The Abdus Salam International Centre for Theoretical Physics

Year of Tropics-Midlatitude Interactions & Teleconnections 2017-2019

Intra-seasonal Variability of the Tropics and Mid-latitudes

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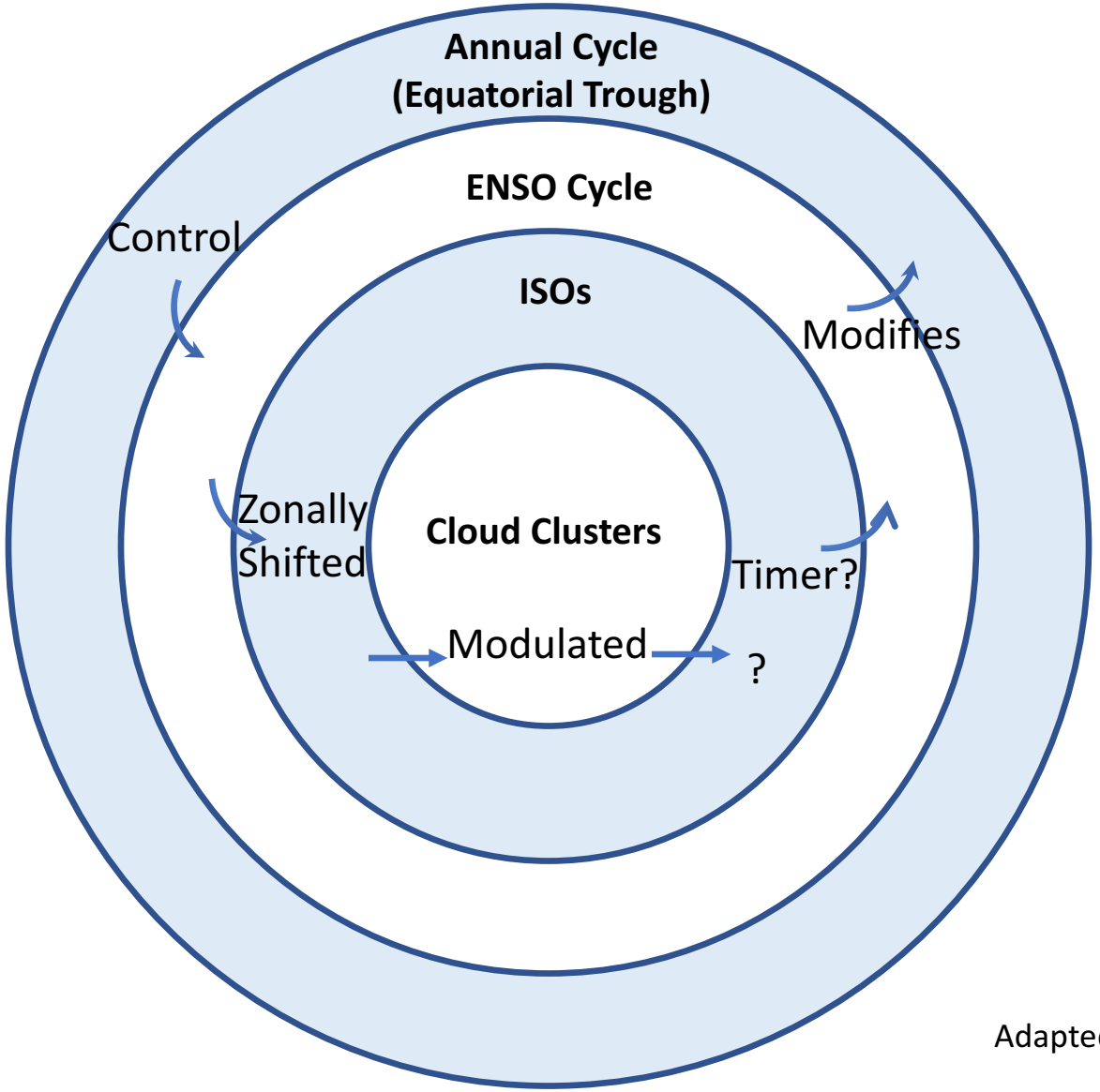
Advanced School on Tropical-Extratropical Interactions on Intra-seasonal Time Scales, ICTP 16-27 October, 2017

Outline

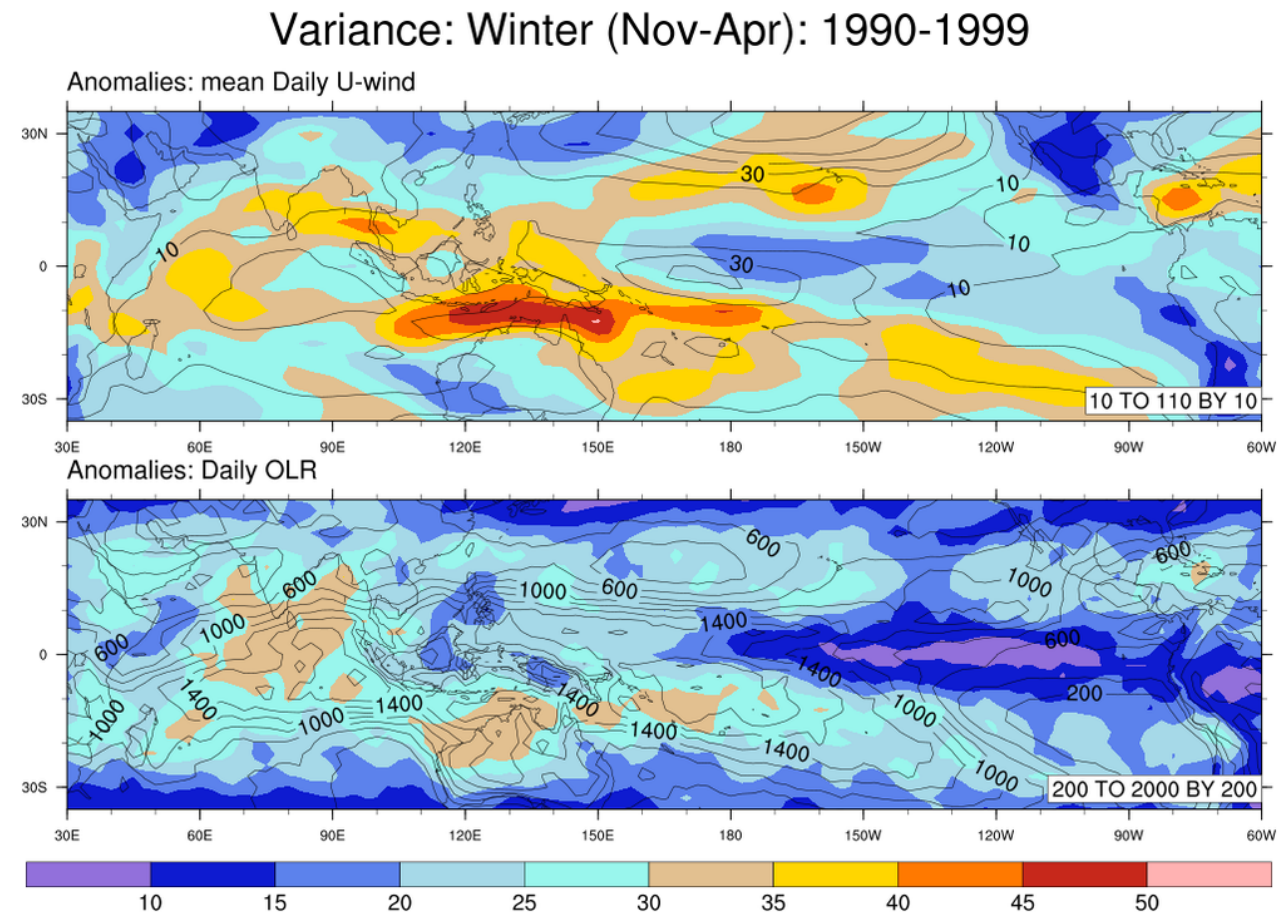
- Intra-seasonal Variability of the tropics
  - The Madden-Julian Oscillation
    - Brief Overview
    - MJO Diagnosis
  - The Boreal Summer Intra-seasonal Oscillation
- Intra-seasonal Variability of the Mid-latitudes
- Conclusions

