

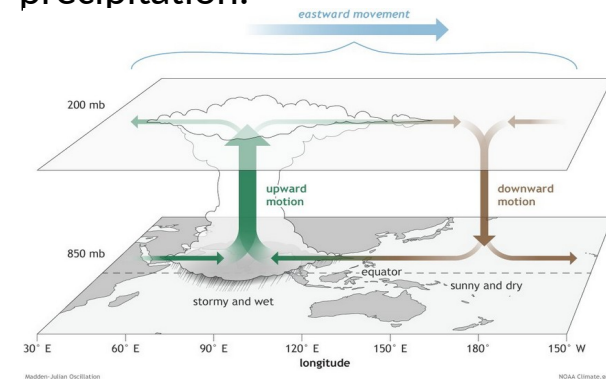
Statistical Analysis of Madden-Julian Events Using Time Series Indices

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Madden-Julian Oscillation (MJO) is the major fluctuation in the tropical weather on subseasonal to seasonal timescales (30-60 days) with a strong influence on the tropical precipitation.



Method and data

Real-time Multivariate (RMM) MJO index (Wheeler and Hendon 2004) from 01.01.1979- 27.04.2020 Australian Government Bureau of Meteorology

EOF principal components (RMM1, RMM2) from latitudinal averages of:

- Outgoing longwave radiation (OLR)
- Zonal wind at 850 and 200 hPa (U850, U200)

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

- Index outside the circle represents a strong MJO
- Index inside the circle represents inactive MJO

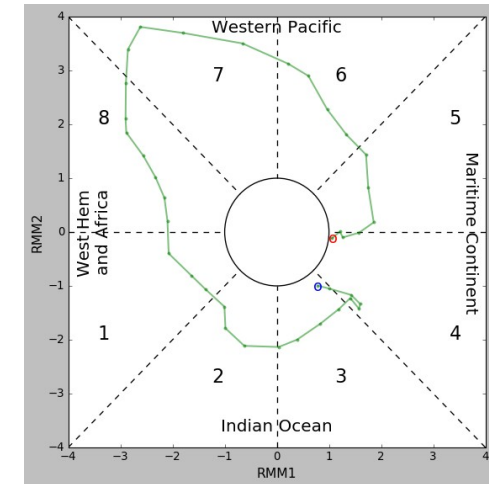
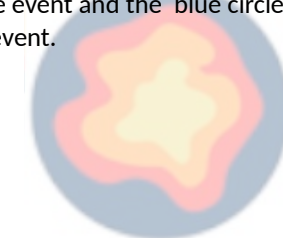


Fig1: MJO progression from 03-03-2015 to 09-04-2015. The red circle marks the beginning of the event and the blue circle the end of the event.

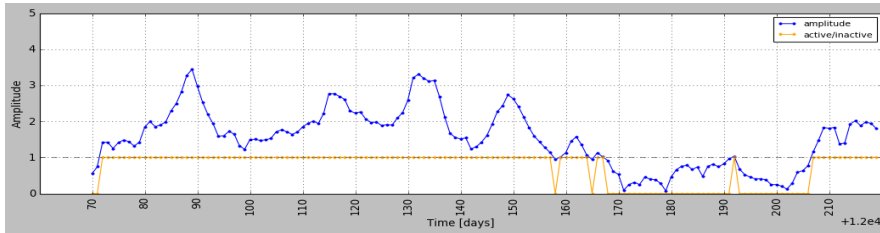


Interacts with other modes

- ENSO,
- Higher latitudes through teleconnections (e.g. NAO)

Event definition

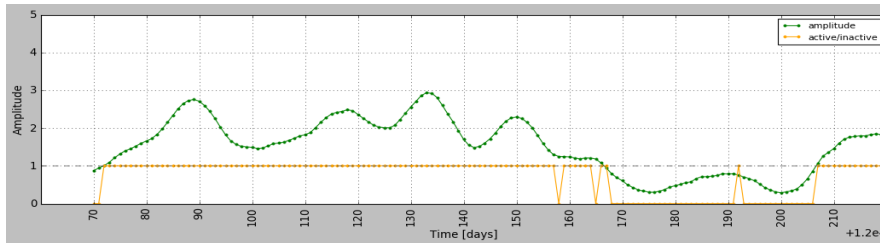
An MJO event takes place when the index Amplitude > 1



Active inactive days, index amplitude.

