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A monthly survey of plans, activities and findings in geophysics—with emphasis on United States contributions to the International Geophysical Year, International Geophysical Cooperation–1959, and similar international endeavors including the World Magnetic Survey, the Year of the Quiet Sun, the Indian Ocean Expedition, the Antarctic research program, and space exploration and research. Preparation and publication of the Bulletin *is supported by the National Science Foundation.*

Whistlers-West

Results from the IGY/IGC-59 Synoptic Program

The following material is based on a more-detailed report by R. A. Helliwell and D. L. Carpenter, entitled Whistlers-West IGY-IGC Synoptic Program, *and published by the Stanford Electronics Laboratories, Stanford University, March 20, 1961.*

The IGY-IGC Ionospheric Physics Program included studies of whistlers and other very-low-frequency (VLF) radio-noise phenomena (atmospherics, or sferics), primarily to gain further knowledge of the characteristics of the earth's upper atmosphere and the exosphere beyond, through which these natural impulses of electrical energy travel. (Figure 1 shows one type of whistler.)

Whistlers are triggered by lightning discharges, which are especially powerful radiators of electromagnetic energy. The very-low-frequency energy from a lightning flash is propagated along lines of force of the earth's magnetic field thousands of miles into near space and down again to a geomagnetically corresponding area, or conjugate point, in the opposite polar hemisphere. Other typical VLF signals (hiss, dawn chorus, etc.) have different origins, as explained below. (A report in *Bulletin No. 6* provides additional historical background on the study of whistlers, and outlines the IGY whistler program.)

The Whistlers-west IGY-IGC program, directed by Stanford University, was conducted in coordination with a similar program, known as Whistlers-east, directed by Dartmouth College. Closely integrated with the Whistlers-west activities were two other Stanford observing programs, one of which, sponsored by the National Science Foundation, provided recordings of whistlers and other very-low-frequency emissions at the Byrd and South Pole IGY Stations, in Antarctica. The other, supported by the US Office of Naval Research, provided measurements of whistler-mode propagation using signals from Navy VLF stations. Much of the data interpretation and theoretical work was carried out under a contract with the Office of Scientific Research, US Air Force.

Whistler data were obtained from a net-

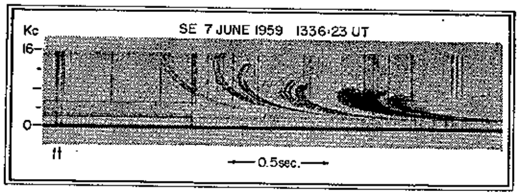

Fig. 1. *Spectrogram Showing Nose Whistlers. Two closely spaced, multi-path, one-hop nose whistlers—and their source atmospherics (arrows)—are shown. Recorded at Seattle (SE).*

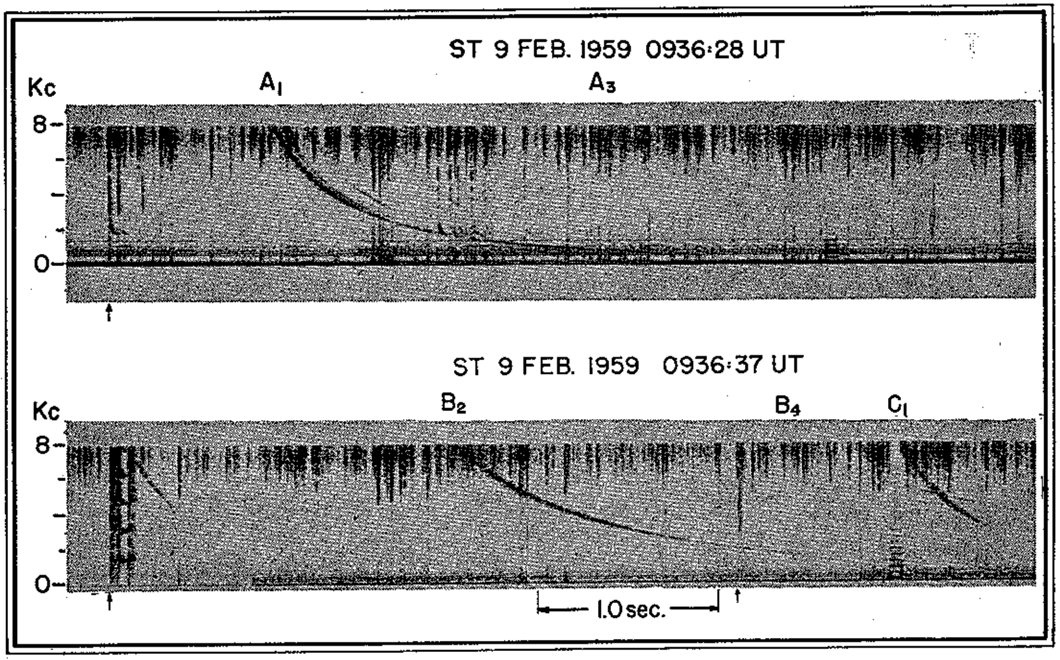

Fig. 2. *Spectrogram Showing Mixed Long and Short Whistlers.* A_1 *and* C_1 *are short, or "one-hop," whistlers;* B_2 *is a long, or "two-hop," whistler. Arrows indicate source atmospherics; source of* A_1 *is a "tweek" that has traveled about 10,000 km; source of* B_2 *is a "bonk." Recorded at Stanford (ST).*

work of 10 field stations operated cooperatively with several other agencies and institutions from the beginning of the IGY, July 1, 1957, to the end of the IGC-59, December 31, 1959. Many of these stations continue to operate, primarily for the purpose of monitoring the waning phase of the 11-year solar cycle (discussed in *Bulletin Nos. 4* and *48*, and others). Instrumentation for the Whistlers-west program was designed and supplied by Stanford University.

The Whistlers-west stations were located at Anchorage, College, Kotzebue, and Unalaska, Alaska; Boulder, Colorado; Seattle, Washington; Stanford, California; Dunedin and Wellington, New Zealand; and Macquarie Island, in the South Pacific between New Zealand and Antarctica. Dunedin-Unalaska and Macquarie-Kotzebue are geomagnetic conjugates (i.e., at opposite ends of the same line of force of the earth's magnetic field.) Stations were located so as to provide data on latitude and longitude variations.

The function of each station was to record whistlers and VLF emissions in the frequency band between 400 and 30,000 cps. Two-minute recordings were made on magnetic tape once each hour. Summaries of most of this information have been forwarded to IGY World Data Center A, Subcenter for Airglow and Ionosphere, at Boulder, Colorado.

Although much remains to be learned about whistlers and VLF emissions, exciting results have already emerged from the IGY-IGC data—in particular, a model of the electron density in the outer ionosphere. This and other results obtained at Stanford are described briefly in the present report.

Classification of VLF Phenomena

As the origins of many natural VLF phenomena are not yet fully understood, it was undesirable to attempt a permanent classification. However, the sounds and spectral properties of VLF phenomena have given rise to various terms and classifications under the main categories of Atmospherics, Whistlers, Ionospheric Noise, and Interactions. These have been modified and extended to give the following terminology, which is used in this report.

Atmospherics: On visual plots of frequency versus time, atmospherics appear as vertical traces. These traces are identified with the VLF energy from lightning discharges that have been propagated between the earth's surface and the lower edge of the ionosphere. These impulses are frequently identified on the visual records as the sources of whistlers.

Tweek is an atmospheric that sounds to the ear like a short musical chirp as a result of dispersion of energy in the range just above the tweek cutoff frequency of approximately 1800 cps. Curvature seen on the spectrogram indicates the distance traveled (see Fig. 2). An atmospheric with no special spectral characteristics is termed an *ordinary impulse.* The spectrographic trace exhibits little or no curvature near the tweek cutoff frequency, and usually shows low intensity in that range. This type of atmospheric constitutes the bulk of short whistler sources appearing on spectrograms. A *bonk* (Figs. 2 and 7) is an unusually long atmospheric heard as a sharp metallic clicking sound in earphones. The bonk is usually associated with storms in the hemisphere of the receiver.

