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Satellite Activities of NOAA 1972.

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

compiled by
U.S. NATIONAL ENVIRONMENTAL SATELLITE SERVICE

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National Oceanic and Atmospheric Administration
TIROS Satellites and Satellite Meteorology

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Satellite Activities of NOAA 1972*

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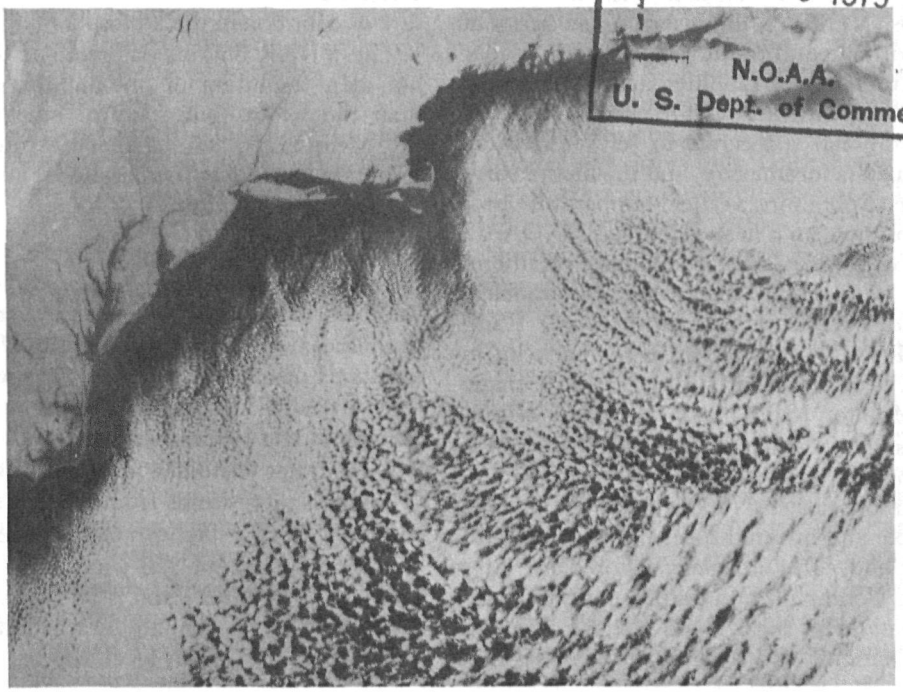

This NOAA 2 very high resolution radiometer infrared image of the U.S. east coast on December 18, 1972, shows clouds formed in cold air flowing across warmer ocean water.

National Oceanic and Atmospheric Administration

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, March 1973.

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Environmental Satellite Operations.—A major improvement in the national operational environmental satellite system occurred October 15 with the launch of the NOAA 2 spacecraft. NOAA 2, commanded and controlled by the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Satellite Service (NESS), is the first in a new series of operational environmental satellites. Although similar in appearance to previous satellites in the Improved TIROS Operational Satellite (ITOS) series, NOAA 2 is the first operational spacecraft to rely entirely on scanning radiometers for imagery, and the first to carry a sensor capable of obtaining vertical temperature profiles of the atmosphere on a near-global basis. NOAA 2 carries two sets of primary sensors: Scanning Radiometers (SR's), Very High Resolution Radiometers (VHRR's), and Vertical Temperature Profile Radiometers (VTPR's); the second set is for back up in case of failure. The spacecraft also carries a single Solar Proton Monitor (SPM) as a secondary sensor.