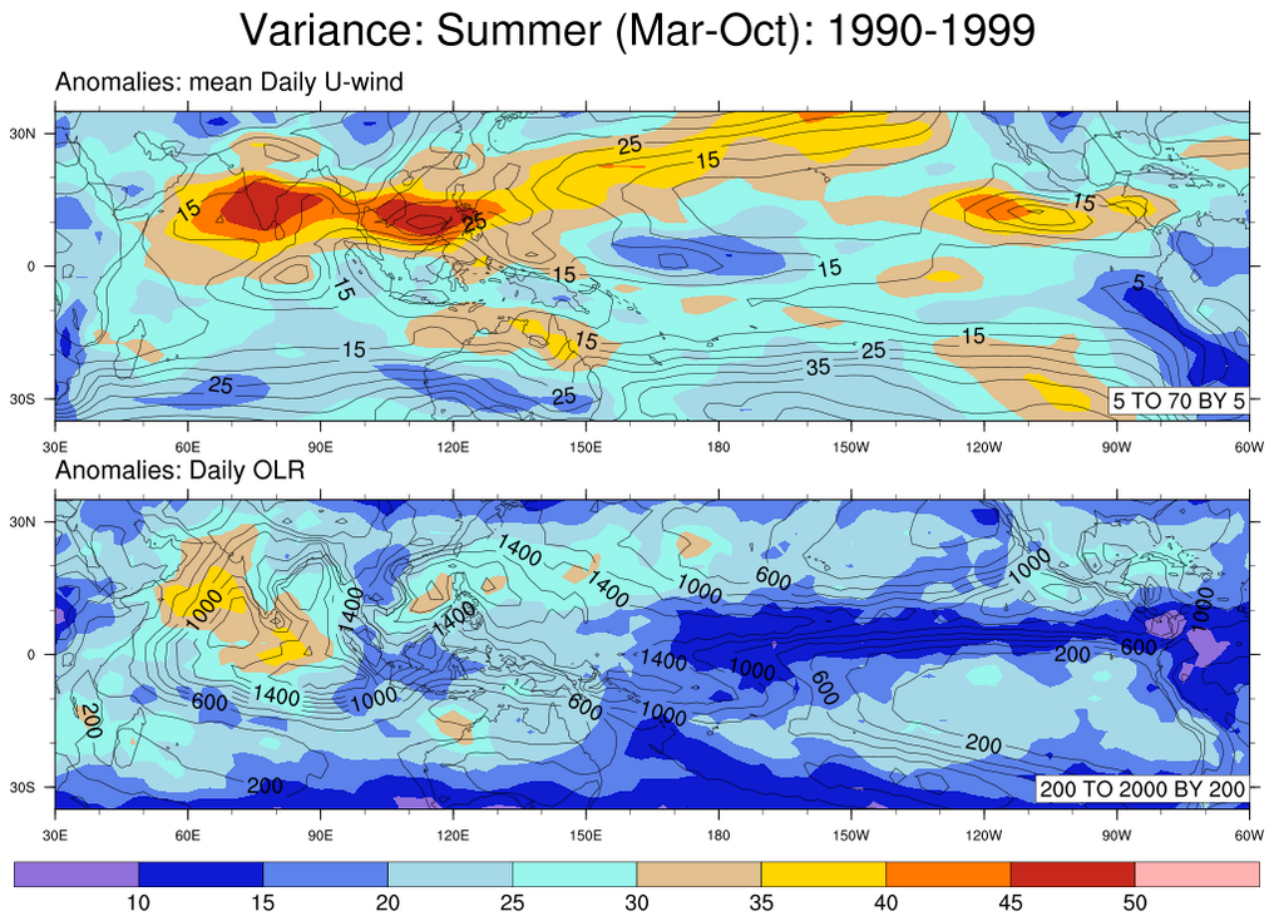
Major Modes of Tropical Precipitation Variability



