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SAHARAN AIR LAYER INTERACTION WITH HURRICANE CLAUDETTE (2003)

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1. INTRODUCTION

For the past thirty years, the significant role that Saharan aerosols play in modulating the atmospheric environment over the tropical Atlantic has become increasingly recognized and better understood. However, more investigations into this phenomenon are necessary to better understand the radiative heating or cooling impact that the Saharan aerosols cause as well as the possible modulations in tropical cyclone track and intensity that may stem from the existence of this particulate matter. Here, a diagnosis of the possible modulation of the atmospheric environment of Claudette (2003) due to Saharan dust will be presented. The diagnosis will specifically focus on how these possible environmental responses of the Saharan Air Layer (SAL) affected the early growth of the easterly wave and the intensity of Claudette in the later time period.

The SAL is known to contribute to easterly wave growth (Karyampudi and Pierce, 2002). In a past study utilizing simulations from the Penn State University Combined Longwave and Shortwave Radiative Transfer Model, the SAL caused heating rates of approximately 1K day^{-1} in the vertical extent from the SAL inversion lid, in the mean at approximately 500 hPa, down through the ocean surface (Carlson and Benjamin, 1979). Figures 1 and 2 show the dry and warm environment respectively at 850 hPa most likely associated with the SAL as the wave of interest emerged off of the North African Atlantic coast on June 29, 2003, and Figure 3 depicts a wide area of moderate aerosol optical depths over the North Atlantic. The maximum in potential temperature is approximately 306K at 850 hPa from the Navy Operational Global Atmospheric Prediction System (NOGAPS) output on 00Z June 29 (Figure 1). The minimum of mixing ratio is on the order of 2 g kg^{-1} from 00Z June 29 NOGAPS output (Figure 2). The maximum aerosol optical depth over the eastern tropical Atlantic is on the order of 0.8 from the Naval Aerosol Analysis and Prediction System (NAAPS) 00Z June 29 analysis (Figure 3).

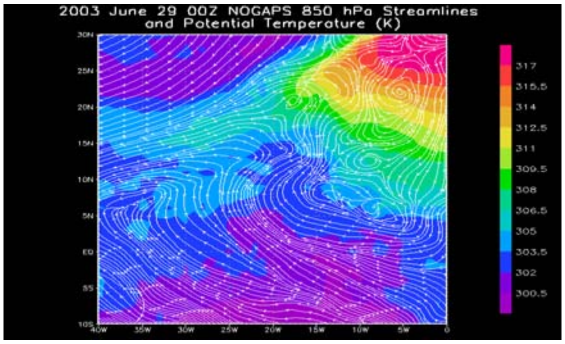

Figure 1. NOGAPS display of streamlines and potential temperature at 850 hPa on 00Z 2003 June 29.

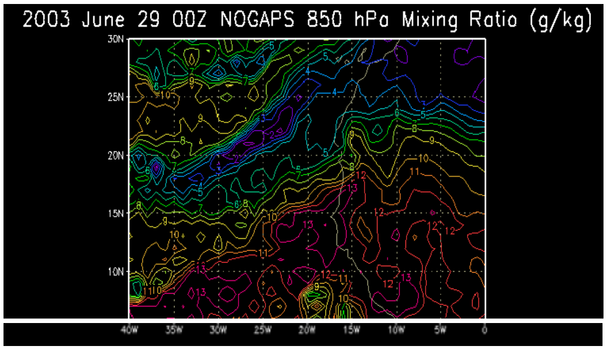

Figure 2. NOGAPS display of mixing ratio at 850 hPa on 00z 2003 June 29.

