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Met.O.15 Internal Report No.69

The frequency and characteristics of frontal systems in the region of the English Channel: a survey.

METEOROLOGICAL OFFICE
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# MET.O.15 INTERNAL REPORT

No 69

## THE FREQUENCY AND CHARACTERISTICS OF FRONTAL SYSTEMS IN THE REGION OF THE ENGLISH CHANNEL: A SURVEY.

by

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THE FREQUENCY AND CHARACTERISTICS OF
FRONTAL SYSTEMS IN THE REGION OF THE ENGLISH CHANNEL: A SURVEY

A 'quick' survey of the frequency and characteristics of frontal systems crossing the hatched area in Fig. 1 has been carried out for a 7 year period for the months September to December inclusive. The stimulus for this investigation was to have some idea of how many fronts are likely to be available for study during the Frontal Dynamics Project set for 1 September to 15 December 1987. The primary area of study during the project is that area hatched in Fig. 1. The notes and tables presented here reflect the requirements of that project, rather than just being a general survey of frontal structure, type etc. The study, based only on a quick inspection of satellite images, surface analyses and 12 hour rainfall accumulations in the Channel Islands has not been carried out in detail, since only a general indication was required for planning the Project.

1. What was done and why

The requirements of the project are that about 6 clear cut examples of fronts, primarily cold fronts, should be studied during the project period. Readers are referred to Frontal Dynamics Project documentation for further information on the goals and on the proposed methods of observation during the project. In this study, a count has been made of the number of fronts that crossed the project area during each of the 7 seasons. The fronts were labelled by type and overall intensity. Further sub-divisions were made: the orientation of each front, its speed and whether the structure appeared essentially 2-dimensional or 3-dimensional.

Some non-meteorological factors have also been included which relate specifically to the needs of the project. These include a count of the number of fronts that would be missed, if during the the project, work could not take place at weekends, or those partially or completely missed because observations could not be taken at night. Such constraints may well be realistic, with observations confined to the working week due to the difficulty of organising rotas at weekends and avoiding long hours on standby; and from the point of view of the difficulty of flying instrumented aircraft at night.

In this survey, fronts were identified when they entered the project area (hatched area in Fig. 1) from satellite images and surface analyses. These two data sources were chosen because they will be primary data sources during the project, eg a possible system for study may well be in mid-Atlantic 24 hours before arrival within the study area, at which time only surface analyses and satellite pictures may be available. The combination of satellite imagery and surface analyses allowed two distinct types of cold front to be distinguished: 'split fronts' where an upper level cloud band precedes the surface front and 'classical' cold fronts where the surface cold front lies beneath (usually near the forward edge) of the associated upper cloud band. The frontal surfaces of the two types slope 'forward' and 'rearward' respectively (Browning 1985).

'Ana' and 'kata' cold fronts are often recognised from imagery as being those that have virtually total cover of upper level cloudiness and those being virtually free of upper level cloudiness respectively. Some fronts fitted these two extremes. However, most fronts showed variation of upper level cloudiness along the band both spatially and temporally thus making it difficult to classify whether 'ana' or 'kata'. It was therefore appropriate in this study to adopt the rearward and forward sloping categories of cold front, except that the 'classical' rearward sloping fronts are labelled 'potentially ana', since satellite imagery often suggested considerable change in structure over say 24 hours.

Although cold fronts formed the basis of the survey, other fronts were also classified: "warm", "occluded", "trough" (usually in cold air ahead of a vortex) or "indeterminate" (usually associated with a developing wave or depression and apparently having different surface and upper air structure).

Each front identified in the survey was then labelled according to one of 3 classes of activity. Most fronts were simply labelled 'typical'. These were fronts that produced generally light or moderate rainfall in the vicinity of the English Channel. However, fronts that produced either no rainfall (or virtually no rainfall), or produced particularly heavy rainfall were labelled either 'very feeble' or 'very active' respectively. During the Frontal Dynamics Project one would hope to encounter several of the very active frontal systems, ideally clear cut cold fronts.

Systems were also classified according to whether they appeared mostly 2 or 3 dimensional whilst within the Project area. 2-dimensional systems were defined for this analysis as those fronts that, according to imagery, had essentially unchanging shape and structure and were either straight or gently curved, and according to surface analyses were non-waving and not containing triple points. Remaining systems were 3-dimensional. A few unclassifiable 3-dimensional systems were also labelled complex.

The survey period included all the months of September to December from 1978 to 1985, with the exception of 1981, when lack of suitable satellite data prevented any analysis. Satellite analyses and surface charts were used to identify and classify each front; additionally the orientation of each front, the time within which it lay in the shaded area in Fig. 1 and its speed were also noted, together with any reference to dramatic changes in speed that might for instance occur during wave development. A separate category included fronts which went through an extended period of being quasi-stationary.

In section 2, the results are described. The main conclusions are listed in Section 3.

## 2. Results

The results of the survey have been summarised in a number of tables. The rest of this text simply comments on the content and the most important conclusions to be drawn from each table; the results obtained in the survey are assumed to resemble the likely distribution and intensity of fronts during a typical Autumn. Comments are made about year to year variability. However, because of the types of data used and the way the survey was done ie. the data for each day were quickly inspected, no quantitative statistical analyses (eg standard deviations etc) have been attempted. Where relevant, 'worst' or 'best' years are given.



With the exception of Table 1, all results exclude 'very feeble' frontal systems. The heading of each Table from Table 2 onwards indicates whether all fronts (cold, occlusion, warm, trough), very active and typical cold fronts or very active (only) fronts or cold fronts are included in the Table.

In all Tables fronts that change character, type, speed or orientation are included under each appropriate category.

### Table 1

This shows a breakdown of all fronts by month and by project period over the 7 years. Additionally, for the project period the breakdown of fronts according to whether cold or 'other' is shown. Due to fronts changing structure the total number of cold fronts is less than the total number of 'split' and 'potentially ana' in the breakdown of cold fronts on the far right. The table indicates that most fronts were cold fronts, which will be a high priority during the project.

### Table 2

This looks at the number of days between frontal events (all fronts). The time elapsed from 1st September until the first event of each season is marked with a 'B' followed by the year. In 1982 for example it was the 18 September before a frontal event occurred. About one half of the frontal events occurred on the same day or the day following cessation of the previous frontal event. It was very rare that a period of a fortnight or more occurred without the passage of a front.

### Table 3

This shows the same statistic as Table 2, the number of days between events, but in this case for cold fronts only. One third of the events still occurred on the same day or the day following cessation of the previous event. The mean separation between cold fronts was $3^3/_4$ days. Again it was very rare for more than a fortnight to elapse between cold frontal events.

### Table 4

This again shows the same statistic as Table 2, but in this case is restricted to very active systems only. The majority of very active systems were cold fronts, but there were a few very active events from each of the other frontal categories. In particular, a number of fronts closely associated with either their parent depression or a wave were very active in terms of precipitation. As in the previous tables, there is a tendency for one event to be closely followed by another; this table showing a peak at a 2 day interval. However, the notable feature is the relatively large number of occasions when there are 3 weeks or more between events, and in particular at the beginning of 1978 when 76 days elapsed before an active cold front occurred. The table has also been redrawn (top right) with the period between events clustered into weeks. This has been done because in the project only one event per week may be able to be adequately observed. One half of events take place within one week of the previous events.

