A New Method for Identification of Madden-Julian Events

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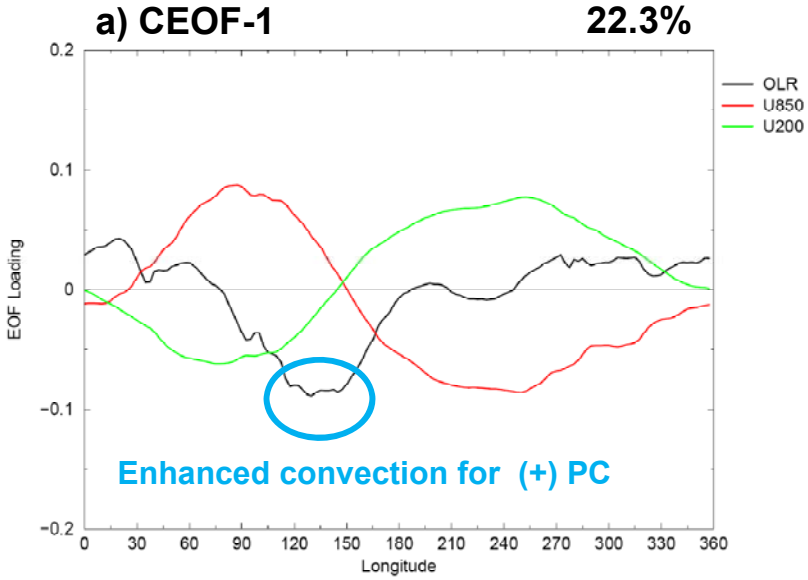
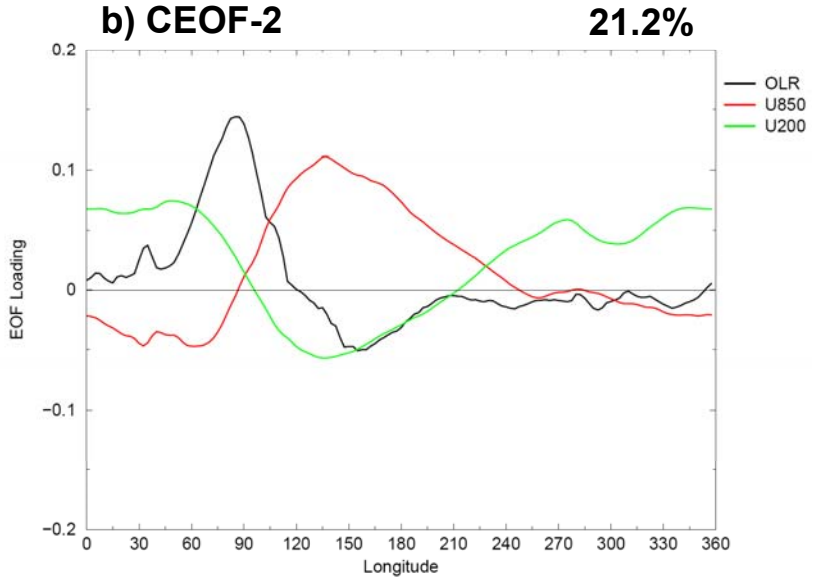
Outline

- Isolating the MJO (1979-2007)
  - Combined EOF analysis (Wheeler and Hendon 2004)
    - 15^{o}N-15^{o}S averaged OLR, u_{850}, u_{200}
- Characteristics of the principal components
- Experimental real-time MJO forecasts
- Reconstructing 20-100 day filtered OLR anomalies
  - Best case situation: How well do the 2 leading modes of variability represent 20-100 day filtered variability (data from which the EOF's were calculated)?
  - Problems of isolating the MJO with 2 modes of variability
- New approach for identifying MJO events

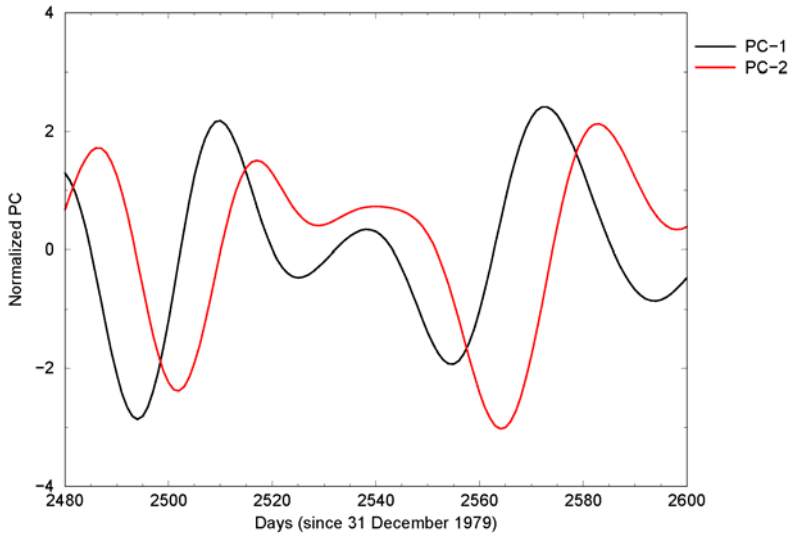
Isolating the MJO
(after Wheeler and Hendon 2004)

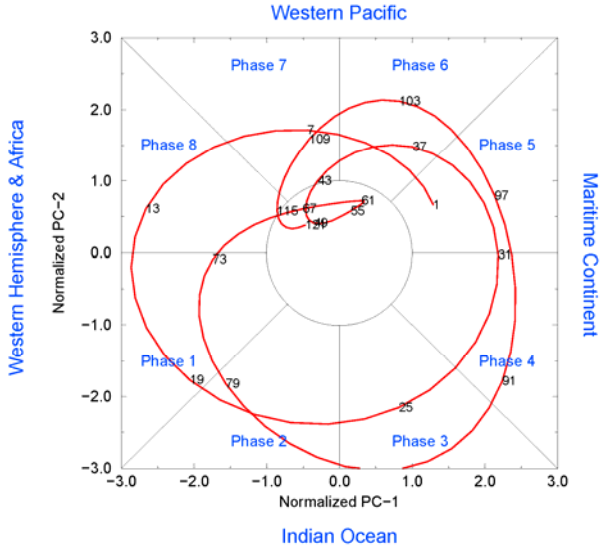
- The combined EOF (CEOF) analysis of 15°N-15°S averaged satellite derived OLR and reanalysis u_{200}, and u_{850} provides the basis functions onto which forecast anomalies are projected in an attempt to predict the state of the MJO (Gottachalck et al. 2010, *BAMS*, in press)
- This CEOF approach has also been used in the development of a diagnostics package for evaluation GCM simulations of the MJO (CLIVAR MJOWG 2008, J. Clim.; Kim et al. 2008, J. Clim.)

