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# Communicating environmental uncertainty: the nature of weather forecasts

One of the most common man-environment experiences is daily interaction with the elements of weather. Most young children probably pay little attention to patterns of change in the elements, but they are concerned with how conditions at a given moment influence some favorite outdoor activity. As we increasingly adhere to a daily schedule, however, concern with weather conditions becomes more important, and we learn to seek information that will help us plan both our activities and our wardrobe. A primary source of information is official weather forecasts available through the communications media. Constant repetition of the technical language of weather forecasts in newspapers and on radio and television ensures that weather forecasting terms become part of our vocabulary, albeit a part that often has little specific meaning. The purpose of this paper is to provide geography teachers with some basic information on weather forecasts, some material on the interpretation and misinterpretation of forecast terms, and some indications of the format of weather forecasts in the future. Additionally, we have included suggestions for bringing these topics into the classroom.

## SOURCE AND DISSEMINATION OF FORECASTS

Weather forecasts received by the public from local news media are at the end of a long and complex chain of communication. Official forecasts in this country are made by the National Weather Service (NWS), a part of the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. NWS's National Meteorological Center (NMC) in Camp Springs, Maryland, is the core of a data-gathering and -disseminating system of worldwide scope. NMC meteorologists provide information on weather and climate conditions as well as forecast guidance to 52 National Weather Service Forecast Offices (NWSFO) across the United States and its possessions. These offices have primary responsibility for NWS's state and zone forecast programs. Forecasts for each state are prepared every twelve hours for periods of up to 48 hours. NWSFOs also prepare individual forecasts for 5,000 to 15,000 square mile geographic subdivisions (zones) of each state. Zones usually are multi-county areas in which the NWS expects some degree of meteorological homogeneity. These state and zone forecasts are passed to the 243 Weather Service Offices (WSO) for use in local forecast programs. At this level, WSO meteorologists prepare and disseminate forecasts for the nation's metropolitan areas.[1]

In addition to routine weather forecasts, NWS provides forecast and warning services related to major weather events. The National Hurricane Center (Miami, Florida), Eastern Pacific Hurricane Center (San Francisco, California), and Central Pacific Hurricane Center (Honolulu, Hawaii) have responsibility for hurricane warnings and forecasts, while the National Severe Storm Forecast Center (Kansas City, Missouri) handles forecasts and warnings for tornadoes and severe thunderstorms. Other severe conditions for which NWS personnel issue warnings include winter weather, coastal floods, weather conducive to fire, flash floods, tsunami, and air stagnation. NWS also prepares forecasts that are tailored to the specialized needs of agriculturists, sailors, and aviators.[2]

Forecasts and other information, in a form most nonspecialists would not understand, are communicated between various NWS facilities through a complex series of teletype and facsimile networks. Some news media outlets have access to the NWS teletype system called NOAA Weather Wire, but many depend upon

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[1]National Weather Service, *Operations of the National Weather Service* (Washington, D. C.: National Oceanic and Atmospheric Administration, Department of Commerce, 1977), pp. 9-25.

[2]Ibid., pp. 26-71.

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information sources that are easily accessible to the general public.

## PUBLIC ACCESS TO NWS

NWS supports two forms of direct contact with the public for the purpose of disseminating routine forecasts and other weather information. In a large number of cities, those seeking up-to-date forecast information may use a multiple-access recorded telephone announcement system. These telephone systems can handle from ten to more than 10,000 local calls simultaneously and operate on a 24-hour basis. The recordings are updated at regular intervals and at any time when new information makes it necessary to adjust the forecast. If a city has a telephone outlet, the number can be found in the white pages of the telephone directory under United States Government, Department of Commerce.[3]

