

A grayscale satellite image of a tropical cyclone, showing a well-defined eye and spiral cloud bands. The image is framed by a thick red border.

Modulation of Atlantic Basin Tropical Cyclone Activity by the Madden-Julian Oscillation (MJO) Using an Extended MJO Index

Phil Klotzbach
Colorado State University

Eric Oliver
University of Tasmania

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Outline

- § **Background**
- § **Data**
- § **Century-Long Atlantic TC - MJO Modulation (1905-2011)**
- § **MJO –Atlantic TC Modulation by Climate Mode – ENSO and AMO**
- § **Conclusions and Future Work**

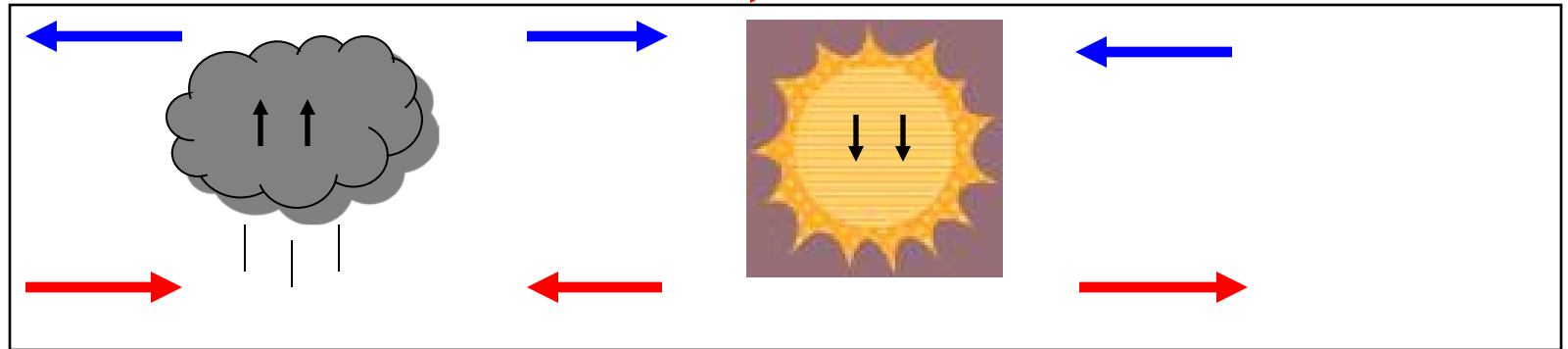
MJO Propagation



200 mb

Day 0

850 mb



Indian Ocean

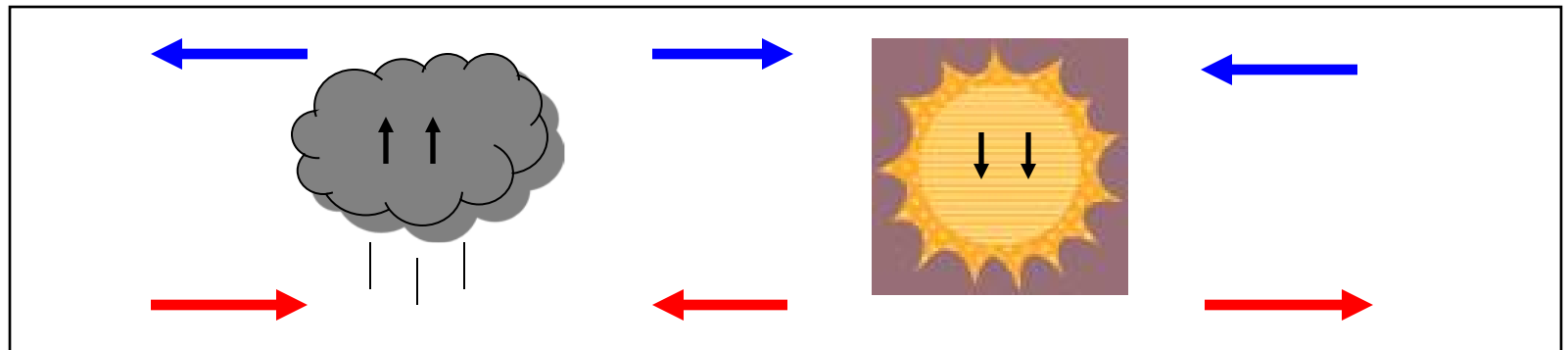
Pacific Ocean

Atlantic Ocean

200 mb

Day 10

850 mb



Indian Ocean

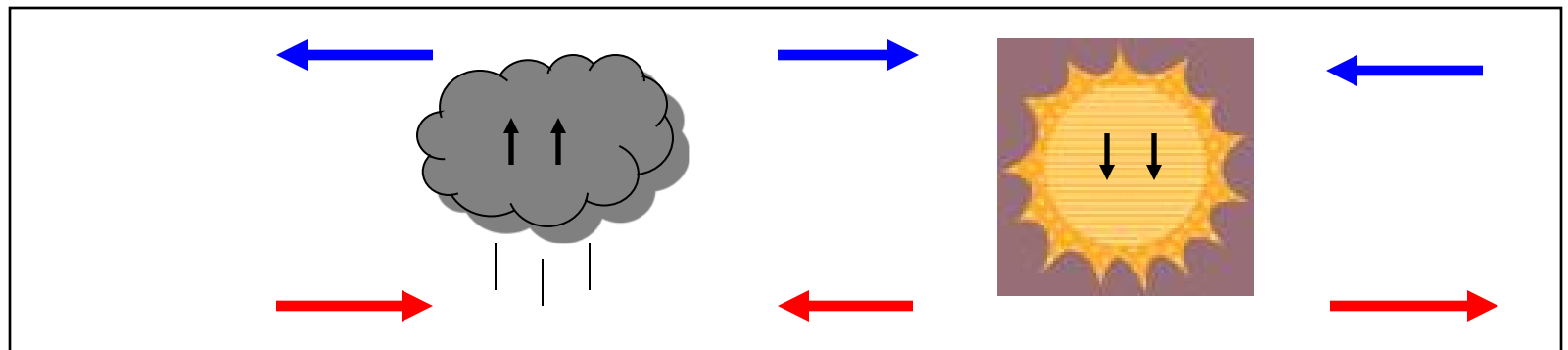
Pacific Ocean

Atlantic Ocean

200 mb

Day 20

850 mb

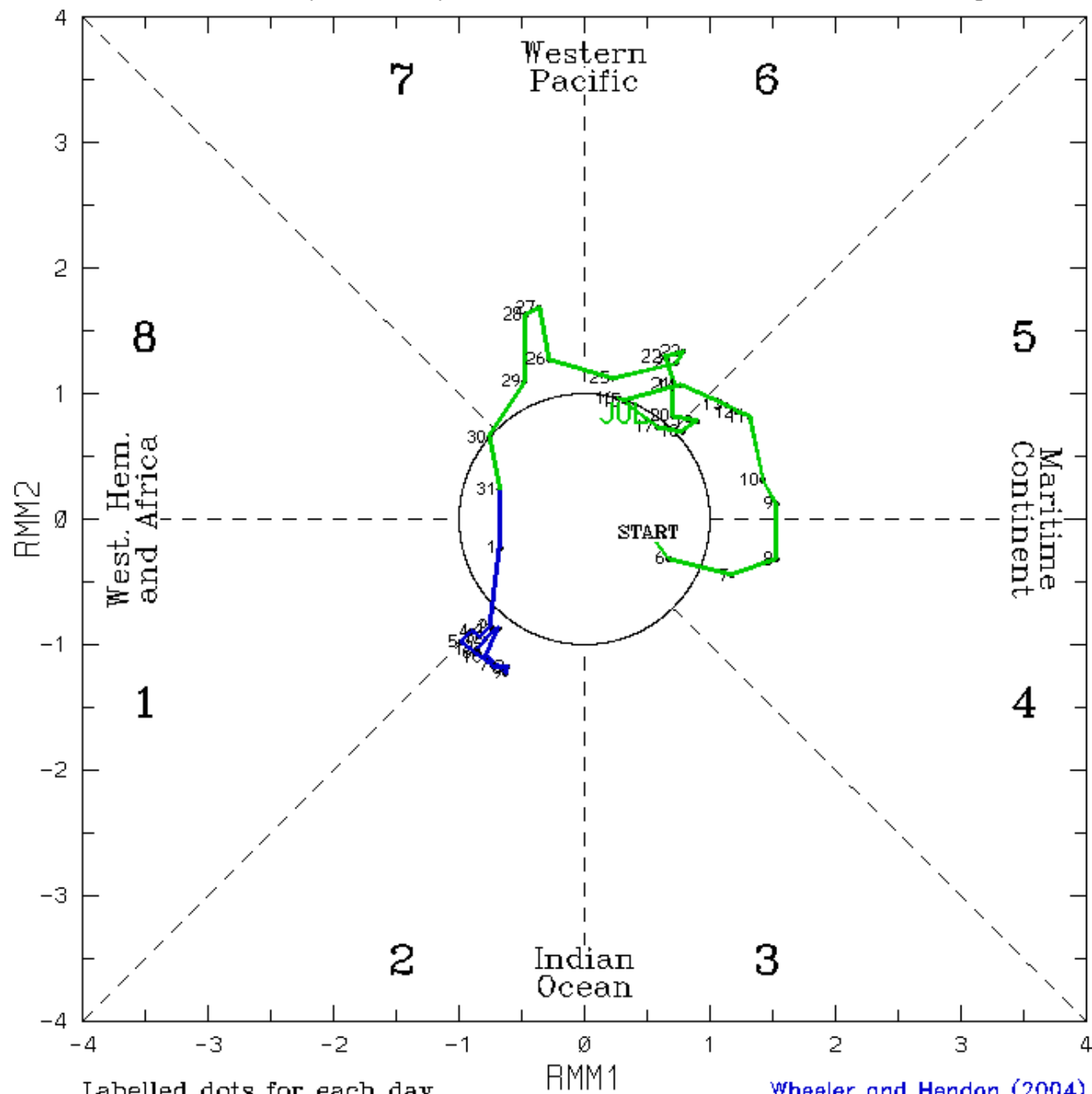


Indian Ocean

Pacific Ocean

Atlantic Ocean

(RMM1,RMM2) phase space for 5-Jul-2014 to 13-Aug-2014



Labelled dots for each day.

Blue line is for Aug, green line is for Jul.

Wheeler and Hendon (2004)

CAWCR/Bureau of Meteorology

Background

- Several studies have documented MJO modulation of TC activity in the Atlantic (e.g., Maloney and Hartmann 2000, Barrett and Leslie 2009, Camargo et al. 2009, Klotzbach 2010, Ventrice et al. 2011)
