Evolution and Impacts of Extreme MJO Events

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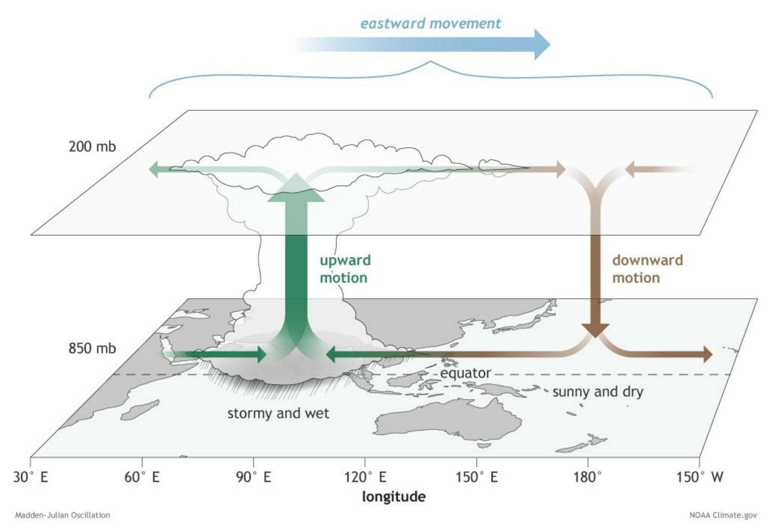
1. MJO and MJO Events

MJO (Madden-Julian Oscullation) is an eastward equatorially propagating mode with a strong influence on the precipitation in the tropics on sub-seasonal timescales.



An MJO takes place when the Index Amplitude >1

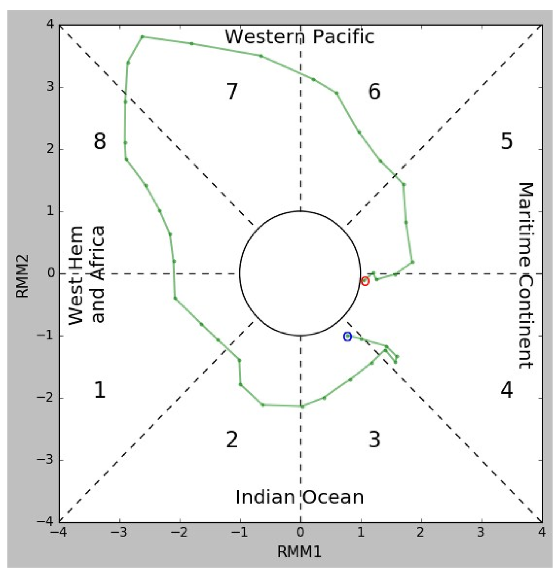


Fig1: Phase diagram, example of MJO progression from 03-03-2015 to 09-04-2015. The red circle marks the beginning of the event and the blue circle the end of the event.

MJO event's variables:

- Maximum amplitude
- Duration
- Size

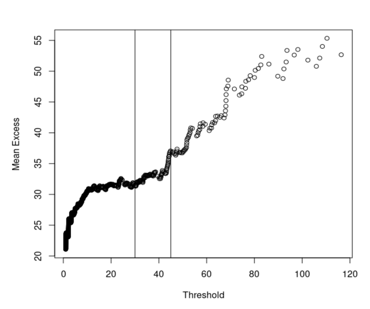
Phase diagram illustrates the MJO through different phases (1-8), they coincides with locations along the equator around the globe.

Real-time Multivariate (RMM) MJO index (Wheeler and Hendon 2004) from 01.01.1979- 31.12..2021
Australian Government Bureau of Meteorology

2. Extreme Value Analysis, Peak over threshold

Optimal threshold to define extreme MJO events
We consider x an extreme if x > t

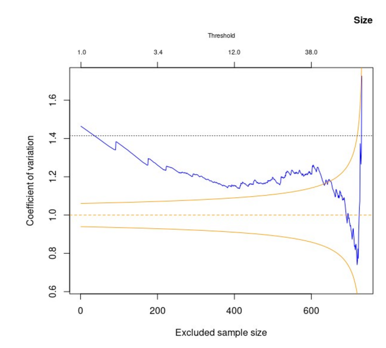
Mean Excess



The mean excess function represents the conditional mean of the exceedance size over threshold (given that and exceedance ocurred.)

