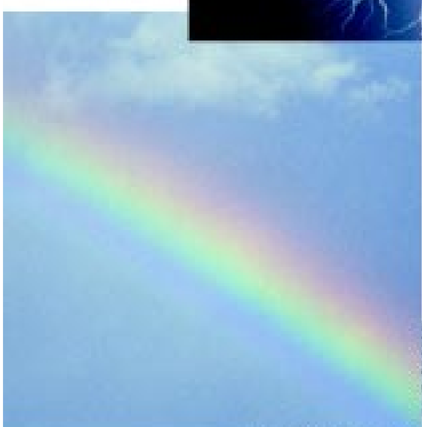
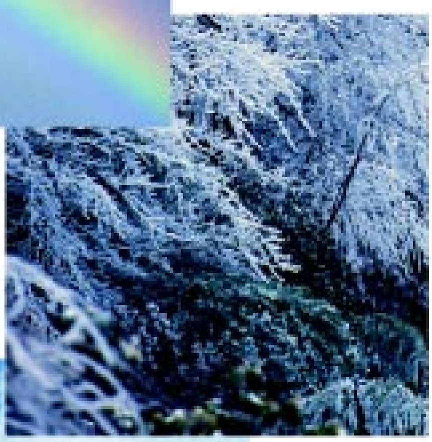
Meteo

Weather forecasting using the Internet





BENJAMIN FRANKLIN ONCE SAID "SOME people are weatherwise, but most are otherwise" (1735). That was before the Internet. Today, worldwide, up-to-the-minute weather information is just a few mouse clicks away on sites such as *wunderground.com* (The Weather Underground, Inc.) and *weather.gov* (The National Weather Service). It is almost as easy to check on the current weather conditions in Bangkok or La Paz as it is to look out the window to see if it is raining or snowing. We have far more weather information now than Ben Franklin ever did.

But does that make us wise? Not a chance. More is not necessarily better, and we are fast becoming saturated with ever-increasing amounts of readily available weather data. The trick is to apply this flood of weather information in ways that make us think and learn more effectively.

WEATHER IN THE CURRICULUM

Meteorological educators have long struggled with the challenge of effectively using the constant stream of real-time weather data. Toward this end, many universities have invested considerable time and effort in developing state-of-the-art computer visualization laboratories (Nielsen-Gammon et al, 1996). Outside the educational arena, international repositories of historical climate records have also developed user-friendly, Web-based interfaces that allow users to access enormous quantities of archived data (Scott et al, 1997).

So now that we have copious amounts of current weather data, as well as the graphical tools with which to view them, what next? Weather forecasting is an obvious way to apply this information. In many ways, forecasting is an ideal application of the scientific method

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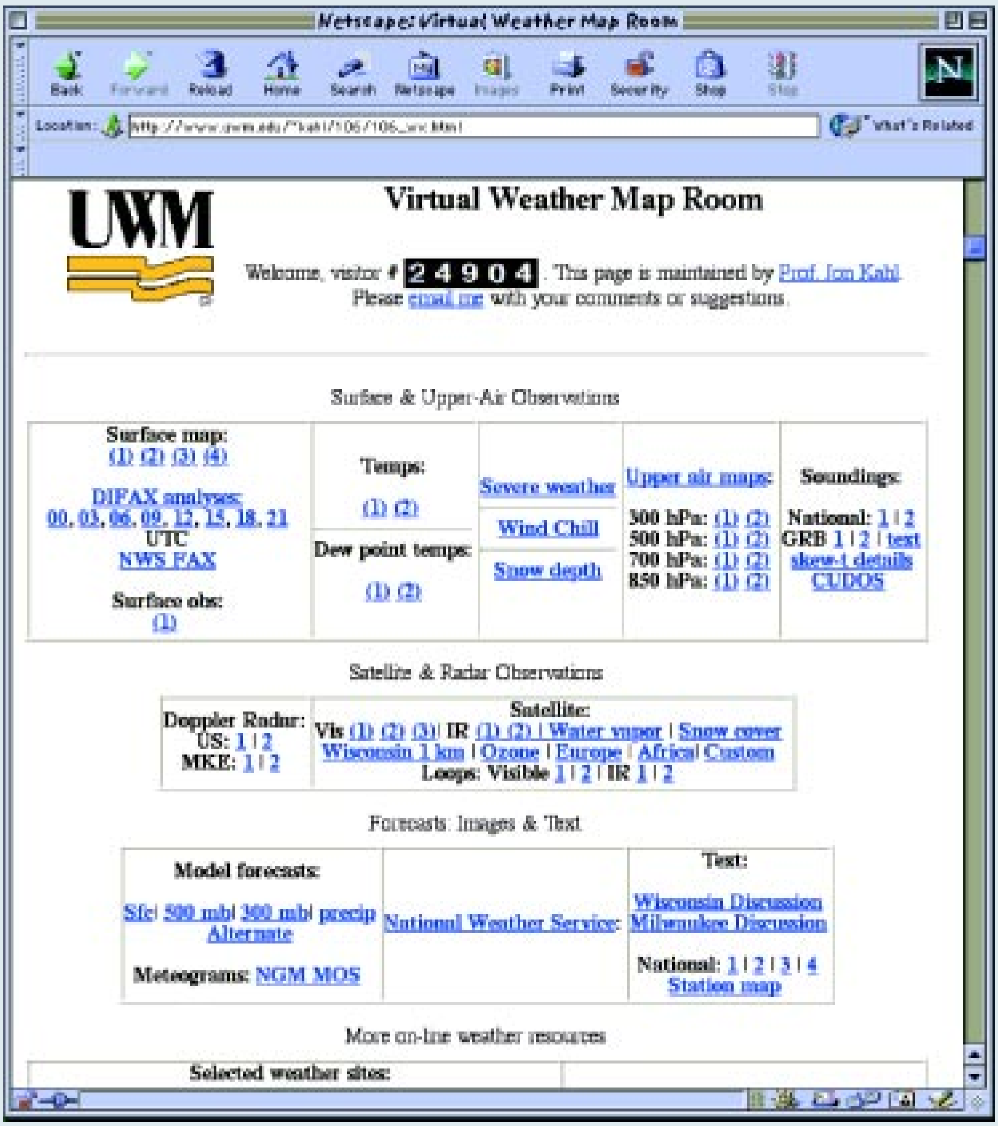
because framing a hypothesis (making a forecast) requires analyzing data in light of previously learned concepts, and the outcome is never known in advance. Virtually all university programs in atmospheric science incorporate weather forecasting as an important component of the curriculum.

