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Satellite Activities of NOAA 1979

Compiled by:
NATIONAL ENVIRONMENTAL SATELLITE SERVICE

Washington, D.C.
July 1980

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Environmental Satellite Service

NOAA

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

U.S. DEPARTMENT OF COMMERCE

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National Oceanic and Atmospheric Administration
TIROS Satellites and Satellite Meteorology

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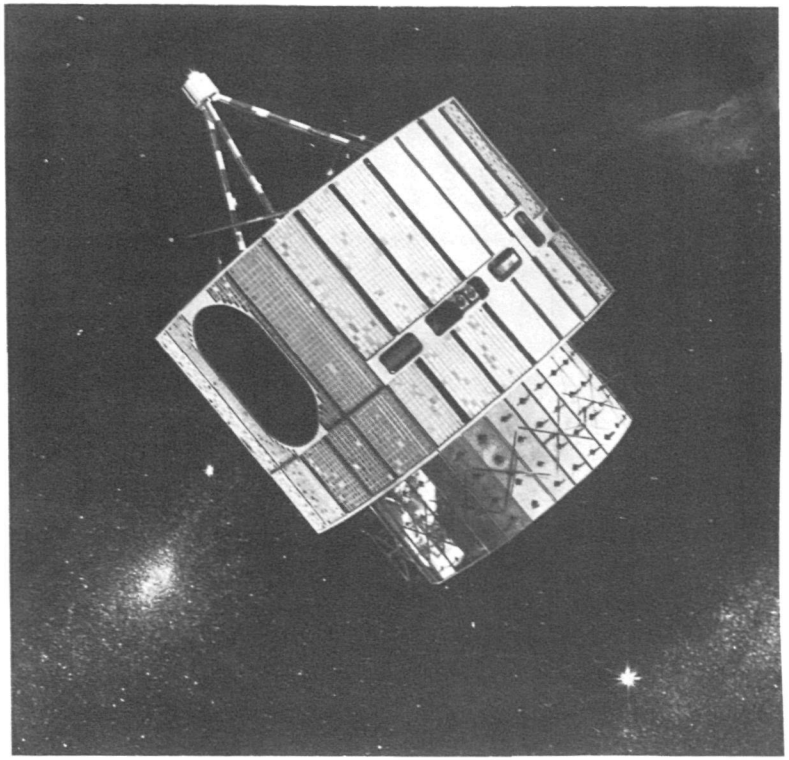
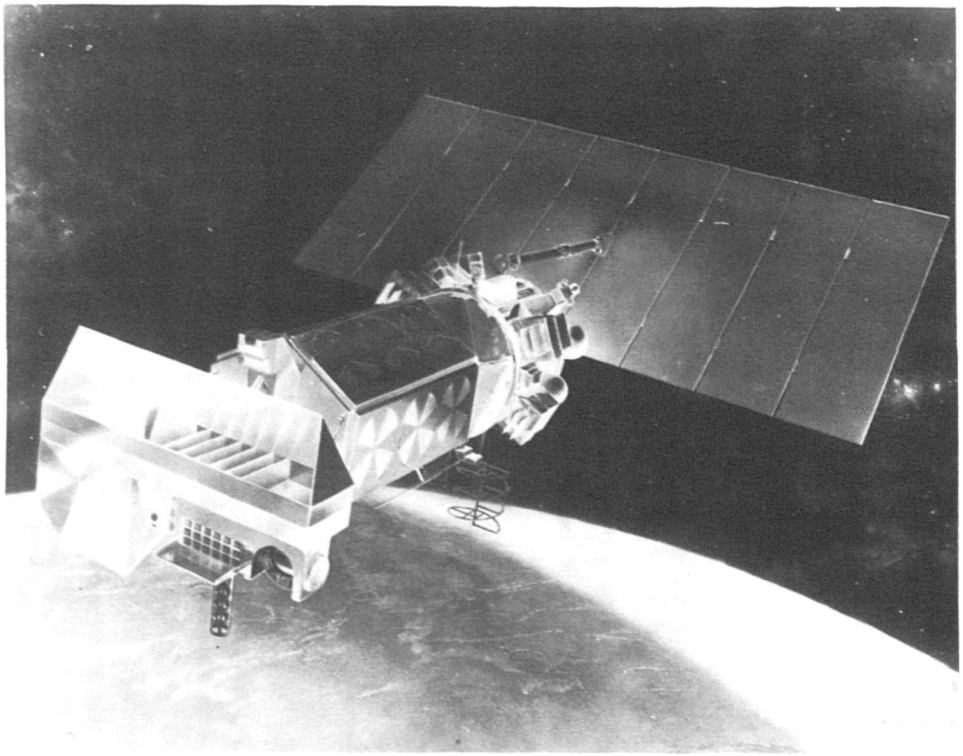


GOES SATELLITE



TIROS-N SATELLITE

National Oceanic and Atmospheric Administration

Introduction

The National Oceanic and Atmospheric Administration (NOAA) was established within the United States Department of Commerce in 1970. NOAA's mission is to improve the safety and quality of life through better comprehension of the Earth's environment and through more efficient use of its resources. To this end, NOAA operates, manages, and improves the nation's operational environmental satellite systems; provides satellite data on the impact of natural factors and human activities on global food and fuel supplies and on environmental quality; uses satellite data and aerial photography for charting, coastal mapping, and geodetic research; employs satellite data to improve the assessment and conservation of marine life; and upgrades weather services by developing new forecasting techniques, automating field operations, and improving dissemination of weather information. NOAA elements that participate directly in aeronautics and space programs are: The National Environmental Satellite Service, the Environmental Data and Information Service, the National Ocean Survey, the Office of Ocean Engineering, the National Marine Fisheries Service, and the Environmental Research Laboratories.

Space Systems

The National Environmental Satellite Service (NESS) of NOAA operates two satellite systems: the polar-orbiting system and the geostationary system.

Polar-Orbiting Satellites. During the first half of 1979, NESS converted from the Improved Tiros Operational Satellite (ITOS) system to the new generation Tiros-N series. Tiros-N, the NASA prototype and the first of this series, was launched October 13, 1978. NOAA 6, NOAA's first operational satellite of this series, was launched June 27, 1979. These two satellites are known as the Tiros-N system. The Tiros-N and ITOS systems overlapped until July 16, 1979, when NOAA 5, the last of the ITOS series, was deactivated.

Redundancy is achieved in the Tiros-N system by two identical satellites rather than two identical instruments on a single satellite. Tiros-N was launched into a near-polar, Sun-synchronous 870-kilometer orbit crossing the Equator in a northward direction at 1500 local time. NOAA 6 orbits at 830 kilometers, crossing the Equator in a southward direction at 0730 local time.

The Tiros-N system satellites carry four primary instruments: An Advanced Very High Resolution Radiometer; a Tiros Operational Vertical Sounder, consisting of three complementary sounding instruments, one of which is provided by the United Kingdom; an Argos Data Collection and Platform Location System, which is furnished by France; and a Space

Environment Monitor. In addition, the extremely large volume of digital data delivered by these satellites required installation of a new ground system, which was accepted in February 1979.