Upward trend- heavy tailed behavior (a straight line with positive gradient above some threshold is a sign of Pareto behaviour in tail)

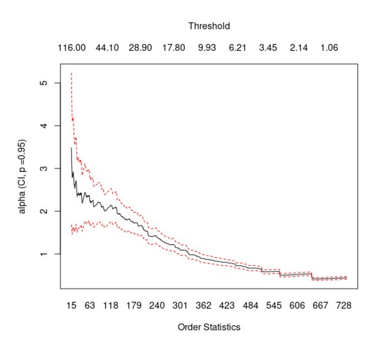
Coefficient of variation



Given a sample $\{x_k\}$ of size n of positive numbers, we denote the ordered sample $\{x_{(k)}\}$, so that $x_{(1)} \leq x_{(2)} \leq \cdots \leq x_{(n)}$. The CV-plot is the function cv(t) of the sample coefficient of variation of the threshold excesses $(x_j - t)$ for the exceedances $\{x_j : x_j > t\}$ given by

$$t \rightarrow cv(t) = \frac{sd\{x_j - t \mid x_j > t\}}{\text{mean}\{x_j - t \mid x_j > t\}}, \qquad t = x_{(k)}$$

Hill plot



The Hill estimator is derived as the max. likelihood estimate of the power coefficient in the Power-law distribution.

where $\alpha=1/\xi$ is the tail index

Tm test – multiple threshold test for a GPD, **u** is the lower value for which the GPD is not rejected (Castillo & Serra, 2015)..

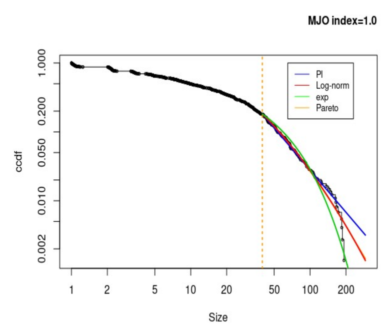
Clauset et al's and A. Deluca's method (power-law fit)
Fit by maximum likelihood and test goodness of fit by Kolmogorov-Smirnov, using Montecarlo Simulations.

Extremes:

- 162 events
- Duration >= 24 days
- Size >= 39

$$\ell(\alpha) = \frac{1}{N}\ln L(\alpha) = \frac{1}{N}\sum_{i=1}^{N}\ln f(x_i)$$

$$\text{AIC} = 2k - 2\ln(L)$$

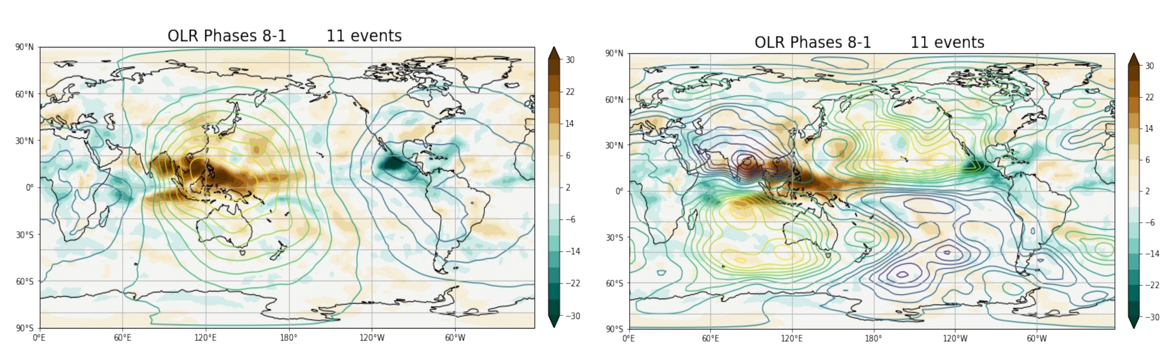


Model	log-likelihood
Log-normal	-595.2748
Weibull	-576.4721
Gamma	-577.5835
Exponential	-581.2817
GPD	-574.0162
Power-law	-574.8893

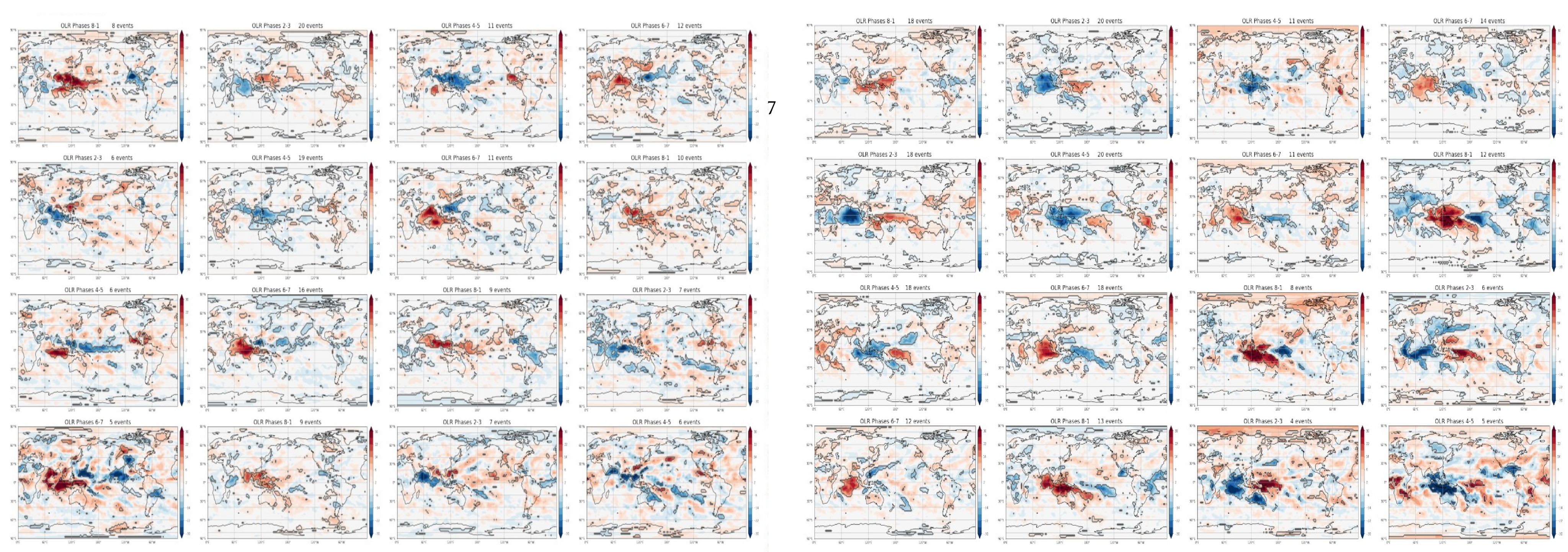
3. Evolution of MJO events based on the initial phase

