

26 March 1953

SOLAR RESEARCH MEMORANDUM

FROM: Dorothy E. Trotter and Walter Orr Roberts

SUBJECT: Possible Test of Response of Atmosphere to Solar Corpuscular Streams.

I. Introduction.

Some time ago W. O. Roberts suggested to Dr. H. C. Willett and others the possibility of a check on the relative roles played by corpuscular invasions from the sun and by ultraviolet irradiation of the upper atmosphere. 1) The suggestion was as follows:

At times of great solar activity (major sunspot maxima) there are frequent large changes in solar radiation in the short-wave region of the spectrum, in all probability, as evidenced by SIDs and the accompanying solar flares. The changes in radiation are sudden and violent. These are generally followed some time later (on the average about 26 hours) by corpuscular showers showing in high latitudes as aurorae and resulting in magnetic disturbances.

At times of lesser solar activity, and particularly during the few years just after sunspot maximum, leading down approximately to sunspot minimum, we find that there are pronounced recurrences in geomagnetic disturbances, particularly those of moderate magnitude. Bartels designated the hypothetical solar regions responsible for these as "M-regions". 2)

Referring to the work of Willett, 3) Roberts then called attention to the fact that the most pronounced M-region effects in geomagnetism occur in the years when Willett expects the zonal high-index pattern in atmospheric circulation, suggesting a cause-effect relationship.

Thus, if there is a specific change towards the zonal high-index pattern at times of corpuscular showers, there should be a reflection of this in atmospheric pressures in high latitude stations at just the times when M-regions are present. Roberts then proposed selection from geomagnetic records of all periods of pronounced M-regions of the past 50 years, and the subsequent subsection of the selected station

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- 1) See W. O. Roberts, Report to Trans World Airlines on Research Program of High Altitude Observatory, 18 October 1952.
 - 2) Bartels, Terr. Magn. 39, 201 (1934).
 - 3) H.C. Willett, "Atmospheric and Oceanic Circulation as a Factor in Glacial-Interglacial Changes of Climate" presented at the Symposium of Climatic Change of the American Academy of Arts and Sciences, May 9-10, 1952. To be published by the Academy with other Symposium papers.

barometric pressures for these times to a sensitive statistical analysis (perhaps of the Chree type) designed to uncover evidences of a 27-day (solar rotation) period of recurrence in the barometric pressures. Establishment of the recurrence would be a strong corroborative link in the theory of corpuscular origin of the zonal high-index pattern.

This Research Memorandum contains a compilation by Miss Trotter of a list of the principal geomagnetic storms regarded by her as storms of M-region character during the period from January 1906 through December 1952. It should be profitable to study whether there is any evidence of 27-day recurrence in barometric pressures from appropriate stations at the times of the more pronounced of the geomagnetic disturbance theories listed in this report.

II. List of Geomagnetic Storms of M-region Character.

We list below geomagnetic storms showing M-region characteristics: namely, a strong tendency to recur at 27-day intervals. This recurrence tendency is generally confined to intervals of declining post-maximum sunspot activity. In a few cases in the list below, Bartels or Newton was the authority for designating a storm region as an M-region type. But in most cases the designation was made by Miss Trotter.

All the dates and numbers of rotations given are approximate. Dates refer to the center of the magnetic disturbance. In all cases selections were made from Bartels' diagrams of geomagnetic activity. The first 14 storm-sequences came from charts of the international magnetic character figure, C. The remainder of the sequences were made from charts of the planetary index K_p , an index presumably more closely tied than the other to corpuscular effects on geomagnetism.

All periods from January 1906 through December 1952 were included. It may be possible later to secure records going back to 1874, if it proves desirable to expand the present list. Sources of basic observational material were the following:

- Sequences 1 - 10: Bartels, Terr. Magn. 37, 1, (1932)
- 11 - 14: Bartels, Terr. Magn. 32, 201, (1934)
- 15 - 16: Geomagnetic Indices K and C 1949, IATME Bulletin 12c.
- 17 - 21: Bartels monthly charts of geomagnetic activity
based on K_p values (on file in HAO library).

The tabulation follows, with remarks regarding the character of the recurrent series of magnetic disturbances.

