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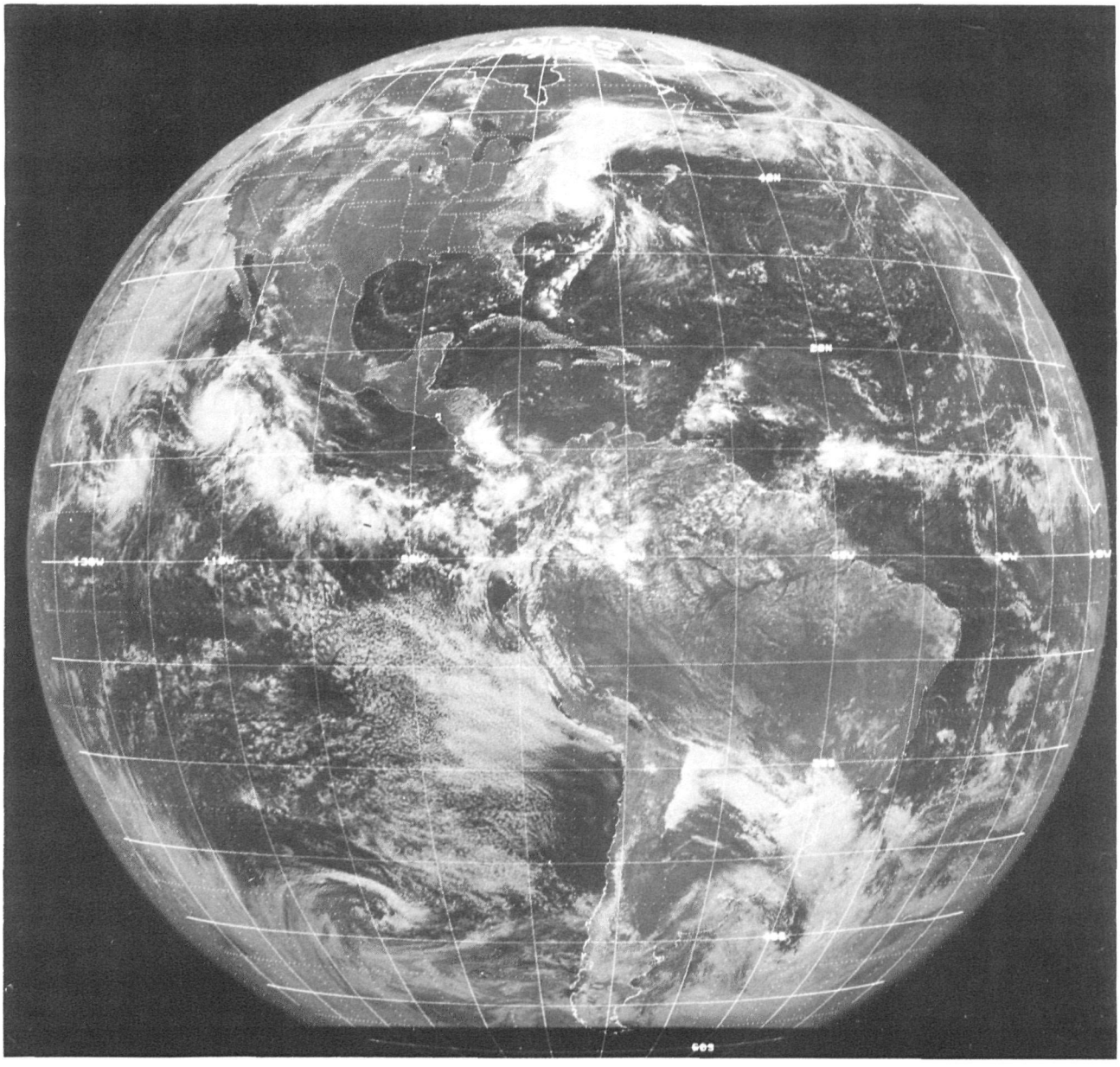
Satellite Activities of NOAA 1976

compiled by
NATIONAL ENVIRONMENTAL SATELLITE SERVICE
Washington, D.C. April 1977

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration



Full-disc visible image from GOES 1, located at 75°W, shows Hurricane Belle in the Atlantic Ocean (top center) and Hurricane Hyacinth in the Pacific Ocean (left center) at 1700 GMT, August 9, 1976.

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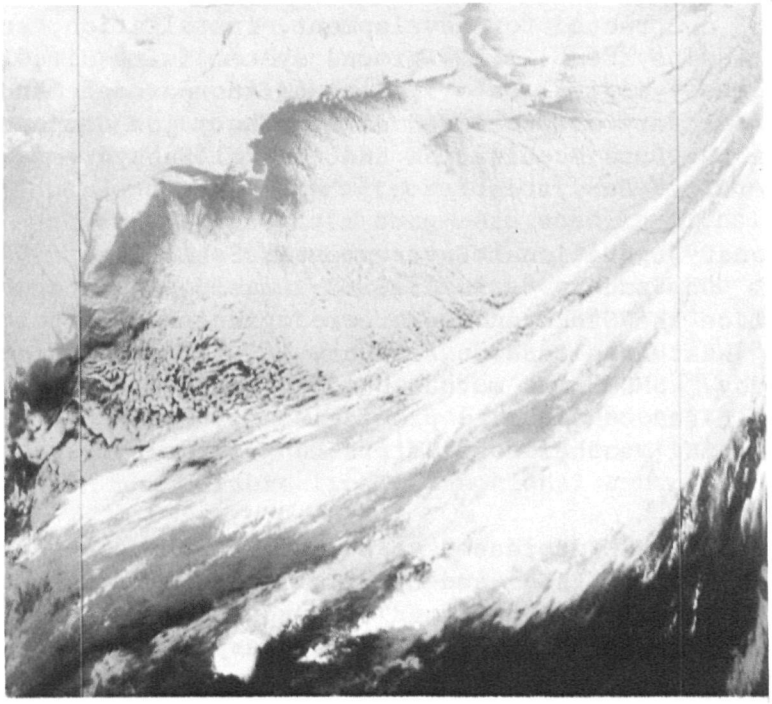
Introduction

