Intraseasonal Variability of the Impacts of the Madden-Julian Oscillation on Rainfall along the Gulf of Guinea

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Introduction

The livelihood of millions of people in West Africa is linked to the variability of precipitation in the region (e.g., Janicot et al. 2011). Therefore, understanding intraseasonal rainfall variability in the region is vital for developing long-range forecasting approaches to enhance agricultural production and decision making and to mitigate impacts of extreme departures from normal rainfall. The Gulf of Guinea (GG) obtains bimodal rainfall with peaks in June and September and a drier period in July–August during the core of the West African monsoon (Reason and Rouault 2006, Figure 1). Many studies have found that the Madden-Julian Oscillation (MJO) impacts summer precipitation over West Africa (e.g., Mohino et al. 2012).

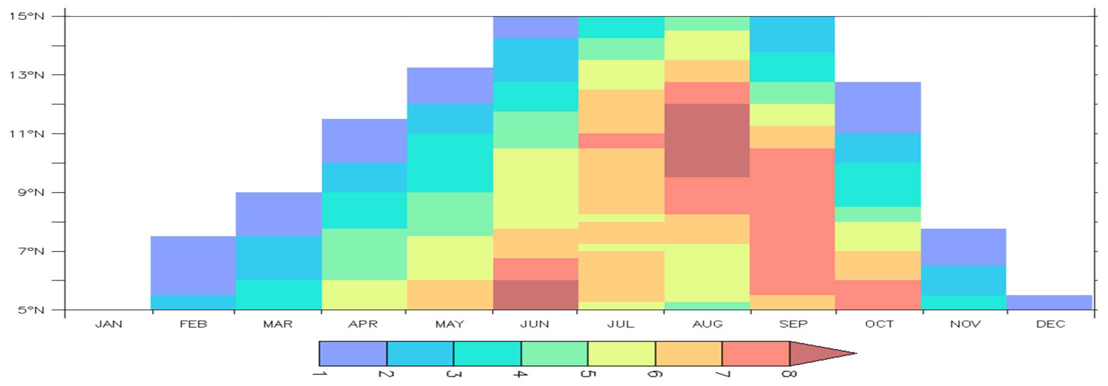

Figure 1. The mean seasonal cycle of rainfall (mm/day) over West Africa through a time- latitude cross-section derived from the Tropical Rainfall Measuring Mission (TRMM) 3B42 averaged over 10^{0}W-15^{0}E.

