11B.3

Impact of an African squall line on large scale fields of heat, moisture and momentum

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1. INTRODUCTION

Most studies about the impact of convection at large scale has been based either on observations or on cloud resolving idealized simulations (CRM). In the CRM approach, the two-way interactions between the large scale flow and convection are generally not considered, due to the limited extension of the domain of simulation.

Recently Diongue et al. (2001) (also paper P1.52 in this conference) succeeded to explicitly simulate the whole life cycle of an observed sahelian squall-line (Redelsperger et al. 2002) and its interactions with the large scale flow thanks to the use of grid-nesting technique. This simulation started from the ECMWF analysis fields. It offers the opportunity to study the impact of the convection by avoiding some shortcomings of previous idealized CRM simulations.

2. Methodology

The Meso-NH simulation system (Lafore et al. 1998) used to perform this gridnested simulation allows to provide inline budget computation of all model prognostic variables. The apparent sources of heat Q1, moisture Q2 and horizontal momentum (Qu and Qv) due to convection are estimated from these budgets. For example the vector source of horizontal momentum, is computed as the difference between the total evolution and the large scale forcing (frc). This forcing is defined on a given domain of horizontal extent Lx, which would correspond to the grid size of a General Circulation Model (GCM).

$$\bar{Q}_u = \left[\frac{\partial \bar{\rho} u}{\partial t} - \left(\frac{\partial \rho u}{\partial t}\right)_{frc}\right]$$

$$\bar{Q}_v = \left[\frac{\partial \bar{\rho} v}{\partial t} - \left(\frac{\partial \rho v}{\partial t}\right)_{frc}\right]$$

$$\left(\frac{\partial \rho u}{\partial t}\right)_{frc} = \left[-\bar{u}\frac{\partial \bar{u}}{\partial x} - \bar{v}\frac{\partial \bar{u}}{\partial y} - \bar{w}\frac{\partial \bar{u}}{\partial z} - \frac{\overline{\partial p}}{\partial x} + fv\right]\bar{\rho}$$

The over bar denotes an average operator both in space (20 minute here) and in the horizontal space over Lx. So the forcing term includes the advection by the mean flow, the mean pressure term and the Coriolis force.

This diagnostic is applied to the simulation at different periods of the system life cycle to evaluate the sources that should be parameterized by a convective scheme of a GCM with different resolutions Lx ranging from 100 km to 300 km.

3. Main results

Figure 1 shows the evolution of mean vertical velocity and precipitation between 17UTC and 02UTC for 2 scales (200 and 300 km). Both domains experiment the passage of a mature squall line. The signature is similar but weaker and more extended for Lx=300km than Lx=200km as the system takes more time to cross the domain (~6h). The evolution of the vertical velocity resembles to the typical vertical cross section of a squall line, due to the steady state reached at that time by the system. One interesting result is that the ascent at low level is weaker for Lx=300 km as compared to the Lx=200 km, due to the impact of the stratiform subsidence.

Main results concern the importance of the rain evaporation for this sahelian system and of the transport by convective eddies. Due to the large size of this well structured convective system, the horizontal transport by eddies can not be neglected especially at low and upper levels. This key result applies to all variables; temperature, humidity and momentum.

The source of momentum (Figs. 2 and 3) is significant and mainly acts in the direction of propagation of the squall line but depends on its position inside the large scale mesh. At the system rear, it allows to explain the intensification of the African Easterly Jet (up to 3m/s/hr for Lx=300 km) and the lowering of its altitude. In the upper troposphere the momentum apparent source due to convection is even stronger (up to 15 m/s/hr and 8 m/s/hr for Lx= 200 km and 300 km, respectively) and coherent with an acceleration and a deceleration of the Tropical Easterly Jet ahead and behind the system, respectively.

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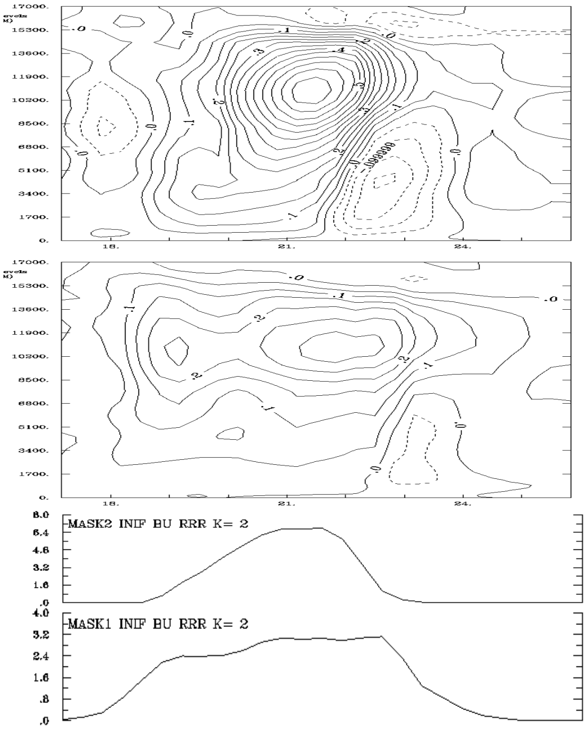

