Introduction

It is a pleasure to have this opportunity to talk to you about global monitoring. It is a topic whose scope is increasing every day. It is a topic which has been most important to the development of weather forecasting for over a century. And it is a topic about which I, like so many of you, do a substantial amount of reading, a considerable amount of listening, and at least a little bit of thinking. With the many environmental activities under way, I of course cannot offer an explicit solution to the environmental problems but I do hope to reinforce many of the imaginative things that others have been saying and doing in the area of environmental monitoring.

At the beginning of the decade of the 1960’s, President Kennedy called upon the nations of the world to undertake a major effort to bring about better weather predictions for all of mankind. The timing of this plea stemmed from the potential capability of the Earth-orbiting satellite to monitor—the weather on a global basis—a potential capability which has been brought to fruition in many areas. But the need for protecting man from his environment through better warning, prediction, and eventual control was the main motivation of the President. And it is this need that motivated the leaders of other nations to join in the efforts that were born with that speech—the World Weather Watch and the Global Atmospheric Research Program, which collectively we have dubbed the World Weather Program here in the United States.

One major aspect of this program is global monitoring of the atmosphere, which I’ll discuss later. Equally important or fundamental in meeting the goals concerning long-range prediction and inadvertent and inadvertent modification, is the research—the numerical modeling and other theoretical efforts to improve our understanding of the processes of the atmosphere. All too often and all too conveniently the research can be forgotten or relegated to next year.

Need for environmental monitoring

Let me now turn to the 1970’s. President Nixon sounded the call for an intensified and expanded effort to stop the deterioration of the environment and improve its quality. In contrast to the main motivation of the program of the 1960’s, the main motivation of the effort in the 1970’s is to protect the environment from man.

What is involved in this effort? Certainly those things we have talked about under the World Weather Program. But there is much more. The reports of the International Biological Program and last summer’s Study of Critical Environmental Problems coordinated by the Massachusetts Institute of Technology provide us with an excellent summarization. Let me mention only some of the global problems they described. First those primarily associated with the atmosphere—the climatic effects of CO\textsubscript{2}, of the particulates in the atmosphere, and of the contamination of the atmosphere by aircraft. These are problems that we meteorologists have been talking about for some time.

Other problems that the summer study identified are associated both with the atmosphere and its water counterpart. The chlorinated hydrocarbons have already caused serious problems. DDT and pesticides are threatening bird populations. They may be upsetting the insect balance by killing off predators. They also collect in marine organisms. Yet, the concentrations and effects of DDT in the oceans are not well known. Mercury and other toxic heavy metals have also become significant problems. You are all aware of the fact that mercury has contaminated tuna, a deep-ocean fish.

Another area where marine pollution is becoming rampant is from oil. However, very little is known about the effects of oil in the oceans on marine life. Potential effects include killing marine organisms and their food and decreased fish reproduction. Housewives have also been fertilizing our rivers and estuaries with phosphorous and nitrogen from their detergents; thereby, accelerating the eutrophication process.

The list of potential environmental calamities which man can impose upon himself is literally endless—the
use of lead in gasoline, the output of sulphur and nitrogen products, thermal wastes, and the elimination of forests which changes the reflectivity of the planet are some examples. Let it suffice, however, to note that there are an abundant number of environmental areas that must be considered and monitored, and today the monitoring of atmospheric variables is but one part of the whole.

The monitoring and research programs required to solve these problems have many similarities with and many differences from our World Weather Program. The monitoring effort, for some of these problems, may be global in scope but may amount to only a few tens of stations. Or, the frequency of observations may be much less than required for the Global Experiment of the World Weather Program. Even the processing may be quite different—some requiring real time, others not. But there is an equally long or longer list of similarities.

Environmental research is essential
The research that is needed to understand these problems well enough to specify their long term effects and to determine what should be the corrective course of action has many ties to the efforts under the World Weather Program. In the case of the climatic effects from CO$_2$, particulates, or changes in the albedo, we simply cannot hope to determine the long-term implications without the mathematical models that are being developed under GARP. These atmospheric models must be extended so as to include at least a part of the oceans to determine what is happening to its physical and chemical state.

Monitoring is rarely an end in itself. It only provides data to be interpreted. And without an understanding of the physical, chemical and biological processes involved, we will make errors in interpretation. For example, in the case of the CO$_2$ monitoring alone does not provide adequate insight, in the long term. The oceans are major sinks for CO$_2$. However, we are not certain of the capacity of the oceans to absorb CO$_2$ from natural and man produced causes. If the rate at which the oceans absorb CO$_2$ decreases, it could mean that a large portion of the new emissions would remain in the atmosphere.

Therefore, research programs must be instituted which permit us to gain a fuller understanding of our environment. These programs must occur in parallel with monitoring programs, and in some cases well in advance of the institution of monitoring programs. Our GARP experiments should be examined closely to determine whether interdisciplinary research can increase their effectiveness and make their contribution to society greater.