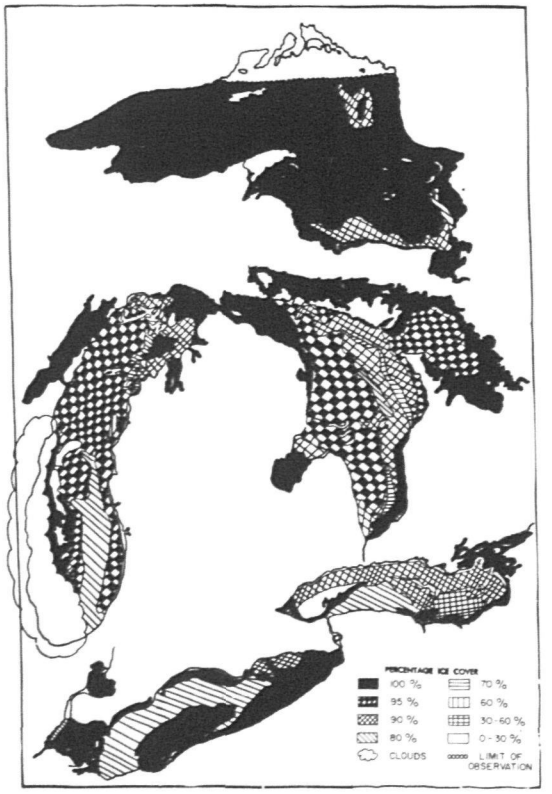
Geostationary Satellites. The NOAA designation for its Geostationary Operational Environmental Satellite system is GOES, the successor to NASA's prototype geostationary Synchronous Meteorological Satellites (SMS). Since 1974, two SMS and three GOES satellites have been launched. Presently, GOES 3 and SMS 2 are the operational geostationary satellites covering the Western Hemisphere. SMS 2 is located over the Equator at 75° West longitude and GOES 3 at 135° West longitude. SMS 1 (130°W) and GOES 2 (105°W) are on standby status. GOES 1 remained at its position of 56° East longitude over the Indian Ocean. The spacecraft was under control of the European Space Agency until November 30, 1979, to support the Global Weather Experiment. On November 30, 1979, it was commanded to drift eastward at 2° longitude per day. GOES 1 arrived at its destination of 90° West longitude during March 1980.

A new interactive computer system designed to improve the accuracy of the navigation and gridding of GOES images became operational in March 1979. This computer system is called the Visible Infrared Spin Scan Radiometer (VISSR) Interactive Registration and Gridding System (VIRGS). It will provide a faster response time in computing accurate grids on images after normal spacecraft maneuver operations, improve the accuracy of gridded image products, and potentially reduce the amount of costly ground tracking equipment. The more accurate gridding aids in the production and use of "movie loops" which depict cloud motions. These "movie loops" are frequently used for storm warnings such as Hurricanes David and Frederic in August and September 1979 and by TV meteorologists as part of their daily weather programs.

Land Programs. On November 16, 1979, the President designated the Department of Commerce through NOAA to manage all operational civilian remote sensing activities from space. NOAA's experience in successfully operating and managing three generations of environmental satellites prepares it to assume the responsibility for land remote sensing in addition to its on-going atmospheric and oceanic activities. NOAA will establish and manage an operational satellite program of land remote-sensing based upon the NASA-managed Landsat research and development program.

NOAA completed a preliminary plan by December 15, 1979, and will submit a final transition plan to the President by June 1, 1980. Landsat was begun in 1972 by NASA as a satellite effort specifically designed to test remote sensing techniques for observing surface features of the Earth.

Satellite Data Distribution. During 1979, NESS began upgrading the Satellite Field Services Stations (SFSS) by phasing out their photo laboratories and converting to an all-electronic image displaying system. Electronic processing of satellite images will significantly reduce the NESS annual operating costs by more timely production of animated data, improved system flexibility, elimination of photographic laboratory costs, and minimizing equipment complexity. The new satellite image display devices



TIROS N visible picture (left) showing near total ice coverage of the Great Lakes on February 17, 1979. The analysis (right) shows the percentage of ice cover on each lake.

offer low capital investment, low cost for expendables, reliability, unattended operation, consistent good quality imagery, no photo processing, and compatibility with NESS's existing image animation devices.

The GOES Weather Facsimile (WEFAX) Service is now broadcasting data via the geostationary satellites located at 75°W, 105°W, and 135°W. The WEFAX data have been expanded to include standard meteorological charts broadcast from the central satellite in addition to the satellite image transmissions already provided by the east and west satellites. This allows users of the central satellite to have both satellite images and standard meteorological charts. The WEFAX user community has expanded to more than 70 national and international land stations, some of them located in the Caribbean, Central and South American countries, and to over 50 mobile stations carried aboard naval and merchant vessels.

"AM Weather," a new TV weather program produced by the Maryland Center for Public Broadcasting in cooperation with NOAA, the Federal Aviation Administration (FAA), and the Aircraft Owners and Pilots Association, was initiated in 1979. Meteorologists from NESS and the National Weather Service participate in daily (Monday through Friday) 15-minute broadcasts describing the weather over the continental United States. Approximately 200 public television stations across the country transmit the program live. Real-time satellite images and "movie loops" afford an opportunity to show the public where the weather is occurring. This program also is highly beneficial to the aviation and agricultural communities.

The GOES-Tap system, implemented in 1975 to provide for the dissemination of GOES satellite images by geographic sectors, was further expanded in 1979 to include lines to several FAA Air Route Traffic Control Centers. Initial GOES-Tap lines were installed in those centers that control high-density aircraft operations along the east coast. Meteorologists, trained by NESS in weather satellite image interpretation, are collocated with the FAA controllers and provide them with the latest weather information.

The GOES Data Collection System (DCS) has a total of 41 national and international users that operate more than 1000 Data Collection Platforms (DCP). During 1979, 11 new users and more than 350 platforms were added to the system. A new remote command feature was added to the system; now the user can change the configuration of one or more DCPs in the network by sending a command either by telephone or by satellite directly to the DCS computer which relays the command by satellite to the platforms. This feature saves time and reduces errors inherent in a manual system.

Plans also were completed to develop a GOES DCS Automated Monitoring System which, when it becomes operational in early 1981, will sample the characteristics of the platform radio transmissions. Frequency stability, signal strength, and other performance aspects relating to platform condition can be monitored and automatically recorded as a means of detecting platform malfunction.

Satellite Data Uses

Determining Winds and Temperatures. During 1979, atmospheric temperature soundings and sea-surface temperatures were obtained operationally over the entire globe from the polar-orbiting satellites, and wind measurements were obtained operationally three times each day over the Western Hemisphere from geostationary satellites. Cloud-motion winds were determined at three atmospheric levels at a 300-kilometer spatial interval. These data were provided to the National Weather Service, the United States Air Force and Navy, and twenty foreign governments. In addition, these data become part of the Global Weather Experiment data base.

Digital infrared data from the geostationary satellites are stored in a data base. Real-time users can obtain these data to supplement conventional observations. Satellite-derived cloud-top temperatures and land temperatures provide an instantaneous view of conditions associated with the development, intensity, and surface coverage of convective storms. These observations are used in determining the potential for the development of damaging winds and flash flood events. Land-surface temperature patterns are used to determine the potential for frost or freeze conditions threatening agriculture, and the sea-surface temperature patterns are used to assist the fishing industry and route ships in major ocean current regions. This improves the efficiency of operations at sea for two major users.

During 1979 NESS implemented a program to compare information on cloud-motion derived winds from geostationary satellites operated by the United States, the Japanese Meteorological Satellite Center, and the European Space Agency. These studies included special data sets produced by the Space Science and Engineering Center at the University of Wisconsin and two research laboratories in Europe. This year's comparisons coincided with the Global Weather Experiment Intensive Observation Periods of January and May 1979. The results so far show that observations from these diverse sources are quite compatible. Two comparison periods each year are to be continued indefinitely to ensure accuracy and compatibility of these data for the World Weather Watch.

The NOAA Wave Propagation Laboratory (WPL) completed the second phase of a systems analysis on the feasibility of measuring the global winds with a satellite-borne lidar (laser-light-detection-and-ranging system). The technique involves the tracking of dust and other particles suspended in the atmosphere. The attenuating effects of typical cloud distributions, ranging from fair weather cumulus to intertropical convergence zone clouds, were added to the study in this past year. The failure of the laser beams to penetrate thick, water-droplet clouds resulted in some loss in accuracy at pressure levels below 700 millibars, but in most cases wind speed could be determined to within 2 meters per second in the presence of clouds, and better than 1 meter per second in the clear air.