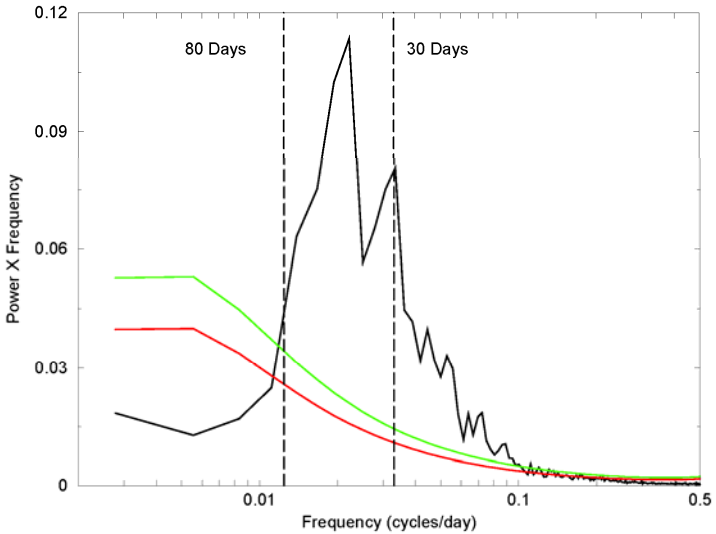


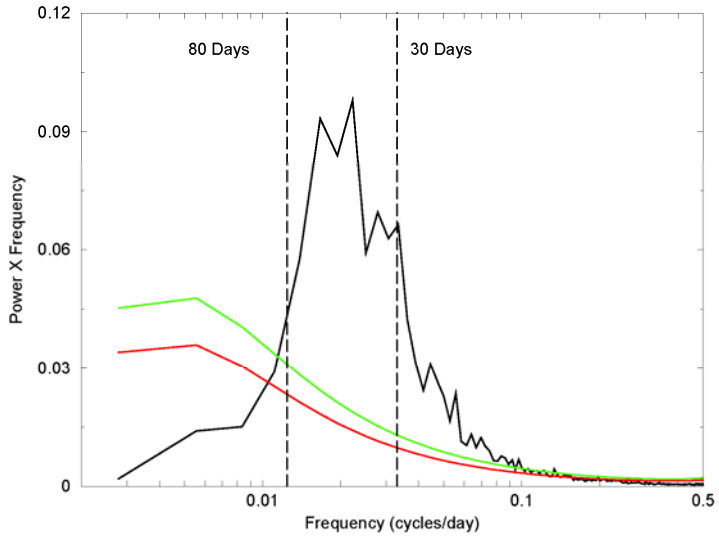


Characteristics of the principal components



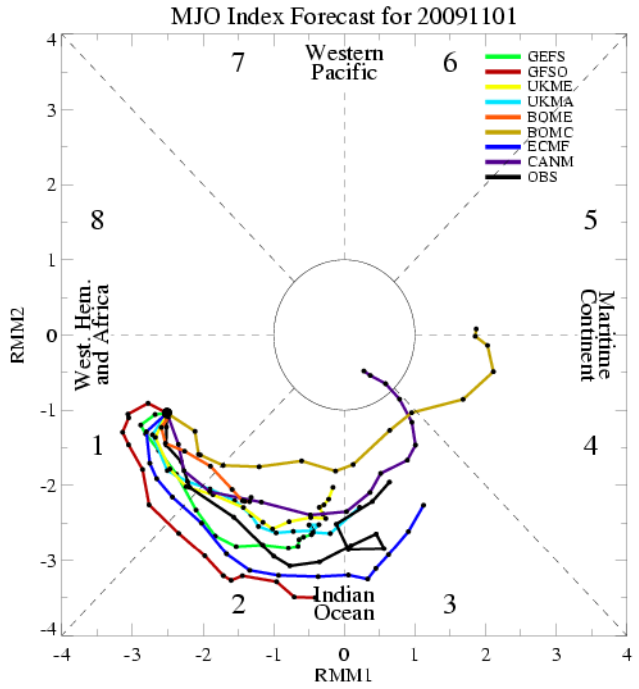


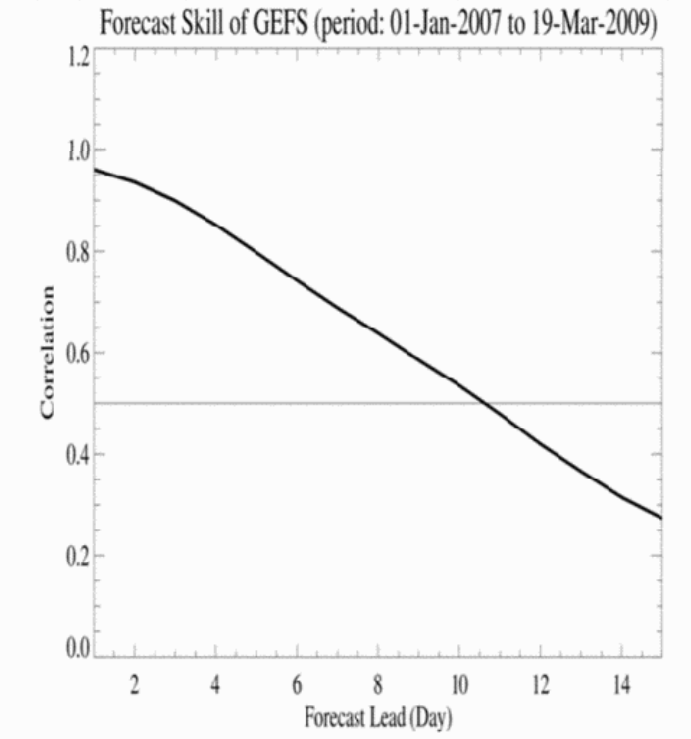




Experimental real-time MJO forecasts are being made using NWP output

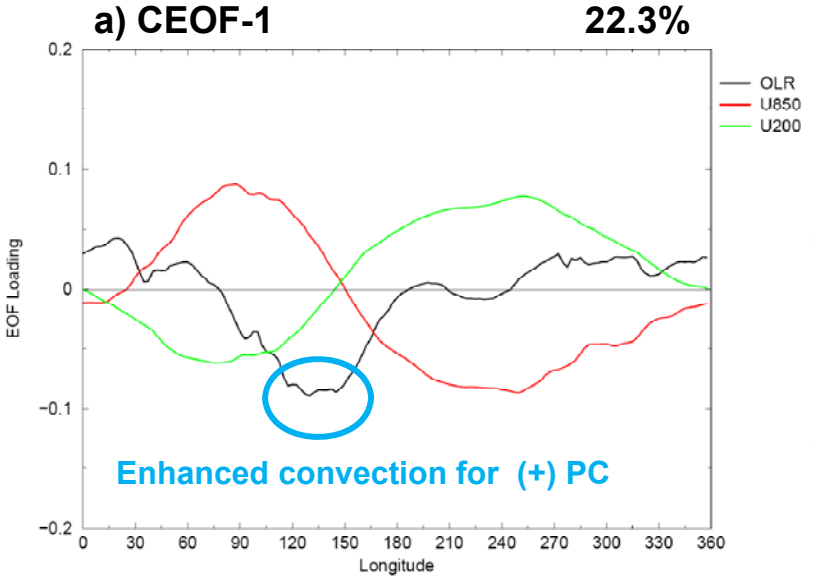
- Activity initiated by the CLIVAR MJOWG and endorsed and by the Working Group on Numerical Experimentation (WGNE)
  - Each day 8 NWP centers are providing ~10-45 day forecasts of OLR, u_{200}, and u_{850}
  - The resulting MJO forecasts are being disseminated by Jon Gottschalck of NCEP