But because weather data is no longer the exclusive province of the professional meteorologist, weather forecasts can be made by anyone with a computer. And because most schools and increasing numbers of individual classrooms have Internet access, weather forecasting can be easily incorporated into precollege curricula.

Internet-based weather forecasting is already beginning to trickle down into the realm of the non-meteorologist. For instance, a comprehensive forecasting system is used in large-lecture, introductory meteorology courses at Iowa State University (Yarger et al, 2000). In the course, a weather forecasting activity that constitutes half the students' course grade has transformed the course from a passive, lecture-only format to a collaborative, learning-by-doing experience.

FIGURE 1.

A portion of the Virtual Weather Map Room website (*www.uwm.edu/~kahl/106/106_wx.html*), a comprehensive collection of links to a variety of real-time, global weather data.



A similar Internet-based weather forecasting activity developed at the University of Wisconsin (UW)–Milwaukee is a required element of large-lecture introductory meteorology courses. The system is unique, though, because it is simple enough to use in middle and high school classrooms; can be readily adapted to a wide range of subject areas, both within and outside of the sciences; and requires no specialized software, only an Internet connection, a Web browser, and an e-mail account for the teacher.

FIGURE 2.

Examples of the subjective system used to assess forecast justifications. In this example, the justifications refer to the maximum temperature forecast.

Explanation of forecast assessment.
Maximum temperature forecast: 10°C.

No thought (score = 1)	"because it's fall" "because it's in the north"
Some thought (score = 2)	"because it's been warm for a while, and it's about time for it to get cold" "because it might get cloudy"
The correct thought (score = 3)	"because the winds shifted" "because the wind is from the west, and Iowa had temperatures around 12°C yesterday"

FORECASTING ONLINE

The UW–Milwaukee weather forecasting activity can be found on the Internet at *www.uwm.edu/~kahl/100/weather_forecasting_exercise.html*. Participating students examine current weather text, maps, and charts that are provided on the Virtual Weather Map Room (Figure 1), a weather data resource linked to the forecasting website. Using this information, students make a structured weather forecast once per week for a location that changes weekly. The forecast consists of the following elements:

- Maximum daily temperature,
- Justification for the maximum daily temperature forecast,
- Minimum daily temperature,
- Justification for the minimum daily temperature forecast,
- Wind speed at noon,
- Justification for the wind speed at noon forecast,
- Wind direction at noon, and
- Justification for the wind direction at noon forecast.

Once a student enters a forecast and clicks the "Submit" bar, an e-mail message containing the student's name and forecast is automatically sent to the teacher. A copy can also be sent to the student (if the student's e-mail address is included). Descriptions of the weather that actually occurred at the forecasted location are posted to the website each week.

The required forecast elements include justifications for each of the four basic weather features. These justifications, rather than the forecast elements themselves, provide a means for assessing student forecasts. Teachers may examine the justifications to evaluate the thought process that produced the forecasts. The justifications provide a more valuable means of assessment than the forecasts themselves, because students cannot possibly be expected to be expert forecasters. After all, even professional meteorologists are often wrong!

The course, entitled "Survey of Meteorology," satisfies a general education requirement and has no prerequisites of any kind. In one class, from January to May, 1999, weekly forecasts were submitted by 160 students, 50 percent of whom were freshmen and sophomores. None of the students were meteorology majors.

Students' forecast justifications were assessed and assigned scores according to the system shown in Figure 2. A score of 1 indicated that the student had, in making a forecast, used essentially none of the concepts presented in the class. A score of 2 indicated a genuine attempt to incorporate relevant meteorological considerations into the forecast; however these considerations were relatively unsophisticated or wide of the mark. A score of 3 was awarded if the student's justification included some of the meteorological concepts relevant to that particular day's weather.