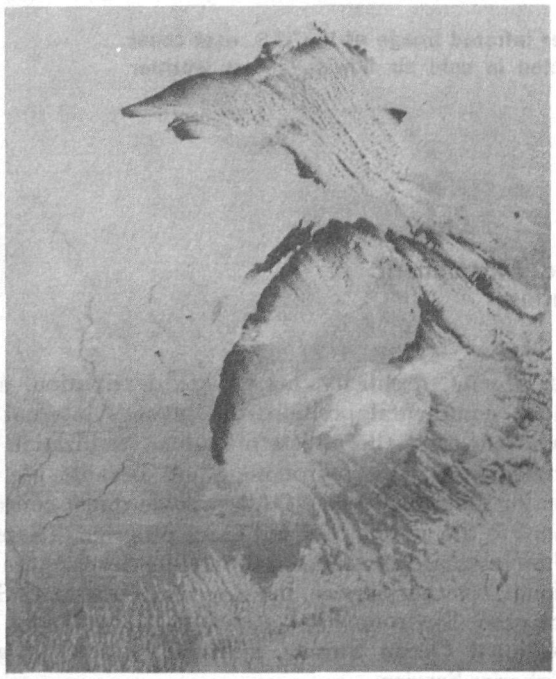
The SR subsystem, which replaces the Automatic Picture Transmission and Advanced Vidicon Camera Systems carried by earlier NOAA satellites, gathers data in the visible and infrared spectrum both day and night. Global cloud cover imagery is stored for later readout to U.S. Command and Data Acquisition stations; direct readout of local cloud cover imagery is available to all nations.

The operational VTPR is a major step toward obtaining the quantitative global measurements needed for numerical weather forecasting. The VTPR measures infrared energy radiated from six levels of the atmosphere and from the Earth's surface or cloud tops. These data are used to calculate the vertical temperature distribution in the atmosphere.

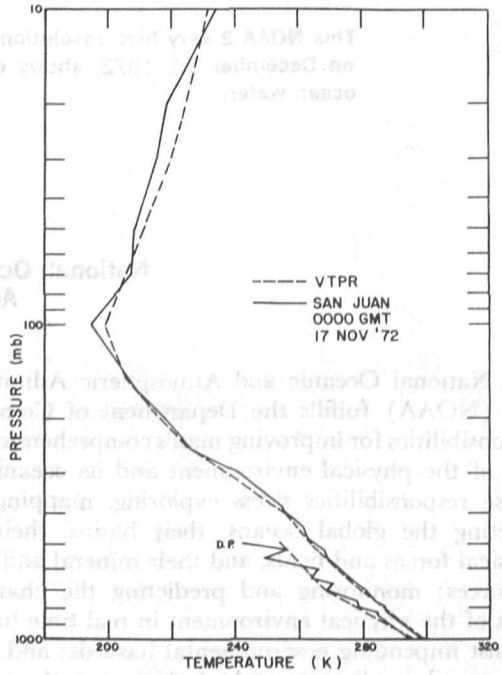
The VHRR obtains data similar to that of the SR but at a resolution of one-half nautical mile rather than the two-to-four nautical mile resolution of the SR. Measurements from these instruments can be used to obtain cloud top temperatures, and, in clear areas, sea surface temperatures.

Development and Application of Environmental Satellite Technology.—An improved technique for analysis of tropical cyclone intensities from satellite pictures was developed and used by the NESS in 1972. Its use resulted in better tracking and forecasting of hurricanes and lesser intensity storms.

A computer technique for the derivation of low-level (1.5 kilometers) winds from Applications Technology Satellite (ATS) pictures, was developed and used operationally. About 250 winds were computed daily, 125 each from ATS 1 and ATS 3 pictures. After October, ATS 1 picture capability was lost. Approximately 80 winds at the 10Km level also are derived daily by



NOAA 2 VHRR infrared image of the Great Lakes on December 7, 1972. St. Louis, Mo., is in the lower left corner; the Missisippi and Illinois Rivers extend northward from St. Louis.



Comparison between 0054GMT VTPR sounding from NOAA 2 at 20.3°N 65.6°W and 0000GMT radiosonde sounding at San Juan, P. R., November 17, 1972

manual techniques. All wind information derived from satellite pictures is used operationally by the National Meteorological Center.

