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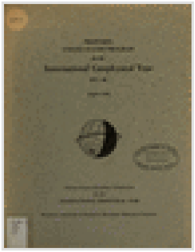

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Proposed United States Program for the International Geophysical Year
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for the
INTERNATIONAL GEOPHYSICAL YEAR

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UNITED STATES NATIONAL COMMITTEE

for the

INTERNATIONAL GEOPHYSICAL YEAR.

PROPOSED UNITED STATES PROGRAM FOR THE INTERNATIONAL GEOPHYSICAL YEAR 1957-58

August 1956.

National Academy of Sciences-
National Research Council
Washington, D. C.

PREFACE

This report presents the current plans for United States participation in the International Geophysical Year 1957 - 58, as requested by the Secretary General of the Special Committee for the International Geophysical Year (CSAGI) for the CSAGI Barcelona Meeting, September 10 - 15, 1956. The report has been prepared by the U. S. National Committee for the IGY, its Technical Panels in the various IGY disciplines, and its Secretariat. While the plans presented here are more specific than in the Committee's 1955 report for the CSAGI Brussels Meeting, and subsequent CSAGI Regional Conferences on the Arctic, Western Hemisphere, and Antarctic, plans for occupation of certain stations and for some of the individual programs are still tentative.

In previous reports of the U. S. National Committee, references were made to stations or sites in territories of other nations. Geophysicists of U. S. institutions have long conducted cooperative scientific research with scientists and institutions in other countries. Some current cooperative work is expected to continue during the IGY and additional cooperative work for IGY objectives has grown from the past history of such bilateral arrangements. Reference is again made in this document to cooperative work. Plans are already underway for some of these projects. It is hoped to initiate discussions with the appropriate national committees for the remaining projects at an early date.

Joseph Kaplan
Chairman

Washington, D. C.
August, 1956

PROPOSED UNITED STATES PROGRAM FOR THE INTERNATIONAL GEOPHYSICAL YEAR 1957-1958

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INTRODUCTION

International cooperation in the study of our physical environment is not new. The importance of geophysical data gathered over relatively remote areas of the earth was recognized in the last century in the conduct of the First International Polar Year in 1882-83 when meteorological, magnetic, and auroral stations were first established in Arctic regions. Investigations at that time disclosed how northern auroras were distributed in a band of maximum auroral activity some 23° wide, centered approximately at the geomagnetic pole, and the geomagnetic data obtained at that time remain useful to this day in the studies of the earth's magnetism. A Second International Polar Year was held in 1932-33, fifty years later. Again, many nations collaborated in making geophysical measurements in the north polar regions. Probably the most important contribution of this effort was an increased knowledge of the ionosphere, obtained by utilizing the radio sounding techniques developed a few years earlier by Tuve and Breit. This knowledge greatly advanced the science of radio communications.

With these precedents of demonstrated scientific value, though limited to a single region and to but several geophysical disciplines, scientists were emboldened to undertake a more complete study of our geophysical environment encompassing the whole of the earth. In 1950 the matter was discussed at the meeting of the Joint Commission on the Ionosphere in Brussels, and a resolution was presented to the Executive Board of the International Council of Scientific Unions (ICSU), urging that a third international effort in geophysics be undertaken in 1957-58. Acting upon this recommendation and similar recommendations from various international scientific unions, the Executive Board of ICSU in 1951 appointed a special committee, the Comité Special de l'Année Geophysique Internationale (CSAGI), to coordinate the scientific planning of a world-wide cooperative program of geophysical observations. The period of July 1, 1957 to December 31, 1958 was designated for the International Geophysical Year.

The membership of CSAGI is composed of representatives of the International Council of Scientific Unions, the International Astronomical Union, the International Union of Geodesy and Geophysics, the International Union of Pure and Applied Physics, the International Union of Geography, the International Union of Biological Sciences, and the World Meteorological Organization which also represents the Joint Commission of the Ionosphere and the Joint Commission on Solar and Terrestrial Relationships. The CSAGI held a provisional meeting in October, 1952, and asked all nations to form national committees for the International Geophysical Year (IGY) and to transmit their recommendations as to the content of the program to be included in the IGY. The first plenary sessions of the CSAGI were held in Brussels in July 1953. Here the program proposals of twenty-six collaborating nations were considered. This meeting led to the establishment of criteria for and the tentative outlining of the basic IGY program. The national committees then turned to the detailed geographical, as well as geophysical aspects of the projects that would make up those parts of the program for which they were to be responsible. By 1954, thirty-eight nations had prepared detailed programs. These nations came together at the CSAGI meeting in Rome in late September and early October 1954, to discuss and integrate their plans. The meeting led to the development of a basic plan for IGY operations which was adopted by all the delegations at the meeting.

At the third plenary sessions of the CSAGI in Brussels in September 1955, about thirty-eight nations again presented national reports. At the end of the Brussels meeting the international IGY program was well integrated with the participation of about forty countries. Since that time additional countries have announced their intention to participate; there are about fifty countries now with National Committees.

A series of conferences on special regions was inaugurated with the First Antarctic Conference, Paris, July 6-10, 1955, followed by the Second Antarctic Conference at Brussels, September 8-14, 1955. In 1956 there were the CSAGI Regional Conference on the Arctic at Stockholm, May 22-25, the CSAGI Regional Conference in the Western Hemisphere at Rio de Janeiro, July 16-25, and the Third Antarctic Conference at Paris, July 30-August 4.

The proposed international effort for 1957 and 1958 surpasses in scope, intensity, and geographical coverage those earlier programs, which were largely limited to the North Polar Regions. Areas throughout the entire world will be included in this new enterprise - - the Arctic and Antarctic Regions as well as the major land and sea masses of the earth. In keeping with the constantly increasing activity and interest in geophysics the size of the effort to be devoted to each of the fields under study will be appreciable.

The principal fields of study during the IGY will be aurora and airglow, cosmic rays, geomagnetism, glaciology, gravity, ionospheric physics, longitudes and latitudes, meteorology, oceanography, seismology, solar activity, and upper atmosphere studies using rocket and satellite vehicles. Inherently these fields are characterized by their global nature. The chemist or the physicist can perform experiments in his laboratory, establishing the conditions of his experiments. The laboratory of the geophysicist is the earth itself and the experiments are performed by nature; his task must be to observe these natural phenomena on a global basis if he is to secure solutions and to develop adequate theoretical explanations. This is one of the compelling reasons for the world-wide scope of the IGY in 1957-58: to observe geophysical phenomena and to secure data from all parts of the world; to conduct this effort on a coordinated basis by fields and in space and time so that the results secured not only by American observers, but by participants of other nations, can be collated in a meaningful manner. Only through such an enterprise as the IGY can synoptic data be satisfactorily and economically acquired.

The proposal that 1957-58 be the time for this major international effort was based in part upon the fact that this period corresponds with a period of maximum solar activity. It is planned to take advantage of this expected increased activity by a series of Alerts and of Special World Intervals, called on occasions when it is predicted that unusual magnetic, ionospheric, or auroral activity will occur and on days of solar eclipses and unusual meteor showers. Special cooperative efforts on a world-wide scale will be made during these intervals to record the many phenomena which react so remarkably to the complex activities of the sun.

I. WORLD DAYS

During the IGY there will be four types of specially designated world days or series of days on which special observing programs may be scheduled.

1. Regular World Days (RWD).

Two consecutive days at new moon, others near quarter phase and at times of expected prominent meteor showers, were selected by CSAGI. There will be increased observational activity in ionospheric physics, geomagnetism and other IGY disciplines on RWD.

2. Alerts.

The National Bureau of Standards radio forecasting center at Fort Belvoir, Virginia has been designated by the CSAGI as the IGY World Warning Agency with responsibility for issuing Alerts, with the advice of or after consultations with forecasting centers in other countries. Generally they will be issued when there is an unusually active region on the solar disk indicating a high probability of ensuing solar flares and geomagnetic disturbances. The Alert will also warn scientists that a Special World Interval (SWI) may be called in a few days.

3. Special World Intervals (SWI).

This will be called by the IGY World Warning Agency on about 8 hours notice, to start at 0000 U. T. the following day, where there is a strong possibility that a significant geomagnetic disturbance will commence within the 24 hours following the start of the interval. The interval will be terminated when the disturbance has subsided, or in about 24 hours in case the forecast disturbance does not materialize.

Programs in ionospheric physics, geomagnetism, solar activity, cosmic rays, and aurora will be intensified during Alerts and SWI. Some special cosmic ray balloon flights and rocket launchings may be made during these periods, with experiments on a stand-by basis, awaiting notification of special conditions from the warning center.

4. World Meteorological Intervals (WMI).

These are series of ten consecutive days each quarter including the solstice or equinox day and also three RWD. Upper air soundings will be increased and special attention will be given to the attainment of high altitudes during the WMI. The rocket launchings are almost all scheduled for these intervals.

5. Distribution of Alerts, SWI information, and data.

It is now planned to distribute Alert and SWI information via the international meteorological teletype networks. Backup messages may be broadcast on WWV, WWVH, and other special facilities. It is not expected to send special warnings, or short term data summaries, or collect information into the warning services by these teletype networks, but rather to use whatever other facilities (e.g., commercial teletype, telephone, etc.) may be most convenient to the recipient.

In the western hemisphere there will be available weekly reports giving a summary on the past week's observations of solar activity, geomagnetism and any other fields for which a need may be expressed. The reports will be sent airmail to all stations desiring them and will be an extension of the present weekly report on solar activity issued jointly by High Altitude Observatory (HAO) and National Bureau of Standards (NBS).

6. Solar Eclipse.

There are tentative plans for an expedition to the Pacific (probably Danger Island) to observe the solar eclipse of October 12, 1958. Thus far, only optical observations are planned. The possible organizations participating include the Naval Research Laboratory, High Altitude Observatory, Sacramento Peak Observatory, and the California Academy of Sciences.

U. S. STATION LIST FOR THE IGY

Project Code:

DC	World Day Communication
DD	Data Distribution
EE	Eclipse Expedition
WWA	World Warning Agency

CSAGI No.	Stations	Latitude	Longitude	Program
NA 113	Anchorage, Alaska	61°10'N	149°55'W	DC
NB 473	Boulder, Colorado	40 03	105 18	DD
	Danger Island	11 S	166	EE
	Ft. Belvoir, Virginia	38 44 N	77 08	WWA,DC

II. METEOROLOGY

The proposed United States program in meteorology for the IGY is designed primarily to increase knowledge of :he structure and motions of the atmosphere. The thermal, moisture, and motion fields in the atmosphere have been observed systematically only in rather restricted areas and then only to 20 km in height. These observations have shed some light on the complicated quasi-horizontal planetary wave motions associated with the westerlies of middle latitudes. These waves of length 2,000 - 5,000 miles move slowly eastward, sometimes westward, change their amplitude, appear and disappear; and in so doing they determine the west-east air mass distribution over a good portion of the hemisphere. In addition to these zonal motions, there exists also another class of motions which affect the shape of the meridional pressure profile and the north-south distribution of storms and fair weather belts. The complete understanding of both the zonal and meridional flow patterns still eludes the meteorologist. Necessary for this understanding is a better knowledge of the intensity and mode of exchange of energy, momentum, water vapor, and mass flow between tropics and polar regions, between troposphere and stratosphere, and between Northern and Southern Hemispheres.

Increasing the height of aerological soundings to at least 30 km and extending their coverage deep into the Southern Hemisphere will provide essential data for the study of these important transport problems on a global basis and to a height comprising 99% of the mass of the atmosphere.

The proposed United States program in meteorology expects to provide data in the Northern Hemisphere, where there are stations presently in normal operation and also in the Southern Hemisphere where strategic new stations (mostly in cooperation with other countries) are proposed in order to better understand this region and in order to strengthen the 70-80 degree Pole-to-Pole chain. The United States meteorological program therefore includes the following proposals:

1. Hugh Altitude Observations.

The thermal, moisture and motion fields in the atmosphere have been observed systematically only to levels of about 20 km. Our understanding of both the zonal and meridional flow patterns, of the intensity and mode of exchange of energy, momentum, water vapor and mass flow between tropics and polar regions, between troposphere and stratosphere is dependent upon observations to greater heights.

By using 800-gram balloons throughout the IGY at about 100 U. S. rawinsonde stations, it will be possible to increase the height of rawinsonde observations up to nearly 30 km. These stations are distributed over continental U. S., Alaska, weather ships, and several Pacific islands. As part of this program it is anticipated that these special balloons will be supplied to about 28 additional stations operated by other countries jointly with the U. S.

2. 70-80 Degree West Meridian Line.

A pole-to-pole cross section along the 70-80 meridian west will be part of the joint Western Hemisphere effort. (The CSAGI actually defines the region as between 55° and 95°W.) The U. S. will operate 57 stations in continental U. S. and plans to cooperate directly in 9 others. These stations will provide data on temperature, moisture and wind fields of large-scale meteorological studies. The stations marked with an asterisk are considered part of this program.

3. Arctic Meteorology.

A complete surface and upper air observational program in meteorology probably will be carried out at each of two U. S. drifting stations in the Arctic. The measurements include: continuous recording of surface temperature, pressure, precipitation, wind, sunshine, and humidity, visual surface observations at 3 hour intervals; twice daily rawinsonde observations; pilot balloon observations when necessary; direct and diffuse solar radiation. At one of the drifting sites, observations will also be made of: solar radiation; reflectivity of the snow surface; net radiation heat flux; sky brightness; total atmospheric ozone with a Dobson spectrophotometer; and vertical wind and temperature structure near the ground.

4. Antarctic Meteorology.

A complete surface and upper-air meteorological observation program is planned for the Main Base, Marie Byrd, South Pole, Cape Adare (in cooperation with New Zealand), Knox Coast, Williams Air Operations Facility at McMurdo Sound (upper-air only), and Weddell Sea stations in the Antarctic. In addition, special observations of ozone, carbon dioxide and the structure of the lowest layers of the atmosphere are planned for the Main Base. The program includes the following:

Standard weather observations at all stations:

3 hourly surface observations
12 hourly rawinsonde observations
Pilot balloon observations when required for aircraft operations
Continuous recording of surface temperature, humidity, pressure, precipitation amount, wind and sunshine
Solar radiation (direct and diffuse) received on a horizontal surface

Special observations at Main Base Station:

Solar radiation (direct) received at normal incidence
Net radiative heat flux
Sky brightness
Air samples for carbon dioxide determination (possibly for other bases also)
Total atmospheric ozone
Vertical wind and temperature structure near the ground

Special equipment:

Dobson total ozone spectrophotometer
Infrared hygrometer
Sunshine duration-photometric switches
Mt. Rose snow samplers
Ceiling lights for measuring direction, speed and height of clouds
Pyrheliometers and recorders for measuring solar radiation and for albedo measurements
Hemispheric radiometer, Gier and Dunkle
Net radiometer, Gier and Dunkle
Recorders for radiometers

5. Atmospheric Ozone.

Measurements will be made with Dobson spectrophotometers to determine the total atmospheric ozone. These measurements will be made at four continental U. S. stations; Little America; College, Alaksa; and on one of the Arctic Ice Floe stations. Surface ozone concentrations will be recorded at Albuquerque, New Mexico and arrangements are under discussion with the Bolivian National Committee to conduct additional studies at Chacaltaya, Bolivia.

6. Radiation Measurements.

The total radiation received will be measured at about 80 continental stations in the U. S. using the Eppley pyrheliometer. In addition, this work will be done also at 6 Alaskan, 2 Arctic, and 6 Antarctic stations.

7. Geochemical Measurements.

Air samples will be collected at all Antarctic stations during the IGY as well as selected sites elsewhere. Analysis of the collected air with a mass spectrometer or infra-red spectrometer will be completed at a laboratory in the U. S. Samples will be analyzed to determine amounts of important constituents and for isotope ratios. The program also includes air sampling for carbon dioxide determinations, and total ozone measurements in Antarctic air.

8. Additional Plans.

In addition to increasing the number of fixed aerological stations, it is expected that the program of weather reconnaissance using aircraft will be continued and perhaps extended, permitting a profile to be taken of the meteorological elements along the flight path as well as visual observations of the extent of snow and ice cover.

A number of commerical and Military Sea Transport Service ships will provide rawinsonde data during the whole period of the IGY. Finally, it is planned to have some sferics and radar activity.

1. U. S. STATION LIST FOR THE IGY

Project Code:

HA	High Altitude Rawinsonde	Sfe	Sferics
HF	Heat Flux	RON	Solar Radiation Measurements
OZO	Ozone Measurements	RW	Rawinsonde

*70-80° W - Meridian Line

CSAGI No.	Station	Nominal Location Latitude	Nominal Location Longitude	Program
Continental United States				
NB	*Albany, N.Y.	42°45'N	73°48'W	HA
NC 738	Albuquerque, N.Mex.	35 03	106 37	HA,OZO,RON
NC	Amarillo, Texas	35 14	101 42	HA,Sfe
NC	*Apalachicola, Fla.	29 44	84 59	RON
NB	Astoria, Ore.	46 09	123 53	RON
NC	*Athens, Ga.	33 57	83 19	HA
NC 755	*Atlanta, Ga.	33 39	84 25	RON
NB	*Belmar, N.J.	40 11	74 04	Sfe
NB 385	Bismarck, N.Dak.	46 46	100 46	HA,OZO,RON
NB	*Blue Hill, Mass.	42 13	71 07	RON
NB 435	Boise, Idaho	43 34	116 13	HA,RON
NB 455	*Boston, Mass.	42 21	71 04	RON
NC 807	Brownsville, Texas	25 54	97 26	HA,RON
NB 440	*Buffalo, N.Y.	43 07	78 55	HA
NC 801	Burrwood, La.	28 58	89 22	HA
NB 382	*Caribou, Maine	46 52	68 01	HA,RON
NC 765	*Charleston, S.C.	32 54	80 02	HA,RON
NB	*Cleveland, Ohio	41 24	81 51	RON
NC	*Cocoa, Fla.	28 14	80 36	HA
NB 487	*Columbia, Mo.	38 58	92 22	HA,RON
NB	*Columbus, Ohio	39 58	83 00	RON
NC	Corpus Christi, Texas	27 46	97 26	RW
NB	Davis, Calif.	38 32	121 45	RON
NB 476	*Dayton, Ohio	39 52	84 07	HA
NC	Del Rio, Texas	29 20	100 53	HA
NB 479	Denver, Colo.	39 46	104 53	HA
NB 497	Dodge City, Kansas	37 46	99 58	HA,RON
NB	*East Lansing, Mich.	42 42	84 28	RON
NB	*East Wareham, Mass.	41 46	70 40	RON
NC 779	El Paso, Texas	31 48	106 24	HA,RON

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Continental United States - cont.				
NB 481	Ely, Nevada	39°17'N	144°51'W	HA,RON
NC	Flagstaff, Ariz.	35 12	111 40	OZO
NB	*Flint, Mich.	45 58	83 44	HA
NC	Ft. Huachuca, Ariz.	31 35	110 20	RON
NC	Fort Worth, Texas	32 46	97 25	HA,RON
NC	Fresno, Calif.	36 46	119 43	RON
NC 799	*Gainesville, Fla.	29 39	82 21	RON
NB	Glasgow, Mont.	48 13	106 37	HA,RON
NB 485	Grand Junction, Colo.	39 07	108 32	HA,RON
NB	Grand Lake, Colo.	40 15	105 51	RON
NB 366	Great Falls, Mont.	47 29	111 21	HA,RON
NB	Grandview, Mo.	38 50	94 33	Sfe
NB 421	*Green Bay, Wis.	44 29	88 08	HA
NB 501	*Greensboro, N.C.	36 05	79 57	HA,RON
NC	*Griffin, Ga.	33 17	84 17	RON
NB 503	*Hatteras, N.C.	35 13	75 41	HA,RON
NB	*Indianapolis, Ind.	39 44	86 16	RON
NB 344	*International Falls, Minn.	48 34	93 23	HA
NC	Inyokern, Calif.	35 39	117 40	RON
NB 448	*Ithaca, N.Y.	42 27	76 28	RON
NC	*Jackson, Miss.	32 20	90 13	HA
NC 788	*Jacksonville, Fla.	30 25	81 39	HA
NC 810	*Key West, Fla.	24 33	81 48	RW
NC 791	*Lake Charles, La.	30 13	93 09	HA,RON
NB 443	Lander, Wyo.	42 48	108 43	
NC 721	Las Vegas, Nevada	36 05	115 10	HA,RON
NB	*Lemont, Ill.	41 42	87 59	RON
NB	*Lexington, Ky.	38 02	84 30	RON
NB 465	Lincoln, Nebr.	40 49	96 42	RON
NB 505	*Little Rock, Ark.	34 44	92 14	HA,RON
NC 746	Los Angeles, Calif.	34 03	118 14	RON
NC	Los Angeles, Calif.	33 56	118 23	RON
NB	*Madison, Wis.	43 08	89 20	RON
NB 450	Medford, Ore.	42 22	122 52	HA,RON
NC 808	*Miami, Fla.	25 49	80 17	HA,RON
NC 778	Midland, Texas	31 56	102 12	HA,RON
NC	*Montgomery, Ala.	32 23	86 21	HA
NB 461	*Nantucket, Mass.	41 15	70 04	HA
NB 500	*Nashville, Tenn.	36 07	86 41	HA,RON
NB	*Newport, R.I.	41 30	71 19	RON

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Continental United States - cont.				
NB	*New York, N.Y.	40°30'N	73°47'W	RON,RW
NB 498	*Norfolk, Va.	36 53	76 12	HA
NB 462	North Platte, Nebr.	41 08	100 41	HA
NC 700	Oakland, Calif.	37 44	122 12	HA
NC	*Oakridge, Tenn.	35 55	84 19	RON
NB 502	Oklahoma City, Okla.	35 24	97 36	HA,RON
NB 460	Omaha, Nebr.	41 22	96 01	HA,RON
NB	*Peoria, Ill.	40 40	89 41	HA
NC 760	Phoenix, Ariz.	33 26	112 01	HA,RON
NB 470	*Pittsburgh, Penn.	40 30	80 13	HA
NB 434	*Portland, Maine	43 39	70 19	HA,RON
NB	Prosser, Wash.	46 15	119 45	RON
NB 426	Rapid City, S.Dak.	44 02	103 03	HA,RON
NB	Richland, Wash.	46 34	119 35	RON
NC	Riverside, Calif.	33 58	117 28	RON
NB 408	*St. Cloud, Minn.	45 35	94 11	HA,RON
NC	St. George, Utah	37 07	113 34	HA
NB	Salem, Ore.	44 55	123 01	HA
NB	Salt Lake City, Utah	40 46	111 58	HA
NC 800	San Antonio, Texas	29 32	98 28	HA,RON
NC 790	San Diego, Calif.	32 49	117 08	HA
NC 740	Santa Maria, Calif.	34 54	120 27	HA,RON
NC	Santa Monico, Calif.	34 01	118 27	HA
NB 389	*Sault Ste. Marie, Mich.	46 28	84 22	HA,RON
NB	*Sayville, N.Y.	40 46	73 05	RON
NB 360	Seattle-Tacoma, Wash.	47 27	122 18	HA,RON
NB	Seattle, Wash.	47 39	122 18	RON
NB	*Seabrook, N.J.	39 30	75 14	RON
NB	*Schenectady, N.Y.	42 50	73 53	RON
NC	*Shreveport, La.	32 28	93 49	HA,Sfe
NB 364	Spokane, Wash.	47 37	117 31	HA,RON
NB	Stillwater, Okla.	36 08	97 04	RON, Sfe
NC	Table Mountain, Calif.	34 22	117 41	RON
NC	*Tallahassee, Fla.	30 26	84 18	RON
NC 804	*Tampa, Fla.	27 58	82 32	HA,RON

CSAGI No.	Station	Nominal Location Latitude	Nominal Location Longitude	Program
Continental United States - cont.				
NB 347	Tatoosh Isl., Wash.	48°23'N	124°44'W	HA
NC	Tonopa, Nevada	38 04	117 13	HA
NB	Topeka, Kansas	39 04	95 37	HA
NC 775	Tucson, Ariz.	32 08	110 57	HA,RON
NB	*Upton, N.Y.	40 52	72 53	RON
NB 466	*University Park, Penn.	40 48	77 52	RON
NC	*Valpariso, Fla.	30 29	86 31	HA
NB 489	*Washington, D.C.	38 51	77 02	Sfe
NB 489	*Washington, D.C. (Silver Hill, Md.)	38 50	76 57	HA,OZO,RON
NC	*West Palm Beach, Fla.	26 41	80 06	Sfe
NC 772	White Sands, N.Mex.	32 24	106 52	Rockets, RW
NB	Winnemucca, Nevada	40 54	117 48	HA
NC	Yuma, Ariz.	32 52	114 26	RON
Alaska and Arctic Sea				
NB 296	Adak	51°53'N	176°39'W	RW
NA 113	Anchorage	61 10	149 59	HA
NB 245	Annette	55 02	131 34	HA,RON
NB	Attu, Aleutian Is.	52 50	173 11 E	RW
NA 041	Barter Island	70 07	143 40 W	HA
NA 115	Bethel	60 47	161 43	HA,RON
NB 243	Cold Bay	55 12	162 43	HA
NA 075	Fairbanks	64 49	147 52	HA,RON
NA	Ft. Greeley	63 59	145 43	RON
NB 213	King Salmon (Naknek)	58 41	156 39	HA
NB	Kodiak	57 45	152 31	RW
NA 064	Kotzebue	66 52	162 38	HA
NA	Matanuska	61 34	149 16	RON
NA 095	McGrath	62 58	155 37	HA
NA 079	Nome	64 30	165 26	HA
NA 035	Pt. Barrow	71 18	156 47	HA,RON
NB 220	St. Paul Isl.	57 09	170 13	HA
NA 126	Yakutat	59 31	139 40	HA
NA	Arctic Ice Floe Station "A"	78	160	HA,RON
NA	Arctic Ice Floe Station "B"	85	100	HA,RON

CSAGI No.	Station	Nominal Location Latitude	Nominal Location Longitude	Program
Atlantic Weather Ships				
NA 137	Atlantic Station B	56°30'N	51°00'W	HA
NA 145	Atlantic Station C	52 45	35 30	HA
NB 427	Atlantic Station D	44	41	HA
NB 504	Atlantic Station E	35	48	HA
Antarctica				
SA 004	Byrd Station	80° S	120° W	HF,RON,RW
SA 009	Little America	78 16	162 28	HF,OZO,RON,RW
SA 001	Pole Station	90	-	HF,RON,RW
SA 011	Weddell Sea	78	35	HF,RON,RW
SA 020	Knox Coast	66	110 E	HF,RON,RW
SA 007	Williams Air Operation Facilities (McMurdo Sound)	77 50	100 36 W	RW
Pacific Ocean Area				
CE 112	Canton Is., Phoenix I.	2°46'S	171°43'W	HA,RON
CE 104	Eniwetok Is., Marshall I.	11 20 N	162 20 E	HA
CE 096	Guam	13 34	144 55	RON
NC 825	Hilo, T.H.	19 44	155 04 W	HA,RON
CE	Iwo Jima	24 44	141 20 E	HA
CE 113	Johnston Is.	16 44	169 31 W	HA
CE 088	Koror Isl., Caroline I.	7 20	134 29 E	HA
CE 107	Kwajalein, Marshall Is.	8 43	167 44	RW
NC 825	Lihue, T.H.	21 59	159 21 W	HA
CE 109	Majuro, Marshall Is.	7 05	171 23 E	HA
NC	Midway	28 13	177 22 W	RW
CE 086	Okinawa	26 20	127 40 E	HA
CE 102	Ponape, Caroline Is.	6 58	158 13	HA
CE 100	Truk, Caroline Is.	7 28	151 51	HA
CE 105	Wake Is.	19 17	166 39	HA,RON
CE 092	Yap Isl., Caroline Is.	9 31	138 08	HA
Pacific Weather Ships				
NC 797	Pacific Station N	30°00'N	140°00'W	HA
NC 751	Pacific Station V	34	164 E	HA
Central America				
NC 850	*Albrooke AFB, C.Z.	8°58'N	79°34'W	HA,RON
NC 832	*San Juan, P.R.	18 26	66 00	HA
NC 836	*Swan Island	17 24	83 56	HA,RON

2. COOPERATIVE STATION LIST FOR THE IGY

Some of the stations listed below have been long in existence under cooperative arrangements and are expected to continue during the IGY; others are newly planned stations of a cooperative kind: in some cases arrangements have been made with the countries involved and in others it is hoped that arrangements will be made soon.

