Impact of the Indian part of the summer MJO on West Africa using nudged climate simulations

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Mohino E, Janicot S, Douville H, Laurent L (2012) Impact of the Indian part of the summer MJO on West Africa using nudged climate simulations. *Clim Dyn* 38:2319-2334

Rationale

* Agricultural production in West Africa depends heavily on intraseasonal rainfall variability (Gadgil & Rao 2000; Sultan et al. 2005)
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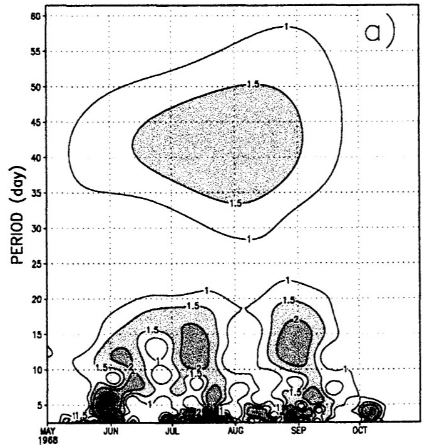

25–60 days

10–25 days

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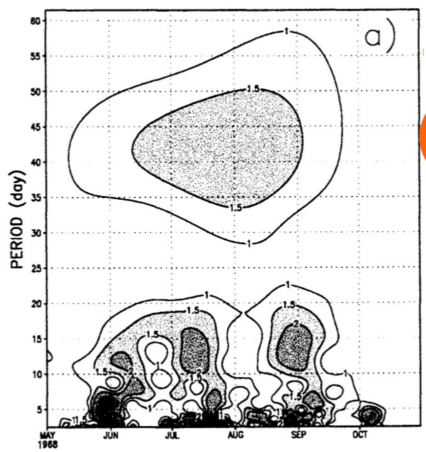

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25–60 days → Madden Julian Oscillation (MJO) (Madden & Julian 1994)

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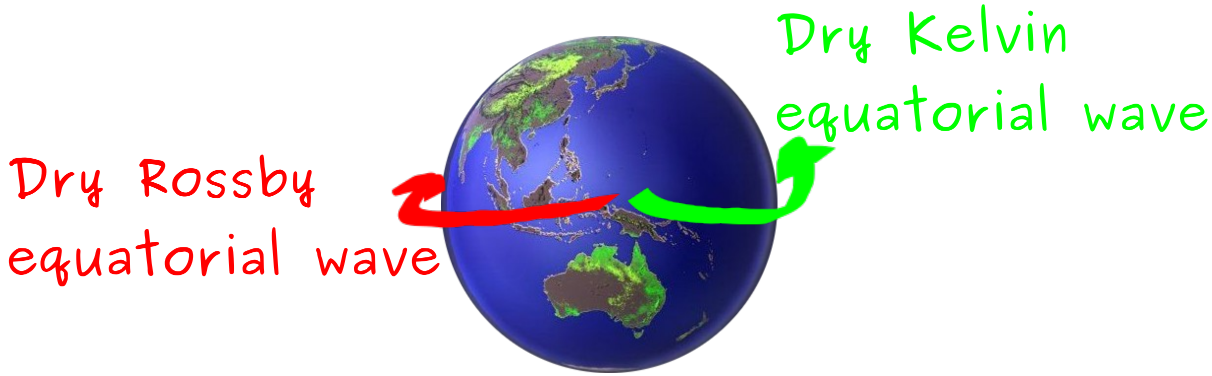

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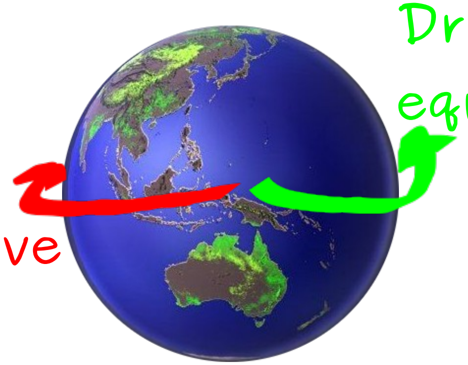
Dry Rossby equatorial wave



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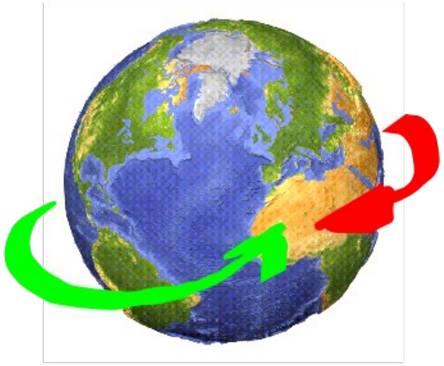

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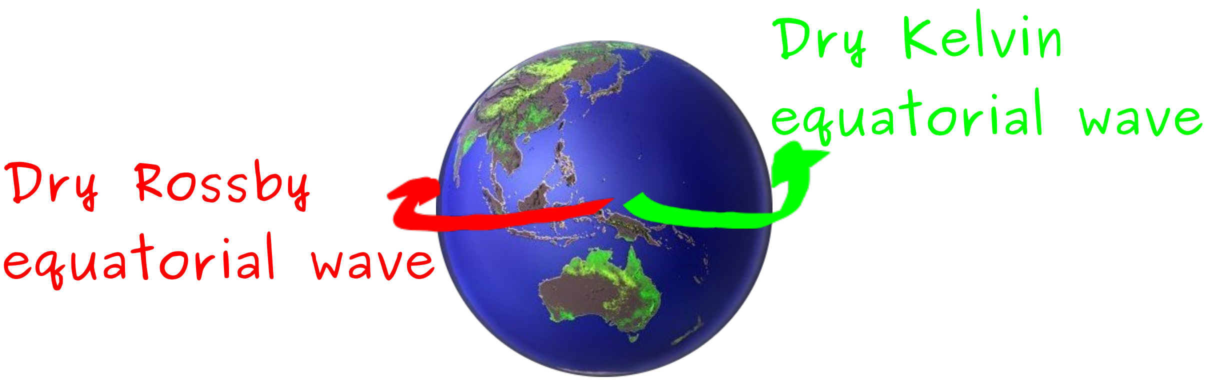

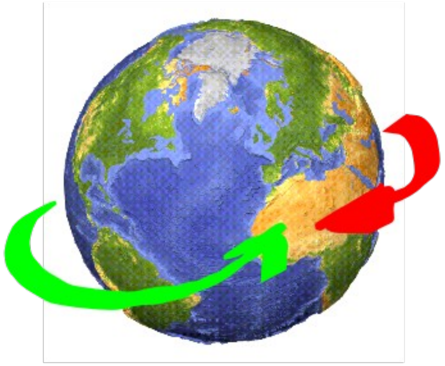

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However, Janicot et al. (2009, 2010) and Pohl et al. (2009) stressed the contribution of a **convectively coupled Rossby equatorial wave**

Aim

* Study the impact of summer MJO events on West Africa
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By nudging the LMDZ AGCM

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*T,u,v variables & strong relaxation (half hour)
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By analysing observations & simulations

*daily NOAA outgoing longwave radiation (OLR), ERA40 & ERA-Interim reanalysis
*using **Wheeler & Hendon (2004) approach** based on EEOF (standard index for monitoring & predicting MJO)

MJO analysis (based on W&H 2004 approach)

(1) EEOF Analysis

- *Standardized anomalies of OLR, u at 850hPa & 200hPa
- *averaged in latitudinal band 15ºS–15ºN

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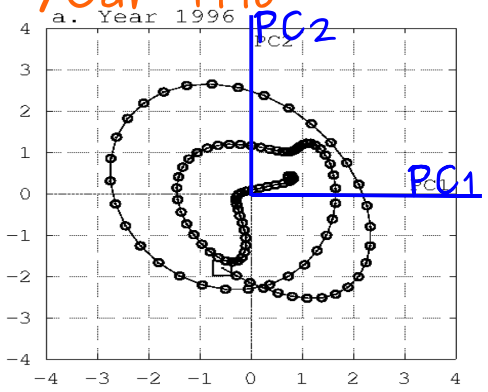
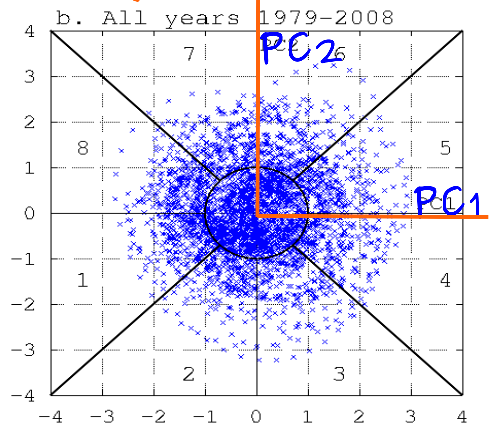
*Represent each day of data as a point in the two-dim. phase space given by PC1&PC2

Year 1996



Anticlockwise rotation (PC1 leads)

All years



Average time between phases: 5 days. Whole cycle of 40 days

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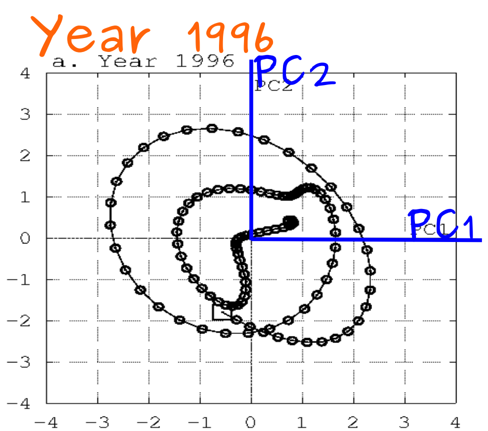

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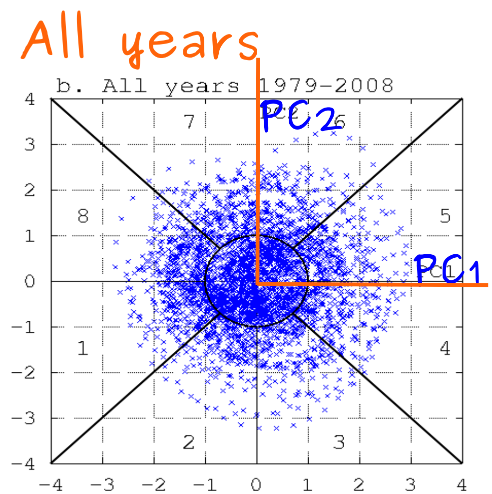

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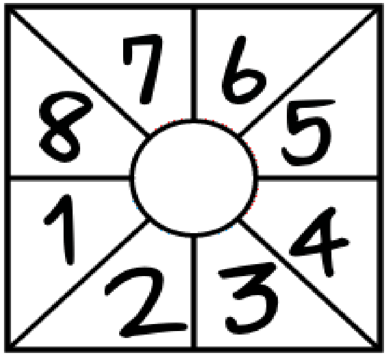

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*Choose all dates in a given phase above a threshold (1.0 std. dev.) to build the composite