Wind data derived from ATS pictures have been important in the derivation of a 4-year circulation climatology of the tropics. This climatology has revealed details of long-period mean circulations in large areas of the tropics where data were not previously available. Sun reflection patterns visible in ATS photographs were used to detect the areal extent of a localized wind and wave pattern affecting shipping along the west coast of Mexico and Central America.

Real-time use of the ATS 1 and 3 cloud cover photographs continued at the National Weather Service's National Severe Storms Forecast Center, the National Hurricane Center, and the National Meteorological Center. Real-time service was extended to the San Francisco Weather Forecast Office but was terminated in October following the loss of ATS 1 picture capability.

NESS has made preparations to obtain vertical temperature profiles in the atmosphere using information expected from new instrumentation on NASA's Nimbus E satellite. Global data from Nimbus E and NOAA 2 will be used to test and improve numerical weather predication models. NESS is developing a sophisticated Earth Radiation Budget (ERB) radiometer for test on Nimbus E. The ERB will provide accurate long-term measurements of radiation-induced heating or cooling of the Earth's surface and atmosphere both synoptically and globally. These measurements will provide bench mark data that should permit diagnosis of future climatic change from satellite radiation observations.

Detection and tracking of large eddies of cool water that break off from loop patterns of the Gulf Stream was resumed following launch of the NOAA 2 satellite. The eddies, representing enormous pools of stored energy, have been detected in the VHRR visible and infrared imagery.

NESS studies of satellite infrared and visible imagery of the Beaufort Sea show the characteristic seasonal changes in ice cover. These changes range from long north-south leads in spring, to giant floes in early summer, and finally to increasingly smaller floes at the autumn freeze-up. Some ice areas appear significantly warmer than others, thus suggesting consistently thinner ice in those areas. In spring, the 24-hr range of temperature was significantly larger for areas with high ice concentration than for areas with low concentrations of thin ice. Other studies demonstrated the use of satellite infrared imagery for ice mapping during the polar night.

Preliminary NESS studies show that imagery from the Earth Resources Technology Satellite (ERTS) is valuable in certain oceanographic research. Circulation patterns are revealed by sediment distributions in coastal areas; shore-line details, shoals, and shallow water bathymetry are delineated by light penetration into shoal water. Delineation is limited only by the degree to which light from the several spectral bands available on ERTS can penetrate the water surfaces. ERTS data confirmed an earlier finding that melting ice could be detected by noting the difference in near infrared and visible reflectance measurements. Atlantic Oceanographic and Meteorological Laboratory (AOML) scientists have found ERTS imagery useful for detecting acid wastes outside of designated dumping areas off New York harbor. AOML and NASA are working together to obtain sub-orbital path, ground-truth oceanographic data to evaluate the ERTS observations; the data are being gathered by AOML research ships.

Other studies of satellite remote-sensing capabilities have identified the potential for measuring chlorophyll and ocean color from space, and improved methods and materials for studying coastal and estuarine circulations by dye dispersal and tracing.

Hydrologic studies conducted by NESS demonstrated the usefulness of satellite thermal infrared imagery in mapping the extent of snow cover, particularly in flat terrain. Snow covered areas have radiation temperatures 5 to 10° Celsius lower than the surrounding snow free areas.

NOAA's Weather Modification Program Office is correlating visible and infrared satellite imagery with quantitative radar measurements of precipitation. Preliminary results for the tropics suggest that the brightest and coldest cloud masses viewed from the satellite are the regions of active precipitation. When correlation and calibration are completed, it will be possible to use the satellite-rainfall relationship to make more accurate estimates of rainfall in remote regions than is now possible.

A little know facet of the space program is the full range of weather forecasting and observing services required. During the past year the National Weather Service provided:

Forecasts and briefings for the Apollo 16 and 17 missions.

Daily forecasts of cloud cover along the global ERTS track to assist in determining where useful observations could be obtained.

