Laboratoire d'Océanographie et du Climat: Expérimentation et Approches Numériques

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Seasonal and intra-seasonal variability of the West African monsoon

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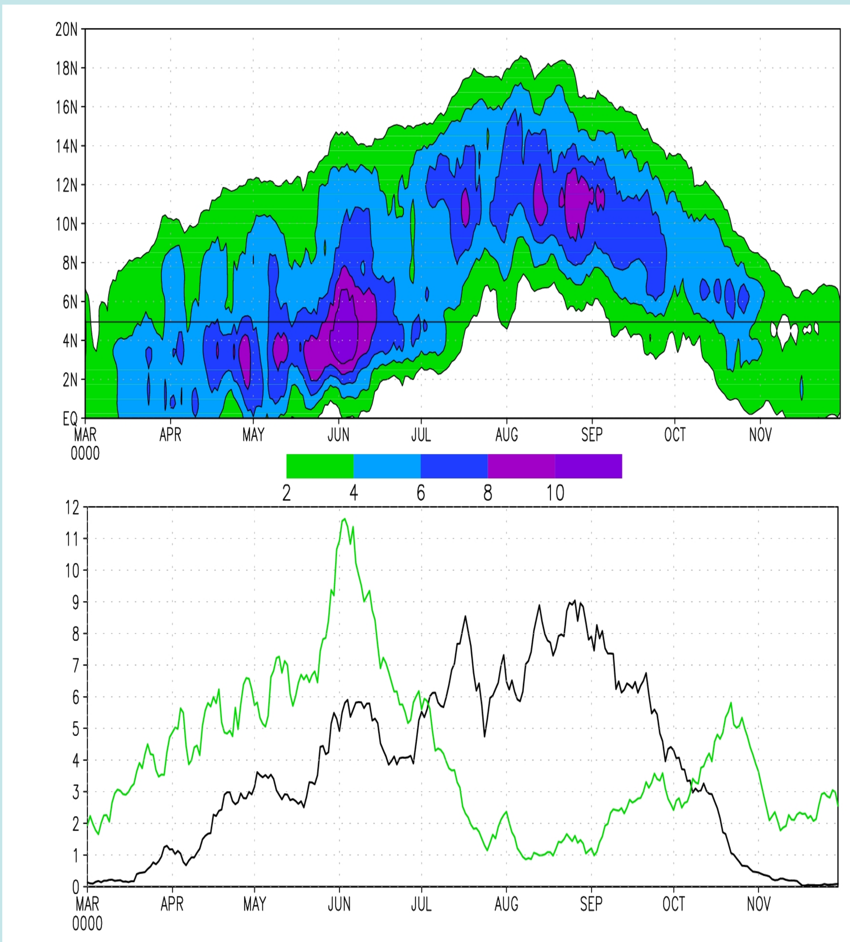
Abstract. The intraseasonal time scale is critical in West Africa where resources are highly rainfall dependent. Three main modes of variability have been identified, two with a mean periodicity of 15 days and one with a mean periodicity around 40 days. These modes have a regional scale and can strongly influence precipitation and convective activity. They are mainly controlled by atmospheric dynamics and land-surface interactions. They can also modulate the very specific phase of the African summer monsoon onset. A better knowledge of the mechanisms controlling this scale is necessary to improve its predictability.



