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Satellite Activities of NOAA 1978

Compiled by:
NATIONAL ENVIRONMENTAL SATELLITE SERVICE

Washington, D.C.
June 1979

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

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National Oceanic and Atmospheric Administration
TIROS Satellites and Satellite Meteorology

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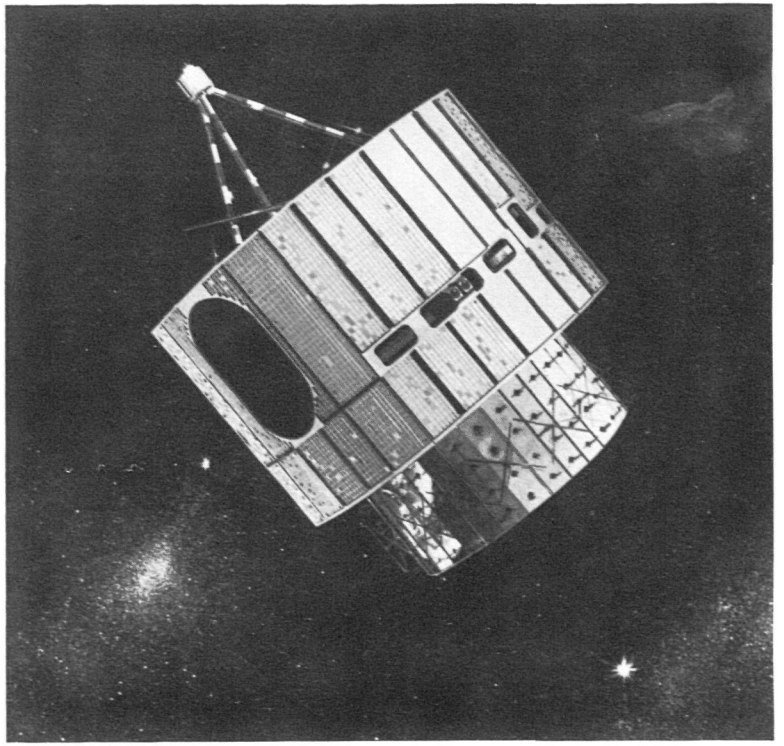
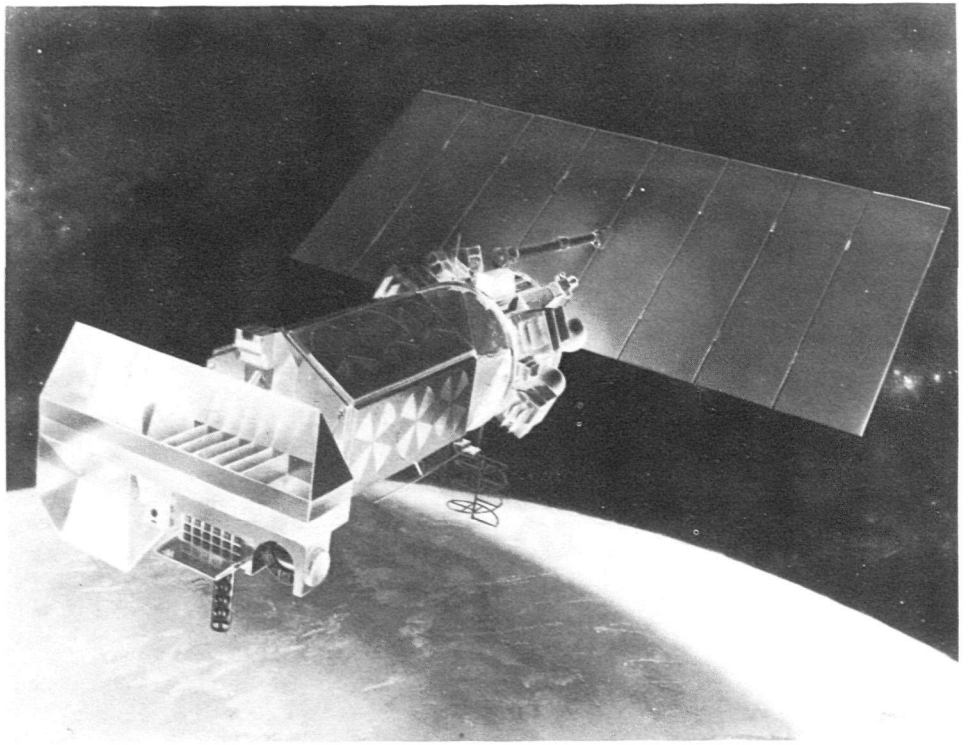


GOES SATELLITE



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. The long-range goal of NOAA is to improve the safety and quality of life through greater comprehension of the Earth's environment and through more efficient use of its resources. To meet this mission, NOAA operates, manages, and improves the Nation's operational environmental satellite systems; provides satellite data to assess 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 improves weather services by automating forecast and observation stations, by installing better radar systems, and by continued atmospheric research. 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, the National Weather 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 1978 NESS operated two polar-orbiting satellites. They were NOAA 4 and NOAA 5, the last of the Improved Tiros Operational Satellite (ITOS) series. NOAA 4 was deactivated November 18, 1978. NOAA's third generation of polar-orbiters, the TIROS-N series, began to replace the ITOS series in December 1978. TIROS-N, the NASA prototype and the first of this series, was launched October 13, 1978. NOAA A, NOAA's first operational satellite of this series, is scheduled for launch in mid-1979. The TIROS-N system will overlap the ITOS system for a short time to ensure uninterrupted service. The TIROS-N system consists of two satellites in orbit, so there will not be instrumental redundancy on either satellite. TIROS-N was launched into a near-polar, Sun-synchronous, 850-kilometer orbit crossing the Equator in a northward direction at 1500 local time. NOAA A will orbit at 870 kilometers, crossing the Equator in a southward direction at 0730 local time.

The TIROS-N series 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.

Because of the extremely large volume of digital data being delivered by these satellites, it was necessary to install a new ground system. This installation was completed in June 1978. The system is functionally divided into two subsystems called the Data Acquisition and Control Subsystem (DACS) and the Data Processing and Services Subsystem (DPSS). The DACS equipment is located at Wallops, Virginia; Gilmore Creek, Alaska; San Francisco, California; Suitland, Maryland; and Lannion, France. Satellite data acquired at the Wallops and Gilmore Creek sites are relayed to the NESS Suitland Facility via a domestic commercial communications satellite. The DPSS, located in Suitland, preprocesses and conditions the data for archiving and storage and directs it to the NOAA Central Computer Facility. Products are then developed and distributed to the users. The data are archived in a mass storage system and retained by NOAA's Environmental Data and Information Service.

