

DESCRIPTIVE TEXT
AND
INDEX
FOR
CRPL-F PART B
SOLAR - GEOPHYSICAL DATA

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U. S. DEPARTMENT OF COMMERCE
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CENTRAL RADIO PROPAGATION LABORATORY
BOULDER, COLORADO

SOLAR - GEOPHYSICAL DATA

INTRODUCTION

This pamphlet describes the data published in the monthly CRPL-F Part B report series which are intended to keep research workers abreast of the major particulars of solar activity and the associated ionospheric, radio propagation and other geophysical effects. It is made possible through the cooperation of many observatories, laboratories and agencies as recorded in the detailed description of the tables and graphs which follow. The report is prepared in the Radio Warning Services Section, edited by Miss J. V. Lincoln. These reports should not be considered as definitive publications because of the rapid publication schedule involved. Errata are included from time to time. Additions to the descriptive text will appear with the data when new material is added or revision is made.

I DAILY SOLAR INDICES

Relative Sunspot Numbers -- The table includes (1) the daily American relative sunspot numbers, R_A' as compiled by Sarah J. Hill, Wellesley College, Wellesley, Massachusetts; for the Solar Division of the American Association of Variable Star Observers, and (2) the provisional daily Zurich relative sunspot numbers, R_Z , as communicated by M. Waldmeier of the Swiss Federal Observatory. Because of the time required to collect and reduce the observations, R_A' will appear one month later than R_Z .

The relative sunspot number is an index of the activity of the entire visible disk. It is determined each day without reference to preceding days. Each isolated cluster of sunspots is termed a sunspot group and it may consist of one or a large number of distinct spots whose size can range from 10 or more square degrees of the solar surface down to the limit of resolution (e.g. $1/8$ square degrees). The relative sunspot number is defined as $R=K(10g+s)$, where g is the number of sunspot groups and s is the total number of distinct spots. The scale factor K (usually less than unity) depends on the observer and is intended to effect the conversion to the scale originated by Wolf. The observations for sunspot numbers are made by a rather small group of extraordinarily faithful observers, many of them amateurs, each with many years of experience. The counts are made visually with small, suitably protected telescopes.

Final values of R_Z appear in the IAU Quarterly Bulletin on Solar Activity, the Journal of Geophysical Research, these reports, and

elsewhere. They usually differ slightly from the provisional values. The American numbers, R_A° , are not revised.

Solar Flux Values, 2800 Mc -- The table also lists the daily values of solar flux at 2800 Mc recorded in watts/m²/cycle/second bandwidth ($\times 10^{-22}$) in two polarizations by A. E. Covington of the National Research Council at Ottawa, Canada. These solar radio noise indices are being published in accordance with CCIR Report 162 as a basic index for ionospheric propagation which can be observed objectively and is related to the main ionizing photon radiation which is responsible for the normal E and F layers and which determines ionospheric frequencies during undisturbed conditions.

Graph of Sunspot Cycle -- The graph illustrates the recent trend of Cycle 19 of the 11-year sunspot cycle and some predictions of the future level of activity. The customary "12-month" smoothed index, R , is used throughout, the data being final R_z numbers except for the current year. Predictions shown are those made for one year after the latest available datum by the method of A. G. McNish and J. V. Lincoln (Trans. Am. Geophys. Union, 30, 673-685, 1949) modified by the use of regression coefficients and mean cycle values recomputed for Cycles 8 through 18. Cycle 19 began April 1954, when the minimum \bar{R} of 3.4 was reached. Tabular values of the smoothed index, R , appear regularly in the CRPL-F Part A "Ionospheric Data" reports and are available upon request.

II SOLAR CENTERS OF ACTIVITY

Calcium Plage and Sunspot Regions -- The table gives particulars of the centers of activity visible on the solar disk during the preceding month. These are based on estimates made and reported on the day of observation and are therefore of limited reliability.

The table gives the heliographic coordinates of each center (taken as the calcium plage unless two or more significantly and individually active sunspot groups are included in an extended plage) in terms of the Greenwich date of passage of the sun's central meridian (CMP) and the latitude; the serial number of the plage as assigned by McMath-Hulbert Observatory; the serial number of the center in the previous solar rotation, if it is a persisting region; particulars of the plage at CMP: area, central intensity; a summary of the development of the plage during the current transit of the disk, where b = born on disk, l = passed to or from invisible hemisphere, d = died on disk, and / = increasing, - = stable, \ = decreasing; and age in solar rotations; particulars of the associated sunspot group, if any, at CMP: area and spot count and the summary of development during the current disk transit, similar to the above. The unit of area is a millionth of the area of a solar hemisphere; the central intensity of the calcium plages

is roughly estimated on a scale of 1 = faint to 5 = very bright.

Calcium plage data are available through the cooperation of the McMath-Hulbert Observatory of the University of Michigan. The sunspot data are compiled from reports from the U.S. Naval Observatory, and from reports from Europe and Japan received through the daily URSIgram messages.

Coronal Line Emission Indices -- In the table entitled Provisional Coronal Line Emission Indices are summarized emission intensity indices for the green (Fe XIV at $\lambda 5303$) and red (Fe X at $\lambda 6374$) coronal lines. The indices are based on measurements made at 5° intervals around the periphery of the solar disk by the High Altitude Observatory at Climax, Colorado, and by Harvard University observers at Sacramento Peak (The USAF Sacramento Peak Observatory at Sunspot, New Mexico, under contract AF 19(604)-146). The measurements are expressed as the number of millionths of an Angstrom of the continuum of the center of the solar disk (at the same wavelength as the line) that would contain the same energy as the observed coronal line. The indices have the following meanings:

G_6 = mean of six highest line intensities in quadrant for $\lambda 5303$.

R_6 = same for $\lambda 6374$.

G_1 = highest value of intensity in quadrant, for $\lambda 5303$.

R_1 = same for $\lambda 6374$.