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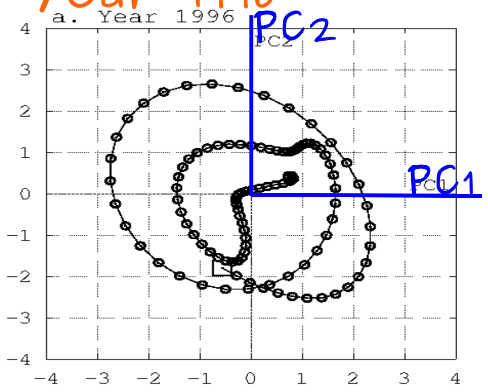

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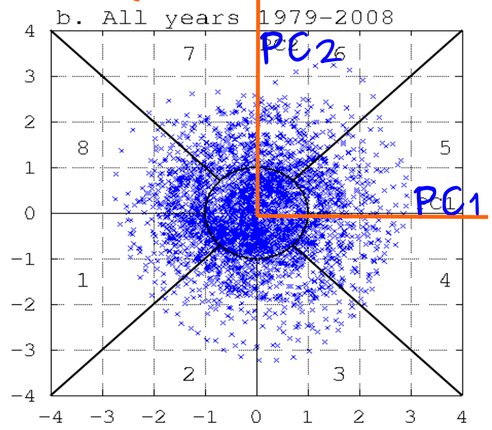

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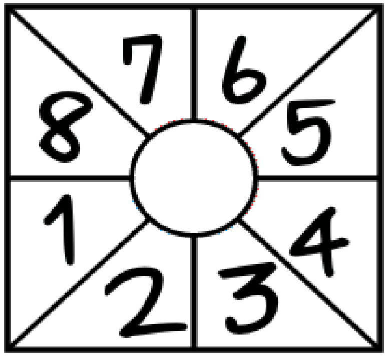
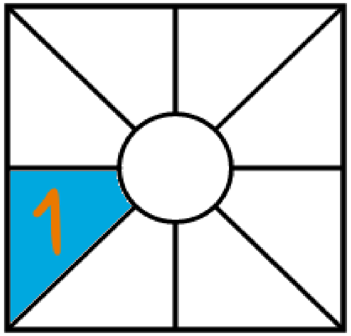
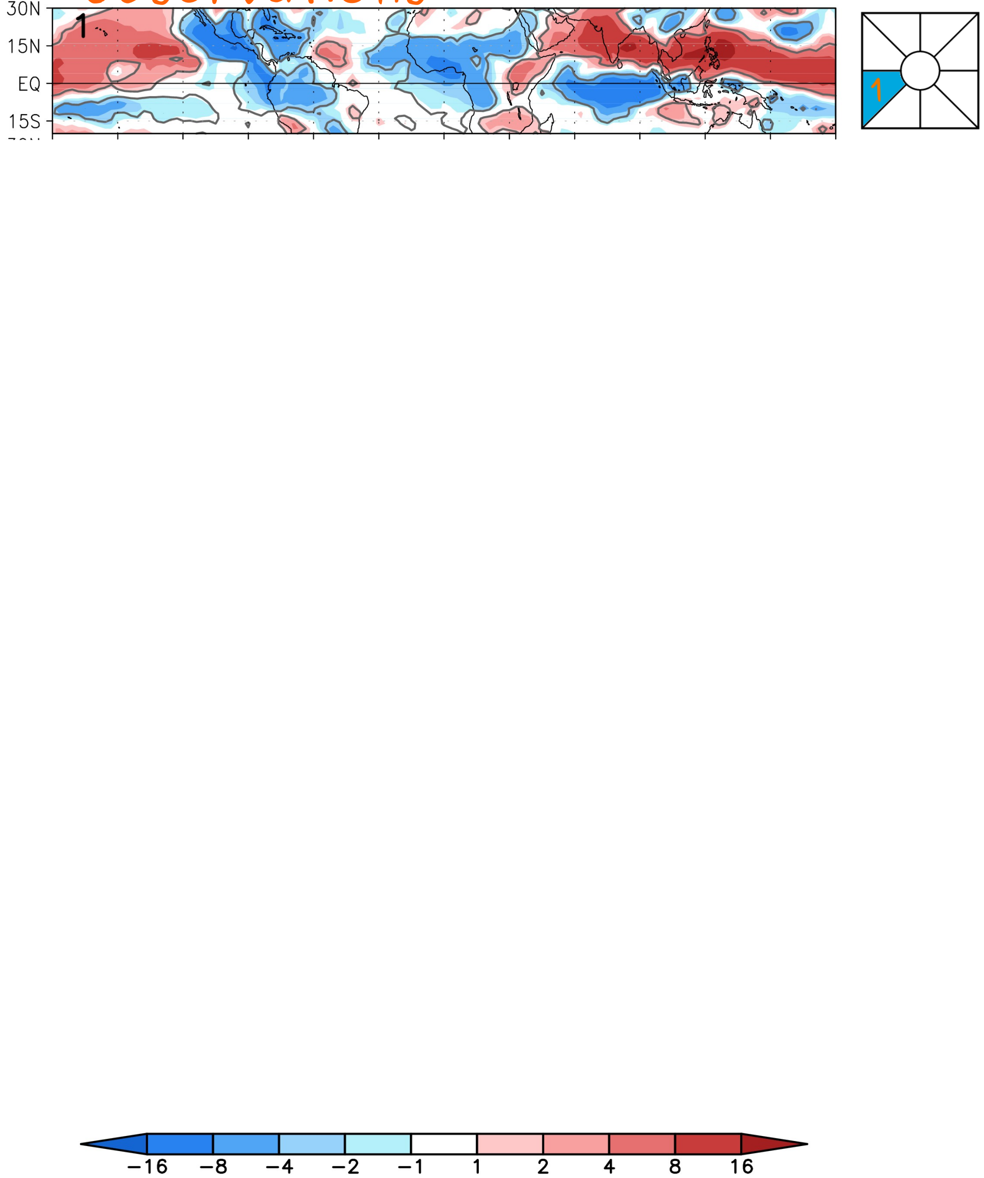




OLR Composites

Observations



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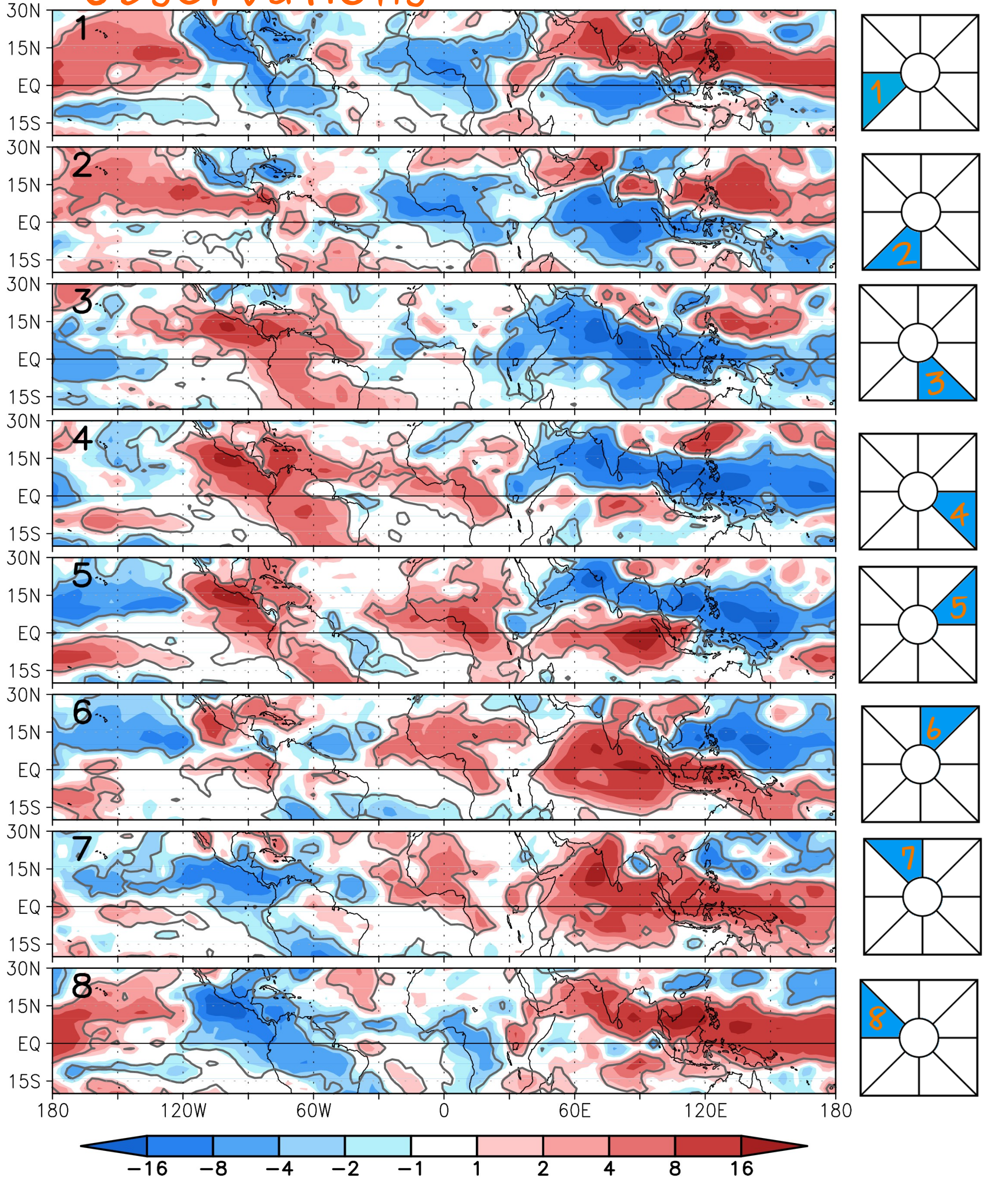