Geostationary Satellites. NOAA's designation for its Geostationary Operational Environmental Satellites is GOES. GOES 3 was launched June 16, 1978. On July 13, 1978, it was positioned over the equator at 135° West longitude and replaced GOES 1 as the western operational satellite. GOES 1 was moved to 59° East longitude over the Indian Ocean on November 29, 1978, where it will be operated by the European Space Agency throughout 1979 to support the Global Weather Experiment. GOES 2 remained at 75° West longitude as the eastern operational satellite.

Equipment to improve the gridding and registration accuracy of the images produced by GOES satellites was delivered to NESS and will become operational in early 1979. This equipment improves the placing of grids on satellite images and permits registration of sequential images to an accuracy which allows animation of these images automatically.

Satellite Data Uses

Determining Winds and Temperatures. During 1978 research continued on the derivation of winds by tracking cloud motions from geostationary satellite images. NESS and NASA joined in experiments with a man-computer interactive system. Results indicated that automatic cloud tracking yields accurate vectors in all but complex situations. Experiments also were performed in error characteristics of satellite-derived winds. NESS developed computer programs to determine error in wind data provided by the University of Wisconsin and by NESS operations. These error statistics are required by data users for the Global Weather Experiment.

NESS researchers have implemented plans and written computer programs for the first international comparison of winds determined from cloud motions common to the fields of view of neighboring geostationary satellites. The derived winds to be examined are those from the geostationary satellites operated by the U.S., the Japanese Meteorological Agency, and the European Space Agency. These comparisons were proposed to study the global compatibility of geostationary winds prior to the Global Weather Experiment.

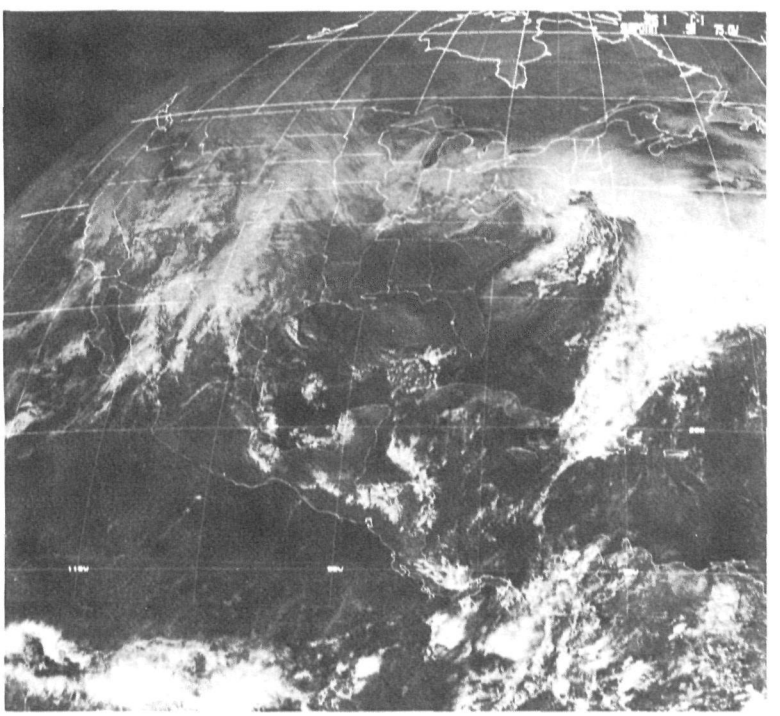
The NOAA Wave Propagation Laboratory completed the first phase of a systems analysis on the feasibility of measuring the global winds with a satellite-borne Lidar. Assuming available infrared detector technology and

the laser pointing accuracies attainable with current platforms, it was found feasible to measure the average winds through a one-kilometer thickness of the atmosphere to accuracies greater than one meter per second from a satellite in a 300-kilometer orbit.

The Earth's background radiation has an unknown influence on atmospheric temperatures derived from satellite radiometer data. A joint study between NESS and the Wave Propagation Laboratory has been initiated to determine how temperature data obtained from ground-based radiometers can be used to correct for this radiation effect on satellite systems.

Numerous case studies were conducted in 1978 using Nimbus 6 infrared and microwave sounding data. This research contributed to modification of the computer programs used to process TIROS-N radiance data, with the goal of improving temperature and water vapor measurements.

As part of a joint effort with NASA and the University of Wisconsin's Space Science and Engineering Center, NESS scientists have developed and tested computer programs for manually interacting with the computer to process satellite temperature sounding data. This approach allows the meteorologists, through instant video presentation, to judge the quality of the soundings and edit the data. The technique was successfully tested using research satellite data, and the processing system is being applied to direct read-out TIROS-N sounding data for experimental application to short-term weather forecasting. The technique also will be used to edit and enhance global sounding data obtained during the Global Weather Experiment.



GOES 2 VISIBLE IMAGE SHOWING SEVERE SNOWSTORM THAT STRUCK THE MIDDLE ATLANTIC AND NEW ENGLAND STATES FEBRUARY 6, 1978.

Monitoring Global Radiation. Radiation budget data derived from the NOAA 5 Scanning Radiometer continued to be compiled through February 1978. Mapping of monthly, seasonally, and annually averaged data, and seasonal and annual differences was completed. This effort began in June 1974, and these maps are an important climate diagnostic tool for examining seasonal and annual global patterns of various heat budget components.

Maps showing the annual differences in outgoing longwave radiation and albedo were used to examine major strengthening in clouds over the central tropical Pacific Ocean from June 1976 to February 1978. Longwave radiation decreases for two consecutive winters were 40 to 70 watts per meter along the equator from 170 E to 150 W.

A display of satellite-derived quantities, used to monitor current climate-scale fluctuations on the Earth, was established. The display shows radiation budget data, sea surface temperatures, tropical winds, Northern Hemisphere snowcover, and the solar constant.

The Earth Radiation Budget (ERB) experiment on Nimbus 6 continued to monitor the solar constant. Preliminary analysis of the observations from July 1975 to May 1978 showed a decrease of 0.35 percent. Nimbus 7, launched October 24, 1978, carried a second ERB experiment. During the past year many studies were conducted to develop and improve the data processing. Much of the work centered on sensor calibration and computer program development, especially for angular models and data validation.