- General consensus is that TC activity in the Atlantic is enhanced in MJO Phases 1-2, while it is suppressed in MJO Phases 6-7
- Studies are typically calculated based on the Wheeler-Hendon MJO Index (extends back to 1974) – uses 200-850-hPa wind and OLR

Research Question

Can a long-period MJO dataset be used to analyze MJO modulation of Atlantic basin TC activity over the past century?

Extended MJO Dataset (1905-2011)

- Documented in Oliver and Thompson (2012) – utilizes surface pressure from 20th Century Reanalysis to reconstruct an MJO index
- 120-day mean removed – eliminates most of the ENSO signal

20th Century Reanalysis

- Documented in Compo et al. (2011) – assimilates surface pressure, sea surface temperature and sea ice
- Uses Ensemble Kalman filter to arrive at most likely state of the atmosphere

HURDAT2

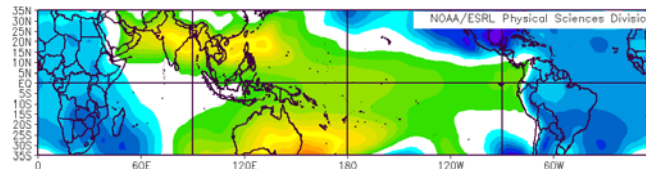
- Provides six-hourly estimates of Atlantic basin tropical cyclone intensity and location for all systems since 1851
- Data from 1851-1945 has recently been analyzed and revised – revised data from 1905-1945 used in this analysis

Extended Multivariate ENSO Index

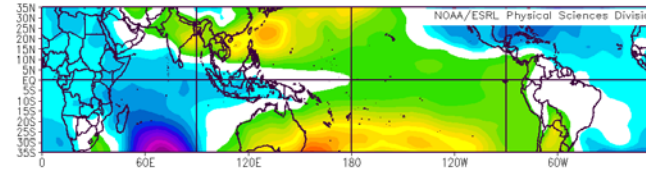
- Documented in Wolter and Timlin (2011) – 0.75 used as threshold – uses SLP, U and V wind, SST, surface temperature and cloudiness to define ENSO

JASO SLP Anomaly – WH MJO Index (1979-2011)

