A DOCUMENTARY-DERIVED CLIMATIC CHRONOLOGY FOR SOUTH AFRICA, 1820–1900

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Abstract. There is a paucity of detailed information regarding the climate of South Africa for the period preceding reliable meteorological instrumentation. Documentary evidence of climatic change, including missionary, official and archival material, is a useful surrogate source of information that is used to extend the rainfall record in the southern and south-eastern parts of the country. Chronologies of yearly rainfall variations for these areas are deduced from a detailed study of various documentary sources. The nature and extent of extreme events such as drought and flood episodes are identified. Corroboration of the chronologies with relevant dendrochronological and meteorological data enhances the documentary-derived weather chronology. Frequency analysis of rainfall for both the eastern and southern Cape, for the periods 1820–1900 and 1900–1980, indicates that the pattern of rainfall variability in these areas has not changed greatly over the past two centuries. Documentary evidence is shown to be a viable means of reconstructing past climates of areas in South Africa devoid of long and detailed instrumental records.

1. Introduction

The determination of the frequency of climatic phenomena, particularly drought and flood episodes, has long been a preoccupation of meteorologists and climatologists. Patterns of climatic variability have been inferred from several sources, chiefly instrumental records, but for periods when instrumental data are unavailable or unreliable, attention has shifted to proxy climatic data sources. Dendrochronological (Fritts *et al.*, 1981), palynological (Sissons, 1979), and phenological data (Le Roy Ladurie, 1972) have been used to extend the climatic record back in time beyond the existing meteorological data. Details of climatic variations for Britain, France and China have been obtained from several documentary sources including chronicles, travellers' reports, diaries, newspapers and official writings (Beveridge, 1922; Pearson, 1973a; b; Wang, 1979; Lamb, 1982). The reconstruction of past climates using documentary sources has also been attempted for areas in Africa (Nicholson, 1978, 1979, 1981). Apart from the work of Hutchins (1889), van der Merwe (1937) and Kokot (1948), few documentary-derived climatic chronologies or compendia of weather variations exist for the nineteenth century.

Instruments recording climatic variables such as temperature, rainfall and atmospheric pressure were installed in 1841 at the Royal Observatory in Cape Town. Approximately twenty years later a network of meteorological observa-

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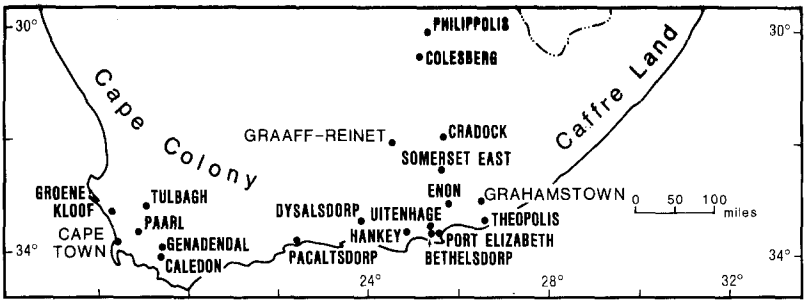

Fig. 1. Chief mission stations of South Africa, c. 1850. Meteorological observing stations such as Cape Town, Grahamstown and Graaff-Reinet are indicated in light type (adapted from the Report of the Directors of the London Missionary Society, 56 Meeting, 1850, p. 75).

tion stations was established with stations including Clanwilliam, Simonstown, Graaff-Reinet and Grahamstown (Figure 1). This instrumental network was extended and by 1878 fifty-one meteorological stations were operational in the Cape. The instruments used were, however, beset with calibration problems and were often neglected. Furthermore the older records, excepting those of the Royal Observatory, are not continuous (Tripp, 1888). The compilation of weather chronologies derived from documentary research largely overcomes problems such as the unreliability of early instrumental data by supplementing the extant meteorological records. A time series of yearly details of weather derived from documentary sources also permits the extension of climatic chronologies into periods preceding instrumental recordings. The intention in this paper is therefore to show that documentary research is a useful means of obtaining chronologies of weather variations for the southern and south-eastern areas of South Africa for the period 1820–1900. This period covers both the time preceding the introduction of a reliable network of meteorological observing stations in the area and that of the earliest series of South African meteorological records. The derived chronologies are then compared with instrumental as well as dendrochronological data and inferences about particular atmospheric phenomena, associated with the rainfall variations highlighted in the chronologies, are made.

2. Precursory Documentary-Derived Cape Weather Chronologies

The most informative previous documentary research on past climates of South Africa (Hutchins, 1889; van der Merwe, 1937; Kokot, 1948; Nicholson, 1978, 1979, 1981) is that of Nicholson (1981) who has inferred that severe drought occurred in the southern portions of South Africa during the early 1800s. Affected areas were thought to include the central, north-eastern and north-western Cape, Griqualand, south and south-eastern Botswana and southern Namibia. The only areas not affected by the prevailing droughts were those

areas along the south-eastern coast of Africa (Nicholson, 1981). Further research of missionary and official documents for the early 1800s (Vogel, 1988) has indicated that a period of wetter conditions during the years 1822–1823 ended the drought of the preceding years in the Cape with flood damage being noted for several coastal areas. Similar references to excessive rainfall along Cape coastal areas are made in the documents used by Hutchins (1889) and Theal (1964). Hutchins (1889, p. 26) quotes the work of Brownlee and Thompson who describe the early 1820s as a period characterised by floods following a severe drought:

"...the winter of 1822 was a remarkable season in the west caused by the Storm cycle; so that the Albany floods of 1822 were probably 'mitigation' rains reinforced by the Storm cycle".

