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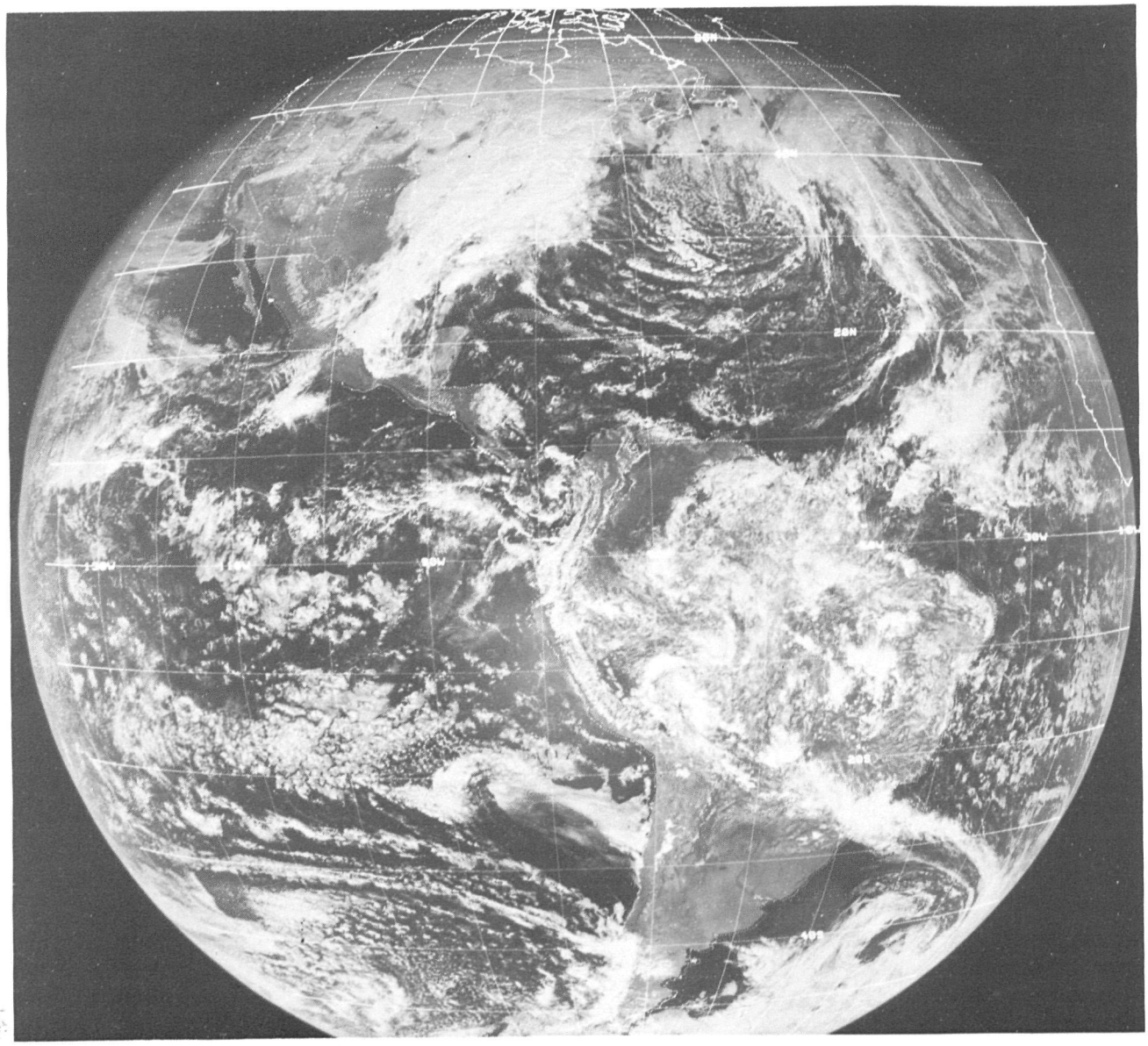
Satellite Activities of NOAA 1975

compiled by
NATIONAL ENVIRONMENTAL SATELLITE SERVICE
Washington, D.C. April 1976

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



Full-disc visible image from SMS 1 located at 75°W over the equator. At 1700 GMT on December 30, 1975, a large winter storm covers the eastern half of the United States.

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National Oceanic and Atmospheric Administration

Introduction

The National Oceanic and Atmospheric Administration (NOAA) was established within the United States Department of Commerce in 1970 to improve man's understanding and increase his uses of the air and water environment. NOAA is in the vanguard of the U. S. effort to ensure that the Earth will continue to serve and sustain its people. NOAA carries out these responsibilities by maintaining an operational satellite system; by continuing programs for monitoring and predicting marine resources; by monitoring our marine environment continuously with improved sensors on ships, aircraft, and satellites; by improving our weather observations and forecasts through the use of automated observation stations, improved radar systems, and continued atmospheric research programs; by conducting research in weather modification; and by improving data collection, processing, and dissemination techniques. Six major components of NOAA contribute directly to the aeronautics and space program. These 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.

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NOAA 4 VHRR visible image of Southern Europe and North Africa on July 23, 1975. Snow cover can be seen on the Alps.

