IMPACT OF THE MADDEN JULIAN OSCILLATION ON SUMMER RAINFALL OVER WEST AFRICA IN AMIP SIMULATIONS

NIANG Coumba (1,2,3,4), Elsa Mohino (3), Amadou T. Gaye (1)

(1) Laboratoire de Physique de l'Atmosphere et de l'Ocean Simeon Fongang (LPAO-SF), ESP, Dakar, Senegal

(2) Instituto de Geociencias (IGEO), Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC), Madrid, Spain.

(3) Departamento de Fisica de la Tierra, Astronomia y Astrofisica I, Geofisica y Meteorologia, Universidad Complutense de Madrid (UCM), Madrid, Spain

(4) WASCAL, Department of Meteorology and Climate Science, Federal University of Technology Akure (Nigeria)

Email: niangcoumba@hotmail.fr

Abstract

At intra-seasonal timescales, convection over West Africa is modulated by the Madden Julian Oscillation (MJO). In this work we investigate the simulation of such relationship by 11 state-of-the-art Atmospheric General Circulation Models run with prescribed observed Sea Surface Temperatures (SST). In general, the simulations shows good skill in capturing the main characteristics of the summer MJO as well as its influence on convection and rainfall over West Africa. Most models simulate an eastward spatiotemporal propagation of enhanced and sup- pressed convection similar to the observed MJO, although their signal over West Africa is weaker in some models. In addition, the ensemble average of models gives a better performance in reproducing the main features and timing of the MJO and its impact over West Africa. Our analysis of the equatorial waves suggests that the main impact over West Africa is established by the propagation of low-frequency waves within the MJO and Rossby spectral peaks. Results from the simulations confirm that it may be possible to predict anomalous convection over West Africa with a time lead of 15-20 day.

Introduction

1. Rainfall variability over West Africa in the 20-60 day which share the same range of periodicity as the MJO (Janicot and Sultan, 2001; Matthews, 2004) .
2. Very few studies in evaluating the simulations of MJO impact over WA as well as the mechanisms however need to improve our understanding of the mechanisms underlying the MJO-West Africa link (Lin et al., 2006; Mohino et al., 2012)
3. Need to evaluate the impact of the MJO on rainfall/convection over WA and the dynamical mechanism involved in state-of-the-art AMIP's models.

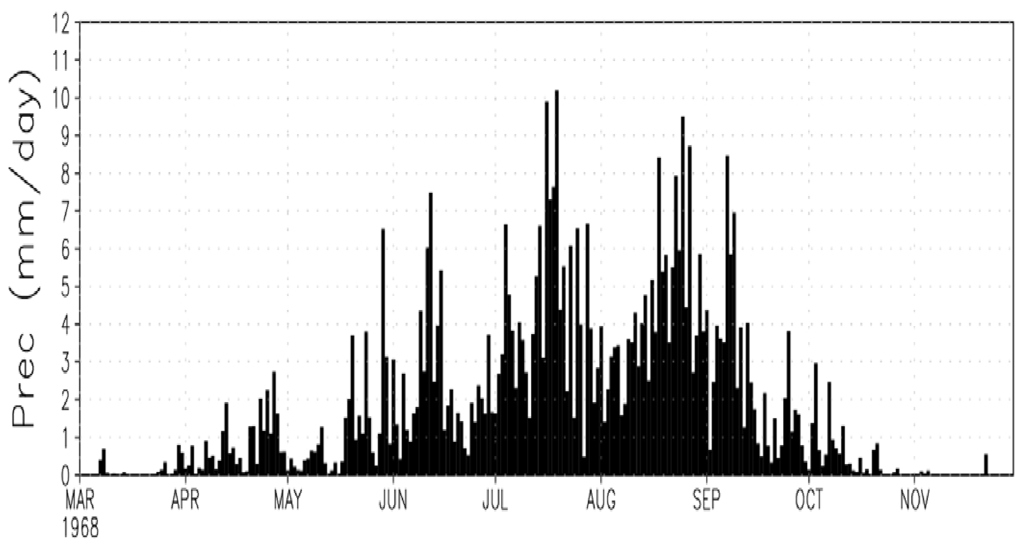

Figure 1: Fluctuations between 10 and 90 days (Janicot et al, 2001).

