**1B.3**

# TWO SYNOPTIC CASE STUDIES OF TROPICAL SQUALL LINES IN THE SOUDANIAN CLIMATE ZONE OF WEST AFRICA

J. M. Schrage[1] and Andreas H. Fink[2]
[1]Dept. of Environmental and Atmospheric Sciences, Creighton University, Omaha, USA
[2]University of Cologne, Cologne, Germany

## 1. INTRODUCTION

Within the framework of the German IMPETUS ("An Integrated Approach to the Efficient Management of Scarce Water Resources in West Africa") project, a surface and upper-air field campaign was conducted in the Soudanian climate zone of Benin (West Africa) between May and mid-October 2002. For the first time, twice-daily radiosonde measurements at a high vertical resolution were levied at the synoptic station of Parakou (9°N, 2°E) and assimilated in the (Re-)Analysis of the European Centre for Medium-Range Weather Forecasts (ECMWF). Moreover, hourly synoptic observations from stations in western Nigeria, Benin and Togo, as well as data from 50 recording rain gauges in an 20,000 km$^2$ region in central Benin, were collected to establish an unprecedented instrumental data set in this usually data sparse region of the Tropics. Using ECMWF Reanalysis (1957–2002) and operational analyses, as well as half-hourly METEOSAT Infra-red images, as complementary data sources, preliminary results of a case study of two squall lines, observed on 26 June and on 15 September 2002, respectively, are discussed. These rainfall events will be placed into the context of the synoptic-scale thermodynamic and kinematic environments, as well as into the seasonal cycle of 2002.

## 2. RESULTS

On the continental-scale, squall lines in 2002 occurred in a drier than normal West African monsoon year (cf. Waple and Lawrimore 2003, their Fig. 72) with the driest conditions occurring in the extreme west of the subcontinent mainly during the months of July and August. These rainfall anomalies were associated with an anomalously equatorward position of the mid-level African easterly jet (AEJ) and weaker low-level monsoonal winds at about 10°N. This is evident for the longitude of the study region (i.e. 2.5°E) in Fig. 1 for the zonal winds anomalies at 925 hPa (top panel) and 700 hPa (lower panel). Note that the strongest anomalies occurred during the months of July and August, consistent with the period of the driest condition when averaged over the whole of West Africa. According to the rainfall anomalies obtained from blending rain gauge and satellite information (Waple and Lawrimore 2003), not only was the Sahel (>12.5°N) unusually dry, but annual rainfall deficits also affected the Guinea Coast and Soudanian zone west of about 3°E. Maps of surface dewpoint (adiabatic equivalent temperature) indicate anomalous wet (high) values prevailing between latitudes 8° and 10°N during July and August, and, with a smaller amplitude and areal extent in September 2002. The question arises why the higher than average values of convective available potential energy in the later region was not associated with higher rainfall totals, provided that the annual deficit of the blended rainfall product, shown in Waple and Lawrimore (2003) reflects the conditions during the climatologically wettest month in the area, July-September.

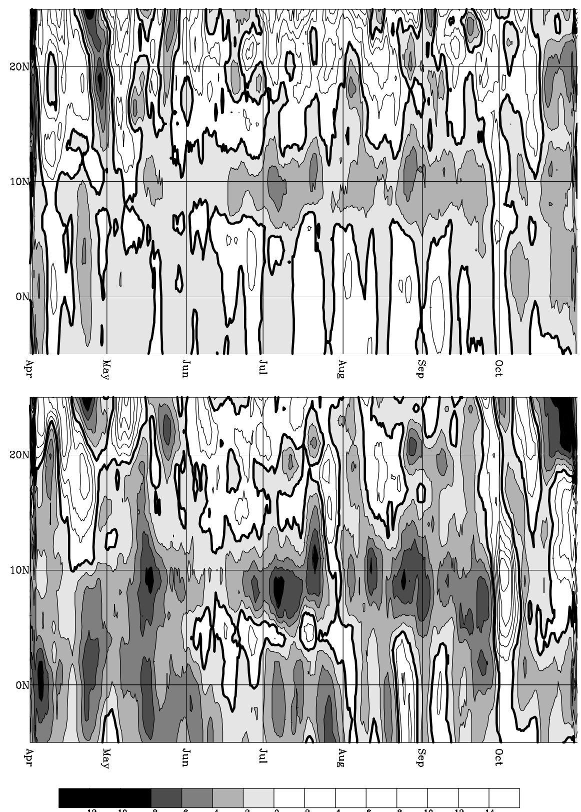


Fig. 1: Zonal wind anomalies along 2.5° during the 2002 monsoon season at 925 hPa (top) and 700 hPa (bottom).