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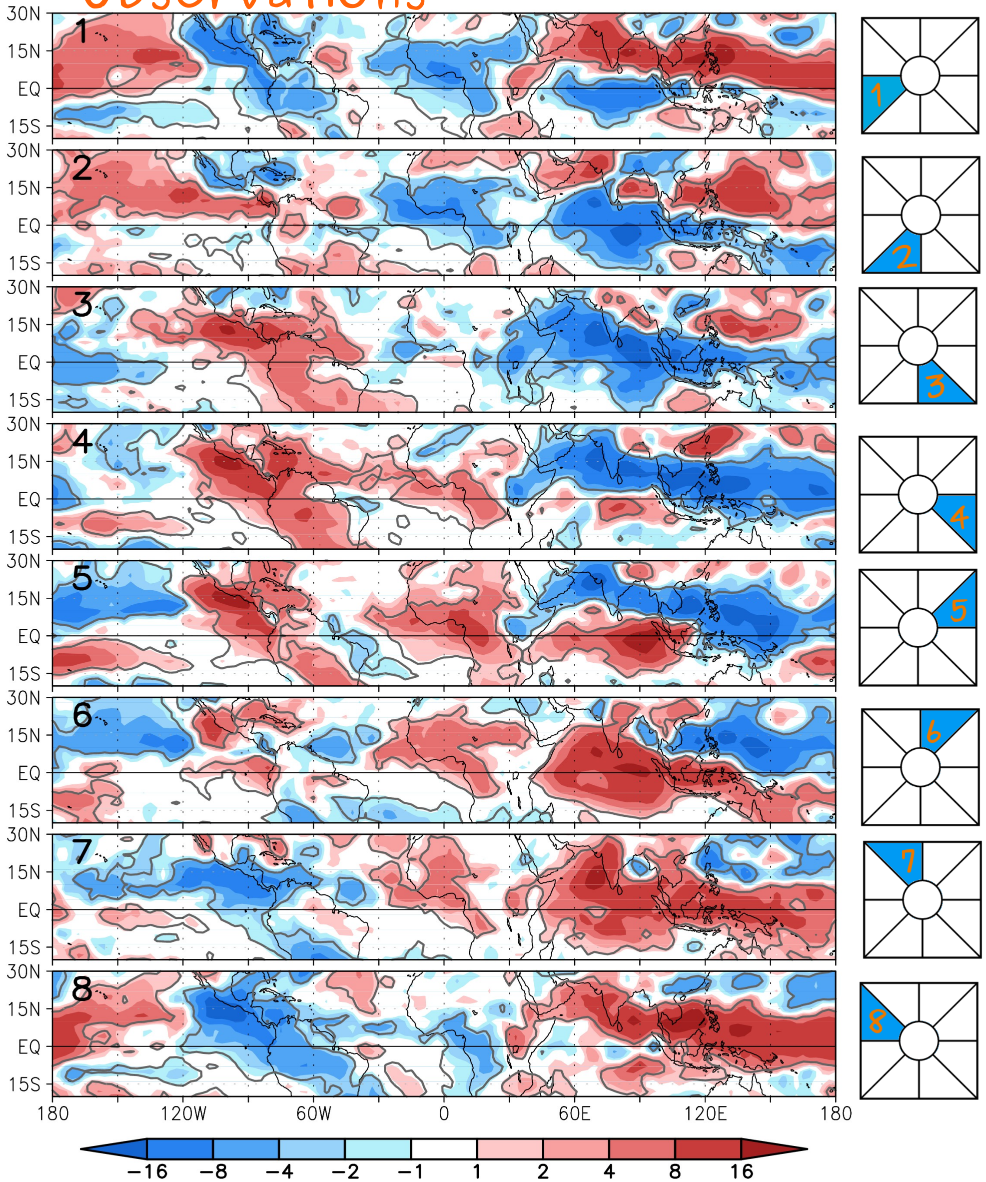

Over the Indian Ocean & warm pool:

*negative OLR anomalies (increased convection) start in phase 1, grow in 2, propagate North & East in 3−5, and decay in 6 and 7

*The evolution of a decreased convection MJO event in phases 5−3

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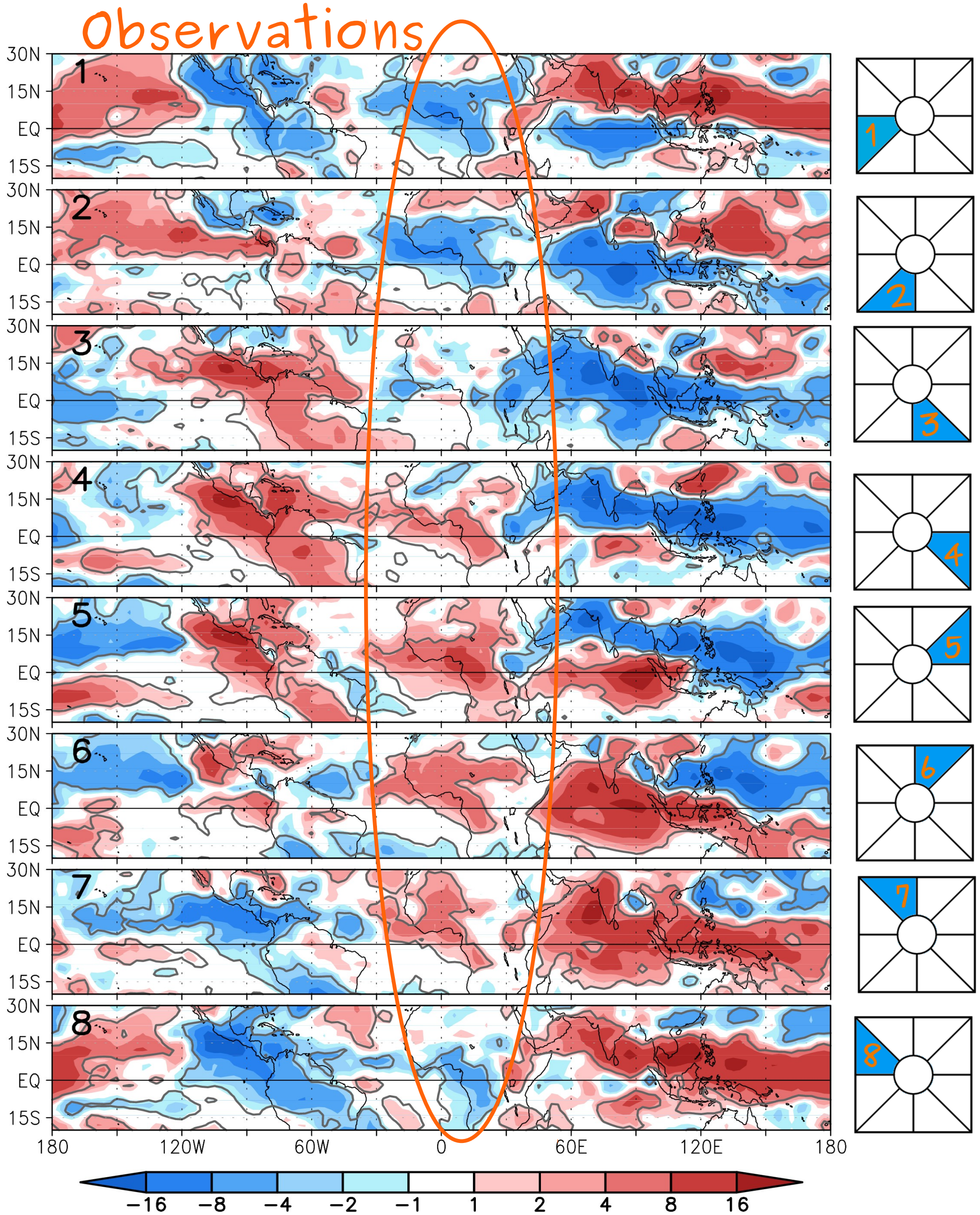

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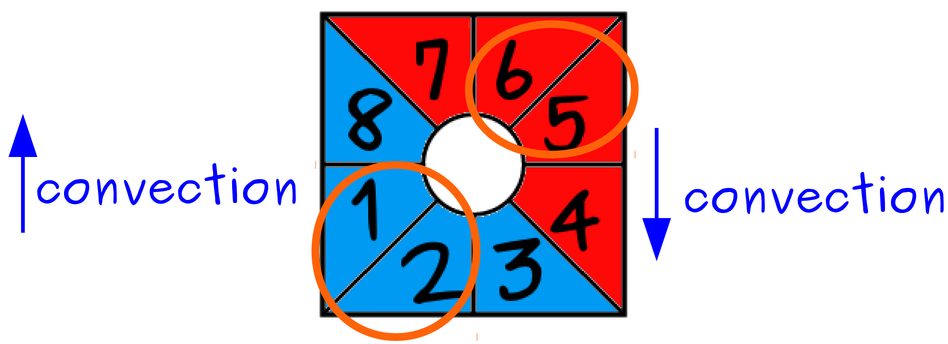
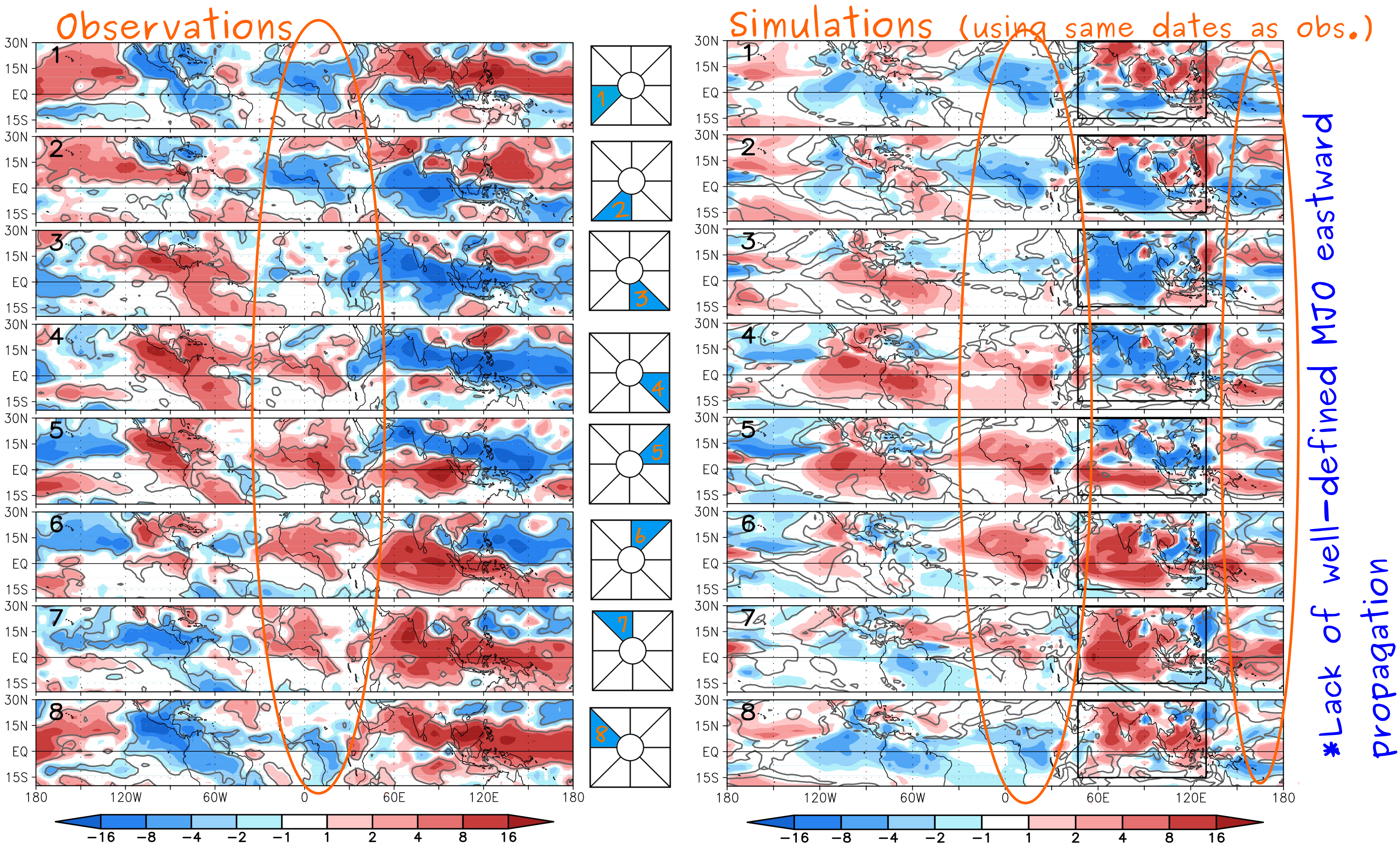
Over West Africa (WA): link between MJO & convection over WA



