

Source: Hugh Odish:, Executive Director, US National Committee for IGY, "The Meaning of the International Geophysical Year," 4 December 1959, U.S. President's Committee on Information Activities Abroad (Sprague Committee) Records, 1959-1961, Box 6, A83-10, Dwight D. Eisenhower Library, Abilene, Kansas.

National Academy of Sciences

Washington, D.C.

The Meaning of the International Geophysical Year

(Remarks by Dr. Hugh Odish:, Executive Director, US National Committee for IGY, before the National Press Club, Dec. 4, 1958)

Members of the National Press Club and distinguished guests, I am pleased to be here today, sensible of the honor that an invitation from you holds. I am also sensible of the honor accorded me by the distinguished gentlemen at the head table; most of them are members of the U. S. National Committee for IGY.

Now I am only, as Henry V put it, a warrior for the working day. But I understand that what you want is a personal assessment of the IGY from someone who has become completely enmeshed in its tentacles--a description which fits me perhaps all too well. This personal assessment, of course, is compounded of my own convictions and prejudices, cultivated over the last five exciting and consuming years.

My contention is a simple one: the IGY is the single most significant peaceful activity of mankind since the Renaissance and the Copernican Revolution. Accordingly it must and does have a variety of meanings. It has meaning in terms of (1) science, (2) its social significance as a pattern of activity, (3) its role in affecting the future, and (4) its general and intellectual implications.

1. Meaning to Science

Although the IGY observational program is still under way, with all the limitations that this entails in terms of assessing its results at this time, the remarkable thing is what has already been achieved--and achieved on several levels. Three areas of accomplishment suggest its meaning to science: first, the mapping of man's physical environment; second, the interdisciplinary revolution; and, third, specific discoveries, clearly meaningful in themselves.

The basic objective of the IGY was a mapping of our physical environment. Just as geographic mapping has its self-evident necessity to man before he can know a region and before he can begin to assess and utilize it, geophysical mapping is a prerequisite to a scientific understanding of the earth and its cosmic environs. So the fundamental purpose of the IGY was the acquisition of synoptic data---data taken simultaneously on and about the earth in order to get a planetary view of weather, geomagnetism, the ionosphere, the aurora, and the like. In this objective the IGY has been fully successful---as the quantity and quality of data in the IGY world data centers prove. The reduction and analysis of these data have already begun, but it will be years before the value of these precious records can be fully realized and appreciated. Moreover, as time goes on and new and fundamental discoveries are made, these data shall often assume a new life of their own, because research scientists will re-examine this unprecedented storehouse of facts in the light of such new discoveries.

Aside from the obvious significance of obtaining a worldwide view of a particular field--for example, atmospheric circulation which is crucial to a better understanding of weather and climate--the IGY program has been remarkably rich because its investigations included the principal fields of geophysics.

What this inclusion means is simply the following: that measurements were made which relate one field to another, permitting a better understanding of what happens in each field. In the area of high atmosphere physics, for

example, the interplay between solar activity, cosmic rays, auroral displays, geomagnetic storms, and ionospheric disturbances--a complex drama of a host of phenomena and processes--was carefully studied. So too with oceanography, glaciology, and meteorology, which combine to make up the earth's heat and water budget.

The IGY has not only provided the basis for better correlations among these disciplines of science, but it has drastically altered the attitudes of scientists themselves. Their approach to problems of our physical environment has undergone a great change--from a discipline approach to an inter-disciplinary one. To encourage this development, which recognizes the facts of nature, the IGY is now granting \$1.75 millions specifically for analysis and theoretical researches of this interdisciplinary character.

Any discussion of the synoptic objectives of IGY and of interdisciplinary relationships suffers because either it must be presented in general, as I have attempted to do, or many hours are needed. Fortunately, the third category dealing with the scientific aspects of IGY permits me to be both brief and highly specific. This category relates to particular findings of remarkable significance. Let me enumerate a few.

1. Using seismic sounding techniques, IGY scientists have laid bare the nature of a considerable portion of the land mass of Antarctica. This region now appears as a complex of island and mountain chains, particularly certain coastal parts where a few mountains now protrude above the vast ice mantle but where, even were the ice to melt, some mountain chains would lie hidden beneath sea level. Moreover, there are increasing indications of a major division between East and West Antarctica. These studies are for the first time in history establishing the character of the least known continent in the world, whose area is some 6,000,000 square miles.