I would now like to cover in broad outline the status, internationally, of the planning and implementation of the needed monitoring systems. For convenience I will divide the discussion into atmospheric, ocean, health and land monitoring.

Atmospheric monitoring
Global atmospheric monitoring has come a long way, particularly during the latter part of the decade of the 1960's. It was during this period that dreams were transformed to proven concepts as a result of developments with the polar orbiting and geostationary satellites. During the 1970's these new developments will be further translated into operational capability.

The successful test on Nimbus 3 of the Satellite Infrared Spectrometer and the Infrared Interferometer Spectrometer heralded the beginning of a whole new era in global monitoring. The vertical temperature profiles obtained from these instruments met the expectations in terms of accuracy of even the most optimistic proponents. With the advanced versions of the sensors now under development, the coverage in most of the cloudy areas will be adequate to meet the need for temperature and possibly moisture observations as specified by our GARP scientists. This breakthrough, combined with the now demonstrated capability of geostationary satellites to provide wind data from the measurements of cloud displacements, can provide much of the data needed in extratropical regions. In addition, we are now monitoring routinely the sea surface temperature with satellite infrared measurements. Tests of constant-level balloons by the National Center for Atmospheric Research (NCAR) and the National Aeronautics and Space Administration (NASA) are being planned and buoys are being developed for the reference level observations that may be needed to complement the sounders. Our primary problem still rests in the tropics. None of the systems that have been tested to date can meet the minimum requirements there.

The National Environmental Satellite Center has scheduled the launch of the first operational sounder for 1972 on their polar-orbiting Improved TIROS Operation Satellite (ITOS). In addition, we understand the Soviets have plans for satellites with sounders.

The collective plans of the nations of the world offer hope of four or five geostationary satellites for global coverage. The Geostationary Operational Environmental Satellite (GOES) system will be introduced in 1972, with the launch of an operational prototype Synchronous Meteorological Satellite (SMS), being developed by NASA. This prototype will be followed by a subsequent second geostationary satellite. The French are planning for 1975 or 1976 a geostationary satellite to be positioned over Africa. The Japanese are hoping to launch a geostationary satellite in the Western Pacific during the same time frame. These four satellites would provide the proper type of coverage for GARP scientists, except for a few tens of degrees of longitude over the Indian Ocean. These geostationary satellites will also be able to collect data from ships, buoys, constant-level balloons and other remote platforms.
The plans and implementation of these platforms fall internationally under the World Weather Watch and the First GARP Global Experiment. The First GARP Global Experiment is presently projected for 1976 or 1977. It will require additional observational and processing capabilities not available in the World Weather Watch at that time. NASA has the lead in the United States to prepare a detailed plan for the Global Experiment so that decisions on its scope and timing can be taken.

The World Weather Watch Plan has a four-year cycle. The next plan is for the period 1972–75. It will be agreed to at the WMO Congress in April of this year. This second-phase plan calls for implementation of the polar-orbiting and geostationary satellites along the lines just described. In addition, it calls for the completion of the global communication circuits laid out in the first-phase plan and places heavy emphasis on the installation of conventional sounding systems in the tropics.

A new dimension is also being added formally. It is concerned with monitoring of atmospheric pollutants. A plan for a network of regional and baseline stations has been proposed. Already some of the regional stations have been implemented here in the United States by the National Air Pollution Control Administration (NAPCA). A regional station is intended to document the long term changes in atmospheric composition due to changes in regional area land use practices, and will measure at least turbidity and certain aspects of precipitation. A baseline station is designed primarily as an observing site to document long-term changes in atmospheric environmental parameters of particular significance to weather and climate with a minimum influence from local or regional factors. These global baseline stations will measure at least carbon dioxide, turbidity and the constituents of precipitation and fallout.

Another area where atmospheric monitoring is underway is in the arena of radio nuclides. The International Atomic Energy Agency (IAEA) is responsible for pursuing programs designed to protect health and minimize danger to life and property from the peaceful applications of nuclear energy. Together with United Nations Agencies, the IAEA has established a worldwide sampling network to measure the amount of radioactivity in precipitation and in the water of the world's major rivers. For about seven years now approximately 100 weather stations throughout the world, under the auspices of the World Meteorological Organization, have been collecting monthly precipitation samples for the Isotopes-in-Precipitation Network.

Ocean monitoring
Monitoring in the oceans is in a very early state of development. It, too, is a most complicated problem involving an array not only of physical but biological and chemical observations.

