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VIPOS (VAAL DAM INTEGRATED PRECIPITATION OBSERVING SYSTEM): USING RADAR AND GAUGES FOR RAINFALL ESTIMATION OVER AN IMPORTANT CATCHMENT IN SOUTH AFRICA

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1. INTRODUCTION

The Vaal Dam is situated just south of Johannesburg, South Africa. The supply catchment of this dam (Figure 1) covers 40 000 km^2 of the Highveld, an elevated plateau characterized by a rolling landscape about 1600 m amsl. This region supports important industrial, mining and agricultural activities. For example, almost half the electricity generated in Africa comes from coal-fired power stations on the Highveld. On average the demand for water exceeds the supply within the Vaal Dam catchment and this initiated the construction of several inter-catchment water transfer schemes.

Summer convective storms produce a large fraction of the annual rainfall over the catchment. Being located in the sub-tropical high-pressure belt, periods of drought are common but these are often abruptly interrupted by disastrous flooding episodes.

The above background sets the scene for the radar-based system developed to provide real-time rainfall estimation over the Vaal Dam catchment.

2. INFRASTRUCTURE

The Vaal Dam catchment is covered by the South African Weather Bureau's (SAWB) C-band radars at Ermelo and Pretoria towards the north and the Water Research Commission's (WRC) MRL-5 S- and X-band radar near Bethlehem in the southwest (Figure1).

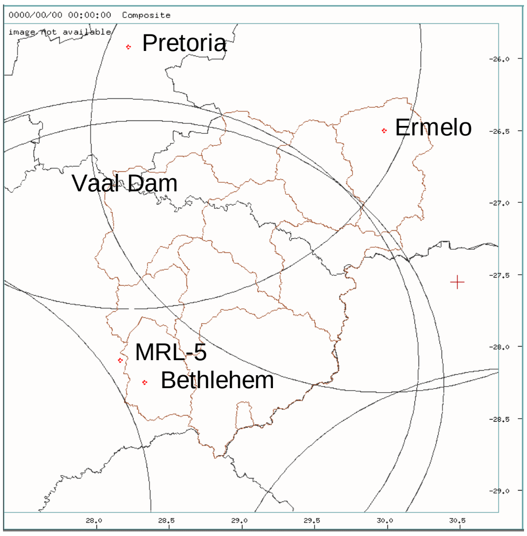

Figure 1. The Vaal Dam sub-catchments and radar coverage at 200 km range.

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3. DATA PROCESSING AND COMMUNICATION

The South African radar network, the data processing and communication systems, as well as the underlying MDV format, were described at the previous radar conference (Terblanche et al., 1999). At present the network consists of 11 radars and a wide range of products are made available on the web. The information is well utilized and close to 900 000 hits were recorded during February 2001.

Radar rainfall estimates are obtained by applying $R = (Z/200)^{1/1.6}$ to the composite reflectivity field of the large scale, 1 minute latitude-longitude resolution, merged reflectivity field, which is produced every 5 minutes. Composite reflectivity is used as a compromise due to the non-ideal spacing of radars for rainfall estimation in South Africa. The fields are produced in MDV format.

Daily rainfall figures obtained from automatic weather stations and manned observation sites across South Africa are obtained daily from the SAWB climate data base. The data are transferred to Bethlehem and also converted to MDV format.

Recently systems that treat Meteosat 7 IR information in a similar manner were implemented and a satellite rainfall estimation scheme introduced.

4. PRODUCT GENERATION

The Vaal Dam catchment is subdivided into 12 quaternary sub-catchments and masks are used to extract the average radar estimated rainfall for each of these catchments. The following products are generated for the Vaal Dam catchment and are available at http://metsys.weathersa.co.za/vaal_dam.htm:

- Previous Day's 24 hour Rainfall Map - updated at 06:00 GMT.
- Table of previous day's accumulated rainfall over catchments of Vaal Dam updated at 06:00 GMT.
- Previous day's 24 hour catchment totals and rain gauge measurements. Updated 09:30 GMT.
- Present Day's Rainfall Map - updated every 30 minutes from 06:30 GMT.
- Previous Hour's Rainfall Map - updated at 10 minute intervals.
- Download Archives

Examples of the first and third products in the list above, for a typical convective rain day, are shown in Figure 2a and b.