Adapted from Rasmusson and Arkin, 1993

20-100 Day Variability

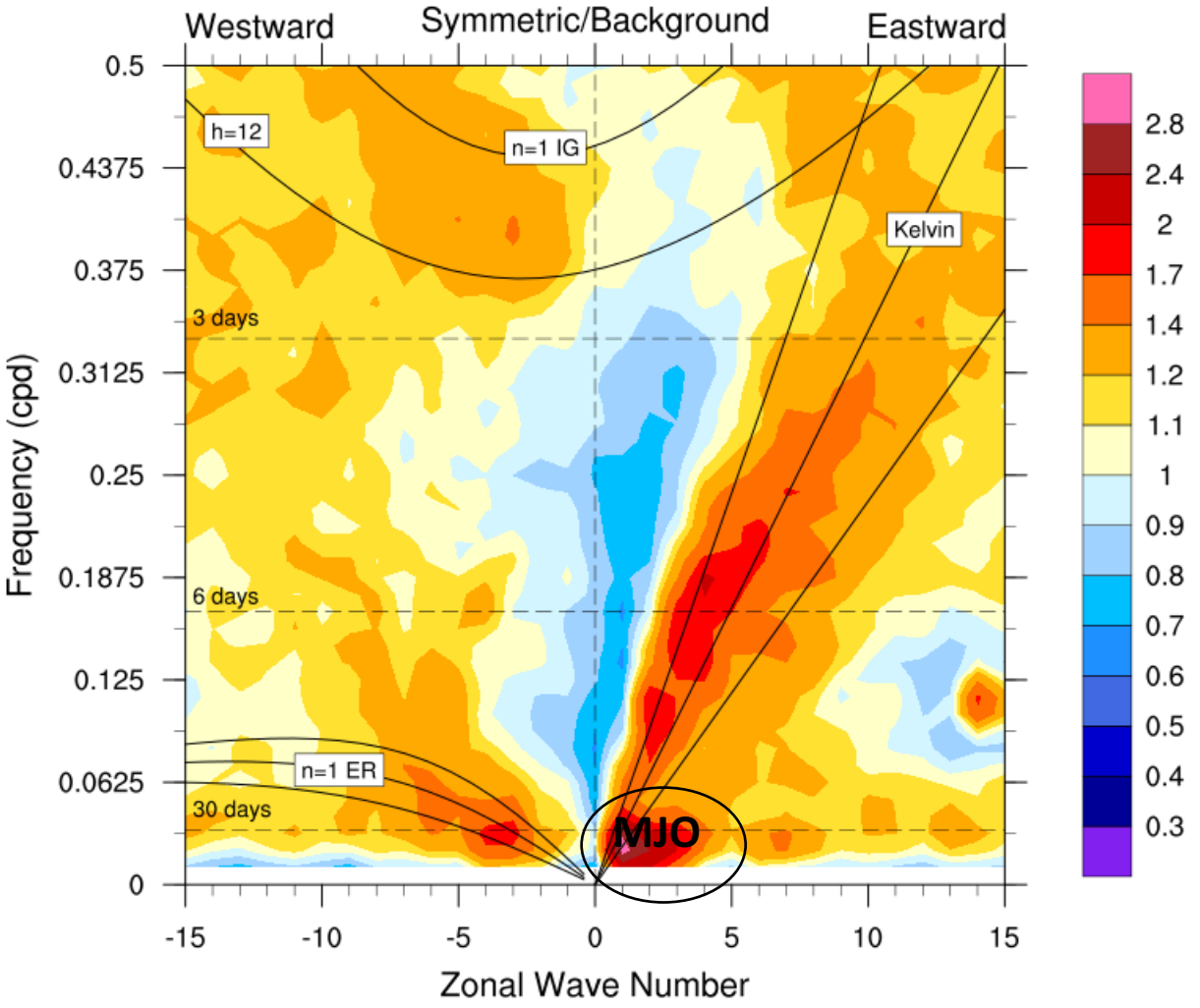


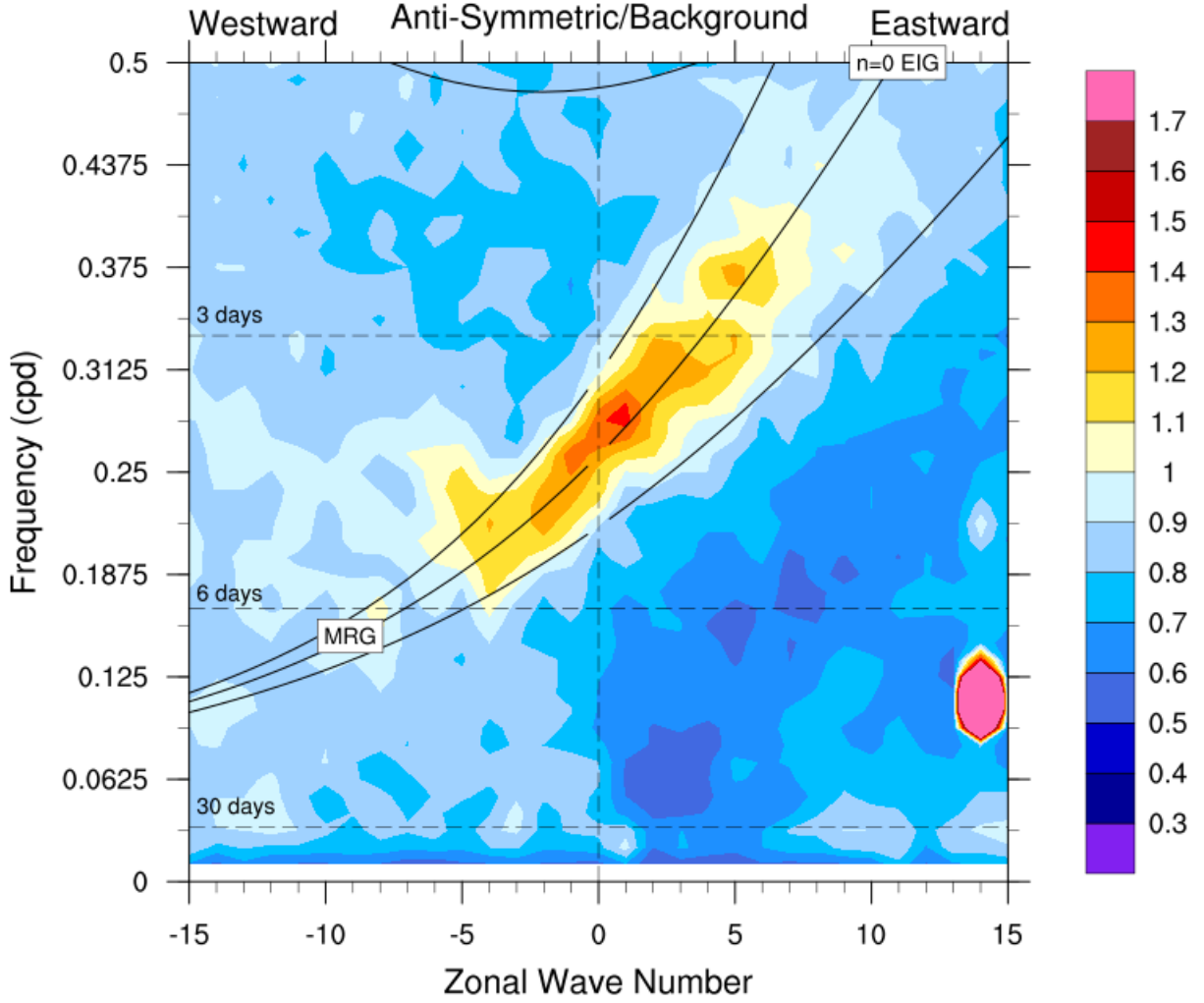


http://www.ncl.ucar.edu/Applications/mjoclivar.shtml

Wavenumber –Frequency Spectra (15S-15N)

Wheeler and Kiladis, 1999





$$OLR(\phi) = OLRA(\phi) + OLRS(\phi)$$

$$OLRA(\phi) = \frac{OLR(\phi) - OLR(-\phi)}{2}$$

$$OLRS(\phi) = \frac{OLR(\phi) + OLR(-\phi)}{2}$$

MJO Overview

Rolland Madden (left) and Paul Julian (right)

MJO life-cycle

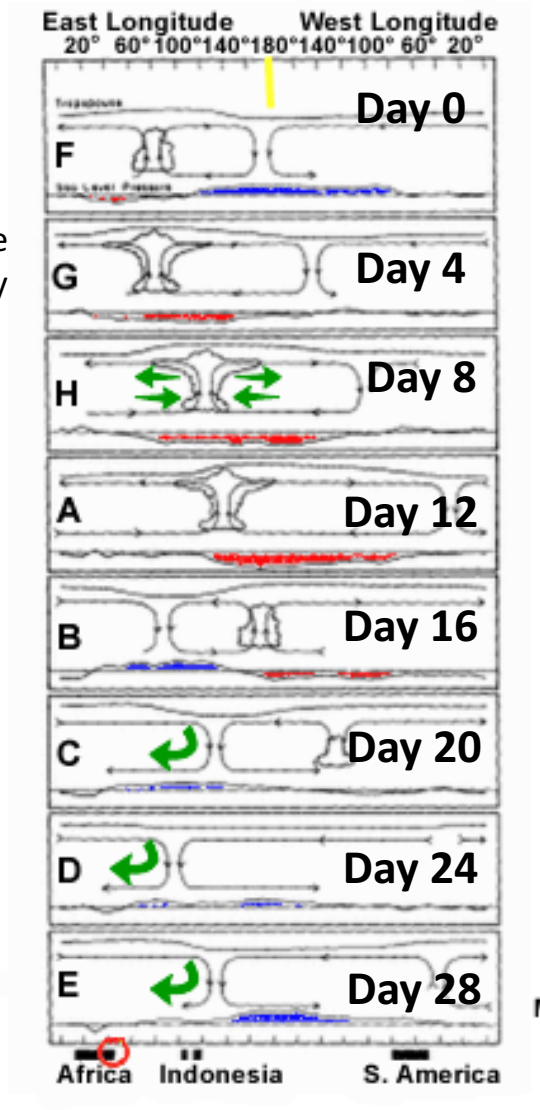
Date line

positive pressure anomaly

negative pressure anomaly

Nairobi

local circulation



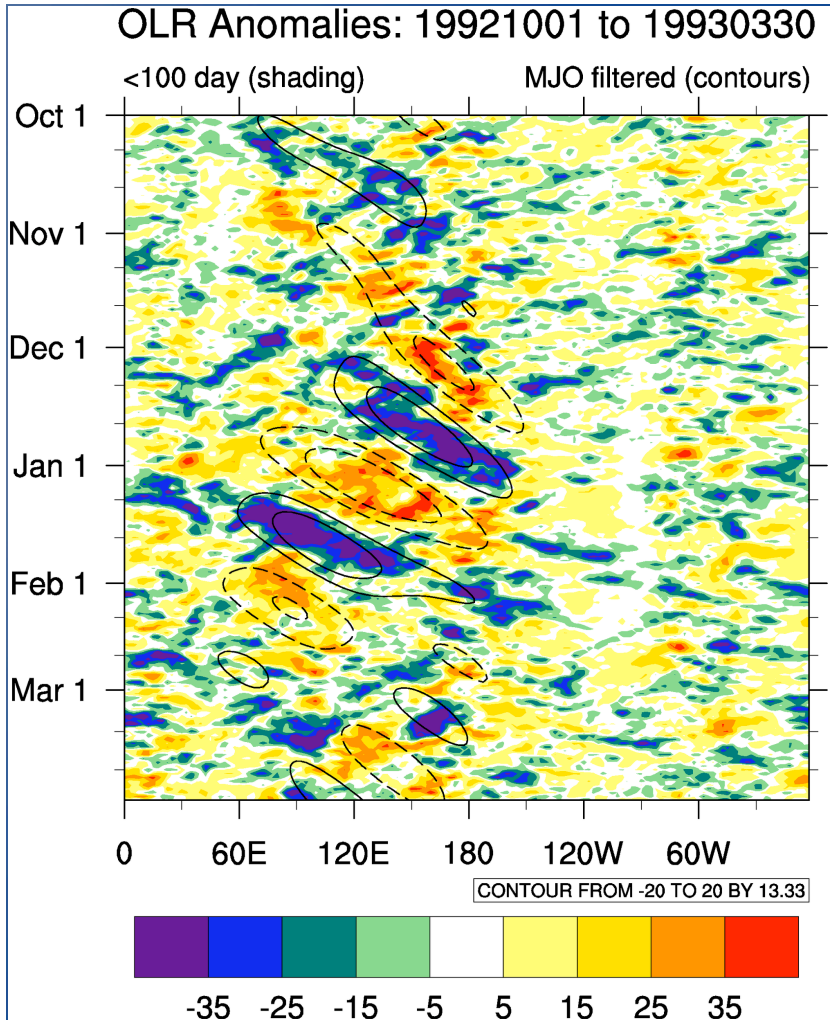
Madden and Julian 1972

- Convection builds up in the Indian Ocean first, so this would be the initial time of an MJO
- Circulation cell east to the convection anomaly reaches to the Date line
- Circulation cell to the west has strong upper tropospheric westerlies
- Low pressure anomaly in the Indian Ocean propagates rapidly eastward
- A: two symmetric circulations
- C: weak convection but not coupled to the circulation
- E: high pressure at Canton is maximum

Methods of Identifying the MJO

- Temporal filtering (e.g., 20-100 days)
- Space-time filtering (e.,g, 20-100 days and wavenumber 0-6)
- EOF analysis of a single variable
- Multivariate EOF analysis