Whistlers: A whistler that has traveled once through the outer ionosphere is a *short whistler,* or a "one-hop" whistler. A *long whistler* is one that has traveled twice through the outer ionosphere; these are often called "two-hop" whistlers (Fig. 2).

Nose whistlers, which have nose-shaped traces on spectrograms (see Fig. 1), are simultaneous rising and falling tones joined in a smooth, continuous manner at the frequency of minimum time delay, or the "nose frequency." The dispersion characteristics of the descending tone of the nose whistler are similar to those of whistlers that do not exhibit the nose. Whistlers exhibiting two or more whistler components closely associated in time are called *multiple whistlers.* They are subdivided into multi-path and multi-source whistlers. In the former, each component appears to originate in the same lightning discharge; in the latter, each component appears to originate in a separate lightning discharge.

Strictly speaking, every whistler is of the multi-path variety, single-trace whistlers being a special class of this type. Multi-source whistlers are, then, simply a series of closely spaced multi-path events. The distinction between the two types is primarily one of convenience in describing the details of visual records.

The combination of a long and a short whistler from a single source produces a *hybrid whistler.* Only a small number of such whistlers have been recorded.

A *whistler echo train* is a succession of whistlers resulting from repeated traverses of the original impulse through the outer ionosphere. Usually, the time delays of echoes of short whistlers are in the ratios 1:3:5:7, etc., while for long whistlers the ratios are 2:4:6:8, etc. Echoes of multi-path whistlers sometimes show delays that are combinations of integral multiples of the basic one-hop delays. (An echo train is shown in Figure 3.)

Ionospheric Noise: All naturally occur-

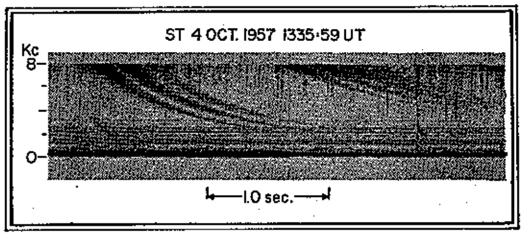

Fig. 3. *Echo Train of Long Whistler. The spectrogram illustrates "coupling" between the paths of the short whistler (left) and the long whistler (right); in such coupling, whistler components (at 4 kc) spaced up to one second apart may be "combined" in the whistler echoes.*

ring electromagnetic noise originating in the earth's atmosphere, with the exception of atmospherics and associated phenomena (whistlers and whistler interactions), are classed as ionospheric noise. In the audio-frequency range, ionospheric noise may be divided into three types: *hiss, dawn chorus,* and *discrete events.*

Hiss is a noise resembling band-limited "white noise." It may occur in one broad band or in one or more narrow bands. Narrow-band hiss is usually about 1 kc wide but may be as narrow as 750 cps. Hiss usually exhibits a slow increase and decrease in intensity, and is usually continuous in time.

Dawn chorus is a series of short, distinct musical tones, either rising or falling in pitch and often overlapping in time (see Fig. 4). It occurs almost solely in the frequency range 1-5 kc. Chorus and hiss spectrograms often appear alike, but close inspection reveals the discontinuous nature of the chorus spectrum. The distinction is considerably more obvious when heard. Dawn chorus may occasionally begin suddenly, and is divided, somewhat arbitrarily, into continuous and discontinuous types.

Noises that are isolated in time and show well-defined spectra are termed *discrete events,* but they may be associated with or arise from the dawn chorus, hiss, or both. On a spectrogram, they appear as individual traces with bandwidths rarely exceeding 150 cps at any instant. Probably the most common, distinct, and easily recognizable of these events is the *hook*—a relatively pure tone that usually falls slowly in frequency over a period of about 0.5 second, and then rises rapidly over an octave or more. Within this "tail," the higher frequencies may arrive slightly earlier than the lower, presumably owing to the dispersion during propagation. The tails often show a tendency to "flatten out" in their upper frequency ranges. (See Figure 5.)

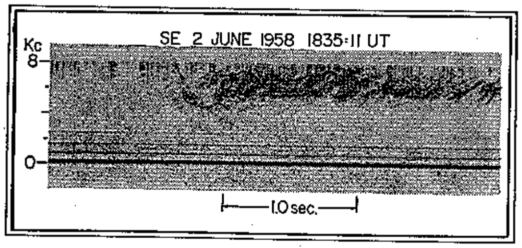

Fig. 4. *Whistler and Dawn Chorus. In this example, the dawn chorus (horizontal dark area) is a "suivant" following the whistler.*

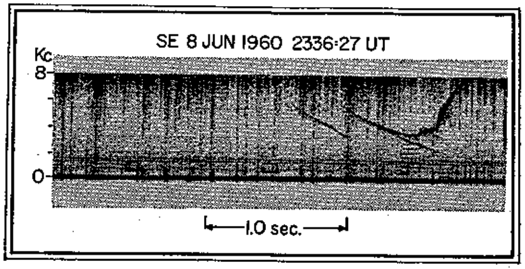

Fig. 5. *Hook and Falling Tones. Hooks drop slowly in frequency and then rise rapidly; falling tones usually show a slow frequency decrease (falling from left to right in the spectogram) and are relatively rare. The Seattle 0-15.5 kc record for this event shows distinct flattening of the "tail" of the hook.*

Almost all other discrete events are also well-defined in the frequency-time plane. Some are tones of nearly constant frequency and others may show a distinct rise or fall of frequency with time, but seldom both within the same event. The rate of change of frequency may vary considerably, however. For descriptive convenience, these events have been divided into three types; *risers, falling tones,* and *quasi-constant tones.* (See Figures 5 and 7.)

Risers (Fig. 7), for the most part, show a constant or increasing rate of change of frequency with time, but seldom decreasing. The rise is usually rapid, and the events last only a small fraction of a second. They are frequently found in bursts, several occurring in rapid succession, and are by far the most common of the discrete events.

Falling tones (Fig. 5) usually show a comparatively slow decrease in frequency and typically last much longer than risers. They are comparatively infrequent.

Quasi-constant tones, found most often in the frequency range below 4 kc, have a bandwidth of up to 150 cps and may last a second or more. The absence of spectra of quasi-constant center frequency showing bandwidths between 150 cps and 750 cps suggests that quasi-constant tones are in fact a separate class of noise and not merely a limiting case of narrow-band hiss.

All other discrete events are called "unusual." Though their occurrence is comparatively frequent, they rarely satisfy the criterion of repeatability and are apparently due to anomalous conditions associated with the generation mechanism.

Interactions: These noises appear to be associated with whistlers, and may be divided into two main classes—*precursors,* which precede a whistler, and *suivants,* which follow.

Precursors are quite distinct and have thus far been identified in but one generic form, a narrow-bandwidth rising tone with a rate of rise increasing as it approaches the whistler (Fig. 6). The interaction often disappears when the precursor's frequency equals that of the whistler, but it may on rare occasions continue beyond this point.

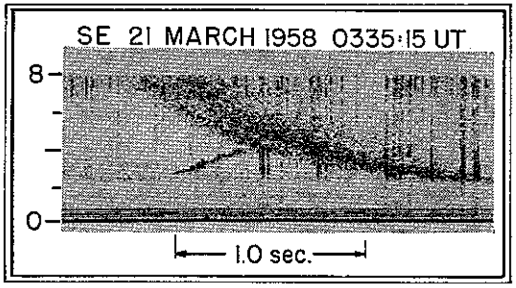

Fig. 6. *Whistler and Precursor. Precursors have thus far been identified only as brief, short-bandwidth, rising tones.*

Suivants are all interactions following whistlers. They may or may not be discrete, and may or may not be joined to the whistler. The sudden commencement of dawn chorus or of a burst of risers just after a whistler may be coincidental, but the numerous occurrences of such events make this appear unlikely. (See Figures 4 and 7.)

