HURRICANES AND REMOTE SENSING

By

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Abstract

Students of the Earth's natural environment are calling attention, with increasing urgency, to particularly unusual and dangerous weather and climate conditions. Informed opinions have indicated concerns respecting permanent changes. The experts have relied on data and analyzed information obtained via remote sensing to describe past events and to make predictions and recommendations for future action. Killer hurricanes have been selected to demonstrate the scientific basis for concerns and as a rallying point for national and international responses.

Important measures will be necessary to preserve and protect the world's ecosystems against continued threats and to allow for an acceptable quality of life for the world's inhabitants. To reach these goals there will have to be very careful planning, the execution of meaningful plans, and jointly shared international accountability since exceedingly large costs will be entailed.

1. Introduction

The international lawyers, who in 1986 drafted the Principles Relating to Remote Sensing of the Earth from Outer Space, demonstrated a practical awareness of the capabilities of remote sensing and the general conditions of the Earth's natural environment.

Principle I spoke generally of the need to improve "natural resources management, land use, and the protection of the environment." Principle X recited that "Remote sensing shall promote the protection of the Earth's natural environment." Principle XI stated that "Remote sensing shall promote the protection of mankind from natural disasters." Those who forged these principles, while recognizing the utility of ensuring that remote sensing would serve environmental needs and that there was a linkage between such needs and the prospect of international disaster, had no way of knowing how quickly and gravely the Earth's natural environment would deteriorate. Although predictions by respected scientists were being published, doubts

were being voiced. It was not until the 1972 United Nations Conference on the Human Environment that widespread international recognition was given to the seriousness of the environmental crisis.

By the time the Remote Sensing Principles were adopted the space-resource countries had perfected sophisticated means for obtaining raw data. At that time and in the following years the world's scientific community was almost entirely in agreement that, owing in large part to large volumes of greenhouse gases that the world's temperature, including the Ocean--and very noticeably the South Atlantic—was rising and that changes in climate could produce dire consequences.

Traditional concerns over the atmosphere and climate relating to public safety, agriculture, business operations, fishing, mining, transportation, and other pursuits, had produced studies of the weather, and weather forecasting, including predictions respecting precipitation and wind levels, and hours of sunshine or darkness. With the evolution of sensing procedures and expertise in the interpreting of raw data, national measuring and reporting institutions were greatly enlarged, international cooperation was substantially increased, and international intergovernmental weather organization began to multiply. The results of their investigations were widely distributed.

The concerns of environmentalists, expressed over 30 years ago, have materialized. During the ensuing years there have been substantial changes to the Earth's atmosphere, air quality, and climate. Not the least of the scientific factors under constant study has been the hurricane cycle affecting the Western Hemisphere including the East Coast of the United States, the Gulf Area, much of Eastern Mexico, and the Caribbean islands. In the Orient in those areas prone to typhoons comparable concerns and studies have attracted the attention of countries and international organizations.

2. A Bit of History.

Hurricanes, which are produced by heightened sea-surface temperatures, when the surface reaches 80 degrees F, have been observed in the above areas for many years. Such temperatures are reached in the South Atlantic in August and September. A storm in the Lesser Antilles in 1780 resulted in 22,000 deaths. The Galveston, Texas, hurricane in 1900 caused 12,000 deaths and resulted in the destruction of the city.

The U. S. Weather Service uses the Saffir-Simpson model to classify hurricanes with category 5 being the most serious. Of the five classes number 3 requires winds of 110-130 miles per hour and storm surges of 9-12 feet; class 4 winds of 131-155 mph and surges to 13-18 feet; class 5 winds of over 155 mph and surges exceeding 18 feet. Comparative figures reveal that the average number of hurricanes and average size impacting the South Atlantic Coast of the United States had increased in 1970-1974 over 1955 and that since 1974 even more increases have been recorded.

Heavy precipitation accompanies hurricanes. When Katrina, a class 5 hurricane, came ashore in the New

Orleans area of Louisiana on August 29, 2005, following heavily publicized warnings by the U. S. Weather Service, precipitation rapidly reached 8-10 inches along much of the hurricane's path. As it moved inland and became a tropical storm rainfall was measured between 2-4 inches across much of the Gulf Coast and into the Ohio Valley. Katrina also produced quantities of hail with widespread damage in Georgia. The storm produced levee breaks. Portions of New Orleans were covered with 20 feet of water. Mobile, Alabama, was submerged, while Biloxi and Gulfport, Mississippi, were very heavily flooded. Katrina produced power outages, and destroyed or damaged oil wells and oil-refining facilities. As Katrina receded it was estimated that 95% of these facilities were non-operational. Damages were estimated at over $100B with more than 1,300 deaths and enormous social costs. Normalcy cannot be expected for many years.

3. Governmental Activities

To provide warnings of impending hurricanes so that lives might be saved and property damages and social costs might be minimized governments acting alone and collectively have taken measures designed to promote their self-interests. In the United States the national government, though a large number of departments, agencies, and offices, has been the guiding force. International agreements have been entered into with foreign governments and international intergovernmental organizations. Since weather and climate are of universal concern international cooperation has become the means to secure the needs of humanity.