Time Filtering



Pros

Captures the spatial and temporal scales of the oscillation

Does not constrain the spatial scale

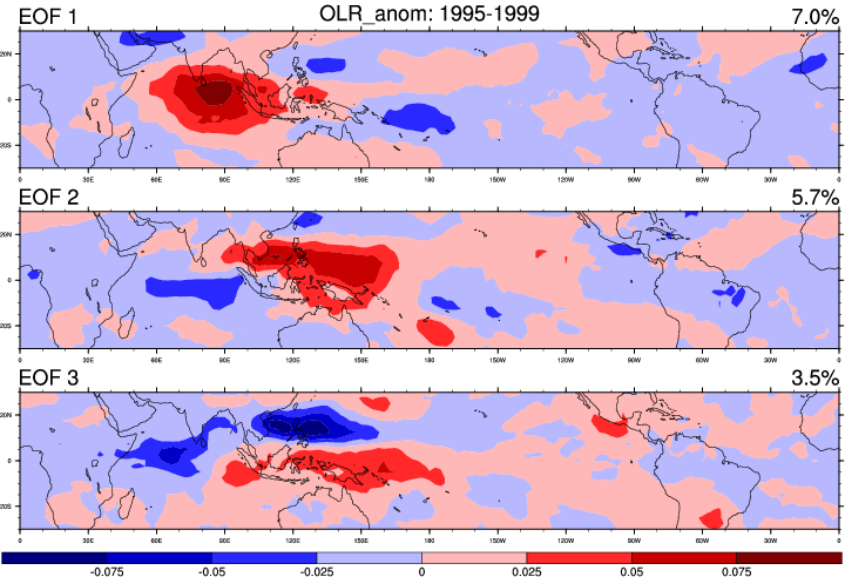
Cons

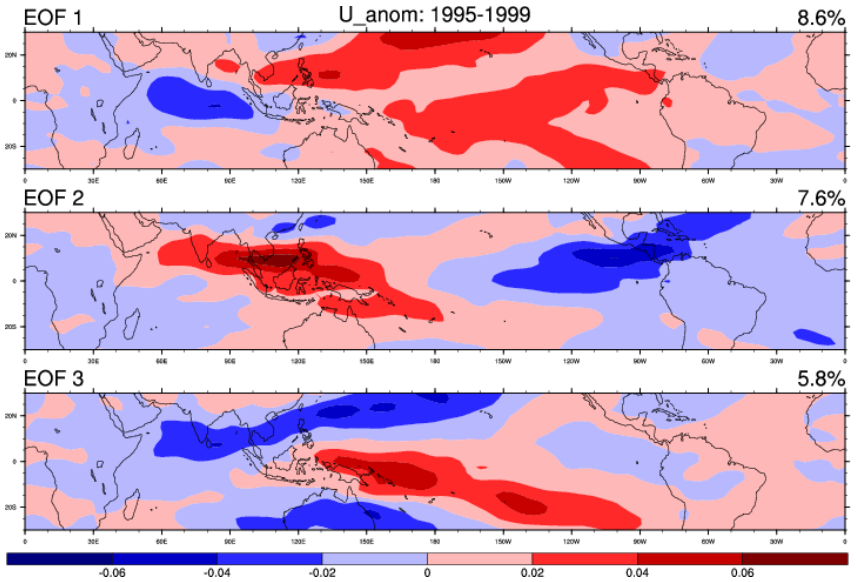
Based on only one variable

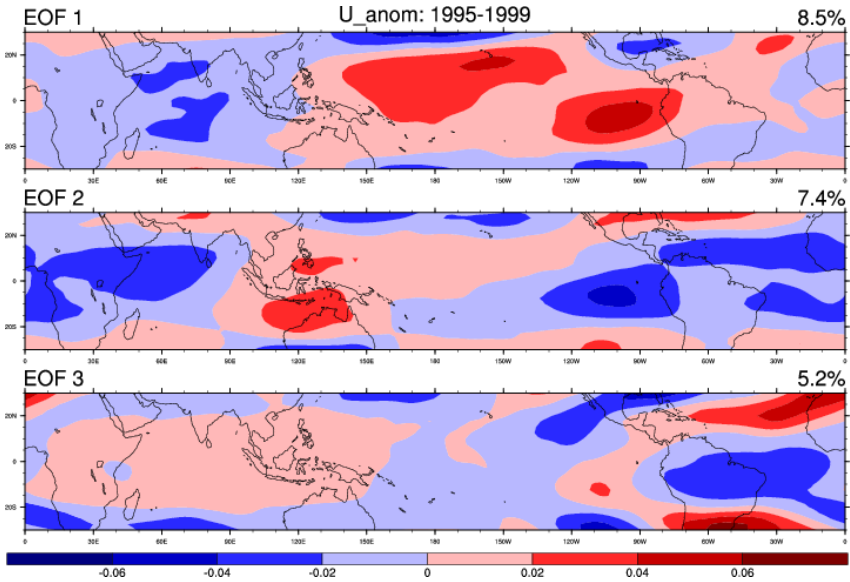
Are the events linked?

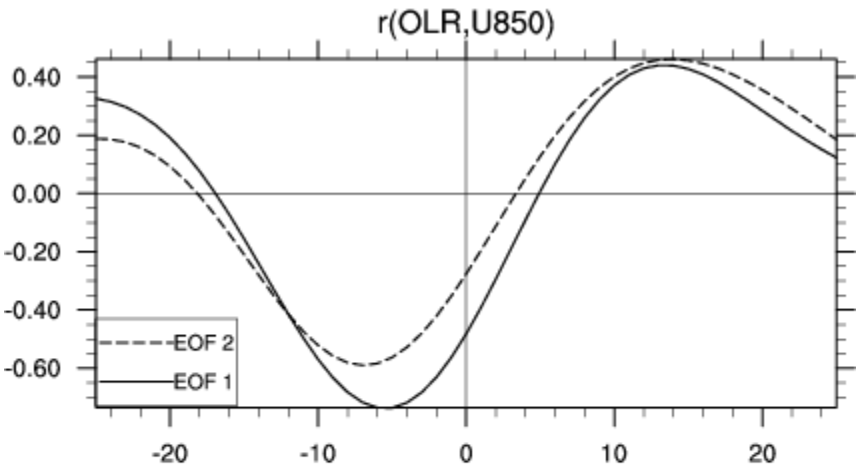
When do events begin and end?