Environmental Warning Services. The GOES Data Collection System (DCS) has a total of 30 national and international users that operate more than 600 Data Collection Platforms (DCP). During 1978, eight new users and about 200 DCPs were added to the program. The frequency assignment program was refined for the GOES DCS by assigning all odd-numbered reply channels to the eastern satellite and even-numbered reply channels to the western satellite. This allows a larger frequency spread on each channel and lessens the chance of interference between adjacent channels. Another change to the system included the addition of a higher speed transmission line between the NOAA processing center and the users so that data can be extracted more rapidly from the system for the users. A multiple-dissemination capability is now being installed in the GOES DCS. This feature will allow the same data to go to a maximum of four separate users. This capability is being installed in response to hydrology requirements of the National Weather Service, U.S. Army Corps of Engineers, and the Department of Interior's Geological Survey.

The GOES-Tap system, begun in 1975 to provide for the dissemination of weather images by geographic sectors from GOES, was expanded in 1978. By year's end there were more than 90 Federal and 25 civil users of the system. Also, more than 165 other Federal and non-Federal offices received limited amounts of GOES data through connections to the National Weather Service Forecast Offices.

A Customer Controlled Switching System was implemented at the Washington, Kansas City, and San Francisco Satellite Field Services Stations (SFSS). This system allows GOES-Tap users to select sectors of interest merely by tapping several buttons on a touch-tone telephone. Formerly, each GOES-Tap

user had to make a long-distance telephone call to the SFSS, and SFSS personnel had to make the switching change manually. The procedure now is completely automatic.

Meteorologists at NOAA's National Hurricane and Experimental Laboratory and the Miami Satellite Field Services Station used digitally enhanced GOES visible and infrared images to estimate rainfall from tropical storms. The National Hurricane Center used these estimates when issuing severe weather warnings. This technique is experimental and is under evaluation. In addition, satellite-derived rainfall estimates were provided to NWS Weather Service Forecast Offices to aid them in issuing flash flood warnings.

During the past several winters, NWS and NESS have been using GOES enhanced infrared images to determine ground temperatures critical to freeze situations. This forecasting technique has been tested in support of the Florida citrus industry. During the 1978-79 winter, the satellite-derived temperature data will be displayed in digital rather than image form. These digital thermal patterns will be color enhanced and shown on television when frost conditions are expected.

A "heat island" is a city or major industrial area where human activities are sufficient to warm the area significantly with respect to the undisturbed environment. These local "hot spots" increase convection above them and distort local weather patterns, which influence pollution levels, cloud cover, temperatures, and precipitation. Enhanced infrared images from NOAA satellites have been used experimentally to quantitatively monitor these "heat islands." One example was seen in a NOAA 5 satellite image of the Washington-Baltimore area where the central parts of both cities were 6°C warmer than the surrounding rural areas.

Determining Ocean Conditions. Seasat 1, the NASA oceanographic satellite, was launched June 26, 1978. Circling the Earth 14 times a day in a near-circular, 850-kilometer polar orbit, the satellite covered most of the ocean area every 36 hours. The microwave sensors aboard the satellite have demonstrated the capability to measure oceanic features. On October 9, 1978, Seasat 1 experienced a massive short-circuit which permanently shut down the satellite. More than 90 days of data had been obtained from the microwave instruments. NOAA mounted a comprehensive surface-truth experiment in the Gulf of Alaska during September 1978 to assess the application of Seasat data to its oceanic and atmospheric monitoring responsibilities. This experiment involved U.S. and Canadian ships and aircraft and NOAA buoys. The surface and airborne measurements obtained during this experiment will be correlated with the Seasat data to determine oceanographic parameters such as waves, winds, currents, circulation dynamics, surface temperatures, geodesy, and sea ice. Studies of the relationship of these factors to living marine resources are in progress and demonstrations of their applicability are planned.

NOAA's Wave Propagation Laboratory developed computer programs for estimating significant wave heights using Geodynamics Experimental Ocean Satellite (GEOS) radar altimeter data. Wind speed and wave height in hurricanes, observed by satellites, were compared with measurements of the same parameters from aircraft. A mathematical model was completed on the

effects of wave motion using measurements made by Seasat's Synthetic Aperture Radar.

Ocean color research increased substantially in support of the October 24, 1978 launch of Nimbus 7, which carried the Coastal Zone Color Scanner. Results of an experiment conducted in the Gulf of Mexico in October 1977 demonstrated that ocean radiance measurements vary systematically with increasing concentrations of both suspended particulate matter and chlorophyll. If sea surface radiance measurements can be corrected for atmospheric influences, it should be possible to estimate six to eight concentration ranges of chlorophyll and suspended particulates using the Nimbus 7 Color Scanner. A post-launch experiment was carried out in the Gulf of Mexico during October and November 1978 by scientists from NOAA, NASA, Scripps Institution of Oceanography, Texas A&M University, and the University of Southern California. The objectives were to gather in-situ measurements of chlorophyll and total suspended particulate matter to correlate with data obtained from the Color Scanner.

To evaluate oil spill detection capability from the Nimbus 7 Color Scanner, measurements were made of the optical characteristics of 10 samples of crude oil at the Environmental Protection Agency test facility in Leonardo, New Jersey. Visible and thermal infrared measurements were made for a one-week period as the oil was aged under conditions simulating those found in the ocean. The measurements showed increased reflectance, above background water, in the visible region, and increased equivalent blackbody temperatures over surrounding waters in the infrared.

Continued research by NESS scientists, using monthly mean sea-surface-temperature fields derived from satellite data, has revealed a slight, gradual cooling of the oceans in the Southern Hemisphere since 1975. The large cold water anomaly in the North Pacific that developed over the 1976-77 winter reappeared last winter and appears to be occurring again this year. There is continuing evidence that an ocean-atmosphere link exists that will favor a colder-than-normal winter over much of the United States east of the Rocky Mountains when such a sea surface temperature anomaly occurs.

A large iceberg from Antarctica, nearly the size of Delaware, finally drifted clear of the ice fields of the Weddell Sea in January 1978 and moved across the Drake Passage into the South Atlantic near South Georgia Island during March. Since March it has been monitored daily using GOES visible images, and it has lost over 50 percent of its original mass. By December it is expected to be about 800 kilometers south of Tristan da Cunha moving toward South Africa, its remnants possibly encroaching on the more heavily traveled shipping lanes during 1979.