2. Seismic measurements have also given us a better measure of the amount of snow and ice in the world. The old figure was about 3,240,000 cubic miles. So much more ice has been found in Antarctica, to depths of 14,000 feet---and bear in mind that Antarctica accounts for 90 per cent of the total--that this figure must be revised upwards by about 40 per cent, to some 4,500,000 cubic miles. If the earth's climate, which is dynamic as geological history shows, changes, the significance of this number is apparent. The revised figure is critical for the study of the delicate balance of the heat and water regimen of the earth.

3. Three major counter-currents in the oceans have been found and measured. One in the Atlantic flows beneath and opposite to the Gulf Stream, traveling at a rate of 8 miles per day some 9000 feet beneath the surface. The second, at depths between 200 and 1000 feet, flows against the surface equatorial current of the Pacific, transporting a billion cubic feet per second. The third lies beneath the surface 200 miles north of the Pacific equator, transporting 1.5 billion cubic feet per second. These measurements add critical new elements to our understanding of the major circulation systems of the oceans, circulation systems which hold great significance for the dynamics of weather and climate and even for the location and quantity of food stocks in the seas.

4. In studying ocean bottoms, a vast mineral-rich region in the Pacific has been discovered. Millions of square miles of the Southeast Pacific bear a surface-bottom sludge laden with nodules of manganese and iron with up to one per cent of cobalt mixed with copper. The value of these minerals is estimated at about \$500,000 per square mile, and the economics of dredging up the sludge appear promising.

5. Studies of ice coverings in both polar regions are shedding light upon weather and climate of the past. For example, during the last fifty years or so the amount of precipitation in the Arctic has averaged twice that of the Antarctic. These records are preserved in the ice layers, affording the opportunity to read them much as we read tree rings. The significance of these studies transcends historical interests: for these data are also clues to the future of weather and climate.

6. In meteorology, the IGY has provided the first census of Antarctic weather. Recording of temperatures to a low of at least minus 124 degrees Fahrenheit suggests the possible role of this vast continent of cold in world weather. Studies of temperature, pressure, humidity, and winds have provided data from which the influence of this region on world weather can be examined.

7. Using sounding rockets, H. Friedman discovered solar X-rays low in the ionosphere. These X-rays, rather than the ultraviolet radiation responsible for the general electrification of the ionosphere, extend downward the lowest,

D-region of the ionosphere and increase its ionization to such an extent that radio blackouts occur. Friedman has recently, during the eclipse expedition, found the source of the X-rays to be the sun's corona rather than its disk while the absence of ultraviolet radiation during total eclipse, noted in one rocket study, suggests the disk as the source of ultraviolet light. These findings have marked value for ionospheric physics in general and radio communications in particular.

8. During several voyages to Antarctica, supplemented by balloon studies and an aircraft flight around the equator, J. A. Simpson and his colleagues found deviations in cosmic ray trajectories from those to be expected using the classical description of the earth's magnetic field in space, which should uniformly affect paths of charged particles. The Simpson Equator for cosmic rays turns out to be skewed westward by as much as some 45 degrees. This points to perturbances of the earth's magnetic field by other magnetic fields in space, probably associated with recurring clouds of solar particles.

9. Discovery of the Van Allen Radiation Zone indicates that a vast region of space around the earth is populated with charged particles, probably replenished by solar plasmas. Trapped in the earth's magnetic field, leakage of these particles appears associated with geomagnetic variations and auroral displays. The discovery is of striking basic significance and of interest in terms of space exploration in the popular sense.

10. Throughout the IGY period the sun was kept under perpetual watch every minute. One purpose was the detection of solar flares in whose wakes frequently follow important effects in the upper atmosphere. But in addition photographs in the light of hydrogen were taken each minute, and sometimes more often. These provide a fabulous record of the history of the sun during the IGY period of sunspot maximum. The prospects of research, both into solar processes and into terrestrial correlations, using this unparalleled record seem immense to astronomers.