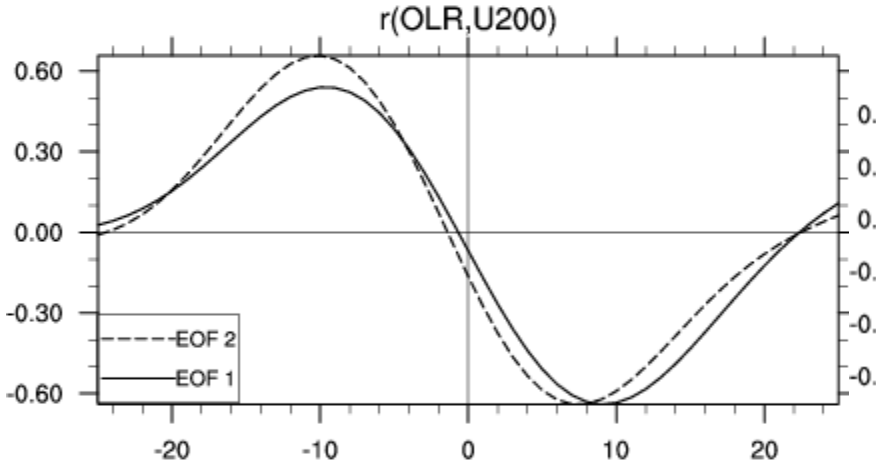
Univariate EOF Analysis

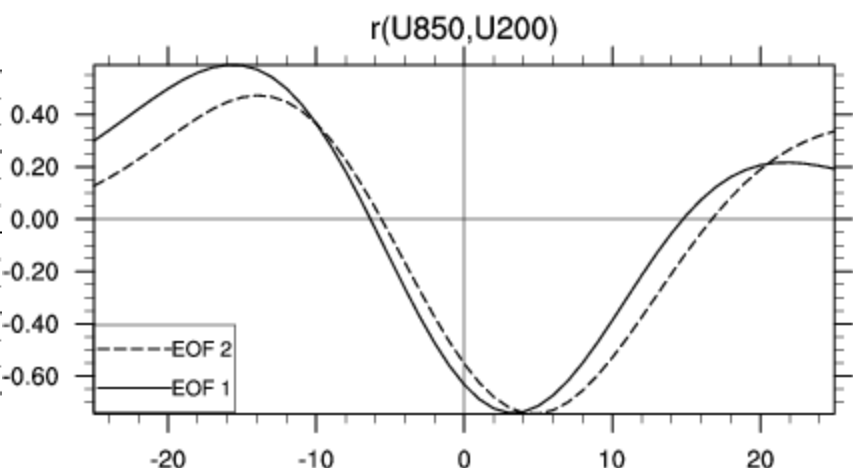












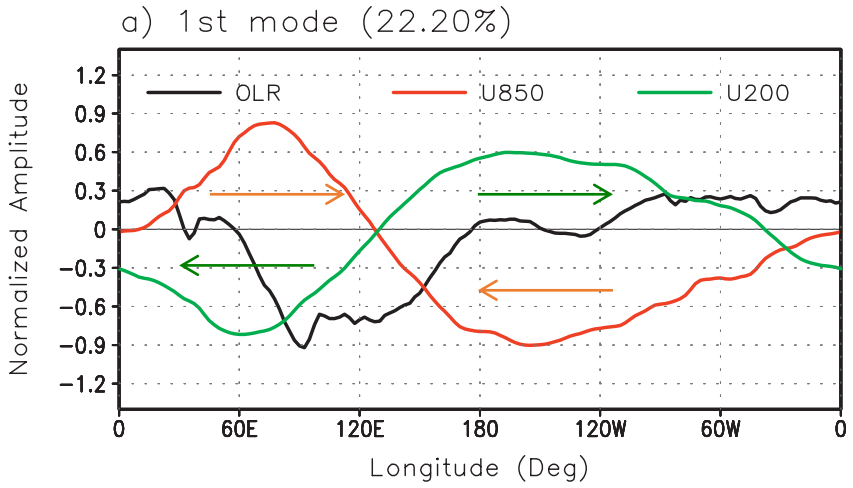
Multivariate EOF Analysis

Wheler and Hendon, 2004

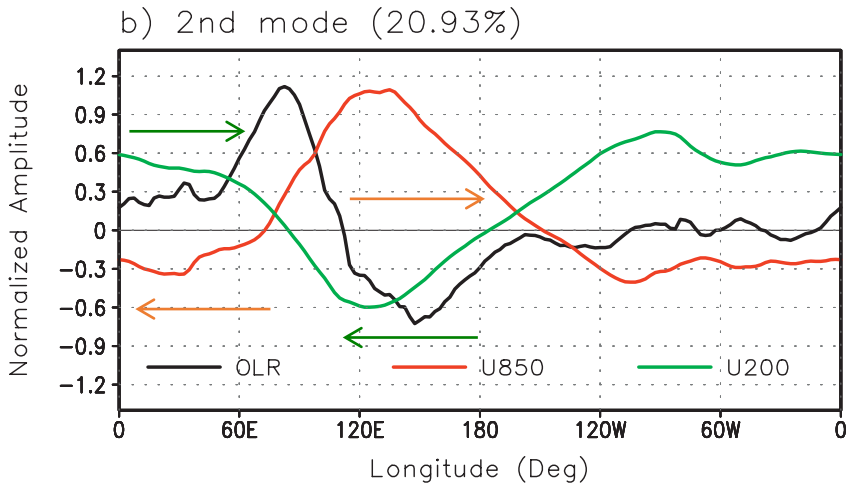
- Calculate 20-100 day bandpass filtered daily anomalies of OLR, u850, and u200
- EOF analysis of 15S to 15N averaged OLR, u850, and u200
- Each variable is normalized by its standard deviation
- First two combined EOFs describe the propagating structure of the MJO
- First two PCs (RMM1, RMM2) combined into the Real Time Multivariate MJO (RMM) index:

$$RMM = \sqrt{RMM_1^2 + RMM_2^2}$$

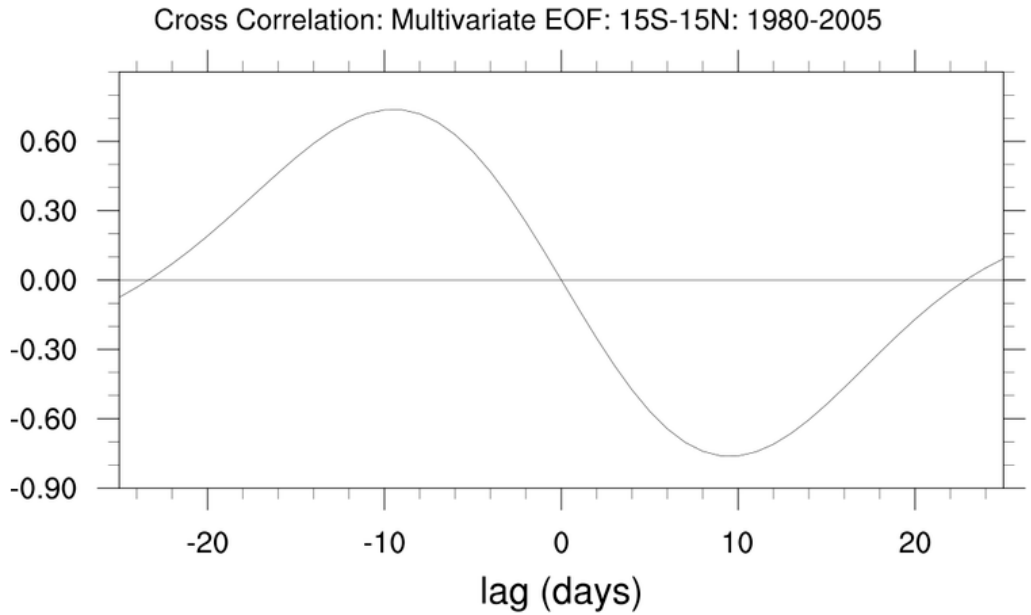
MJO EOF Patterns



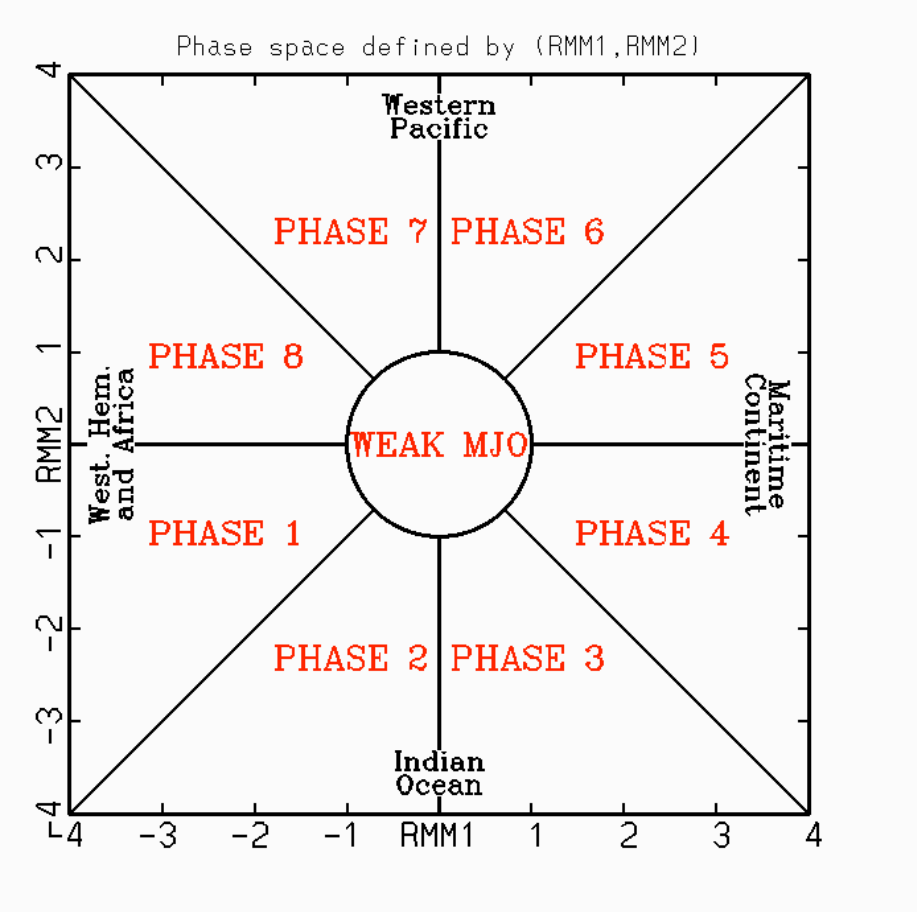
*Variance accounted for:
OLR=13.21%; u850=31.73%; u200=21.66%