Investigators of NOAA's Outer Continental Shelf Environmental Assessment Program (OCSEAP) used satellite and other remote sensing data to assess the development and decay of fast ice, coastal geomorphology and ecology, sediment plumes, and offshore suspended sediments along the Alaskan coast. Supported by OCSEAP a fully operational facility has been established by the University of Alaska to provide remote sensing data to scientists involved in Alaskan studies. The university operates a library to acquire, catalog,

TIROS N HIGH RESOLUTION VISIBLE IMAGE OF OCTOBER 26, 1978
SHOWING EASTERN U.S. AND GULF OF MEXICO.

and disseminate satellite and aircraft remote sensing data; operates and maintains data processing facilities; develops photographic and computer techniques for data storage and retrieval; and consults with and assists investigators in processing and interpreting these data.

In other studies, NOAA and Landsat satellite images of observed ice conditions were used to correlate seismic data with major episodes of ice movement in Kotzebue Sound and ice mapping in the Beaufort and Chukchi Seas. Remote sensing data were used to determine sediment transport in the Bering Sea and to evaluate the hazards of volcanic eruptions in the Alaskan Peninsula. Also, efforts are underway to relate side-looking radar images of sea ice to seal distribution in the Beaufort Sea, and to map bird habitats by digital analysis of Landsat data.

During 1978, a Gulf Stream Analysis was generated weekly from the NOAA and GOES high resolution infrared images. This is a composite map of qualitative sea-surface thermal boundaries which shows location and direction of the Gulf Stream, the warm and cold eddies in the Gulf Stream, the thermal interface between the slope and shelf waters, and the Gulf of Mexico Loop Current. Since fish congregate at thermal boundaries, fishermen use these maps to go directly to productive fishing grounds, thus increasing their yield and reducing fuel costs. Even participants in the Newport-to-Bermuda boat race in June 1978 benefited from knowing the latest position of the Gulf Stream and eddies.

The Gulf Stream Wall Bulletin, also generated from satellite images, describes only the north or west boundary of the Gulf Stream. Updated three times a week and broadcast twice daily over Coast Guard radio, this bulletin gives a sequence of points that represent the west wall of the Gulf Stream. The maximum current lies 7 to 9 kilometers seaward at this line. Coastal shipping interests used this information to route their ships to take advantage of the ocean currents. The mariners were able to reduce their operational costs of both time and fuel.

Determining Lake Conditions. The accuracy of the satellite derived Great Lakes Surface Temperature Analyses, used by the NWS to predict the onset of ice on the Great Lakes, was greatly improved in 1978 with the adoption of a new atmospheric-attenuation correction. This new technique integrates observed atmospheric temperatures and corrects for absorption and terrestrial radiation.

The NOAA Great Lakes Environmental Research Laboratory joined others of the Great Lakes Experiment Team to test the feasibility of using satellite data to monitor water quality in the Great Lakes. Scientists will be using data from the Nimbus 7 Coastal Zone Color Scanner (CZCS). The objectives are to acquire enough standardized surface-truth samples to evaluate the potential of the scanner for obtaining accurate observations of algae, suspended sediment, and calcium carbonate; to develop, test, and evaluate scanner water-quality computer programs; and to develop products using the scanner data.

Determining Hydrological Conditions. NESS produced operational snow maps from satellite data for thirty critical United States and Canadian river basins during the 1977-1978 snow season. Six hundred snow maps were compiled and used

by Federal and State agencies to aid in water runoff prediction, flood prevention, dam and reservoir regulation, hydroelectric power generation, and monitoring of irrigation and human consumption. Snowcover throughout the western United States was generally more extensive and persisted longer into the spring months than during the previous year. Heavy rainfall in California, combined with an above-normal snowpack in the Sierra Nevada Mountains, signified the end of that State's two-year drought.

On a global basis, NESS continued the annual monitoring of Northern Hemisphere snowcover using satellite data. January 1978 proved to be a record snowcover month for North America. This record was promptly exceeded in February 1978. From December 1977 through March 1978, the average snowcover for Eurasia was 51.4 percent and for North America 67.2 percent. For North America, January had 7.4 percent, February had 12.1 percent, and March had 9.1 percent more snowcover than the 10-year average for each of these months. For the entire winter, the Northern Hemisphere snowcover, overall, was about 8 percent above the 10-year average for each month.

In 1978 a research effort was started to estimate rainfall from geostationary satellite data for operational input to the National Weather Service's (NWS) Office of Hydrology riverflow models. The specific need is to determine six-hour mean rainfall amounts over individual river basins. Case studies are being investigated to compare satellite-measured cloud brightness and infrared temperatures with recorded rainfall. Initial results show good correlation between cold, bright clouds and heavy rainfall.

The Environmental Data and Information Service is working with NASA, the University of Wisconsin, and the Environmental Research Laboratories to evaluate and calibrate techniques for using visible, infrared, and microwave satellite data to estimate rainfall over the tropical oceans. The program is using very accurate precipitation estimates derived from shipboard digital radar data for a 125,000-square-kilometer area over the eastern tropical Atlantic.

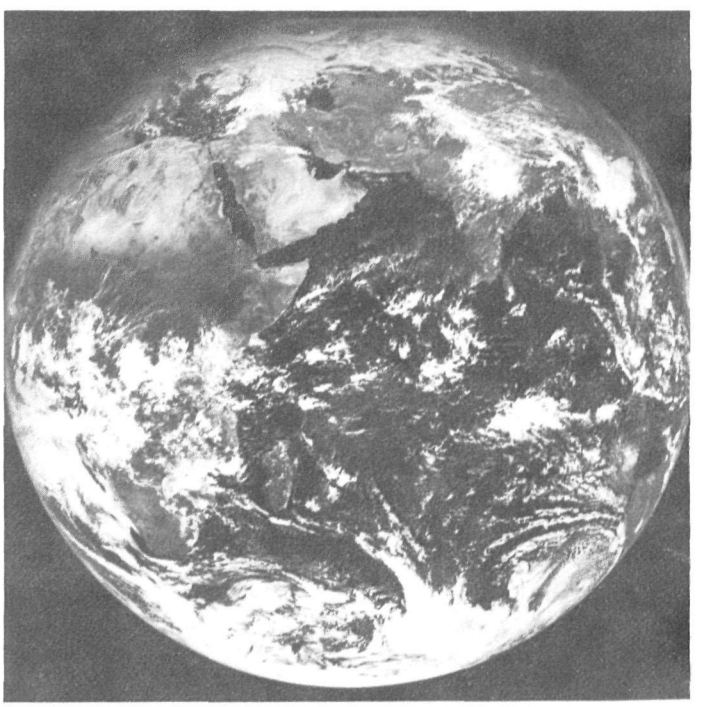
Monitoring Agricultural Conditions. In 1978, NESS joined with the Department of Agriculture, the Environmental Data and Information Service, and the National Weather Service to establish a Joint Agricultural Weather Facility to increase the use of satellite data for agricultural interests. This facility was designed to provide up-to-date global weather information to Agriculture's decision makers. Specifically, satellite images are used to monitor rain-producing clouds and temperature trends for worldwide agricultural areas. Satellite data are used exclusively in the tropics and Southern Hemisphere to forecast movements of weather systems.

