Short communication

First rainfall data from the KZN Drakensberg escarpment edge (2002 and 2003)

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Abstract

Rainfall measured on the KwaZulu-Natal Drakensberg escarpment, the first from above 2 800m a.s.l., are presented from two locations. Total rainfall at the top of Sani Pass (2 850 m a.s.l.) in the southern Drakensberg was 742 mm in 2002, while the January months of 2002 and 2003 averaged 109 mm. Rainfall on Sentinel Peak (3 165 m a.s.l.) in the northern KZN Drakensberg during 2003 totalled 765 mm and 145 mm was measured in January 2003. Recorded rainfall was marginally lower than, but within 6% of, rainfall recorded at adjacent lower altitude Drakensberg stations over the same period. The number of rain days increased marginally with altitude and the data suggest that even though the amount of rainfall on the escarpment is similar to that at lower altitude, the frequency of rainfall events is higher on the escarpment. Although 2002 and 2003 were dryer than normal years in the region, comparisons between these data and prior estimations, where rainfall was expected to range between 1 500 and 2 000 mm/a, shows that totals for the summit of the escarpment could have been over-estimated in the past. Measurement of rainfall is ongoing.

Keywords: KwaZulu-Natal Drakensberg, rainfall, Lesotho

Introduction

Rainfall data and accurate rainfall estimation in the Drakensberg and adjacent Lesotho highlands are of fundamental importance in geomorphological, hydrological and botanical research and form a basis for palaeoenvironmental reconstruction. For example, Partridge (1997) predicts precipitation at the Last Glacial Maximum (approx. 18 000 B.P.) to be in the region of 70% of current values. However, contemporary meteorological data are sparse (Boelhouwers and Meiklejohn, 2002) and measured rainfall data for the Drakensberg escarpment region (above 2 500 m a.s.l.) do not exist on record. Rainfall estimation for the escarpment zone has been a topic of research in the past, notably by Tyson et al. (1976) and Schulze (1979). All rainfall data for the high Drakensberg are derived by projection from stations at lower altitudes. No rainfall records from the top of the escarpment have been forthcoming in recent years to verify these estimates, and most contemporary geomorphological research in the Drakensberg cite the values given by Tyson et al. (1976) and/or Schulze (1979) (e.g. Boelhouwers, 1988; 1991; 1994; Grab, 1994; 1996; 1999; 2002; Sumner, 2003). This paper presents the first measured rainfall data from the southern and northern KwaZulu-Natal Drakensberg escarpment as part of ongoing meteorological monitoring in the high mountain regions at the South Africa-Lesotho border.

Previous research

The most comprehensive and most cited rainfall analyses for the escarpment area come from the 1970s. Tyson et al. (1976) indicate that mean annual rainfall increases with altitude, and that the top of the escarpment should receive over 2 000 mm of rain annually. Stations in the Drakensberg are noted to experience an average of 16 to 18 rainy days in December and January, and the summer months November to March account for 70% of the annual rainfall, while May to August for less than 10%.

Schulze (1979) sketched a transect through the Central Drakensberg depicting mean annual rainfall and mean January rainfall from Hoffenthal in KZN to Mothelsessane in Lesotho. At Cleft Peak, situated on a transect and on the escarpment edge at 2 880 m a.s.l., rainfall was only recorded for an unspecified short duration, and the monthly data synthesised to 21 years using Cathedral Peak 2A as base station. Schulze (1979) found a clearly defined relationship between altitude and rainfall, with the rainfall attaining a maximum before the highest altitude is reached. On the escarpment, mean annual rainfall is predicted at over 1800mm, just 200 mm less than the estimate from Tyson et al. (1976). Mean January rainfall is estimated at over 250 mm (Schulze, 1979). From these two studies, contemporary rainfall exceeding 1 500 mm/a is typically quoted for the escarpment (e.g. Boelhouwers, 1991; Grab, 2002) and the value applied as a basis for palaeoenvironmental extrapolations.

Equipment and calibration

In this study, rainfall at the escarpment edge is measured at two locations using a Davis-MC Systems (D-MCS) automated tipping-bucket rain-gauge. The guages are at the top of Sani Pass in the southern Drakensberg, and on Sentinel Peak in the northern Drakensberg. Both sites have established South African Weather Service stations at lower altitudes using standard SAWS manual-recording rain-gauges. As with the SAWS stations, daily rainfall is measured over a 24 h cycle from 08:00 to 08:00 the following day. A rain day is defined as one on which at least 0.5 mm of rainfall is measured (Schulze, 1979).

