Proceedings of the Iowa Academy of Science

Volume 65 | Annual Issue Article 8

1958

Invited Address: Some Goals and Accomplishments of the International Geophysical Year

Wallace E. Akin
Drake University

Some Goals and Accomplishments of the International Geophysical Year

By Wallace E. Akin

We meet here today just after the midpoint of the greatest period of coordinated scientific observation ever undertaken by man, the International Geophysical Year. Begun July 1, 1957, the 18-month period of geophysical observations will end December 31, 1958. Although our topic is concerned with goals and accomplishments of the IGY, we must wait, perhaps for decades, before realizing all of the accomplishments, although certain events such as the launching of the earth satellites and the Antarctic activities already have made history. Most of us, as spectators to this magnificent experiment in international cooperation in science, will await with intense interest the publication and correlation of the vast quantity of data that have been and are being accumulated. It is doubtful if there is any field of science here represented which will not be profoundly affected by the results of the International Geophysical Year.

The background for the IGY lies in two previous periods of coordinated geophysical observation, the First International Polar Year (1882-83), and the Second International Polar Year (1932-33). The First IPY yielded valuable data on auroras and earth magnetism which are still used today, and the Second IPY contributed to the increased knowledge of the ionosphere and furnished valuable information for the advancement of radio communications. The accelerated pace of our ability to utilize data and the growing list of unanswered questions about the earth and its atmosphere is indicated by the fact that the IGY follows the Second International Polar Year by 25 years, an interval only half as long as that separating the two polar years. Although geophysical research has not stood still during these intervals, most of it has been uncoordinated on a world-wide basis and many of the problems have been attacked more-or-less in a haphazard fashion.

Formal proposals for this international undertaking were made at the 1950 meeting of the Joint Commission on the Ionosphere in Brussels and the organization was carried out by the International Council of Scientific Unioins (ICSU) through a special committee. The 18-month period in 1957-58 was not an arbitrary choice, but was based on the expected 11-year maximum of solar activity. That this was a wise choice has been demonstrated by a number of spectacular auroral displays which many of you undoubtedly observed here in Iowa.

The subject of these coordinated observations is the physical nature of the earth and its atmosphere, and the extra-terrestrial effects which play a part in determining these characteristics. The sciences which pertain to the physical earth collectively are called geophysics. Although this is, in a true sense, a unified field of science which must turn to the earth, the solar system, and the universe for its laboratory, a division of labor becomes necessary. With this in mind, the activities during the IGY have been grouped under ten sections: Meteorology, Oceanography, Glaciology, Ionospheric Physics, the Aurora, Geomagnetism, Cosmic Rays, Seismology, Gravity, and Latitudes and Longitudes. Obviously, all of these phenomena are not independent of each other and there will be considerable overlap, especially in the interpretation of the data. These features of the earth have one thing in common; they must be viewed in context with the whole earth and its environs in space. This makes imperative international cooperation on a global scale because weather, the earth's gravitational and magnetic fields, aurora, and the other phenomena know no limits of national sovereignty and are not respectors of international boundaries. To be of value, local geophysical observations must be fitted into the total picture of the earth and its universe.

Observations during the IGY will be made during specially designated times referred to as Regular World Days—two days together at each new moon, and one day at quarter moon—and World Meteorological Intervals, of which there are six, each 10 days in length. Three of the World Meteorological Intervals already have been observed in September, December, and March, and three remain in June, September, and December. When it appears that spectacular solar activity may result in unusual magnetic storms and auroral activity, a World Alert is issued four to six days ahead of the expected disturbance. If the disturbance continues to develop, a Special World Interval may be called to concentrate on observation of the phenomena which result, such as geomagnetic effects, radio fadeouts, auroral displays, and a world-wide picture of the event can be constructed.

This effort requires the services of some 10,000 scientists and technicians from 67 nations, making observations and measurements at more than 2,000 stations. The vast volume of data which are being collected are being assembled at three world data centers. World Data Center A is in the United States with 11 subcenters at various universities, government observatories and bureaus, and the National Academy of Sciences. World Data Center B is operated by the U.S.S.R. with subcenters at Novosibirsk and Moscow. World Data Center C is operated by several Western European countries and Japan, with subcenters in each of the countries.