In the United States satellites have been the principal means used to identify hurricanes, although these have been supplemented by aircraft, maritime buoys, maritime vessels, radar, and visual observations. The collection and integration of the data acquired from these resources is very complex. The large number of government agencies engaged in such activities has resulted in calls for consolidation. The early dissemination of suitable warnings has become a major challenge. Comparisons have been made of the accuracy of forecasts. Records indicate that this has improved over time

The National Hurricane Center (NHC) working with the National Weather Service (NWS), agencies of the National Oceanic and Atmospheric Administration (NOAA), provides public advisories on an hourly basis on storms in the Atlantic and Pacific Oceans. NOAA operates Geostationary Operational Satellites (GOES). These satellites hover at 22,300 mile above the equator. Remaining on a fixed position the GOES has a full-disc view of the Earth. They are critical to monitoring rapid changes in weather conditions. GOES measure sea-surface temperatures on a one-half hourly basis. This allows for short-range warnings of impending hurricane conditions.

NOAA also operates Polar Orbiting Environmental Satellites (POES). These satellites make a nearly polar orbit 14.1 times a day. They have been designed to provide data for long-range weather and climate forecasting. The POES system is augmented by Very High Resolution Radiometers (AVHRR) and by TIROS Operational Vertical Sounders (TOVS).

PEOS facilitates the gathering of ocean data including weather analysis and forecasting, climate research and prediction, global sea surface temperatures, atmospheric sounding of temperature and humidity, and ocean dynamics research, as well as studies of land-based conditions.

The number of U. S. governmental entities having an interest in Earth observation has been identified by the subcommittee of the National Science and Technology Council of the larger committee on Environmental and Natural Resources. Included in this inventory are 15 member agencies, 3 White House Offices, 10 departments, and a host of other governmental offices. Among these bodies is NASA and the Department of Defense (DOD). NASA through its Earth Observing System (EOS) engages in global climate change research . The DOD Defense Meteorological Satellite Program (DMSP) focuses on supplying weather and environmental information and support to military operations.

NASA has conducted extensive studies on atmospheric radiation since such radiation has substantial effects on climate change. Studies reported in July, 2006, revealed that there had been significant increases in the number of heavy rain storms between 1991 and 2004 as compared with storms bringing moderate amounts of precipitation. There was an increase in the number of category 3-5 hurricanes during this period. The NASA Goddard Space Flight Center also called attention to various types of aerosols differently affecting cloud cover, which could enhance or reduce sunshine, which in turn would have an influence of the surface temperatures of the ocean. The Goddard Institute of Space Studies using historic records for comparative purposes reported in 2006 that the five hottest years on record occurred since 1998, with the record being established for the hottest in 2005. These temperatures have produced rapid melting of the Greenland and Antarctic ice sheets with progressive threats to coastal areas
and to hurricane formation.

With so many offices being involved in a common project it has become necessary to achieve coordination and cooperation. This can produce additional supervisory bodies. For example, there is National-Polar Orbiting Operational Environmental Satellite System (NPOESS) designed to integrate existing polar-orbiting satellite systems under a single national program. This has allowed for the combination of NOAA's POES and the DOD DMSP. This has resulted in increasing the timeliness and accuracy of forecasting severe weather changes.

4. International Organizations and International Cooperation

A European Organization for the Exploitation of Meterological Satellites (EUMETSAT), now consisting of 20 countries, was established on May 24, 1983. Created by treaty it became operational on June 19, 1986. Using eighth generation METEOSAT satellites EUMETSAT serves world needs by supplying information on global weather, environmental, and climate changes. It engages in studies of the atmosphere, the environment, natural hazards and disasters occurring on Earth, snow and ice conditions, and establishes

formats and standards. Its survey of clouds includes their wind motion, cloud and sea-surface temperatures, and upper tropospheric humidity.

NOAA maintains close contact with EUMETSAT. Cooperation has benefited through their involvement in the Initial Joint Polar Orbiting Operational Satellite System (IJPS). Coordinated efforts have improved operational meterological and environmental forecasting and world-wide climate monitoring services. Dissemination of data and analyzed information has been made to the World Meterological Organization (WMO), the UN Environmental Program (UNEP), and the Intergovernmental Oceanographic Commission (IOC), and other related programs. Principal beneficiaries have been those less-developed countries located in tropical storm areas.

In July, 2006, EUMETSAT's plan to launch a METEOSAT was interrupted when a failure occurred in the SOYEZ/ST launcher. It was to have been equipped with instruments furnished by the European Space Agency (ESA), the French Space Agency (CNES), and NOAA.

5. Conclusion

Satellites have been very effective in capturing data allowing for an effective assessment of weather and climate conditions in general and of hurricanes in particular. Disasterous as prior hurricanes have been their increase in number and their growing size, coupled with the planet's increase in temperature, has raised the question of whether the global warming trend can be reversed. Unfortunately, green house emissions show no sign of abating in the United States, which has rejected the Kyoto Protocol, and are now growing at an alarming rate in India, China, and the developing countries. Observers of this larger picture have speculated that if reduction efforts are not soon adopted on a world wide-basis that a worst scenario case of very substantial, if not unrivaled proportions, will befall the human race. At this time serious thought has been given to adaptation strategies, but it may be possible that prospects for such a course of action may be too little and too late. Experience with hurricanes will have to be taken into account in determining what will have to be done in the future.

Suggested Readings

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