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Some Recent Advances in Meteorology

INSTRUMENTATION

Ever since the beginning of organized meteorology in the United States in 1870, when the Signal Corps was first authorized to take meteorological observations, the development of instruments with which to measure the atmospheric elements has been an important phase of the advancement of meteorology as a science. Recent advances in this field include the development and use of 1. weather reconnaissance radar, 2. upper air instrumentation, such as radiosonde, rawinsonde, transosonde, 3. automatic ceilometer, 4. transmissometer, and 5. automatic weather station.

Weather reconnaissance radar: These instruments, which have been especially adapted for weather purposes, have an effective range of 200 miles in radius. Besides showing areas of precipitation, they can also give some indication of the amount of precipitation that is falling. This is extremely valuable in the forecasting of flash floods. Frequently tornadoes show up on the radar scope as a hookshaped echo. With the use of a new experimental radar, employing the Doppler principle, which is also commonly used for speed monitoring by highway police, it is hoped that tornadoes can be detected by means of radar measurements of wind velocity. One such measurement was taken of a tornado at Wichita Falls, Texas, on April 2, 1958, when winds of 250 miles per hour were detected. An interesting phenomenon which has occasionally been observed on radar scopes is that of monetary echos which have been correlated with lightning flashes. Whether these echos are due to a sharp temperature gradient or to ionization has not been established.

Upper air instrumentation: Recent developments in upper air instrumentation include the latest type of radiosonde and rawinsonde equipment, whereby the atmosphere can be explored up to about 100,000 feet. Balloons which carry instruments to this height will often travel long distances from their point of origin. Therefore the tracking device used is a radio theodolite which follows the balloon by means of radio directional finding equipment, making use of the signal transmitted from the instrument attached to the balloon. This system, of course, is far superior to the old method of visual theodolite tracking for winds aloft information, in that cloud decks which would prevent visual observations do not hinder the radio theodolite.

An experimental method of obtaining more upper air data over the oceans has been carried out by sending so-called transosondes from Japan across the Pacific Ocean, the North American continent, and across most of the Atlantic Ocean, before they drop into the sea. These instrumented balloons are devised so as to remain at a constant pressure altitude of about 300 millibars. Thus the analysis of the 300 millibar level over the oceans can be greatly improved.

Automatic ceilometer: At airfields it is extremely important to obtain accurate and frequent measurements of the ceiling, or base of the lowest cloud deck, near the approach to the instrument runway. For this purpose an automatic rotating-beam ceilometer has been developed. This operates on the triangulation principle, making use of the photo-electric cell, as follows. A beam of light rotates in a vertical plane so as to illuminate the base of the clouds every six seconds. At a set distance from the beam projector a photo-electric scanner is aimed vertically at the clouds. As the scanner picks up the reflection of the beam from the cloud base, the angle of the projector at that moment, together with the known distance between projector and scanner, can be utilized to determine the height of the cloud base, which is the opposite side from the known angle in the triangulation.

Transmissometer: In like manner, the visibility at the end of the runway can be measured automatically by means of a transmissometer. This instrument consists of a stationary light beam aimed horizontally at a photo-electric cell a set distance away. The amount of light received by the cell is a function of the visibility, and can be calibrated so as to agree with human vision.

Automatic weather station: Several automatic weather stations are now in operation, which take observations of certain weather elements and even transmit these observations on a teletypewriter circuit, all without human attention. The elements presently being observed by these stations are temperature, dew point, wind direction and speed, pressure and amount of precipitation.

COMMUNICATIONS

Weather observations, no matter how accurate, how many, or how frequent, are useless for forecasting purposes unless they can be communicated quickly to all potential users. For this reason the weather teletypewriter circuits which transmit the observations across the nation must be continually improved for speed and capacity of transmittal. The present system is capable of 75 words per minute. The next target is 100 words per minute. And eventually this will be replaced by an electronic system in which printers will select only that information which is required at a particular station from a stream of data that will flow through the system at electronic speed.

Another form of communication which has done much to cut down the workload at individual stations is the facsimile recorder. This device is capable of transmitting analyzed charts from Washington, D. C., to all receivers at the rate of three charts per hour.

FORECASTING

Numerical weather prediction: The art of forecasting the weather has always relied heavily upon the experience of the individual forecaster, since there has never been sufficient data or enough time to make purely mathematical predictions of the weather. However, with the aid of the high-speed electronic digital computer, commonly spoken of as the "electronic brain," it is now becoming possible to make purely mathematical weather predictions. At the present time the work is limited chiefly to the prediction of upper air wave patterns of the atmosphere. These have proved to be just about as accurate as human predictions by a trained meteorologist. However, the hope for numerical weather prediction lies in the fact that as the input is improved, the product will improve, whereas the skill of qualitative forecasting by individuals has just about reached its limit of improvement.