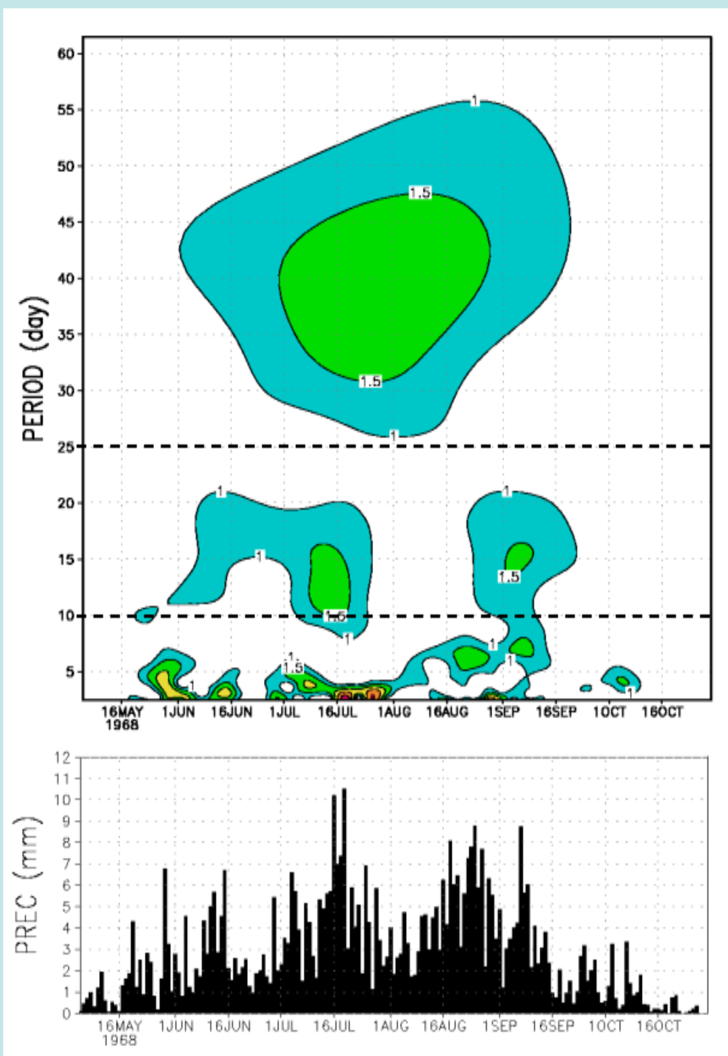


Figure 1. *Top Panel: Top: The mean seasonal cycle of rainfall over West Africa through a latitude cross-section. March-November daily precipitation values (mm.day^{-1}) from GPCP satellite-estimated values are averaged over 5°W-5°E and over the period 1997-2006. A seven-day moving average has been applied to remove high-frequency variability. The black horizontal line at 5°N represents the Guinean coast. Bottom: Cross-sections at 11°N (black line) and 5°N (green line). Bottom Panel: Bottom: Time series from 1st of May to 31st of October 1968 of daily rainfall (mm.day^{-1}) averaged over the Sahel area 2.5°W - 2.5°E/12.5°N - 15°N. Data set from IRD in-situ measurements. Top: Associated wavelet diagram.*