In 1970, the National Oceanic and Atmospheric Administration (NOAA) was established within the United States Department of Commerce to improve man's understanding of the environment, and to ensure that its resources were widely used. To make sure the Earth will continue to serve and sustain its people, NOAA pursues a variety of programs. These include operating and maintaining an operational environmental satellite system; continuing marine resource assessment and prediction efforts; monitoring the marine environment continuously with improved sensors on ships, aircraft, and satellites; improving weather observations and forecasts through the use of automated observation stations and improved radar systems, and continued atmospheric research; conducting research in weather modification; and improving data collection, processing, and dissemination techniques. Six major components of NOAA contribute directly to the aeronautics and space program. They are the National Environmental Satellite Service, the National Ocean Survey, the National Marine Fisheries Service, the National Weather Service, the Environmental Research Laboratories, and the Environmental Data Service.



NOAA 5 VHRR infrared image of the U.S. East Coast on December 4, 1976. Clouds are formed as cold continental air traverses the warmer ocean after cold-frontal passage.

National Oceanic and Atmospheric Administration
TIROS Satellites and Satellite Meteorology

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Satellites in Environmental Monitoring and Prediction

Environmental Satellite Operations. - At the beginning of 1976, the National Environmental Satellite Service (NESS) of the National Oceanic and Atmospheric Administration (NOAA) was operating three polar-orbiting satellites: ESSA-8 of the TIROS Operational Satellite (TOS) series and NOAA-3 and NOAA-4 of the Improved TOS (ITOS) series. On March 12, 1976, ESSA-8 was deactivated after its second camera failed. Launched December 15, 1968, the satellite had completed more than 33,000 orbits and provided Automatic Picture Transmission service to more than 120 nations. NOAA-5 was launched on July 29, 1976, and became the primary operational polar-orbiting satellite on September 15, 1976. At the same time NOAA-4 was placed on standby as the in-orbit backup. NOAA-3 was deactivated August 31, 1976.

Development of the TIROS-N series, the third generation of operational polar-orbiting satellites, is continuing. These satellites will replace the present ITOS series and provide more accurate data for environmental monitoring and prediction. This new system will consist of two satellites in orbit at 833 kilometers. Sun-synchronous, one satellite will orbit south across the Equator in the local morning and the other north across the Equator in local afternoon to provide maximum daylight coverage. TIROS-N, the NASA prototype, is scheduled for launch in the second quarter of 1978; about 6 months later NOAA-A, NOAA's first operational version of this series, will be launched.

In 1976, NESS contracted for development, installation, and test of the TIROS-N series ground system. A new ground system is required because of the change to a completely digital data system and increased demand by operational users for timely delivery of processed data. The major components of the ground system are the Data Acquisition and Control Subsystem and the Data Processing and Services Subsystem.

No Geostationary Operational Environmental Satellites (GOES) were launched in 1976. On January 8, 1976, GOES-1 was positioned at 75° West longitude to replace the Synchronous Meteorological Satellite, SMS-1, which was moved to 105° West longitude on February 16, 1976, and placed on operational standby. SMS-2 was moved to 135° West longitude on December 19, 1975. These satellites continue to provide nearly constant viewing of severe storms, helping weather forecasters to provide timely warnings to the public.

In October 1976, NESS increased to 68 the number of experimental Weather Facsimile broadcasts from GOES-1 and SMS-2. The duration of each broadcast is 8 minutes. The products transmitted are processed visible and infrared spin-scan radiometer images from the geostationary satellites and processed scanning radiometer images from the polar-orbiting satellites. Plain language operational messages also are broadcast once a day from each satellite.

Determining Winds and Temperatures. - Geostationary satellite wind data continued to be provided to the National Meteorological Center (NMC) for use in their numerical weather forecast models. However, research continued on automated computation of winds from cloud motions observed by these satellites. Motions were computed from temperature data at three levels. Objective analysis was made of the computed winds at the lowest level to eliminate invalid estimates and improve the quality and quantity of wind data. Similar objective analyses applied to upper levels provided wind field information in data-sparse areas. This technique is being implemented operationally.

Wind data derived from geostationary satellite pictures were used to study the relationship between diverging jet streams and severe weather. Studies of five cases suggested that severe weather occurs between the polar and subtropical jet streams but is sharply inhibited at and to the south of the subtropical jet stream.

Radiance measurements from the NOAA-4 and -5 Vertical Temperature Profile Radiometer were being used to derive polar jet stream and upper tropospheric winds. Radiation from the 150- to 100-millibar level provides direct indication of the thermal wind pattern above the polar jet level. Using these data, a wind scale giving 300-millibar speeds as a function of radiance gradient and latitude has been derived. These data also are used routinely by the NMC in numerical weather forecasting programs.