Theal (1964) refers to great storms occurring in the south-western Cape in 1822 and to the inundation in 1823 that destroyed Theopolis (Figure 1). During the mid-1820's, however, the weather of areas in the south-eastern Cape appeared to be characterised by drought with some relief occurring in 1828–1829 (Nicholson, 1981). Although the documents used by Hutchins (1889), Theal (1964) and Nicholson (1978, 1979, 1981) for the reconstruction of weather chronologies were drawn from a range of authors the resultant chronologies are not continuous but rather tend to focus on isolated time periods during the nineteenth century.

A detailed study of various documents for the eastern and south-western Cape has been undertaken to establish continuous climatic chronologies for these areas for the years 1820–1900. Various missionary sources were used together with official documents and bank archival reports to build up a composite picture of yearly rainfall variations pertaining to particular places within the eighty-year study period.

3. Reconstruction of Cape Climate Using Documentary Evidence

Before illustrating the method that was used in the reconstruction of past climates a brief outline of the present day climate of the area under study is provided. "More than 80 per cent of the annual rainfall in the south-western Cape occurs in winter in an annual cycle in anti-phase to that over the summer rainfall region" (Tyson, 1986, p. 2). The southern Cape coastal belt and adjacent interior receive rainfall more uniformly throughout the year with areas to the north-east being characterised by convective and all-seasons rainfall along the southern coast (Tyson, 1986).

A simple method has been adopted for the reconstruction of the southern and south-eastern Cape documentary-derived rainfall record. Documents for a particular time period and place were consulted for descriptions of the prevailing weather and these were then cross-checked with other available documents for that period. Results for the 1860–1870 period are outlined below as an

illustration of the method adopted in this study. This period was chosen as an example of the method adopted for the following reasons. First, the period is characterised by a preponderance of various documents including missionary, official, bank and newspaper reports. Secondly, the drought years of the mid-1860s were unusually harsh, ranking as some of the most severe droughts of the nineteenth century in both the eastern and southern Cape. Thirdly, several meteorological instruments were operational during the 1860s thereby enabling corroboration of the documentary-derived chronologies obtained for the period.

From the various documents studied for the period 1860–1870 it is evident that drought conditions prevailed for the early years of the 1860s. Reference made to the exceedingly dry conditions of 1862 include:

CRADOCK – "This division, in common with most or indeed all the north and north-eastern divisions has suffered greatly during the past year from the unprecedented drought. Farmers who have lived upwards of fifty years in this locality state that the drought of 1862 is the greatest ever known" (Cape Blue Books, Civil Commissioners' Reports, 1862, Appendix JJ. 20).

Secondly, similar reports of the harsh drought from *missionary* sources:

GENADENDAL – (United Brethren Mission, location indicated in Figure 1). "The continued severe drought, which prevailed not only in this neighbourhood, but over the whole colony, and even beyond its boundaries, caused great distress throughout the country" (Diary extract, 1 July–31 December, Periodical Accounts of the United Brethren, Volume 24 (252), September 1861, p. 64).

Thirdly, *newspaper* reports pertaining to the same period:

NORTH-EASTERN COLONY – "The drought continues unabated, Colesburg, Hanover, Hopetown, the western part of the Free State, Griquatown, and the country beyond it, are all in a pitiable state" (Burghersdorp Gazette, 15 November, 1862, cited in Kokot, 1948, p. 34).

Finally, a *bank manager's report* confirms that the weather of the 1860s was extremely harsh:

"The breaking up of the terrible drought by which the land has been afflicted and which has entailed such heavy losses on producing population has begotten in many minds the hope that we are now to be favoured with a propitious cycle of years" (Letter, General Manager to Secretary, London, 07.04.1866, Standard Bank Archives).

Adopting the reconstruction procedures described above, a spatial and temporal distribution of the incidence of above- or below-normal rainfall (normal designated as a mean rainfall of 545 mm for the eastern Cape and a mean rainfall of 459 mm for the south-western Cape for periods with reliable instrumental records) and the nature of the harvest yield were determined from the documentary sources for the Cape Colony (Figure 2). Climatic chronologies for the southern and eastern Cape outlining year-by-year rainfall variations, including the severity of drought and flood occurrences, were also compiled. Periods of noted above-normal rainfall for the entire Cape area identified for the eighty year study period include the years 1830–1833, 1844–1848 and 1852–1860 whereas years of below-normal rainfall include 1825–1829,

