DATA INTERCHANGE DURING THE INTERNATIONAL GEOPHYSICAL YEAR*

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INTRODUCTION

The International Geophysical Year, as an endeavor of world-wide cooperation in science, stands unparalleled in man's history. Sixty-seven nations, through their scientists, formally participated in an essentially civilian enterprise dedicated to a fuller understanding of man's physical environment. More than 30,000 scientists, engineers, and observers engaged their energies at more than 4,000 stations scattered over the earth. Their studies, which began on July 1, 1957, did not cease on December 31, 1958, at the end of the eighteen-month IGY period. Moreover, the interchange of data had not been completed; analyses and interpretations were only in their beginning; and, indeed, even the observational and experimental activities were extended, in one way or another, simply because the scientific needs and interests were apparent and compelling.

IGY AND IGC-1959

The interchange of data represented but one of the several major aspects of the IGY. The first of these was planning of the scientific program, which began rather casually in 1950 with Dr. Lloyd V. Berkner's original proposal and led to the formation under the International Council of Scientific Unions (ICSU) of a Special Committee for the IGY (Comité Spécial de l'Année Géophysique Internationale--CSAGI). Planning continued not only to the beginning of the IGY, but throughout the eighteen month observational period, and beyond. The critical period lay between 1953 and 1957, when scientists themselves, in their particular fields, determined what studies were most important and required international collaboration. By the time of the Fifth Meeting of CSAGI, in Moscow, August, 1958, the value of international cooperation had become apparent, the success of the program had exceeded all hopes. It was recommended that the IGY program of observations and data exchange be continued, on a slightly modified basis, throughout 1959, a period designated International Geophysical Cooperation--1959 (IGC-59).

GEOPHYSICS--PLANETARY AND INTERDISCIPLINARY SCOPE

Geophysics differs from the physics and chemistry of the laboratory, in which experiments can be devised and conducted, then reproduced with great precision, and at will. In geophysics, the universe is the laboratory, the earth is the experiment. Nature conducts the experiment; for the most part, man can do little to influence the time or the manner in which nature conducts these experiments. In simple or in ingenious ways, man can monitor these great natural experiments.

It is further apparent that the earth and its environment are in a constant state of change; the significant parameters change with position and with time. Many types of measurement have little meaning taken alone; synoptic measurements on a continuing basis are required to produce intelligible results. Meteorology, or the study of weather, is an example. Observations of aurorae, cosmic rays, or the ionosphere are dependent not only on synoptic observations, but are interdependent on one another; all three phenomena are intimately related to fluctuations in the earth's magnetic field.

Consideration of the interrelationships in geophysics led to the outlining of three broad areas encompassing eleven disciplines of geophysics: (1) the earth's interior (seismology, gravimetry, and determinations of longitude and latitude); (2) the hydrosphere (meteorology, oceanography, glaciology); (3) the geomagnetic disciplines (geomagnetism, aurora and airglow, ionosphere, solar activity, and cosmic rays). These three areas are commonly called the solid earth, heat and water budget, and upper atmosphere, respectively. Two additional disciplines were included in the program of the IGY: nuclear radiation, the study of air-borne radioactive isotopes with reference to the meteorological problem of the circulation of the troposphere and stratosphere; rockets and satellites, a discipline encompassing various geophysical experiments, mostly relating to the upper atmosphere, conducted by means of rockets and satellites. The pioneering satellite program has also yielded significant information on the shape of the earth, and has ranged far into the depths of space.

Although nominally not devoted to the study of chemistry, programs in most IGY disciplines were intimately related to chemistry. This relation is more evident when considered with reference to the three areas: heat and water budget, upper atmosphere (geomagnetic), and the solid earth. In the heat and water group, direct chemical measurements were made in meteorology (carbon dioxide and ozone measurements); glaciology (O^{18}/O^{16} analyses, gas analyses, chloride ion content, radioactive constituents); oceanography (salinity, concentrations of carbon dioxide various elements and radicals); nuclear radiation (various airborne radioactive isotopes); and measurements of chemical and ion composition of the upper atmosphere by rockets. To greater or lesser extent, observations in all the disciplines of the upper atmosphere group are related

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to the chemical environment. Observations in the third of the three areas, the physics of the solid earth, apparently are least related to chemical considerations. Yet models of the structure of the earth's interior, based on seismic and gravimetric evidence, must be related to the available chemical and physical-chemical data. Of the IGY scientists, the oceanographer, most particularly, deals with an environment in which physics, chemistry, biology, and geology may rarely be viewed separately. In fact, in the great terrestrial laboratory with which geophysics concerns itself, it is quite difficult to draw sharp lines between the sciences.