*max. negative (positive) OLR anomalies occur aprox. 15-20 days after main decrease (increase) of convection over Indian Ocean

OLR Composites



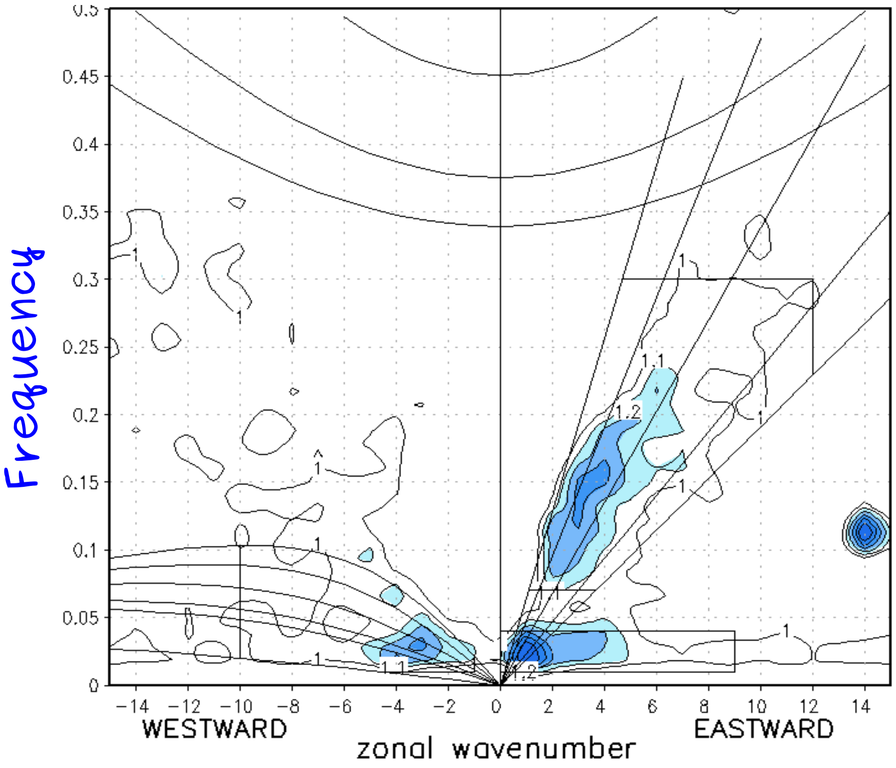
*Over WA: anoms similar in magnitude, structure & timing to obs.

*Casual link between MJO & WA anoms.

Equatorial waves

Wavenumber-frequency spectra of symmetric (about equator) OLR anomalies (Wheeler & Kiladis 1999)

Observations



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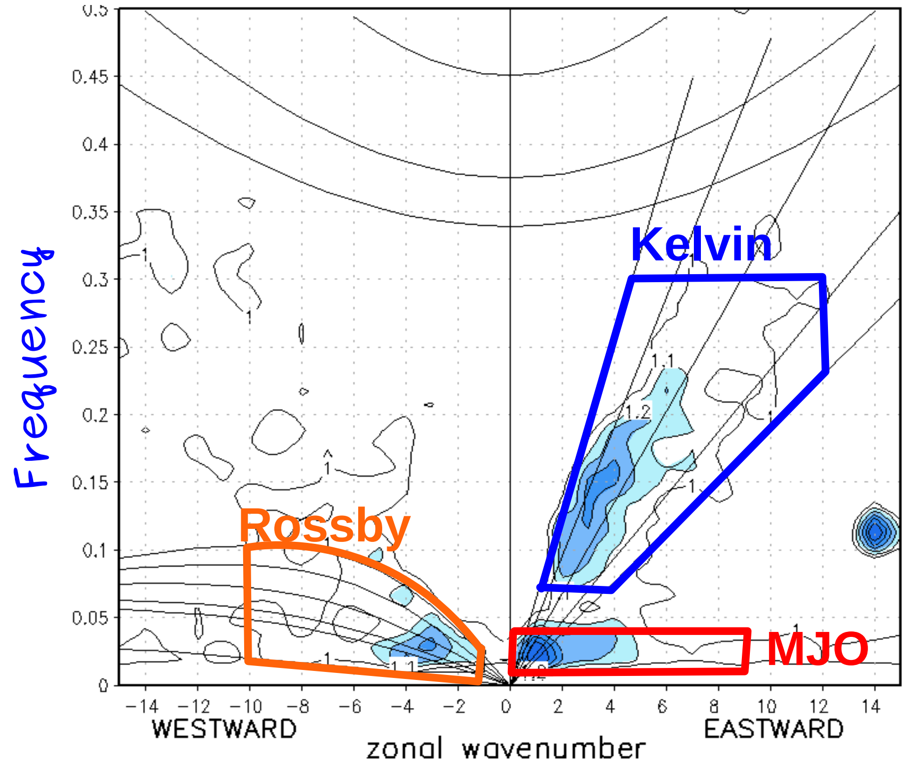

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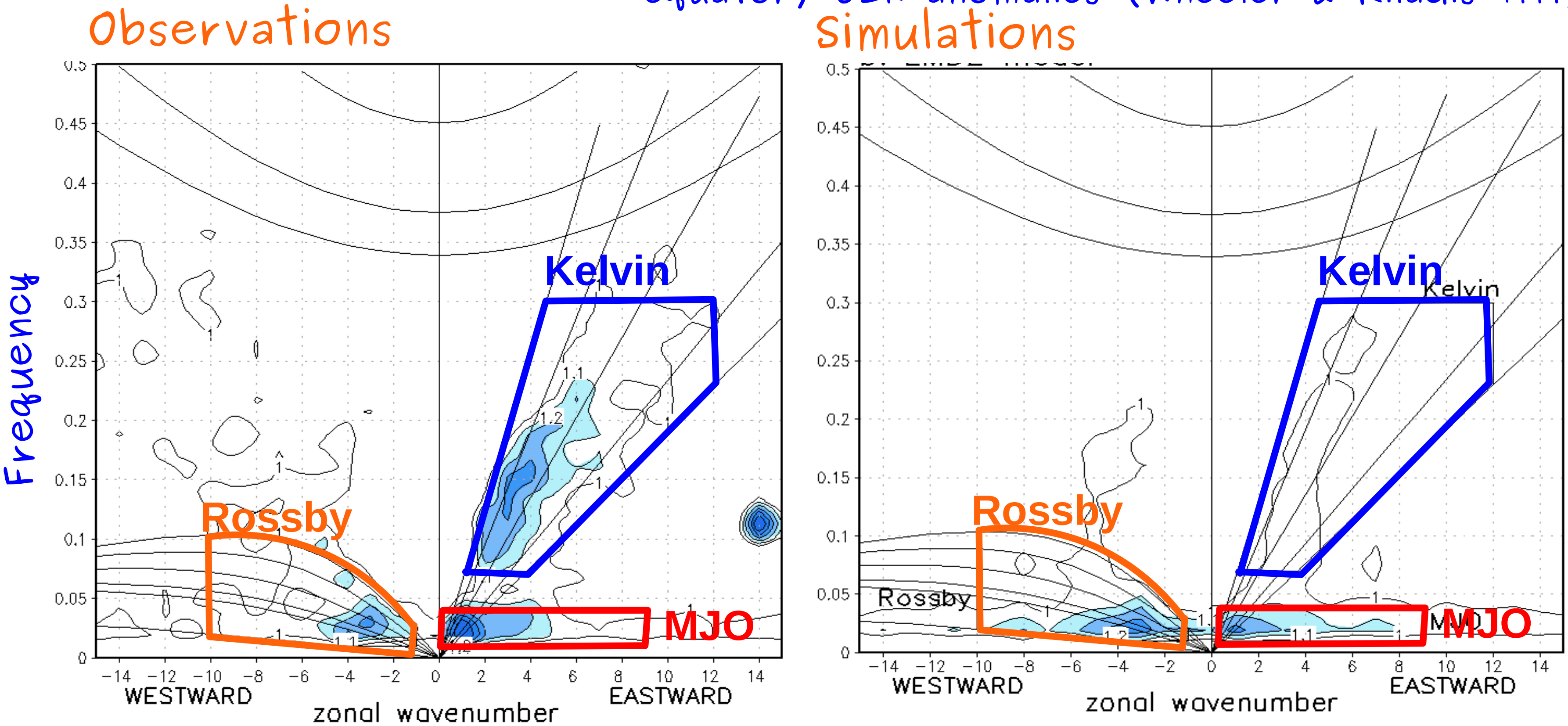


*Good correspondence of MJO & CCE Rossby signals between obs & sim

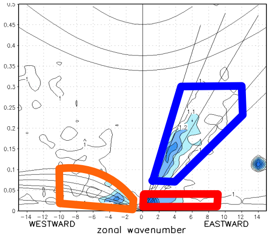
*Very weak power specta of OLR in the Kelvin wavenumber-frequency region (unlike obs)

→ The simulation suggests that the **impact of summer MJO on WA** convection is **independent** of the propagation of both **dry and convectively coupled equatorial Kelvin waves**

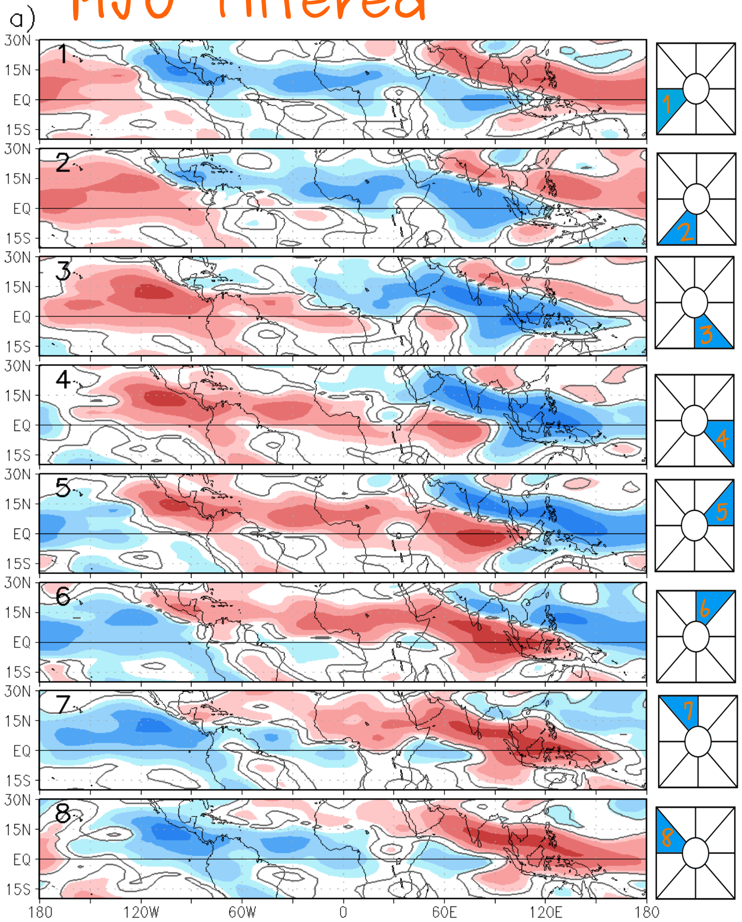
Equatorial waves

Observations

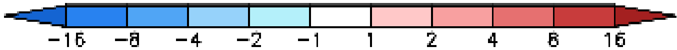
Composite of OLR filtered using the boxes



