International Scientific Action: The International Geophysical Year 1957-58

L. V. Berkner[1]

Associated Universities, Inc., New York 1

FOR the third time in a century the scientists of the world will join, during 1957–58, in a critical examination of the ever-changing aspects of man's immediate physical environment. Throughout the ages, man's curiosity about and observations of the gross manifestations of nature have provided him the elementary facts and ideas that have "hatched" into one great scientific discipline after another. The clues to nature's organization are not often related very directly to man's special sense organs. Consequently, his reconstruction of nature's processes requires the exhaustive examination of those few clues of which his senses are immediately aware, so that other phenomena, more privy to nature, may be discovered.

As Fraser (*1*) points out, for example, the external phenomena of electricity and magnetism are "sufficiently rare and unimportant in the zoological world that animals, in general, have not developed special sense organs to perceive them." The classic emergence of the science of electromagnetism, with its enormous influence on our comprehension of nature, has followed the thorough scrutiny of the implications of the simple adherence of dust to amber, the unusual behavior of lodestone, and the inspiring spectacle of lightning. The pursuit of simple clues of "Faraday, a chemist; Dufay, a botanist; Gilbert, a physician; Gray, a classicist; Franklin, a printer; Bennet, a churchman; Wesley, an evangelist; Canton, a schoolmaster; Geissler, a glassblower; Marat, a revolutionist; Morse, a painter, and so on," has led to a synthesis of the knowledge of electricity and magnetism far beyond the direct recognition of our senses. Such powerful precedents in the history of science are a challenge to man to study the clues that nature gives him, so that in comprehending them he may find new approaches to nature's organization.

Among the sciences, the discipline of geophysics has played a leading role in directing man's critical attention to new aspects of his natural surroundings. Throughout the history of science, geophysical studies and analyses have been the starting point for the growth of new sciences. Moreover, the development of geophysics has been closely allied with the evolution of our culture from superstition to comprehension; particularly so, because superstition is so often related to the gross aspects of our immediate environment. From the divining rod to modern hydrology and from the rain gods to meteorology are long steps in the process of man's civilization.

But quite apart from its honored place at the fountainheads of science and from its civilizing influence on our culture, geophysics has contributed enormously to the immediate benefit of mankind. Among innumerable examples, we may cite the multiplication of deeply buried fuel resources and minerals from precise surveys of geomagnetic and gravitational fields of the earth; or the dependence of navigation upon our knowledge of the earth's geomagnetic distribution; or the fundamental dependence of modern radio communication on our discoveries in the earth's outer atmosphere. Just within the past 3 or 4 years entirely new and vitally important modes of radio propagation have emerged as a consequence of geophysical research and resultant mathematical generalizations that have led in turn to the prediction and discovery of these otherwise unsuspected possibilities for radio propagation.

The subject matter of geophysics is necessarily broad. Geophysics includes geodesy, techtonophysics, seismology, vulcanology, hydrology, oceanography, all of which involve the physical structure and origin of the earth's crust and interior. Extending above the surface, geophysics includes meteorology, climatology and glaciology, geomagnetism and geoelectricity, and physics of the mesosphere, ionosphere, and aurora. In these latter regions of geophysical research, constant and sometimes radical change is the rule, and here the effects of extraterrestrial influence is most evident. Each of these elements of geophysics is related to others in an extraordinary number of ways: for example, meteorology to hydrology, vulcanology, and oceanography; and geomagnetism to the ionosphere, the aurora, and the physics of the earth's interior. But beyond the known relationships lie others that are suspected but remain to be established, and still others that may yet be unsuspected.

The tools of geophysics are drawn from all the natural sciences, and the discipline is synthesized by the common language of mathematics. In fact, the science of geophysics as we now know it was born with the introduction of exact mathematical means of exploring the complexities of our geoid. The forebears of geophysics were those fabulous mathematicians, Laplace, Legendre, Gauss, and Maxwell. The interaction between the natural sciences and geophysics is strong. Where astronomy and astrophysics can give clues to the source of geophysical disturbance, geophysics finds in radio noise a disturbance that is traced back

[1] Vice chairman, Special Committee on the International Geophysical Year.

to the hitherto unsuspected existence of "radio stars" and the means "to see through" the opaque arms of the galaxy. Where nuclear physics describes the interaction of cosmic rays on our atmosphere, geophysics examines their world-wide distribution to obtain clues to their origin, or discloses phenomena that reveal an unsuspected behavior of the sun. When atomic physics provides basic knowledge of the photochemical reactions of the outer atmosphere, geophysics examines these quantitatively in the superb low-pressure laboratory of the outer atmosphere that is unbounded by side walls. The forces of the universe, whether they act through electromagnetic or gravitational fields, through direct impingement of elementary particles on matter, or in other and yet unknown respects, become evident by their action on the earth's surface, its atmosphere, and its fields. As we become able to account for the character of the interaction between our surroundings and the influences upon them that act through space, we are better able to describe the nature of our extraterrestrial environment.