National Oceanic and Atmospheric Administration
TIROS Satellites and Satellite Meteorology

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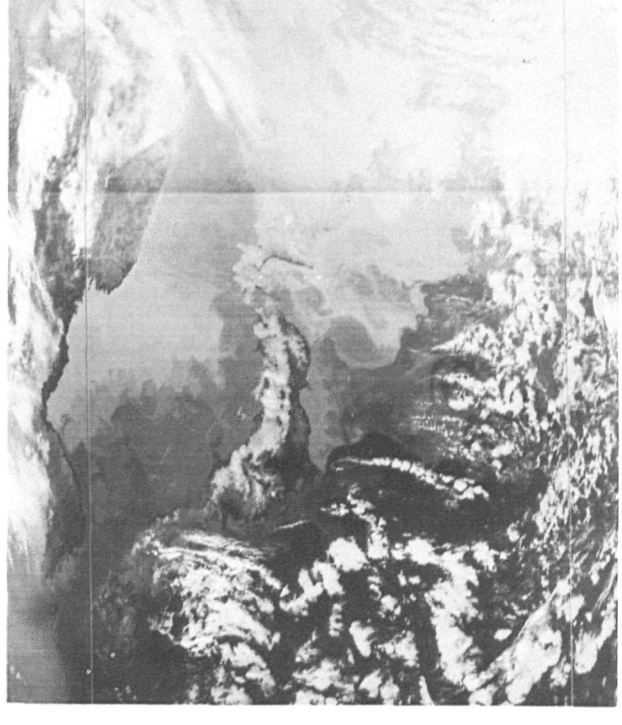
Satellites in Environmental Monitoring and Prediction

Environmental Satellite Operations. - On January 1, 1975, the National Environmental Satellite Service (NESS) of the National Oceanic and Atmospheric Administration (NOAA) was operating four polar-orbiting satellites: ESSA-8 of the TIROS Operational Satellite (TOS) series and NOAA-2, NOAA-3, and NOAA-4 of the Improved TOS (ITOS) series. ESSA-8 has been providing data to users of Automatic Picture Transmission (APT) on a worldwide basis for nearly seven years. NOAA-4 has been the primary global data-gathering satellite throughout 1975. NOAA-3 was placed on operational standby in December 1974 and serves as a backup to NOAA-4, and NOAA-2 was deactivated on January 30, 1975. ITOS-E2 (to be named NOAA-5 when in orbit) was scheduled for launch in July 1975. Its launch was deferred month-by-month because NOAA-4 continued to operate satisfactorily, and NOAA-3 was an adequate backup. ITOS-E2 will be launched when needed to replace the in-orbit operational satellite.

On February 6, 1975, NASA launched the Synchronous Meteorological Satellite, SMS-2, the second and final prototype for the Geostationary Operational Environmental Satellite (GOES) system. SMS-2, was placed in geostationary orbit, 35,785 kilometers above the equator at 115° West longitude. The instrument and communication systems are identical to those on SMS-1: a Visible and Infrared Spin-Scan Radiometer (VISSR), a Space Environment Monitor, a Data Collection System (DCS), and a Weather Facsimile broadcast system. SMS-1, located over the equator at 75° West longitude, and SMS-2, together provide a viewing of the area from 70°N to 70°S and westward from 5°W to 175°E. Full-disc pictures are acquired at 30-minute intervals from the VISSR instruments on each of the



NOAA 4 infrared image of Japan and surrounding waters on April 4, 1975 showing the Kuroschio Current and the temperature structure in the Sea of Japan.

spacecraft. This permits nearly continuous viewing of severe storms and helps weather forecasters to provide the public with timely warnings.

GOES-1, the first NOAA operational version of SMS, was launched on October 16, 1975, into geostationary orbit 35,769 kilometers over the equator at 55° West longitude. GOES-1 carries the same instrument and communication systems as SMS-1 and 2. Late in 1975, SMS-2 was moved to 135°W arriving on station on December 19, 1975. GOES-1 was moved to 75°W and replaced SMS-1 as the eastern operational satellite on January 8, 1976. SMS-1 was moved to 105°W arriving at that location on February 16, 1976. SMS-1 was placed on operational standby to serve as an in-orbit backup.

Development is continuing on the third generation of polar-orbiting satellites, the TIROS-N series. These satellites, destined to replace the current ITOS system, will provide more accurate data for environmental monitoring and prediction. The instruments to be included are the Advanced Very High Resolution Radiometer, the TIROS Operational Vertical Sounder, the Space Environment Monitor, and the Data Collection and Platform Location system. The NASA prototype of TIROS-N is scheduled for launch in early 1978.

Because of the higher data rate, the fully digital data system, and the increased operational demand for timely delivery of processed data, a new ground system is needed to accommodate the data from the TIROS-N. This ground system, incorporating as many parts of the ITOS system as practicable, will consist of two major subsystems: the Data Acquisition and Control Subsystem (DACS) and the Data Processing and Services Subsystem (DPSS). DACS comprises the equipment for the Wallops, Virginia, and Gilmore Creek, Alaska, Command and Data Acquisition (CDA) Stations, the Satellite Operations Control Center (SOCC), and the interconnecting communications between the CDA's, SOCC, and DPSS. DPSS consists of NESS data processing facilities and interfaces with the NOAA large-scale central computing capability.

Uses of Environmental Satellite Data

Vertical Temperature and Wind Profiles. - A long-term goal of NESS is to develop a system for monitoring global atmospheric temperature and wind profiles that are operationally independent of the world-wide radiosonde network. Vertical Temperature Profile Radiometer (VTPR) data obtained from NOAA satellites have contributed toward this goal. VTPR soundings are used routinely in the National Meteorological Center's numerical weather prediction program. NESS continues research toward development of satellite instruments and analysis methods that can determine the vertical temperature structure of the atmosphere and the global distributions of atmospheric constituents such as water vapor, carbon dioxide, and ozone, all of which influence the accuracy of measurements. The High Resolution Infrared Radiation Sounder (HIRS) experiment was carried on Nimbus 6, launched on June 12, 1975. The HIRS is a third-generation instrument with new features, one of which is measurement in the 4.3-micrometer CO_2 band. This should greatly improve soundings of the atmospheric temperature to the 40-kilometer level and of the water vapor profiles to the 10-kilometer level.

