The U.S. Program for the IHD,

with Special Reference to Snow and Ice

by

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## The Problem

These are times of excitement in the earth sciences. In order to cope with industrialization and urbanization, burgeoning population, and higher standards of living, we require more complete understanding of the air we breathe, the oceans we fish or traverse, the land we live on, and the water we use or drink. Public acknowledgment of the need for this understanding is greater than ever before. New tools in the scientist's kitbox permit experiments and approaches not even conceived a few decades ago. Meteorologists have exploited recent scientific developments in space and computer technology to derive important new facts about fluxes at the top of the atmosphere and the nature of global weather patterns. Oceanographers have joined in international programs, and through the use of new sensors and greatly expanded research facilities are beginning to achieve an understanding of oceanic circulation comparable in some respects to our knowledge about the circulation of the atmosphere. Similar major advances can be found in almost all other earth sciences.

Hydrology, however, has developed rather slowly, in spite of the rising importance of water resource problems, ample public support of research, and powerful new technological tools. Most of the world's people are hungry, and we produce people faster than food--but the earth's supply of water to produce food remains constant. In the next two generations, the population will double--yet the supply of water for drinking and other human needs remains constant. The water used per capita in developing countries will increase 10 to 50 times--while the earth's supply of water remains constant. Even those areas of the world which are generously endowed with water, such as northeastern and northwestern United States, still experience water shortages.

Man cannot hope to overcome these ominous statistics of supply and demand by the simple empirical procedures of the past. To survive, he must develop a new science of hydrology to comprehend (and then utilize) the whole hydrologic cycle, and all of its variations in time and space. This can only be done through international cooperation in a scientific effort which fully exploits modern technological advances--this is the rationale for the International Hydrological Decade.

## The International Hydrological Decade

The IHD is to be a sort of "scientific spearhead," aimed at increasing our understanding of the international and continental aspects of the water cycle. It is not to be a panacea for the solution of world water problems, and the U.S. program is not a national panacea for our own water problems. Most of the scientific work in hydrology in the United States will not be part of the IHD program. The IHD is concerned with understanding, not with any specific water resource developments. Without this understanding, there can be no long-term solution to water problems of the world or even of individual nations. The IHD is to be a catalyst, to spark more life into the science of hydrology.

The need for an international program in hydrology was recognized in the late 1950's by a number of influential hydrologists in the United States and in other countries. In 1960 and 1961 an ad hoc panel of the Federal Council for Science and Technology outlined such a program, which was also considered by the Committee on International Programs in Atmospheric Sciences and Hydrology of the National Academy of Sciences--National Research Council. The International Association of Scientific Hydrology held discussions in Athens in 1961 on a proposed program, and in the same year the United States Permanent Representative to UNESCO brought the matter to the attention of UNESCO. Subsequently, UNESCO's General Conference decided to sponsor an IHD and other international agencies decided to participate. Among these are the World Meteorological Organization, Food and

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Agriculture Organization, International Atomic Energy Agency, and World Health Organization. Thus in 1963 and 1964, meetings of experts, convened by UNESCO, established a program for the IHD. The General Conference created an international Coordinating Council and declared the Decade open as of January 1, 1965.

The International Hydrological Decade is not a program of the United Nations nor of UNESCO. Each Nation is responsible for its own programs, through its own National Committee. UNESCO serves as an "intergovernmental umbrella"--a coordinating center. Scientific advice is provided to the Coordinating Council by the International Council of Scientific Unions, including especially the International Association of Scientific Hydrology and, for the field of ice and snow, the Commission of Snow and Ice. Thus the program evolves in two parallel channels: one of projects planned by National Committees and the international Council, and the other of scientific needs as determined and stated by national and international scientific associations and commissions.

The Framework of the U.S. Program

The central thrust of the U.S. effort for the IHD is to enhance our ability to gain understanding of the global hydrological cycle. This broad view is required to obtain basic knowledge of these phenomena which transect national and even continental borders; the task is urgent because continental water development plans are already envisioned. The U.S. program is steered by a National Committee for the IHD, housed in the Division of Earth Sciences of the National Academy of Sciences. This IHD program will, undoubtedly, become an integral but distinct part of the President's new Water for Peace Program.

Activities are selected by the U.S. National Committee for inclusion in the U.S. IHD Program. Seven criteria have been adopted to guide the formulation and inclusion of projects. A scientific project may be considered acceptable if it meets one or more of these criteria:

1. It is sufficiently fundamental or aimed at results so widely useful that it will have special interest to hydrologists abroad.

2. It requires joint or coordinated work in two or more countries.

3. It requires joint work by scientists of several countries.

4. It concerns continental, hemispheric, or global phenomena or processes.

5. It requires studies or action in international areas.

6. It involves the use of orbiting spacecraft.

7. It involves inter-country exchange or visits of personnel.

The U.S. Program for the IHD is divided into five categories: Global water and waterborne materials, experimental and representative basins, educational and training activities, topical research, and supporting activities. These activities are described in two publications of the National Academy of Sciences which are often referred to as the "Green Book" 2/ and the "Blue Book" 3/.

