

Dependence of the MJO propagation speed on SST and its reproducibility on NICAM-AMIP run

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Talk overview

PART I - Analysis on dependence of MJO propagation speed on SST

- Introduction
- Motivation
- Methods
- Results
- Summary

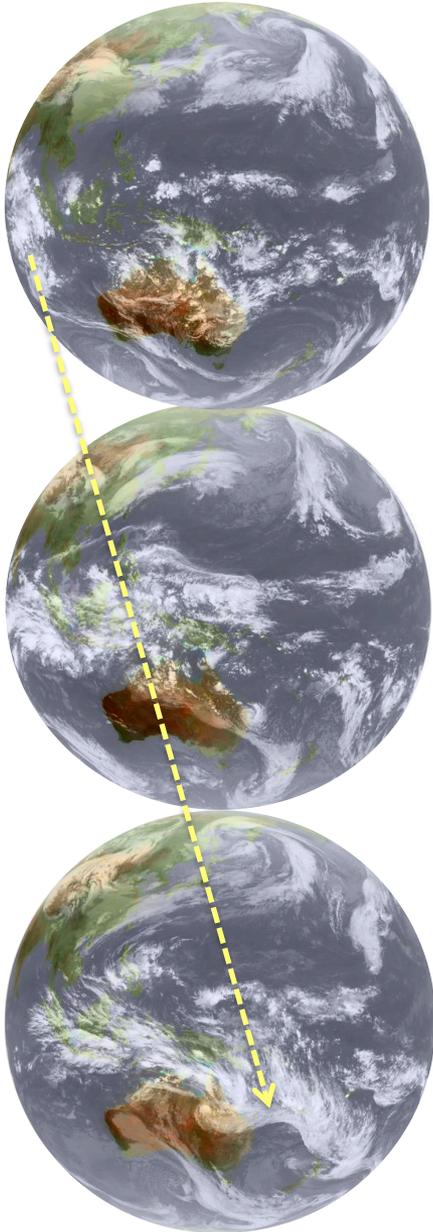
PART II - Assessment of NICAM- AMIP run

- Introduction of the NICAM-AMIP run
- MJOs in NICAM-AMIP MJO events
- Discussions
- Summary

PART I

Analysis on dependence of MJO
propagation speed on SST

Introduction



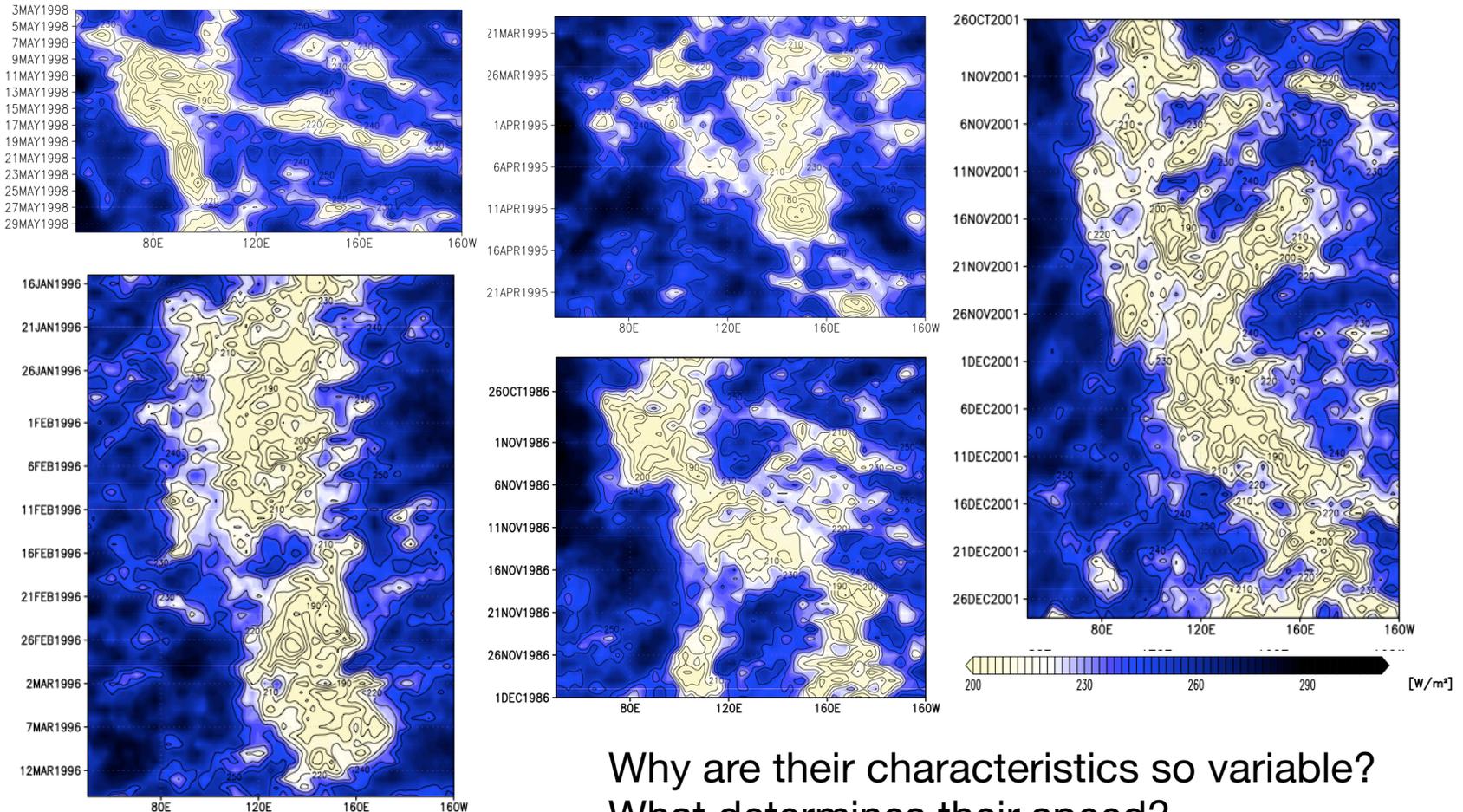
Madden Julian Oscillation

Dominant intraseasonal variability in the tropics characterized by slowly eastward propagating convective activity in 30-60 days

Introduction

MJO comes in many variations...

Events of eastward moving convective activities are highly variable



Why are their characteristics so variable?
What determines their speed?
How should they be defined ?

Motivation

Can systematic variability of MJO be explained by focusing on the differences in the propagation speed?



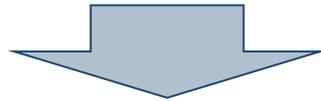
1. Construct an MJO detection method on RMM phase space based on simple assumptions of conventional MJO properties
2. Track MJO convection on OLR hovmoller and determine MJO propagation speed
3. Examine relationship between MJO propagation speed and SST distribution

Method

Detecting MJO events

Data

- NOAA Interpolated Outgoing Longwave Radiation
2.5×2.5 degrees resolution
- NCEP/NCAR Reanalysis1 daily mean
zonal wind at 200hPa and 850hPa horizontal winds
2.5×2.5 degrees resolution



Calculate the Wheeler and Hendon (2004) RMM index

- NOAA's Optimum Interpolated Sea Surface Temperature V2
0.25×0.25 degrees resolution
⇒ reduced to 2.5×2.5 degrees by 100 points area averaging

Incorporating continuity to RMM sequence

MJO Criteria on RMM phase space

1. Proceed from phase 2 to phase 7
2. Does not skip more than 1 phase
3. Does not recede more than 1 phase
4. Average RMM amplitude is greater than 0.8
5. Consecutive days with amplitude less than 0.8 under 15 days
6. Tracking is completed between 20-90 days



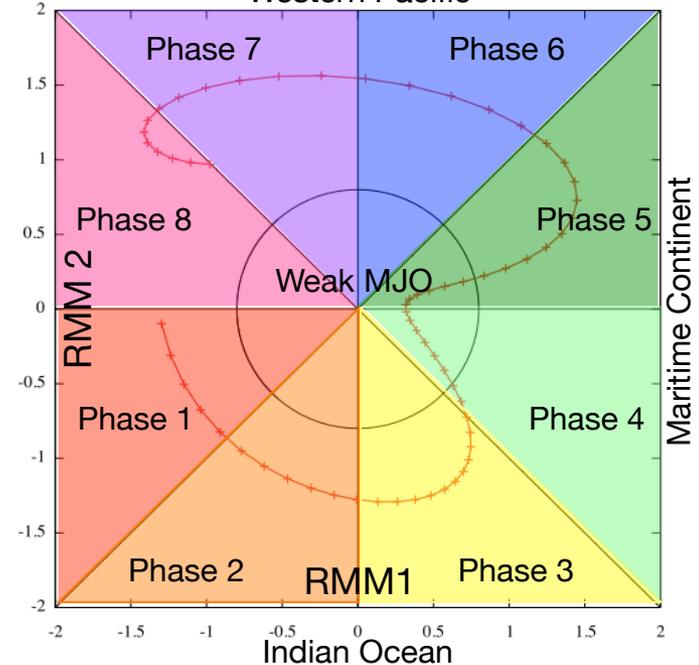
Physical meaning of MJO Criteria

- Convective activity propagates from Indian Ocean to Western Pacific
- Continuity of propagation of convective activity in space
- Dismiss major westward propagating convective activity
- Maintenance of typical MJO structure
- Completion of an event in an intraseasonal time scale

