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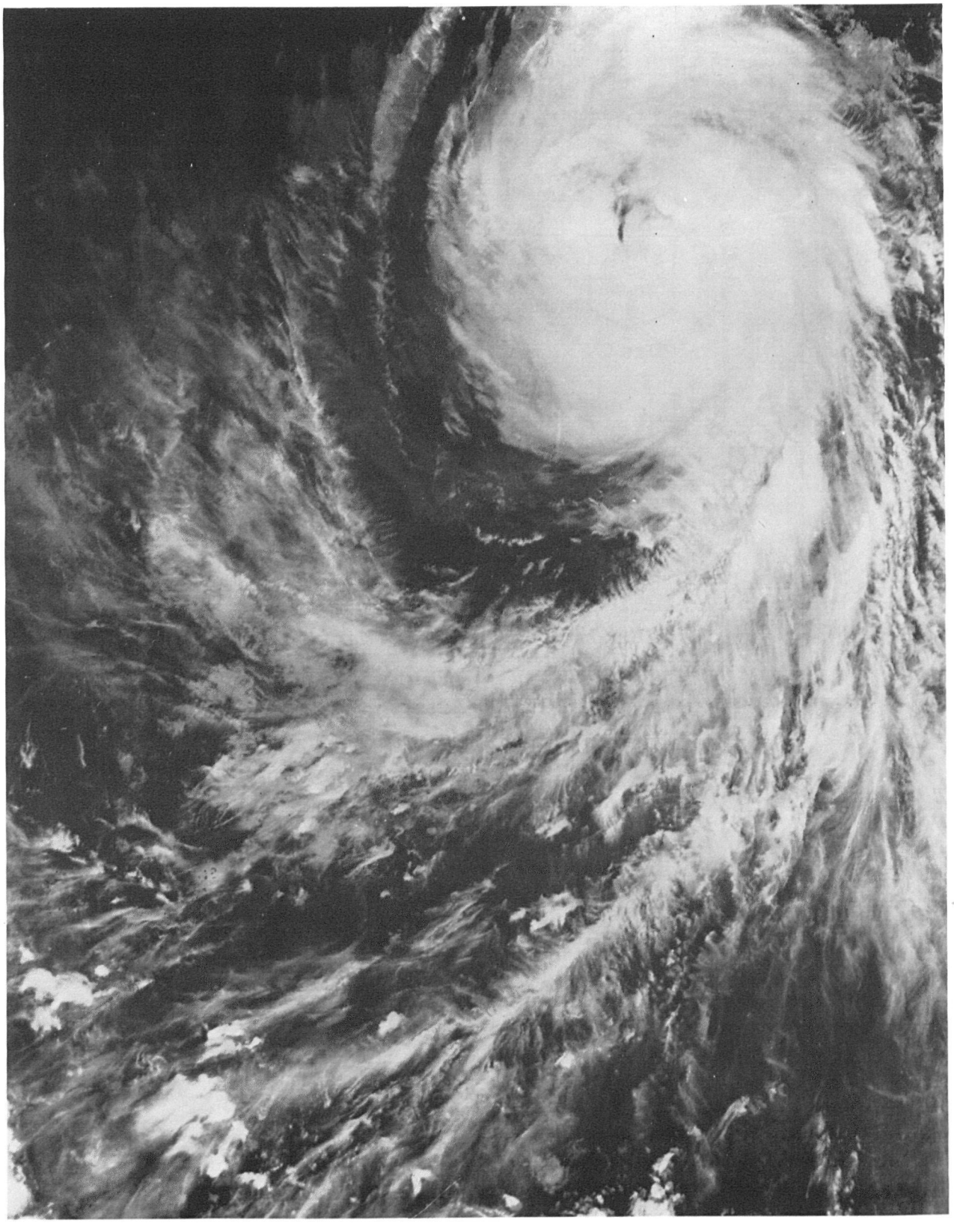
Satellite Activities of NOAA 1973

compiled by
NATIONAL ENVIRONMENTAL SATELLITE SERVICE
Washington, D.C. June 1974

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION



NOAA 2 VHRR infrared image showing Typhoon Ruth in the South China Sea on October 16, 1973.

Satellite Activities of NOAA 1973

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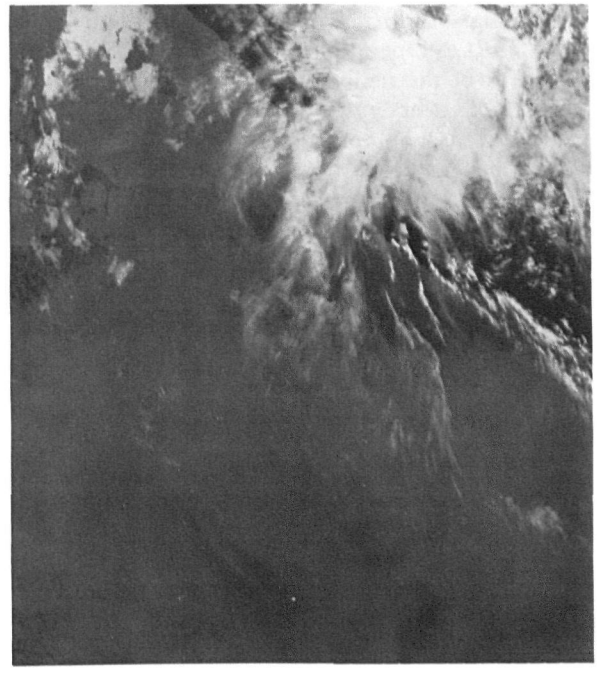

NOAA 2 VHRR visual (left) and infrared (right) images of the west coast of South America on November 20, 1973, showing clouds formed from warm air flowing across colder ocean water.