CSAGI No.	Station	Nominal Location Latitude	Nominal Location Longitude	Program
Canada				
NA 003	*Alert, Ellesmere Isl.	82°30'N	62°20'W	HA
NB	Argentia, Nfld.	47 18	54 00	RW
NB	*Harmon AFB, Nfld.	48 44	58 34	HA
NA 006	*Eureka, Ellesmere Isl.	79 59	85 57	HA,RON
NA 129	*Ft. Churchill, Manitoba	58 45	94 05	Rockets
NA 010	Isachsen, NWT	78 47	103 32	HA
NA 020	Mould Bay, NWT	76 17	119 28	HA
NA 024	*Resolute, NWT	74 41	94 54	HA,RON
NB	St. Johns, Nfld.	47 37	52 45	Sfe
Greenland				
NA 112	Narsarssuak	61°11'N	45°25'W	HA
NA 019	*Thule	76 31	68 50	HA
Atlantic Ocean Area				
NC 733	*Bermuda	32°22'N	64°40'W	HA,Sfe
NC	*Eleuthera	25 16	76 18	HA
NC	*Grand Bahama	26 37	78 20	HA
NB 494	Lajes, Azores	38 45	27 05	HA,Sfe
NA 086	Reykjavik, Iceland	63 57	22 37	HA
Europe				
NB	Bitburg, Germany	49°57'N	6°34'E	HA
NB	Chaumont, France	48 04	5 02	HA
NB	Wiesbaden, Germany	50 03	8 20	HA
Africa				
NC	Port Lyautey, Fr.Afr.	34°18'N	6°34'W	RW
NC 764	Tripoli, Libya	32 06	13 12 E	HA,RW
Antarctica				
SA	Adare Station	71°17'S	170°15'W	RON,RW

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Pacific Region and Far East				
CE 078	Clark AFB, Philippines	15°10'N	120°34'E	HA
NC	Kimpo, Korea	37 34	126 42	HA
CE 080	Manila, Philippines	14 31	121 00	RON
NC	Masulpo, Korea	33 31	126 32	HA
NC	Yakosuka, Japan	35 17	139 46	RW
Mexico				
NC 811	Mazatlan, Sinaloa	23°11'N	106°25'W	HA
NC 819	*Merida, Yucatan	20 58	89 31	HA
NC 827	Tacubaya, D.F.	19 24	99 12	HA
NC 830	Vera Cruz	19 11	96 07	HA
Central American and Caribbean				
NC 816	*Camaguey, Cuba	21°25'N	77°52'W	HA
NC 847	*Curacao, Neth.West Ind.	12 11	68 59	HA
NC 828	*Grand Cayman, Brit.W.I.	19 15	81 51	HA
NC 837	*Guadeloupe, French W.I.	16 16	61 32	HA
NC 823	*Guantanamo Bay, Cuba	19 54	75 09	RW
NC 812	*Havana, Cuba	23 09	82 21	HA
NC 835	*Kingston, Jamaica,BWI	17 56	76 47	HA
NC 829	*Sabana de la Mar, D.R.	19 03	69 23	HA
NC 846	*St. Andrews I., Colomb.	12 30	81 40	HA
NC 834	*St. Maarten I., NWI	18 02	63 06	HA
NC	*Trinidad, Brit.West Ind.	10 40	61 32	RW
South America				
CE	*Antofagasta, Chile	23°26'S	70°28'W	HA
CE 124	*Guayaquil, Ecuador	2 10	79 53	HA
CE 127	*Lima, Peru	12 04	77 02	HA
SC	*Puerto Montt, Chile	41 28	72 47	HA
SC	*Quintero, Chile	32 47	71 32	HA
CE	*Chacaltaya, Bolivia (tentative)	16 19	68 10	OZO

III. GEOMAGNETISM

The United States IGY geomagnetic program consists of a series of experiments mainly designed to yield facts about the magnetic field fluctuations which arise from influences external to the surface of the earth. These influences have their origin in the upper atmosphere and above.

The large fluctuations or "magnetic storms", usually accompanied by disturbances in radio wave propagation and often by auroral displays, increase and decrease in number and intensity with the number and intensity of sunspots. It is believed that they are due to disturbances in the upper atmosphere of the earth caused by bursts of solar radiation of some sort - charged particles, or ultra-violet light and X-rays, or both. The energy from the solar bursts may cause winds and electrical currents in the high atmosphere. The main features of the magnetic disturbances are such as would be caused by zonal electrical current systems, measured in hundreds of thousands of amperes, flowing in the upper atmosphere in the auroral zones of high latitudes and in a zone around the geomagnetic equator. The demonstration of the actual existence of these currents, their nature, and their relation to the bursts of solar energy is an outstanding problem of geomagnetism.

The primary effort of the U. S. program will be the collection of detailed data from existing and new observatories so disposed, especially in the northern auroral zones, equatorial zones, and in the Antarctic region as to promise a fuller understanding of the zonal current systems. Additional geomagnetic data on vertical gradients and the actual location of electrical currents will be obtained by rocket sounding: magnetometers carried in the IGY earth satellites may provide unique information on equatorial current systems both in the high atmosphere, and at large distances from the earth, such as the Störmer current ring.

1. North American Network.

1.1 East-West Chain. Three-component Askania Variographs will be installed at five locations at separations of about 350 km. in an East-West direction. One station will be at Climax, Colorado, with the remaining four tentatively scheduled for Wasatch, Utah; Limon, Colorado; Phillipsburg, Kansas; and Lawrence, Kansas. It is also planned to provide a short North-South axis of stations by installing similar equipment at Casper, Wyoming; and Shiprock, New Mexico. These stations will provide a network with sufficiently close spacing and lineal extension to study in detail the overhead current sheets.

1.2 North-South Chain. Five new stations will be installed in Alaska, each station to consist of three-component Askania Variographs installed in pre-fabricated non-magnetic shelters. The sites will be Anchorage, Kotzebue, Northway, Fort Yukon, and Barter Island. These stations, spread across the northern zone of maximum auroral frequency and the zone of the electrical current of magnetic disturbances, will obtain information regarding the electric currents in the ionosphere that effect the geomagnetic field.

1.3 Operations at College. In addition to the regular observatory operation at College, Alaska, a Ruska rapid-run magnetograph and a differential magnetograph will be installed. The differential magnetograph will consist of a control station at the observatory connected by cable to two outpost stations distant by about six miles. This arrangement is expected to furnish data that will be used for computing the intensity and location of the electrical currents in the ionosphere that are presumed to be responsible for disturbances in the magnetic field.

1.4 Magnetic Gradient Study. Two stations equipped with Ruska standard magnetographs of normal and low sensitivity, and Ruska rapid-run magnetographs will be established at Healy and Big Delta, Alaska. Absolute observations will be made with a standard magnetometer and earth inductor. The records will be used for a study of magnetic gradients by correlating the variations at these two stations with those recorded at the College Magnetic Observatory.

1.5 Ice Floe Stations. An Askania three-component variograph will be maintained at Drifting Station A, in the vicinity of 80°N. 160°W. This station will serve as an extension of the North-South chain mentioned in 1.2.

2. Equatorial Measurements.

2.1 Western Pacific. Standard magnetic observatories will be operated on the islands of Guam and Koror, using Ruska standard and rapid-run magnetographs with auxiliary equipment for absolute calibrations.

2.2 Central Pacific. Magnetic stations will be established on Jarvis and Palmyra Islands using three-component Askania Variographs. It is expected that these two stations, which will be coordinated with oceanographic studies, will be in operation for about one year. Efforts will be made to investigate the nature of the diurnal variation in the oceanic area adjacent to the islands using anchored buoys and ship-towed magnetometers.

The Jarvis-Palmyra and Guam-Koror observatories, being located close to the position of the geomagnetic equator at the earth's surface, will provide new information on the anomalous behavior which has been observed in the past of the geomagnetic field at the equator.

2.3 Cooperative Network in South America. It is hoped that the Geophysical Institute of Huancayo, Peru, in cooperation with the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, will operate a close-spaced five station net of three-component Askania Variograph stations to study the equatorial electrojet in detail. Valuable corollary data will be provided by the similar network of ionospheric stations.

3. Antarctic Observations.

It is expected that the magnetic observatories to be established by various countries in the Antarctic will allow a reliable determination of the location of the Southern Auroral Zone. These magnetic observations will be indispensable for the interpretation of observations at the same sites in other disciplines, particularly aurora and ionospheric physics, as well as permitting investigations of the time relationship and spatial comparisons of disturbances in the Arctic and Antarctic.

Standard magnetic observatories, equipped with Ruska magnetographs and Ruska rapid-run magnetographs, will be established at Little America, Byrd, and Knox Coast stations where absolute calibrations will also be made. The Pole Station and probably Cape Adare (in cooperation with New Zealand) will have Askania Variographs.

4. Auxiliary Investigation.

4.1 Rapid-Run Magnetographs. Ruska rapid-run magnetographs will be provided for operation at Point Barrow, Sitka, Tucson, and Honolulu, in addition to those for installation at the new observatories. The rapid-run magnetographs, having a chart speed of 4 mm. per minute which allows resolution of disturbances of 6 to 8 second periods, will be run continuously.

4.2 Warning Service. Magnetic variometers with pen-and-ink recorders, to allow immediate information on magnetic activity, will be installed at about 6-12 stations (depending upon the type of instrument chosen) primarily for the benefit of ionosphere recording stations. Probable installation sites include Boulder, Colorado; Little America, Antarctica; Thule, Greenland; Climax, Colorado; and College, Alaska.

4.3 Sub-Audio-Frequency Geomagnetic Fluctuations.

The objectives of this program are to obtain a description of the geomagnetic fluctuations in the 1 to 50 cps frequency range and to determine, as far as possible, the sources of the fluctuations. Both atmospherics (sferics) and ionospheric sources contribute to the signal, with the latter becoming more important at the higher latitudes. The small amount of data presently available indicates that in the auroral zone the largest fluctuations tend to precede the large magnetic disturbances, as measured by the K indices, by intervals of several hours. This phenomenon, in addition to its intrinsic interest, may prove to be a useful addition to the IGY warning service. It is planned to put one auroral zone station into operation before the start of the IGY to investigate further the value of such measurements as an advance warning of magnetic disturbance.

The special observing equipment, consisting of detection coils, low-level preamplifiers, and amplifiers for the 1 to 50 cps range, switching systems to provide for automatic data sampling, and low-speed (one-fourth inch per second) magnetic tape recorders, is to be installed at five field measurement stations located near Thule, Greenland; Boston, Massachusetts; College, Alaska; Denver, Colorado; and one station at low latitudes at a yet undetermined site.

In lower latitudes, it has been recently ascertained that much of the electro-magnetic radiation of frequencies about 50 to 150 cycles per second (as well as the well known sferics signals) probably originates in the electrical discharges of thunderstorms. The great wave lengths of these radiations (about equal to earth dimensions) apparently allows propagation with only moderate attenuation. An observation program is under way at the present time to study the propagation of these radiations and it is hoped that the program will continue throughout the IGY. The work is being done in the vicinity of Los Angeles, California and the Island of Maui, Hawaiian Islands.

5. Data and Publications.

Plans for publication of IGY data are not yet definite but data from the existing network of observatories operated by the United States Coast and Geodetic Survey (identified in the station list as PO) are published in volumes for each observatory representing a year's data. The volume contains the mean value for the three components for each hour and a reproduction of the magnetogram for each day. These volumes are distributed by the United States Coast and Geodetic Survey internationally to interested scientists.

1. U. S. STATION LIST FOR THE IGY

Project Code:

DM	Differential Magnetograph	SA	Sub-Audio Measurements, 1-200 cps
PO	Permanent Observatory- Ruska Standard Magnetographs	SP	Semi-portable equipment (Askania variographs)
QR	Quick Run Ruska Magnetographs	VI	Visual indicating equipment

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Continental United States				
NB 455	Boston, Mass.	42°21'N	71°04'W	SA
NB 473	Boulder, Colo.	40 02	105 18	VI
NB 442	Casper, Wyo.	42 51	106 18	SP
NB 480	Climax, Colo.	39 22	106 11	SP,VI
NB 479	Denver, Colo.	39 45	105 00	SA
NB 495	Fredricksburg, Va.	38 12	77 22	PO,QR,SA
NB 486	Lawrence, Kansas	38 58	95 14	SP
NB 482	Limon, Colo.	39 16	103 40	SP
NB	Philippsburg, Kansas	39 45	99 19	SP
NB 499	Shiprock, N.Mex.	36 47	108 41	SP
NC 775	Tucson, Ariz.	32 14	110 57	PO,QR
NB 469	Wasatch, Utah	40 34	111 46	SP
Alaska and Arctic Sea				
NA 113	Anchorage	61°10'N	149°59'W	SP
NA 041	Barter Island	70 08	143 40	SP
NA 085	Big Delta	64 09	145 51	PO,QR
NA 074	College	64 51	147 50	DM,PO,QR,SA,VI
NA 065	Ft. Yukon	66 34	145 18	SP
NA 094	Healy	63 51	149 00	PO,QR
NA 064	Kotzebue	66 40	162 30	SP
NA 096	Northway	62 58	141 57	SP
NA 035	Pt. Barrow	71 20	156 46	PO,QR,VI
NA 136	Sitka	57 03	135 20	PO,QR
NA	Drifting Station "A"	80	160	SP
Antarctica				
SA 004	Byrd Station	80° S	120° W	PO,QR
SA 009	Little America	77	164	PO,QR,VI
SA 001	Pole Station	90	-	SP
SA 020	Knox Coast	67	105 E	PO, QR
	Shipboard en route	-	-	Rockets

CSAGI No.	Station	Nominal location Latitude	Longitude	Program
Pacific Region				
CE 096	Guam	13°27'N	144°45'E	PO,QR
NC 817	Honolulu, T.H.	21 18	158 06 W	PO,QR
CE 115	Jarvis	0 23 S	160 03	SP
CE 088	Koror	7 16 N	134 32 E	PO,QR
CE 114	Palmyra	5 53	162 05 W	SP
Central America				
NC 932	San Juan, P.R.	18°26'N	66°00'W	PO

2. COOPERATIVE STATION LIST FOR THE IGY

Some of the stations listed below have been long in existence under co-operative arrangements and are expected to continue during the IGY; others are newly planned stations of a cooperative kind: in some cases arrangements have been made with the countries involved and in others it is hoped that arrangements will be made soon.

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Canada and Greenland				
NA 062	Davis Strait (Shipboard)	67° N	58° W	Rockets
NA 129	Ft. Churchill, Manitoba	58 46	94 10	Rockets
NA 089	Frobisher Bay, NWT (Shipboard)	63 20	67 20	Rockets
NA 112	Narsarssuak, Greenland	61 11	45 25	VI
NA 019	Thule, Greenland	76 33	68 50	SA,VI
South America				
CE 128	Huancayo and 4 sub-stations, Peru	12°03'S	75°20'W	SP
Antarctica				
SA	Cape Adare	71°19'S	170°15'W	SP

IV. AURORA AND AIRGLOW

The aurora and airglow are both optical phenomena of the upper atmosphere, however, it is generally believed that different mechanisms of excitation are involved. The aurora is generally thought to be excited through bombardment of the atmosphere by ionozed particles emanating from the sun, whereas the airglow is thought to result from chemical reactions in the upper atmosphere. Investigations have been designed to assist in determining the modes of excitation. Since both phenomena are essentially world-wide, the aurora occuring on less frequent occasions, the most promising attack on the problem appears to be studies of the distribution of the phenomena over the globe at specific times, and their changes with time. These distributions, or synoptic maps, will then be studied with respect to solar phenomena and other geophysical phenomena occurring simultaneously.

A. AURORAL STUDIES

The auroras are the visible paths created as the bombarding particles travel through the atmosphere. The particles, thought to be mostly protons, not only excite the atoms and molecules to radiate but ionize many of them, thus producing trails of electrons. Furthermore, when the protons are slowed sufficiently, they may recombine with an electron of the ionosphere and thus radiate the characteristic hydrogen spectrum.

There are three very important types of data concerning auroras which need be observed on a synoptic basis; namely, the locations of auroras by optical methods, the locations of the incidence of hydrogen, and the location of the ionized regions associated with the visible auroras using radar techniques.

1. Geographical Incidence of Auroras.

The primary consideration of observing programs of auroras has been to construct synoptic maps showing the distribution of auroras. The data derived from observations of auroras will be forwarded to regional centers, one at College, Alaska, the other at Ithaca, New York, for processing and dissemination.

1.1 Photographic Observations. The photographic observations will be made with an all-sky camera consisting of a convex mirror and a 16 mm motion picture camera adjusted to time-lapse photography, which photographs the entire sky as seen in the mirror. If the height of the lower edge of the aurora is assumed, the calibrations may be made directly in geomagnetic or geographical coordinates. In Alaska, it is planned to locate the all-sky cameras in pairs separated 300 to 500 km. along a magnetic meridian so that height determination may be made. It is planned to construct the synoptic maps of auroras at 00, 15, 30, and 45 minutes of each hour.

1.2 Visual Observations. The bulk of the visual observations of aurora will be made by a network of amateur observers under the guidance of C. W. Gartlein, Cornell University. It is expected that some 200 locations will be in the network. Observers will use alidades, diagram cards, and mark sense punch cards to record observations along the meridian zone through each station. Assuming a height of the base of the aurora, the distance to the point over which the aurora is incident is readily computed. The observations are quite accurate for auroras near the zenith. All stations will make diagrams of sky positions of aurora for each quarter hour. All of the visual observations will be forwarded to the regional Aurora Data Center at Ithaca, New York, for recording on punched cards.

1.3 Radar Observations of Auroras. Echoes from auroras are not necessarily coincident with the optical auroras since the radio signal is returned from the electrons associated with the aurora. Current research in Alaska using pulsed radio techniques has demonstrated that echoes from auroral ionization may be readily distinguished from those due to ground backscatter and reflections from sporadic E.

Observations are planned along two chains of stations. One chain of stations will be situated across the auroral zone in Alaska, a second chain of stations (to monitor the longitudinal distribution of auroras) will be in the Northern United States at approximately 56° North geomagnetic latitude. U. S. radar stations will operate at approximately 50 Mc.

2. Spectroscopic Observations of Auroras.

2.1 Patrol Spectrograph. A patrol spectrograph of the type designed by A. B. Meinel and N. J. Oliver will be used for the major portion of the U. S. program. The observing program is planned to give a profile of spectral features of the aurora along a meridional line showing the production of auroral luminosity of the earth's atmosphere by primary protons and by subsequent secondary processes. Included will be studies of the variations of the spectral components of the aurora, including hydrogen, as functions of type of aurora, height, and latitude.

2.2 Scanning Spectrometer. The scanning spectrometer for this program is the one designed by D. M. Hunten of the University of Saskatchewan. The program is expected to provide information on the rapid changes of the auroral spectrum during periods of high geomagnetic activity. Latitude variations of short-lived auroral spectral features, especially the ionized oxygen bands, will provide much useful information on the constituent-altitude profile where records can be correlated with flight measurements.

3. Special Techniques for Auroral Investigations. The principal techniques for investigations of aurora other than those mentioned above is the application of radio astronomy.

3.1 Absorption of Extra-Terrestrial Radio Waves in the Auroral Zone. A method of measuring the absorption of radio waves passing through the ionosphere has been developed at the Geophysical Institute, College, Alaska. Current observations and theoretical studies indicate that the absorption results from bombardment of the atmosphere by charged particles from the sun, that the absorption is not uniform and that there may be a rather sharp southern boundary. The absorption extends farther south at times of greater magnetic activity and there are two components, one with maximum frequency at mid-day, and the other at midnight. Advantage is taken of the general background of radio noise associated with the galaxy and a continuous recording is made of its intensity. Absorptions at frequencies of 30 Mc and 65 Mc appear to correlate well with the polar radio blackout. The absorption measurements will be made across the auroral zone in Alaska. A series of stations along the Pacific Coast will measure the absorption at greater distances from the auroral zone and additional stations are planned for Eastern United States to check on variations with geomagnetic longitude. Also discussions are now underway with the Canadian National Committee for the operation of equipment at two stations in Canada.

3.2 Radio Noise Associated with Auroras. The question of radio noise emitted by auroras is far from being settled. Marked increases of the noise level on high frequency radio circuits have been observed during periods of auroral displays. However, up to the present, it has been impossible to determine whether the increased noise level originated with the auroras or merely resulted from the auroras producing a good reflecting and scattering medium which propagated noise and other radio interference from large distances. The records taken with the equipment for radio wave absorption in paragraph 3.1 should give evidence of radio noise emitted from auroras.

3.3 Scintillation of Radio Stars through Auroral Disturbances. The scintillations of radio stars have been shown to vary rapidly in the auroral zone. Marked changes in the scintillations occur within minutes, and it seems highly possible that this may result from the transit of an aurora or auroral sporadic E cloud across the line of sight. It is hoped that measurements will be made of the scintillations with existing equipment at College, Alaska and Ithaca, New York.

4. Meteor Studies.

4.1 Visual Meteor Observations. Observers, using the method employed by Thomas C. Poulter during the Byrd Expedition II (1933 - 1935), will undertake a program of visual meteor observations at each Antarctic station.

4.2 Low Power Radar. Operation of low power radar equipment at approximately 30 Mc is planned at the Little America Station for detailed meteor and some auroral studies.

B. AIRGLOW STUDIES

The main problem in connection with studies of the airglow which requires international cooperation appears to be the temporal and geographical variation of intensity of this radiation from the night sky. The stronger components of the airglow spectrum are the OH bands in the infra-red region; the red and green auroral lines, both of which are emitted by oxygen atoms; and the D lines of sodium. Each of these radiations undergoes different types of variations of intensity as a function of time. In addition to the temporal variations, all of the airglow radiations show irregular variations, or "patchiness" over the sky, which vary with time.

The U. S. program is concerned mainly with the chain of stations at the longitude of the Americas. Each station will be equipped with a photoelectric photometer of the Roach-type as modified by Manring. These are rapid-scanning quadruple telescopes, each provided with a narrow interference filter and self-calibrating system. They measure the distribution of intensity of the faint radiations from the dark upper atmosphere in three different colors characteristic of specific atomic and molecular processes and a fourth control color.

1. U. S. STATION LIST FOR THE IGY

Project Code:

AP	Airglow Photometer	RWA	Radio Wave Absorption
AR	Auroral Radar	SC	All-Sky Camera
DR	Data Reduction	SS	Sanning Spectrometer
MR	Meteor Radar Studies	VO	Visual Observations
PS	Patrol Spectrograph	VM	Visual Meteor Observations

CSAGI No.	Station	Nominal Location Latitude	Nominal Location Longitude	Program
Continental United States				
NC 725	Alamogordo, N.Mex.	35°54'N	105°58'W	Rockets
NB 424	Alexandria Bay, N.Y.	44 20	75 54	VO
NB 403	Battle Creek, Mich.	42 19	85 11	VO
NB	Bend, Ore.	44 04	121 20	SC
NB	Black Hills, N.Dak.	45	103	AP,AR,PS,SC,VO
NB 473	Boulder, Colo.	40 02	105 18	DR
NB 449	Cambridge, Mass.	42 25	71 10	DR,SC,SS,VO
NB 457	Chicago, Ill.	41 50	87 40	PS,VO
NB 357	Coulee Dam, Wash.	47 58	119 00	VO
NC 767	Dallas, Texas	32 47	96 48	VO
NB 479	Denver, Colo.	39 45	105 00	VO
NB 467	Elmhurst, L.I., N.Y.	40 44	75 53	VO
NB 381	Fargo, N.Dak.	46 53	96 47	SC,VO
NB 483	Fayette, Mo.	39 08	92 40	VO
NB 477	Fritz Peak, Colo.	39 52	105 31	AP,AR,PS,SC,VO
NB 463	Glen Rock, N.J.	40 58	74 09	VO
NB 366	Great Falls, Mont.	47 29	111 21	SC
NB 459	Hamden, Conn.	41 22	72 58	VO
NB 433	Hanover, N.H.	43 42	72 18	RWA
NB 448	Ithaca, N.Y.	42 27	76 31	AR,DR,RWA,PS, SC,VO
NB 454	Jackson, Mich.	42 17	84 27	VO
NB 457	Kalamazoo, Mich.	42 20	85 38	VO
NB 348	Malott, Wash.	48 17	119 43	VO
NB 416	Massena, N.Y.	44 57	74 54	VO
NB 458	Meriden, Conn.	41 32	72 48	VO
NB 461	Nantucket, Mass.	41 15	70 04	VO
NB	Newton, N.Dak.	48	102	AP,SC
NB 447	Orono, Maine (or Caribou)	44 53	68 41	SC,VO
NB 428	Oshkosh, Wis.	44 00	88 30	VO
NB	Pocatello, Idaho	42 50	112 25	SC

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Continental United States - cont.				
NB 409	Portland, Ore.	45°30	122°37'W	VO
NB	Pullman, Wash.	46 43	117 10	RWA,SC
NB 438	Rochester, N.Y.	43 08	77 35	VO
NC 768	Sacramento Peak, N.Mex.	32 43	105 45	AP,PS,VO
NB 394	Shingleton, Mich.	46 21	86 28	PS,SC,VO
NC 706	Stanford, Calif.	37 26	122 10	RWA,VO
NB 475	Swarthmore, Penn.	39 54	75 21	VO
NB 464	Tuckahoe, N.Y.	40 57	73 49	VO
NB 439	Utica, N.Y.	43 07	75 13	VO
NB 489	Washington, D.C.	38 55	77 04	RWA
NB 436	West Scarboro, Maine	43 34	70 22	VO
NB 468	West Hempstead, N.Y.	40 42	73 39	VO
NB 446	Williams Bay, Wis.	42 34	88 03	PS,SC,SS,VO
NB 419	Wilton, Maine	44 35	70 12	VO
NB 456	Wrentham, Mass.	42 03	71 20	VO
Alaska and Arctic Sea				
NA 041	Barter Island	70°08'N	143°40'W	AR,RWA,SC
NA	Bettles	66 54	151 50	SC
NA 074	College	64 51	147 50	AP,AR,DR,RWA SC,SS,VO
NA 065	Ft. Yukon	66 34	145 18	RWA,SC
NB 213	King Salmon (Naknek)	58 42	156 42	AR,RWA
NA 035	Pt. Barrow	71 20	156 46	AR,RWA,SC,VO
NA 064	Kotzebue	66 53	162 36	AR,SC
NA	Skwentna or Farewell	61 53	151 32	AR,RWA
NA 209	Unalaska	53 53	166 32	AR,RWA
NA	Arctic Ice Floe "A"	78	160	SC,PS.,VO
Antarctica				
SA 004	Byrd Station	80° S	120° W	PS,SC,VO
SA 009	Little America	77	164	MR,PS,SC,SS,VO,VM
SA 001	Pole Station	90	-	PS,SC,VO
SA 011	Weddell Sea	77	35	PS,SC,VO
SA 020	Knox Coast	67	105 E	PS,SC,VO
	Ship Operations	-	-	Rockets

2. COOPERATIVE STATION LIST FOR THE IGY

Some of the stations listed below have long been in existence under cooperative arrangements and are expected to continue during the IGY; others are newly planned stations of a cooperative kind: in some cases arrangements have been made with the countries involved and in others it is hoped that arrangements will be made soon.