Both SMS-1 and SMS-2 visible and infrared images are being used to derive wind vectors from cloud motions. Infrared data are used to determine cloud-top temperatures and cloud heights, which enable wind vectors to be assigned to their proper atmospheric level. Comparison of satellite-derived wind vectors produced operationally with those processed on an experimental basis agree within reasonable tolerances. The low-level wind values generally agreed within 1 meter per second while high-level winds agreed within 3 meters per second.

Research is being conducted to develop better techniques to measure winds from geostationary infrared images of cloud motions. Much of the effort is concentrated on establishing the heights of clouds through accurate determination of the equivalent blackbody temperature.

Monitoring Global Radiation. - The Earth Radiation Budget experiment, carried on Nimbus 6, is designed to measure with high accuracy the radiation of the Sun and Earth. A terrestrial radiation budget can then be determined on both the synoptic and planetary scales. The measurements will serve as an initial bench mark for the long-term monitoring of global radiation.

Environmental Warning Services. - The launch of SMS-2 increased the primary warning platforms to a two-spacecraft system. In addition two new Satellite Field Services Stations (SFSS) have been established. In July 1975, an SFSS began operations in Honolulu, Hawaii using data from the SMS-2 spacecraft, and in November an SFSS was established at Anchorage, Alaska, to use data from the polar-orbiting satellites via the Gilmore Creek CDA. Data are received at the Gilmore Creek CDA from an average of seven orbits each day.

Full-disc or sectors of VISSR images received at each SFSS are sent to Weather Service Forecast Office (WSFO) facilities. Twenty-nine WSFO/GOES facilities were commissioned in 1975, completing a planned network of 50 National Weather Service field offices to receive and use GOES pictures. Forecasters are using the pictures to improve short-term forecast and advisory services to the public, aviation, and shipping. The opportunity to receive the data distributed to any SFSS has been extended to television stations, universities, local governments, and Federal agencies. This system, called GOES-TAP, allows the user to receive any one of the standard sectors available to the SFSS every 30 minutes.

The SMS/GOES satellites are equipped with a Data Collection System (DCS) to collect and relay environmental data sensed by widely dispersed surface platforms such as river and rain gages, seismometers, tide gages, buoys, ships, and automatic weather stations. Each spacecraft can accommodate data from 10,000 or more individual observing platforms every six hours. Platforms transmit sensor data by radio, either at scheduled intervals or upon interrogation from the satellite. Platforms also may operate in an emergency alarm mode, during which a signal is transmitted immediately whenever an observational parameter exceeds a preset threshold value. Data received by the satellite are transmitted on S-band to the Wallops CDA Station and relayed to the World Weather Building, Camp Springs, Maryland. From here the data are disseminated by paper tape fed into a telephone system using commercial

circuits. The GOES DCS began providing service to users on August 18, 1975; currently services are provided to various agencies in the United States and Canada.

In March 1975, France began relaying Vertical Temperature Profile Radiometer data to the United States operationally. These data are from NOAA-4 orbits that do not pass within range of the United States CDA Stations.

Tornadoes and severe thunderstorms can frequently be predicted shortly before they occur by noting the intersection of lines of convection on SMS high-resolution satellite pictures. Experiments in using satellite pictures at five-minute intervals instead of the usual thirty-minute interval hold hope for considerable improvement in tornado warning.

Determining Ocean Conditions. - SEASAT-A, an oceanographic satellite being developed by NASA, is scheduled for launch in 1978. NOAA has begun to plan experiments that will exploit SEASAT-A data for satellite altimetry; sea and lake ice monitoring; geodesy; ocean tides, waves, winds, currents, and temperatures; and meteorology.

NOAA-4 Very High Resolution Radiometer (VHRR) infrared images are being used to produce weekly composite charts that depict water masses and thermal fronts in the Gulf Stream along the east coast of the United States. These charts are sent to users over the National Facsimile network and by mail. The National Weather Service also uses these data to prepare the Gulf Stream Wall Bulletin, which is broadcast to the public by radio. Researchers are using these infrared data in their studies of warm anticyclonic and cold cyclonic eddies associated with the Gulf Stream. The satellite measurements provide an instantaneous view of sea-surface temperature patterns that cannot be identified by in-situ data alone. SMS-1 infrared images of Gulf Stream features also are put in time-lapse movies that enable scientists to continually monitor motions of thermal features in and adjacent to these currents. Further exploitation of SMS data is expected to permit monitoring of turbidity fronts, which in some areas are strongly correlated with fish concentrations. Shipping interests are using Gulf Stream data to route their ships along the east coast, minimizing transit times and saving fuel. The Coast Guard also is using this information in computerized search and rescue operations.

The Coast Guard uses SMS images to determine the presence of low clouds and fog over the U. S. portion of the International Ice Patrol area. With this information, unproductive ice reconnaissance flights have been cancelled and redirected to other portions of the area.

Composite ice charts of Alaskan coastal waters, based on infrared imagery, are produced and disseminated weekly over National Facsimile and by mail. The severe ice conditions along the north coast of Alaska during the summer of 1975 were of special interest. Numerous barges carrying supplies to the pipeline project had difficulty in reaching Prudhoe Bay. The Fairbanks Weather Service Forecast Office used VHRR images in developing ice advisories and forecasts to assist this shipping. NOAA-4 images also were used during 1975 in helping to free the U. S. Coast Guard ice-breaker GLACIER and the Argentinian ship SAN MARTIN from the Antarctic ice pack.

NOAA satellite images and remotely sensed data from aircraft were used to support the Arctic Ice Dynamics Joint Experiment. Studies are being conducted to relate ice thickness to infrared and microwave radiometer measurements.

Determining Lake Conditions. - NOAA-4 VHRR images in the visible part of the spectrum were used to produce the Great Lakes ice charts, transmitted twice weekly on National Facsimile. Use of these charts to route ships through the ice is credited with extending the 1974-75 shipping season in most of the Lakes by more than 30 days. Ships were able to operate between Chicago and Duluth the entire 1974-75 winter season.