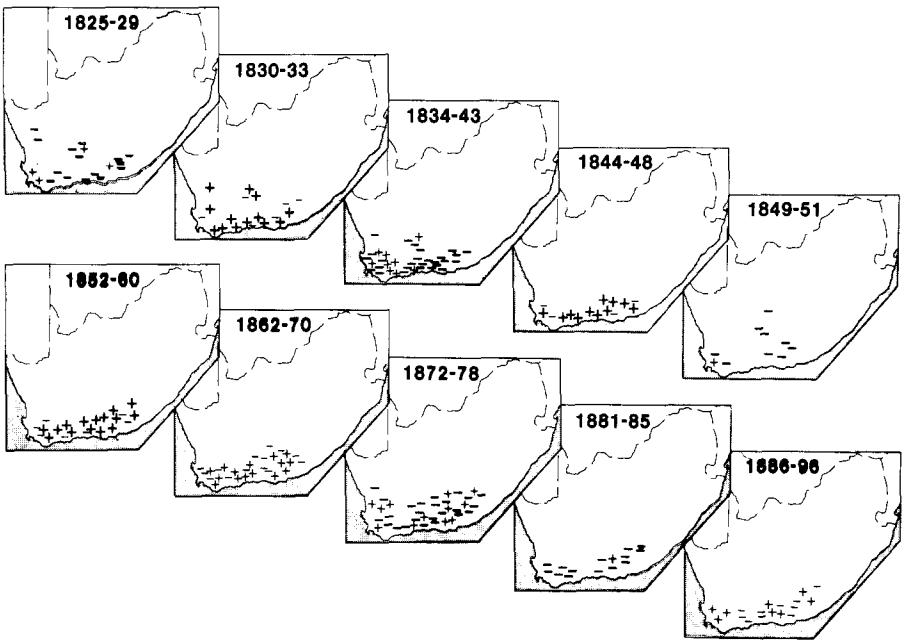

Fig. 2. Spatial variations of weather as inferred from documents. Years grouped into periods of either pronounced above-normal or below-normal rainfall. Plus symbols denote reports of flooding or above-normal rainfall, minus symbols denote reports of drought or below-normal rainfall.

1849–1851, 1872–1878 and 1881–1896. From these chronologies it is apparent that in the *eastern* Cape (Figure 3a) years of generally above-normal rainfall include 1823, the early 1830s, 1844–1845, 1847–1848, 1852–1857, 1863–1864, 1867–1872, 1874–1875, 1886–1891 and 1900. Reports of reduced rainfall embrace the latter years of the 1820s, 1833–1838 (although some relief did occur in 1835), the early years of the 1840s, 1846, 1849, 1851, the latter years of the 1850s, the early 1860s, 1865–1866, 1869, 1872–1873, the closing years of the 1870s, 1881–1885, 1892 and 1894–1899. Extreme weather events such as flood and extreme drought episodes, which are given particular mention in the various documents studied, were identified. Reports of severe drought occurrences in the eastern Cape include the years 1833–1834, 1837–1839, 1859, 1861–1862, 1865, 1877–1878 and 1895–1896. Incidences of severe flooding include the years 1823, 1832, 1844–1845, 1848, 1856–1857, 1863, 1875, 1886 and 1900. A similar chronology to that outlined here was compiled for the southern Cape (Figure 3b).

There are certain problems associated with the type of documentary research outlined above. The transmission of second-hand information, inherent subjectivity of documentary research, misdating, failure to distinguish between reliable and unreliable sources, the presence of critical gaps and the possibility of compound parameters whereby reports indicating a famine often mask the role of