Table 5

Weekends are considered. The weekend has been defined as the end of the working day on Friday until the beginning of the working day on Monday, except that any system captured by a late finish on Friday - say up to about 2100 - is not included as a 'weekend system'. On the left hand side, the number of events (all fronts) missed each weekend during the 100 complete weeks during the 7 year survey period has been plotted. (Those systems labelled 'partially missed' are those that occur over the area during the latter half of Friday (and persist after 2100 on Fridays), and those that are within the area prior to, as well as during the Monday working day. On the right hand side is the number of events that occurred during each working week (including both night and day)). Mostly, at least one frontal event occurred during each working week.

Table 6

The constraint of operating during daylight only Monday to Friday. In this table we look at the number of days during each of the 100 weeks in the survey period when a frontal system of any kind lay within the area for more than 5 daylight hours. A quasi-stationary or slow moving frontal system was counted separately for each successive daytime period during which it lay within the project area. The main table, on the left hand side, indicates that during most weeks a frontal system lay within the area on one or more days. The right hand side of the table gives a breakdown of the total number of typical and very active events and separately the very active events occurring during each working week. We see here that the inclusion of only the very active events alters considerably the number of events which would have been available for study during daylight hours of each working week. A very active system would only be available for study just less than one week in 4. Significantly, in 1978, 1979 and 1983 there were either no events or only one very active event occurring during daylight in the project period.

Tables 7 to 9

The breakdown of fronts according to speed, orientation and time within the project area. Tables 7 and 8 show the orientations and speeds of all very active and typical cold fronts and of the very active cold fronts only respectively. It is clear from Tables 7 and 8 that the vast majority of cold fronts have orientations between north to south and southwest to northeast; also most fronts may be considered essentially 2-dimensional. Table 9 shows the time each front (all types of front) lay within the project area. These times are broken down into 3 hour periods, and the orientation of each front in each of the 3 hour periods is also shown. The Table indicates that one half of the events take place over less than 15 hours whilst two thirds of events last less than 21 hours. There is little bias towards different orientations for shorter or longer events. However there is a slightly higher percentage of events with a SSE/SE/ESE orientation that last 15 hours or less, and fronts with a WSW orientation are often slow moving.



3. Conclusions [Very feeble fronts excluded]

We now draw out some of the major conclusions from the tables.

1. There is little annual variation in total number of fronts (all types) during the project period.

2. Considerable monthly variation in the frequency of fronts exists. Some months in 1978 and 1985 had very few fronts. These two autumns were exceptional: the autumn of 1978 over southern Britain was exceptionally dry. Mean surface pressures over the period September to November were high over western France, with a +8 mb pressure anomaly off southwest England (Bader and Warrilow, 1979). The autumn of 1985 was also dry with few fronts, although some active events did occur. Significantly, in December 1978 and from late November 1985 frontal systems were frequent.

3. From September to December, there tends to be a gradual increase in the total number of typical and very active events; ranging from an average of 7.5 events in September to 12 in December.

4. Apart from 1978, even during 'dry' periods, there were occasional very active events. In 1978, no very active event occurred until 15 November.

5. Most fronts were cold fronts (74%).

6. When all fronts are considered, one half of events occur within one day of the previous event. This figure drops to about one third when only cold fronts are considered.

7. If only the very active category is considered, then the tendency towards bunching of events over a few days is very marked. Nearly one half of the events will be missed if say a 4 day gap is required between observing events.

8. All years except 1982 and 1984 had a period of more than one month when no very active events occurred.

9. One or more event is likely to be missed each week by not working weekends.

10. During most weeks (70%) a frontal event occurs.

11. During daylight hours, within the working week, at least one front may be studied most weeks (70%).

12. Very active events are only likely to be studied during 22% of working weeks (Monday to Friday) ie in 3-4 working weeks each season (1st September to 15 December).

13. Under the restrictions of the 5 day week and daylight observations only, it is possible that in 3 years out of 7 either no or only one very active event would be captured.

14. Because of the restriction in 13 above, consideration must be given in the Frontal Dynamics Project to capturing typical events rather than waiting for an active event to appear. In each of the 7 years studied one such event occurred on average at least every other week.

15. Orientation. A very high proportion of events have a S/SSW/SW orientation, especially in the very active category. (34 out of 39).

16. The most common time period for a front to cross the area was about 11 hours. 14% of fronts took longer than 36 hours to cross the area (many of these became quasi-stationary and totally decayed, rather than moving out of the area).

17. Most systems (approximately 70%) appeared to be essentially 2-dimensional: this is true of both the very active and typical classes.

4. Alternative project period

The question has been raised as to whether a different project period is possible, centred on early Spring. Just 2 years of data were prepared for January to April with an imaginary project period from 16 January to 30 April. Although only a 2 years sample, the conclusions are as follows:

1. Far more variability was found in frontal frequency, especially in March/April. In 1984, only 5 active cold frontal systems occurred, all but one in January, whilst the remaining front was 'complex'. No simple 2-dimensional fronts occurred after 2 March, indeed only one frontal passage occurred in April, on the 4th. In 1985, frontal variability was less, but during the whole period only 2 active cold fronts occurred, and one of these had a southeast to northwest frontal orientation.

2. In both years, the percentage of cold fronts in comparison to other weather systems was far less than in the 7 autumn seasons.

3. The maximum frequency of fronts was in January, the minimum in April. From a project point of view this could be very frustrating, particularly if 'teething problems' prevented good observational coverage early in the project period.

References

Bader, M J; Warrilow, D A 1979 Why it was dry in the Autumn of '78 Water No. 25 pp 2-5.

Browning, K A 1985 Conceptual Models of Precipitation Systems, Met. Mag. 114, 293-319.



Figure Captions

Figure 1. Map showing the location of the area (hatched) used in the survey of fronts and corresponding to the inner experimental area for the frontal dynamics project. For the purposes of this note only, the hatched area is referred to as the 'project area'.

Table 1 A summary showing the number of fronts affecting the project area shown in Figure 1 by month from September to December and separately during the period 1 September to 15 December each year from 1978 to 1985 with the exception of 1981. The number of fronts within each of 3 categories, 'very active' (A), 'typical' (T) and 'very feeble (F)' are shown as well as the total number of fronts. On the far right, a breakdown of fronts during the period 1 September to 15 December is shown for a combination of the typical and very active events. Classical cold fronts with rearward slope are labelled as 'potentially ana', those with forward slope are labelled 'split'. Fronts that exhibit both characteristics over their length or by changing with time are labelled in both categories, thus the total number of cold fronts is not the sum of the two previous columns. All other frontal events are labelled under 'other fronts'. The final column is a total of frontal systems, not individual fronts eg a partly occluded system composed of an occlusion, a cold front and a warm front is considered as a single frontal system.

Table 2 Number of days between each typical and very active frontal event. The time elapsed from the beginning of the project period in each year until the first event is labelled 'B' followed by the year.

Table 3 As Table 2, except for typical and very active cold fronts only.

Table 4 As Table 2 except for all very active frontal events. The inset shows the same table, but with the abcissa divided into 7 day intervals.

Table 5 The effect of restricting operations to Monday to Friday. Left: number of typical and very active frontal events missed or partially missed each weekend. See text for definition of weekend. There were 100 complete weeks in the 7 year first September to 15 December period; thus the ordinate may be interpreted as a percentage frequency. Right: number of frontal events captured during each working week.

Table 6 The effect of daylight only operation between Monday and Friday. Left: the abcissa refers to the number of days between Monday and Friday, during daylight only, when a frontal system lay within the project area.

Right: breakdown of left hand table into seasonal totals for 7 years. For example, in 1978, there were 14 complete weeks in the season. There were no very active or typical events during 6 of the weeks, one event occurred in 5 weeks etc; and there was only one week when a very active event occurred.