The dates given in the table correspond to the approximate time of CMP of the longitude zone represented by the indices. The actual observations were made for the North East and South East quadrants 7 days before; for the South West and North West quadrants 7 days after the CMP date given.

Once every three months Final Coronal Line Emission Indices are printed. These tables contain data from Pic du Midi and Kislovodsk as well as Sacramento Peak and Climax. The indices are computed in the same manner as for the provisional table.

To obtain rough measures of the integrated emission of the entire solar disk in either of the lines, assuming the coronal changes to be small in a half solar rotation, it is satisfactory to perform the following type of summation given in example for 15 October:

$$\left(\text{MEAN DISK EMISSION} \right)_{\text{IN } \lambda 5303} \Big|_{15 \text{ OCT}} = \frac{1}{N} \left[\sum_{15 \text{ OCT}}^{22 \text{ OCT}} \left\{ (G_6)_{\text{NE}} + (G_6)_{\text{SE}} \right\} + \sum_{8 \text{ OCT}}^{14 \text{ OCT}} \left\{ (G_6)_{\text{SW}} + (G_6)_{\text{NW}} \right\} \right]$$

where N is the number of indices entering the summation.

Such integrated disk indices as well as integrated whole-sun indices are computed for each day and are published quarterly in the "Solar Activity Summary" issued by the High Altitude Observatory at Boulder, Colorado. In the same reports are given maps of the intensity distribution of coronal emission derived from all available Climax and Sacramento Peak observations, as well as other information on solar activity, such as maps made from daily limb prominence surveys in $H\alpha$ and notes regarding the history of active regions on the solar disk.

Preliminary summaries of solar activity, prepared on a fast schedule, are issued Friday of each week from High Altitude Observatory in conjunction with CRPL and include solar activity through the preceding day. These are useful to groups needing information on the current status of activity on the visible solar disk, but are not recommended for research uses unless such a prompt schedule of reporting is essential. The same information is included in the subsequent quarterly reports, with extensive additions, corrections and evaluations.

Notes: From calibrations in February - March 1960 it was determined that all intensities from the Climax and Sacramento Peak Observatories during the years 1956 - 1959, inclusive, if multiplied by the factor 0.60, will be expressed in millionths of equivalent Angstroms to a somewhat lower precision. Intensities prior to 1956 cannot be compared precisely with those obtained later because of changes in observing and reduction techniques. They may be converted roughly to millionths of equivalent Angstroms by the use of the table given by Billings and Varsavsky, 1955, Zs.f. Ap. 38, 160. In F185B several corrections were made to October and November 1959 coronal line emission indices published in F183B and F184B, respectively.

III SOLAR FLARES

Optical Observations -- The table presents the preliminary record of solar flares as reported to the CRPL on a rapid schedule at the sacrifice of detailed accuracy. Definitive and complete data are published later in the Quarterly Bulletin on Solar Activity, I.A.U., in

various observatory publications and elsewhere. The present listing serves to identify and roughly describe the phenomena observed.

Reporting directly to the CRPL are the following observatories: McMath-Hulbert, Wendelstein, Sacramento Peak, Lockheed and Swedish Astrophysical Station on Capri. The remainder report through the URSIgram centers or are available through the IGY World Data Center-A for Solar Activity, High Altitude Observatory, Boulder, Colorado. Observations are made in the light of the center of the H-alpha line unless noted otherwise. The reports from Sacramento Peak, New Mexico (communicated to CRPL by the High Altitude Observatory at Boulder), are from observations at the USAF Sacramento Peak Observatory at Sunspot, New Mexico, by Harvard University observers, under contract AF 19 (604)-4961.

For each flare are listed the reporting observatory, the date, beginning and ending times, time of maximum phase, the heliographic coordinates in degrees, McMath serial number of the region, duration, the flare importance on the IAU scale of 1- to 3+, observing conditions where 1 means poor, 2 fair and 3 good, time of measurement for tabulated width of H α or tabulated area, measured (i.e. projected) maximum area in square degrees, corrected maximum area in square degrees (which equals measured area times secant h where h is the heliocentric angle), maximum effective line-width in H α expressed in Angstroms, and maximum intensity of H α expressed in per cent of the continuous spectrum. The following symbols are used in the table:

D = Greater than	U = Approximate
E = Less than	□ = Not reported

In older lists G = Plus

A final column lists provisionally the occurrence of simultaneous ionospheric effects as observed on selected field-strength recordings of distant high-frequency radio transmissions; a more nearly definitive list of these ionospheric effects, including particulars, appears in these reports after the lapse of a month (see below). All times are Universal Time (UT or GCT). Subflares (importance 1-) are listed by date, time of beginning and their heliographic coordinates. Only subflares received within two months after observation are listed. However, reports of all subflares, in the same detail as for flares of importance one or greater, are available on IBM punch cards. A graph presents intervals for which there were no patrols for flare observations from the observatories whose complete data are published in the table.

Notes: All the flare data are recorded on IBM punch cards. As errata are received the punch cards are corrected. These errata are

not always published in these reports. Copies of the cards or tabulations from them are available at cost through the IGY World Data Center A for Ionosphere and Airglow, CRPL, National Bureau of Standards, Boulder, Colorado, U.S.A.

Major errors have occurred in the area listing in these reports for the Russian flares until 1960 data. We at NBS misunderstood some of the original entries. The Simeiz flares in F156B, for example, were for June 1957, not July 1957. Revised flare lists, as well, have been received for IGY-IGC flares from the following observatories: Abastumani, Alma-Ata, Moscow Gaish, Kiev University, Pirculi, Simeiz, Tashkent, and Voroshilov.

The flare position reports from Hawaii have been corrected from February 1960 through August 3, 1960. The period September 1959 - January 1960 is to be analyzed for possible errors. The measured and corrected areas for flares from Hawaii as published for July 1957 through November 1959 should be divided by two to make the entries correct.

The flares incorrectly labelled "Boulder" in F178B and F179B are those for R. O. Herst (Greenwich Royal Observatory, Herstmonceux). As stated above the corrected data are available on IBM punch cards.

