1B.5 CASE STUDY OF AN INTENSE AFRICAN EASTERLY WAVE

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1. INTRODUCTION

The purpose of this study is to explore the life cycle of an observed African Easterly Wave (AEW) that directly preceded the genesis of Hurricane Alberto (2000) in the East Atlantic. Despite past studies, there are still large deficiencies in our understanding of AEWs; we are not confident what initiates them; how they will develop once initiated, nor do we have a thorough understanding of their interactions with convection including mesoscale convective systems. Whilst the composite studies (e.g. Reed et al, 1977) have significantly enhanced our understanding of these systems, they include little or no information about the evolution of the AEWs and their interactions with physical processes. While idealized modeling (e.g. Thorncroft and Hoskins, 1994) has highlighted potential growth mechanisms, we do not know if significant feedbacks exist between the theorized Rossby wave dynamics and the mesoscale convection that is frequently observed with AEWs. This research takes the form of a case study that uses observations and numerical analyses of an AEW to produce a conceptual model of the evolution of such a system.

2. DATA SOURCES

The primary data used in this case study are the (1.125°x1.125°) operational analyses (OA) produced by the European Centre for Medium range Weather Forecasts (ECMWF). Surface and upper air observations plus satellite images from METEOSAT are also used extensively in this case study.

3. RESULTS

Analysis of satellite data (figure 1) indicates that a region of convection that is later associated with Alberto can be traced back to the Darfur region of Western Sudan (11°N 23°E). Examination of the wind and temperature fields in the OA indicates that a low-level circulation is created close to the initial convection on the intense low-level potential temperature (θ) gradient that exists on the southern fringe of the Sahara. This northern vortex (NV) is centred on a region of anomalously high θ air and tracks along the low-level baroclinic zone as far as the West African coast.

Potential vorticity (PV) analysis of this system indicates that the observed convection is associated with the generation of westward moving, sub-synoptic scale PV maxima at the level of the African easterly jet (AEJ). These PV maxima are generated within a strip of PV that exists on the cyclonic shear side of the AEJ and could be responsible for the distortion of this PV strip into wave-like features.

Figure 2 shows an example of the configuration of the low-level (925hPa) θ and AEJ level (~315K near 10°N) PV fields over West Africa. In this figure, synoptic scale wave-like perturbations to the 315K PV strip and 925hPa θ gradient can be seen. Sub-synoptic scale PV maxima associated with convection are clearly embedded within the perturbation to the PV strip. The anomaly associated with the perturbation to the θ gradient is in excess of +5K (relative to a 4-week mean centred on this event). From a PV-thinking perspective, it is clear that these fields are in a configuration that is consistent with baroclinic growth.

Over West Africa, the NV appears to be a significant feature of this intense system. Analysis indicates the NV has two key roles that influence convection south of it in two main ways:

- Mutual intensification of the NV and wavelike perturbation to the PV strip via a baroclinic growth mechanism.

- By advection of high equivalent potential temperature air, the low level circulation associated with the NV modifies the environment ahead of the westward propagating convection, making it more favourable for convection.

A secondary region of convection is initiated over the Guinea highlands, ahead of the main (westward moving) region of convection, in the large-scale northerly flow centred on the NV. This results in the creation of stationary PV maxima at the AEJ level that has a cyclonic circulation near the surface. These stationary PV maxima and the westward propagating PV maxima merge near the West African coast (see figure 3). This creates an intense, deep (up to ~400hPa) PV maximum with a significant cyclonic circulation at the surface. Approximately 6 hours after moving into the Atlantic basin, the NOAA Tropical Prediction Center identifies tropical depression three in the centre of this PV maximum. The OA subsequently shows this feature becomes more axisymmetric and strengthens into the PV signature of hurricane Alberto.

4. DISCUSSION

By combining the analysis of convection based on satellite imagery with a PV-θ analysis from ECMWF OA data, this research has highlighted the multiple scales and processes that characterize the evolution of an intense AEW. This case was characterized by a synoptic-scale displacement of PV and θ contours

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consistent with baroclinic instability, along with embedded sub-synoptic-scale PV anomalies generated by convection. A strong role was played by the NV that developed on the low-level baroclinic zone. Finally, the sub-synoptic scale PV anomalies embedded in the AEW and their subsequent merger may have been important for the triggering of Alberto so close to the West African coast.