CSAGI No.	Station	Nominal Location Latitude	Nominal Location Longitude	Program
Canada				
NA 129	Ft. Churchill, Manitoba	58°46'N	94°10'W	Rockets
NA 139	Knob Lake	54 48	66 49	RWA,SC
NA	Meanook	54 37	113 20	RWA
NA	Sachs Habor	72 00	125 30	SC,
NA 147	Saskatoon	52 08	106 40	PS,SS
Greenland and Europe				
NA 019	Thule, Greenland	76°33'N	68°50'W	AP,PS,RWA,SC,VO
NA 055	Kiruna, Sweden	67 50	20 15 E	RWA
Mexico and South America				
CE 128	Huancayo, Peru	12°03'S	75°20'W	AP
SC 671	San Juan, Argentina	31 40	68 35	AP
NC 831	Tonanzintla, Mexico	19 02 N	98 02	AP,SC
Pacific Ocean Area				
SB	Camden, Australia	34°04'S	150°38'E	AP
SB	Campbell Is., N.Z.	52 32	169 09	SC,
SB 207	Invercargill, N.Z.	46 25	168 22	PS,SC,
Antarctica				
SA	Adare Station	71°19'S	170°15'W	PS,SC,VO

V. IONOSPHERIC PHYSICS

The ionosphere program of the U. S. is quite diversified but may be conveniently presented as consisting of: 1) Synoptic Observations such as vertical-incidence sweep-frequency soundings, oblique-incidence pulse backscatter observations on three fixed frequencies with rotating yagi antennas, recording of naturally occurring terrestrial radio noise on eight frequencies, and the very low frequency signals-whistlers; and 2) Special Studies which are partially synoptic, or which will be carried out at places made accessible only by IGY expeditions, or which are controls for synoptic programs such as oblique-incidence forward scatter and sweep-frequency backscatter experiments, measurement of Es reflection coefficients, true height calculations, scintillations and drift studies, absorption measurement using pulse echoes and galactic noise, and deductions from radio amateur communication experience at vhf using ionospheric signals.

1. Synoptic Observations.

1.1 Pulse Echo Soundings at Vertical Incidence. The existing network of vertical incidence stations will be expanded according to resolutions of CSAGI to help fill out the pole-to-pole chain of stations along the Americas and to help give the recommended coverage in the Arctic and Antarctic regions. Measurements with modern ionosondes (NBS Model C: frequency sweep 1-25 Mc, peak pulse power 10 kw) will be taken at least every 15 minutes, with a stepped-up schedule on Regular World Days and Special World Intervals.

There are plans for a cooperative experiment with the Instituto Geofisico de Huancayo to study the details of the trough in F2 critical frequencies which occur in the daytime near the geomagnetic equator with two new sites in Peru to provide the necessary spacing of about 3 degrees. This experiment will be coordinated with the analogous geomagnetic equatorial fine structure experiment.

Vertical sounding stations to be operated by the U. S. are:

Arctic Sea Drifting Station "B"
Adak, Alaska
Anchorage, Alaska
College, Alaska
Point Barrow, Alaska

Fort Belvoir, Virginia, U. S. A.
Fort Monmouth, New Jersey, U. S. A.
Florida, U. S. A. (tentative)

Stanford, California, U. S. A.
White Sands, New Mexico, U. S. A.

Fort Randolph, Canal Zone
San Juan, Puerto Rico (Ramey AFB)

Byrd Station, Antarctica
Knox Coast, Antarctica
Little America, Antarctica
South Pole, Antarctica
Weddell Sea, Antarctica (tentative)

Kihei, Maui Island, Hawaiian Islands
Okinawa, Ryuku Islands

Data from a number of vertical sounding stations in the U. S., established to service other ionospheric experiments, will be available for at least some of the IGY period. These include sites in Colorado, Nebraska and Illinois.

For a number of other stations, the U. S. is cooperating with various scientific institutions and national committees in the planning, equipping or operation. These include: Godhavn, Greenland; Narsarssuak, Greenland (Narsarssuak AFB); Thule, Greenland (Thule AFB); St. Johns, Newfoundland (Pepperrel AFB); Reykjavik, Iceland; Bogota, Colombia; Huancayo, Talara, Chiclayo and Chimbote, Peru; La Paz, Bolivia; Concepcion, Chile; Sao Paulo, Brazil; Cape Adare, Antarctica; and Baguio, Philippines.

1. Oblique-Incidence Pulse Backscatter. A network of stations will have pulse equipment on three fixed frequencies (approximately 12, 18, and 27 Mc; 2 kw power; and 2 millisecond pulse duration with shorter pulses also available for 27 Mc) to observe backscatter at oblique-incidence. The yagi antennas used will be rotated and the echoes presented in polar plot (PPI display). The experiment will provide synoptic information on Es, meteor ionization trails, some forms of aurora, and the regular ionospheric layers.

Fixed-frequency backscatter stations to be operated by the U. S. will be at:

Adak, Alaska
College, Alaska
Boulder, Colorado, U. S. A.
Fort Monmouth, New Jersey, U. S. A.
Pullman, Washington, U. S. A.
Stanford, California, U. S. A.
Fort Randolph, Canal Zone

For a number of stations the U. S. is cooperating with various scientific institutions and national committees in the planning, equipping, installation, or operation. They include: Thule, Greenland (Thule AFB); Knob Lake, Quebec, Canada; Meanook, Alberta, Canada; Tonanzintla, Mexico (or San Juan, Puerto Rico) (tentative); Natal, Brazil (tentative); Sydney, Australia (tentative).

1.3 Naturally Occurring Terrestrial Radio Noise. Fully automatic equipment for measurement of noise parameters on eight fixed frequencies (15, 51, 170, 535 kc; 2.5, 5, 10, 20 Mc) will be employed in a synoptic study of atmospheric noise. The program has been integrated with existing noise measuring station, and sferics df stations.

The National Bureau of Standards noise equipment measures the absolute power level of the noise picked up by a standard antenna, averaged over a seven-minute interval, sampled twice an hour for each frequency, and recorded on a paper-tape chart. The dynamic range of average power levels that can be recorded is 100 db, with reliability for fluctuations up to 40 db regardless of the waveform of the fluctuations.

The equipment will operate satisfactorily in the presence of strong off-band signals, rejection being 126 db for signals 1 kc or greater from the recording frequency. The stability of the equipment is such that, if necessary, it will operate for a week without attention, maintaining an accuracy of 2 db. At some locations the NBS equipment will also measure two additional moments of the received noise: the average voltage and average logarithm of the noise envelope. At other locations, amplitude distributions will be measured by equipment provided by the University of Florida. The complete details of cooperative station locations are now worked out yet; in order to cover the areas from which data is needed, it is desired to work with other governments, institutions, or individuals who are interested in the noise stations.

Atmospheric noise stations to be operated by the United States are:

Bill, Wyoming, U. S. A.
** Boulder, Colorado, U. S. A.
Front Royal, Virginia, U. S. A.
Fort Amador, Canal Zone
Byrd Station, Antarctica
Maui, Hawaiian Islands

For a number of other stations, the U. S. is cooperating with various scientific institutions and national committees in the planning, equipping or operation. These include: * Accra, Gold Coast; Darwin, Australia; ** Johannesburg, Union of South Africa; Rabat, Morocco; Rio de Janeiro, Brazil; * Singapore, Malaya; Stockholm, Sweden; Thule, Greenland (Thule AFB); Tokyo, Japan.

<u>Notes</u>: * To be operated simultaneously at these locations with the British Thomas subjective method of measurement.

** Additional parameters to be measured at these locations with equipment supplied by the University of Florida.

1.4 <u>Whistlers</u>. Whistlers are a special kind of natural radio signal in the audio and very low frequency range. They are believed to be caused principally by energy from lightning discharges that has traveled from one hemisphere to the other along lines of the earth's magnetic field in the little-explored longitudinal extraordinary mode of propagation. During propagation through the ionosphere, the energy from the causative lightning impulse is dispersed in such a way that the lower frequencies usually (but not always) are retarded with respect to the higher frequencies of the pulse, producing a signal of descending frequency; hence the descriptive term - whistler.

Because the propagation path extends several earth radii above the earth's surface, the study of whistlers offers a new method for detecting the presence of ionization far beyond the reaches of the known ionosphere. It is hoped to secure (i) quantitative information on the amount of ionization at great distances from the earth, (ii) integrated ion-density along a line of the earth's magnetic field and possibly a determination of the first-order variations, (iii) the amount of hydrogen ions in the F2 layer, and (iv) a better determination of the paths of magnetic field lines by studying the arrival and intensity of whistlers at conjugate opposite ends of the magnetic field and comparing intensities at close-spaced stations.

Each station will be capable of recording on magnetic tape the amplitudes of all signals from below 400 cycles to 30 kc. Calibration is to be given in terms of the electric or magnetic field component measured by the antenna. Timing of events on the magnetic tape will be accurate to at least ± 0.1 second and each recording period will be not less than 2 min/hr. Special runs during World Days, periods of magnetic disturbances, rocket firings, etc., will be scheduled in accordance with the needs of the program.

Whistler stations in the Western Hemisphere to be operated by the U. S. are:

Anchorage, Alaska
College, Alaska
Nome, Alaska
Unalaska, Alaska
Battle Creek, Michigan, U. S. A.
Boulder, Colorado, U. S. A.
Columbia, South Carolina, U. S. A.

Gainesville, Florida, U. S. A.
Hanover, New Hampshire, U. S. A.
Key West, Florida, U. S. A. (tentative)
Seattle, Washington, U. S. A.
Stanford, California, U. S. A.
Washington, D. C., U. S. A.
Weddell Station, Antarctica

For a number of other stations the U. S. is cooperating with various scientific institutions and national committees in the planning, equipping, or operation. These include: Thule, Greenland (Thule AFB) (tentative); Father Point, Quebec, Canada; Frobisher Bay, N. W. T., Canada (tentative); Knob Lake, Quebec, Canada; Bermuda, United Kingdom (Kindley AFB); Huancayo, Peru (tentative), (or Talara or Trujillo); Port Lockroy, Antarctica; Falkland Islands, United Kingdom; Dunedin, New Zealand; Macquarie Islands, Australia; and Wellington, New Zealand.

2. Special Studies.

2.1 Oblique-Incidence Forward Scatter. Oblique-incidence D- and E-region forward scatter measurements are planned for the equatorial regions, and confirmation will be sought for the existence of F-region forward scatter of vhf over long equatorial paths. This experiment will benefit greatly from the measurements of the vertical incidence soundings network in the vicinity of the geomagnetic equator. It will provide information for comparison with results on hand from middle and high latitudes. Some discussions have taken place with scientific laboratories in Chile, Peru and Ecuador and two parallel circuits are tentatively arranged with the national committees, each crossing the equator near Huancayo. One circuit will be from near Antofagasta, Chile to Guayaquil, Ecuador; the other from Arequipa, Peru to Trujillo, Peru. In addition, the transmitter at Antofagasta will beam eastward to receiving stations at Clorinda, Argentina and Sao Paulo, Brazil.

The transmitters will operate at frequencies close to 50 Mc, CW emission at about 3 kw power. Routine operation will be 24 hours per day except for occasional brief tests at 20 kw power.

2.2 Sweep-Frequency Backscatter at Oblique Incidence. Sweep-frequency backscatter measurements using 10 kw pulses are planned at Knob Lake, Quebec, (by arrangement with McGill University Subarctic Research Laboratory) in the direction of Hanover, New Hampshire as part of a coordinated program of high-frequency studies at Knob Lake and Hanover. The direct sweep frequency signal will be observed at Hanover. In addition, a three-station sweep-frequency triangulation project, using the Knob Lake transmitter as a master station, and two slave stations 60 miles distant is planned.

2.3 Es Reflection Coefficients at Oblique Incidence. CW transmissions, at a frequency of approximately 49 Mc, using directional antennas with about 0.5 kw power, are planned on two circuits to supply further information on observed differences in Es at similar geomagnetic latitudes between the longitudes of Japan and Eastern United States.

One suggested circuit would be from the Canal Zone (probably CRPL-NBS field station) to a receiving location in Cuba (Guantanamo Bay is under consideration); the other would be from Okinawa to a receiving location in The Philippines (probably near Baguio).

2.4 True Height Calculations. A particular part of the processing of IGY ionospheric data will be the derivation of electron-density-height profiles from selected vertical sounding records. One ionogram per hour for the 5 magnetically quiet, 3 Regular World Days or other selected periods each month will be processed by the Budden technique. In addition it is expected that ionograms taken in conjunction with selected rocket ascents will be reduced in this way. It is tentatively planned to analyse records from University Park, Pennsylvania; Ft. Belvoir, Virginia; Fort Randolph, Canal Zone; Huancayo and Talara, Peru; and possibly Thule, Greenland.

2.5 Radio Star Scintillations and Ionospheric Drift Program. The scintillations in the received signal from cosmic sources of radio-frequency electro-magnetic radiation (radio "stars") are related to drift motions of irregularities in the ionosphere apparently caused by air movements or winds in the ionospheric regions. The scintillations vary with the frequency selected, time of day, and season, and the apparent air movements can be detected and mapped with suitable astronomical radio receivers. Operation of a network of three closely-spaced receiving stations over suitable base-lines is planned at Charlottesville, Virginia, as a means of measuring the apparent vector velocity. Information of this type will provide valuable data concerning dynamic properties of the ionosphere.

Ionospheric drifts will also be determined at Mayagüez, Puerto Rico from the correlation of the fading at three close-spaced receivers of vertical incidence echoes.

2.6 Absorption. The observations of the extra-terrestrial (cosmic) radio noise background provides the most satisfactory means of measuring the large ionospheric absorption which occurs at high latitudes. Using freqiemcoes betweem 20 and 30 Mc, a satisfactory compromise is achieved between available noise signals, a sensitivity to absorption, and interference from terrestrial signals. (A technique in use by the High Altitude Observatory, Boulder, Colorado, to obtain satisfactory observation in the presence of interfering signals is to sweep the receiving frequency over a small band and observe the level between interfering carriers.)

Cosmic radio noise absorption stations to be operated by the U. S. will be at:

Barrow, Alaska
Barter Island, Alaska
College, Alaska
Fort Yukon, Alaska
Naknek, Alaska
Sitka, Alaska
Skwentna, Alaska
Unalaska, Alaska
Boulder, Colorado, U. S. A.
Hanover, New Hampshire, U. S. A.
Ithaca, New York, U. S. A.
Pullman, Washington, U. S. A.
Stanford, California, U. S. A.

For a number of other stations the U. S. is cooperating with various scientific institutions and national committees in the planning, equipping or operation. These include: Knob Lake, Quebec, Canada; Meanook, Alta., Canada; Thule, Greenland (Thule AFB).

Note: Some of the above absorption stations are operated as part of the program in Aurora.

The vertical incidence pulse-echo method of measuring absorption on 2 Mc will be employed as a principal experiment at one station - University Park, Pennsylvania, U. S. A. Some of the vertical incidence sounding stations (see 1.1) will probably be equipped to make less precise absorption measurements by this method.

2.7 Radio Amateur Observations. The project intends to utilize the activities of the radio amateurs to study vhf propagation circuits over a wide-spread geographical distribution. Amateurs will be able to make useful contributions by reporting their observation on the frequency bands of about 50, 140, and 220 Mc. These can provide supplementary data on Es propagation, reflections from aurora and auroral propagation, and trans-equatorial scatter propagation. The information will be collected and analysis of records of two-way communication will be made by the American Radio Relay League (ARRL). Reception reports of the 50 Mc transmitter of the Trans-Equatorial Scatter Propagation experiment (see 2.1) will be included.

3. Publications.

The interchange of detailed results of ionospheric soundings is handled by the Central Radio Propagation Laboratory of the National Bureau of Standards. The CRPL-F reports are available on an exchange basis: other exchanges are by individual arrangements. There are plans for publication of all necessary details for the IGY period.

1. U. S. STATION LIST FOR THE IGY

Project Code:

AF	Audio Frequency Waves	RN	Radio Noise
AM	Absorption Measurements	SB	Sweep Frequency Backscatter
Dr	Drifts	Sc	Scintillations
Es	Sporadic E Measurements	TH	True Height
FB	Fixed Frequency Backscatter	VI	Vertical Incidence
FS	Forward Scatter		

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Continental United States				
NC 725	Alamagordo, N.Mex.	32°54'N	105°58'W	Rockets
NB 452	Battle Creek, Mich.	42 16	85 10	AF
NB 473	Boulder, Colo.	40 02	105 18	AF,AM,FB,RN
NB	Bill, Wyo.	43 15	105 18	RN
NB	Charlottesville, Va.	38 02	78 13	Sc
NB 506	Columbia, S.C.	34 00	81 02	AF
NB	Ft. Belvoir, Va.	38 44	77 08	VI
NB 471	Ft. Monmouth, N.J.	40 15	74 01	FB,VI
NB 488	Front Royal, Va.	39	77	RN
NC 799	Gainesville, Fla.	29 38	82 18	AF
NB 433	Hanover, N.H.	43 42	72 18	AF,AM,FB,SB
NB 448	Ithaca, N.Y.	42 27	76 31	AM
NC 870	Key West, Fla.(tent.)	24 33	81 47	AF
NB	Pullman, Wash.	46 43	117 10	AM,FB
NB 360	Seattle, Wash.	47 45	122 25	AF
NC 706	Stanford, Calif.	37 26	122 10	AF,AM,Es,FB,VI
NB 466	University Park, Penn.	40 48	77 46	AM,TH
NB 489	Washington, D.C.	38 55	77 04	AF
NC	West Florida (tent.)			VI
NC 772	White Sands, N.Mex.	32 24	106 52	VI
Alaska and Arctic				
NB 216	Adak	51°54'N	176°39'W	FB,VI
NA 113	Anchorage	61 10	149 55	AF,VI
NA 041	Barter Island	70 08	143 40	AM
NA 074	College	64 51	147 50	AF,AM,FB,VI
NB 213	Naknek	58 44	157 02	AM
NA 079	Nome	64 30	165 26	AF
NA 035	Pt. Barrow	71 08	156 48	VI
NA 136	Sitka	57 03	135 20	AM
NA	Skwentna	61 53	151 32	AM
NB 209	Unalaska	53 53	166 32	AF,AM
NA 065	Ft. Yukon	66 34	145 18	AM
NA	Arctic Ice Floe "B"	85	100	VI

CSAGI No.	Station	Nominal Location Latitude	Nominal Location Longitude	Program
Antarctica				
SA 004	Byrd Station	80° S	120° W	RN,VI
SA 009	Little America	77	164	VI
SA 001	Pole Station	90	-	VI
SA 011	Weddell Sea	77	35	AF,VI
SA 020	Knox Coast	67	105 E	VI
Central America and Caribbean				
NC	Ft. Amador, C.Z.	8°56'N	79°33'W	RN
NC 849	Ft. Randolph, C.Z.	9 23	79 53	Es,FB,VI
NC	Mayaguez, P.R.	18 11	67 07	Dr,Sc
NC	Ramey AFB, P.R.	18 30	67 12	VI
Pacific Ocean Area				
NC 821	Kihei, Maui, T.H.	20°50'N	156°30'W	RN,VI
CE 086	Okinawa	26 30	128 00 E	Es,FB,VI

2. COOPERATIVE STATION FOR THE IGY

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CSAGI No.	Station	Nominal Location Latitude	Nominal Location Longitude	Program
Canada				
NB	Father Point, Que.	48°05'N	68°05'W	AF
NA 129	Ft. Churchill, Manitoba	58 46	94 10	Rockets
NA 089	Frobisher Bay, NWT(tent.)	63 28	67 23	AF
NA 139	Knob Lake, Que. (tent.)	54 48	66 49	AF,AM,Dr,FB,SB
NA	Meanook, Alberta	54 37	113 20	AM,FB
NB 365	St. Johns, Nfld.	47 33	52 40	VI
Greenland				
NA	Godhavn	69°15'N	53°30'W	VI
NA 112	Narsarssuak	61 11	45 25	FB,VI
NA 019	Thule	76 33	68 50	AF(tent.),FB,RN,VI

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Mexico and Caribbean				
NC 823	Guantanamo, Cuba	19°04'N	75°09'W	Es
NC 831	Tonanzintla, Mexico(tent.)	19 02	98 02	FB
South America				
CE	Antofagasta, Chile	23°26'S	70°28'W	FS
CE 132	Arequipa, Peru	16 28	71 30	FS
CE 130	Bogota, Colombia	4 32 N	74 15	VI
CE	Chiclayo, Peru	6 49 S	79 46	VI
CE	Chimbote, Peru	9 06	78 22	VI
CE	Clorinda, Argentina	25 13	57 50	FS
SC 631	Concepcion, Chile	36 35	72 59	VI
SC 607	Falkland Island	51 45	59 00	AF
CE 124	Guayaquil, Ecuador	2 10	79 53	FS
CE 128	Huancayo, Peru	12 03	75 20	AF(tent.),FS,VI
CE 138	La Paz, Bolivia	16 29	68 03	VI
CE	Natal, Brazil (tent.)	5 20	35 07	FB
CE 158	Rio de Janeiro, Brazil	22 54	43 14	RN
CE 158	Sao Paulo, Brazil	23 33	46 38	FS,VI
CE 123	Talara, Peru	4 34	81 15	VI,FS
CE 125	Trujillo, Peru	8 00	79 00	FS
Antarctica				
SA	Adare Station	71°17'S	170°15'W	VI
SA 026	Port Lockroy	64 49	63 33	AF
Pacific Ocean Area and Far East				
CE 080	Baguio, Philippines	16°25'N	120°36'E	Es(tent.),VI
SC 732	Darwin, Australia	12 20 S	130 59	RN
SB 208	Dunedin, N.Z.	45 52	170 32	AF
SA 044	Macquarie Is.,Australia	54 30	158 45	AF
CE 069	Singapore, Malaya	1 14 N	103 55	RN
SC	Sydney, Australia (tent.)	33 53 S	154 12	FB
NC 730	Tokyo, Japan	35 40 N	139 45	RN
SB 219	Wellington, N.Z.	41 17 S	174 46	AF

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Europe and Africa				
CE	Accra, Gold Coast	5°34'N	0°10'W	RN
SC 702	Johannesburg, Transvaal, Union of South Africa	26 12 S	28 05 E	RN
NA 055	Kiruna, Sweden (tent.)	67 50 N	20 15	AM
NC 750	Rabat, Morocco	34 00	6 50 W	RN
NB	Stockholm, Sweden	59 21	17 57 E	RN
Atlantic Ocean Area				
NC 773	Bermuda	32°22'N	64°40'W	AF
NA 086	Reykjavik, Iceland	63 57	22 37	VI

VI. SOLAR ACTIVITY

The U. S. program in solar activity includes the basic patrols carried on by existing solar observatories supplemented by an intensive photographic patrol for solar flares with new instrumentation and specialized studies of flares and other unusual solar phenomena. Thus the program contributes to the 24-hour watch on the sun during the IGY and will provide detailed astrophysical data on many of the solar events which may be associated with the terrestrial phenomena studied in the purely geophysical disciplines.

1. Patrol of Sunspots, Plages, Coronal Emission.

Mount Wilson, U. S. Naval, McMath-Hulbert, Sacramento Peak and High Altitude Observatories will intensify their patrol of slowly varying aspects of solar activity. On a once-daily schedule, weather permitting, the following photographic measurements will be made by the indicated number of observatories: sunspot positions, areas and type (2), calcium plage position, area and intensity (2), coronal emission intensity (2), sunspot magnetic fields (1 or 2), and prominence survey (1 or 2). In respect to the coronal emission line studies, the intensities will be reported on an absolute intensity scale and will be measured from films photoelectrically.

2. Photographic Flare Patrol.

It is expected that there will be five observatories with special photographic flare patrol instruments: Naval Research Laboratory and McMath-Hulbert Observatory (SECASI flare patrol instrument with OPL 0.5 Angstrom H-alpha filter); Climax, Sacramento Peak and University of Hawaii (Halle 0.7 Angstrom filter). The observing program will be in accord with IAU recommendations. Very complete coverage is expected since each continental longitude belt is covered by two observatories with equivalent programs and equipment. The coverage from Hawaii is also expected to be fairly complete in view of the good record of clear skies reported from early surveys. In addition to these five principal flare patrols, it is expected that observations will also be continued with the Mt. Wilson spectroheliograph and the U. S. Naval Observatory 1 Angstrom Baird H-alpha filter.

3. Indirect Flare Detectors.

Three of the solar observatories will also have indirect flare detectors - McMath-Hulbert, Sacramento Peak and High Altitude Observatory (Climax or Boulder). One of the two channels of the recorder will monitor sudden cosmic noise absorption (SCNA) on about 20 Mc, as designed by Lee of HAO. The other will patrol either for sudden enhancement of atmospherics (SEA) at 27 kc, or for short wave fadeouts (SWF) of one-hop high-frequency transmissions, depending on local conditions. Rensselaer Polytechnic Institute will also operate an SCNA recorder of their own design. These measurements of sudden ionospheric disturbances (SID) will serve as automatic alerts of flare-type events and will also constitute important data on solar flare effects on the ionosphere, as coordinated by the Central Radio Propagation Laboratory.

4. Radio Noise Patrol.

Continuous daytime patrol observations will be made at Boulder (168 and 465 Mc), at Cornell (200 Mc), at Naval Research Laboratory (10 cm, 3 cm) and possibly at College, Alaska and Hawaii (200 Mc). These will include measurements of mean flux and of outstanding events. Interferometric measurements to localize burst sources on the solar disk will be done at Cornell and by the knife-edge technique at Boulder.

It is possible that data on the radio spectrum of bursts will be available during the IGY period from University of Michigan and Harvard Observatory (high frequencies) and from Naval Research Laboratory (centimeter wavelengths).

5. Special Studies.

Electron Corona. A new K-coronameter is expected to be operating on a patrol basis at Climax.

Height Gradients of Emission Corona. Coronal spectra will be taken successively over a range of heights above the limb on a quasi-patrol basis at Climax and Sacramento Peak.

Special Spectrographic Studies. High resolution spectrographs at McMath-Hulbert, Climax and Sacramento Peak will be used on selected flares, prominences, and flocculi. Particular emphasis will be placed on line profiles, their changes with time, and the variation of total energy during the lifetime of a phenomenon.