Computer programs were successfully developed for various man-machine interactive methods to process and evaluate Tiros-N temperature and moisture soundings. Comparisons made between satellite-derived temperatures and

radiosonde temperatures showed Root Mean Square errors of about ±2°C at most levels. Many case studies were conducted integrating the Tiros-N temperature data with geostationary satellite cloud-cover images and radiosonde observations. Data sets were collected and processed for regional forecast studies by groups at the Australian Numerical Meteorological Research Centre and the United States National Center for Atmospheric Research. One case study included an orbit over tornadoes in the United States on May 2, 1979. In this study, detailed analyses made of the Tiros-N data 12 hours prior to the tornado development along the Oklahoma-Kansas border detected the low pressure area, the intense moisture front with convectively unstable air, and the strong divergence of the upper level jet over the area where the severe weather subsequently occurred. Thus, the Tiros-N data were able to delineate the precursor conditions of severe weather development.

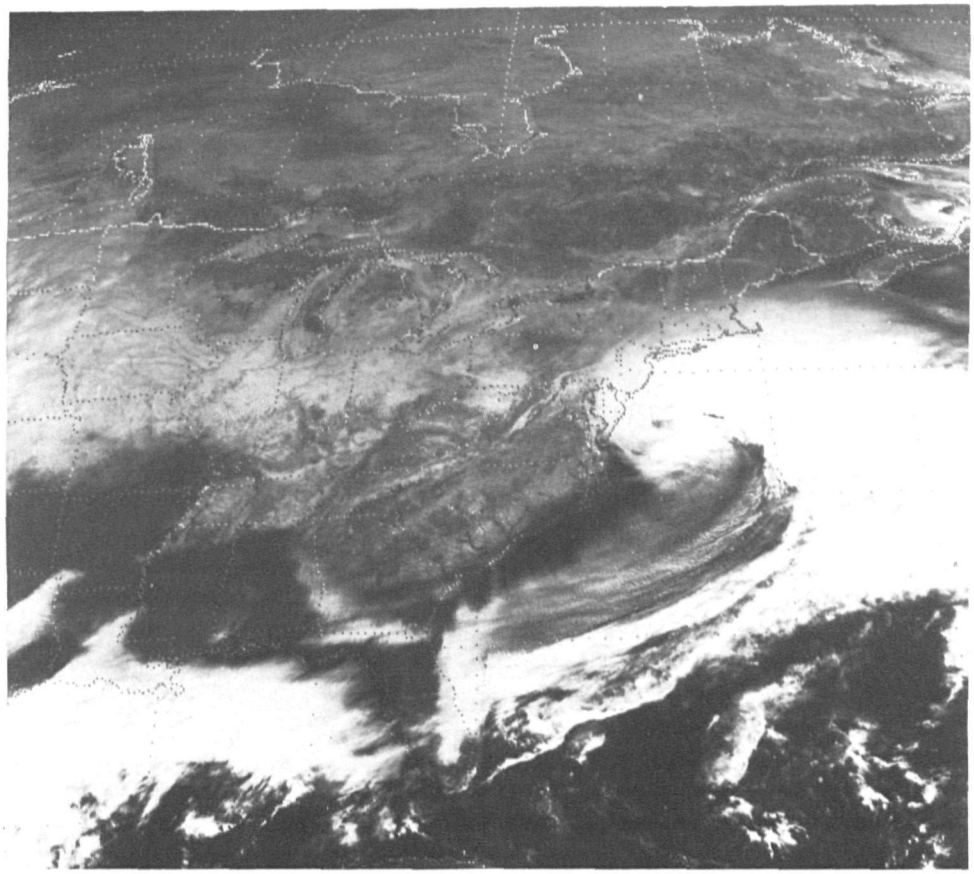
Geostationary-satellite-derived winds often were obtained simultaneously with Tiros-N overpasses. The capability was developed to use Tiros-N soundings to assign pressure heights to these winds. Evaluations suggest that the cloud-height determination is considerably improved by merging these data sources. This procedure was used at the University of Wisconsin to determine cloud heights from GOES 1-derived winds over the Indian Ocean during the Global Weather Experiment.

Monitoring Global Radiation. Radiation budget data were derived from the Tiros-N Advanced Very High Resolution Radiometer beginning January 1, 1979. Data from the Tiros-N satellites, like the ITOS series, include measurements from which various heat budget components are derived and mapped globally on different time scales. These heat budget components are important diagnostic tools for meteorological and climatic studies and a source of information to the growing number of scientists interested in climate fluctuations. These data also provide information on the radiative regimes of the Earth, and they yield indirect evidence on variations in cloudiness, ice and snow cover, and other heat sources.

The Earth Radiation Budget (ERB) experiment, carried on Nimbus 7 (launched October 24, 1978), continued to monitor solar output during 1979. The derived solar constant remained at a value of 1376 watts per square meter. The ERB experiment, by observing in detail both incoming and outgoing radiation, will provide accurate information on the Earth's radiation budget as a function of location and time.

Environmental Warning Services. On selected days from March through June 1979, NESS operated GOES satellites in a special three-minute-interval imaging mode to support the Severe Environmental Storms and Mesoscale Experiment (SESAME). The objective of SESAME is to use a combined set of satellite and conventional observations to allow meteorologists, for the first time, to observe convective cloud and storm development with a resolution in space and time comparable to the scales of the atmospheric phenomena being observed. Meteorologists are trying to determine the fine-scale, short-lived mechanisms that trigger thunderstorms and thunderstorm systems which produce

hail, tornadoes, and damaging winds. Additional support consisted of communications services and the provision of the new electronic satellite image video display system. This system was placed at NOAA's National Severe Storms Laboratory, Norman, Oklahoma, for use by the researchers. In addition to being the first integrated use of satellite data, this also was the first field use of an electronic satellite image animation device. The benefits of satellite data and satellite image animation to the research were convincingly demonstrated on April 10, 1979, when tornadoes along the Red River Valley devastated the towns of Vernon and Wichita Falls, Texas, and Lawton, Oklahoma. Satellite data called attention to this threat and allowed forecasters to sound an early alert, thus preventing the possibility for further loss of lives and property. The data from Project SESAME are currently being analyzed.



Geostationary visible image showing the storm system that caused blizzard conditions in the northeast U.S. on February 18-19, 1979.

NESS's Satellite Field Services Stations (SFSS) were instrumental in many new environmental warning activities during 1979. One of the primary functions of the SFSS is to support the National Weather Service (NWS) by providing interpretation of GOES images to improve the accuracy of routine forecasts and to provide timely severe weather warnings to the public.

In response to a demonstrated need to improve marine and coastal weather services in the Gulf of Mexico, a Gulf of Mexico satellite support unit was staffed in June 1979 and located with the Kansas City SFSS. In 1980, the "Gulf Support Unit" will be moved to Slidell, Louisiana and will be collocated with the NWS Forecast Office.

In 1979, NESS's Synoptic Analysis Branch placed into operation a procedure for estimating precipitation intensities from GOES satellite images. These precipitation estimates were provided as input to the NWS forecasts of possible flash-flood events. The most notable event for which rainfall estimates were provided was the Pearl River flood in Mississippi. Rainfall estimates also are provided for the International Water Commission (United States and Mexico) and are useful for planning the regulation of water flow in the Rio Grande River.

In research, infrared measurements from geostationary satellites continued to be used in a statistical approach to measuring rainfall for input to the NWS river-flow models. While a correlation was found between infrared cloud-top temperatures and rainfall, results were improved by adding other meteorological variables derived from a combination of satellite measurements and conventional observations. Testing the repeatability of these relationships under various meteorological conditions continues.