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The National Oceanic and Atmospheric Administration (NOAA) fulfills the Department of Commerce *responsibilities for improving man's comprehension and* uses of the physical environment and its oceanic life. These responsibilities stress exploring, mapping, and charting the global oceans, their basins, their geophysical forces and fields, and their mineral and living resources; monitoring and predicting the characteristics of the physical environment in real time to warn against impending environmental hazards; and monitoring and predicting gradual changes such as those of climate, seismicity, marine-life distribution, earth tides, continental position, the planet's internal circulations, and the effects of human civilization and industry on the environment and oceanic life. Six major subelements of NOAA provide direct contributions to the aeronautics and space program. These are the National Environmental Satellite Service, the National Weather Service, the Environmental Data Service, the Environmental Research Laboratories, the National Ocean Survey, and the National Marine Fisheries Service.

* Extracted from "Aeronautics and Space Report of the President," transmitted to Congress, April 1974.

National Oceanic and Atmospheric Administration
TIROS Satellites and Satellite Meteorology

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Use of Satellites in Environmental Monitoring and Prediction

Environmental Satellite Operations.—As the year began, the National Environmental Satellite Service (NESS) of the National Oceanic and Atmospheric Administration (NOAA) had operational control of three polar-orbiting satellites: ESSA 8 and 9 of the older TIROS Operational Satellite (TOS) series, and NOAA 2 of the new Improved TOS (ITOS) series. ESSA 9 was deactivated on November 29, 1973. ITOS E, whose sensor complement was identical to NOAA 2, was launched on July 16, 1973, but failed to achieve orbit because of a hydraulic pump failure in the second stage of the launch vehicle. ITOS F, the backup satellite, was successfully launched on November 6, 1973, and named NOAA 3. NESS assumed control of NOAA 3 on November 29, 1973, following the NASA postlaunch systems checkout. NOAA 3 will become the operational satellite in 1974 and NOAA 2 will then serve as an "in-orbit" backup. Like its predecessor, NOAA 2, the satellite is equipped with radiometers that provide visible and infrared images of cloud cover, snow, and ice, and the sea surface, and gathers information on temperatures and moisture in the atmosphere. Another sensor provides data on the solar proton count and distribution in polar regions. A new feature introduced on NOAA 3, direct readout from the Vertical Temperature Profile Radiometer (VTPR), has evoked considerable international interest. Several foreign countries, including France and Norway, are receiving the VTPR direct transmissions. A VTPR workshop was held at NESS in July to familiarize representatives of European and South American environmental services with NOAA 2 VTPR products.

Vertical Temperature and Wind Profiles.—Approximately 1,000 vertical profiles of atmospheric temperatures are derived daily from VTPR data by NESS. These are transmitted to users worldwide via the Global Telecommunications System. These VTPR soundings have become a primary source of temperature information for the National Meteorological Center (NMC) upper-air analyses over Northern Hemisphere oceans. NMC is now testing a global analysis and forecast scheme which will rely almost entirely upon VTPR for data in the Southern Hemisphere. A preliminary test of the impact of VTPR data on NMC forecasts over North America showed some improvement in forecast skill. Research is underway to develop a four-dimensional data assimilation technique for direct use of satellite information in numerical forecast models.

The launch of NASA's Nimbus 5 in December 1972, provided data from three new sounding instruments: the Infrared Temperature Profile Radiometer (ITPR); the Selective Chopper Radiometer (SCR); and the Nimbus E Microwave Spectrometer (NEMS). The results of NESS studies using these sensor data have demonstrated the ability to determine the vertical thermal structure of the atmosphere at selected levels from the Earth's surface up to 50 kilometers through broken cloud or cloudless skies from infrared radiometer measurements and through dense clouds from microwave radiometer measurements. Indications are that temperature fields observed in the Northern Hemisphere by satellite instruments are markedly similar to those observed by radiosonde instruments. The satellite sounders can economically produce many more soundings per day than is possible with ground-released radiosondes. This is particularly advantageous over oceans and inaccessible land areas.

Cloud vector data, derived from the Applications Technology Satellite (ATS) 3, have been used to supplement high- and low-level winds obtained from balloon and rawinsonde observations. In meteorologically disturbed areas where multilevel clouds often preclude the tracking of low-level clouds, inferences about the nature and intensity of the disturbance frequently can be obtained from a pattern of high-cloud vectors.