Curiously enough, the gross features of our natural surroundings are as yet little understood in a generalized way. When the weather "storms," we realize that the weather is fair in another place; we realize, too, that the weather at every place over the earth consists of related elements of a definable whole that changes in response to specifiable natural forces. When the aurora plays, we know that it may be playing, though somewhat differently, at another place in response to natural forces. The extension of natural phenomena in varied forms over the whole of the earth's surface makes their general description extraordinarily difficult; yet how are we to understand phenomena if we cannot describe them? Our desire to compile such a description is heightened by the educated suspicion that such a description will lead to new and vital clues to our understanding of nature and to the growth of whole new disciplines of science.

The purpose of geophysics is to provide a concise generalized description of our gross natural environment from which we can comprehend its variations from time to time and from place to place. Many aspects of this environment, such as the earth's principal surface features, change so slowly that we may travel from place to place to observe them and can synthesize our observations with the leisure of ages.

Other aspects, such as the level of the sea, or the extent of the glaciers change more appreciably. But since they remain sensibly constant over a year or a lifetime, we can make "epochal" observations to ascertain the nature of these changes over the generations. Oddly enough, man has shown little enthusiasm for establishing these "epochal bench marks" that are unlikely to produce immediate benefit to him, however important these may be to his successors. How eagerly modern scientists make use of such infrequent records as the one left by Henry Hudson, who sailed his Half Moon in the early 16th century into that great bay in Canada named after him. His journal records that he stood on the ice at the shore to mark the event on the stone of the cliff that arose out of the bay. Today that record has risen some 60 ft, indicating the rate of rise of the northern end of our continent as it recovers from the glacial loading of the Pleistocene epoch around the hinge that passes through the Great Lakes. Such simple epochal records as these are enormously important to geophysics.

Other aspects of our surroundings, such as the weather, or the ionization of the earth's atmosphere, or the strength and direction of the earth's magnetic field, or the tides of the air, the sea, and the earth's crust, change more quickly. Many such phenomena are found to vary periodically, either simply or as the complex sum of differing and superimposed periodic variations. These may be connected with the earth's rotation, or "day," its orbital motion, the relative positions of nearby astronomical bodies such as the moon and the sun, the sun's rotation on its axis and the extent of activity on its surface. Moreover, the variations of two or more of these phenomena may be directly related in the sense of cause and effect. For instance, the diurnal change of geomagnetism appears to rise from the daily variation of ionization and of the great tides in the atmosphere, produced, respectively, by direct effects of the sun's radiation and the combined gravitational forces of the sun and the moon.

Then, finally, there are quickly changing and too-often unpredictable events in our surroundings known as "disturbances" or "storms" that occur at irregular intervals. In some elements of nature, such as the weather, storms may be relatively local, and a large number may simultaneously, with ever-changing character, move rather slowly over the earth's surface. In other elements, such as geomagnetism, the onset of the storm may occur everywhere over the earth simultaneously, with varying aspects appearing in different locales as the storm develops. In still other elements, such as the aurora or the ionosphere, some storms may spread rather quickly from a region near the poles, although in such cases there remains considerable doubt concerning the morphology of auroral disturbance. Auroral curtains have been observed to move as quickly as 100 km/min over the earth's surface.

Because great storms occur at irregular intervals and are nonperiodic, they are not regularly anticipated and often have a major influence on human behavior and even existence. Great storms, because of their unusual character, provide a multitude of clues to the fundamental character of nature. But such irregular disturbances are often most difficult to describe with precision because of their unexpected and transient character, their existence beyond the view of a single observer, and their varying complexity from place to place. Moreover, even when a succession of storms is observed at one place, each disturbance may appear to differ from the others because of the intervening change in the general environment with the passage of time. Yet a generalized description of the morphology and origins of storms in nature's several elements promises to extend substantially our comprehension, control, and utilization of nature's organization. The history of the progress already achieved confirms this expectation abundantly.