Using the available raingauge data for Benin, Togo and western Nigeria, a much more dissected rainfall anomaly pattern is evident for July–September 2002 with regions of above-normal rainfall lying next to areas with rainfall deficits. This reflects the convective nature of the rainfall and also points to the fact that blended raingauge-satellite rainfall products must be interpreted with caution, especially if the raingauge network is

* *Corresponding author address*: Jon M. Schrage, Dept. of Environmental and Atmospheric Sciences, Creighton University, Omaha, USA,
e-mail:jon@creighton.edu

sparse and if the information is regionalized. From the surface information available to us it seems, however,

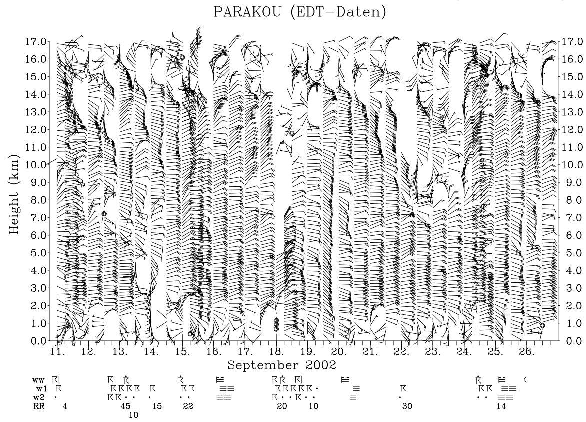


Fig. 2: Wind barbs at a vertical distance of 200 m over Parakou (Benin) for the period between 11 Sept. 00 UTC and 26 Sept. 2002 12 UTC. Wind barbs having a southerly component are shaded in light grey. Significant weather symbols and 24-h rainfall totals measured at 06 UTC at the synoptic station of Parakou are indicated below the abscissa.

that the area of Benin and surrounding countries was mostly dry during the July-September period.

While the September squall system occurred in an synoptic environment of strong African Easterly Wave (AEW) activity (see alternating southerly and northerly wind components at 4 km in Fig. 2), any consistent westward propagation a southerly moist AEW was hardly detectable during the June case (not shown). It is speculated that the overall less dry conditions in West Africa during September 2002 west of Nigeria were the results of a well-developed AEW acticity. This is consistent with the finding of Fink and Reiner (2003) that the ability of AEWs to organize large squall clusters substantially increases from the longitudes of Lake Tchad westward towards the West African coast.

However, the September case occurred in the ridge of well developed southerly AEW, not found to be a preferred AEW phase of squall line appearance (cf. Fink and Reiner 2003). The September squall line system developed over the Nigerian Jos Plateau and crossed central Benin around midnight (Fig. 3, upper panel), close to the climatological diurnal peak of squall occurrence. In contrast, the June squall line developed from a regenerating old cloud cluster just east of the study region in the afternoon hours and, while crossing central and south Benin around 18 UTC, it developed into a large squall cluster affecting southern Togo, Ghana, and Ivory Coast (Fig. 3, lower panel). The respective roles of the synoptic flow (e.g., AEW-related flow, mid-level dry layers, moisture convergence, upper-level subsidence etc.) and the squalls themselves on the thermodynamic structure and vertical stability at Parakou (Benin) will be compared. The results will be discussed in terms of what synoptic-scale forcing mechanisms might have played the major role in the organization and maintenance of the two squall lines.

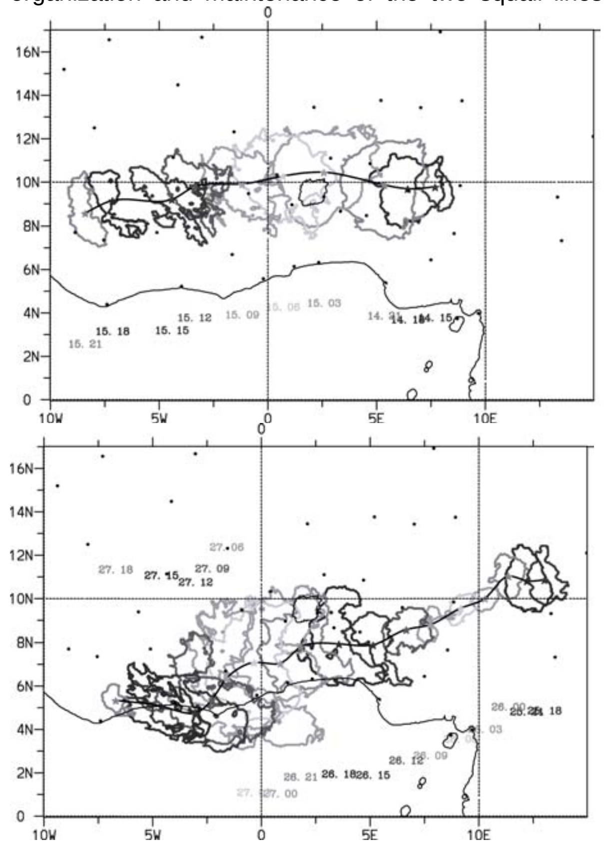


Fig. 3: Three hourly 233 K envelope obtained from METEOSAT 7 IR imagery for a West African squall system tracked between 14 September 1500 UTC and 15 September 2002 2100 UTC in (a), and between 25 June 1800 UTC and 27 June 2002 1800 UTC in (b). The numbers indicate the longitudinal positions of the center of gravity of the coldest cloud-top temperatures in dd.hh format and the curvy line connects these centers.

## 3. REFERENCES

Fink, A. H., and A. Reiner, 2003: Spatio-temporal variability of the relation between African easterly waves and West African squall lines in 1998 and 1999. *J. Geophys. Res.*, **108 (D11),** 4332, doi:10.1029/2002JD002816.

Waple A.M., and J. H. Lawrimore, 2003: State of the climate in 2002. Bull. Amer. Meteor. Soc, **84** (June), S1–S68