Table 7 Orientation and speeds of typical and very active cold fronts. Fronts that change their orientation and speed or become temporarily quasi-stationary are labelled in all the appropriate categories. Additionally, on the far right, is a breakdown according to whether in satellite imagery and surface analyses the front appeared either 2-dimensional or 3-dimensional. Particularly complex fronts are also labelled.

Table 8 As Table 7, but for very active cold fronts only.

Table 9 The time in hours each front will lay within the project area and its orientation. The orientation of each front is shown against the period it lay within the project area.



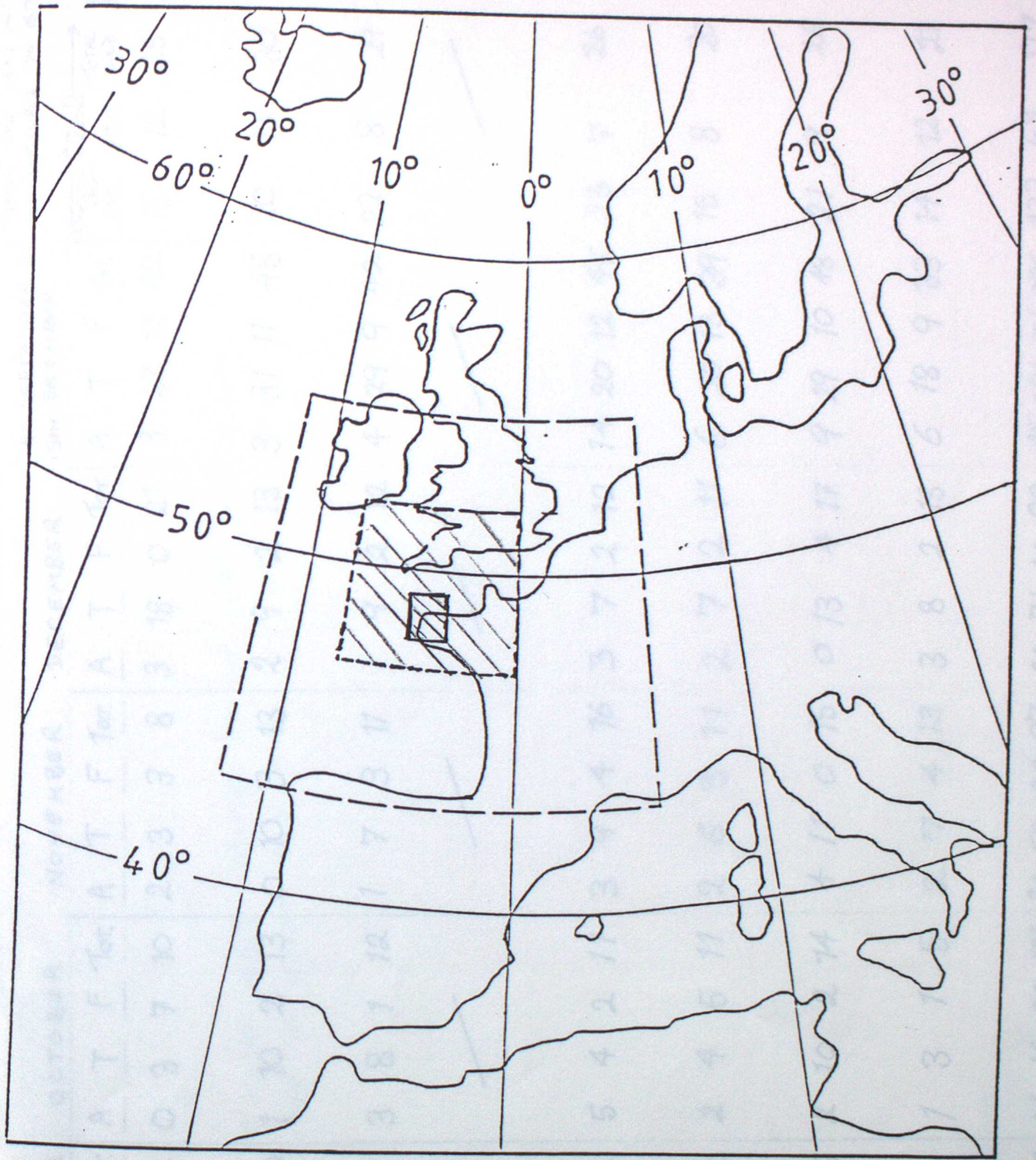



FIG. 1

TABLE 1. NUMBER OF FRONTS (ALL TYPES)

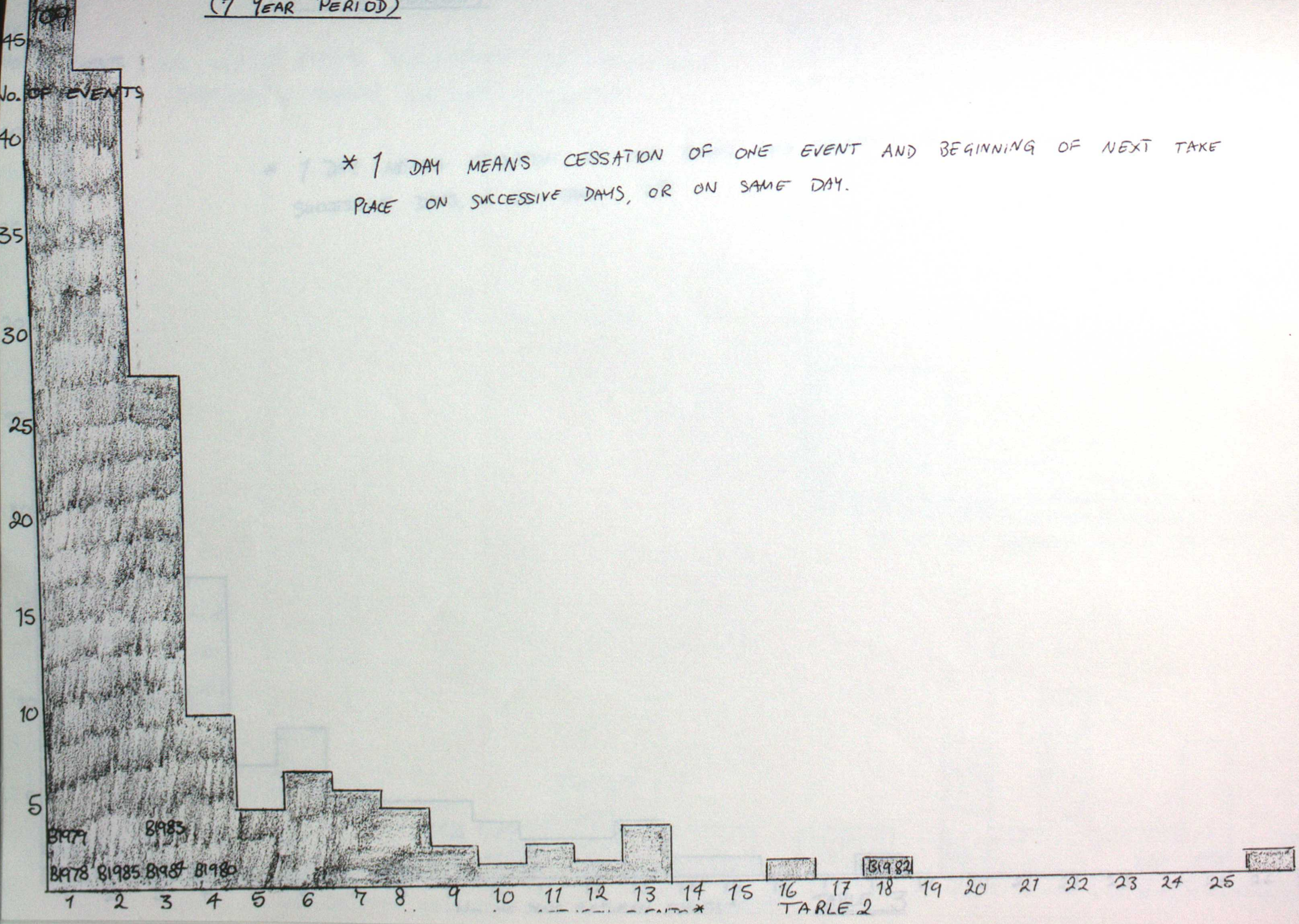
KEY: VERY ACTIVE = A; 'TYPICAL' = T; VERY FEEBLE = F

