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THE FREQUENCY AND DURATION OF COLD SPELLS IN SOUTHERN TASMANIA

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Abstract: A method to enable ready extraction of the dates of occurrence of cold spells using only the afternoon temperature readings for the Hobart Divisional Office is devised and checked on 8 years' records (1951-1958). These criteria are used to extract dates of cold spells over the 20 year period 1939-1958. These occasions are then subdivided according to the extent of snow on Mt. Wellington and further subdivided according to the time elapsed between the onset of cold conditions and a marked change, if any, to milder conditions. Some conclusions are drawn as to the probability of widespread snow during each month of the year and also the probable duration of cold spells.

1. INTRODUCTION

With the introduction of television into Tasmania, suitable sites for the transmitters were required. Due to the mountainous nature of the State, sites at more than 4000 feet were found to be necessary and suitable locations were selected at Mt. Wellington (4165 feet) 12 miles southwest by road from Hobart and at Mt. Barrow (4644 feet) 19 miles east-north-east of Launceston. These transmitters are linked to the State's road network by recently much-improved access roads.

Widespread snowfalls on higher ground are not an unusual feature of the Tasmanian weather during the period March to November and occasionally occur even during the summer months. As these snowstorms can block access to the transmitters, sometimes for extended periods, it is necessary for the television companies to have a knowledge of the frequency of snowstorms and the duration of the cold spells associated with them.

The heavier snowfalls, which bring significant snow to heights of 1000 feet or less, also cause considerable traffic disruptions to many of the State's highways. The main highways affected are the Lake Highway which runs from Hobart via the Great Lake to the northwest coast, the Lyell Highway between Hobart and the west coast mining centres (at present the only road outlet from the west coast) and the Huon Highway from Hobart south to the Huon Valley. The last named road is, on the average, blocked 3 times a year within 6 miles of the Hobart G.P.O.

The Hobart - Mt. Wellington area is directly affected by these cold spells. Mt. Wellington is clearly visible from the Hobart Divisional Office and with the aid of several good land-marks, e.g. the Springs Guest House at 2400 feet above sea level, it is possible to estimate the snowline to within 500 feet. This is also the only area in Tasmania for which detailed records of the extent of snow have been made and as surface temperature, relative humidity and a limited amount of upper air data for this area are readily available, it was suitable for the investigation contemplated.

2. TREATMENT OF DATA

(a) Listing occurrences of cold spells

The first necessity in an investigation of this nature is a list of the occurrences of cold spells, associated with widespread snow, over as long a period as possible. Such a list could be compiled by the time-consuming method of checking through the original records. It was considered that an alternative method using only a single, readily extracted parameter, for instance surface temperature, might be devised. Such a method would, of necessity, include some cases of cold temperatures without snow and possibly exclude some cases of significant snow. With the idea of finding such a parameter, a careful study of all significant snowfalls during the period 1951-1958 was made. This period was selected because an adequate set of records of the snowline on Mt. Wellington was readily available. For the purpose of this part of the investigation "significant snow" was defined as "snow lying at or below 3500 feet".

44 cases were investigated and the lowest maximum temperature and the lowest 3 p.m. temperature recorded at Hobart Divisional Office during each of these 44 cold spells were logged. It was noted that quite often the lowest 3 p.m. dry bulb occurred on the afternoon before the snowfall observation was made and the lowest maximum on the day following the snowfall. The results are shown in Table 1.

Table 1. Number of occurrences of snow below 3500 ft on Mt. Wellington during period 1951-58 with given temperatures at Hobart (temperatures quoted were the lowest during each of the 44 periods investigated)

	Above 50°	50°	49°	48°	47°	46°	45°	44°	43°	42°	41°	40°	Below 40°
Maximum	7	2	4	4	9	6	4	4	3	-	-	1	-
3 p.m.	-	3	2	-	4	5	8	6	1	5	1	4	5

From this table it is seen that "significant" snow can occur without the maximum or 3 p.m. temperature falling below 50°, which is only 3 degrees below the normal maximum for the coldest month. To eliminate an excessive number of cold days without snow, a lower set of temperatures is required.