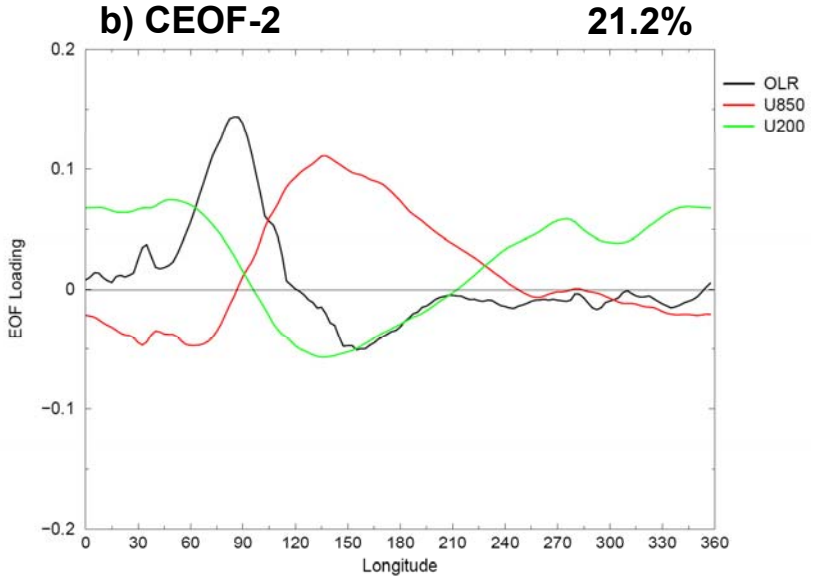


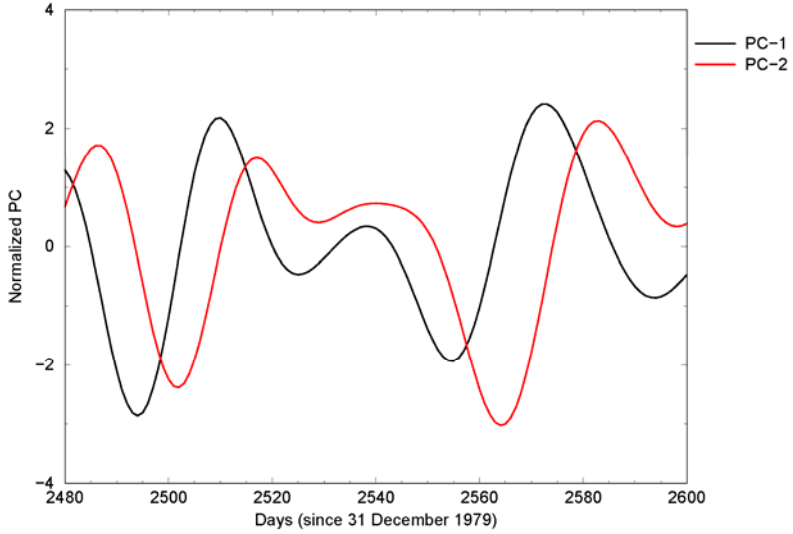


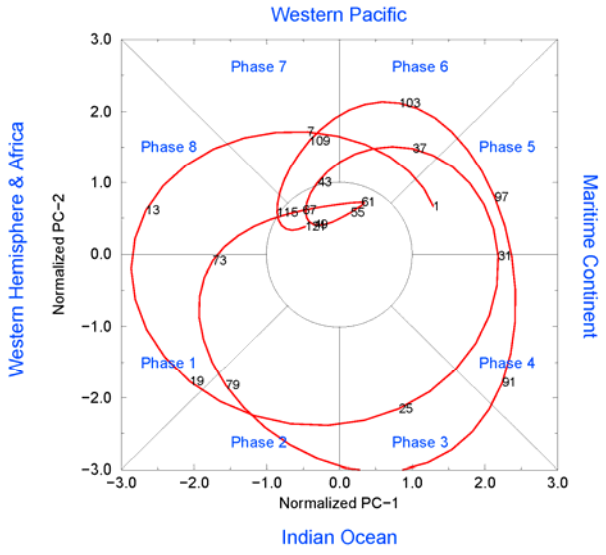
How well to the 2 leading modes recover MJO variability?

Oct. 15, 1985 – Feb. 12, 1986



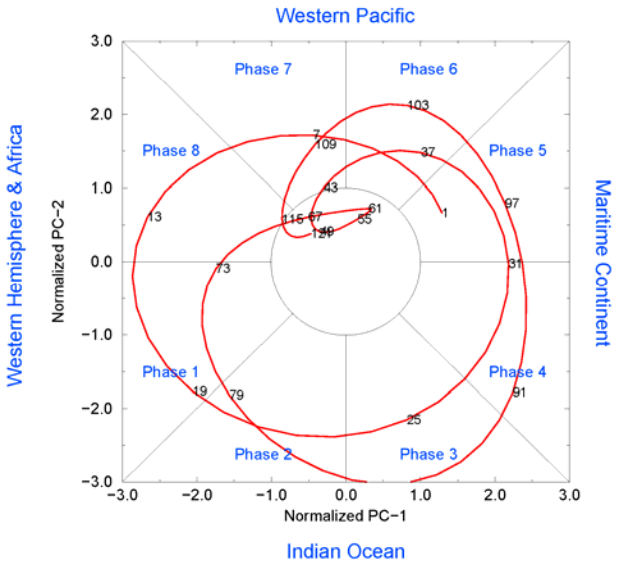


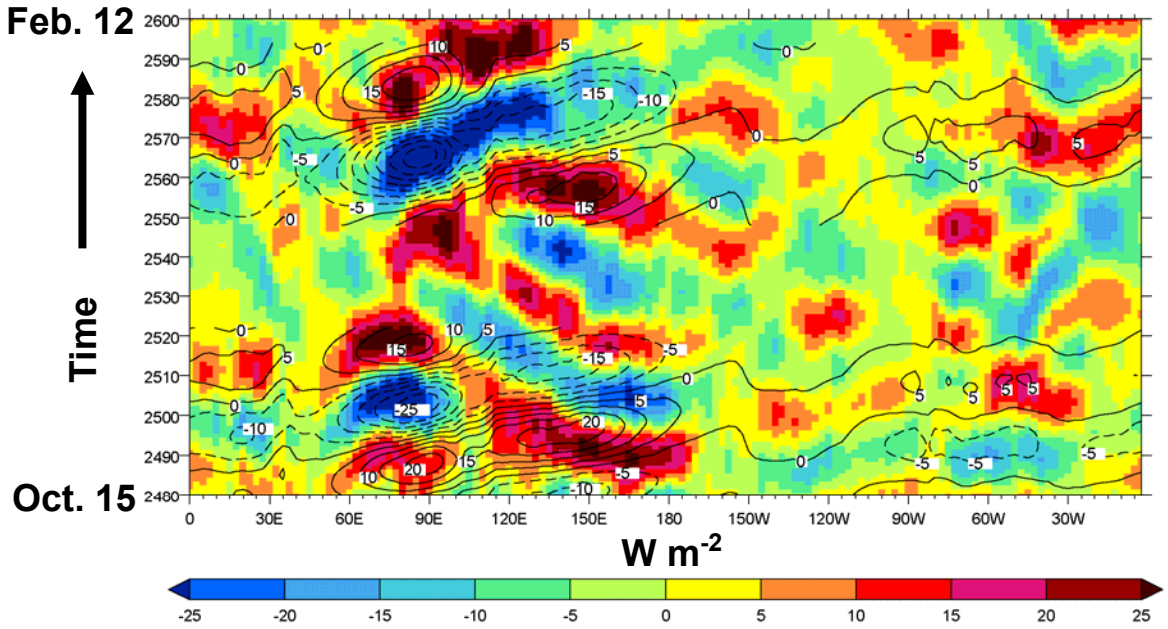




(A) CEOF's 1-2: generation of an event when none exists

Oct. 15, 1985 – Feb. 12, 1986

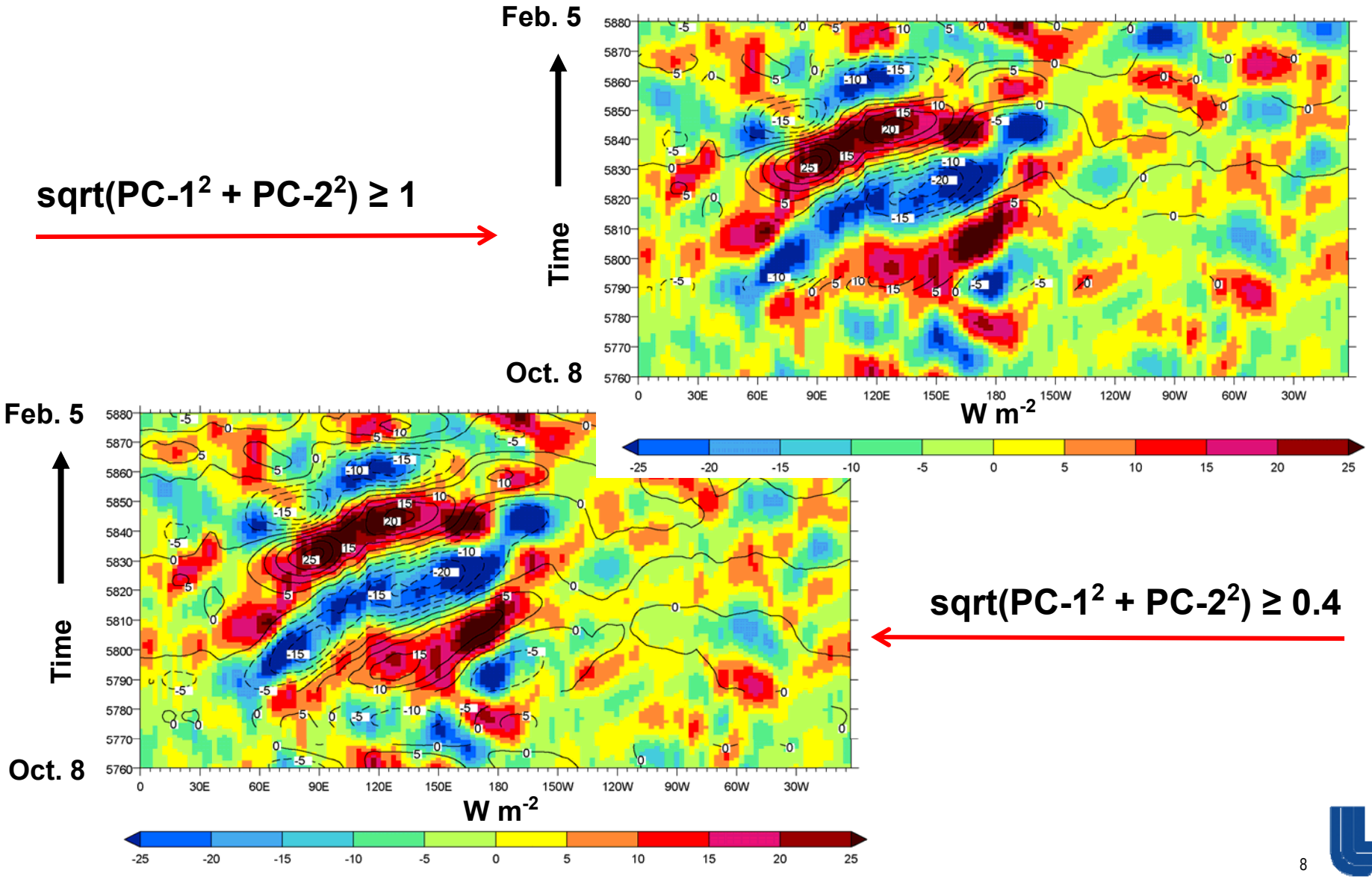




- Shading: 20-100 day filtered AVHRR OLR
- Isolines: OLR reconstruction using CEOF's 1-2, plotted for an MJO amplitude: sqrt(PC-1^2 + PC-2^2) ≥ 1