| | SEPTEMBER | | | | OCTOBER | | | | NOVEMBER | | | | DECEMBER | | | | 1st SEPTEMBER to 15th DECEMBER | | | | 'TYPICAL' AND VERY ACTIVE ONLY 1st SEPTEMBER TO 15th DECEMBER | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | T | F | Tot. | A | T | F | Tot. | A | T | F | Tot. | A | T | F | Tot. | A | T | F | Tot. | COLD: POTENTIALLY ANA | COLD: SPLIT | TOTAL COLD | OTHER FRONTS | TOTAL ALL |
| 1978 | 0 | 10 | 2 | 12 | 0 | 3 | 7 | 10 | 2 | 3 | 3 | 8 | 3 | 18 | 0 | 21 | 3 | 27 | 12 | 42 | 15 | 12 | 25 | 6 | 30 |
| 1979 | 1 | 5 | 4 | 10 | 1 | 10 | 2 | 13 | 0 | 10 | 3 | 13 | 2 | 9 | 2 | 13 | 3 | 31 | 11 | 45 | 20 | 13 | 30 | 6 | 34 |
| 1980 | 0 | 9 | 5 | 14 | 3 | 8 | 1 | 12 | 1 | 7 | 3 | 11 | 1 | 9 | 2 | 12 | 4 | 29 | 9 | 42 | 22 | 8 | 29 | 7 | 33 |
| 1981 | — | | | | — | | | | — | | | | — | | | | — | | | | — | | | | |
| 1982 | 4 | 3 | 5 | 12 | 5 | 4 | 2 | 11 | 3 | 9 | 4 | 16 | 3 | 7 | 2 | 12 | 14 | 20 | 12 | 46 | 23 | 7 | 26 | 16 | 34 |
| 1983 | 0 | 7 | 5 | 12 | 2 | 4 | 5 | 11 | 2 | 6 | 3 | 11 | 2 | 7 | 2 | 11 | 6 | 20 | 13 | 39 | 15 | 8 | 20 | 8 | 26 |
| 1984 | 3 | 5 | 7 | 15 | 2 | 10 | 2 | 14 | 4 | 11 | 0 | 15 | 0 | 13 | 4 | 17 | 9 | 29 | 10 | 48 | 21 | 9 | 26 | 13 | 38 |
| 1985 | 2 | 3 | 3 | 8 | 1 | 3 | 1 | 5 | 2 | 7 | 4 | 13 | 3 | 8 | 2 | 13 | 6 | 18 | 9 | 33 | 14 | 12 | 21 | 5 | 24 |
| TOTAL: | 10 | 42 | 31 | 83 | 14 | 42 | 20 | 76 | 14 | 53 | 20 | 87 | 14 | 71 | 14 | 99 | 45 | 174 | 76 | 295 | 133 | 69 | 177 | 61 | |

TABLE 1

TABLE 2

1ST SEPTEMBER TO 15TH DECEMBER (7 YEAR PERIOD) ALL VERY ACTIVE AND TYPICAL FRONTS NO. OF DAYS BETWEEN EVENTS.




* 1 DAY MEANS CESSATION OF ONE EVENT AND BEGINNING OF NEXT TAKE PLACE ON SUCCESSIVE DAYS, OR ON SAME DAY.

TABLE 2

TABLE 3 1ST SEPTEMBER TO 15TH DECEMBER (7 YEAR PERIOD) VERY ACTIVE AND TYPICAL COLD FRONTS No. OF DAYS BETWEEN EVENTS

* 1 DAY MEANS CESSATION OF ONE EVENT AND BEGINNING OF NEXT TAKE PLACE ON SUCCESSIVE DAYS, OR ON SAME DAY.