Figure 1: *Evolution (X-axis corresponds to 17 to 02 UTC) of the vertical profile of mean vertical velocity (a, b) (cm/s) and of the mean precipitation rate (mm/hr) (c, d). The average is performed at two scales: Lx=200 km (a, c) and Lx=300 km (b, d) size.*

3. References

Diongue, A., J.P. Lafore, J.L. Redelsperger and R. Roca, 2001: Numerical study of a sahelian synoptic weather system: Interactions between cloud and synoptic scales. Submitted to Q. J. R. Meteorol. Soc

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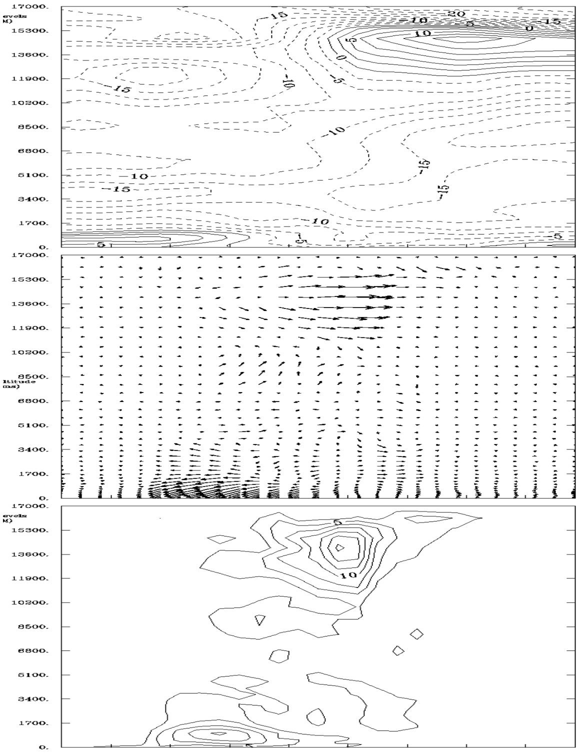

Figure 2: *Evolution (X-axis corresponds to 17 to 02 UTC) of the vertical profiles of zonal wind (m/s), (Qu, Qv) vector and its module (m/s/hr) averaged at the 200 km scale (Lx). The isoline contour for module is 2.5 m/s.*

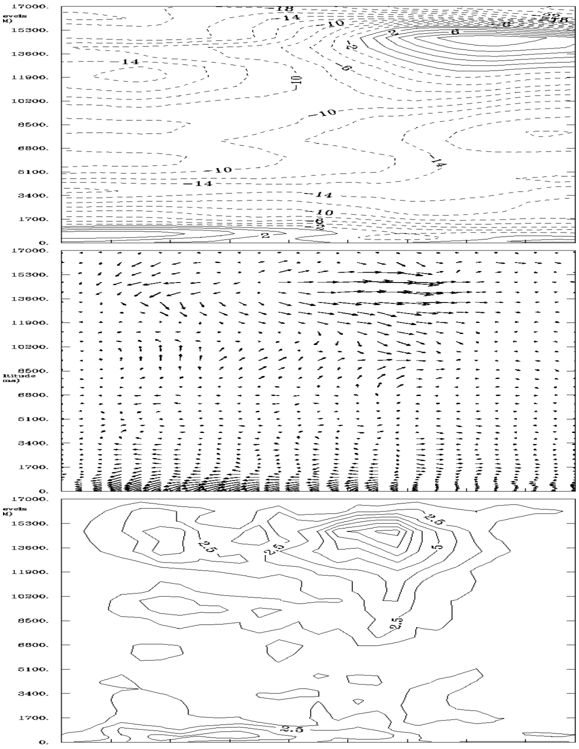

Figure 3:*As Fig. 2 but for Lx=300 km. The isoline contour for module is 1.25 m/s*