11. The successful launching of artificial satellites in the IGY program is a pioneering and historic event per se. It has ushered in the space age. It will inevitably lead to greatly increased knowledge of the earth and the solar system. The space age, taken in its fullest technical sense, means that a new era of science is opening up, with all that that suggests.

One must remember that these specific discoveries are the results of preliminary inspection of only a small portion of the total data. Add to the total data the compounding effects and vast implications of interdisciplinary studies, and there can be no question of the scientific import of IGY.

Let me venture two additional observations:

First, a matter of anticipation. I have not the slightest doubt, quite aside from space science, that we are on the verge of many new and radical developments, foreshadowed by what has happened in the three categories I have mentioned.

Within a century or so the oceans can become serious competitors of the continents in terms of material resources.

Within the same period it is likely that the energy and material resources of the deeps of the earth will initially be tapped.

Wall within the same period it is conceivable that new and fundamental discoveries of solar processes will revolutionize our approaches to man's energy problems.

Now these opinions are based upon what has happened, upon what appears historically the consequences of research, upon what appears theoretically reasonable. The opinions may prove wrong but if so, other quite similar events will or can occur -- always provided we continue to search for answers in nature.

Whether in fact we do continue the search is not self-evident. I feel strongly that we are plagued by frozen attitudes which may preclude right thinking and right action. We are polarized within our culture by two extremes: either we fall back on daydreams fed by ³space cadets² who for one reason or another prophesy all types of materialistic

advances ever so easily and simply and inexpensively, or we are congealed by the cash-results-today approach of those who cry for applications and practicality.

Second, I hope very strongly that one of the by-products of IGY may be this: that it drive the last nail in the coffin of the juvenile, and dangerous argument over the value of basic research. Scientific advances, whether national or international, can no longer be sustained on a crash basis or by gifted tinkerers. They depend almost exclusively upon the rewards of basic research. The mere symbols of basic research have become fantastically powerful in recent years.

2. Public Affairs and IGY

The IGY has had a double impact upon society, first as a purely scientific enterprise, and this I have already briefly discussed. That IGY also has overriding significance as a purely human engagement, as an activity of man without specific reference to its subject matter. I say overriding significance because almost alone among human enterprises it achieved remarkable international cooperation among 60 nations in a period of sharp and perhaps unparalleled political unrest.

What then was the IGY as such an activity?

First, it was not a government program, although governments at home and abroad supported it generously. Second, it was not a military program, although the military establishments of many governments, like our own, provided a variety of logistic support. Third, it was not an ³internationalized² program, even though one of its greatest achievements was in the field of international cooperation. The very fact that it was none of these things accounts for a large measure of its success, scientific and international.

What it was and what it is, is this: a gathering together of private human beings, each of whom had a vital personal interest in a particular subject, each of whom felt that this subject needed, out of its own exigencies, a concerted attack, but one for which a simple, uncluttered mechanism would suffice.

Thus the IGY was at root an enterprise of private persons, an enterprise in the hands of doers, and the form and shape it took largely reflect this. This form and this shape reveal much about the character of the IGY and may well afford a pattern worth noting, worth using again in other areas.

Look first at the international structure of IGY. The International Council of Scientific Unions, under whose aegis the international effort was coordinated, is a non-governmental body. Its private as against official nature is a known fact. The CSAGI, the special committee that ICSU established for IGY, achieved international coordination through general assemblies of experts from the participating IGY committees in various parts of the world. The criteria for this unprecedented study of the earth, and the broad program, were worked out by these experts.

No elaborate bureaucracy was called for or established. CSAGI is temporary. Its officers are temporary and unpaid. Its small secretariat is temporary.

Deliberations at the general assemblies suffered from no obvious considerations of national ³face,² or considerations of official positions in other areas or at other times, as formal governmental deliberations inevitably appear to do. Energies were directed to the restricted problem at hand. By and large, the problem's own objectivity led to objectivity in discussions, conduct, and actions.

It is for these reasons, in my opinion, that the IGY succeeded brilliantly in marshalling international cooperation. Yet within this framework competition was not lacking: indeed, competition helped. While internationally-agreed-upon criteria established the basic content of the program, the burden of execution rested upon national groups, which naturally wished to do well. Even more fundamentally, the burden fell upon individuals, who were personally interested in their part of the program and were individually anxious to achieve meritorious results.