Solar Magnetic Fields. A new Babcock solar magnetograph is expected to be in daily operation at Mt. Wilson Observatory during the IGY. It is possible there may be similar measurements at Sacramento Peak.

Coronal Line Profiles. High dispersion coronal spectra will be taken of selected regions at Climax and Sacramento Peak, for studies of coronal emission line profiles.

Rocket Studies. Various solar observations from rockets are planned, as outlined under the US-IGY rocket exploration program.

6. Solar Activity Reports.

Daily summaries of patrol observations will be reported promptly to the IGY World Day centers for use in selecting times for Alerts, and Special World Intervals, and for further distribution to IGY stations needing very prompt knowledge of current solar activity. A special effort will be made to make the HAO-NBS weekly solar activity airmail reports comprehensive and quickly available to IGY stations and research centers needing such data. Final reports of these solar observations are also expected to be available on an accelerated schedule.

1. U. S. STATION LIST FOR THE IGY

Project Code:

CP	Coronal Emission Patrol	RFS	Radio Frequency Spectra
FL	Flare Line Profiles	RNP	Radio Noise Patrol
IFP	Indirect Flare Patrol	SM	Spot Magnetic Fields
LPP	Limb Prominence Patrol	SO	Special Solar Observations
MC	Solar Magnetic Fields	SP	Spot Patrol
PFP	Photographic Flare Patrol	VFP	Visual Flare Patrol
PP	Plage Frequency Spectra	WLC	White Light Corona

CSAGI No.	Station	Nominal Location Latitude	Nominal Location Longitude	Program
United States and Territories:				
NC 725	Alamogordo, N.Mex.	32°54'N	105°58'W	Rockets
NB 453	Ann Arbor, Mich.	42 17	83 44	RFS
NB 473	Boulder, Colo.	40 07	105 18	RNP
NB	Boulder, Colo. (HAO)	40 00	105 16	PFP,SP
NB 496	Chincateague, Va.	37 56	75 23	Rockets
NB 480	Climax, Colo.	39 22	106 11	CP,FL,IFP,SO, LPP,WLC
NA 074	College, Alaska	64 51	147 50	RNP
NC	Ft. Davis, Texas	30 04	105 07	RFS
NB	Grafton, N.Y.	42 47	73 27	IFP,RNP
NB 448	Ithaca, N.Y.	42 27	76 31	RNP
NC	Makapuu Pt.,Oahu,T.H.	21 16	157 40	PFP,RNP
NC 745	Mt. Wilson, Calif.	34 14	118 04	MC,PFP,PP,SO, SM,SP
NC	Pt. Mugu, Calif.	34 11	119 05	Rockets
NB 445	Pontiac, Mich.	42 40	83 18	FL,IFP,PFP,PP, SO
NC 768	Sacramento Peak, N.Mex. (Sunspot, N.Mex.)	32 43	105 45	CP,FL,IFP,LPP, PFP,PP,RFS,SO
NB 489	Washington, D.C.	38 55	77 04	PFP,RFS,RNP,SP, VFP
NC 772	White Sands, N.Mex.	32 24	106 42	Rockets

2. COOPERATIVE STATION LIST FOR THE IGY

Canada

NA 129	Ft. Churchill, Manitoba	58°46'N	94°10'W	Rockets

VII. COSMIC RAYS

Cosmic radiation, as understood at the present time, consists of streams of electrically charged particles, mostly protons with some alpha particles and a few heavier nuclei. The exact percentages are still being studied and expert opinion is not unanimous. The energy spectrum is known to extend from about 5×10^8 ev up to a possible value of 10^{19} ev or more. There is evidence for a small diurnal variation whose amplitude varies with time. Correlations also exist between fluctuations in the cosmic ray intensity and solar phenomena. The fluctuations are in most cases due to variations in the primary spectrum.

The purpose of the U. S. program is to throw as much light as possible on fundamental problems. The program for investigations of the cosmic ray spectrum calls for exploration of the variations in mass and energy of the primary cosmic radiation as well as recording variations in cosmic radiation intensity. For a better understanding of these phenomena, their relationship to solar activity and to various types of solar-influenced terrestrial effects must also be investigated.

1. Primary Spectrum Investigations.

In order to study the primary spectrum, a series of nearly simultaneous flights will be made at various latitudes, using both balloons and rockets. Sets of flights will be made at coordinated times, since there is evidence that the cosmic ray intensity fluctuates enough to make results from non-simultaneous flights of less value. It is planned to make such flights both on magnetically disturbed days and on quiet days, in order to permit evaluation of how much the fluctuations add to the intensity. The flights will be made from several stations and at different latitudes and will carry aloft Cerenkov counters, proportional counters, pulsed ionization chambers and Geiger counters, as well as photographic emulsions.

2. Latitude Effect Investigations.

To evaluate the latitude effect and to determine whether cosmic ray intensity is, in fact, symmetrical about the geomagnetic equator, it is planned to make a series of flights by aircraft and by balloon, as well as to make measurements in the equatorial regions aboard ship. Both neutron counters and ionization meters will be carried on these flights. Two neutron intensity monitors will also be operated on shipboard throughout the IGY.

3. Fluctuations in Intensity.

To study the fluctuation in cosmic radiation, and to correlate these with solar disturbances and with geophysical phenomena, it will be necessary to operate long time recording equipment at various stations. It is planned to employ cosmic ray telescopes, air shower detectors, ionization chambers, and neutron monitors at these stations.

3.1 It is known that cosmic radiation shows marked fluctuations, occasionally of appreciable intensity even at sea level. These fluctuations are correlated with solar disturbances. To make the situation more complex, not all solar disturbances produce cosmic ray fluctuations. Further, there appear to be at least two quite different types of intensity variations.

(a) One type is a slow change (usually a decrease) in intensity which generally occurs at times of disturbances in the magnetic field of the earth. Such variation could result from a change in the magnetic cut-off at any given place resulting from a fluctuation in field, the primary radiation remaining constant.

(b) The second type of variation is an abrupt increase in the intensity, over a short time, which percentage-wise is larger for locally produced neutrons than for the total ionizing radiation. These increases are thought to be produced by additional charged particles originating on the sun. All these large increases have been associated with chromospheric eruptions, or solar flares, and are sometimes spoken of as the "solar flare effects" although it is not clear that they are actually radiation produced in the flare itself. Possibly the origin is in active regions associated with the flare or the spots usually adjacent to the flare.

3.2 The purpose of the IGY cosmic ray fluctuation studies is, in general, to learn more about these effects and their interrelations. Specifically, we seek to ascertain the mass and energy spectrum of the additional radiation which originates in the sun, and to evaluate its history, the mechanism of its origin, the physics of its traversal of the interplanetary distance, and the results of its arrival at the earth and penetration through the atmosphere to the measuring instrument. Further, we seek to understand the mechanism at work producing the intensity variations associated with magnetic storms, and finally to answer the question as to just how constant the primary radiation actually is, over short and long periods.

4. Program Summary.

4.1 Distribution of heavy primary cosmic rays.

(a) Photographic material will be exposed at balloon altitudes to study heavy component of primary cosmic rays. Measurements of the charge of the heavy primaries will be done by delta ray counting, gap counting and grain counting. Exposures will be restricted to polar and equatorial regions.

(b) Balloon flights at 95 to 100 thousand feet in an equatorial area will be made to expose emulsions to determine the flux in order to obtain information on the energy spectrum of the primary radiation.

(c) Also balloon flights in the Arctic will be carried out where the average energy of the primary cosmic ray nuclei is sufficiently low so that a large fraction of them will stop in a stack of nuclear emulsions. It is not now anticipated that emulsions will be flown in the Antarctic.

4.2 Neutron Monitor Stations.

(a) Two neutron pile structures with recording apparatus will be set up on shipboard to record the latitude variations intensity of the low energy portion of the primary cosmic ray spectrum. They will also provide data regarding time variations, and the effects of solar disturbances upon the intensity.

(b) Work will be continued in measuring the time variation of neutron components and the hard and soft components of the cosmic radiation. A standard IUPAP neutron monitor will be set up to determine the large fluctuations in the low energy protons of the nucleonic components at northern latitudes at College, Alaska. It is possible that another monitor may be set up at Thule also.

(c) Isotopic constituents of cosmic rays at balloon altitudes will be determined by exposing emulsion blocks of large size and suitable shape to the primary cosmic rays at different latitudes. Particular attention will be paid to ascensions from high northern latitudes beyond the knee in the cosmic ray intensity and from the geomagnetic equator.

4.3 Measurements of high-energy mu-mesons.

(a) It is planned that two cloud chambers will be put into action in conjunction with a Geiger counter hodoscope and trigger set. The trigger set will probably include a large volume liquid scintillation detector for electron showers. The overall objective is to study the zenith angle of the intensity of high-energy mu-mesons. Preliminary work appears to indicate an anomalous maximum in the intensity at angles away from the vertical (about 20 or 30 degrees) for mu-mesons above 50 to 100 bev. If this is correct it may possibly be explained in terms of the competitions between decay and absorption of the parent pi-mesons high in the atmosphere.

(b) In addition, two standard cubical triple-coincidence Geiger counter telescopes with a prescribed counting rate and absorber thickness will be used to determine mu-meson component of the cosmic radiation. Extra counter trays above each cubical array will provide two vertical narrow angle meson telescopes. A central tray common to both vertical arrays will provide a pair of narrow angle east-west telescopes.

4.4 Fluctuations. Rapid cosmic ray intensity fluctuations will be investigated by means of cosmic ray counter arrays which will be sensitive to such fluctuations. It is planned to use two trays with the output of each tray being fed to a coincidence circuit which will drive a count rate meter.

4.5 Primary cosmic ray composition and intensities. Balloon facilities will be used to make measurements of protons and heavy particle intensity as the total intensity undergoes changes with time at the top of the atmosphere. A special effort will be made to study the kinds of particles which arrive at the times of cosmic ray intensity increases. It is planned to do this work at Chicago, Illinois; White Sands, New Mexico; near the Geomagnetic Equator. A joint Canadian-US Program in this scientific field to be conducted at Saskatoon, Canada is presently under discussion.

4.6 Air Shower Detectors. Air showers produced by primary cosmic ray particles with energies in the range of 10^{17} to 10^{19} ev will be detected with a series of large area detectors at separations of several hundred meters. Simultaneous pulses from two or more detectors will be recorded with the times of the event. Time variation in the frequency of these events will be sought, and correlations that may occur between stations located on the Atlantic and Pacific Coasts of the United States will give information on very large showers.

4.7 Correlation of cosmic rays and atmospheric pressure. The nature of the semi-diurnal planetary variation of the atmospheric pressure, which has maximum amplitude near the geographical equator and which is free in that region from disturbances due to the irregular variations of the general circulation which occur in the temperate zones, may be studied in the equatorial region by means of recording the cosmic radiation. Two complete directional recorders involving counter-tube equipment will be utilized. Discussions are now underway with the Bolivian National Committee to conduct this experiment on a cooperative basis at Chacaltaya, Bolivia.

4.8 Correlation of solar activity with high altitude primary cosmic rays intensity.

(a) Constant level high altitude balloons will be sent up with G-M counters and pulsed ionization chambers to establish possible correlation between intensity of various components of the primary cosmic ray and solar activity as manifested by flares and solar radio noise.

(b) Balloon flights are proposed during which basic cosmic ray measurements with a single Geiger counter, the rate of a vertical counter telescope, and the rate of a single scintillation crystal together with its total current will be determined. Correlation in time and amplitude with solar phenomena will be attempted. The possibility of making these flights at Fort Churchill, Canada as an adjunct to some experiments of the rocket program is under discussion with the Canadian National Committee.

(c) It is not known at present whether the mass and energy spectrum of particles arriving from the sun at times of disturbances on the solar surface is the same as the normal spectrum of the cosmic ray particles. With the aid of proportional counters flown to high altitudes in balloons, it may be possible to learn much more about the mass and energy spectrum of these particles.

(d) It is planned to send balloons at high elevation into the night atmosphere and determine any changes in neutron counting rate. Primary neutrons from the sun would not be deflected in the earth magnetic field and thus a diurnal effect should be noted as the earth turns away from the sun.

4.9 Antarctica. Cosmic Ray activity will be monitored in South Polar regions by means of sea level coincidence telescopes of Geiger counters which will be operated continuously. The Geiger tubes will be arranged in three trays spaced vertically apart from each other to form a cubical geometry of tubes. This arrangement will detect the hard component of the cosmic radiation when a suitable absorber is placed between the trays. Data, consisting of counts of cosmic rays in 15 minutes and 2 hour intervals, will be printed and plotted out immediately. A small rocket is under test which may prove feasible for use in the Antarctic (and Arctic). If the tests are favorable, flights of Geiger counters would augment the telescope data.

1. U. S. STATION LIST FOR THE IGY

Project Code:

C	Cerenkov Counters	P	Proportional Counters
E	Emulsions	PI	Pulsed Ion Chambers
G	Geiger Counters	S	Showers
I	Ionization Chambers	-A	Indicates equipment operated during aircraft flight
MT	Meson Telescopes		
N	Neutron Detectors	-B	Indicates equipment operated during balloon flight
NM	Neutron Monitors		

* Aerological Station Nearby

CSAGI No.	Station	Nominal Location Latitude	Nominal Location Longitude	Program
Continental United States				
NC 738	*Albuquerque, N.Mex.	35°05'N	106°37'W	NM
NC 697	*Berkeley, Calif.	37 52	122 18	MT,NM
NB 385	*Bismarck, N.Dak.	46 49	100 46	I-B
NB 492	*Cheltenham, Md.	38 44	76 50	I
NB 457	*Chicago, Ill.	41 50	87 40	NM
NB 480	*Climax, Colo.	39 22	106 11	C-A,G,I,N
NB 487	*Columbia, Mo.	38 56	92 24	C,G
NB 484	*Derwood, Md.	39 07	77 10	I
NB 465	*Lincoln, Nebr.	40 49	96 41	MT,NM
NB 415	*Minneapolis, Minn.	44 58	93 14	C-B,E-B
NC 768	*Sacramento Peak, N.Mex.	32 43	105 45	C-A,G,N
NC 744	*Santa Barbara, Calif.	34 25	119 51	S
NB 475	*Swarthmore, Penn.	39 54	75 21	(C-B,G-B,P-B-tentative)
NB 489	*Washington, D.C.	38 55	77 04	G-A,MT,S
NC 703	White Mountain, Calif.	37 37	118 12	MT,NM
NC 772	*White Sands, N.Mex.	32 24	106 52	C-B,E-B,N-B,P-B
Alaska				
NA 074	*College, Alaska	64°51'N	147°43'W	NM
Antarctica				
SA 009	*Knox Station (or Little America)	67° S	105° E	MT,G-rockets(tent.)
	Shipboard Operation en route to Antarctica	-	-	I-B, Rockets
	Shipboard (USS Arneb)	-	-	NM

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Arctic Region and Atlantic				
	Shipboard to Thule	-	-	E-B,I-B
Pacific Area				
NC	Makapuu Pt.,Oahu, T.H.	21°16'N	157°40'W	MT,NM
	Magnetic Equatorial Region	-	-	C-B,G-B,N-B, P-B
Central America				
NC	*Rio Piedras, P.R.	18°24'N	66°03'W	NM,(E-B,P-B-tent.)

2. COOPERATIVE STATION LIST FOR THE IGY

Some of the stations listed below have been long in existence under co-operative arrangements and are expected to continue during the IGY; others are newly planned stations of a cooperative kind; in some cases arrangements have been made with the countries involved and in others it is hoped that arrangements will be made soon.

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Canada				
NA 062	Davis Strait	67°00'N	58°00'W	Rockets
NA 089	Frobisher Bay, NWT	63 28	67 23	Rockets
NA 129	*Ft. Churchill, Manitoba	58 46	94 10	Rockets,(G-B tent.)
NA 147	*Saskatoon	52 08	106 40	(C-B,E-B,N-B tent.)
Arctic Region				
NA 019	*Thule, Greenland	76°33'N	68°50'W	G-Rockets (tent.) E-B,I-B, NM
Atlantic Ocean				
	Shipboard from Sweden to South Africa	-	-	NM
South America				
CE	*Chacaltaya, Bolivia	16°19'S	68°10'W	MT
Pacific Area				
SB 208	Dunedin, N.Z.	45°33'S	170°32'E	I-B

VIII. LONGITUDES AND LATITUDES

The longitude and latitude program consists of two parts: (a) Astronomical Longitudes and Latitudes and (b) the Moon position program. The United States will participate in both programs at three stations.

1. Astronomical Longitudes and Latitudes.

Astronomical longitudes and latitudes are obtained by observing the positions of celestial bodies with respect to the plumb line, or the direction of gravity. Since the astronomical longitude and latitude of a station are defined by the direction of gravity at the station, the values of the coordinates are affected by local anomalies in gravity. Hence, these coordinates do not give the true geometric position of the station with respect to the center of the earth. The anomalies in gravity are of no concern, however, in the determination of differential shifts between continents, which is one of the principal aims of the forthcoming program.

The stars will be observed with impersonal astrolabes and quartz-crystal clocks will be used for timekeeping purposes. The values of the coordinates for each station will be determined with probable errors of only a few feet. A comparison of these values with others to be obtained in the future will enable the determination of what amounts, if any, the continents are shifting relative to each other.

2. Moon Position Program.

The moon position program of the IGY is a new program which has for its aims the solution of several special problems in astronomy, geophysics, physics, and geodesy. These problems concern uniform time, irregular rotation of the earth, and the size and shape of the earth. The program uses a new observation technique, employing the Markowitz camera.

The construction of the dual-rate moon position camera has made it possible to determine the position of the moon on any night when it is clearly visible. The camera takes a simultaneous exposure of the moon and surrounding stars. The moon is held fixed relative to the stars during the exposure, so that the images of both the moon and the stars are sharp. Measurement of the plate gives the position of the moon with respect to the stars with a precision which is considerably higher than has been obtained by other methods.

3. Scientific Evaluation Projects.

3.1 Speed of Rotation of Earth. The time given by the rotation of the earth, called mean solar time or Universal Time, is known to be non-uniform because of variation in the speed of rotation of the earth. There is a fairly regular annual variation which is determined by comparing Universal Time with the time indicated by quartz-crystal clocks. The earth is found to be about 35 milliseconds fast on October 1 and about 35 milliseconds slow on June 1.

The earth is also subject to unexplained irregular changes in rotation, whose magnitude and time of occurrence cannot be predicted. The irregularities have been determined by comparing non-uniform Universal Time with uniform time derived from the orbital motion of the moon. This latter kind of time is called Ephemeris Time. Ephemeris Time at present is about 30 seconds ahead of Universal Time, as determined with the moon position camera.

The intensive observation of the moon during the IGY will enable Ephemeris Time to be determined with greater accuracy than at present, when only one camera is in operation. It should be possible to pick up the irregular changes in acceleration and speed of rotation of the earth, which might then be correlated with other geophysical phenomena.

3.2 Geodetic Results. The observations of the moon will also be used for geodetic purposes. The lunar ephemeris gives the position of the moon as it would be seen by a fictitious observer located at the center of the earth. The real observer sees the moon displaced with respect to the more distant stars by an amount which depends upon his geometric position with respect to the center of the earth. The observed displacement of the moon is not affected in any way by gravity.

In theory the three coordinates of the observer with respect to the center of the earth can be obtained from two observations of the moon, which may be made on the same night. About 200 observations will be made at each station, however, in order to increase the precision of the results.

One of the quantities to be found for each station is its distance to the center of the earth. By combining the values from the 20 stations it will be possible to determine the size and shape of the earth, that is, the polar flattening and whether the equatorial section is circular or elliptical. This kind of determination differs from all other kinds in that it is based solely on geometry and is independent of gravity.

The distance from the earth to the moon, which is needed in applying the lunar method, is to be obtained by triangulation. The distance from Washington, D. C. to San Diego has been measured, and the two stations will serve as one base line.

4. Instrumentation and Data Evaluation.

The United States will supply dual-rate cameras suitable for attachment to long-focus telescopes at about 20 astronomical observatories suitably located in other countries. It will also undertake to measure approximately one-fourth of the photographic plates taken with the 20 cameras, and will supply three measuring engines of special design to observatories in other countries willing to undertake the remaining measures. The U. S. Naval Observatory has been designated as the central agency for the moon position program.

1. U. S. STATION LIST FOR THE IGY

Project Code:

- A Astrolabe Measurements
- M Measuring Center
- PM Photographic Observations of the Moon

CSAGI No.	Stations	Latitude	Longitude	Program
Continental United States				
NC 770	San Diego, Calif.	32°43'N	117°12'W	A,PM
NB 489	Washington, D. C.	38 55	77 04	A,M,PM
Pacific				
	Hawaiian Islands	21 N	157 W	A,PM

IX. GLACIOLOGY

The United States program includes detailed studies at various points in the Northern Hemisphere and in Antarctica, as well as reconnaissance observations in western United States and Alaska, and in portions of the Arctic where this country operates with Danish cooperation. The objective of these observations will be to record the status and behavior of glaciers during the 1957-58 period for comparison with observations made in the past and in other parts of the world with the view to their repetition in future decades. Associated with the field work will be a concentrated effort to assemble in usable form the scattered results of observations which have previously been made and the interpretation of existing air photographs.

1. Northern Hemisphere.

In the Northern Hemisphere the extent of the programs will vary from aerial photography of scattered glaciers as far south as the Sierra Nevada of California to full programs in specially selected sites where parties will winter-over and devote considerable effort to detailed studies such as glacier regimen and glacial micrometeorology, physical properties of snow and ice, ice flow mechanics, and depths of ice using seismic techniques.

1.1 Western United States. Reconnaissance studies are planned for glaciers in the western United States to determine the present distribution and qualitative aspects of growth and shrinkage. Terrestrial and aerial photogrammetry will be employed in the Cascade, Sierra Nevada, and Rocky Mountains in coordination with the photogrammetric mapping presently carried on in Glacier National Park, Montana, and on a few glaciers on Mt. Rainier and Mt. Baker in Washington.

An intensive program is planned by a group at the University of Washington at Blue Glacier in the western part of the Olympic National Park. A micrometeorological station will be maintained for an entire year in the accumulation zone of the glacier. The program will be somewhat flexible, depending on conditions and interests of the observers, but will include observations of energy exchange at the snow surface under annual variations of weather conditions; penetration and dissipation of winter cold wave in firn; measurement of annual mass increment added to the glacier by solid precipitation and annual mass loss by ablation; measurements of glacier movement; mapping of the glacier; studies of the firnification process in snow; and runoff measurements at the outlet stream.

This study of the material balance of the glacier and its meteorological environment will be complemented by studies of the mode and mechanism of flow occurring in the relatively simple ice tongue of the Blue Glacier by a group from California Institute of Technology. The glacier dynamics studies will include determination, by seismic and possibly other geophysical means, of the ice thickness in the lower tongue and of the form and configuration of the bedrock floor at as many places as possible; careful survey of approximately 50 fixed stations on the glacier surface to determine the magnitude and the absolute direction of surface movements at these points; and determination of the vertical velocity profile by measurement of deformation of a pipe or pipes in boreholes extending from the glacier surface to the glacier floor.

These studies will make the Blue Glacier one of the most intensively studied valley glaciers of North America.

1.2 Alaska. In southern Alaska the behavior of glaciers, as indicated primarily by changes in their terminal areas, will be studied by a group from the American Geographical Society. Both botanical and geological evidence will be studied and comparative observations will be made by means of photography and surveys. In general, to the extent practicable, all factors relating to glaciation will be investigated, including determinations of the firn limit during the period of observation. Where suitable organic evidence is available, dating of late Pleistocene events by radiocarbon methods will be employed.

The areas of investigation are primarily to be in coastal mountain ranges and have been selected because of previous studies and the significance of their glaciers in terms of geographical distribution, diversity of morphological types, and the dynamics of glaciation. The areas which are believed most important are: (1) fiord region of southeastern Alaska from LeConte Bay to White Pass, (2) Glacier Bay, (3) Yakutat Bay, (4) lower Copper River, (5) Prince William Sound, (6) northern slope of Western Chugach Mountains, (7) interior of Kenai Peninsula. In the cases where no ground observations can be made there will be attempted to obtain aerial photographs of the principal glacier termini.

Photogrammetric maps of selected glaciers which are reasonably accessible will be prepared from aerial photographs and ground surveys (including glacier limits, surface elevations, and other features of glaciological interest) of a high order of accuracy. It is anticipated that one or more glaciers will be selected in each of the following mountain ranges: (1) Coast Mountains of southeastern Alaska, (2) St. Elias Mountains, (3) Chugach Mountains, (4) Kenai Mountains, (5) Wrangel or Skolai Mountains, and (6) Alaska Range.

The Arctic Institute of North America plans to occupy a glacier in the eastern Brooks Range (Mt. Michelson), northern Alaska, for a period of about fifteen months. The program will include pit studies to develop a physical history of one season's snowpack in the névé region of the glacier; development and dissipation of winter cold wave; total annual accumulation and ablation and their distribution over the glacier area; calculation of balance between net annual accumulation or ablation and mass divergence of glacier flow for various sections of the glacier; measurement of the net energy exchange at the glacier surface and correlation with ablation or accumulation and local meteorological conditions; and studies of mechanics of glacier flow through deep boring studies, seismic soundings, or other geophysical means.

The Juneau Ice Field Research Project observations of Lemon Creek and "Ptarmigan" Glaciers near Juneau in the coast mountains of Southeastern Alaska will include regimen studies to determine the hydrological economy of the glaciers during one budget year, volume transfer of ice as measured at the surface and in drill pipes for an indication of the velocity profile, survey of the glaciers by terrestrial phtogrammetry, standard meteorological and micro-meteorological observations, measurements of radiation and heat transfer, and measurements of runoff during one year. Reconnaissance observations will also be made to determine regimen, flow and the behavior of the termini of neighboring glaciers.

1.3 Greenland Ice Cap Studies. A cooperative Danish - U. S. program of glaciological and related studies has been in operation for some years on the Greenland Ice Cap. The U. S. portion of this program is conducted by the Snow, Ice and Permafrost Research Establishment (SIPRE) of the Corps of Engineers, U. S. Army. It is expected that this work will continue through the IGY. Included in SIPRE's total program are many efforts of interest to the IGY such as crevasse studies including not only detection but studies of the origin, nature, and life cycle of crevasses; ice movement studies for an increased comprehension of the magnitude, direction, and velocity of ice flow using survey methods; relations between white-out, visibility and radiation; studies to provide knowledge of the mechanics of ice cliff and steep ramp formation and perpetuation, and to measure the forces involved; ice cap drilling studies to develop methods and equipment for obtaining an undisturbed continuous core sample of glacial ice to a depth of about 500 meters; and the occupation of a network of snow pits to study in detail the conditions of the upper snow, firn, or ice layers. In addition there are seismic studies and aerial mapping and during the summer of 1956 a special study course was established to train U. S. personnel and some non-U. S. scientists who will work in the Arctic and Antarctic during the IGY. Personnel received training in techniques of obtaining, evaluating, and interpreting snow measurements; the instruments concerned; trail equipment; clothing; and general living and working on an ice cap.