Beginning October 1, 1960 the following U. S. observatories: Climax, Hawaii, Lockheed and Sacramento Peak, are reporting maximum area in square degrees corrected according to a method proposed by C. S. Warwick of the National Bureau of Standards. These observatories are now basing their flare importances on this corrected area in accordance with IAU rules. Previously they had based their importances on the measured areas. The formula being used is:

$$\text{Corrected area} = \frac{\text{measured area}}{\cos \phi + 0.2 \sin \phi} \text{ where } \phi \text{ is the central}$$

distance. This factor represents the variation in apparent area that depends only on central distance, and avoids an infinity at the limb.

Ionospheric Effects -- SID, sudden ionospheric disturbance (and GID--gradual ionospheric disturbance) may be detected in a number of ways: short wave fadeouts (SWF), enhancement of low frequency atmospherics (SEA), increases in cosmic absorption (SCNA), sudden phase anomalies at VLF (SPA) and sudden signal enhancements at VLF (SES).

A table lists SWF events that have been recognized on field-strength recordings of distant high-frequency radio transmissions. Under a coordinated program, the staffs at the following ionospheric sounding stations contribute reports that are screened and synthesized

at CRPL-Boulder: Puerto Rico, Ft. Belvoir, Va., Boulder, Colo., and Anchorage, Alaska (CRPL Stations: PR, BE, BO, AN); Huancayo, Peru (CRPL-Associated Laboratory: HU); and Ft. Monmouth, N. J., White Sands, N. Mex., Adak, Alaska, and Okinawa (U.S. Signal Corps Stations: FM, WS, AD, OK). McMath-Hulbert Observatory (MC) also contributes such reports. In addition, reports are volunteered by RCA Communications Inc., Marconi Wireless, Netherlands Postal and Telecommunications Services, Swedish Telecommunications, New Zealand Post and Telegraph Department and others; these usually specify times of SWF and the radio paths involved. Through the URSIgrams, reports are available from still other stations as given monthly in the footnotes.

In the coordinated program, the abnormal fades of field strength not obviously ascribable to other causes, are described as short wave fadeouts with the following further classification:

- S-SWF: sudden drop-out and gradual recovery
- Slow S-SWF: drop-out taking 5 to 15 minutes and gradual recovery
- G-SWF: gradual disturbance; fade irregular in either drop-out or recovery or both.

When there is agreement among the various reporting stations on the time (UT) of an event, it is accepted as a widespread phenomenon and listed in the table.

The degree of confidence in identifying the event, a subjective estimate, is reported by the stations and this is summarized in an index of certainty that the event is widespread, ranging from 1 (possible) to 5 (definite). The times given in the table for the event are from the report of a station (underlined in table) that identified it with high confidence. The criteria for the subjective importance rating assigned by each station on a scale of 1- to 3+ include amplitude of the fade, duration and confidence; greater consideration is given to reports on paths near the subsolar point in arriving at the summary importance rating given in the table.

Note: The tables of SID observed at Washington included in CRPL F-reports prior to F-135 were restricted to events classed here as S-SWF.

A second table lists sudden ionospheric disturbances which have been recognized on recorders for detecting cosmic absorption at about 18 Mc (SCNA) or on recorders for detecting enhancements of low frequency atmospherics at about 27 kc (SEA) together with solar radio bursts at 18 Mc as identified on the SCNA records.

Reports are received either directly or through the IGY World Data Center A for Solar Activity at the High Altitude Observatory, Boulder, Colo. The following observatories report SCNA: Rensselaer Polytechnic

Institute Observatory, Grafton, N. Y. (RE); McMath-Hulbert Observatory (MC); Sacramento Peak, N. Mex. (SP); High Altitude Observatory, Boulder, Colo. (BO); University of Hawaii, Makapuu Pt., Hawaii (HA). All of these also report solar noise bursts observed at 18 Mc. The SEA reports come from the following: Dunsink Observatory, Ireland (DU); three stations operated by the Netherlands PTT at Hollandia, Dutch West Indies (HO), Nederhorst den Berg, Netherland (NE), and Paramaribo, New Guinea (PA); Panska Ves Observatory near Prague, Czech. (PU); High Altitude Observatory, Boulder, Colo. (BO); Sacramento Peak, N. Mex. (SP); McMath-Hulbert Observatory (MC); University of Hawaii (HA); Neustrelitz (NU); Kuhlungsborn (KU); and a group of American Association of Variable Star Observers located at Brooklyn, N. Y. (A1), Pittsburgh, Pa. (A2), Paterson, N. J. (A3), Powell, Ohio (A4), Ramsey, N. J. (A5), Oshkosh, Wis. (A6), China Lake, Calif. (A7), Manhattan, Kansas (A8), Oakland, Calif. (A9), Blauvelt, N. Y. (A10), Manila, Philippines (A11) and Addis Ababa, Ethiopia (A12).

These reports are coordinated at CRPL-Boulder. When there is agreement among the various reporting stations on the time (UT) of an event, it is accepted as a widespread phenomenon and listed in the table. Some phenomena are listed, if noted at only one location, if there has been a flare or another type of flare-associated effect reported for that time.

In the table under the type of event the importance of the event is given on a scale of 1 minus to 3 plus. Next there is the index of widespread certainty ranging from 1 (possible) to 5 (definite). The time of beginning, maximum and end of the event in UT is given as reported by the station underlined in the group of observing stations. If the event is an SCNA, a percent absorption figure is given. This absorption is calculated by the formula:

$$\text{SCNA \%} = \frac{I_n - I_f}{I_n} \times 100$$

where I_n = noise diode current required to give a recorder deflection equal to that which would have occurred in the absence of a flare, i.e. a value extrapolated from cosmic noise level trend before and after a flare. The previous day's record may be considered if necessary.

and I_f = noise diode current required to give a recorder deflection equal to the level at the time of maximum absorption.

