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Criteria for Ionospheric Storminess.

The object of this report is to give a general description of the characteristics of ionosphere storms, and of the criteria that are used at the IRPL for determining the relative ionospheric storminess at Washington. It is intended for use as a guide by other ionosphere stations in devising methods for determining and expressing relative storminess at their locations.

An ionosphere storm is a world-wide disturbance of the ionosphere, of maximum intensity in the auroral zones and decreasing toward the poles and equator, manifested by abnormalities, sometimes extreme, in critical frequencies, virtual heights, ionospheric absorption and, in general, in the distribution of ionization density with height. An ionosphere storm is also generally accompanied by geomagnetic disturbance. The characteristics of a storm are so pronounced in the auroral zones that the occurrence of even relatively small storms is unmistakable. At places far removed from the auroral zones, say 40° or more from the zones, ionosphere storms of any but the greatest severity may show no effect whatever, although there are in general fairly large and probably localized day-to-day variations in critical frequencies, virtual heights, and absorption. At places within 30° or less of the auroral zones ionosphere storms usually show definite effects, but these may often be of the same magnitude as localized day-to-day variations in the ionosphere characteristics.

Consequently, for stations other than those within a few degrees of the auroral zones, it is often impossible to say, from observations at a single station, whether a world-wide ionosphere storm is in progress or merely local abnormalities are being observed. To resolve this doubt, supplementary information, such as ionospheric data or geomagnetic data from other locations, is necessary.

As a guide to aid ionospheric observers in identifying storms, or in setting up a procedure appropriate to their locations for identifying storms, the following is the method now in use at the Interservice Radio Propagation Laboratory, Washington, D.C. This procedure is probably only valid for locations of approximately the same geomagnetic and geographic latitude as Washington; elsewhere the predominant characteristics of an ionosphere storm may be quite different, so that different standards will have to be set up. For example, one of the characteristics of a storm in the auroral zone appears to be the occurrence of much sporadic-E layer, especially at night; at Washington, however, sporadic-E layer is generally less prevalent during ionosphere storms than at other times.

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The most weight is given, at Washington, to the deviation from normal of the critical frequency and virtual height of the FF_2 layer. Five-hour averages of the heights and critical frequencies of the night-F and daytime-F_2 layers, centered around 0600 and 1800 GCT, respectively, are calculated, and 31-day running averages of these are also calculated. The ratio of the daily average of each characteristic to its 31-day running average as of the same day is calculated, and a character figure (a preliminary "I" figure) is assigned according to the following table:

I figure	F Layer (0400-0800 GCT)		F_2 Layer (1600-2000 GCT)	
	Virtual height ratio	Critical frequency ratio	Virtual height ratio	Critical frequency ratio
9	>1.70	<0.17	>2.44	<0.26
8	1.57-1.69	0.18-0.32	1.85-2.43	0.25-0.44
7	1.41-1.56	0.33-0.48	1.47-1.84	0.45-0.59
6	1.30-1.40	0.49-0.61	1.26-1.46	0.60-0.71
5	1.21-1.29	0.62-0.74	1.13-1.25	0.72-0.78
4	1.12-1.20	0.75-0.85	1.06-1.12	0.79-0.88
3	1.05-1.11	0.86-0.94	1.02-1.05	0.89-0.94
2	0.99-1.04	0.95-1.07	0.96-1.01	0.95-1.01
1	0.92-0.98	1.08-1.33	0.97-0.95	1.02-1.07
0	0.88-0.91	1.34-1.38	0.95-0.96	1.08-1.11
1	0.86-0.87	1.39-1.42	0.92-0.94	1.12-1.13
2	0.84-0.85	1.43-1.45	0.88-0.91	1.14-1.15
3	0.82-0.83	1.46-1.47	0.83-0.87	1.16-1.18
4	<0.81	>1.48	<0.84	>1.19

The two night figures are averaged to give a "night I figure" and similarly for the two day figures. These class intervals were set up to provide the same type of frequency distribution of I figures as of K figures. After using this procedure for some time it was found that an I figure of 4 corresponded to approximately the minimum degree of disturbance that experience showed as indicating a storm. This preliminary I figure is, however, not an infallible storm indicator, for frequently the I figure may be only 2 or 3 when a world-wide storm is unmistakably in progress, while an I figure of 4 or 5 sometimes occurs when no world-wide storm is in progress.

There are several other indications of ionospheric storminess which are not as susceptible to statistical treatment and therefore cannot be easily handled objectively. These include general characteristics of the multifrequency (h'f) records as follows, and are best evaluated through comparison by an experienced observer with normal records.

a. Ionosphere storms are often characterized by rapid fluctuations in heights and critical frequencies; normal days are apt to show less rapid hour-to-hour variations.

b. During severe storms the F_1-layer critical frequencies are often lower than normal.

c. Diffuse scattered reflections (spread echoes) are often observed during disturbed periods, perhaps indicating an instability of some kind in the ionosphere. The F_2-layer critical frequencies, under these conditions, are not well defined. In summer, this effect seems to go with storminess; in winter it is doubtful.

d. The general appearance of the h'-f records is also considered. Unusual shapes of the traces on the records may often occur at times of disturbance.

Finally, the preliminary I-figures are adjusted insofar as the degree of disturbance appears to be greater or less than that indicated at first, and the times of beginning and ending of the disturbances are obtained by an experienced observer as indicated by the times when the various characteristics depart from or return to normal. The geomagnetic K-figures are taken account of in this process as an indication of whether there is a world-wide storm or merely a local abnormality.