The next step was to try the double parameter; 3 p.m. dry bulb less than 46° and/or maximum below 48°. This double parameter included all but 7 of the 44 cases investigated, that is 84 percent of occasions of "significant" snow. An investigation of these 7 cases showed that only on 4 of them did the snowline fall below 3000 feet, and not once did the snowline descend below 2000 feet. It was therefore concluded that by using the above limitations of surface temperature almost every occasion of extensive snow will be included, whilst less than 10 percent of occasions of snow below 3000 ft will be excluded.

As cold days are not always associated with snowfall it was necessary to check that the list, compiled by using the double temperature parameter, did not include an excessive number of days on which no snow fell. The limits are only about 6 degrees below the corresponding normals for the mid-winter months and so will include a number of days on which persistent fog or an overcast sky keeps temperatures 6 or more degrees below normal. The period 1951-1958 was again the one investigated and the results are shown in Table 2.

Table 2. Number of occasions of snow or no snow on days on which either 3 p.m. temperatures were below 46° or maximum below 48° at Hobart Divisional Office during specified months for the period 1951-1958

	Apr	May	June	July	Aug	Sept	Oct	Nov	Year
Occasions with snow	2	7	13	14	13	8	6	2	75
Occasions without snow	-	2	3	4	1	1	-	-	11

It is to be noted that whereas Table 1 incorporates only the 44 occurrences of significant snow, Table 2 includes every day on which the temperature requirements were met and did not limit these to one per period as in Table 1. This table shows that only in the mid-winter months of June and July did the number of included snowless days become significant and that over the year only on about 12 percent of days selected by our double parameter was no snow reported.

As a further test of the temperature criteria the limits were raised by one degree for both maximum and 3 p.m. readings and the extra cases admitted during the 4 year period 1954-1957 were examined. An additional 9 days were included and only on two of these snow fell on Mt. Wellington Neither of these snow falls were extensive, snow being limited to the top 500 feet of the mountain.

It was therefore decided that the most satisfactory temperature criteria were maximum less than 48^{o} and/or 3 p.m. temperature less than 46^{o}. Days satisfying these criteria were denoted as "cold" days, and a "cold spell" as one or more "cold" days.

The next step was to make a list of those days on which the above temperature conditions were satisfied over a period of considerable length. The period considered was from January 1939 to December 1958. The dates were determined by reference to the Hobart Journal and these were listed, along with comments on the weather (with particular reference to snowfall) again taken from the Hobart Journal and in some cases the appropriate field book.

(b) Subdivision of "Cold Spells"

The "cold spells" were firstly subdivided on a monthly basis and then further subdivided according to the extent of the snow associated with each spell. Three subdivisions were used, as described below.

(i) Type I. Snowline at or below 1500 feet: This figure was chosen because a snowline below 1500 feet is usually associated with either snow or sleet showers at the Hobart Office while with a snowline above 1500 feet snow or sleet at the Hobart Office is rare. For this reason all occasions when either snow or sleet was reported at the Hobart Office were included in this subdivision. Snow below 1500 feet also means that it has settled on the Huon Highway at Ferntree (6 miles from Hobart) and serious traffic disruptions occur.

(ii) Type II. Snowline at or below 3000 feet but above 1500 feet: The height of 3000 feet was chosen as the upper limit because a snowline below this level makes access to the television transmitters by ordinary vehicle impossible, usually for a period of 24 hours or more, whilst when the snowline does not descend below 3000 feet prolonged closure of the higher sections of the Pinnacle Road is unusual.

(iii) Type III. All remaining cases, including those when no occurrence of snow on Mt. Wellington has been noted: On these occasions little or no traffic disruptions occur. The results of the subdivision are shown in Tables 3 and 4.

(c) Discussion of Tables

From Table 3 we see that at least once in every year snow settled at or below 3000 feet and only once (1942) did snow fail to settle below 1500 feet. The maximum number of extensive snowfalls recorded in any year was seven, whilst in 1948 and again in 1955 on six occasions snow settled below 1500 feet.