The results for one forecast justification element are shown in Figure 3. It is clear that the students' justification scores, and hence the quality of their analytical thought processes, improved substantially over the course of the semester. The results for the other forecast justification elements showed similar trends. The nearly constant standard deviation indicates that the increasing weekly scores reflected the improvement of the class as a whole.

Meteorology embodies elements of physics, geography, mathematics, statistics, and chemistry, and thus is an ideal framework for an integrated curriculum.

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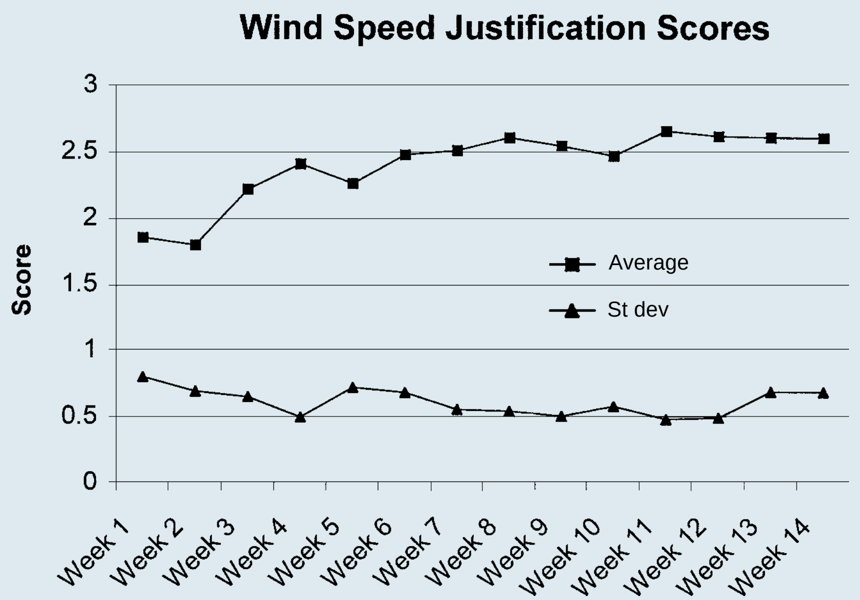
FIGURE 3.

Assessment of the students' "Justification of the Wind Speed Forecast" over the course of a semester. The squares indicate mean scores according to the scheme shown in Figure 2, and the triangles show the standard deviation of each week's scores.



IDEAL INTEGRATED FRAMEWORK

Meteorology embodies elements of physics, geography, mathematics, statistics, and chemistry, and thus is an ideal framework for an integrated curriculum. Obviously, weather forecasting is directly relevant to an Earth science curriculum, but it also can be a valuable part of other subjects. For instance, the progression of the Earth's shadow across successive time zones is a common topic in geography and astronomy curricula and can be easily tracked using (visible) weather satellite imagery. The movement of high- and low-pressure systems and hurricanes across the weather map offers opportunities to study velocity and acceleration. The formation and dissipation of clouds involves the physical chemistry topics of condensation and evaporation. The development of storms is closely tied to heat and radiation processes. Wind, a result of the balance of several large- and small-scale forces, is a direct application of Newton's second law of motion. Evaluating the accuracy of weather forecasts is done with statistics.

Studying math and science via weather forecasting can make a subject come alive, especially if the forecast location has special significance to the students. Whatever the curriculum, subjects can often be made more exciting by studying a constantly changing system and attempting to solve an unknown problem (determining tomorrow's weather). Moreover, students delight in working on a problem for which even the teacher does not know the answer. ✧

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REFERENCES

Franklin, B. 1735. *Poor Richards Almanack.* Online at *www.fi.edu/qa99/musing4/almanack1735.html.*

Nielsen-Gammon, J.W., M.I. Biggerstaff, M.E. Alcorn, D. Austin, K.P. Bowman, D. Djuric, J. Guynes, R.L. Panetta, R. White, and L.J. Wicker. 1996. Texas A & M University's Laboratory for the Exploration of Atmospheric Processes—TAMU's LEAP. *Bulletin of the American Meteorological Society* 77(12):2907–2918.

Scott, J., M. Alexander, J. Collins, and C. Smith. 1997. Interactive visualization of climate data on the World Wide Web. *Bulletin of the American Meteorological Society* 78(9):1985–1989.

Yarger, D.N., W.A. Gallus, Jr., M. Taber, J.P. Boysen, and P. Castleberry. 2000. A forecasting activity for a large introductory meteorology course. *Bulletin of the American Meteorological Society* 81(1):31–39.

AUTHOR'S NOTE

The author would like to extend an invitation to interested teachers to use the Internet weather forecasting system. While the most direct application would likely be in an Earth science curriculum, the system may also be used as a supplement to other science or mathematics areas. For further information, or to register a class for the forecasting system, please contact the author.

ACKNOWLEDGMENTS

The author wishes to thank Duffy Tilleman, a remarkable student at Whitefish Bay Middle School, for his help in preparing the statistical results. Funding for this project was provided, in part, by the University of Wisconsin System PK–16 Initiative.