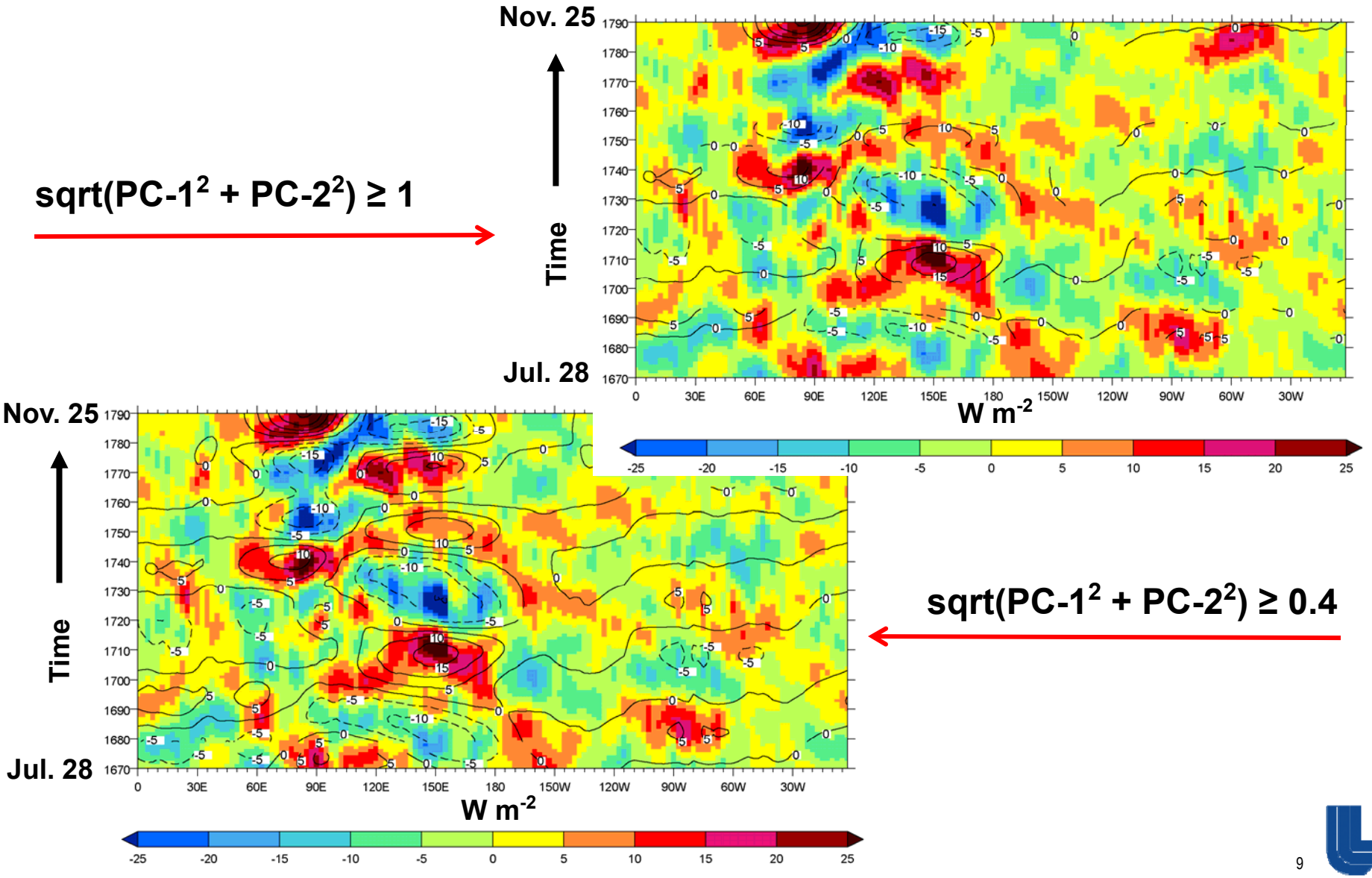
(B) Failure to capture an event

(improved with reduced amplitude threshold) Oct. 8, 1994 – Feb. 5, 1995



(C) Does not exclude periods of erratic non-MJO activity

(worsened with reduced amplitude threshold) Jul. 28 – Nov. 25, 1983



Use of only 2 leading CEOFs is problematic

- Many cases exist in which CEOF's 1+2 reconstructions
  - (A) produce a MJO when none exists
  - (B) fail to capture a MJO event
  - (C) do not exclude periods of erratic non-MJO activity
- Rectifying these issues is not simply just a matter of selecting a new amplitude threshold for defining strong MJO events

Impact of using only CEOF's 1-2

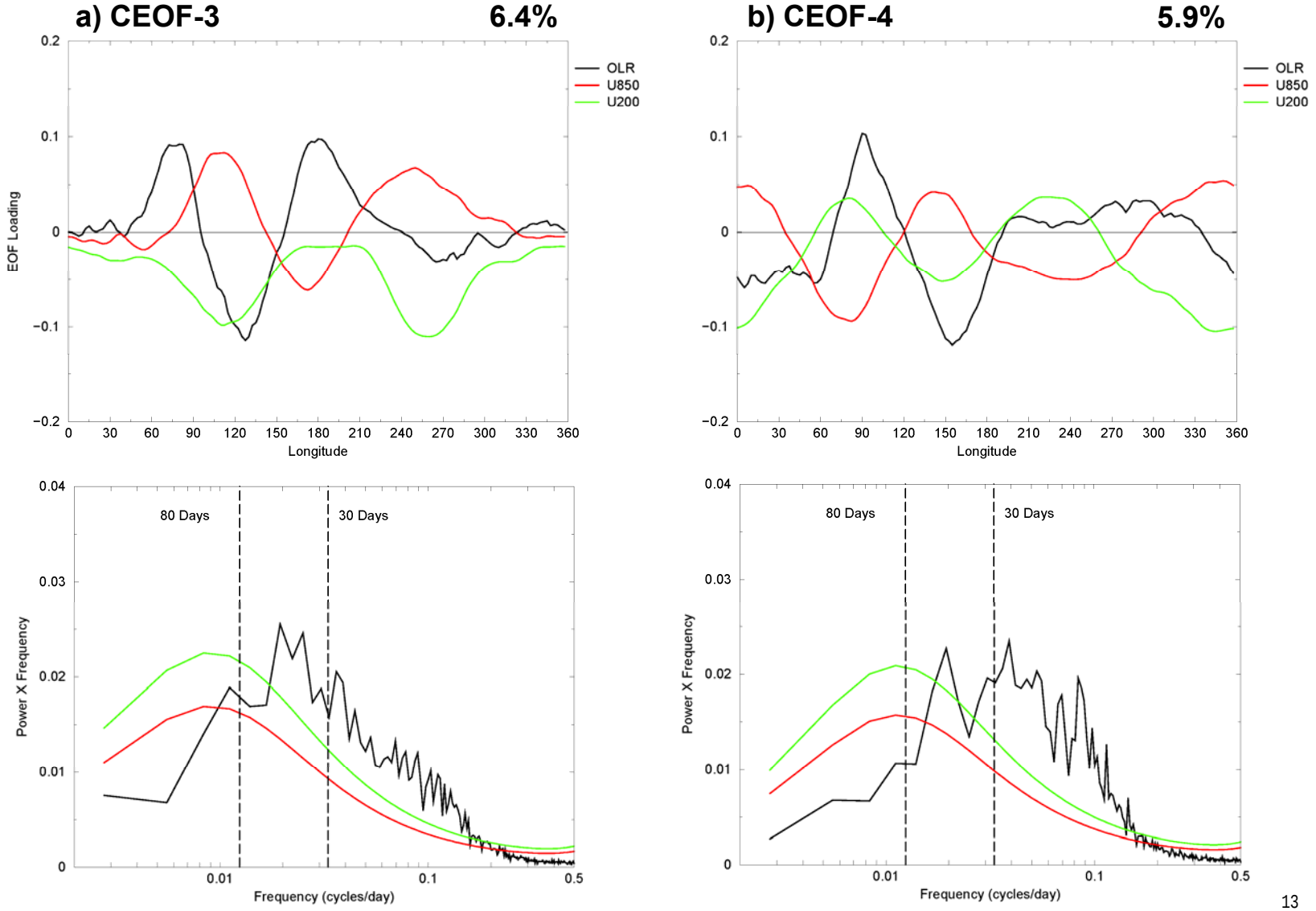
- Objectively identifying individual MJO events is difficult
  - Problematic for forecasting due to possible misdiagnosis of whether an MJO event is actually underway
  - Impacts the ability to identify primary and successive MJO's (Matthews 2008)
  - Potentially compromises the understanding of MJO processes
- Composites will be affected
  - May have minimal impact given the multitude of actual MJO's that go into making the composite