From March to June 1978, NESS furnished satellite-derived ground temperatures to the Water Conservation Laboratory in Phoenix, Arizona. These data were compared with surface measurements of solar, thermal, and moisture conditions to assist in stress analysis of crops in central California. There is increased stress on vegetation when plant temperatures increase and the moisture is low. The Department of Agriculture is presently evaluating this technique.

Fisheries Monitoring. The National Fisheries Engineering Laboratory joined with NASA, U.S. Fish and Wildlife Service, and Bureau of Land Management to investigate the feasibility of mapping submerged seagrasses, using Landsat and aircraft measurements. Results demonstrate that grass beds in shallow coastal waters can be mapped, and work is continuing to determine how well the technique differentiates common species.

The National Marine Fisheries Service (NMFS) demonstrated the feasibility of tracking marine turtles using remote sensing techniques. Loggerhead turtles were hatched and fitted with small radio transmitters and tracked in the Gulf of Mexico by aircraft for periods up to three weeks. This research was conducted in advance of a larger tracking effort to be carried out in 1979 to see if endangered species, like the Atlantic Ridley turtle, can be tracked using the TIROS-N Argos Data Collection System. The object of these experiments is to see if adult turtles return to lay eggs in the same place where they hatched, as salmon do.

The final design of a transmitter for tracking porpoises in the eastern tropical Pacific, using the Nimbus 6 Remote Access Management System, was completed in 1978. Three transmitters will be available for testing and evaluation on captive and wild animals in 1979. The transmitters are designed for operation for periods of up to one year from anywhere on Earth.



FULL DISC VISIBLE IMAGE FROM GOES 1 LOCATED OVER THE INDIAN OCEAN AT 59°E.

Plans were completed to evaluate the feasibility of using Seasat 1 scatterometer data to measure ocean surface circulation patterns. These plans involve a field study to determine the relationship between water circulation and shrimp yield in the northern Gulf of Mexico. If this concept proves feasible, it may be possible to forecast potential yields of shrimp and certain other estuarine dependent species significantly in advance of the fishing seasons. Enough data were collected from Seasat 1 to conduct this experiment.

A theoretical investigation to establish the capabilities of airborne laser systems for assessment of pelagic fish schools was completed. The investigation indicated that laser systems have significant potential for detection and quantification of schooling fishes. Plans for a cooperative program with NASA and segments of the fishing industry were developed to demonstrate this potential in 1979 with an existing airborne laser system.

NMFS, NASA, and the Coast Guard have demonstrated that satellite and aircraft synthetic aperture radar systems have significant potential for fishery surveillance and management applications. Analysis of radar data collected over concentrations of foreign fishing vessels off Georges Bank show that the vessels can be detected and located, and their speed and direction extracted from digitally processed data. In 1979, research will be directed toward vessel classification.

Environmental Monitoring Using Data Buoys. At the beginning of 1978, the NOAA Data Buoy Office was operating 19 moored data buoys--9 in the Northeast Pacific and Gulf of Alaska, 7 in the Western Atlantic, and 3 in the Gulf of Mexico. Three additional buoys were stationed in the Atlantic in late 1978. Sixteen of these buoys transmit environmental data through the GOES satellite, and in 1979 all buoys will use GOES. The buoys provide meteorological, surface and subsurface water temperature, and wave data to the National Weather Service for forecasting and storm warning activities, to the Bureau of Land Management for continental shelf assessment activities, and to various scientific programs with specialized marine data requirements. All moored buoys are equipped with position-fixing systems which permit the Nimbus satellite to locate buoys that have gone adrift. Buoys soon will be modified to use the TIROS-N Argos Data Collection System for position fixing.

International Cooperation

Global Weather Experiment. This is a planned international effort scheduled from December 1, 1978 to November 30, 1979 to provide coordinated intensive analysis of the world's weather. It was organized by the World Meteorological Organization and the International Council of Scientific Unions. A major source of wind data for the experiment is a network of five geostationary satellites, positioned to provide contiguous weather coverage around the globe in tropical and mid latitudes. Two of these satellites were to be provided by the United States and one each by Japan, the European Space Agency (ESA), and the Soviet Union.

In late 1977 the U.S. was informed that Russia could not provide the fifth geostationary satellite which was to be located over the Indian Ocean. Since the loss of this satellite would have produced a gap in data coverage,

the U.S. and ESA were asked to work together to provide a replacement satellite. In less than a year, GOES 1 was moved to 59° East longitude to fill the void. A data acquisition station was constructed at Villafranca, Spain; the European Space Agency's Control Center at Darmstadt, Germany was modified to accept GOES data; personnel were provided and trained to operate and maintain the GOES system; and a data processing facility was established at the University of Wisconsin.

By the end of 1978 the fifth satellite system was fully installed, tested, and turned over to ESA for operation. During 1979, GOES 1 data will be processed at the University of Wisconsin to obtain wind fields over the Indian Ocean to support the Global Weather Experiment.

