THE RELATIONSHIP BETWEEN WEST AFRICA MESOSCALE CONVECTIVE SYSTEMS AND HURRICANES IN THE TROPICAL ATLANTIC DURING 2004

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Resumo

Este trabalho avalia a hipótese de que os sistemas convectivos de mesoescala (MCS), iniciados no oeste de África, são potenciais geradores dos cyclones tropicais no Oceano Atlântico. Observou-se que existem MCS iniciados na Africa cuja as fases da dissipação e/ou de madura estão associados à geração de ciclones tropicais. Estes MCS são iniciados na África Ocidental entre 7°N-15°N e na faixa 0-12°W e aparentemente, a grande extensão de nuvens estratioformes favorecem o início de um ciclone tropical. Apresentamos também um exemplo destes MCS que destaca essa influência da região estratiforme, na fase madura do MCS e na posterior formação de um cyclone tropical

Abstract

We study a possible link between the Mesoscale Convective Systems (MCS) initiated in West Africa and the generation of the tropical cyclones. We showed that there is MCS initiated in Africa and whose dissipation phase or the mature phase corresponds to the generation of the tropical cyclones. These MCS are initiated in West Africa between 7°N-15°N and the band 0-12°W. We present in the same way an example of these stratiforms clouds associated to an MCS, at the mature phase, and the further generation of a tropical cyclone.

Palavras-chave: Sistemas convectivos, furacõess, nuvens estratiformes

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INTRODUCTION

The North tropical Atlantic basin is a zone of intense cyclonic activities. It presents a substantial interannual and interdecadal variability generally marked for the periods of strong hurricane activity. The number of tropical storms formed each year is linked to the atmospheric and oceanic conditions. Most tropical cyclones form from an intensification of the African easterly waves which propagate westward, from West Africa towards the North Atlantic and the Caribbean Sea in the band 10°N-20°N (Goldenberg and Shapiro, 1996). Satellite images show that MCS on tropical oceans often evolve into tropical cyclones. In the tropical Atlantic, the hurricane is hardly identified as been initiated spontaneously, but rather a depression which often evolves in time and space to transform itself into hurricane. The main goal of this work is to study a possible connection between MCS initiated in West Africa and the tropical cyclones in the northern basin of tropical Atlantic. Mathon and al. (2002) noted MCS which crossed West Africa and dissipated in the ocean towards 20°W.

DATA AND METHOD

We used Meteosat (MSG-7) images recorded by CPTEC/INPE. These data are archived each 30 min and covered the period June to September of 2004. This period is appropriated for the cloud systems characterization and classification mainly in West and Central Africa where convection is well defined in a very large scale and covers the rainy season and the tropical cyclones season. The zone of study lies between 25°S-25°N and 44°W-20°E. NCEP data was also used in this study to contributes to the characterization of the dynamics features associated to the MCS and hurricanes During its life, a MCS can move, grow, decrease, change a form, split or merge in one or more systems. A tracking algorithm must be able to identify this MCS in successive images. In this framework, we used a Tracking Convective Clusters model (FORTRACC) operational in the INPE/CPTEC. FORTRACC needs a definition of a specific threshold to classify MCS, however, MCS are strongly modulated by the diurnal cycle over Africa and Atlantic Ocean. Therefore, a dynamic temperature threshold would thus be more adapted to follow the development of MCS. Figure 1 shows the diurnal evolution of the dynamical threshold calculated using the oceanic area 10°S-5°N; 30°W-5°E and the Meteosat images of 2005/02/20. The use of FORTRACC model with T_{dyn} (dynamical threshold) gives more continuous trajectories than using T_{235} (fixed threshold commonly used by the operational FORTRACC model). The number of MCS tracked with T_{dyn} is higher than those tracked with T_{235} by a factor of 1.3. That agrees with the results of Morel and Senesi (2002) which used this dynamical threshold to determine MCS over Europe. They showed that this method discriminates 80 % of the MCS and more than 90 % of the electrically active ones.