Inclusion of higher order modes is essential for isolating MJO events

- Continue to define strong MJO's by

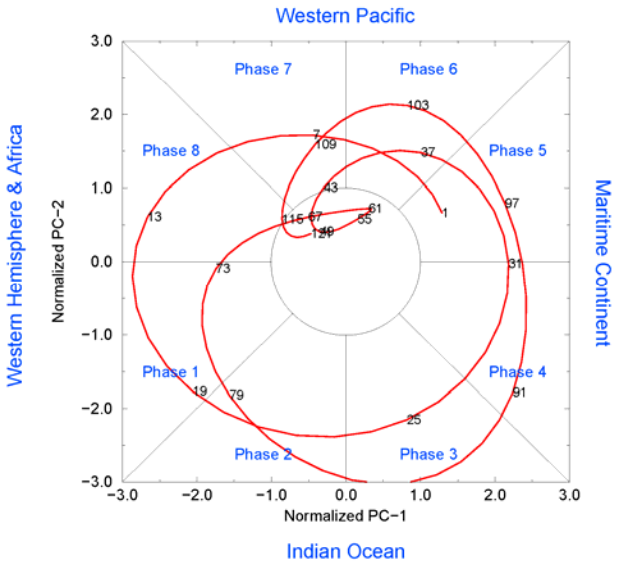
  $\text{sqrt}(\text{PC-1}^2 + \text{PC-2}^2) \geq 1$
- However, also project data onto CEOF's 3-4 to do the space-time reconstruction
- Retrospective skill can be assessed by evaluating
  - How well the forecast tracks the validation PC-1 vs. PC-2 phase space
  - How well the CEOF 1-4 reconstructed OLR anomalies validate against observations

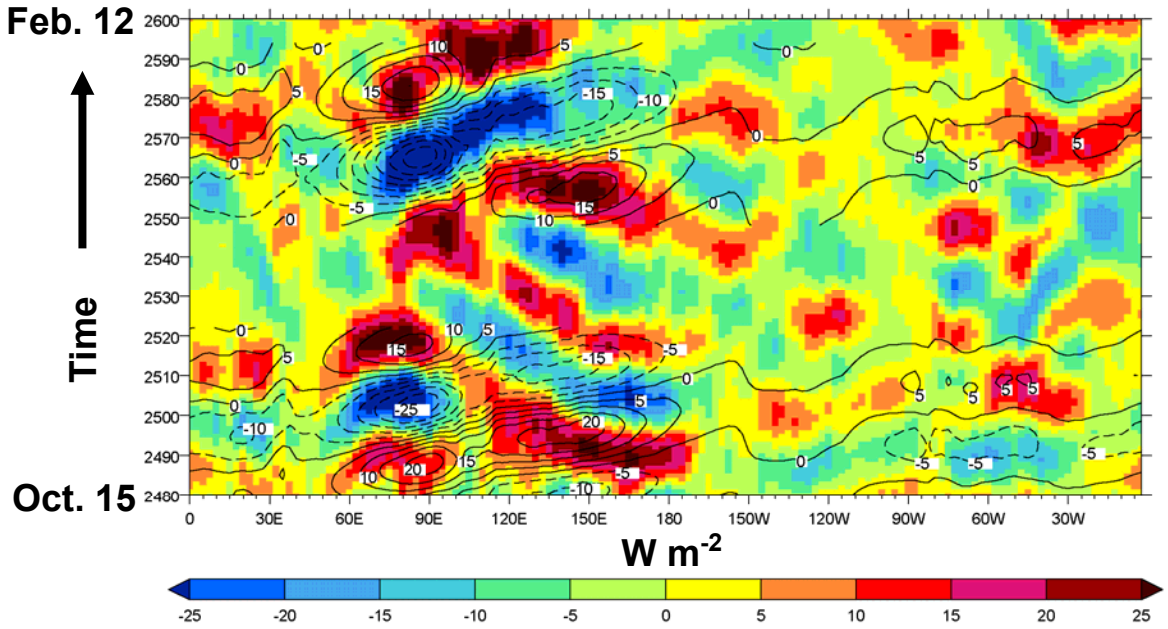
Combined EOF analysis of 20-100 day filtered AVHRR OLR and NCEP/NCAR reanalysis u_{850} and u_{200} (15°N-15°S average)



(A) CEOF's 1-2: generation of an event when none exists

(MJO amplitude: sqrt(PC-1^2 + PC-2^2) ≥ 1) Oct. 15, 1985 – Feb. 12, 1986

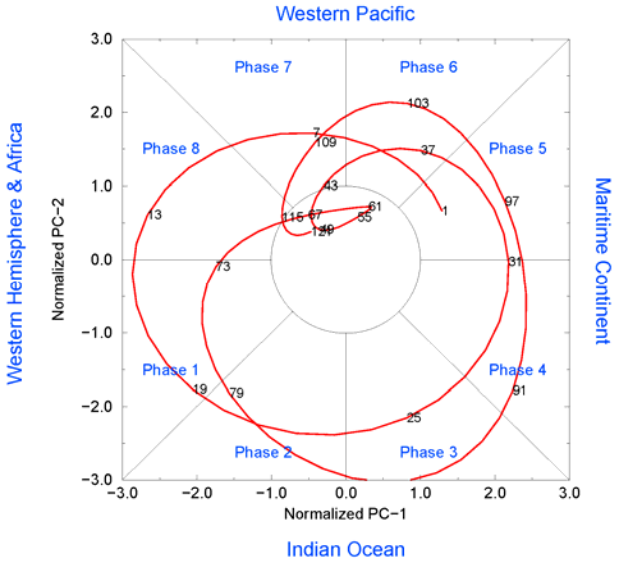


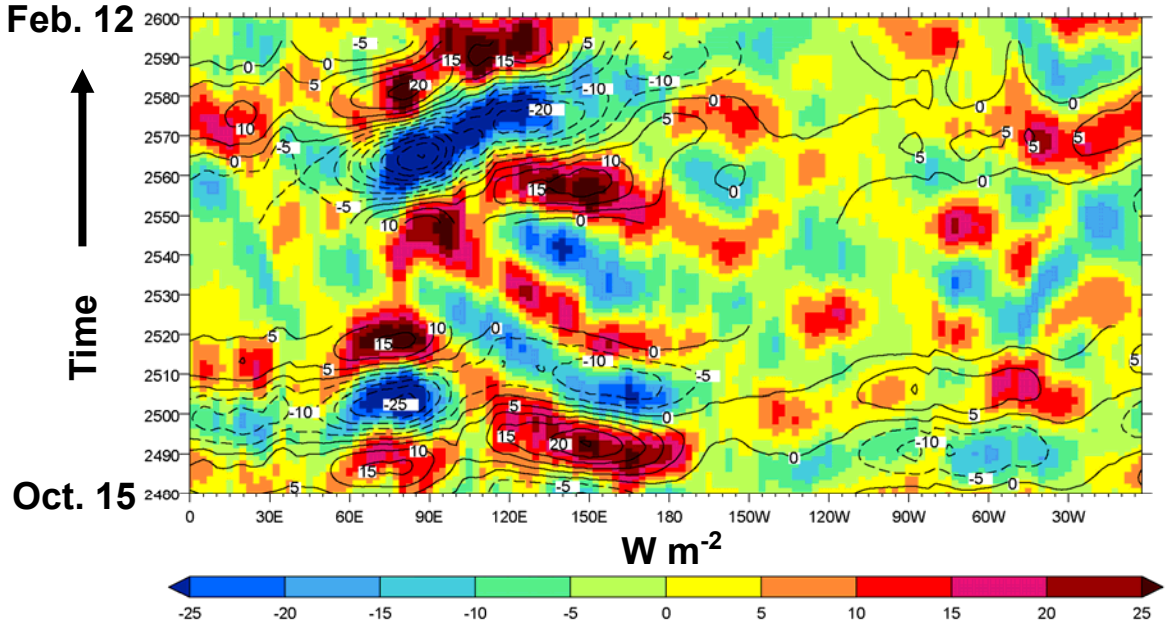


- Shading: 20-100 day filtered AVHRR OLR
- Isolines: OLR reconstruction using CEOF's 1-2

