1B.3 ROLE OF EASTERLY WAVES IN THE MAINTENANCE OF THE AFRICAN EASTERLY JET

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1. INTRODUCTION

About fifty percent of all hurricanes in the Atlantic Ocean form within African easterly waves (AEW). Many previous studies have indicated that these waves result from combined barotropic-baroclinic instability of the African Easterly Jet (AEJ). The AEJ is in turn believed to be due to the strong temperature gradient between the very warm Sahara Desert and the cooler Sahel and Gulf of Guinea to the south.

Zonally averaged latitude-pressure cross-sections of summertime zonal winds over Africa show the AEJ as a 8-12 m/s jet centered at 600-700 mb near 15°N (e.g.Burpee, 1972). Such cross-sections also show a weaker southern hemisphere easterly jet near 5-15°S, monsoonal westerlies centered beneath the AEJ, and upper tropospheric features such as the Tropical Easterly Jet (TEJ) near 3°N and the subtropical westerly jet near 35°N .

Thorncroft and Blackburn (1999) performed zonally symmetric simulations that showed that the effect of thermal wind balance over the observed low level meridional temperature gradient over northern Africa is particularly important in the formation of the AEJ. They also found that in order to reproduce some of the other aforementioned features of the summertime climatological wind field over Africa it is necessary to include the effects of ITCZ convective heating.

While the diabatic effects of Saharan and ITCZ heating tend to strengthen the AEJ, AEW remove energy from the AEJ, thereby weakening it. In this study we take the next step towards understanding the maintenance of the AEJ by including the effects of AEW.

2. MODEL

This study uses a dry, multilayer, finite difference global model that uses σ-coordinates in the vertical (Suarez and Takacs, 1995). The model's resolution is 2.5x2.0° in the horizontal and 20 σ layers in the vertical. The model includes dry convective adjustment of temperature at low levels, Newtonian relaxation of the temperature field to initial profiles, and Rayleigh damping of the momentum fields at low levels.

The simulations are performed in either zonally symmetric (for *control* purposes) or asymmetric mode. The latter allow assessment of the role of easterly waves in the maintenance of the AEJ. All simulations are initialized with a state of rest.

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For each mode, three types of forcings are used: 1) diabatic heating that mimics the temperature gradient found in Northern Africa (hereafter *SAHARA*), 2) diabatic heating that mimics the presence of ITCZ convection (hereafter*ITCZ*), and 3) both (hereafter *SAIT*). The ITCZ heating has a maximum of 5°/day at 10°N and 500 mb. The Sahara heating consists of a 30° wide region of 6°/day heating at the lowest model layer centered at 23°N.

3. RESULTS

Our *control* zonally symmetric simulations reproduce the steady state results of Thorncroft and Blackburn (1999) quite closely.

Easterly jets of 12-14 m/s easterly jets near 15°N, and 600-700 mb occur in all runs. The zonally averaged zonal winds at 50 days for the *SAHARA* and *SAIT* control runs are shown in figures 1,2. Note that the *control SAHARA* run produces an AEJ of about 12 m/s that remains near 15°N once it is produced (figure 1).

The zonal mean zonal winds for the zonally asymmetric simulations at 50 days are shown in figures 3-5. The *SAHARA* simulation produces a 16 m/s easterly jet at 7°N, 650 mb. In this simulation the easterly jet is initially produced near 15°N and drifts southward to 7°N once easterly waves appear. This southward displacement of the jet in the asymmetric run is caused by transient momentum fluxes of the modeled easterly waves (not shown).

In the zonally asymmetric simulations, once the diabatic heating produces jets that are strong enough to support baroclinic and barotropic instabilities, small perturbations from zonal symmetry in the initial conditions begin to extract energy from the mean jets and grow into propagating waves (figure 6). This occurs after about 30 days in the *ITCZ* simulation and 15 days in the *SAHARA* and *SAIT* simulations. The *SAIT* run easterly waves have wavenumber 12-14 and about 6m/s speed of propagation. These values are comparable to the observed characteristics of AEW (wavenumber 10-20 and 5-7 m/s).

The SAIT simulation produces a zonal mean circulation that is closest to the observed circulation than any of the other simulations. Moreover, the circulation produced in this run seems dominated by features produced by the ITCZ heating.

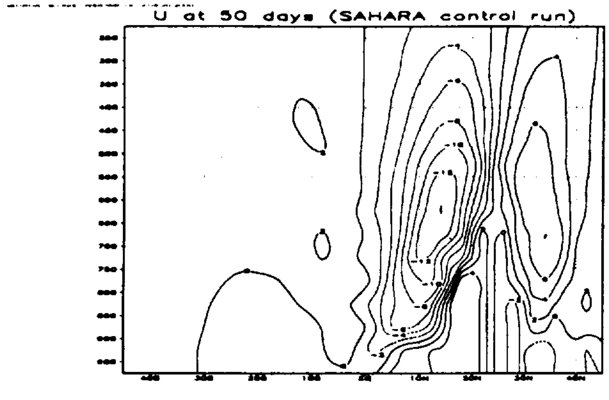

Figure 1: Zonal mean zonal circulation produced by the control *SAHARA* run at 50 days.

