AT LAST, A USE FOR COMPUTERS: WEATHER FORECASTS AT THE BED LEVEL

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Computer-based communications are a powerful way of getting the latest weather information, and we are making good progress on building computer models of the cranberry bed environment. We believe that communications and environmental modeling will be major roles of computers in cranberry management. In this paper I will describe our efforts at predicting low temperatures in cranberry beds, and how we are experimenting with disseminating these forecasts using the World Wide Web.

The work that I am going to share is part of a larger project, named TiSDat --Timely Satellite Data for Agricultural Management. I introduced TiSDat in an article in the program for the 1996 Annual Summer Meeting and Field Day. TiSDat was initially funded by the National Aeronautics and Space Administration (NASA) in 1994, and will continue through 1997. NASA is always interested in fostering new applications of satellite data, so that the benefits of space technology can be shared among the citizenry. Additionally, the US government is interested in encouraging growth of the Internet and faster computer communications, because such capability improves the economic competitiveness of country. TiSDat thus has two goals: develop new ways to use satellites in agriculture and encourage use of the Internet (or World Wide Web) as a business tool. The TiSDat project involves three major products: estimates of evapotranspiration from well-watered crops for use in irrigation scheduling, frost predictions in cranberry beds, and estimating the relative humidity around the leaves of potato, for use in disease predictions.

The Basic Weather Forecast

All modem day weather forecasting begins with “soundings” of the atmosphere, that is measurements of T, rh, wind, and pressure, made with weather balloons. There is a worldwide system of balloon launches that gives meteorologists a snapshot of the atmosphere twice each day. In Wisconsin, weather balloons are launched routinely only at Green Bay.

Data from all of these soundings are entered into computers and transmitted via networks to various users, including the National Weather Service headquarters near Washington. Here the data are fed into some of the world’s biggest computers, which are loaded with some of the world’s biggest programs -- computer models of Earth’s atmosphere. Meteorologists are always among the first in line for the latest computers, because trying to describe and predict the behavior of the entire atmosphere is a big job. These computer models take in the recent soundings and begin making millions of calculations to predict what the atmosphere will look like in the coming hours, typically out to two days. Once the model predictions are made they are put on the computer networks for dissemination to local forecasters. Local forecasters use the model predictions in a variety of ways: to help fuel the forecaster’s intuition, as input to rules of thumb developed for a particular forecasting task, or as input for yet another computer model.

Cranberry Forecasts

Back when I was youngster and Len Purvis was raising mink instead of cranberries, a U.S. Weather Bureau (as it was called then) fellow named Jim Georg, who apparently loved frost and/or hated winter, would to come to Wisconsin to do cranberry forecasts in summer, then move to Florida to do citrus frost forecasts. Georg and some UW-Madison folks, perhaps Champ Tanner and Vern Soumi, also did some field research to help refine methods for cranberry weather forecasts. I know that a few growers recall some of this, and I would like to visit with you so that I can write a record of the work.

The forecasting method Georg and company developed was used during the following decades by the Weather Bureau and successor National Weather Service (NWS). At the heart of the method were two tables of likely bog temperatures, one as predicted by dewpoint temperature and expected cloudiness, and the other as predicted by the amount of water in the atmosphere (called precipitable water) and the air temperature at 850 mb pressure (about 3/4 of a mile above ground level). Use of these tables required forecasting dewpoint, clouds, precipitable water, and temperatures in the atmosphere. This step originally was largely based on forecaster judgment, but decades of advances in meteorology, such as large computer models, offer great help nowadays.

New Tools

The opportunity that we saw for improving cranberry weather forecasts was based on two tools that had not been fully applied to the problem: GOES and ASOS. GOES is the satellite that provides your TV weather forecaster with the pictures of clouds that he or she shows each night. As an aside, the late UW-Madison Professor Vern Soumi is generally considered the father of the GOES system Perhaps you have seen advertisements for UW-Madison during televised sports events in which we claim to have invented weather satellites. This is largely true, and refers to Soumi's pioneering work.

The Automated Surface Observation System (ASOS) and its cousin the Automated Weather Observation System (AWOS) are just now coming into operation. The first priority of these stations is landing airplanes, which seems right if you're flying in an airplane, but can be frustrating if you are interested in other uses of weather data, like growing food. Figure 1 is a map of ASOS and AWOS locations in Wisconsin. There appears to be reasonable coverage of the state by these automated weather stations, and there is a crew of federal employees driving around doing maintenance on them. We should work darn hard to be sure that we fully exploit the potential usefulness of these stations before we resort to routinely operating our own observation network. The continuing support of the cranberry industry for our research weather stations is critical to our efforts to learn more about the applicability of this new federally-operated network.