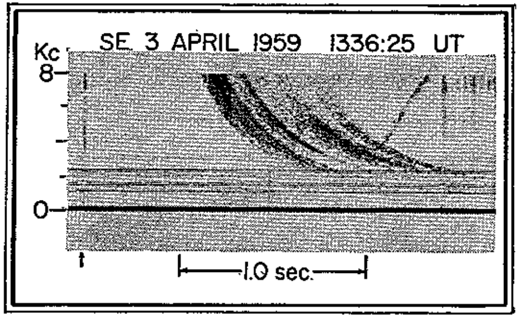

Fig. 7. *Whistler followed by Riser. The riser is a "suivant." Records from Boulder and Stanford for the same event, at 0-8 kc, are virtually identical with this Seattle record.*

Occurrence Statistics

The statistical results obtained from the aural whistler data are subject to some uncertainty because of differences in the training and ability of the listeners. However, the following results appear to be demonstrated by the occurrence data that have been examined:

Diurnal Variation of Whistler Occurrence: Many more whistlers are heard during the night than during the day, probably as a result of D-region absorption that affects not only the whistler duct proper (the magnetic field lines along which it travels) but also the sub-ionosphere path between the source and the duct entrance and between the duct exit and the receiver.

Latitude Variations of Whistler Activity: The over-all whistler rate reaches a peak at approximately 50° geomagnetic latitude, and whistlers are virtually unknown at latitudes near the equator (see Fig. 8). Note in the figure that the Dunedin rate for 1958 is well below that of its conjugate, Unalaska, and that most of the stations represented are in the Northern Hemisphere.

Statistical data on VLF emissions and whistler rates at high latitudes are only gradually becoming available. Recent work with data from Byrd Station (70.5° S geomagnetic latitude), in Antarctica, suggests

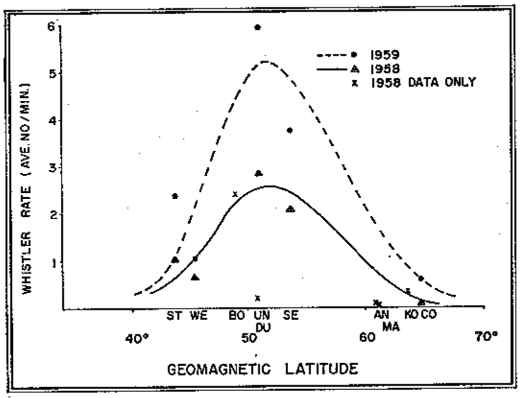

Fig. 8. *Variation of Whistler Rate with Geomagnetic Latitude for several IGY-IGC Stations. Stations are: Stanford (ST); Wellington (WE); Boulder (BO); Unalaska (UN); Dunedin (DU); Seattle (SE); Anchorage (AN); Macquarie (MA); Kotzebue (KO); and College (CO).*

that whistler rates in latitudes above the auroral zones may be high during certain periods.

During 1958, stations at geomagnetic latitudes lower than roughly 52° and greater than 62° showed a wintertime maximum in whistler occurrence, while stations between 52° and 62° showed a summertime maximum. This may be related to differences in the behavior of long and short whistlers. Theoretically, wintertime should be more favorable for the observation of whistlers because the local noise level is generally low and there is more thunderstorm activity in the conjugate area that is experiencing summer. However, at locations where long whistlers occur frequently (principally in middle latitudes), strong summer thunderstorm activity could easily produce a whistler rate exceeding that in winter. At high and low latitudes, where long whistlers are seldom heard, activity consists mainly of short whistlers, and the wintertime peak above 62° and below 52° can be understood. This hypothesis can be tested by comparing the latitude variations of long and short whistlers during summer and winter.

Whistler Occurrence and Magnetic Activity: Daily whistler rates show little correlation with the daily average magnetic index. However, any such effect that may exist may be masked by the day-to-day variation of whistler rate caused by variations in thunderstorm activity. The influence of magnetic activity on whistlers may eventually be found by use of man-made whistler-mode signals.

Spaced-Station Correlations: Comparison of whistler coincidence rates from many pairs of stations indicates that when the distance between stations exceeds 1000 km (except for conjugate pairs) the occurrences tend to be independent. However, very strong whistlers are often detected by stations spaced many thousands of kilometers apart. Recent studies of records from Byrd Station for the summer of 1959 show a surprisingly large number of whistlers with middle-latitude characteristics.

Dawn Chorus and Hiss Variations: Dawn chorus and hiss occurred most often near geomagnetic latitudes of 56° and 80°, with the distribution skewed toward the higher latitudes. Figure 9 shows the data for the period July 1957-December 1958. It was

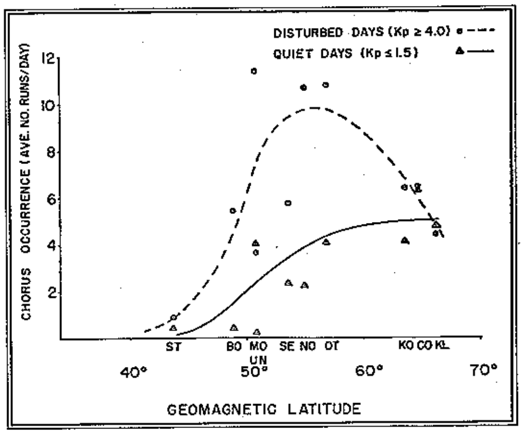

Fig. 9. *Variation of Occurrence of Dawn Chorus with Geomagnetic Latitude during Magnetically Disturbed and Quiet Days. Stations ST, BO, UN, SE, KO, and CO as in Figure 8; the others, not part of Whistlers-west chain, are: Moscow (MO); Norwich (NO); Ottawa (OT); and Knob Lake (KL).*

discovered that the latitude distribution of chorus is sensitive to magnetic activity. On days when the average magnetic index (K_p) is 1.5 or less (on an intensity scale increasing from 0 to 9), the chorus index peaks at approximately 64° geomagnetic latitude (solid line in the figure). On days when the average K_p is 4 or greater, the chorus index peaks at approximately 58° (dashed line in the figure). It thus appears that dawn chorus activity, like the aurora, moves toward the equator during geomagnetically disturbed periods.

Dawn chorus and hiss occur more frequently on days of low background noise than on days of high noise (data for one year from six stations were studied). This effect is apparently not a result of increased detectability on days of low noise, since whistler rates do not also show this correlation. On the average, there was twice as much chorus and hiss on days of low noise as on days of high noise. The reduction in background noise is believed to have been caused mainly by increased absorption, often localized, of atmospherics of relatively distant origin. This interesting and apparently significant result could be interpreted to mean that a highly localized type of VLF absorption occurs in correlation with dawn chorus and hiss.

Comparison of Simultaneous Events at Spaced Stations

Effective Area of Reception of VLF Emissions: Discrete VLF emissions show a 25% coincidence rate between Dunedin and Wellington when all intensity levels are included. This percentage is even higher when emissions of intensity 3 (on a rising scale of 0-5) are observed at one of the two stations. It would seem from these results that the effective reception area has a diameter somewhat greater than the 600-km spacing between these stations.

One hundred discrete VLF emissions of intensity 5 observed at Boulder were sought on corresponding records from Stanford and Seattle. None was found, suggesting that the effective radius of reception of discrete events in this region is less than 1000 km; it is probably about 500 km.

It will be possible to make a more-detailed determination of effective area of whistlers and VLF emissions when further studies of high-latitude phenomena have been completed. These studies will be greatly facilitated by fast-read-out spectrum analyzers.

Effective Area of Reception of Whistlers: Comparison of whistler components recorded simultaneously at spaced stations indicates that a component of average strength spreads over an area with a radius of roughly 500 km before it disappears into the background noise. The similarity of effective areas of both discrete VLF emissions and individual whistler components suggests that both types of event are propagated in the same way.

Conjugate stations constitute a valuable source of information on whistler and VLF activity. Thus far, only a few detailed studies have been made on conjugate activity, although the data from opposite hemispheres have been used extensively in identifications of causative impulses.

Daily and Monthly Averages of Whistler Dispersion: Records for the stations at Stanford, Seattle, Wellington, and Unalaska show a large annual variation in monthly average whistler dispersion in 1958, with a minimum in June or July and a maximum in November, December, or January (see Fig. 10). (Dispersion is the weighted time delay from the lightning-flash origin to the appearance of whistler energy at 5 kc, expressed as $D = \sqrt{5000}\ t$, where D is dispersion and t is the delay from the leading edge of the source to the "center of mass" of the whistler.) The phase of the variation is generally the same at all four stations, and the variation range depends upon latitude, with Stanford exhibiting the widest range.

