9B.6 The JET2000 EXPERIMENT: MESOSCALE STRUCTURES, DIURNAL CYCLE AND NWP ISSUES

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1 INTRODUCTION

The JET2000 experiment took place over West Africa in late August 2000. Four flights, involving transects along and across the African easterly Jet (AEJ), were made using the UK Met Office C-130 Hercule aircraft. They deployed 111 dropsondes at 0.5-1 degree resolution in addition to the aircraft measurements of the boundary layer. Thorncroft *et al.* (2002) has provided logistical details of the experiment and preliminary results. Here, we describe first the mesoscale features observed during Flight 2 (across the AEJ) and study the diurnal cycle of the saharan boundary layer evolution through study of global model analyses and forecasts. Second, we explore a significance of different data sources in analysis from ECMWF model and Unified Model of the Met Office.

2 MESOSCALE STRUCTURES

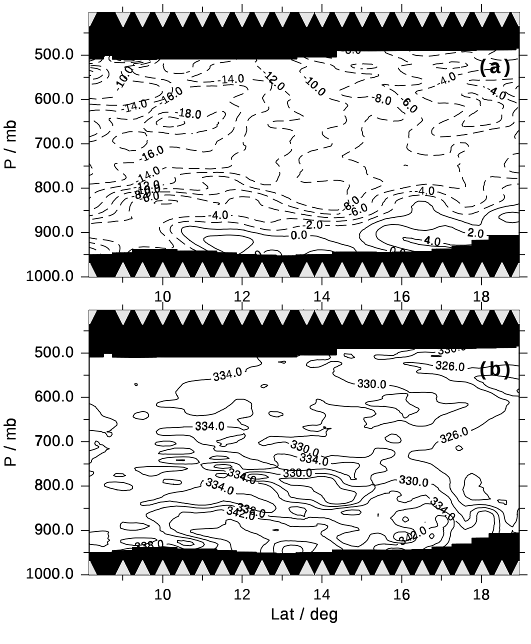

Figure 1: Meridional vertical cross sections derived from the dropsondes during Flight 2 for (a) the zonal wind (contour every 2 ms^{-1}), (b) the equivalent potential temperature (contour every 4 K). The top and bottom positions of the sondes are indicated.

Figure 1 presents the zonal wind u and the equivalent potential temperature θ_e in a height-latitude section derived from the dropsondes deployed during Flight 2 in the eastern leg. The AEJ is evident at 10 °N around 670 hPa with a peak value of -21 ms^{-1}. The equivalent potential temperature presents an intermittent structure in both horizontal and vertical directions. Around 600 hPa and 14°N- 17°N there is an intrusion of high θ_e from the south (positive meriodional wind) and below there is a region of very low θ_e around 800 hPa and 12°N -15 °N. The θ_e field also presents below $850hPa$ overturning structures of up to $200km$ extend and $2km$ deep at 10.5°N and 16°N with low θ_e air descending from the south beneath higher θ_e air ascending towards the south. These mesoscale shallow circulations are also present in humidity mixing ratio, hmr, and the relative humidity fields (not shown). The question is how do these circulations evolve? Do they represent an adjustment from horizontal inhomogeneities present in the previous day's convective boundary layer? Another striking feature concerns the correlation between u and conserved fields such as θ_e and hmr (Figure 1 a, b). Does it mean that the zonal wind is conserved in diurnal time scale? And why?

3 THE DESERT BOUNDARY LAYER AND THE DIURNAL CYCLE

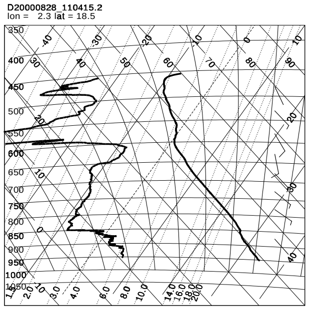

Figure 2: Mixing ratio (gkg^{-1}) and temperature ($^\circ C$) profiles from droponde at 2.3°E and 18.5°N deployed during Flight 2

Figure 2 shows an example of dropsondes taken on the edge of the Sahara during Flight 2. Those dropsondes exhibit a split in the boundary layer: a turbulent layer well mixed in water vapour up to around 900 hPa and above a deeper adiabatic layer less turbulent up to 600 hPa. This state is neither marginal nor transitional but is observed in several profiles at 11UTC (12Z). It seems then

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er. The Unified Model of the Met Office (UM hereafter) also shows this split in the boundary at least until 09UTC. The internal layer, compared with the residual layer, presents a higher water vapour content. In view of the low humidity values in the profiles and the dryness of the surface in this region, moisture can be brought only by surface fluxes or meridional advection. Analysis and forecasts every three hours from the UM indicate that a southwesterly low-level nocturnal jet (up to 8 ms^{-1} for each wind component) takes place in the whole monsoon region just above the surface and advects moisture from the south to the Sahara. This nocturnal low-level jet also produces a low-level convergence over the Sahara. A similar behaviour has been found by Racz and Smith (1999) in their study of dynamics of heat lows with an idealized model.