MJO filtered



*MJO signal travels all around the world and affects WA (weaker than composite of the whole field)



Equatorial waves

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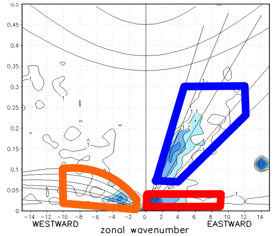
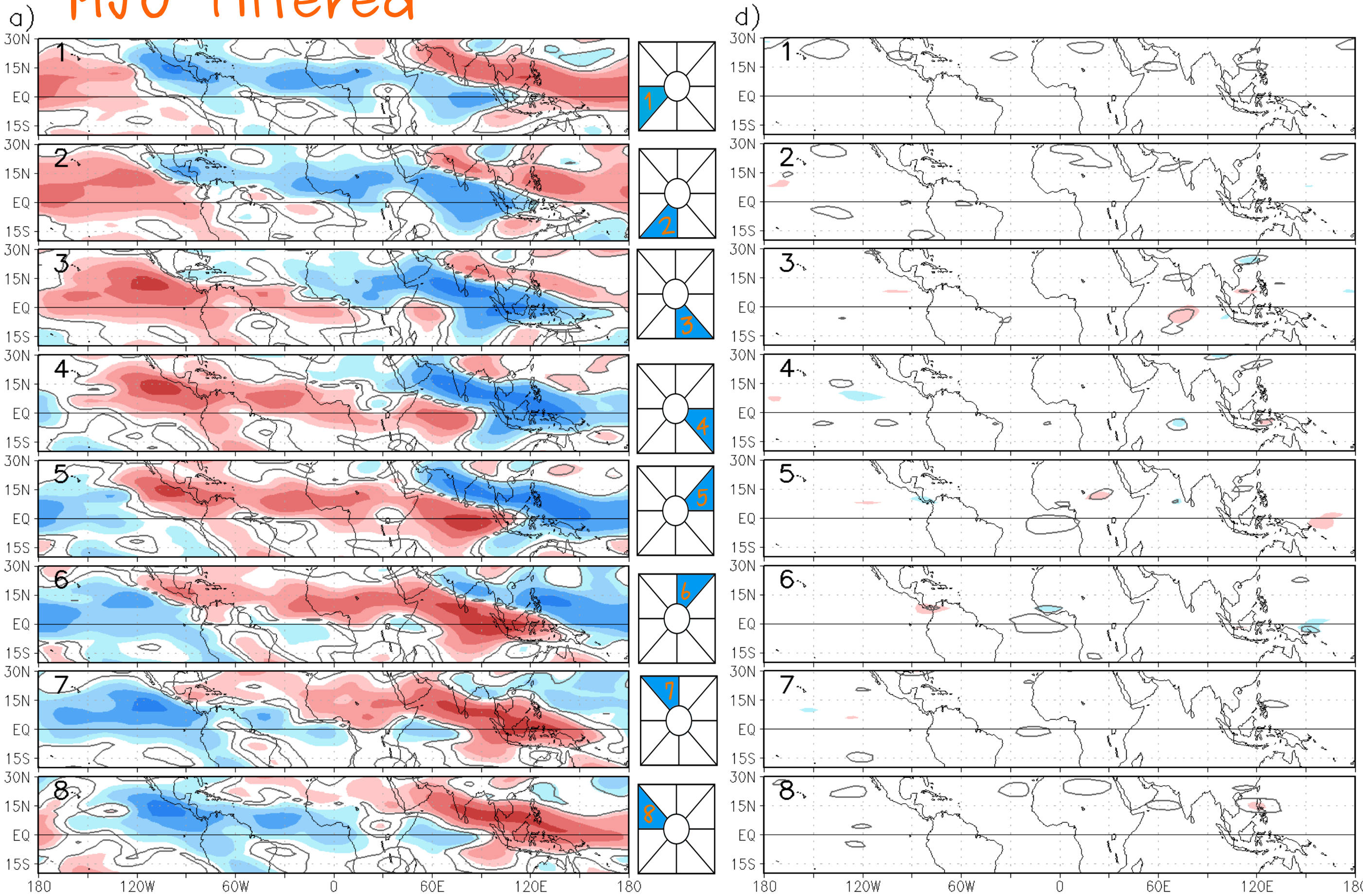
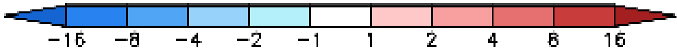


Observations

MJO filtered

Kelvin filtered





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Equatorial waves

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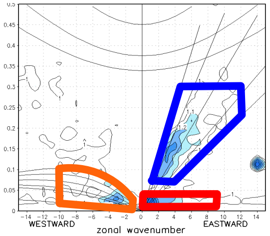
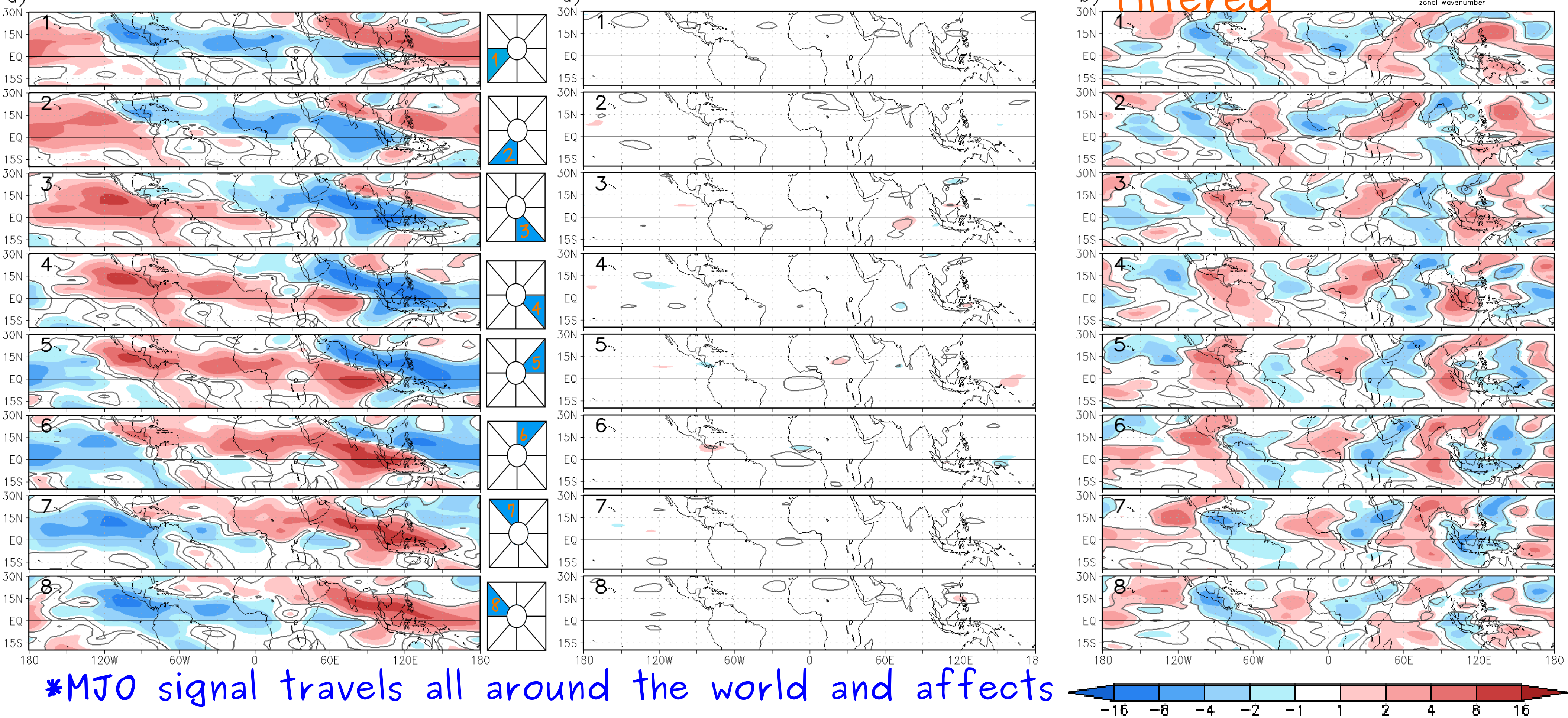


Observations

MJO filtered

Kelvin filtered

Rossby filtered

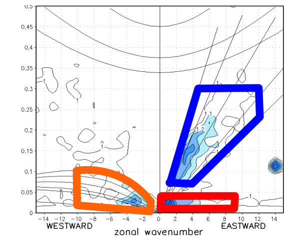


- *MJO signal travels all around the world and affects WA (weaker than composite of the whole field)
- *Kelvin signal non significant → neglibible effect on the MJO–WA connection
- *Rossby signal is relevant in the MJO–WA connection
- *Similar conclusions from sim.