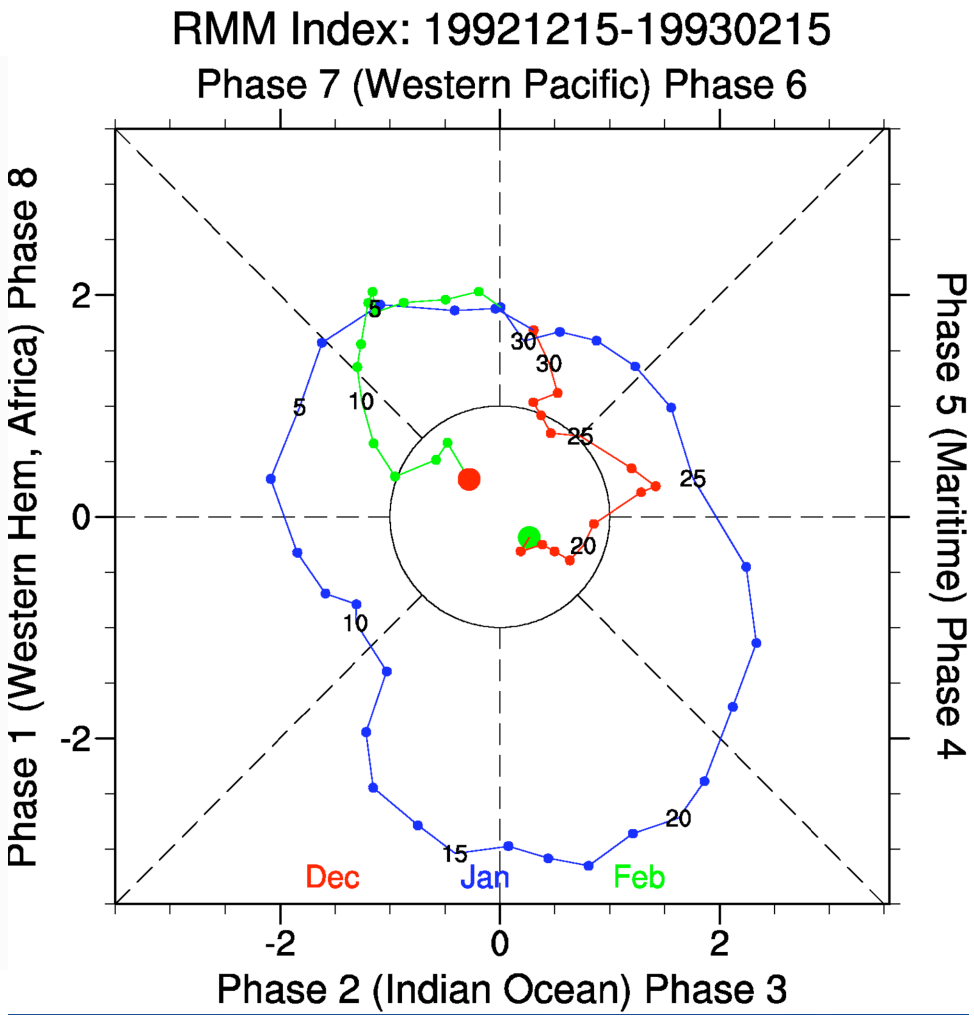


*Variance accounted for:
OLR=15.91%; u850=23.11%; u200=23.78%



MJO Phases





Pros

Shows the MJO initiation

Can distinguish between events

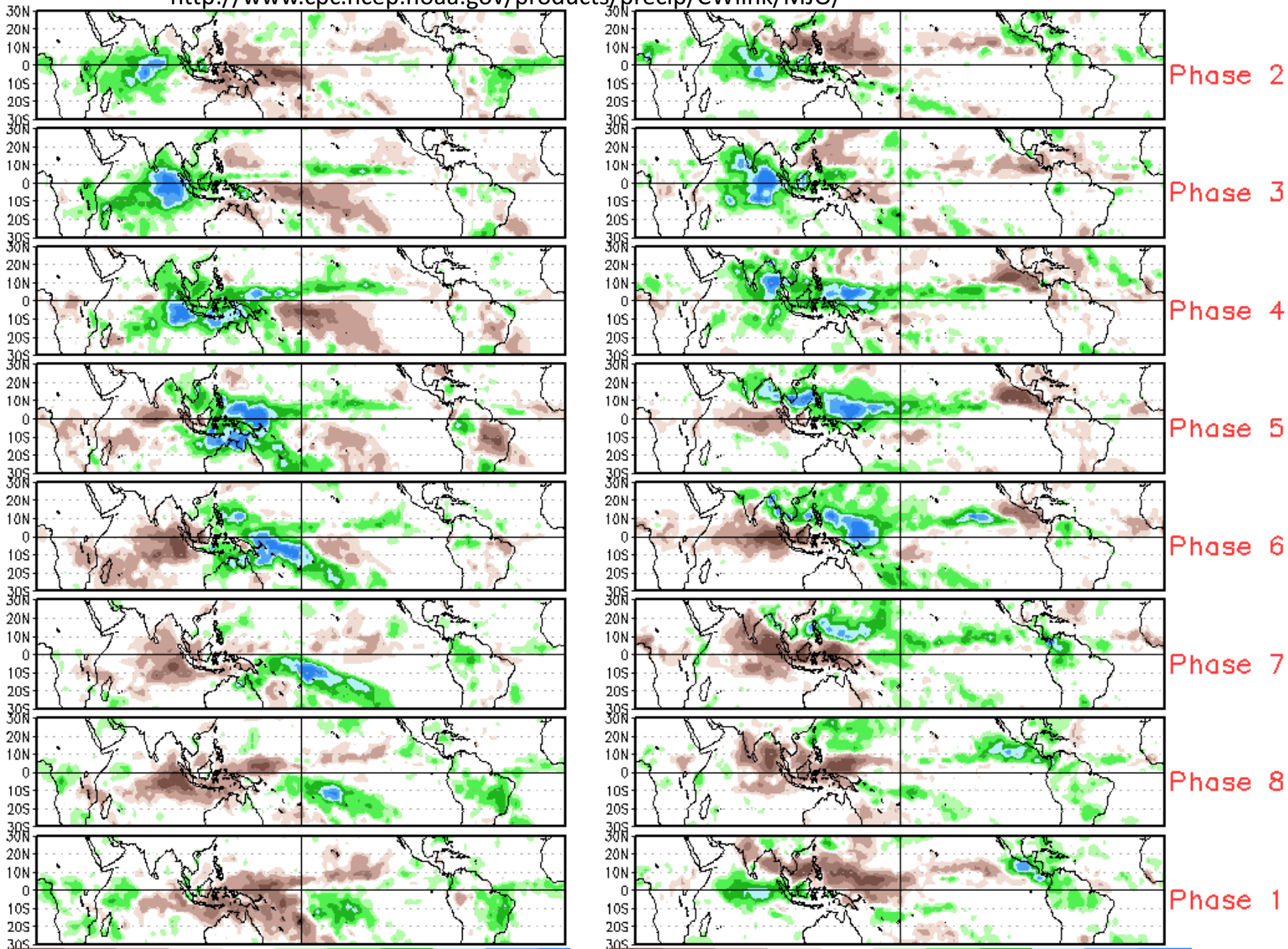
Based on multiple variables

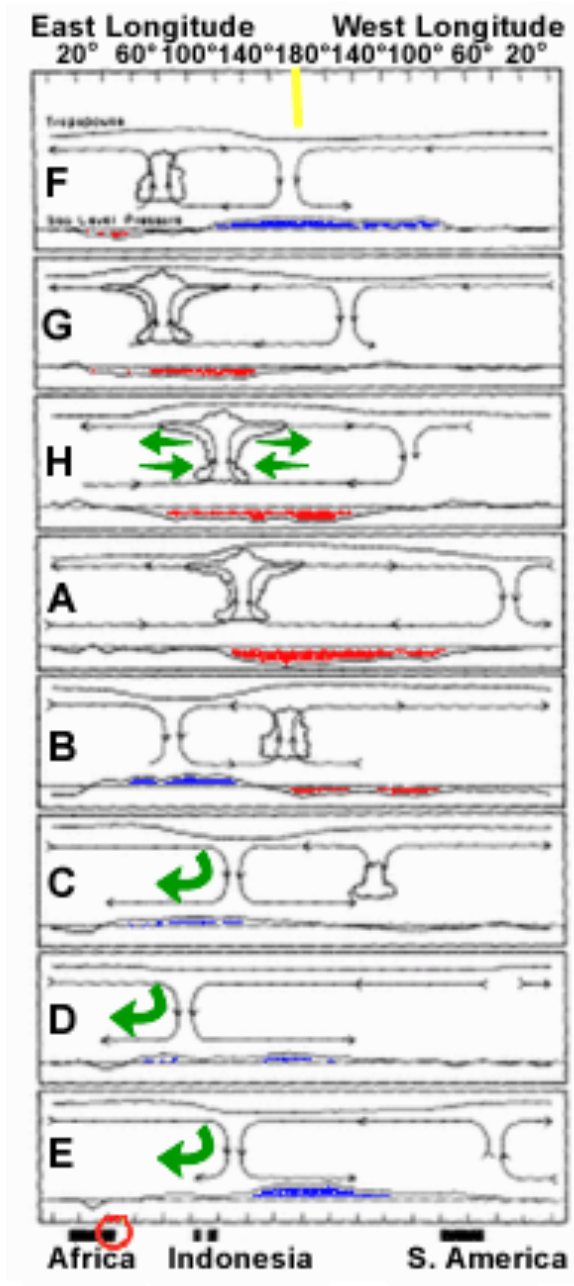
Cons

Wind dominates the signal

Gives false MJO events

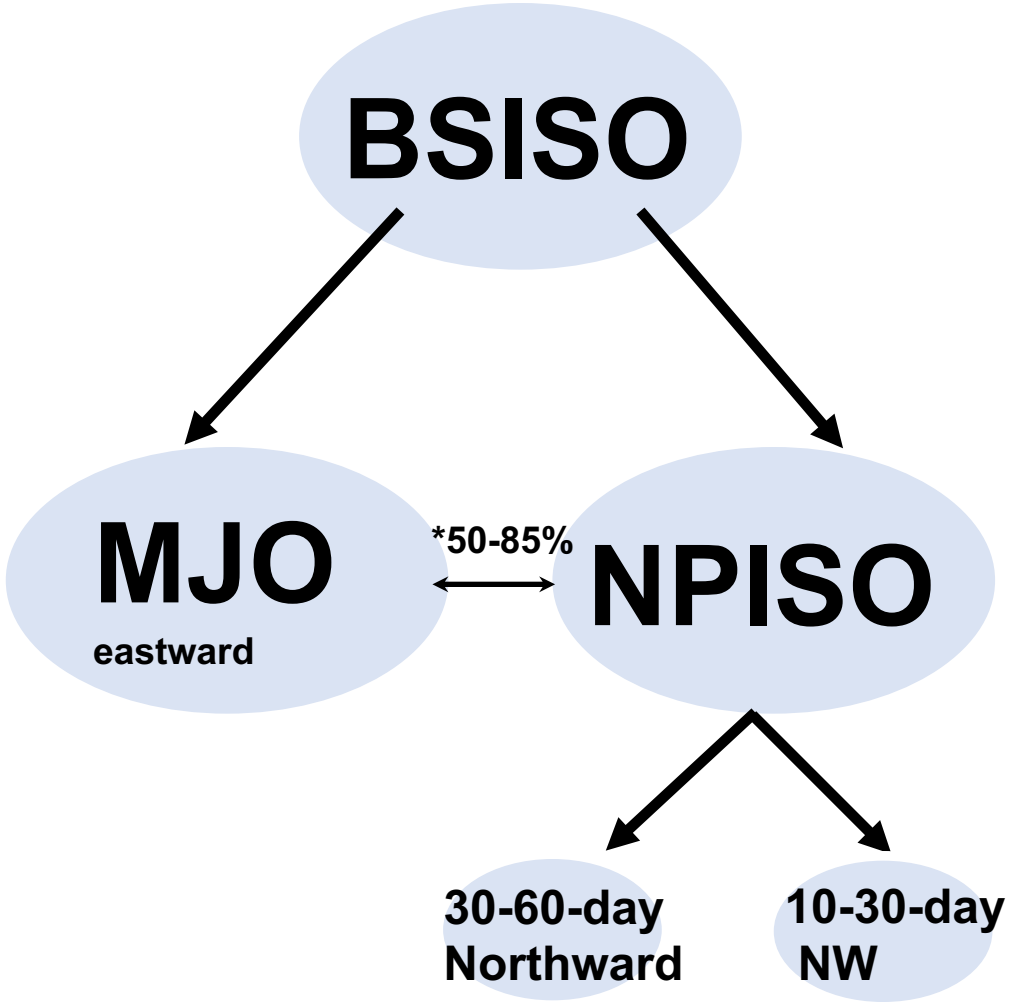
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/





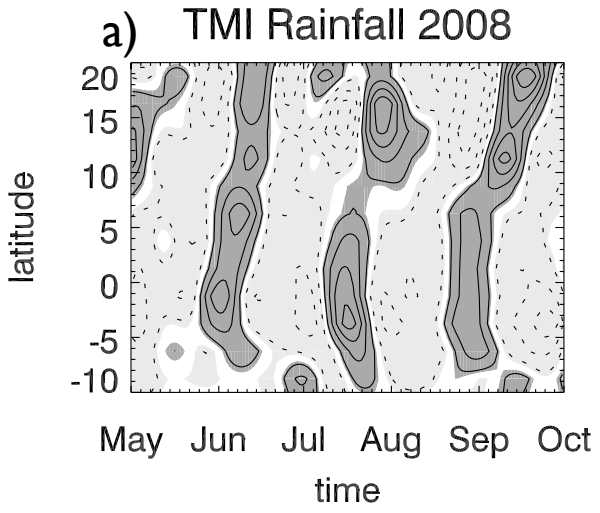