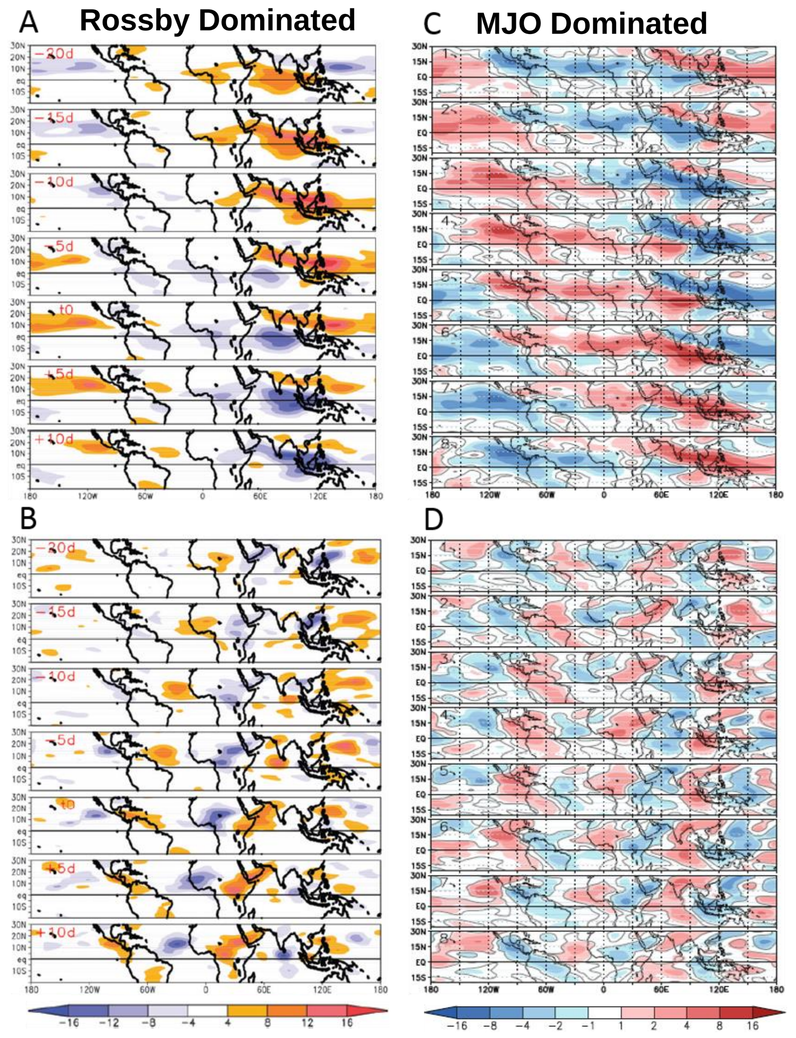

Figure 2.
(A) MJO-filtered OLR, (B) equatorial Rossby-filtered OLR composite fields over the whole tropics from t_0 - 20 to t_0 + 10 days with a time lag of 5 days, where t_0 is the maximum of the time series of the principal component of the first mode of spatial empirical orthogonal function analysis performed on 25–90-day bandpass filtered June–September OLR values over the domain 10^{0}S–30^{0}N, 30^{0}W–30^{0}E.

(C,D) Summer composites (based on MJO indices derived using extended empirical orthogonal function analysis Of zonal wind at 850 and 200 hPa and OLR standardized anomalies over the whole tropical belt and averaged in latitude between 15^{0}S and 15^{0}N) of observed OLR (C) MJO-filtered; (D) Rossby-filtered. (A,B) from Janicot et al. 2009; (C,D) from Mohino et al. 2012.

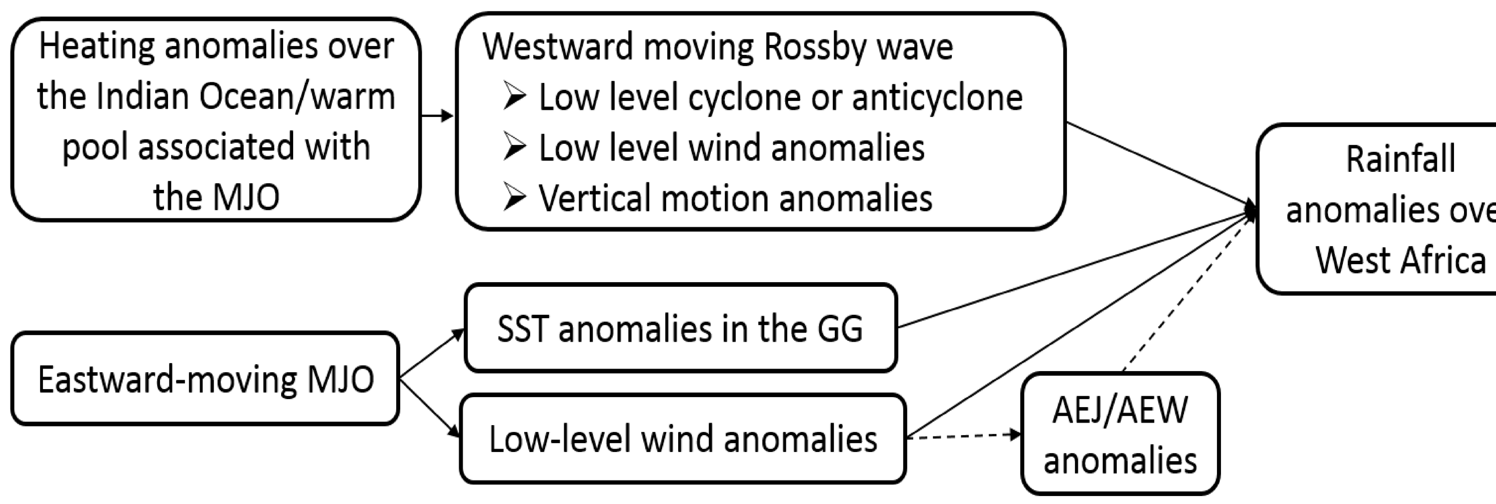

Figure 3. Mechanisms of MJO influence on West African precipitation.