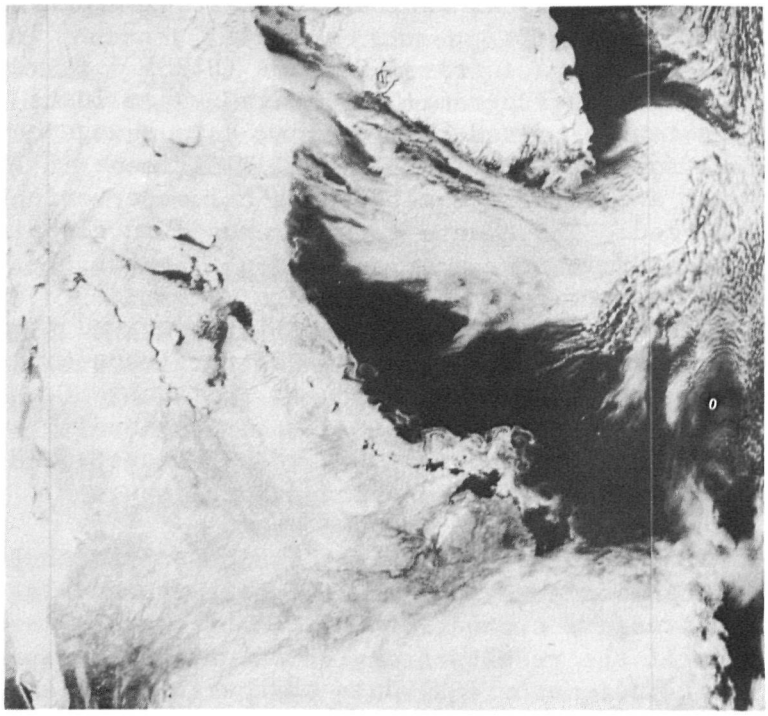
Nimbus-6 High Resolution Infrared Sounder (HIRS) data were used in two Global Atmospheric Research Program (GARP) Data System Tests (DST). This concept was used to test proposed observation, data management, and data utilization systems for the First GARP Global Experiment in 1978. Global sets of conventional and satellite meteorological observations were collected, processed, and analyzed. These data sets were used in global analysis and forecast models to determine the accuracy and utility of the various observing systems. In particular, experiments were made to determine the impact on numerical forecast systems by satellite-derived atmospheric temperatures and cloud-tracked winds. During DST 5, Nimbus-6 temperature profiles were compared with mean temperatures from the NMC analyses. The results approached the theoretical limit of remote sounding by the Nimbus-6 HIRS. Introducing these data into the NMC model demonstrated that they provide accurate information unavailable from conventional sources.

Monitoring Global Radiation. - Processing of Nimbus-6 Earth Radiation Budget (ERB) Experiment data continued in 1976. Global maps and latitudinal profiles of albedo, longwave radiation, and net radiation to space were produced. Limited comparisons of the results from ERB scanning data agreed more closely with NOAA-4 Scanning Radiometer (SR) data than with calculated Nimbus-6 HIRS data. Also, monthly global net radiation values derived from the ERB wide-angle data show a cyclical variation about zero, similar to those observed

from earlier satellites. The solar constant, which is important in determining net radiation, varied less than 0.2 percent during the first year in orbit.

In 1976 NOAA SR-derived heat budget information continued to be processed. Results from a study comparing albedo and longwave radiation data for the summers of 1974 and 1975 showed that in 1975 more solar energy was available for heating over continental Asia, more absorbed solar energy reached North Pole regions, and more net radiation over the eastern North Atlantic reached the sea surface. Consequently, there was increased intensity of the Asian monsoon, decreased ice and snow cover in the Canadian Arctic, and warmer water temperatures near the Azores.

Environmental Warning Services. - Over 100 satellite-interrogated platforms of the GOES Data Collection System (DCS) provided data and services to users in the United States and Canada during 1976. Requests for DCS services also were received from Chile and Bolivia. This system is being upgraded with second-generation ground processing equipment, and through automation of the operational and test function. For this purpose four computers, two at NOAA's Wallops, Virginia, Command and Data Acquisition Station and two at NOAA's World Weather Building, Camp Springs, Maryland, have been installed and are now undergoing operational tests. This fully redundant system will permit continuous 24-hour reception except during the spring and autumn equinox periods when the satellites are eclipsed by the Earth. Data will be received from 2,000 platforms and can be expanded to handle more. The DCS provides a



NOAA 4 VHRR visible image on May 8, 1976, shows ice coverage along the coasts of Baffin Island, Labrador, and eastern Greenland.

near-instantaneous source of information for many applications such as river and flood monitoring and forest-fire index measurements. A recent test involving relay of data from a prototype Shipboard Environmental Acquisition System demonstrated the technical feasibility of collecting marine environmental data from ocean vessels.

To improve reception from Data Collection Platforms located on the periphery of the communication range (Earth edge), a new DCS Ultra High Frequency antenna is being developed; this antenna will provide maximum omnidirectional gain at low elevation angles to the spacecraft. Two prototype antennas have been built; one will be placed on a buoy and the other on a ship for extended operational tests.

The GOES-TAP system, instituted in 1975 for distributing images received from the GOES satellites, has now been expanded to more than 20 subscribers. This system permits Federal, state, and local agencies, television stations, universities, private enterprise environmental consulting firms, and others to receive any of the variety of standard sectors available to the NESS Satellite Field Services Stations. The National Weather Service now provides this service directly from its Weather Service Forecast Offices (WSFO). Users near the local WSFOs may obtain the limited inventory of satellite products more economically because of shorter communication lines.

In 1976, NESS initiated a new cloud analysis chart based on geostationary infrared data. The chart was transmitted experimentally on facsimile circuits once each day. Prepared primarily for aviation use, it depicted the areas and types of clouds and cloud tops over the continental United States and adjacent oceans.

On July 6, 1976, the Satellite Field Services Station (SFSS) at Kansas City started to monitor and analyze satellite photographs showing weather conditions in the Gulf of Mexico. This is an area where severe weather systems go undetected because of the sparsity of conventional surface and upper air observations. The Kansas City SFSS combines low-level satellite wind data with other satellite meteorological interpretations into a Gulf of Mexico Satellite Interpretation Message. These messages are transmitted each 6 hours to the WSFOs at New Orleans and San Antonio. Whenever observed weather conditions warrant, messages are updated and transmitted off schedule. Strong emphasis is placed on the early detection of small scale, short-lived severe weather phenomena which can adversely affect oil drilling operations, boating, and aviation in the Gulf. Three times each week this message includes an analysis of the Gulf Loop Current, providing information to commercial and sports fishermen on the probable locations of the most productive fishing areas with significant savings to fishermen of both time and fuel.