IGY WORLD DATA CENTERS

Before the observational period of IGY had begun, scientists had recognized that successful planning and operations were but the means to an end: the acquisition of synoptic data. But acquisition alone was not enough; the data had to be accessible for analysis and study. This need led to the establishment of three world data centers, each to collect a complete set of IGY data: one in the United States, one in the USSR, and one distributed by discipline in eight nations of Western Europe, in Australia, and in Japan. The locations of these three World Data Centers (WDC's), designated WDC-A, WDC-B, and WDC-C (C-1 and C-2 for five disciplines in which WDC-C is duplicated), are shown in Table I. The purposes for establishing three centers were several: to ensure that the data would be available in orderly form to all research workers, to provide for some measure of geographic convenience to users and some measure of safety for the data by having three depositories for most disciplines, four for some.

WDC DATA INTERCHANGE

In the manner of the planning and observational aspects of the IGY, decisions on data interchange were made by the scientific community. In each field, the specialists themselves determined the nature and form of data interchange, based on their needs as research workers. Thus the tasks of the world data centers differ from discipline to discipline.

The details of the form and quantity of data to be exchanged are set forth in the CSAGI Guide to World Data Centers, IGY Annals, Vol. VII. In several disciplines, copies of original records are exchanged, e.g., 35 mm. ionogram film, microfilm copies of magnetograms, or all-sky camera observations of aurorae (35 or 16 mm. film). In other disciplines, tabular observational data are exchanged, e.g., most meteorological observations, cosmic ray counting rates, seismic and gravity readings. Other exchange agreements involve a much greater degree of reduction of data; in this category, the program requiring perhaps the most extensive data reduction prior to exchange is the moon position program, which ultimately will yield the positions of the twenty participating observatories. In several disciplines, the volume of data exchanged as such is small; the exchange arrangements are centered around reports and published results, e.g., in glaciology and in rockets and satellites.

In collecting data, the basic functions of the data centers are: (1) to accept data from participating scientific workers, (2) to archive the data in orderly fashion, (3) to reproduce the data, when necessary, for the other world data centers. The IGY World Data Centers are further obligated: (1) to prepare catalogues of available data at six-monthly intervals, (2) to provide copies of data (for the cost of reproduction) to any scientist upon request, (3) to permit visiting scientists to consult and work with the data at the center.

SPECIAL ACTIVITIES OF WDC-A

World Data Center A was established in the United States under the cognizance of the National Academy of Sciences. As a consequence of the decision that WDC-A should be located by discipline in an institution with a history of active interest in the discipline, WDC-A was divided into eleven subcenters in eight cities (see Table II).

The basic functions of the data centers have been described; the detailed exchange agreements which are set forth by discipline in the CSAGI Guide to WDC's are too lengthy to present here. Several of the data centers are engaged in rather special activities, in most cases in response to direct international agreements. Some of these activities are:

METEOROLOGY.—WDC-A is preparing daily weather maps for the Northern Hemisphere (20-90°N.) for the surface and 500 mbar. levels. These maps will show wind, temperature, dew point, pressure (surface), and height (500 mbar). WDC-A is also preparing pole-to-pole cross-sections along 75°W. meridian, from surface to 10 mbar. showing temperature, potential temperature, west wind component, humidity, and tropopause.

AURORA.—As part of the international plan for publication of IGY results, diagrammatic catalogues are being prepared for three kinds of auroral observations: all-sky camera (ascaplots), spectrographic (spectroplots), and visual (visoplots). WDC-A in Alaska is undertaking the first two, WDC-A in Ithaca the third.

IONOSPHERE.—WDC-A is preparing tables of monthly medians of hourly values of (up to) twelve parameters for those stations which transmit data direct to this center.

SOLAR ACTIVITY.—This center has issued a series of reports containing daily tabulations of reports of surges and active prominence regions. The reports are intermediate; final publication will be made in the IGY Annals. WDC-A has responsibility for coordination of the D_1 maps (daily multi-colored maps of the sun showing sunspot magnetic fields, calcium plages, flares, surges and active prominence regions); preparation of surge and active prominence sketches and final tabulations for the D_1 maps; preparation of green coronal polar diagrams at the limb for D_2 daily solar maps; and preparation of synoptic maps showing coronal isophotes for each 27-day period.