For these reasons, some 30,000 scientists and technicians, and an equal number of volunteer observers, spread from pole to pole at 4000 principal scientific stations and an equal number of secondary sites, representing 66

nations and marshalling their support, succeeded in the conduct of this 18-month adventure into the unknown.

The character of this enterprise is gaining recognition. In our own Congress, during hearings before the Subcommittee of the Committee on Appropriations of the House, the Chairman, Representative Albert Thomas, said, and I quote the record: ³I think you gentlemen of the International Geophysical Year have set a pattern of world-wide cooperation that nations and governments, and particularly our good State Department, can take a leaf out of your book.²

On a national level, also, the IGY has established a pattern largely new to the country. The American program, as generally in other nations, was planned and directed by a national, non-governmental committee. The Committee and its panels actually comprised a coalition of experts vitally concerned with geophysical research. The scope of our program was established by three sets of contributions: first, the existing programs in public and private laboratories, especially the networks in geomagnetism, meteorology, and ionospheric physics of the Coast and Geodetic Survey, the Weather Bureau, and the National Bureau of Standards; second, the special stations and facilities made possible by \$43.5 millions appropriated by the Congress through the National Science Foundation; and, third, contributions from private institutions, particularly universities. Each of these represents about a third of the total research effort. Very important and extensive technical and logistics support was contributed by the Department of Defense, particularly for the Antarctic, the Arctic, rocket and satellite efforts.

Very simply, the scientific community, assembled as individuals by the National Academy of Sciences, without regard to their institutional affiliations but only with regard to their competence and interest, established what needed to be done and then called for such support, both financial and logistic, as they needed from every available source.

It appears now that this was an excellent way in which to do a job so broad in scope. Whether the pattern will be followed in other ventures, including even scientific ones, remains to be seen.

3. The Immediate Future

The future influence of the IGY has many aspects, and its progeny are destined to be highly variegated as well as numerous. The most immediate scientific offsprings seem to be five in number.

1. International cooperation in geophysical research will certainly continue for an indefinite period. While the IGY as such ends this calendar year, plans are under way for continuing through another year the kind of cooperation and activity that marked the IGY. This program is called International Geophysical Cooperation - 1959 (IGC-1959). The International Council of Scientific Unions has established a Special Committee for Inter-Union Cooperation in Geophysics (SCG) which will assume responsibilities for IGC-59 similar to those that CSAGI assumed for IGY.

The program for 1959 will consist in part of continuing geophysical research programs in various nations, marked by international cooperation in the observational aspects and by data interchange as in the IGY. By ³continuing geophysical research programs,² I am referring to two types of activity: first, the permanent networks of stations in such fields as meteorology, ionospheric physics, seismology, and geomagnetism; second, a variety of research projects, particularly in the midlatitudes, in many fields of geophysics, which would be conducted even were there no IGC-59.

While some rather modest needs exist for additional research in the mid-latitudes, the supplements to the above effort, thus making up the total, stem largely from the following four other specific endeavors under new and separate auspices.

2. The sheer size of the oceans, our current ignorance of them because of this and in spite of the oceanographic accomplishments during the IGY, and the need to learn more as rapidly as possible about them, led to the establishment of a Special Committee for Oceanographic Research (SCOR) by the ICSU. This new committee has planned a program emphasizing sea level, circulation, and sea floor studies. The American counterpart to this international body is the Academy's Committee on Oceanographic Research under the chairmanship of Dr.

Harrison Brown of the California Institute of Technology.

3. Even two years of IGY could represent no more than a good start on the scientific exploration of Antarctica. For such reasons ICSU established the Special Committee for Antarctic Research more than a year ago, and a continuing international effort has been planned. In the United States, the Academy's Committee on Polar Research, under the chairmanship of Dr. L. M. Gould (President, Carleton College), developed a \$2 million program for 1959, which has been implemented by the National Science Foundation and the Navy. This Committee has also looked into the north polar scientific needs.

4. Another special program, calling for continuation of what was done in the IGY, relates to a watch on the sun. The program of solar patrols and alerts proved most rewarding during the IGY. The ICSU has arranged for the international continuity of this effort, establishing the International Service for World Days, as the program will be known.