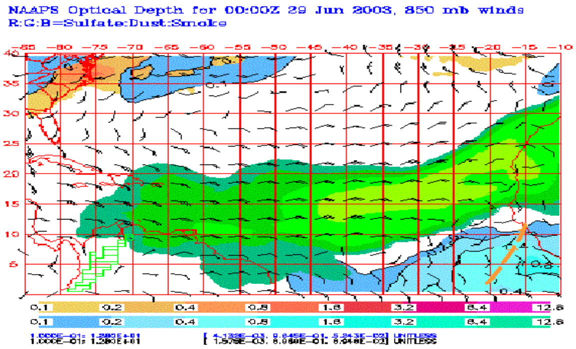

Figure 3. NAAPS display of aerosol optical depth and 850 hPa winds on 00Z 2003 June 29.

2. EASTERLY WAVE DIAGNOSIS

One of the possible lifting mechanisms contributing to convection is the linear forcing due to the SAL frontal boundaries (Karyampudi and Carlson, 1988). As depicted in figure 1, there are meridional temperature gradients on the order of approximately 1 degree Celsius per 100 kilometers corresponding to the northern and southern SAL boundaries over the Atlantic Ocean. To partially test for frontogenesis, the tilting term, as shown in equation 1, is considered:

$$F \approx \left(\frac{\partial \theta}{\partial p}\right)_p \left(\frac{\partial \omega}{\partial y}\right) \qquad (1)$$

where θ is potential temperature, p is pressure, ω is vertical velocity in a pressure plane and y is the meridional distance. More specifically, cross sections of potential temperature were used as a proxy for frontogenetic potential. Figure 4 shows a frontogenetic profile in the young easterly wave turbid environment. Figure 5 shows a frontolytical profile a day later in the easterly wave environment. The temperature gradients of either boundary (not shown) are weaker most likely in response to the more diffuse Saharan dust concentration.

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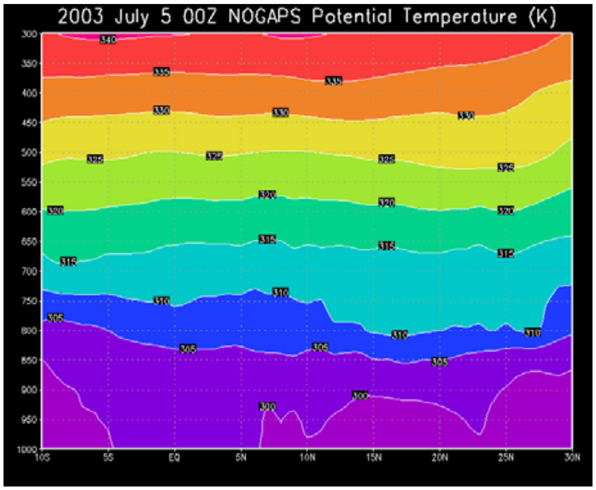

Figure 4. NOGAPS cross-section of potential temperature along 35 west longitude on 00Z 2003 July 5.

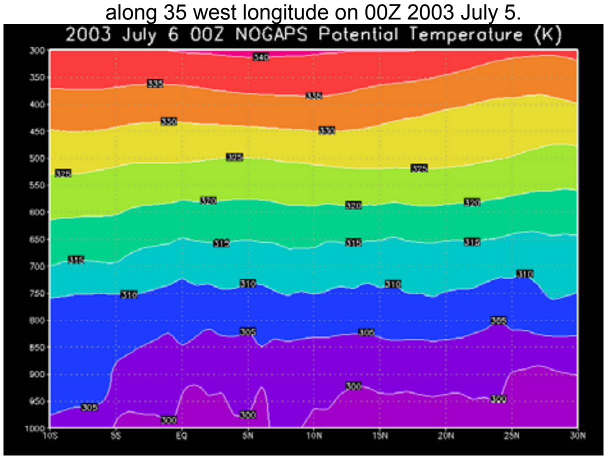

Figure 5. NOGAPS cross-section of potential temperature along 50 west longitude on 00Z 2003 July 6.