COSMIC RAYS.—WDC-A has the responsibility to prepare cosmic ray data for publication in the IGY Annals. Prior to publication, all cosmic ray data are being printed on punched cards for verification.

GLACIOLOGY.—WDC-A has issued a series of reports on the US-IGY glaciological program (including seismic, gravity, and magnetic observations on traverses in Antarctica). This center has acquired and catalogued a considerable volume of unpublished material antedating IGY; the collection of glacial photographs dates back to the nineteenth century.

ROCKETS AND SATELLITES.—WDC-A has issued two series of reports to make available results of the IGY program in this discipline, one series for rockets, one for satellites.

As indicated above, four report series have been issued by the subcenters of WDC-A in order to fulfill and supplement the international obligations to make IGY results broadly available. In addition, the IGY Data Center Coordination Office in the National Academy of Sciences has prepared a series of General Reports containing material pertaining to various IGY disciplines as well as the cumulative 6-monthly catalogues of data received by all subcenters of WDC-A. (Since preparation of this paper, two additional series of reports, Aurora (Instrumental) and Oceanography, have been issued by the respective subcenters of WDC-A.)

IGY ANNALS

Formal international publication of IGY material is accomplished through the Annals of the International Geophysical Year, published by Pergamon Press. The first eleven volumes, nine of which have been published, contain the accounts of the meetings of CSAGI and associated bodies, and the CSAGI instruction manuals. Subsequent volumes of the Annals will contain data and results of the IGY programs by discipline. For example, the D_1 and D_2 maps (solar activity) will occupy two volumes; other solar activity maps and tables are expected to fill four additional volumes. In addition to discipline reports, a bibliography and final catalogue of data are planned. The total number of volumes should be approximately thirty.

FUTURE INTERNATIONAL COOPERATION IN PHYSICS

IGY scientists had recognized very early that some fields would require world-wide study and cooperation far beyond 1959. Accordingly, ICSU established Special Committees for Oceanic Research (SCOR), in August, 1957, and for Antarctic Research (SCAR), in February, 1958, and a Committee for Space Research (COSPAR) in October, 1958.

The National Academy of Sciences established three corresponding national committees to cooperate with these international committees in coordinating international programs in the respective fields: Committee on Oceanography (Chairman, Harrison Brown); Committee on Polar Research (Chairman, Laurence M. Gould); Space Science Board (Chairman, Lloyd V. Berkner).

In 1959, ICSU established an Inter-Union Committee to be known as the "International Geophysical Committee—Comité International de Géophysique" (CIG). It is the responsibility of CIG to effect the orderly termination of the work of the IGY and IGC-59, and to develop and coordinate plans for the furtherance of cooperation in geophysics and related sciences, especially those of an inter-disciplinary nature.

At its first meeting in November, 1959, CIG addressed itself to these tasks. CIG recognized the value of the international data exchange and urged IGY participating committees and World Data Centers to take prompt steps in completing the exchange of IGY/IGC-59 data. CIG noted that the energy of many scientists had been devoted largely to the conduct of the IGY/iGC-59 programs; CIG underscored the necessity of devoting increased effort to analysis and research and, to this end, recommended that the period January 1, 1960—December 31, 1961, be characterized as the IGY-IGC Analysis and Theoretical Research Period.

CIG recommended that the observational and experimental efforts during 1960-61 be maintained at the level of IGC-59, so far as possible, especially in fields characterized by synoptic observations. Looking to the future, CIG suggested that a World Magnetic Survey be scheduled for a quiet interval in the solar sunspot cycle, e.g., 1963.

CIG concentrated particular attention on the data interchange activities, reaffirming the value of such interchange and recommending that this interchange through the WDC's continue as in IGY/IGC-59. The form and quantity of data to be

interchanged during the coming few years is subject to review and revision. Such a study is now being undertaken to ensure that the data interchange arrangements, originally established for IGY as part of the great experiment in international scientific cooperation, will be responsive to changing needs and interests in the various geophysical disciplines.