RMM Trajectory of an MJO Event

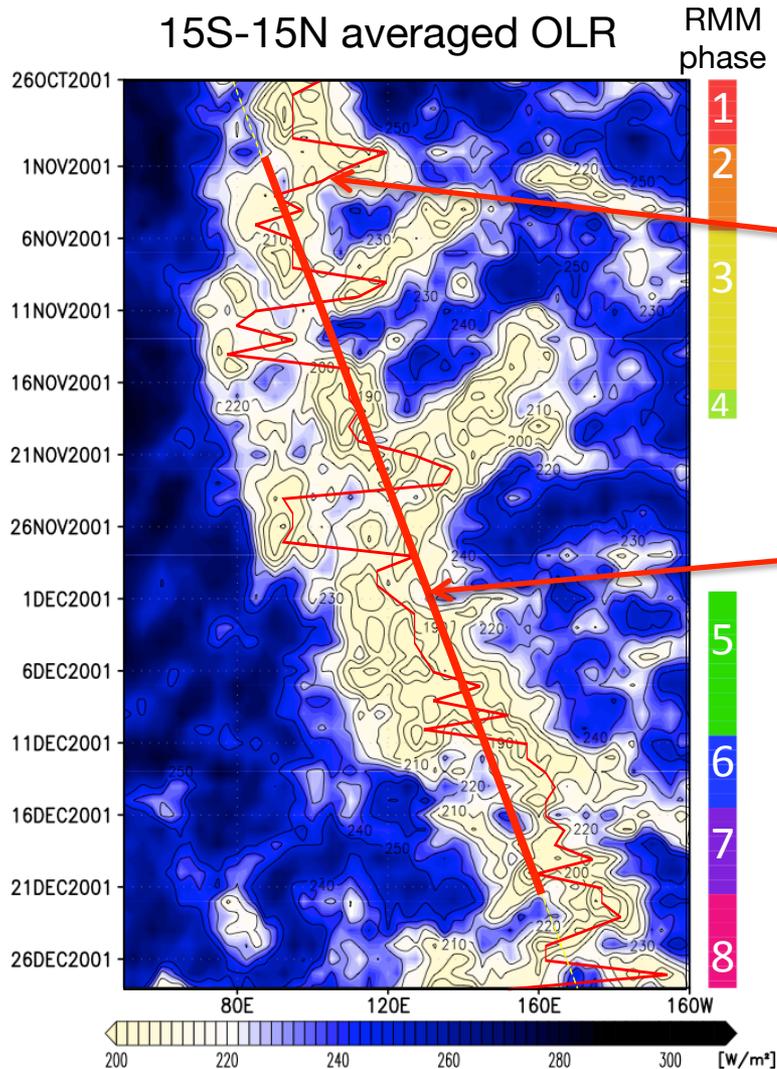
26 Oct 2001- 28DEC2001

Western Pacific



Tracking MJO

Calculate MJO speed and confirm convective activity

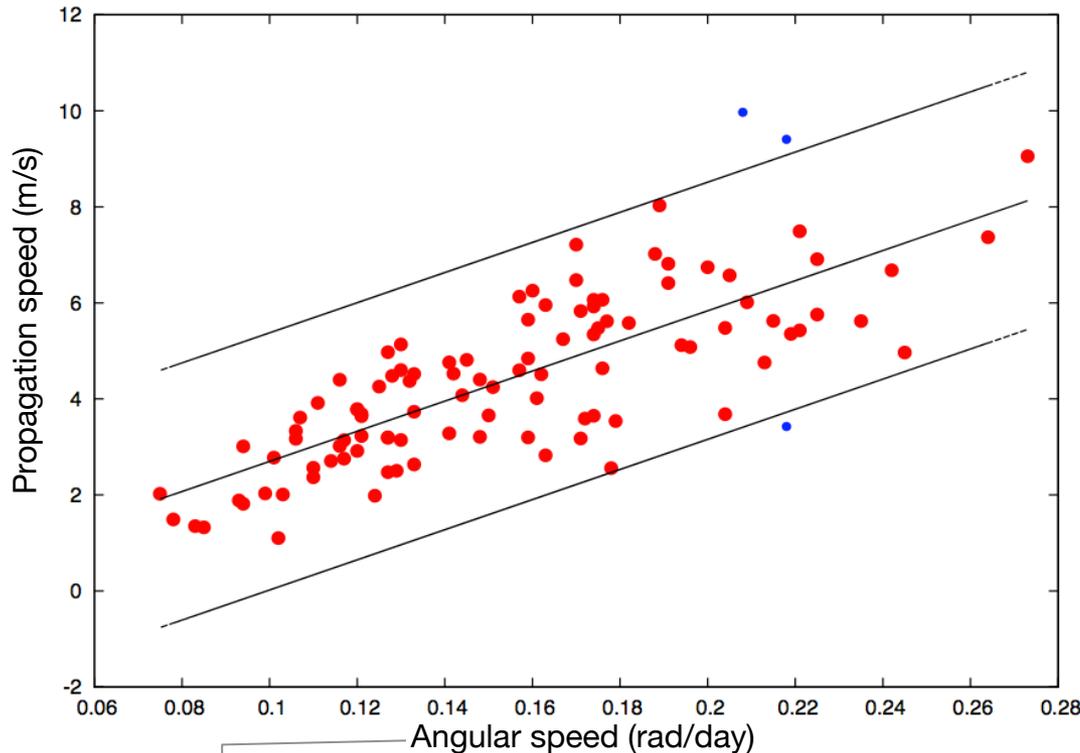


- Daily tracking of longitude of minimum OLR
 - 50E - 120E for phases 1-4
 - 120E - 150E for phases 4-5
 - 150E - 140W for phases 5-8
- Calculate the regression line of the tracking
- Statistical test of the regression line at 95% confidence level

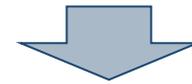
Selecting MJO events

Propagation Speed & Angular Speed should have linear relationship!

Average propagation speed and angular speed of MJO events



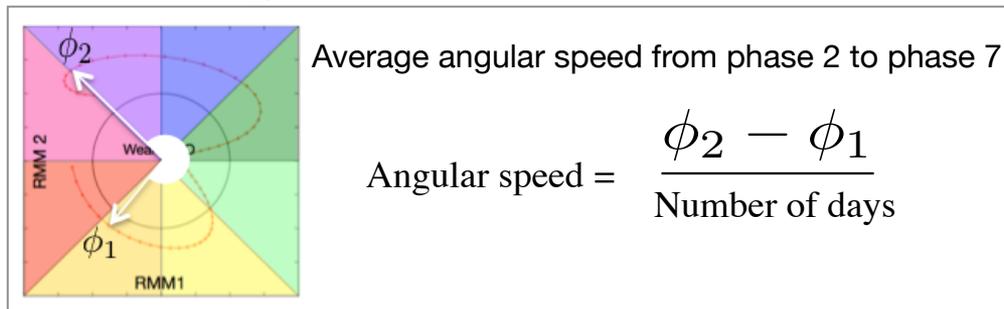
Average speed of eastward propagation of convection calculated from minimum OLR tracking and average angular speed on the RMM phase space should have linear relationship to be consistent with each other



1. Calculate regression line of propagation speed and angular speed
2. Remove events farther than the regression line by 2 standard deviation of the residual