Another possible lifting mechanism leading to convection is associated with the ageostrophic circulations Mid-Level Easterly Jet (MLEJ) associated with thermal balance (Karyampudi and Carlson, 1988). Figure 6 shows the MLEJ in the easterly wave environment most likely corresponding to the southern SAL boundary as well as a westerly jet most likely corresponding to the northern SAL boundary well off the west African coast by 00Z July 5. Figure 7 shows a minimum of potential vorticity in the vicinity of both the easterly and westerly jet on the order of –0.6 to –0.7 pvu, indicating that there is a sign reversal in the potential vorticity field and that the necessary condition of Charney and Stern (1962) is satisfied. As a result, combined barotropic-baroclinic instability may exist, leading to increases in both of the horizontal and vertical shearing in the environment, and hence the strong possibility of an unstable jet still exists well off of the coast of Africa. Since the Charney-Stern condition is met, the wave is though to grow due to the conversion of the available potential energy from the mean flow to eddy kinetic energy of the perturbation (Burpee, 1972). Wave growth is evident as the 950 hPa vorticity along the wave axis doubles between 00Z July 5 and 00Z July 6 (not shown).

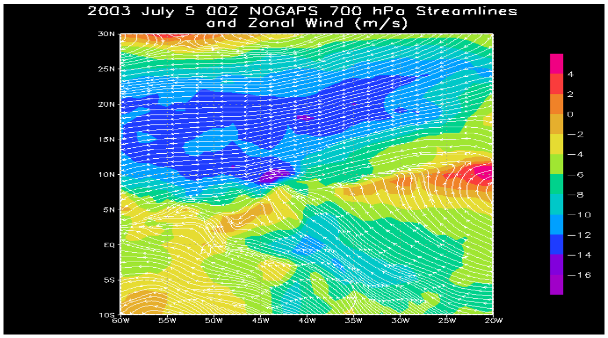

Figure 6. NOGAPS isotachs of the zonal wind at 700 hPa on 00Z July 4.

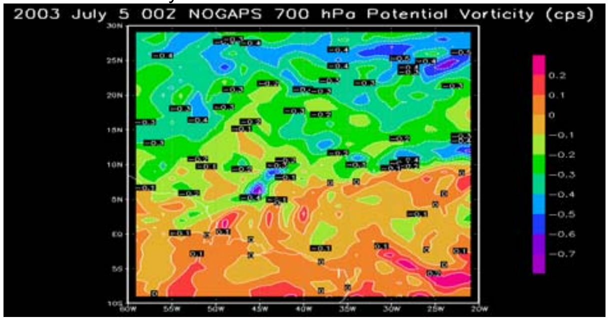

Figure 7. NOGAPS potential vorticity contours in pvu at 700 hPa on 00Z July 4.

3. FUTURE WORK- SENSITIVITY STUDY

A sensitivity study is to be perfomed to quantify relationships between intensity fluctuations, the modified storm environment due to the SAL, and the aerosol loading in the storm environment. The NOGAPS gridded output will be used to parameterize the storm environment and intensity. Sources of aerosol data are currently being evaluated.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

Burpee, R.W., 1972: The origin and structure of easterly waves in the lower troposphere of North Africa. *J. Atmos. Sci.,* ***29***, 77-90.

Carlson, T.N., and Benjamin, S.G., 1980: Radiative heating rates for Saharan dust. *J. Atmos. Sci.*, **37**, 193-213.

Charney, J.G., and Stern, M., 1962: On the stability of internal baroclinic jets in rotating atmosphere. *J. Atmos. Sci.*, **19**, 159-172.

Karyampudi, V.M., and Carlson, T.N., 1988: Analysis and numerical simulations of the Saharan Air Layer and its effect on easterly wave disturbances. *J. Atmos. Sci.*, **45**, 3102-3136.

Karyampudi, V.M. and Pierce, H.F., 2002: Synoptic-scale influence of the Saharan Air Layer on tropical cyclogenesis over the Eastern Atlantic. *Mon. Wea. Rev.*, **130**, 3100-3127.