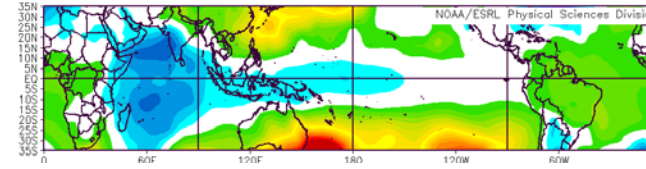
Phase 1



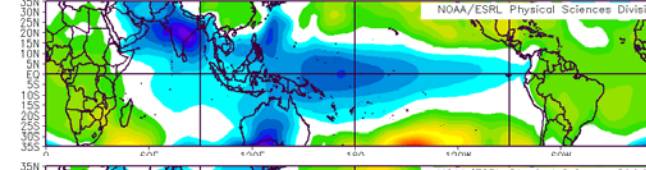
Phase 2



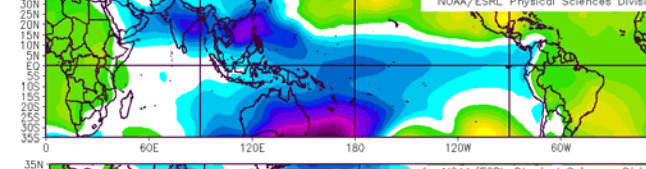
Phase 3



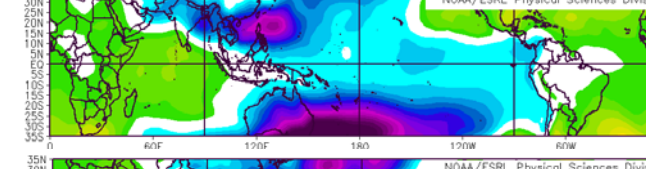
Phase 4



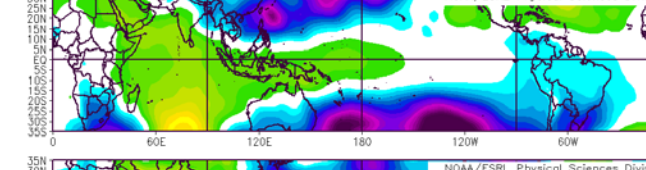
Phase 5



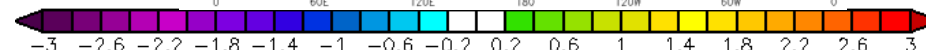
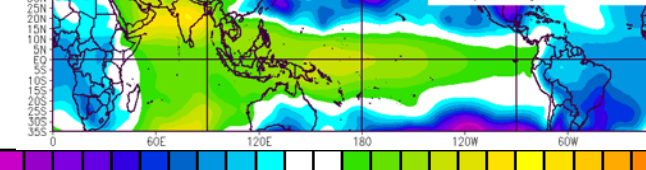
Phase 6



Phase 7

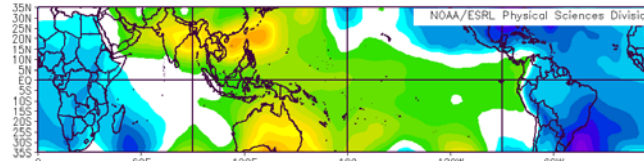


Phase 8

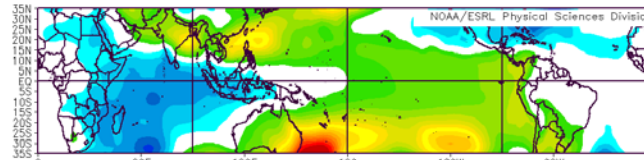


JASO SLP Anomaly – Extended MJO Index (1979-2011)

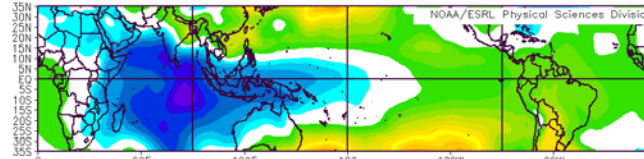
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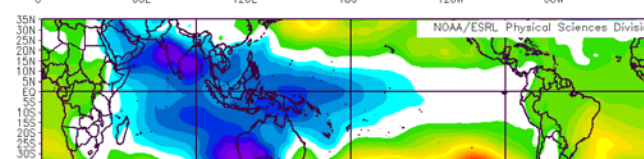
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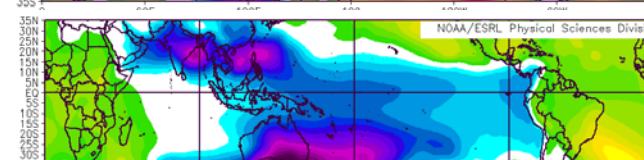
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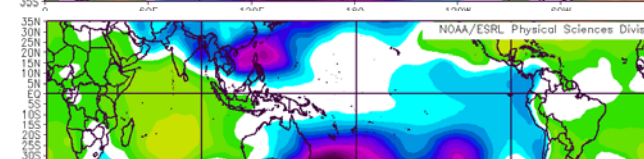
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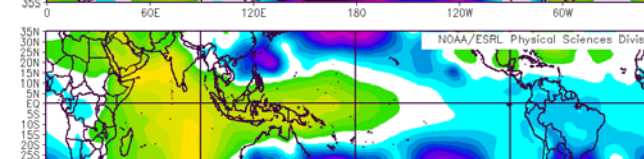
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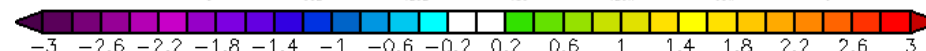
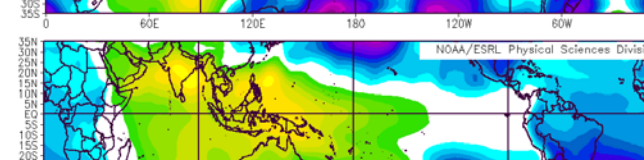
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Phase 7

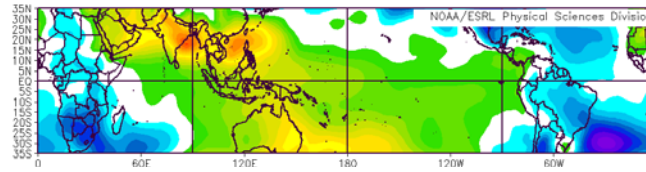


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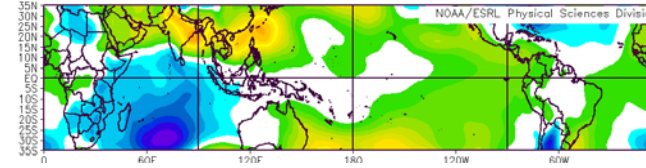


JASO SLP Anomaly – Extended MJO Index (1905-1978)