IV SOLAR RADIO WAVES

2800 Mc Observations

The data on solar radio wave events made in Ottawa, Canada, by the Radio and Electrical Engineering Division of the National Research Council (A.E. Covington) at 2800 Mc (10-cm emission) are presented. Near local noon (about 1700 UT) the sensitivity of the radiometer is determined and a mean flux for the whole day calculated. These values are given in a tabular form (see table I-1) in units of 10^{-22} watts/m²/c/s. Burst phenomena are measured above this level and are given in terms especially suitable for the variations observed on this frequency. The basis for the classifications is described by Covington-J. R. Astro. Soc. Can. 45, 1951 and Dodson, Hedeman and Covington, Ap. J. 119, 541, 1954. A modification in terminology with a view to simplification has been introduced and consists essentially of the omission of the descriptive word "Single" from the "Single-Simple" and "Single-Complex" classes; in designating the "Single", "Single-Simple" and "Rise and Fall" bursts into a single classification designated as "Simple Bursts" with an appropriate type number; in the addition of the letter "f" to indicate that the burst deviates from the basic pattern by the presence of one or more small fluctuations in intensity; and by the addition of the letter "A" to indicate that the event has another smaller duration event superimposed upon it.

Simple Burst

Any single burst which rises to one maximum and then decreases to the pre-burst level.

1 - Simple 1 -- Simple burst, type 1 (formerly "single").
Bursts of intensity less than 7 1/2 flux units and duration less than 7 1/2 minutes.

2 - Simple 2 -- Simple burst, type 2 (formerly "single-simple").
Bursts of impulsive nature with intensity greater than 7 1/2 flux units.

3 - Simple 3 -- Simple burst, type 3 (formerly "rise and fall").
Bursts of moderate intensity with duration greater than 7 1/2 minutes.

4 - Post-burst increase -- Postburst level is greater than the preburst level. The gradual return to normal flux may require as long as several hours.

5 - Absorption following burst (negative post).

6 - Complex -- (formerly "single-complex"). A single burst which shows two or more comparable maxima before the activity has declined to zero.

7 - Period of irregular activity of fluctuations -- Series of overlapping bursts of moderate intensity and duration.

8 - Group -- Series of single isolated bursts occurring in succession with intensity between the events equal to the level before and after the group.

9 - Precursor -- A small increase of intensity occurring before a larger increase.

Great Burst

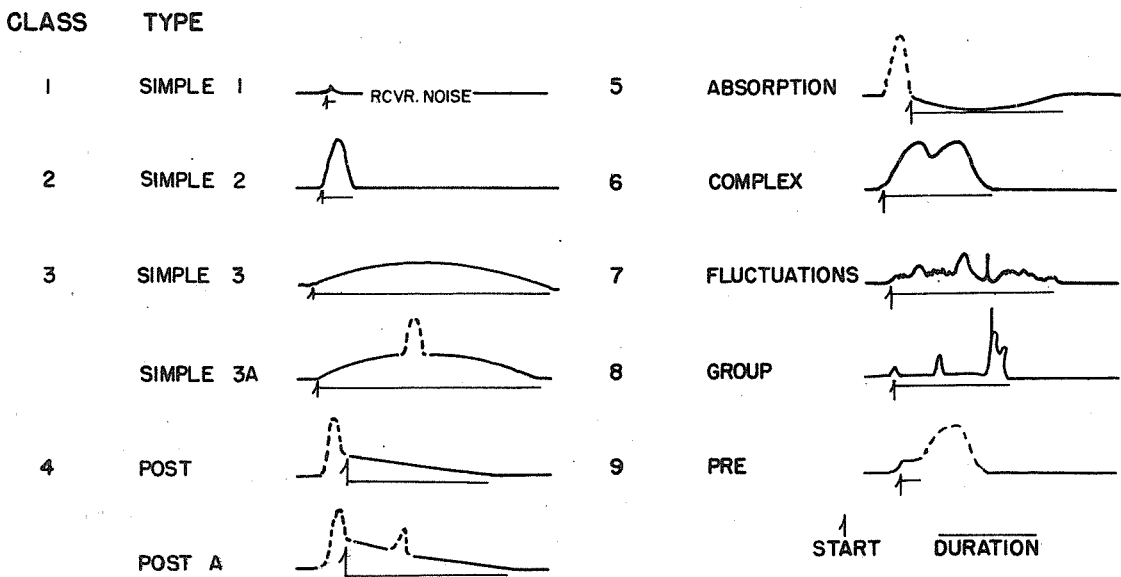
Infrequently occurring bursts of great intensity, often of complicated structure.

Letter "A"

Indicates that this event has another event superimposed upon it.

Letter "f"

Indicates that the basic form of the event is modified by secondary fluctuations.



169 Mc Interferometric Observations

The 169 Mc interferometric observations are recorded around local noon at Nançay (Cher), France, ($N47^{\circ}23'$, $E8^m47^s$), the field station of the Meudon Observatory.

The main lobes are parallel to the meridian plane: the half-power width is 3.8 minutes in the East-West direction and much larger than the solar diameter in the North-South direction. The main lobes are about 2° apart (Ann. Astrophys. 20, 155, 1957). The records give the strip intensity distribution from the center of the disk to 30° to the West and East.

These daily distributions are plotted on the same chart giving diagrams of evolution (C.R. 244, 1460, 1957). Points of intensity 0.5 - 0.75 - 1.0 - 1.5 and 2.0 times 10^{-22} watts/m²/c/s are joined day after day in the form of isophotes. A bracketed line indicates the width of the recorded lobe pattern in the East-West direction. A short East-West line is used where the source width is not known. The direction of the horizontal pip indicates whether the radio source is in the northern solar hemisphere (pip points toward earlier dates), or in the southern hemisphere (pip points toward later dates). If a pip extends on both sides of the line, the radio source was observed to be close to the solar equator. A circle or semicircle replaces the pip when the North-South coordinate of the position is unknown. For each radio spot the smoothed intensity around noon is given in 10^{-22} watts/m²/c/s.

Note that the isophotes cannot be measured when a radio spot of large intensity is on the disk.