Table 4 shows that cold spells occur in all months of the year except the midsummer months of December and January, although heavy snow is unlikely before May or after October. A marked preference is observed for heavy snowfalls to occur in late winter and early spring, and half the heavy falls have occurred after the end of July. Snow below 1500 feet is more probable in October than in May and is only slightly less probable in October than in June. The less extensive snowfalls, however, do not show this tendency and the distribution is almost exactly symmetrical about the midwinter month of July.

Table 3. Number of cold spells in specified years

Year	1939	40	41	42	43	44	45	46	47	48
Type I	3	2	5	-	4	1	2	3	4	6
Type II	-	2	2	3	-	1	-	-	-	1
Type III	7	5	5	2	6	6	7	10	4	3
Total	10	9	12	5	10	8	9	13	8	10
Types I and II	3	4	7	3	4	2	2	3	4	7

Year	1949	50	51	52	53	54	55	56	57	58	Total
Type I	4	1	5	3	5	5	6	2	3	3	67
Type II	-	-	1	4	2	1	1	1	1	1	21
Type III	2	2	5	3	7	4	7	3	-	1	89
Total	6	3	11	10	14	10	14	6	4	5	177
Types I and II	4	1	6	7	7	6	7	3	4	4	88

Table 4. Frequency of cold spells in given months
(Number of occurrences in the 20 years 1939-1958)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Type I	-	-	-	2	6	11	15	15	9	8	1	-	67
Type II	-	1	1	2	3	4	6	-	1	1	2	-	21
Type III	-	-	-	2	5	24	26	23	5	3	1	-	89
Total	-	1	1	6	14	39	47	38	15	12	4	-	177
Types I and II	-	1	1	4	9	15	21	15	10	9	3	-	88

(d) Investigating the Length of Cold Spells

The next part of the investigation is concerned with the length of these cold spells. For a true indication of the time of onset and end of a cold spell, that is the time at which a cold air mass replaces a relatively milder one and vice versa, an examination of upper air conditions should be made. This procedure, however, was impracticable as the only upper air data available for Tasmania is one sounding per day taken at either Hobart Divisional Office or Hobart Airport and these only commenced in 1949. The only alternative method then was by examination of the thermograph traces for Hobart.

This method, of course, suffers from a number of defects. The main one is that the only element considered is the surface temperature and this is affected by many factors other than change of air mass. The diurnal variation in temperature, which itself is affected by cloudiness and wind, is a major complication. However, the range is small in the winter season, of the order of 12^{o}, and the interdiurnal variation in Hobart is largely governed by air mass changes. Whilst any sharp rise in temperature during the hours of darkness can be confidently taken as the termination of the cold spell, a similar rise during the daylight hours, especially before midday, may be entirely due to a temporary break in the cloud. To make the method as objective as possible, the following conditions were imposed after a preliminary investigation of several cases: - the cold spell ends after

(i) A rise in temperature during the morning of at least 10° in three hours, together with a maximum for that day in excess of 50°F.

(ii) A rise in temperature of at least 5° in 3 hours during the early afternoon, again with a maximum in excess of 50°F.

(iii) A rise in temperature during the hours of darkness of at least 3° in 8 hours. No conditions regarding temperature on the following day were imposed as in some cases a further cold change had arrived before the normal time of the maximum.

(iv) It was harder to apply a strict rule to the case of a cold spell which ended during the late afternoon, but in general a fall of not more than 2° between 3 p.m. and 9 p.m. followed by a slight rise overnight was taken as sufficient.

The other case, where although the air mass has changed the surface temperature remains low, presents a more difficult problem. This is often the case when a layer of high or middle level cloud restricts the sunshine to a minimum, following a frosty night and preceding a further change.

The time of the arrival of the cold air mass was, in general, taken from the thermograph trace, but occasionally when no sharp drop in temperature was apparent it was necessary to take into consideration the anemograph trace and the comments from the journal and field book. The length of the cold spells were then listed and the results of this analysis are given in Tables 5 and 6.