(A) CEOF's 1-4: Better represents westward propagation

(MJO amplitude: sqrt(PC-1^2 + PC-2^2) ≥ 1) Oct. 15, 1985 – Feb. 12, 1986





- Shading: 20-100 day filtered AVHRR OLR
- Isolines: OLR reconstruction using CEOF's 1-4

Intermediate findings

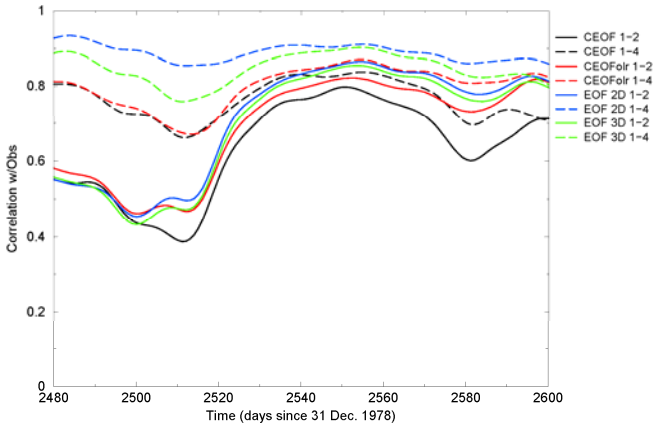
- EOF 1-2 reconstructions of MJO convective signals result in (A) false positive indications of the presence of MJO's, (B) failure to capture events, and (C) periods of erratic behavior
- EOF 1-4 reconstructions result in more realistic spatial patterns and amplitudes compared to the EOF 1-2 reconstructions, but this does not correct selection effects when using the mode 1 and 2 MJO amplitudes to identify events
- Rectifying issues A-C is not simply just a matter of selecting a new MJO amplitude threshold for defining strong events
- A new approach for identifying MJO's is needed

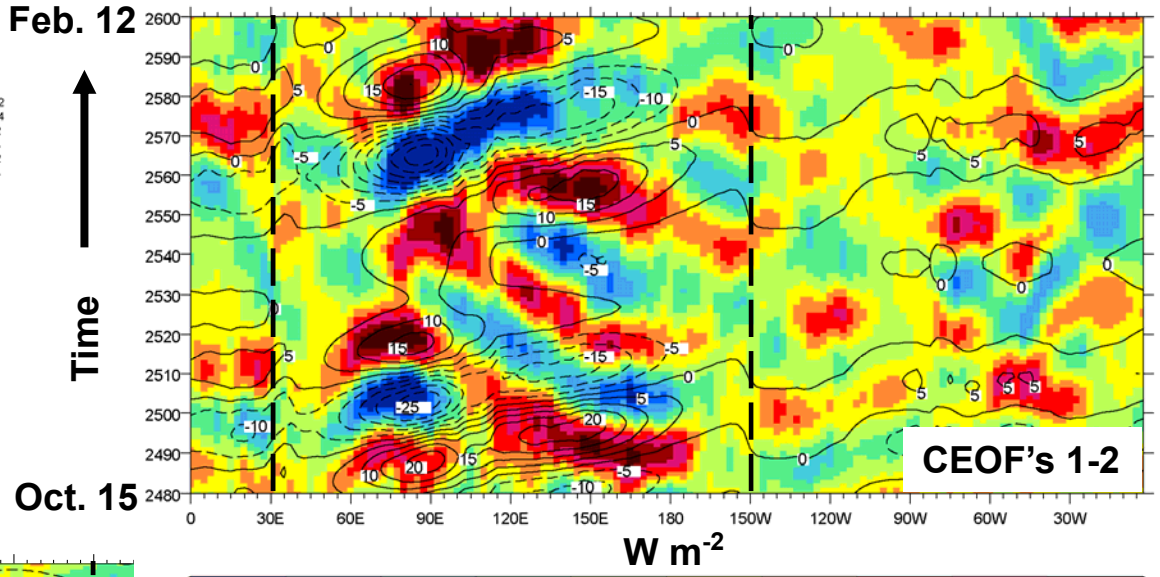
New approach for identifying MJO events
Premise

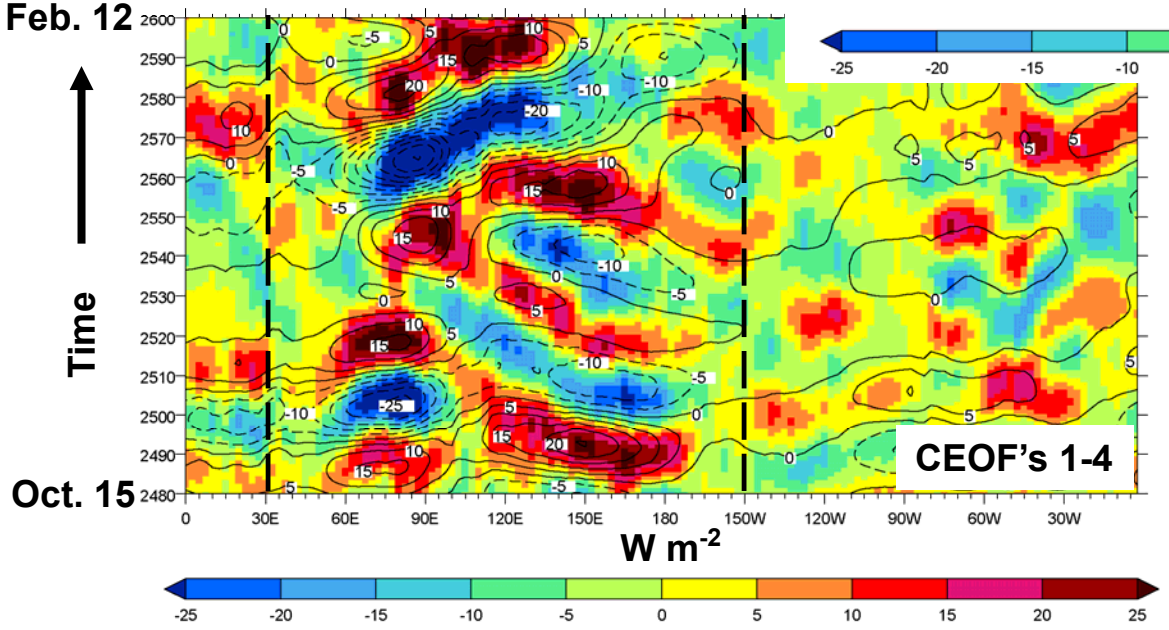
- Validate the reconstructions against the 20-100 day filtered AVHRR anomalies
- If the reconstruction using EOF's 1-4 is similar to the reconstruction using EOF's 1-2, then an MJO is most likely occurring (i.e., the higher order modes are not contributing to the reconstruction in a substantive way)
- The skill metric for quantifying the agreement between the reconstruction and the validation data is the pattern correlation, which is calculated in a 40-day moving window between 30^{o}E-150^{o}W, where the MJO convection is strongest
- For example …