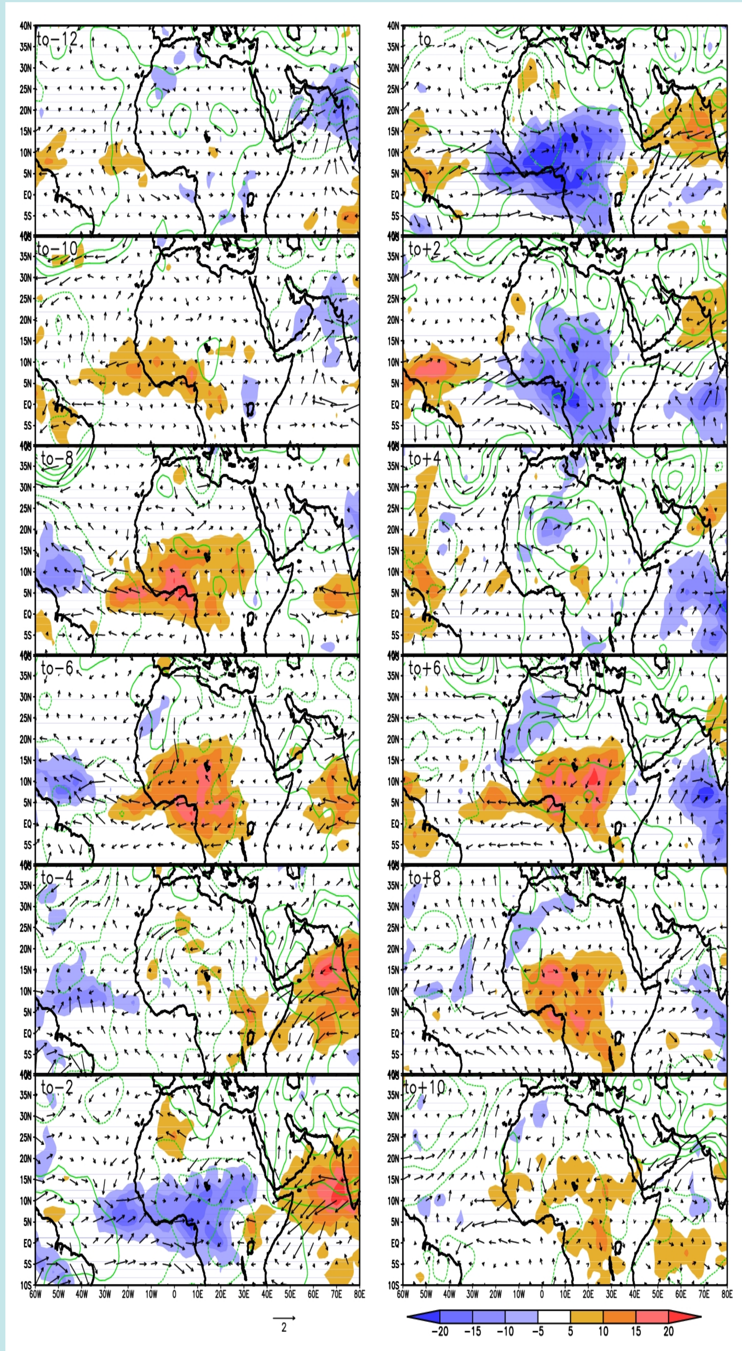


Figure 2. Time sequence of strong minus weak convective events for June-September 1979-2006 based on the reconstructed 10-25-day filtered OLR ITCZ index by the first EOF mode: unfiltered OLR values (colours; W m^{-2}), 925 hPa wind vectors (m s^{-1}) and 925 hPa geopotential heights (green solid (dashed) contours for positive (negative) values; isolines are drawn every 2 mgp with zero-isoline omitted). For clarity, only one grid point out of two is represented for the wind vectors. The sequence goes from t_0-12 to t_0+10 days with a time lag of 2 days. The convection increase is represented by blue colours, and convection decrease by red colours.