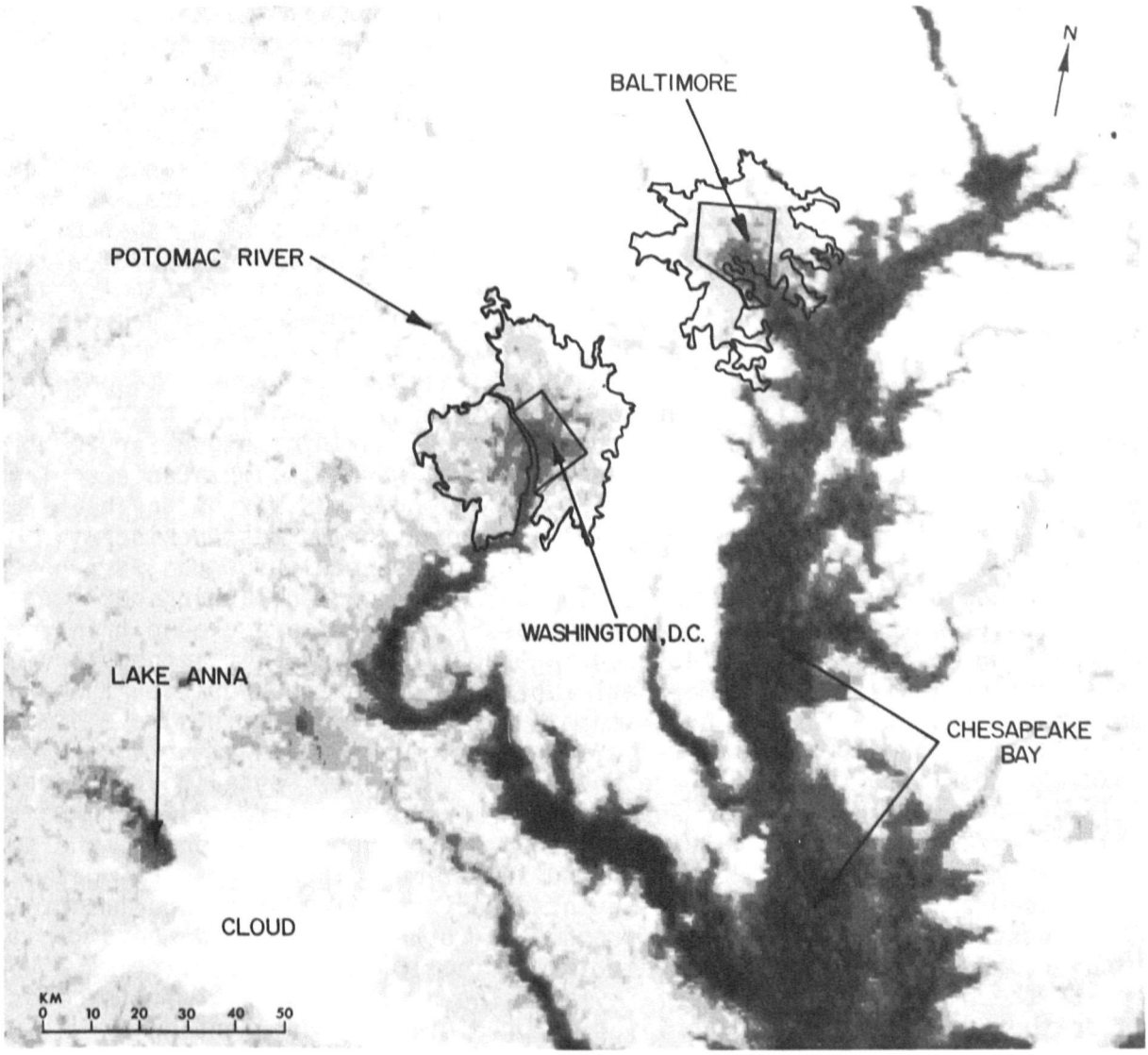
Sharing Data. During the year, the National Weather Service, under the Voluntary Assistance Program of the World Meteorological Organization, established ground stations capable of receiving direct broadcasts from U.S. environmental satellites in about a dozen countries in the Caribbean area, South America, Asia, and Africa. NESS assisted with the assembly and installation of this equipment.

Rocket Experiment. The Environmental Data and Information Service participated in a joint American-Soviet Particle Inter-Calibration Project scheduled from June 2 to 20, 1978. Two Nike-Apache rockets and one Nike-Tomahawk rocket were launched from NASA's Wallops Flight Center, and five Soviet rockets were launched from a Russian research ship located off the Virginia coast. Ground-based measurements at the Service's Wallops Ionosphere Station were used to monitor local ionospheric conditions for selecting specific launch times. The ionosphere station prepared special analyses of observations for daily briefings to participating scientists and relay to the Soviet vessel. Because of unfavorable ionospheric conditions, the final launch was delayed until September 27, 1978. Results from these measurements may answer differences in past interpretation of ionospheric data in the 80- to 120-kilometer-height range.

Other Uses of Satellites and Space

Numerical Weather Forecasting. During 1978 the National Weather Service made some important advances in using satellite data as input to their numerical weather forecasting models. For the large-scale computerized analyses and guidance forecasts, atmospheric temperature and moisture soundings and cloud-motion-derived winds from satellite data were used to supplement the classical observational data for rapid global coverage. The number of satellite-derived measurements was increased over the northern hemisphere, and measurements in the stratosphere were extended to cover the entire globe. Detailed knowledge of stratospheric conditions is important for ozone monitoring and for supporting Space Shuttle and satellite experiments.

Determination of the Earth's Shape and Gravity Field. The National Ocean Survey worked with NASA to evaluate applications of space systems to geodesy and geodynamics. A network of accurately positioned ground stations is fundamental to all surveying and mapping. Major areas of study included the application of space observation systems to polar motion and Earth rotation,



NOAA 5 INFRARED IMAGE SHOWING TEMPERATURE DIFFERENCES BETWEEN URBAN AND RURAL AREAS AND BETWEEN LAND AND WATER AREAS. THE BLACK (WARM) AREAS ARE AS MUCH AS 6°C WARMER THAN THE WHITE (COLD) AREAS.

making extensive ground position and gravity measurements to compare with results from laser ranging to satellites and the Moon, Doppler tracking of satellites, and Very Long Base Line Interferometry. Interferometry data were analyzed to extract polar motion, Earth rotation, and baseline vector information. Polar motion values obtained by interferometry agreed to ± 10 milliseconds of arc with Doppler values. Baselines computed at 13 different times over a 20-month period were accurate to within 15 centimeters for lines as long as 4000 kilometers. Methods are being analyzed or developed to determine accurate positions and densify geodetic control networks with the Defense Global Positioning System. Precise positioning involves making observations on an array of 24 Defense satellites to be launched between 1978 and 1985. Simulation studies indicate that relative geodetic accuracies of 10 centimeters or less can be obtained over distances of 10 to 100 kilometers when the requisite ground receiving equipment is developed.

Altimeter data obtained from the Geodynamics Experimental Ocean Satellite (GEOS) 3 were used to track ocean eddies and currents, independent of surface observations. Correlations of GEOS 3 data with NOAA 5 infrared data showed good results. A continuous record of GEOS 3 orbits is being computed for accurate referencing of altimeter data.