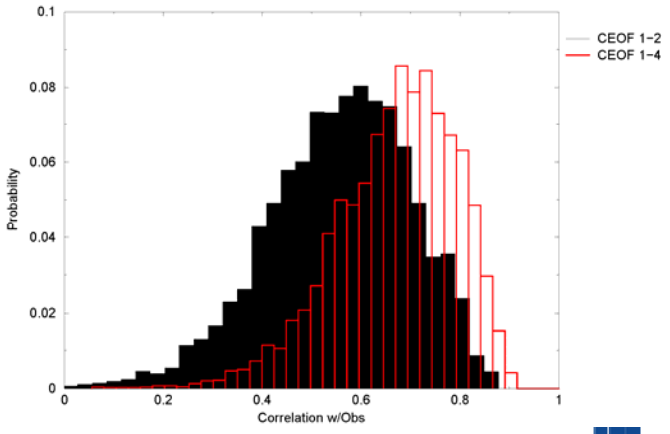
New approach for identifying MJO events

Oct. 15, 1985 – Feb. 12, 1986









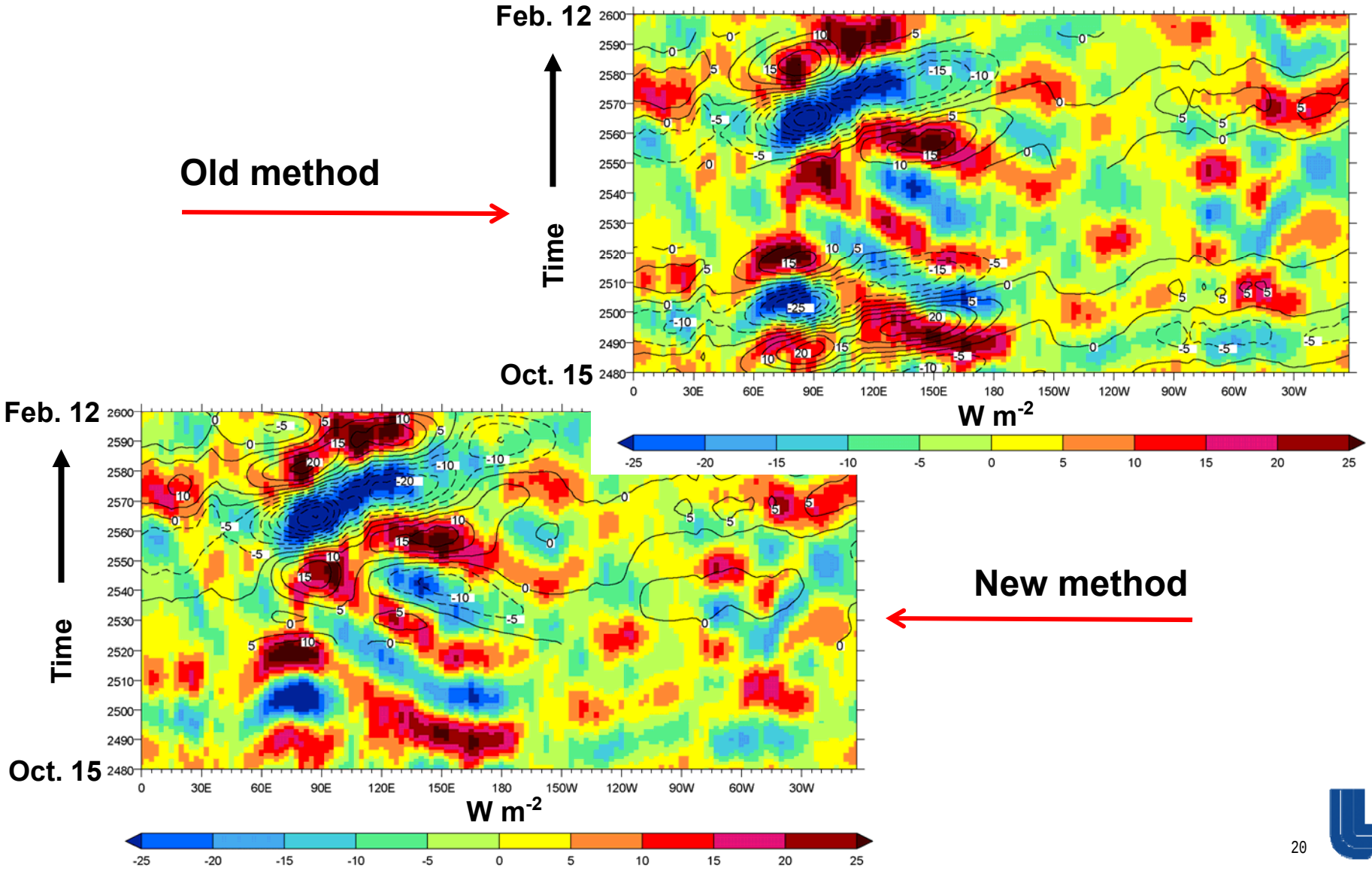
New approach for identifying MJO events

Recipe

- sqrt(PC-1^2 + PC-2^2) ≥ 1
- Relative to observations the pattern correlation of the EOF 1-4 reconstruction ≥ mean pattern correlation + 0.5σ (0.4 σ if an event is underway)
- The difference in the pattern correlations between the EOF 1-4 and the EOF 1-2 reconstructions is <1.1σ
- If these 3 criteria are satisfied the MJO is taken to be present on the given day and 39 days thereafter (due to the width of the time window over which the pattern correlations are calculated)