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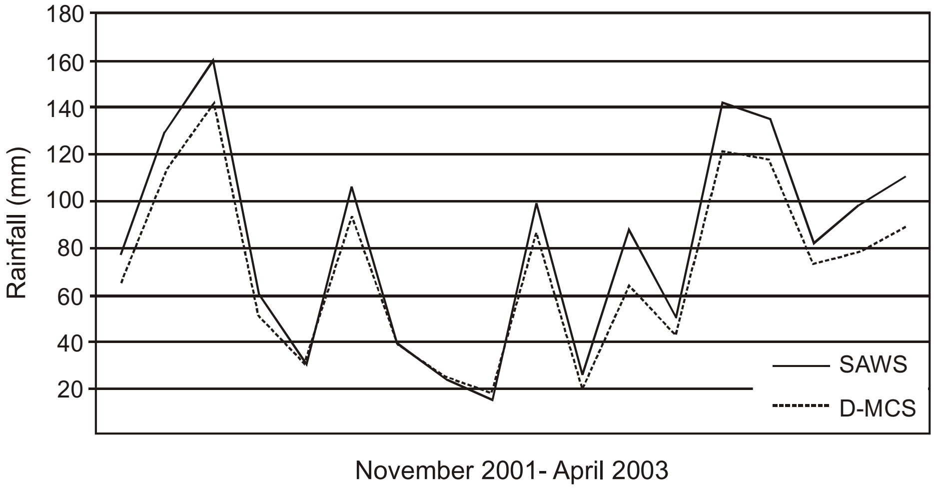

Figure 1
Monthly rainfall measured at Glenisla from November 2001 to April 2003

The D-MCS gauge has a 163 mm collection diameter and logs total rainfall every 5 minutes on a tipping resolution of 0.2 mm rainfall. Snowfalls are not recorded although some snow falls into the bucket and subsequent melt will be reflected in the records. No continuous snowfall records are available for the escarpment area. Rough estimates from observations in the area during 2002 and 2003, the beginning of the monitoring period, are that less than 0.5m of snow fell on the escarpment each year, which translates into a water equivalent of approximately 50 mm (10%). In general, observations by the authors are that annual average snowfall cumulative depth is unlikely to exceed 1m on horizontal surfaces during any calendar year, and the water equivalent will generally be less than 100 mm contribution to total precipitation.

Fundamental inaccuracies in the rain-catch by standard rain-gauges are well documented (e.g. Ward, 1975; Schulze, 1975; 1979). To test the difference in rain-catch between the standard SAWS rain-gauge and the D-MCS automatic rain-gauge, two D-MCS gauges were installed within a few metres from manual gauges at established SAWS stations; Glenisla Farm near Winterton in the central Drakensberg foothills (1 060 m) and at the Royal Natal National Park office complex in the northern Drakensberg (1 392 m). During the period from November 2001 to April 2003 the manual SAWS rain-gauge at Glenisla recorded 1 471 mm of rainfall and the automatic rain-gauge recorded 1 266 mm, a deficit of 14% from the SAWS data. The monthly rainfall totals measured by the two rain-gauges shows a similar trend (Fig. 1), however the deficit is apparent especially when rainfall is higher. In contrast, at the Royal Natal National Park station the D-MCS logger measured 3% more than the SAWS station records. Differences at stations could be attributed to gauge calibrations and human error, while the effect of varying intensities (possibly related to altitude and location) on accuracy may be a factor. Rain-catch deficiency is also exaggerated by windy conditions because of the formation of turbulent fields (Schulze, 1979) and it has been estimated that on the windswept higher altitudes of the Drakensberg, deficiencies in rain-catch are in excess of 8.1% (Schulze, 1979), possibly approaching 20% as reported by Rodda (1967) for windy sites (Schulze, 1979). Since the Royal Natal National Park station is located at a higher altitude and nearer to an escarpment monitoring site, more details on those comparative data are also provided in Table 1. Although the totals are similar at Royal Natal National Park, four fewer rainfall days are apparent from the manually recorded (SAWS) data, which could represent human error in records. This may apply only to small rainfall events recorded by the logger but not noted by observers and thus will not significantly affect totals. The difference in measured rainfall at Glenisla (Fig. 1) can only be contributed to gauge calibration, and between- gauge calibration still requires more detailed investigation given a larger data set. Notwithstanding this, the totals are deemed similar enough for direct comparison between SAWS and D-MCS data.

TABLE 1
Rainfall and rain days in the northern Drakensberg during 2003

Rainfall Station	Rain-fall in 2003 (mm)	Rain Days	Rain Days (Dec-Jan)	Rain Days (May-Aug)
Royal Natal National Park (SAWS)	774	100	26	10
Royal Natal National Park (D-MCS)	798	104	26	10
Sentinel Peak	765	107	26	8

Rainfall data from 2002 and 2003

At the southern Drakensberg escarpment edge site, monitoring of rainfall at the top of Sani Pass (2 850 m a.s.l. 29.57º South, 29.27º East) adjacent to the chalet complex commenced from October 2001. High wind speeds caused the logger support platform to be damaged in mid-2003 and records for that year are incomplete. Data presented here are for the calendar year 2002 and for the two January months of 2002 and 2003. The logger has been subsequently re-established and monitoring is ongoing. Total rainfall recorded for the calendar year 2002 was 742 mm, while the rainfall in January 2002 and 2003 gave a mean of 109 mm (Tables 2 and 3).