Objectives

- **Explore impacts of the MJO on West African coast intraseasonal rainfall.**
- **Understand the associated changes in tropospheric circulation.**

Data

- **TRMM 3B42 V7**
- **NOAA OI SST V2 high res.**
- **NCEP/NCAR Reanalysis**
- **CPC MJO indices**

Results

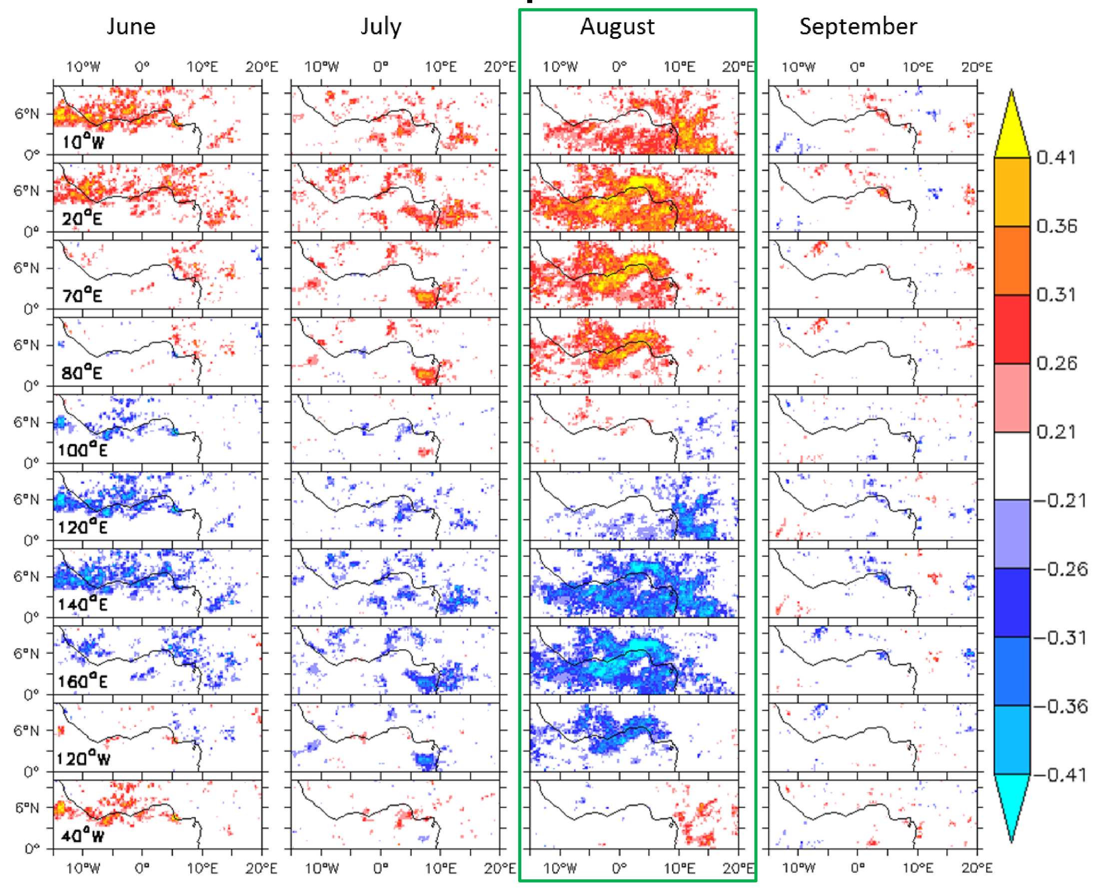

Figure 4. Correlations of precipitation and MJO indices. Shading shows results significant at the 95% confidence level. Maps of precipitation composites at 95% significance level are nearly identical and are not shown.

