

# Catching the weather coming

**A global weatherwatch system may aid the daily weatherman as well as hurricane hunters**

by Kendrick Frazier

Forecasts are the weatherman's bane. Not only do they make him the butt of tired old jokes, but every time the weather makes the news, pressure for longer range and more accurate forecasts builds up like the eye of a storm.

This was the case in August, when Vice President Spiro Agnew, after reviewing the devastation caused along the Gulf Coast by Hurricane Camille, reported to his boss that better hurricane prediction was needed.

President Nixon echoed Mr. Agnew's call. But even the President can be no more successful than King Canute in ordering the elements.

The trouble is that hurricanes are just not that predictable. A comprehensive hurricane-watching system has made it possible to give a 24-hour notice of where a hurricane will strike, but anything beyond that is going to be far in the future. Too much about hurricanes is unknown: what causes them, why some are more powerful than others, what makes them veer in one direction rather than another.

**In a sense**, the hurricane problem is part of the general difficulty in predicting what the weather will do over more than a short period.

The atmosphere is a complex turbulent fluid containing motions in a variety of scales ranging from molecular movement to cyclones and planetary waves of 1,000 kilometers and more. Energy is exchanged continuously from one scale to another and from one form to another.

In the past few decades meteorologists' study of the atmosphere and forecasts of its whims have moved out of the semi-subjective art they once were into the status of a science. Numerical analysis by computers has made it possible to supply reasonably accurate forecasts two or three days in advance. But longer predictions will need more data.

The data will come in the coming years: It is hoped that the dream of long-range forecasting—up to about two weeks—could be within reach about a decade from now. And although hurricane prediction can't be included in that general picture, chances are that the increased, worldwide data will give some clues to the puzzle of what makes hurricanes act as they do.

**Numerical weather** prediction (SN: 11/9, p. 480) is based on the idea that, given initial conditions at any one time and knowledge of the fluid dynamic equations of motion, the equations can be integrated forward to predict the distribution of such variables as wind velocity, temperature and moisture content at some future time.

The atmosphere, however, is basically unstable. Small disturbances grow quickly into larger ones. In the same way, the inevitable small differences between actual conditions and observed conditions soon become larger. How fast they grow determines how soon the predictability limit is reached.

In the last few years scientists have realized that the limit of predictability comes fundamentally not from observational error but from turbulence of the flow. It is not possible to measure turbulences of all sizes, so the information on the very smallest must necessarily be in error by some amount. As small turbulences interact with larger ones, these errors, appearing as initial data for the computer, will be transferred and possibly amplified, leading to a breakdown of predictability.

**To test this**, computer simulation studies compare an unperturbed model atmosphere with one into which a small perturbation has been entered. One then observes how the two depart from each other. When the disturbed atmosphere varies from the first by the same amount that any randomly chosen atmosphere

does, the inherent limit of predictability is said to have been reached.

Evaluating these studies, a report by the National Academy of Sciences in 1966 declared, "If the initial state of the entire atmosphere were known with sufficient accuracy, the large-scale motions would, in principle, be predictable as a determinate physical system for a period of approximately two weeks."

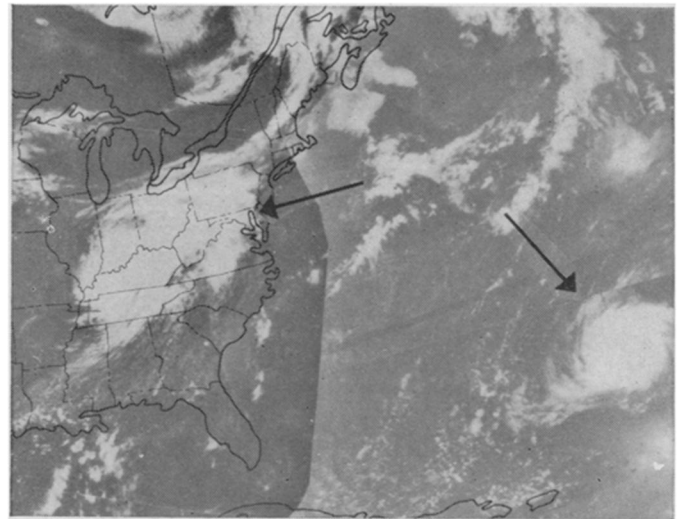
Further studies since then confirm that the inherent theoretical limit is at least that long. One by Dr. Joseph Smagorinsky of the Environmental Science Services Administration's Geophysical Fluid Dynamics Laboratory at Princeton, simulating nine levels of the atmosphere, places the limit at at least three weeks. There seems little hope for anything better. Dr. Edward N. Lorenz of the Massachusetts Institute of Technology says the results of his work are "discouraging to those who may have hoped that two-week forecasts . . . could actually be pushed closer to a month."