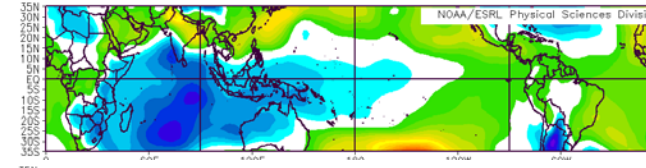
Phase 1



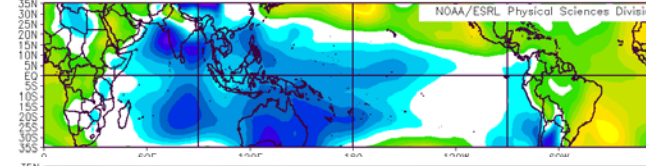
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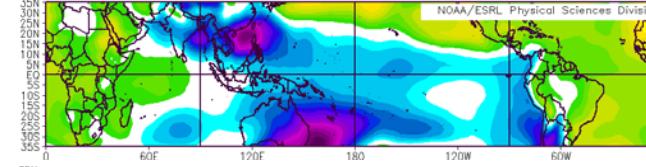
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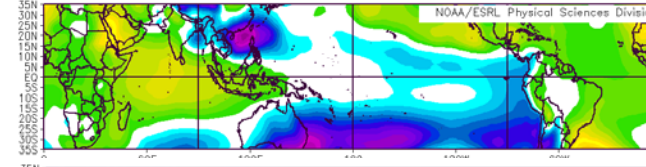
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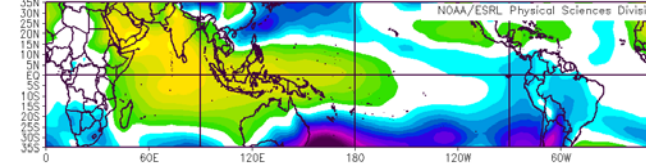
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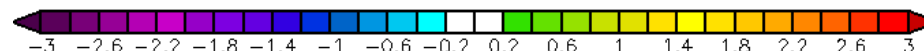
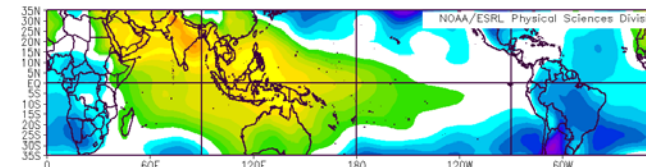
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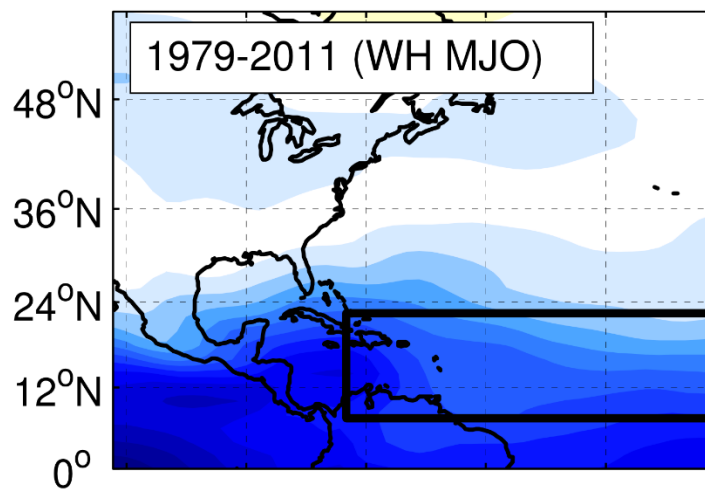
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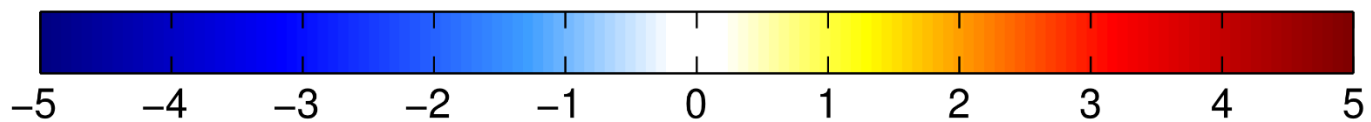
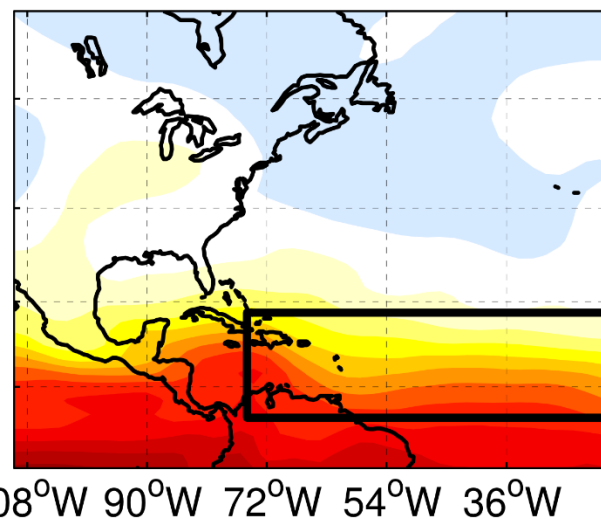
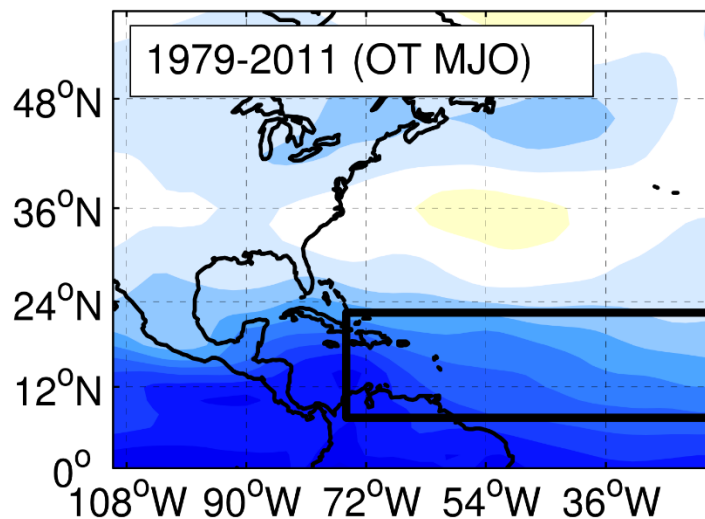
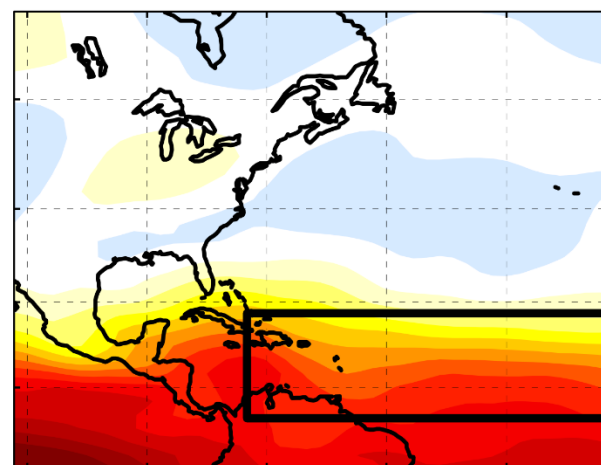
Phase 8