Almost daily weather forecasts for aircraft in the NASA Earth Resources Aircraft Program.

Meteorological support to the NAVY Pacific Missile Range stations at San Nicolas Island, Calif., and Barking Sands, Hawaii, and to the Army Missile Range on Kwajalein Island.

The National Marine Fisheries Service (NMFS) investigated application of remote sensing technology to improving fisheries research and management. With NASA cooperation, NMFS acquired aircraft and ERTS earth resources data to show correlations between remotely sensed environmental parameters and living resources. NMFS and NOAA's Environmental Research Laboratories conducted other experiments to evaluate the usefulness of ERTS data for detecting currents around islands. The Fisheries Service and the U.S. Coast Guard used data from Airborne Radiation Thermometer flights in determining currents and temperature structure along U.S. coastal areas.

Environmental satellite data are incorporated in weather forecasts and charts of sea surface temperatures routinely transmitted to the U.S. tuna fleet in the tropical eastern Pacific. In return, the fleet sends the Fisheries Service detailed oceanographic and meteorological reports for fishery prediction projects. NMFS receives much of their environmental data via the Automatic Picture Transmission system, and prediction products are prepared in cooperation with the National Weather Service.

The prototype hardware for the National Data Buoy Project (NDBP) was delivered for test and evaluation. This hardware included two experimental buoys (one now deployed in the Gulf of Alaska, the other in the Gulf of Mexico); position location devices for drifting buoys (using Omega and navigation satellite systems); drifting, moored, and deep keel hull buoys; and experimental polar application buoys which use the Nimbus IV satellite for data relay and position location.

International Cooperation.—Direct exchange of environmental satellite data continued between the United States and the U.S.S.R. over the direct Washington-Moscow circuit. The data exchanged included television and infrared photographs of cloud cover and analyses of meteorological information. Data flow in both directions has been uninterrupted except during short-period circuit outages. The U.S.S.R. discontinued transmission of television photographs in March but resumed on a sporadic basis in July. At the close of the year the exchange consisted of data from the U.S. NOAA 2 and the U.S.S.R. Meteor 10, 11, 12, and 13 satellites. The Meteor satellites have an experimental direct readout capability similar to the U.S. Automatic Picture Transmission system. However, this is only available over U.S.S.R. territory.

Under the World Meteorological Organization Voluntary Assistance Program, NOAA's National Weather Service completed installation of Automatic Picture Transmission ground stations in three countries and procured stations for installation in four others. Bilingual NWS and NESS instructors conducted classes and training seminars in satellite picture interpretation in six Central and South American countries.

Representatives of the United States, the European Space Research Organization (ESRO), Japan, and observers from the World Meteorological Organization met in Washington in September to discuss coordination of efforts for establishing geostationary environmental satellite systems. Two ad-hoc working groups were established to study engineering aspects and user requirements.

Satellite ground stations in over 100 countries and trust territories around the world continued to receive spacecraft imagery by direct readout from polar-orbiting Automatic Picture Transmission satellites and by relay through the geostationary ATS satellites.

Geometric Satellite Triangulation.—Data processing and analysis for the Worldwide Geometric Satellite Triangulation Program was completed. Geometric data are being used, independently and in combination with Doppler data, to determine a world ellipsoid of best fit to the geoid.

The National Ocean Survey (NOS) cooperated with the Department of Defense in satellite positioning experiments using the Doppler method. In cooperation with NASA, NOS studied the magnitude of gravity gradients that would be sensed by a satellite-borne gravity gradiometer.

Solar Physics.—The NOAA Environmental Research Laboratories' Space Environment Laboratory (SEL) provided solar-observing and forecasting services for NASA and other government agencies. Foremost among these was the operation of the Solar Proton Alert Network (SPAN), which consists of four stations spaced around the world to permit continuous solar observations. Solar disturbances are forecast and monitored as part of the environmental warning service provided to programs such as the Apollo 16 and 17 missions. The SPAN had an intense period of activity

in August 1972 during the occurrence of the largest solar flare events of the current solar cycle. Geophysical effects of these flares were felt as disturbances in ground power distribution systems, in long-distance communications lines, and in high frequency and very high frequency radio propagation.