Table 5. Frequency of cold spells of given duration and type
(Number of occurrences in the 20 years 1939-1958)

	Abrupt Ending				Gradual Ending			
Type/Duration	≤ 24h	> 24 ≤ 48h	> 48 ≤ 72h	> 72h	≤ 24h	> 24 ≤ 48h	> 48 ≤ 72h	> 72h
Type I	8	13	6	1	4	13	6	2
Type II	2	1	-	-	6	4	1	-
Type III	13	17	2	1	9	17	4	-
Total	23	31	8	2	18	34	11	2
Type I and II	10	14	6	1	10	17	7	2

	No Apparent End	All types with definite endings				Total
Type/Duration		≤ 24h	> 24 ≤ 48h	> 48 ≤ 72h	> 72h	
Type I	14	12	26	12	3	67
Type II	7	8	5	1	-	21
Type III	27	21	34	6	1	89
Total	48	41	65	19	4	177
Type I and II	21	20	31	13	3	88

Table 6. Frequency of occurrence of cold spells of given durations and types

Type	Length	Occurrences	Percentage of all occurrences of given type
Type I	Duration at most 24 hr	12 $(\frac{12}{67} \times 100) =$	17
	Duration at most 48 hr	38	57
	Duration at most 72 hr	50	75
Type II	Duration at most 24 hr	8 $(\frac{8}{21} \times 100) =$	38
	Duration at most 48 hr	13	62
	Duration at most 72 hr	14	67
Type III	Duration at most 24 hr	21 $(\frac{21}{89} \times 100) =$	24
	Duration at most 48 hr	55	62
	Duration at most 72 hr	61	69
All types	Duration at most 24 hr	41 $(\frac{20}{88} \times 100) =$	23
	Duration at most 48 hr	106	60
	Duration at most 72 hr	125	71
Type I and II	Duration at most 24 hr	20 $(\frac{41}{177} \times 100) =$	23
	Duration at most 48 hr	51	58
	Duration at most 72 hr	64	75

(e) Discussion of Tables 5 and 6

These tables show that almost one cold spell in four does not last longer than 24 hours and that three in five do not last more than 48 hours. Only one in four of the severer types of cold spells lasts more than three days. Of this "one in four", further investigation shows that one cold air mass was replaced by another equally cold without conditions ever becoming mild enough to say that the first cold spell had ended.

(f) Comparisons

It was assumed that given a Type I snowfall, the period of traffic disruption would be approximately the same as the period of the cold spell.

Television transmitters on the pinnacle of Mt. Wellington have now been manned for two winters, thus a comparison can be made between the above assumption and road conditions actually experienced.

(i) The Winter of 1960

From the Hobart temperature observations using the criteria defined above we find:-

Total No. of cold spells of all types	....	7
No. of cold spells of Type I	....	1
No. of cold spells of Type II	....	3
No. of cold spells of Type III	....	3
No. of cold spells duration at most 24 hours	....	6
No. of cold spells duration between 24 and 48 hours	....	-
No. of cold spells duration between 48 and 72 hours	....	1
No. of cold spells duration more than 72 hours	....	-

That is, during this period only on one occasion was a protracted traffic disability probable.

The records of the P.M.G. technicians who operate the A.B.C. television transmitter were consulted and these showed that although on several occasions the operators remained at the transmitter site overnight, on all occasions they were able to return the following morning. Reasons for these overnight stops were not available, but the P.M.G. staff were of the opinion that many were due to driving hazards other than snow, mainly fog and ice.

(ii) The Winter of 1961

Again from the Hobart temperature observations we find:-

Total No. of cold spells	....	6
No. of cold spells of Type I	....	5
No. of cold spells of Type II	....	-
No. of cold spells of Type III	....	1
No. of cold spells duration not more than 24 hours	....	-
No. of cold spells duration between 24 and 48 hours	....	2
No. of cold spells duration between 48 and 72 hours	....	2
No. of cold spells duration more than 72 hours	....	2

That is, there were five occasions on which prolonged traffic disabilities were probable and on two of these occasions the period of the traffic disability could have been four days or more.