1.4 Arctic Sea Ice Physics. It is planned to occupy two stations in the Arctic ice pack (one of these may possibly be the ice-island T-3), where work in many disciplines will be carried out. Glaciological work on the ice pack will mainly be concerned with the heat budget of the Arctic Ocean, including studies of the stratigraphy and petrofabrics of the ice pack and the relationship of growth or shrinkage, stratigraphy, and crystallographic characteristics of the pack to the thermodynamics of the ice as well as their relationship to mass and energy exchange between the ice pack and its meteorological and oceanographic environments; and determination and analysis of the rate of growth or shrinkage of the ice pack. The program will include measurement of solar radiation; determination of the albedo of snow and ice surfaces at regular intervals throughout the year; measurements of wind gradients above the ice surface; study of ablation and accumulation of the snow and ice at the surface;

determination of variations in pack ice thickness; measurements of temperature profiles on vertical sections from within or below the ice to a point above the surface; and the study of age of the ice at different depths by stratigraphic means and by crystal orientation studies.

2. Antarctic Studies.

The main objectives of the glaciological program in Antarctica are studies of the present status of the Antarctic Ice Sheet as regards nourishment and wastage, volume and extent, structure and variations, and thermal regimen.

2.1 Station Observations. Detailed observations will be performed at each U. S. station by means of glaciological and seismological techniques, including a study of the deformation of the Ross Shelf Ice. It is also planned to undertake a drilling operation to obtain deep firn and ice cores (300 to 500 meters) for stratigraphic and structural studies to determine the changing physical properties of firn as a function of depth in a high polar continental glacier and on a floating ice shelf and to provide a deep hole in these locations to instrument for short and long term thermal and deformation studies.

Studies of the deep firn cores will include investigations of density profile; petrology (grain shape and size and interpretation of ice types); petrofabrics; particulates; bubble structure; and geochemical collections (oxygen-isotope analysis, gas analysis, chloride ion content, and natural and artificial radioactive constituents). The cores will be studied at the SIPRE laboratory in Wilmette, Illinois. It is expected that the oxygen isotope analysis (to be conducted at the California Institute of Technology) of the deep cores will provide information on secular climatic changes during the past 500 - 1000 years in the region.

The deep holes will be instrumented for thermal studies (glacial temperatures will be measured to 1/10 degree Centigrade using thermohms) and deformation studies (instrumentation is being developed to measure the rate of closure of the hole as a function of depth on short term observations and long term studies will include the observation of the inclination of the drill hole as a function of time).

To complement the studies of the present glaciation, some work in glacial geology (a branch of geomorphology dealing with the configuration of the surface, and the changes in land forms that have taken place in areas once covered with glacial ice) will provide information on past glacial history. Ice-free areas will be studied with particular attention directed to glacial valleys, moraines, raised beaches, glacial silt, cirque erosion, erratics, ice polishing, striations, and frost action. Possible areas are the Knox Coast, McMurdo Sound, and inland West Antarctic regions, the latter during the operations of the oversnow traverse groups. Aerial surveys will be made over coastal areas and glacial termini to provide data in inaccessible areas.

2.2 Field Studies. In addition to the work at the stations, observations will be carried out by three oversnow traverses radiating from Little America, Byrd Station, and Weddell Sea, and by an airborne seismic and glaciological program.

The traverses will be carried out by teams of glaciologists and seismologists using tractor-type equipment in a series of operations that will provide data in west Antarctica and on the Ross Ice Shelf. Traverses radiating from Little America will study the Ross Ice Shelf, while the Filchner Ice Shelf and the ice sheet of Ronne Land will be covered by the Weddell Traverses. The Byrd Station traverse party will work on the ice cap of Byrd Land. Finally, an airborne seismic, gravity, and glaciological team will operate from McMurdo Sound or Kainan Bay to make spot measurements in areas inaccessible to the oversnow traverse parties.

The traverse parties will employ seismic, gravimetric, and glaciological techniques to provide information on the climatic patterns of the interior of the continent; the hydrological budget of the ice sheet, its volume, and the changes in its mass which have occurred in recent geological time; and the nature of the subglacial floor and exposed land surface of the continental interior.

Shallow-drilling and pit-study techniques will supply data on the rate of annual accumulation; the rate and form of annual wastage; the stratigraphy and structure to depths of 25 feet in pits and 100 feet with manual auger; the thermal regimen to a depth of 100 feet, or more if possible; and surface movement.

Seismic and gravimetric techniques will provide determination of the ice thickness; information on the interval structure as regards the depth of transition from firn to ice; information on the ice shelves as to what portion of the shelf is afloat and the depth of underlying water; information on the character of the subglacial topography underlying those portions of the ice shelves that are aground and the inland ice.

Meteorological observations will be made during the traverses for relation to observations carried out at the stations and to study the response of the shelf and continental ice to meteorological conditions.

1. U. S. STATION LIST FOR THE IGY

Project Code:

GRM	Glacier regimen and glacial meteorological studies	PGF	Investigation of present glacier fluctuations (photogrammetry)
HGF	Investigation of historical glacier fluctuations	SD	Seismic depth measurement
IFM	Ice flow mechanics studies	SIP	Physical properties of snow and ice studies

FP Full Program (above)

CSAGI No.	Station	Nominal Location Latitude	Nominal Location Longitude	Program
Continental United States				
	Blue Glacier (Olympic Nat'l. Park)	47°45'N	123°45'W	FP
	Cascade Mountains	41-49°	122-121°	PGF
	Rocky Mountains	39-49°	105-115°	PGF
	Sierra, Nevada	37°	118°	PGF
Alaska and Arctic				
	Lemon Creek Glacier	58° N	134° W	FP
	Mt. Michelson	69	144	FP
	Coast Ranges	55-60°	130-140°	PGF,HGF
	Alaska Range	63	145-151°	PGF,HGF
	Arctic Ice Pack	80	160	SIP,SD,GRM
Antarctic				
SA 004	Byrd Station	80° S	120° W	IFM,SIP,SD
SA 009	Little America	77	164	GRM,SIP,SD
SA 001	Pole Station	90	-	GRM,SIP
SA 011	Weddell Sea	77	35	SIP
SA 020	Knox Coast	67	105 E	GRM,SIP,SD
	Traverses	-	-	SIP,SD

2. COOPERATIVE STATION LIST FOR THE IGY

Greenland

NA 019	Thule	76°31'N	68°50'W	PGF,SIP,SD,IFM

X. OCEANOGRAPHY

The two major aspects of the U. S. Oceanography Program are 1) the establishment of new Tide Gauge and Long Period Wave Recorder Stations throughout the islands of the Pacific and Atlantic, and 2) Deep Water Ship Operations. Included in (2) is a program (3) in Geochemistry with emphasis on carbon dioxide, carbon-fourteen, and tritium. In addition, some measurements (4) will be taken from the Drifting Ice Floe Stations in the Arctic.

1. Island Observatories.

This program will establish new tide gauge and long period wave recording stations at selected islands in the Pacific and Atlantic Oceans to augment the existing network of tide stations. Of particular importance are the stations in the equatorial regions and the Southern Hemisphere, where observations are lacking compared to these available in the North.

A part of the program at the island stations will be devoted to the seasonal fluctuation of the sea level. As an adjunct to the measurement of the sea level the temperatures and salinities will be measured (steric observations) in the vicinity of as many as possible of the stations to depths up to 1000 feet in order to determine what part of the sea level change is due to volumetric changes rather than actual changes in water mass.

In addition to the study of the seasonal sea level changes, as mentioned above, Van Dorn or similar equipment will be installed at many of the stations to record waves of periods five to fifteen minutes. These waves are related to tsunamis, severe storms, high altitude jet streams in the atmosphere and such occurrences as the great eruption of the volcano Krakatau. Surges in the sea which followed that event were caused by the coupling of energy to the ocean from the great pressure waves in the atmosphere. While catastrophic events such as the eruption of Kratatau and earthquakes have long been known to be responsible for waves of this period it is believed that this period wave is present to a considerable extent at all times.

To complete the study of wave spectrum from tide periods to periods of about 2 seconds, ocean wave recorders will be installed at some location in the Atlantic Ocean. Sensitive, recording microbarographs will be installed at most stations to permit a study of the energy transfer between sea and air.

The list of the tide gauge stations at the end of this chapter includes stations specially set up to complete gaps in the international network and existing stations, operated by the United States Coast and Geodetic Survey, which are judged to be of considerable value to the IGY effort. In addition many tide gauge stations along the coasts of Alaska and the United States, at port and harbor facilities, are in operation. The data from these stations are readily available independent of the IGY but they are not listed because of possible difficulties of interpretation, due to local effects and conditions, for the purposes of the IGY program.

1.1 Cooperative Activities. Scientists from Scripps Institution of Oceanography and Lamont Geological Observatory are presently in communication with scientists at various locations abroad for cooperative establishment of new island observatory stations. Also some locations have already been proposed and discussed informally. It is hoped that plans and arrangements will be clarified in the near future.

2. Deep Water Ship Operations.

The overall objectives of this part of the program for both the Atlantic and Pacific Oceans are:

2.1 A study of the deep circulation of the Atlantic and Pacific. This will include the study of the water moving northward from Antarctica into and along the bottom of the Atlantic and Pacific as well as the study of the bottom water formed at the surface in the northern Atlantic and its subsequent sinking and movement toward the equator. The IGY oceanographic cruises are being planned internationally and it is expected that U. S. oceanographic ships will join with Canadian ships to run a line of synoptic stations from North to South along the coasts of North and South America. In the East Atlantic, United States ships will cooperate with those of various European countries and the Union of South Africa in a similar meridional study.

2.2 Detailed, multiple ship surveys. This type of activity differs from that of 2.1 in that the ships will spend considerable time together in limited areas, making detailed studies of currents, at the surface and at depths. The Geomagnetic Electrokinetograph (GEK) will be used to study the surface currents, while deep currents will be determined indirectly by depth profiles of temperature and chemical concentrations, and directly by the use of drogues, neutral buoyancy floats and possibly recording current meters. Currents at all depths will be calculated from the density field as determined by measurements of the temperature and salinity.

During all deep water ship operations, including the supply cruises for the establishment of the island observatory stations, routine observations, such as bathythermographs and meteorological observations will be taken. Echo-sounders will be used to provide a continuous record of bottom topography; towed magnetometers, both flux-gate and nuclear resonance types, will be used in certain areas; standard oceanographic stations will be taken with Nansen bottle casts, some gravity and piston cores, dredge hauls, bottom photographs, bottom heat flow measurements, etc.; and, as part of the U. S. Seismology Program, seismic refraction and reflection profiles will be run in areas of particular interest to geophysicists.

2.3 Planned Cruises. Many of the cruises are of an international cooperative nature, coordinated with the assistance of the CSAGI Working Group on Oceanography, the ICES, etc., as well as by direct negotiations and agreements between oceanographers of the various countries and institutions. Details of much of this work are not completely worked out yet, but some of the cruises are blocked out in sufficient detail to describe.

In the South Pacific the Scripps Institution of Oceanography plans to make a two ship expedition, with Research Vessel HORIZON and Research Vessel SPENCER F. BAIRD to the area bounded by the Society Islands, South America, and 45° South Latitude. The approximate time will be from November 1957 to March 1958. The measurement schedule includes deep hydrographic casts, heat flow in bottom sediments, coring and dredging, isotopic sampling of carbon-14 and tritium and bathymetry; IGY programs in seismology, geomagnetism, radiochemistry and atmospheric CO_2 sampling will be carried out during the expedition.

During the Spring and Summer of 1958, two multiple ship operations will be conducted in the eastern equatorial Pacific. The HORIZON and BAIRD will take part in this work and it is hoped that arrangements can be made for other U. S. ships and ships of other countries to participate. One operation would study the variations in the equatorial countercurrent between the equator and 10° N, and longitudes 90° and 120° West. The second operation would study the nature and extent of the equatorial undercurrent in the region bounded by 5° South, and 90° and 150° West.

Based on experience from Operation NORPAC (1955) and on surveys being conducted in the summer of 1956, a synoptic survey of a part of the North Pacific Current is planned for the summer of 1957 with operations by a number of vessels including those of Japan, Russia, Canada, and the United States. The general area will probably be between 40° North and the Aleutian Islands.

A Longitudinal Profile Survey will be carried out in the summer of 1958 by the Research Vessel BROWN-BEAR of the University of Washington in coordination with the previously mentioned ships of Scripps as well as Canadian ships. It is planned to extend the profile as far north as the Bering Strait: details as to station locations and types of observation to be made are currently under review, but will probably include bathymetry, bottom sampling, physical and chemical studies of the water, etc., with particular attention devoted to the deep water, that is below about about 2500 meters.

In the Atlantic Ocean it is proposed that the Research Vessel VEMA of Lamont Geological Observatory and the Research Vessel ATLANTIS of Woods Hole Oceanographic Institution, traveling together, will study the southern Atlantic deep water and the equatorial current system in both the western and eastern basins. During this time it is planned that the Research Vessel A.A. JAKKULA of the Agricultural and Mechanical College of Texas will occupy about fifty deep sea oceanographic stations in the Gulf of Mexico and the northwestern mid-Atlantic. These stations will be concentrated in the area of the Gulf Stream and are being planned in such a way as to obtain a maximum number of sections across the stream, constituting an essential part of the coordinated effort to obtain a synoptic picture of the Atlantic circulation..

The ATLANTIS during November 1957 to February 1958, will travel as far south as time and fair weather permit. The main oceanographic objective is to learn what changes have taken place in the physical and chemical properties of the water masses of the South Atlantic Ocean since the historic oceanographic survey made by the German oceanographic ship METEOR, 1925-1930. Particular attention will be devoted, moreover, to gaining a better understanding of the circulation of the deeper layers of the South Atlantic Ocean with especial reference to the meridional transport. Samples of surface and subsurface waters will be collected for radioactive element analysis; certain seismic geological observations will be made; and as much other oceanographic study as operations permit will be carried out.

After returning from the southward voyage the VEMA and ATLANTIS plan to join with European vessels to conduct a multiple ship operation in the north central Atlantic with the prime objective of making actual measurements of currents at all depths over a limited area.

2.4 Other Related Work. Aspects of other oceanographic work will be of interest for coordination with the IGY effort. For example, bathythermograms are regularly taken by U. S. Ocean Station Vessels and will be taken by the North Atlantic Weather Ships. This information will be useful in determining the temperature distribution in the upper layers of the North Atlantic Ocean.

In the course of detailed physical oceanographic and marine biological studies undertaken by the oceanographic institutions in co-operation with the U. S. Fish and Wildlife Service, many observations of interest will be taken in the coastal waters and in lines of oceanographic stations extending perhaps 1000 miles from the coast. Bathythermograms, deep casts, limited current surveys, chemical analyses, marine biological net hauls, etc., are among the types of work done. Information gathered by this type of program is published in the normal course of events and will contribute somewhat to both the deep current program and the sea level program, to the latter by providing steric observations that may be coordinated with some of the tide data from coastal locations.

3. Geochemical Program.

It is planned to take extensive water and air samples to analyse for carbon dioxide content in order to obtain a valid world average of carbon dioxide content in the atmosphere, and to study the processes by which carbon dioxide is distributed in the atmosphere by wind systems and in the oceans by current systems. The thermal regime of the water masses, the water-air equilibrium cycle, effects of photosynthetic processes, the effects of surface roughness on exchange coefficients are facets in this study. It is expected that the role of carbon dioxide in the energy balance of the atmosphere will be clarified and that the average content determined during the IGY will be a valuable fiducial point for future reference.

An infra-red spectrometer is now being tested and evaluated for shipboard use. If this instrument proves successful it will greatly facilitate the rapid and accurate measurement of the concentrations of carbon dioxide in the atmosphere and sea water, and will be placed on several of the oceanographic ships, especially those which will make long North-South cruises in the middle Atlantic and Pacific, and at selected island stations in the mid-oceanic areas. The study will be augmented by meteorologists who will take air samples from stations in the Antarctic and elsewhere.

During the deep water cruises, water samples from selected areas will be taken for analysis of carbon-fourteen and tritium. These samples will provide a means for dating some of the deep waters, and if sufficient samples are taken and analyzed they will also help to determine some of the characteristics of the deep current systems.

4. Arctic Oceanography.

Two scientific stations are to be established on the Arctic ice pack in the vicinities of 78° N, 160° W and 85° N, 100° W. Gravity cores, water samples, bathythermograms and heat exchange data will be collected. As the pack drifts, the surface currents will be computed, and with the temperature and salinity depth profiles plus the value of the concentration of tritium and carbon-fourteen at various depths much new information will be obtained on the circulation of the deep water masses. The analyses of the bottom cores will allow a direct comparison of Arctic Ocean sedimentation, stratigraphy and marine life with that of other oceans.

It is planned to make systematic aerial reconnaissance flights at possibly two-week intervals from March to September, 1957 and 1958, to secure information on the extent of the ice coverage.

5. Antarctic Oceanography.

Some oceanographic work is being done by the expeditionary ships to the Antarctic. Because of the requirements on the icebreakers with regard to reconnaisance, patrol of convoy operation, etc., the oceanographic work is not planned in detail but is carried out whenever and where ever possible. Standard oceanographic stations consisting of biological samplings, Nansen casts, some bottom sampling, bathythermographs, etc., and routine bathymetry comprise the present work. It is possible that some operations in 1957-1958 may be coordinated with the cooperative cruises in the southern oceans. The possibility of obtaining some tide gauge observations is also being investigated.

1. U. S. STATION LIST FOR THE IGY

Project Code:

LP	Long Period Wave Recorders	SL	Sea Level (Tide Gauge)
OW	Ocean Wave Recorders	ST	Steric Observations

CSAGI No.	Station	Nominal Location Latitude	Longitude	Program
Continental United States				
NB	Cape Hatteras, N.C.	36° N	76° W	LP,OW,SL
NB	Gilgo Beach,L.I.,N.Y.	40 34	73 30	LP,OW,SL
NB	"Texas Tower" No.2	41 41	67 40	LP,OW,SL
Alaska and Arctic Sea				
NB 296	Adak	51°52'N	176°38'W	LP,SL,ST
NB	Attu, Aleutian Is.	52 50	173 11 E	LP,SL,ST
NA 041	Barter Island	70 07	143 30 W	SL
NA	Drifting Station "A"	78	160	Special Obs.
NA	Drifting Station "B"	85	100	Special Obs.
NB	Kodiak	57 45	152 31	LP,SL,ST
NA 035	Pt. Barrow	71 20	156 46	SL
NB 209	Unalaska	53 53	166 32	SL
Pacific Area				
CE 112	Canton Is.	2°48'S	171°43'W	LP,SL,ST
CE	Christmas Is.	1 58 N	157 28	SL
CE 104	Eniwetok, Marshall Is.	11 22	162 21 E	SL
CE 096	Guam	13 26	144 39	LP,SL,ST
NC 825	Hilo, Hawaiian Is.	19 44	155 03 W	SL
NC 817	Honolulu, Hawaiian Is.	21 18	157 52	SL
CE 115	Jarvis Is.	0 23 S	160 03	LP,SL,ST
CE 113	Johnston Is.	16 45 N	169 31	LP,SL,ST
NC	Kahului, Hawaiian Is.	20 54	156 28	SL
CE 088	Koror, Caroline Is.	7 20	134 29 E	LP,SL,ST
CE 107	Kwajalein, Marshall Is.	8 44	167 44	SL
NC	Midway	28 13	177 22 W	SL
CE 100	Moen, Truck Is.	7 27	151 51 E	LP,SL,ST
NC	Nawiliwili, Hawaiian Is.	21 58	159 21 W	SL
CE	Palmyra Is.	5 53	162 03	LP,SL,ST

XI. ROCKETS AND SATELLITES

A. ROCKET PROGRAM

The scientific basis for the proposed rocket IGY program is to be found in the need for basic data which ground based experiments are unable to provide.

The relative roles of solar ultraviolet light, solar X-rays, and incoming particle radiations in the formation of the ionosphere are yet to be determined. The place of the simple Chapman layer in a complete theory of the ionosphere is still an open question, as are the relative importances of recombination, diffusion, and the earth's magnetic field.

In the field of solar terrestrial relationships the rocket alone can supply many of the needed answers. The character of the solar radiation at the bottom of the atmosphere is already considerably affected by the absorption of the high energy photons in the exosphere, the ionosphere, and the ozone layer. Ground based measurements, for example, cannot indicate which solar radiations are responsible for producing the different ionospheric layers. Indeed, the entire problem of determining an adequate solar index for such effects as solar-weather relationships, SID's, geomagnetic disturbances (including the M type), and cosmic ray increases, seems almost totally dependent upon measurements made from rockets.

The relations between the aurora, ionospheric currents, high altitude winds, and observed fluctuations in the earth's magnetic field are still to be clarified.

For a full understanding of the energy balance and general dynamic conditions within the high atmosphere, one must know at what levels, in what quantities, and in what spectral regions energy is absorbed or radiated.

The examples listed above indicate but a few of the many problems in the high atmosphere awaiting solution. To this end experiments will be performed in the following disciplines:

1. Atmospheric Structure.

Basic upper atmosphere meteorological data will be obtained at new locations and at various times by the employment of established rocket techniques. The parameters measured will be pressure, temperature, density, winds, and optical horizon.

2. Atmospheric Composition.

The chemical and ionic composition of the high atmosphere will be determined by spectrographic and mass spectrometric methods. Special emphasis will be placed on the nature of the ions at the various ionospheric levels, since this is vital to further development of ionospheric theory. The vertical distribution of ozone, and the question of the presence of NO and water vapor in the high atmosphere will also receive attention. Much of this work will be done within the auroral zone.

3. Radiation Studies.

There will be measurements of auroral Lyman alpha and air fluorescence, determinations of the heights and intensities of dayglow radiations. Rocket spectrograms will be made of the solar ultraviolet spectrum to wavelengths shorter than the Lyman β line of hydrogen. The solar spectrum in the ultraviolet and X-ray regions will also be studied by means of photon counters, with special attention to its behavior during solar flares.

4. Particle Studies.

The nature and intensities of auroral particles, and the directional characteristics of auroral particle streams will be studied. Low energy cosmic rays will be measured as a function of geomagnetic latitude, and an effort will be made to correlate fluctuations in cosmic ray intensity with solar and magnetic phenomena.

5. Ionospheric and Geomagnetic Measurements.

The variation of charge density with altitude in the ionosphere will be determined in the auroral zone by a variety of techniques. An effort will be made to distinguish between electrons and ions. Measurements will be made of the earth's magnetic field at various latitudes to provide information on the position and magnitude of electrical currents flowing in the lower ionosphere, and on auroral particle streams.

B. EARTH SATELLITE PROGRAM

An important group of scientific experiments has been planned for inclusion in the Earth Satellite Program.

The design and construction of geophysical research satellites and the rockets for placing them in orbit during the International Geophysical Year are now under way in response to the CSAGI resolution on this subject. Experiments involving satellites now under construction are expected to contribute significantly to our fund of geophysical data, particularly in determinations of the shape and crustal structure of the earth, geodetics and the physics of the upper atmosphere.

Most of our knowledge of the exosphere is based on indirect observations: only rockets and satellites can provide direct measurements. Rockets are short-lived and restricted in atmospheric coverage, but satellites are expected to remain a long time in orbit, with repeated revolutions about the earth giving broad coverage. Direct observations of particles and radiations which are absorbed or reflected by the atmosphere before reaching the surface of the earth (or the lower altitudes within the reach of balloons) will be possible.

In addition, the satellite makes possible a unique class of experiments which rest upon the precise observations of its flight along an earth-encircling orbit susceptible to calculation. The realization of the full scientific possibilities of these experiments will depend upon the precision and completeness of the orbital observations and computations. There is the need and opportunity for significant contribution to the satellite experiments by many countries participating in the IGY program, particularly those which are favorable located for carrying out effective observations of the orbit. Particular attention is called to Section 4 of this portion of the USNC-IGY program where the ground station observing program is summarized: participation of the many IGY-participating countries in this technical program appears most valuable.

1. Placement of the Satellite in Orbit.

The placement of an earth satellite in orbit is an engineering problem of appreciable magnitude. Studies by the USNC-IGY clearly indicated the feasibility of its achievement during the International Geophysical Year provided performance representative of extremes of accomplishment in several phases of jet propulsion engineering could simultaneously be achieved. The USNC-IGY, recognizing the accomplishments of civilian laboratories of the Department of Defense in the field of upper atmosphere rocketry and the need for large scale logistics facilities involved in meeting the rigorous time schedule for the establishment of a satellite during the IGY, requested the Department of Defense to assume responsibility for the engineering and logistics phases of the satellite program. In response to the Committee's request, the Department of Defense has undertaken the design and development of the satellite vehicle and the rocketry for its establishment of orbit, the proof of achievement of orbit, and the general logistics support for the satellite program. This three-service participation in the USNC-IGY satellite program is under the management of the Naval Research Laboratory, which has given the designation "Project Vanguard" to its contribution.

The VANGUARD launching vehicle is a three-stage unit, with the first two stages guided and the third maintained in fixed orientation during firing. Although its design represents the smallest vehicle combination consistent with present rocket development, the launching vehicle will be seventy-two feet long (22 meters) and forty-five inches (115 cm) in maximum diameter. The first stage, delivering a thrust of 27,000 pounds (12,250 kg) will start the system on the first part of its flight. When its fuel is exhausted, some 40 miles (64 km) from the launching site and in about two minutes after take-off, the system will have attained a velocity of 3000 - 4000 mph (4800 - 6400 km/hr). The second rocket stage will then take over, attaining a velocity of about 11,000 mph (17,700 km/hr), burning out at about 130 miles (209 km) altitude, and coasting onward. When the system has reached an altitude of about 300 miles (480 km), the last rocket will impel the satellite into its orbit at a speed of about 18,000 mph (28,900 km/hr).

The Naval Research Laboratory has contracted with the Glenn L. Martin Company of Baltimore for this launching vehicle. Martin in turn has announced several subcontractors. The General Electric Company is building the 27,000 pound (12,250 kg) thrust rocket motor for the first stage. The Aerojet General Corporation of Azusa, California, is building the propulsion system, including the integral fuel tanks for the second stage. For the flight control section of the vehicle, which is contained in the second stage, the Minneapolis-Honeywell Regulator Company of Minneapolis, Minnesota, is building the three-axis reference system and the Vickers Electric Division, Vickers, Inc., St. Louis, Missouri (a unit of the Sperry-Rand Corporation), is providing a magnetic amplifier autopilot. Two contractors are working on solid propellent rockets for the third stage, Grand Central Rocket Company of Redlands, California, and Allegheny Ballistics Laboratory of Cumberland, Maryland.

2. The Orbit of the Satellite.

The satellite will be launched from Patrick Air Force Base at Cape Canaveral on the east coast of Florida. Although aimed toward a circular orbit at 300 miles (480 km) altitude, the satellite will probably assume an elliptical orbit with perigee of over 200 miles (320 km) and apogee of from 800 (1300 km) up to perhaps 1500 miles (2400 km). An orbit is planned which will cause the satellite to move around the earth in an apparent latitude range of about 40 degrees on either side of the equator, completing its circuit around the earth once every hour and a half. Since approximately one-sixteenth of a revolution will be made by the earth during one circuit of the satellite, successive transits of the satellite will be displaced by about 25 degrees.

Over the course of many revolutions the orbit of the satellite will shift within a band between 40 degrees north and 40 degrees south of the earth's equator. Two important advantages accrue from such a course: (1) the satellite's instruments will be able to record observations over a broad expanse of the high atmosphere and (2) scientists of many nations will be able to take measurements and make observation. In the planned orbit the satellite will be observable from various areas of South, Central, and North America; Africa; southern Europe and possibly some regions in mid-northern latitudes; the Balkans and Middle East; the Caspian Sea and part of the USSR; Pakistan, China, Japan, India and several other countries in Asia in the mid-northern latitudes; Indonesia, Australia, and New Zealand.