NESS used enhanced infrared images from the geostationary satellites to develop a method for estimating hourly rainfall. Empirical relationships were established between rainfall amounts and the growth, merging, and decay of convective cloud systems. The method, now being tested, will be applicable

to flash flood forecasting, especially in areas where there are no reporting stations. These infrared images also were used to estimate hurricane intensity, especially during nighttime.

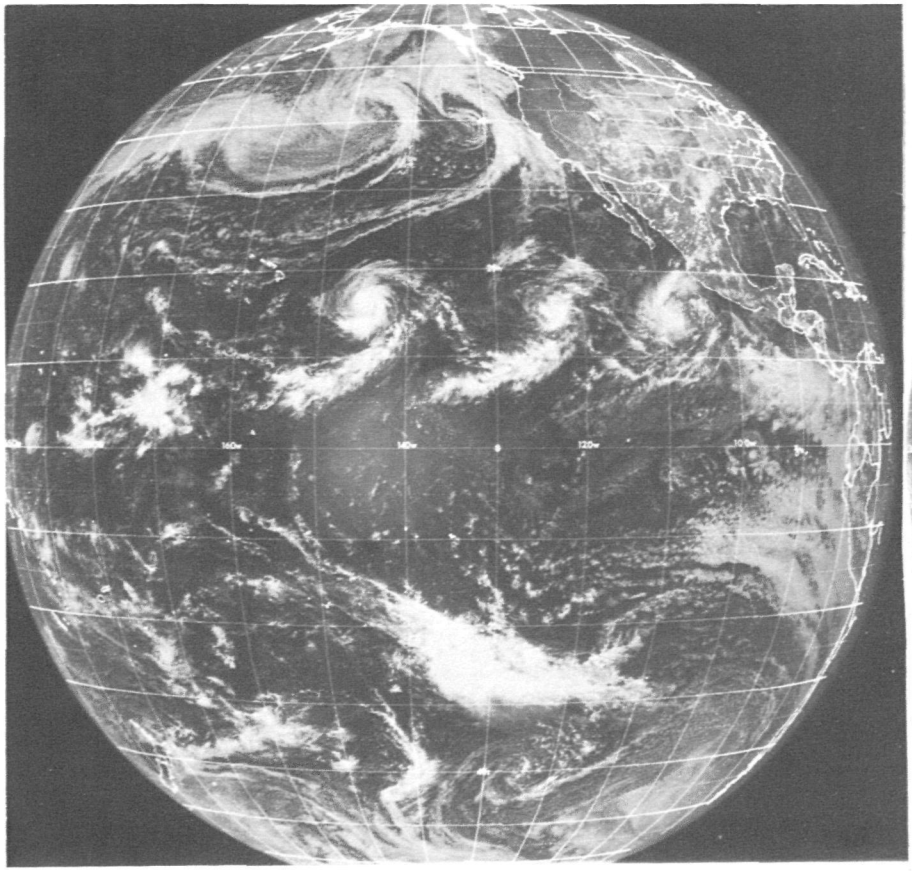
NESS is developing a method to estimate winds by tracking low-level cumulus clouds visible in one-half-mile-resolution GOES-1 images taken at 3-minute intervals. This method will provide up to twice as many wind samples as obtained from longer interval images. This includes areas where no winds can be obtained from 30-minute images. These short-interval pictures give new insight into the development, growth, and movement of severe storms.

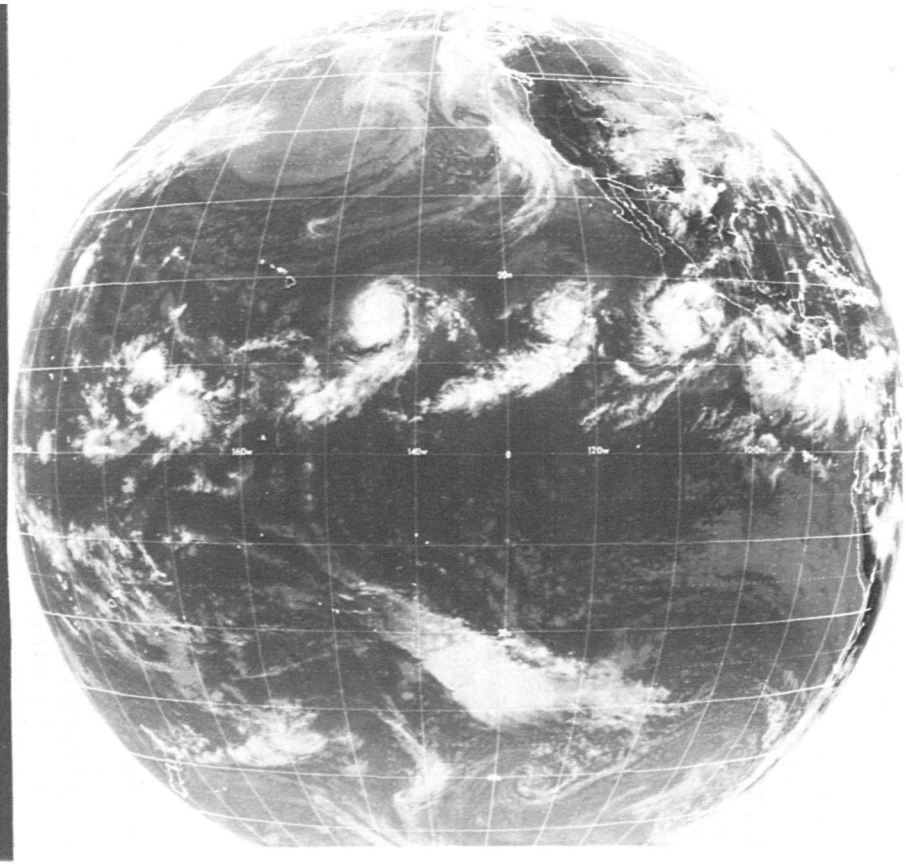
Severe drought in much of the Midwest and Canada in 1976 contributed to many forest fires. By early June more than 243 square kilometers were on fire in a number of remote locations in Ontario. NOAA-4 and GOES-1 images were used to establish the location and relative size of the fires, thus providing considerable assistance to the firefighters.