MJO Phases 1-3



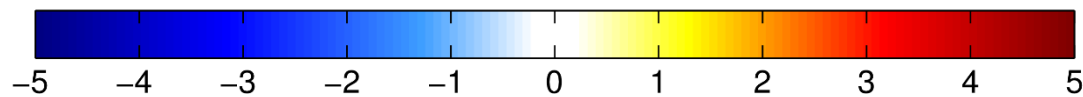
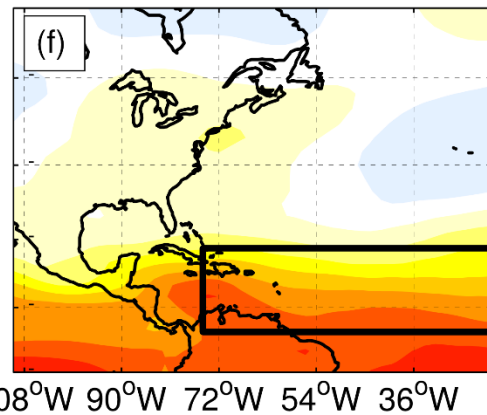
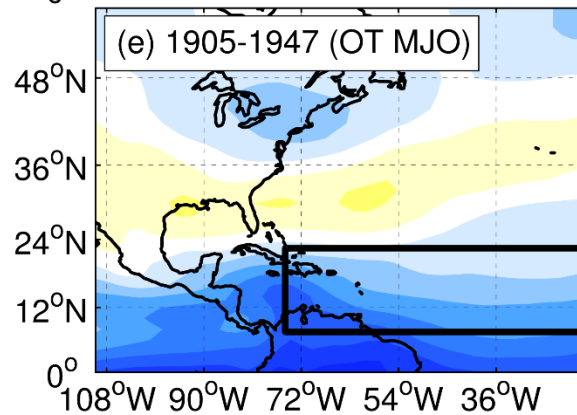
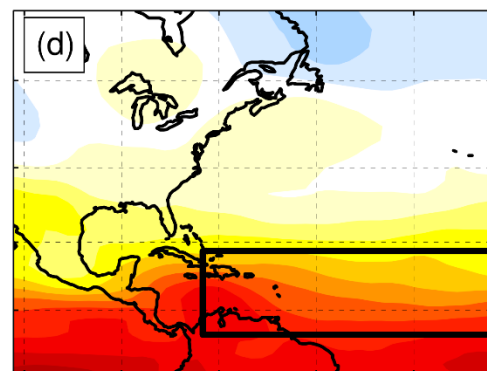
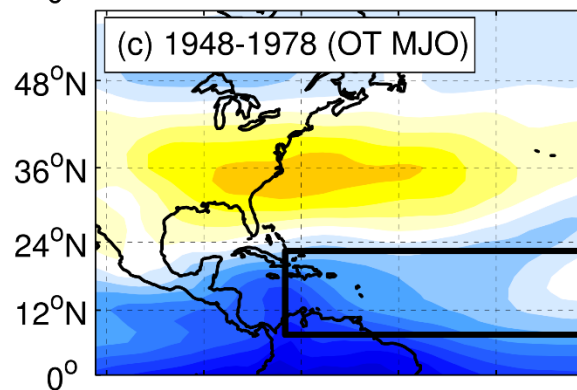
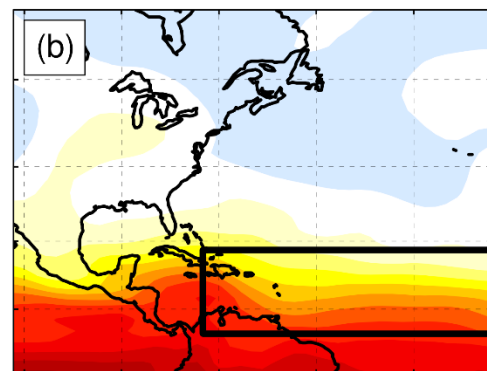
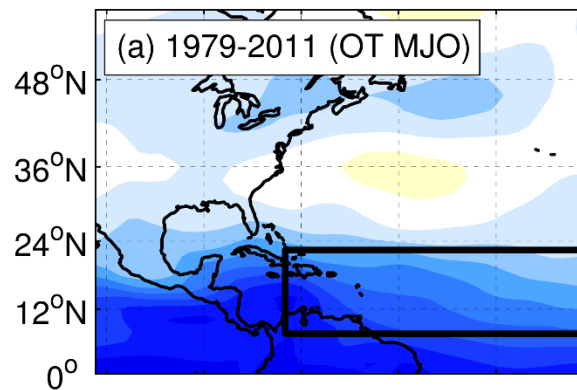
MJO Phases 5-7



Vertical shear of zonal wind [m/s]

MJO Phases 1-3

MJO Phases 5-7

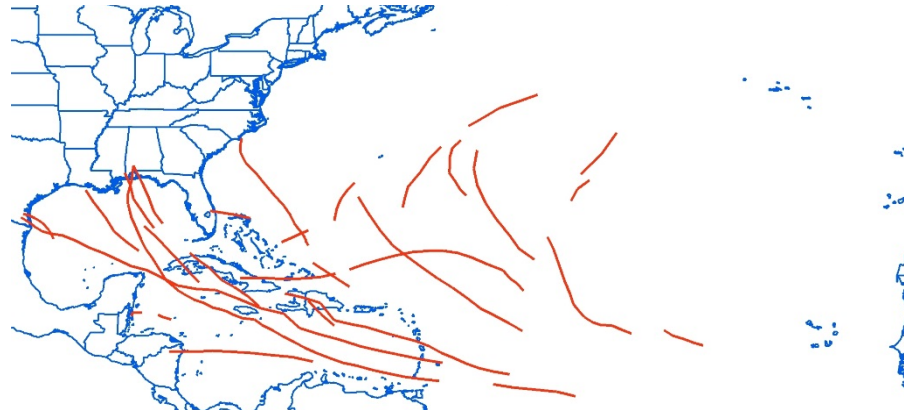


Vertical shear of zonal wind [m/s]