3. Physical Characteristics of the Satellite.

The first satellite will be spherical in shape, about 20 inches (50.8 cm) in diameter, and will weigh approximately 21.5 pounds (9.8 kg). About half this weight will be required for the satellite structure itself, leaving half for the instrumentation, including the telemetering systems. A number of experiments are planned including the measurements of ambient air density, surface composition and shape of the earth, temperature and pressure, meteoritic incidence, intensity of solar radiation in the extreme ultraviolet, and intensity of cosmic radiation.

4. Ground Station Observations and Measurements.

Precise determination of the orbit of the satellite is necessary to the achievement of some of the planned experiments and is of appreciable importance in other cases. Plans call for precision tracking and observation by both optical and radio methods.

4.1 Ground Station Program. One of the most important sets of experiments made possible by the Earth Satellite Program relates to observations, measurements, and calculations which can be made from ground stations. Here both radio and optical observation stations play significant roles. The following are three areas of study that can be conducted:

(i) Air Density. Very little is presently known about the density of the upper atmosphere. From the geometry of the satellite and observations of its flight, especially the deceleration near the end of the flight, calculations can be made of the air density.

(ii) Composition of the Earth's Crust. The satellite orbit will have a basic periodicity with perturbations dependent upon local non-uniformities in gravitational field. Careful observations of the orbit and its perturbations will permit calculations of mass-distribution in the earth. This, in turn, should yield information about the composition of the crust.

(iii) Geodetic Determinations. Determinations similar to those noted above will provide data and increase our knowledge of the earth's oblateness. Improved determinations of longitude and latitude should lead to more precise interconnections among the various geodetic systems. These observations would supplement the observations that are planned in the IGY Longitude and Latitude Program

Fundamental to these experiments is the acquisition of the satellite. Once placed in its orbit, it becomes in effect a celestial body newly arrived upon the cosmic scene. As such, the first problem becomes its acquisition -- those initial observations which not only establish its celestial existence but which provide data for preliminary calculations of its orbit in order that ephemerides may be made. These predictions will permit: (1) the concentration of ground stations on the preliminary orbit, and (2) the subsequent acquisition of more extensive data on the basis of which the studies noted above, items (i), (ii), and (iii), can be conducted.

Optical observations may be conducted by several means. Precision optical tracking and observation, described in Section 4.2 below, is primarily useful once the satellite has been acquired and will provide data of high precision. The precision radio tracking system should provide acquisition data, but in the event of failure of the transmitter in the satellite, other means of acquisition are necessary. Here teams of observers using binoculars may prove most valuable. Although a particular individual will, for obvious reasons, have difficulty in viewing the satellite, trained teams of observers can undertake a satellite acquisition program. By placing binoculars on fixed mounts and employing a group of such installations disposed so as to cover a large region of the heavens, with good data as to position of the installation, timing of observations, and critical review of the observations by professional leaders, a major contribution to the overall program becomes possible.

Once the satellite has been acquired, not only can the precision optical equipment be brought rapidly into play, but also other types of telescopes in astronomical observatories can participate in the observation program.

One of the difficulties in the initial optical acquisition of the satellite, aside from considerations relating to the effectiveness of the simple acquisition net, is the effect of atmospheric conditions. Extensive cloud cover, for example, would minimize the chance of optical acquisition. Here the radio tracking systems can play an important part. The radio systems under consideration are described in section 4.3 below. These systems, barring an unlikely equipment failure in the satellite transmitter, will permit acquisition without regard to atmospheric conditions. In addition, the precision radio system will provide data of sufficient accuracy for the experiments noted above, items (i), (ii), and (iii).

4.2 <u>The Optical Tracking Program</u>. Ultimate precision of tracking will be provided by the optical system, consisting of a primary net of twelve or more stations. The USNC-IGY has assigned the Astrophysical Observatory of the Smithsonian Institution the responsibility for the optical tracking program, including the equipping, establishing, and the operating of the stations, as well as the computing of orbital data.

Observation stations will use improved Schmidt cameras and crystal clocks. The clocks will have estimated rates of a few milliseconds a day and will be readable to one millisecond; this time accuracy promises a positional determination of the satellite's position to less than 10 seconds of arc along its path. The cameras use an F/1 Schmidt-type system of 20-inch (50.8 cm) aperture with mirror aperture of 30 inches (76.2 cm). With the predicted angular speed and brightness of the satellite this equipment is expected to provide an accuracy of about two seconds of arc in a direction transverse to path.

The optical tracking equipment has an estimated capability of tracking a 15-inch (38.1 cm) diameter sphere at a distance of 1000 miles (1600 km). This corresponds to a stellar magnitude of 10 to 11, and is more than adequate for tracking the satellite, which should vary approximately from stellar magnitude 6 to 9 in passing from perigee to apogee.

Limitations of the optical observation system are: (1) the path of the satellite must be initially known to a precision of 3 degrees so that preliminary sighting positions can be established for insuring photographic acquisition; and (2) conditions of visibility will restrict optical observations to brief twilight periods.

On the basis of the studies of the optical observation problem made to date by the USNC, it appears that the minimum acceptable coverage of the satellite orbit would require thirteen optical observation stations. More stations would add appreciably to the IGY effort. Some desirable locations for stations appear to be White Sands, New Mexico, U. S. A.; Cocoa Beach, Florida, U. S. A.; Venezuela or Netherlands Antilles; Quito, Ecuador (with radio observations); Antofagasta, Chile (also with radio observations); Cordoba, Argentina; Bloemfontein, South Africa; Australia; Maui, Hawaii; Southern Japan; India or Pakistan; Egypt or east edge of Mediterranean; Southern Spain or French Morocco. Additional stations would be desirable to increase the coverage both in longitude and in latitude, particularly in latitudes about 40 degrees north and 40 degrees south near the nodal bands of the satellite orbit. It is hoped that discussions in the Working Group Sessions of the CSAGI Conference at Barcelona will provide a basis for the establishment of additional optical observation stations by countries desiring to contribute to the satellite program. Also it is expected that technical design information on the equipment for optical tracking and observing stations will be made available soon to the National Committees requiring this information.

4.3 Radio Tracking System. The USNC-IGY has assigned the Naval Research Laboratory the responsibility for the precision radio tracking system, including the development and design of equipment, the establishment and operation of tracking stations, and the computation of orbital data.

The radio tracking system which has been developed in the Naval Research Laboratory is known as Minitrack. It uses a phase comparison method in which a radio signal is transmitted from the satellite to the ground station, which acts essentially as a radio-frequency interferometer. Satellites will transmit Minitrack signals at about 108 Mc. Each ground station will include a precision multiple antenna array and an involved electronics installation, requiring a considerable operating staff. The expected precision of operation is about 3 minutes of arc under normal conditions with improvement to 20 seconds of arc for observation at small zenith angles, or for nighttime operation. In terms of a minimum north-south chain of stations, intended to ensure radio tracking and necessary spacing (taking economic factors into account), the USNC-IGY believes that the following station sites will be desirable: Santiago, Chile; Antofagasta, Chile (with optical observation station); Lima, Peru; Quito, Ecuador (with optical observation station); Panama; Antigua, British West Indies; Havana, Cuba; Jacksonville, Florida, U. S. A.; Washington, D. C., U. S. A.; and San Diego, California, U. S. A. Plans for the cooperative establishment of some of these stations are underway. Additional stations are desirable and it is hoped that many nations will participate in the radio tracking program. Such participation might consist of a ground station of the precision type or a simplified ("Mark II Minitrack") system, which has been developed for supporting the primary network; results from the latter, if a broad network could be established, would be very important in the acquisition of the satellite. Information on receiving station design, as well as the radio tracking signal characteristics, will be made available to CSAGI as soon as the Committee can prepare reports on technical work still in progress.

5. Internal Satellite Experiments.

In addition to the experiments described in Section 4 above, the satellite affords a unique tool for observations of atmospheric and cosmic phenomena not directly susceptible to measurements on the earth and phenomena which in many instances are masked by the earth's atmosphere. It is expected, within the payload limitations of the satellite, that a number of research experiments can be conducted. At the present time the USNC-IGY is evaluating thirty-one experiments which have so far been proposed for the Satellite Program by various research laboratories. Among the criteria for the selection of proposed experiments are the scientific importance, technical feasibility, and the degree of dependence of the proposed work upon a satellite vehicle. The following are examples of typical experiments now under consideration:

(i) Temperature. Measurements of temperature within the satellite and at its surface will be made. The heat within the satellite is derived from solar radiation, the power supplies, thermal radiation emitted by the earth, and a very small amount from friction.

(ii) Pressures. The satellite shell will be airtight and may contain an inert gas. Pressure gauges will be used to measure pressures during the satellite's life in order to check on leakages and in connection with possible meteoric effect.

(iii) Meteoritic Particles. Small meteoritic particles, a few thousandths of an inch in diameter, are constantly impinging upon the earth's atmosphere. Estimates of the quantity reaching the earth's surface vary. These micro-meteorites are believed to contribute a measurable amount to the ionization of the atmosphere in the E-region. With the use of simple impact detectors these micro-meteorites can be observed. Moreover, measurements of pressure within the satellite will reveal meteoritic penetration and some information on size.

(iv) Solar Ultraviolet and X-Radiation. Much of the radiation from the sun is masked from the earth by the atmosphere. This is particularly true of the extreme ultraviolet radiations in the Lyman-alpha region. The satellite offers an opportunity to observe this radiation on a long term basis. This experiment might, for example, determine the influence of solar flares on its emission from the sun.

(v) Cosmic Rays. Cosmic rays have an energy spectrum from an unknown minimum up to very high energies. Because the earth's magnetic field deflects these particles, only those with the highest energies penetrate the mid-latitudes. Many of the low-energy particles are absorbed in the earth's atmosphere, and observations of cosmic rays are generally of "secondaries." The satellite will permit direct studies of the primary cosmic ray spectrum above the masking atmosphere.

6. Data on the IGY Satellite.

On July 29, 1955, in a letter to Dr. Sydney Chapman, President of the CSAGI, Dr. Joseph Kaplan, Chairman of the U. S. National Committee for the IGY made known the intention of the USNC to attempt the placement of earth satellites in orbit as part of the U. S. participation in the IGY; at the same time the President of the United States released an announcement concerning support for the USNC-IGY Earth Satellite Program. On January 27, 1956, the USNC released (1) description of the proposed orbit; (2) information on the rocket system for placing the satellite vehicle in orbit; (3) preliminary description of the ground observation portion of the program; (4) physical description of the vehicle itself; and (5) discussion of some kinds of scientific information that might be obtained from both the ground observations of the orbit and from the satellite internal instrumentation.

The U. S. Program report of August 1955 provided summary information on the satellite program; the report on the proposed U. S. Program for the Western Hemisphere IGY Conference described the ground observing program in as much detail as the planning status then permitted; the CSAGI Secretary General distributed this on August 6, 1956. The present report, August 1956, on the U. S. Program presents the most current details.

Summary reports on satellite plans were presented by U. S. scientists before the CSAGI during the third meeting at Brussels, September 8-14, 1955; the CSAGI Arctic Conference at Stockholm, May 22-25, 1956; and the CSAGI Conference on the Western Hemisphere at Rio de Janeiro, July 16-21, 1956. A series of reports summarizing the U. S. rocket and satellite program for the IGY are planned for presentation during the fourth meeting of the CSAGI at Barcelona, September 10-16,1956. These reports, along with the information in this report, will describe the IGY satellite as well as present knowledge allows.

The USNC will continue as in the past to make technical information on the satellite, ground observation programs, and internal instrumentation available to CSAGI and through it to all interested countries as rapidly as planning and technical developments allow.

UNITED STATES IGY ROCKET PROGRAM

(As of 1 June 1956)

SCHEDULE OF ROCKET FIRINGS

The attached table sets forth a schedule of rocket firings for the United States IGY Rocket program. It is felt that such a schedule may be helpful to the various technical panels in correlating the different activities with rocket firings.

To facilitate referencing, the vehicle symbol used in Col. 1 of the table has been created with the following meaning:

IGY A M 2. 21 N

Place 1: Directing Agency
Place 2: Instrumenting Agency
Place 3: Type of vehicle
Place 4: Directing Agency's serial number
Place 5: Purchaser of vehicle, if not directing agency

Symbols used in Places 1,2,5 are as follows:

A: Air Force
B: Ballistic Research Laboratories, Aberdeen Proving Ground, Md.
C: University of Colorado
F: National Science Foundation
I: State University of Iowa
M: University of Michigan
N: Navy
O: Army Ordnance
S: Army Signal Corps
T: University of Maryland
U: University of Utah

The symbols used in Place 3 are:

1: Aerobee, Model RTV-A-1a (AJ10-25).
2: Aerobee, Model RTV-N-10c (AJ10-34).
3: Aerobee, Model RV-N-13a, called Navy Aerobee-Hi.
4: Aerobee, Model AJ11-6, called Air Force Aerobee-Hi.
5: Balloon-rocket combination, called Rockoon.
6: Nike-Cajun rocket combination.

Normally the symbol in Place 4 will be a two-digit number. If more vehicles are added to the program, however, it may be necessary to use three-digit numbers in Place 4.

Place 5 will be empty unless the vehicle purchaser differs from the directing agency indicated in Place 1.

Agency abbreviations used in the table are as follows:

AFCRC: Air Force Cambridge Research Center, 415 Summer Street, Boston, Massachusetts
NRL: Naval Research Laboratory, Washington 25, D.C.
SCEL: Signal Corps Engineering Laboratories, Ft. Monmouth, N.J.
SUI: State University of Iowa, Iowa City, Iowa
BRL: Ballistic Research Laboratories, Aberdeen Proving Ground, Md.

SUMMARY

AGENCY	VEHICLE	NUMBER OF VEHICLES	PLACE OF FIRING
		PRE-IGY	
AFCRC	Aerobee	1	Churchill
AFCRC	Nike-Cajun	1	Churchill
AFCRC	Nike-Cajun	1	White Sands
BRL	Nike-Cajun	1	White Sands
NRL	Aerobee	4	Churchill
NRL	Rockoon	10	Pacific-off San Diego
SCEL	Aerobee	2	Churchill
		IGY	
AFCRC	Aerobee	8	Churchill
AFCRC	Nike-Cajun	16	Churchill
AFCRC	Aerobee	7	Holloman
BRL	Nike-Cajun	2	White Sands
BRL	Nike-Cajun	10	Churchill
NRL	Aerobee	17	Churchill
NRL	Aerobee	5	White Sands
NRL	Nike-Deacon	50	Pt. Mugu
NRL	Rockoon	20	Antarctic
SCEL	Aerobee	8	Churchill
SCEL	Nike-Cajun	8	Guam
SUI	Nike-Cajun	16	Churchill
SUI	Rockoon	40	Antarctic-Arctic Equator

UNITED STATES IGY ROCKET PROGRAM

(As of 1 June 1956)

Schedule of Rocket Firings

Pre - IGY

IGY No.	Date	Location	Principal Experiment
AM6.30	20 Jul 56 D	White Sands	Pressure, temperature, density
OB6.00	22 Jul 56 D	White Sands	Charge density
NN5.27 thru NN5.36	16 Jul thru 29 Jul 56 D	Pacific-Off San Diego	Solar ultraviolet and x-ray during flares
AM2.21	16 Oct 56 D	Churchill	Pressure, temperature, density
AM6.31	19 Oct 56 N	Churchill	Pressure, temperature, density
NN3.02	23 Oct 56 N	Churchill	Auroral particles; mag. field
SM.01	1 Nov 56 N	Churchill	Temperatures, winds
NN3.12	6 Nov 56 D	Churchill	Pressure, temperature, density
SM1.02	13 Nov 56 N	Churchill	Temperature, winds
NN3.07	16 Nov 56 D	Churchill	Charge density in ionosphere
NN3.17	20 Nov 56 N	Churchill	Chemical and ion composition of atmosphere

I G Y

IGY No.	Date	Location	Principal Experiment
NN3.08F	4 Jul 57 D	Churchill	Charge density in ionosphere
SS1.03	12 Jul 57 N	Churchill	Temperature, winds
SS1.04	26 Jul 57 N	Churchill	Temperature, winds
NN3.13F	27 Jul 57 D	Churchill	Pressure, temperature, density
AM6.32	27 Jul 57 D	Churchill	Pressure, temperature, density
II6.20F	15 Jul 57 N	Churchill	Cosmic Rays, auroral radiations and magnetic field
II6.21F	22 Jul 57 N	Churchill	Cosmic Rays, auroral radiations and magnetic field
II6.23F	10 Aug 57 N	Churchill	Cosmic Rays, auroral radiations and magnetic field
AM6.33	12 Aug 57 D	Churchill	Pressure, temperature, density
SS1.05	12 Aug 57 D	Churchill	Temperature, winds
AM4.01	25 Aug 57 D	Churchill	Pressure, temperature, density
NN1.01	25 Aug 57 N	Churchill	Auroral particles & mag. field
SS1.06	26 Aug 57 D	Churchill	Temperature, winds
II6.22F	29 Aug 57 N	Churchill	Cosmic Rays, auroral radiations and magnetic field
AM6.02	23 Sep 57 D	Churchill	Density, temperature

IGY No.	Date	Location	Principal Experiment
NN3.09F	24 Sep 57 D	Churchill	Charge density
AA4.03	30 Sep 57 D	Churchill	Dayglow
AM6.34	30 Sep 57 D	Churchill	Pressure, temperature, density
AM6.04	13 Dec 57 D	Churchill	Density, temperature
NN3.03F	13 Dec 57 N	Churchill	Auroral particles & mag. field
NN3.18F	15 Dec 57 N	Churchill	Chemical & ion composition
SS1.07	16 Dec 57 N	Churchill	Temperature, winds
SS1.08	21 Dec 57 D	Churchill	Temperature, winds
NN3.04F	21 Dec 57 N	Churchill	Auroral particles & mag. field
AM6.35	22 Dec 57 D	Churchill	Pressure, temperature, density
NN3.19F	14 Jan 58 N	Churchill	Chemical & ion composition
NN3.10F	19 Jan 58 D	Churchill	Charge density
SS1.09	19 Jan 58 D	Churchill	Temperature, winds
NN3.14F	20 Jan 58 N	Churchill	Pressure, temperature, density
AM6.36	20 Jan 58 D	Churchill	Pressure, temperature, density
II6.24F	22 Jan 58 N	Churchill	Cosmic rays & auroral radiations
II6.25F	24 Jan 58 N	Churchill	Cosmic rays & auroral radiations
II6.26F	28 Jan 58 N	Churchill	Cosmic rays & auroral radiations
II6.27F	30 Jan 58 N	Churchill	Cosmic rays & auroral radiations
OB6.08	2 Feb 58 D	Churchill	Horizon study
II6.28F	4 Feb 58 N	Churchill	Cosmic rays & auroral radiations
II6.29F	6 Feb 58 N	Churchill	Cosmic rays & auroral radiations
II6.30F	8 Feb 58 N	Churchill	Cosmic rays & auroral radiations
SS1.10	10 Feb 58 D	Churchill	Temperature, winds
II6.31F	12 Feb 58 N	Churchill	Cosmic rays & auroral radiations
NN3.20F	18 Feb 58 N	Churchill	Chemical & ion composition
AM6.37	18 Feb 58 D	Churchill	Pressure, temperature, density
AM6.05	19 Feb 58 D	Churchill	Density, temperature
AM4.06	26 Feb 58 D	Churchill	Pressure, temperature, density
NN3.15F	26 Feb 58 N	Churchill	Pressure, temperature, density
OB6.09	2 Mar 58 D	Churchill	Horizon study
II6.32F	6 Mar 58 N	Churchill	Cosmic rays & auroral radiations
II6.33F	10 Mar 58 N	Churchill	Cosmic rays & auroral radiations
II6.34F	14 Mar 58 N	Churchill	Cosmic rays & auroral radiations
II6.35F	18 Mar 58 N	Churchill	Cosmic rays & auroral radiations
NN3.11F	20 Mar 58 D	Churchill	Charge density
NN3.05F	20 Mar 58 N	Churchill	Auroral particles & mag. field
NN3.21F	21 Mar 58 N	Churchill	Chemical & ion composition
NN3.06F	28 Mar 58 N	Churchill	Auroral particles & mag. field
AM6.38	28 Mar 58 D	Churchill	Pressure, temperature, density

IGY No.	Date	Location	Principal Experiment
AU3.07F	17 Jun 58 D	Churchill	Charge density in ionosphere
AM6.08	18 Jun 58 D	Churchill	Density, temperature
AA4.09	18 Jun 58 D	Churchill	Airglow
AM6.39	20 Jun 58 D	Churchill	Pressure, temperature, density
AM6.40	20 Jun 58 D	Churchill	Pressure, temperature, density
AU3.10F	24 Jun 58 D	Churchill	Charge density in ionosphere
OB6.04	3 Jul 58 D	Churchill	Magnetic field, electron density
OB6.10	7 Jul 58 D	Churchill	Horizon study
OB6.11	11 Jul 58 D	Churchill	Horizon study
AU3.11F	16 Jul 58 D	Churchill	Charge density in ionsophere
NN3.16F	17 Jul 58 D	Churchill	Pressure, temperature, density
OB6.03	17 Jul 58 D	Churchill	Water vapor
AM4.12	27 Jul 58 D	Churchill	Pressure, temperature, density
AM6.41	27 Jul 58 D	Churchill	Pressure, temperature, density
AM6.42	11 Oct 58 D	Churchill	Pressure, temperature, density
AM6.43	12 Oct 58 D	Churchill	Pressure, temperature, density
OB6.05	4 Nov 58 D	Churchill	Water vapor
OB6.06	11 Nov 58 D	Churchill	Magnetic field electron density
OB6.07	18 Nov 58 D	Churchill	Water vapor
OB6.12	14 Nov 58 D	Churchill	Horizon study

IGY - Other than Churchill

IGY No.	Date	Location	Principal Experiment
OB6.01	Jul 57 D	White Sands	Charge density & water vapor
OB6.02	Jul 57 D	White Sands	Charge density & magnetic field
NN3.22F	Jul 57 D	White Sands	Solar ultraviolet spectrum
NN3.23F	Jul 57 D	White Sands	Solar ultraviolet spectrum
	Jul 57 D	Pt. Mugu	Solar ultraviolet and x-ray during flares
II5.01F thru II5.19F	Jul-Aug 57	Arctic-from ship	Soft particle radiation; mag. field
II5.50F thru II5.90F	Oct 57-Feb 58 N	Antarctic & Equator from ships	Soft particle radiation; cosmic ray intensity, mag. field
NN3.26	Jan 58 D	White Sands	Ozone
SS6.30F thru SS6.37F	April-Jul 58	Guam	Temperature, winds
NN3.24F	Jul 58 D	White Sands	Solar ultraviolet spectrum

IGY No.	Date	Location	Principal Experiment +
NN3.25	Jul 58 D	White Sands	Solar ultraviolet spectrum
	Jul 58 D	Pt. Mugu	Solar ultraviolet and x-ray during flares
NN5.87 thru NN5.96	Nov-Dec 58	Antarctic-from ship	Auroral air luminescence
NN5.97 thru NN5.106	Nov-Dec 58	Antarctic-from ship	Magnetic field & auroral particles
AA4.22	Jun 57 D	Holloman	Dayglow
AC4.24	Jul 57 D	Holloman	Solar ultraviolet spectrum
AU4.26	Jul 57 D	Holloman	Charge density in ionosphere
AU4.27	Sep 57 D	Holloman	Charge density in ionosphere
AU4.28	Sep 57 D	Holloman	Charge density in ionosphere
AA4.25	Dec 57 D	Holloman	Solar ultraviolet spectrum
AA4.23	Oct 58 D	Holloman	Dayglow

+In addition to the principal experiment, each daytime, Ft. Churchill, NRL Aerobee will measure solar Lyman alpha and x-rays, and from the x-ray data will get E-region pressures. Also, each nighttime, Ft. Churchill, NRL Aerobee will measure auroral Lyman alpha and air fluorescence.

XII. SEISMOLOGY

Seismological programs for the IGY may be classed in the following categories: (1) Earthquake Studies with emphasis on special studies of long period waves; (2) Seismic Exploration of the Crustal Structure; (3) Microseismic Studies; (4) extension of earthquake studies and seismic exploration techniques to Antarctica.

1. Earthquake Studies.

1.1 New Standard Stations. Existing seismographic stations are naturally concentrated near areas of known earthquake activity and in the more densely populated regions of the earth. In order to increase coverage, some new standard stations will be established for the IGY, increasing our data in presently neglected areas. At four Antarctic stations (Byrd, Pole, Knox Coast and Adare (in cooperation with New Zealand) three component instruments are planned; at Thule a combination of Benioff and Sprengnether instruments is planned and possibly at Point Barrow also.

In the Pacific area there will be stations at Truk (Benioff vertical and possibly horizontal components, and three-component Sprengnether), Guam (Benioff vertical component and three-component Sprengnether), Koror (Sprengnether horizontal components and either Benioff or Wilson-Lamigan vertical components), and at Jarvis and Palmyra at least one three-component instrument and possibly additional components.

The U. S. Coast and Geodetic Survey operates eight seismological stations at College and Sitka, Alaska; Eureka, Nevada; Tucson, Arizona; Ukiah, California; Washington, D. C.; Honolulu, Hawaiian Islands; and San Juan, Puerto Rico. Records are processed by the Coast Survey and published in monthly bulletins from stations operated by other agencies and institutions at Boulder City, Nevada; Bozeman, Montana; Burlington, Vermont; Butte, Montana; Chicago, Illinois; Columbia, South Carolina; Hoover Dam, Arizona; Hungry Horse, Montana; Lincoln, Nebraska; Philadelphia, Pennsylvania; Rapid City, South Dakota; and Salt Lake City, Utah. Fifteen additional stations operated independently supply P-wave data to the Coast Survey. Stations at Boulder, Colorado; Duluth, Minnesota; Fayetteville, Arkansas; and Balboa Heights, Canal Zone are operated cooperatively with the Survey but process their own records.

This is but an indication of the seismological coverage: the Lamont Geological Observatory, the University of California, Jesuit Seismological Association, and the Seismological Laboratory also operate networks of observatories.

1.2 Long Period Waves. Recent advances in equipment design make possible the study of very long period earthquake waves. Large earthquakes will excite waves with periods of up to many hundreds of seconds and corresponding wavelengths of many hundreds of miles. The amplitudes of the ground waves at periods of the order of 400 seconds may amount to one-half to one millimeter. These waves (mantle Rayleigh waves) were recently recorded for the great Kamchatka quake of October, 1952 by the Lamont Geological Observatory, in New York.

The instrumentation consists of pendulums with a period of 15 seconds, carrying small coils that move in a fixed magnetic field. The electrical signal generated is then recorded with special Benioff galvanometers with a period of 75 seconds. The total magnification (i.e. amplitude of galvanometer trace to amplitude of ground movement) is about 2000 for waves of 10 second periods, and falls off to 10 or 20 for the large waves of the order of 400 second periods.

The lower magnification for longer periods is somewhat offset by the appreciable amplitude of such waves for the large earthquakes. These great surface waves penetrate deep into the earth by virtue of their extremely long wave lengths, and may be considered as resulting from free earth vibration.

