according to the linear regression model.

Alvarez and Vera (2013)
MJO influence on surface air temperature

Alvarez and Vera (2016, Clim. Dynamics)
MJO influence on precipitation in SON

Probability of weekly averaged rainfall exceed the upper tercile, expressed as a ration with the mean probability (33%)

SON
Mean weekly rain
Upper tercile

Daily precipitation data from Liebmann and Allured (2005)

Alvarez and Vera (2016)
MJO influence on precipitation in DJF

Probability of weekly averaged rainfall exceed the upper tercile, expressed as a ration with the mean probability (33%)

Daily precipitation data from Liebmann and Allured (2005)
MJO influence on precipitation in MAM

Probability of weekly averaged rainfall exceed the upper tercile, expressed as a ration with the mean probability (33%)

MAM
Mean weekly rain
Upper tercile

Daily precipitation data from Liebmann and Allured (2005)

Alvarez and Vera (2016)
Intraseasonal (IS) variability in South America

Leading EOFs: Seasonal IntraSeasonal (SIS) Patterns

ONDEFMA (rainy season)

First EOF of FOLR 30-90 (21.5% of explained variance)

Vera et al. (Climate Dynamics, 2017)
Phases of the SIS Pattern

**POSITIVE SIS PHASE**
- Weakened SACZ
- Intensified SESA rainfall

**NEGATIVE SIS PHASE**
- Weakened SACZ
- Intensified SESA rainfall

Higher frequency of **extreme daily rainfall events at the subtropics**

Higher frequency of **heat waves and extreme daily temperature events at the subtropics**
Activity of the leading 30-90 SIS pattern

OLR anomalies

Upper-level Streamfunction anomalies

Maps of linear lagged regressions between (Left) OLR, (center) 0.21-sigma streamfunction anomalies and the standardized PC1 30-90 (Right) Regression between local OLR anomalies and the standardized PC1 30-90 at (green) SESA and (brown) SACZ centers of action.

Vera et al. (Climate Dynamics, 2017)
Rainy season: October to April

**Positive SIS events**
(negative precip anomalies in SACZ)

**Negative SIS events**
(positive precip anomalies in SACZ)

*Relationship between SIS pattern activity and MJO*

MJO phase diagram with the daily MJO index values during positive SIS events within an MJO event. The yellow diamond indicates the day in which the SIS index is maximum.

Alvarez et al. (Atmosphere, 2018)
Positive SIS events (negative precip anomalies in SACZ)

MJO phase diagram with the daily MJO index values during positive SIS events within an MJO event. The yellow diamond indicates the day in which the SIS index is maximum.
MJO monitoring and prediction at NOAA/CPC

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml#discussion
Monitoring of the intraseasonal variability in southern South America

climar.cima.fcen.uba.ar