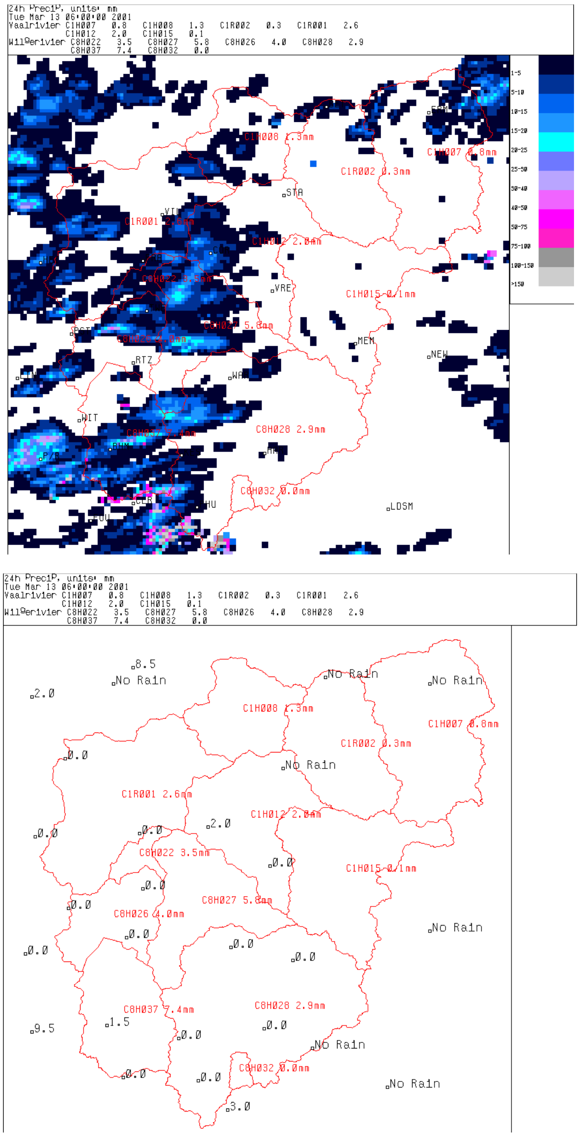

Figure 2. Radar-derived convective rainfall field and corresponding gauge values.

5. SUPPORTING RESEARCH AND TESTS

Rainfall from convective storms is not well measured by rain gauges. A case study of a typical South African convective rain day (Mittermaier and Terblanche, 2000), using the typical density of gauges in South Africa, showed that the probability of underestimating area rainfall is about 0.75. The probability that the gauges will measure less than 25% of the actual rainfall is about 0.5. Occasionally the rain gauge data will lead to a gross overestimation of the area rainfall. These statistics have an important bearing on water resource management based on daily rain gauge figures and highlight the need to improve the spatial resolution of rainfall estimation.

Research in South Africa to address the rainfall estimation problems related to ground clutter, anomalous propagation, the bright band and hail are described by Terblanche et al. (2001). In these studies the network of 45 gauges, on a 10 km grid, in the Liebenbergsvlei sub-catchment of the Vaal Dam plays a central role.

6. INTEGRATING RADAR AND GAUGE INFORMATION

Mittermaier and Terblanche (2000) describe a method to integrate radar rainfall estimation and rain gauge values using the Wetted Area Ratio (WAR) to vary the influence the gauge values will have on the radar rainfall field. The 4500 km^2 Liebenbergsvlei catchment was used as the study area. The WAR is a factor between zero and unity determined by the fraction of this catchment receiving > 2.5 mm according to the radar. To achieve the adjustment effect, a linear scaling function F_k is devised, so that when WAR is zero, the radar-rainfall field need not be adjusted. Conversely, when WAR is unity, the radar rainfall field (R_k) is forced to coincide with the gauge measured rainfall (G_k) at the gauge locations (k):

F_k = 1+ WAR[(1/RGR_k) - 1] where $RGR_k = R_k/G_k$.

A modified rainfall field R_1(i) is then determined using

$$R_1(i) = R_0(i)\frac{\left(\sum_{k=1}^{Ng} w_{ik}F_k\right)}{\left(\sum_{k=1}^{Ng} w_{ik}\right)}$$

where $R_0(i)$ is the original radar-rainfall field, *i* a specific radar rainfall pixel, and *k* a particular rain gauge in the range of rain gauges between 1 and N_g, the total number of gauges.

7. CONCLUSIONS

Using the above method for 12 rainfall events over the catchment, representing about 250 mm, the following improvement in overall statistics were obtained:

Field	Ratio	Correlation coefficient	Standard error (mm)
Unadjusted	1.13	0.92	7.82
Adjusted	1.04	0.99	1.97

At present more advanced integration methods are being developed for the entire South African region using an optimal combination of radar, satellite and gauge information.

References

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