A WEATHER STATE CLIMATOLOGY AND ITS APPLICATION TO THE VARIABILITY OF VARIOUS PRECIPITATION TYPES

H Stern, R R Dahni and J D Jasper
Bureau of Meteorology, Australia

Climate surveys generally restrict their analyses to a small number of weather parameters. These parameters may include monthly mean minimum and maximum temperatures, sunshine hours, precipitation amount, and number of days of precipitation, thunder, snow and fog. However, there are many subtle features of the data that are not analysed. These include the frequency distributions of the less significant precipitation types such as drizzle, rain and showers, and the frequency distributions of different cloud states such as cloudy, part-clouded and clear. Furthermore, the manner in which the frequency of occurrence of these various weather states display diurnal and year to year variations is also not covered. Knowledge of these variations would be of considerable value to users of climatic data. The purpose of this paper is to introduce a different approach to weather data analysis and to illustrate it, by way of example, when applied to Melbourne weather data, placing particular emphasis on diurnal, seasonal and inter-annual variability of the frequency of occurrence of the various precipitation types. The methodology described has not, as far as the authors are aware, been applied hitherto.

To achieve the aim of the paper it is first necessary to establish an objective system of weather terminology. Stern (1979) completely specifies a system of terminology that may be used to describe a day's weather and in the formulation of forecasts. The second author of the present paper (Dahni) has, in fact, written a computer programme for the purpose of deriving the descriptions automatically. Observations of weather development are documented three-hourly, employing the World Meteorological Organization's code for present and past weather (hereafter referred to as 'ww'). The code contains one hundred mutually exclusive weather states (Bureau of Meteorology, 1982). These components of the weather states may be reduced in number by combining similar states. This was done by Stern (1979) and further reduction has been carried out for the purposes of the present work. For each three-hourly period, the weather state definition is based on the ww code numbers and cloud cover. Table 1 lists the order of priority of the weather states and in the event of the present and past weather ww code numbers suggesting different weather states, the weather state is taken to be the higher priority one (lower numbered) from the Table.

Tables 2, 3 and 4 respectively present analyses of the diurnal, seasonal and inter-annual variations in the frequency of occurrence of the various weather states at Melbourne. Each Table demonstrates a number of interesting aspects of the climatology of Melbourne's weather, namely :

the afternoon peak in the frequency of convective precipitation types;
the morning peak in the frequency of rain and drizzle;
the morning peak in the frequency of fog;
the afternoon peak in the frequency of dust;
the late-morning peak in the frequency of cloudy conditions;
the midnight peak in the frequency of clear conditions;
the summer peak in the frequency of thunder;

the rather flat winter peak in the frequency of rain and showers;
the late autumn/early winter peak in the frequency of drizzle;
the summer/early autumn minimum in the frequency of precipitation and the cloudy conditions, and the fact that if precipitation occurs it is most likely to be convective during the late winter and spring;
the early winter peak in the frequency of fog;
the summer peak in the frequency of dust;
the rather large variation that the frequency of most weather states displays from year to year;
the fact that 1972, a drought year, showed up as the year of least frequent precipitation, least frequent cloudy conditions and most frequent clear conditions;
the fact that 1967 and 1983, two other years characterized by drought, showed up as the years of most frequent dust;
the fact that 1978, the wettest year over the period under consideration, showed up as the year of most frequent thunder.

Finally, an objective system of weather state terminology may be applied to weather descriptions prepared for publication in the daily newspapers. Table 5 presents an illustration of a possible application in this area.

To conclude, a new approach to weather data analysis has been described. By way of illustration, a number of tables, derived by applying this approach to Melbourne weather data, are presented. It is the authors' view that the real value of the method lies not only in its potential use in the preparation of climate surveys for publication but also in providing an understanding of some of the gross physical processes which affect the weather at various localities.

Table 1 The order of priority of the various weather states

Order	ww code number	cloud cover	
1	13,17,19,29,91-99	and/or low type = 9	thunder
2	22-23,26,36-39,68-79,83-86	not applicable	snow
3	21,24,58-67	not applicable	rain
4	15-16,25,27,80-82,87-90	not applicable	showers
5	20,50-57	not applicable	drizzle
6	10-12,28,40-49	not applicable	fog
7	6-9, 30-35	not applicable	dust
8	0-5,14,18	and total = 7 or 8*	cloudy
9	0-5,14,18	and total = 4,5 or 6	part-clouded
10	0-5,14,18	and total = 0,1,2 or 3	clear

* or sky obscured

Table 2 Diurnal variation of the frequency (%) of the different weather states at Melbourne (based on data 1960-1983 inclusive), looking at three aspects, namely :

a. the weather states being taken individually;

b. combining the five precipitation states;

b. examining the likelihood that the precipitation is convective (weather state 1 or 4) given that precipitation occurs.