Obtaining a geophysical description of any natural element of our surroundings as it appears over the earth's surface, means that observations must be made at a sufficient distribution of points over the surface to permit generalization with the required precision. This process of "exploration" was known to the ancients in the development of general geography. In recent times, it has been extended to include world surveys of gravity, of the earth's general magnetism, of geodesy, of ocean features, and of climatology, among many others. The spacing of observation depends on the precision required; and in geophysical surveying for oil or minerals, where small anomalies prove of utmost importance, the survey points must be close together indeed. When the quantity to be surveyed varies in magnitude with time, then the observation at each survey-point on the surface must be repeated at time intervals that are sufficiently short to permit description of the variation at that point. When the variation is rapid, as it is during a storm, then observation must be continuous at each of a sufficient number of survey-points spread over the affected area, if we are to obtain a description of the storm. When it is spread over the earth, then the survey must be world wide. Furthermore, all measurements or observations must be referred to defined standards and procedures if the resultant description is to be generalized in a quantitative way.

Moreover, geophysics is predominantly an observational science, because the quantity to be observed is rarely under laboratory control. Therefore, the data for each station may include a complex of two or more superimposed variables whose independent status can be separated and established only by statistical treatment of a sufficiently long observational series.

The quantitative general description of a highly variable, world-wide aspect of nature is a most difficult task. The geography of the earth, with its political subdivision of nations having varying policies, makes the arrangements for simultaneous survey over the earth's surface according to prescribed standards a matter of detailed prearrangement. Full advantage must be taken of geography to obtain sufficient coverage of ocean areas, and "open" areas must be spot checked by observation from ships or aircraft to permit controlled extrapolation. The polar regions offer special problems of accessibility that require expensive expeditionary coverage. Therefore, a substantial part of geophysical progress is dependent upon intimate collaboration of the scientists of many nations. To geophysics, the world must be its laboratory.

The study of world-wide variables of geophysics, looking to their generalized description follows two general courses. First, phenomena may be studied continuously and in detail at each of a number of carefully selected stations. Over an interval of time long enough to obtain all representative variations, a phenomenon at a station can be generalized through analysis to represent its variations and to relate this representation at that station to the fluctuation of other associated geophysical elements. Moreover, time variations of phenomena between stations can be compared, to provide their generalized description over the earth. This is the basis for such great centers of geophysical activity as those near Greenwich (now Hurstmanceaux), Paris, Potsdam, Washington, Tokyo, Leningrad, Canberra, Ottawa, and the Geophysical Institute of Alaska. Furthermore, strategically located satellite stations operate out from such centers to provide simultaneous information representative of a larger area, so that a better spatial picture can be conceived. From these continuing geophysical activities, the broad outlines of the geophysical organization of nature's variables are principally derived. Unfortunately, certain key areas, such as the antarctic, are entirely devoid of very essential continuing activity of a kind that seems essential to the solution of geophysical problems.

Experience has shown that these continuing activities are far from sufficient to provide all information needed for a detailed synoptic description of the organization and behavior of particular events. What is the world-wide description of the appearance and growth of a particular auroral disturbance? Does a succession of such disturbances develop along a common pattern? Questions of this type, applying to almost every geophysical variable, lead to the second great class of geophysical observation—namely synoptic observation. Although this type of observation is applied to meteorological phenomena in limited areas of the world, it can seldom be extended to the whole world, because of cost and effort involved. Because simultaneity of synoptic observation everywhere is essential to a world-wide description of an event, geophysical scientists are strongly impelled to agree on an interval when they will all concentrate on the operation of a sufficient network of synoptic stations to obtain its universal description.

An International Geophysical Year is such an interval. An international year serves two purposes: It provides an internationally agreed upon interval of unusual geophysical activity when it is especially profitable to occupy inaccessible areas, such as the antarctic, for the purpose of supplementing the great continuing geophysical activities with observations in vital areas. And it provides opportunity for the geophysicists of the world to plan strategic networks for synoptic description of particular kinds of world-wide geophysical events, particularly meteorological, magnetic, ionospheric and auroral "storms" or disturbances whose spatial morphology and history are otherwise beyond our grasp.