Within the time remaining perhaps we should consider briefly some of the major activities which are a part of the IGY. Time will not permit a thorough discussion of any of the phases of the program, but we can summarize what is being done and speculate on some of the possible results. We will confine our remarks chiefly to the earth and its lower atmosphere, and leave the discussion of the upper atmosphere and the satellite program to the very able hands of Dr. Van Allen in his address this evening.

The Earth's Surface and Interior. The interior of the earth is a case in point of being so close to a thing that it is difficult to determine its true nature. It is probable that we know more about the structure of the moon and sun than we do about the interior of our own planet. Most of our methods of observation must be indirect since we can know from direct observation only the top few miles of the earth's interior.

Gravity observations furnish one of the means by which we can gain some knowledge about the size and shape of the earth. In spite of centuries of measurement, we are still not sure of the exact size and shape of the *geoid,* as the sealevel earth is called, and gravity observations of sufficient accuracy and number will help determine the true shape. With modern instruments it is possible to measure gravity to an accuracy of 1 part in 50 million by the use of a swinging pendulum for absolute values. A more portable instrument, and one which requires much less time to operate, is the gravimeter which gives relative values of gravity by measuring the amount of stretching of a thin wire of Invar metal on which hangs a weight. This instrument weighs only a few pounds and gives readings in 3 to 5 minutes, although the readings must be tied to a base station pendulum reading for absolute values of gravity. Although gravity readings can be made without undue difficulty for points on the continents or on islands, the 70 per cent of the earth's surface occupied by oceans presents more difficulty. Until very recently, the readings had to be made from submerged submarines to eliminate as much motion as possible and readings were necessarily limited because of the difficulty of obtaining the services of the navies of the world for extensive surveys. However, the first successful measurement of gravity from the surface of the open sea was made in November, 1957 by use of a new gyro-stabilized instrument which will make possible a much more complete coverage of the ocean basins. Also, super-sensitive gravimeters are now in use which can detect variations on the order of one part in one billion of the average value of gravity, making possible a more accurate observation of displacements of a few tenths of an inch to a few inches which result from earth tides caused by the gravitational attraction of the sun and moon.

Another method of determining the characteristics of the interior of the earth is by seismology, the study of the waves generated in the earth by earthquakes. More than 50 nations are making such observations during the IGY. Analysis of earthquake waves has permitted the determination of the thickness, density, and probable physical state of the various zones of the earth's interior. It is on the basis of seismic studies that we assume that the earth has a liquid core. Details obtained by the study of earthquakes also help in the formulation of theories as to the origin of the earth's magnetic field. During the first half of the IGY, seismologists from the Department of Terrestrial Magnetism of the Carnegie Institute in Washington have made some interesting discoveries while exploring the roots of the Andes Mountains in South America by means of seismic and gravity studies. They have found that the roots of the Andes, composed of material that is less dense than the neighboring ocean basins, are much deeper than formerly thought. Another development in connection with the IGY is the use of several new types of seismographs with wide range and high sensitivity. Some of these instruments are sensitive only to surface waves generated by very large earthquakes during which the whole earth may be set into vibration. These detailed seismic studies should yield new information on the distribution of materials within the interior of the earth.

A part of the study of earth structure is the further refinement of the determination of latitude and longitude. The need for more exact measurements of position on the surface of the eath is indicated by the fact that in 1948 the French system of coordinates differed by 600 feet from the English surveys, and no one is sure how great the differences are between the major geodetic surveys of the world. During the IGY, 45 stations in 29 countries will make observations to determine with a much higher degree of accuracy their location on the globe. In addition to observations by standard methods, a special device called the dual rate moon position camera is being used to photograph the moon against the background of stars. This yields the precise latitude and longitude of the observer without the distortion caused in standard instruments by gravity anomaly. An interesting side application of moon camera data may be the determination, sometime in the future, of whether the continents are drifting from their present positions or not.

Study of the earth's magnetic field, although it is carried out outside of the earth itself, should shed some light on the structure and history of the planet. The magnetic field has long been a puzzle to students of earth phenomena and it has been observed and recorded since the introduction of the compass as an aid to navigation. Therefore, we have a fairly complete picture of changes in the magnetic field over more than 400 years which indicates that the magnetic field is constantly shifting westward and will complete a circuit of the geographic pole in about 1,600 years. It is now almost certain that the earth has two magnetic fields, the main field which is always lined up with the axis of earth rotation, and the residual field which causes the numerous irregularities in the magnetic compass at different locations. Apparently, the westward drift of the north magnetic pole is due to shifts in the residual field rather than in the main field. However, we have evidence from the new science of paleo-magnetism—the study of fossil magnetism of magnetic particles frozen in lava flows and sedimentary rocks and aligned with the ancient magnetic field of the earth rather than the present one—that not only has the magnetic pole undergone shifts due to the residual field, but that shifts in the main field have been so great as to suggest radical changes in the location of the axis of rotation with respect to the surface of the earth. Since Pre-Cambrian time, more than 600 million years ago, the North Pole seems to have wandered from the coast of California, through the Central Pacific to within 20 degrees of the present equator, and thence across China and eastern Siberia to its present location in the Arctic Ocean.