For comparative purposes, monthly rainfall data from 1970 to 2002 were obtained from the SAWS stations at lower altitude, namely the Sani Pass Border Post (2 055 m a.s.l. 29.60º S, 29.35º E) and Himeville (1 524 m a.s.l. 29.75º S, 29.53º E). These three stations depict rainfall trends with changing altitude in the southern Drakensberg (Table 3). The number of rain days increases with altitude, but the rainfall totals for 2002 show that rainfall on the escarpment was slightly less than at the lower altitude stations (e.g. 6% less than the Sani Pass Border Post station for the same period) (Table 2).

At the northern Drakensberg escarpment edge site, the free-standing Sentinel Peak (28.74º South, 28.89º East) is the highest point where rainfall is currently measured in Southern Africa (3 165 m). Monitoring commenced in November 2001 although the D-MCS rain-gauge was either blown off the site or stolen during 2002 and the data lost. Data presented here are from the calendar year 2003. Rainfall for the year totalled 765 mm, a similar value to that obtained the previous year at the top of Sani Pass. Rainfall in January 2003 was 145 mm (Table 3), 36mm more than the Sani average for 2002 and 2003 but substantially less than the estimate by Schulze (1979) of 250mm. For comparison with lower altitudes data, long-term data from the SAWS station at Royal Natal National Park were obtained and, as noted above, a D-MCS rain-gauge logged during this period. As recorded at the top of Sani Pass, slightly less precipitation fell on the escarpment edge than at the next-lowest station, Royal Natal National Park (4% less than the D-MCS record) and three more rain days were recorded at the higher altitude.

TABLE 2
Rainfall and rain days in the southern Drakensberg during 2002

Rainfall station	Rainfall in 2002 (mm)	Rain days	Rain days (Dec-Jan)	Rain days (May-Aug)
Himeville	799	83	32	9
Sani Pass Border Post	787	107	36	18
Sani Pass Top	742	141	44	28

TABLE 3
Altitudinal transect through the southern and northern Drakensberg

Rainfall station	Altitude (m)	Record	Mean annual rainfall (mm)	Mean January rainfall (mm)
Southern Drakensberg				
Himeville	1524	1970-2002	912	166
Sani Pass Border Post	2055	1970-2002	1176	221
Sani Pass Top	2850	2002	742	109 (2002, 2003)
Northern Drakensberg				
Royal Natal National Park (SAWS)	1392	1970-2002	1311	244
Sentinel Peak	3165	2003	765	145

In comparison to mean annual rainfall totals from established stations since 1970, years 2002 and 2003 were dryer than normal. Analysis of rainfall measured in 2002 at eight stations in the Drakensberg, all with well-established weather stations, ranges from 78 to 100% of the mean annual rainfall MAR (33 years) and analysis of rainfall in 2003 at four stations ranges from 60 to 82% of the MAR (33 years). The totals measured at the top of Sani Pass in 2002 (742 mm) and on the Sentinel in 2003 (765 mm) are thus probably below long-term rainfall averages for the sites. Both escarpment edge sites recorded totals that were less than the next-lowest SAWS sites for the corresponding year, namely the Sani Pass Border Post (787 mm) in 2002 and the Royal Natal National Park station (774 mm) in 2003. Long-term averages for these two SAWS stations are 1 176 mm/a and 1 311 mm/a respectively (Table 3). It is thus unlikely that long-term averages for the high-altitude sites will exceed these lower station mean values and earlier estimates (Tyson et al., 1976; Schulze, 1979) for rainfall totals at the escarpment of between 1 500 mm and 2 000 mm/a may thus be an over-estimation. The lower precipitation values at the escarpment edge also challenges the assumption of increasing rainfall with altitude in the Drakensberg. This is supported by recent research elsewhere that suggest altitude is not necessarily the only important factor influencing rainfall in mountainous areas (e.g. Prudhomme and Reed, 1998; Johansson and Chen, 2003; Konrad, 1996).

Summary and ongoing research

The rainfall data collected from above 2 800 m in the southern and northern Drakensberg are the first records from high-altitude sites in Southern Africa on the escarpment. The data are part of an ongoing monitoring programme and the first complete calendar years are presented here. Although 2002 and 2003 were dryer than average years, estimates based on corresponding stations suggest that earlier estimates for rainfall totals at the escarpment of between 1 500 mm and 2 000 mm/a may be an over-estimation. A similar scenario apparently exists for January estimates. More long-term data are required to verify findings.

Inherent and apparent errors also need further consideration. Rain-gauge calibration requires detailed investigation where different gauge types are used for comparison. Rain-catch deficiency is also exaggerated by windy conditions and recording errors in manual measurements are apparent given the difference in rain days recorded with the two instruments at the Royal Natal National Park station in 2003. Since no snowfall records exist, the contribution of snow to precipitation totals remains largely unknown.

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