

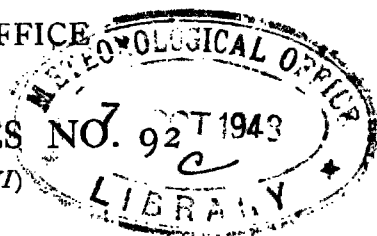
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By E. G. BILHAM, B.Sc., D.I.C.



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PERSISTENCE OF WEATHER

By E. G. BILHAM, B.Sc., D.I.C.

How often is the weather now a good forecast for an hour hence?

Summary.—Common experience in this country shows that on most occasions the weather an hour ahead will not be materially different from what it is now. But no exact figures have been available as to the actual frequency of change, or of the material change from one hour to the next. Accordingly the results of the hourly observations at nine stations have been examined and classified in such a way as to give answers to the questions :—

(1) How frequently is the weather for the next hour exactly the same as it is now?

(2) How often is the weather an hour hence practically the same as it is now, i.e. changes are small?

(3) How often is the weather an hour hence significantly different from what it is now from the point of view of flying?

(4) How often is the weather an hour hence, although not the same as now, still in the same category (bad or good) from the flying point of view?

The following note gives the first results of the inquiry for two stations wide apart, Croydon and Leuchars. Broadly the figures show :—

(1) Only in 1 case out of 5 are the conditions an hour hence exactly the same as they are now.

(2) In 7 cases out of 10 the changes are slight and not of material significance from the flying point of view.

(3) In 1 case in 6 there are material changes in an hour—half the changes being improvements and half deteriorations.

(4) In 9 cases out of 10 the conditions an hour hence will be either about the same or better than they are now.

There are annual and diurnal variations—but the latter have not yet been examined. The annual variation shows, as might perhaps be expected, that winter is the season of most frequent material change.

It is hoped to provide similar summaries for other stations in further notes, and also to consider changes in a period of three hours in addition to those in a period of one hour.

Objects and data.—The object of the inquiry to which the present note relates was to obtain statistical information regarding the frequency with which a statement of present conditions is a good or bad forecast of conditions (a) one hour ahead, (b) three hours ahead. Nine stations were asked to examine their records over a period of two years with this end in view. The statistical material provided by the nine stations is very voluminous, and its full analysis and discussion is not yet completed. It has been thought desirable, however, to put on record some results which have emerged from a preliminary examination of the hourly data from two widely separated stations, Croydon and Leuchars. In this note attention is confined to conditions one hour ahead, as that is probably the question of most immediate practical importance. The discussion is purely statistical and the elements dealt with are those of chief importance for flying operations, namely, weather (ww), visibility (V), height of cloud base (h), and amount of low cloud (N_h). These elements are those comprised in the international group wwVh N_h .

Classification by Categories.—The stations were instructed to classify their hourly reports in four categories, defined as follows:—

Category I, Steady conditions.—The figures in the group $wwVhN_h$ for the succeeding hour are identical with those for the hour of entry (with the exception that if the first figure of ww is 2 at both the hours, the cases are not counted as identical, because the weather is not steady).

Category II, Practically steady conditions.—The figures at the succeeding hour are practically the same as the figures in the group for the hour of entry, i.e. the difference between the figures for V , h and N_h at the two hours in no case exceeds 1 and for ww the following rules apply. The cases are counted as practically the same,

(a) if the first figure of ww is 0 or 1 at each of the two hours,

(b) if the first figure of ww having been 2 at the earlier hour changes to 0 or 1 at the following hour (but not *vice versa*),

(c) If the first figure having been 3–9 at one hour is the same figure at the succeeding hour.

Note that

(i) If the initial figure of ww is 2 at both the hours, the cases are not counted as practically the same.

(ii) Cases of a change of one point which qualify for category III are not included under category II.

Category III, Significant changes.—This category includes all cases—

(a) when the visibility having been 4 or more changes to 3 or less, or *vice versa*.

(b) when the cloud height having been 4 or more changes to 3 or less, or *vice versa*.

(c) when the first figure of ww having been 0–4 changes and becomes 5 or more, or *vice versa*.

These 6 cases form 6 sub-categories of category III, viz. $V-$, $V+$, $h-$, $h+$, $ww-$, $ww+$ (the minus sign is used in all three cases for deterioration).