Symbolic of the growth of man's civilized values, two international geophysical years have been conducted, and the third, the International Geophysical Year of 1957–58, is now being planned. With the growth in geophysics in the last century, exact information of the little-known portions of the world became imperative. Moreover, this information was needed in synoptic form, representative of the whole area involved. As a consequence, in 1883, a joint international effort to collect such data was made; it was known as the First International Polar Year. This early and concentrated exploration of geophysical phenomena produced enormous results: It led to great clarification of our knowledge of geomagnetism and to the first orderly representation by Fritz of auroral phenomena, which described the zone of maximum auroral activity some 23° from the geomagnetic pole. A real step had been taken to destroy the old beliefs in the magic of common phenomena and to transform these to a rational scientific basis. The Second International Polar Year was held in 1932–33 on the 50th anniversary of this first great international effort. In spite of the fact that this effort coincided with a period of international economic disaster, the leadership of Dr. D. LaCour brought the program to fruition. Many advances grew out of this effort, not the least of which was the realization that the polar regions of the earth had become easily accessible for scientific observation. It was this second polar year that led directly to the conception of the Geophysical Institute of Alaska.

The interval following this second era of international cooperation in geophysics was extraordinarily fruitful in the production of the means for further geophysical exploration. With the radiosonde, meteorologists have extended their range of observation to nine-tenths of the mass of the atmosphere. The multifrequency ionospheric recorder has come into being, making possible the delineation of the principal features of the outer atmosphere; the discovery of ionospheric storms coincident with auroral and geomagnetic storms; and the discovery of "radio fadeouts," those sudden ionospheric disturbances that are coincident with solar chromospheric eruptions, with a most peculiar geomagnetic effect, and sometimes with extraordinary bursts of cosmic-ray intensity. Rockets have flown into high reaches of the atmosphere and, in conjunction with other techniques, provide measures of composition and temperature. Moreover, rockets permit us to see the sun as it appears outside the blanket of the earth's atmosphere. New radio and meteoric techniques give direct knowledge of wind motions in the high atmosphere. Views of the composition of the outer atmosphere have undergone a revolution as measurements of winds and patterns of atmospheric circulation have been disclosed. Complex apparatus discloses the existence of centers of night airglow that move. Auroral spectroscopy has disclosed the influx of protons at least at the outset of auroral disturbance, and movements of the aurora are now studied by special photographic instrumentation. And finally, the powerful tools of wave-mechanics and the electronic computer have come into widespread use in the synthesis of observed results.

This revolution in our power to observe and to synthesize has vastly extended our comprehension of the organization of nature around us. But in doing so, it has extended our perception to include new phenomena and has whetted our curiosity to have the descriptions of both old and new phenomena on a world scale. Against such a background has the world organization of science arrayed itself for the solution of these problems.

Meeting at Brussels in 1950, the Mixed Commission on Ionosphere recommended to its sponsoring unions that a Third International Year be held in 1957–58 to coincide with the eminent peak of the solar cycle and the 25th anniversary of the Second International Polar Year. After 1957–58, it is anticipated that geophysical disturbance will not again be as frequent until about 1970. The idea caught on quickly, and these unions recommended to the International Council of Scientific Unions that an International Geophysical Year (IGY), or Année Geophysique Internationale (AGI) be internationally sponsored. Substitution of the words *geophysical year* for *polar year* reflects recognition of the need for world-wide synoptic observation and analysis.

The International Council of Scientific Unions has appointed a Special (International) Committee on the International Geophysical Year, or CSAGI (Comité Special de l'Année Geophysique Internationale), with responsibility for planning geophysical activities and coordinating the programs of the unions and of the national committees. This committee has been organized under the presidency of the world's most distinguished geophysicist, Prof. Sydney Chapman, Queen's College, Oxford. It is composed of representatives from all the sponsoring international unions, including the International Union of Geodesy and Geophysics, the International Scientific Radio Union, the International Union of Pure and Applied Physics, the International Astronomical Union, and the International Geographical Union, together with representatives of the World Meteorological Organization. At a provisional meeting in Brussels in Oct. 1952, the CSAGI urged the formation of national committees and requested reports by the national committees and by the sponsoring unions and the WMO outlining suggested elements of the program for the IGY.