NOAA's National Hurricane and Experimental Meteorology Laboratory has continued to use satellite data for its research into hurricanes and convective cloud systems. Satellite data were collected over Hurricanes David and Frederic as these storms passed over Hispaniola, Cuba, and the United States. Simultaneous data also were collected by NOAA's research aircraft. Aircraft data included low-level wind fields, storm intensities, and digitized radar depicting the rain distributions with time. Aircraft and satellite data sets will be used to study the degree to which cloud motions represent winds at the lower levels, the accuracy of storm intensity estimates from satellites when compared with observed values, the accuracy and detail of rainfall estimates from satellite images when compared with quantitative airborne radar measurements, the possible indications of diurnal variations in the satellite-observed cloud field when compared with radar observations and observed wind fields, and forecast changes in storm intensity and motion from satellite-observed cloud characteristics by comparison to the research aircraft measurements. Wind fields have been determined from cloud motion in the outer fringes of hurricanes but not within the inner core of the storm. Rainfall estimates from satellite images seem to give reasonable results, but quantitative comparisons over lengthy periods of time have not been possible because of little surface truth data. An accumulation of digitized radar measurements over long periods will provide data for these comparisons.

Satellite storm-intensity estimates have been reasonably good, but large errors are occasionally found. Further study of the satellite and concomitant aircraft data should provide more reliable comparisons.

The Navy-NOAA Joint Ice Center became operational in June 1979. The Alaskan and Hemispheric Ice Analyses are now produced at the Joint Ice Center at Fleet Weather Facility, Suitland, Maryland. These ice charts are an important aid to shipping companies that resupply Arctic ports. The companies can route their ships to avoid severe ice conditions, reducing the risk of damage and reducing the costs in time and fuel.

During 1979, the Anchorage SFSS expanded its operation to provide 24-hour service to Alaska. A new technique to forecast the intensification of storm systems in the mid-Pacific and Gulf of Alaska was operationally tested. Because of the limitations of numerical forecasting over the oceans, it is often difficult to locate, track, and forecast the development of storms in the mid-Pacific. This technique, developed at the Anchorage SFSS, used satellite data to locate and provide a quantitative estimate of the central pressure that can be used by NWS forecasters to estimate storm severity and issue weather and gale warnings. Of 81 operational cases, the SFSS surface pressure forecast guidance averaged 1.28 millibars lower than the observed value; the numerical predictions of central pressures averaged 15 to 19 millibars higher than observed values.

Cloud images of the western Pacific Ocean from Japan's Geostationary Meteorological Satellite are now available to forecasters at Honolulu and the National Meteorological Center. These pictures cover a large area of the Pacific not viewed by United States geostationary satellites; and they are an important addition to observing upstream weather conditions over the open ocean.

In 1979 an operational program was started to measure natural passive gamma radiation by flying instrumented aircraft over selected areas of the north-central Plains. This radiation information is used to help estimate water content of snow cover. When used with satellite information on the areal extent of snow cover, NWS has a powerful new tool to better judge the threat of flooding from snowmelt.

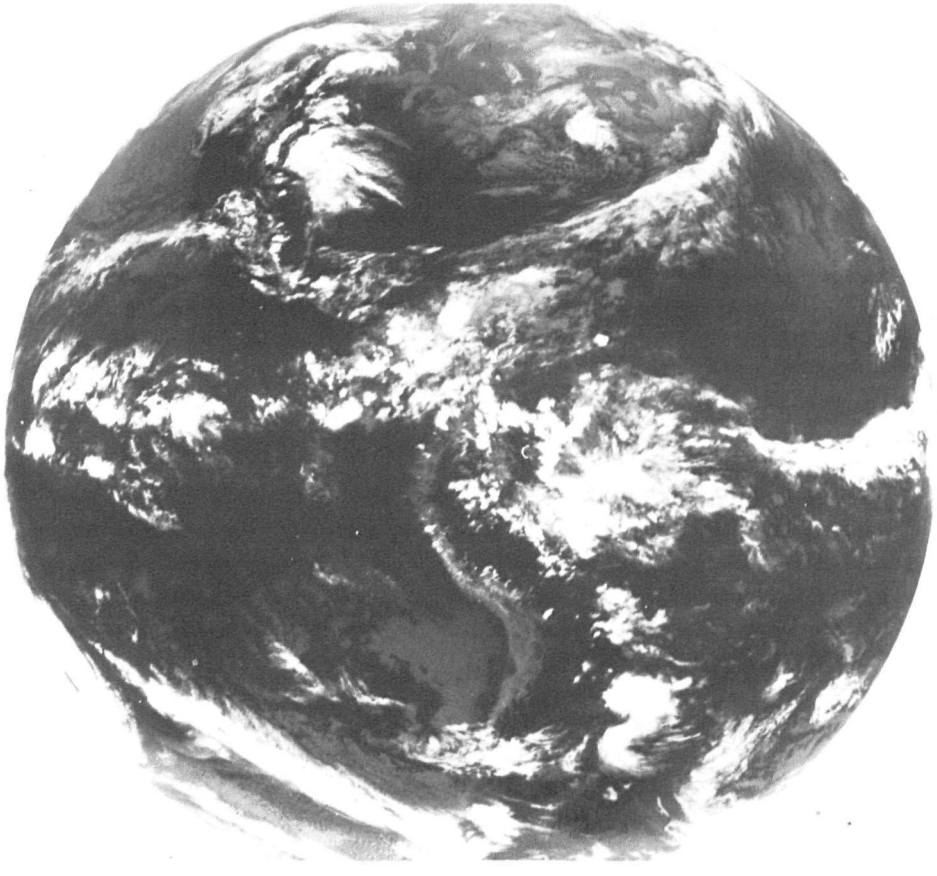
Determining Ocean Conditions. The NOAA Seasat program was subjected to an intensive review immediately following the satellite's demise on October 9, 1978. Adjustments were made in the planned experiment program to account for certain data which could not be collected. The result was cancellation of certain experiments. Major emphasis was directed toward the surface truth areas where concurrent ship, aircraft, and satellite data were collected during the 99-day Seasat lifetime. These were the NOAA-coordinated Gulf of Alaska Seasat Experiment, the Joint Air Sea Interaction experiment, oceanic tropical and extratropical storms, Gulf Stream, polar ice and other areas where significant surface truth was available.

During its period of operation Seasat covered most of the 1978 tropical

storms. It made 126 passes over 21 hurricanes and typhoons, 179 passes over 20 tropical storms, and 64 passes over tropical depressions. Seasat radar images were compared with coincident surface observations made by NOAA during the Gulf of Alaska experiment. The results indicate that satellite-borne imaging radars are extremely valuable tools in the study of ocean surface and internal waves, surface currents, and mesoscale atmospheric disturbances.

NOAA's Pacific Marine Environmental Laboratory (PMEL) provided the meteorological analysis of conventional surface observations for comparison with Seasat scatterometer wind fields. The scatterometer potentially is a useful tool for operational meteorology because it can accurately locate low pressure centers, storm producing regions, and zonal bands of high winds.

NOAA's National Hurricane and Experimental Meteorology Laboratory evaluated the usefulness of satellite-sensed surface observations in the



Geostationary infrared image showing eruption of Mount Soufriere volcano on St. Vincent Island, April 17, 1979 (bright-white cloud, center right).

vicinity of hurricanes to provide information concerning the areal extent of hurricane and gale force winds and to provide initial data to hurricane forecast models and storm surge models. Data gathered during the 1978 hurricane season by the Seasat microwave scatterometer system have been used in this study. Preliminary results indicate that the satellite surface wind speeds, below gale force, are overestimated by about 15 percent. Although winds in the hurricane's inner core are not well resolved, this method of remote sensing offers great potential in obtaining a snapshot of the hurricane wind field.

NOAA's Wave Propagation Laboratory developed a computer program for estimating significant waveheight and mean sea level using Seasat radar altimeter data. Comparisons with sources of surface truth show agreement for significant waveheights up to 30 centimeters. PMEL and Geodetic Research and Development Laboratory investigators completed the first definitive baseline experiment comparing satellite-altimeter-derived ocean surface topography with shipboard observations. Results show that the satellite altimeter can measure surface topography within 10 centimeters of that measured with standard shipboard oceanographic measurements.