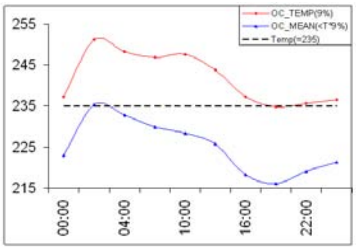

Figure 1: *Thresholds used to track the MCS. The dotted line represents the threshold generally used in the FORTRACC model. The red curve is the dynamical threshold and the blue curve is the dynamical threshold to track the convective cells (the second threshold usually used as 210K).*

RESULTS

Most of MCS formed on West Africa during the period of July to September 2004 dissipated on the continent and a few of MCS dissipated in the ocean. Since we track MCS linked to the tropical cyclone initiation, we studied only those that dissipated on the ocean. During the period analyzed, 5 hurricanes were formed in this studied region, the Danielle, Frances, Ivan, Karl and Lisa. Our first step in this study, were to analyse the atmosphere dynamics at the around the hurricane initiation time. The ocean surface wind field shows a cyclonic circulation present at the initiation day for the hurricanes Danielle, Frances, Ivan, Karl and Lisa. The surface wind fields plotted at 2-lag didn't show a cyclonic circulation before the initiation of Daniel and Frances but for Ivan, Karl and Lisa it was observed. In the second step, we tried to find MCS linked to the initiation of these hurricanes. There were not MCS that dissipated in the ocean for the hurricanes Danielle and Frances. We hypothesized that their initiation could be due to a local oceanic convection. A MCS initiated on the ocean can develop and reach a state able to produce a cyclone. The ocean is the first source of energy for the tropical cyclones and a strong SST can increase this activity (Shapiro, 1982). However, we have noted MCS dissipation on the ocean before the initiation of the hurricanes Ivan, Karl and Lisa. The figure 2 shows the MCS trajectories and the figure 3 shows wind field associated at 0-lag only for these three hurricanes.

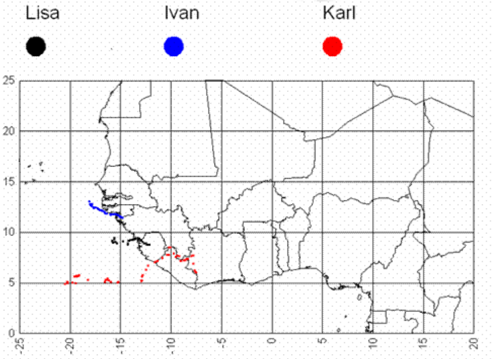

***Figure 2**: Trajectory of Mesoscale convective systems initiated in Africa for Ivan, Karl and Lisa.*

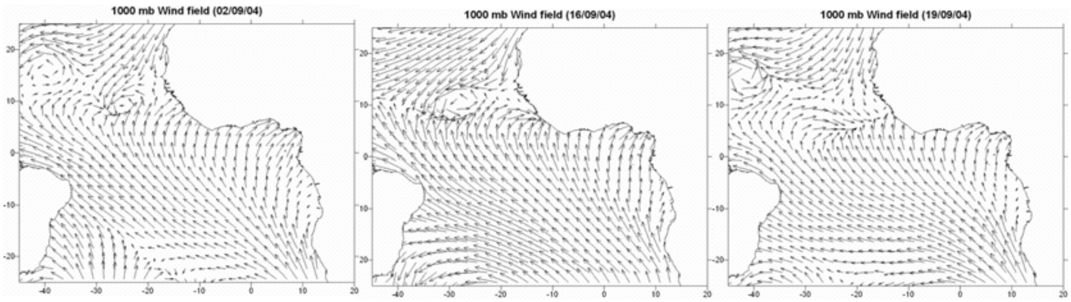

Figure 3*: The associated ocean surface wind (bottom) at 0-lag for Ivan (left), Karl (middle) and Lisa (right).*