State		Local time Three hours ended.... 03	06	09	12	15	18	21	24	ALL
1	a	0.8	0.4	0.4	0.8	1.9	2.0	1.6	1.1	1.1
2	a	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	a	7.1	8.3	7.9	6.5	6.2	7.0	7.1	7.3	7.2
4	a	7.4	8.1	10.0	10.6	13.8	13.7	10.9	9.1	10.4
5	a	1.5	2.7	3.0	1.1	0.8	0.7	0.9	1.6	1.6
6	a	4.6	6.2	5.8	2.4	0.5	0.7	2.0	3.1	3.2
7	a	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.0	0.1
8	a	20.6	24.2	28.2	26.9	24.8	21.4	18.5	17.8	22.8
9	a	20.6	19.7	18.8	24.4	22.1	20.9	22.2	21.0	21.2
10	a	37.5	30.4	25.7	27.2	29.7	33.4	36.7	38.9	32.4
1-5	b	16.7	19.5	21.3	19.0	22.7	23.5	20.6	19.1	20.3
Prob 1 or 4 given 1-5	c	48.7	43.6	48.9	59.9	69.2	66.8	60.8	53.3	57.0

Table 3 Seasonal variation of the frequency (%) of the different weather states at Melbourne (based on data 1960-1983 inclusive), looking at the three aspects examined in Table 2.

State		Month Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	a	2.0	1.5	1.7	0.4	0.3	0.3	0.6	1.2	1.0	1.5	1.5	1.5
2	a	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	a	4.6	4.6	5.2	7.7	9.8	8.1	7.8	9.4	8.0	7.9	6.8	6.1
4	a	5.6	5.5	7.7	9.6	12.9	10.6	13.6	14.1	13.7	12.0	11.3	8.2
5	a	1.3	1.2	1.5	1.6	2.1	2.3	1.5	1.4	1.3	1.5	1.6	1.4
6	a	0.6	0.8	1.4	4.4	6.1	9.0	6.4	3.6	2.7	1.2	0.9	0.7
7	a	0.1	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1
8	a	21.2	20.8	21.0	23.5	24.5	24.9	22.2	21.7	21.9	24.1	24.9	23.1
9	a	21.4	20.3	20.3	20.0	18.7	20.9	23.0	21.9	21.5	20.8	22.8	22.7
10	a	43.2	45.1	41.1	32.8	25.5	24.0	24.9	26.7	29.8	30.9	29.8	36.3
1-5	b	13.5	12.9	16.1	19.2	25.1	21.2	23.5	26.1	24.1	22.8	21.4	17.2
P (1 or 4 if 1-5)	c	55.8	54.5	58.5	51.9	52.6	51.2	60.6	58.6	61.2	59.0	60.3	56.8

Table 4 Inter-annual variability of the frequency (%) of the different weather states at Melbourne (based on data 1960-1983 inclusive), looking at the three aspects examined in Table 2.

State		Lowest (year in parentheses)	25th percentile	Median	75th percentile	Highest (year in parentheses)
1		0.3 (1965)	0.9	1.1	1.3	2.2 (1978)
2		0.0 (all)	0.0	0.0	0.0	0.0 (all)
3		4.3 (1972)	6.1	7.1	8.1	10.3 (1960)
4		6.0 (1979)	8.7	10.5	11.7	18.2 (1964)
5		1.0 (1967)	1.2	1.5	1.9	2.4 (1966, 1976)
6	a	0.7 (1981)	1.5	2.2	5.3	8.3 (1963)
7		0.0 (most)	0.0	0.0	0.1	0.3 (1967, 1983)
8		19.4 (1972)	22.0	23.0	24.0	26.0 (1968)
9		16.3 (1963)	19.5	21.5	22.5	26.5 (1979)
10		26.3 (1964)	30.0	32.2	34.1	38.7 (1972)
1-5	b	14.3 (1972)	17.9	20.2	21.5	29.4 (1964)
P (1 or 4 if 1-5)	c	42.3 (1969)	53.4	56.8	61.8	65.1 (1964)

Table 5 Temperature and weather state at the eight Australian capital cities and the three main New Zealand cities on 21 May 1984 at 0900 and 1500 local time (observations taken at each city's main airport).

