errors encountered. The MOS QPFs are strongly reliant on the ARPE prognosis, and particularly on its identification of the various weather-producing systems. They also depend heavily on the quality of the forecast moisture field and thus on the initial moisture analysis. Further, prognoses are presently only available at the beginning of the forecast period, so that major errors may occur if the 24hr prognosis does not identify the rain-generating mechanism during the period. This and errors in the timing of systems may also result in errors in the temporal distribution of precipitation (e.g. Canberra, 26-27 July 1980, see Fig. 3). More general problems concern the degree to which the predictors selected represent the rain-producing mechanism on any particular occasion, and the extent to which a statistical procedure, used in an unstratified form, can capture mechanisms operating on all occasions.

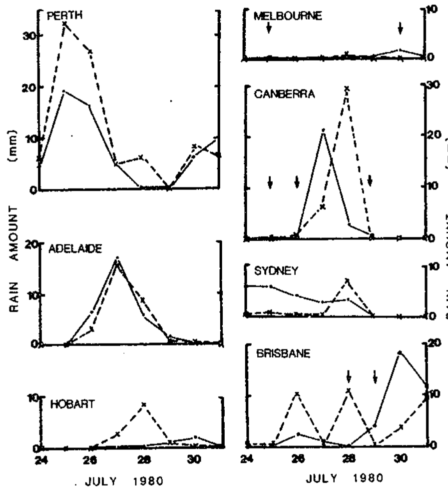

FIG 3 MOS QPFs (crosses) and observed rainfall (dots) at seven Australian cities, 24-31 July 1980. Arrows indicate wrong categorical forecasts.

CONCLUDING REMARKS

The Australian MOS system in its present form has the capacity to independently predict 24hr rain totals approximately one day in advance with slightly greater skill than subjective forecasts produced operationally, which have a shorter lead time. Particular improvement has been achieved in the prediction of larger rain totals (in excess of 5mm in 24hr) which the operational forecasters have shown a reluctance to predict (Fig. 1). Further improvement of the MOS QPFs must await the ability to overcome any or all of the various problems which presently limit the usefulness of the MOS approach. Some can be addressed now, others must await more fundamental developments in observation and forecasting.

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THE APPLICATION OF A MARKOV MODEL TO THE SHORT-TERM FORECASTING OF WEATHER STATE, PARTICULARLY PRECIPITATION

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Where a mathematical model, or a physical process, has the property that the outcome of any trial depends only on the outcome of the immediately preceeding trial, it is referred to as a Markov process or a Markov chain. The chain consists of a transition probability matrix......

$$P_{ij} = \begin{matrix} P_{11} & P_{12} & \cdots\cdots & P_{1m} \\ P_{21} & P_{22} & \cdots\cdots & P_{2m} \\ \cdots\cdots & & P_{ij} & \cdots\cdots \\ P_{m1} & P_{m2} & \cdots\cdots & P_{mm} \end{matrix}$$

where the probability that a system in state A_i will undergo a transition to A_j (there being m possible states) is P_{ij}. The transition probabilities P_{ij} are conditional probabilities for the state j following the state i after a one-step transition (Whitton, 1977).

The purpose of the present paper is :

1. to document the transition probability matrix for various weather states at Melbourne (these states being as defined by Stern et al, 1984a) for three-hourly transitions. The probabilities are given in Table 1 for eight three-hourly transitions, namely : 0000/0300, 0300/0600, 0600/0900, 0900/1200, 1200/1500, 1500/1800, 1800/2100 and 2100/2400 (all local times);

2. to demonstrate the substantial dependence of the matrix on the surface pressure pattern. This is achieved by documenting a selection of probabilities for Melbourne, specifically for the six-hourly transition 0900/1500 for each of Jasper and Stern's (1983) thirty-eight synoptic types over southeast Australia (Table 2). These types are depicted by Stern et al (1984b).

In concluding, the authors wish to note the potential for this approach over a range of short-term forecasting applications (e.g. for aviation purposes).

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Table 1 : The transition probability matrix for various weather states (determined by cloud cover and present and past ww observations) at Melbourne. Probabilities for eight three-hourly transitions (starting times 00, 03, 06, 09, 12, 15, 18 and 21) are given for different weather states at the starting time (based on data 1960-83 inclusive).

(a) Starting time state = 1

State 3 hours later:	Starting time 00	03	06	09	12	15	18	21
1-5	63	68	72	75	82	82	72	69
6	1	2	0	0	0	0	0	1
7	0	0	0	0	0	0	0	0
8	13	9	18	8	4	4	6	8
9	8	15	5	8	11	10	13	8
10	13	8	5	8	3	4	8	14

(b) Starting time state = 3

State 3 hours later:	Starting time 00	03	06	09	12	15	18	21
1-5	68	77	78	73	79	80	76	75
6	1	0	1	0	0	1	1	1
7	0	0	0	0	0	0	0	0
8	13	12	11	15	11	10	11	10
9	11	6	6	9	7	7	7	8
10	7	4	5	3	2	2	5	6