In 1979, two major oceanographic cruises were conducted to obtain surface truth data to support the Nimbus 7 Coastal Zone Color Scanner (CZCS) experiments. The first cruise was conducted in March 1979 in the Gulf of California, and the second cruise was conducted in May and June 1979 in the northwest Atlantic. The cruises were supplemented by two field trips to Bermuda to obtain atmospheric transmittance measurements. Optical and biological measurements were obtained from a wide range of water masses by scientists from NESS, PMEL, Scripps Institution of Oceanography, University of Southern California, University of Miami, and San Jose State College. Results from these cruises provide the first comparisons between remotely sensed ocean color from the CZCS, surface-measured ocean color, and the distribution of suspended particulate matter, especially that associated with biological activity.

The Gulf Stream Analysis, which began in 1973, continued to be produced in 1979. Based on high-resolution infrared images from the Tiros-N and GOES satellites, the weekly composite map shows the location of the Gulf Stream, warm and cold eddies, and the thermal interface between the slope and shelf waters. Since fish congregate at thermal boundaries, fishermen use these charts to locate productive fishing grounds. A related product which describes only the north or west boundary of the Gulf Stream also was produced three times a week. The Gulf Stream Wall Bulletin, broadcast twice daily over Coast Guard radio, gives a sequence of points that represent the west or north wall of the Gulf Stream. Coastal shipping interests used this information to route their ships to take advantage of the ocean currents.

A tri-agency group conducted a study related to the development of a National Oceanic Satellite System (NOSS) and formally published its findings in March 1979. This group, with representation from Commerce, NASA, and Defense, focused on the operational needs of the civil and defense communities requiring oceanographic information, and on the space and ground systems that

would be necessary to satisfy those needs. NOSS would provide a limited operational demonstration of the ability of satellites to sense oceanic phenomena.

Determining Lake Conditions. The Great Lakes Ice Analysis was produced twice weekly during the ice season from January through April 1979. Visible high-resolution satellite images from both the Tiros-N and GOES satellites were used to analyze the ice conditions in the lakes. Ice conditions were very severe during the second half of February. Between February 17-22, 1979, all five Great Lakes were completely frozen except for a small area in southwestern Lake Ontario and an area in central Lake Michigan. These analyses provide information to ships navigating this vital waterway.

Determining Hydrological Conditions. Elements of NOAA, NASA, and the Department of Agriculture cooperated in conducting two soil moisture field missions at the Luverne, Minnesota, hydrologic test site in November 1978 and June 1979. Although the ground data sets have been processed, aircraft and satellite measurements have not yet been received. A nuclear-powered, combination snow-water-equivalent and soil-moisture gage was installed, and a Data Collection Platform will be modified to transmit the data through the GOES Data Collection System.

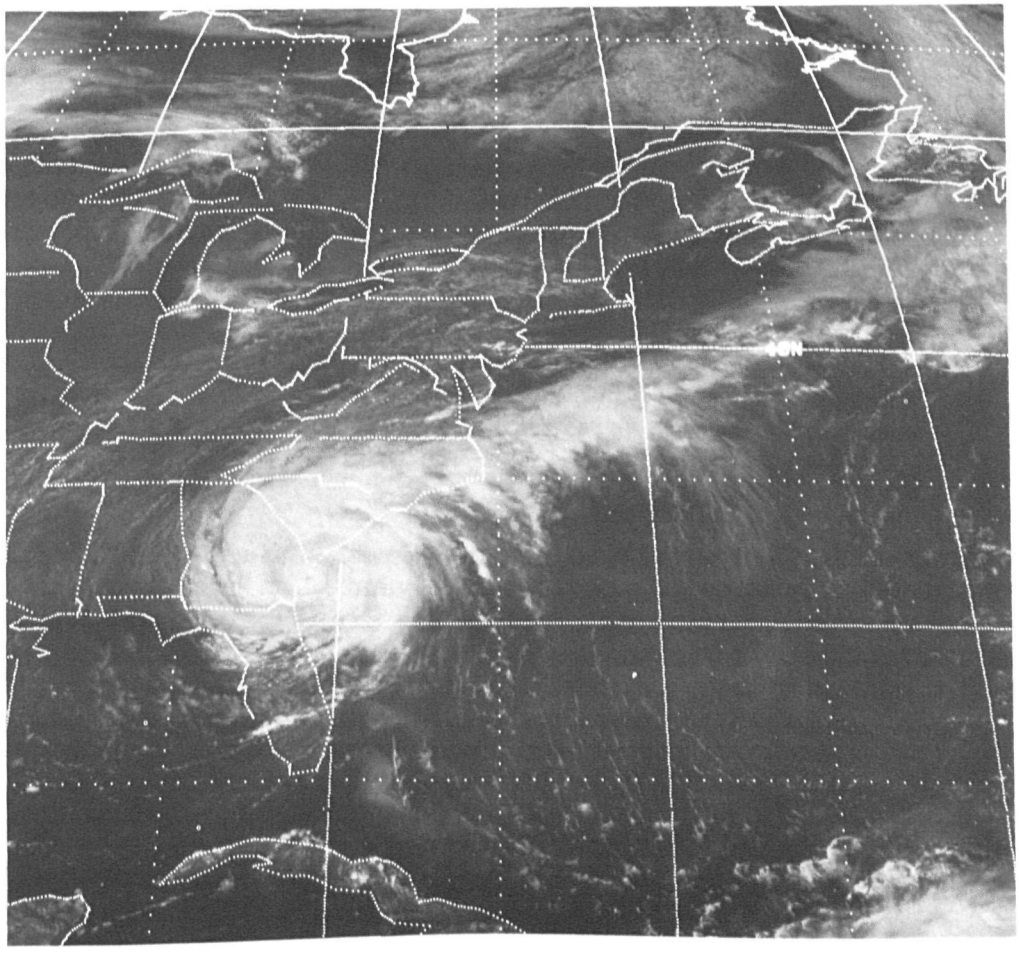
NESS continued operational snowmapping from satellite data for thirty river basins in the United States and Canada. Snowcover during the 1978-79 winter season was found to be slightly below average in the Pacific Northwest, average in California's Sierra Nevada, and above average in the mountains of Arizona, Colorado, and Wyoming. Snowmapping of the Missouri River basin (40,700 square kilometers) above Helena, Montana, was begun during the 1978-79 season at the request of the Department of Agriculture's Soil Conservation Service and the National Weather Service. Also, weekly satellite-derived snow maps for Afghanistan and neighboring Himalayan nations were begun in April 1979 at the request of Agriculture's Joint Agricultural Weather Facility.

Monitoring Agricultural Conditions. A new program was initiated by NESS in 1979 to provide dedicated support to NWS agricultural meteorologists in the states of Oregon, Washington, California, and Arizona. Satellite data are used to improve frost forecasts to prevent crop loss. Detailed analyses of satellite data from polar-orbiting and geostationary satellites are made and disseminated to the agricultural meteorologists who are in direct contact with the fruit growers. These analyses incorporate cloud cover, movement of clouds, and changes of intensity of clouds on a mesoscale in areas of concentrated agricultural activity. Further research is being conducted to correlate satellite-derived temperature and ground-moisture-level measurements with surface-observed data so that future satellite analyses may be used to reveal actual readings. These readings will be used to establish the probability of frost with sufficient lead time to allow producers to take preventive measures to protect crops.

From November 1974 until November 1978, NOAA, U.S. Department of

Agriculture, and NASA cooperated in a Large Area Crop Inventory Experiment (LACIE). The purpose of LACIE was to determine if satellite crop monitoring and meteorological observations could be used with climate and crop-yield models to make timely and accurate estimates of future crop production in the major wheat-producing countries of the world.