Data and Methodology

1- Data

* NOAA daily interpolated Outgoing Longwave Radiation (OLR) as convection proxy with 2.5°x2.5° resolution(Liebmann and Smith,1996).
* Daily GPCP global rainfall data (1° x1°; Huffman et al., 2001).
* ERA-40 (Uppala et al., 2005) and ERA-Interim (Dee and Uppala et al., 2009) zonal wind interpolated into a grid of 3°x 2° (1979-2008).
* Atmospheric Model Intercomparison Project (AMIP) simulations from eleven models (1979-2008).

2- Methods

* Similar method as Wheeler and Hendon, (2004) based on CEOF analysis on U850 and U200 hPa and OLR (filtered over 20-90 day band-pass) averaged between 15°S-15°N.
* CEOF1 and CEOF2 modes used to describe the MJO evolution using composites maps.
* Wavenumber-frequency analysis and filtering on OLR to separate the different convectively coupled equatorial waves (CCEW).

Results

1- Evolution of summer MJO through AMIP

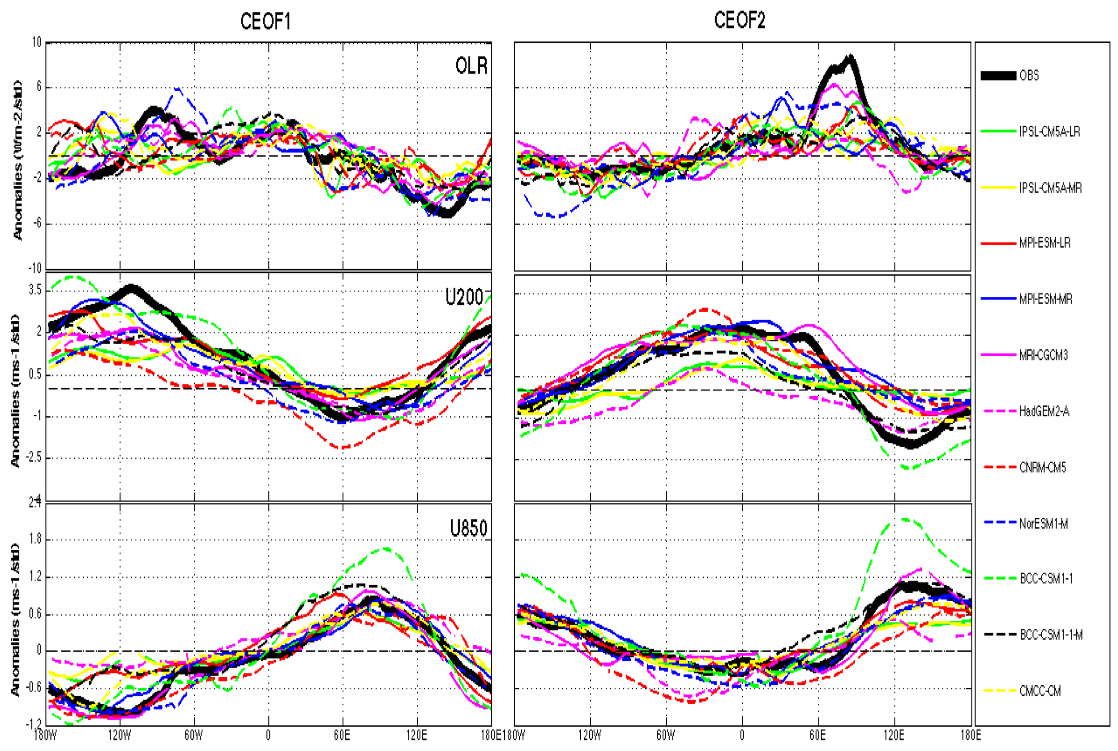

Figure 2: Observed (thick black line) and simulated first two CEOFs of summer OLR and zonal wind at 850 and 200 hPa anomalies from AMIP simulations.