108 Mc Observations

Data on solar radio emission at the nominal frequency of 108 Mc recorded at the Table Mesa (Boulder) station of the National Bureau of Standards (R. S. Lawrence) are presented. The antenna is equatorially mounted and linearly polarized. The plane of polarization is parallel to the solar rotation axis.

Note: Data on solar radio emission at 167 Mc recorded at the Gunbarrel Hill (Boulder) station of the National Bureau of Standards were terminated September 30, 1960. (see earlier CRPL-F Part B reports for details.)

Only the outstanding occurrences are reported. A scale of 1 to 3 is now used where for the estimate of smoothed maximum flux:

- 1 signifies <10 x quiet sun
- 2 signifies >10 <100 x quiet sun
- 3 signifies >100 x quiet sun

Starting and maximum times are read to the nearest 1/10 minute if they are very definite and otherwise to the nearest minute. If the duration is less than five minutes, it is given to the nearest 1/10 minute; otherwise to the nearest minute. The following qualifying symbols are used:

- E = Event in progress before observations began.
- D = Event continues after observations cease.
- I = Event apparently continued during an interruption of the observations. The period of the interruption may be given in the remarks.
- S = Measurement may be influenced by interference or atmospherics.

The types of the outstanding occurrences follow the classification described for 200 Mc observations originally by Dodson, Hedeman and Owren (Ap J. 118, 169, 1953), in which the types are identified by numbers which describe the character of the trace, but not the magnitude of the event, as follows:

0 - Rise in base level -- A temporary increase in the continuum with duration of the order of tens of minutes to an hour.

1 - Series of bursts -- Bursts or groups of bursts, occurring intermittently over an interval of time of the order of minutes or hours. Such series of bursts are assigned as distinctive events only when they occur on a smooth record or show as a distinct change in the activity.

2 - Groups of bursts -- A cluster of bursts occurring in an interval of time of the order of minutes.

3 - Minor burst -- A burst of moderate or small amplitude, and duration of the order of one or two minutes.

4 - Minor burst and second part -- A double rise in flux in which the early rise is a minor burst.

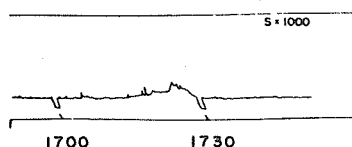
6 - Noise storm -- A temporary increase in radiation characterized by numerous closely spaced bursts, by an increase in the continuum, or by both. Duration is of the order of hours or days.

7 - Noise storm begins -- The onset of a noise storm occurs at some time during the observing period.

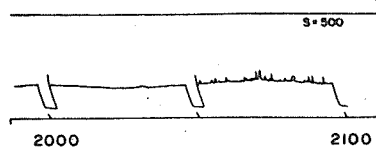
8 - Major burst -- An outburst, or other burst of large amplitude and more than average duration. A major burst is usually complex, with a duration of the order of one to ten minutes.

9A, 9B, or 9 -- Major burst and second part or large event without distinct first and second parts -- If there is a double rise in flux, the first part, a major burst, is listed as 9A and the second part as 9B. The second part may consist of a rise in base level, a group or series of bursts, a noise storm. A major increase in flux with duration greater than ten minutes but without distinct first and second parts, is listed simply as 9.

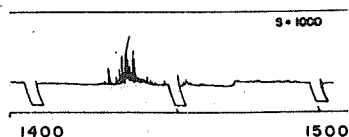
0-RISE IN BASE LEVEL



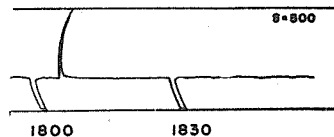
1-SERIES



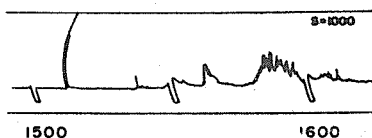
2 - GROUP



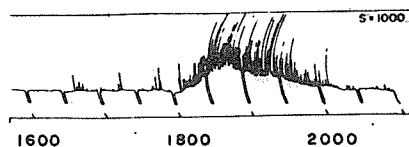
3 - MINOR



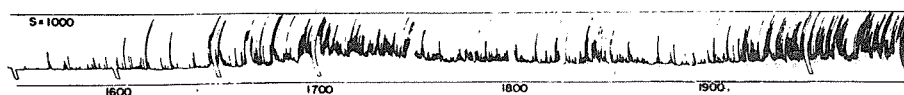
4 - MINOR+



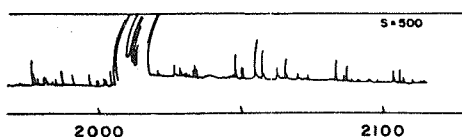
7-ONSET OF NOISE STORM



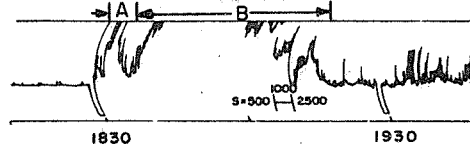
6-NOISE STORM IN PROGRESS



8-MAJOR



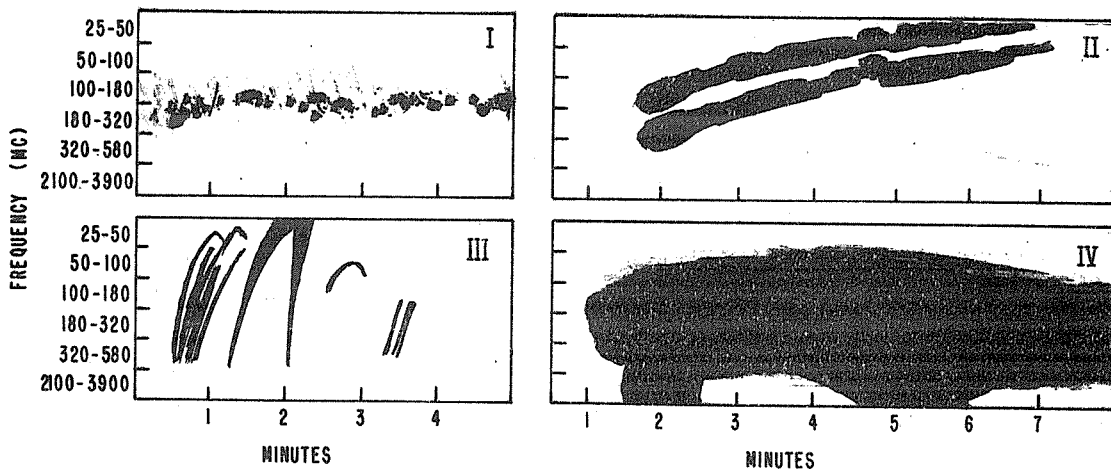
9-MAJOR+



Note: In the present table, the type classifications 0 and 1 are not used; they have been included above only for information.