City	0900 conditions Temp. (°C)	Weather state	1500 conditions Temp. (°C)	Weather state
Adelaide	20	Rain	18	Rain
Auckland	6	Clear	12	Clear
Brisbane	18	Showers	22	Part-clouded
Canberra	11	Cloudy	15	Cloudy
Christchurch	-2	Clear	9	Cloudy
Darwin	26	Clear	32	Part-clouded
Hobart	8	Part-clouded	17	Cloudy
Melbourne	13	Part-clouded	18	Cloudy
Perth	15	Part-clouded	18	Cloudy
Sydney	15	Cloudy	19	Cloudy
Wellington	7	Cloudy	9	Cloudy

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SOME STATISTICAL CHARACTERISTICS OF AUSTRALIAN RAINFALL

R Srikanthan and T A McMahon
University of Melbourne, Melbourne

INTRODUCTION

Of all the climatic variables, rainfall is the most important one. It influences most other climatic varaibles, including evaporation and temperature. In addition, it plays a direct role in water supply and agricultural production. Modelling rainfall processes enables one to investigate its consequences, such as streamflow and soil moisture, more thoroughly. This paper examines the statistical characteristics of rainfall at several time intervals from a stochastic modelling point of view. The statistical characteristics are derived from rainfall data for 12 stations located throughout Australia. Figure 1 shows the location of the twelve stations used in the study.

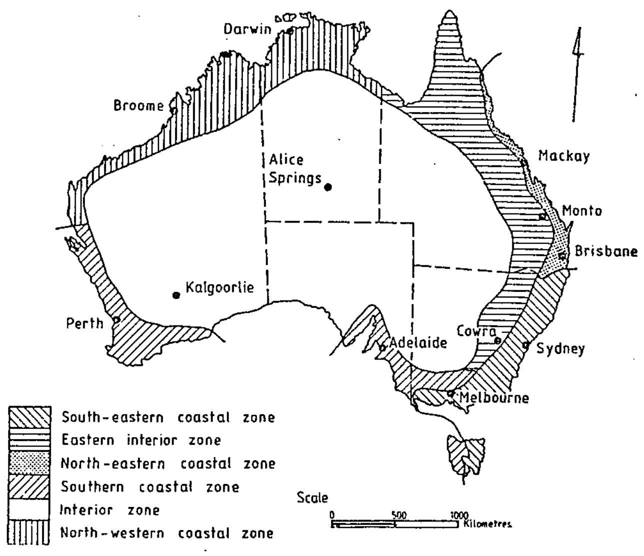

Figure 1 Location of stations.

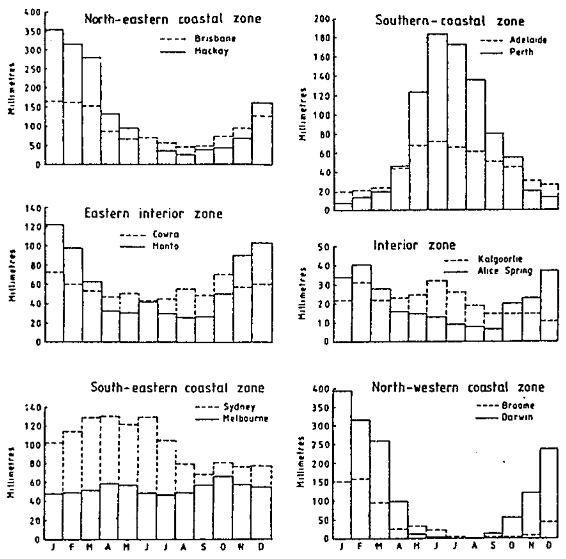

Figure 2 Mean monthly rainfall.

OBSERVED STATISTICAL CHARACTERISTICS

For the 12 stations, the coefficients of variation of annual rainfall lie in the range of 0.17 to 0.54, the data are normally distributed and for most stations exhibit small autocorrelations. Characteristics of annual rainfall are presented in Table 1.

The mean monthly rainfall at each station is shown in Figure 2. For the stations chosen considerable variability exists. In Table 2, it is observed that the coefficients of variation of monthly rainfall are high, monthly rainfalls are mostly skewed for most months and the serial correlations between successive monthly totals are small.