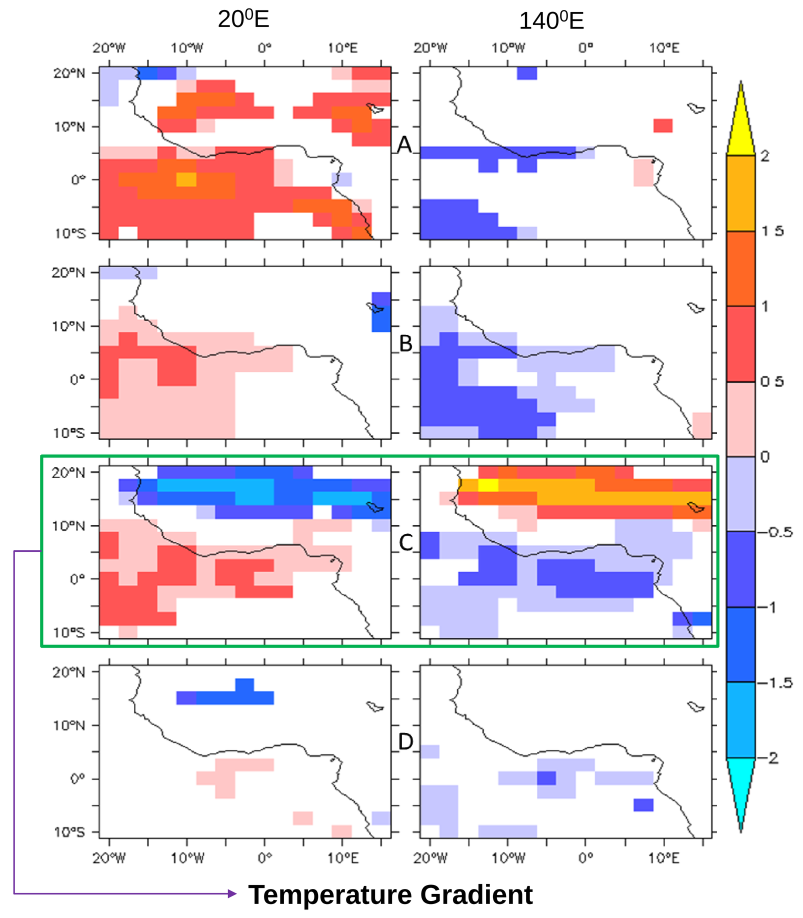

Figure 5. Composites of near surface air temperature (K) based on MJO indices at 20°E and 140^{0}E. (A) June, (B) July, (C) August, (D) September. Shading shows results significant at the 90% confidence level.

