A severe weather event on 29 December 1997: Synoptic and mesoscale perspectives

E de Coning*, BF Adam and L Banitz

Weather Forecasting Research Programme, South African Weather Bureau, Private Bag X097, Pretoria 0001, South Africa

Abstract

On 29 December 1997 a severe hailstorm occurred over the eastern parts of the Free State. Hailstones with a diameter of 10 to 25 mm were reported. In this paper the authors try to establish the nature of the storm by looking at the synoptic and mesoscale analyses of the weather features at that time. Due to a lack of sufficient data, the South African version of the Eta model's 3 and 6 h forecast fields were used to establish the storm environment. Most of the model parameters indicated that severe weather could have been anticipated in the area of interest. Mesoscale analyses showed that steep temperature, pressure and dew point temperature gradients were evident over the area and that this contrast in air masses served as a good trigger mechanism for the development of thunderstorms. Analyses with the upper-air data showed that the air was very unstable at Bloemfontein earlier that afternoon, while Bethlehem was under the influence of an inversion (subsident motion in the upper layers of the atmosphere). The latter was removed during the early evening due to orographic forcing. With the high amount of energy available underneath the inversion, it exploded into a severe storm later that night. With the aid of software like TITAN and CIDD it was possible to analyse the radar data with much more detail than would have been the case under operational circumstances where forecasters did not have access to these software packages. Looking at all available data, the authors are of the opinion that this was an isolated severe thunderstorm which displayed several supercell characteristics.

Introduction

On 29 December 1997 between 20:00 and 22:00 (all times are SAST) a hailstorm passed over an area of about 80 km long and 30 km wide from Clarens, over Fouriesburg, Bethlehem, Danielsrus and up to Reitz and Petrus Steyn. Bethlehem's METARs (meteorological aviation reports) mentioned that hail fell between 20:00 and 21:00 and that it was accompanied by rain and thundershowers for most of the evening. According to the Volksblad (31 Dec 1997) the storm passed through Reitz at about 21:30 and grape to walnut sized hailstones (10 to 25 mm in diameter) caused R15 m. damage to crops in this area. Although this event was short-lived and resulted in relatively small rainfall amounts, the severity was responsible for a vast amount of structural damage to farm buildings, as well as the damage to corn, sunflower and wheat fields. Radar rainfall measured by Bethlehem's MRL5 radar over a 24 h period is shown in Fig. 1. This clearly depicts the swath of severe weather in a band stretching from south to north just east of the location of the radar. The radar rainfall usually overestimates the rainfall due to the hail stones' high reflectivity. Bethlehem measured a 24 h rainfall total of 20.8 mm (more detail in paragraph on 5 min AWS data), Deneysville (Vaaldam) reported 29.5 mm, while other rainfall totals for the Free State were less than 5 mm. Rainfall totals of more than 25 mm were also measured at: Johannesburg International Airport: 30.5 mm, Pretoria Weather Office: 33 mm, Alldays: 25.8 mm, Tzaneen: 26.2 mm, Doornlaagte: 43 mm, Lichtenburg: 42.5 mm. Most of the rainfall reported over the rest of the country was less than 10 mm, however.

In South Africa supercells are relatively rare. This is evident from studies surrounding the nature of hail producing thunderstorms in South Africa by various authors (Held, 1978; Held, 1982; Carte and Held, 1978). A comparative study of hailstorms in South Africa, Switzerland and Canada (Admirat et al., 1985) over a 5 to 20 year period revealed that very few supercells with a quasi-steady state were observed over South Africa (at least one in a 20 year period). Analysing the available data, the authors show that several supercell criteria were met, making this particular storm one of these rare supercell examples.

* To whom all correspondence should be addressed.
☎(012) 309-3081;fax (012) 323-4518 e-mail: estelle@cirrus.sawb.gov.za
Received 13 April 1999; accepted in revised form 26 November 1999.

Data

Routine surface observations, 5 min AWS (automatic weather station) data, satellite imagery (mostly Infrared) and the MRL5 radar (stationed northeast of Bethlehem [Synoptic ID: 68461]) data were used to analyse the event. In addition to normal displays, TITAN (thunderstorm identification, tracking and nowcasting, Dixon and Wiener, 1993), RAOB (Rawinsonde observation system) and CIDD (Cartesian interactive data display) were used to interpret the raw data. Due to the lack of upper-air data the local version of the Eta model's 3 and 6 h forecast fields were also utilised to get an estimation of the model's short-term forecast ability in the storm's environment. For a more detailed description of the Eta model, the reader is referred to Mesinger et al. (1988). The South African version of the Eta model has a 48 km horizontal resolution and 38 levels in the vertical.

Analysis of the data

At the surface, at 14:00, a high pressure system was ridging in on the KwaZulu/Natal coast, advecting moist, cool air over the eastern parts of the country. A low pressure system was present over the central interior. A relatively steep pressure gradient was present between the higher pressures in the east and the low pressure system over the interior (Fig. 2). Pressure tendencies were mostly negative over the region of interest. Very high temperatures were recorded over the western Free State and Northern Cape. A steep