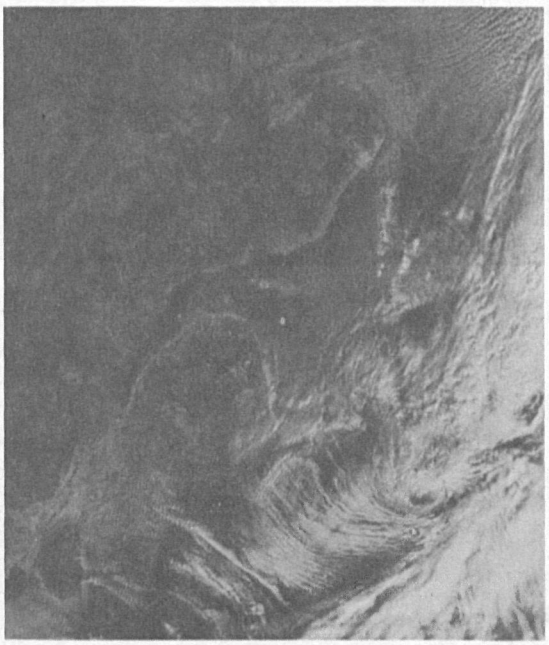
Studies of the magnetic field configuration of the solar disk and active solar regions resulted in successful tracing of the solar proton streams to the solar disk. These studies were done using interpretative analysis of hydrogen-alpha photographs correlated with observed solar proton streams near Earth.

Upper Atmosphere Physics.—NASA's Small Scientific Satellite, for which NOAA's Space Environment Laboratory provided instrumentation, has obtained a variety of data on the magnetosphere. Among these were the first observations of the equatorial pitch-angle distribution of alpha particles and heavy ions. These data should provide a unique clue to the source of particles found in the Earth's near-space environment. Observations by this satellite of the evolution of plasma instabilities in the magnetosphere proton population provide a unique insight as to how such instabilities may evolve in a naturally occurring geophysical plasma.