Geomagnetic
(Dates and

	Start	Center	End
1.	11 Dec. 1907	23 May 1908	31 Oct. 1908
2.	24 July 1908	8 Nov. 1908	28 Jan. 1909
3.	13 May 1910	30 Aug. 1910	16 Dec. 1910
4.	24 July 1910	2 Jan. 1911	13 June 1911
5.	3 June 1911	21 Sep. 1911	11 Dec. 1911
6.	22 Aug. 1912	7 Dec. 1912	26 Feb. 1913
7.	2 July 1918	10 Dec. 1918	22 May 1919
8.	13 Dec. 1921	18 June 1922	30 Nov. 1922
9.	30 Jan. 1923	22 Apr. 1923	11 July 1923
10.	9 Dec. 1929	7 Aug. 1930	14 Feb. 1931
11.	13 Feb. 1930	2 June 1930	15 Oct. 1930
12.	26 June 1931	24 Jan. 1932	14 Dec. 1932
13.	25 Aug. 1931	2 Mar. 1932	9 Sep. 1932
14.	22 Jan. 1933	19 Apr. 1933	5 Aug. 1933

Storms of M-region Character
(rotations are approximate)

# of Rotations	Remarks
13	Moderate storms of few days duration.
8	The disturbances stand out strongly from adjoining quiet days.
9	<u>Dubious.</u> 27-day recurrence evident, but disturbances not clearly marked.
13	Designated by Bartels. Lengthy moderate storms.
8	Storms sharply distinguished from quiet days on both sides.
8	<u>Dubious.</u> Average length of storms about two days.
13	Storms last five to six days.
15	Designated by Bartels. Moderate storms lasting 8 - 10 days. Trotter feels the sequence lasted a couple more cycles.
7	Designated by Bartels. Storms in this sequence stand out distinctly from adjoining very quiet days.
17	Designated by Bartels. Very distinct from other magnetic activity especially in later rotations. Two weeks of quiet conditions between the disturbances of sequences 10 and 11.
10	See above
20	Bartels designation. Storms last about 6 days.
15	<u>Dubious.</u> Prolonged storms of 8 to 10 days, but only a day or so of quiet conditions between the disturbances of sequences 12 and 13.
8	quiet conditions exist on both sides of the disturbances of this sequence. First two storms severe. Possibly sequence lasts a few more cycles.

	Start	Center	End	# Rotations	Remarks
15.	10 Aug. 1942	29 Oct. 1942	21 Dec. 1942	6	<u>Dubious.</u> Quiet conditions on both sides of storms.
16.	4 July 1943	30 Aug. 1943	4 Mar. 1944	10	Moderate storms of 5-6 days duration.
17.	7 Aug. 1950	2 Oct. 1950	22 Dec. 1950	7	Newton calls this "a marked 27-day sequence of small geomagnetic storms." (Observatory 71, 45-47.) November passage associated with extended interference on long-distance radio transmission resulting in serious dislocation and delay in commercial and press communications.
18	25 Aug. 1951	16 Oct. 1951	5 Jan. 1952	6	Newton says sequence from 19 Sep. to 16 Nov. (Observatory, 72, 45.)
19.	23 Feb. 1951		20 Apr. 1951	3	<u>Very dubious.</u>
20.	16 July 1951		6 Oct. 1951	4	<u>Very dubious.</u> Newton says there were two sequences in 1951. No. 18 seems clear. This one far less.
21.	10 Jan. 1952		28 Apr. 1952	5	Designated by Newton. The May passage could be added. All rotations noted by Newton associated with poor reception on long-distance radio channels, especially those directed near auroral zones.

The following show a 27-day recurrence, but they are not clearly distinguishable from other magnetic activity, and thus should probably be excluded from a barometric pressure analysis of the type suggested.

22.	11 Feb. 1906		12 Sep. 1906	10	Two to three days duration: C figure below 1.0 on some.
23.	23 Aug. 1912		23 Feb. 1913	8	About two day duration. Slightly disturbed.
24.	5 July 1915		12 Jan. 1916	8	Quite disturbed particularly in last few rotations.
25.	5 Feb. 1916		17 July 1916	7	
26.	10 Sep. 1916		20 Feb. 1917	7	
27.	16 Feb. 1924		19 June 1924	6	Three to four days duration. Slight to great disturbance.
28.	14 Aug. 1929		5 Nov. 1929	4	

One other storm series came to our attention, but outside only pronounced recurrent series of N-region type, however

	Start	End	# of Rotations
29.	22 June 1886	20 Feb. 1887	10

END

the range of dates systematically covered; This is the
, in the years 1884-1889.

Remarks

Moderate storms with low activity on adjoining days.
Source: Terrestrial Magnetism and Atmospheric
Electricity, 52, 33, "Daily International Magnetic
Character Figures, C, for Years 1884-1889". Table
published by Bartels.