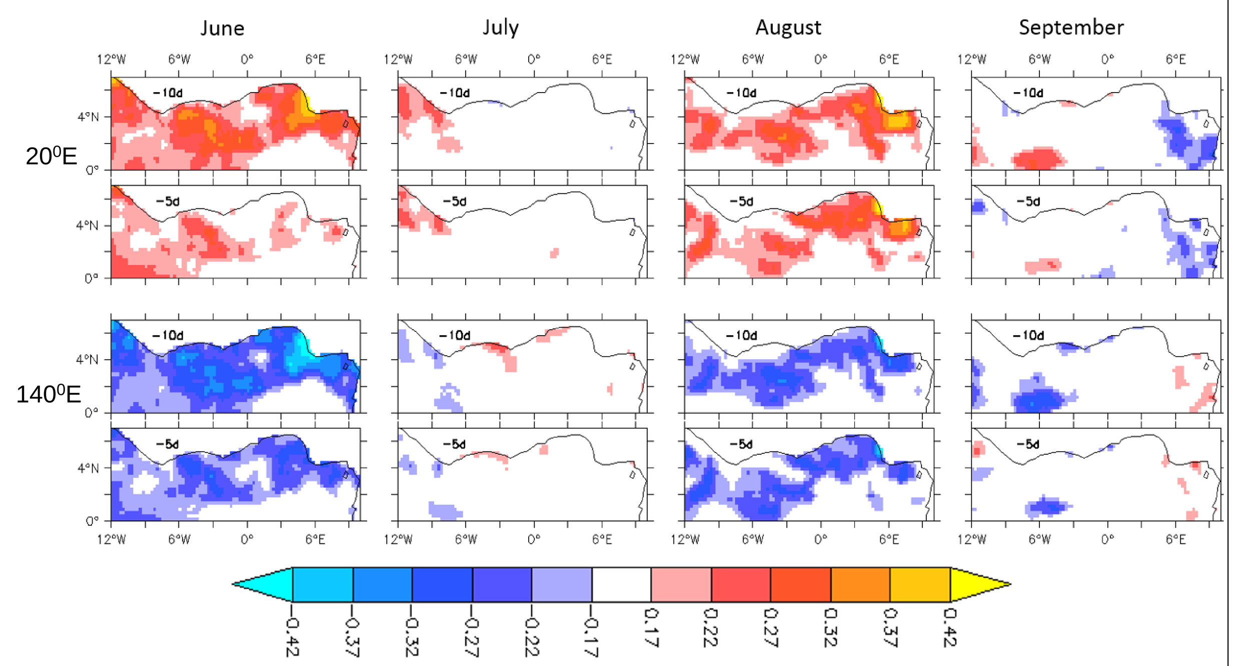

Figure 8. Correlations of sea surface temperature, at one and two pentads lead/lag, and MJO indices at 20^{0}E and 140^{0}E. Shading shows results significant at the 90% confidence level.

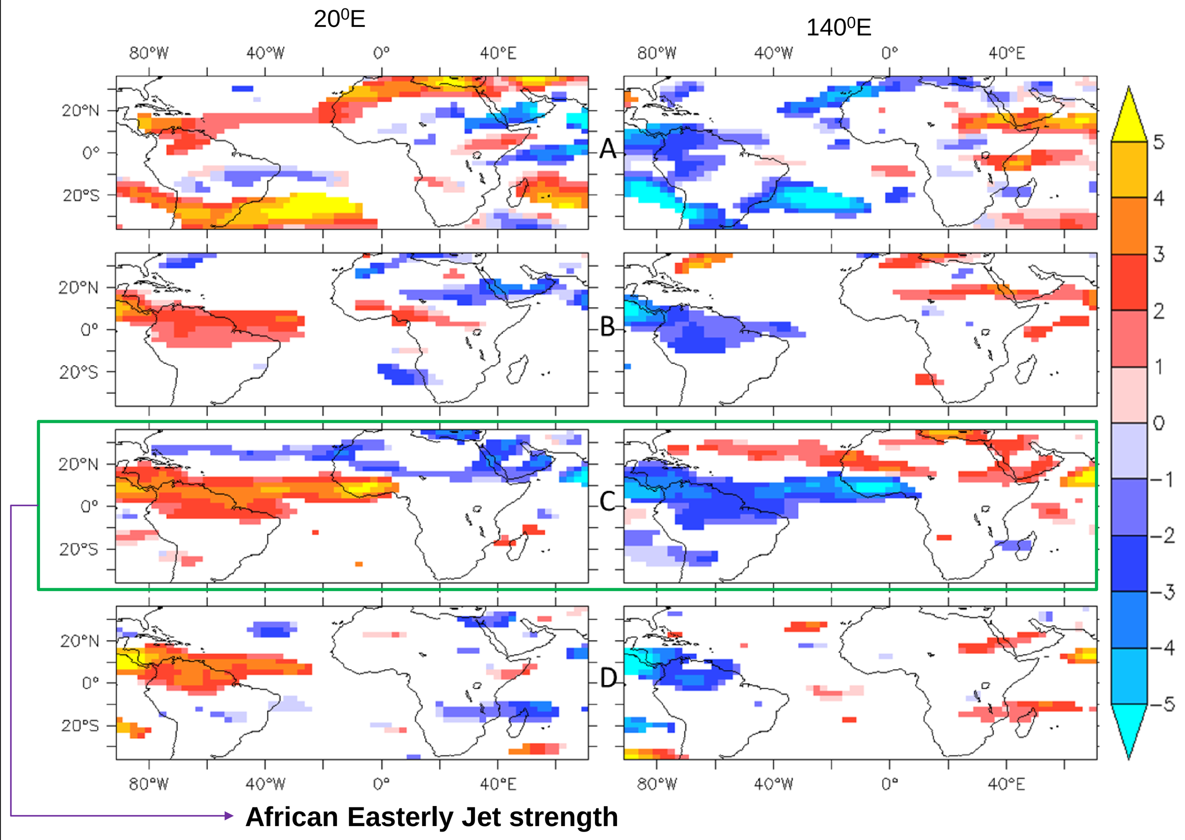

Figure 6. Composites of zonal wind (m s^{-1}) averaged from 700-600 hPa based on MJO indices at 20°E and 140°E. (A) June, (B) July, (C) August, (D) September. Shading shows results significant at the 90% confidence level. Maps of zonal wind, averaged from 700-600 hPa, correlations with the MJO indices at 90% significance level are nearly identical and are not shown.