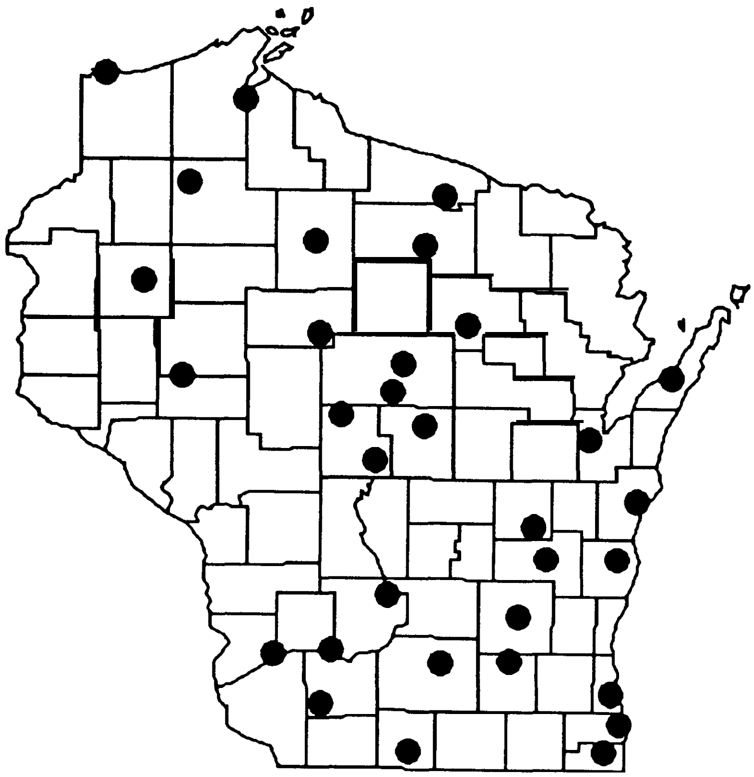

Figure 1. Locations of ASOS and AWOS stations in Wisconsin.

The TiSDat Forecast

Like everyone else, we start with a sounding, specifically the "12Z", which is made at noon in Greenwich England, which is about 7 am here in the summer. It takes several hours to get the data gathered and the NWS computer model results out to us in Madison.

At this point the other folks working on this project at the Space Science and Engineering Center of UW-Madison take the NWS model results and feed them into what is called a mesoscale model (named CRAS), which attempts to simulate conditions over North America in greater detail than did the NWS models. Forecasts from CRAS then move by computer network to the Soil Science Building and to one of our computers, which runs another model, CranEB. Now CranEB operates at the cranberry bog scale--we run it for a handful of locations in WI, including the two sites (Cranmoor and Manitowish Waters) where we have 30 foot-tall towers to take measurements just as they are made at ASOS stations. Our first forecast comes out about lunch time.

Instead of just forecasting the minimum temperature, we draw a graph of what the temperature will be through the night (Fig. 2). We create graphs for what the model thinks will be the cloud conditions, and for the case if the model is wrong about clouds and skies will be clear. Often, the model predicts clear skies so the two lines are the same. In the figure, clear skies were forecast until just after midnight, when the clear and cloudy forecasts become different.