4 NWP ISSUES

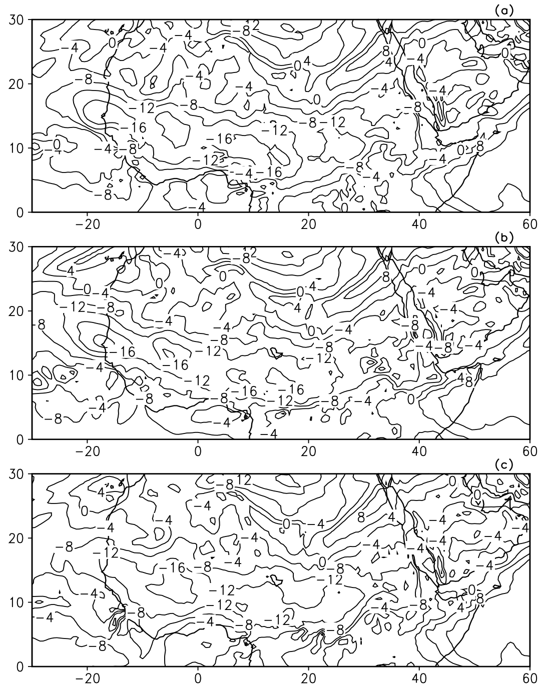

Figure 3: Horizontal cross section of the wind (contour every 4 ms^{-1}) at 700 hPa for (a) the control analysis, (b) the anlysis without satellite data and (c) the analysis without upper-air data, using the ECMWF model.

Thorncroft *et al.* (2002) have shown that for both UM and ECMWF model, the analysis without the JET2000 dropsondes (noJET2000) represent quite well the AEJ observed during Flight 2. However, the 5-days forecast for both models exhibit very weak AEJ associated with weak vertical and horizontal shears, indicating that in this case the physics and dynamics of these models are not sufficient in representing the AEJ. To explore the significance of different data sources in generating a good analysis from a poor forecast, we perform sensitivity tests experiments. In these experiments, the analysis noJET2000 is considered cal window (0-30°N, 30°W-60°E) from five days to the date of Flight 2. Here, we present analysis from the experiments denying the satellite data (noSAT) and upper-air data (noRS) using the ECMWF model. The model is run with T511 truncation (horizontal resolution of 0.3 °) and 60 hybrid vertical levels, using a 4-dimensional (4D-var) variational analysis scheme.

Figure 3 presents the zonal wind at 700 hPa for the control, the noSAT and the noRS experiments. Analysis from both denial experiments weaken the AEJ east of 0°E by $2ms^{-1}$ for the noSAT experiment and 4 ms^{-1} for the noRS experiment, with less horizontal shear. The impact of the noRS experiment is more significant at the west as well. The AEJ core at the East Atlantic coast present in the control analysis vanishes in the noRS analysis while it reinforces in the noSAT analysis. Vertical cross section of the zonal wind taken at 2.5°E around the longitude of Flight 2 (not shown) indicate also a decrease of the AEJ intensity and the vertical shear, which is more apparent for the noRS experiment. This is sympathic with the replacement of the westerlies at low levels present in the control analysis by easterlies. The decrease of the AEJ and the vertical shear in the denial experiments is coherent with the low-level warm anomalies around 10°N (up to 5 K) and low-level cold anomalies (2 K) surmonted by warm anomalies at mid levels in the Sahara (2 K). In the 5 days forecast where the AEJ is poorly represenred the warm anomalies in the Sahara exceed 3 K and the cold ones $6K$.

These results indicate that the radiosoundings, despite their sparsity, have a significant impact in the way the numerical weather forecast models, at leat the ECMWF model, represent the features of the west african monsoon region. Similar denial experiments will be presently performed with the UM. On the other hand, the poor 5-days forecast in this case might indicate an existence of systematic errors in the UM and the ECMWF model. To assess eventual systematic forecast errors, longer periods at different time of the monsoon season need to be considered.

References

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