Environmental Warning Services.—With the advent of the Geostationary Observational Environmental Satellite (GOES) system, expected to be in operation by the summer of 1974, the development and movement of destructive weather phenomena will be observed almost continuously. An important aspect of the GOES system is the regional service provided by the Satellite Field Services Stations (SFSS) already established at Washington, D.C., Miami, Kansas City, and San Francisco. These stations, established in preparation for GOES and currently utilizing ATS-3 data, will provide analysis and interpretation of near-continuous GOES imagery to regional centers for use in preparation of short range forecasts, advisories, and warnings of severe local disturbances such as thunderstorms, tornadoes, and gales and for tropical storms and large-scale mid-latitude storms.

Determining Ocean Conditions.—Following the 1972 launch of NOAA 2, research was renewed to develop improved methods for mapping global sea surface temperatures using the Scanning Radiometer (SR) and the Very High Resolution Radiometer (VHRR) data. Multiday compositing of the infrared SR data is combined with climatological information to produce glo-

bal sea-surface temperature charts.

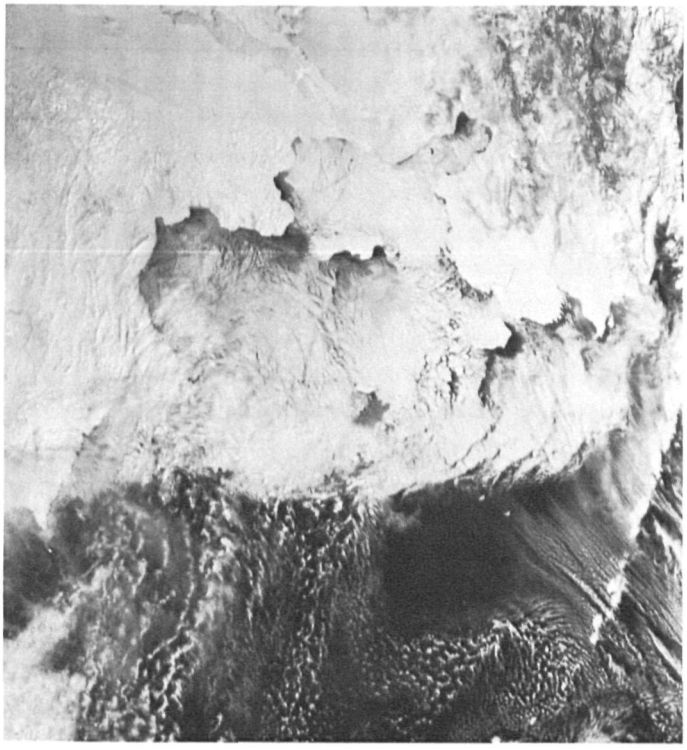
The VHRR data have been used extensively in detailed studies of temperature fields associated with phenomena such as the Gulf Stream, warm and cold eddies, coastal upwelling, and discharge of river water into the oceans. Experimental charts showing many of these thermal features of the sea surface in the Western Atlantic are derived routinely from analyses of VHRR imagery; these charts are transmitted experimentally to subscribers via the National Weather Service facsimile circuit. Response to this new satellite product from a diverse group of Government and non-Government users has been favorable. Using these data, NESS scientists have suggested that the satellite-observed cold water eddies that have broken away from the Gulf Stream may some day be used for ship routing purposes.

VHRR imagery has proved to be nearly ideal for sea-ice studies. Satellite observations of ice conditions in the Ross Sea and McMurdo Sound in Antarctica assist the U.S. Navy Fleet Weather Facility, Suitland, Md., in routing resupply ships. The Fleet Weather Facility, using VHRR and Earth Resources Technology Satellite (ERTS) imagery, prepared sea-ice and weather forecasts that were transmitted via the ATS 3 Weather Facsimile (WEFAX) to Jacques Cousteau's ship *Calypso* after it sustained ice damage in Antarctic waters.