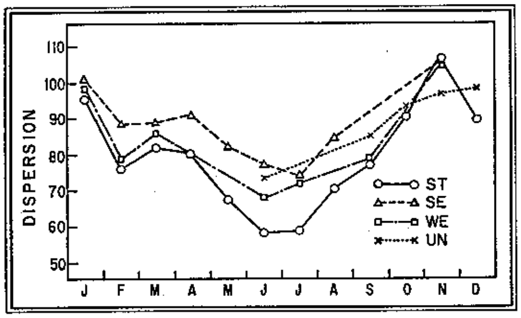

Fig. 10. *Monthly Whistler Dispersion Averages during 1958 for Four IGY Stations. Based on measurements at 5 kc; stations as listed for Figure 8.*

The extent to which the annual variation of 1958 is repeated in other years is not yet known. At Stanford, the 1959 pattern roughly repeats the 1958 pattern, although the November and December values for 1959 are substantially lower than those of 1958, and the 1959 summer minimum is in August.

Results of Investigations of Various Types of Whistlers

Ordinary Whistlers: Whistlers that do not have echoes, hybrid traces, noses, etc. are called ordinary whistlers and constitute the bulk of those included in routine analysis. The principal finding concerning them is that during a recording period of two minutes, all short whistlers are similar in appearance. Detailed analysis of two or more whistlers from the same run shows that the delays from source to individual traces are very nearly the same.

Whistler Echo Trains: The delays of components in whistler echo trains have been studied in some detail. The results may be summarized as follows: In the frequency range 4-8 kc, the time spacing between successive hops, measured at a fixed frequency, is constant throughout any train. When the first hop of an echo train exhibits several components, the succeeding hops sometimes exhibit delays that are combinations of integral multiples of the one-hop delays. In most echo trains, there is a tendency for the path associated with the strongest trace of the first hop to be preferred over others.

The fact that some echo-train delays are combinations of one-hop delays indicates the existence of a rather efficient mechanism for the coupling of energy from one path to another. Coupling between paths may occur such that whistler components (at 4 kc) spaced up to 1 sec apart may be "combined" in the whistler echoes (Fig. 3).

Mixed Long and Short Whistlers: Several detailed studies have been made of whistler runs showing mixed long and short whistlers. These and related investigations (of echo trains, for example) indicate that in nearly all cases an integral relation exists between the delays of the short and the long whistlers.

Hybrid Whistlers: Following the discovery, in 1958, of the first hybrid whistlers, several other examples have been found—on October 4, 1957; February 1, 1958; and February 20, 1958. Identification of such events is complicated by the relatively high rate of occurrence of "pseudo-hybrids," that is, short whistlers exhibiting two widely-spaced components, or long and short whistlers excited by nearly coincident lightning flashes.

Anomalous Whistlers: A number of whistlers have been recorded that exhibit types of anomalous characteristics. On several occasions, whistler echo trains have been recorded in which the peak intensity of the first hop of the whistler occurs above 3.5 kc, for example, while the first echo peaks in the range below 3.5 kc.

Another anomaly is the crossing of traces within a single whistler. In those observed, the usual form of the nose whistler was not evident. Instead, the earlier traces of the whistler developed noses while the later traces continued without substantial deviation, thus giving the appearance of two types of whistler superimposed one upon the other.

Recent studies of this type of whistler indicate that it is more common than originally supposed, and suggest that the crossing traces represent substantial and rapid variations in ionization density as a function of path latitude.

Nose Whistlers: Although the occurrence rate of nose whistlers is quite low, they are nevertheless very useful because the effective latitude of the propagation path can easily be obtained from the nose frequency.

The two commonly used parameters from nose whistlers are the nose frequency and the time delay of the nose. One fairly consistent feature can be noticed in plots on log-log paper of data from nose whistler groups. (A "group" is a set of separate whistler traces having a common origin.) Most of the trains show nearly identical slopes for nose frequency and time delay, indicating a fairly consistent *shape* of ionization distribution along the whistler path, although the scale factor may change from one whistler to another.

A seasonal variation of about 2:1 in the ionization density appears in the data, most of which was collected during the IGY-IGC period of sunspot maximum. The logarithmic departures of the time delays from the average also demonstrate this behavior.

In a model of the outer ionosphere that fits the present nose whistler data satisfactorily, electron densities are proportional to magnetic field strength. This model, shown in Fig. 11 for both December and June, indicates an electron density of about 2000 at two earth radii (R_e), 500 at 3 R_e, and 100 at 5 R_e.

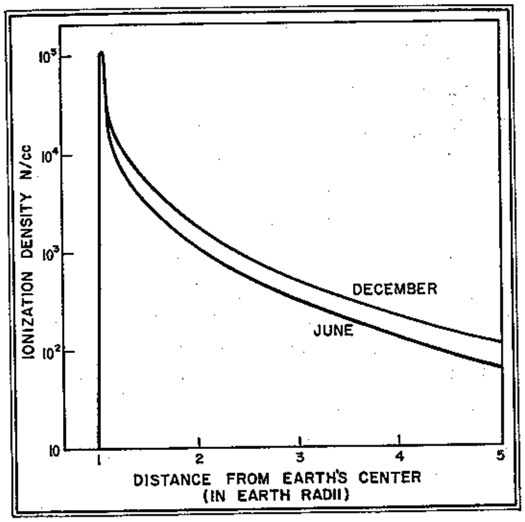

Fig. 11. *Model of Ionization Density in the Outer Ionosphere. This model fits nose whistler data obtained in the Whistlers-west program.*

Suggested Further Experiments

The following experiments are suggested by the Stanford group on the basis of the results of the IGY whistler studies:

1. Direction finding for individual whistler components to determine the locations of the end points of the paths of propagation through the ionosphere.

2. Intensive study of short time variations in whistlers and ionospheric noise.

3. Extension of observations to higher and lower frequencies than were used during the IGY; frequencies as high as the E-layer gyrofrequency should be studied.

4. Study of the relation between ionospheric noise and auroral and energetic-particle phenomena.

5. Observation of ionospheric noise and whistler-mode propagation with satellites and rockets. Measurements above the lower boundary of the ionosphere would help to locate more precisely the paths of propagation of whistlers and the regions of generation of ionospheric noise. They would also provide unique information on the coefficient of transmission of whistler-mode energy across the lower boundary of the ionosphere and on the intensity of VLF ionospheric noise.

6. Extension of the use of man-made signals for the study of whistler-mode propagation. Such experiments provide a great advantage over natural sources as they are controllable with respect to both radiation characteristics and geographical location.

National Center for Atmospheric Research

The following report was prepared by Edwin L. Wolff, staff member, Office of the Director, National Center for Atmospheric Research.

The National Center for Atmospheric Research (NCAR), with headquarters in Boulder, Colorado, recently (December 13, 1961) celebrated the establishment of its scientific program. The primary aim of NCAR's effort is to mount an interdisciplinary attack on broad, fundamental problems of the atmosphere—actually consisting of sub-problems spanning several fields—using a higher concentration of varied scientific talent and more-adequate facilities than have been utilized in the past.

The scientific community's appreciation of the vast scope of the fundamental problems in the atmospheric sciences (for example, the so-called general-circulation problem) has heightened at a time when, by fortunate coincidence, adequate tools for observation and analysis are ready for development and application. At hand or in prospect for use in atmospheric research are such vehicles as satellites, meteorological rockets, infrared sensing devices, and radar capable of making quantitative measurements of internal cloud structure. On the analytical side stand the high-speed, high-capacity digital computer and the mathematical methods developed in response to the computer's existence.

The tools are thus available for scientists to use in the development of fundamental theory essential to progress in understanding the many interacting processes of the atmosphere. This understanding possesses both scientific and practical significance.