AgRISTARS (Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing) is a new project that began in 1979. AgRISTARS is a cooperative research effort among five Federal agencies - Departments of Commerce, Agriculture, and Interior, Agency for International Development, and NASA. The objectives of AgRISTARS are to develop an early warning system able to detect conditions affecting crop production and quality and to provide techniques for more accurate forecasts of domestic and foreign commodity production. The AgRISTARS effort will develop and test techniques using advanced remote sensing data obtained from NOAA and NASA satellites and selected



Geostationary visible image showing Hurricane David as it reaches land on September 4, 1979.

remote-sensing data from aircraft. While the potentially most valuable return of AgRISTARS research will accrue from improved information concerning foreign crop production, domestic agriculture information also will be useful. Satellite data should mean better commodity information at the county and regional level.

Fisheries Monitoring. During 1979, NESS began issuing surface temperature maps of the ocean waters adjacent to Alaska. High-resolution infrared digital data from Tiros-N are used. Analyses are prepared weekly for cloud-free areas, and they are distributed to 35 locations by the National Weather Service Alaskan facsimile network. The maps also are mailed to 25 other subscribers. Since the behavior of the sea-surface temperature field of Alaskan waters is relatively unknown, these maps allow researchers, commercial fishermen, and state and Federal management personnel to study and correlate fish catch statistics. Since the salmon, halibut, and crab fisheries are the economic backbone of most of coastal Alaska, the value and support of this product among commercial and recreational fishermen continues to grow.

The National Fisheries Engineering Laboratory (NFEL), the National Weather Service, and NASA are cooperating to develop a small portable satellite communications terminal for the use of government observers stationed on foreign and domestic fishing vessels within the U.S. Fisheries Conservation and Management Zone (320-kilometer limit). This will provide the observer with a means to relay weather data, catch, position, and other information to the land on a nearly real-time basis.

The prototype Marine Mammal Transmitter developed for tracking porpoise using the Nimbus 7 Random Access Management System was tested in 1979. Field tests of the instrument were conducted in Hawaiian waters by attaching transmitters to Hawaiian spotted dolphins and observing their movement. If these experiments are successful, operational units will be procured for further tagging experiments in 1980.

NFEL has modified its effort to measure ocean surface circulation using scatterometer data because of the loss of Seasat. An experiment to determine surface layer transport in the Gulf of Mexico is being conducted. Bathythermograph data will be combined with coastal circulation and open ocean models to develop a complete interactive display of the Gulf of Mexico's circulation. A grid of 78 stations has been established to determine continental shelf circulation in homogeneous water masses to provide insight into the expected sea-level response to various wind fields. Menhaden and shrimp data are being obtained to correlate with these models. The first implementation of the coastal circulation model for Gulf waters adjacent to Louisiana and Texas has been completed, showing a correlation between water circulation and shrimp yield.

Environmental Monitoring Using Data Buoys. In 1979, the NOAA Data Buoy Office converted all 22 of its data buoys to transmit environmental and communications data through the GOES satellites. Some buoys were relocated to provide maximum coverage of the most critical data-sparse marine areas.

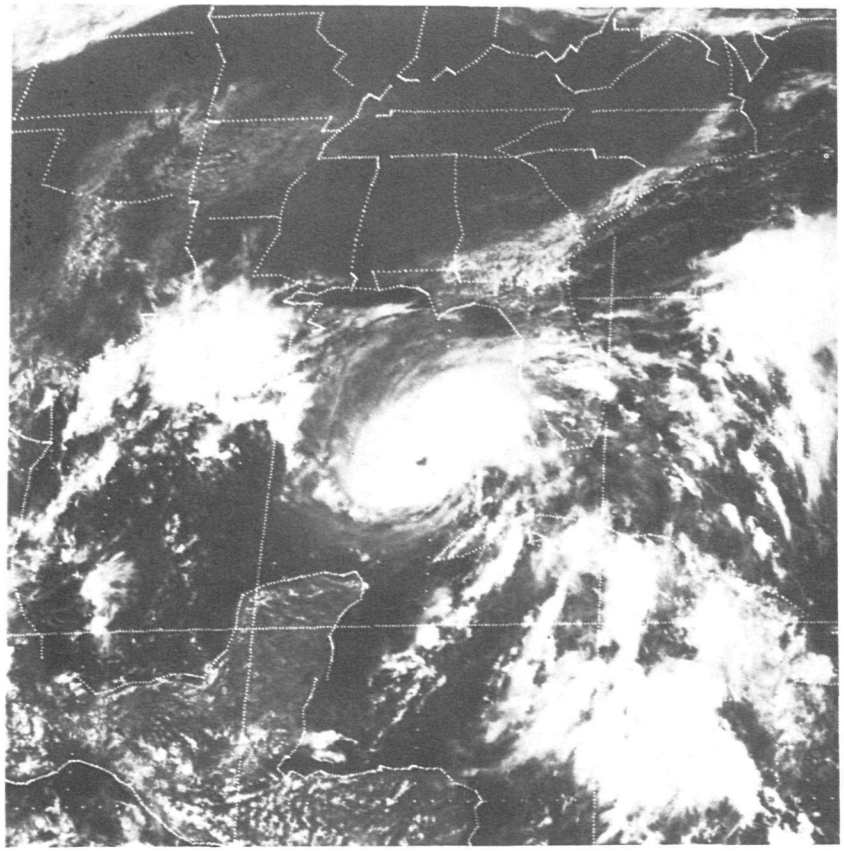
Six buoys are located in the Northeast Pacific and Gulf of Alaska, four are located in the Gulf of Mexico, ten are located in the Atlantic, and two are located in a new Great Lakes data buoy network. The Great Lakes network will be expanded to eight buoys over the next two years. Plans are also underway to incorporate the 12 Coast Guard large navigational buoys, located at the sites of former lightships, into the GOES Data Collection System. A prototype system now is in operation on the Columbia River Bar Navigational Buoy. Both the data buoys and the navigational buoys provide meteorological data and surface water temperatures. Subsurface water temperatures and wave data are obtained from selected buoys. These data are used by the National Weather Service for forecasting and storm warning, by the Bureau of Land Management for continental shelf assessment, and by various scientific programs with specialized marine data requirements. All moored buoys are equipped with position-fixing systems which permit the Nimbus or Tiros-N satellite to locate them when they go adrift. Most buoys have been modified to use the Tiros-N Argos Data Collection System for position fixing.