Madden and Julian, 1972

The Boreal Summer Intra-seasonal Oscillation

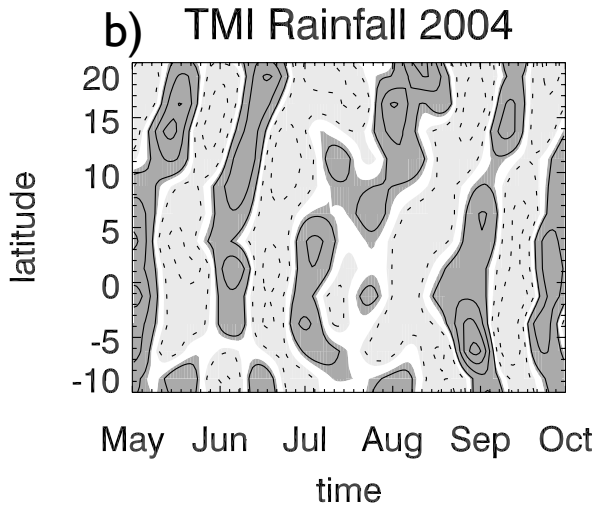


* Wang and Rui, 1990: 63%
  Lawrence and Webster, 2002: 78%

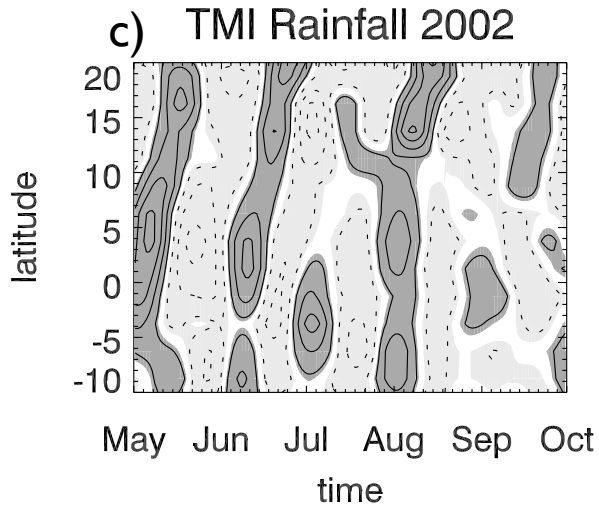
NPISO Variety



Robust continuous northward propagation from the equator to ~20^{0}N



Interaction of northward – and southward – propagating events



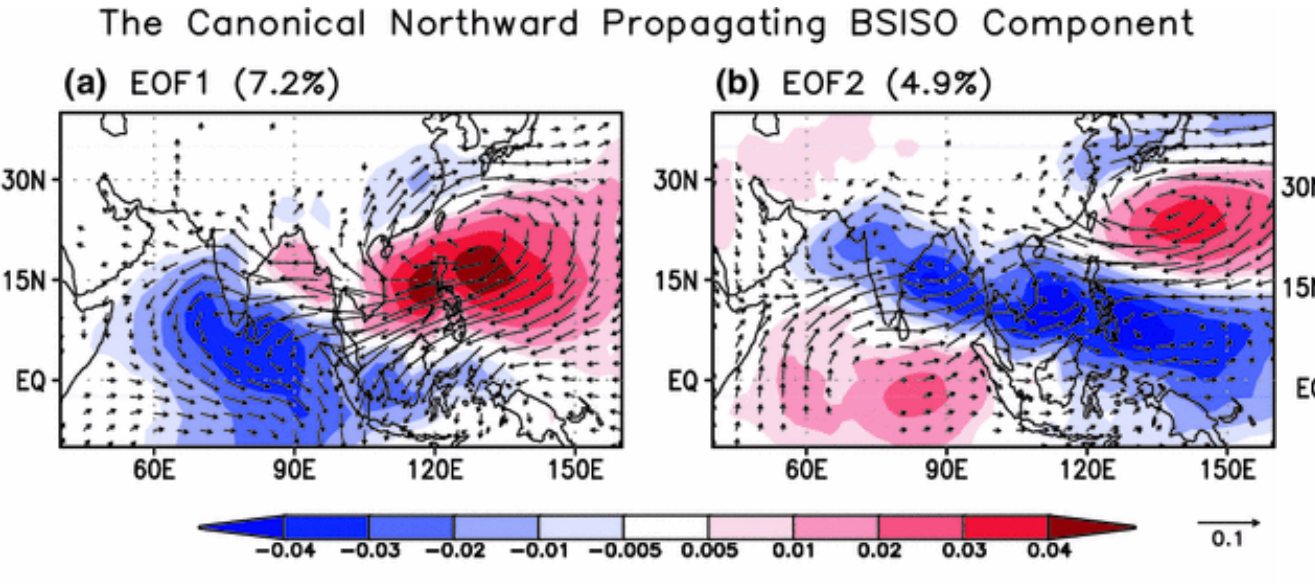
Equatorial ISO events that do not result in NPISO