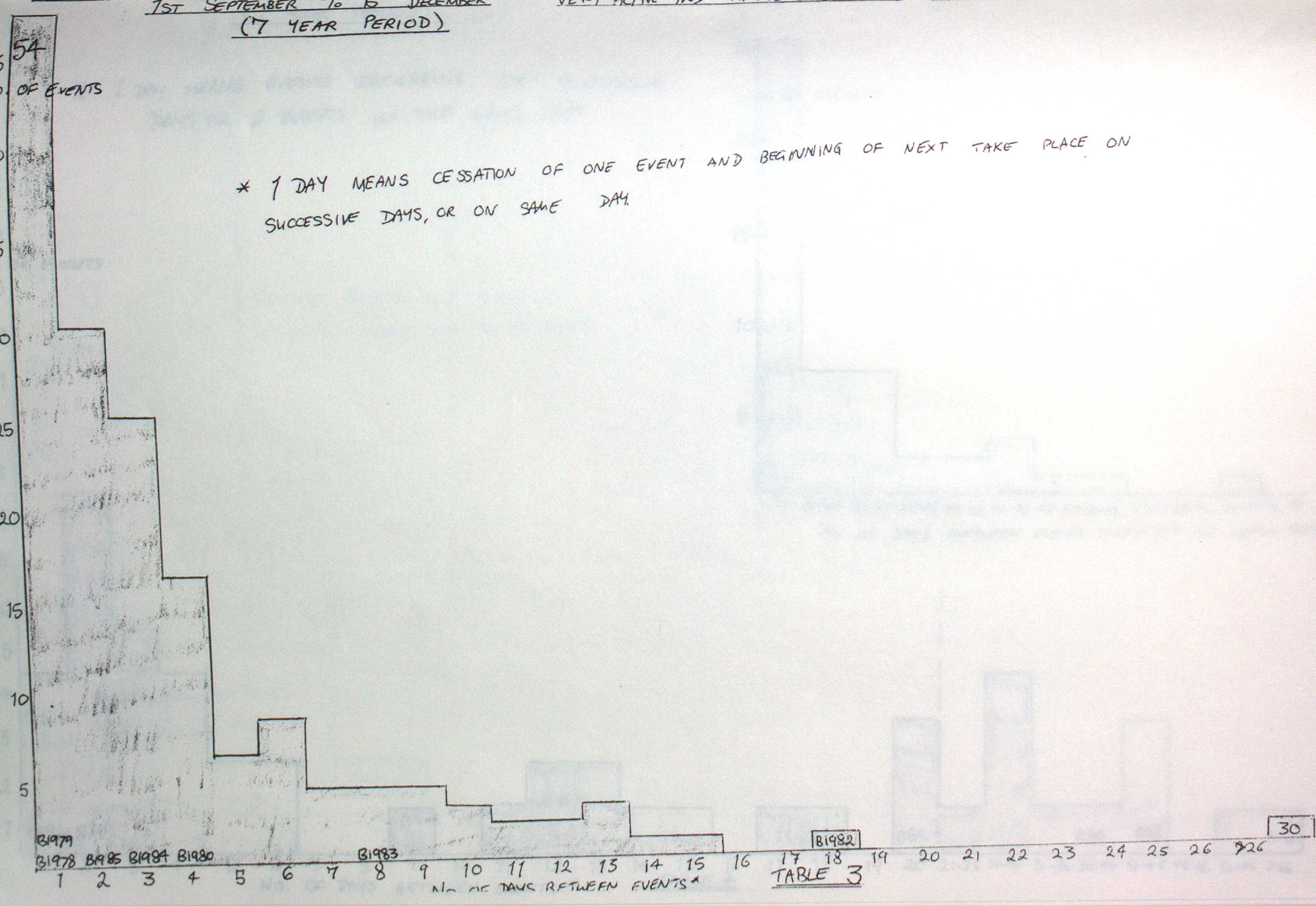
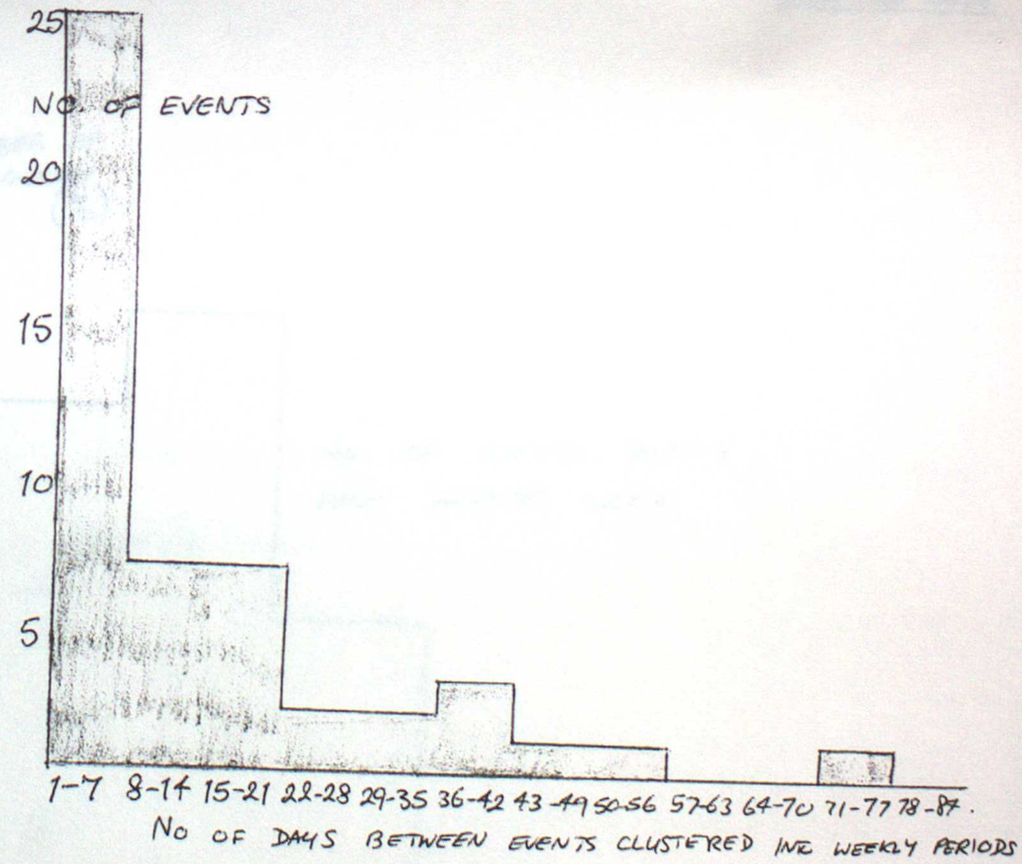



TABLE 3

1st September to 15th December. (7 year period)   All very active fronts   No. of days between events.

* 1 day means events occurring on successive days, or 2 events on the same day.



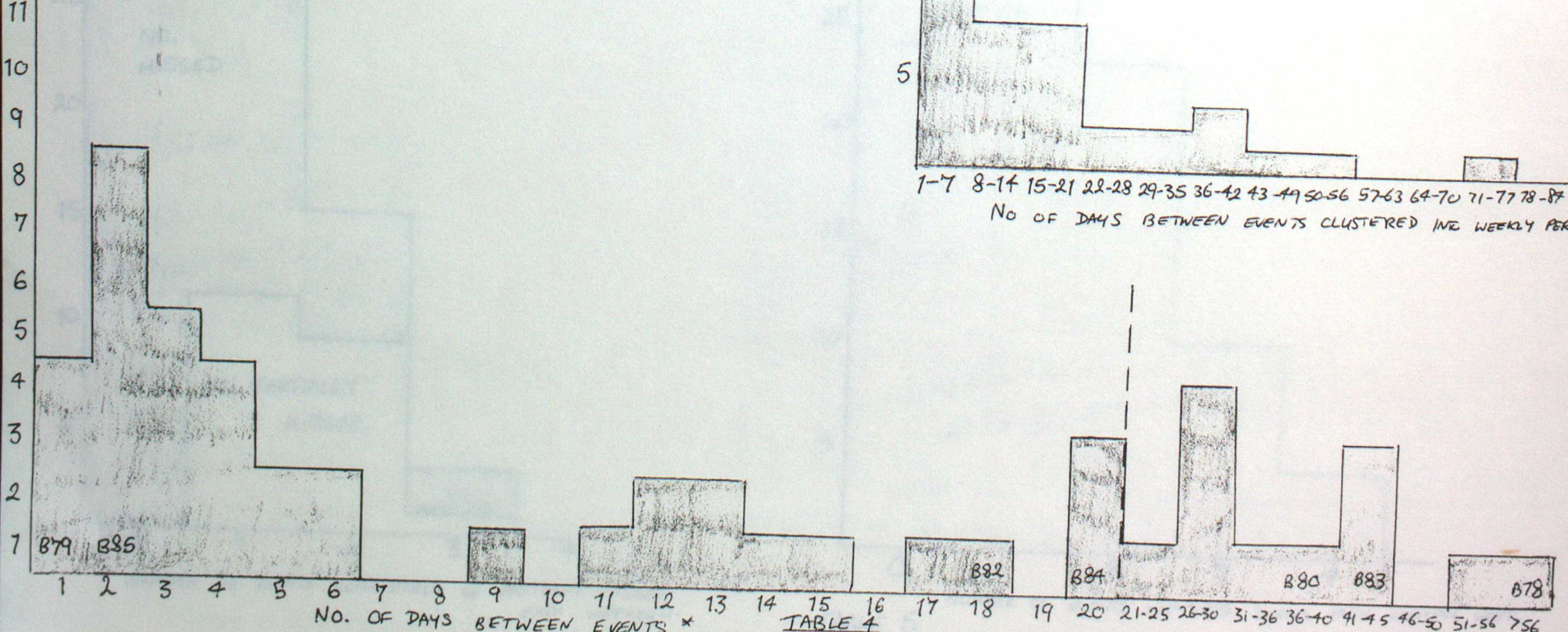
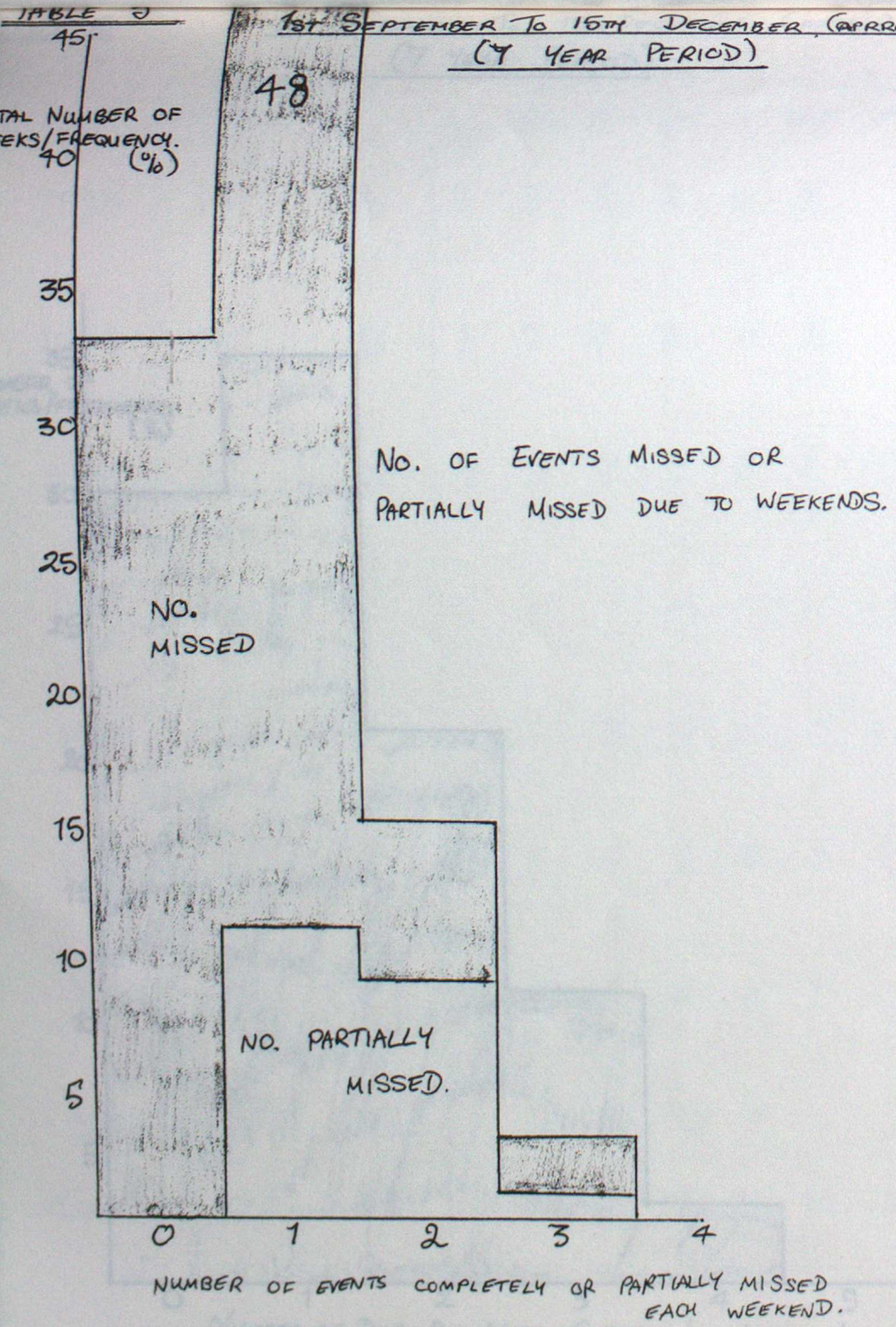