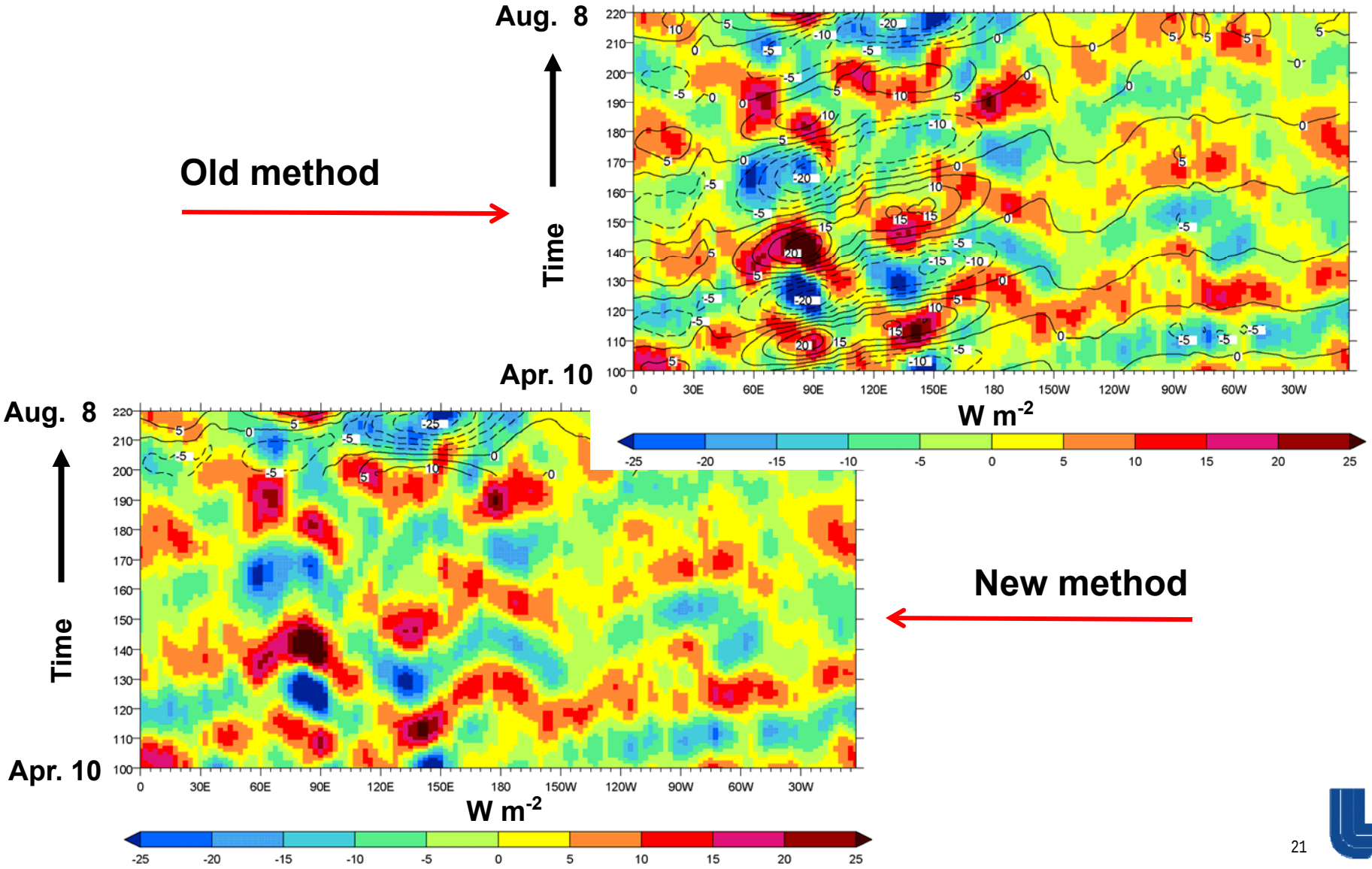
Improved identification of MJO events

Oct. 15, 1985 – Feb. 12, 1986



Improved identification of MJO events

Apr. 10 – Aug. 8, 1979



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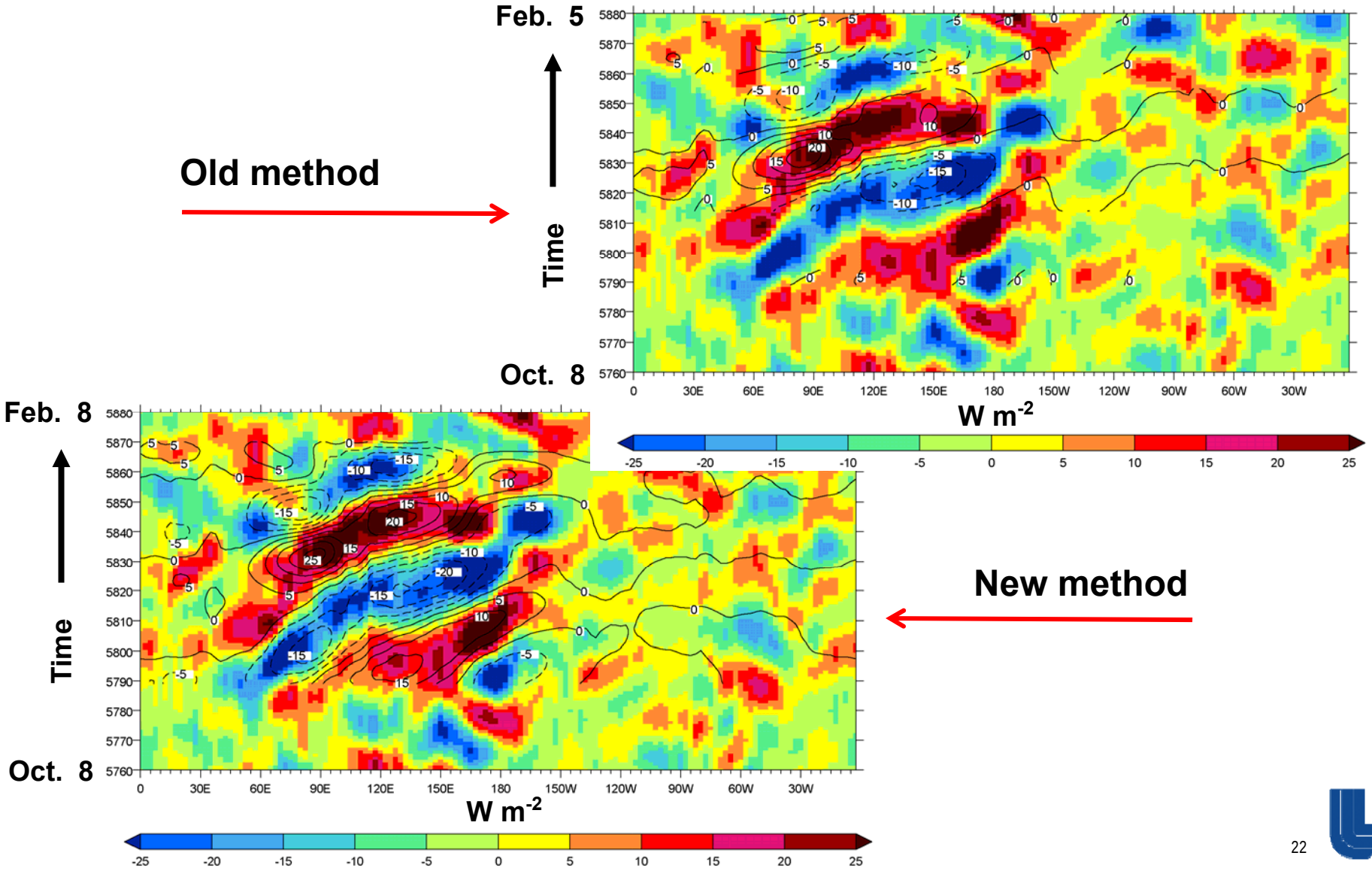

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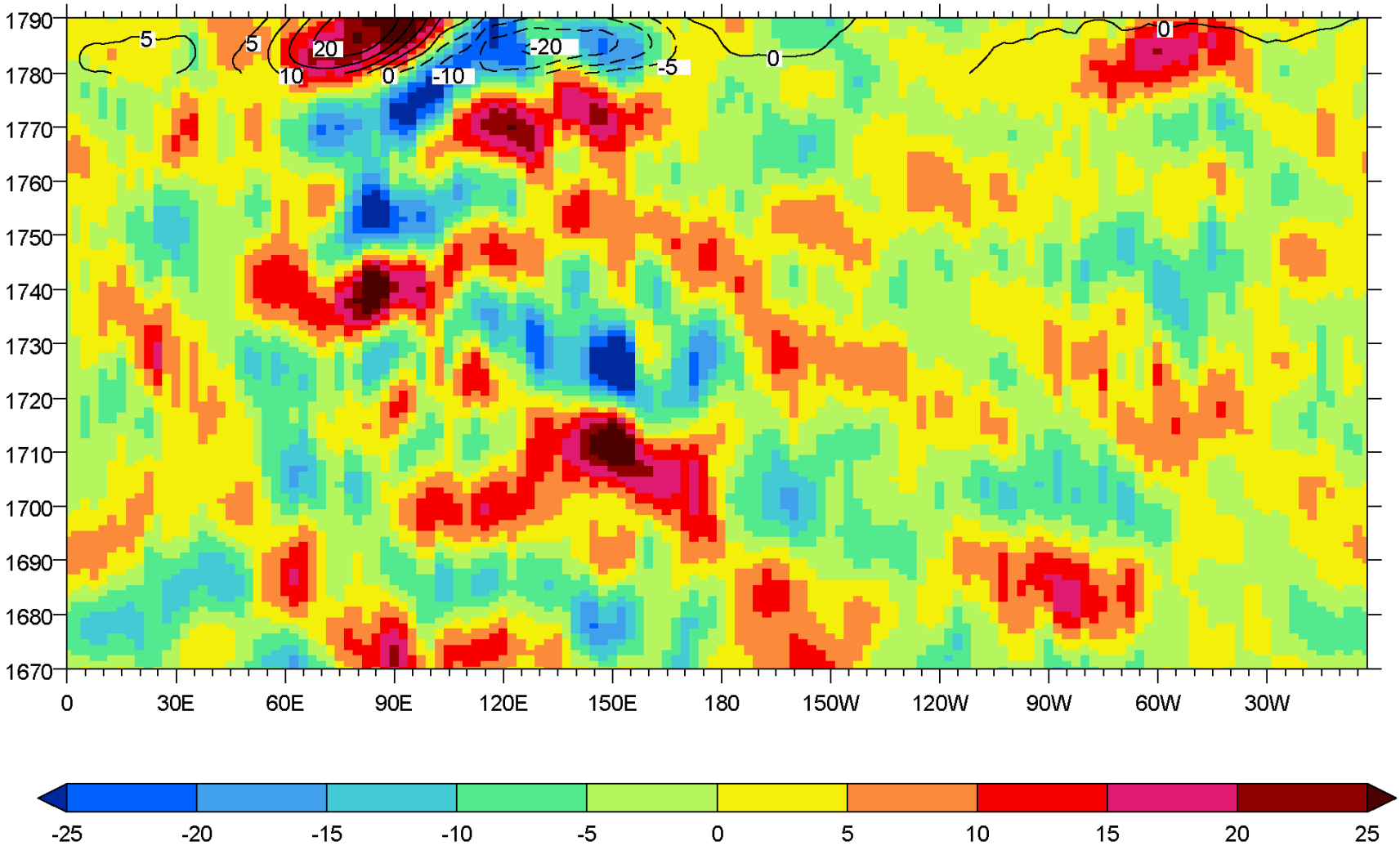

Benefits of the new identification method

- The method provides an improved representation of the propagation of near-equatorial OLR anomalies
- May improve forecasts of MJO and non-MJO intraseasonal variability
- Reduce the incidence of false-positive MJO episodes that arise based on forecasts that only use CEOF's 1-2
- If you are interested in the MJO OLR anomalies, it is best to use EOF's based solely on the OLR, not those from the CEOF approach of Wheeler and Hendon (2004)