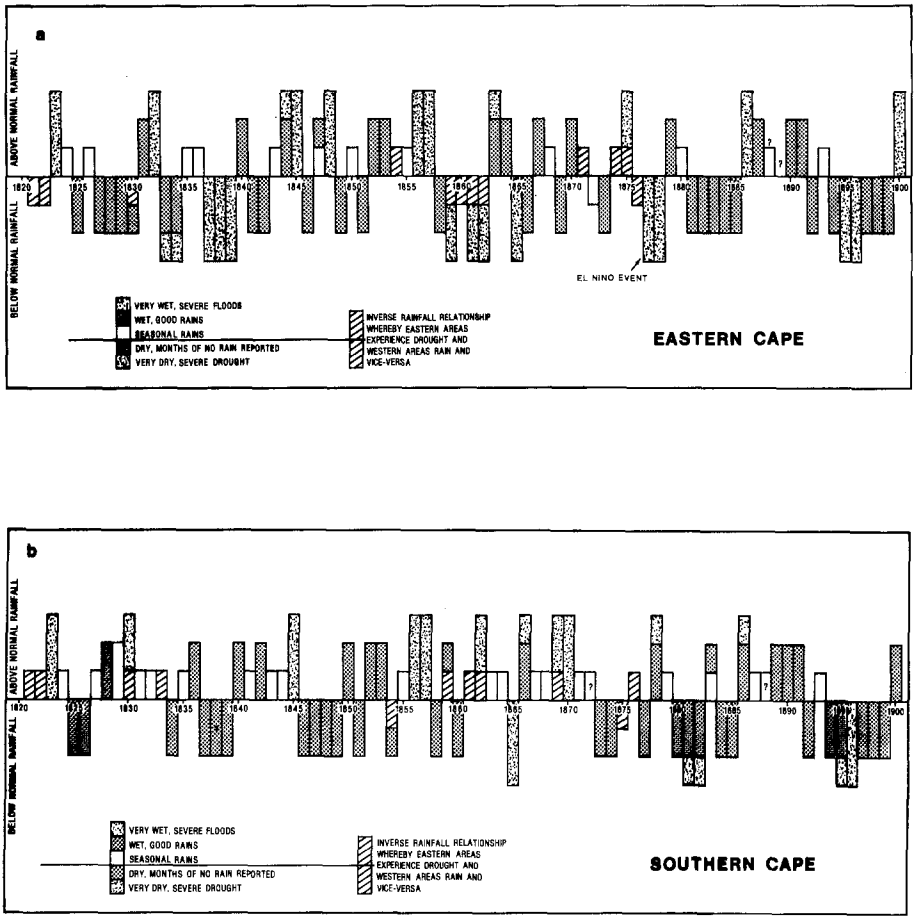

Fig. 3. Documentary-derived chronologies of precipitation variations for (a) eastern and (b) southern Cape, 1820–1900.

economic causative factors may all affect the accuracy of documentary-derived chronologies (Bell and Ogilvie, 1978; Bryson and Padoch, 1980; Fischer, 1980; Herlihy, 1980; Nicholson, 1979). The missionary, official and banker's documents used in this study ensure that references to weather for a period are continuous, reliable, and easily datable. Missionary sources are continuous and the validity of the reports is enhanced because the documents were often compiled by the same observer for several years. It is nevertheless necessary to supplement the documentary sources using comparative, quantitative data which are independent of the historical sources.

Weather reports pertaining to rainfall variations for the southern and eastern Cape were compared with dendrochronological and meteorological data for the area to supplement the documentary-derived chronologies. Dendrochronological data otained from Cape trees such as *Podocarpus falcatus* and *Widdringtonia*

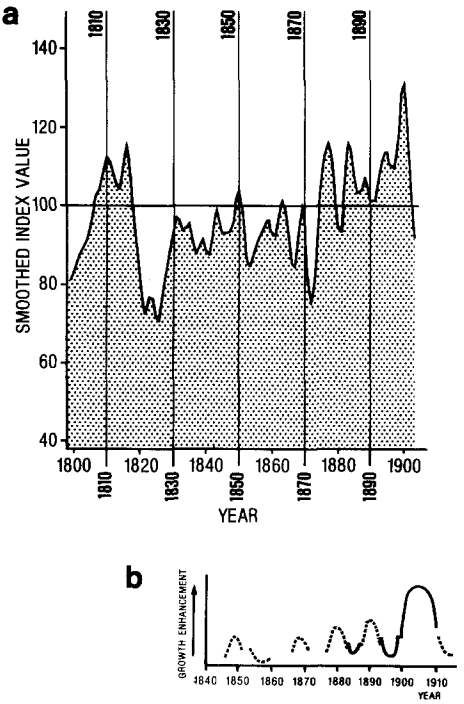

Fig. 4. (a) Tree-ring chronology from Die Bos Site, Cape Province (after Dunwiddie and LaMarche, 1980). (b) Tentative generalised growth patterns of *Podocarpus* specimen at Witelsbos, 1840–1860 (after McNaughton and Tyson, 1979).

cedarbergensis (McNaughton and Tyson, 1979; Dunwiddie and LaMarche, 1980) were used. Years of particularly close correspondence between the documentary reports and the tree-ring data, during which suppressed tree-ring growth and reports of dryness occur, include the early 1820s, the 1850s, early 1870s, mid-1880s and the mid-1890s (Figures 4a and 4b). Years of increased growth, possibly because of above-normal rainfall, were the early 1850s, late 1870s and the early 1900s. Indications of suppressed tree-ring growth possibly associated with reduced rainfall are also evident for the years 1860 and 1865 (Figures 4a and 4b).

Caution must, however, be exercised in interpreting dendrochronological data since the relationship between increased rainfall and tree-ring growth is not always direct. In some instances excessive rainfall can have the effect of retarding tree-ring growth. There are also numerous other problems associated with dendrochronological studies in South Africa (Nicholson, 1979). Problems including diffuse and poorly defined tree-ring boundaries, multiple intra-annual bands, the 'wedging-out' of individual rings in *Podocarpus* species and the situation whereby trees do not necessarily respond to moisture fluctuations with annual periodicity of rings (Lilly, 1977; LaMarche, 1978; Nicholson, 1979) all