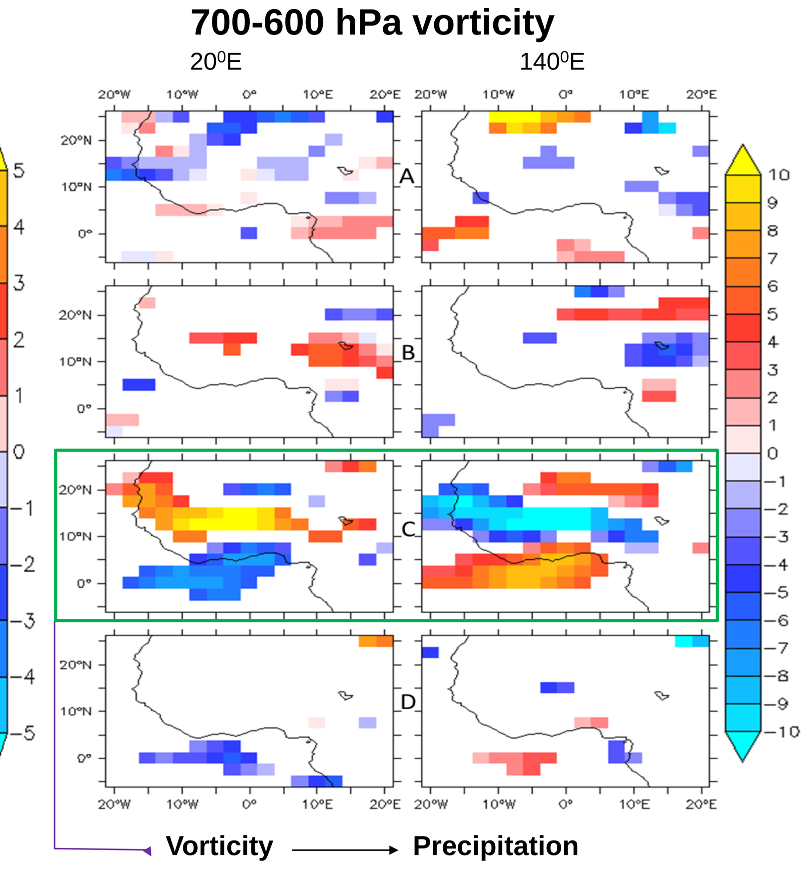

Figure 7. Composites of vorticity (10^{-6} s^{-1}) averaged from 700-600 hPa based on MJO indices at 20°E and 140^{0}E. (A) June, (B) July, (C) August, (D) September. Shading shows results significant at the 90% confidence level.

Discussion

- **The impacts of the MJO on precipitation along the GG show strong Intraseasonal variability.**
- **The strongest association is observed in August, however, there is no significant association with the MJO in September and October.**
- **Increased cyclonic shear on the equatorward flank of the African Easterly Jet (AEJ), which leads to enhanced African Easterly Waves (AEW) and transient convective activities, is significant in August only.**
- **Consistent with the AEJ composites, anomalies in the meridional temperature gradient between the warm Sahara Desert to the north and the cool GG to the south are observed in August.**
- **In June and August, one-two pentad lead/lag SST in the GG shows significant associations with the MJO, which is consistent with the precipitation anomalies since SST in the GG controls static stability and development of convection along the coast.**
- **Wavenumber-frequency spectral analysis is required to quantify the equatorial convectively coupled signals.**
- **The lead/lag SST anomalies are suggestive of direct MJO signal.**

Future Work

Quantify rainfall anomalies associated with the MJO and Rossby wave signals, and understand why the anomalies are strongest in August.

Acknowledgments

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