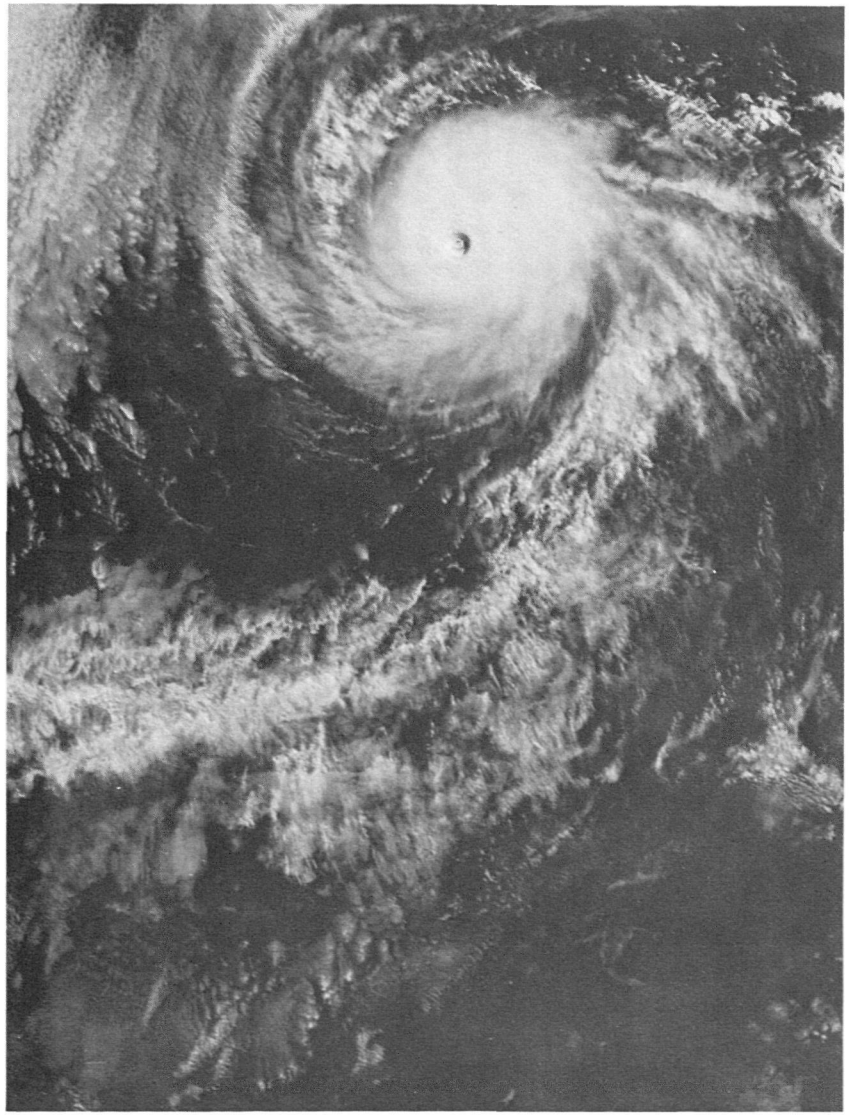
Ice Analysis charts based on VHRR satellite imagery were prepared for the Bering and Beaufort Seas and also transmitted experimentally via facsimile circuit to the Alaskan area. Such information was useful for routing ships for resupply of Arctic ports and for search and rescue, for supporting Coast Guard icebreaker activities and for scientific studies such as the Arctic Ice Dynamics Joint Experiment (AIDJEX).

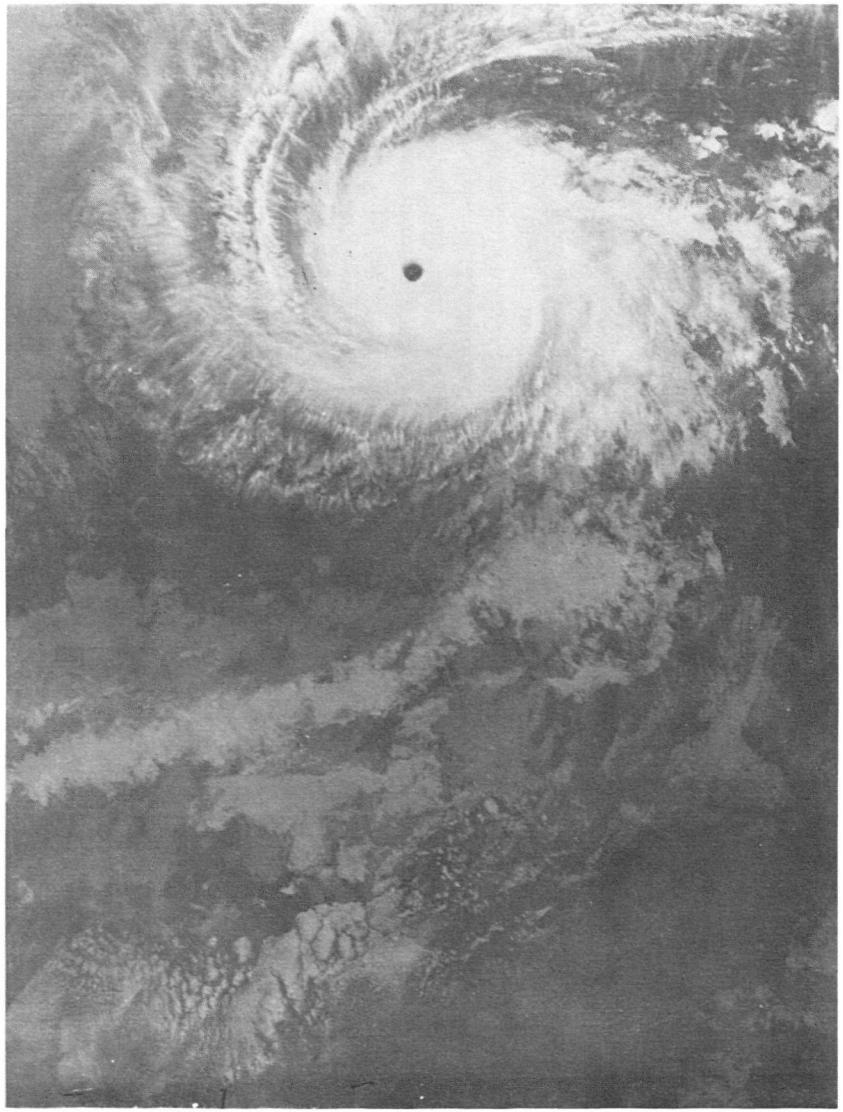
Determining Lake Conditions.—The VHRR and ERTS 1 imagery have also proved to be of considerable value in the International Field Year for the Great Lakes (IFYGL) and related Great Lakes studies. For example, spring warming processes, which occur in different stages in each lake, are clearly delineated in a time sequence of VHRR infrared images. Cloud-free VHRR observations, together with virtually simultaneous ERTS coverage of Lake Erie ice conditions, were obtained during freezeup, growth, and breakup stages. Furthermore, the added capability of near-infrared sensing on ERTS permitted detection of melt water on the ice surface. This type of information is useful for routing merchant ships and extending the navigation season on the Great Lakes.