In a cooperative effort between the National Weather Service (NWS) and NESS, on nights when frost is expected, the Miami SFSS provides specially enhanced infrared GOES-1 images and interpretations to the Weather Service Office at Ruskin, Florida. This program was developed by NASA and NWS to support the Florida citrus industry. The method was first successfully tested in January 1976, and became operational during the 1976-77 winter. The satellite images display ground temperatures critical to freeze predictions. Ground temperatures, monitored every 30 minutes over the entire citrus belt, are accurate to within 1°C. Heating the citrus groves costs the growers an average of $830,000 an hour as opposed to $37,000 an hour during normal operating periods. Thus more reliable forecasts produce significant economic benefits.

Search and Rescue Support.- NESS provided satellite data to assist in Search and Rescue (SAR) planning throughout the U.S. Air Force Inland SAR area and for U.S. Coast Guard SAR missions in United States coastal waters.

The Air Force Rescue and Coordination Center used geostationary satellite cloud pictures to detect areas of severe weather not observed by conventional means. This information enabled the Center to provide almost immediate aid to pilots in distress. Satellite photographs, available every 30 minutes, were used to determine if certain preferred mountain routes were open or blocked by weather, and to determine if a missing pilot could have flown over a storm or had to fly through the weather. The California wing of the Civil Air Patrol has been able to reduce most of its searches from an average of 2 weeks to 2 days by using satellite data. Also, satellite data enable SAR forces to avoid many of the hazards they normally would face during a rescue attempt.





SMS 2 full-disc visible (L) and infrared (R) images on September 26, 1976, shows Hurricane Kathleen (left center), a tropical depression (center), and Hurricane Liza (right center). SMS 2 is located at 135°W.

The Coast Guard has been using both polar-orbiting and geostationary satellite data to find lost or disabled ships and aircraft. Wind velocities and directions, major ocean currents such as the Gulf Stream, low-level cloud cover and fog, and sea surface temperatures are carefully evaluated from satellite data. Using this material, NESS personnel can suggest to the Coast Guard the areas with the greatest potential for successful search and rescue operations.

Determining Ocean Conditions. - NOAA has prepared a Program Development Plan and established within NESS a special project to coordinate research and applications of SEASAT-A data. SEASAT-A is a NASA oceanographic satellite scheduled for launch in 1978. Planned research includes experiments on surface winds, waves, sea surface temperatures, ice, tides, and geoid determinations, and a demonstration element directed toward applying SEASAT-A data in near-real time to meteorology and oceanography.

NESS continues to sponsor development of techniques to use satellite data to measure ocean color and chlorophyll-a, an important chemical indicator of ocean productivity. These data will be obtained from a Coastal Zone Color Scanner to be carried on the Nimbus-G satellite.

NESS has developed a technique to improve the accuracy of sea surface temperatures (SST) derived from polar-orbiting satellite scanning radiometer measurements. The calibrated Vertical Temperature Profile Radiometer (VTPR) water vapor channel (18.69 micrometer) data and SST data were used in new equations to produce temperatures corrected for atmospheric absorption. To account for the amount of cloud cover, data from the VTPR 11.97- and 13.38-micrometer channels were applied to the uncorrected SST measurements to determine if the data were from clear, moderately cloudy, or heavily cloudy areas. The result of these modifications is a 40-percent increase in the number of reliable SSTs. Today, the SST field is derived solely from satellite data and is no longer dependent on climatology for estimates in data-sparse areas.

Infrared images from GOES-1 were used by NESS to produce time-lapse films of the Gulf Stream thermal front along the Florida coast. Northward propagating eddies were detected at the inshore edge of the current. A project was initiated to study the Gulf Stream deflection at 32°N. Satellite data were used to demonstrate topographical control of the current in this area.

Investigations conducted during the Arctic Ice Dynamics Joint Experiment support the hypothesis that different sea ice types (multiyear, first year, etc.) can be determined from temperature distributions. Very High Resolution Radiometer data from the NOAA satellites were compared with aircraft infrared scanner data. Aircraft and satellite data sets show a striking similarity.

NOAA, NASA, and the Coast Guard conducted a joint remote-sensing ice reconnaissance experiment along the north coast of Alaska. A Coast Guard C-130 aircraft demonstrated the feasibility of observing ice conditions with

a Side-Looking Airborne Radar. The ice data proved valuable to the barge operators resupplying Prudhoe Bay. In addition, the Anchorage Satellite Field Services Station supplied ice charts from satellite data for use by the barge and oil companies in their daily planning.

Determining Lake Conditions. - The NOAA Great Lakes Environmental Research Laboratory (GLERL) and NESS continued their studies of whitings (chemical precipitation of calcium carbonate). Comparisons of aircraft, ship, and satellite data show that whitings occur just below the lake surface in relatively warm water and are most evident in late summer following periods of upwelling. The whitings, which can continue for several months, serve as a tracer mechanism for assessing horizontal circulation in the Great Lakes, and also are useful in studies of carbon dynamics and the distribution of nutrients in the Lakes.

GLERL used Landsat and *in situ* data to detect sediment transport patterns to verify circulation models for western Lake Erie, Lake St. Clair, and the St. Clair River. Landsat data, used to study the influence of the spring runoff into Lake Michigan, show the shape of the river plumes in the Lake and the distribution of sediment, carbon compounds, and nutrients.

GLERL used NOAA satellite data to monitor ice formation, growth, decay, and distribution on the Great Lakes. In addition, these data are being used to support ship operations, and for research on the geographical extent and physical properties of ice.

