Reports

Relation of Geomagnetic Disturbances to Circulation Changes at 30,000-Foot Level

Abstract. From analyses of waves in the circulation pattern at the jet-stream level of the atmosphere during the winters of 1956–57 and 1957–58, it was found that, in comparison with other waves, those which appeared in the Alaska-Aleutian area about 3 days after a magnetic disturbance subsequently developed into large-amplitude disturbances.

In a recent review of solar-terrestrial relationships, Roberts (*1*) has emphasized the importance of corpuscular emissions from the sun as a possible factor in solar-weather relations. In the investigation discussed in this report, our solar index is the Cheltenham A-index (A_{CH}) of geomagnetic field fluctuation at Cheltenham, an index generally taken to measure the strength of solar corpuscular energy received at the earth.

A preliminary survey (*2*) of charts of the 300 mbar (30,000 ft or "jet stream") level, covering the half hemisphere from 180°W to 0°, indicated that "troughs" in the wave development at this level appeared to amplify or deepen more frequently following abrupt increases in the A_{CH} index than at other times (*3*). To test the magnitude of the change, an objective "trough index" (I_t) was developed. The trough index, which describes the amount of wave amplification by the degree of cyclonic curvature of a trough, was computed for all troughs from the day they first appeared at the western extremities of the charts—that is, north of 40°N, west of 120°W, and east of 180°W—until they dissipated or moved off the limits of the maps. The Alaska-Aleutian area is near the auroral zone, where, on the average, the maximum particle flux occurs in the high atmosphere. But that region was chosen because it marks the western limit of our maps, and we wanted to follow each eastward-moving trough as long as possible. Individual troughs exhibited varying values of I_t, depending on the large-scale features of the circulation, but at some time a maximum I_t occurred for each trough. From the distribution of all the maximum values of I_t, each trough was classified large, medium or small; these three classes were approximately equal.

"Magnetically disturbed days" ("A_{CH} key days") were chosen to include all those on which magnetic storms and magnetic disturbances described in the weekly "Preliminary Reports of Solar Activity" (*4*) occurred—days when, presumably, corpuscular clouds arrive from the sun. During the pilot-study period, from October 1956 through March 1957, an A_{CH} key day was defined as any day when the value of A_{CH} reached or exceeded 23 and had increased by a value equal to, or greater than, 12 over its value on the preceding day. During this period of time 19 key days occurred. It should be noted that the frequency distribution of the daily values of A_{CH} and I_t shows some skewness toward large values and that there is a slight autocorrelation ($\sim .2$) over intervals of a day or two.

The total number of troughs that had appeared before and after all the key days was then determined. Using this superposed epoch method, we found that, over the pilot-study period, troughs which appeared in the Alaska-Aleutian area about 3 days after an A_{CH} key day quite often developed into troughs with a large amplitude. To determine whether the association of trough development and A_{CH} key days was statistically significant, we compared the occurrence of large, medium, and small troughs with the occurrence of A_{CH} key days; this comparison is shown in Table 1. In the table we have listed troughs as "A_{CH}" if they first appeared in the Alaska-Aleutian area 3 ± 1 days after an A_{CH} key day and "no A_{CH}" if they appeared in the same area at any other time.

Application of the chi-square test to these data shows that the probability p of no association between A_{CH} and trough development is .01. Thus, the 1956–57 statistics support the hypothesis that larger troughs tend to follow magnetic disturbances.

Our analysis of trough development at the 300-mbar level during the past winter half year (1957–58) has just been completed. We followed the same procedure as that used in the pilot study. However, to remove any possible unconscious bias based on our knowledge of the occurrence of magnetic storms, the dates of first appearance of troughs in the Alaska-Aleutian area were determined from the maps by two meteorologists who had no prior knowledge of the behavior of A_{CH} over the study period.

