

MESOSCALE CONVECTIVE SYSTEMS OVER SOUTH AFRICA: A CASE STUDY

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1. INTRODUCTION

Mesoscale convective systems (MCS) are associated with a host of severe weather phenomena, such as flash flooding and strong winds, but they may also provide much of the all important rainfall to semi-arid South Africa. Although these systems are not uncommon over South Africa, very little work has been done on cases in the region.

Heavy rainfall, in excess of 100 mm, was recorded by weather stations positioned along the northern KwaZulu-Natal coastline during the night of 11-12 February 2005 (Fig. 1). This heavy rainfall was associated with a MCS that was initiated from small convective storms beginning early in the afternoon on 11 February 2005. The MCS case study is investigated with a non-hydrostatic numerical model (MM5) to help determine which processes were important in its initiation and development, as well as what factors contributed to the associated heavy rainfall.

2. DATA

A combination of Medium Range Forecast (MRF) model analysis (Kanamitsu 1989; Kalnay et al. 1990; Kanamitsu et al. 1991), National Center for Environmental Prediction (NCEP-NCAR) re-analysis data (Kalnay et al. 1996) and South African Weather Service station data were used to identify synoptic and mesoscale patterns that influenced the MCS evolution. The MRF data was also used to supply the initial and boundary conditions for the model.

The numerical model used was the non-hydrostatic fifth generation mesoscale model version 3 (MM5; Dudhia 1993; Grell et al. 1994). This mesoscale model has been used to research MCS in other parts of the world, including the U.S., Africa, Europe and parts of Asia (e.g. Tucker and Crook, 1998; Chen et al. 2000; Romero et al. 2000; and others), but not to date over South Africa.

3. RESULTS

An analysis of MRF model output suggests that a combination of synoptic features contributed to the evolution of the system. It is likely that the high-lying topography of the eastern escarpment and high diurnal surface heating provided the trigger for the event.

The MM5 model results suggest that the eastern escarpment played a key role in triggering the convective event, as well as influencing the low level winds that advected moisture into the region. It was also apparent that the Agulhas Current played an important role in supplying moisture to fuel the extreme rainfall. The development of the MCS and the heavy nocturnal rainfall was due to a combination of the continuous moisture supply into the region (Fig. 2), a conditionally unstable atmosphere, and uplift due to low level convergence (Fig. 3) and the local topography.

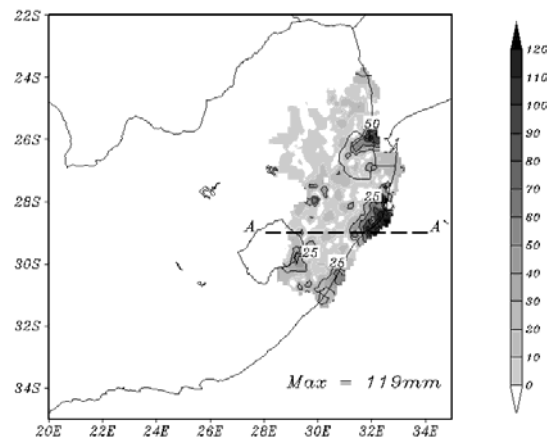


Figure 1: Rainfall (mm) pattern observed by SAWS stations during 11-12 February 2005.

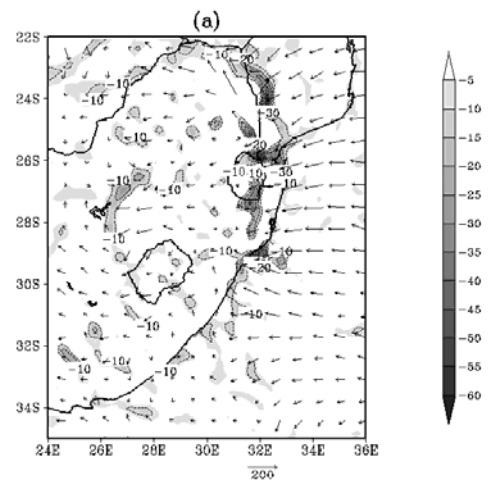
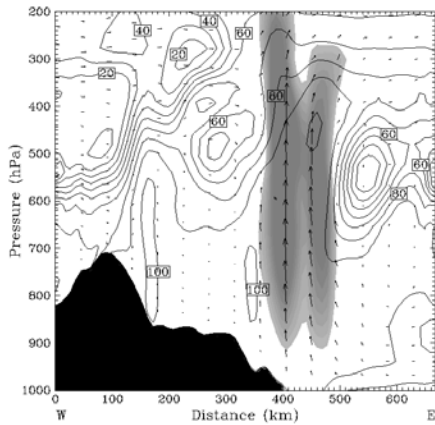


Figure 2: Moisture flux (vector scale in $\text{g kg}^{-1} \text{m s}^{-1}$ given at the bottom) and moisture flux convergence (shaded $5 \text{ g kg}^{-1} \text{s}^{-1}$ interval) at the 0.995 sigma level from the control at 23h00 UTC 11 February.

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a)



b)

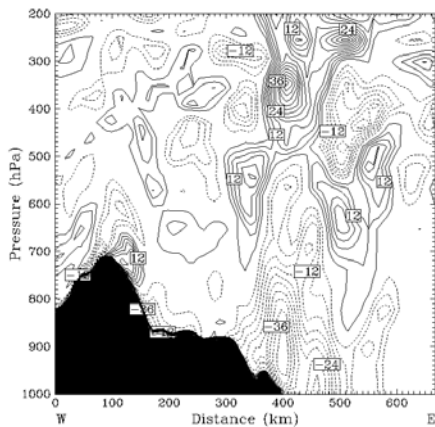


Figure 3: Vertical cross-sections taken at 2300 UTC 11 February along A-A' (see fig. 1) in the control simulation of a) wind vectors, vertical velocity greater than 40 cm s^{-1} (shaded) and relative humidity (contours with an interval of 10%), and b) divergence (interval 4 s^{-1}).

4. DISCUSSION

South Africa is frequently affected by severe weather events, but the scarcity of observations restricts our understanding of these weather systems. The main emphasis here was using the available observations and MM5 simulations to identify the processes that resulted in the development of the system as well as the heavy precipitation.

Consistent with Doswell (1987) and Romero et al. (2000), the interaction of synoptic and mesoscale processes allowed the system to become large enough and persist long enough to be classified as an MCS. Furthermore, the heavy precipitation along the north coast was due to sustained periods of favourable conditions for deep convection with significant onshore low level flux of moist air.

Although we have only considered a single case study, we believe that the model results provide further evidence of the importance of the Agulhas Current and the topography of eastern South Africa for the development of severe storms in the region.

Further details of the study analysis and model can be found in Blamey and Reason (2009).

6. REFERENCES

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