TABLE I
LOCATIONS OF IGY WORLD DATA CENTERS

CSAGI NO.	Discipline	WDC-A (USA)	WDC-B (USSR)	WDC		Permanent Services
				C-1	C-2	
II	Meteorology	Asheville, N. C.	Moscow, B-1	Geneva, Switzerland		
III	Geomagnetism	Washington, D. C.	Moscow, B-2	Charlottenlund, Denmark	Kyoto, Japan	De Bilt, Holland; Gottingen, Germany; Tortosa, Spain
IVa	Aurora (Instr.)	College, Alaska	Moscow, B-2	Stockholm, Sweden*		
	(Visual)	Ithaca, New York	Moscow, B-1	Edinburgh, U.K.		
IVb	Airglow	Boulder, Colorado	Moscow, B-2	Paris, France	Tokyo, Japan	
V	Ionosphere	Boulder, Colorado	Moscow, B-2	Slough, England**	Tokyo, Japan	
VI	Solar Activity	Boulder, Colorado (HAO)	Moscow, B-2	Zurich, Switzerland		
				Arcetri-Firenze, Italy		
		Boulder, Colorado (CRPL)	Simeis, Crimea	Cambridge, England		
				Meudon, France		
				Pic-du-Midi, France		
				Freiburg, Germany		
				Sydney, Australia		
VII	Cosmic Rays	Minneapolis, Minnesota	Moscow, B-2	Stockholm, Sweden*	Tokyo, Japan	
VIII	Longitude and Latitude	Washington, D.C.	Moscow, B-1			Paris, France; Turin, Italy
IX	Glaciology	New York, New York	Moscow, B-1	Cambridge, England		
X	Oceanography	College Station, Texas	Moscow, B-1			Birkenhead, England
XI	Rockets and Satellites	Washington, D. C.	Moscow, B-1	Slough, England**		
XII	Seismology	Washington, D. C.	Moscow, B-1	Strasbourg, France		
XIII	Gravimetry	Washington, D. C.	Moscow, B-1	Uccle, Belgium		Paris, France
XIV	Nuclear Radiation	Asheville, N. C.	Moscow, B-1	Stockholm, Sweden	Tokyo, Japan	

* and ** These two Centers are located in the same institution.

TABLE II
INTERNATIONAL GEOPHYSICAL YEAR WORLD DATA CENTER A

National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington 25, D. C., U.S.A.

World Data Center A consists of eleven archives

Airglow and Ionosphere
IGY World Data Center A: Airglow and Ionosphere, Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado, U. S. A.

Aurora (Instrumental)
IGY World Data Center A: Aurora (Instrumental), Geophysical Institute, University of Alaska, College, Alaska

Aurora (Visual)
IGY World Data Center A: Aurora (Visual), Hollister Hall, Cornell University, Ithaca, New York, U.S.A.

Cosmic Rays
IGY World Data Center A: Cosmic Rays, School of Physics, University of Minnesota, Minneapolis 14, Minnesota, U.S.A.

Geomagnetism, Gravity, and Seismology
IGY World Data Center A: Geomagnetism, Gravity & Seismology, Geophysics Division, U.S. Coast and Geodetic Survey, Washington 25, D.C., U.S.A.

Glaciology
IGY World Data Center A: Glaciology, American Geographical Society, Broadway at 156th Street, New York 32, New York, U.S.A.

Longitude and Latitude
IGY World Data Center A: Longitude & Latitude, U. S. Naval Observatory, Washington 25, D. C., U.S.A.

Meteorology and Nuclear Radiation
IGY World Data Center A: Meteorology and Nuclear Radiation, National Weather Records Center, Asheville, North Carolina, U.S.A.

Oceanography
IGY World Data Center A: Oceanography, Department of Oceanography and Meteorology, Agricultural & Mechanical College of Texas, College Station, Texas, U.S.A.

Rockets and Satellites
IGY World Data Center A: Rockets and Satellites, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington 25, D. C., U.S.A.

Solar Activity
IGY World Data Center A: Solar Activity, High Altitude Observatory, Boulder, Colorado, U.S.A.

Note: (i) Communications regarding data interchange matters in general and World Data Center A as a whole should be addressed to: Director, World Data Center A, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington 25, D. C., U.S.A.; (ii) Inquiries and communications concerning data in specific disciplines should be addressed to the appropriate archive listed above.