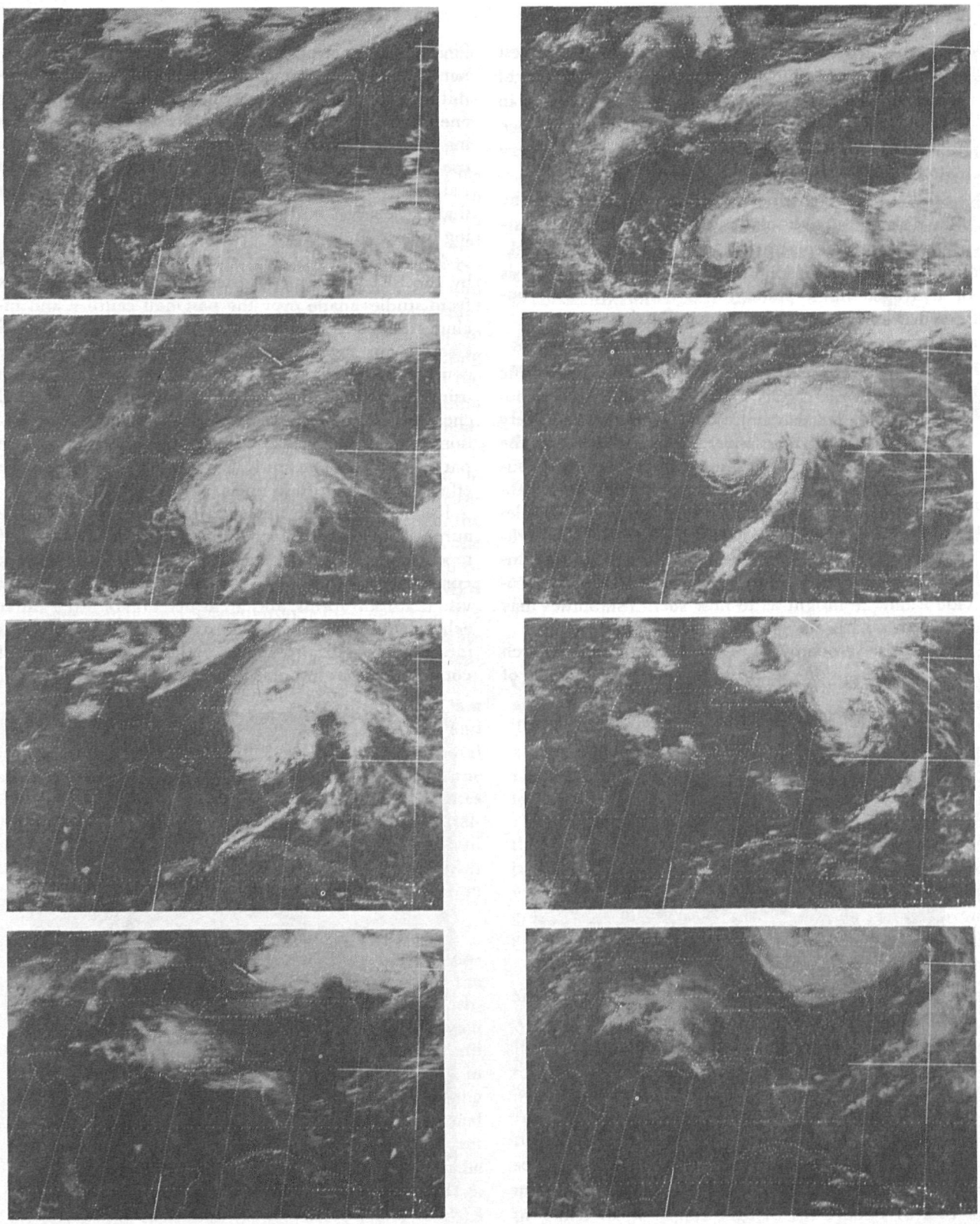
NOAA's Aeronomy Laboratory continued research on optical emissions sensitive to abnormal heating of ionospheric electrons produced naturally during magnetic storms and artificially by a high-powered transmitter. The data obtained will clarify the source of the energy and the basic collision processes that occur during heating. High-powered radio transmitters also were used to produce artificial irregularities similar to the natural irregularities of equatorial and auroral regions that cause severe perturbations to communications relying on satellite relay.

A global model of the ionosphere is being produced by the SEL. The model incorporates useful features from studies made over the past half century and includes data on atmospheric densities, solar flux, and electron and ion densities. The Aeronomy Laboratory continued investigations of D-region ion composition using numerical modeling and laboratory controlled chemical reaction rates. Emphasis was on the composition changes likely to occur during periods of intense particle influx. The study has a direct bearing on the effects of high-altitude nuclear explosions.

Radar studies of the small-scale structure of the auroral ionosphere were made during periods of moderate geomagnetic activity. The studies show a correlation between some radar echoes and the edges of visual auroral forms, and an association of other radar echoes with the auroral electrojet current system. This information will provide a better understanding of communications in polar regions.



Very high resolution NOAA 2 visual (left) and infrared (right) images of northeastern United States and eastern Canada, December 11, 1972.



Eight ATS 3 views of Hurricane Agnes. Reading left to right from the top the photographs are for June 15 through June 22, 1972.

Aeronautical Programs

Aeronautical Charts.—Evaluation of remote sensors for use in cartography was begun by the NOS. Emphasis was on small-scale aeronautical charts for use under visual flight rules. Two new series of charts were issued. One depicts the Standard Terminal Arrival Route (STAR) procedures, previously published in textual form in the Airman's Information Manual (AIM); the other, Airport Taxi Charts (published for selected airports), provides details on items such as airport buildings, service areas, runways, and taxi ramps.