Spectrum Observations

Data are presented on solar radio emission in the spectral ranges 25-580 Mc and 2100-3900 Mc recorded at the Radio Astronomy Station of Harvard College Observatory, Fort Davis, Texas. The research program is supported by financial assistance from the Sacramento Peak Observatory and the Geophysics Research Directorate of the United States Air Force. The equipment used at the Station has been described elsewhere (Maxwell, Howard, and Garmire, *J. Geophys. Res.* 65, November 1960). Commencing 1 January 1960 the following activity is listed: limited information on noise storms (type I); slow-drift bursts (type II); groups of fast-drift bursts with more than 10 individual bursts (type III G); continuum bursts (type IV). Idealized examples of the bursts are shown below; photographic examples have been published by Swarup, Stone, and Maxwell (*Astrophys J.* 131, 725, 1960).



Observations are made daily from sunrise to sunset. Entries in the tables are given in Universal Time (U.T.), and the accuracy is to the nearest half minute, except in the case of major outbursts which are specified to the nearest 0.1 minute. The symbol \rightarrow is used to indicate continuity of solar activity between two Greenwich days. Three classes of intensity are listed: 1 (faint), 2 (moderate), and 3 (strong). At 100 Mc these correspond to 5-40, 40-200, and >200 , $\times 10^{-22}$ watts m^{-2} cps $^{-1}$ respectively.

Details of other activity may be obtained on request from the Station.

V COSMIC RAY INDICES

15

The table presents the scaled hourly count rate averaged for each 24 hour interval (Universal Time) from the Climax, Colorado, USA, neutron monitor, as communicated by J. A. Simpson and G. Lentz of the Enrico Fermi Institute for Nuclear Studies, University of Chicago. The instrument is a standard Chicago type neutron monitor, utilizing 12 BF₃ counter tubes. The station is located at an altitude of 3400 meters at 39° 22'N, 106° 11'W, geographic, with mean barometric pressure P = 504.0 mm Hg. For a more detailed description of the neutron intensity monitor and its associated electronics see J. A. Simpson, Annals of the IGY, Vol. IV: Part VII, pages 351-373 (1957). The following correction factor is used at Climax:

$$R_{\text{corr}} = R_{\text{obs}} e^{\delta P/L}$$

where $\delta P = P - P_{\text{obs}}$, the mean minus the observed pressures, and L is the absorption mean free path of 106.0 mm Hg. The publication of these data in this monthly C.R.P.L. series began September 1960. Earlier data are available at the I.G.Y. World Data Centers.

The chart presents the pressure corrected hourly totals from the Deep River, Ontario, Canada standard neutron monitor, as submitted by H. Carmichael and J. Steljes of Atomic Energy of Canada Limited, Chalk River, Ontario. The station is 145 meters above sea level at 46°06'N, 77°37'W. The magnetic rigidity cut off is 0.87 GV according to the Quenby and Webber formulation. The data are plotted mechanically and the graphs are not in error by more than about the width of the ink trace. The vertical scale lines mark the days in UT. It is possible to count individual hours from any scale line to find the time of an event. The horizontal scale lines are at intervals of 5% based upon 55,500 counts per hour arbitrarily taken as 100%. The standard deviation of the hourly totals is 0.43%.

VI GEOMAGNETIC ACTIVITY INDICES

C, Kp, Ap, and Selected Quiet and Disturbed Days -- The data in the table are: (1) preliminary international character figures, C; (2) geomagnetic planetary three-hour range indices, Kp; (3) daily "equivalent amplitude," Ap; (4) magnetically selected quiet and disturbed days.

This table is made available by the Committee on Characterization of Magnetic Disturbances of IAGA, IUGG. The Meteorological Office, De Bilt, Holland collects the data from magnetic observatories distributed throughout the world, and compiles C and selected days. The Chairman of the Committee computes the planetary and equivalent amplitude indices. The same data are also published in the Journal of Geophysical Research

along with data on sudden commencements (sc) and solar flare effects (sfe), and principal magnetic storms.

The C-figure is the arithmetic mean of the subjective classification by all observatories of each day's magnetic activity on a scale of 0 (quiet) to 2 (storm).

Kp is the mean standardized K-index from 12 observatories between geomagnetic latitudes 47 and 63 degrees. The scale is 0 (very quiet) to 9 (extremely disturbed), expressed in thirds of a unit, e.g. 5- is $4 \frac{2}{3}$, 5 is $5 \frac{0}{3}$, and 5+ is $5 \frac{1}{3}$. This planetary index is designed to measure solar particle-radiation by its magnetic effects, specifically to meet the needs of research workers in the ionospheric field. A complete description of Kp has appeared in Bulletin 12b, "Geomagnetic Indices C and K, 1948" of the Association of Terrestrial Magnetism and Electricity (IATME), International Union of Geodesy and Geophysics.

Ap is a daily index of magnetic activity on a linear scale rather than on the quasi-logarithmic scale of the K-indices. It is the average of the eight values of an intermediate 3-hourly index "ap," defined as one-half the average gamma range of the most disturbed of the three force components, in the three-hour interval at standard stations; in practice, ap is computed from the Kp for the 3-hour interval. The extreme range of the scale of Ap is 0 to 400. The method is described in IATME Bulletin No. 12h (for 1953) p. viii f. Values of Ap (like Kp and Cp) have been published for the polar Year 1932/33 and for the years 1937 onwards.