All the sponsoring unions, the Mixed Commission on the Ionosphere, and the newly organized national committees of many nations have submitted preliminary proposals. These nations include Argentina, Australia, Austria, Belgium, Brazil, Canada, Czechoslovakia, Denmark, Finland, France, Germany, Great Britain, Greece, India, Japan, Netherlands, New Zealand, Norway, Pakistan, Spain, Sweden, Switzerland, Tunisia, Union of South Africa, United States of America, and Yugoslavia. Since the time has been short, not all nations have yet submitted provisional programs, but it is reasonable to suppose that within the year world adherence will be accomplished.

The CSAGI held its first formal plenary session in Brussels June 30 through July 3, 1953. At this meeting, the CSAGI promulgated a provisional program, based on the proposals received, for the development of means for further and more exact planning by the unions, the national committees, and other interested agencies. The CSAGI is now awaiting detailed national programs for observations, synoptic networks, and expeditionary operations, which are due from the national committees by May 1954. During the summer of 1954, particular elements of these national programs will be synthesized at meetings of the IUPAP (London, July 12); Mixed Commission on Ionosphere (Brussels, Aug. 16); URSI (The Hague, Aug. 22); IUGG (Rome, Sept. 15); and the Special and Executive Committees of WMO (September). Finally, the world program will be integrated by the CSAGI (Rome, Sept. 30–Oct. 4). An important aspect of this work throughout the summer of 1954 is the detection of defects in the program, so that these can be corrected. Thus, a volume outlining the world program for the International Geophysical Year 1957–58 should be ready for distribution early in 1955, in time for adequate advance preparation.

The organization and operations of the U.S. National Committee for the IGY is an example of the national function in the preparation of the international plan. This committee is organized by the National Academy of Sciences and reports to CSAGI through the National Research Council, which is the formal United States organization through which American science adheres to the International Council on Scientific Unions. Under the chairmanship of Prof. Joseph Kaplan, University of California at Los Angeles, it comprises leading American geophysicists, representing all related geophysical disciplines and organizations, including interested United States Government agencies, as well as academic and educational institutions. The committee responds to the requests of CSAGI by recommending the program for United States participation. Moreover, at the request of the committee, the National Science Foundation has agreed to organize and sponsor the United States participation in the program of the IGY. The committee and the Foundation are cooperating splendidly in developing United States participation.

The CSAGI has proposed for purposes of planning that programs be organized in nine general scientific areas: meteorology; latitude and longitude determinations; geomagnetism; the ionosphere; aurora and airglow; solar activity; cosmic rays; glaciology; and oceanography.

The CSAGI has designated as the world rapporteurs for each discipline, member scientists who will be ultimately responsible for the organization of the world program in that discipline. In addition, a special world committee on World Days has been named to designate specific intervals of special observation during the International Geophysical Year. Corresponding to this organization, the United States National Committee has designated member scientists as United States reporters to supervise the planning of United States participation in each discipline. These United States reporters are supported by special committees of United States national committees of sponsoring international unions to aid in the planning of programs for the disciplines in which they are involved. Thus, for example, the United States reporter on aurora and airglow is supported by the very active committee of the U.S. National Committee of the International Scientific Radio Union.

In order that the concentrated effort may be reduced to the minimum needed for adequate analysis, special intervals of observation to be known as World Days are to be designated. Three regular World Days will be specified each month, one near full moon and two near new moon. In addition, an average of two special World Days will be designated each month, about 3 weeks in advance, to coincide with predicted geophysical disturbances, solar eclipses, solar flares, and unusual meteor showers, and with special rocket launchings.

The announcement of beginnings of world-wide disturbances, designation of special World Days, and other pertinent and current information will be made over a world-wide network of radio stations. Ten consecutive days each season may be designated as Meteorological Intervals for studies of special meteorological significance. The scientific agencies responsible for prediction will be designated by CSAGI this summer.

The scientific program for the IGY is already taking form. But discussion of it here can include only a very few illustrative problems and these in the barest outline. The ultimate plan will fill a thick volume.