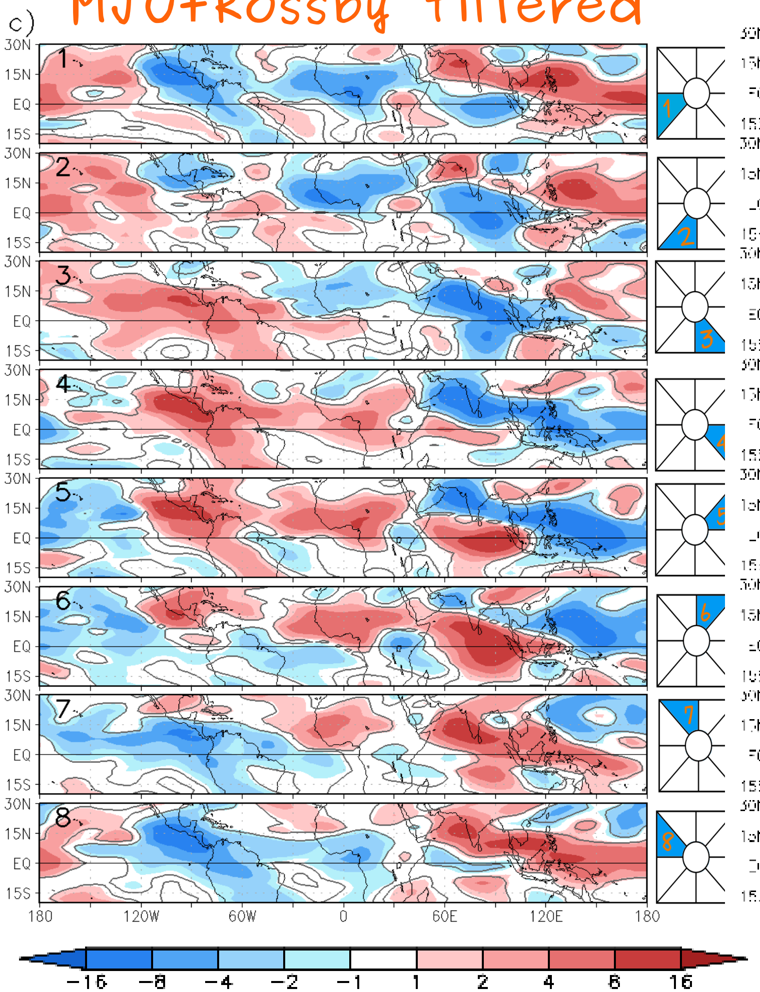
Equatorial waves

Observations

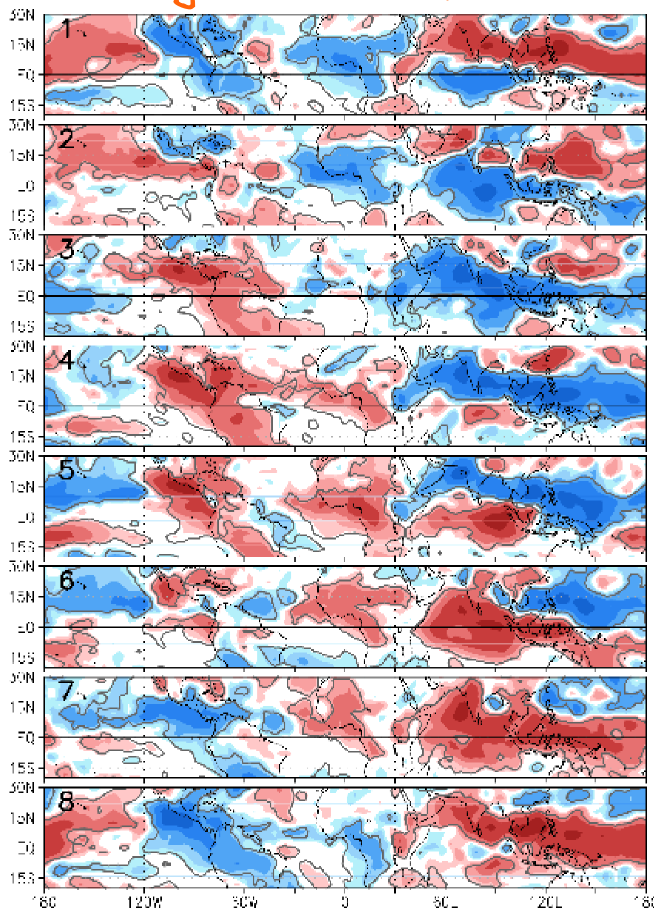
Composite of OLR filtered using the boxes



MJO+Rossby filtered



Original field



*In addition to the eastward moving MJO signal, the westward propagation of convectively coupled equatorial Rossby waves is needed to explain the overall impact of the MJO on West Africa

*Same conclusion can be obtained from the simulation composites

Conclusions

* The **MJO has a clear impact on WA** convection: 15-20 days after the main positive (negative) convection anomalies over the equatorial Indian Ocean there is reduced (increased) convection over WA

* The **causal link** between observed summer MJO and anomalous convection over WA has been confirmed with the model

* In addition to the eastward moving MJO signal, the westward **propagation of convectively coupled equatorial Rossby waves is needed** to explain the overall impact of the MJO on West Africa

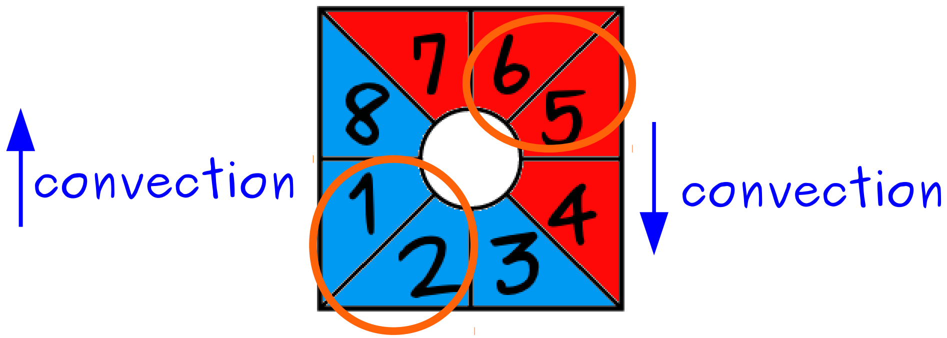
* **Dry & convectively coupled Kelvin** waves seem to **play no role** in the impact of MJO on WA

* **Indian** part of the summer MJO seems to be a **key area** for the impact over WA

* **Potential predictability** of regional-scale anomalous convection and rainfall spells over WA at intraseasonal time scales with 15-20 days advance

Conclusions

Potential predictability: an example from this season



Conclusions

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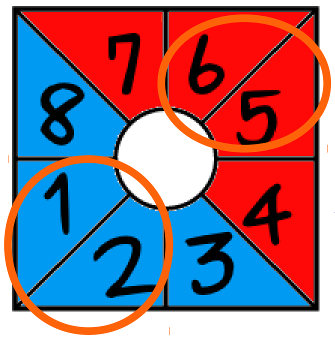
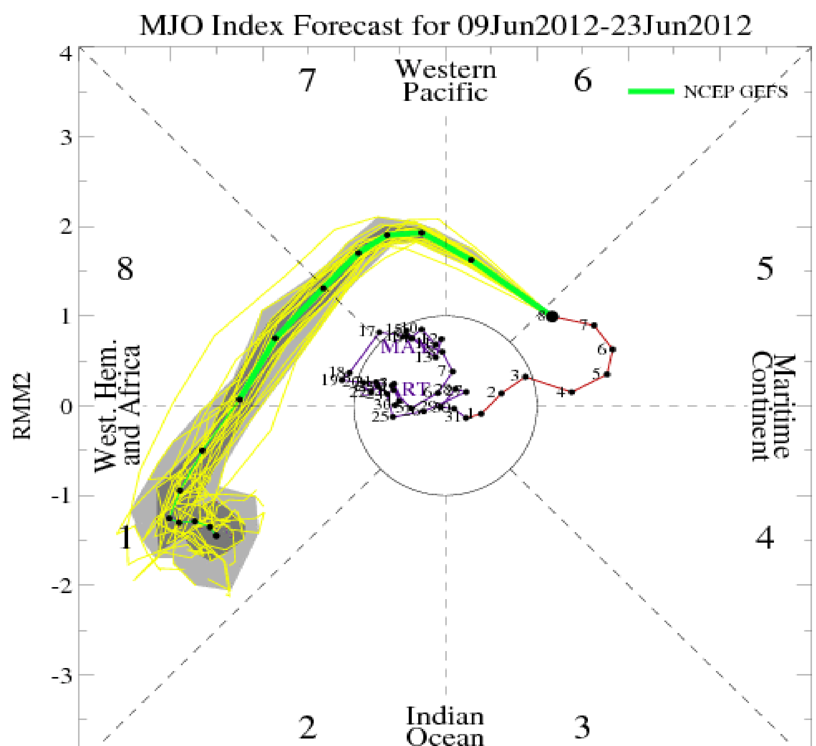


convection ↓



NCAR MJO prediction for 19–23 june (courtesy of O. Ndiaye in the discussions of the ***AMMA working group on Intraseasonal variability and its impacts***)

Conclusions

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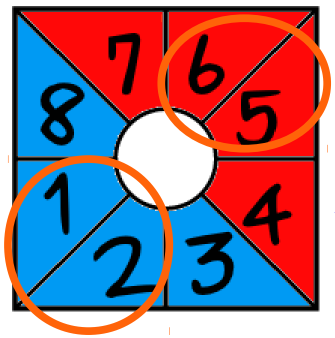
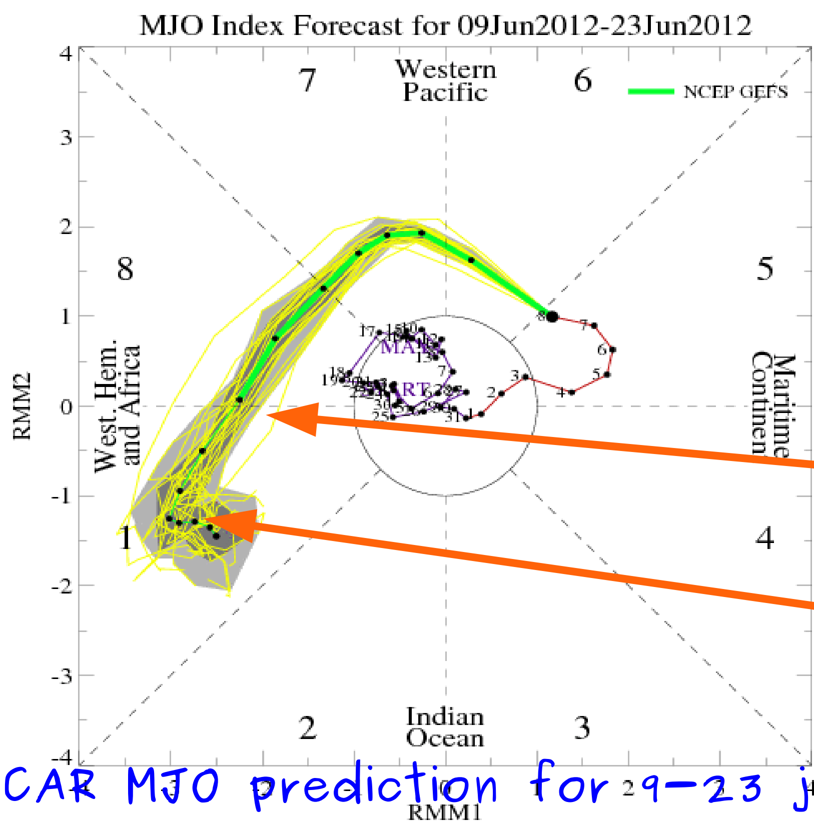


↓ convection



Expect increased convecton over WA from June 15 onwards

Maximum convection June 20 onwards

NCAR MJO prediction for 29-23 june (courtesy of O. Ndiaye in the discussions of the ***AMMA working group on Intraseasonal variability and its impacts***)

Conclusions

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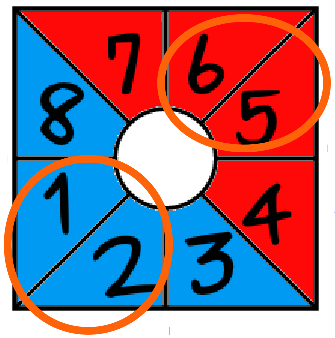
convection ↑