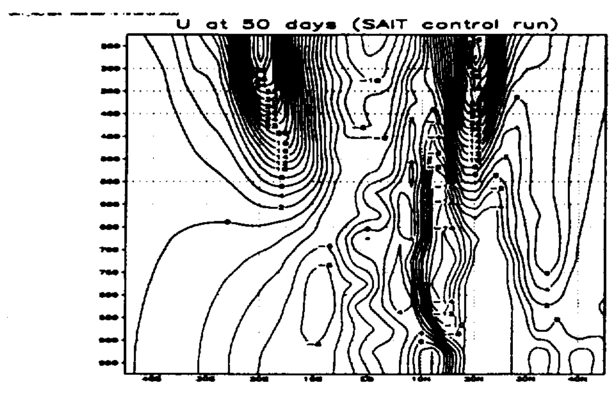

Figure 2: Same as figure 1 but for control SAIT run.

4. CONCLUSIONS

The results from the zonally symmetric simulations corroborate the findings of Thorncroft and Blackburn (1999) in that the low level heating over the Sahara desert and the ITCZ convective heating together maintain the AEJ.

A somewhat different picture emerges when the effects of zonal asymetries are considered. Then, it becomes evident that the effects of diabatic heating from ITCZ convection are the main contributor in maintaining the AEJ in the presence of the weakening effect of African easterly waves.

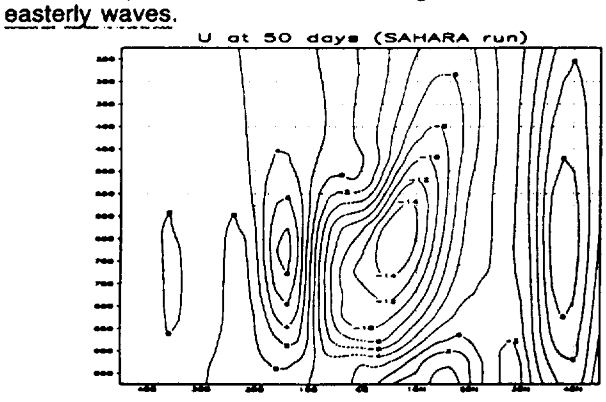

Figure 3: Same as figure 1 but for SAHARA run.

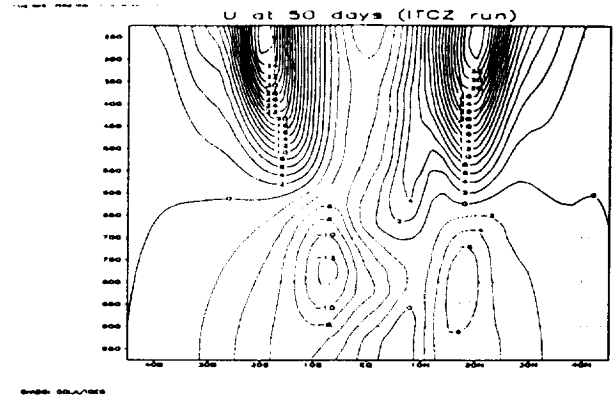

Figure4: Same as figure 1 but for the ITCZ run.

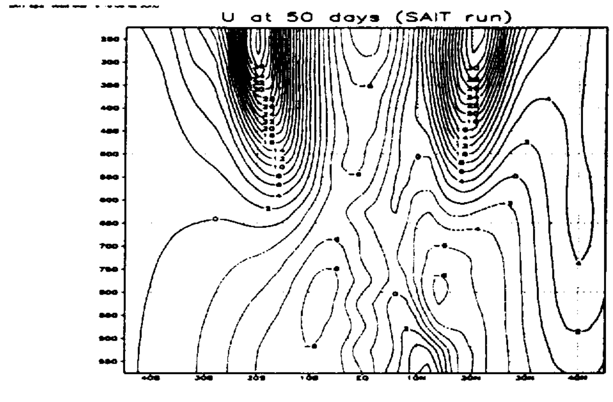

Figure 5: Same as figure 1 but for SAIT run.

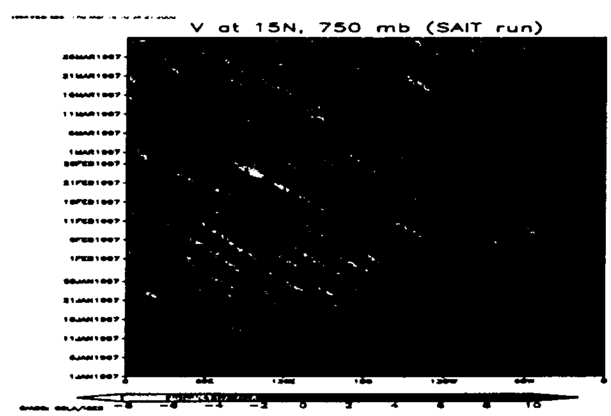

Figure 6: Easterly waves in SAIT run.

5. REFERENCES

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