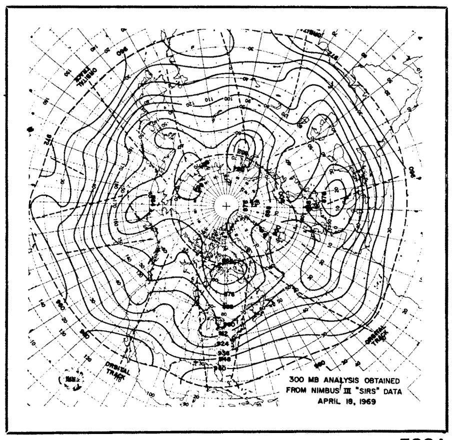
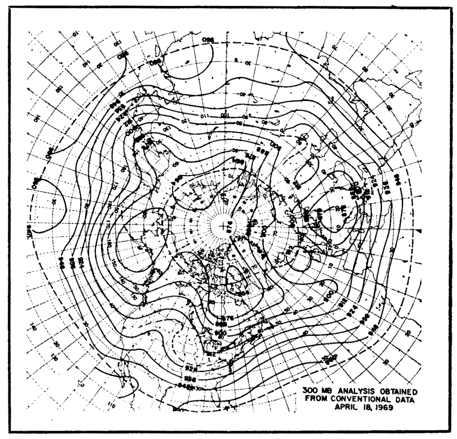
METEOROLOGY

Sounding from above

First space measurements of temperatures in the atmosphere herald a new era in global monitoring

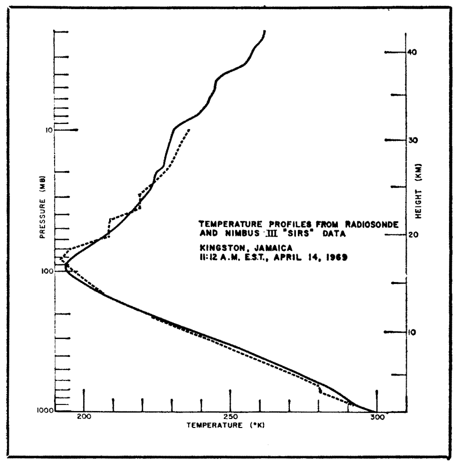
by Kendrick Frazier





ESSA

Circulation map from Nimbus (above, left) shows patterns not present in standard map; temperature readings (right) matched dotted-line radiosonde readings closely.



In the predawn hours of April 14, a satellite known as Nimbus III was launched into a near-circular, 690-mile polar orbit, and a new era in satellite meteorology began. Quietly and with little fanfare, a data gap was closed and the essential element of a prototype global atmospheric monitoring system needed for improvements in weather prediction (SN: 9/6, p. 185) was in operation.

What this 1,270-pound satellite carried that has continued to excite meteorologists in the following weeks and months were two devices—a satellite infrared spectrometer (SIRS) and an infrared interferometer spectrometer (IRIS). On their success hung new means of measuring temperatures within the atmosphere.

All previous meteorological satellites had been little more than spaceborne camera platforms. Their function was to take, and transmit to earth, photographs of the cloud cover beneath them. This itself was a significant advance; today up-to-the-minute weather satellite cloud photographs are used routinely in forecasts around the world.

But only a limited amount of information about atmospheric conditions can be inferred from cloud photographs. Meteorologists have long recognized the need for measurements of the conditions deep within the atmosphere, at a variety of altitudes, over the 80 percent of the earth's surface not now adequately monitored.

The two new infrared instruments aboard the Nimbus III show that such measurements can be made. They are experimental devices. Use of remote probers in operational satellites is still a few years off.

Looking down vertically into the atmosphere, Nimbus's SIRS sensor observes the infrared absorption bands of carbon dioxide. These observations, taken every 8 seconds, are used to calculate temperatures. By observing at weaker and weaker absorption bands, it can sense temperature at levels deeper and deeper in the atmosphere. The information can also be used to derive data on pressures at different heights. The Nimbus IRIS sensor, using a somewhat different technique, analyzes the absorption bands of carbon dioxide, water vapor and ozone to obtain vertical distributions of temperature, water vapor and ozone.