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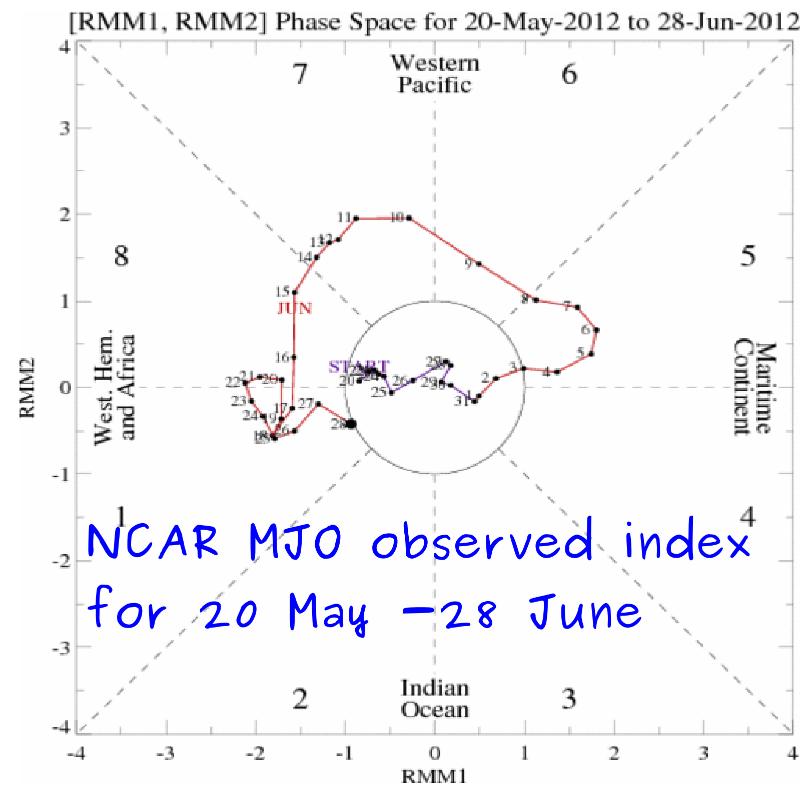
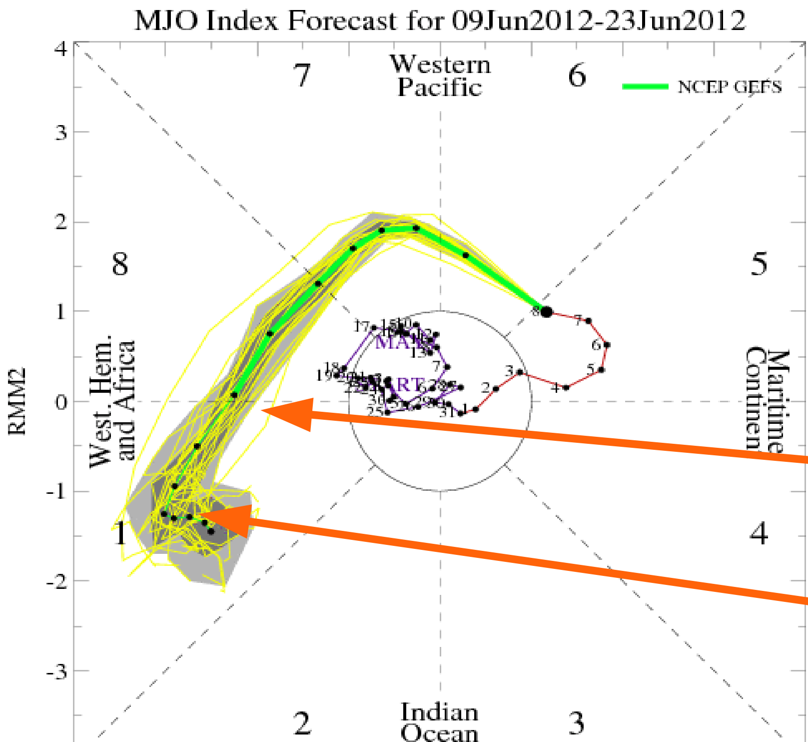


NCAR MJO observed index for 20 May – 28 June



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NCAR MJO prediction for 9–23 june (courtesy of O. Ndiaye in the discussions of the **AMMA working group on Intraseasonal variability and its impacts**)

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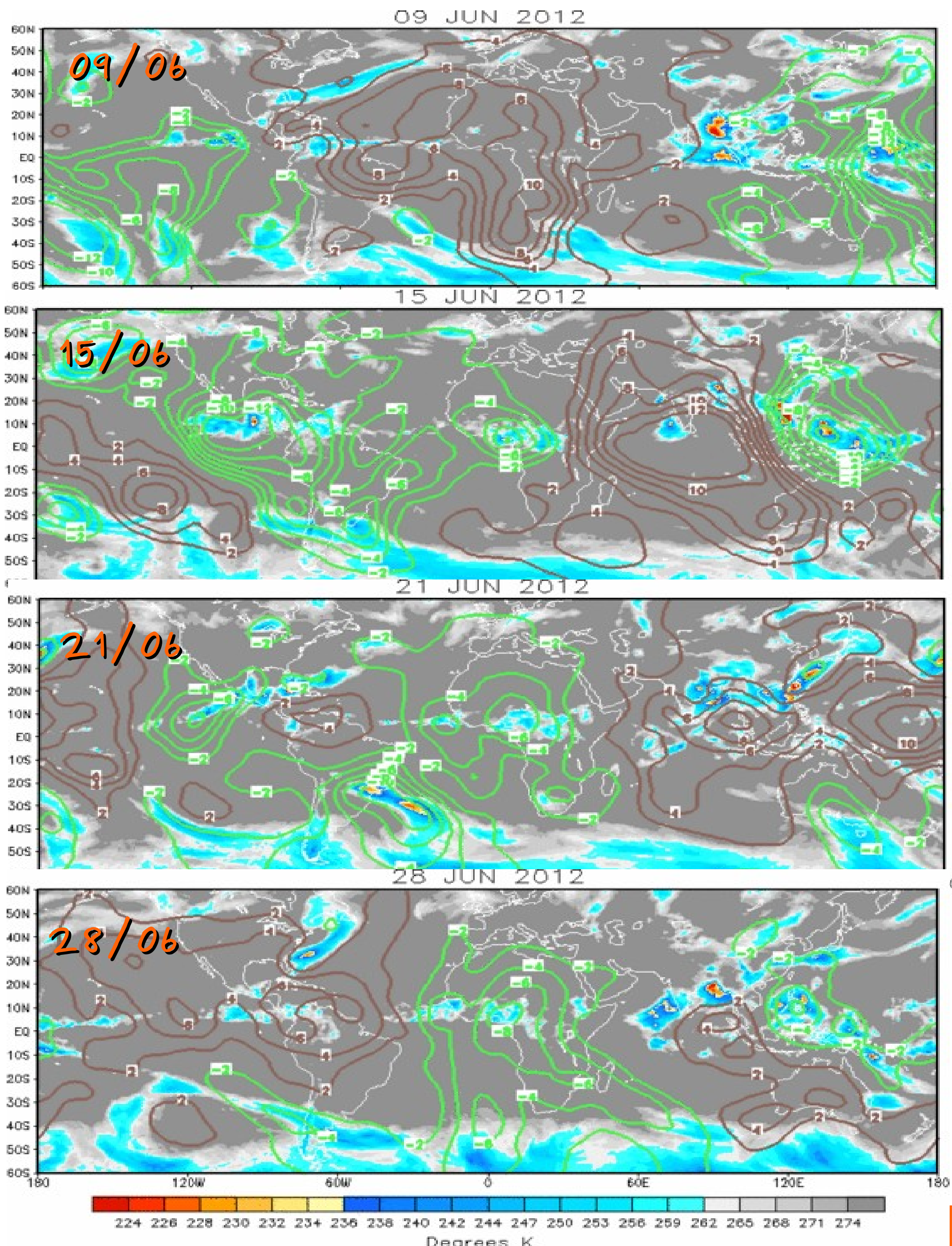
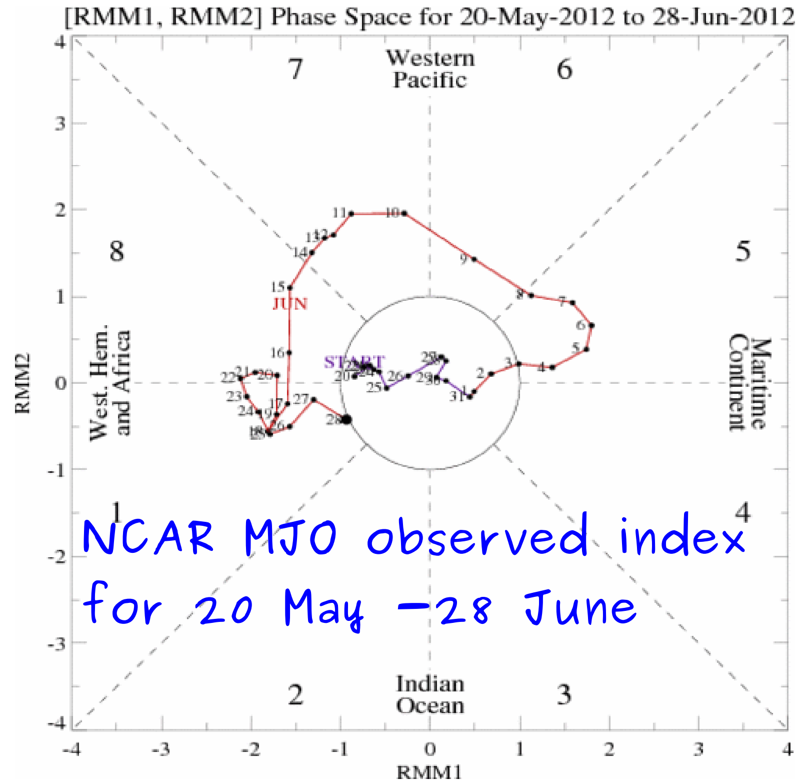