NOAA 5 visible image of the eastern Mediterranean Sea, eastern Africa, and the Nile River. A thin cloud cover can be seen over the southern Red Sea.

NESS has demonstrated that the Multi-Spectral Scanner data from the Landsat satellite can be used to assess the coverage of chlorophyll-a in the Great Lakes when concentrations exceed 10 micrograms per liter. Use of these satellite data enables scientists to obtain information on nutrient productivity and to describe surface current circulation.

Determining Hydrological Conditions. - The NOAA geostationary satellites continued to play an important role in monitoring snow cover in United States and Canadian river basins. The number of snow basins mapped during the 1975-1976 winter season was increased to 22. Images from GOES-1 and SMS-2, every 30 minutes, increase the chances of obtaining a cloud-free view of the Earth. These geostationary satellite images are superior to polar-orbiting satellite data for delineating small bodies of water such as lakes and reservoirs. NESS hydrologists forward daily interpretations of snow cover conditions to the National Weather Service River Forecast Center in Kansas City. These data are used to forecast river levels and issue flood warnings and also are critical to irrigation planning, hydroelectric power generation, and reservoir regulation.

Snow and ice charts of the Northern Hemisphere, derived from satellite data from 1966 through 1975, were used by NESS to determine the extent of snow cover in Eurasia and North America. These analyses showed no significant overall increase in snow cover but larger fluctuations occurred in Eurasia than in North America. Using satellites to monitor worldwide snow cover provides important information on global temperature and albedo, each of which has an impact on hydrology, agriculture, and weather forecasting.

Monitoring Agricultural Conditions. - In cooperation with the Great Plains Council, NESS is investigating the ability of geostationary satellites to gather insolation data. These data will be compared with data collected at ground test sites. Insolation is an important parameter in yield models for many Great Plains crops such as sorghum and wheat.

NOAA-4 satellite data were used in the development of a method to control locusts in southern Algeria. The U.N. Food and Agricultural Organization used Very High Resolution Radiometer images to locate rainfall areas and hence areas of emergent vegetation. Algerian control teams examined these areas to determine if insecticide spraying was needed to inhibit the development of migratory swarms. This application of satellite data to locust control shows promise and may eventually be applied to the entire desert locust zone, covering about 31 million square kilometers from Dakar, Senegal, to Dacca, Bangladesh.

The Large Area Crop Inventory Experiment, a cooperative effort of NOAA, NASA, and the Department of Agriculture, is designed to develop technology to provide accurate and timely crop production estimates. Computer-assisted analyses of archived meteorological satellite data are used to develop mathematical models to relate weather to crop yields. In 1976, the Environmental Data Service Center for Climatic and Environmental Assessment developed mathematical models for Russia, Argentina, Brazil, Australia, and India and refined existing yield models for the United States and Canada.

Fisheries Monitoring. - To help tuna and salmon fishermen find productive fishing grounds along the California coast, chart coverage was expanded during 1976 to include the area between the Strait of Juan de Fuca and Point Concepcion, California. These charts, based on NOAA-4 and -5 and SMS-2 images, depict the ocean surface thermal structure. They are produced by the San Francisco Satellite Field Services Station and transmitted experimentally to fishermen by NOAA's Sea Grant Advisory Agent. The National Marine Fisheries Service (NMFS) and Western Fishboat Owners Association transmit this information operationally by single-sideband radio.

In another effort to assist fishermen, the Inter-American Tropical Tuna Commission (IATTC), in cooperation with the NMFS Southwest Fisheries Center, correlated NOAA and Landsat satellite images with surface-truth data to determine the feasibility of using satellite data to identify upwelling areas and ocean frontal boundaries. Albacore migration in the eastern North Pacific has been found to be associated with ocean fronts.

NMFS, state agencies, and private industry demonstrated that the distribution of menhaden and thread herring can be inferred from Landsat Multi-Spectral Scanner data. A test conducted in July 1976 used color differentiation in Landsat images to determine high-probability fishing areas. Reports from the fishing industry indicated that most of the predicted high-probability fishing areas produced good fish yields.

Environmental Monitoring Using Data Buoys. - The NOAA Data Buoy Office (NDBO) expanded its capability to acquire environmental data from oceanic areas by advancing data buoy technology. In June 1976 the NDBO conducted a pilot data communication demonstration between a Pacific Ocean buoy and the World Meteorological Center, Suitland, Maryland, using the GOES satellite as a communications link instead of standard radio links. All NDBO meteorological buoys used this satellite communication link by the end of 1976. Marine meteorological information from data-sparse areas is obtained from deep ocean, continental shelf, and drifting buoys. The deep ocean buoys provide three-hourly data for national and international weather services. Continental shelf and drifting buoys provide environmental data to the scientific research community, offshore industries, fisheries, environmental protection groups, and recreational interests. During 1976, the NDBO had nine deep ocean and eight continental shelf buoys operating in the Atlantic and Pacific Oceans and the Gulf of Mexico. Over 80 drifting buoys were deployed in the oceans of the world.

Other Satellite and Space Applications

International Cooperation. - NESS expanded assistance in the form of satellite views of major disaster areas to the Office of Foreign Disaster Relief Coordinator of the Agency for International Development (AID), Department of State. This information was used to plan relief operations for and aerial photographic surveys of disaster areas, including earthquakes in Italy and Guatemala, floods in Nicaragua, Typhoon Pamela in Guam, and Typhoon Ruby in the Phillipines.

The United States and the Soviet Union continued to exchange environmental satellite data in 1976. Russia received data from NOAA-4 and -5, and the U.S. received data from Russia's Meteor series. Russia launched Meteor 23, 24, 25, and 26 in 1976.

The National Weather Service, under the Voluntary Assistance Program of the World Meteorological Organization, has established Automatic Picture Transmission (APT) stations with improved satellite video capability in Ethiopia and Trinidad. These stations can receive data from both polar-orbiting and geostationary satellites, and are the prototype for eventual replacement of most of the older APT equipment.