5. Recognizing the importance of international cooperation in space research, the ICSU established last October the Committee on Space Research (COSPAR). This committee had its first meeting at The Royal Society in London last month when it established its own working procedures, outlined its program, and set up working groups concerned with (i) space experiments, (ii) tracking and communications, and (iii) data interchange and publications. The Committee elected its officers, consisting of a President, Dr. H. C. van de Hulst of the Netherlands, and two Vice-Presidents, Dr. W. Albert Noyes, Jr., of the United States and Academician E. K. Federov of the Soviet Union.

In the United States, the counterpart to COSPAR is the Academy's Space Science Board under the chairmanship of Dr. Lloyd V. Berkner (President, Associated Universities, Inc.). The Board and its committees represent a complex of some 100 scientists, who have been studying space science needs and prospects, serving as advisory to the several government agencies which will implement the program.

4. General Implications

IGY results already at hand suggest that it has opened new doors for man in relation to his environment. Some of these are specific research doors, for as new insight is gained into nature, new questions come to mind, and many major, specific scientific endeavors challenge the scientist. Other doors open up possibilities relating to resources -- as in, for example, the intelligent exploitation of the seas. But doors of an intellectual and psychological kind can also be opened by imaginative and far reaching enterprises of the type that IGY has been. It is in this area that I should like to make two remarks.

First of all, I believe that the IGY has greatly extended the physical and psychological frontiers on earth. In spite of, and perhaps precisely because of, the results accumulated during the IGY, it is clear that we have only scratched the surface of our ignorance with respect to Antarctica, the Arctic Basin, the oceans that cover 70% of the earth, and the depths of the earth itself. In my opinion, the drama and romance of the IGY have contributed to a recognition that much exciting work remains to be done on earth itself: (1) Some of this work has the nature of exploration in almost the common sense. (2) Even more important, however, is the challenge of detailed scientific exploration.

Of course, the fact that these two almost unlimited horizons have always existed was no secret before the IGY, but this is beside the point. As a result of the IGY, countless people, including many scientists, have a new and invigorating attitude toward our planet.

Second of all, I need not emphasize that the age of space affords a limitless frontier to the human mind and spirit. The pursuit of knowledge of the universe using the tools now at hand will occupy the interests and energies of innumerable men as they reach, no longer earthbound, far into space. The drama and excitement here, if but properly construed, are incomparable, and the ultimate place of IGY in history may be as the initiator of space research. History may well regard this innovation as the most striking departure of man in this or any century.

For these two reasons then -- the new horizons on earth and those beyond earth -- it appears that another

renaissance can be ours. Now, the Renaissance was not merely the Revival of Learning, it was that coupled with much else. Of the latter, one of the most provocative ingredients was new knowledge about new lands and new waters.

Looking back, we can see that the period following Columbus' discovery of America was charged with an excitement stemming in large part from the adventures on strange waters and unknown lands. This excitement and these discoveries were apprehended broadly and generally, entering into the imagery of poetry and influencing almost every aspect of life.

Again looking back, we can see that the Copernican astronomy achieved not alone a revolution in science but changed man's concepts of man, of his religion, and of his philosophy, and the impact of heliocentricity was felt over the course of several generations.

The onset of the space age affords the possibility of a comparable impact.

It may be argued that the new astronomy of Copernicus had its large effect because it was an important scientific discovery while space is not a revolutionary discovery: it has been there all along and all that has happened is the availability of engines that can travel there. To this the answer is twofold.

Firstly, that space has no meaning unless realizable, and its now being tangibly within reach is intellectually and emotionally comparable to the impact from the findings of Copernicus: to be at the threshold of an age which releases man from the confines of his ancestral, primordial, planetary home is no small matter.

Secondly, the very fact that the results of man's coming space ventures are still unknown and mystery-laden to him, only furnishes added intellectual provocation.

Provided that the complexity of modern society does not hide what is at hand, provided that the destructive forces present in our day not only do not eliminate civilization but do not, by their necessary insistence upon man's attention, mask the wonders of earth and universe, and provided that teachers and poets, scientists and philosophers sense the possibilities, there is at hand an unparalleled situation for stimulating the best in man.

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