Determining Hydrological Conditions.—Quantitative estimates of snow cover, in terms of percent of basin coverage, were derived from VHRR imagery, and snow maps were prepared for the American River,

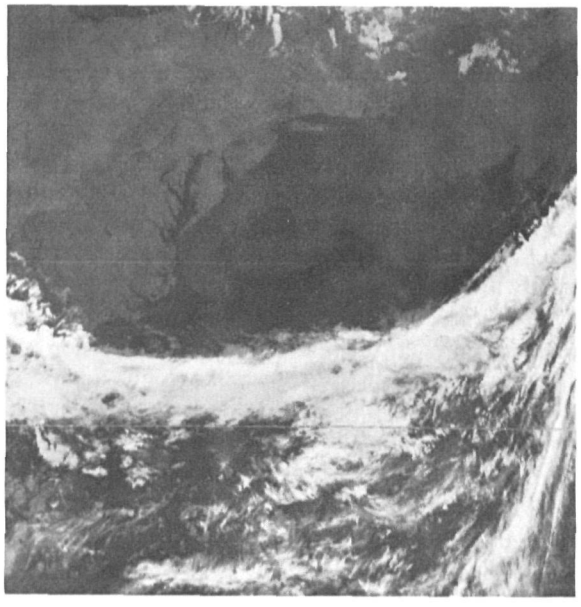


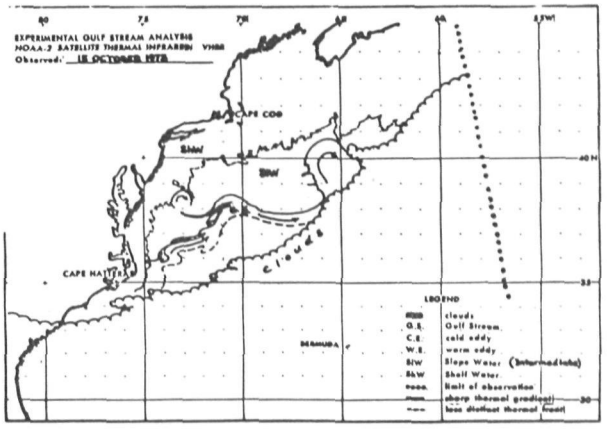
NOAA 2 VHRR visual image of ice conditions between Siberia (left) and Alaska (right) on April 1, 1973. Ice floes are especially evident in the Bering Sea and Norton Sound (center).





NOAA 2 VHRR visual (left) and infrared (right) images of Hurricane Ava in the eastern Pacific on June 7, 1973.





NOAA 2 VHRR infrared image (left) of the east coast of U.S. on October 14, 1973, showing variations in sea surface temperatures. On the right is a corresponding analysis of the oceanographic conditions.

Feather River, Upper Columbia River, Red River of the North, and Genesee River basins. These compared favorably with ERTS snow maps and showed a considerable cost improvement over more conventional high-altitude aircraft photography. Quantitative snow cover data needed for river and flood potential forecasts were sent to the appropriate River Forecast Centers within 36 hours after sufficiently cloud-free satellite images of each basin were received.

Estimating Rainfall.—NOAA's Environmental Data Service Center for Experiment Design and Data Analysis conducted a review of methods for estimating rainfall from satellite data. The primary purpose was to determine the usefulness of the methods for the GARP Atlantic Tropical Experiment (GATE). The methods include the use of cloud-top temperatures deduced from radiation measurements, visible image brightness, image area, and qualitative cloud-type identification from visible images. Ground-truth data have been obtained from various rain gage networks and radar records.

Pollution Monitoring.—A Marine Ecosystems Analysis (MESA) program pilot experiment using satellite data was carried out over the New York bight [1] area during April 1973. The principal aims of the MESA program are to develop a better understanding of the biological, chemical, geological, and physical properties of the area, to assess man's impact on the system, and to predict the consequences of current and future actions. The experiment, a cooperative effort of a number of Government agencies and private industry, involved the use of two satellites (NOAA 2 and ERTS 1), two helicopters, and supporting oceanographic vessels and equipment. Detailed photography, multispectral imagery, and ocean-surface data were acquired in a 500-square-mile area in the vicinity of Sandy Hook, N.J., and the west end of Long Island. The remote sensing experiment verified that strong physical and chemical features manifest themselves throughout the apex of the New York bight area. For example, ERTS imagery clearly showed large pollution areas such as acid and sewage dumps.