Tornadoes: Much work has been done in recent years on the study and prediction of tornadoes. In 1950 Fawbush and Miller of the U. S. Air Force developed a technique for pin-pointing the probable area of potential tornado development. Since that time this science has progressed to the point where tornado forecasts have become almost routine. The Weather Bureau now operates a severe local storm forecast unit in Kansas City, whose sole responsibility is the forecasting of tornadoes and severe thunderstorms in the United States.

Stated very crudely, ideal conditions for tornado formation occur when a moist tongue of warm air near the surface, coming up from the south, intersects a cool dry stream of air aloft coming in from the west. At this intersection all that is needed to release the unstable characteristics of such a condition is a triggering mechanism, — something to start the ball rolling, or, in this case, the air tumbling. This trigger is usually supplied by an active cold front, which gives the warm air an initial boost and sends it whirling up in turbulent thunderstorms and possible tornadoes. The exact dynamic model for the beginning of a tornado is still one of nature's closely guarded secrets, but at least the net is gradually closing in on this capricious killer in nature.

DISSEMINATION OF WEATHER INFORMATION

The best forecast in the world is useless unless it reaches the people who can make use of it. Getting forecasts to the public as quickly as possible has become a major concern of the Weather Bureau. In many cities automatic telephone service gives out the latest forecast and current weather information to thousands of users every day. Specialized forecasts for aviation will soon be broadcast by tape-recorder over low-frequency radio ranges on a national scale. Pilot briefing via closed circuit TV at certain airports is in prospect for the near future. Just this year an important step was taken to warn the public more adequately of danger from tornadoes, hurricanes and floods. This occurred when the Weather Bureau was authorized to make use of Civil Defense CONELRAD procedures for public warnings of imminent danger from weather. This means that any one having a radio with a CONELRAD signaling device can receive warnings any time of the day or night. This is how it works. The

Weather Bureau gives the warning to a radio station which has been designated by Civil Defense as a "sky-wave key station." This radio station emits the signal which automatically turns up the speakers of receiver sets which are equipped with such a device. The receivers may also be equipped to set off an alarm, or flash a light. The warning is then broadcast. This procedure can be particularly effective for such institutions as schools and industrial plants. The minimum cost of equipping a radio set with this device has been estimated at about $15.00.

WEATHER OBSERVATIONS BY EARTH SATELLITES

Perhaps the most exciting development of the last year in meteorology is the successful launching of earth satellites. The possibilities for observing weather on a global scale by this means almost stagger the imagination. The most immediate use of instrumented space vehicles will be in the field of theory, rather than in practical forecasting. It has been proposed to equip one of the IGY satellites with tiny spheres the size of ping-pong balls, placed on the tips of the radio antenna, which will measure three types of radiation: 1. direct solar radiation, 2. reflected solar radiation from cloud tops, and 3. infra-red radiation from the earth. With this information, gathered along the tropical belt between 35° N and 35° S latitude, the heat balance of the earth in this area of maximum insolation can be checked and observed for variations with time. It may even be possible to detect clues in the fluctuations of energy received which would signal such major changes in weather patterns as that from latitudinal flow of weather systems to a more longitudinal exchange of contrasting air masses.

For the practical forecaster, another proposed device is even more exciting. That is the proposal to equip a satellite with a TV camera to take continuous pictures of the earth and its cloud patterns. Dr. Harry Wexler, director of meteorological research for the Weather Bureau, envisages a satellite which would be launched from the equator in the direction of true north, to orbit the earth pole to pole, 4000 miles above the earth's surface, with a period of rotation of once every four hours. Such a vehicle, if it should find itself crossing the equator at noon on the zero meridian, would be directly over the north pole after one hour, crossing the equator

southward after two hours, over the south pole at three hours, and over the equator again in four hours, this time at the 60° West longitude. During this rotation it would be exactly noon for two hours and exactly midnight for two hours on the earth directly beneath the satellite. In 24 hours' time the vehicle would be back where it started, relative to the earth. What would be seen from such a height? Dr. Wexler believes that the whole North American continent plus much of the Atlantic and Pacific Oceans would be in view at one time, with the coastlines clearly delineated. Besides this, the cloud systems of large-scale cyclones and anti-cyclones would be very evident, almost as though one were looking at an analyzed weather chart.

CONCLUSION

These are only a few of the more exciting advances in meteorology during recent years. This is a challenging field for young scientists of the future to consider. Of one thing they can be certain: whatever achievements are won in this science will benefit all people, for the atmosphere is our element. In it we live and breathe and have our being. Whatever we can do to find order in this element, we do for all.

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