P1.52 NUMERICAL STUDY OF A SAHELIAN SYNOPTIC WEATHER SYSTEM: INITIATION AND MATURE STAGE OF CONVECTION AND ITS INTERACTIONS WITH THE LARGE SCALE DYNAMICS

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1 INTRODUCTION

Redelsperger *et al.* (2001) provided a multiscale description of the 21-22 August 1992 weather system observed during the HAPEX-Sahel (Hydrological Atmospheric Pilot Experiment) conducted in Niger Their study shows that a wide range of scales (intra-seasonal, synoptic and convective ones) are involved and interact together. The principal features are the monsoon flux at low levels, the Tropical Easterly Jet (TEJ) in upper troposphere and the African Eaterly Jet (AEJ) and Easterly waves (AEWs) at mid levels. In this large scale context a long-lasting convective system developed on the 21-22 August over Niger.

The main goal of this paper is twofold: first, to present and validate a multi-scale simulation of the life cycle of this Squall Line (SL) and second, to analyse the impact of the SL at larger scale.

2 MODELLING STRATEGY

We used the Méso-NH model in gridnesting configuration with full physics. The atmospheric fields are initialised from ERA-15 on 21 August 1992 at 00UTC and integrated for a 24 *hrs* period. The outer model (domain 1 in Fig. 1), allowing the representation of large scales, covers a domain of 2400x2400 km^2 with a mesh grid of 30 km and coupled to ERA-15 fields (every 6 hours). A first inner domain of 750x590 km^2 with a mesh grid of 5 km is run from 21 August 1992 at 00UTC up to 16UTC, in order to simulate the first stage of convective system (domain 2a in Fig. 1). At 16UTC a second inner domain of 900x590 km^2 is set up to simulate later stages of the propagating squall line up to 24UTC (domain 2b in Fig. 1). Parameterization of convection (Kain-Fritsch scheme) is used only in the outer domain. The vertically stretched grid varies from 70 m at ground level to 700 m at the model top.

3 SQUALL LINE MODELISATION

3.1 Life cycle of the Squall line

Convection genesis is a result of 2 mechanisms: First, convection is thermally forced at 11 UTC over the most southern peak of the Air Mountains (1600 m) where less dry conditions prevail. Second, a cold advection (due to the monsoon flow and previous convection in the outer domain) entering the inner domain through its southern boundary helps to trigger convection three hours later. The spreading of the north and south cold pools allows the formation of the SL at 16 UTC at the southwest foothills of Air Mountains where a tongue of high moist static energy creates favourable conditions for its development. The evolution of the SL leading edge as depicted by the synthetic picture (Fig. 2) illustrates the high degree of steadiness (speed of 17 ms^{-1}) reached by the SL during its mature stage. The interested reader may refer to Diongue *et al.* (2002) for further details. Comparisons of deduced model-synthetic radiances (Roca, 2000) to Meteosat IR ones indicate that the simulated scenario is realistic. Also, structure, speed and direction of the SL propagation and its surface signature agree with observations.

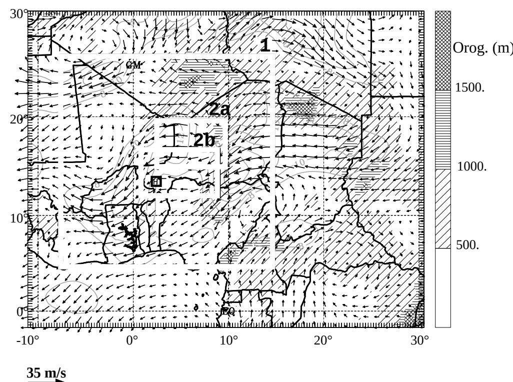

Figure 1: Different domains (1, 2a and 2b) plotted (in white) over the wind vector at 650 hPa and the orgraphy (hath[illegible]).

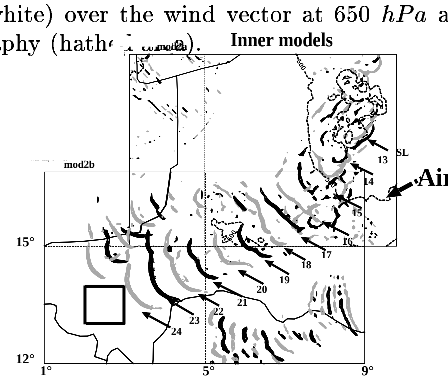

Figure 2: Summary of the SL propagation over Niger, in the inner domains. The arc-shaped leading edge of the SL is depicted by black and grey areas every hour from 13UTC with $W > 1ms^{-1}$ near the surface. The position of HAPEX-Sahel is outlined by the heavy square.