Space Support Activities

Launching Activities. The Environmental Data and Information Service prepared a climatological study for NASA's Marshall Space Flight Center. The study provides probabilities for flying weather conditions for "piggy backing" the Space Shuttle orbiter on a Boeing 747 jumbo jet during test periods. Weather conditions will determine the precise time schedule for the ferry flights because unfavorable weather could cause unscheduled landings or diversions. Favorable terminal weather is desirable for safe ground transfer of the orbiter to and from the 747. During 1978, the National Weather Service assigned meteorologists to the Marshall facility to provide operational weather support to the Shuttle testing program.

Solar Activity. The NOAA Space Environment Services Center, operated jointly by NOAA and the U.S. Air Force, is the National and World Warning Agency for disturbances on the Sun, in space, in the upper atmosphere, and in the Earth's magnetic field. Predicted and real-time solar geophysical data were provided to agencies for planning and executing scientific experiments and for operational activities being conducted in the same environment. In particular, the Center provided predictions of solar sunspot activity used to calculate the predicted lifetime of Skylab. The National Bureau of Standards assisted the Center in the Skylab lifetime prediction by documenting an analysis of sunspot variations for the period of January 1848 to February 1978 and the 13-month averaged values. The Center obtains its data from Space Environment Monitors on NOAA and GOES satellites, the global solar flare patrol, and data collected from the International Ursigrams and World Days Service.

Space and Atmospheric Research

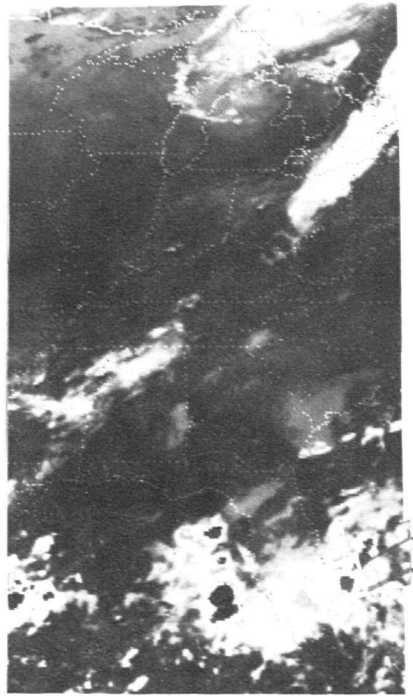
Interplanetary Physics. The effect of a multi-fluid composition in the solar wind was examined by NOAA's Space Environment Laboratory. For steady state conditions, frictional drag on protons by alpha particles produced a reduction in the alpha-to-proton abundance ratio near the Sun when nonradial flow occurs within some coronal holes. At the Earth's orbit, the alpha particles achieved a velocity higher than the protons when their temperatures at the Sun were very much higher than the protons. For unsteady conditions, the anomalous observations of variable electron to proton temperatures, obtained by numerical simulations, were a result of the high thermal conductivity of the electrons and their frictional coupling to the protons.

Magnetospheric Physics. The enhanced resolution and spatial coverage of the instruments comprising the energetic particles experiment on board one of the two International Sun-Earth Explorer satellites permit a much more complete description of the particle environment. This is very important to the understanding of the dynamical processes occurring in the magnetosphere. Initial published research by NOAA's Space Environment Laboratory and the Max Planck Institute for Aeronomy has revealed some characteristics of the magnetospheric boundary not known from earlier, less sophisticated measurements. Availability of data of this quality will significantly enhance our understanding of the magnetosphere. The Space Environment Laboratory scientists demonstrated that the geomagnetic disturbances called substorms can be predicted. Magnetic disturbances have an important impact on radio communications, power distribution, and long-line telephone systems. Laboratory scientists used the NOAA satellite data and observations from the 25 ground observatories of the North American International Magnetospheric Study network to analyze space and time characteristics of magnetic substorms and the associated magnetospheric currents.

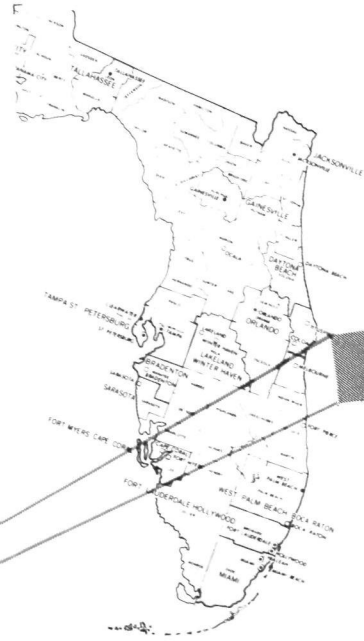
Ionospheric Physics. A new generation of high-frequency ionospheric sounders were constructed and tested. The design took full advantage of the latest electronics and minicomputer technology. These instruments will provide major improvements in ionospheric measurements of the ionization as a function of altitude and time. A field station is under construction near Fairbanks, Alaska.

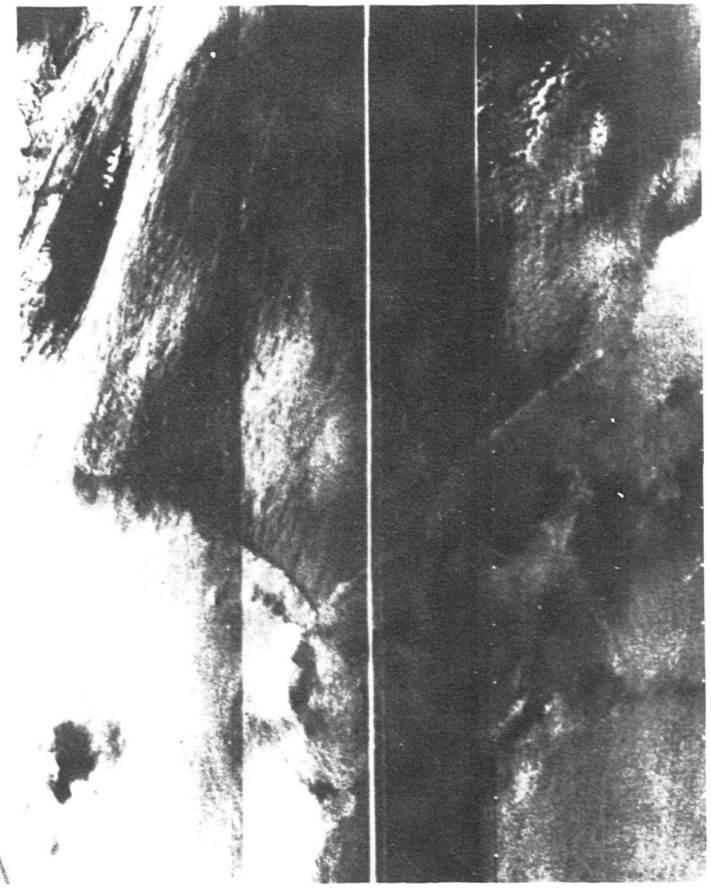
Stratospheric Physics. NOAA's Aeronomy Laboratory developed a new technique to measure wind profiles through the atmosphere from the ground up to about 100 kilometers using pulsed Doppler radar. A single measurement through the troposphere and lower stratosphere up to about 30 kilometers takes about one minute.