It is proposed to take advantage of existing seismological observatories and arrangements are being made by the Lamont Geological Observatory with various scientific institutions and national committees to supply Long Period Seismographs to observatories at: Honolulu, Hawaiian Islands; Lwiro, Belgian Congo; Resolute Bay, Northwest Territories, Canada; Santiago, Chile; Trinidad, British West Indies; and Uppsala, Sweden. It is also planned to install an instrument at Knox Coast Station, Antarctica, and before the IGY begins it is hoped to make arrangements for the operation of several additional instruments.

The Lamont Geological Observatory has a long period seismograph in operation at Palisades, New York and plans to coordinate their records with those obtained from similar instruments at Waynesburg, Pennsylvania, U. S. A.; Perth, Australia; and Pietermaritzburg, Union of South Africa.

1.3 Lg Phase Waves. The Lg wave is a transverse vibration of moderate period which was found by observers at the Lamont Geological Observatory a few years ago. These waves are transmitted only over the type of outer crust associated with continents or continental blocks, whereas the Long Period wave transmission is insensitive to crustal material. Hence the geographical distribution of these continental type crusts can be outlined by the study of earthquake records of stations where instruments are tuned to Lg wave frequency.

The pendulums used are the same as for Long Period waves, but a short-period galvanometer (period of about 6 seconds) is used to serve as the low frequency cut-off. Amplifications of about 3000 are obtained at periods of 10 seconds. Arrangements are being made with various scientific institutions and national committees to supply Lg phase instruments to observatories at Trinidad, British West Indies; and Huancayo, Peru. It is planned with the cooperation of the New Zealand National Committee, to operate an Lg phase seismograph at Adare, Antarctica.

1.4 Strain Accumulation. It is hoped to make a direct contribution to the study of earthquake characteristics by the installation of two linear strain seismographs by the California Institute of Technology at Huancayo, Peru and Santiago, Chile in cooperation with the National Committees of Peru and Chile.

2. Seismic Exploration of the Crustal Structure.

The use of seismic waves from explosive charges provides information on crustal structure unobtainable otherwise. The Society of Exploration Geophysicists is planning to organize a program to collect data on reflections from the Mohorovicic discontinuity. This data will be probably collected by exploration seismic crews during their regular work. In addition, special programs are planned.

2.1 Seismic exploration at sea. During some of the long oceanographic voyages in the Atlantic and Pacific, seismic reflection and refraction studies will be made for determining sediment thickness and delineating details of crustal layering. These activities will be carried out by Lamont Geological Observatory and Scripps Institution of Oceanography. Exact details as to the location of the work cannot be specified now but attention will be given to areas such as the Eastern Island Rise, South American Trench and Tuamoto Archipelago in the Pacific Ocean, and at least traverses along the length of the Western and Eastern basins of the Atlantic Ocean.

2.2 Coastal Region Exploration. As part of the seismic exploration of the crustal structure, the margins of ocean basins and continental regions, where the transition from ocean to continent is found, need to be explored. This will take the form of a combined land and sea exploration program in which measurements on land will be made simultaneously with those at sea. This work will be done off the eastern and probably western coasts of the United States.

2.3 Continental Exploration. In the past year it has been found that the Colorado plateau and Rocky Mountains do not have great roots of 70-80 km as their heights have indicated. Instead, the continental crust is hardly different in structure from that of the low lands, being about 30 km in thickness. The result is that no hypothesis presently employed can describe a continental structure. This radical result needs confirmation in other regions, possibly in South America.

3. Microseisms.

Microseisms, the background noise that interferes with the recording of weak seismic signals, have been studied in detail recently, and it appears that they are connected with atmospheric disturbances such as severe storms. No particular project is planned specifically for studies of microseisms but increased meteorological and oceanographic studies (it is through the medium of the hydrosphere that the majority of microseismic energy is transmitted from the air to the earth) along with the new seismological stations, expecially in the Pacific and the Antarctic, will considerably increase the data available for research on microseisms.

4. Antarctic.

Since the Antarctic continent is almost an unknown quantity, seismologically speaking, it is of interest to treat it separately.

4.1 Station Seismographs. As mentioned under section 1, 3-component units will be installed at Byrd, Pole, Knox Coast and Adare Stations (in cooperation with New Zealand) if local conditions allow. These stations will provide a southern control for earthquakes in the Southern Hemisphere including those in the South Indian and South Atlantic Oceans. These observations will allow a more accurate delineation of the seismic belts of the Far South, including those which may extend into Antarctica. In addition it is expected that the units will give valuable information for determining the average ice thickness, provide data on microseisms, and give information concerning the impulsive development of cracks and crevasses formed by the movements of the inland and shelf ice.

4.2 Portable Seismographs. Observation made by these units will complement glaciological studies in the oversnow traverses, to be conducted during the Antarctic summers. These traverses will be made by teams of glaciologists whose objectives will include measurements of ice thickness. Portable seismographs will be used (i) to determine the thickness of the ice, point by point, on the inland ice, shelf ice, and on the valley glaciers, (ii) to obtain the vertical variation of velocity with depth in ice--expecially important in the upper few hundred feet where it indicates the gradation from firn to the underlying ice--and (iii) to determine the velocity of the elastic waves in the subglacial floor from which the nature of the bedrock can be ascertained or, in the case of floating shelf ice, the depth of water beneath it.

XIII. GRAVITY

The gravity program of the United States will consist of research activities in: 1) Pendulum and Gravimeter Measurements, 2) Underwater Gravimeter Measurements, 3) Submarine Pendulum Gravity Measurements, and 4) Earth Tide Studies.

1. Pendulum Gravimeter Measurements.

The International Geophysical Year affords an opportunity to significantly extend our knowledge of the earth's gravimetric field. Advantages will be taken of the occupation of remote areas and supply flights to such areas to allow pendulum and gravimeter measurements where none have ever been taken before. In addition, and perhaps most important, the connection of pendulum networks throughout the world will provide a much needed international common denominator for measurements with gravimeters, as well as help establish a first-order international pendulum network.

1.1 Pendulum Measurements. The pendulum provides an independent first-order measurement of gravity. A determination of gravity reliable to better than one-half of a miligal is obtained with the Gulf compound quartz pendulums. Since pendulum measurements require only about two days at each location, measurement series can be readily planned, using air transportation, connecting points on existing world networks with intermediary points for new measurements. In a special way it is hoped to complete three North-South meridional lines of measurements.

1.2 Gravimeter Measurements. Measurements with gravimeters are made with greater ease than with pendulums--about five minutes, as against about two days for a pendulum measurement. The gravimeter measurements, however, depend on pendulums or other first-order absolute stations for control since the measurements are relative. Also the absolute calibration of the instruments is dependent on reading between stations of known gravitational values. With the coverage of pendulum stations that is now anticipated, the gravimeter can be used to establish new second-order nets, and to provide connections between existing nets.

1.3 Observation sites and schedules. The pendulum and gravimeter studies will be carried out under the supervision of Dr. G. P. Woollard, University of Wisconsin. It is desirable, both from the standpoint of personnel and reliability of the gravimeter measurements, that the schedules be planned for minimum elapsed time and frequent connection to already established stations, but it is not now possible to list planned sites as such details are attendant upon arrangements covering transportation and discussions with other national committees.

Certain connections of pendulum networks can be mentioned, however, though still only tentative. For example, it is hoped that arrangements will be completed to make pendulum determinations at Rio de Janeiro, Brazil, and Balboa, Canal Zone. These two points would provide essential reference points for extending coverage in South America. Another important station will be at McMurdo Sound, Antarctica, with others possibly in Australia, New Zealand, and Japan.

Gravimeter series will be arranged on a more extended world-wide basis. For Arctic work it is planned to calibrate the gravimeters against the North American gravity range established jointly by the Dominion Observatory of Canada using the Cambridge compound invar pendulums, U. S. Coast and Geodetic Survey using the single invar Brown pendulums, and the Gulf pendulums of the University of Wisconsin. Points of connection to the world network will be based on Washington, D.C. with auxiliary ties to other bases in the North such as Thule, Greenland, and Pt. Barrow, Alaska.

1.4 Antarctic measurements. The pendulum station at McMurdo Sound will provide a base for gravimeter measurements at the other Antarctic bases. Gravity observations with gravimeters will also be made in conjunction with seismic and glacial studies by field expedition. On traverses based from McMurdo Sound, Little America Station, Byrd and Weddell Sea Stations, gravimeters will be employed (i) to determine the approximate ice thickness in support of seismic measurements (especially important in regions of poor seismic reflections), (ii) to study the underlying geology, and (iii) to study problems of isostatic compensation of Antarctica as a whole and the region of varied topographic relief.

1.5 Arctic Ice Floe Stations. At the two Arctic ice floe stations essentially driftless gravimeters, such as the Frost meter (a zero length spring type), the North American, or Western units, will be read daily throughout the period of occupation of the stations. As the ice-pack drifts in the Arctic Sea, a series of gravimeter readings will be obtained. These measurements will be based on ties at Point Barrow, Alaska; and Thule, Greenland.

2. Underwater Gravimeter Measurements.

Underwater gravimeter measurements are needed (i) for determining gravity information in the continental shelf areas, particularly in the zone from the coast out to about the fifty fathom line, (ii) in order to evaluate submarine gravimetric values at sea (other than port stations), and (iii) to accumulate knowledge concerning the nature of the crustal transition between continental and oceanic structures. These objectives will be met using surface vassels and underwater gravimeters placed on the ocean bottom. The operation area includes some work off the East Coast of the United States, the Gulf of Mexico and possibly the West Coast. It is desirable that these measurements should be made in areas where there are submarine gravity measurements.

3. Submarine Pendulum Gravity Measurements.

Approximately 64% of the earth is covered by water of depths greater than 2000 fathoms, where, with present technology, gravity can be determined only by the use of instruments carried on underwater vessels. It is hoped that submarine facilities will be available during the IGY to make these measurements.

This program is an important adjunct to the pendulum measurements planned for land areas and also provides means to study the structure and tectonics of continental margins, island arcs, ocean-island areas and, indirectly, the geology of the crust overlaid by deep water.

Although final arrangements are not yet consumated, it is hoped that some work will be done in the southern Pacific and Atlantic Oceans with approximately 20% of the available time used for such studies as detailed investigation of continental margins, oceanic islands, island arcs, ocean depths, and earthquake epicenter regions.

A project is in progress to develop a direct-or-quick reading gravimeter for submarine use. Such an instrument will greatly facilitate gravity measurements at sea and subsequent reduction of observed data.

4. Earth Tide Studies.

The objective of this project is an important determination of the rigidity of the earth at the tidal periods of approximately 12 to 24 hours. It is desired to observe the gravitational solar-lunar tide with two special LaCoste-Romberg gravimeters which provide a sensitivity about 10 fold greater than that previously available. The gravimeters will be modified to be relatively insensitive to the high level of microseisms encountered at island stations in mid-ocean. These gravity and tide observations will be of special value if taken during the IGY, because observations both of ocean tides and of meteorological conditions will be more extensive during this period. Accordingly, corrections and correlations involving these conditions (especially the ocean tides) can be more effectively made.

Measurements under the direction of Dr. L. B. Slichter, Institute of Geophysics, University of California at Los Angeles, include the following locations:

Austin, Texas, U. S. A.
Los Angeles, California, U. S. A.
Boston, Massachusetts, U. S. A.
Williams Bay, Wisconsin, U. S. A.
Wake or Marcus Island, Mariana Islands

Pre-IGY tests will be conducted in Hawaii and it is hoped that arrangements can be made with the various national committees to make measurements at Bermuda; the Azores; England; Rome, Italy; Cairo, Egypt; Bombay, India; and Japan.

5. Relations with Other Studies.

Besides the above-mentioned direct sutides in gravimetry, it is expected that some observations and results from the IGY Earth Satellite Program (i.e., studies dependent upon observations of perturbation of the orbits of the satellites) may contribute to our knowledge of the earth's gravimetric field and related geodetic work.

XIV GEOGRAPHICAL DISTRIBUTION

In this chapter the stations listed elsewhere in the report for Meteorology, Geomagnetism, Aurora and Airglow, Ionospheric Physics, Solar Activity, and Cosmic Rays are collected according to the geographic region and meridian lines set forth by CSAGI. The stations are listed alphabetically within each region and the CSAGI index number is given, where known.

Program Code

Meteorology	M
Geomagnetism	Gm
Aurora and Airglow	A
Ionospheric Physics	I
Solar Activity	SA
Cosmic Rays	C

Geographic Distribution Code

Northern Auroral Region — NA

The Northern Auroral Region is defined as a region of geomagnetic latitudes greater than 60°N or of geographic latitude greater than 60°N.

Northern Subauroral Belt — NB

This region extends between geomagnetic latitudes 45°N and 60°N, or between geomagnetic latitude 45°N and geographic latitude 60°N.

Northern Minauroral Belt — NC

This region extends between geomagnetic latitudes 20°N and 45°N.

Equatorial Belt — CE

This region extends from geomagnetic latitudes $\pm$ 20°.

Southern Minauroral Belt — SC

This region extends between geomagnetic latitudes 20° S and 45°S.

Southern Subauroral Belt — SB

This region extends between latitudes 45°S and 60°S, or between geomagnetic latitude 45°S and geographic latitude 60°S.

Southern Auroral Region — SA

The Southern Auroral Region is defined as a region of geomagnetic latitudes greater than 60°S or of geographic latitudes greater than 60°S.

The 10°East meridian line extends from 10°W to 30°E.
The 140° East meridian line extends from 120°E to 160°E.
The 180° meridian line extends from 160°E to 160°W.
The 70°--80°West meridian line extends from 95°W to 55°W.

XIV. GEOGRAPHICAL DISTRIBUTION

NORTHERN AURORAL REGION

1. U. S. STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NA 113	Anchorage	Alaska	61°10'N	149°55'W	Gm,I,M
NA 137	Atlantic Station B		56 30	51 00	M
NA 145	Atlantic Station C		52 45	35 30	M
NA 041	Barter Island	Alaska	70 08	143 30	A,Gm,I,M
NA 115	Bethel	Alaska	60 47	161 43	M
NA	Bettles	Alaska	66 54	151 50	A
NA 085	Big Delta	Alaska	64 09	145 51	Gm
NA 074	College	Alaska	64 51	147 50	A,C,Gm,I
NA 075	Fairbanks	Alaska	64 49	147 52	M
NA	Farewell	Alaska	62 30	153 49	A
NA	Ft. Greeley	Alaska	63 59	145 43	M
NA 065	Ft. Yukon	Alaska	66 34	145 18	A,Gm,I
NA 094	Healy	Alaska	63 51	149 05	Gm
NA	Ice Floe Station A	Arctic	78	160	A,Gm,M
NA	Ice Floe Station B	Arctic	85	100	I,M
NA 064	Kotzebue	Alaska	66 40	162 30	A,Gm,M
NA	Matanuska	Alaska	61 34	149 16	M
NA 095	McGrath	Alaska	62 58	155 37	M
NA 079	Nome	Alaska	64 30	165 26	I,M
NA 096	Northway	Alaska	62 58	141 57	Gm
NA 035	Pt. Barrow	Alaska	71 20	156 46	A,Gm,I,M
NA 136	Sitka	Alaska	57 03	135 20	Gm,I
NA	Skwentna	Alaska	61 53	151 32	A,I
NA 126	Yakutat	Alaska	59 31	139 40	M

2. COOPERATIVE STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NA 003	Alert, Ellesmere Is.	Canada	82°33'N	62°35'W	M
NA 062	Davis Strait	Canada	67	58	Rockets
NA 006	Eureka, Ellesmere Is.	Canada	80 13	86 11	M
NA 129	Ft. Churchill	Canada	58 46	94 10	Rockets,C(tent)
NA 089	Frobisher Bay	Canada	63 28	67 23	Rockets,I(tent)
NA	Godhavn	Greenland	69 15	53 30	I
NA 010	Isachsen, NWT	Canada	78 47	103 32	M
NA 055	Kiruna	Sweden	67 50	20 15 E	A,I
NA 139	Knob Lake	Canada	54 48	66 49 W	A,I
NA	Meanook	Canada	54 37	113 20	A,I

NORTHERN AURORAL REGION

2. COOPERATIVE STATIONS - cont.

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NA 020	Mould Bay	Canada	76°17'N	119°28'W	M
NA 112	Narsarssuak	Greenland	61 11	45 25	Gm,I,M
NA 024	Resolute, Cornwallis	Canada	74 43	94 59	M
NA 086	Reykjavik	Iceland	63 57	22 37	I,M
NA	Sachs Habor	Canada	72 00	125 30	A
NA 147	Saskatoon	Canada	52 08	106 40	A,C
NA 019	Thule	Greenland	76 33	68 50	A,C,Gm, I,M

XIV. GEOGRAPHICAL DISTRIBUTION

NORTHERN SUBAURORAL BELT

1. U. S. STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NB 296	Adak	Alaska	51°54'N	176°39'W	I,M
NB	Albany, N.Y.	USA	42 45	73 48	M
NB 424	Alexandria Bay, N.Y.	USA	44 20	75 54	A
NB 453	Ann Arbor, Mich.	USA	42 17	83 44	SA
NB 245	Annette	Alaska	55 02	131 34	M
NB	Astoria, Ore.	USA	46 13	123 52	M
NB 427	Atlantic Station D		44	41	M
NB 504	Atlantic Station E		35	48	M
NB	Attu, Aleutian Is.	Alaska	52 50	173 11 E	M
NB 403	Battle Creek, Mich.	USA	42 19	85 11 W	A,I
NB	Belmar, N.J.	USA	40 11	74 04	M
NB	Bend, Ore.	USA	44 04	121 20	A
NB	Bill, Wyo.	USA	43 15	105 18	I
NB 385	Bismarck, N.Dak.	USA	46 46	100 45	C,M
NB	Black Hills, N.Dak.	USA	45	103	A
NB	Blue Hill, Mass.	USA	42 13	71 07	M
NB 435	Boise, Idaho	USA	43 34	116 13	M
NB 455	Boston, Mass.	USA	42 21	71 04	Gm,M
NB 473	Boulder, Colo.	USA	40 02	105 18	A,Gm,I,SA
NB 440	Buffelo, N.Y.	USA	43 07	78 55	M
NB 449	Cambridge, Mass.	USA	42 25	71 10	A
NB 382	Caribou, Maine	USA	46 52	68 01	M
NB 442	Casper, Wyo.	USA	42 51	106 18	Gm
NB	Charlottesville, Va.	USA	38 02	78 13	I
NB 492	Cheltenham, Md.	USA	38 44	76 50	C
NB 457	Chicago, Ill.	USA	41 50	87 50	A,C
NB 496	Chincoteague, Va.	USA	37 56	75 23	SA
NB	Cleveland, Ohio	USA	41 24	81 51	M
NB 480	Climax, Colo.	USA	39 22	106 11	C,Gm,SA
NB 243	Cold Bay	Alaska	55 12	162 43	M
NB 487	Columbia, Mo.	USA	38 58	92 22	C,M
NB	Columbus, Ohio	USA	39 58	83 00	M
NB 357	Coulee Dam, Wash.	USA	47 58	119 00	A
NB	Davis, Calif.	USA	38 32	121 45	M
NB 476	Dayton, Ohio	USA	39 52	84 07	M

NORTHERN SUBAURORAL BELT

1. U. S. STATIONS - cont.

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NB 479	Denver, Colo.	USA	39°46'N	104°53'W	A,Gm,M
NB 484	Derwood, Md.	USA	39 07	77 10	C
NB 497	Dodge City, Kansas	USA	37 46	99 58	M
NB	East Lansing, Mich.	USA	42 42	84 28	M
NB	East Wareham, Mass.	USA	41 46	70 40	M
NB 467	Elmhurst, L.I.,N.Y.	USA	40 44	73 53	A
NB 481	Ely, Nevada	USA	39 17	114 52	M
NB 381	Fargo, N.Dak.	USA	46 53	96 47	A
NB 483	Fayette, Mo.	USA	39 08	92 40	A
NB	Flint, Mich.	USA	45 58	83 44	M
NB	Ft. Belvoir, Va.	USA	38 44	77 08	I
NB 471	Ft. Monmouth, N.J.	USA	40 15	74 01	I
NB 495	Fredricksburg, Va.	USA	38 12	77 22	Gm
NB 488	Front Royal, Va.	USA	38 56	78 11	I
NB	Glasgow, Mont.	USA	48 13	106 37	M
NB 463	Glen Rock, N.J.	USA	40 58	74 09	A
NB	Grafton, N.Y.	USA	42 47	73 27	SA
NB 485	Grand Junction, Colo.	USA	39 07	108 37	M
NB	Grand Lake, Colo.	USA	40 15	105 51	M
NB	Grandview, Mo.	USA	38 50	94 33	M
NB 366	Great Falls, Mont.	USA	47 29	111 21	A,M
NB 421	Green Bay, Wis.	USA	44 29	88 08	M
NB 501	Greensboro, N.C.	USA	36 05	79 57	M
NB 459	Hamden, Conn.	USA	41 22	72 58	A
NB 433	Hanover, N.H.	USA	43 42	72 18	A,I
NB 503	Hatteras, N.C.	USA	35 13	75 41	M
NB	Indianapolis, Ind.	USA	39 44	86 16	M
NB 344	International Falls, Minn.	USA	48 34	93 23	M
NB 448	Ithaca, N.Y.	USA	42 27	76 31	A,I,M,SA
NB 454	Jackson, Mich.	USA	42 17	84 27	A
NB 457	Kalamazoo, Mich.	USA	42 20	85 38	A
NB 213	King Salmon (Naknek)	Alaska	58 42	156 42	A,M
NB	Kodiak	Alaska	57 45	152 31	M
NB 443	Lander, Wyo.	USA	42 48	108 43	M
NB 486	Lawrence, Kansas	USA	38 58	95 14	Gm
NB	Lemont, Ill.	USA	41 42	87 59	M

NORTHERN SUBAURORAL BELT

1. U. S. STATIONS - cont.

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NB	Lexington, Ky.	USA	38°02'N	84°30'W	M
NB 482	Limon, Colo.	USA	39 16	103 40	Gm
NB 465	Lincoln, Nebr.	USA	40 49	96 41	C,M
NB 505	Little Rock, Ark.	USA	34 44	92 14	M
NB	Madison, Wis.	USA	43 08	89 20	M
NB 348	Malott, Wash.	USA	48 17	119 43	A
NB 416	Massena, N.Y.	USA	44 57	74 54	A
NB 450	Medford, Ore.	USA	42 22	122 52	M
NB 458	Meriden, Conn.	USA	41 32	72 48	A
NB 415	Minneapolis, Minn.	USA	44 58	93 41	C
NB 213	Naknek	Alaska	58 44	157 02	I
NB 461	Nantuckett, Mass.	USA	41 15	70 04	A,M
NB 500	Nashville, Tenn.	USA	36 07	86 41	M
NB	Newport, R.I.	USA	41 30	71 19	M
NB	Newtown, N.Dak.	USA	48	102	A
NB	New York, N.Y.	USA	40 30	73 47	M
NB 498	Norfolk, Va.	USA	36 53	76 12	M
NB 462	North Platte, Nebr.	USA	41 08	100 41	M
NB 502	Oklahoma City, Okla.	USA	35 24	97 36	M
NB 460	Omaha, Nebr.	USA	41 22	96 01	M
NB 447	Orono, Maine	USA	44 53	68 41	A
NB 428	Oshkosh, Wis.	USA	44 00	88 30	A
NB	Peoria, Ill.	USA	40 40	89 41	M
NB	Philippsburg, Kansas	USA	39 45	99 18	Gm
NB 470	Pittsburgh, Penn.	USA	40 30	80 13	M
NB	Pocatello, Idaho	USA	42 50	112 25	A
NB 455	Pontiac, Mich.	USA	42 40	83 18	SA
NB 434	Portland, Maine	USA	43 39	70 19	M
NB 409	Portland, Ore.	USA	45 30	122 37	A
NB	Prosser, Wash.	USA	46 15	119 45	M
NB	Pullman, Wash.	USA	46 43	117 10	A,I
NB 426	Rapid City, S.Dak.	USA	44 02	103 03	M
NB	Richland, Wash.	USA	46 34	119 35	M
NB 438	Rochester, N.Y.	USA	43 08	77 35	A
NB 408	St. Cloud, Minn.	USA	45 35	94 11	M

NORTHERN SUBAURORAL BELT

1. U. S. STATIONS - cont.

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NB 220	St. Paul Island	Alaska	57°09'N	170°13'W	M
NB	Salem, Ore.	USA	44 55	123 01	M
NB	Salt Lake City, Utah	USA	40 46	111 58	M
NB 389	Sault Ste. Marie, Mich.	USA	46 28	84 22	M
NB	Sayville, N.Y.	USA	40 46	73 05	M
NB	Seabrook, N.J.	USA	39 30	75 14	M
NB	Seattle, Wash.	USA	47 45	122 25	I,M
NB 360	Seattle-Tacoma, Wash.	USA	47 27	122 18	M
NB	Schenectady, N.Y.	USA	42 50	73 53	M
NB 394	Shingleton, Mich.	USA	46 21	86 28	A
NB 499	Shiprock, N.Mex.	USA	36 47	108 41	Gm
NB 364	Spokane, Wash.	USA	47 37	117 31	M
NB	Stillwater, Okla.	USA	36 05	97 04	M
NB 475	Swarthmore, Penn.	USA	39 54	75 21	A,C
NB 347	Tatoosh Isl., Wash.	USA	48 23	124 44	M
NB	Topeka, Kansas	USA	39 04	95 37	M
NB 464	Tuckahoe, N.Y.	USA	40 57	73 49	A
NB 209	Unalaska	Alaska	53 53	166 32	A,I
NB 466	University Park, Pa.	USA	40 48	77 56	I,M
NB	Upton, N.W.	USA	40 52	72 53	M
NB 439	Utica, N.Y.	USA	43 07	75 13	A
NB 469	Wasatch, Utah	USA	40 34	111 46	Gm
NB 489	Washington, D.C.	USA	38 55	77 00	A,C,I,M,SA
NB	Washington, D.C. (Silver Hill, Md.)	USA	38 50	76 57	M
NB 468	West Hempstead, N.Y.	USA	40 42	73 39	A
NB 436	West Scarboro, Maine	USA	43 34	70 22	A
NB 446	Williams Bay, Wis.	USA	42 34	88 03	A
NB 419	Wilton, Maine	USA	44 35	70 12	A
NB	Winnemucca, Nevada	USA	40 54	117 48	M
NB 456	Wrentham, Mass.	USA	42 03	71 20	A

NORTHERN SUBAURORAL BELT

2. COOPERATIVE STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NB	Argentia, Nfld.	Canada	47°18'N	54°00'W	M
NB	Bitburg	Germany	49 57	6 34 E	M
NB	Chaumont	France	48 04	5 02	M
NB	Father Point, Que.	Canada	48 05	58 05 W	I
NB	Harmon AFB, Nfld.	Canada	48 44	58 34	M
NB 494	Lajes, Azores	Portugal	38 30	28 00	M
NB	St. Johns, Nfld.	Canada	47 33	52 45	I,M
NB	Stockholm	Sweden	59 21	17 57 E	I
NB	Wiesbaden	Germany	50 03	8 20	M