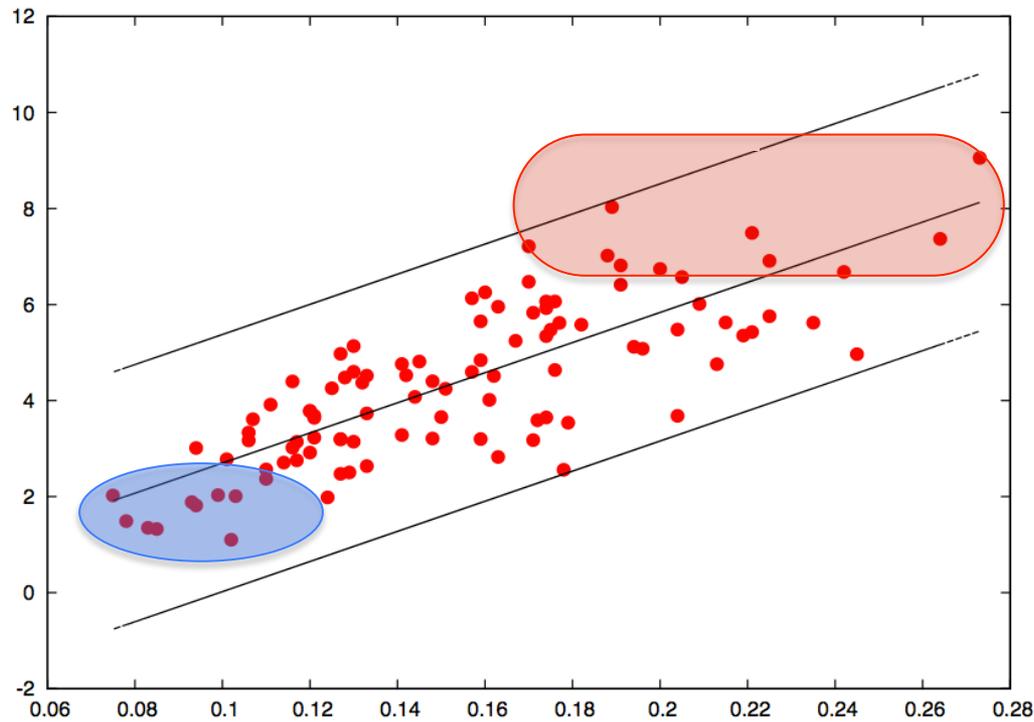


102 MJO events
1982-2012



Results

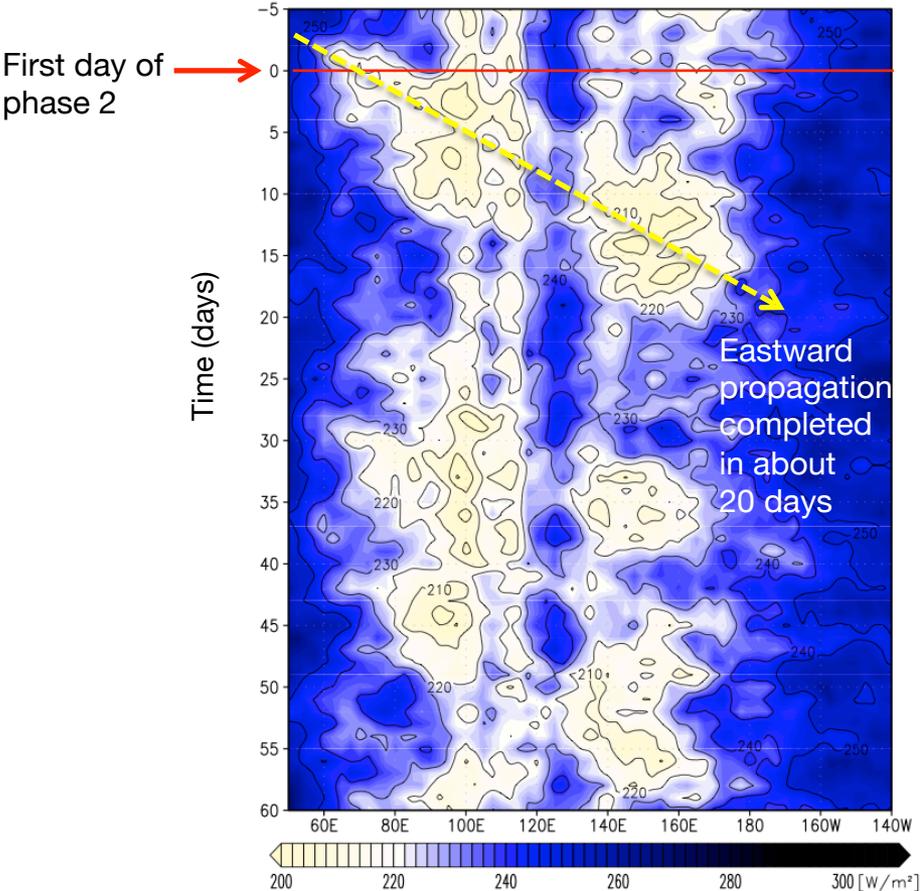
How are **Fast** and **Slow** MJOs different?



Comparing 10 fastest and 10 slowest events...

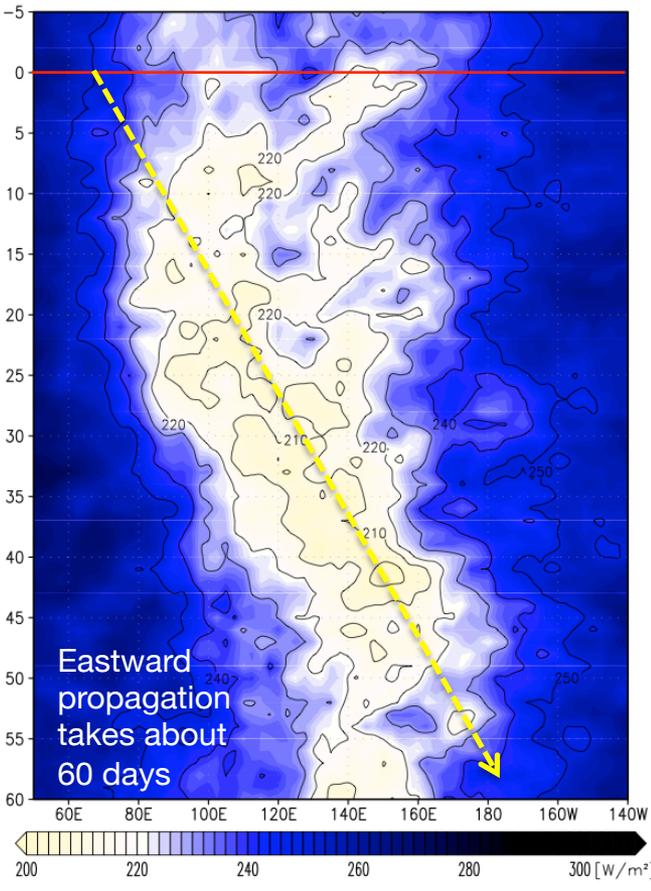
Composite OLR Hovmoller of 10 fastest and 10 slowest events