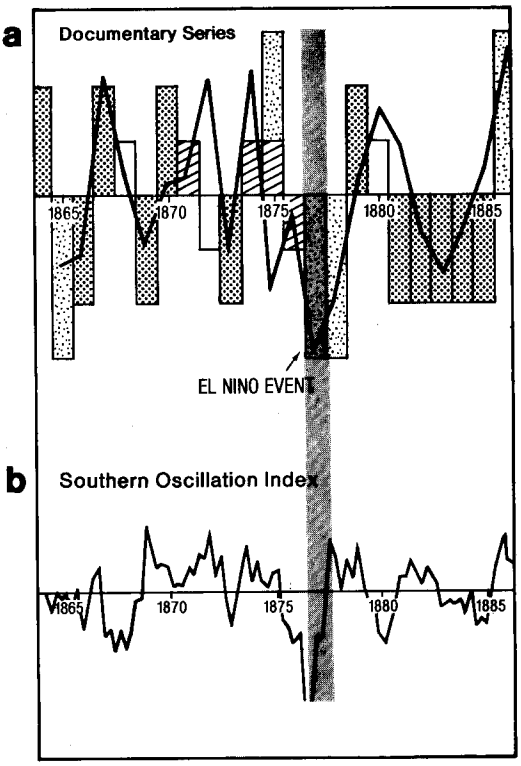

Fig. 5. (a) Correspondence between the documentary-derived rainfall series (bars) and instrumental reports (solid line) for the eastern Cape, 1860–1890. Key to rainfall departures as in Figure 3. (b) Historical record of the Southern Oscillation index, 1850–1895 (after Wright, 1975). Shaded bar highlights the extremely dry year and El Niño event, 1877.

mitigate against conclusive inferences of climatic change being made from South African tree-ring chronologies.

Comparisons between the available instrumental data (such as Grahamstown rainfall records) and the derived chronology for the eastern Cape were also made to verify the documentary reports. Years of close correspondence (Figure 5a) between the documentary sources and the instrumental record include the years 1865, 1866, 1867, 1869, 1874, 1877, 1880 and 1881–1885. Dry years were those of 1865, 1869, 1873 and 1877 with 1865 and 1877, emerging as particularly dry years. Wetter years include 1867, 1871, 1874, 1880 and 1886.

4. Discussion

Having outlined the variations in rainfall that occurred in the last century for the Cape, southern Africa, it is now pertinent to determine spatial weather patterns and possible atmospheric phenomena that may be associated with these weather features. An apparent inverse relationship, whereby rainfall is abundant in the eastern Cape but reduced in the southern Cape (Figures 3a, 3b and Figure

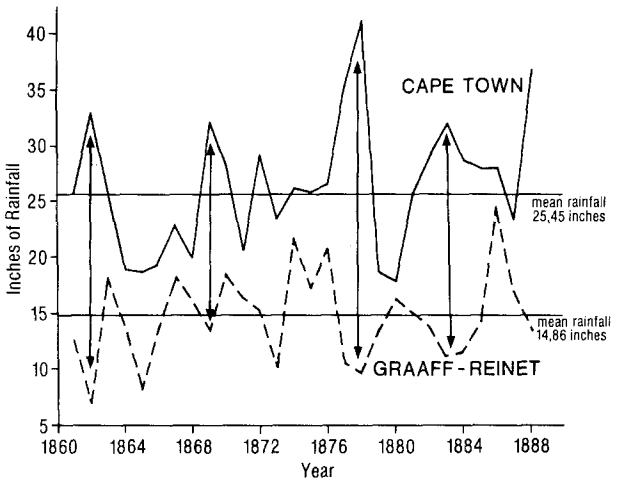

Fig. 6. Inverse rainfall relationship (indicated by arrows) between instrumental records for the southern Cape (Cape Town) and eastern Cape (Grahamstown) in the period 1860–1890.

6) emerges from time to time in the documentary-derived chronologies. Corroboration of this inverse phenomenon is evident in the meteorological record (Figure 6), particularly for the years 1860–1862, 1868–1870, and 1876–1878 and also in more recent analysis of twentieth century data (Muller and Tyson, 1988). The inverse rainfall relationship is not persistent or strong, however; it occurs during only 7 to 10% of years in the period 1820–1900, and is marked only during excessively dry periods such as 1828, 1862 and 1876–1878.

A possible atmospheric phenomenon that may be associated with the aforementioned extremely dry periods is the El Niño Southern Oscillation. The El Niño Southern Oscillation event is an extreme of the largest known mode of atmospheric variation, the Southern Oscillation, and is associated with severe weather anomalies including drought in South Africa (Lindesay, 1988a; b). Relationships between ENSO events and temperature have been documented (Rasmusson and Wallace, 1983; Ropelowski and Halpert, 1987). Furthermore, rainfall has been correlated with ENSO events including the relationship between rainfall of South America and the 1877 El Niño Southern Oscillation event (Kiladis and Diaz, 1986).

There is a sizeable body of research that suggests that there is a strong relationship, in some instances a very good correlation (Nicholson and Entekhabi, 1986), between phases of the Southern Oscillation and South African rainfall (Dyer, 1979; Harrison, 1983; Pittock, 1983; Schulze, 1983; Lindesay, 1988a; b). More particularly, such analysis indicates that there is a relationship between drought occurrence and below-normal rainfall/low-index values of the Southern Oscillation, particularly in the summer rainfall areas of the country. A notably low index of the Southern Oscillation (Wright, 1975) is evident for the years 1876–1878 (Figure 5b), years during which numerous references to the

TABLE I: Weather for various areas – 1877 (Cape Blue Books, Civil Commissioners' Report)