Weather Modifications.—Using NOAA 2 Satellite nighttime infrared imagery from the SR and VHRR sensors, data were provided to Niger describing the location and size of cloud formations. This information was used to support Niger's cloud seeding project which was part of an effort to alleviate that country's prolonged drought.

The Atmospheric Physics and Chemistry Laboratory

[1] Area covering Long Island, New York City, and New Jersey coastline out to a depth of 100 fathoms.

continued its experimental work in lightning suppression. Seeding thunderstorms from a B–26 aircraft with aluminum-coated nylon chaff significantly reduced electric fields in thunderstorms. Benefits derived from these studies were the reduction of lightning induced forest fires (about 70 percent of the world's forest fires are lightning caused), protection of exposed explosive stores, and the suppression of lightning at Kennedy Space Center during spacecraft launches.

Skylab Experiments.—In connection with the Skylab program, experiments were conducted for development of global wind and wave forecast models utilizing satellite-borne microwave sensors. Surface wind and wave data over test sites in the Pacific Ocean and Gulf of Mexico were collected concurrently from ships, aircraft, meteorological charts, and the Radiometer/Scatterometer sensor of the Skylab Earth Resources Experiment Package.

International Cooperation.—The United States and the Soviet Union completed the ninth year of environmental data exchange over the direct Washington-Moscow circuit. These data include visible and infrared cloud cover pictures from the U.S. NOAA 2 and 3 and the U.S.S.R. Meteor 12, 13, 14, and 15 Satellites.

The second and third coordination meetings on geostationary meteorological satellites were held in Zurich and Tokyo in January and October 1973, respectively. Representatives from the United States, Japan, and the European Space Research Organization participated. Observers from the Soviet Union attended both meetings. Among the subjects considered were determination of satellite locations, standardization of communication frequencies, data rates and formats, message codes, data collection, telecommunications, and uniformity of archival products.

Under the World Meteorological Organization (WMO) Voluntary Assistance Program, the National Weather Service (NWS) installed Automatic Picture Transmission ground stations in 17 countries and procured stations for installation in 4 others.

Fisheries.—Studies conducted by the NOAA National Marine Fisheries Service (NMFS) in cooperation with NASA and industry demonstrated the usefulness of remote sensing from satellites for improving fisheries research, management, and utilization. Image density levels from the ERTS 1 MultiSpectral Scanner were correlated with menhaden distribution patterns in the Mississippi Sound. The correlations were explained statistically using water transparency, color, salinity, and depth measurements. From these, regression models could be developed and used to predict areas of potential menhaden fishing success or failure in the study area.

The data acquisition phase of the Skylab Gamefish Experiment dealing with the North Central Gulf of Mexico was completed during the summer of 1973. Preliminary analysis of sea surface data collected by research and sportfishing vessels suggest that statistically significant correlations may exist between selected oceanographic parameters and the distribution and abundance of billfishes.

Environmental Monitoring Using Data Buoys.—The NOAA Data Buoy Office is adapting technology and improving environmental data buoys; these buoys are equipped with sensors to measure oceanic and atmospheric environmental parameters and are linked through telemetry to Earth satellites and shore stations. Four severe environment buoys were deployed for evaluation: two in the Gulf of Mexico, one off the U.S. mid-Atlantic coast, and one in the Gulf of Alaska. Although these buoys are experimental in nature, synoptic data were collected routinely for dissemination on the national environmental data networks for use in analysis and forecasting. Tests and evaluations were completed on six experimental polar applications buoys deployed as part of the initial phase of AIDJEX using Nimbus 4 satellite for data relay and position location. Tests and analyses are continuing on position location devices for drifting buoys which utilize the previously developed Omega and navigational satellite systems.

Other Satellite and Space Applications

Determination of the Earth's Shape and Gravity Field.—The Worldwide Geometric Satellite Triangulation program was completed and its results published. The system consists of a global network of 45 stations, whose relative configuration was determined by simultaneously photographing the PAGEOS satellite from various locations on the ground. The scale was determined by seven baselines established by direct ground measurements. The entire system was referred to the Earth's center of mass as origin by comparison with 37 stations whose positions were obtained by Doppler satellite measurements and tied to the geometric network by ground surveys. The Earth's gravitational field was determined by using satellite orbital data and ground gravity measurements, using as a constraint the relative