Re-definition of event

To include the days in which the amplitude enters the circle and comes out again a 9-day moving average is applied



Active inactive days , amplitude with 9-day moving average.

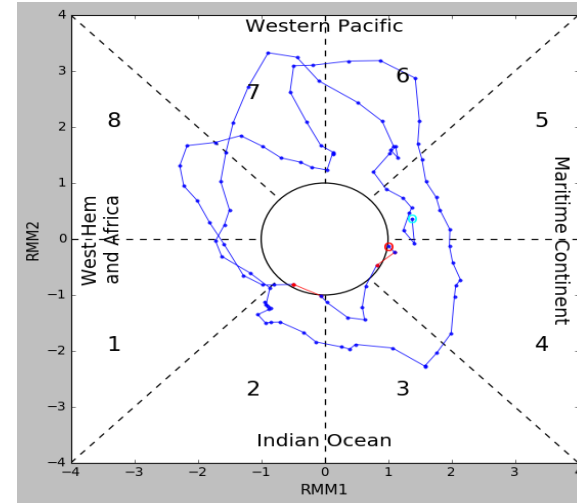


Fig6: MJO event from 20-01-2012 to 14-04-2012 (86 days), Points in red are the days with amplitude < 1 . The cyan circle marks the beginning of the event and the red circle marks the end.

With the definition of event we obtain the variables to be analysed:

- Maximum amplitude
- Duration
- Size (sum of Amplitudes)
- Mean Amplitude



Power-law

- Functional relationship where a quantity varies as a power of another.
- In terms of probability distributions:

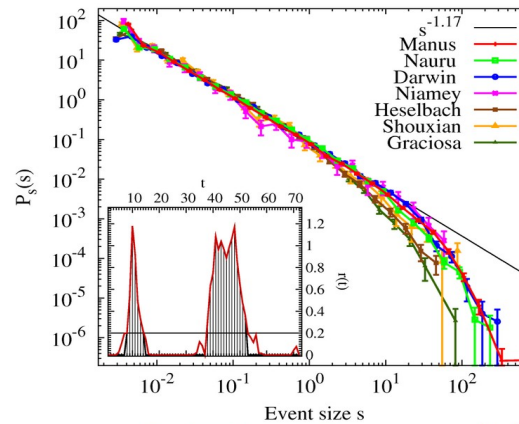
$$f_{pl}(x) = \frac{\beta - 1}{a} \left(\frac{a}{x}\right)^\beta$$

- for $x > a$.

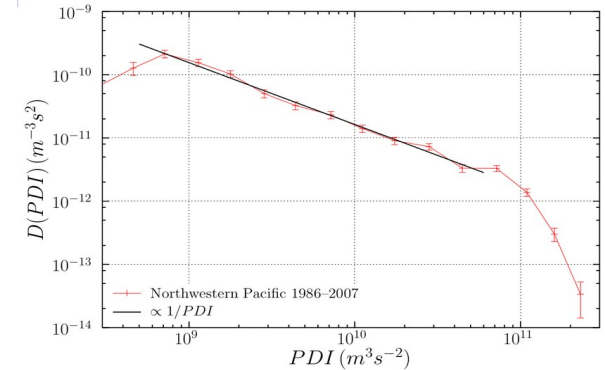
$$S_{pl}(x) = \left(\frac{a}{x}\right)^{\beta-1}$$

- for $x > a$ and $S_{pl}(x)=1$ for $x < a$.

- In Geophysics, Economics, etc., used to study the “severity” or “size” of natural disasters.
- Adequate fits of size distribution together with the temporal occurrence rate are used for assessing long-term hazards.