The magnetically quiet and disturbed days are selected in accordance with the general outline in Terr. Mag. (predecessor to J. Geophys. Res. 48, pp 219-227, December 1943. The method in current use calls for ranking the days of a month by their geomagnetic activity as determined from the following three criteria with equal weight; (1) the sum of the eight Kp's; (2) the sum of the squares of the eight Kp's; and (3) the greatest Kp.

Chart of Kp by Solar Rotations -- The graph of Kp by solar rotations is furnished through the courtesy of Dr. J. Bartels, Geophysikalisches Institute, Gottingen.

VII RADIO PROPAGATION QUALITY INDICES

One can take as the definition of a radio propagation quality index: the measure of the efficiency of a medium-powered radio circuit operated under ideal conditions in all respects, except for the

variable effect of the ionosphere on the propagation of the transmitted signal. The indices given here are derived from monitoring and circuit performance reports, and are the nearest practical approximation to the ideal index of propagation quality.

Quality indices are expressed on a scale that ranges from one to nine. Indices of four or less are generally taken to represent significant disturbance. (Note that for geomagnetic K-indices, disturbance is represented by higher numbers.) The adjectival equivalents of the integral quality indices are as follows:

1 = useless	4 = poor-to-fair	7 = good
2 = very poor	5 = fair	8 = very good
3 = poor	6 = fair-to-good	9 = excellent

CRPL forecasts are expressed on the same scale. The tables summarizing the outcome of forecasts include categories P-Perfect; S-Satisfactory; U-Unsatisfactory; F-Failure. The following conventions apply:

P - forecast quality equal to observed	U - forecast quality two or more grades different from observed when <u>both</u> forecast and observed were > 5, or both < 5
S - forecast quality one grade different from observed	F - other times when forecast quality two or more grades different from observed

Full discussion of the reliability of forecasts requires consideration of many factors besides the over-simplified summary given.

The quality figures represent a consensus of experience with radio propagation conditions. Since they are based entirely on monitoring or traffic reports, the reasons for low quality are not necessarily known and may not be limited to ionospheric storminess. For instance, low quality may result from improper frequency usage for the path and time of day. Although, wherever it is reported, frequency usage is included in the rating of reports, it must often be an assumption that the reports refer to optimum working frequencies. It is more difficult to eliminate from the indices conditions of low quality for reasons such as multipath or interference. These considerations should be taken into account in interpreting research correlations between the Q-figures and solar, auroral, geomagnetic or similar indices.

North Atlantic Radio Path -- The CRPL quality figures, Qa, are compiled by the North Atlantic Radio Warning Service (NARWS), the CRPL forecasting center at Ft. Belvoir, Virginia, from radio traffic data for North Atlantic transmission paths closely approximating New York-

to-London. These are reported to CRPL by the Canadian Defense Research Board, Canadian Broadcasting Corporation, and the following agencies of the U.S. Government:--Coast Guard, Navy, Army Signal Corps, U.S. Information Agency. Supplementing these data are CRPL monitoring, direction-finding observations and field-strength measurements of North Atlantic transmissions made at Belvoir.

The original reports are submitted on various scales and for various time intervals. The observations for each 6-hour interval are averaged on the original scale. These 6-hour indices are then adjusted to the 1 to 9 quality-figure scale by a conversion table prepared by comparing the distribution of these indices for at least four months, usually a year, with a master distribution determined from analysis of the reports originally made on the 1 to 9 quality-figure scale. A report whose distribution is the same as the master is there-by converted linearly to the Q-figure scale. The 6-hourly quality figure is the mean of the reports available for that period.

The 6-hourly quality figures are given in this table to the nearest one-third of a unit, e.g. 5o is 5 and 0/3; 5- is 4 and 2/3; 5+ is 5 and 1/3. Other data included are:

(a) Whole-day radio quality indices, which are weighted averages of the four 6-hourly indices, with half weight given to quality grades 5 and 6. This procedure tends to give whole-day indices suitable for comparison with whole-day advance forecasts which seek to designate the days of significant disturbance or unusually quiet conditions.

(b) Short-term forecasts, issued every six hours by the North Atlantic Radio Warning Service. These are issued one hour before 00^h, 06^h, 12^h, 18^h, UT and are applicable to the period 1 to 7 hours ahead.

(c) Advance forecasts (CRPL-J) are issued once a week and are applicable to 1 to 7 days ahead. They are modified as necessary by the Special Disturbance Warning (CRPL-SDW) applicable 1 to 3 days ahead, which may be followed by a supplementary forecast (CRPL-Js) applicable to days remaining until next CRPL-J forecast. The forecast entitled "final" consists of the most recent of the above forms and is scored against the whole-day quality index.

(d) Half-day averages of the geomagnetic K indices measured by the Fredericksburg Magnetic Observatory of the U.S. Coast and Geodetic Survey.

A chart compares the short-term forecasts with Qa-figures. A second chart compares the outcome of the final advance forecasts

with a type of "blind" forecast. For the latter, the frequency for each quality grade, as determined from the distribution of quality grades in the four most recent months of the current season, is partitioned among the grades observed in the current month in proportion to the frequencies observed in the current month.

Ranges of useful frequencies on the North Atlantic radio path are shown in a series of diagrams, one for each day. The shaded area indicates the range of frequencies for which transmissions of quality 5 or greater were observed. The blacker the diagram, the quieter the day has been; a narrow strip indicates either high LUHF, low MUF, or both. These diagrams are based on data reported to CRPL by the German Post Office through the Fernmeldetechnischen Zentralamt, Darmstadt, Germany, being observations every one and a half hours of selected transmitters located in the eastern portion of North America. Since January 6, 1958 the transmitters monitored are restricted to those located north of 39° latitude. The magnetic activity index, A_{Fr} , from Fredericksburg, Va., is also given for each day.