Figure 4 presents the wind shear in the upper troposphere (850 mb - 200 mb) only for the MCS initiation date of the hurricanes Ivan, Karl and Lisa. Weak shear in the upper troposphere is present at the MCS initiation date and increases after its formation in the continent indicating a progressive inhibition of the convection on the continent. It could be due to the MCS development that stabilizes the atmosphere. This situation is favourable to the MCS initiation of long life cycle which can generate a vorticity. Laing and Fritsch (2000) also showed that these MCS, in Africa, developed with a strong shear in low troposphere and could favour a cyclogenesis.

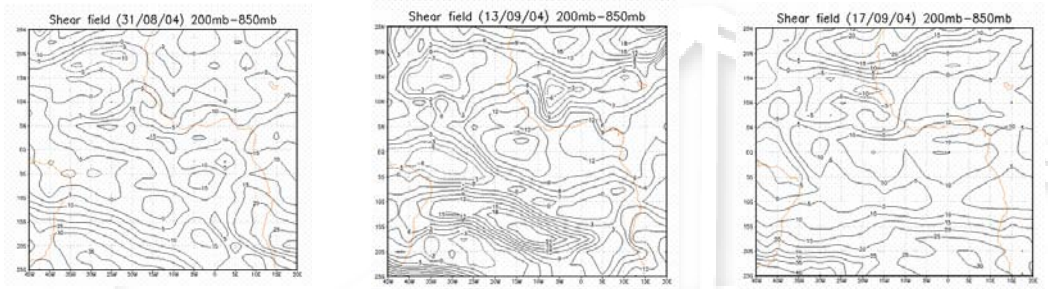

Figure 4*: Shear fields for the upper troposphere (850 mb - 200 mb). The shear field are ordered following the MCS initiation date: Ivan (left), Karl (middle) and Lisa (right).*

Figure 5 shows an example of Meteosat images during the maturation and dissipation phases of the MCS associated to the hurricane Karl and containing a stratiform area. We noted a beginning of a cyclonic structure organization between both phases. Houze (2004) noted that a vortex tends to form in middle levels at the base of the stratiform cloud in the mature and later stages of the MCS. As the stratiform cloud develops, air in middle-to-upper levels saturates over the mesoscale storm cloud deck. The saturation causes the Rossby radius of deformation to become smaller since the buoyancy frequency is determined by the moist static stability rather than the dry static stability, and the stratiform cloud deck is made up of buoyant air from the upper portions of previously more active convective cells. The buoyancy of the middle-to-upper level cloud leads to a low-pressure perturbation at the base of the stratiform cloud, and the lowered Rossby radius allows a quasi-balanced cyclonic vortex to form there (Chen and Frank, 1993).

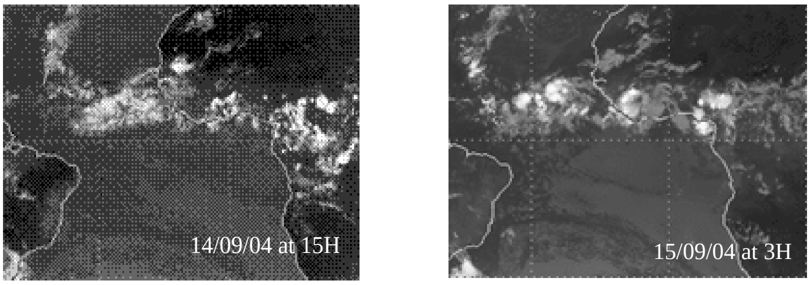

Figure 5*: Example of the maturation phase and dissipation phase on the ocean for MCS tracked for the hurricane Karl).*

CONCLUSION

This work is a first part of a study of the hurricanes in the tropical Atlantic during years 2004 to 2006. It shows that in some cases there is a direct influence of the MCS initiated in Africa on the generation of these hurricanes. This study deserves to be thorough by taking of account the oceanic component.

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