NCAR MJO monitoring IR/Vpot 200hPa

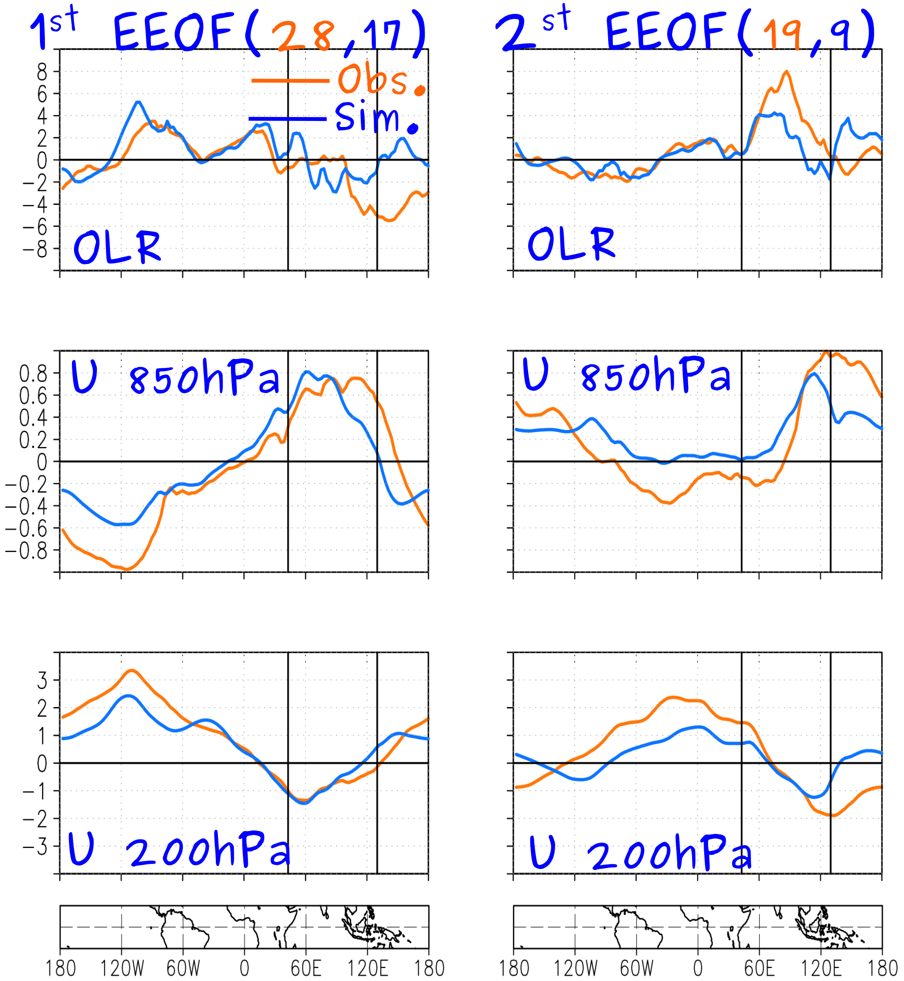


NCAR MJO observed index for 20 May –28 June

Thanks for your attention!

Additional Material

Extended EOF (EEOFs)



Observations

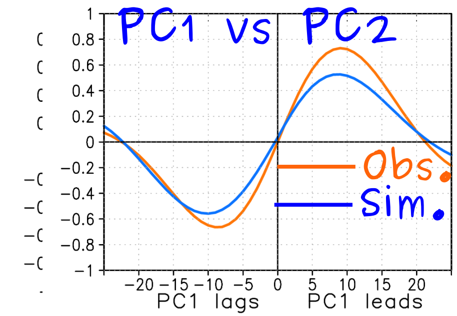
*EEOF#1: max. convection over West Pacific, zonal wind anomalies show baroclinic wave-like structure

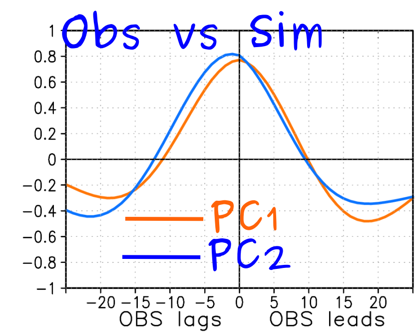
*EEOF#2: min. convection over Indian Ocean; wind anomalies shifted 60º to the east

Associated PCs

*PC1 leads PC2 by 9 days → eastward propagation of MJO anomalies (also in simulation)

*PCs from observations and simulations are highly related





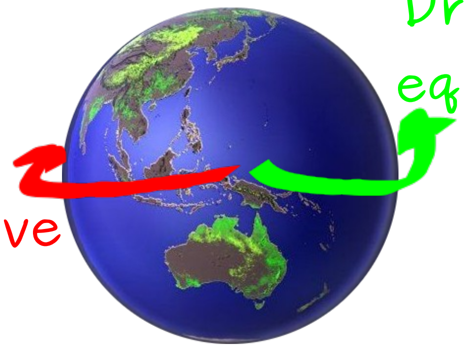
Simulations

*Similar to observations with some exceptions (e.g. OLR in EEOF#1 over the West Pacific)

Equatorial waves

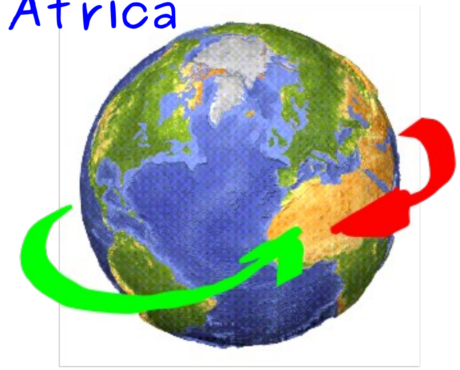
Matthews (2004):

Dry Rossby equatorial wave

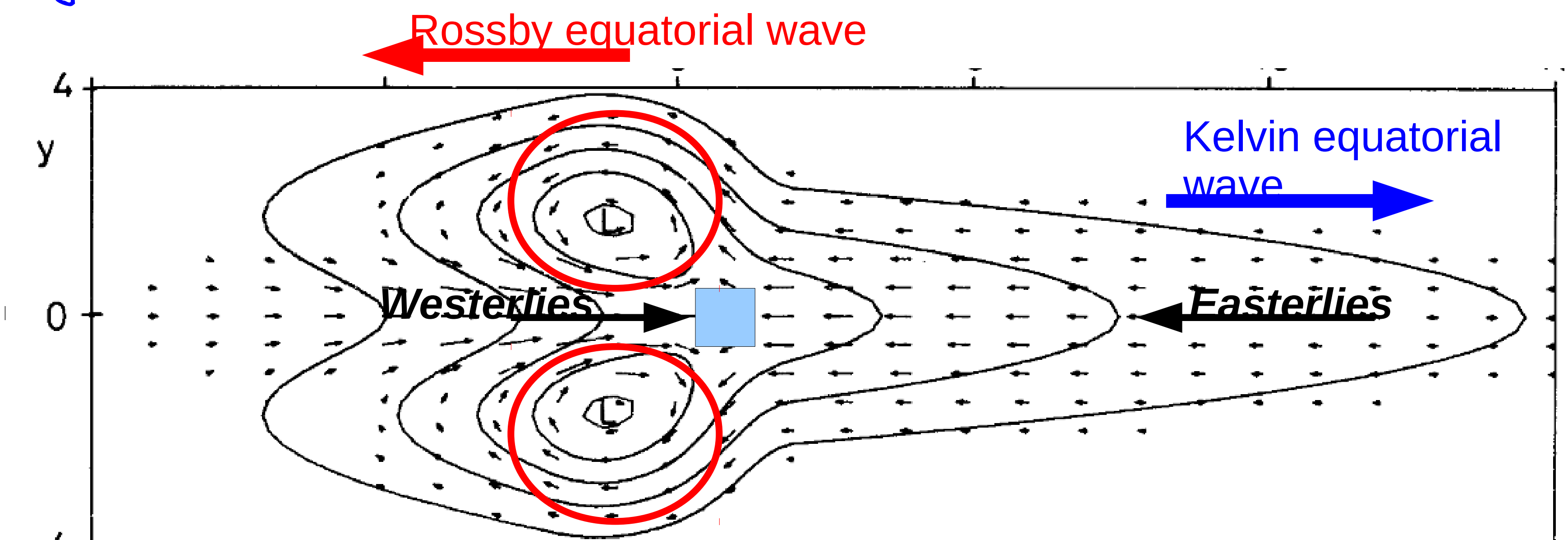


Dry Kelvin equatorial wave

Meet 20 days afterwards over West Africa



Signature on low level winds:

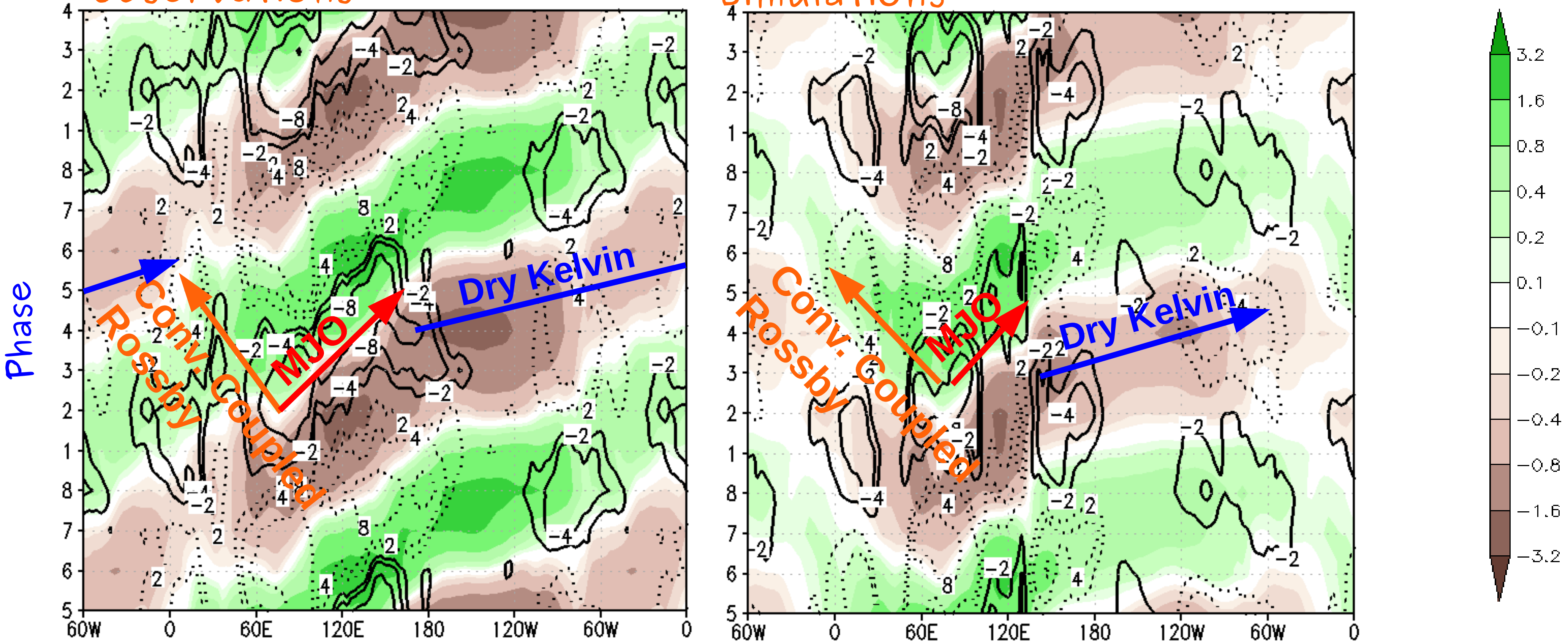


Gill et al. (1980)

Equatorial waves

Hovmöller diagram of equatorial (10ºS–10ºN) anomalies of OLR (contour:) & U at 850hPa (shaded)

Observations Simulations



*MJO eastward 7m/s
*Dry equatorial Kelvin wave 32m/s
*To the west: u850 anomalies propagate west at 6m/s → consistent with a convectively coupled equatorial Rossby (CCER) wave (not dry)

*Eastward MJO prop. in nudged region
*To the west: CCER at 7m/s reaches WA
*To the east: dry Kelvin at 30m/s does not reach WA → Not related to WA convection anomalies