The World Aeronautical Chart series covering the contiguous United States and Alaska was completed. These charts meet the Inter-Agency Air Cartographic Committee specifications for common use by civil and military aviation.

Support to Environmental Programs.—Techniques for obtaining measurements of the water equivalent of snow by remote sensing from aircraft have been developed and refined over the past three years. Operational testing of the technique in suport of flood forecasting was initiated in the north-central plains region and around Lake Ontario, the latter in support of the International Field Year of the Great Lakes.

The National Severe Storms Laboratory has conducted studies to improve aircraft flight safety in the vicinity of thunderstorms. As part of this program, a dual-Doppler radar network is being constructed to map the horizontal wind within thunderstorms. Direct observations of thunderstorm turbulence obtained by aircraft have been correlated with measurements made indirectly by Doppler radar. Satellite data are used in these studies to correlate radar echoes and weather characteristics, to identify cloud and storm systems in their incipient phases, and to estimate the role of meteorological parameters in storm development.

The National Weather Service continued to provide a wide variety of services essential to safe and efficient aircraft operations. Observations, forecasts, warnings, pilot briefings, and in-flight advisory services were provided to domestc and international aviation interests.

Environmental Data Programs

NOAA's Environmental Data Service, (EDS) working with the National Environmental Satellite Service, established a program to provide NASA earth resources data to users. Photographic products acquired by NASA from airborne and spaceborne platforms in the NASA Earth Resources Survey Program are available for purchase through the EDS National Climatic Center (NCC), Asheville, N.C. As part of this effort the NESS established an Earth Resources Survey (ERS) Data Center at Suitland, Md. The ERS Data Center has distributed more than 7,000 photographic products to government and non-government scientific investigators since the launch of ERTS I on July 23. EDS coordinated the establishment of earth resources imagery "browse files" for local users at 22 NOAA locations throughout the United States.

High altitude meteorological data received from cooperating foreign countries, the Meteorological Rocket Network, and the Inter-American Meteorological Rocket Network were processed and published. Data for March 1970 through March 1971 were published in the *High Altitude Meteorological Data* series.

Monitoring-type solar-terrestrial data recorded by satellites and space probes are archived by the National Geophysical and Solar-Terrestrial Data Center (NGSDC). NGSDC is the primary sources for the ionograms taken by the topside ionosonde satellites. Solar parameters (protons, X-rays, and solar wind) measured by satellites and space probes are published monthly in *Solar-Geophysical Data*—a primary reference for the international scientific and technical community. During 1972, new data on interplanetary electric- and magnetic-field measurements obtained by the PIONEER space probes were added. Similar monitoring-type solar-terrestrial data recorded by satellites and space probes are included in the Special Data Compilations in the World Data Center A for Solar-Terrestrial Physics UAG-Report series.

During 1972, the National Oceanographic Data Center continued to process aircraft expendable bathythermograms, and prepared to assess sea surface temperature data remotely sensed by aircraft and satellites.

Climatological applicatons of meteorological satellite data were explored by the Laboratory for Environmental Data Research. Monthly cloud cover amounts were estimated from meteorological satellite data for tropical areas of the Pacific and Atlantic Oceans. Long period variations in cloud amount in these ocean areas, and interocean cloud cover variations, are being studied because the amount of cloud cover is closely related to characteristics of the general atmospheric circulation.

U.S. Applications Satellites 1958–1972

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 I 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 spacecraft 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	Thora-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 meteorological data for the study of the characteristics and movements of air masses. New balloons are released daily from three sites in Argentian, for this cooperative French/U.S. project.
Oct. 15, 1972	NOAA 2 (ITOS D)	Thor-Delta	Second generation operational meteorological satellite.