At the same time, NOAA, NASA, and the Coast Guard conducted a joint remote-sensing ice reconnaissance experiment. A C-130 aircraft, equipped with Side-Looking Airborne Radar, recorded ice conditions over the Great Lakes and relayed these data in near-real time to the Ice Central in Cleveland via the GOES Data Collection System. This timely reception of data allowed a more rapid dissemination of ice information to the ships.

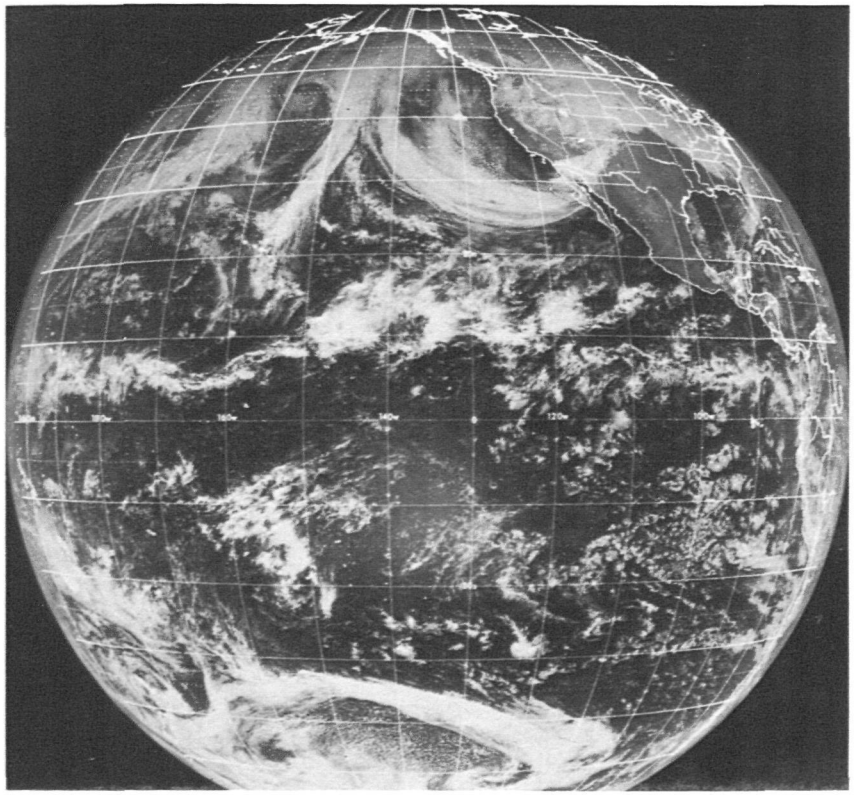
Studies of Great Lakes whitings (chemical precipitation of calcium carbonate) have been expanded to include frequency of occurrence and areas affected. One of nature's largest dye operations, the whiting provides the limnologist with an ideal tracer for assessing horizontal circulation.

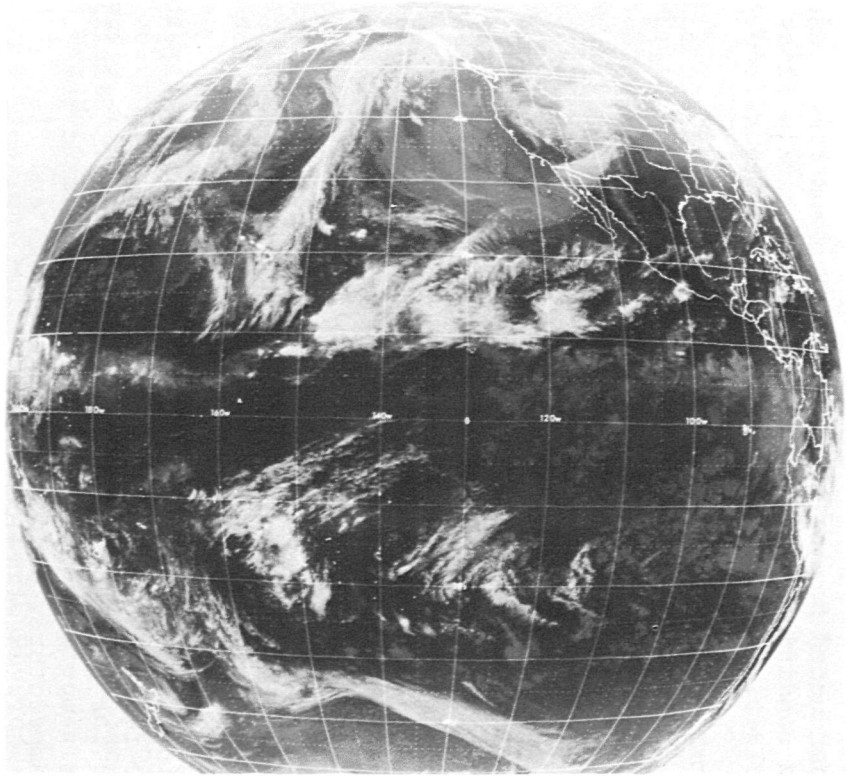
In 1975, Great Lakes surface temperature charts were prepared from satellite infrared data for the first time. These charts are mailed biweekly to the Eastern and Central Regions of the National Weather Service for use in forecasts of Lake freezeup and in upwelling studies.

Determining Hydrological Conditions. - Quantitative estimates of snow cover derived from VHRR and GOES VISSR data were extended to 18 river basins in the United States and 4 in Canada. Also radio transceivers were installed on river and rainfall gages at 44 remote locations. Data from these platforms are obtained by interrogation by the GOES Data Collection System. The ability to make earlier assessments of rainfall and snow cover enables the National Weather Service (NWS), River Forecast Centers to improve their river forecasting and flood warning services and their estimates of water supplies.