Since it is improbable that the earth has been subjected to forces of sufficient magnitude to change the axis of the earth in relation to the plane of the ecliptic, the discarded theory of continental drift has been revived. This furnishes a possible explanation for the polar shift by postulating a shift in the mantle of the earth with relation to the inner core without appreciably changing the distribution of mass in relation to the axis of rotation or the plane of the orbit. This theory, if substantiated by further observation, including that made during the IGY, may explain the presence of ancient glacial materials in equatorial regions. Recent studies by scientists from Imperial College in London and the Tata Institute of Bombay have found evidence, based on the dip of magnetic particles in ancient lava flows, that India has drifted northward from south of the present equator between 100,000,000 and 50,000,000 years ago. It should be pointed out that the hypothesis of polar and continental drift cannot account for the most recent glacial period, the Pleistocene, which occurred within the last million years when the North and South Poles were essentially at their present locations. We must look for other explanations for the waxing and waning of the glaciers of recent geologic time, probably in studies of the atmosphere, ocean currents, and changes in solar radiation. Also, it should be stated that not all geophysicists accept the evidence of paleo-magnetism and much work remains to be done to establish the credibility of the fossil record. A clearer understanding of the behavior of the present magnetic field, which may result from the intense scrutiny of its behavior during the International Geophysical Year, may help clear up this problem.

Meteorology. In the study and forecasting of weather there is a great need for more detailed information about the structure and motions of the atmosphere. There is a serious lack of knowledge about winds aloft, particularly in the southern hemisphere, and, until the IGY, about the general weather conditions in Antarctica. Since the global circulation of the atmosphere is powered by energy received from the sun, it is important to determine the magnitude of the power available to run the atmospheric machine. This can be computed by measuring the *albedo* of the earth—that part of the sun's energy that is reflected back into space. This is being done during the IGY by measurement of earth-light reflected from the dark hemisphere of the moon. Of particular interest will be the record of fluctuations from day to day of the amount of energy reflected from the earth, and conversely, the variations in the energy available to drive the global circulation.

Other vital meteorological questions which may be answered as a result of observations during the IGY include more details about the exchange of air between the equatorial and polar regions, and between the northern and southern hemispheres. An explanation of the process by which the temperature of the earth is kept in balance depends on a more complete understanding of the zonal and meridional flow of air throughout the year. In order to facilitate the study of atmospheric circulation during the IGY, three chains of stations, extending from pole to pole, have been established. These are located along meridians 75° W, 10° E, and 140° E. To supplement these chains of stations, 12 nations have established 50 observatories on the Antarctic continent and, for the first time, synoptic meteorological charts of this part of the earth are being drawn on a daily basis. The stations already have made possible improved weather forecasting in the southern hemisphere and have yielded some very valuable data on atmospheric circulation.

The meteorological program includes measurement of ozone in the lower atmosphere because of its important capacity to absorb and release energy. Although it is a very minor constituent of the air, it is thought to play an important role in the circulation of the upper atmosphere. Preliminary results of the ozone measuring program show that there is about 25 per cent more ozone at ground level in Antarctica than there is in New Mexico.

Carbon dioxide is another minor component of the atmosphere which may play a major role in climatic changes. Because of the large quantities of carbon dioxide being released by our industrial civilization, some climatologists believe that we may be creating a warmer climatic situation since this gas is effective particularly in preventing the escape of long-wave radiation from the earth's surface, much as does the glass in a greenhouse. Studies of carbon dioxide content throughout the earth as part of the IGY meteorological program have shown that the concentration is about uniform over the earth except very near large industrial concentrations. Although an 18-month period of observation is much too short to determine the rate of increase of carbon dioxide in the atmosphere, it will provide valuable information for comparisons at a later date, say 20 years in the future.