Weather Modification. - The NOAA National Hurricane and Experimental Meteorology Laboratory (NHEML) expanded its use of satellite data in research on the modification of hurricanes and tropical convective clouds. Using geostationary satellite data, real-time estimates of rainfall from Atlantic Ocean tropical storms were made for the National Hurricane Center and the River Flood Forecast Offices of the National Weather Service.

NHEML also used satellite and aircraft data to construct sea surface temperature patterns in advance of and in the wake of eastern Pacific hurricanes. These measurements were used to calibrate satellite-determined temperatures used in the study of air-sea interactions in and near hurricanes.

Determination of the Earth's Shape and Gravity Field. - The National Ocean Survey (NOS) Geodetic Research and Development Laboratory (GRDL) used GEOS-3 satellite altimeter data to measure large-scale features of the Earth's gravitational field. A system was developed to handle data from GEOS-3 and the planned SEASAT-A satellite. GRDL prepared plans to use SEASAT-A data experimentally for computing precise satellite positions and for obtaining more accurate determinations of the geoid commensurate with the expected 10-centimeter precision of the SEASAT-A altimeter.

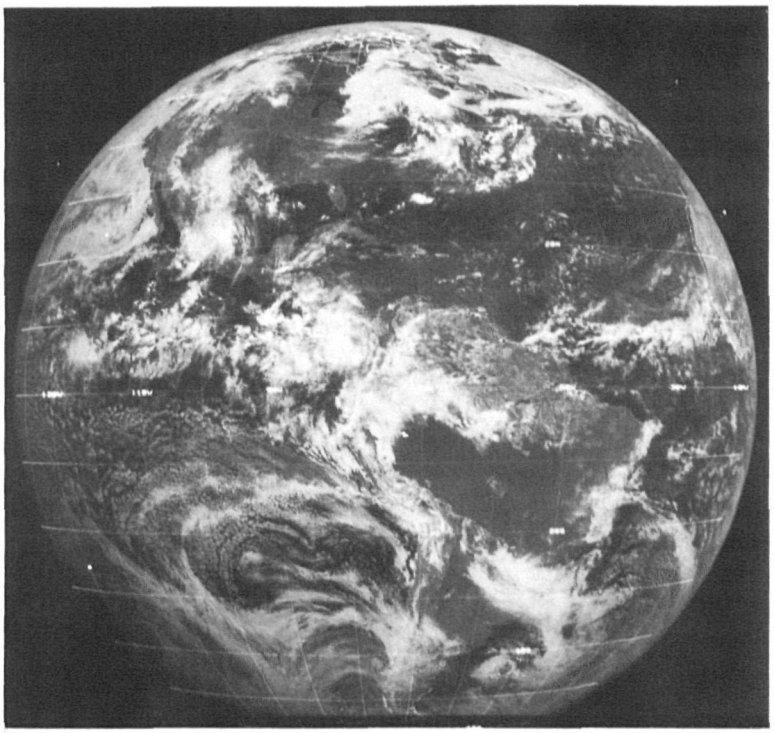
NOS continued to evaluate the use of LAGEOS satellite laser observations and very long base-line radio interferometry to monitor temporal variations in horizontal and vertical positions, polar motion, and Earth rotation. One application of these methods is to provide more accurate information on the slope of mean sea level along the U.S. Pacific coast; the Sea Level Observation and Prediction Experiment has been initiated for this purpose. Another study showed that adding Doppler observations to a ground network improved the accuracy of horizontal positioning. Doppler satellite stations were established at 67 United States locations including 6 on offshore oil platforms.

Space Support Activities

Weather Support. - The National Weather Service (NWS) assisted Johnson and Kennedy Space Centers in preparing background and planning studies for the Space Shuttle flights. NWS also worked with the Jet Propulsion Laboratory

in predicting potential weather effects on signals from the Mariner Jupiter-Saturn mission scheduled for launch in 1978. Weather support was provided to the Wallops Flight Center for its rocketsonde and atmospheric ozone measurement programs.

Solar Activity. - The Space Environment Services Center (SESC), operated jointly by NOAA and the U.S. Air Force, is the National and World Warning Agency for disturbances in space and the upper atmosphere. SESC provided forecasts and warnings of adverse effects of solar and geomagnetic activity to military command and control systems; scientists performing diverse experiments with balloons, rockets, and satellites; operators of communication satellites; the Federal Aviation Administration; electric power utilities; and geophysical exploration groups. Interference with geosynchronous satellite operations by the type of geomagnetic storms that occur most often near solar sunspot minimum continued to be a frequent problem. The SESC uses data from a variety of space and terrestrial sensors, relying primarily on information from the SMS/GOES Space Environment Monitors, the NOAA-4 and -5 Solar Proton Monitors, and the NOAA-Air Force Global Flare Patrol network.



GOES 1 full-disc visible image at 1600 GMT, July 12, 1976, showing dust clouds (right center) from Africa forming over the eastern Atlantic Ocean.

Space and Atmospheric Physics Research

Interplanetary Physics. - The NOAA Space Environment Laboratory (SEL) performed numerical simulations of the magnetohydrodynamic (MHD) solar wind stream interaction and shock propagation for comparison with data from several spacecraft. Skylab observations of the solar corona also were simulated with steady-state, nonradial flow models of MHD solar wind dynamics in the corona. The simulations produced information on the temperature and magnetic field in coronal holes.

As a result of a cooperative theoretical study with the University of Mexico, the viscous-like solar wind interaction observed by the Soviet spacecraft Venera is now well understood. The theory is especially applicable to Venus because of its weak magnetic field.

Ionospheric Physics. - The ATS-6 geosynchronous satellite, moved to a location near India from July 1975 to August 1976, observed the seasonal and diurnal variations of equatorial ionospheric and plasmaspheric electron content. Indian scientists, in cooperation with Stanford Research Institute scientists, also studied the severe scintillation of ATS-6 satellite radio signals in equatorial regions. These scintillations affect satellite-to-ground telecommunications.