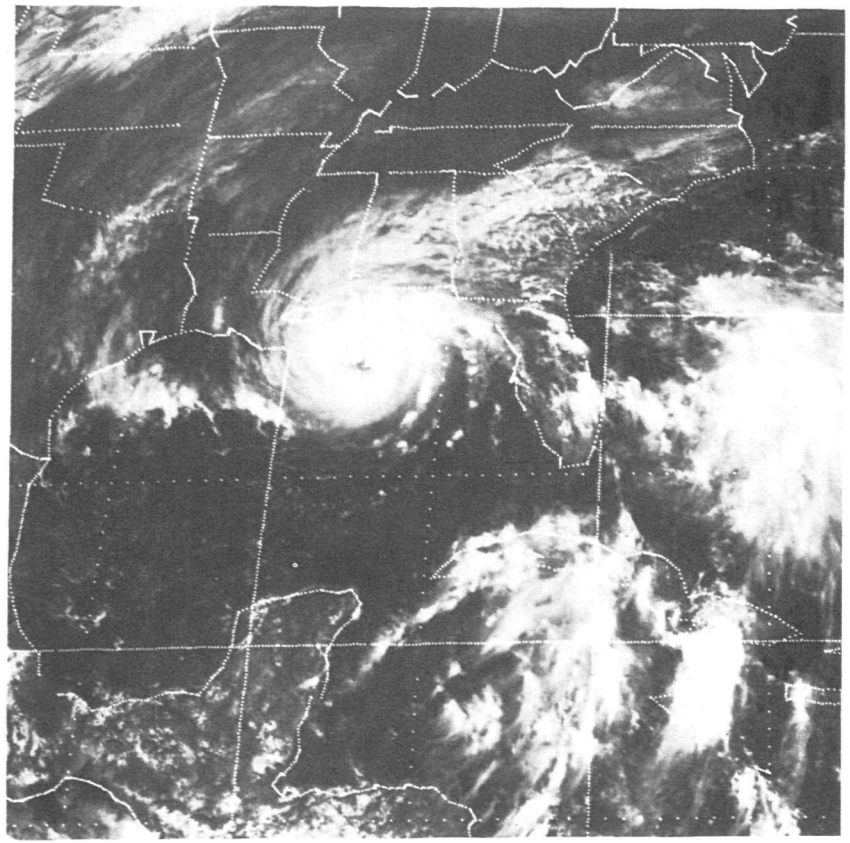
International Cooperation

Global Weather Experiment. During the Operational Year (December 1, 1978 to November 30, 1979), NESS has archived satellite-derived observations of cloud-motion vectors, sea-surface temperatures, and vertical temperature profiles on magnetic tapes that are sent to the Special Observing Data Centre in Sweden. Approximately 40,000 cloud motion vectors per month are derived from the GOES east and west satellites. About 1 million sea-surface temperatures and 40,000 atmospheric temperature soundings per month are obtained from the Tiros-N satellite. The European Space Agency provided the control and data handling functions of GOES 1, located over the Indian Ocean. The University of Wisconsin processed GOES 1 data to obtain wind fields over this area. The quantity and quality of satellite-derived meteorological observations are expected to greatly enhance the utility of the final data base obtained from the Global Weather Experiment. These data will be used in global atmospheric modeling research.

Sharing Data. More than 120 countries now avail themselves of the medium-resolution Automatic Picture Transmission services provided by the polar-orbiting Tiros-N system satellites, and at least 16 countries now have the capability to receive High Resolution Picture Transmissions and Direct Sounder Broadcasts from which atmospheric temperature/humidity profiles may be generated. While the primary applications of these direct readout transmissions are in storm detection and aviation forecasting, these satellite observations also are supporting special hydrologic, oceanographic, agricultural, and other operational and research programs overseas. Sea-ice reconnaissance, snow accumulation and melt, agricultural weather forecasts, locust control activities, and pelagic fish migration and harvesting are among the many activities being supported by direct readout of satellite data.

Environmental Satellite Assessments. Precipitation estimates from Tiros-N and GOES satellite images are used by the Environmental Data and Information Service to directly support the Department of State's Agency for





Geostationary satellite visible pictures showing Hurricane Frederic over a two-day period (September 11 and 12, 1979) as it approaches the U. S. Coast from the Gulf of Mexico.

International Development (AID) disaster assistance effort. These assessments evaluate the effects of weather variables on crops in the developing nations of Africa, Southeast Asia, and the Caribbean basin, alerting AID of potential droughts, floods, and other weather-induced natural disasters. This support has enabled earlier shipments of food and improved efficiency in planning and implementing emergency operations.

Other Uses of Satellites and Space

Determination of the Earth's Shape and Gravity Field. The National Ocean Survey (NOS), as a part of its mission to maintain a network of accurately positioned ground stations for geodetic surveying and mapping, continues its work with NASA to evaluate applications of space systems to geodesy and geodynamics. In its continuing investigations into Very Long Baseline Interferometry (VLBI), a system based on interferometric observations of extragalactic radio sources, NOS is establishing a network of three observatories to regularly monitor polar motion and universal time. Two of the three required stations, located near Ft. Davis, Texas, and Westford, Massachusetts, are scheduled for test operations in 1980. This network should be capable of determining polar motion to $\pm$ 10 centimeters and universal time to $\pm$ 0.1 millisecond over 8 hours. NOS continues to collect satellite Doppler data for precise positioning to compare with other newly developed space technology, such as lunar laser ranging, satellite laser ranging, and VLBI. Satellite Doppler data also are used as inputs to the model of the Earth being refined by the Doppler orbital computations in the international polar motion experiment.

Studies of ways in which the signals from the Global Positioning System (GPS) satellites can be used to measure crustal movement and in general surveying requirements are being carried out by the National Bureau of Standards (NBS), the Jet Propulsion Laboratory, the Naval Surface Weapons Center, a joint Massachusetts Institute of Technology-Draper Laboratories group, and the National Geodetic Survey. The work at Geodetic Survey and NBS has shown theoretically that phase-difference measurements on signals reconstructed from the incoming GPS signals are capable of accurately determining the baseline between the receivers with only two hours of observations per site.

NOS also published a new global model for the Earth's gravity field based on the density layer method. Altimeter observations from the Geodynamics Experimental Ocean Satellite (GEOS 3) and gravity, Doppler, and satellite triangulation data were used. NOS began an analysis of altimeter data from Seasat and provided assistance to the Jet Propulsion Laboratory in preparing data reduction programs. Altimeter data have been used to obtain elevation variations over land. NOS also prepared a study on Gravsat, a proposed pair of low-altitude satellites that sense high-frequency variations in the gravity field. This study confirmed that at an altitude of 200 kilometers the system can recover gravity data within 3 milligals over one-degree blocks.

Satellite Communications. Distribution of National Bureau of Standards (NBS)-referenced time code at 468 MHz from two of NOAA's GOES satellites was continued and improved during 1979. An NBS-developed instrumentation system was installed at NOAA's Command and Data Acquisition station, Wallops, Virginia. The new system provides more reliable and stable timing signals for a variety of applications in navigation, communications, electric power network operations, and scientific data monitoring throughout the Western Hemisphere.

Solar Activity. The International Solar Maximum Year (ISMY) program, begun in August 1979, will continue through February 1981. This period coincides with the solar cycle maximum (sunspot surge). Constellations of satellites poised around the Sun and Earth will record detailed development of active regions on the solar surface, and arrays of Earth-surface solar observatories will coordinate their viewing of the growth of these regions. In particular, scientists with experiments on board the Solar Maximum Mission satellite, to be launched in early 1980, are receiving support from a Space Environment Services Center (SESC) unit established at Goddard Space Flight Center. Data from the Tiros-N and the three International Sun-Earth Explorer satellites will be available for operational use by SESC in late 1980.

Space and Atmospheric Research

Interplanetary Physics. The effect of coronal mass motion, initiated by solar flares and other transient disturbances on the Sun, was examined by NOAA's Space Environment Laboratory (SEL) in cooperation with the NASA Marshall Space Flight Center, the Harvard College Observatory, and the University of Alabama, Huntsville. Major features of coronal transient events, such as their expanding bubble-like characteristics and the development of shock waves, were successfully described by theoretical computer simulations. Additional studies have been made on multi-dimensional, time-dependent simulations of the interplanetary consequences of these solar disturbances.

Magnetospheric Physics. Significant advances in the understanding of the dynamics of the ring current (produced by geomagnetically trapped charged particles comprising the Van Allen radioactive belts) have been made by SEL scientists. Following earlier laboratory studies defining the importance of ions heavier than hydrogen, further study has indicated an important aspect of ring current enhancement during geomagnetic disturbances. A physically consistent theory of the production of magnetospheric electric fields responsible for the acceleration of auroral electrons has been formulated.

The comprehensive data base provided by the two International Sun-Earth Explorer satellites now extends over more than a year, providing long time, spatial, and energy resolution data throughout the region surrounding the Earth out to its approximate apogee of 21 Earth radii. Analysis techniques have been developed which enable the motion of the magnetospheric boundary to be determined near satellite crossing. A wave structure also has been found on that boundary which provides information on the nature of the interaction

and momentum and energy transfer from the solar wind into the magnetosphere. The coupling of the solar wind and the magnetosphere and the explosive energizing of charged particles in the magnetospheric tail - responsible for auroral precipitation of energetic particles and for magnetospheric substorms - are crucial to the understanding of the global dynamics of the magnetosphere.

