4B.3 Impact of the West African summer monsoon intra-seasonal variability on the life cycle of convective systems

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1. INTRODUCTION

The intra-seasonal variability of the West African summer monsoon is characterised by three main modes around 15 days and 40 days periodicity (Mounier & Janicot, 2004). Around 15 days, two types of modes are differentiated: one quasi-stationary centre close to the equator along the Guinean coast which can be coupled with atmospheric Kelvin waves propagating eastward; a second mode finding its origin in Central Africa and propagating westward on Sahelian latitudes similarly to equatorial Rossby waves to the west side of the tropical Atlantic. Around 40 days, one mode modulating the whole of the west and central African convection was also depicted and shows links with the Madden-Julian Oscillation coming from the Indian Ocean. The impact of these modes on the convective activity is examined using high resolution mesoscale convective systems (MCS) data. These analyses show that reinforcement or weakening of convection anomalies linked to these modes modulates significantly the cloud cluster distribution.

2. DATA

These analyses are based on the use of different resolution convection proxy. First, the daily Interpolated OLR dataset of 2.5° resolution from the Climate Diagnostics Centre have been used as they are a reference for tropical studies where deep convection and rainfall can be estimated through low OLR values.
Then, a database identifying cloud clusters from the full-resolution (30 mn, 5 x 5 km^2) Meteosat infrared channel (10.5-12.5 µm) has been employed. The MCS identification was carried out through tracking algorithm based on an area overlap method (Mathon and Laurent 2001, Mathon et al. 2002). MCS systems have been defined as convective clouds larger than 5000 km^2 at the 233K brightness temperature threshold commonly used for identifying deep convection (Duvel 1989) and accumulated convective precipitation in the Tropics (Arkin 1979). MCS lasting more than 12 hours have been retained and a set of daily duration of MCS occurrences has been built on a 1° x 1° grid. This dataset is available for the monsoon period (June to September) between 1983 and 1999 over the domain 0°-20°N/ 60°W-40°E. Because of the varying availability of Meteosat data, the extracted areas are not identical, the overlapping area being 5°N-20°N and 20°W-20°E. No data were available east of 20°E over the period 1989-1991, south of 5°N and west of 29°W for the year 1992, and west of 25°W over the period 1993-1997.
Finally, the NCEP-DOE AMIP-II Reanalysis (R-2) dataset has been used to document the low level circulation associated with the different intra-seasonal modes.

3. AN EXAMPLE

Focus is given in this abstract to the case of the impact on the life cycle of convective systems of the Rossby waves associated to the 15 days second intra-seasonal mode of variability.
A Spatial Empirical Orthogonal Function analysis (SEOF) has been performed on the Rossby-filtered June-September OLR values over the domain 10°S-30°N/30°W-30°E for the period 1979-2000 (see Wheeler & Kiladis (1999) for more detail on the filtering technique). The two first modes form an "effectively degenerate multiplet" and have been recombined together. The figure hereafter (*top right*) displays the composite map of unfiltered OLR and associated wind and geopotential circulation at 925 hPa. It exhibits a clear coherence with the theoretical representation of equatorially trapped Rossby waves (*bottom right*): an area of convection reinforcement in blue up to 20 W.m^{-2} (associated with low levels convergence) with at 925 hPa on its east (west) side an anti-cyclonic (cyclonic) area of high (low) pressure. The equatorial symmetry of the equatorially trapped Rossby waves is not visible concerning the OLR and geopotential anomalies. However it is clearly visible in the wind circulation even if the axis is 7.5°N instead of the equator underlining the coupling with the convection which disturbs the wave, imposing the ITCZ (Inter-Tropical Convergence Zone) position as an axe of symmetry.

A similar analysis is done on convection thought MCS occurrences (left). At t0, areas of convection reinforcement (weakening) are coherent with more (less) MCS occurrences (the average per day being about 3 occurrences, values of +/-1.5 represent a 50% change). The sequence highlights also the westward propagation of these anomalies. Moreover, on this higher resolution levels, the symmetry about the ITCZ appears clearly from t0-6 to t0-3 indicating the enlargement of the ITCZ associated with the propagation of the Rossby wave.

4. CONCLUSION

This example analyses the impact of one feature of the African monsoon linked to the 15 days second mode of intra-seasonal variability onto the life cycle of convective systems. It has also depicted the coherence between different sets of data as well as the agreement of the high resolution MCS occurrence data with details of the theoretical structure of equatorially trapped Rossby waves.