In the field of meteorology, the World Meteorological Organization, together with representatives of the Association of Meteorology, IUGG, has proposed a particularly comprehensive program in the study of world atmospheric circulation. Along the 10°E, 140°E and 75°W meridians from pole to pole, for example, measurements across the vertical sections of the atmosphere will be established. The objective of this program is to study the mass transfer of atmosphere in the east-west direction. Furthermore, a dynamical study of the equatorial atmosphere, which will lead for the first time to a knowledge of the mass interchange of atmosphere between the two hemispheres and of the relation of this transfer to the general circulation pattern, is proposed. The program of meteorology particularly emphasizes the study of the interdependence between the geophysical phenomena of the high atmosphere and the meteorological phenomena of the low atmosphere in relation to variations of weather and climate. The antarctic, with its 6,000,000 mi^2 at an average altitude of nearly 6000 ft, represents the coldest area of the earth, and its influence on weather and climate is little known. G. S. Simpson has suggested that pressure waves, or surges, spread outward from this area and northward across the equator to influence the weather everywhere. Expeditionary observations in the antarctic and the stations along the meridian lines will check the existence and movement of such surges. The radisonde will extend observations to nearly 30 km during Meteorological Intervals. These, together with rockets and meteoric measurements and ionospheric observations, will permit studies looking toward synthesis of the relationships between circulation and behavior in the troposphere, the mesosphere, and the ionosphere.

This very brief and inadequate discussion of some aspects of the program on meteorology suggests the possibility that the IGY may disclose for the first time some of the really basic information that we need in understanding the world circulation pattern.

In the field of geomagnetism, the CSAGI considers the two major problems to be (i) the changing morphology of magnetic storms and activity, including bays and pulsations, and (ii) the daily variation of the three magnetic elements in the zone containing the magnetic and geographic equator. The program of geomagnetism not only is designed to produce information bearing on these problems, but it recognizes, also, the great need for geomagnetic information by other scientific disciplines operating during the IGY—in particular, special observations, in unusual and inaccessible areas of the earth, established to aid ionosphericists and others. Rocket observations will be extended to very high altitudes, which may show whether or not at times of intense aurora the electric currents producing geomagnetic change are localized along auroral sheets or arcs, and which may also provide more direct information on the electric currents in the atmosphere, particularly the intense flow across the polar caps.

Special attention is given to the observation of the aurora and airglow. The CSAGI recognizes the great need for synoptic information of the development of auroral displays. Does the auroral zone simply move south during magnetic activity or are the auroral displays extended southward from the normal auroral zone? What are the relationships between specific auroral phenomena at various places around the earth at times of great activity? Are there special auroral phenomena associated with periods of magnetic calm, particularly over the polar cap? Are the characteristics of the aurora in the antarctic comparable in detail with those of the arctic, or how do they differ? These are questions that require a concentration of observation by all nations during the IGY. Emphasis will be placed on the synoptic studies of the worldwide great displays. Plans are being made to permit relatively inexperienced observers located over very wide areas to make simple but significant observations, on punched cards, which can be readily synthesized by the scientists working on the program. Pilots of commercial aircraft over land and sea and officers of ships will be mobilized as observers.

In one especially exciting experiment, an attempt to identify simultaneous auroral arcs in the Northern and Southern Hemispheres will be made. In what amounts to a particle spectrometer 7000 mi long, using the earth's magnetic field as a lens, stations near both ends of a magnetic line of force will observe time coincidence and parallax of auroral arcs. Such an experiment will involve simultaneous cooperation of expeditionary stations of many nations, but it may be critical in establishing the causes and nature of auroras. Measurements using spectrometers of very high dispersion look to definition of regions where primary particles enter the atmosphere and to comparing the aurora borealis and the aurora australus. More accurate location of the southern auroral zone is anticipated. It seems probable that a really great advance in our knowledge of the origin, character, and distribution of auroral displays will be made during the IGY. This seems especially appropriate when we remember the impetus given to auroral research by the work of Fritz on the data produced 75 years ago during the First Polar Year.

During the IGY, the growth of our knowledge of airglow and the development of instrumentation needed for its observation will make possible important new corollary observations. Proposals are, therefore, under consideration for the synoptic observation of the airglow in specified areas connecting Europe and America and of the movements of intense centers of airglow with the new instrumentation now available.

The ionospheric program recognizes the need for the establishment of meridian lines for observation that coincide with those proposed for the meteorological vertical sections. The importance of recording normal incidence ($P'f$) is recognized, with hourly observations under normal circumstances, but with observations at quarter-hour intervals during the special World Days and during unusual disturbances. The CSAGI has recommended special studies devoted to the observation of ionospheric winds and tides and to the morphology of ionospheric storms. In particular, measurements of radio-wave absorption in the ionosphere by related methods will be emphasized to give the key to distribution of ionization in the D-region.