TABLE 4

TABLE 5

1st September to 15th December (approx) (4 year period) — All Very Active and Typical Fronts — Effect of Monday to Friday operation only.



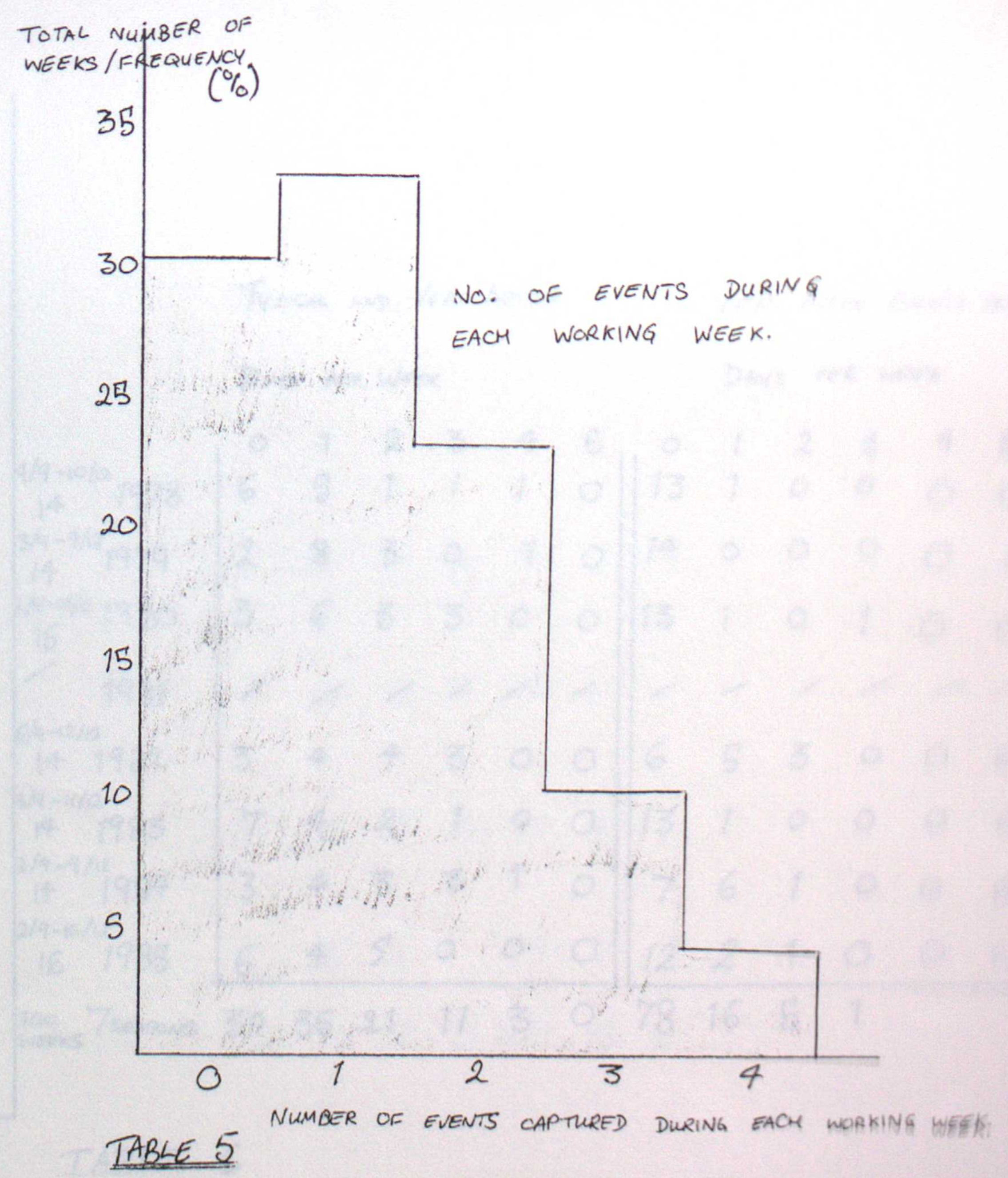
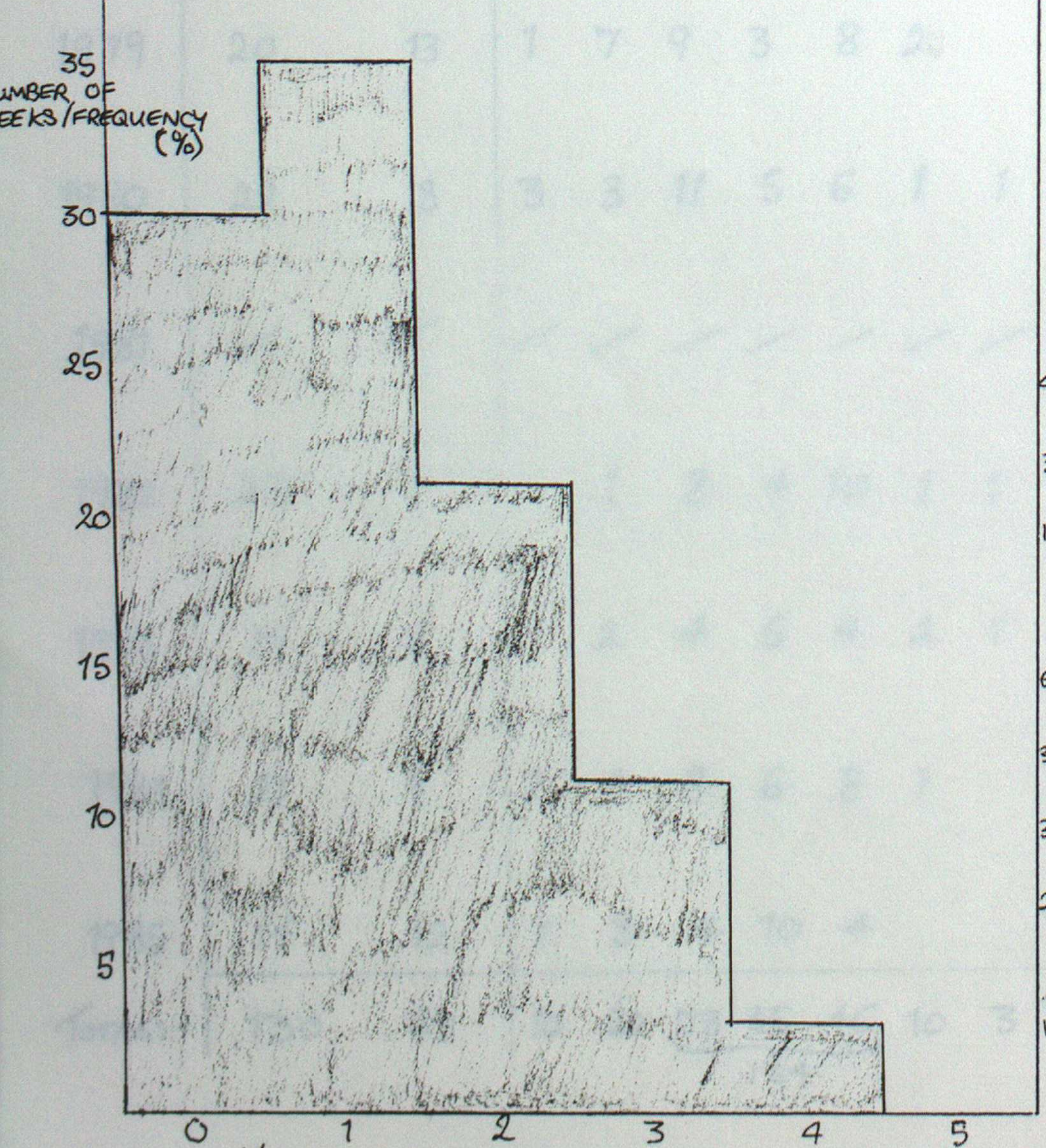