But the optimism for even two-week predictions is contingent on three developments: A global observation system making use of satellites, balloons, ocean buoys and sophisticated new sensors; better understanding of several crucial atmospheric processes, and computers at least a hundred times as fast as those currently in use.

**A major** obstacle in the extension of forecasts is the lack of adequate data coverage. No more than 20 percent of the earth's area is now measured with the detail needed for computer models.

Fortunately, this now appears simpler than it did three or four years ago. When the feasibility study for a global observation system was completed in 1966, scientists thought a fixed system blanketing the globe with a uniform grid of sensors, all taking the same measurements at the same intervals, was needed.

Now that concept has changed. A



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*Hurricanes Camille (left) and Debbie: A long way to go.*

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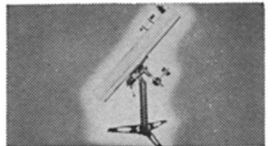
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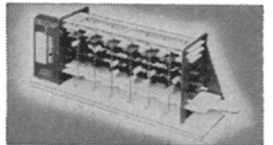
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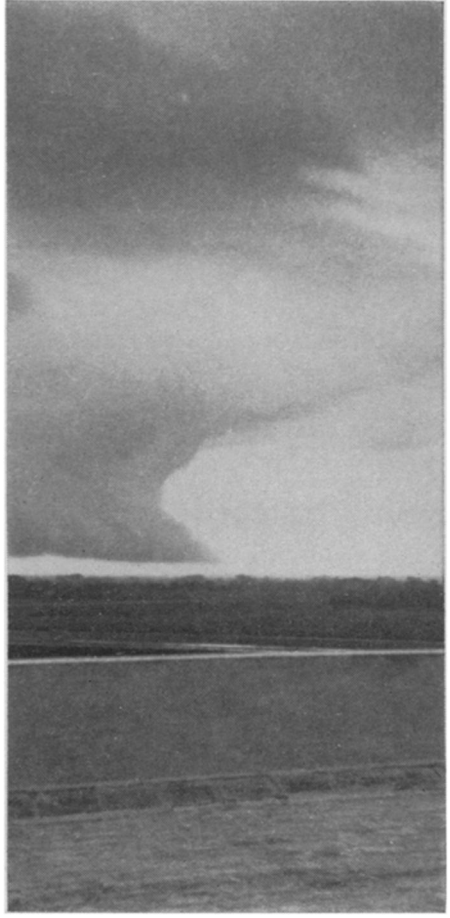
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To test how such a system might work, the U.S. GARP committee is proposing a project be carried out in an area of the Pacific Ocean, possibly the Marshall Islands, in 1973. Much smaller in scale than the eventual global network, it would use one geo-stationary and one polar-orbiting satellite, 800 constant-level balloons and 145 buoys of three different types.

The Pacific test is expected to be about the same size as the three-month Barbados Oceanographic and Meteorological Experiment (SN: 4/26, p. 411), completed on July 28.

But before a global observing capability can lead to extended forecasts, scientists need a much better understanding of the complex processes that restore energy to the atmosphere. Two of the most important are turbulence near the earth's surface, which transfers sensible and latent heat from the surface to the air, and cloud convection, which carries heat and moisture upward through great depths of the atmosphere.

"The various modes of interaction of cloud convection with the large-scale atmosphere represent the most formidable series of obstacles to the practical extension of numerical forecasting toward its theoretical limit," the GARP committee says.

The GARP unit recommends a Tropical Cloud Cluster Experiment be carried out in conjunction with the 1973 Pacific test to improve the rudimentary understanding of the processes.

The super-computer is the final component needed for long-range prediction. The best known is the parallel-processing ILLIAC IV, being developed by the University of Illinois and built by the Burroughs Corp. under sponsorship of the Defense Department's Advanced Research Projects Agency. The first quadrant of the modular machine, scheduled for delivery to the university in June 1970, is capable of handling 250 million instructions a second. The full system could process 1 billion instructions a second, in comparison with the 3-million-a-second CDC 6600 and the approximately 20-million-a-second CDC 7600, recently installed at Lawrence Radiation Laboratory. ◇

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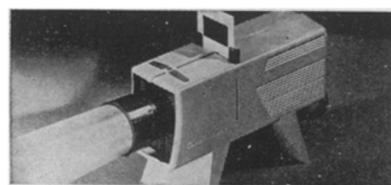
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