A second direct source of communication from NWS is NOAA Weather Radio, a system of more than 100 radio stations that will be expanded to 370 stations by the end of 1979. Taped weather messages tailored to the local area are broadcast at four to six minute intervals from VHF-FM transmitters. The high frequency of the broadcasts makes it impossible to receive them on most ordinary radios; but many manufacturers are now including a weather band on some models, and a few produce low-cost weather radios especially designed to receive the three NOAA frequencies (162.400, 162.475, and 162.550 MHz). Some of the receivers have a feature that allows forecasters to activate them. When a weather emergency exists, the receivers either sound an alarm to alert the listener or are automatically turned on. Most listeners within approximately 40 miles of an NOAA station's antenna should be able to receive the broadcasts. When the system is complete, more than 90 percent of the nation's population will have NOAA radio reception. In many school systems and public places, the emergency feature of NOAA Weather Radio is used to avert possible disaster.[4]

## WEATHER FORECASTS AND THE NEWS MEDIA

Despite the existence of direct public links with NWS, most Americans obtain their weather forecasts from the news media. No definitive information concerning frequency of use of various sources exists, but it is probably true that the amount of use is directly related to reporting frequency. This assumption would place radio first, television second, and daily newspapers third.

The virtual ubiquity of radio and television in the daily lives of Americans puts weather forecasts within easy reach. There are, however, some obvious disadvantages to receiving forecasts via these forms of communication. Radio weather reports and forecasts are read on a frequent basis, but the degree to which the forecasts are accurate and up-to-date greatly depends on the links between the station and NWS and the relative importance that the station management places on weather news in the programming schedule. Television weather reporting and forecasting is usually more thorough than that found on radio, but it is available only two or three times each day.

The potential for misinterpretation of weather information by untrained radio and television "celebrities" has concerned professional meteorologists. As a result, the American Meteorological Society has initiated "seal of approval" programs for radio and television weathercasters.[5] Each applicant for a "seal of approval" must show evidence that on-the-air programs contain elements of informational value, audience interest, educational value, and professional attitude. Additionally, the individual weathercasters are required to have a certain amount of on-the-air experience and knowledge of weather. Although the certification program's potential for improving media weather forecasting is high, only 30 radio and 100 television announcers are currently active in it.[6]

In most cases, short-term weather forecasts carried by daily newspapers are outdated before they reach the readers. Newspapers might overcome part of their obvious timing disadvantage, in relation to radio and television, by concentrating on detailed reporting of three-to-five-day and six-to-ten-day weather outlooks issued daily by the NWSFOs and by describing past weather in more detail. All news outlets would probably be able to increase confidence in their reports if they routinely included the date and time of issuance of a particular forecast and the time and date to which the forecast is effective. Because many disadvantages of media trans-

[3]Ibid., pp. 194-97.

[4]National Weather Service, *NOAA Weather Radio* (Washington, D. C.: National Oceanic and Atmospheric Administration, Department of Commerce, 1978), pp. 1-5.

[5]Bob Thomas, "Meteorology: Science to Show Biz," *Bulletin of the American Meteorological Society* 53 (1972):1165-66; Ivan W. Brunk, "Improvement of TV Weather Programs," *Bulletin of the American Meteorological Society* 53 (1972): 1169-71; and D. Ray Booker, "A Comparison of Program Ratings of Professional and Non-professional Weathercasters," *Bulletin of the American Meteorological Society* 43 (1962): 223-28.

[6]Persons who present weather forecasts on radio and television are usually called "weathercasters" as opposed to the professional meteorologist in a non-media position who is called a weather forecaster. For information on the "seal of approval" for weathercasters, see American Meteorological Society, "Seal of Approval Program for Radio and Television Weathercasting," *Bulletin of the American Meteorological Society* 58 (1977): 802-06.

mission of weather forecasts will probably be slow in disappearing, an educational effort aimed at promoting voluntary use of direct links with NWS would serve the public well.

Weather forecasting, as indicated by frequent jokes, is sometimes taken very lightly by the public. At least a part of the public's attitude is related to misunderstandings of the nature of weather forecasting and to problems in communication of forecasts and understanding forecast terminology. Misunderstandings can lead to unrealistic expectations and evaluations by the public.