Categories II and III are mutually exclusive, i.e. no case included in category II is included in category III or *vice versa*.

Category IV includes all cases not included under categories I to III.

The investigation covered two years, March 1939 to February 1941. Monthly frequency tables were prepared for each of the twenty-four hours, and the results were summarised by seasons, Spring (March, April, May), Summer (June, July, August), Autumn (September, October, November), Winter (December, January, February).

Conversion to percentages.—The first stage in the preliminary analysis was to convert the seasonal means to percentages. In this analysis all the twenty-four hours were lumped together. The percentages so obtained are set out in Tables I and II. The figures given in these tables thus represent the percentage frequency of occurrence of the conditions specified without regard to the hour of the day. The percentages in the lines marked "Year" in Tables I and II are the means of the seasonal means. They represent the frequency of the specified conditions without regard to time of day or time of year.

Means for the whole year.—Looking first at the results in the last lines of Table I, we see that at Croydon category I occurs approximately once in every four observations and category II about once in every three. The total of

TABLE I.—CROYDON, PERCENTAGE FREQUENCIES (HOURLY FORECASTS)

Season	Category I	Category II	Category III							Category IV
			ww+	ww-	h+	h-	V+	V-	Total	
Spring										
1939	22.9	34.7	3.9	4.3	1.7	1.9	0.8	0.8	13.4	28.8
1940	25.6	34.3	4.0	4.0	1.7	1.8	0.7	0.5	12.7	27.3
Mean	24.3	34.5	3.9	4.1	1.7	1.9	0.7	0.7	13.1	28.1
Summer										
1939	21.3	37.8	4.9	5.6	2.5	2.9	0.2	0.2	16.3	24.8
1940	29.5	36.4	2.6	2.8	1.2	1.4	0.2	0.2	8.4	25.7
Mean	25.4	37.1	3.7	4.2	1.9	2.1	0.2	0.2	12.3	25.3
Autumn										
1939	18.4	36.4	4.8	5.2	2.9	3.0	1.4	1.3	18.6	26.4
1940	29.6	27.7	3.5	3.6	2.1	2.1	1.4	1.5	14.2	28.2
Mean	24.0	32.1	4.1	4.4	2.5	2.5	1.4	1.4	16.4	27.3
Winter										
1939-40	30.3	27.0	4.6	5.5	3.7	4.1	2.6	3.0	23.5	19.3
1940-1	25.1	26.4	5.4	5.7	2.6	2.4	2.6	2.4	21.1	27.5
Mean	27.7	26.7	5.0	5.6	3.1	3.3	2.6	2.7	22.3	23.4
Year	25.3	32.6	4.2	4.6	2.3	2.5	1.2	1.2	16.0	26.0

TABLE II.—LEUCHARS, PERCENTAGE FREQUENCIES (HOURLY FORECASTS)

Season	Category I	Category II	Category III							Category IV
			ww+	ww-	h+	h-	V+	V-	Total	
Spring										
1939	20.2	48.4	5.1	4.9	3.2	3.0	0.9	0.6	17.7	13.8
1940	23.3	47.9	4.5	4.8	1.8	2.1	0.5	0.5	14.2	14.8
Mean	21.7	48.1	4.8	4.9	2.5	2.5	0.7	0.5	15.9	14.3
Summer										
1939	20.2	52.4	5.5	5.9	1.9	3.0	0.9	1.1	18.2	9.0
1940	23.0	53.1	4.4	5.3	1.8	2.1	0.2	0.4	14.2	9.7
Mean	21.6	52.7	4.9	5.6	1.9	2.5	0.5	0.7	16.2	9.3
Autumn										
1939	17.1	49.3	4.8	5.4	2.6	3.3	1.3	1.3	18.7	14.9
1940	21.9	54.1	5.4	5.6	1.6	1.9	0.1	0.4	15.0	9.0
Mean	19.5	51.7	5.1	5.5	2.1	2.6	0.7	0.9	16.9	11.9
Winter										
1939-40	28.1	42.4	5.6	6.1	1.7	2.7	0.9	1.2	18.2	11.2
1940-1	28.1	43.0	6.2	6.9	1.8	2.1	1.0	1.4	19.4	9.1
Mean	28.1	42.7	5.9	6.5	1.7	2.4	0.9	1.3	18.8	10.1
Year	22.7	48.8	5.2	5.6	2.1	2.5	0.7	0.9	16.9	11.4