FAST MJO



Average speed 7.3 m/s

SLOW MJO



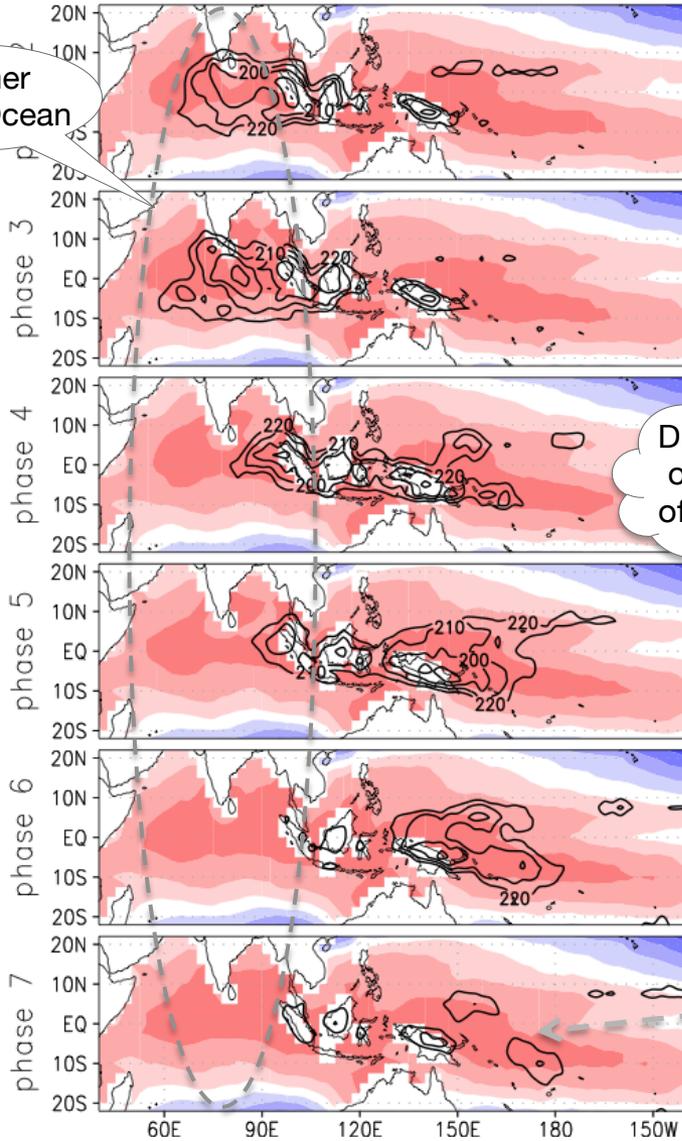
Average speed 1.7m/s

Phase composites of 10 fastest and 10 slowest events

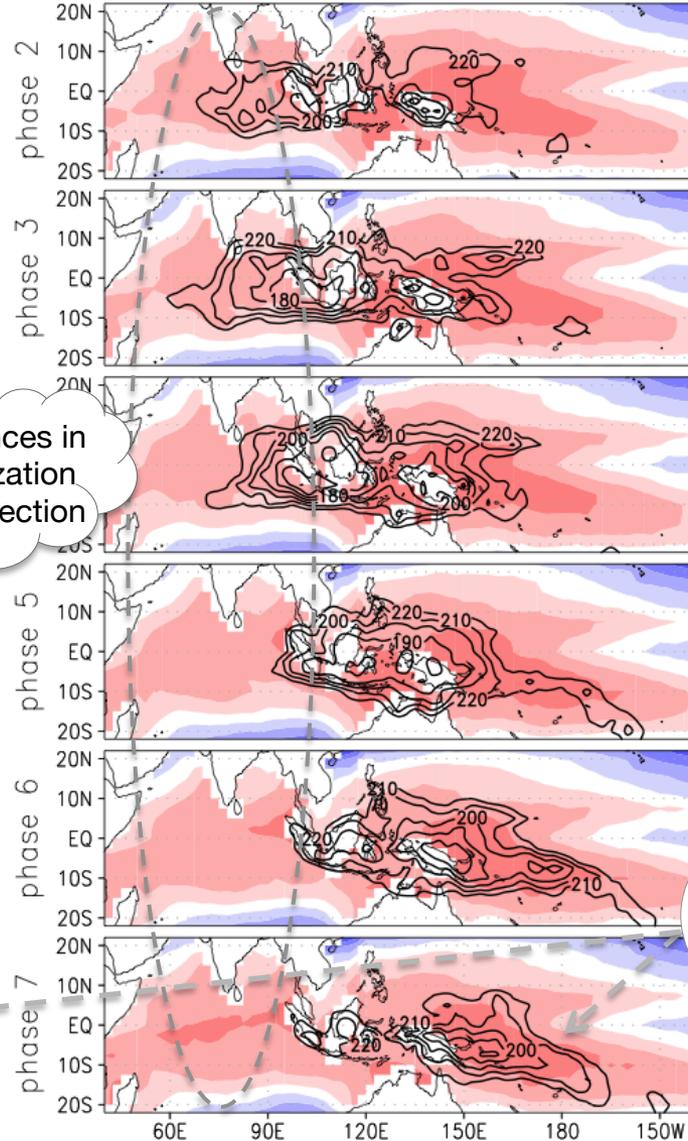
Fast MJO

Slow MJO

Warmer Indian Ocean



Differences in organization of convection



Convective activity persists in to later phases in slower events



Contour: OLR W/m²

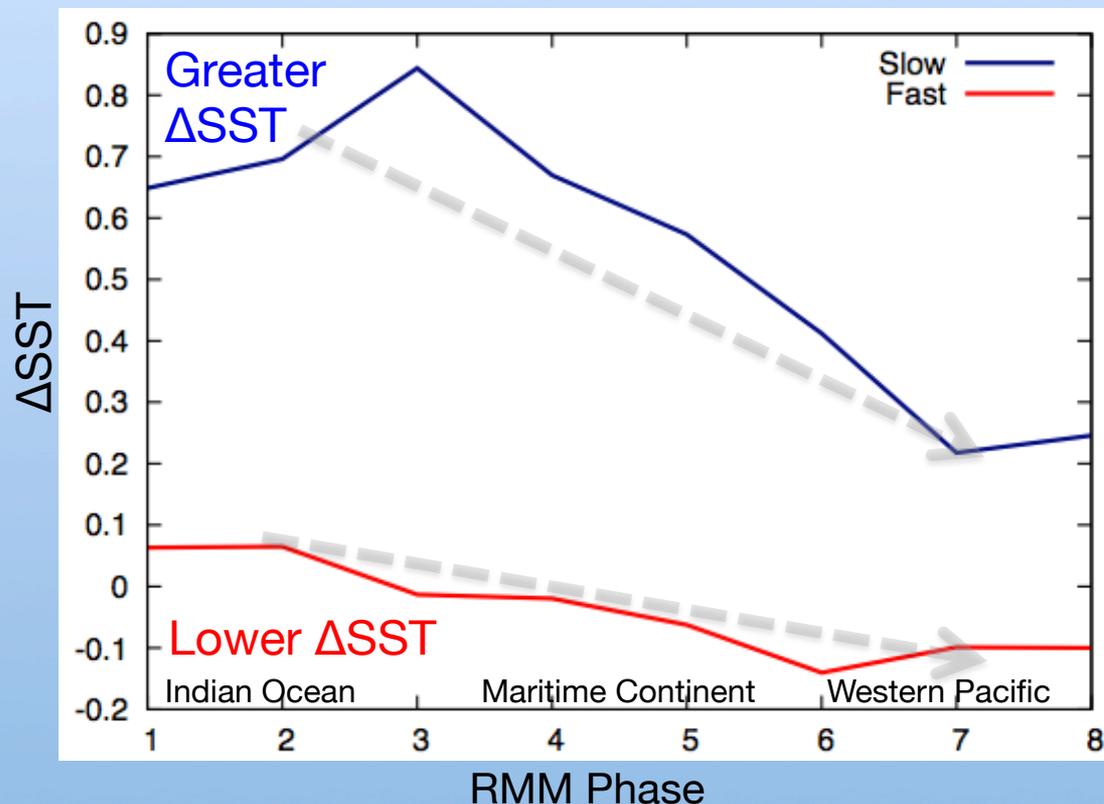
Zonal SST difference and propagation speed

Define ΔSST to evaluate the zonal SST difference between the Western Pacific and the Indian Ocean

$$\Delta SST = \overline{SST}(WP) - \overline{SST}(IO)$$



Evolution of ΔSST for Fast and Slow events

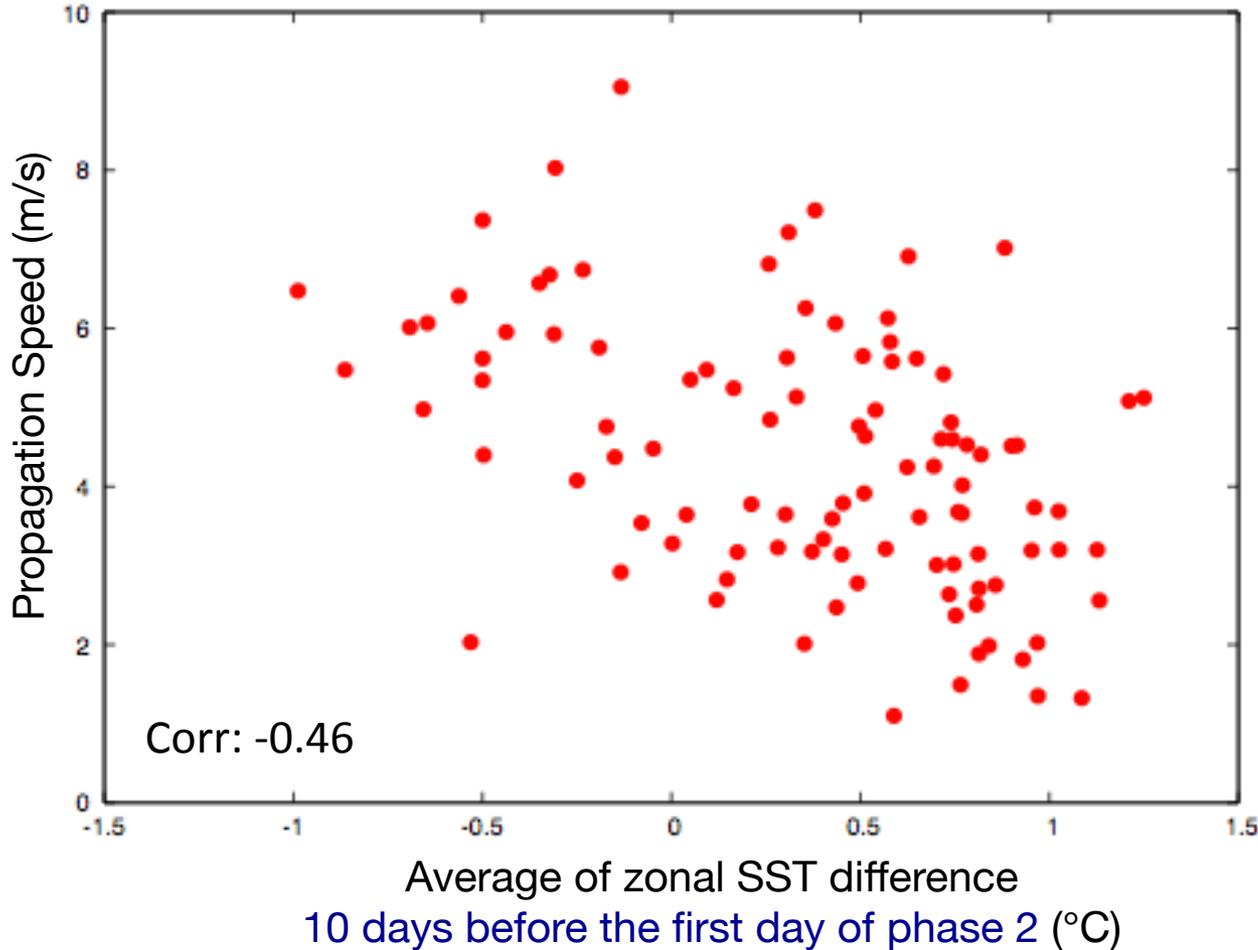


Slower events starts off with greater ΔSST than the faster events

ΔSST and difference of ΔSST between fast and slow events diminishes towards later phases

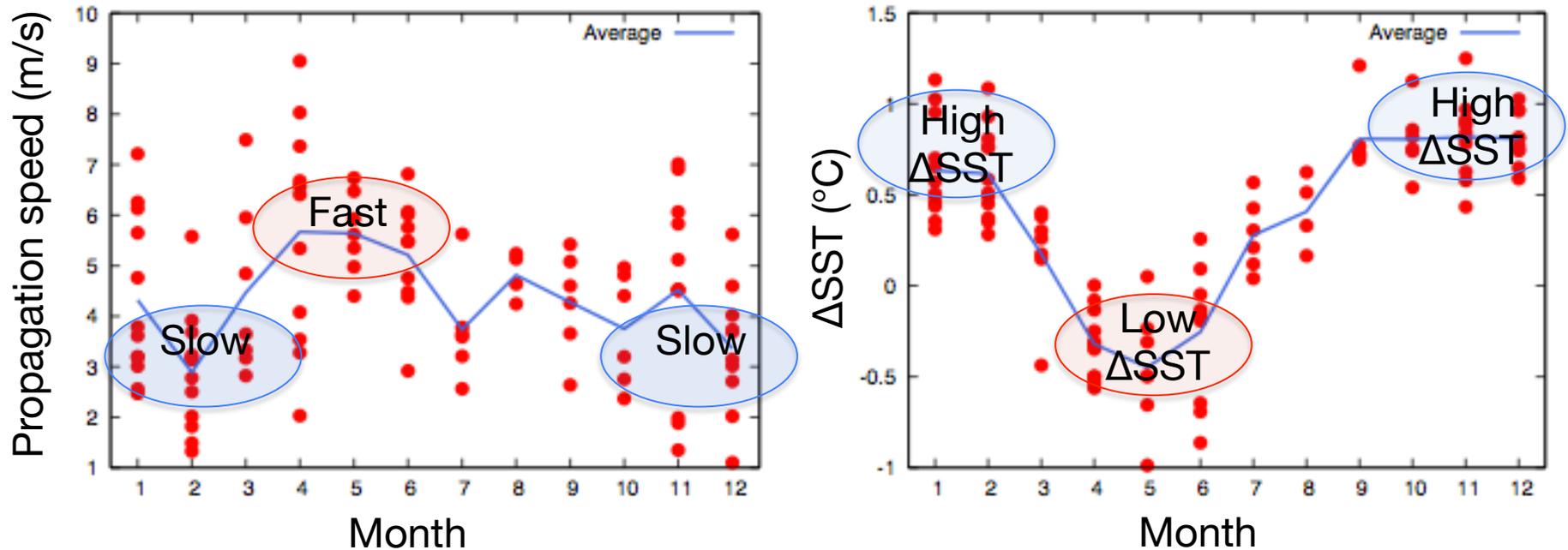
Zonal SST difference and propagation speed

Δ SST and Propagation Speed of All Events



MJO propagation speed seems to have negative correlation with the initial value of Δ SST