Area	Weather
Piketberg	"Rain has fallen in abundance, and the grain crops have, upon the whole been very good" (App. 1, p. 2).
Fraserburg	"Scarcely a year passes without a report on the effects of drought in this division, and, perhaps, with exception of the years 1859, 1862, 1865, 1868 and 1873–1874, that of the year just closed has been one of the most severe" (App. 1, p. 3). This division did not suffer as much as the surrounding areas.
Victoria West	"...the unprecedented and protracted drought of 1877 – which, for its severity and disastrous effects, will bear no comparison with that of 1862" (App. 1, p. 4).
Beaufort West	"The severe drought under which this district has suffered during the last sixteen months still continues with unabated severity..." (App. 1, p. 6).
Bredasdorp	"The drought has been severely felt" (App. 1, p. 7).
Robertson	Suffered from the drought although to a lesser extent than other districts.
Riversdale	"Like almost every other district in the colony, the district of Riversdale has suffered severely from drought during the past year" (App. 1, p. 9)
George	"During the greater portion of the past year this division has suffered from drought although perhaps not to such an extent as some of the neighbouring districts" (App. 1, p. 10).
Oudtshoorn	"The past year has been attended by a most protracted drought, which only partially broke up in November; now (January, 1878), it is more severe than ever" (App. 1, p. 11).
Humansdorp	"The year 1877 has been the most unfavourable one that this district has experienced for many years past. The Gamtoos River, which usually carries a large body of water, is now perfectly dry..." (App. 1, p. 12).
Uitenhage	"The long protracted drought, the severest experienced for many years, has, with few exceptions stopped all agricultural activities. The Sunday River, which flows the length of the district... has been for a considerable time so low that irrigation has been impossible..." (App. 1, p. 13).
Alexandria	"...running water is at present almost unknown in this division, the vleys are nearly all dried up, and water is very scarce" (App. 1, p. 15).
Bathurst	Drought conditions reported causing a stagnation in trade (App. 1, 15).
Victoria East	"The district has been almost deserted by its agricultural European inhabitants, many have been driven away by drought..." (App. 1, p. 16).
Stockenstrom	Division suffering from a very severe drought (App. 1, p. 18).
Middelburg	"The year 1877 has been one of partial drought in this division" (App. 1, p. 18).
Murraysburg	"The almost unprecedented drought, ...has caused very severe losses to flock masters and agriculturalists. Dams which have never been known to fail have been dry during the greater part of the year..." (App. 1, p. 19).
Richmond	Suffered from the drought along with other Midland Divisions (App. 1, p. 20).

Table I (*continued*)

Hope Town	"The long-continued drought has occasioned great loss in this district" (App. 1, p. 21).
Colesberg	"No rains of material advantage have fallen during a period of seventeen months. We have had no drought since 1829 equal in duration and intensity to the one which we now hope is drawing to a close" (App. 1, p. 21).
Queenstown	"In the year 1877, a larger area of land was brought under cultivation, ...but in consequence of drought the crops were anything but as was expected" (App. 1, p. 24).
Tarka	"The past year has been one of severe trials to farmers and others in this district, in consequence of the drought which prevailed for nearly ten months" (App. 1, p. 25).
Bedford	"Losses in cattle and small stock were very numerous owing to the protracted drought" (App. 1, p. 29).

harsh drought in the southern and eastern Cape were made. It is evident from both the Southern Oscillation Index (Figure 5b) and from the documents studied (Table I) that an El Niño event of considerable magnitude occurred in 1877 probably influencing the weather of both South America and South Africa. Extreme drought occurred in the eastern (summer-rainfall) areas of the Cape with apparently good rainfall in the south-western (winter rainfall) areas of the country. Such preliminary findings are consistent with those of Lindesay (1988a; b).

The documentary-derived chronology has furthermore proved to be a useful supplement to the early South African meteorological records. Careful study of the documentary evidence for the latter years of the nineteenth century has revealed that the wet and dry spells determined previously for the country may not have been as consistently dry or wet as was first postulated. The period 1890–1900, for example, has been noted as one of the wettest on meteorological record (Tyson and Dyer, 1975). A detailed study of numerous documentary sources together with instrumental measurements for the period (Table II) indicates that although *above-normal rainfall* characterised the early 1890s *severe drought* prevailed at numerous places in the middle years of the decade. Documentary reports illustrating the lack of rainfall include:

"A severe and protracted Drought has prevailed, affecting Namaqualand, portions of the T.V.L. (Transvaal), the Free State and nearly the whole of the Cape Colony". "The disastrous effects of drought combined with the serious havoc wrought by locusts, have impoverished large areas of the country, and distress in some districts is already acute" (parenthesis added) (Standard Bank Archives, GMO 3/2/1/1, 308:4, 1890–1896, 12 Feb. 1896, pp. 48, 49 and 69).

Dendrochronological evidence from Cape trees such as *Podocarpus* suggests that suppression of tree-ring growth occurred toward the close of the nineteenth century, followed by a pronounced period of enhanced growth after 1900

TABLE II: Weather for various areas by year (1890–1900)