The world-wide program of coordinated meteorological observations is particularly valuable because it will permit the meteorologist to see what is going on throughout the world at a given time. From the over-all picture of weather, cause and effect will be more easily discernible. Also, other phases of the IGY such as glaciology, oceanography, and upper-atmospheric studies, will aid the meteorologist in answering some of the most pressing questions which he faces today. Recently, the Advisory Committee on Weather Control in Washington suggested eight areas which are of vital importance to the science of meteorology, some of which may be explained partially by analysis of the data collected during the IGY. These are: (1) the effect of solar disturbances on weather; (2) the factors which control our global atmospheric circulation; (3) factors governing the genesis and movement of large-scale storms; (4) dynamics of cloud motions; (5) processes of rain and snow formation; (6) the role of electricity in meteorological phenomena; (7) natural sources of condensation and ice-forming nuclei; and (8) the methods, materials, and equipment employed in weather modification.

Oceanography. The oceans, covering more than 70 per cent of the earth's surface, play a major role in world weather and climate. As great storehouses of energy, they absorb solar energy in the equatorial regions and transport much of it into higher latitudes by way of ocean currents such as the Gulf Stream. The movements of these surface currents are closely related to the prevailing winds of the lower atmosphere and long have been recognized and studied. However, the deeper currents in the oceans are much more difficult to observe. It is known that cold water is formed from melting ice in the polar regions where it sinks, displacing warmer water which flows toward the equator. These currents are difficult to determine because of the topography of the ocean bottom and lack of information as to the speed and direction of flow. Actually, there is some question as to whether the circuit of water from the pole to equator and its return requires tens of years or thousands of years. Since these bottom waters play an important role in the biological life of the oceans by supplying chemical nutrients to the surface where they upwell, their behavior with regard to potential world food supplies is important. Most of the world's great fishing areas are found where these waters reach the surface. Also, a study of the time it takes for deep waters to appear again at the surface may determine the desirability of using the oceans as dumping grounds for radioactive wastes.

Another phase of the oceanographic observations is the study of mean sealevel throughout the world. There are indications of changes in sealevel between winter and summer, possibly resulting from changes in density of the waters and seasonal exchange of water between the hemispheres. About 200 tide gages are being operated throughout the world. Also, included in the study of the oceans is a program of charting the bottom of the oceans and taking samples of bottom materials.

Glaciology. The IGY also includes a broad program for the study of glaciers existing in the world today. This program is designed not only to map the extent and volume of glaciers as they exist today, but also to try to understand their behavior and their relationship to present and past climates. Glacial studies are being carried on from the Arctic to the Antarctic, including equatorial glaciers of Mount Kilimanjaro and Mount Kenya in East Africa. The thickness of the glacial ice in Antarctica has been determined by seismographs at numerous locations including the South Pole itself where the ice shows a depth of 8,300 feet. An understanding of the volume of water locked in glacial ice may be of importance in determining the water budget of the earth. This quantity is of such magnitude that estimates of the rise in sealevel which would result if all the ice in the world's glaciers were melted range from 200 to 300 feet. This would be enough to submerge most of the world's coastal cities and great areas of lowlands on the continents.

In this short report on the goals and accomplishments of the International Geophysical Year at its midpoint, we have considered only briefly some of the broader aspects of the various programs. In addition to those programs mentioned in some detail, we have said little about the study of ionospheric physics, cosmic rays, solar activity, or the earth satellite program. I am sure that this part of the IGY program will be covered adequately this evening by Dr. James Van Allen in his address on *Satellites of the Earth.*

Pertinent Literature

1. Bates, D. R., 1957. The Earth and Its Astmosphere. Basic Books Inc., New York.
2. Bullen, K. E., 1955. The Interior of the Earth. Scientific American 193:3, pp. 56-61.
3. Heiskanen, W. A., 1955. The Earth's Gravity. Scientific American 193:3, pp. 164-174.
4. Odishaw, H., 1958. International Geophysical Year. Science 127:115-128.
5. Runcorn, S. K., 1955. The Earth's Magnetism. Scientific American 193:3, pp. 152-162.

6. U. S. National Committee for the IGY 1956. Proposed United States Program for the Geophysical Year. National Academy of Sciences, Washington.

7. Wexler, H. 1955. The Circulation of the Atmosphere. Scientific American 193:3, pp. 114-124.

Department of Geology and Geography
Drake University
Des Moines, Iowa