## VARIATIONS IN FORECASTING SKILL

As a general rule, weather forecasts contain reference to temperature, precipitation, wind, and sky conditions. A meteorologist's skill in forecasting future states of these elements varies from one element to another and changes with the size of area and length of time for which the forecast is effective. In terms of the time span for which they apply, forecasts are divided, for this discussion, into the following categories: (1) current, sometimes called "nowcasting," (2) short-range, (3) medium-range, (4) long-range, and (5) climate forecasts.

Accuracy in prediction of weather is closely related to the time span of the forecast. Although the details of current (up to one hour) and short-range (one to twelve hour) forecasts are often not released to the public, such predictions can be made with considerable accuracy during stable weather conditions. For the twelve- to 48-hour period of medium-range forecasts, NWS demonstrates a significant amount of skill in predicting temperature, wind, and sky conditions. A fairly high rate of success also is achieved in predicting the occurrence or absence of precipitation up to twelve hours in advance, but abilities to predict amounts of precipitation have not significantly improved. Perhaps the greatest deficiency in medium-range forecasting is the inability to predict location of severe local storms, including tornadoes and thunderstorms. Much effort is now focused on technical developments in the use of radar to detect a tornado's presence so that sufficient warning may be given before it strikes a populated area.[7] The prediction of severe winter weather for the medium time-ranges also is not notably effective. Long-range forecasts are for periods of 48 hours to five days. In this range, the prediction of temperature is moderately successful, but the ability to predict precipitation falls far short. Climate forecasting (for periods greater than five days) is in its infancy, and little skill has been attained. It is probably safe to say that meteorologists' abilities to forecast accurately are inversely related to length of forecast period and severity of weather and directly related to size of the area for which the forecast is being made.

The outlook for major improvements in forecasting abilities is none too promising. Several studies have shown that application of sophisticated computer and satellite technology has not perceptibly improved forecasting accuracy.[8] The greatest technological strides in the near future will probably be made in the areas of identifying and tracking severe storms at a local scale.

## UNDERSTANDING THE FORECAST

Because meteorologists are applying limited technological ability to the extremely complex problem of weather, forecasts are judgmental in nature. The forecasters attempt to employ a narrative in which they communicate the most probable state of events. Misunderstandings that result from inefficient interpretation of an absolutely correct narrative can have the same detrimental effect as a highly erroneous forecast.

The essential tasks of the NWS forecaster are to take large amounts of information concerning climatic and meteorological conditions into consideration, to judge which weather conditions will occur in the forecast area during a specific time period, and to create a forecast for public release that accurately reflects his or her best judgment. The potential for the public's misunderstanding is inherent in the last part of this three-step process. The crux of the problem is that forecasts must be presented in words that the public will understand and find useful, while at the same time forecasts must be in a form that will allow the NWS, at a later point in time, to verify their accuracy. Checking forecasts for accuracy requires measuring conditions at a specific place, usually the official weather station.

NWS policies have favored a forecast vocabulary that is categorical in nature. A categorical term such as *partly cloudy* is used in the forecast to indicate that .3 to .7 of the sky will be covered by clouds. In this way, ordinary words are used by forecasters to depict a situation that could be expressed numerically. A typical forecast illustrating the use of categorical terms

[7]David Atlas, "Overview: The Prediction, Detection, and Warning of Severe Storms," *Bulletin of the American Meteorological Society* 57 (1976): 398-401; Louis J. Battan, "Detection of Severe Local Storms," *Bulletin of the American Meteorological Society* 57 (1976): 431-35; and H. Stuart Muench, "Use of Digital Radar Data in Severe Weather Forecasting," *Bulletin of the American Meteorological Society* 57 (1976): 298-303.

[8]Roger A. Pielke, "An Overview of Recent Work in Weather Forecasting and Suggestions for Future Work," *Bulletin of the American Meteorological Society* 58 (1977): 506-19; C. S. Ramage, "Prognosis for Weather Forecasting," *Bulletin of the American Meteorological Society* 57 (1976): 4-10; C. S. Ramage, "Further Outlook—Hazy," *Bulletin of the American Meteorological Society* 59 (1978): 18-21; and Frederick G. Shuman, "Numerical Weather Prediction," *Bulletin of the American Meteorological Society* 59 (1978): 5-17.

is shown below. Each categorical term is italicized.