TABLE 5

TABLE 6 — 1st September To 15th December (approx) All Very Active and Typical Fronts (7 Year Period) — Effect of "Daylight Only" operation.




| | Typical and Very Active — Days per week 0 | 1 | 2 | 3 | 4 | 5 | Very Active Events Only — Days per week 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4/9–10/12 14 1978 | 6 | 5 | 1 | 1 | 1 | 0 | 13 | 1 | 0 | 0 | 0 | 0 |
| 3/9–9/12 14 1979 | 2 | 8 | 3 | 0 | 1 | 0 | 14 | 0 | 0 | 0 | 0 | 0 |
| 1/9–14/12 15 1980 | 3 | 6 | 3 | 3 | 0 | 0 | 13 | 1 | 0 | 1 | 0 | 0 |
| / 1981 | / | / | / | / | / | / | / | / | / | / | / | / |
| 6/9–12/12 14 1982 | 3 | 4 | 4 | 3 | 0 | 0 | 6 | 5 | 3 | 0 | 0 | 0 |
| 3/9–11/12 14 1983 | 7 | 4 | 2 | 1 | 0 | 0 | 13 | 1 | 0 | 0 | 0 | 0 |
| 3/9–9/12 14 1984 | 3 | 4 | 3 | 3 | 1 | 0 | 7 | 6 | 1 | 0 | 0 | 0 |
| 2/9–15/12 15 1985 | 6 | 4 | 5 | 0 | 0 | 0 | 12 | 2 | 1 | 0. | 0 | 0 |
| 100 weeks 7 seasons | 30 | 35 | 21 | 11 | 3 | 0 | 78 | 16 | 5 | 1 | | |

TABLE 6

TABLE 7 — 1ST SEPTEMBER TO 15TH DECEMBER (7 YEAR PERIOD) — VERY ACTIVE AND TYPICAL COLD FRONTS. — ORIENTATION AND SPEED.

| | COLD FRONT TYPE | | ORIENTATIONS. | | | | | | | | | SPEED. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | POTENTIALLY ANA | SPLIT | W (-E) | WSW | SW | SSW | S | SSE | SE | OTHER | CYCLONIC | QUASI-STATIONARY | SLOW (<10ms⁻¹) | MOD. (10-20ms⁻¹) | FAST (>20ms⁻¹) | 2D | 3D | COMPLEX |
| 1978 | 15 | 12 | 3 | 3 | 8 | 2 | 6 | 3 | | | | 2 | 20 | 5 | 1 | 24 | 1 | |
| 1979 | 20 | 13 | 1 | 7 | 9 | 3 | 8 | 2 | | | | 10 | 25 | 3 | 1 | 22 | 8 | 2 |
| 1980 | 22 | 8 | 3 | 3 | 11 | 5 | 6 | 1 | 1 | 1 | 1 | 10 | 18 | 12 | | 23 | 6 | 1 |
| 1981 | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| 1982 | 23 | 7 | | 1 | 8 | 4 | 10 | 1 | 1 | | 1 | 7 | 11 | 14 | 2 | 16 | 10 | 4 |
| 1983 | 15 | 8 | | 2 | 4 | 5 | 4 | 2 | 1 | | 1 | 3 | 14 | 5 | 3 | 13 | 8 | 1 |
| 1984 | 21 | 9 | 2 | 1 | 8 | 6 | 8 | 1 | | | | 8 | 15 | 10 | 3 | 18 | 8 | 1 |
| 1985 | 14 | 12 | 1 | 3 | 4 | 10 | 4 | | | | | 9 | 16 | 6 | | 14 | 7 | 1 |
| TOTAL:- | 130 | 69 | 10 | 20 | 53 | 35 | 46 | 10 | 3 | 1 | 3 | 49 | 93 | 52 | 10 | 129 | 48 | 10 |

(SW + SSW + S = 134.)