It is difficult to determine whether snow cover in forested river basins differs in depth, area, and water equivalents from snow cover in non-forested areas. Remote sensing images from aircraft are being compared to in-situ measurements to determine the spectral reflectance of snow in forest-covered areas. The NWS Hydrologic Research Laboratory also is conducting airborne gamma radiation surveys of snow-covered areas to obtain reliable, current information on snow-cover water equivalents for use in NWS forecasts of snowmelt runoff.

Monitoring Agriculture Conditions. - A joint United States-Mexico program to eradicate screwworms throughout Mexico is using NOAA satellite temperature and moisture data. The object of the program is to push the screwworm barrier, now along the U. S.-Mexican border, southward. The barrier is maintained by continously seeding the area near this barrier with sterile





SMS 2 fill-disc visible (L) and infrared (R) images on December 31, 1975. SMS 2, located over the equator at 135°W, shows major cloud patterns over the Western United States and Eastern Pacific Ocean.

flies. Studies are being conducted to see if there are optimum times, based on temperature and moisture conditions, for breeding so the sterile flies can be introduced at selected times, rather than continuously, to reduce program costs.

Pollution Monitoring. - From April 7 to 17, 1975, NOAA and NASA conducted an extensive experiment in the New York Bight using Landsat, NOAA, and SMS satellites, three research airplanes, four helicopters, and one research ship. Although similar to the 1973 field program the effort covered a larger area and included more measurements. This experiment was designed to demonstrate the capability of remote sensing methods to determine water circulation, water mass characteristics, and amounts of suspended particulates, chlorophll-a, and pollutants such as acid waste and sewage sludge.

Fisheries. - The Inter-American Tropical Tuna Commission continues to study the use of NOAA satellite infrared data for locating and mapping oceanographic fronts and upwelling areas related to the distribution and abundance of several commercially important species of fish.

The National Marine Fisheries Service (NMFS) is using geostationary-satellite data to study the relationship of Gulf Stream meanders in continental shelf waters to the presence of biological organisms. Satellite-derived and in-situ surface temperature data are used to determine the relationship between sea temperatures and coastal upwellings and fish migrations.

NMFS, state governments, and private industry are conducting a 22-month investigation to determine the feasibility of using satellite data to improve the management and use of coastal fishery resources in the northern Gulf of Mexico. Menhaden and thread herring are the target species. Data from SMS, NOAA, and Landsat satellites and aircraft remote sensors will be correlated with sea-truth data to provide NMFS with increased knowledge of coastal water ecology.

Environmental Monitoring Using Data Buoys. - The NOAA Data Buoy Office (NDBO) is developing prototype buoy systems for the acquisition of environmental data. Development has started on an air-deployable ice buoy and an oceanographic and meteorological ice buoy. The data acquired will be used in studies of ice behavior on the continental shelf and elsewhere. The air-deployable buoy will be placed at the ice edge to measure ice motion. The second type will measure oceanographic and meteorological parameters. Data from these buoys are to be relayed to analysis centers through the Nimbus 6 satellite.

Development was started on drifting buoys for use in the open ocean. The impetus for a drifting buoy capable of measuring simple environmental parameters comes in part from the Global Atmospheric Research Program. Prototype drifting buoys are now under test, using the Nimbus 6 satellite to relay data. These open-ocean drifters also can be used by oceanographers for tracking surface currents.

Other Satellite and Space Applications

International Cooperation

Sharing Data. - Under the Voluntary Assistance Program of the World Meteorological Organization, the NWS installed ground stations for Automatic Picture Transmission (APT) in Costa Rica, Barbados, and the Bahamas. In addition APT equipment was sent to Cambodia. This makes a total of 25 countries that have received APT facilities. A new ground receiver station, designed by NASA to receive the APT broadcasts from polar-orbiting satellites and S-band Weather Facsimile broadcasts from geostationary satellites, was installed in Trinidad for operational test and evaluation.

NESS and the Office of Foreign Disaster Relief Coordinator of the Department of State, Agency for International Development (AID), initiated a cooperative program in which AID is advised daily of weather conditions that could lead to natural disasters anywhere around the world. This information, based on satellite images, alerts the AID office to probable requests for assistance.

The exchange of environmental satellite data between Washington and Moscow continues. The U. S. receives data from Meteor 18, 21, and 22, and the U.S.S.R. receives data from NOAA-4. The most recent launch by the Soviets was Meteor 22 on September 17, 1975.

Weather Modification. - The NOAA Atmospheric Physics and Chemistry Laboratory (APCL) conducted an aircraft flight program to measure electric fields over the Kennedy Space Center lightning warning network. The findings were used to modify existing rules about lightning hazards during spacecraft launches. APCL personnel were on hand to advise NASA on the hazards of electric fields in clouds over the launch site and the danger of lightning triggered by the launch vehicle during the Apollo-Soyuz and Viking launches.

The NOAA National Hurricane and Experimental Meteorology Laboratories continued to use satellite data to study the modification of hurricanes and tropical convective clouds. Satellite data were used to estimate winds from cirrus cloud motions, to evaluate the accuracy of estimating hurricane and typhoon position and intensity, to evaluate rainfall from convective clouds by comparing satellite images with radar data and surface rainfall, and to determine surface thermal properties of the Florida peninsula for use with numerical models of the sea breeze.

Determination of the Earth's Shape and Gravity Field. - The National Ocean Survey (NOS) continued to prepare computer programs for the analysis of altimetry data from the Geodynamic Experimental Ocean Satellite, GEOS-3. New mathematical methods were devised for measuring the Earth's gravity field. Analysis was begun on determination of accurate orbits for the SEASAT-A satellite, which will carry an altimeter with an expected 10-centimeter precision.