Seasonality of zonal SST difference and propagation speed

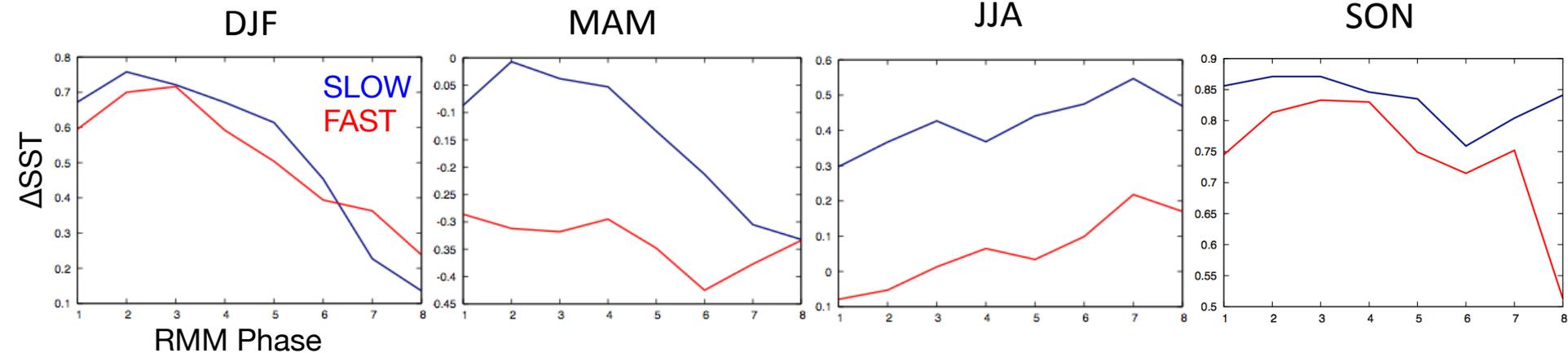


Strong seasonal cycle in ΔSST

Fastest month corresponds with the month of lowest ΔSST

→ Relationship between zonal SST difference and MJO propagation speed should be examined by the season

Seasonality of Zonal SST difference and propagation speed



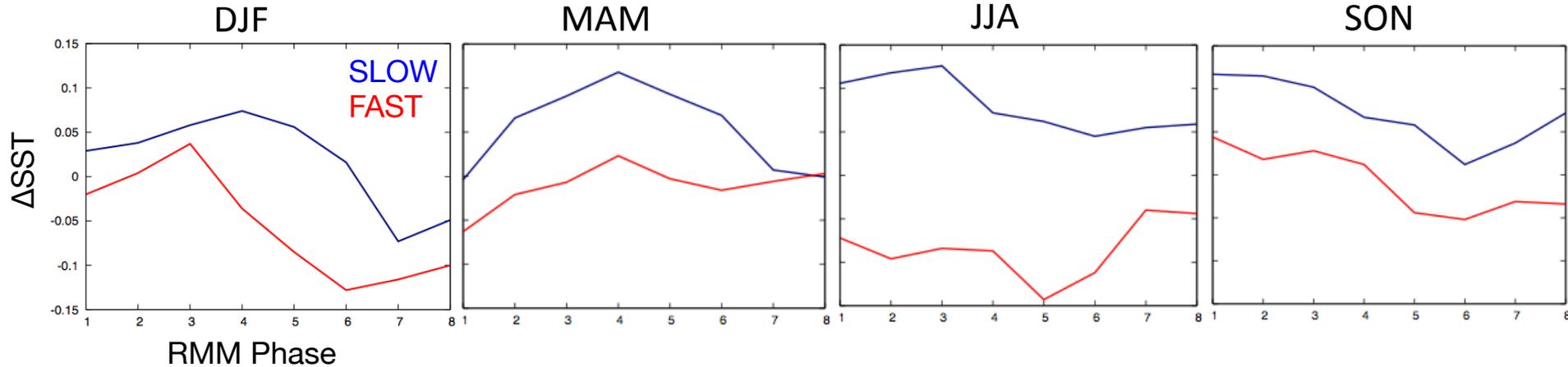
Events sorted into slow and fast group of each season by the average speed of the events in each season

Zonal SST difference is still larger for slower group of each season

Pattern of ΔSST evolution over the RMM phases follows the seasonal trend of ΔSST

Seasonality of Zonal SST difference **anomaly** and propagation speed

Evolution of Δ SST anomaly from the climatological cycle of Δ SST



Δ SST anomaly is also larger for slower group of each season

Δ SST anomaly seems to be diminished as MJO proceed in RMM phase

Slower events tends to reduce Δ SST anomaly to later phases than faster events



MJO propagation speed is slower under higher Δ SST

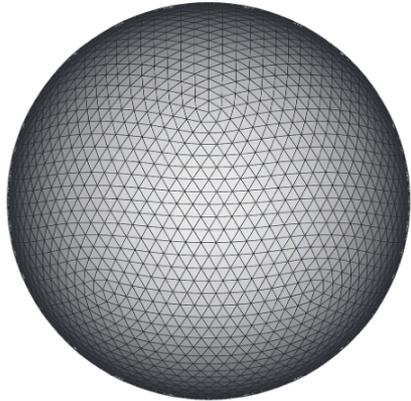
Part 1 Summary

- Detected 102 MJO events in 1982-2012 by constructing a MJO detection method
- Identified differences in eastward propagation speed of MJOs
- Slow MJOs tend to occur with initial SST condition in which Western Pacific SST is warmer than Indian Ocean SST
- Pattern of zonal SST difference over a course of an MJO event imply MJOs are working to reduce the zonal SST difference

PART II

How well can **NICAM-AMIP** run reproduce MJOs and the relationship between MJO propagation speed and SST ?

NICAM-AMIP simulation



Tomita 2008

The first AMIP-type simulation for NICAM !

NICAM : Non-hydrostatic Icosahedral Atmospheric Model
a cloud resolving model that explicitly computes cloud microphysics scheme

Experimental Design

AMIP-type condition : SST and sea ice nudging to HadISST1 with slab-ocean model

Integration : Jun. 1, 1978 – Dec. 31, 2008(~ 30 years)

Mesh size : 14 km

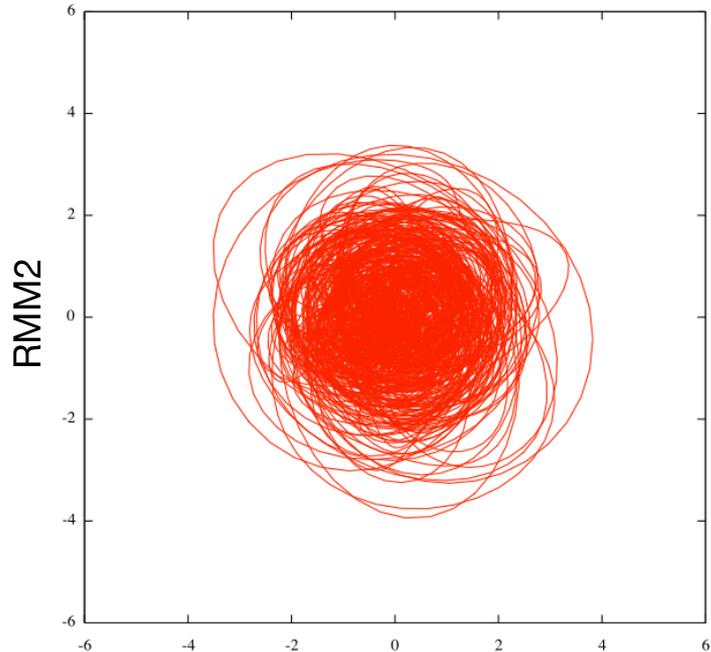
Kodama et al. 2015

Here we use data from January 1, 1979 taking spin up time of 7 month
And analyze performance of NICAM-AMIP reproduction of MJOs