Initial Development of the NCAR

The idea of a National Center arose out of a consensus within the atmospheric-sciences community that rapid progress in the field was unlikely without the existence of laboratories capable of a broader, more-concentrated research effort than a single university department can mount, either in manpower or facilities. The first formal expression of this consensus was a report in 1958 by the Committee on Meteorology (now the Committee on Atmospheric Sciences) of the National Academy of Sciences. A national laboratory, the Committee recommended, should be operated by a group of actively interested universities and supported by the National Science Foundation.

Two years later, NCAR had come into being, operated by a 14-university management corporation, the University Corporation for Atmospheric Research (UCAR). Director of the laboratory and principal officer of UCAR is Walter Orr Roberts. Philip D. Thompson and John W. Firor are Associate Directors.

There are now a dozen scientists on the NCAR staff (as of January 15, 1962) and by summer of this year the number will be 25 to 30. By mid-1964, when the Center will move into its permanent laboratories on Table Mountain, a 500-acre tract near Boulder donated by the State of Colorado, approximately 100 scientists, and a total staff of 300, will be at work at NCAR. Half of the NCAR scientists are to be meteorologists and half will come from other disciplines integral to the modern view of the atmospheric sciences—chemistry, hydrodynamics, magnetohydrodynamics, cloud physics, radiation physics, oceanography, astrophysics, mathematics, hydrology, etc. Up to half will be visitors from universities and research laboratories, from the United States and from abroad, at NCAR for sojourns of a few weeks to one or two years.

Last December, UCAR merged with the High Altitude Observatory (HAO), an independent astrophysical and geophysical research organization founded in 1946.

HAO's scientific program is being closely integrated with that of the National Center, especially in the study of the interaction between the terrestrial atmosphere and solar and cosmic activity. The total staff of HAO now numbers about 75.

Mission of the NCAR

From the outset, NCAR has had a threefold mission in the service of the atmospheric sciences. It is developing facilities and programs that will help to make the new research tools more available to universities and research organizations. It is also serving as a center of research planning on a national scale or in response to nationally felt needs.

The heart of the NCAR idea, however, is the development of an intellectual center, an extension of the traditional university system, where scientists may gather to consider and attack various aspects of some of the sprawling, but crucial problems of the atmospheric sciences. NCAR planning documents delineate four more or less distinct "major problem areas": (1) dynamical aspects of atmospheric circulation on all time and distance scales; (2) thermodynamical, physical, and chemical aspects, ranging from studies of nucleation and coalescence of droplets to heat-balance studies on a planetary scale; (3) interaction between the atmosphere and the underlying ground or ocean surfaces, especially with respect to transfer processes of heat, energy, and moisture within the turbulent boundary layer; and (4) interaction between the terrestrial atmosphere and astrophysical influences.

The directors of NCAR's scientific program make it clear, however, that these divisions are arbitrary in the broad view, and are laid out mainly as guide lines to assure that a balance of emphasis is maintained and that no discipline or interest important to the atmospheric sciences is overlooked. The actual working scientific program is being built around the interests of individual scientists, who plan their programs and help recruit their own "teams." Moreover, a concerted attack on any major problem—such as a theory of long-range prediction—demands that interactions among scientists span almost all categories of interest, however defined. Thus, the goal of the National Center is to build a community of science without formal departments or divisions—that is, a place where the maximum amount of easy, informal cooperation among scientists may occur naturally. The underlying belief is that such a milieu will help to stimulate the conception and growth of basic and essentially new scientific ideas—the end toward which effort must be devoted in order to replenish our scientific capital and to justify the creation of an interdisciplinary basic research laboratory.

Current and Planned Efforts

Current scientific work at NCAR includes microanalysis of atmospheric particulates and chemical constituents, by James P. Lodge and his staff; theoretical studies of various aspects of the general circulation, by P. D. Thompson and Aksel Wiin-Nielsen; and investigations in ionospheric physics and plasma physics, by Andrew Skumanich and Friedrich Meyer, who is at NCAR on a one-year visit from the Max Planck Institüt für Physik and Astrophysik, in Munich, Germany.

Patrick Squires, of Australia, arrived in late February 1962 to begin organizing the Center's program in cloud physics. Later this year, Hans Dütsch and Jitendra Dave will join the NCAR staff and begin a program in radiation physics; Arnt Eliassen, of the Institute of Theoretical Astrophysics at the University of Oslo, and Ragnar Fjortoft, from the Norwegian Meteorological Institute, will spend sabbatical leaves at NCAR in pursuit of dynamical studies.

About a dozen visiting scientists are expected to spend from one to three months at

NCAR in the summer of 1962. A similar program brought the following eight visitors to Boulder in the summer of 1961: Glenn Brier of the US Weather Bureau; Eric B. Kraus, of Woods Hole Oceanographic Institute; Edward N. Lorenz, of MIT; Sherman Lowell and Michael Yanowitch, of Adelphi College; Herbert Riehl, of Colorado State University; and Ralph Shapiro, of the Air Force Cambridge Research Laboratories.

The first of NCAR's programs to provide facilities to the scientific community is already under way. This is the NCAR National Balloon Program. Its aim is to spur rapid improvement in balloon technology —e.g., development of stronger and thinner balloon films, of balloon systems capable of reaching heights above 150,000 feet, and of reliable methods of launching and recovering very heavy loads. In pursuit of this aim, NCAR is in the process of acquiring a site for year-round scientific ballooning, a type of facility that does not now exist in the United States. Use of the site will be open to all scientists with balloon experiments, on the basis of merit alone. When the site is fully developed, scientists will have available permanent support facilities for launching, telemetry, tracking, and recovery. For some studies, the National Center will supply balloon flights, or flight elements, for experiments funded from other sources and approved by the NCAR Panel on Scientific Use of Balloons, Verner E. Suomi, chairman.

NCAR facilities are to be developed only after a clear national need has been established. Studies to determine the needs of the universities for research facilities—such as research aircraft, meteorological rockets, etc.—are under way. Once such needs are defined, NCAR will then move vigorously to see that they are met, either directly by NCAR or by arrangement for their provision elsewhere.

Solar-Terrestrial Activity during the Second Half of 1961

The following report is one of a series published periodically during and since the IGY/IGC period. It is based on material issued by the World Warning Agency (AGIWARN), Fort Belvoir, Virginia, and on compilations of Solar-Geophysical Data *issued by the Central Radio Propogation Laboratories (CRPL), Boulder, Colorado. AGIWARN and CRPL are administered by the US National Bureau of Standards. A similar report for the first half of 1961 appeared in* Bulletin No. 52. *The plan for Geophysical Alerts and Special World Intervals (SWI) developed for use during 1961 and 1962 was described in* Bulletin No. 47.

During the period July 1—December 31, 1961, the various solar observatories throughout the world reported a total of 14 major solar flares (classes 3 and 3+ on a scale ranging from —1 to 3+); 15 geomagnetic storms were recorded by AGIWARN during this calendar interval. World-wide Geophysical Alerts were issued for all of these storms, and Advance Geophysical Alerts were issued for all but three. For nine of the disturbances, Advance Alerts were received from Regional Warning Centers (RWC's). Five of the magnetic storms during this half of 1961 were classified as severe (i.e., having magnetic intensity indices, or "A" indices, of about 50 or higher

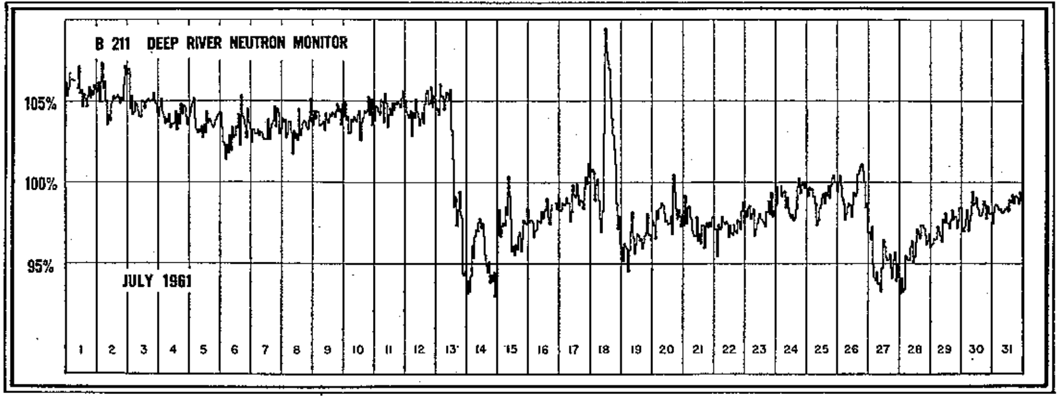

Fig. 12. *July 1961 Record of Cosmic-Ray Neutron Monitor at Deep River, Canada.*

on a scale of 0–400); their A indices were 67, 53, 86, 90, and 108, respectively, in the order of their occurrence (see list below).