NOS initiated studies of new methods to determine geodetic control and to monitor temporal variations in horizontal and vertical positions, pole locations, and Earth rotation. Doppler observations from the Navy navigation satellites were obtained at 71 stations throughout the United States, at 6 stations emplaced near the Cook Inlet area of Alaska to support

pre- and post-earthquake horizontal positioning, and at 10 stations placed on offshore oil platforms in the Gulf of Mexico to extend the offshore horizontal positioning network.

NOS completed work on the network of North American station locations. The adjustment covers the North American continent and includes ties to Greenland, Iceland, and Norway. Results showed an average standard deviation of less than 3 meters per station coordinate.

Marine Surveys and Maps. - NOS investigated the feasibility of using Skylab photography in analytic aerotriangulation procedures. The Coastal Mapping Division identified 29 photo control points of known position and elevation on a strip of 12 photographs along a 570 kilometer track extending from Charlotte, North Carolina, to the Rappahannock River in Virginia. The photo coordinates, processed through an established analytic aerotriangulation system of computer programs, showed a root-mean-square error of 15 meters in horizontal position; the maximum observed error was 25 meters.

Lunar Ranging. - NOS and NASA's Johnson Space Center completed work on the Selenocentric Reference System Project. A simultaneous adjustment of all 1244 usable photographs from the Apollo 15, 16, and 17 missions was completed. The horizontal positions and elevations of more than 90 percent of 5325 lunar-surface features were determined to within 45 meters.

Space Support Activities

Apollo-Soyuz Support. - The National Weather Service provided forecasts for the Apollo-Soyuz Test Project, made daily cloud-cover predictions to aid in scheduling photography from Landsat, provided sea-truth support for GEOS-3, and provided forecasts for NASA's Earth Resources aircraft program.

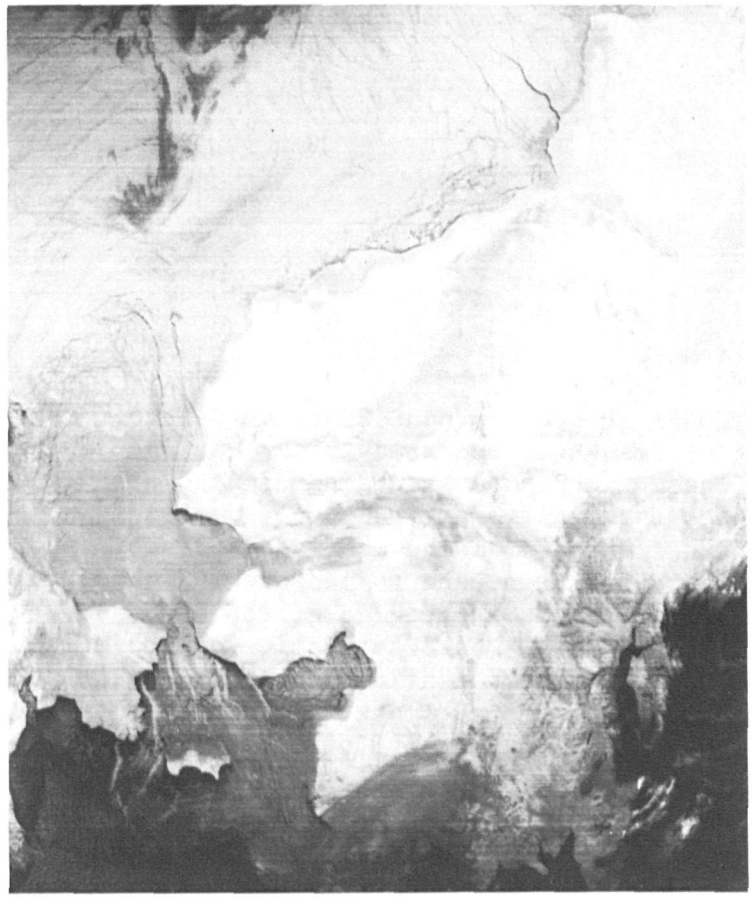
The NOAA Space Environment Services Center (SESC) provided warning and hazard evaluation of solar proton radiation to NASA for the Apollo-Soyuz joint mission. Warnings were coordinated with the Hydrometeorological Service of the U.S.S.R. This project included exchange of data on solar emissions and radiation levels in the near-Earth environment.

Space Environment Services. - The SESC provided forecasts and warnings of adverse environmental conditions, including geomagnetic storms and polar cap absorption events, to communication satellite operators, electric power utilities, geophysical exploration groups, pipeline companies, scientific experimenters, the Federal Aviation Administration, and Air Force and Navy commands responsible for military communication and navigation systems. The year was especially marked by the disruption or temporary loss of operation of several satellites because of high-voltage arcing. Geomagnetic disturbances occurring near the end of the solar activity cycle, when flare activity is near minimum, appeared to be the main cause of these outages. SESC used data from the global solar flare patrol, from satellite sensors, and from terrestrial magnetometers. Data obtained from the Space Environment Monitor systems aboard SMS-1 and SMS-2 provided real-time information on solar X-rays, solar particle emissions, and the near-Earth geomagnetic field. Other data were obtained from the NOAA, Vela, and Pioneer satellites.

Space Physics

Interplanetary Physics. - The NOAA Space Environment Laboratory (SEL) continued to develop time-dependent numerical codes to forecast the arrival at Earth of material ejected during solar flares and to simulate space probe data associated with shock waves. The theory of the nonlinear interactions between high- and low-speed solar wind streams was extended to small amplitude disturbances and to the solar equatorial plane.

Cooperative research of SEL with the University of Iowa and the Applied Physics Laboratory of Johns Hopkins University demonstrated the possibilities for predicting ionospheric and magnetic disturbances several hours in advance. Signals received by a large radiotelescope at Clark Lake Observatory, California, exhibit scintillations caused by irregularities in the interplanetary electron density, which in turn are caused by propagating shock waves from solar flares and complex interplanetary stream interactions. These data, supplemented by solar and interplanetary data, can be used to track shock waves and solar streams in the interplanetary medium.