Only hours after the April 14 launch, at 11:12 a.m. over Kingston, Jamaica, Nimbus III made the historic first vertical sounding of the atmosphere from space. Its readings were matched against those of a conventional radiosonde carried aloft by balloon over Jamaica at the same time as a check. The correlation was remarkable: The SIRS readings closely coincided with the radiosonde's measurements. Other comparative soundings throughout the summer and fall have been similarly successful.

Tests of the readings derived from the IRIS also have yielded high-quality results for temperature, humidity and ozone. Remote sensing of the atmosphere from earth orbit is now a reality: a major meteorological advance.

"It is a very exciting development," says Dr. Frederick G. Shuman, director of the Environmental Science Services Administration's National Meteorological Center, of the SIRS. "The instrument has proven to be able to remotely sense the temperature of the atmosphere with uncanny accuracy."

"Even the greatest doubters have been convinced that these results are absolutely fabulous," says Dr. Verner E. Suomi of the the University of Wisconsin. "We have the beginnings of a global monitoring system."

Whole areas of the earth inaccessible to frequent conventional measurements are now open to regular monitoring. Nimbus's SIRS has already produced maps of temperature and pressure variations above the entire Antarctic continent. The few places where observations above the southern ice cap have been made by radiosondes have verified the accuracy of the satellite-derived maps. Using the information, ESSA meteorologists have developed a method to infer the atmosphere's daily circulation in the Southern Hemisphere.

A recent ESSA Weather Bureau experiment found that data the SIRS gathered led to a better forecast of conditions at about 18,000 feet—the 500-millibar level where many other measurements are available for comparison—than did the data acquired by conventional means.

In a one-day prediction, June 24, the SIRS produced a better forecast of

. . . Nimbus III

an intensifying trough of low pressure off the northwest coast of the United States. A day later, the SIRS forecast predicted the development of a separate area of low pressure off the coast; the forecast from conventional data did not even include the low. A three-day forecast derived from the SIRS readings closely resembled conditions as they occurred. It predicted a double-low over the United States that was not forecast by conventional data.

The experiment, says ESSA, suggests that a relatively small improvement in the analysis over the Pacific Ocean can produce a large improvement in long-range prediction.

Although Nimbus III is an experimental satellite only, the Weather Bureau since late May has been using some of the SIRS data in compiling one type of daily hemispheric weather analysis, prepared 12 hours after the readings are obtained and used mainly for later documentation purposes. But the success of that effort led to plans to incorporate the soundings into the two major operational analyses of Northern Hemisphere weather, prepared daily by computers at ESSA's National Meterological Center in Suitland, Md.

This was to be started on Oct. 21, but computer problems and some difficulties in installing a special computer-to-computer link between Suitland and the Goddard Space Flight Center of the National Aeronautics and Space Administration in Greenbelt, Md., caused a 10-day delay.

But the problems were solved. On Oct. 31, SIRS soundings of weather conditions over the eastern Atlantic and most of the Pacific Ocean, from an altitude of 53,000 feet all the way to the surface, were used for the first time to prepare the basic maps of

Northern Hemisphere weather—the 48-hour forecasts that are updated and issued twice a day.

Despite its success, Nimbus III is only a first-generation, experimental atmospheric prober. The infrared instruments have several serious limitations. One problem is the wide field of the sensors; from the altitude of the Nimbus III orbit they see an area of the atmosphere about 100 miles wide. And, since infrared readings cannot be obtained through clouds, the wide view means that only about 10 percent of the soundings are completely cloud-free and fully useful. Another limitation is that the instrument points only vertically; in the areas between orbital paths (about 1,900 miles at the equator) no readings are possible.

Nimbus D, now scheduled for launch in the spring of 1970, will carry improved versions of both the SIRS and IRIS instruments.

The SIRS on Nimbus D will be able to view to the left and right of the orbital track. Six additional sensor channels will enable it also to measure humidity. The future models of both the SIRS and the IRIS will have much narrower fields of view, allowing them to see down through smaller openings between scattered clouds.

Nimbus E and Nimbus F, scheduled for launch in the springs of 1972 and 1973, will carry more advanced infrared spectrometers and infrared interferometers, plus microwave sounders that will be able to penetrate most types of cloud cover. The NASA Nimbus program, a research and development effort, has a current budget of $28 million.

ESSA expects sounders based on the principles of the SIRS to be incorporated in its operational satellites by about 1972. □

View of India was produced by the Nimbus high resolution infrared radiometer.
NASA