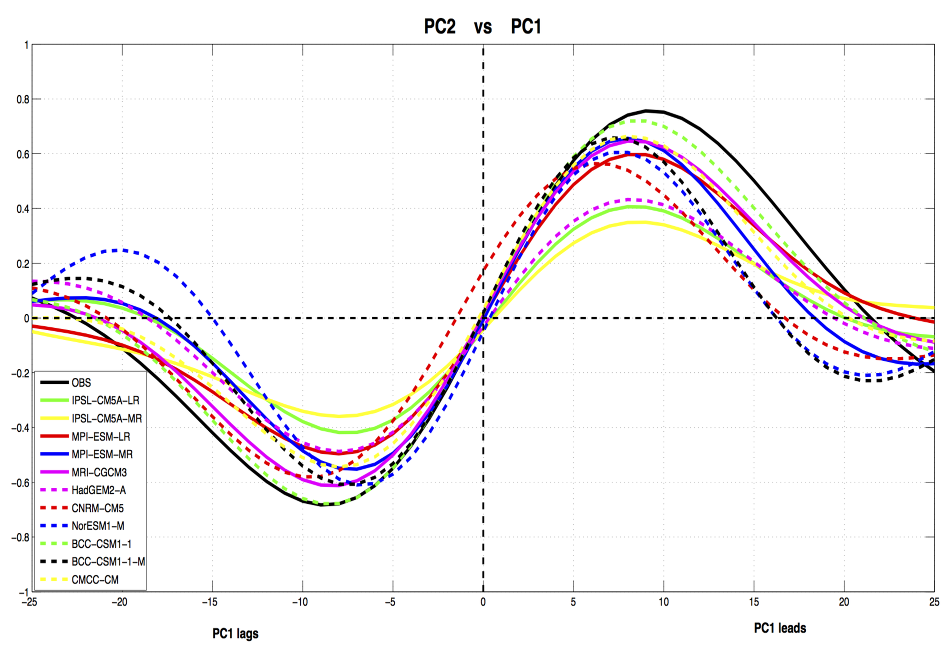

Figure 3: Lead-lag correlations between the principal components associated with the first and second CEOF from observation and AMIP simulations.