Aeronautical Programs

Aeronautical Charting. The National Ocean Survey (NOS), which publishes and distributes the Nation's domestic aeronautical charts, has developed a new bound-volume format for Instrument Approach Procedure Charts (IAPCs). These charts portray all aeronautical data required to make an instrument approach to airports in the contiguous United States, Puerto Rico, and the Virgin Islands. This replaces the traditional loose-leaf volume which pilots had to manually update every 14 days. NOS now issues 15 bound volumes containing all current Federal Aviation Administration (FAA)-approved IAPCs every 56 days. Changes in procedures, within the publication cycle, are issued in a single-volume at the 28-day mid point of the cycle. The next 56-day issue incorporates these changes and replaces all preceding volumes.

The expanded use of the National Airspace System has increased the demand for more controlled airspace and for applicable aeronautical charts and services. At the request of the FAA, NOS began development of 20 Minimum Instrument Flight Rule (IFR) Altitude Sector Charts, which provide air traffic controllers with minimum IFR altitude information for radar vectoring and off-airway operations. NOS also has compiled a special-use Terminal Area Control Chart for the Saranac Lake, New York, area to accommodate the heavy air traffic expected for the 1980 Winter Olympics.

Forecast Guidance. The NWS National Meteorological Center (NMC) developed several forecast models to provide improved forecasts basic to safe and economic aircraft operations. During 1979 an optimum interpolation scheme was developed that updates the models by incorporating winds and temperatures measured from high altitude jet aircraft along standard routes. In addition, global synoptic stratospheric analyses and predictions have enabled NMC to provide valuable support to the ozone monitoring program. Studies are being conducted to determine the effects of cabin ozone on passengers and crews of stratospheric flights.

Automation of Airways Observations. NWS, in cooperation with the FAA, has developed a system to automatically measure surface wind and altimeter settings and to generate a voice report which is automatically transmitted to the pilot through aeronautical navigation aids. The prototype of this device, called Wind, Altimeter, and Voice (WAVE), is being tested at Frederick, Maryland. Automated weather observations have been made more complete by the addition of new cloud ceiling and visibility measuring equipment at airports. Seven of the new improved automatic observation stations were installed during 1979, as well as 16 remote, unmanned, automatic weather observation stations. Weather information from the latter two types of automatic observing stations

is not transmitted directly to pilots but is added to the national aviation weather reporting system and used by forecasters to monitor rapid weather changes.

Automated Route Forecasts. NWS is cooperating with the FAA to develop a system to provide automated route forecasts to pilots. This is a large effort that requires the development of a new data base of objective weather information. Operationally, this grid data base would be computer-searched to provide specific route forecasts which could be delivered to the pilot by machine-generated voice. Important to this new system is the development of a forecaster-computer interface so the data base can be continually updated.

U.S. Environmental Satellite 1960-1979

Satellite	Purpose (1)	Launch	Average Altitude (KM) (2)	Ceased Operation	Remarks (3)
Tiros 1	R	04/01/60	720	06/19/60	First weather satellite providing cloud cover photography.
Tiros 2	R	11/23/60	672	02/01/61	
Tiros 3	R	07/12/61	760	10/30/61	
Tiros 4	R	02/08/62	773	06/12/62	
Tiros 5	R	06/19/62	778	05/05/63	
Tiros 6	R	09/18/62	694	10/11/63	
Tiros 7	R	06/19/63	645	02/03/66	
Tiros 8	R	12/21/63	749	01/22/66	First APT satellite.
Nimbus 1	R	08/28/64	S/677	09/23/64	Carried AVCS, APT, and High Resolution Infrared Radiometer for night pictures.
Tiros 9	R	01/22/65	S/1630	02/15/67	First Tiros satellite in Sun-synchronous orbit.
Tiros 10	0	07/01/65	S/792	07/03/66	
ESSA 1	0	02/03/66	S/765	05/08/67	First satellite in the operational system; carried 2 wide-angle TV cameras.
ESSA 2	0	02/28/66	S/1376	10/16/70	Carried APT cameras. APT carried on all even-numbered ESSA satellites.
Nimbus 2	R	05/15/66	S/1136	01/18/69	
ESSA 3	0	10/02/66	S/1427	10/09/68	Carried first AVCS cameras. AVCS carried on all odd-numbered ESSA satellites.
ATS 1	R	12/06/66	G/35,765	10/16/72 (pictures)	WEFAX discontinued December 31, 1978.
ESSA 4	0	01/26/67	S/1373	12/06/67	
ATS 2	R	04/05/67	-	-	Unstable attitude-data not useful.
ESSA 5	0	04/20/67	S/1379	02/20/70	
ATS 3	R	11/05/67	G/35,815	10/30/75 (pictures)	WEFAX discontinued December 31, 1978.
ESSA 6	0	11/10/67	S/1437	11/04/69	
ESSA 7	0	08/16/68	S/1440	07/19/69	
ESSA 8	0	12/15/68	S/1429	03/12/76	
ESSA 9	0	02/26/69	S/1456	11/15/73	

Satellite	Purpose (1)	Launch	Average Altitude (KM) (2)	Ceased Operation	Remarks (3)
Nimbus 3	R	04/14/69	S/1100	01/22/72	Provided first vertical temperature profile data of the atmosphere on a global basis.
ITOS 1	R/0	01/23/70	S/1456	06/17/71	Second generation prototype.
Nimbus 4	R	04/08/70	S/1108	-	Termination Recommended.
NOAA 1	0	12/11/70	S/1438	08/19/71	First NOAA funded second generation satellite.
ITOS B	0	10/21/71	-	-	Failed to orbit.
Landsat 1	R	07/23/72	S/918	02/16/78	
NOAA 2	0	10/15/72	S/1460	01/30/75	First operational satellite to carry all scanning radiometers.
Nimbus 5	R	12/12/72	S/1110	-	Still providing data.
ITOS E	0	07/16/73	-	-	Failed to orbit.
NOAA 3	0	11/06/73	S/1510	08/31/76	First operational satellite to permit direct broadcast of VTPR data.
SMS 1	R/O	05/17/74	G/35,788	-	First NASA prototype; 130°W on standby.
NOAA 4	0	11/15/74	S/1460	11/18/78	Deactivated.
Landsat 2	R	01/22/75	S/918	-	
SMS 2	R/0	02/06/75	G/35,780	-	Second NASA prototype; 75°W.
Nimbus 6	R	06/12/75	S/1110	-	
GOES 1	0	10/16/75	G/35,783	-	First NOAA operational geostationary satellite; 90°W on standby.
NOAA 5	0	07/29/76	S/1511	07/16/79	Deactivated.
GOES 2	0	06/16/77	G/35,778	-	Second NOAA operational geostationary satellite; 105°W on standby.
Landsat 3	R	03/05/78	S/918	-	First Landsat with infrared capability.
GOES 3	0	06/16/78	G/35,782	-	Third NOAA operational geostationary satellite; 135°W.
Seasat 1	R	06/26/78	850	10/10/78	Electrical failure.
Tiros N	R/0	10/13/78	S/850	-	Third generation prototype.
Nimbus 7	R	10/24/78	S/954	-	Carrying Coastal Zone Color Scanner.
NOAA 6	0	06/27/79	S/814	-	First NOAA funded Tiros-N system satellite.

(1) R - Research 0 - Operations, R/0 - Operational Prototype
(2) S - Sun-synchronous, G - Geosynchronous
(3) APT - Automatic Picture Transmission, AVCS - Advanced Vidicon Camera System, WEFAX - Weather Facsimile, VTPR - Vertical Temperature Profile Radiometer