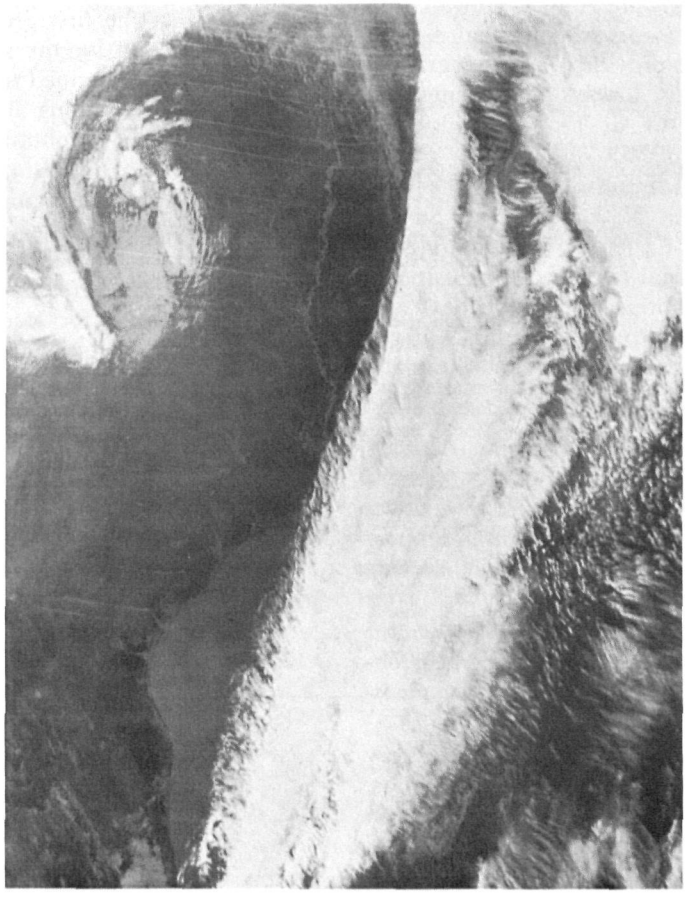
configuration of 17 of the Doppler observing stations. This program increases the density of stations on the North American Continent.

Skylab and ERTS Support.—Other NOAA support to the Skylab and ERTS programs included National Weather Service forecasts of cloud cover for use in scheduling Earth sensing experiments from Skylab, supporting aircraft, and ERTS–1. In addition, forecasts were made for Skylab launchings and recovery areas.

The NOAA Space Environment Laboratory provided continuous observations and forecasts of phenomena on the sun for daily planning of observations by Skylab astronauts with the Apollo Telescope Mount (ATM) experiment. The specialized needs of the ATM program were satisfied by a network of globally dispersed solar observations and by real-time data from ITOS satellites.

Ionospheric Physics.—NOAA's Aeronomy Laboratory, in collaboration with the Institut de Physique du Globe, Paris, made radar observations of electron irregularities in the equatorial electrojet from two sites in Chad, Africa, during the June 30, 1973, solar eclipse. The purpose was to observe the effects of the reduced electron densities during the eclipse on the distribution of irregularities and electrical currents in the electrojet. These observations will contribute toward the development of a better model of the electrojet, which can be an important medium of communication in equatorial countries.

NOAA's Aeronomy Laboratory has discovered that ground-based measurements of twilight emission from molecular oxygen can be used to observe both ozone densities and atmospheric temperatures at altitudes of 80 to 120 kilometers. These emissions in the night-glow yield mesospheric temperatures that show major fluctuations at midlatitudes for several days after auroral-zone geomagnetic activity. NOAA's Air Resources Laboratories are studying coincident stratospheric ozone and water vapor data to determine possible relationship between these constitutents. The Laboratories also are studying data from the NASA Backscatter Ultraviolet (BUV) instrument to provide a benchmark of global total ozone amount (2–3 year



NOAA 2 VHRR infrared image showing flooding along the Mississippi River (upper center) on April 1, 1973. A cold front (right side) is oriented in a north-south direction.

data record) for comparison with future data, and also to determine if any impact on increased oxides of nitrogen (NO_x) is observable in the data obtained near the time of several recent nuclear detonations. Results of these studies also should be useful for assessing the impact of supersonic aircraft on the environment.

Aeronautical Programs

Use of Remote Sensing to Study Coastal Processes.—Airborne and spacecraft remote sensors are being evaluated for use in studying and monitoring coastal processes and estuarine dynamics, and in cartography. A photographic and thermal remote sensing survey was conducted in Boston Harbor to investigate circulatory patterns and to develop new remote sensing techniques for water quality studies. The circulatory survey will provide additional data for charting tidal currents; the data also will be included in the Tidal Current Tables published by the National Ocean Survey.

Aeronautical Charts.—Two new Controller Chart Supplements have been prepared for the Federal Aviation Administration and updated on prescribed revision cycles. The supplements are Alaska, Hawaii, and Puerto Rico Airways and Standard Terminal Arrival Routes. These supplements provide precise geographic position information along airways and routes not otherwise readily available to Air Traffic Facility personnel for the management and control of air traffic.

The Federal Aviation Administration, the Defense Mapping Agency, and the National Ocean Survey agreed on the production of a joint civil/military issue of combined Alaska Terminal (Airport) publications. The publication will be produced every 56 days and will include Instrument Approach Precedure Charts, Standard Instrument Departure Charts, and Standard Terminal Arrival Routes.

Support to Environmental Programs.—Aircraft equipped with remote sensors designed to measure water equivalent of snow and soil moisture were flown on field surveys over the Lake Ontario basin in support of the IFYGL. During the winter of 1972–73, surveys were flown along 28 selected ground tracks; water equivalent of snow was computed for each mile segment of track flown. Ground surveys provided corroborating information for evaluating soil moisture measurements obtained by remote sensing.

The NOAA National Severe Storms Laboratory conducted experiments, utilizing dual Doppler radars, to obtain information on the processes that occur in and around severe storms such as thunderstorms and tornadoes. Among the parameters explored were turbulence, winds, and wind shear. Also investigated were possibilities for using Doppler radar to detect signs of severe weather development.