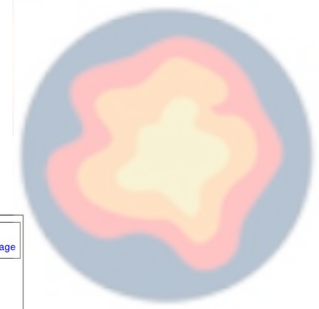
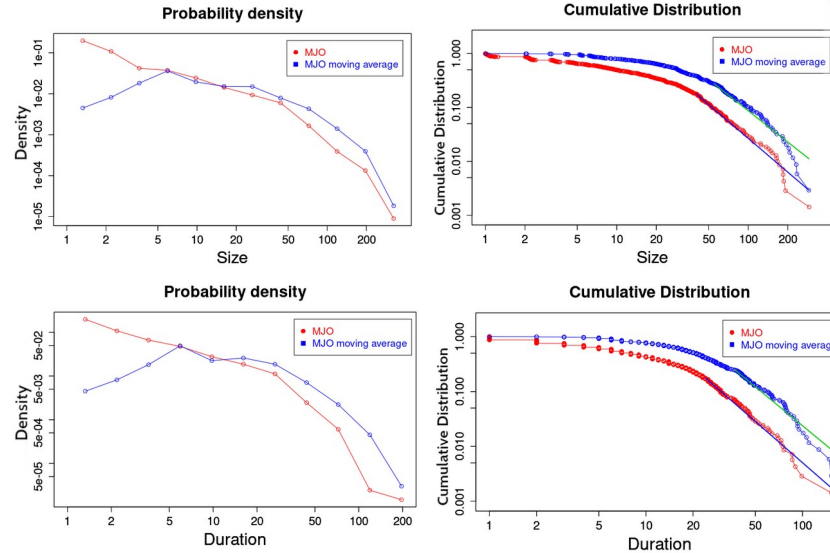
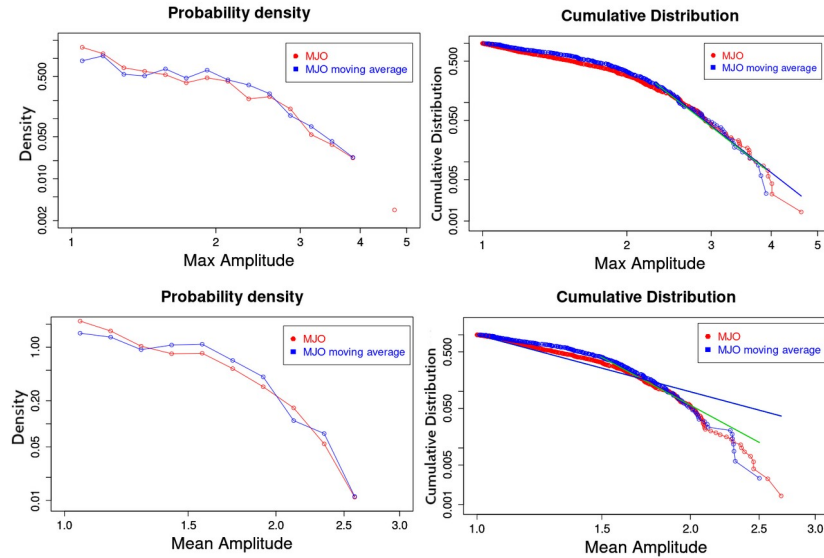
Rainfall, Peters et al. Stat Mech 2010



Tropical Cyclones, A. Corral et al. 2010



Characterization of MJO events by power-law



The statistics of MJO events seems to indicate a complex behavior, that may not be present in other more common indices. The complex behavior is indicated by a possible power-law tailed distribution, as derived from the Clauset et al.'s method. Nevertheless, there is considerable uncertainty, due to the low number of events in the tail of the distribution (extreme events).

The statistical properties of the distributions conditioned to ENSO, initial phase and seasonality will be analysed (work in progress)