July 1961 was marked by the greatest amount of solar-terrestrial activity of any month since November 1960 (see *Bulletin No. 47*), with 11 of the 15 major solar flares and three of the five severe magnetic storms of the six-month period occurring during this month, mostly in association with a region of unusual activity on the visible hemisphere of the sun between July 8 and July 22. This solar-terrestrial activity resulted in the receipt by AGIWARN of three Solar Flare and three Magnetic Storm Advance Alerts. (Figure 12 is the July record of the cosmic-ray neutron monitor at Deep River, Canada, showing a cosmic-ray increase—beginning at 1100 UT on July 18 with the influx of solar particles associated with the flare at 0720 UT on the previous day—and several Forbush-type decreases in the intensity of galactic cosmic rays following flares.)

The severe geomagnetic storm of September 30, which began about 45 hours after a class 3 flare, was covered by a Predicted SWI. The next severe storm, with an even higher A index, began about 27 days later and was not preceded by reports of important flare activity. These two storms, and a minor disturbance, began suddenly ("sudden commencements," or SC), while all of the others began gradually. Substantial portions of about ¼ of the days during the second half of 1961 were marked by geomagnetic disturbance.

Each of the geomagnetic disturbances was associated with at least one whole-day index of disturbed radio quality. Altogether, during the six-month review period, there were 39 days for which the whole-day quality index was in the disturbed range (4 or lower on a scale of 1–9). On 26 additional days, a half-day index showed disturbed conditions. This points up the tendency of disturbed-radio-propagation conditions to persist long after a geomagnetic disturbance has ended. In association with the December 1–4 storm, the whole-day radio-quality index showed disturbance for seven consecutive days, beginning on December 2; this was the longest period of consecutively disturbed days since sometime prior to September 1, 1955.

List of Major Events

The following is a list of major solar flares, geomagnetic disturbances, and World-Wide Geophysical Alerts and SWI during the period July 1—December 31, 1961:

Jul	4	13xx*	Magnetic storm begins
	5	1600	Alert issued (MAGSTORM)**
	6	05xx	Magnetic storms ends
	11	1615	Class 3 flare; S-SWF†
	12	1950	Class 3+ flare; S-SWF
		1600	PREDICTED SWI starts††
	13	1115	Severe magnetic storm begins

		1600	Alert issued (MAGSTORM; AURORA PROBABLE)**
			SWI continues
	14	1600	SWI continues
	15	1433	Class 3+ flare; S-SWF
		1520	Class 3 flare
		2359	SWI finishes
	16	09xx	Severe magnetic storm ends
		1600	PREDICTED SWI starts
	17	0720	Class 3 flare
		1600	PREDICTED SWI continues
		1827	Severe magnetic storm begins
	18	0920	Class 3+ flare; S-SWF
		1600	Alert issued (MAGSTORM; COSRAY INCREASE)**
		2359	SWI finishes
	19	06xx	Severe magnetic storm ends
	20	0249	Magnetic storm begins
		1525	Class 3+ flare; S-SWF
	21	13xx	Magnetic storm ends
		1600	Alert issued (MAGSTORM)
		1736	Class 3 flare
	24	0410	Class 3+ flare; Slow S-SWF
		1722	Class 3 flare; Slow S-SWF
	26	1960	Severe magnetic storm begins
	27	1600	Alert issued (MAGSTORM; AURORA PROBABLE)
			SWI starts
	28	10xx	Severe magnetic storm ends
		1512	Class 3 flare
		2359	SWI finishes
Aug	1	23xx	Magnetic storm begins
	2	1600	Alert issued (MAGSTORM)
	4	09xx	Magnetic storm ends
	29	17xx	Magnetic storm begins
	30	1600	Alert issued (MAGSTORM)
			SWI starts
	31	2359	SWI finishes
Sept	1	23xx	Magnetic storm ends
	16	1057	Class 3+ flare
	24	08xx	Magnetic storm begins
		1600	Alert issued (MAGSTORM)
			SWI starts
	25		SWI continues
	26	12xx	Magnetic storm ends
		22xx	Magnetic storm begins
		2359	SWI finishes
	27	14xx	Magnetic storm ends
		1600	Alert issued (MAGSTORM)
	28	2202	Class 3+ flare; Slow S-SWF
	29	1600	PREDICTED SWI starts
		1600	PREDICTED SWI continues
	30	1847	Severe magnetic storm begins
Oct	1	1600	Alert issued (MAGSTORM)
			SWI continues
		23xx	Severe magnetic storm ends
	2	2359	SWI finishes
	26	1940	Magnetic storm begins
	27	1600	Alert issued (MAGSTORM)
		24xx	Magnetic storm ends
	28	0812	Severe magnetic storm begins
		1600	Alert issued (MAGSTORM; AURORA PROBABLE)
			SWI starts
	29	12xx	Severe magnetic storm ends
		2359	SWI finishes
Nov	3	1600	PREDICTED SWI starts
	4	1600	PREDICTED SWI finishes
	6	23xx	Magnetic storm begins
	7	1600	Alert issued (MAGSTORM)
	8	08xx	Magnetic storm ends
	17	14xx	Magnetic storm begins
	18	1600	Alert issued (MAGSTORM)
	19	09xx	Magnetic storms ends
Dec	1	07xx	Magnetic storm begins
		1600	Alert issued (MAGSTORM; AURORA PROBABLE)
			SWI starts
	2		SWI continues
	3	2359	SWI finishes
	4	13xx	Magnetic storm ends
	23	1856	Class 3 flare

* "xx" indicates gradual beginning or ending of a disturbance, following the hour indicated, such that the precise moment could not be determined.

** No ending times for Alerts are issued; this is left to the discretion of the individual observatories. Capitalized acronyms indicate the kind of Alert issued, i.e., MAGSTORM = magnetic storm; AURORA PROBABLE = auroras should be expected; COSRAY INCREASE = unusual cosmic-ray increase has been reported.

† S-SWF = sudden short-wave fadeout and gradual recovery; Slow S-SWF = slow short-wave fadeout (taking 5–15 minutes) and gradual recovery.

†† SWI's start at the time the associated Alert is issued (1600 UT) and finish at the end of the day indicated (2359 UT). PREDICTED SWI's are based on the expectation that important geomagnetic and associated activity will begin in a few hours. If such activity occurs, PREDICTED SWI's become actual SWI's and follow the same rules; if the expected activity does not occur, PREDICTED SWI's end at 1600 UT on the day indicated.

Activities of The Space Science Board

The Space Science Board (SSB) was established in 1958 by the President of the National Academy of Sciences to investigate scientific research opportunities and needs arising from the advent of rockets, satellites, and space probes as tools for scientific research; to provide advice and recommendations on space science to interested Government and private agencies and institutions; to stimulate scientific research using these new tools; and to cooperate with scientists in these fields in other countries—in particular through the Committee on Space Research (COSPAR), to which the SSB adheres as the United States member.

In contrast to its earlier activities, which were centered around the review of proposals providing a basis for beginning the US space research program, the principal Board emphasis during the past year and a half has been on longer-range problems, in anticipation of planetary explorations in the 1970's. The Board believes that careful planning of the research of the 1960's is essential to the success of the later, more ambitious programs of space exploration.

During 1961, the Space Science Board devoted a major portion of its time and attention to longer-range topics. Although only a limited number of the Board's regular committees were convened during the year, a large number of specialized groups have met and an even greater number of informal discussion sessions have been held. A total of 30 meetings took place during the year.