The Aeronomy Laboratory has developed a radar technique for detecting flying birds hazardous to aircraft near airport runways. The technique uses the distinctive Doppler radar spectrum arising from the moving wings of the birds to distinguish the size and species of the birds observed.

Environmental Data Programs

The National Geophysical and Solar-Terrestrial Data Center, (NGSDC), of NOAA's Environmental Data Service (EDS), in its capacity as World Data Center A for Solar-Terrestrial Physics, is collecting reports of the times and nature of solar observations made by ground-based observatories, rockets, and satellites that coincide with Skylab solar observations. Global scientists are interpreting Skylab observations by comparing them with the many different types of ground-based observations made during the same time periods. NGSDC has already produced a preliminary data catalog covering the period May 28 through June 21, 1973, when the first group of Skylab astronauts were on duty, and for the intervening period before the second Skylab manned mission began, when some experiments were running automatically.

Data users can now obtain from NGSDC 35-millimeter film copies of auroral photographs taken by U.S. Air Force DAPP (Data Acquisition and Processing Program) satellites. The auroral phenomena are photographed on the dark side of the Earth by these satellites. The ground features that appear in the photographs are useful for locating the position of the aurora with respect to the ground.

U.S. Applications Satellites 1958–1973

Date	Name	Launch vehicle	Remarks
		WEATHER OBSERVATION	
Apr. 1, 1960	Tiros I	Thor-Able	First weather satellite providing cloud-cover photography.
Nov. 23, 1960	Tiros II	Thor-Delta	
July 12, 1961	Tiros III	Thor-Delta	
Feb. 8, 1962	Tiros IV	Thor-Delta	
June 19, 1962	Tiros V	Thor-Delta	
Sept. 18, 1962	Tiros VI	Thor-Delta	
June 19, 1963	Tiros VII	Thor-Delta	
Dec. 21, 1963	Tiros VIII	Thor-Delta	First weather satellite designed to transmit continuously local cloud conditions to ground stations equipped with APT receivers.
Aug. 28, 1964	Nimbus I	Thor-Agena B	Carried advanced videcon camera system, APT, and a high resolution infrared radiometer for night pictures.
Jan. 22, 1965	Tiros IX	Thor-Delta	First weather satellite in a sun-synchronous orbit.
July 2, 1965	Tiros X	Thor-Delta	
Feb. 3, 1966	ESSA 1	Thor-Delta	First operational weather satellite; carried 2 wide-angle TV camera systems.
Feb. 28, 1966	ESSA 2	Thor-Delta	Complemented ESSA 1 with 2 wide-angle APT cameras.
May 15, 1966	Nimbus II	Thor-Agena B	
Oct. 2, 1966	ESSA 3	Thor-Delta	Odd-number ESSA spacecraft carry 2 advanced videcon camera systems. Even-numbered spacraft carry 2 automatic picture transmission camera systems.
Dec. 6, 1966	ATS-1	Atlas-Agena D	Provided continuous black-and-white cloud-cover pictures from a synchronous orbit, using a Suomi camera system.
Jan. 26, 1967	ESSA 4	Thor-Delta	
Apr. 20, 1967	ESSA 5	Thor-Delta	
Nov. 5, 1967	ATS-3	Atlas-Agena	Provided continuous color cloud-cover pictures from a synchronous orbit, using 3 Suomi camera systems.
Nov. 10, 1967	ESSA 6	Thor-Delta	
Aug. 16, 1968	ESSA 7	Thor-Delta	
Dec. 15, 1968	ESSA 8	Thor-Delta	
Feb. 26, 1969	ESSA 9	Thor-Delta	
Apr. 14, 1969	Nimbus III	Thor-Agena	Provided first vertical temperature profile on a global basis of the atmosphere from the spacecraft to the Earth's surface.
Jan. 23, 1970	ITOS I (Tiros M)	Thor-Delta	Second generation operational meteorological satellite.
Apr. 8, 1970	Nimbus IV	Thor-Agena	Fifth in a series of 7 advanced research and development weather satellites.
Dec. 11, 1970	NOAA-1 (ITOS-A)	Thor-Delta	Second generation operational meteorological satellite.
Aug. 16, 1971	Eole (CAS-1)	Scout	French satellite to gather data from constant density surface ballons relaying meterological data for the study of the characteristics and movements of air masses. New balloons are released daily from 3 sites in Argentian, for this cooperative French/United States project.
Oct. 15, 1972	NOAA-2 (ITOS D)	Thor-Delta	Second generation operational meteorological satellite.
Dec. 11, 1972	Nimbus V	Thor-Delta	Provided the first atmospheric vertical temperature profile measurements through clouds.
Nov. 6, 1973	NOAA-3 (ITOS F)	Thor-Delta	
		EARTH OBSERVATION	
July 23, 1972	ERTS-1	Thor-Delta	Acquired synoptic multi-spectral repetitive images that are proving useful in such disciplines as agriculture and forestry resources, mineral and land resources, land use, water resources, marine resources, mapping and charting, and the environment.