



Self-Organizing Maps and Tropical Intraseasonal Variability



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INTRODUCTION

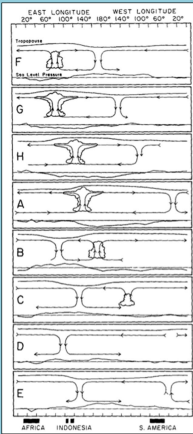


Figure 1: Schematic diagram of the eastward propagating MJO (Madden and Julian, 1972).

Madden-Julian Oscillation (MJO) is characterized by regions of suppressed and enhanced convection (Figure 1). It is a tropical, eastward-propagating atmospheric wave on a time scale of 30-60 days (Madden and Julian, 1972).

The Real-time Multivariate MJO (RMM) Index is a means of finding, comparing, and recording global MJO activity based on the use of empirical orthogonal functions (EOFs) to compare of OLR and 850mb winds (Figure 2, Wheeler and Hendon, 2004). One deficiency of the RMM index is that it can include signals that are not associated with MJO.

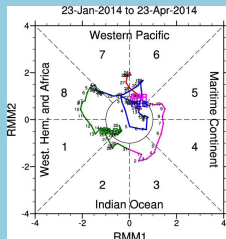


Figure 2: Phases of MJO as defined by RMM Index for 23 Jan 2014 to 23 Apr 2014 (CICS-NC, 2014).

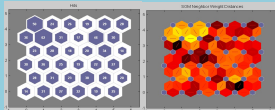


Figure 3: Nodal distribution of data points (Mathworks, 2014).

PURPOSE

- Explore the application of SOMs in identifying the principle nodes of MJO variability through the recreation of Figure 4
- Goal: Prove the utility of SOM to model MJO in tropical regions through the methodology described, and to test the sensitivity of this method.

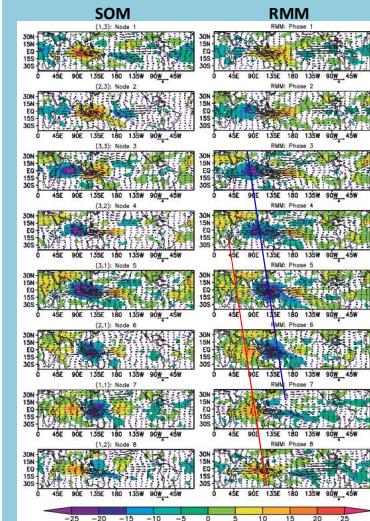


Figure 4: RMM and nodal MJO comparison (Chattopadhyay et al., 2012).

DATA

- MJO index values (1979-2011) from the RMM Index (Wheeler and Hendon, 2004) were used to define MJO phase and amplitude.
- To recreate RMM-based figures, NCEP/DOE AMIP-II Reanalysis (Reanalysis-2) Daily Averages at the nominal top of atmosphere spanned 1979 to 2008.
- NOAA Outgoing Longwave Radiation (OLR) data ranging from November 1979 – April 2009 was used for the SOM figures.
- All datasets analyzed only months November – April.

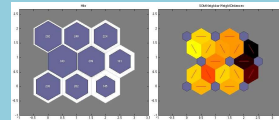


Figure 5: Nodal distribution at 2000 iterations

METHODS

- RMM Methodology:
 - NCEP OLR data binned by month.
 - Each month binned by phase of MJO (using RMM index values) and like phases combined into datasets.
 - Average of each phase was taken and the climatology subtracted to find the active phase days which were then plotted.
- SOM Methodology:
 - NOAA OLR data was binned by month.
 - Daily anomaly found by subtracting the average of all like calendar days.
 - All months compiled into one dataset and run through the SOM function on MATLAB using a 3x3 matrix to group the data into 9 nodes.
 - The resulting nodes were binned by phase of MJO and plotted to determine their similarities to the RMM methodology (Figure 6).
 - Method repeated using different numbers of iterations (200, 2000, 10000).
 - Phase counters placed within each node.

RESULTS

The use of SOM to model MJO phases (Figure 6) creates comparable figures to the ones produced using Wheeler and Hendon's RMM Index.

- Eastward-propagation observed (follow red and blue lines in Figure 6)
- Pattern of very strong positive and negative anomalies seen in each node created by the SOM. Supports predicted MJO characteristics.
- Number of iterations used causes some differences but not significant.
 - Based on 3 trials (200, 2000, and 10000 iterations), more iterations are not necessarily better because the plots of the differences (Figure 6) have opposite anomalies in the same areas.
- Ordering of data inputted into SOM function does not matter. When data was rearranged to test this, no differences were observed.
- Each node has multiple phases present but one is always prominent (prominent phase matches phase number).

CONCLUSIONS AND FUTURE WORK

- SOM is an effective and efficient means to observe and analyze MJO. Phases observed had eastward propagation and presented strong positive and negative anomalies.
- Further work includes analyzing the effect of changing number of iterations and how the produced nodes can be identified as a specific phases.

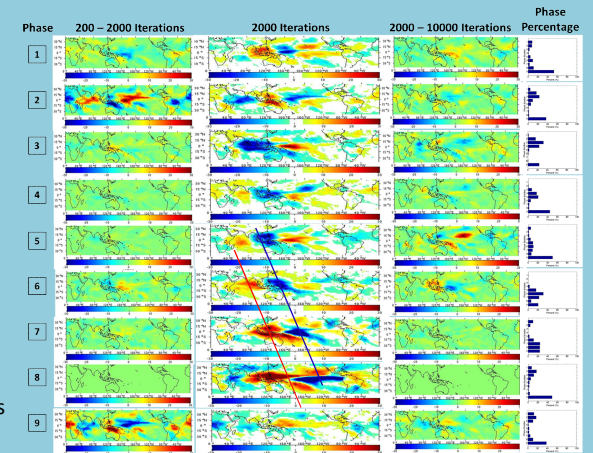


Figure 6: MJO phases as produced by SOM with an input of 2000 iterations flanked by plots of the differences in iterations used. The percent of phases present in each node (right).

Chattopadhyay, R., Vintzileos, A., and C. Zhang (2012), A description of the Madden-Julian Oscillation based on a self-organizing map, *J. Climate*, 26, 1716-1732.

CICS-NC: RMM (Real-time Multivariate MJO) Index provided by CICS-NC, Asheville, North Carolina, USA, from their website at <http://monitor.cicsnc.org/mjo/current/rmm/>.

Interpolated OLR data provided by NOAA/OAR/ESRL PSD, Boulder Colorado, USA, from their website at <http://www.esrl.noaa.gov/psd/>.

Madden, R. A., and P. R. Julian, 1972: Description of global-scale circulation cells in the tropics with a 40-50 day period, *J. Atmos. Sci.*, 29, 1109-1123.

Mathworks, 2014, Cluster with self-organizing maps neural network, <http://www.mathworks.com/>, accessed January 2014.

NCEP/DOE AMIP-II (Reanalysis 2) data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their website at <http://www.esrl.noaa.gov/psd/>.

Vesanto, J., Himberd, J., Alhoniemi, E., and J. Parhankangas, 2000: Self-organizing map in Matlab: the SOM toolbox: Helsinki University of Technology, Lab of Computer and Info Sci., 1-8.

Wheeler M.C., and H.H. Hendon (2004), An all-season real-time multivariate MJO index: Development of an index for monitoring and prediction, *Mon. Weather Rev.*, 132, 1917-1932.