the percentages for categories I and II is 57·9, which means that on rather more than half of all occasions, the conditions after the lapse of one hour are either the same or practically the same, so far as flying contingencies are concerned. Leaving category III for the moment we see that the percentage of category IV is 26. Category IV is broadly a category in which the changes are either, good conditions becoming better or becoming appreciably less good but still remaining good, or bad conditions becoming appreciably better or appreciably worse, but still remaining bad. We may thus add the entries in categories I, II and IV in order to determine the frequency of persistence of conditions classified broadly as "good" or "bad" while ignoring variations of goodness or badness. The total thus reached is 84 per cent. Thus at Croydon, taking average values for the whole day and the whole year, if conditions are good (or bad) now they will be good (or bad) an hour hence 17 times out of 20.

The percentage 16 in category III represents the frequency of a major change from one hour to the next. At Croydon this total is made up of 8·8 per cent. due to changes of weather, 4·8 due to changes of cloud height and 2·4 due to changes of visibility. Thus weather is the most frequent and visibility the least frequent, cause of the change. It will be seen also that for each element improvements and deteriorations are about equally balanced.

A further question of importance is the frequency with which a flight undertaken on the basis of existing weather would not encounter conditions significantly worse than the existing conditions. The required percentage is given broadly by the sum of categories I, II, IV and the "plus" categories in category III. The total for Croydon is 91·7 per cent.

The corresponding value for Leuchars are :

	per cent.
Category I	22·7
Categories I and II	71·5
Categories I+, II+, IV+	82·9
Categories I+, II+, IV+, plus categories of III.. .. .	90·9

The chief difference between Leuchars and Croydon is the markedly higher frequency of category II and lower frequency of category IV at Leuchars. Another interesting point about the Leuchars results is the very low frequency of entries under V+ and V- in category III. On this evidence significant changes of visibility from one hour to the next are relatively rare at Leuchars.

Seasonal values.—Taking first the results for Croydon, it seems clear that there are no very marked seasonal variations in the frequencies of categories I, II and IV. The most striking differences to be seen in Table I are those relating to entries in category III. In winter the frequencies of V+ and V- are markedly higher than at other seasons, totalling 5·3 per cent. as compared with 1·4 per cent. in spring, 0·4 per cent. in summer, and 2·8 per cent. in autumn. The entries under h+ and h- and under ww+ and ww- are also highest in winter, though the seasonal differences in this case are not so marked.

These seasonal variations under category III are not so prominent in the results for Leuchars, though there is a tendency for V+ and V- to be most frequent in winter. The largest seasonal variation at Leuchars seems to occur in category I, which shows a winter maximum (as does Croydon). The seasonal range of variation is, however, small in all categories at Leuchars.

Further summaries of the seasonal results are given in Tables III and IV. Here the seasonal similarities and the similarities of the results for the two stations are more striking than the differences. The sums of categories I and II are markedly higher at Leuchars than at Croydon, and there is a slight

seasonal fluctuation with a summer maximum. The sums of I, II and IV are very similar in all seasons at both stations, and each shows a slight winter minimum. A similar remark applies to the sums of I, II, IV and the plus categories of III. The differences of these latter from 100 per cent. represent the frequencies of really serious deviations from persistence, over a period of one hour. In the worst season (winter) this frequency is about 11 per cent. at both stations.

TABLE III.—CROYDON, SEASONAL SUMMARIES (PERCENTAGES)

	Spring	Summer	Autumn	Winter	Year
Category I	24.3	25.4	24.0	27.7	25.3
Categories I+II	58.8	62.5	56.1	54.4	57.9
Categories I+II+IV	86.9	87.8	83.4	77.8	83.9
Categories I+II+IV+ plus categories of III	93.2	93.6	91.4	88.5	91.7

TABLE IV.—LEUCHARS, SEASONAL SUMMARIES (PERCENTAGES)

	Spring	Summer	Autumn	Winter	Year
Category I	21.7	21.6	19.5	28.1	22.7
Categories I+II	69.8	74.3	71.2	70.8	71.5
Categories I+II+IV	84.1	83.6	83.1	80.9	82.9
Categories I+II+IV+ plus categories of III	92.1	90.9	91.0	89.4	90.9

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