Date	Area	Weather
1891	Cape Colony	"Floods, locusts, and unseasonable weather in many districts, have aggravated the losses of farmers..." (Standard Bank Archives, Johannesburg, GMO 3/2/1/1, 1890–1896, 308:4, 17 Feb. 1892, p. 1).
1895	Enon	"For the last *seven or eight years* the harvest in that district had been a failure, and the year 1895 showed no great improvements on the record of those years. A terrible drought was last year the cause of the disaster" (Jottings from the Western Province, 2nd Century, Periodical Accounts of the United Brethren, Vol. 3 (27), Sep. 1896, p. 118).
	Herschel Area	"Between 1895 and 1899, peasant production in this district was disrupted by droughts, locusts and rinderpest. Here, as elsewhere, numerous Africans were reduced to the most severe poverty – thousands left the district in search of work, while others stayed, living on edible weeds" Primary source: Letter, J. H. Bone, 31 Dec. 1898; Secondary source: Bundy, 1980, p. 216).
	Cape Colony	"It is much to be regretted that a favourable report cannot be given of the prospects of the *farming community*. A severe and protracted Drought has prevailed, affecting Namaqualand, portions of the T.V.L., the Free State and nearly the whole of the Cape Colony, and although partial rains have recently fallen, they came to late to prevent distress and disaster. *Sheep and cattle* are generally in poor condition, and in several districts insolvencies among the farming community are already occurring on an unusual scale" GENERAL COMMENTS: "The disastrous effects of *drought* combined with the serious havoc wrought by *locusts*, have impoverished large areas of the country, and distress in some districts is already acute" (Standard Bank Archives, 12 Feb. 1896, GMO 3/2/1/1, 308:4, 1890–1896, pp. 48, 49 and 69).
1896	Goshen	"Owing to protracted drought in the previous year, that crop had been a very poor one" (Diary extract, 2nd Century, P.A.U.B., Vol. 3 (30), Jun. 1897, p. 291).
	Cape Colony	Reports of drought prevailing in several districts (Standard Bank Archives, 4 Aug. 1897, G.M.O. 3/2/1/2, 308:4, 1896–1902, pp. 1 and 48).
1897	Shiloh	"...a long continued drought prevailed" (2nd Century, Vol. 3 (33), Mar. 1898, p. 427). "Respecting the drought referred to before we hear from Shiloh that 'for *seven months* not enough rain has fallen to lay the dust'. Drought ceased after Christmas (Letter, Br. Hastings, 29 Jan. 1898, 2nd Century, Periodical Accounts of the United Brethren, Vol. 3 (33), Mar. 1898, p. 427).
1898	Cape Colony	Reports of drought being severe. Northern and eastern areas suffering from the drought and rinderpest. "The country districts have been of late suffering severely, especial-

Table II (*continued*)

		ly from Drought, and consequently the imports of food stuffs have largely increased" (Standard Bank Archives, 9 Feb. 1898, G.M.O. 3/2/1/2, 308:4, 1896–1902, pp. 1, 56 and 79).
1899	Cape Colony	"King Williamstown, Maraisburg, Victoria West and many other parts of the Cape Colony, have also suffered severely from Drought, and in the generally fertile district of Oudtshoorn, the crops are not only in consequence far below average but the inhabitants are in serious straits for want of water" (Standard Bank Archives, 8 Feb. 1899, G.M.O., 3/2/1/2, 308:4, 1896–1902, p. 57).
	Cape Colony	"The Beaufort West, Oudtshoorn, George, Swellendam and King Williamstown districts have suffered somewhat from *Drought*, and those of Jansenville, Alice and Fort Beaufort very severely. In the Alice district, the crops were entirely lost, the drought being reported as the *worst since 1877, while at Fort Beaufort, the Kat River ceased flowing for the first time in 50 years*" (emphasis added). (Standard Bank Archives, 31 Dec. 1899, G.M.O., 3/2/1/2, 308:4, 1896–1902, p. 52).

(Figures 4a and 4b). Documentary data therefore provides a detailed account of rainfall variations and is a useful means of supplementing an otherwise sterile and possibly inadequate meteorological data source.

Having outlined the type of climatic chronologies that may be derived from documentary sources and discussed some of the inferences made from these chronologies it is useful to consider whether such documentary sources can yield any details of long-term climatic change. An analysis of the relative below- and above-normal rainfall was conducted for both the eastern and southern Cape areas for two independent 80-yr periods; the period of documentary data studied here (1820–1900) and that for which reliable meteorological data are available for the Cape (1900–1980). Based on the documentary-derived chronologies years were assigned to the categories extremely dry, dry, normal, wet and extremely wet. Twentieth-century annual rainfall totals, expressed as percentage deviations from the long-term mean, were assigned to categories as follows: rainfall less than 77% of normal denoted as extremely dry, rainfall between 77 and 93% of normal denoted as dry, rainfall equal to or below 108% of normal denoted as normal, rainfall between 108 and 123% of normal denoted as wet and rainfall greater than 123% of normal denoted as very wet.