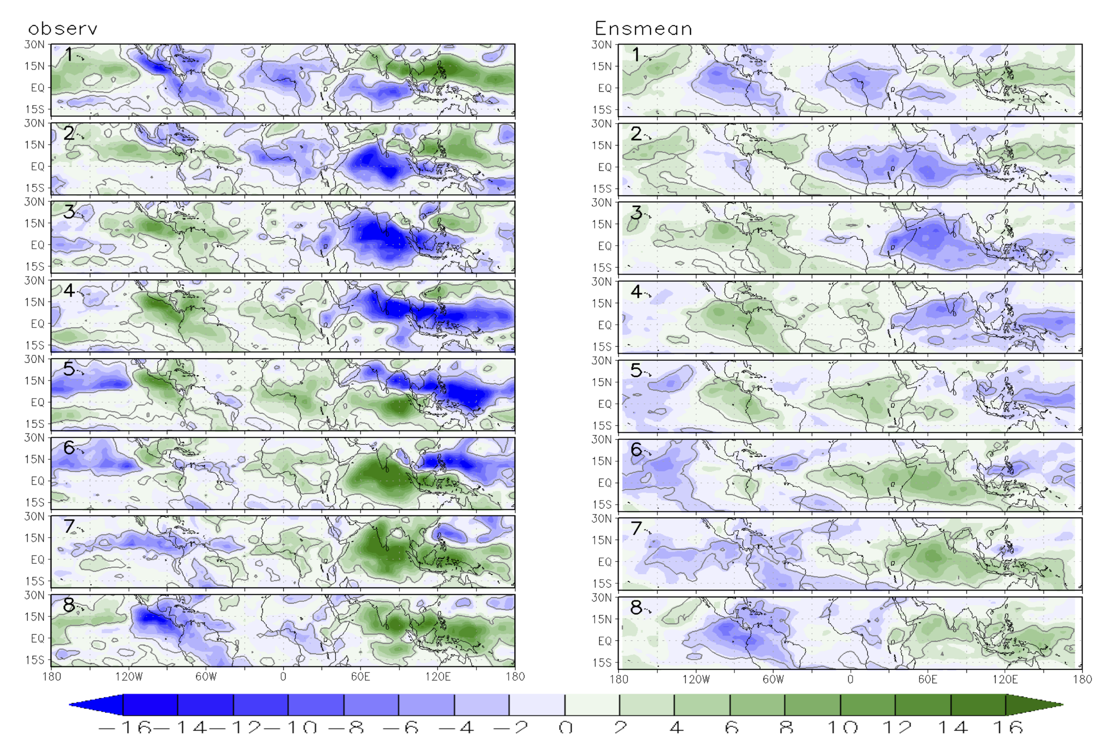

Figure 4: Summer composites of deseasonalized anomalies of OLR (Wm-2) according to the eight phases of the MJO, from observation (left) and the ensemble of AMIP simulations (right). The grey contours represent 95% significant regions obtained from a tailed t-test.

3- Impacts of MJO over West Africa

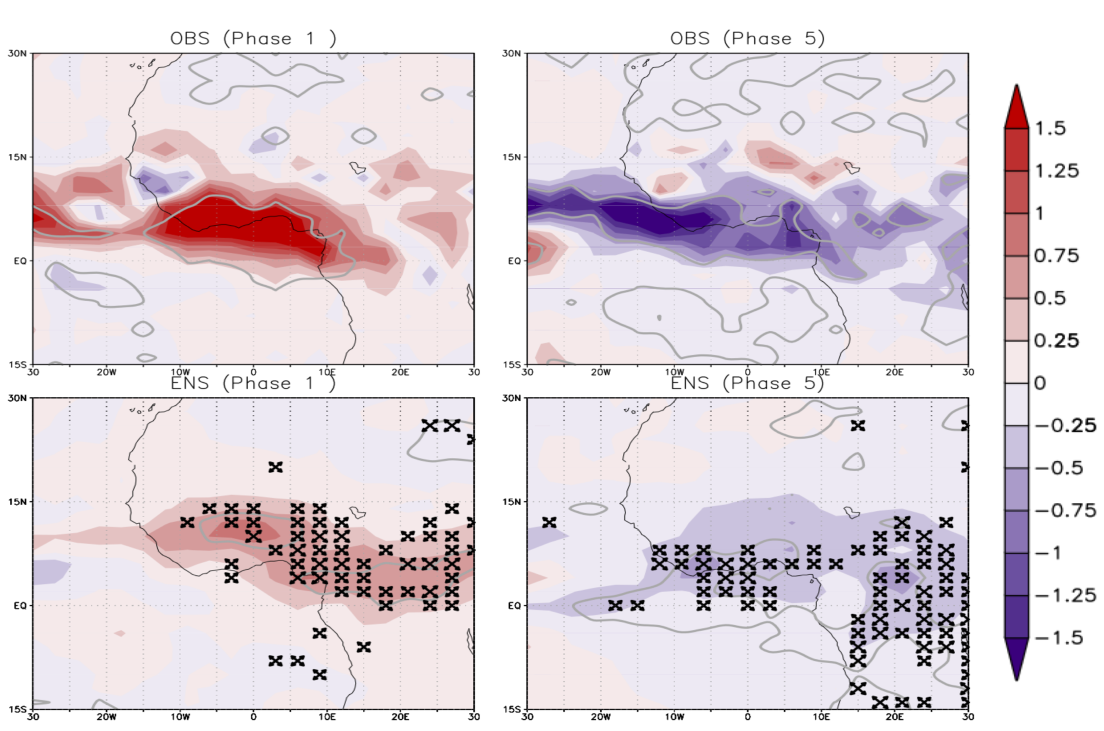

Figure 5: Rainfall anomaly composites (shaded) during the convective phase 1 (left) and phase 5 (right) of MJO for obs (top) and the ensemble average (bottom) over WA. The units are in mm/day. The marked (x) points represent the area where at least eight (8) out of 11 models are consistent on the sign of the composite. Grey contours represent the area where rainfall anomalies are 95% significant.