(c) Starting time state = 4

State 3 hours later:	Starting time 00	03	06	09	12	15	18	21
1-5	52	63	59	60	62	65	57	52
6	1	1	1	0	0	0	1	2
7	0	0	0	0	0	0	0	0
8	13	12	19	18	15	12	11	13
9	17	15	13	16	15	15	18	18
10	17	10	9	6	8	8	14	15

(d) Starting time state = 5

State 3 hours later:	Starting time 00	03	06	09	12	15	18	21
1-5	39	53	51	38	50	50	49	59
6	4	4	3	1	1	0	2	0
7	0	0	0	0	0	0	0	0
8	37	29	35	37	32	37	38	27
9	16	11	8	19	15	8	6	11
10	4	5	4	5	2	4	5	4

(e) Starting time state = 6

State 3 hours later:	Starting time 00	03	06	09	12	15	18	21
1-5	4	6	5	3	6	6	2	4
6	80	74	70	39	20	65	86	77
7	0	0	0	0	0	0	0	0
8	5	5	8	15	14	8	4	5
9	3	4	6	15	20	6	2	5
10	8	11	11	29	40	15	7	9

(f) Starting time state = 8

State 3 hours later:	Starting time 00	03	06	09	12	15	18	21
1-5	14	18	21	11	20	19	15	17
6	1	2	1	0	0	0	1	1
7	0	0	0	0	0	0	0	0
8	55	57	54	53	51	51	50	47
9	19	15	16	23	20	22	24	25
10	10	8	8	13	9	8	10	10

..../Contd

Table 1:(cont)

(g) Starting time state = 9

State 3 hours later:	Starting time 00	03	06	09	12	15	18	21
1-5	10	14	12	9	14	10	8	10
6	1	2	1	0	0	0	1	1
7	0	0	0	0	0	0	0	0
8	23	30	36	26	26	20	16	19
9	40	34	31	43	35	38	43	42
10	26	20	20	23	25	32	32	28

(h) Starting time state = 10

State 3 hours later:	Starting time 00	03	06	09	12	15	18	21
1-5	2	3	3	3	3	2	2	2
6.	3	5	2	0	0	1	3	2
7	0	0	0	0	0	0	0	0
8	7	10	13	8	6	5	5	6
9	16	20	22	24	20	15	14	12
10	71	62	59	65	70	77	76	77

(i) Starting time state = 1-5

State 3 hours later:	Starting time 00	03	06	09	12	15	18	21
1-5	58	68	66	62	68	70	64	62
6	1	1	1	0	0	0	1	1
7	0	0	0	0	0	0	0	0
8	15	14	18	19	14	12	11	12
9	14	11	9	14	12	12	14	13
10	12	7	6	5	5	6	10	11

(j) Starting time state = 2 or 7 (for all times combined)

State 3 hours later:	State.. 2	7
1-5	71	18
6	0	0
7	0	32
8	0	16
9	14	23
10	14	11

Table 2: A selection of 0900/1500 transition probabilities for Melbourne weather states for thirty-eight synoptic types (based on data 1960-78 inclusive).

Three precipitation state transition probabilities are examined namely :

(a) the probability of the weather state at 1500 being one of the five precipitation states (1-5) given the state at 0900 being one of these states.

(b) the probability of the weather state at 1500 being one of the 1-5 given the state at 0900 being one of 7,8 or 9.

(c) the probability of the weather state at 1500 being one of the 1-5 given the state at 0900 being one of "the settled weather" states i.e. 6 or 10.

NOTE: Weather state 7, occupying only a minute portion of the data sample is included only for the purposes of completion.

Synoptic type	(a) Prob. State at 1500 = 1-5 if state at 0900 = 1-5	(b) Prob. State at 1500 = 1-5 if state at 0900 = 7, 8, 9	(c) Prob. State at 1500 = 1-5 if state at 0900 = 6, 10
1	42	25	14
2	51	34	35
3	73	58	52
4	38	8	2
5	48	18	4

.../Contd

Table 2: (Cont)

Synoptic type	(a) Prob. State at 1500 = 1-5 if state at 0900 = 1-5	(b) Prob. State at 1500 = 1-5 if state at 0900 = 7, 8, 9	(c) Prob. State at 1500 = 1-5 if state at 0900 = 6, 10
6	58	13	4
7	50	13	4
8	19	6	6
9	55	11	4
10	36	18	5
11	50	27	7
12	11	7	0
13	54	41	37
14	57	24	25
15	60	16	2
16	60	2	0
17	25	10	4
18	74	30	0
19	21	5	0
20	56	16	9
21	61	37	13
22	0	0	6
23	5	8	3
24	18	0	0
25	25	0	0
26	76	50	20
27	17	6	0
28	62	16	6
29	0	0	0
30	50	0	8
31	69	45	20
32	69	36	11
33	33	8	3
34	0	0	5
35	100*	5	0
36	67	7	10
37	33	18	29
38	100*	0	0

* Based on only one case

Economic Implications of Rainfall Variability