5. ACKNOWLEDGEMENTS

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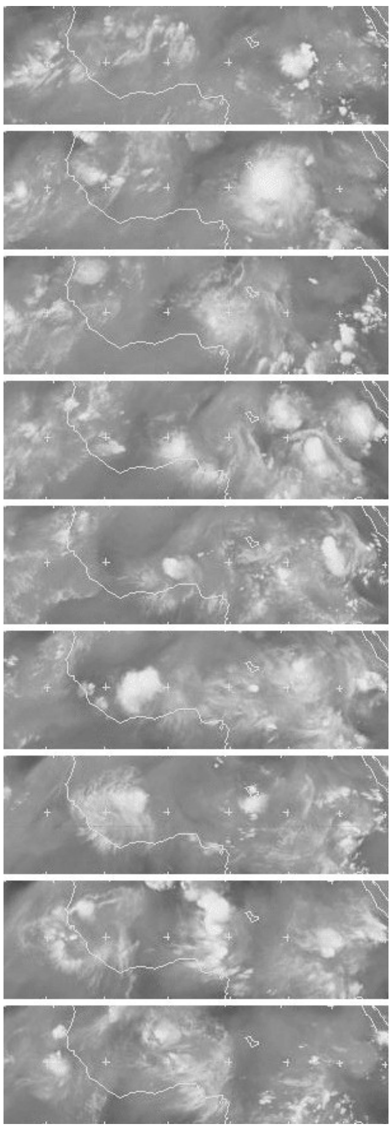

Figure 1 – METEOSAT Water Vapour imagery, shown every 12 hours from 12Z on 30th July 2000 (top) to 12Z on 3rd August 2000 (bottom). Each image spans 30°W to 40°E and 0°N to 20°N, the African coast is outlined.

6. REFERENCES

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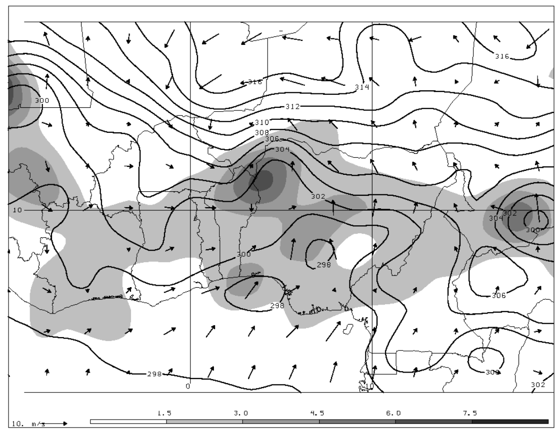

Figure 2 – Map of 315K Potential Vorticity (shaded, units in tenths of PVU with key along bottom of figure), 925hPa Potential Temperature (contoured every 2K) and 925hPa wind vectors (scale of $10ms^{-1}$ shown in bottom left corner) at 12Z on 1st August 2000. The African coast is outlined and latitude/longitude lines drawn every 10 degrees.

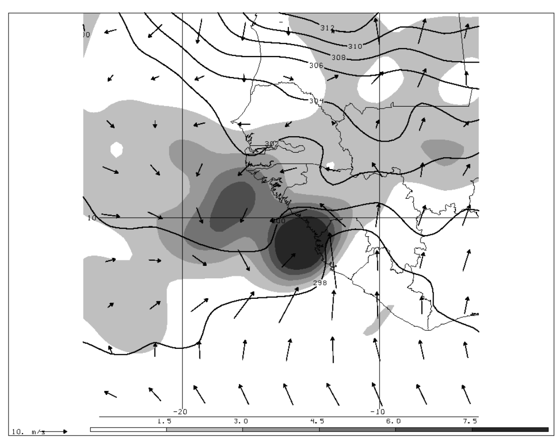

Figure 3 – As figure 2, except shown at 12Z on 3rd August 2000.