3- Mechanisms through which MJO impacts West African rainfall

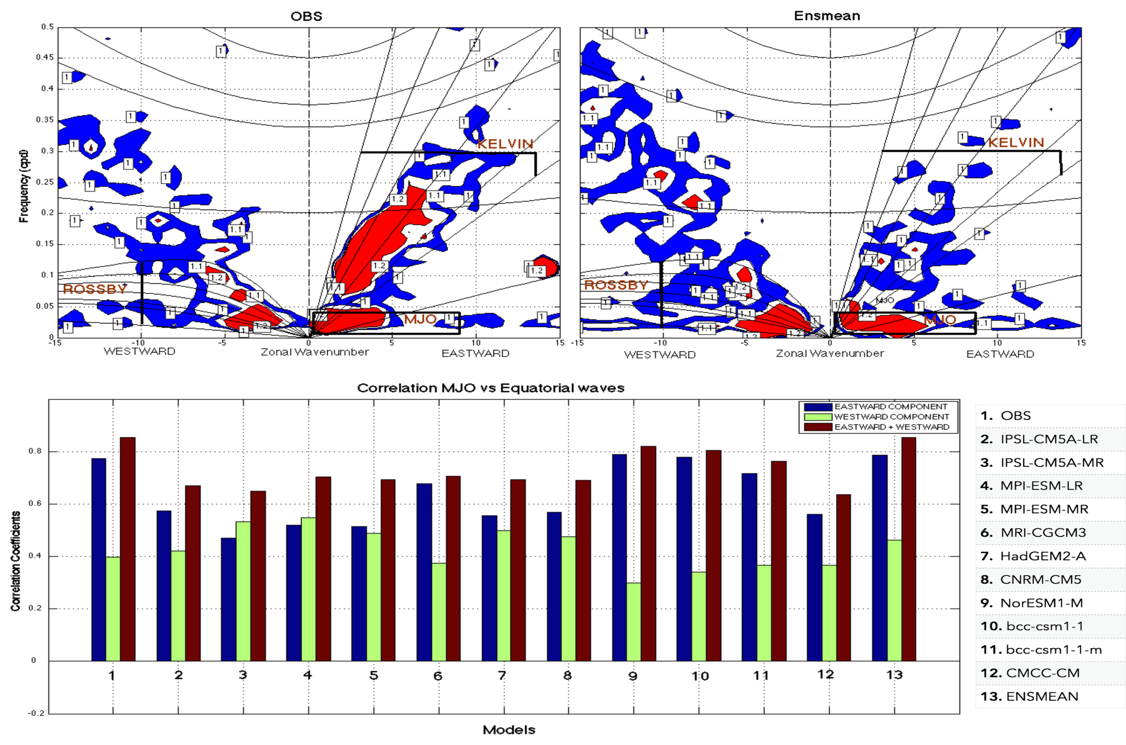

Figure 6: Wavenumber frequency spectral analysis of deseasonalized OLR from the observation and the ensemble averaged of models simulation (top) and Correlation of the non-filtered OLR composites and each of the convectively equatorial waves from observation and AMIP models over the wavenumber-frequency domain (down).