1979-2011 Wheeler-Hendon MJO > 1

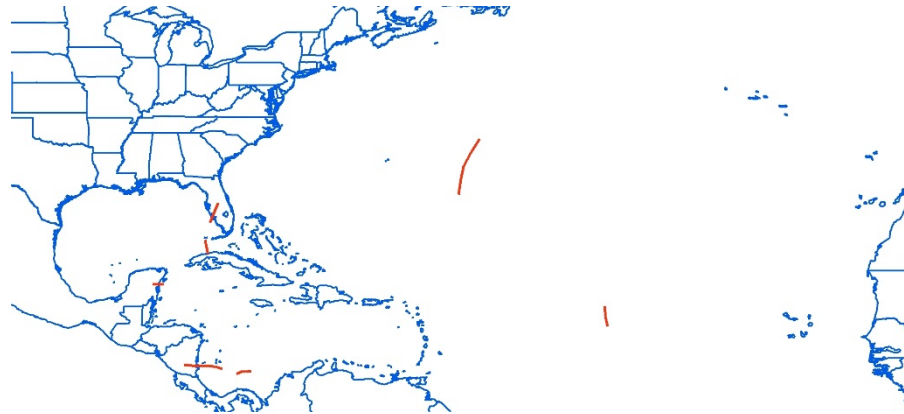
MJO Phases 1-2

25 MH, 57.5 MHD



MJO Phases 6-7

5 MH, 4.25 MHD



Normalized Ratio

3.2:1 MH, 8.6:1 MHD

1979-2011 Extended MJO > 1

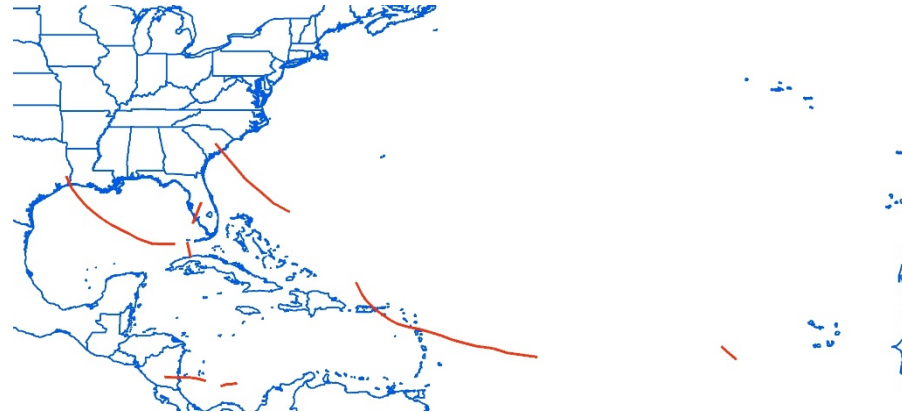
MJO Phases 1-2

20 MH, 37.25 MHD



MJO Phases 6-7

6 MH, 13.75 MHD



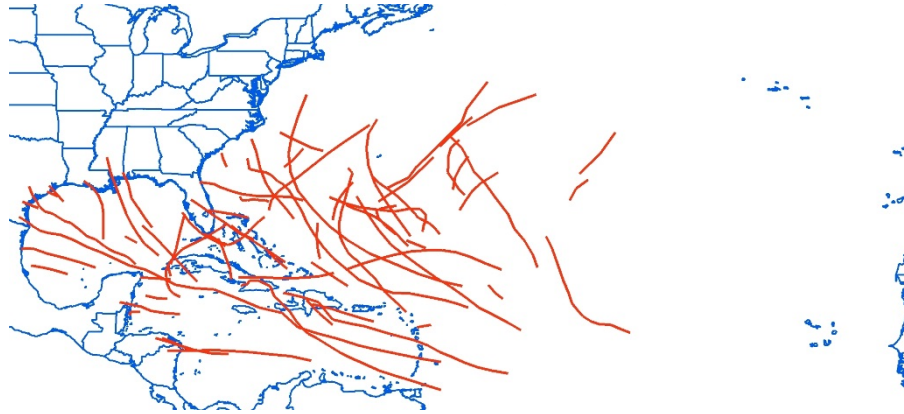
Normalized Ratio

2.4:1 MH, 2.0:1 MHD

All Years (1905-2011) Extended MJO > 1

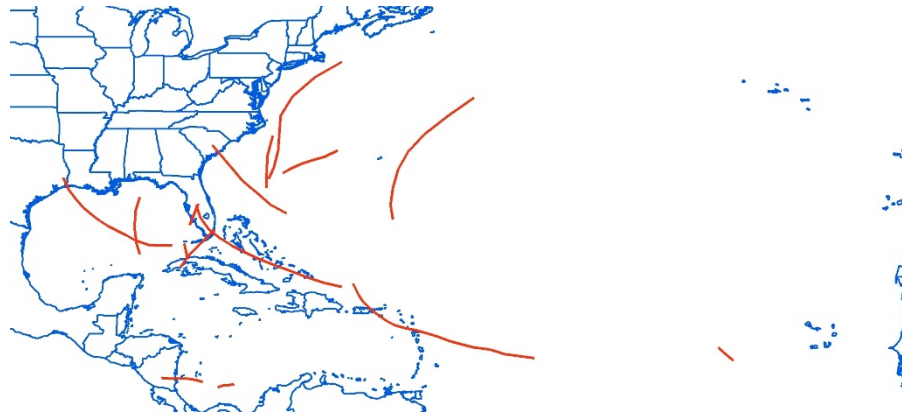
MJO Phases 1-2

60 MH, 133 MHD



MJO Phases 6-7