I would like to begin by discussing the Integrated Global Ocean Station System, IGOS for short. It is the oceanographers' World Weather Watch. It is an international program for monitoring or observing physical, chemical and biological aspects of the ocean, collecting and processing the data, and providing a variety of products in real time for use by marine interests. This is a primary program of the Intergovernmental Oceanographic Commission (IOC). The interrelationship of IGOS with WWW was recognized at the outset and therefore much of the planning is done jointly with WMO. The IGOS Phase One Plan was approved in 1969. Therefore, its implementation has hardly begun.

IGOS was initiated in anticipation of the need for monitoring in the oceans. Its importance in the total environmental watch is now just becoming apparent. As of October 1970, some 20 countries reported national programs which were to participate in IGOS. This participation, for the time being, is principally through the employment of various type ships and coastal and island stations which measure and report oceanographic data. Several of the countries also have reported buoy development efforts—of course, you are all well aware of the United States National Data Buoy Project which now forms part of NOAA.

IGOS is a service-oriented program, and, therefore, is really a new dimension in the field of oceanography. For those oceanographic data that must be transmitted in real time, like meteorological data, we had to develop appropriate codes and obtain the agreement of the nations through WMO. This has been accomplished and we hope to initiate a pilot project for the exchange of subsurface data for at least one ocean basin during 1971. We will use the World Weather Watch Telecommunication Circuits for transmission of these data.

It will take time, but the technological improvements of the 60's provide us with many opportunities in the 70's to extend our knowledge of the dynamics of the ocean.

Biological and health monitoring
Biological monitoring and the monitoring of pollutants in the ocean is now receiving substantial attention internationally. There are a great many agencies involved in the planning. The International Council of Scientific Unions (ICSU) with its International Biological Program, the Intergovernmental Maritime Consultative Organization, the Food and Agriculture Organization, and the Intergovernmental Oceanographic Commission and the WMO have focused a great deal of energy in this area.

Just as in our own arena, there is a dual need for biological monitoring. We need the observations to manage the quantity of fish as a resource. We also need the observations to monitor the quality of the environment since these organisms are susceptible to and indicators of deterioration in the marine environment. In fact, we might monitor the whole food chain to
detect and understand the processes that will control the future of life on Planet Earth.

The required monitoring systems are most interesting from a technological point of view and their operation will interact in many ways with the weather system. For example, the marine biologists need samples of plankton and they have such a sampling device—the Undulating Ichthyoplankton Recorder developed in the United Kingdom. I hope we will see in the near future ships—research and merchant—which will acquire these plankton observations and expendable bathymetric observations as well as meteorological observations.

Let me skip for a moment to an area which has possible immediate implications to all of us. This is the arena of health monitoring. There is growing concern about how crop pestilence, infectious disease and other disturbances can affect the global health balance of man. This is an area of great concern to the World Health Organization (WHO), a United Nations specialized agency concerned with all aspects of the environment that affect human health in the broad sense of physical, mental and social well-being and not merely the absence of disease. In this role, the World Health Organization is directly or indirectly involved in the prevention and control of pollution in any form.

Finally, an area which poses significant problems is related to land use and conservation of natural resources. As the population changes, so too will the face of the planet change. Destroying forests in one country could impact flood conditions in another. Or, changing forest land to agricultural land could change the albedo significantly or upset the CO₂ cycle. Proper land and natural-resource use are important to all countries. Shortsighted and extravagant exploitation of forest or mineral resources can impact future generations. As a result, these elements must be monitored.

Many schemes and techniques could be suggested for categorizing monitoring systems. I used the categories of ocean, atmosphere, health and land to describe the systems. Another way might be to have a monitoring system for the total physical environment; one for health, and one to describe and define the Earth's living and non-living resources. Or, we could treat marine biology separately by dividing the resources monitoring systems. In summary, many international agencies are working on monitoring systems. In many cases the systems are for multiple purposes, of which protecting the environment from man is only one. In some cases these monitoring systems are only at the beginning. In others they need augmenting, and, admittedly, the potential for overlap does exist.

**Institutional arrangements**

Often the need for a program is well recognized, and we can see the way scientifically and technologically. But, if we don't have an adequate institutional framework within which to plan and execute the program, it will falter. So I should like to discuss one possible institutional arrangement for the Global Environmental Monitoring System (GEMS).

It is easy to say that everything that has been done to this point is wrong. It is easy to say, Let's take the total systems approach. It is also easy to say, Let's have one institution handle all of the monitoring. But I do not believe these attitudes will result in early significant progress because they do not take into account the present situation. Conceptually the job in organizing for the environmental monitoring effort is similar to that we have found under GARP and the World Weather Watch. There, too, our first reaction was to establish a supranational arrangement. However, we have found that a better approach is to determine the minimum institutional arrangements required for the next major phase of the program and seek agreement among the nations to that extent.