Note: Beginning with data for September 1955, Q_a has been determined from reports that are available within a few hours or at most within a few days, including for the first time, the CRPL observations. Therefore these are the indices by which the forecasters assess every day the conditions in the recent past. Over a period of several years, they have closely paralleled the former Q_a indices which excluded CRPL observations and included three additional reports received after a considerable lag. Q_a was first published to the nearest one-third of a unit at the same time.

North Pacific Radio Path -- The CRPL quality figures, Q_p , are compiled by the North Pacific Radio Warning Service (NPRWS), the CRPL forecasting center at Anchorage, Alaska, from radio traffic data for moderately long transmission paths in the North Pacific equivalent to Seattle-to-Anchorage or Anchorage-to-Tokyo. These include reports to CRPL by the Army Command and Administrative Network, U.S. Air Force and Federal Aeronautical Administration. In addition, there are CRPL monitoring, direction finder observations and field strength measurements of suitable transmissions.

The original reports are on various scales and for various time intervals. The observations for each 12 hours or 24 hour period are averaged on the original scale. This average is compared with reports for the same period in the preceding two months and expressed as a deviation from the 3-month mean. The deviations are put on the 1 to 9 scale of quality which is assumed to have a standard deviation of 1.25 and a mean for the various periods as follows:

07-18 hours UT	5.33	00-24 hours UT	5.67
19-06	6.00		

The 12-hour and 24-hour indices Q_p are determined separately. Each index is a weighted mean where the CRPL observations have unit weight and the others are weighted by the correlation coefficient with the CRPL observations.

The table, analogous to that for Q_a , includes the 12-hourly quality figures; whole day quality figures; short-term forecasts issued by NPRWS twice daily at 06^h and 18^h UT, applicable to the stated 12-hour periods; advance forecasts issued weekly by NPRWS (CRPL-Jp report) modified as necessary by Special Disturbance Warnings (CRPL-SDW) and supplementary forecasts (CRPL-Jps); and half-day averages of geomagnetic K indices from Sitka.

The chart compares the outcome of the final advance forecasts, on the same basis as the similar chart for the North Atlantic Radio Path.

Note: Beginning with March 15, 1959 the short-term forecast schedule was changed from three times daily to twice daily. The North Pacific quality figures used for evaluation are now 12-hourly rather than 8-hourly.

VIII ALERT PERIODS AND SPECIAL WORLD INTERVALS

This table gives the Advance Geophysical Alerts as initiated by the Western Hemisphere Regional Warning Center at Ft. Belvoir, Va., and also the Worldwide Geophysical Alerts and Special World Intervals as designated by the World Warning Agency, Ft. Belvoir, Va.

Advance Alerts are of four types, defined as follows:

- 1 - Solar Flare Alert -- this warning is issued whenever a solar flare of median importance 2 plus or greater has been reported. There will be only one alert issued per flare and only one a day at most.
- 2 - Magnetic Storm Alert -- this warning is issued whenever a significant magnetic storm, K figure 5 or greater at a middle latitude station has begun.
- 3 - Cosmic Ray Alert -- this warning is issued whenever a very outstanding change in cosmic ray flux has been observed -- increase or decrease.
- 4 - Aurora Alert -- this warning is issued whenever a magnetic storm in middle latitudes has reached K figure 7 intensity or whenever selected auroral stations report the presence of outstanding aurora.

Worldwide Alerts are of the same types as the Advance Alerts, except that the Solar Flare Alert and Cosmic Ray Decrease Alert are omitted. Alert announcements include the event and time of event upon which the alert is based, and, in the case of the Advance Alerts, the station reporting the event.

The World Alerts and Special World Intervals are issued by the World Warning Agency on decisions based on Advance Alerts, advice received from Regional Warning Centers and overall policy.

IX INDEX FOR CRPL-F PART B

On the following pages the index gives the number of the CRPL-F Part B report or reports in which data for any month in question will be found.

INDEX FOR 1960 DATA PUBLISHED IN CRPL-F Part B

	1960	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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Zurich Provisional Relative Sunspot Number R _Z	186	187	188	189	189	190	191	192	193	194	195		
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Calcium Plage and Sunspot Regions	186	187	188	189	190	191	191	192	193	194	195		
Coronal Line Emission Indices - Provisional	189	189	189	193	193	193	193						
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Ionospheric Effects (SCNA-SEA-Bursts)	189	190	191	192	193	194	195						
2800 Mc-Outstanding Occurrences (Ottawa)	187	188	189	190	191	192	193	194	195				
2800 Mc-Hours of Observation (Ottawa)	188	189	190	191	192	193	194	195					
169 Mc-Interferometric Observations (Nançay)	188	188	188	191	191	191	191						
167 Mc-Outstanding Occurrences (Boulder)	186	187	188	189	190	191	191	192	193	194	195		
167 Mc-Hours of Observation (Boulder)	188	188	188	189	190	191	191	192	193	194	195		
Geomagnetic Indices C, Kp, Ap, - Selected Days	187	188	189	190	190+	191	192	193	194	195			
NARWS - CRPL Quality Figures & Forecasts	187	188	189	190	191	191	192	193	194	195			
NARWS - Comparison Graphs	187	188	189	190	191	191	192	193	194	195			
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NPRWS - CRPL Quality Figures & Forecasts	187	188	189	190	191	191	192	193	194	195			
NPRWS - Comparison Graphs	187	188	189	190	191	191	192	193	194	195			
Alert and SWI Decisions	186	187	188	189	190	191	191	192	193	194	195		
Cosmic Ray Neutron Counts (Deep River)	195	195	195	195	195	195	195	195	195	195	195		
Cosmic Ray Neutron Counts (Climax)													195

+F190 also includes R, relative sunspot number and C₉, magnetic index in 27-day diagram January 1958-April 1959.

*Data beginning October 1960 for 108 Mc (167 Mc terminated).