The Board itself met in February and November 1961 to receive reports of its special study groups, to formulate its current advice and recommendations for executive agencies concerned with the civilian space science program, and to develop its international-relations program activities. At each of these meetings, comprehensive briefings by personnel of the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the Department of Defense (DOD) supplemented and expanded prepared program documents and information distributed earlier to Board members. A brief description of the activities of the Board during 1961 follows.

Domestic Activities

Policy Position on Man's Role in Space: Studies of the role of man in space led to the preparation, at the February meeting, of the Board's position on this subject; the SSB position was transmitted to the US Government in late March. In essence, the Board points out that man's direct participation in scientific programs in space will be necessary as soon as it becomes technologically feasible. The scale of programs to support man's activities in space for scientific objectives is likely to be little different from that required to conduct a complex and extensive program of scientific investigations using instruments alone. Accordingly, the Board believes that the man-in-space portion of the national space research effort should be conducted vigorously and in parallel with programs for the investigation of space, the Moon, and the planets by instruments alone.

Basic Research: At its February 1961 meeting, the SSB also developed a policy position concerning the need for a broad, imaginative program of fundamental research—not immediately oriented to flight experiments—based upon the broadest possible collaboration by the national scientific community. In this recommendation, the Board stressed the role of universities and academic science in general, emphasizing that these are the sources from which must spring the support and the personnel for the national space science program in the years ahead.

Increased SSB Emphasis in Biology: The Board increased its emphasis on the biological sciences by the creation of three committees for phases of space biology; these committees met initially early in 1961. Consonant with the Board's policy on man's role in the national space program, by far the greatest activity in the biological fields has been undertaken by the Man in Space Committee. The other two biology committees have also vigorously pressed on with their consideration of fundamental biological investigations in space.

With respect to man's role in space, the Board has undertaken a careful analysis of the known facts about the radiations that will be encountered in near and interplanetary space, and is evaluating its findings in terms of their effects on man. In another SSB study, a group of national and international specialists met to consider the effects on man of high-gravity accelerations and similar stresses in order to review the current state of knowledge in this field and to define the most urgent objectives for future investigations. The findings of these inquiries into the effects of radiation and gravity stresses should be available in 1962 for application to the national space program.

The SSB Man in Space Committee also plans to consider other important man-in-space factors, such as weightlessness, disorientation, the gaseous environment, and temperature considerations in a manned spacecraft; nutritional problems; medical selection criteria; and crew training.

Echo Balloon Study: In response to a request from the NASA-DOD Unmanned Spacecraft Panel, the SSB Committee on Optical and Radio Astronomy carried out an analysis of the effects of multiple Echo-type balloons, simultaneously in orbit, on fundamental scientific observations in radio and optical astronomy. In summary, the report found that many Echo-type balloons, simultaneously in orbit, could seriously interfere with fundamental ground-based observations in astronomy, the extent of the damaging interference depending upon the number of balloons in orbit at one time. This report was formally transmitted to the US Government for its use and guidance in planning future communications experiments using Echo-type balloons.

Satellite Tracking Requirements: Acting on a NASA request, the SSB established a special study group to assess the present NASA program for satellite tracking and orbit determinations in terms of scientific needs. This report, concluded and formally transmitted to NASA in early November 1961, summarizes the scientific requirements for satellite tracking and precise orbital information for a number of fields of investigation, including geodesy and gravitational studies, meteorology, atmospheric physics, air-drag studies, ionospheric physics, magnetic fields, cosmic rays and trapped particles, ultraviolet, X-rays and gamma rays from the outer atmosphere and extraterrestrial sources, and the interplanetary medium.

Balloon and Rocket Research: The Board presented the views of scientists throughout the country on proposed Federal Aviation Agency regulations to govern the launching and flights of balloons and rockets in the United States. This action was taken because FAA's draft regulations appeared to place very serious limitations on scientific research using these tools, with consequent grave implications to the future of other aspects of space research as well. A special report summarizing the views and suggestions of the scientific community was forwarded to the FAA in May 1961. The Board has continued to work closely with the FAA in its revision of the original draft regulations and, in particular, assisted in arranging for representative scientists to participate in a hearing on this matter before the FAA on December 7, 1961.

Science in Space: A nine-chapter report by the SSB, entitled *Science in Space* and originally issued in 1960, was amplified and expanded for publication in book form. The volume, also entitled *Science in Space,* was published in 1961 by the McGraw-Hill Book Company, and since then has had very wide distribution both nationally and internationally. In pamphlet form, some 20,500 copies of the chapters were distributed by the Academy; in book form, some 12,500 were sold.

Geodetic Satellite: Beginning in 1960, the SSB has represented the interests of science to the Government regarding the need for a satellite that can be used for fundamental geodetic investigations. A geodetic satellite program would supply, with immediacy and directness, data for scientific objectives falling into the following three broad categories: (i) establishment of a world-wide coordinate system into which all land masses could be placed with a precision about 10 times greater than at present; (ii) mapping of the coarser structure of the earth's gravitational field, which is the only direct way to locate regions of above- or below-normal density in the earth's interior; and (iii) discovery of possible variations of the so-called "gravitational constant" with time, position, or direction, which certain physical theories predict and which would profoundly alter our views of the universe.

The Board has reported to the Government that it carefully examined the scientific needs for such a program and believes that they are most important with respect to advances in geodesy.

Planetary Atmospheres Report: Following a symposium convened by the Board in June 1960 to examine the state of current knowledge of the atmospheres of the planets, a special study group was assembled to investigate present knowledge more thoroughly and to prepare a report on the most important unknowns in this area that require investigation as part of the nation's space research effort.

A five-chapter report was published by the Academy in January 1962. The report appears to be the most authoritative compilation of current knowledge of planetary atmospheres yet assembled in one volume and should prove useful as a reference work on this subject and, in particular, for designing planetary missions.

Project West Ford: A special Space Science Board study group has continued to work closely with the organizations responsible for the conduct of Project West Ford in order to assess the impact of this experiment on all fields of science, particularly radio and optical astronomy. During the past year, every opportunity was taken to bring the facts and implications of this experiment to the attention of scientists both in the US and abroad.

In pursuance of these aims, the SSB arranged for publication in the April 1961 issue of the *Astronomical Journal* four reports under the heading "Project West Ford—Properties and Analyses." The individual papers were as follows: "Introduction," by Leo Goldberg; "Properties of Orbiting Dipole Belts," by W. E. Morrow, Jr., and D. C. MacLellan; "Effects of Project West Ford on Optical Astronomy," by William Liller; and "Radio Properties of an Orbiting Scattering Medium," by A. E. Lilley. Fourteen hundred reprints were distributed to members of the International Astronomical Union and to others; 800 of these were sent abroad. The reports were summarized in *IGY Bulletin No. 50,* July 1961.

In August, the Academy issued a report, reprinted in *Bulletin No. 51,* summarizing its activities, both national and international, on the West Ford Project. Included in this review was an official policy statement on Project West Ford issued by the US Government, which (i) stated, in essence, that recognized astronomers, in consultation, had concluded that the effects of the initial experiment would be harmless, and (ii) guaranteed that no further experiments would be conducted until the results of the first experiment had been carefully evaluated. This statement was distributed at the General Assembly of the International Astronomical Union in August. Since then, the Academy has secured publication of predicted-lifetime calculations for the dipole belt (I. Shapiro and H. M. Jones, *Science,* 134, 973, October 6, 1961), to provide additional pertinent information to scientists and to other interested persons. Fourteen hundred reprints received the same distribution as the *Astronomical Journal* articles.

Steps have been taken to secure the collaboration of both US and foreign scientists in observations and measurements of the West Ford dipole test belt when it is orbited. The Board's special committee continues to provide scientific advice and information regarding the program to project personnel as well as to government authorities responsible for policy decisions.