Detecting MJO in NICAM-AMIP run

RMM trajectories

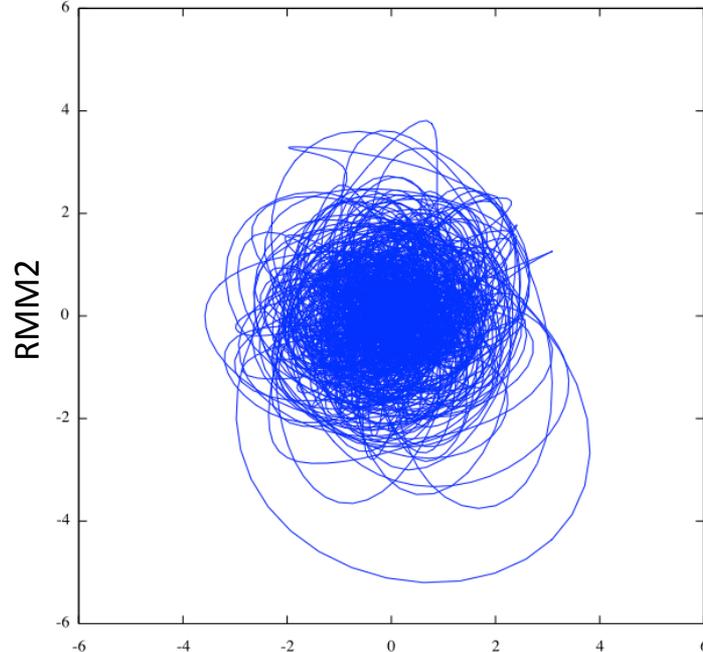
NOAA-NCEP/NCAR



RMM1

May 1979 - Aug 2012

NICAM-AMIP



RMM1

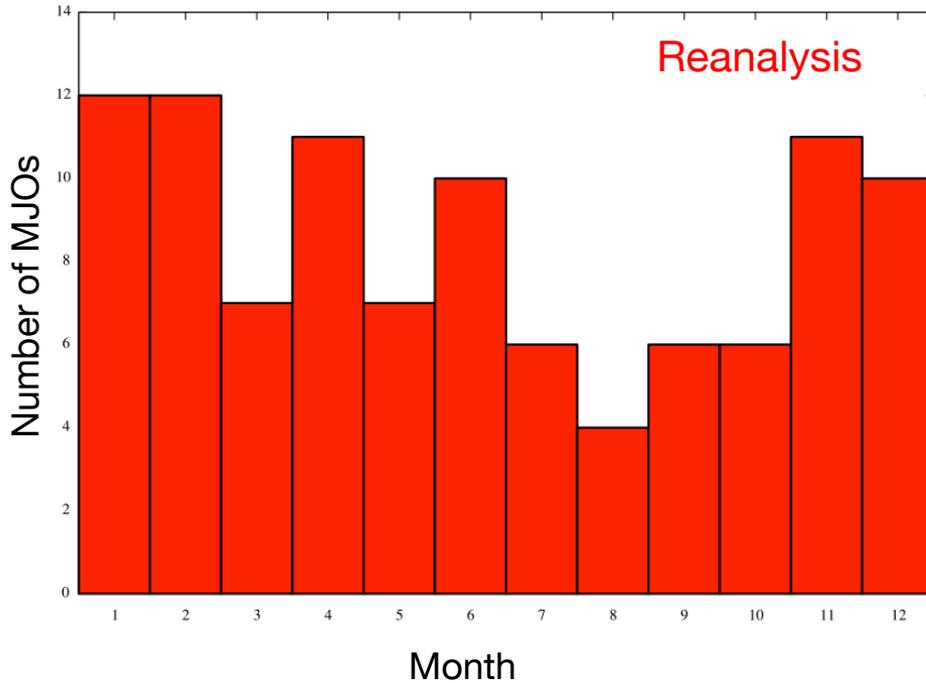
May 1979 - Aug 2008

RMM for NICAM-AMIP using eigenvectors from NOAA interpolated OLR and NCEP/NCAR U850 U200

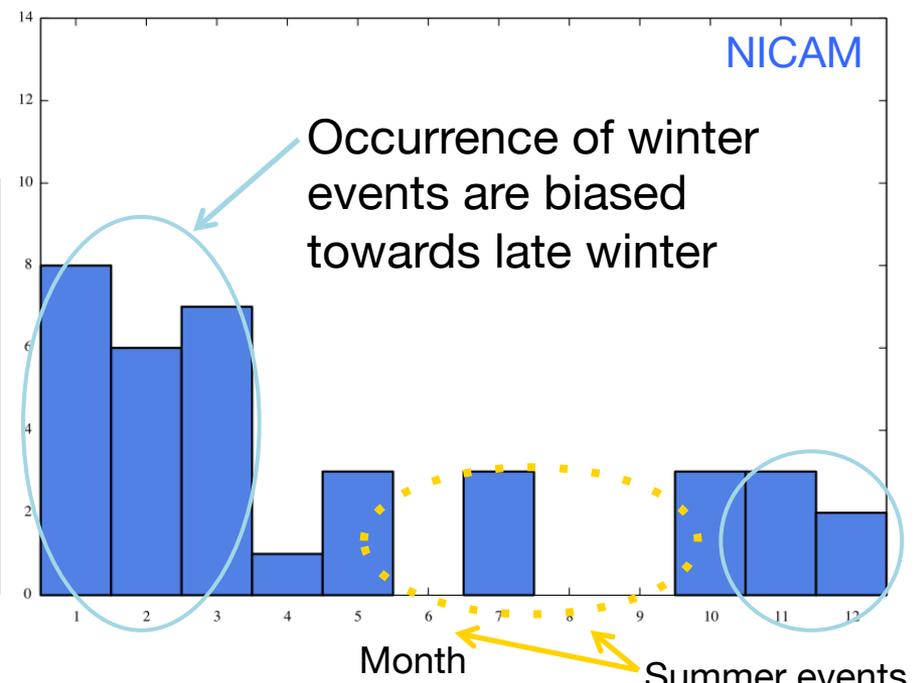
Using the calculated RMM
36 MJO events are detected using the same method as PART I

MJOs in NICAM-AMIP run

Number of MJO per month

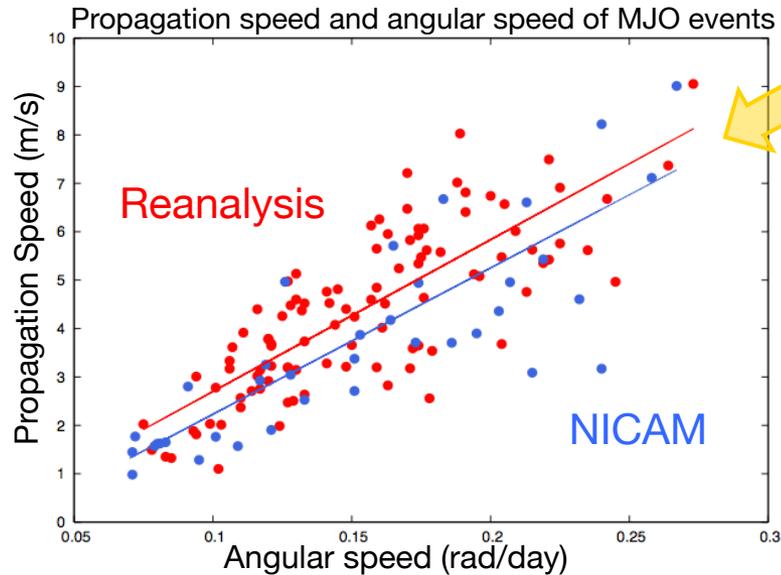


Total of 102 events
May 1979 - Aug 2012
about 3 events per year



Total of 36 events
May 1979 - Aug 2008
about 1.2 events per year

MJOs in NICAM-AMIP run

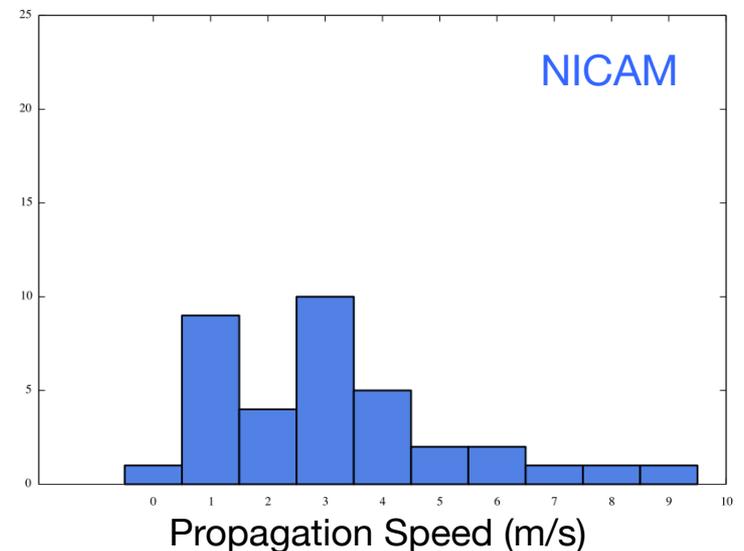
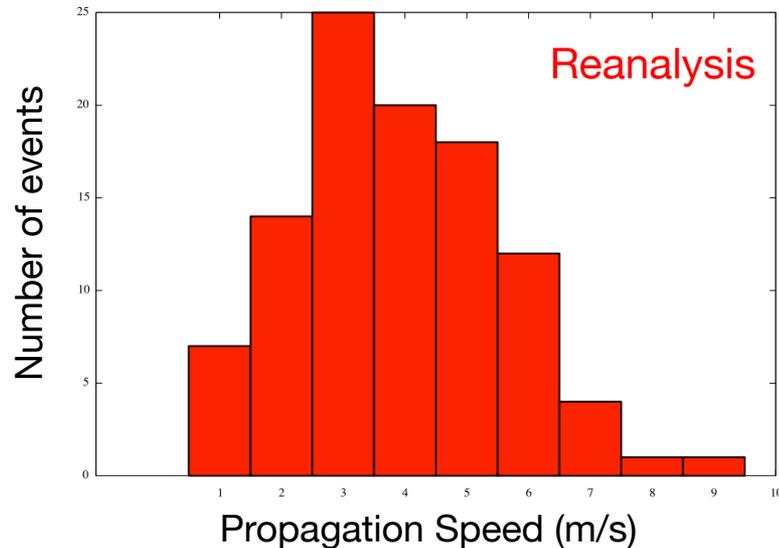