XIV. GEOGRAPHICAL DISTRIBUTION

NORTHERN MINAURORAL BELT

1. U. S. STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NC	Alamagordo, N.Mex.	USA	32° 54'N	105° 58'W	A,I,SA
NC 850	Albrook AFB	Canal Zone	8 58	79 34	M
NC 738	Albuquerque, N.Mex.	USA	35 03	106 37	C,M
NC	Amarillo, Texas	USA	35 03	106 37	M
NC	Apalachicola, Fla.	USA	29 44	84 59	M
NC	Athens, Ga.	USA	33 57	83 19	M
NC 755	Atlanta, Ga.	USA	33 39	84 25	M
NC 697	Berkeley, Calif.	USA	37 52	122 18	C
NC 807	Brownsville, Texas	USA	25 54	97 26	M
NC 801	Burrwood, La.	USA	28 59	89 22	M
NC 765	Charleston, S.C.	USA	32 54	80 02	M
NC	Cocoa, Fla.	USA	28 14	80 36	M
NC	Columbia, S.C.	USA	34 00	81 02	I
NC	Corpus Christi, Tex.	USA	27 46	97 26	M
NC 767	Dallas, Texas	USA	32 47	96 48	A
NC	Del Rio, Texas	USA	29 20	100 53	M
NC 779	El Paso, Texas	USA	31 48	106 24	M
NC	Flagstaff, Ariz.	USA	35 12	111 40	M
NC	Ft. Amador	Canal Zone	8 56	79 33	I
NC	Ft. Davis, Texas	USA	30 04	105 07	SA
NC	Ft. Huachuca, Ariz.	USA	31 35	110 20	M
NC 849	Ft. Randolph	Canal Zone	9 23	79 53	I
NC	Ft. Worth, Texas	USA	32 46	97 25	M
NC	Fresno, Calif.	USA	36 46	119 43	M
NC 799	Gainesville, Fla.	USA	29 38	82 18	I,M
NC	Griffin, Ga.	USA	33 17	84 17	M
NC 825	Hilo, T.H.	Hawaii	19 44	155 04	M
NC 817	Honolulu, T.H.	Hawaii	21 18	158 06	Gm
NC	Inyokern, Calif.	USA	35 39	117 40	M
NC	Jackson, Miss.	USA	32 20	90 13	M
NC 788	Jacksonville, Fla.	USA	38 25	81 39	M
NC 810	Key West, Fla.	USA	24 33	81 47	I,M
NC	Kihei, Maui	Hawaii	21 16	157 40	Gm
NC 791	Lake Charles, La.	USA	30 13	93 09	M
NC 721	Las Vegas, Nevada	USA	36 05	115 09	M

NORTHERN MINAURORAL BELT

1. U. S. STATIONS - cont.

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NC 825	Lihue, T.H.	Hawaii	21°59'N	159°21'W	M
NC 741	Los Angeles, Calif.	USA	34 03	118 15	M
NC	Makapuu Pt., Oahu	Hawaii	21 16	157 40	C,SA
NC	Mayagüez	Puerto Rico	18 11	67 07	I
NC 808	Miami, Fla.	USA	25 49	80 17	M
NC 778	Midland, Texas	USA	31 56	102 12	M
NC	Midway	Pacific	28 13	177 22	M
NC	Montgomery, Ala.	USA	32 23	86 21	M
NC 745	Mt. Wilson, Calif.	USA	34 14	118 04	SA
NC 700	Oakland, Calif.	USA	37 44	122 12	M
NC	Oakridge, Tenn.	USA	35 55	84 19	M
NC	Pt. Mugu, Calif.	USA	34 11	119 05	Rockets
NC 797	Pacific Station N		30	140	M
NC 751	Pacific Station V		34	164	M
NC 760	Phoenix, Ariz.	USA	33 26	112 01	M
NC	Rio Piedras	Puerto Rico	18 24	66 03	C
NC	Riverside, Calif.	USA	33 58	117 28	M
NC 768	Sacramento Peak, N.Mex.	USA	32 43	105 45	A,C,SA
NC 800	San Antonio, Texas	USA	29 32	98 28	M
NC 790	San Diego, Calif.	USA	32 43	117 12	M
NC 832	San Juan	Puerto Rico	18 26	66 00	Gm,M
NC 744	Santa Barbara, Calif.	USA	34 25	119 51	C
NC 740	Santa Maria, Calif.	USA	34 54	120 27	M
NC	Santa Monica, Calif.	USA	34 01	118 27	M
NC	Shreveport, La.	USA	32 28	93 49	M
NC 706	Stanford, Calif.	USA	37 26	122 10	A,I
NC	St. George, Utah	USA	37 07	113 34	M
NC 836	Swan Island		17 24	83 56	M
NC	Table Mountain, Calif.	USA	34 22	117 41	M
NC	Tallahassee, Fla.	USA	30 26	84 18	M
NC 804	Tampa, Fla.	USA	27 58	82 32	M
NC	Tonopa, Nevada	USA	38 04	117 13	M
NC 775	Tucson, Ariz.	USA	32 14	110 57	Gm,M
NC	Valpariso, Fla.	USA	30 29	86 31	M
NC	West Palm Beach, Fla.	USA	26 41	80 06	M
NC	West Florida	USA			I
NC 703	White Mountains, Cal.	USA	37 37	118 12	C
NC 772	White Sands, N.Mex.	USA	32 24	106 52	Rockets
NC	Yuma, Ariz.	USA	32 52	113 56	M

NORTHERN MINAURORAL BELT

2. COOPERATIVE STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NC 733	Bermuda	UK	32°20'N	64°55'W	I,M
NC 816	Camaguey	Cuba	21 25	77 52	M
NC 847	Curacao, W.Ind.	Netherlands	12 11	68 59	M
NC	Eleuthera	UK	25 16	76 18	M
NC	Grand Bahamas	UK	26 37	78 20	M
NC 828	Grand Cayman, W.Ind.	UK	19 15	81 51	M
NC 837	Guadeloupe, W.Ind.	France	16 16	61 32	M
NC 823	Guantanamo Bay	Cuba	19 54	75 09	I,M
NC 812	Havana	Cuba	23 09	82 21	M
NC	Kimpo	Korea	37 34	126 42 E	M
NC 835	Kingston, Jamaica	UK	17 56	76 47 W	M
NC	Masulpo	Korea	33 31	126 32 E	M
NC 811	Mazatlan, Sinaloa	Mexico	23 14	106 25 W	M
NC 819	Merida, Yucatan	Mexico	20 58	89 37	M
NC	Port Lyautey,Fr.Afr.	France	34 18	6 34	M
NC 750	Rabat	Morocco	34 00	6 50	I
NC 829	Sabana de la Mar	Dom.Rep.	19 03	69 23	M
NC 846	St. Andrews Is.	Colombia	12 30	81 40	M
NC 834	St. Maarten, W.Ind.	Netherlands	18 02	63 06	M
NC 827	Tacubaya, D.F.	Mexico	19 24	99 12	M
NC 730	Tokyo	Japan	34 40	139 45 E	I
NC 831	Tonanzintla	Mexico	19 02	98 02 W	A,I
NC	Trinidad, W.Ind.	UK	10 40	61 32	M
NC 764	Tripoli	Libya	22 06	13 12 E	M
NC 830	Vera Cruz	Mexico	19 11	96 07 W	M
NC	Yokosuka	Japan	34 17	139 46 E	M

XIV. GEOGRAPHICAL DISTRIBUTION

EQUATORIAL BELT

1. U. S. STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
CE 112	Canton Isl., Phoenix	US Trust	2°46'N	171°43'W	M
CE 104	Eniwetok, Marshall	US Trust	11 20	162 20 E	M
CE 096	Guam	US Trust	13 34	144 55	Gm,M
CE	Iwa Jima	US Trust	24 44	141 20	M
CE 115	Jarvis Isl.	US Trust	0 23 S	160 03 W	Gm
CE 113	Johnston Is.	US Trust	16 44 N	169 31	M
CE 088	Koror, Caroline I.	US Trust	7 20	134 29 E	Gm,M
CE 107	Kwajalein, Marshall	US Trust	8 43	167 44	M
CE 109	Majuro, Marshall	US Trust	7 05	171 23	M
CE 086	Okinawa	US Trust	26 20	127 40	I,M
CE	Palmyra	US Trust	5 53	162 05 W	Gm
CE 102	Ponape, Caroline	US Trust	7 28	158 13 E	M
CE 100	Truk	US Trust	7 28	151 51	M
CE 105	Wake	US Trust	19 17	166 39	M
CE 092	Yap Is., Caroline	US Trust	9 31	138 08	M

2. COOPERATIVE STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
CE	Accra	Gold Coast	5° N	0°	I
CE	Antofogasta	Chile	23 26'S	70 28'W	I,M
CE 132	Arequipa	Peru	16 28	71 30	I
CE 080	Baguio	Philippines	16 25 N	120 36 E	I
CE 130	Bogota	Colombia	4 32	74 15 W	I
CE	Chacaltaya	Bolivia	16 19 S	68 10	C,M
CE	Chiclayo	Peru	6 49	79 46	I
CE	Chimbote	Peru	9 06	78 22	I
CE	Clorinda	Argentina	25 13	57 50	I
CE 078	Clark AFB	Philippines	15 10 N	120 34 E	M
CE 128	Huancayo	Peru	12 03 S	75 20 W	A,Gm,I
CE 124	Guayaquil	Ecuador	2 10	79 53	I,M
CE 138	La Paz	Bolivia	16 29	68 03	I
CE 127	Lima	Peru	12 04	77 02	M
CE 080	Manila	Philippines	14 31 N	121 00 E	M

EQUATORIAL BELT

2. COOPERATIVE STATIONS - cont.

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
CE	Natal	Brazil	5°20'S	35°07'W	I
CE 158	Rio de Janeiro	Brazil	22 54	43 14	I
CE 158	Sao Paulo	Brazil	23 33	46 38	I
CE 069	Singapore, Malaya	UK	1 14 N	130 55 E	I
CE 123	Talara	Peru	4 34 S	81 15 W	I
CE 125	Trujillo	Peru	8	79	I

XIV. GEOGRAPHICAL DISTRIBUTION

SOUTHERN MINAURORAL BELT

COOPERATIVE STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
SC 631	Concepcion	Chile	36°45'S	72°59'W	I
SC 732	Darwin	Australia	12 20	130 59 E	I
SC	Falkland Isl.	UK	51 45	57 52 W	I
SC 702	Johannesburg	U. of S.Afr.	26 12	28 05 E	I
SC	Puerto Montt	Chile	41 28	72 47 W	M
SC	Quintero	Chile	32 47	71 32	M
SC 671	San Juan	Argentina	31 40	68 35	A

XIV. GEOGRAPHICAL DISTRIBUTION

SOUTHERN SUBAURORAL BELT

COOPERATIVE STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
SB	Camden	Australia	34°09'S	150°38'E	A
SB	Campbell Island	New Zealand	52 32	169 09	A
SB 208	Dunedin	New Zealand	45 52	170 32	C,I
SB	Invercargill	New Zealand	46 25	168 22	A
SB •	Sydney	Australia	33 53	151 12	I
SB 219	Wellington	New Zealand	41 17	174 46	I

XIV. GEOGRAPHICAL DISTRIBUTION

SOUTHERN AURORAL REGION

1. U. S. STATIONS

CSAGI No.	Station	Country	Latitude		Longitude		Program
SA 004	Byrd Station	Antarctica	80°	S	120°	W	A,Gm,I,M
SA 009	Little America	Antarctica	77		164		A,C,Gm,I,M
SA 001	Pole Station	Antarctica	90		-		A,Gm,I,M
SA 020	Knox Coast	Antarctica	67		105	E	A,C,Gm,I,M
SA 011	Weddell Sea	Antarctica	77		35	W	A,I,M
SA 007	Williams Air Operation Facility (McMurdo Sound)	Antarctica	77 50		100 36	W	M

2. COOPERATIVE STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	Program
SA	Cape Adare	New Zealand	71°19'S	170°15'W	A,Gm,I,M
SA 044	Macquarie Island	Australia	54 30	158 45 E	I
SA 026	Port Lockroy, Palmer Peninsula	UK	64 49	63 33 W	I

XIV. GEOGRAPHICAL DISTRIBUTION

10° E. MERIDIAN LINE

COOPERATIVE STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	Program
CE	Accra	Gold Coast	5° N	0°	I
NB	Bitburg	Germany	49 57'	6 34'E	M
NB	Chaumont	France	48 04	5 02	M
SC 702	Johannesburg, Transvaal	U. of S. Africa	26 12 S	28 05	I
NC	Port Lyautey, Fr.Afr.	France	34 18 N	6 34 W	M
NC	Rabat	Morocco	34 00	6 30	I
NA 055	Kiruna	Sweden	67 50	20 15 E	A,I
NB	Stockholm	Sweden	59 21	17 57	I
NC 764	Tripoli	Libya	32 06	13 12	M
NB	Wiesbaden	Germany	50 03	8 20	M

XIV. GEOGRAPHICAL DISTRIBUTION

140° E. MERIDIAN LINE

1. U. S. STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
CE 096	Guam	US Trust	13°34'N	144°55'E	Gm,M
CE	Iwo Jima	US Trust	24 44	141 20	M
CE 088	Koror, Caroline I.	US Trust	7 20	134 29	Gm,M
CE 086	Okinawa	US Trust	26 20	127 40	I,M
CE 102	Ponape, Caroline I.	US Trust	7 28	158 13	M
CE 100	Truk, Caroline I.	US Trust	7 28	151 51	M
CE 092	Yap, Caroline I.	US Trust	9 31	138 08	M

2. COOPERATIVE STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
CE 080	Baguio	Philippines	16°25'N	120°36'E	I
SB	Camden	Australia	34 09 S	150 38	A
CE 078	Clark AFB	Philippines	15 10 N	120 34	M
SC 732	Darwin	Australia	12 20 S	130 59	I
NC	Kimpo	Korea	37 34 N	126 42	M
SA 044	Macquarie Is.	Australia	54 30 S	158 45	I
CE 080	Manila	Philippines	14 31 N	121 00	M
NC	Masulpo	Korea	33 31	126 32	M
CE 069	Singapore, Malaya	UK	1 14	130 55	I
SB	Sydney	Australia	33 53 S	151 12	I
NC 730	Tokyo	Japan	34 40 N	139 45	I
NC	Yokosuka	Japan	35 17	139 46	M

XIV GEOGRAPHICAL DISTRIBUTION

180° Meridian Line

1. U. S. STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NB 296	Adak	Alaska	51°54'N	176°39'W	I,M
NB	Attu, Aleutian Is.	Alaska	52 50	173 11 E	M
NA 115	Bethel	Alaska	60 47	161 43 W	M
CE 112	Canton (Phoenix Is.)	U.S. Trust	2 46 S	171 43	M
NB 243	Cold Bay	Alaska	55 12 N	162 43	M
CE 104	Eniwetok (Marshall Is.)	U.S. Trust	11 20	162 20 E	M
NA	Ice Floe Station A	Arctic	78	160 W	A, Gm, M
CE 115	Jarvis Is.	U.S. Trust	0 23 S	160 03	Gm
CE 113	Johnston Is.	U.S. Trust	16 44 N	169 31	M
NA 064	Kotzebue	Alaska	66 40	162 30	A, Gm, M
CE 107	Kwajalein (Marshall Is.)	Pacific	8 43	167 44 E	M
SA 009	Little America	Antarctica	77 S	164 W	A, C, Gm, I,M
CE 109	Majuro, Marshall Is.	U.S. Trust	7 05 N	171 23 E	M
NC	Midway	U.S. Trust	28 13	177 22 W	M
NA 079	Nome	Alaska	64 30	165 26	I, M
CE	Palmyra Is.	U.S. Trust	5 53	162 05	Gm
NB 220	St. Paul Is.	Alaska	57 09	170 13	M
NB 209	Unalaska	Alaska	53 53	166 32	A, I
CE 105	Wake Is.	U.S. Trust	19 17	166 39	M

2. COOPERATIVE STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
SA	Cape Adare	New Zealand	71°19'S	170°15'W	A,I,Gm,M
SB 208	Dunedin	New Zealand	45 52	170 32 E	C,I
SB	Invercargill	New Zealand	46 25	168 22	A,Gm, M
SB 219	Wellington	New Zealand	41 17	174 46	I

XIV. GEOGRAPHICAL DISTRIBUTION

70° - 80° W MERIDIAN

1. U. S. STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NB	Albany, N.Y.	USA	42°45'N	73°48'W	M
NC 850	Albrook AFB	Puerto Rico	8 58	79 34	M
NB 424	Alexandria Bay, N.Y.	USA	44 20	75 54	A
NB 453	Ann Arbor, Mich.	USA	42 17	83 44	SA
NC	Apalachicola, Fla.	USA	29 44	84 59	M
NC	Athens, Ga.	USA	33 57	83 19	M
NC 755	Atlanta, Ga.	USA	33 39	84 25	M
NB 403	Battle Creek, Mich.	USA	42 19	85 11	A,I
NB	Belmar, N.J.	USA	40 11	74 04	M
NB	Blue Hill, Mass.	USA	42 13	71 07	M
NB 455	Boston, Mass.	USA	42 21	71 04	Gm,M
NB 440	Buffalo, N.Y.	USA	43 07	78 55	M
NC 801	Burrwood, La.	USA	28 59	89 22	M
NB 449	Cambridge, Mass.	USA	42 25	71 10	A
NB 382	Caribou, Maine	USA	46 52	68 01	M
NC 765	Charleston, S.C.	USA	32 54	80 02	M
NB	Charlottesville, Va.	USA	38 02	78 13	I
NB 492	Cheltenham, Md.	USA	38 44	76 50	C
NB 457	Chicago, Ill.	USA	41 50	87 50	A,C
NB 496	Chincateague, Va.	USA	37 56	75 23	SA
NB	Cleveland, Ohio	USA	41 24	81 51	M
NC	Cocoa, Fla.	USA	28 14	80 36	M
NC	Columbia, S.C.	USA	34 00	81 02	I
NB 487	Columbia, Mo.	USA	38 58	92 22	C,M
NB	Columbus, Ohio	USA	39 58	83 00	M
NB 476	Dayton, Ohio	USA	39 52	84 07	M
NB 484	Derwood, Md.	USA	39 07	77 10	C
NB	East Lansing, Mich.	USA	42 42	84 28	M
NB	East Wareham, Mass.	USA	41 46	70 40	M
NB 467	Elmhurst,L.I.,N.Y.	USA	40 44	73 53	A
NC	Ft. Amador	Canal Zone	8 56	79 33	I
NB	Ft. Belvoir, Va.	USA	38 44	77 08	I
NB 471	Ft. Monmouth, N.J.	USA	40 15	74 01	I
NC 849	Ft. Randolph	Canal Zone	9 23	79 53	I
NB 483	Fayette, Mo.	USA	39 08	92 40	A

70° - 80° W MERIDIAN

1. U. S. STATIONS - cont.

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NB	Flint, Mich	USA	45°58'N	83°44'W	M
NB 495	Fredricksburg, Va.	USA	38 12	77 22	Gm
NB 488	Front Royal, Va.	USA	38 56	78 11	I
NC 799	Gainesbille, Fla.	USA	29 38	82 18	I,M
NB 463	Glen Rock, N.J.	USA	40 58	74 09	A
NB	Grafton, N.Y.	USA	42 47	73 27	SA
NB	Grandview, Mo.	USA	38 50	94 33	M
NB 421	Green Bay, Wis.	USA	44 29	88 08	M
NB 501	Greensboro, N.C.	USA	36 05	79 57	M
NC	Griffin, Ga.	USA	33 17	84 17	M
NB 459	Hamden, Conn.	USA	41 22	72 58	A
NB 433	Hanover, N.H.	USA	43 42	72 18	A,I
NB 503	Hatteras, N.C	USA	35 13	75 41	M
NB	Indianapolis, Ind.	USA	39 44	86 16	M
NB 344	International Falls, Minn.	USA	48 34	93 23	M
NB 448	Ithaca, N.Y.	USA	42 27	76 31	A,I,M,SA
NB 454	Jackson, Mich.	USA	42 17	84 27	A
NC	Jackson, Mo.	USA	32 20	90 13	M
NC 788	Jacksonville, Fla.	USA	30 25	81 39	M
NB 457	Kalamazoo, Mich.	USA	42 20	85 38	A
NC 810	Key West, Fla.	USA	24 33	81 47	M
NC 791	Lake Charles, La.	USA	30 13	93 09	M
NB	Lemont, Ill.	USA	41 42	87 59	M
NB	Lexington, Ky.	USA	38 02	84 30	M
NB 505	Little Rock, Ark.	USA	34 44	92 14	M
NB	Madison, Wis.	USA	43 08	89 20	M
NB 416	Massena, N.Y.	USA	44 57	74 54	A
NC	Mayagüez	Puerto Rico	18 11	67 07	I
NB 458	Meriden, Conn.	USA	41 32	72 48	A
NC 808	Miami, Fla.	USA	25 49	80 17	M
NB 415	Minneapolis, Minn.	USA	44 58	93 41	C
NC	Montgomery, Ala.	USA	32 23	86 21	M
NB 461	Nantuckett, Mass.	USA	41 15	70 04	A,M
NB 500	Nashville, Tenn.	USA	36 07	86 41	M
NB	Newport, R.I.	USA	41 30	71 19	M

70° - 80° W MERIDIAN

1. U. S. STATIONS - cont.

CSAGI No.	Station	Country	Latitude	Longitude	IGY Program
NB	New York, N.Y.	USA	40°30'N	73°47'W	M
NB 498	Norfolk, Va.	USA	36 53	76 12	M
NC	Oakridge, Tenn.	USA	35 55	84 19	M
NB 447	Orono, Maine	USA	44 53	68 41	A
NB 428	Oshkosh, Wis.	USA	44 00	88 30	A
NB	Peoria, Ill.	USA	40 40	89 41	M
NB 470	Pittsburgh, Penn.	USA	40 30	80 13	M
NB 455	Pontiac, Mich.	USA	42 40	83 18	SA
NB 434	Portland, Maine	USA	43 39	70 19	M
NC	Ramey AFB	Puerto Rico	18 30	67 12	I
NC	Rio Piedras	Puerto Rico	18 24	66 03	C
NB 438	Rochester, N.Y.	USA	43 08	77 35	A
NC 832	San Juan	Puerto Rico	18 26	66 00	Gm,M
NB 408	St. Cloud, Minn.	USA	45 35	94 11	M
NB 389	Sault Ste. Marie, Mich.	USA	46 28	84 22	M
NB	Sayville, N.Y.	USA	40 46	73 05	M
NB	Seabrook, N.J.	USA	39 30	75 14	M
NB	Schenectady, N.Y.	USA	42 50	73 53	M
NB 394	Shingleton, Mich.	USA	46 21	86 28	A
NC	Shreveport, La.	USA	32 28	93 49	M
NC 836	Swan Island		17 24	83 56	M
NB 475	Swarthmore, Penn.	USA	30 54	75 21	A,C
NC	Tallahassee, Fla.	USA	30 26	84 18	M
NC 804	Tampa, Fla.	USA	27 58	82 32	M
NB 464	Tuckahoe, N.Y.	USA	40 57	73 49	A
NB 466	University Park, Pa.	USA	40 48	77 56	I,M
NB	Upton, N.Y.	USA	40 52	72 53	M
NB 439	Utica, N.Y.	USA	43 07	75 13	A
NC	Valpariso, Fla.	USA	30 29	86 31	M
NB 489	Washington, D.C.	USA	38 55	77 00	A,C,I,M,SA
NB 468	West Hempstead, N.Y.	USA	40 42	73 39	A
NC	West Palm Beach, Fla.	USA	26 41	80 06	I (tent),M
NB 436	West Scarboro, Maine	USA	43 34	70 22	A
NB 446	Williams Bay, Wis.	USA	42 34	88 03	A
NB 419	Wilton, Maine	USA	44 35	70 12	A
NB 456	Wrentham, Mass.	USA	42 03	71 20	A

70° - 80° W. MERIDIAN

2. COOPERATIVE STATIONS

CSAGI No.	Station	Country	Latitude	Longitude	Program
NA 003	Alert, Ellesmere Is.	Canada	82°33'N	62°35'W	M
CE	Antofogasta	Chile	23 26 S	70 28	I,M
CE 132	Arequipa	Peru	16 28	71 30	I
NC 733	Bermuda	UK	32 20 N	64 55	I,M
CE 130	Bogota	Colombia	4 32	74 15	I
NC 816	Camaguey	Cuba	21 25	77 52	M
CE	Chacaltaya	Bolivia	16 19 S	68 10	C,M(tent)
CE	Chiclayo	Peru	6 49	79 46	I
CE	Chimbote	Peru	9 06	78 22	I
CE	Clorinda	Argentina	25 13	57 50	I
SC 631	Concepcion	Chile	36 45	72 59	I
NC 847	Curacao, W. Ind.	Netherlands	12 11 N	68 59	M
NA 062	Davis Strait	Canada	67	58	Rockets
NC	Eleuthera	UK	25 16	76 18	M
NA 006	Eureka, Ellesmere Is.	Canada	80 13	86 11	M
SC 607	Falkland Isl.	UK	51 45 S	57 52	I
NB	Father Point, Que.	Canada	48 05 N	58 05	I
NA 129	Ft. Churchill	Canada	58 46	94 10	Rockets,C(tent)
NA 089	Frobisher Bay	Canada	63 28	67 23	Rockets,I(tent)
NC	Grand Bahama	UK	26 37	78 20	M
NC 828	Grand Cayman, W.Ind.	UK	19 15	81 51	M
NC 837	Guadeloupe, W.Ind.	France	16 16	61 32	M
NC 823	Guantanamo Bay	Cuba	19 54	75 09	I,M
CE 124	Guayaquil	Ecuador	2 10 S	79 53	I,M
NB	Harmon AFB, Nfld.	Canada	48 44 N	58 34	M
NC 812	Havana	Cuba	23 09	82 21	M
CE 128	Huancayo	Peru	12 03 S	75 20	A,Gm,I
NC 835	Kingston, Jamaica	UK	17 56 N	76 47	M
NA 139	Knob Lake	Canada	54 48	66 49	A,I
CE 138	La Paz	Bolivia	16 29 S	68 03	I
CE 127	Lima	Peru	12 04	77 02	M
NC 819	Merida, Yucatan	Mexico	20 58 N	89 37	M
SA 026	Port Lockroy, Palmer Peninsula, Antarctica	UK	64 49 S	63 33	I
SC	Puerto Montt	Chile	41 28	72 47	M
SC	Quintero	Chile	32 47	71 32	M

70° - 80° W. MERIDIAN

2. COOPERATIVE STATIONS - cont.

CSAGI No.	Station	Country	Latitude	Longitude	Program
NA 024	Resolute, Cornwallis	Canada	74°43'N	94°59'W	M
NC 829	Sabana de la Mar	Dom.Rep.	19 03	69 23	M
NC 846	St. Andrews Is.	Colombia	12 30	81 40	M
NC 834	St. Maarten, W.Ind.	Netherlands	18 02	63 06	M
SC 671	San Juan	Argentina	31 40 S	68 35	A
CE	Talara	Peru	4 34	81 15	I
NA 019	Thule	Greenland	76 33	68 50	A,C,Gm,I,M
NC	Trinidad	UK	10 40	61 32	M
CE 125	Trujillo	Peru	8	79	I

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United States. National
Committee for the

Proposed United States