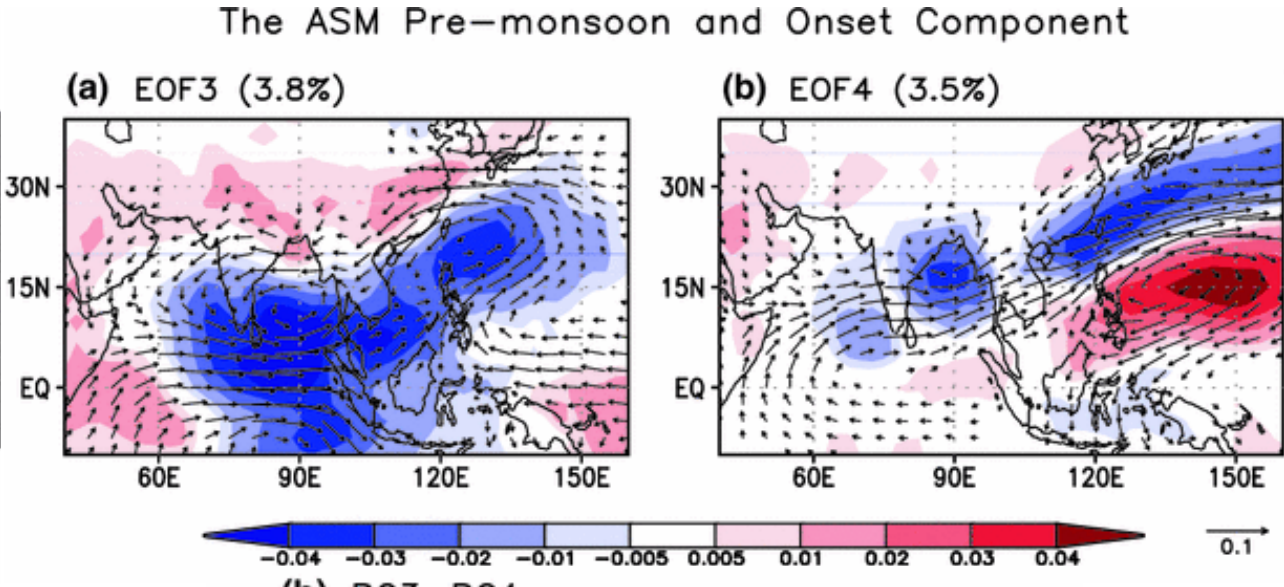
DeMott, Stan and Randall, 2012

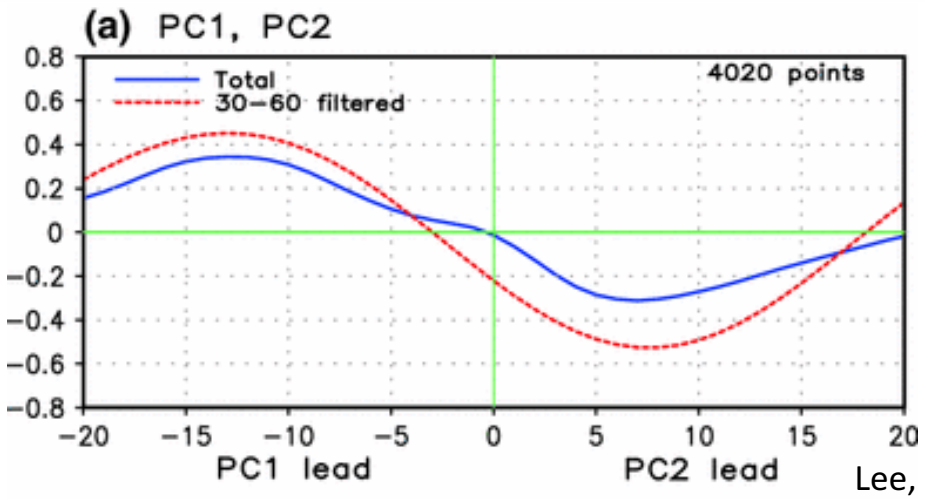
Methods of Identifying NPISO

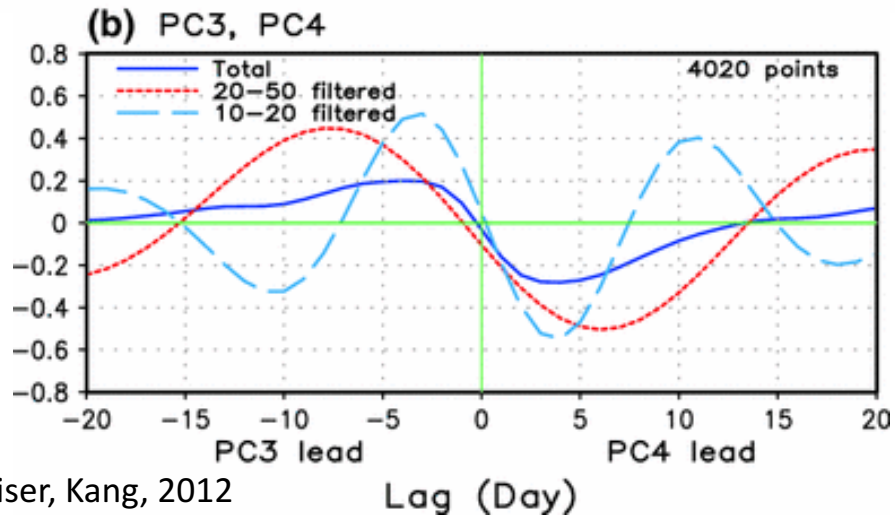
- Multivariate EOF analysis (Lee, Wang, Wheeler, Fu, Waliser, Kang, 2012)
  - No time filtering
  - EOF analysis of 10^0S to 40^0N averaged OLR, u850, and u200 across 40^0-60^0E
  - EOF1 and EOF2 describe the 30-60 day ISO
  - EOF3 and EOF4 describe the 10-30 day ISO

NPISO Patterns







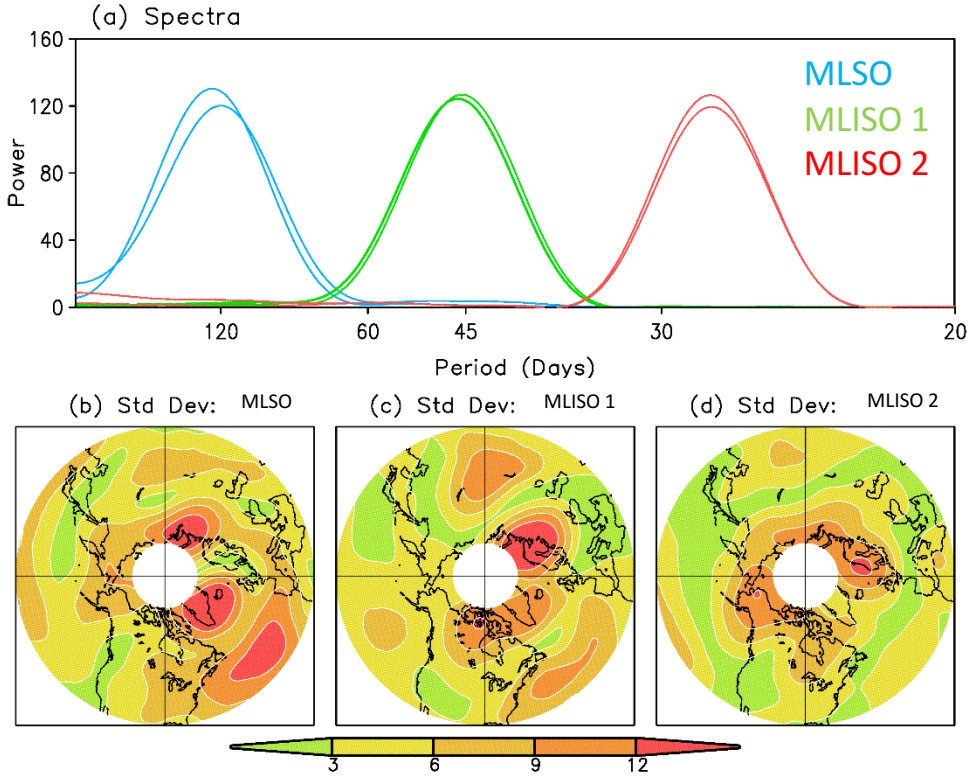


Lee, Wang, Wheeler, Fu, Waliser, Kang, 2012

Mid-latitude Variability

Acknowledgement: V. Krishnamurthy, George Mason University; Laura Ciasto, NOAA/CPC, Daniel Harnos, NOAA/CPC; Michelle L'Heureux, NOAA/CPC

- Data adaptive method (MSSA*) applied to 500-hPa geopotential height daily anomalies between 1979-2012:



*Multi-channel Singular Spectrum Analysis
Ghil, M. et al. 2002 – review of the method

Available
http://research.atmos.ucla.edu/tcd/ssa/guide
/mssa/mssatheory.html

http://www.spectraworks.com/Help/index.html
(KSpectra Toolkit)