Regression lines are almost parallel

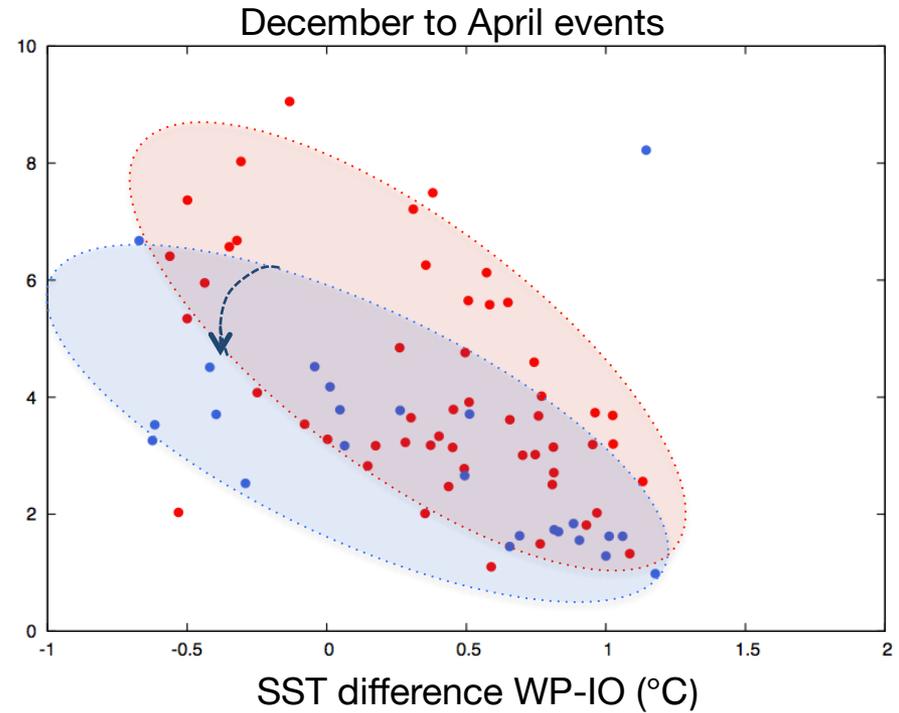
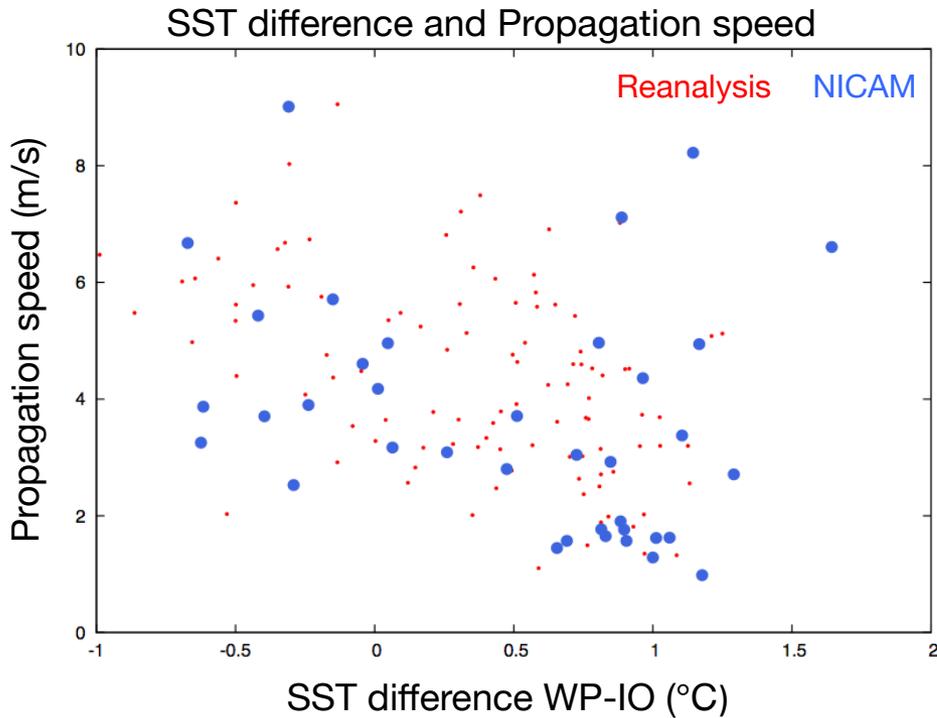
Similar consistency between propagation speed and angular speed holds also on NICAM

But the overall propagation speed seems to be slower...

Number of MJO per speed



MJOs in NICAM-AMIP run



NICAM-AMIP MJOs are slower...

but the relationship between Zonal SST difference and MJO propagation speed seems to be reproduced for boreal winter events

Discussion

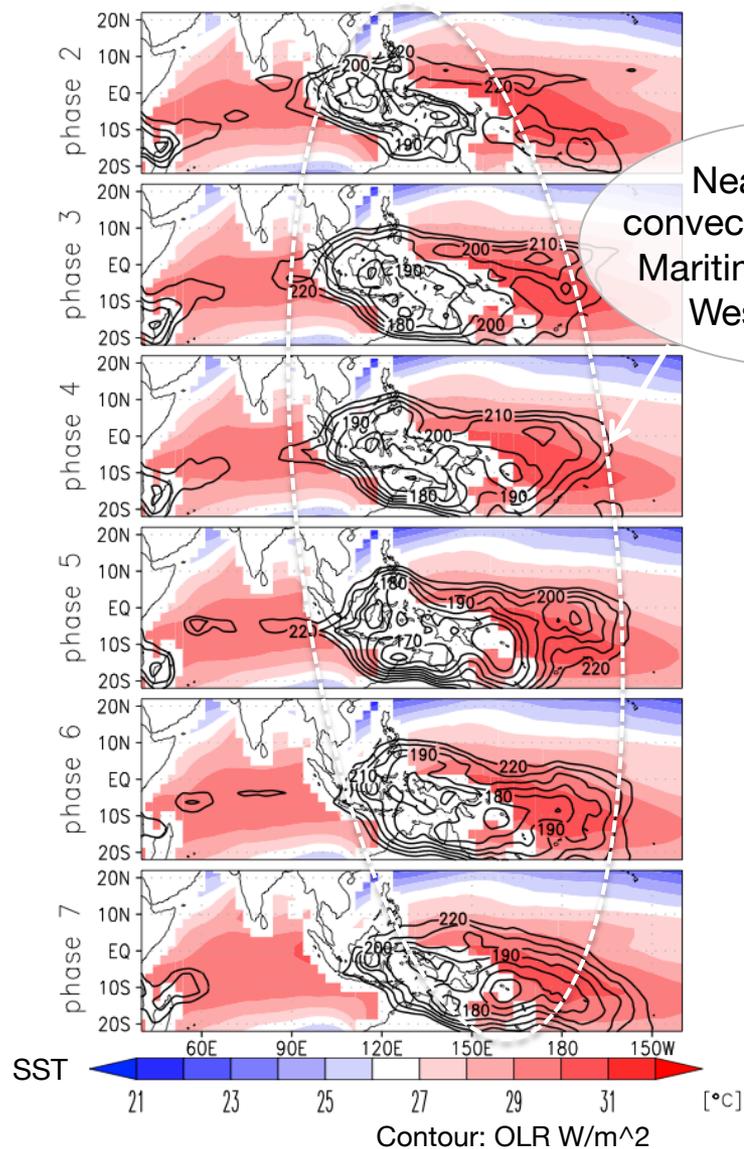
Why are MJOs in NICAM-AMIP so slow ?

What happened to the Summer events?

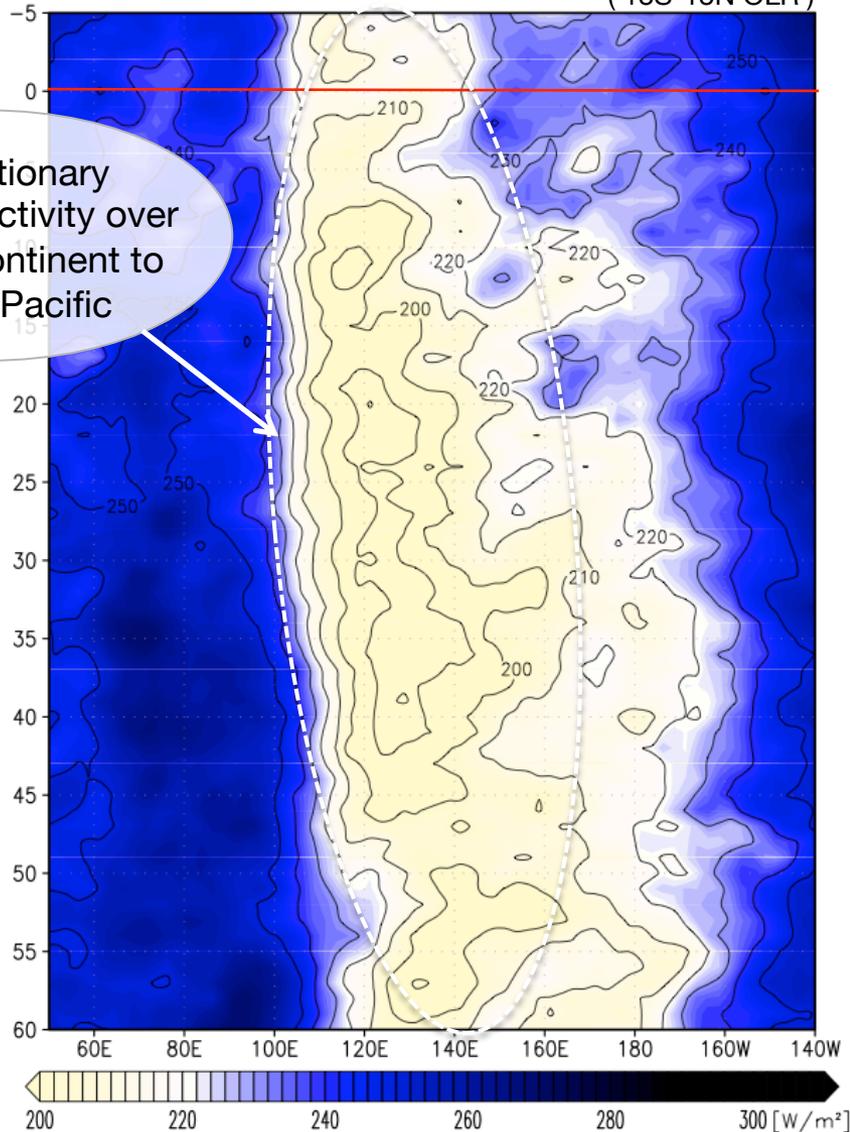
MJOs in NICAM-AMIP run

How similar are they to the real-world MJOs ? and why are they so slow?