Photochemistry. The Aeronomy Laboratory has made some notable contributions toward understanding the chemistry of the stratosphere. Nitrogen trioxide has been measured for the first time using ground-based, long-path, optical-absorption techniques. The stratospheric nitrogen dioxide measurements have been extended to the southern hemisphere and show the winter behavior there to resemble that in the Arctic winter. Methane is a compound almost entirely of natural origin, which is present as a trace gas in the



GOES 2 ENHANCED INFRARED IMAGE
0600 EDT-JULY 8, 1978





SEASAT 1 SYNTHETIC APERTURE RADAR IMAGE
0604 EDT-July 8, 1978

COMPARISON OF GOES 2 IMAGE WITH THE SEASAT 1 IMAGE SHOWING THE ABILITY OF THE SEASAT MICROWAVE INSTRUMENT TO PENETRATE CLOUD COVER. THE GOES 2 IMAGE SHOWS THE DESIGNATED AREA COVERED BY CLOUDS. SEASAT 1 SHOWS OCEAN SURFACE FEATURES SUCH AS GULF STREAM MOTION (UPPER LEFT) AND SURFACE ROUGHNESS (LOWER LEFT) DUE TO RAIN SHOWERS. THE BLACK AREAS WITHIN WHITE AREAS ARE RAIN SQUALLS.

stratosphere. Understanding the disposition of methane in the stratosphere is an important key to understanding stratospheric chemistry. During the past year, the concentration of methane has been measured at various latitudes up to altitudes of 30 kilometers.

Data Programs

Environmental Data. The Environmental Data and Information Service archives about 2000 metrocket observations each year. The rocket obtains primarily temperature and wind data at altitudes of 20 to 90 kilometers. The data are gathered by 30 stations in the worldwide Cooperative Meteorological Rocketsonde Network. The metrocket has been an important data source in determining wind and thermodynamic stresses which manned and unmanned spacecraft must be designed to withstand during launch and reentry operations. These same data now are being used in the design, test, and operational phases of the Space Shuttle. In addition, they will be important in determining design and loading factors for vehicles used in the establishment and operation of the proposed orbiting space station. Periodic metrocket ozone measurements now are being made to determine the effects of aerosols and supersonic aircraft exhausts on the ozone layer.

The Service operates the World Data Center A for Solar-Terrestrial Physics. It is preparing a report documenting observations of the first significant solar flare activity since 1976. Between April 24 and May 8, 1978, solar rotation carried a large and magnetically complex sunspot group across the solar disk that flared four times at intensities great enough to significantly affect the Earth's dayside and polar ionospheres and the planet's magnetic field. The largest flare ever observed occurred on April 28.

Aeronautical Programs

Charts and Manuals. The National Ocean Survey delivered to the Federal Aviation Administration (FAA) certified obstacle and terrain data for 36 of 72 air terminals in the United States which were initially targeted to receive this information. The data are used in support of FAA's Minimum Safe Altitude Warning System which alerts air traffic controllers when an aircraft descends below a safe flight altitude within a 120-kilometer radius of an air terminal facility. The FAA plans to expand this system to include 72 additional airports.

The Survey has implemented the Aeronautical Chart Automation Project. A contract soon will be awarded to develop, design, and process an operational aeronautical chart production system. The proposed system is predicated on several subsystems integrated into a total system for automation of the predominantly manual chart production methods. This will yield higher efficiencies and enhance chart updating and maintenance schedules.

Safety Services. National Weather Service meteorologists, now assigned to FAA Air Route Traffic Control Centers, are using GOES satellite pictures to help them quickly detect weather changes that pose a hazard to aviation or impede traffic flow.

NOAA's Aeronomy Laboratory developed a new pulsed Doppler radar technique to measure vertical profiles of turbulence. This has led to the development of a new turbulence model. This model can be used to calculate profiles of turbulence intensity from routine radiosonde measurements. This model shows considerable promise for the prediction of clear-air turbulence.

U.S. Environmental Satellites 1960-1978

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	O	07/01/65	S/792	07/03/66	
ESSA 1	O	02/03/66	S/765	05/08/67	First satellite in the operational system; carried 2 wide-angle TV cameras.
ESSA 2	O	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	O	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	O	01/26/67	S/1373	12/06/67	
ATS 2	R	04/05/67	-	-	Unstable attitude-data not useful.
ESSA 5	O	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	O	11/10/67	S/1437	11/04/69	
ESSA 7	O	08/16/68	S/1440	07/19/69	
ESSA 8	O	12/15/68	S/1429	03/12/76	
ESSA 9	O	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/O	01/23/70	S/1456	06/17/71	Second generation prototype.
Nimbus 4	R	04/08/70	S/1108	-	Still providing limited data.
NOAA 1	O	12/11/70	S/1438	08/19/71	First NOAA funded second generation satellite.
ITOS B	O	10/21/71	-	-	Failed to orbit.
Landsat 1	R	07/23/72	S/918	02/16/78	
NOAA 2	O	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	O	07/16/73	-	-	Failed to orbit.
NOAA 3	O	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; 72°W on standby.
NOAA 4	O	11/15/74	S/1460	11/18/78	Deactivated.
Landsat 2	R	01/22/75	S/918	-	
SMS 2	R/O	02/06/75	G/35,780	-	Second NASA prototype; 75°W.
Nimbus 6	R	06/12/75	S/1110	-	
GOES 1	O	10/16/75	G/35,783	-	First NOAA operational geostationary satellite; 59°E during Global Weather Experiment.
NOAA 5	O	07/29/76	S/1511	-	
GOES 2	O	06/16/77	G/35,778	-	Second NOAA operational geostationary satellite; 100°W on standby.
Landsat 3	R	03/05/78	S/918	-	First Landsat with infrared capability.
GOES 3	O	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/O	10/13/78	S/850	-	Third generation prototype.
Nimbus 7	R	10/24/78	S/954	-	Carrying Coastal Zone Color Scanner.

1 R - Research O - Operations, R/O - 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

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