The forecast for Metro and vicinity: *partly cloudy tonight, cloudy* with *scattered showers tomorrow afternoon,* changing to snow *tomorrow evening.* Low in the upper 30s, high 40 to 45. Chance of rain or snow 30 percent *tonight,* 60 percent *tomorrow afternoon.* Winds *light* and *variable.*

Continued use of categorical terms by NWS may not be wise, however. Some research has indicated that use of numerical terms in forecasts improves users' abilities to remember forecasts.[9] Additionally, the understanding of numerical terms has been confirmed by the abilities of people to correctly match visual images of cloud cover with measurements of the proportion of sky actually covered.[10] The use of categorical terms usually fails to conform with regional variations in the meaning of such terms as hot, cold, morning, and evening. More significantly, they fail to express the degree of uncertainty in forecasts.

## PROBABILITY FORECASTS

Since 1965, NWS has routinely recognized uncertainty in its predictions by expressing the chance of precipitation in probabilistic terms. For example, when the precipitation probability for an area is given as 10 percent, the forecaster believes that chances are one in ten of having a measurable amount of precipitation (equal to or greater than .01 of an inch) within the forecast period at a specified geographical location (usually that of the official rain gauge for the forecast area). This is called a "point probability forecast." Although the element of uncertainty is indicated in this type of forecast, some people still interpret it incorrectly. Some think a probability statement means that precipitation will occur in a certain percentage of the forecast area; others believe that there is a given chance of precipitation at some unspecified location.[11] Even forecasters differ slightly in their understanding of probability. Two common interpretations are that probability indicates relative frequency (under the same conditions, repeated many times, precipitation would occur a certain percentage of the times) and subjective probability (the forecaster is willing to place a certain degree of confidence in the occurrence of precipitation in the impending unique situation).[12]

Although there is obvious opportunity for misinterpretation of probability forecasts, they do convey the notion that forecasts are judgmental and uncertain in nature. Because NWS wishes to stress these characteristics of forecasts, weather forecasters are being encouraged to include more probability statements, particularly for temperature ranges and areal coverage of precipitation. As time passes, we can probably expect more of the forecast to be expressed in numerical and probability statements rather than in categorical statements.

## SOME TEACHING POSSIBILITIES

Geography teachers have often employed weather forecasts and reports to describe certain aspects of the atmospheric environment. We suggest that forecasts may be further used to demonstrate the complexity of the problem of predicting the state of the atmosphere for small areas even over short periods of time. Forecasts can be used to illustrate the difficulty of expressing an expert's judgment about uncertain environmental events to the public.

For preparing classroom activities, teachers would find it useful to ascertain the location of and to contact the nearest NWSFO or WSO. Through such contact, information on local direct public access to NWS can be obtained. If your city or one nearby has a forecast office, you may be able to use a high frequency radio in your classroom or to record a telephone forecast for later use. Additionally, teachers should be able to acquire some old printed teletype forecasts from a local radio or television station. These forecasts can be used in various ways to illustrate notions of subjectivity and uncertainty in forecast language.

A collection of forecasts for several consecutive days might form a basis for asking students to compare the official forecast to those provided on radio and television. If more than one television station broadcasts in your area, students could, over a period of time, evaluate the various television weathercasters' accuracy in forecasting and effectiveness in communication. See if the students can determine whether a television personality is a professional

[9]Elliot Abrams, "Problems in the Communication of Routine Weather Information to the Public" (M. A. thesis, Pennsylvania State University 1971), p. 71.

[10]William E. Riebsame, "State-of-the-Sky Forecasts: The Evaluation of the Communication of an Environmental Image" (M. A. thesis, University of Utah, 1978).

[11]Roger H. Rogell, "Weather Terminology and the General Public," *Weatherwise* 25 (1972): 126-32; Lewis A. Pitt, "Weather Forecasting and General Semantics," *ETC: A Review of General Semantics* 17 (1960): 293-300; and James R. Scoggins and William W. Vaughn, "How Some Nonmeteorological Professionals View Meteorology and Weather Forecasting," *Bulletin of the American Meteorological Society* 52 (1971): 974-79.