Global water and waterborne materials studies will emphasize the large-scale global and continental phenomena that are outside the range of nearly all present studies. Land-air, land-ocean, and air-sea interactions will be studied, and attempts will be made to estimate the volumes of water which participate in the hydrologic cycle. A major purpose is to develop the data systems, theories, and principles of macroscale phenomena. Hydrologic station networks will be strengthened so that large-scale phenomena will be more adequately sampled. New approaches to measurements of the hydrologic cycle will be tried--such as analysis of the divergence of water vapor flux. Inventories of perennial and ephemeral snow and ice, and measurements of glacier variations will be made on a worldwide basis. The National Committee has encouraged agencies to develop a vastly improved and integrated U.S. Water Information System, which might become a component of a North American and even a global water-information system. Such a system is being planned by meteorologists (the World Weather Watch), and it would seem logical to integrate hydrological sensors and data systems into these plans.

Experimental and representative basins studies will approach hydrology at the intermediate or mesoscale. River basins approximate single identifiable hydrologic units, and they must be understood before one can extend knowledge to global or continental systems. A network of basins will bridge the gap between mesoscales and macroscales. Existing, well-studied basins such as the Coweeta in North Carolina, North Appalachian at Coshocton in Ohio, Central Great Plains in Nebraska, Frazer in Colorado, Walnut Gulch in Arizona, and San Dimas in California will be integrated into this network. Benchmark and Vigil basin networks are being established. Special attention will be given to the Great Lakes, where atmospheric and surface water budget, energy budget, and circulation studies will be made. A chain of representative glacier basin stations is now being established.

Education and training activities include study fellowships for hydrologists in the United States and for a few Americans abroad, on-the-job training at government agencies and universities, and an international exchange of scientists.

Topical research investigations are aimed at understanding single processes, whether they operate at micro-, meso-, or macro-scales. The objective of this topical research program is primarily to gain focus on those aspects of hydrology which are most relevant to the international character of the IHD.

Supporting activities include scientific communications and documents, instrumentation development and standardization, data dissemination and communication, and administration.

## Snow and Ice Studies in the U.S. IHD Program

The U.S. program in this field is patterned closely on the international recommendations drawn up by the Commission of Snow and Ice. The Commission established, at the Helsinki Assembly of the IUGG in 1960, an international program for the measurement of glacier variations. At the Berkeley Assembly in 1963 the framework of an IHD program in snow and ice was drawn up, and finally approved at a meeting of the officers of the Commission in Paris in May 1966. This program focuses on three main projects: A world inventory of perennial and annual snow and ice masses; the worldwide measurement of glacier variations; and heat-, ice-, and water-budget measurements at selected glacier basins.

The inventory program is beginning in the United States with measurement and analysis of the distribution of glaciers, especially in Alaska where very few data are available. However, as the program advances the emphasis will shift to studies of the time and space variations in the annual snow cover, as well as the ice on lakes, rivers, and in the ground.

The glacier variation program will largely consist of collating and coordinating the existing data-collection programs, with strong efforts made to preserve continuity of record of a few well-studied "benchmark" glaciers. Primary attention will be given to advance or retreat of the terminus, but changes in volume and mass will also be recorded and analyzed.

The heat-, ice-, and water-budget measurements at selected glacier basins are being integrated into an international program of stations along two (and perhaps three) chains. One extends along the west coast of the Americas. This includes American stations in the Alaska Range (Gulkana Glacier), Kenai Mountains (unnamed glacier), North Cascade Range (South Cascade Glacier), and Sierra Nevada (Maclure Glacier). Other stations are, or will be, set up in British Columbia, Peru, Chile, Argentina, South Georgia, and the Antarctic. The second chain will extend from the Alps (perhaps even the Pyrenees) east through the Caucasus, Pamir, and Tien Shan ranges. A third chain may be set up along the Arctic Circle, extending from Alaska (Gulkana Glacier) east through Baffin Island (Decade Glacier) and Scandinavia to the Polar Urals. The main United States station (South Cascade Glacier) may be tied in with several secondary stations, such as the Blue Glacier in the Olympic Mountains. The main focus of these glacier-basin studies is to accurately define the glacier-climate interaction at all scales--micro, meso, and macro. These results will be of very great importance, not only to glacier study but also to snow and mountain hydrology in general. A glacierized drainage basin represents one end-member of the spectrum of representative basins ranging from warm or dry to cold and snowy. Thus, these basin studies should contribute to our knowledge of diverse types of hydrologic environments in addition to providing special understanding of high-mountain and snow hydrology.

## REFERENCES


2/ International Hydrological Decade, Phase I - Proposed United States Program (U.S. National Committee for the IHD): National Academy of Sciences - National Research Council, May 1965.

3/ International Hydrological Decade - Framework for United States Program (U.S. National Committee for the IHD): National Academy of Sciences - National Research Council, April 1966.