Phase composites of the 10 slowest events



Composite Hovmoller of the 10 slowest events (15S-15N OLR)



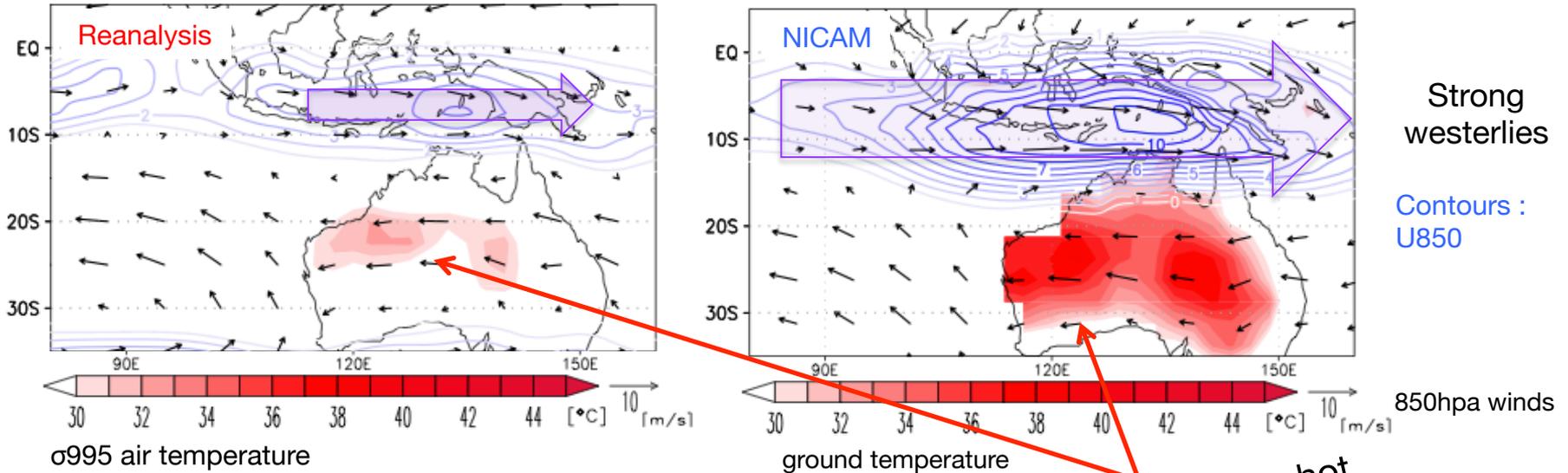
First day of phase 2

Near stationary convective activity over Maritime Continent to Western Pacific

Why is NICAM-AMIP MJOs are so slow?

Examining NICAM-AMIP boreal winter climatology

January – March climatology



Greater land-sea surface temperature contrast

- Stronger Australian Summer monsoon ?
- Persistent westerlies and convective activity over the Maritime Continent regions

→ Slower MJOs?

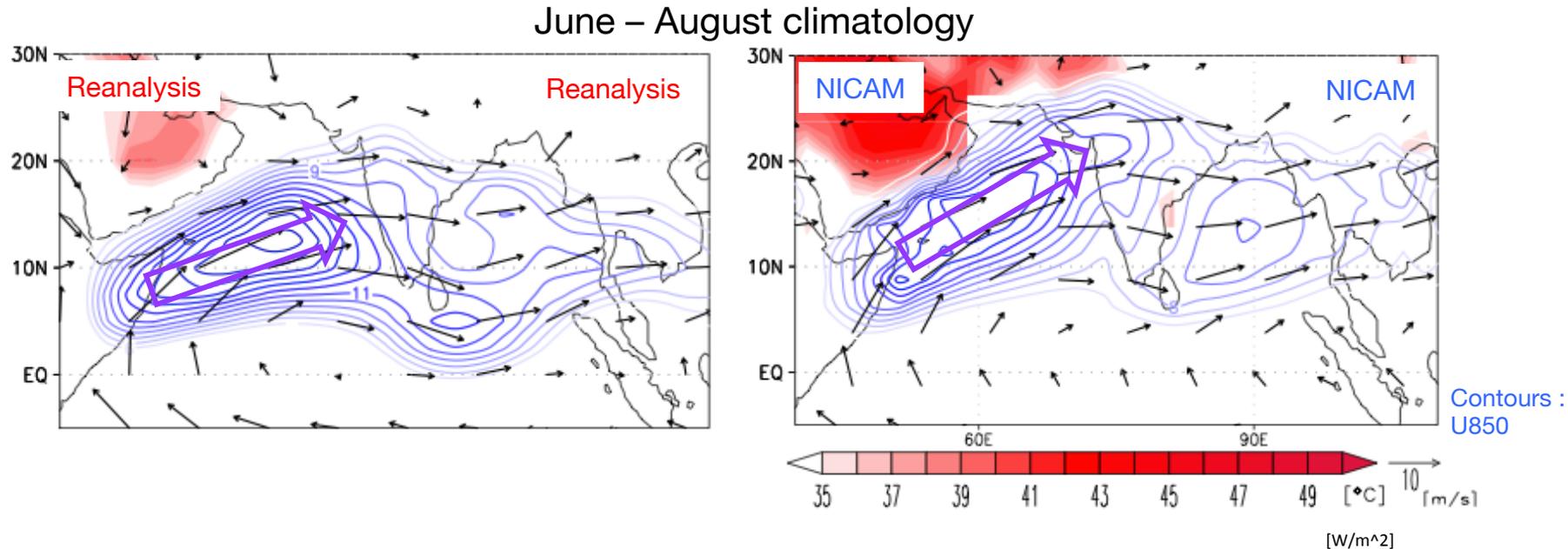
Land temperature too hot

NICAM-AMIP
Australia is an
uninhabitable
hot island !



Where did the summer MJO go ?

Examining NICAM-AMIP boreal summer climatology



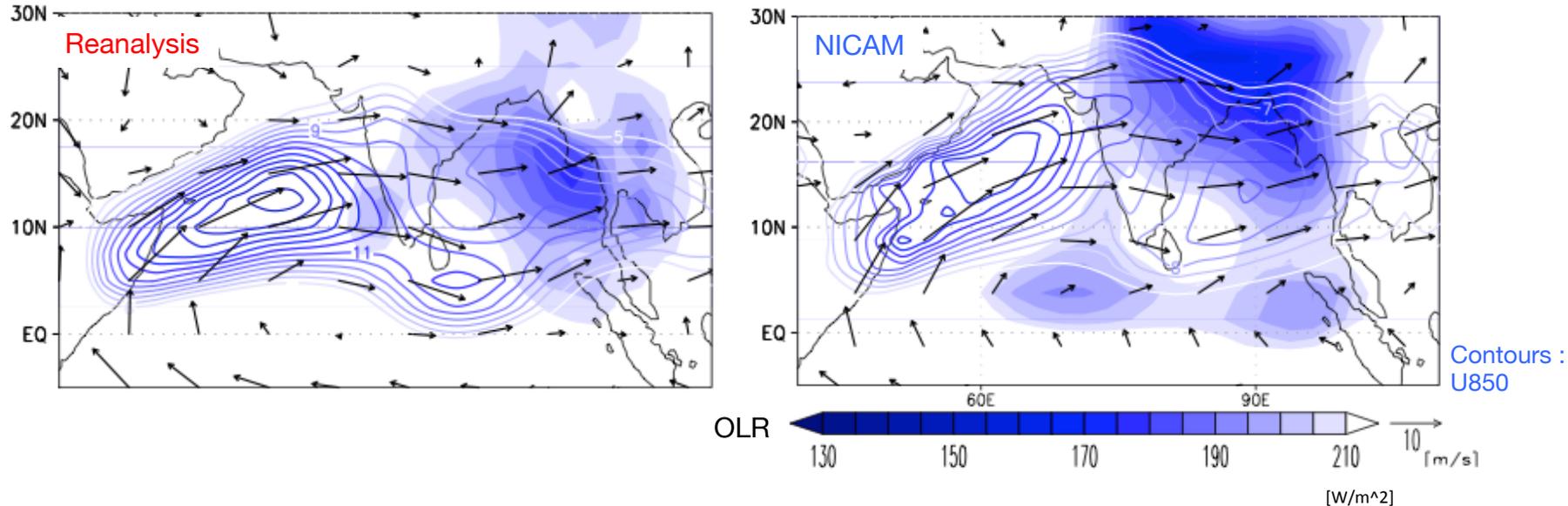
- Westerlies are weaker in NICAM-AMIP
- Region of westerlies are shifted northwards over the Arabian sea
- Region of active convection is shifted towards land north of Bay of Bengal

Not only the strength of the Indian summer monsoon seems to be different
But the position of the monsoon circulation and the accompanied
convective activities takes differing distribution
→ different circulation pattern forced by high ground temperature ?

Where did the summer MJO go ?

Examining NICAM-AMIP boreal summer climatology

June – August climatology



- Westerlies are weaker in NICAM-AMIP
- Region of westerlies are shifted northwards over the Arabian sea
- Region of active convection is shifted towards land north of Bay of Bengal

Not only the strength of the Indian summer monsoon seems to be different
But the position of the monsoon circulation and the accompanied
convective activities takes differing distribution
→ different circulation pattern forced by high ground temperature ?

Part 2 Summary

- NICAM-AMIP run reproduces smaller number of slow MJO-like events
- NICAM-AMIP MJOs occur mostly in late winter and summer events seem to be missing
- Overall propagation speed of NICAM-AMIP MJOs is slower than reality but they seem to be negatively correlated to zonal SST difference during boreal winter
- Spatial pattern of boreal winter MJO convection of NICAM-AMIP is concentrated over the Maritime continent region
- Slowness of NICAM-AMIP MJO and missing boreal summer MJO may be due to the unrealistically warm land surface temperature which alters the monsoonal circulations

Thank you for your kind attention !