Magnetospheric Physics. - On the basis of SEL analysis of Explorer 45 and ATS-6 data, it is now believed that portions of the Earth's radiation belt is composed of ions heavier than protons. A proposed theory is that many of the energetic radiation-belt ions, once believed to have originated from the Sun, actually originate from the Earth's ionosphere.

The analysis of rocket data taken over an auroral arc was used to describe the electrical currents that flow in the Arctic ionosphere. Results indicate that these currents are not necessarily strongest in the highest conducting portion of the ionosphere. Also, ionospheric winds may exert strong control of the currents flowing near auroral arcs and consequently may influence currents flowing in the outer magnetosphere.

Data Programs

International Magnetospheric Study. - The World Data Center-A for Solar and Terrestrial Physics of NOAA's Environmental Data Service (EDS) established an International Magnetospheric Study (IMS) Central Information Office to gather and distribute information about IMS investigations. The IMS, scheduled from January 1976 through 1979, is a study of the structure, time change, and physical processes of the outermost parts of the Earth's atmosphere; emphasis is on simultaneous measurements by groups of satellites and includes complementary experiments and monitoring by rockets, balloons, aircraft, and ground-based sensors.

Satellite Rainfall Estimates. - Scientists at the EDS Center for Experiment Design and Data Analysis (CEDDA) are cooperating with NASA's Goddard Space Flight Center, the University of Wisconsin's Space Science and Engineering Center, and NOAA's National Hurricane and Experimental Meteorology Laboratory to evaluate and calibrate techniques for using visible, infrared, and microwave satellite data to estimate rainfall over tropical ocean areas. The program is based on very accurate precipitation estimates derived by CEDDA scientists from shipboard digital radar data for a 125,000-square-kilometer area over the eastern tropical Atlantic, collected as part of the Global Atmospheric Research Program's Atlantic Tropical Experiment.

Aeronautical Programs

Aeronautical Charts. - Concern for the environment together with the sustained growth of air traffic have added to the complexity of managing the national airspace. Consequently, the National Ocean Survey has introduced new aeronautical charts and products to keep pace with increased requirements. In addition to the continuous maintenance of existing charts, chart services for video maps, instrument approach procedures, and terminal areas were expanded and disseminated to airspace users and controllers. Also a prototype Alaska Planning Chart was developed and submitted to the Federal Aviation Administration for evaluation by the Alaska region.

Outer Continental Shelf Studies. - The NOAA Outer Continental Shelf Environmental Assessment Program scientists used remote-sensing data from the Landsat and NOAA satellites and aircraft data obtained by the Cold Regions Research and Engineering Laboratory, the National Ocean Survey, and the Environmental Research Institute of Michigan to conduct scientific investigations in the Arctic. Side-looking airborne radar and thermal infrared images were used to study large scale geological features and ice activity along the Arctic coast. Low-level optical color and color-infrared images of the western Alaskan coast from the Yukon Delta to Cape Lisburne were used to assist in mammal and bird inventories, habitat studies, and geological investigations. Low-level, high resolution data from a multispectral scanner and color mapping camera were compiled to support inshore ecological studies in the northwest Gulf of Alaska.

Safety Services for Aeronautics. - The NOAA National Severe Storm Laboratory (NSSL) used data from a 460-meter instrumented tower, closely spaced surface weather stations, aircraft, and Dual-Doppler radar to measure the outflow regions of thunderstorms for development of an improved three-dimensional gust-front model. The multiobservational system measures both horizontal and vertical wind shear, the distribution and strength of up and down drafts, and turbulence, all of which can be hazardous to aircraft. NSSL also made Single-Doppler radar measurements of low-level wind shear in clear air as part of a continued effort to develop the use of Pulsed-Doppler radar for flight safety.

The Atmospheric Physics and Chemistry Laboratory continued development of an infrared, water-vapor band, clear air turbulence radiometer. Tests conducted aboard NASA's C-141A aircraft directed the radiometer forward at an elevation between 7° and 22° above the horizon. These tests gave from 4 to 14 minutes of advance warnings of clear air turbulence.

U. S. Environmental Satellites 1960-1976

Satellite	Purpose[1]	Launch	Average Altitude[2] (KM)	Ceased Operation	Remarks[3]
TIROS 1	R	04/01/60	720	06/15/60	First weather satellite providing cloud cover photography.
TIROS 2	R	11/23/60	672	02/07/61	
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	07/31/66	
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	11/15/66	
ESSA 3	O	10/02/66	S/1427	10/19/68	Carried first AVCS cameras. AVCS carried on all odd-numbered ESSA satellites.
ATS 1	R	12/06/66	S/35,765	10/16/72 (pictures)	150°W WEFAX operations continue.
ESSA 4	O	01/26/67	S/1373	06/19/67	
ATS 2	R	04/05/67	-	-	Unstable altitude 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)	105°W WEFAX operations continue.
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	11/29/73	
Nimbus 3	R	04/14/69	S/1100	09/25/70	Provided first vertical temperature profile data of the atmosphere on a global basis.

Satellite	Purpose	Launch	Average 2 Altitude (KM)	Ceased Operation	Remarks[3]
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 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	-	Still providing data
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/35,785	-	First NASA prototype; 105°W on standby
NOAA 4	O	11/15/74	S/1460	-	On standby
Landsat 2	R	01/22/75	S/918	-	
SMS 2	R/O	02/06/75	G/35,790	-	Second NASA prototype; 135°W
Nimbus 6	R	06/12/75	S/1110	-	
GOES 1	O	10/16/75	G/35,769	-	First NOAA operational geostationary satellite; 75°W
NOAA 5	O	07/29/76	S/1511	-	

1 R - Research, O - Operational, 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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