Unlike 1956–57, this year there were very few abrupt increases or sharp, well-defined peaks of A_{CH}. The criterion used in the pilot study was met only nine times from October 1957 through March 1958. In order to include all the days on which magnetic storms had occurred during this period, the magnetic key days were chosen as those days when A_{CH} was equal to or greater than 21 and had increased at some time during the previous 3 days, by an amount equal to or greater than 10. Using this criterion, we found six additional A_{CH} key days (and six additional troughs) over the winter half year of 1957–58. This criterion, if applied to the 1956–57 data, would not change the number or dates of key days.

Table 2 shows the distribution of the three classes of troughs (large, medium, and small) in relation to A_{CH} key days. The designations of the columns and rows are the same as in Table 1. The numbers not in parenthesis were obtained by the lower-disturbance level criterion used in 1957–58, by which 15 key days

Table 1. Troughs and magnetic disturbances, 1956–57.

Troughs	A_{CH}	No A_{CH}	Total
Large	11	8	19
Medium	3	13	16
Small	4	15	19
Total	18	36	54

Table 2. Troughs and magnetic disturbances, 1957–58.

Troughs	A_{CH}	No A_{CH}	Total
Large	11(8)	11(14)	22(22)
Medium	3(1)	16(18)	19(19)
Small	3(2)	19(20)	22(22)
Total	17(11)	46(52)	63(63)

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

were obtained. The numbers in parentheses show the distribution when geomagnetic key days were chosen in exactly the same manner as they were in 1956–57. On two occasions, two troughs followed a single magnetic disturbance; this accounts for the numbers 17 and (11) shown in the totals.

Both sets of data show an association of large troughs following geomagnetic disturbances. A chi-square test of the cases selected by the "loosened" A_{CH} criterion shows that the probability, p, is slightly less than .01. The p for the 1956–57 criterion is slightly greater than .02.

The assumption of a normal distribution of the underlying population of A_{CH} and I_t values necessary for chi-square tests may be questioned, but we chose this simple test because of the obvious significance of the table.

It should also be pointed out that the theoretical frequencies shown in the A_{CH} columns in both Tables 1 and 2 are only slightly larger than the minimum of five set by Yule and Kendall (*5*). But the 1957–58 sample is independent of the pilot study, and a table combining both samples would yield theoretical cell frequencies well in excess of 10 and probability, p, of less than .001.

The pilot study had also suggested that the deepening troughs reach a maximum about 8 or 9 days after an A_{CH} key day, and that this results in a maximum length of the 30,400-ft contour between 180°W and 90°W. This is not supported by the 1957–58 data.

A third hypothesis, based on the 1956–57 sample—namely, that the large troughs follow a set pattern of development—was partly supported by this year's analysis, but the statistics would not be, by themselves, significant.

We do not offer any suggestions about the physical mechanisms which must be in effect if the statistical analyses are valid. Indeed, most numerical-dynamical investigations of the vertical propagation of disturbances from high levels to the troposphere indicate that this is a weak mechanism (*6*). Thus, even though the statistical level of significance is reasonably convincing, no real confidence can be attached to the observed relationships until the analyses have been extended further in time and over a much larger area of the earth. To do this, we plan to use similar procedures at the 500-mbar (18,000-ft) level, for which data are available for the whole Northern Hemisphere back to 1946.

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References and Notes

1. W. O. Roberts, *Bull. Am. Meteorol. Soc.* 37, No. 9 (1956).
2. D. D. Woodbridge *et al.*, "A Possible Effect in 300 mb Circulation Related to Solar Corpuscular Emission," *Inst. Solar-Terrest. Research, High Altitude Observatory, Tech. Rept. No. 3* (1957).
3. We acknowledge the assistance of the Department of Transport of Canada, which supplied the basic analyses of the 300-mbar data, and we wish to thank Robert F. Brun and Sylvia Moscove for their work in determining the dates of origin and the types of troughs.
4. "Preliminary Reports of Solar Activity" is published weekly by the High Altitude Observatory, Boulder, Colo., with the support of the Boulder Laboratories of the National Bureau of Standards and the Air Force Cambridge Research Center.
5. G. U. Yule and M. G. Kendall, *An Introduction to the Theory of Statistics* (Guffin, London, ed. 13, 1945).
6. J. Spar, "Meteorological Models for the Study of Atmospheric Responses to Anomalous Solar Emissions," *Inst. Solar-Terrest. Research, High Altitude Observatory, Tech. Rept. No. 5* (1958).