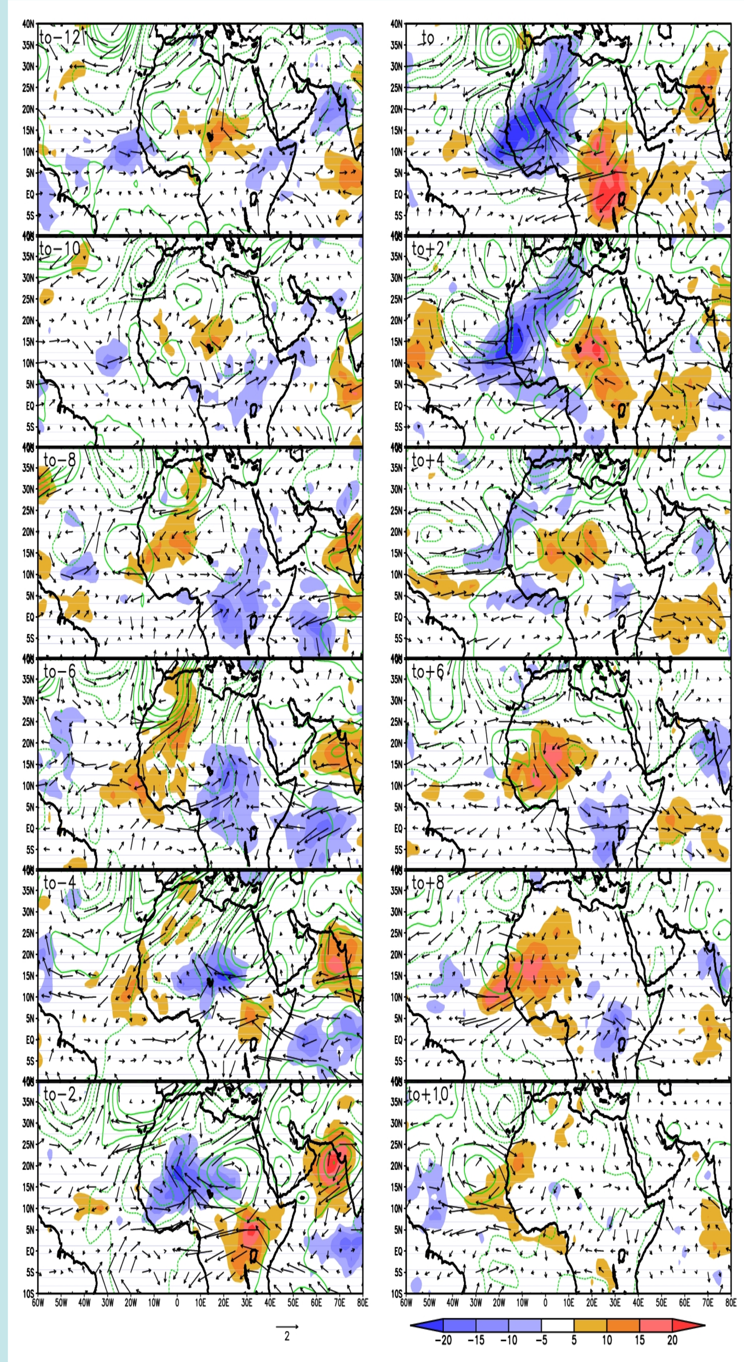


Figure 3. Time sequence of strong minus weak convective events for June-September 1979-2006 based on the reconstructed 10-25-day filtered OLR ITCZ index by the second EOF mode: unfiltered OLR values (colours; W m^{-2}), 700 hPa wind vectors (m s^{-1}) and 700 hPa geopotential heights (green solid (dashed) contours for positive (negative) values; isolines are drawn every 2 mgp with zero-isoline omitted). For clarity, only one grid point out of two is represented for the wind vectors. The sequence goes from t_0-12 to t_0+10 days with a time lag of 2 days. The convection increase is represented by blue colours, and convection decrease by red colours.

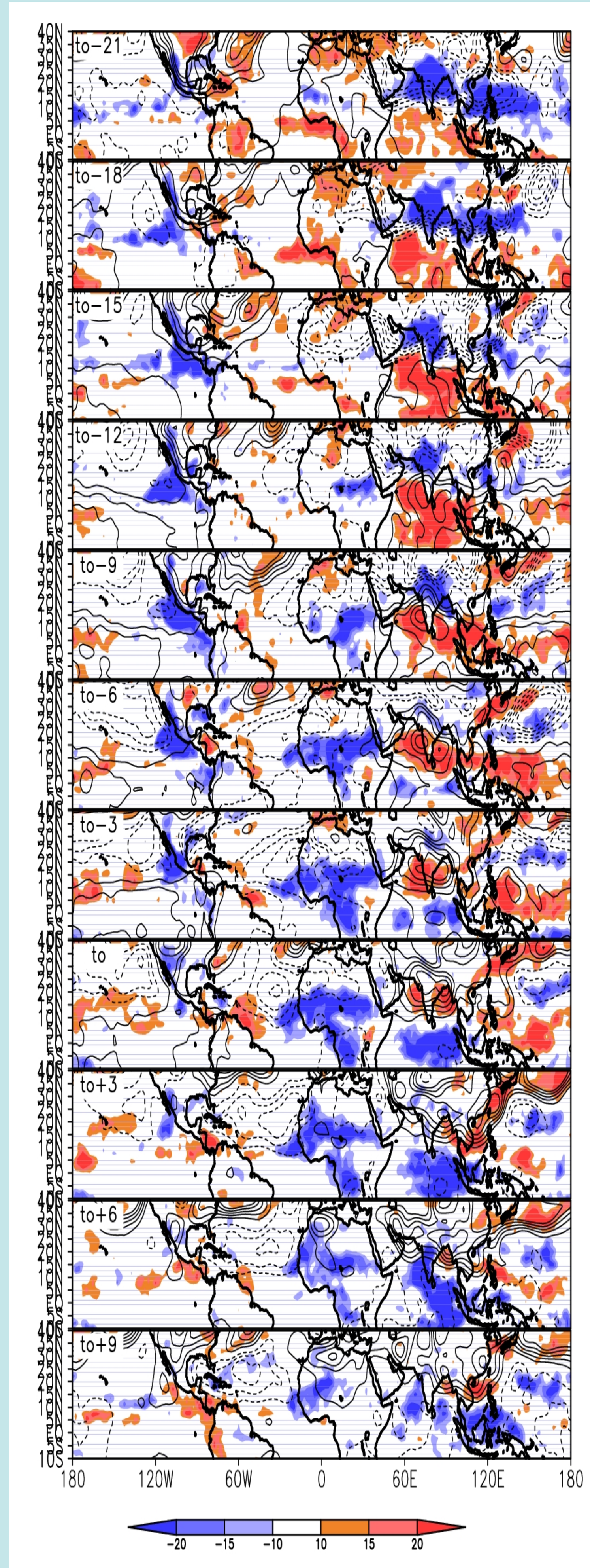


Figure 4. Time sequence of strong minus weak convective events for June-September 1979-2006 based on the reconstructed 25-90-day filtered OLR ITCZ index by the first EOF mode: unfiltered OLR values (colours; W m^{-2}) and 700 hPa geopotential heights (solid (dashed) contours for positive (negative) values; isolines are drawn every 4 mgp with zero-isoline omitted). The sequence goes from t_0-21 to t_0+9 days with a time lag of 3 days. The convection increase is represented by blue colours, and convection decrease by red colours.