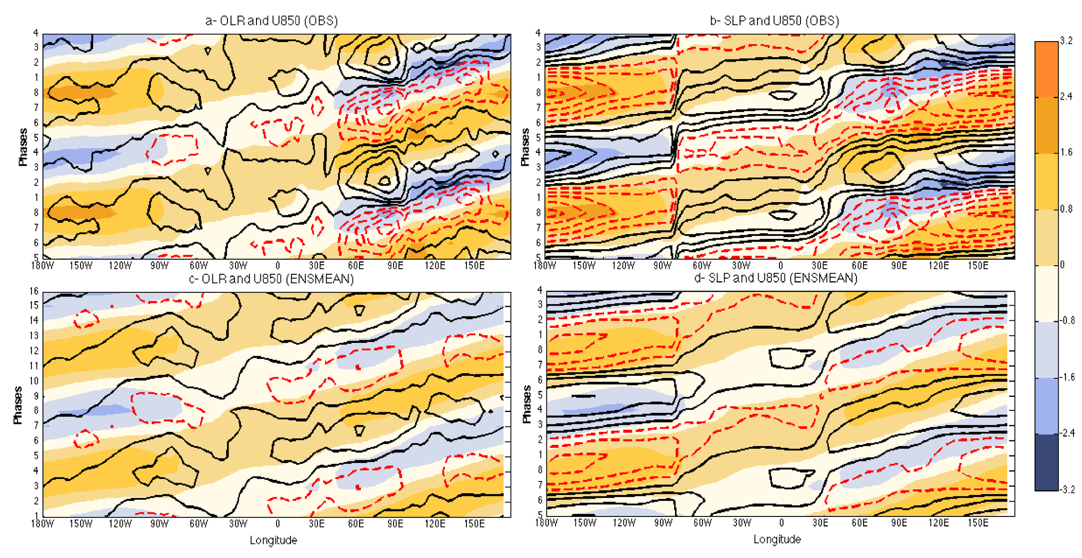

Figure 7: Composites Hovmoller diagram of deseasonalized anomalies averaged between 10°S and 10°N of zonal wind at 850hPa (m/s) for observed (a and b) and simulated (c and d). The red dashed contours represent the positives values of OLR (SLP) while the black solid contours show the negatives ones in a and c (b and d).

Conclusions

* **Clear evidences of the impact of MJO on WA rainfall variability during the summer period**
* **AMIP models tend to show such relationship between the MJO and OLR/rainfall anomalies in phase with observations**
* **MJO also impacts the AEJ, particularly over the coastal regions (not shown)**
* **The combination of westward and eastward propagating signals explain most of the pattern associated with the MJO impact over WA**
* **Influence of MJO could be used to predict the occurrences of wet and dry spells over WA**

References

1. Dee, D. P. and Uppala, S., 2009: Variational bias correction of satellite radiance data in the ERA-interim reanalysis. Q.J.R Meteorol Soc., 135:1830-1841.
2. Huffman, G. J. , Adler, R., F., Morrissey, M. M., Bolvin, D. T., Curtis, S., Joyce, R., McGavock, B., Susskind, J., 2001: Global precipitation at one- degree daily resolution from multisatellite observations. J Hydrometeor, 2: 36-50.
3. Janicot, S and Sultan, J., 2001: Intra-seasonal modulation of convection in the West African monsoon. Geophys Res Lett, 28: 523-526.
4. Liebmann, B. and Smith, C. A., 1996: Description of a complete (interpolated) outgoing longwave radiation dataset. Bull. Amer. Meteor. Soc., 77,1275-1277.
5. Lin, J.-L., Kiladis, G. N., Mapes, B. E., Weickmann, K. M., Sperber, K. R., Lin, W., Wheeler, M. C., Schubert, S. D., Del Genio, A., Donner, L. J., Emori, S., Gueremy, J. F., Hourdin, F., Rasch, P. J., Roeckner, E. and Scinocca, J. F., 2006: Tropical intraseasonal variability in 14 IPCC AR4 climate models. Part I: Convective signals. J. Climate, 19, 2665 -2690, doi:10.1175/JCLI3735.1.
6. Mohino, E., Janicot, S., Douville, H. and Li, Z. X. L, 2012: Impact of the Indian part of the summer MJO on West Africa using nudged climate simulations. Clim. Dyn, vol. 38: pp. 2319-2334 DOI: 10.1007/s00382-011- 1206-y.
7. Uppala, S. M. et al., 2005: The ERA-40 re-analysis. Q.J.R Meteorol Soc, 131: 2961-3012.
8. Wheeler, M. and Hendon, H., 2004: An all-season real-time multivariate MJO index: development of an index for monitoring and prediction. Mon. Weather Rev., 132: 1917- 1932.

Acknowledgements

1- Agencia Estatal Consejo Superior de Investigaciones Cientificas (CSIC) of Spain (I-COOP+ reference COOPA20029 program) / Instituto de Geociencias (IGEO).

2- Universidad Complutense de Madrid (UCM) via the collaboration with LPAO-SF.

3- European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n 603521 and the Spanish project CGL2012-38923-C02-01.

4- WASCAL (West African Science Service Center on Climate Change and Adapted Land Use) project.