12 September 1958

Tenderness, Climate, and Citrus Fruit

Abstract. Tenderness of coastal-grown citrus fruit to fumigation, spray, and storage practices, and to frost, as compared with fruit grown in the drier interior districts of southern California, is correlated with lower puncture-pressures and higher moisture content of peel. The hardening effect of moisture stress is also exhibited by fruit from tree tops.

It has been common horticultural experience that plants grown in submaximum light intensities and near maximum soil moisture (mesophytic habitat) are more tender than those grown in maximum light intensity and low soil moisture (xerophytic habitat). This concept of tenderness is associated with the succulence and edible quality of vegetables, but plants grown in mesophytic habitats cannot be transferred abruptly to xerophytic habitats without severe injury. Plants known to be sensitive to low temperatures may be made more resistant or "hardened" by exposure to short periods of sub-low temperatures. Tenderness in these cases has generally been associated with high moisture content.

Maximov (*1*) reviewed evidence showing the responses of leaf structure to xerophytic conditions. These responses were smaller leaf area, thicker leaves, thicker cuticles, epidermal layers, and greater palisade development. Cellular responses were those that might be associated with a lower moisture content—that is, smaller cells and thicker cell walls. Leaves appear to be the organs most sensitive to water supply and insolation and, because of their relatively simple structure, are more readily studied than other organs. But the few studies on other plant organs have not been definitive. This has been a result of the complexity of fibers, vessels, collenchyma, epidermis, and so forth, and of their cellular organization as well.

A greater sensitivity of citrus fruit grown in coastal locations in southern California to fumigation with hydrocyanic acid and to damage from oil spray (*2*) has also been referred to as tenderness. Also, it has been shown that coastal fruit keep in storage for a shorter period than fruit from the interior (*3*). Careful observers have noted also that coastal fruit freeze at higher temperatures than those growing in the desert.

A study has been recently completed in which the peels of four varieties of mature citrus fruit from four climatic districts in southern California were examined for moisture content and tenderness, as measured by the puncture-pressure of the peel. As many of the variables as possible were put under control before the fruit was randomly picked. The population was defined as (i) four varieties, (ii) two rootstocks, (iii) four climatic districts further defined by mean daily air temperature and evaporation, (iv) mature fruit, (v) without surface scars, (vi) one season, (vii) eight positions on the tree (0.5 to 6 ft high, N-S-E-W, and 6 to 30 ft high, N-S-E-W), (viii) shaded fruit, (ix) midway between irrigations, (x) commercially productive grove or equivalent, (xi) without bruises, (xii) controlled nonexperimental water loss, (xiii) moisture variation within individual fruits, (xiv) noninterplanted, (xv) nonshaded, (xvi) afternoon samples, (xvii) uniform tree spacing, (xviii) clear, quiet weather.

Five fruits were picked from low on the tree and five fruits were picked from high on the tree, at random, from each of five distantly spaced trees randomly

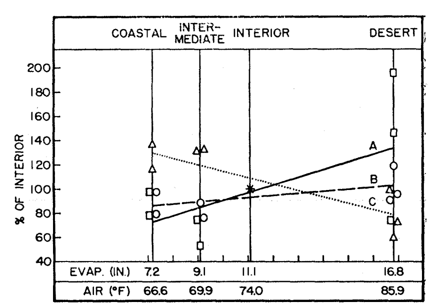

Fig. 1. Regression lines for four varieties of citrus fruit. *A*, puncture-pressures of peels; *B*, dry matter per unit volume of fresh peels; *C*, percentage of moisture in peels of whole fruit, plotted as percentage of the interior against mean daily air temperature and total evaporation for June, July, August, and September of 1955 for four climatic districts in southern California (*4*). Squares represent puncture-pressure; circles, dry matter per unit volume of fresh peel; triangles, percentage of moisture.