Radio Frequency Allocations: The Board has continued to provide advice and assistance to federal agencies concerned with frequency allocations and assignments needed for the space research program. The pressures from all quarters to make maximum use of the available radio spectrum are so great, and the spectrum has become so crowded, that the needs of scientific research are often in danger. In response to this situation, the Academy established, in the spring of 1961, a Committee on Radio Frequency Allocations for Scientific Research, to which the Board has named two members. The Board looks to this Committee to represent the frequency requirements of space science and related fields. These include not only frequency allocations for the telemetry of experimental data and radio command links between ground stations and satellites, rockets, and balloons, but also clear channels for radio and radar astronomy.

World Data Center A for Rockets and Satellites: In 1961, the Academy continued the operation of World Data Center A for Rockets and Satellites as a means for the international exchange of scientific data resulting from research programs employing these tools. The staffs of the Center and the Board have collaborated in the international distribution of scientific information concerning each successful NASA launching of scientific satellites and space probes. During the year, the Center issued Report Numbers 13 and 14 in the *Satellite Report Series.*

International Activities

COSPAR Meeting and Symposium: The Committee on Space Research (COSPAR), established by the International Council of Scientific Unions in 1958, held its fourth meeting and its Second International Space Science Symposium in Florence, Italy, April 7-18, 1961. (See *Bulletin No. 51.*) The Symposium was attended by approximately 300 scientists from 28 countries, and 117 scientific papers were presented by scientists from 14 countries. The Space Science Board organized a US delegation of 65 scientists and a US scientific presentation of 56 papers.

The following is a list of the countries and the number of papers presented: Argentina (1), Belgium (1), Canada (4), Czechoslovakia (1), Denmark (1), France (8), Germany (7), Italy (12), Japan (8), Netherlands (2), Sweden (1), UK (5), USA (56), USSR (12).

The Symposium was divided into the following seven sessions: Rocket and Optical Tracking; Magnetic Observations; Telemetry and Data Recovery; The Special Geophysical Events of July 1959 and November 1960; Recent Results from Instrumented Satellites and Spacecraft; International Reference Atmosphere; and Scientific Research by Means of Small Sounding Rockets. The scientific papers presented at the Symposium have been published in a volume by the North-Holland Publishing Company.

Working Groups of the Fourth COSPAR Meeting produced a number of significant resolutions, including resolutions for COSPAR development of a world list of tracking stations; for a COSPAR study of the need for more tracking facilities in the Southern Hemisphere; for endorsement of Transit-type satellites for ionospheric research; for COSPAR development of an international program of rocket and satellite experiments for the International Year of the Quiet Sun (IQSY; see *Bulletin No. 48*) and World Magnetic Survey (WMS; see *Bulletin No. 51*); for measures to increase the effectiveness of the world-wide SPACEWARN system for rapid communication of satellite information; and for COSPAR action to revise the IGY guide to World Data Centers for rockets and satellites, which establishes the character of international information exchanges.

The Space Science Board has prepared, with the cooperation of NASA and the Smithsonian Astrophysical Observatory, a comprehensive list of tracking stations that report their results to the US, and has submitted this list to COSPAR for its use when similar information is available from other countries.

COSPAR Planning for IQSY and WMS: A meeting of COSPAR Working Group II, on scientific experiments, was held at Kyoto, Japan, in September, 1961, to further the development of plans for the IQSY and WMS. In cooperation with the Academy's Geophysics Research Board, the Space Science Board is also developing proposals for the US program for the IQSY and WMS.

Information and Data Exchange: A new Guide to Rocket and Satellite Information and Data Exchange has been drafted by SSB and is now being circulated internationally to the members of COSPAR Working Group II for their comments. The Draft Guide, an expansion and extension of the IGY provisions, sets forth in detail procedures for announcement of rocket and satellite launchings, for designation of satellites and space probes, for distribution of acquisition and tracking data, for exchange of scientific results, and for presentation of reports and bibliographies of national space programs.

Improvements in the SPACEWARN System: A unified code for the transmission of satellite information is being developed by the Board, and steps are being taken to improve the effectiveness of the SPACEWARN system for world-wide rapid communication of satellite information. This plan provides for the appointment, within member countries of COSPAR, of national contacts for SPACEWARN matters, who are to review the problems of data users and the question of the addition of radio broadcasts of satellite information to stations within the present telegraphic communications network.

COSPAR International Reference Atmosphere: The availability of new and more-precise data as a result of the IGY and of the new tools for space research gave rise to the need for an internationally recognized set of reference data on pressures, temperatures, densities, etc., of the atmosphere above 32 km. In response to this need, COSPAR convened a group of appropriate experts to develop the basis for a COSPAR International Reference Atmosphere. Tentative tables were drawn up and have been published in temporary form, subject to revision as new data become available. The SSB has been cooperating in these efforts.

Fifth COSPAR Meeting and Symposium: At the invitation of the National Academy of Sciences, COSPAR will hold its Fifth Meeting and its Third International Symposium in Washington, D. C., from April 30 to May 9, 1962. (See *Bulletin No. 55.*) The Third Symposium will cover space science research broadly. Preparations for the meeting, including the organization of US scientific contributions to the Symposium, are being actively undertaken by the SSB.

Two other symposia will also be held in conjunction with the COSPAR meeting: a symposium on Rocket and Satellite Meteorology, co-sponsored by the International Union of Geodesy and Geophysics, by the World Meteorological Organization, and by COSPAR, will be held April 23-25; a symposium on the Geodetic Uses of Rockets and Satellites, co-sponsored by the International Association of Geodesy and by COSPAR, will be held April 26-28.

Bibliographic Notes

Abel, W. G., Chisholm, J. H., Fleck, P. L., James, J. C., Radar reflections from the sun at very high frequencies. *Journal of Geophysical Research, 66*(12), 4303–7, December 1961.

Allcock, G. McK., Rodgers, M. F., Geomagnetic activity and the reception of whistlers in polar regions. *Journal of Geophysical Research, 66*(11), 3953–5, November 1961.

Berkner, L. V., Odishaw, H., eds., *Science in Space,* McGraw-Hill Book Co., 458p., 1961.

Binaghi Pages, A. C. F., Lo spazio fisico che circonda la terra. *Missili,* Rome, no. 1, 43–53, February 1961 (*In Italian*).

Bossolasco, M., Elena, A., Caneva, A., On the geomagnetic effect of the solar eclipse of 1961, February 15th, at Genova. *Geofisica Pura e Applicata,* Milan, *48*(1), 102–8, 1961.

Campbell, P. A., ed., *Medical and Biological Aspects of the Energies of Space,* Columbia University Press, 491p., 1961.

Carpenter, D. L., New experimental evidence on the effect of magnetic storms on the magnetosphere. *Journal of Geophysical Research, 67*(1), 135–45, January 1962.

Dietsche, D. A., Crowe, D. V., *India Balloon Program,* General Mills Electronics Group, Minneapolis, 86p., July 28, 1961.

Hillman, L., Haymes, R. C., Modifying a telemetry system for balloon-borne neutron detection. *Electronics, 34*(11), 60–3, March 17, 1961.

Kellogg, W. W., Sagan, C., *The Atmospheres of Mars and Venus:* A Report by the Ad Hoc Panel on Planetary Atmospheres of the Space Science Board, National Academy of Sciences—National Research Council Publication 944, 151p., 1961.

Matsushita, S., Increase of ionization associated with geomagnetic sudden commencements. *Journal of Geophysical Research, 66*(11), 3958–61, November 1961.

Nason, M. E., Evaluation of the Special World Interval Program during the IGY. *Journal of Geophysical Research, 66*(10), 3957–8, October 1961.

Nawrocki, P. J., Papa, R., *Atmospheric Processes,* Geophysics Corporation of America, no. 61-37-A, Bedford, Mass., c. 400p., August 1961.

Odishaw, H., Activities of the Space Science Board. *News Report,* National Academy of Sciences—National Research Council, *10*(4), 49–52, July–August 1960.

Ondoh, T., Ionospheric currents responsible for sudden commencements observed at the geomagnetic equator. *Journal of Geophysical Research, 66*(12), 4155–61, December 1961.

Patterson, T. N. L., Whistler dispersions for a model of the ionic distribution in the exosphere. *Planetary and Space Science, 8*(2), 71–6, November 1961.

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