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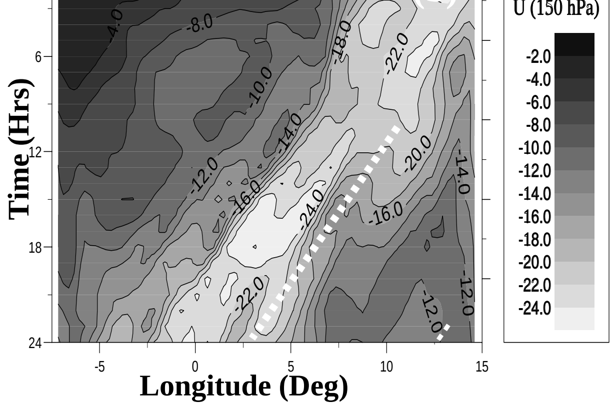

Figure 3: Impact of the SL at large scale: longitude time-diagram of the zonal wind at 150 hPa avaraged from 7 to 12 °N in the outer domain. The position of the SL is added (white dotted line).

3.2 Fine structures

The cross-line structure is very similar to the 2D conceptual model elaborated from observations, simulations and theories. The basic ingredients are a jump updraft and a rear-to-front subsident midlevel flow feeding the DC (head up to 3.5 km) by rain evaporation.

Vertical cross-sections taken along the SL direction at different locations point out the 3D structure of the SL. The rear-to-front flow occurs in a deep layer and on the full width of the squall line. It reaches its maximum speed (30 ms^{-1} relative to the ground) and lowest altitude just behind the convective part. Then, the AEJ is accelarated behind the squall line and can reach low levels. This implies strong horizontal shear on the SL flanks and thus to the generation of a dipole of counter-rotating vortices. This signature locally reinforced the PV gradient sign reversal characteristic of that region.

4 SL IMPACT AT LARGE SCALE

After 24 hrs of simulation the monsoon flow intensified (up to 25 ms^{-1}) to the south of the convective area on a wide longitudinal (from 5 °W to 12 °E) and meridional (between 300 and 600 km) extension. The longitudinal-time diagram (average 7 °N - 12 °N) of the meridional water wapour flux at 600 m indicates that at scales shorter than 24 hrs the maximum of monsoon flow moves eastward whereas at longer time scales it propagates westward in phase with AEW as shown by Redelsperger *et al.* (2002) (see their Fig. 6d).

The local AEJ acceleration behind the SL analysed in section 3.2 is confirmed at larger scale. At 24 UTC, the AEJ simulated maximum intensity reaches 30 ms^{-1} behind the SL. The longitudinal-time diagram (average 12°N - 17 °N) of the horizontal wind intensity at 650 hPa shows that when the SL1 reaches its mature stage (16UTC), the AEJ core is shifted to the rear of the SL whereas it was ahead 9 hrs before.

vective area at 24UTC corresponds to an intense divergence anticyclonic flow resulting in an intensification of the TEJ (30 ms^{-1}) in the southwest sector of the convection up to a large distance (700 km). The longitude-time diagram (Fig. 3) of zonal wind at 150 hPa indicates that the core of the TEJ propagates westward staying in phase with the SL. On the contrary the TEJ is strongly reduced to the east of the convection as is expected for a divergent convective outflow.

5 CONCLUSION AND DISCUSSION

A multi-scale simulation of the life cycle of a sahelian SL interacting with large scale features has been performed using the two-way interactive grid-nestingi technique. The triggering of the S-L has been obtained without any artifice and its whole life cycle is nearly simulated, in good agreement with observations. These results may open new persepectives in simulating sahelian mesoscale convective systems which bring 90% of rainfall in the Sahel.

The squall line has induced a significant impact on the large scale flow. The interactions found need to be evaluated against detailed observations. Nevertheless, the present simulation brings new opportunities in studying the complex problem of scale interactions between the convection and the large scale flow. This simulation has been analysed to study through budget analysis the impact of the convection on the larger scale flow (Lafore *et al.*, 2002).

It is noteworthy that the success of the simulation depends on the correction of instabilities generated by the excess of humudity in the initial fields. This stresses the need to improve the analysis of the humidity field in order to initialise convective-scale simulations. Beside, the simulations have been found sensitive to the initialisation of the soil moisture, confirming the strong coupling between surface processes and convection in that region.

References

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