NOAA 4 infrared image of December 9, 1975, shows extensive ice concentrations in the ocean waters surrounding Alaska.

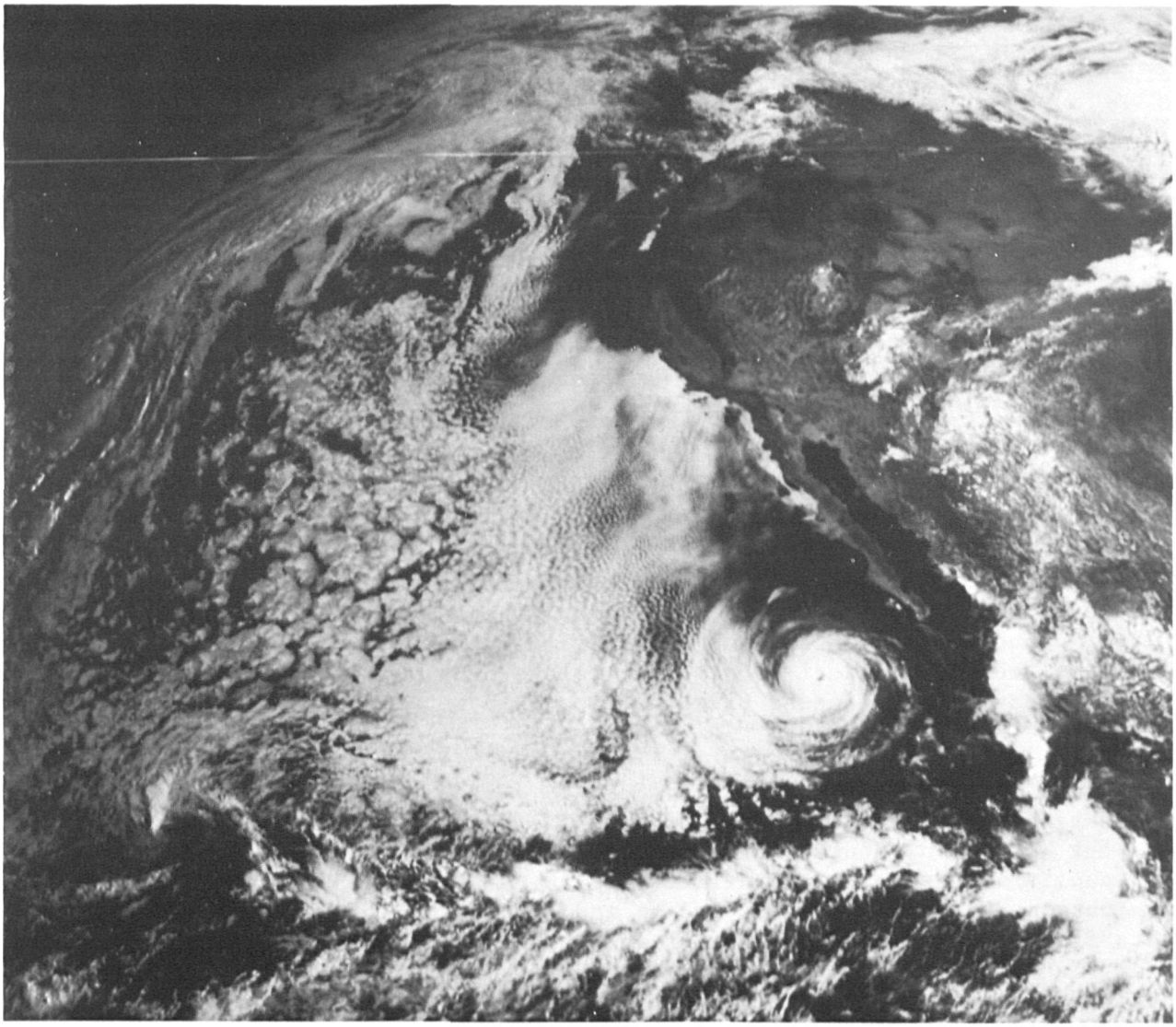
Atmospheric Physics

Ionospheric Physics. - The radio beacon experiment on the ATS-6 satellite and the X-ray measurements from SMS-1 and -2 have provided SEL with the highest resolution and absolute accuracy ever achieved in total-electron-content measurements and the greatest resolution in intensity and largest dynamic range for broadcast X-ray monitoring. The ATS-6 measurements permit the columnar ionospheric electron content up to 2000 kilometer altitude to be separated from the total content up to the satellite altitude. This can be done with sufficient accuracy to determine the residual plasmapheric content between 2000 kilometers and the satellites; such data are used for studies of diurnal, seasonal, and storm variations. The SMS-1 and -2 measurements have permitted study of the time rate of change of the solar soft-X-ray flux and its relation to the implusive solar radio bursts at microwave frequencies. These data are being used to model and verify the effects of solar flares on the E and F regions caused by broadband and impulsive extreme-ultraviolet radiation.

Magnetospheric Physics. - SEL scientists have determined that a resonance between ion cyclotron waves and magnetically trapped radiation-belt protons is a major process that causes precipitation of these protons into the atmosphere during the recovery phases of large magnetic storms. The existence of these energetic, heavy ions has been detected by the SEL instrument on ATS-6. The presence of heavy ions suggests that both the Earth's ionosphere and the Sun may be sources of radiation-belt particles.

Atmospheric Photochemistry. - The Aeronomy Laboratory has developed a technique for measuring the quantity of stratospheric nitrogen peroxide (NO_2) from the ground. This new technique has been used during a global survey with a jet aircraft. Unexpectedly large seasonal variations in the amount of nitrogen peroxide have been found at high latitudes. Automatic monitoring devices are being built, and the first instrument has been installed at Point Barrow, Alaska.

