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METEOROLOGICAL RESEARCH COMMITTEE

LONG-RANGE FORECASTS

Note on the trial at Dunstable October 1942 to March 1943

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Outline of Method

Experimental long-range forecasts of weather have been prepared at Dunstable since October 1942 on the basis of symmetry points and pressure waves. The pressure waves are measured by harmonic analysis, which is applied to the isobars of the weather map in the manner described by Egersdörfer. This method yields a chart of the geographical distribution of the Fourier coefficients of each wave without the necessity of plotting them point by point. Symmetry points are located in pressure graphs by an arithmetical method in which an index is calculated showing the degree of symmetry, and having thus established the positions of past symmetry points an attempt is made to fix the position of a symmetry point in the immediate future by means of phase diagrams or the symmetry point slide rule. The symmetry point slide rule is used in conjunction with the results of harmonic analysis of pressure graphs. This analysis is usually performed mechanically with the harmonic analyser, or if necessary the results for the station under discussion are read off the charts which have been prepared by the synoptic graphical method of harmonic analysis.

Pressure Waves

The method of forecasting indicated in the foregoing paragraph uses pressure waves of known length, so that the fundamental interval of the harmonic analysis can be set at an approximately correct value at the commencement of the work. The pressure waves employed are those of 72 days, 36 days, 24 days, 18 days, 14.4 days and 12 days in length, while the short waves of six and eight days are also calculated separately. The 72-day wave is taken from a fundamental interval of 144 days as the second harmonic, and the waves of 36, 24, 18 and 12 days are taken from an interval of 72 days. The harmonic analysis is repeated every three days in a series of overlapping intervals, and the method eventually affords a check on the lengths assumed for the periods of the waves through the medium of phase diagrams. If therefore the existence of a 20-day wave is indicated in these results a separate 60-day interval is set up to deal with it.

Practical Difficulties

The foregoing programme has not been entirely realized in practice. The Coradi harmonic analyser, which was to have been used on the pressure graphs in connexion with the estimates of future symmetry points, exhibited serious defects of registration, and in the end it was virtually abandoned in favour of the slower but more reliable Mader machine. The scarcity of tracing cloth likewise led to the adoption of a less efficient substitute consisting of ordinary thin paper.

Throughout the trial period the aim has been to issue a fresh forecast every three days. At first however it was found very difficult to work at this pace, which would only have been possible from the outset on the occasions when a forecast by simple extrapolation was permissible; and indeed it must be conceded that a good deal of the trial period has been used up in training the staff for the particular work in hand. Whereas the pure computation of the Fourier coefficients usually proceeded according to plan the discussion of the results

and the deduction of the forecast from them took up more time than had originally been estimated. Eventually the preparation of the forecast as such was entrusted to a small section of the unit, the members of which dealt with the forecasts of pressure by symmetry points, the assessment of the tracks of pressure-difference nuclei and the forecasts of the distribution of air masses.

Smoothing

In applying harmonic analysis to the observations the original data were at first treated just as they were without smoothing. In February however the ordinates were taken as three-day means, but the amount of smoothing thus introduced was very slight, only the short waves of four days duration or less being effectively smoothed out. The question of smoothing is not at this stage a closed one, and latterly we have been inclined to follow the ideas of Vercelli on this subject. The question of smoothing is also important in the forecasts by symmetry points, and the three-day smoothing hitherto used is again felt to be inadequate, because it does not sufficiently dispose of the accidental variations and the short pressure waves which do not come within the scope of scope of symmetry.

Number and Type of Forecasts

The number of forecasts issued between October and March is 42. These forecasts were sometimes based on a process of extrapolation, but more usually on symmetry points. They contained general statements on the type of weather for the next twelve days and also included statements on the probable tracks of cyclonic disturbances and the incidence of air masses. Besides this the forecasts were illustrated by charts of isobars.

Errors of Symmetry Points

Since the charts of isobars largely depend on the accuracy of assessment of a symmetry point, the following summary of the errors in date of the symmetry points as forecast may be of interest: -

Error in date of the forecast of the symmetry point (days)	0	1	2	3	4	5	6	7	8
Number	36	56	33	32	15	15	13	20	6

The number of cases of errors exceeding eight days decreased very rapidly. Although the mean error is approximately three days the mode of the distribution of errors is one day i.e. the symmetry point was most often estimated in advance to within one day. The largest errors in symmetry point estimates occurred in the remoter parts of the map, e.g. Russia, where the observations seem to be less reliable. The period referred to in the table of symmetry point errors is November - March, 1942-43.

Tracks of Disturbance

The forecasts Nos.4 to 43 inclusive contained 48 statements about tracks of disturbances. These were examined as being equivalent to the tracks of 24-hours pressure-difference nuclei, though this is not necessarily true, and 33 of them were found to be approximately correct, i.e. 69%.

Air Mass Forecasts

The number of definite statements of air masses contained in the forecasts

was 12. The last six of these statements culminating with the cold outbreak of the 6th April all seem to have been justified in the event, and likewise two out of the first six were also apparently correct.

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Comparison of Actual and Forecast Pressures at selected stations.

Forecast and actual pressures are, throughout, 3-day means. The points selected for comparison are:-

Vestmannö	Berlin*
Archangel	Gibraltar
Röst	Horta
Kew	
Valentia	50°N.30°W

In nearly all cases the forecast pressures are 12 days ahead. This is necessary, because in many forecasts the procedure has been merely to add the forecast for the final three days to the pressure forecast. Hence only one forecast pressure is as a rule available.

Schedules 1 and 2 shew the actual and forecast pressures, for each of the stations. Schedule 3 is a frequency table shewing the combined distribution of acutal and forecast pressures. The correlation coefficient r is +.176 ±.03 *.

A correlation coefficient of unity can only be obtained if the symmetry is perfect and the positions of the symmetry points are correctly estimated. Since in practice symmetry is never perfect but departs more or less from perfection the maximum correlation coefficient to be expected in these particular forecasts with perfectly correct estimates of the positions of the symmetry points is +0.49 ± 0.03.

Finally, the distribution of differences between actual and forecast pressures may be shewn in another way,

Actual Minus Forecast	%
± 5 mbs. or less	29.0
± 10 " "	51.9
± 15 " "	70.6
± 20 " "	81.2

* "Actuals" are post-facto "estimates".

* For the individual check points the correlation coefficients are

Kew	- .25	± .09
Vestmannö	- .13	± .09
Röst	+ .21	± .09
Valentia	- .19	± .09
Berlin	+ .19	± .09
Horta	- .51	± .07
Gibraltar	- .05	± .10
50°N 30°W	-.22	± .09
Archangel	+.18	± .09