P.M.G. records showed that for a period of approximately eight weeks from June 20th, which corresponds to the first cold spell of the winter, to August 9th, the Pinnacle Road was closed to all traffic by snow drifts estimated to be up to 20 feet deep in places.

A detailed study of the snowfalls during this winter shows that a heavy fall during the period 17th-19th June caused the initial blockage of the road and this was consolidated by the formation of drifts on the 20th and a further heavy snowfall on the 21st. During the following eight weeks no prolonged period of mild weather was experienced while further extensive snowfalls followed at intervals of seven to ten days and as a result the snow-plough was unable to cut through the drifts until late August.

Comparing these two winters with those during the 20 year period investigated, it is seen that they are approaching opposite extremes as regards occasions of extensive snowfalls. In 1960 there was only one occasion in which snow settled below 1500 feet. In the period 1939-1958 only one year (1942) had less occasions of snowfalls to the 1500 feet level, as in that year no extensive snowfalls occurred. In 1961 there were no less than 5 occasions when snow settled at 1500 feet. This figure was exceeded only twice (1948 and 1955) in the 20 years investigated.

3. CONCLUSIONS

In this investigation some statistics have been derived regarding the frequency of occurrence and the distribution through the year of "cold spells" and of snowfalls of different extent and also regarding the length of these "cold spells". These figures can be used to obtain an estimate of the traffic disruptions on the Pinnacle Road due to snowfall. There is, of course, no direct relationship between these two variables as the traffic disruptions are due mainly to drifts and not to direct snowfall which is usually not deeper than the snow plough can handle. This means that a major factor to be considered is the actual location of the road itself. The last half mile is built on the northeastern side of the main ridge which runs northwest to southeast. As the prevailing wind, particularly immediately following a snowstorm, is between west and southwest, it is seen that the road is built in a position highly favourable to the formation of drifts. During the winter of 1961 a drift almost 20 feet in depth formed across this section of road and this was the major cause of the eight-week traffic disruption which was experienced. A further complication is that when a drift ten feet or more in depth has formed, an extended period of mild, and preferably wet, weather (in winter this means temperatures significantly above normal) is needed to melt it sufficiently to allow the snow plough through. In the autumn and spring, when normal temperatures are quite sufficient to cause a rapid melting of the snow, the length of a "cold spell" can be directly associated with the period of the traffic disruption, but during the winter the problem is considerably more complex.

Observations made during the winters of 1960 and 1961, when the television transmitters were manned, give us some useful information as they represent conditions approaching the extremes likely to be encountered. In 1960, which was a relatively snow-free year, no traffic disruptions exceeding 12 hours were experienced and so it can be concluded that during at least some years no significant traffic disruptions will occur. The year 1961, which was characterised by an abnormal amount of snowfall during the winter months, gave a period of 8 weeks during which access to the mountain top was possible only on foot. From this we can conclude that there will be winters during which traffic disruptions lasting eight weeks or even longer will occur, but these winters will not be frequent, probably less than one year in five.

Work has now commenced on the construction of television transmitters on the summit of Mt. Barrow. This peak is less than 500 feet higher than Mt. Wellington and almost 100 miles further to the north. Whereas the main snowfall on Mt. Wellington is from southerly to westerly airstreams, Mt. Barrow is subject to snowfall from southeasterly and from cold northwesterly airstreams and is protected, to a large extent from the south and west. Although snowfalls will not necessarily be concurrent on the two mountains, it is reasonable to assume that the frequency of snowfalls will be approximately the same. Experience has shown that airstreams sufficiently cold to produce snow at or below 4000 feet occur with approximately equal frequency in both areas. The meagre information which is available for Mt. Barrow supports this hypothesis. Also, as the areas being considered are within 100 miles of each other, they are subject to almost identical air mass changes and so we can assume that the duration of cold spells will be approximately the same. Thus we are able to use the results obtained in Southern Tasmania to give forecasts of probable traffic disruptions due to snow on the road to the summit of Mt. Barrow and already the construction companies are making use of these results.