Fig.1 Top : The meridional displacement of the ITCZ is characterized by a succession of active phases and pauses. The first rainy season along the Guinean Coast, between mid-April and the end of June, is followed by the summer monsoon season where the ITCZ is shifted to the north bringing precipitation over the Sahel region. The abrupt northward shift of the monsoon contrasts with the smooth retreat of the ITCZ corresponding to the second rainy season over the Guinean Coast in October-November. This African monsoon onset also characterized by weakened convective activity corresponds to a 10-15-day transition occurring in average between 24 and 30 June with a standard deviation of 8 days. **Fig.1 Bottom**: The succession of active phases and pauses is a recurrent feature of the African Monsoon. Sequences of more than 10 days of persistent high or low rainfall amounts are evident. The wavelet diagram highlights (1) the synoptic time scale below 10 days, (2) a short intraseasonal scale between 10 and 25 days and (3) a long intraseasonal scale between 25 and 60 days.

Fig.2 : The first 10-25-day mode sequence shows a modulation in convection as a standing oscillation growing and decreasing over the southern coast of West Africa and over Central Africa with an opposite polarity is located over 60°W-30°W, and a mean periodicity of 14 days. The OLR anomalies propagate eastwards between these two poles of convection and continues eastwards over the Indian Ocean. This pattern is controlled both by equatorial atmospheric disturbances and by radiation-atmosphere interaction processes over Africa.

Fig.3 : The second 10-25-day mode initiates over the eastern equatorial Africa, enhances in the same place, then moves northwards up to 15°N and finally propagates westwards until it dissipates over the tropical Atlantic with a mean periodicity of 15 days. The atmospheric circulation is characterized by cyclonic circulation at 700 hPa located ahead of negative OLR anomalies bringing more moisture within the enhanced convective area, and vice-versa. Then the westward evolution of this mode structure induces the development of an anticyclonic cell east of 10°E which brings drier air over the equatorial Africa by northerly winds, a favourable condition for decreased convection there and for the northward development of the positive OLR anomalies. Land-atmosphere and radiation-atmosphere interaction processes contributes to the maintenance and the westward propagation of this mode.

Fig.4 : The first 25-90-day mode shows enhanced convection over most of West and Central Africa. Negative OLR anomalies occur northeast of Lake Chad. They grow and propagate westwards and dissipate over the western part of Africa. At the same time an MJO-type signal is evident over the Indian - West Pacific sector, characterized by a meridional dipole of convection moving northwards. This African mode could be controlled by a westward convectively-coupled equatorial Rossby wave. It is also preceded by the development of low geopotential associated with enhanced convection over northern India. This cyclonic circulation extends westwards reaching West Africa in the following days. It contributes to the disappearance of the positive OLR anomaly pattern by westerly moisture advection inland, and to the development of the enhanced convection envelope over Africa. Then the break phase occurs over India, accompanied by a high geopotential which later moves westwards and contributes to the disappearance of the African mode.

Predictability. Some progress has been made in terms of monsoon onset date predictability, even if a more precise evaluation is still needed. It is possible to explain a high level of variance of the onset dates some weeks in advance by performing multivariate linear regressions based on regional atmospheric predictors. Significant correlations have also been found 20 days in advance between the date when the cold tongue area in the Guinean gulf reaches 400.000 km^2 and the monsoon onset date. More generally the predictability of the 10-90-day intra-seasonal variability and of the main individual modes using either a statistical approach or the dynamical forecasts scheme of ECMWF provide some skill. Using dynamical variables usually more reliable than rainfall could help improving this skill. However process investigation is still necessary to improve our knowledge of this time scale so important for crop yields and water resources management.

Reference : Janicot S et al., 2011: Intra-seasonal variability of the West African Monsoon, *Atmospheric Science Letters*, Special issue ASL on AMMA, doi:10.1002/asl.308, vol. 12, 1, 67-74