The percentage frequency of extremely dry, dry and normal events for both the southern and eastern Cape is remarkably similar for both the documentary and instrumental series (Figure 7). Small differences in the percentage frequencies of wet and extremely wet rainfall years for the southern and eastern Cape are, however, evident between these two periods, with more extremely wet years

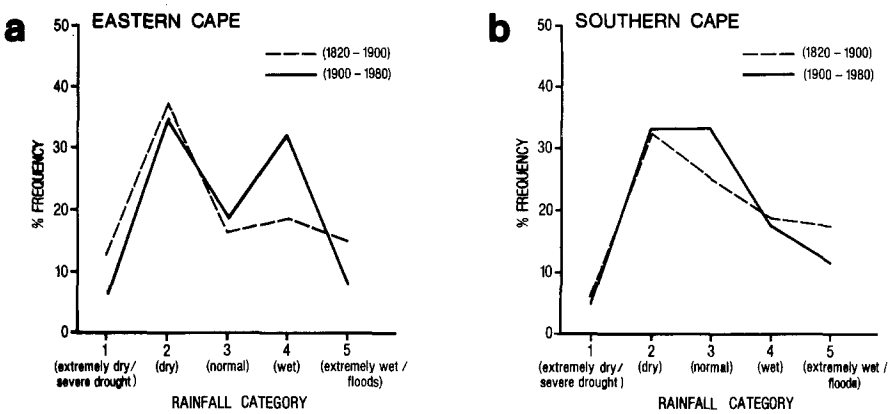

Fig. 7. Percentage frequency of drought, floods and normal rainfall for (a) the eastern Cape and (b) the southern Cape in the period 1820–1900 and 1900–1980. Category 1 denotes severe drought, category 2 dry, category 3 normal conditions, category 4 wet conditions and category 5 flooding conditions. Data for the period 1820–1900 were extracted from the documentary-derived chronologies for the two areas (Figures 3a and 3b); recorded rainfall data were used for the 1900–1980 period.

evident for both these areas during the nineteenth than during the twentieth century. These differences between the nineteenth and the twentieth century rainfall data are probably not indicative of long-term changes in the frequency of extremely wet periods but are probably attributable to the subjective nature of documentary research. Extremely wet events, usually short-lived and catastrophic, may assume unusual importance in the documents as opposed to drought years that are more long-lived and more frequent an occurrence in both the southern and eastern Cape. Percentage frequency analysis of rainfall for both the southern and eastern Cape for the periods 1820–1900 and 1900–1980 not only validates the documentary-derived rainfall chronologies for the Cape, but also indicates that the rainfall of the area has remained essentially the same. The regularity in the rainfall patterns for the eastern and southern Cape for the past 160 yr presented here corresponds well with the conclusions drawn by Kokot (1948) and Nicholson (1981) that:

"...the record affords considerable positive evidence, so far as this can be positive without actual measurements, that the rainfall in the past 100 years or so has been very similar, both in quantity and character, to what it is today" (Kokot, 1948, p. 55)

and that

"The wind and rainfall regime at the Cape has been relatively constant throughout the last three centuries" (Nicholson, 1981, p. 257).

5. Conclusion

Documentary research, particularly for periods with numerous weather reports,

has been shown to be useful when trying to reconstruct past variations of climate and weather. Details obtained from various weather reports have permitted the construction of a time series of maps depicting periods of below- and above-normal rainfall highlighting extreme weather conditions such as years characterised by flooding and/or drought occurrences for southern and south-eastern South Africa. Several of the problems inherent in documentary research have been largely overcome by using a number of sources including missionary diaries, letters, newspapers, official documents and bank archival material. By employing the method outlined here it has been possible to develop a detailed weather chronology for the southern areas of South Africa, delineating in particular rainfall variations for the period 1820–1900. First, notably wet periods span the years 1822–1823, 1831–1832, 1844–1848, 1869–1871 and 1885–1900. Secondly, notably dry or periods of below-normal rainfall include the years 1820–1822, 1824–1829, 1860, 1865, 1877–1885 and 1894–1896.

From the detailed study of the available documents it has also been possible to determine the nature of dry and wet spells, and in most cases the severity of drought. Areas of the eastern Cape were particularly affected by drought in 1862, 1865, 1877 and in the mid-1890s. Furthermore the documentary derived-chronologies have been corroborated by using available dendrochronological data and meteorological instrumental data. In addition, documentary sources together with available dendrochronological data and available instrumental records show that the 1890s were not as consistently wet as had been previously proposed. Rather, good rains were experienced at the outset and close of the decade, offset by severe drought conditions during the middle 1890s.

Spatial patterns of areas characterised by above- and below-normal rainfall have also been deduced from the documentary derived chronology. Particular associations between phases of the Southern Oscillation and periods of drought and below-normal rainfall in the last century have also been described. Indications of an inverse phenomenon, whereby wet conditions characterise the south-western Cape whereas the eastern areas are characterised by dry and drought conditions have been described. Furthermore the dry spell during 1876–1878 has been shown to have been probably related to the occurrence of an El Niño Southern Oscillation event. Finally, no distinct periodicity of below- and above-normal rainfall years is discernible from the various sources of evidence presented. Rather it has been shown that the frequency and type of rainfall event, including below- or above-normal events, that prevailed at the Cape during the last century were essentially similar to those prevailing in the area at the present time. Periods of extreme drought were and are followed by periods of abundant rains.

Documentary evidence has proved to be a useful and reliable surrogate source of information on climatic change for those periods lacking adequate instrumental observations. Missionary, official and archival materials have been used to reconstruct scenarios of past weather, particularly for those periods

devoid of adequate instrumental data. In so doing the extant knowledge of South African climate for the nineteenth century has been extended. A wealth of documentary data for other areas of the country remains untapped and an extension of documentary research, such as that outlined here, would greatly enhance the history of past climates of South Africa.

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