In a joint NOAA/National Bureau of Standards program, techniques were developed to detect, measure, and study the rotational spectra of atmospheric free radicals. These techniques are being used to study chemical reactions between free radicals and different halogenated organic molecules released into the atmosphere from natural and man-made sources. High-resolution electron spectroscopy has been used to measure photoabsorption cross sections of the chlorofluorocarbons in the region of the strongest stratospheric ultraviolet flux. Additional characterization of the molecular energy levels of free radicals derived from potential sources of stratospheric chlorine atoms will provide data on the ultimate fate of these fragments and will indicate means for developing systems for detecting them. A measurement of the rate of reaction between atomic chlorine and ozone has been completed. This is one of the processes in the principal catalytic cycle, during which chlorine from chlorofluorocarbons destroys ozone in the stratosphere. The result indicates a slightly lower rate of reaction than earlier predictions. This work relates closely to the current concern over the role of chlorofluorocarbons as potential destroyers of the ozone balance.



SMS 2 visible image of Hurricane Katrina off Baja, California on September 3, 1975.

Data Programs

Environmental Data

Satellite Data Service. - The Satellite Data Services Branch (SDSB) of the Environmental Data Service (EDS) disseminates environmental and earth-resources satellite data to users. The Branch also provides photographs collected during Skylab missions. SDSB files contain data starting with the early TIROS series, much of the imagery gathered by Nimbus spacecraft, full-Earth disc photographs from ATS-1 and -3, a myriad of images from the ESSA and NOAA satellites, and both full-disc and sectorized images from SMS-1 and -2. Both visible and infrared data are available. A computer terminal, soon to be installed, will link SDSB to NASA's Landsat data base in Huntsville, Alabama.

Climatic and Environmental Assessment. - NOAA, the U. S. Department of Agriculture, and NASA are jointly studying the degree to which computer-assisted analyses of data acquired from archives and satellites can contribute to crop forecasting. This program, the Large Area Crop Inventory Experiment, is designed to find whether use of historical and satellite data can improve the timeliness and accuracy of major crop forecasts. The EDS Center for Climatic and Environmental Assessment is responsible for developing and refining the mathematical models that relate crop yields to weather conditions and for providing processed climatological and meteorological data.

Solar Data

The National Geophysical and Solar-Terrestrial Data Center (NGSDC) of EDS and the World Data Center-A for Solar-Terrestrial Physics are archiving and publishing data from satellites and space probes. Solar proton data are obtained from NOAA-2, -3, and -4 and Pioneer 6, 7, 8, and 9; solar X-ray data from OSO-5 and SMS-1; interplanetary electric and magnetic field data from Pioneer 8 and 9; and solar-wind data from Pioneer 6, 7, 8, and 9, The daily solar-wind speed data are deduced from interplanetary scintillation measurements of several radio sources at three stations of the University of California at San Diego. Solar-geophysical data also include direct observations of the Sun, ground-based optical and radio observations of solar flares, daily maps of solar magnetic fields, and ground-based observations of geomagnetic variations and geophysical cosmic rays. NGSDC also archives auroral data from the U. S. Air Force satellites; more recently, the Center has acquired precipitating electron data from these satellites.

Aeronautical Programs

Use of Sensor Data from Aircraft

Outer Countinental Shelf Studies. - The NOAA Outer Continental Shelf Environmental Assessment Program is using remote-sensing data to investigate the extent, morphology, growth, and decay of land-fast ice, the nature of the pack ice, including the frequency of pressure ridges and leads, coastal morphology and erosion, sediment transport by rivers, and the possibility of detecting walrus, seals, and whales by remote sensing. Geological Survey

remote sensing aircraft, equipped with side-looking radar, an infrared scanner, and a mapping camera, are collecting bi-weekly imagery of ice, sediments, currents, and coastal features along the Arctic coast from Cape Lisburne to Demarcation Point on the Canadian border. NASA's U-2 aircraft based at Ames Research Center is flying along the entire Alaskan coast three times a year to take high-altitude color, infrared, and multispectral imagery.

Safety Services for Aeronautics. - The NOAA Wave Propagation Laboratory (WPL) has developed an acoustic Doppler wind-measuring system capable of monitoring potentially hazardous wind shears in the 30-to-600 meter height range at airports. After successful tests of the acoustic remote sensing system, WPL researchers are continuing development of the device for eventual operational use by the FAA.

The Aeronomy Laboratory is using its recently developed VHF meteorological radar at Sunset, Colorado, to study winds, waves, and turbulence in the troposphere and stratosphere. This long-wave radar measures the parameters of clear-air turbulence and all components of wind velocity in the troposphere with a minimum velocity resolution of 3.7 centimeters per second and a minimum altitude resolution of 150-meters; similar measurements at lower resolutions are made in the stratosphere. The Atmospheric Physics and Chemistry Laboratory also has developed a water-vapor-sensing infrared radiometer that shows considerable promise in the detection of clear-air turbulence.

Aeronautical Charts

Increased use of the national airspace and more complex air traffic control regulations and procedures have had a heavy impact on the number and type of aeronautical charts needed for air safety. The National Ocean Survey has developed a helicopter chart for low-altitude use in the Los Angeles area. World Aeronautical Charts covering the Caribbean and Mexico have been updated to meet civil specifications. A Visual Flight Rules Radio Navigation Chart and bound versions of the Instrument Approach Procedures have been developed and will be tested during the coming year.

Landsat images are being used to improve the accuracy of hydrographic data on charts. The positional accuracy of all navigational features and airway data is being certified by the National Geodetic Survey.

U. S. Environmental Satellites 1960-1975

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	G/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)	70°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	-	Remains operational
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[1]	Launch	Average Altitude[2] (KM)	Ceased Operation	Remarks
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	Deactivated; first operational satellite to carry all scanning radiometer
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	-	On standby; 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	-	
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 satellite; 75°W

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