We did this first in the World Weather Watch in the development of the comprehensive First Phase Plan and the Voluntary Assistance Program. We did it in the case of GARP when we established the Joint ICSU/WMO Organizing Committee so that we would have the best scientists carrying out the planning and have the appropriate intergovernmental action at the proper time. Again in the case of the forthcoming GARP Tropical Experiment, we have set up a board of directors called the Tropical Experiment Board, where governments can commit their facilities and resources to the plan of the project office, which is called the Scientific and Management Group.

The Global Environmental Monitoring System (GEMS) also needs sound scientific planning. And it needs intergovernmental action so that the monitoring system remains intact for a very extended period. The International Council of Scientific Unions has many groups active in the environmental problems of today. As a result, it has established a Scientific Committee on Problems of the Environment (SCOPE). SCOPE is charged with the overall scientific planning in areas related to the environment. It will require the help of many bodies working with ICSU—for example, ICSU's Scientific Committee on Oceanic Research (SCOR), the Joint GARP Organizing Committee (JOC), etc. It can provide the scientific planning which is required for GEMS.

What is lacking is SCOPE's counterpart in the intergovernmental world, a body which could have an overview of the programs in the existing UN Specialized agencies. What is required is a body to plan and coordinate the overall system—a body that would function in a fashion similar to the United Nations Economic and Social Council, ECOSOC. It would not replace the activities or assume the responsibilities of the WMO or WHO or FAO or IMCO or IAEA or UNESCO. It might be called an Environmental Monitoring and Analysis
Council. The functions of EMAC could be along the following lines:

1) To formulate policy regarding international environmental monitoring and to identify specific applications.

2) To be responsible for overall international planning of monitoring programs.

3) To provide overall coordination of global monitoring programs including review and evaluation of separate systems making up the global scheme for monitoring programs.

I would envision SCOPE of ICSU as being the principal scientific advisory body to this new agency, but with other relevant scientific bodies such as the Group of Experts for Scientific Aspects of Marine Pollution (GESAMP), or the JOC, being called upon for scientific or technical advice.

In conclusion, I am encouraged by the activities of many of those in the meteorological community who have been expanding into other environmental areas, and I wholeheartedly endorse our AMS President’s comments that meteorologists can contribute very effectively to the problems of the environment. I believe that the best mathematical modelers in the world exist within our profession. However, we must extend these capabilities into the oceans and the estuaries. More and more, our work is interdisciplinary and we must think as interdisciplinarians. We have, perhaps, more experience in monitoring than any other group. With this experience we are in a position to go out and help, and I emphasize the word help, those responsible for development of other monitoring systems which interact scientifically, technologically and operationally with meteorological monitoring systems.

I have no magic formula by which we can become involved in the total environment, but I do believe that by thinking and speaking as environmentalists we will develop a frame of mind and an attitude that cannot but help this planet of ours.

news and notes

New appointees

Frank E. Clarke, a career employee with the Department of the Interior, has been named to the newly established post of Deputy Under Secretary for Science and Engineering. The new position was established to provide within the office of the Secretary an immediate source of advice and counsel on scientific and engineering research and development activities related to ecology and the environment. Since 1968 Mr. Clarke had been Assistant Director of the U. S. Geological Survey. He has served as a consultant to UNESCO and to 10 foreign governments on scientific matters, is the author of more than 40 scientific publications and the recipient of several national awards and honors for inventions and other contributions to engineering and the hydrological sciences.

David H. Wallace, Director of the Division of Marine and Coastal Resources, New York State Department of Environmental Conservation, was named associate administrator of the National Oceanic and Atmospheric Administration for ocean resource management. In this post Mr. Wallace is responsible for developing NOAA policy and guiding the organization’s efforts in the assessment, conservation, development and management of ocean resources.

Dr. William Aron, Director of the Smithsonian Institution Oceanography and Limnology programs, has assumed direction of NOAA’s Office of Ecology and Environmental Conservation, where he is responsible for full consideration of environmental protection matters and for liaison with governmental and other organizations involved in conservation and ecology.

The newly appointed director of the Office of Congressional and Legislative Affairs in NOAA is John Harris Clotworthy, who was president and chairman of Oceans General, Inc., a Miami engineering and manufacturing firm. He has been active in a broad range of marine and oceanographic affairs, serving on the Man in the Sea Panel of the National Academy of Engineering, on the Chamber of Commerce Committee on Natural Resources, and as a founding member of the Marine Technology Society.

Capt. Robert F. Williams took command as Director of the Lake Survey Center in Detroit, Mich., on 17 May. The Center is a unit of NOAA’s National Ocean Survey which is conducting limnological research on the Great Lakes, the Minnesota-Ontario border lakes, Lake Champlain, New York canals, and part of the St. Lawrence Rivers as well as charting these areas and disseminating water-level information. Capt. Williams is a commissioned officer of NOAA, as is his newly appointed deputy, Lt. Cdr. Sigmund R. Petersen.

(More news and notes on page 570)