ACRONYMS USED IN THIS PAPER

IGY	International Geophysical Year (July 1, 1957–December 31, 1958)
IGC-59	International Geophysical Cooperation–1959
WDC	IGY World Data Center
WDC-A	IGY World Data Center (located in U. S.)
WDC-B	IGY World Data Center (located in USSR)
WDC-C	IGY World Data Center (located in Western Europe, Australia, and Japan)
ICSU	International Council of Scientific Unions
CSAGI	Comité Spécial de l'Année Géophysique Internationale
CIG	Comité International de Géophysique
SCOR	Special Committee for Oceanic Research
SCAR	Special Committee for Antarctic Research
COSPAR	Committee for Space Research

REFERENCES

CSAGI Guide to World Data Centers, IGY Annals, Vol. VII, Part II, pp. 139-373

Fifth Six-Monthly Catalogue of Data in IGY World Data Center A, General Report No. 8, February 1960

Annals of the International Geophysical Year

Vol. I: The Histories of the International Polar Years and the Inception and Development of the IGY

Vol. IIA and IIB: Reports of Meetings of CSAGI and Associated Bodies

Vol. III, IV, V, VI, and VII: CSAGI Manuals

Vol. VIII: Geographical Distribution of the IGY Stations

Vol. IX: First Results of IGY Rocket and Satellite Research

IGY General Report Series

1. Description of the Antarctic Circulation Observed from April to November at the IGY Antarctic Weather Central Little America Station
2. Preliminary Report on Expedition Downwind, University of California, Scripps Institution of Oceanography IGY Cruise to the Southeast Pacific
3. Preliminary Reports on the IGY Pendulum, Gravimeter, and Seismological Programs at the University of Wisconsin
4. Some Aspects of the Antarctic Atmospheric Circulation in 1958
5. United States Program for the International Geophysical Year 1957-58
6. United States Program for International Geophysical Cooperation–1959
7. Interim Catalogue of Data in IGY World Data Center A
8. Fifth Six-Monthly Catalogue of Data in IGY World Data Center A

IGY Glaciological Report Series

1. Preliminary Reports of the Antarctic and Northern Hemisphere Glaciology Programs
2. Oversnow Traverse Programs, Byrd and Ellsworth Station, Antarctica, 1957-58: Seismology, Gravity, and Magnetism

IGY Rocket Report Series

1. Experimental Results of the U. S. Rocket Program for the International Geophysical Year to July 1, 1958
2. Flight Summaries for the U. S. Rocketry Program for the IGY, Part I: July 5, 1956 to June 30, 1958
3. Flight Summaries for the U. S. Rocketry Program for the IGY, Part II: May 23 to December 31, 1958
4. Magnetic Exploration of the Upper Atmosphere
5. Upper-Air Densities and Temperatures from Eight IGY Rocket Flights by the Falling-Sphere Method

(in preparation) Reports on these topics: solar radiation in the Lyman alpha; atmospheric structure in the auroral zone; electron densities in the ionosphere; atmospheric heating in the Arctic; models of the structure of the atmosphere

IGY Satellite Report Series

1. Processed Observational Data for USSR Satellites 1957 Alpha and 1957 Beta
2. Status Reports on Optical Observations of Satellites 1958 Alpha and 1958 Beta
3. Some Preliminary Reports of Experiments in Satellites 1958 Alpha and 1958 Gamma
4. Observational Information on Artificial Earth Satellites
5. Radio Observations of Soviet Satellites 1957 Alpha 2 and 1957 Beta 1
6. Reports and Analyses of Satellite Observations
7. Simplified Satellite Prediction from Modified Orbital Elements
8. Ephemeris of Satellite 1957 Alpha 2 and Collected Reports on Satellite Observations
9. Symposium on Scientific Effects of Artifically Introduced Radiations at High Altitudes
10. The Determination of Ionospheric Electron Content and Distribution from Satellite Observations

(in preparation) Reports on the following topics: gravitational field of the earth; spin and orbital decay; atmospheric densities; solar effects on the acceleration of artificial satellites; micrometeorites; electron densities; determination of orbits; ionospheric research.

IGY Solar Activity Report Series

1. Intermediate Reports of Surges and Active Prominence Regions, July–September, 1957
2. Intermediate Reports of Surges and Active Prominence Regions, October–December, 1957
3. Intermediate Reports of Surges and Active Prominence Regions, January–March, 1958
4. Observations of the Solar Electron Corona, September 1956–January, 1958
5. Intermediate Reports of Surges and Active Prominence Regions, April–June, 1958
6. Intermediate Reports of Surges and Active Prominence Regions, July–September, 1958
7. Intermediate Reports of Surges and Active Prominence Regions, October–December, 1958
8. Intermediate Reports of Surges and Active Prominence Regions, January–March, 1959
9. (in press) Intermediate Reports of Surges and Active Prominence Regions, April–June, 1959
10. (in preparation) Intermediate Reports of Surges and Active Prominence Regions, July–September, 1959