[12]Allan H. Murphy, "On the Misinterpretation of Precipitation Probability Forecasts," *Bulletin of the American Meteorological Society* 58 (1977): 1297-99; Allan H. Murphy and Robert L. Winkler, "Forecasters and Probability Forecasts: Some Current Problems," *Bulletin of the American Meteorological Society* 52 (1971): 239-47; Allan H. Murphy and Robert Winkler, "Reliability of Subjective Probability Forecasts of Precipitation and Temperature," *Journal of the Royal Statistical Society, Series C (Applied Statistics)* 26 (1977): 41-47; and Allan H. Murphy and Robert L. Winkler, "Can Weather Forecasters Formulate Reliable Probability Forecasts of Precipitation and Temperatures?" *National Weather Digest* 2 (1977): 2-9.

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weathercaster or an announcer who takes the forecast directly off the NWS weather teletype system and repeats it without change.

Another strategy is to present some of the more subjective categorical weather forecasting terms to illustrate how persons can have different interpretations of them. Try some of the following terms and phrases: light winds (officially defined as winds between 4 and 14 miles per hour), sunny (0 to .6 cover of low- or middle-level clouds), fair (no precipitation and less than .4 low cloud cover), variable winds (irregular changes in direction rather than changes in speed), colder or warmer temperatures (a change of at least five degrees F), evening (6:00 P.M. to 9:00 P.M.), tonight (6:00 P.M. to 6:00 A.M.), chance of (less than 50 percent chance).

## CONCLUSION

In this period of increasing consumer awareness, young people should become more knowledgeable of the complexity and cost of providing a service that is taken as much for granted as the daily weather forecast. A clearer understanding of the difficulty of accurate weather prediction and dissemination should lead students away from belief in overly simplistic technological solutions and unrealistic expectations. Weather is a complex phenomenon, and forecasting it is an uncertain and judgmental task. Consumers who have full realization of these facts should be better able to evaluate services provided to them through NWS and through news media.

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# Undergraduate geography programs: contemporary characteristics and recent changes

The undergraduate geography curricula and major programs of American colleges and universities have received surprisingly little attention in the geographic literature. In 1968 the Association of American Geographers published *Undergraduate Major Programs in American Geography*, the one detailed curricular analysis in the literature.[1] Since that study appeared, papers proposing new approaches to curriculum design or exemplifying specialized curricula have been published, but no up-to-date analysis of American undergraduate geography major programs has been conducted.[2] Many changes, largely in the direction of relaxing core curriculum and distribution requirements, have occurred since the late 1960s; these changes undoubtedly have been paralleled by alterations in the characteristics and requirements of geography major programs.[3] This paper identifies the important characteristics of present-day major programs and assesses the curricular changes that have occurred in the last ten years. Attention is focused exclusively on geography in the liberal arts curriculum, by far the most prevalent location for geography major programs.

## THE SAMPLE OF UNDERGRADUATE PROGRAMS

To analyze the characteristics of geography major programs, I have collected data on the number and type of courses and the basic course and credit requirements for a sample of geography departments. The sample consists of 40 departments selected randomly from those included in the *Guide to Graduate Departments of*

[1] *Undergraduate Major Programs in American Geography*, Association of American Geographers, Commission on College Geography No. 6 (Washington, D. C., 1968).

[2] See, for example, Janice Monk, "The Geography Major Curriculum: A Behavioral Approach" (Paper presented at the Annual Meeting of the National Council for Geographic Education, San Francisco, November, 1976); and L. T. Foster and K. G. Jones, "Applied Geography: An Educational Alternative," *Professional Geographer* 29, no. 3 (August 1977): 297-300.

[3] Malcolm G. Scully, "Tightening the Curriculum: Enthusiasm, Dissent, and So What Else Is New?" *Chronicle of Higher Education* 16, no. 11 (May 1978): 1 and 12.

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