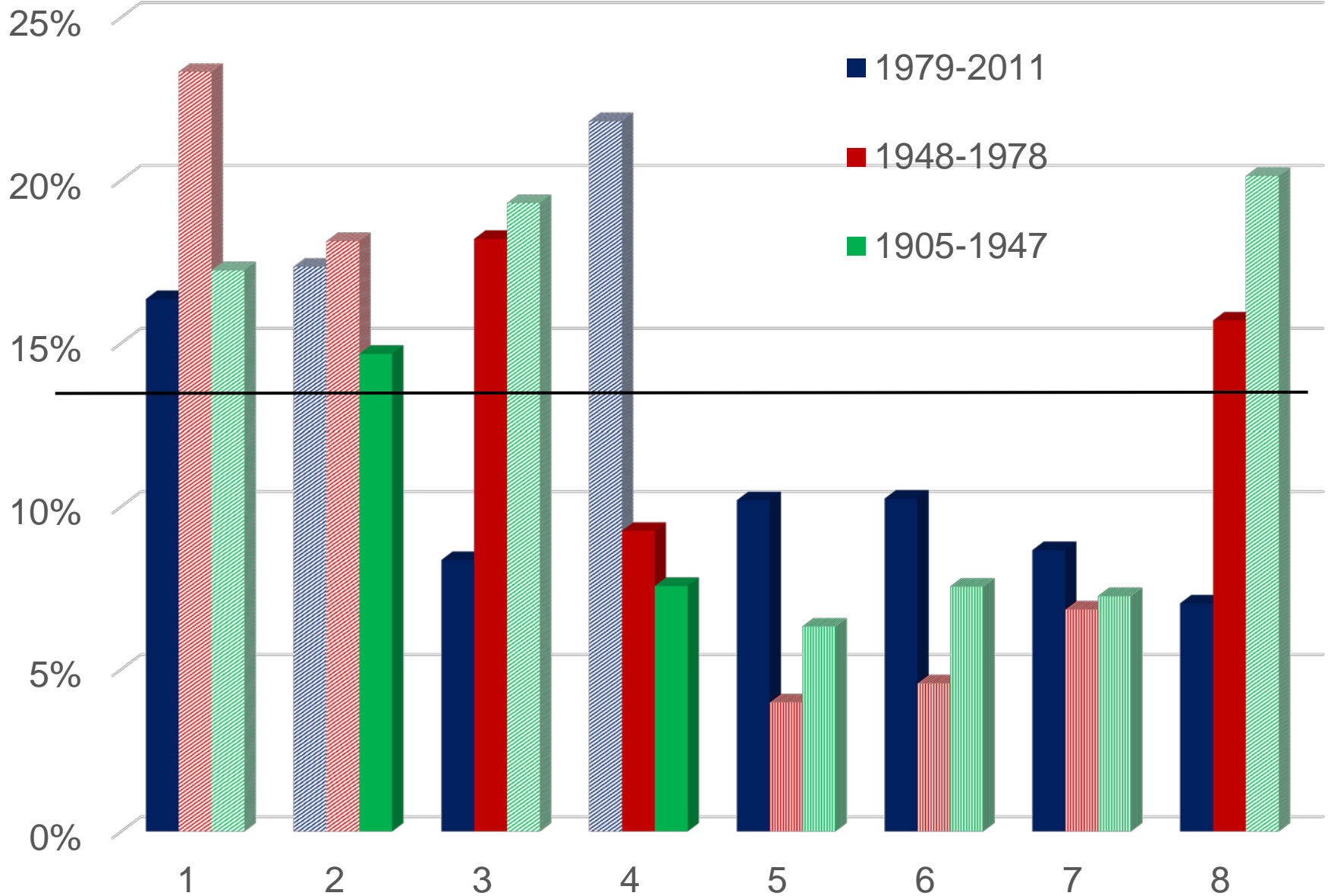
14 MH, 26.75 MHD



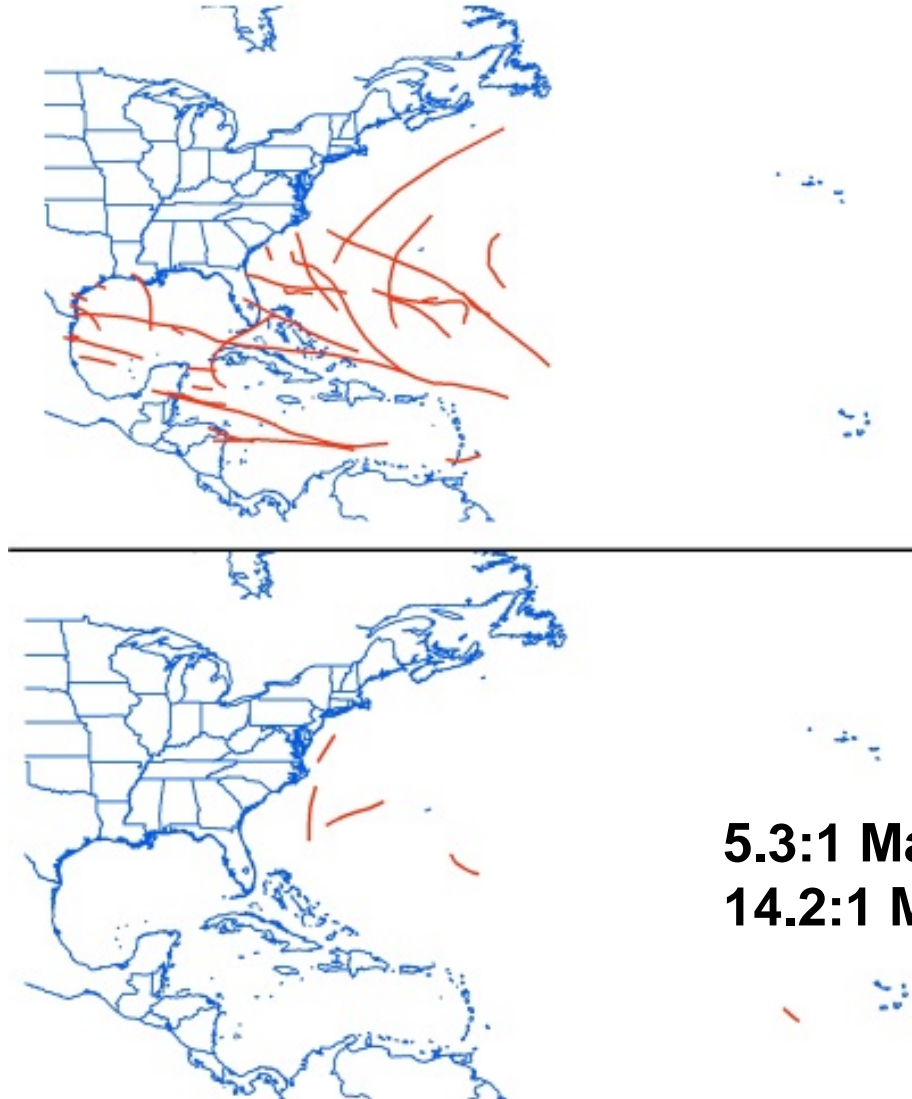
Normalized Ratio

3.0:1 MH, 3.4:1 MHD

Atlantic TC Activity Generated in each MJO Phase

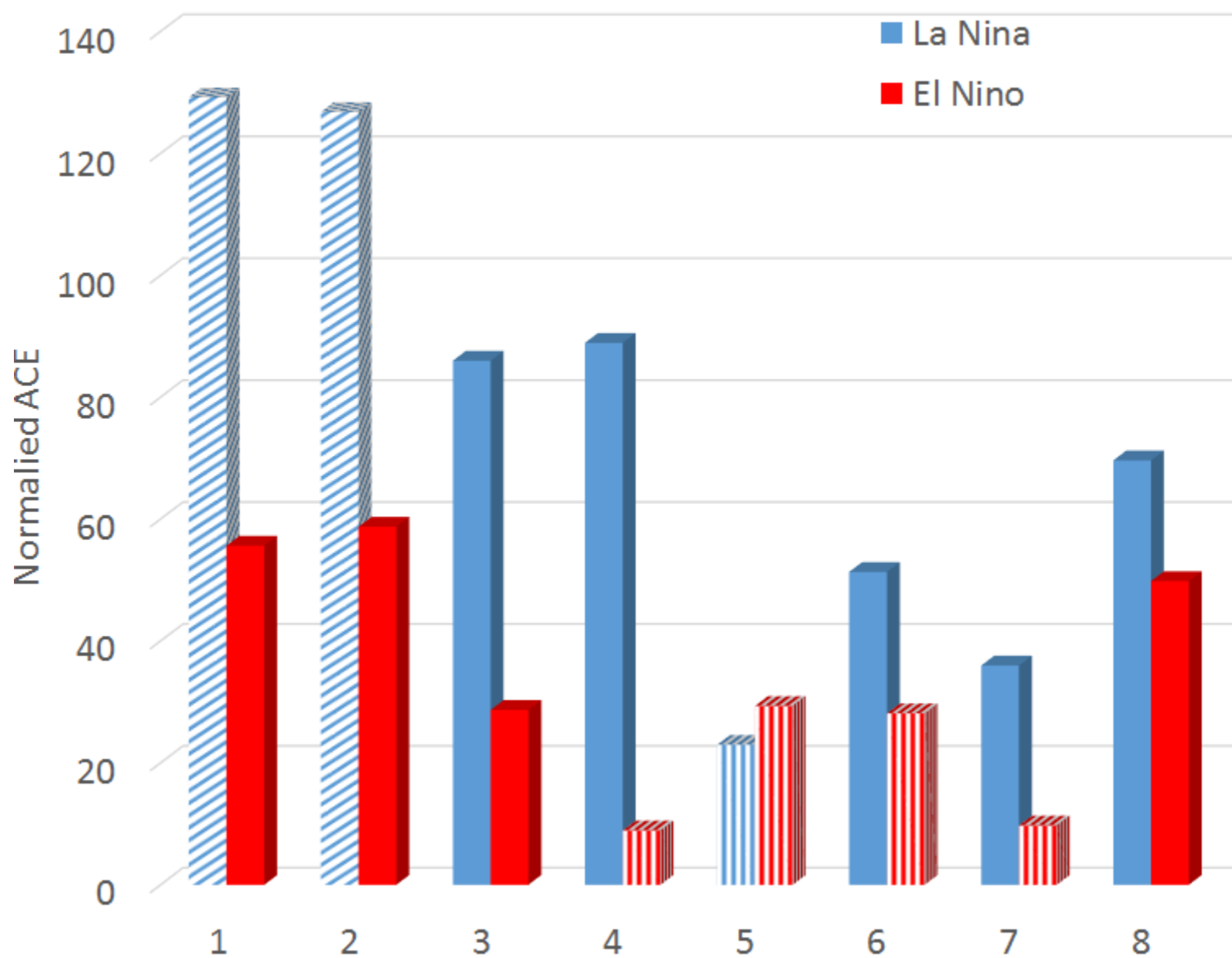


Major Hurricane Tracks in MJO Phase 1-3+La Nina vs. MJO Phase 5-7+El Nino



5.3:1 Major Hurricane
14.2:1 Major Hurricane Day

Atlantic TC Activity Stratified by MJO+ENSO

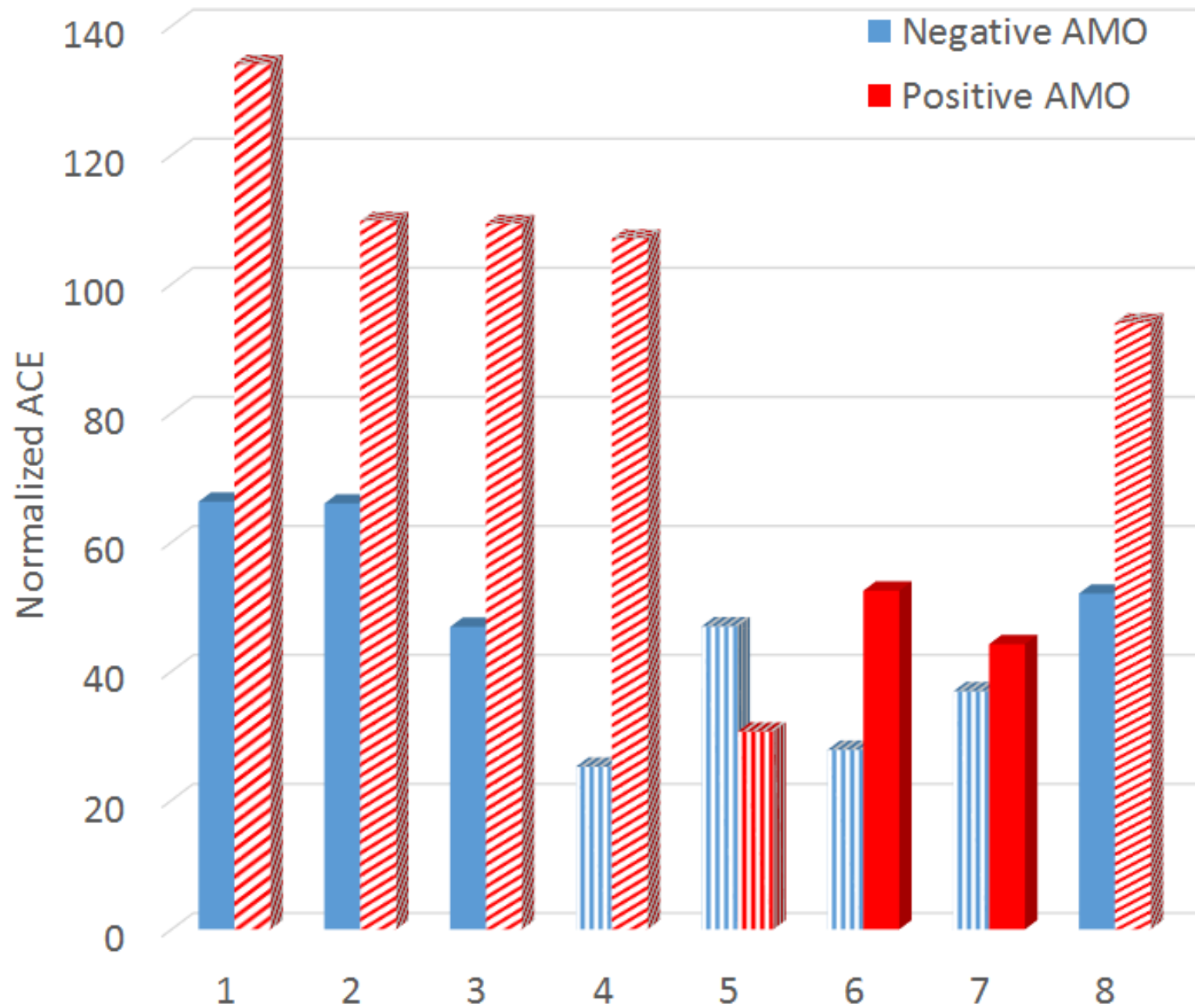


Major Hurricane Tracks in MJO Phase 1-3+Positive AMO vs. MJO Phase 5-7+Negative AMO



3.7:1 Major Hurricane
4.2:1 Major Hurricane Day

Atlantic TC Activity Stratified by MJO+AMO



Conclusions

- The extended MJO dataset shows robust relationships with Atlantic basin TC activity over the past 100+ years
- The MJO-Atlantic TC activity relationship appears to be modulated on seasonal timescales by ENSO and on multi-decadal timescales by the AMO

Future Work

- Examine long period MJO modulation on Atlantic basin landfalls
- Look at global TC modulation by the extended MJO using longer-period historical TC datasets