OLR interpolated dataset from National Oceanic and Atmospheric Administration, **NOAA U850, U200** from **Copernicus** , 2.5° daily data from 1979 to 2021.

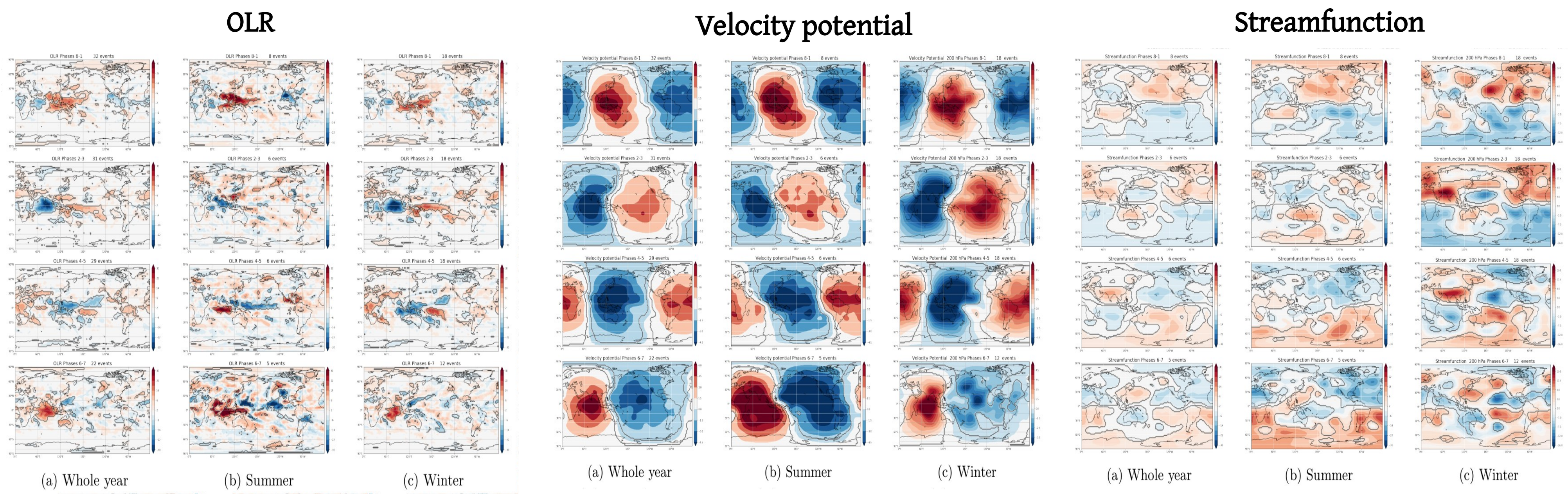
- Velocity potential and Streamfunction were constructed from wind components.
- Composites of OLR, Velocity potential and Streamfunction anomalies.
- Summer (MJJAS), Winter (NDJFM).
- t-test with a 99% signifiance level



MJO composite in phases 8-1. Velocity potential contours with intervals of 0.5 (left) and streamfunction contours with intervals of 0.5 (right)



Composite maps for olr, contour lines delimit the regions with p-values < 0.01. Each column shows events starting in phases 8-1 (top) and ending in phases 6-7 (bottom). Active convection, suppressed convection. Summer events (left), Winter events (Right).



Composite maps for olr, contour lines delimit the regions with p-values < 0.01. Each column shows events starting in phases 8-1 (top) and ending in phases 6-7 (bottom).

Conclusions

- More and longer events in winter than in summer
- More events starting in phases 2-3
- A composite of any phase has more events when it starts in phases 2-3
- In winter phases 2-3 and 6-7 have similar impacts in America but a bit northern for phases 6-7.
- In summer the impact in America has more variability

CAFE Climate Advanced Forecasting of sub-seasonal Extremes

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