Studies of the ionosphere will be strongly supported by auxiliary rocket measurements made with relatively inexpensive high-altitude rockets designed for measurement of temperature, pressure, air motion, and spectroscopy of the sun's ultraviolet spectrum above the level of its atmospheric absorption. Attention will be given to "whistlers," that curious radio noise that appears to originate from lightning strokes in the opposite hemisphere near the opposing end of a magnetic line of force and propagated along that line far outside the atmosphere.

The effects of the various types of solar activity on geophysical phenomena during the IGY represent an important aspect of the total program. Therefore, particularly complete and continuous solar observations are proposed during the IGY. The recommendations related to publication of the results of observation of solar activity place emphasis on the observation of chromospheric flares, continuous observations of wave-frequencies involving chromospheric and coronal radiation, the photometry of the solar corona, and related solar observations. Also emphasized is the great importance of further observations, particularly by rocket measurements, of the solar ultraviolet emission spectra.

An expanded program for the observation of cosmic rays as they relate to geophysical and solar processes is planned. The thorough exploration of the primary cosmic-ray spectrum with respect to both mass and energy is planned. This spectrum will be examined, particularly with respect to latitude, in order that the range of energy of the various mass components may be ascertained. The variation of the neutron component will be recorded as a sensitive indication of variation in the incident primaries with respect to locality. In particular, it is hoped that the "ring-current" hypothesis of geomagnetic disturbance can be tested through cosmic-ray observations. Moreover, the extraordinary soft "solar component" of cosmic rays following certain chromospheric eruptions will be given special attention.

The relative locations of geographic points on two continents are not now known more accurately than a few hundred feet. With new and independent techniques employed at about 15 or 20 stations, this error can now be reduced to less than 100 ft. Therefore, tests of the ideas of continental drift and related crustal deformations can finally be tried. The program of latitudes and longitudes during the IGY will provide the first step toward the accurate and permanent connecting of the geodetic surveys of the continents. The observations will be made on the moon with the use of a new photographic technique of Markowitz, and on the stars with a prismatic astrolabe recently developed by Danjon.

Important programs of glaciology and oceanography are planned for the IGY. The oceans, covering four-fifths of the earth's surface, are closely linked to our lives as avenues of commerce, as important sources of food, and through their effects on meteorology. Glaciers are sensitive indicators of climatic change and retain a quantity of water equivalent to a depth of the order of 100 ft above sea level. Several seeming "anomalies" in seasonal change of ocean levels will be studied. Likewise, measurements to determine mass flow of the oceans are planned. Epochal bench marks will be established or checked in glacial growth and recession. In particular, the nature and extent of the "warming tendency" of the earth will be carefully checked, since at the present rate it seems that the arctic may become navigable in less than a century.

The International Geophysical Year offers a special and exciting opportunity for simultaneous and synoptic geophysical observation that may lead to significant geophysical progress. This interval offers extraordinary opportunity to expeditionary groups to contribute effectively to geophysical science through the addition of vital stations in the arctic, the antarctic, and other inaccessible regions. Scientific observation in arctic areas represents no particular difficulty; and, in view of the widespread occupation of those areas in this hemisphere by the United States, Canada, and Denmark, a widespread arctic program seems certain. The active geophysical program of the Geophysical Institute at College, Alaska, greatly enhances the arctic potentialities.

The antarctic, on the other hand, still constitutes the major geographic challenge. It is strange that in this day and age so little is known of that great continent of extremes that may so greatly influence our environment. With the powerful tools of science and logistics now available, the planned antarctic programs and expeditions should make great progress toward clearing up the scientific unknowns now associated with the area. The report, *Antarctic Research, Elements of a Coordinated Program,* (Washington, 1949), issued by the National Academy of Sciences after a special study, provides an important guide to the antarctic operations.

Perhaps the most important aspect of the IGY is the simultaneity of all the related scientific programs, which will make possible a synthesis of the results of complementary observations in related sciences. Continuous programs of geophysical observation are expensive and burdensome, but concentration on simultaneous programs during 1 year will be feasible and productive, particularly when emphasis is placed on observation during regular and special World Days. The powerful tools now available for observation in themselves insure outstanding contributions to our understanding and comprehension of the environment in which man now finds himself.

But most encouraging of all has been the genuine enthusiasm with which the scientists of the earth, and the nations that support them, have embraced the program. Tired of war and dissension, men of all nations have turned to "Mother Earth" for a common effort on which all find it easy to agree.

Reference

1. Charles G. Fraser, *Half-Hours with Great Scientists: The Story of Physics* (Reinhold, New York, 1948).