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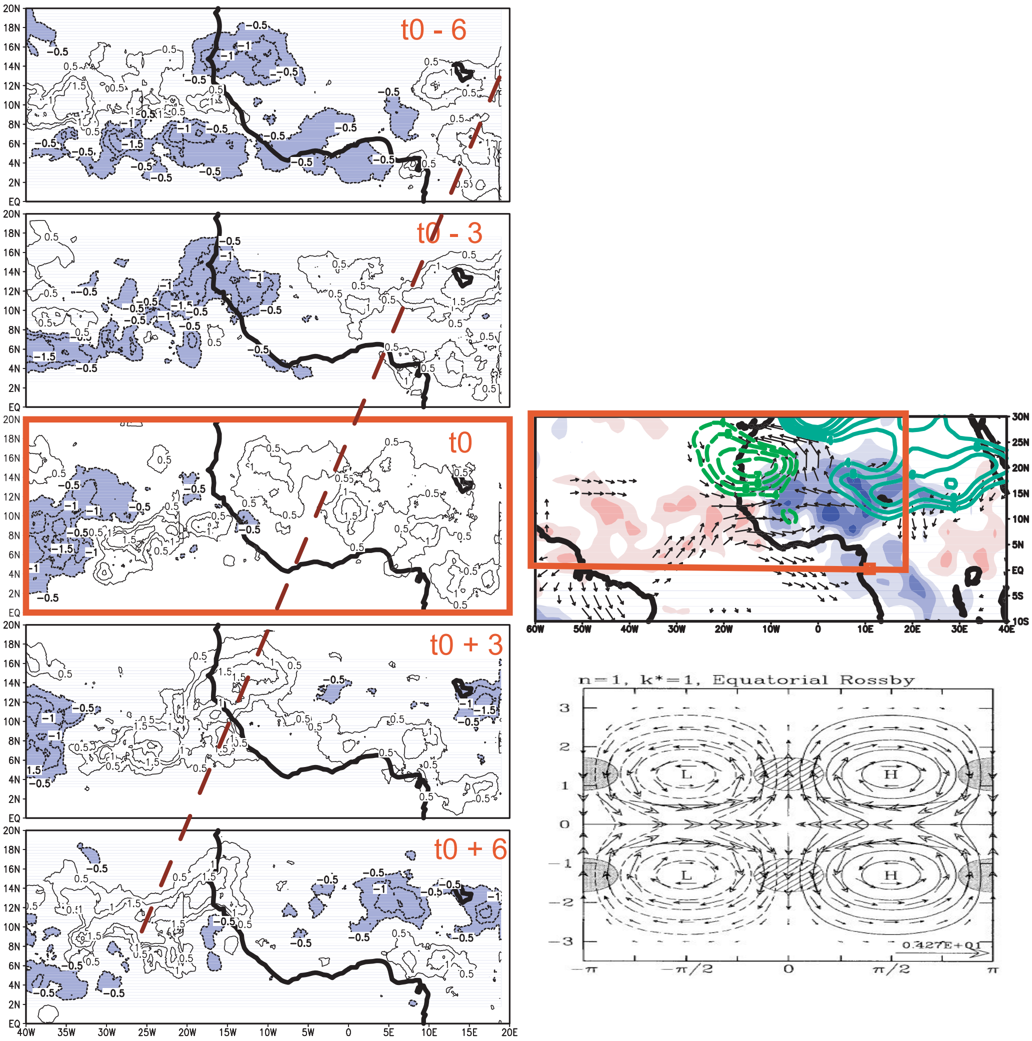

(**Right**) *top***.** Composite based on the OLR rossby-filtered index averaged on the area 7.5°N-12.5°N/10°W-10°E reconstructed by the EOF analysis. For the reconstructed ITCZ index time series, we retained the dates where this index is maximum (minimum) and its deviation from its mean is greater (lower) than its standard deviation to define a dry (wet) phase. The respective wet minus dry composite is shown for the unfiltered: OLR (+/-20 W.m^{-2} by 5 +/-5 not represented; shaded) and 925 hPa wind (vector; significant at 95%) and 925 hPa geopotential height (mgp; contours); *bottom.* Theoretical equatorially trapped Rossby wave solution to the linear shallow water equations on a beta-plane at n=1. Hatching and shaded areas are respectively for convergence and divergence. Unshaded contours are for geopotential (plain for positive values), (from Wheeler et al., 2000). (**left**) Composite sequence based on the same index but for the occurrence of MCS lasting more than 12 hours and at the threshold 233K. The scale maximum is 48 (meaning that 48 images per day, one every 30 minutes) where presenting this type of MCS. This sequence goes (top to bottom) from t_0 minus 6 days to t_0 plus 6 days with 3 days lags.

5. REFERENCES

Arkin P. A., 1979. The relationship between fractional coverage of high cloud and rainfall accumulations during GATE over the B-scale array. *Mon. Wea. Rev*., **107**, 1382-1387.

Duvel, J.P., 1989. Convection over tropical Africa and the Atlantic ocean during northern summer. Part I: Interannual and diurnal variations. *Mon. Wea. Rev.*, **117**, 2782-2799.

Mathon, V. and H. Laurent, 2001. Life cycle of Sahelian mesoscale convective cloud systems. *Quart. J. Roy. Met. Soc.,* **127**, 377-406.

Mathon V., Laurent H. and T. Lebel, 2002. Mesoscale convective systems rainfall in the Sahel. *J. Applied Meteor.,* **41**, 1081-1092.

Mounier F., and Janicot S., 2004. Evidence of two independent modes of convection at intraseasonal timescale in the West African summer monsoon. *Geophys. Res. Lett.,* **31**, L16116.

Wheeler M., and G. N. Kiladis, 1999. Convectively coupled equatorial waves: analysis of cloud and temperarture in the wavenumber-frequency domain. *Journal of Atmospheric Sciences*, **56**, 374-399.

Wheeler m., Kiladis G. N. et P. J. Webster, 2000. Large-scale fields associated with convetively coupled equatorial waves. *Journal of Atmospheric Sciences*, **57**, 613-640.