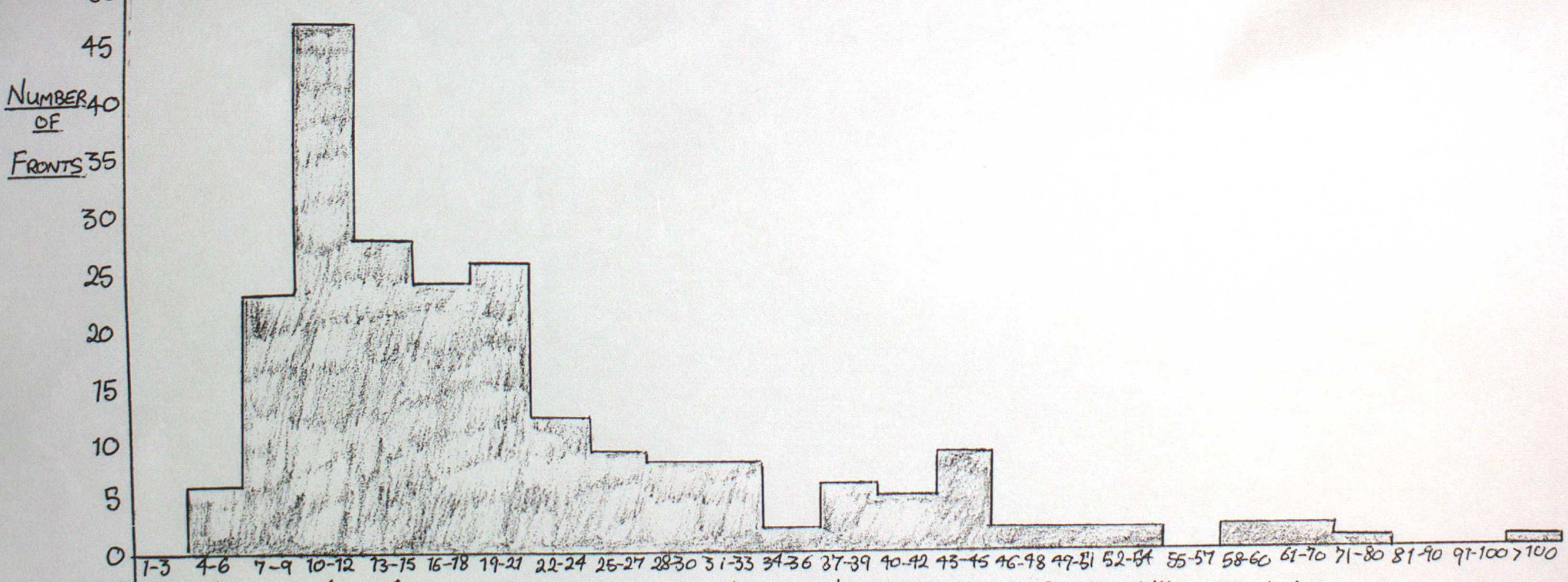
TABLE 8 1ST SEPTEMBER TO 15TH DECEMBER (7 YEAR PERIOD) VERY ACTIVE COLD FRONTS ORIENTATION AND SPEED.

| | POTENTIALLY ANA | SPLIT | ORIENTATION (FROM ~WARM AIR TO RIGHT) W | WSW | SW | SSW | S | SSE | SE | OTHER | CYCLONIC | SPEED QUASI-STATIONARY | SLOW (<10 ms⁻¹) | MOD (10-20 ms⁻¹) | FAST (>10 ms⁻¹) | 2D | 3D | COMPLEX | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1978 | 3 | 0 | | | 2 | | 1 | | | | | | 2 | 1 | | 3 | | | |
| 1979 | 2 | 1 | | | 1 | | 2 | | | | | 1* | 2 | 1* | | 3 | | | * FRONT DECELERATES RAPIDLY AND RETURNS NORTH. |
| 1980 | 3 | | | | 2 | | | 1 | | | | 2* | 1* | 2* | | 1 | 2 | | * 2 FRONTS DECELERATED BECOMES QUASI STATIONARY |
| 1981 | | | | | | | | | | | | | | | | | | | |
| 1982 | 14* | 2+ | | 1 | 2 | 2 | 7 | 1 | | | 1 | 6* | 6* | 3 | 1 | 8 | 6 | 1 | * 2 FRONTS DECELERATED. + BOTH COLUMNS INCLUDE 2 CERTAIN CASES |
| 1983 | 6 | | | | | 2 | 4 | | | | | | 3 | 1 | 2 | 3 | 3 | | |
| 1984 | 6 | | | | 1 | 4 | 1 | | | | | 2* | 2* | 3 | 1 | 5 | 1 | | * 2 FRONTS DECELERATED. |
| 1985 | 3 | 2 | | 2 | 1 | 2 | | | | | | 1 | 3 | 1 | | 5 | | | |
| TOTAL: | 37 | 5 | | 3 | 9 | 10 | 15 | 2 | | | 1 | 12 | 19 | 12 | 4 | 28 | 12 | 1 | |

34 (SW + SSW + S)

TOT:- 40 (2D + 3D + COMPLEX)

TABLE 9 — 1ST SEPTEMBER TO 15TH DECEMBER (7 YEAR PERIOD) — ALL VERY ACTIVE AND TYPICAL FRONTS — TIME WITHIN AREA / ORIENTATION OF EACH FRONT.




NUMBER OF HOURS SYSTEM LAY WITHIN AREA.

| ORIENTATIONS | 1-3 | 4-6 | 7-9 | 10-12 | 13-15 | 16-18 | 19-21 | 22-24 | 25-27 | 28-30 | 31-33 | 34-36 | 37-39 | 40-42 | 43-45 | 46-48 | 49-51 | 52-54 | 55-57 | 58-60 | 61-70 | 71-80 | 81-90 | 91-100 | >100 | TOTALS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ESE | | 1 | | 1 | 1 | | | | | | 1 | | | | | | | | | | | | | | | 4 |
| SE | | 1(1) | | 4 | | 1 | 1 | | 1(1) | | | | | | | | | | | | | | | | | 7 (2) |
| SSE | | | | 7(2) | 2 | | | 2 | 2 | | | | | | 1(1) | | | | | | | | | | | 14 (3) |
| S | | 2(1) | 8(1) | 15(1) | 8(2) | 7(1) | 8(4) | 6(1) | 2(1) | 1 | 3(3) | | 2(1) | | 3(1) | | 1 | | | 1 | | | | | | 67 (17) |
| SSW | | 1 | 4(2) | 6(2) | 5(1) | 5 | 4(1) | 1 | | 2 | 2 | 2(2) | 1 | 1(1) | | 2(1) | | 1 | | | | | | | | 37 (10) |
| SW | | 1 | 8 | 8(2) | 6(1) | 6(2) | 5(1) | 1 | 1 | 3(1) | 2 | | 3 | 2 | 1(1) | | | | | | 2(1) | 1 | | | | 50 (8) |
| WSW | | | 1(1) | 2 | 2 | | 5 | 2(1) | 2 | | | | | 1 | 3(1) | | | | | 1 | | | | | 1 | 20 (3) |
| W | | | 1 | 2 | 1 | 2 | 2 | | | | | | | 1 | 1 | | | | | | | | | | | 10 |
| Variable | | | 1 | 2 | 3(1) | 3(1) | 1 | | 1 | 2 | | | | | | | | | | | | | | | | 15 (2) |

TABLE 9