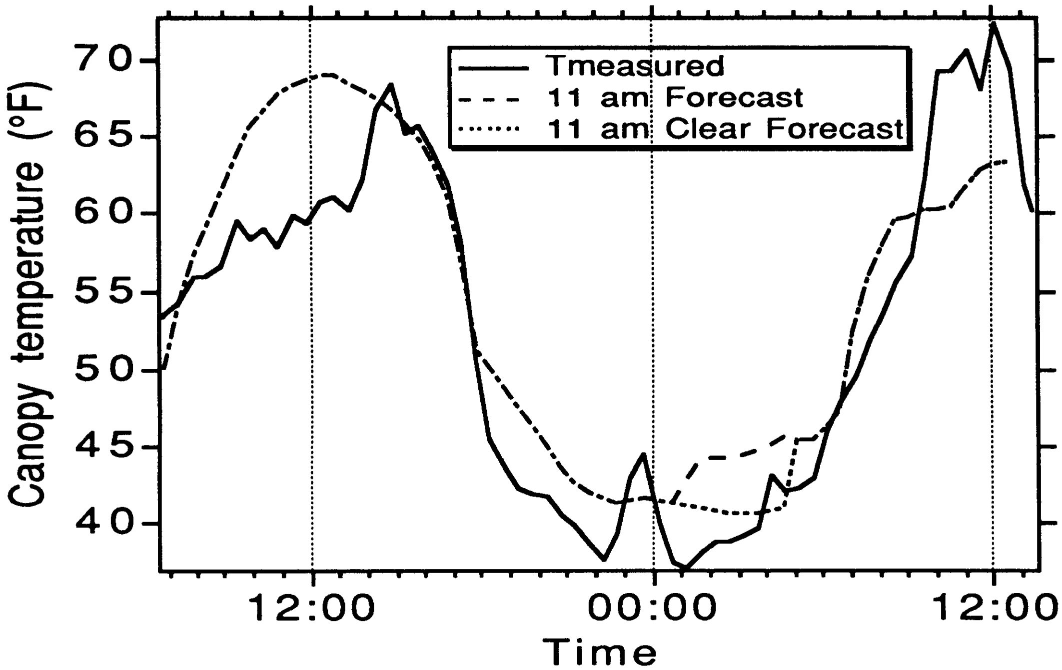

Figure 2. Example forecast made by the TiSDat system during Fall 1996.

In addition to temperature, we also predict wind--you really can't do temperature without wind, and you know from experience how closely the two are connected. The marsh environment is an unusual situation, with large expanses of very smooth areas and bumps with roads where we are allowed to put our instruments to measure the wind. We are confident that our wind forecasts can be improved.

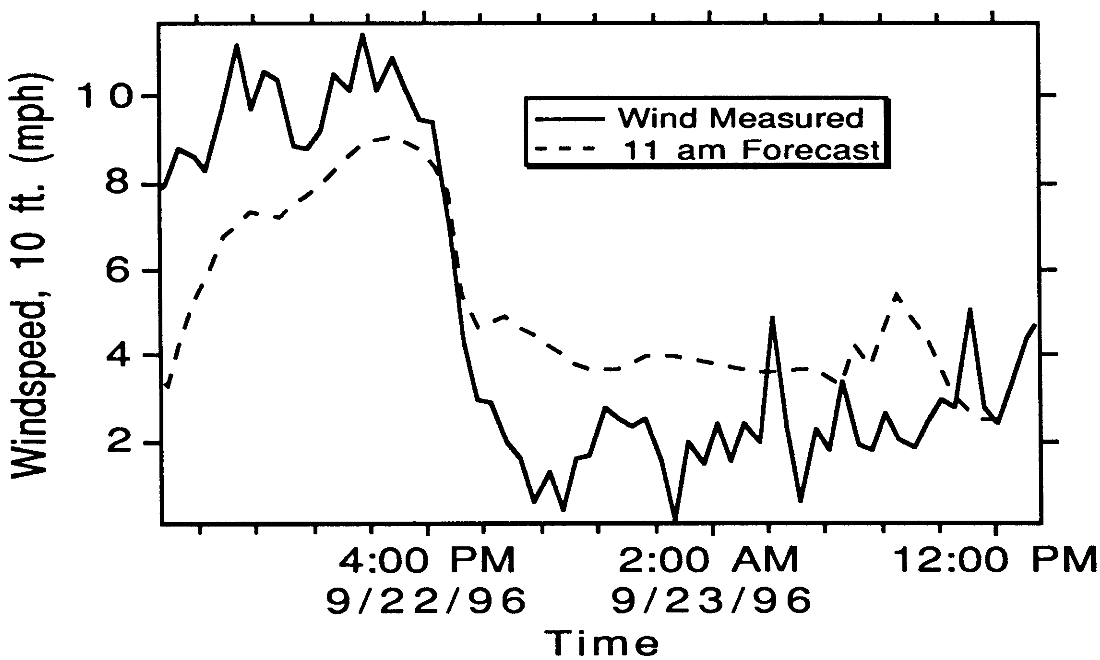

Figure 3. TiSDat automated forecast of the wind at 10 feet above the crop surface.

Through last summer and fall we steadily improved our models by changes and additions in the basics--not by tweaking to match a particular measurement. Ultimately, will need to do some plain-old fudging, but we are still making the model as sound in principle as we can.

Comparison With Conventional Forecasts

The Wisconsin Cranberry Growers Association contracted with a private forecasting firm, American Weather Concepts, for forecasts during last summer. Figure 4 compares our results to theirs for August and September, for days when either a forecast or an observation was below 4O°F.

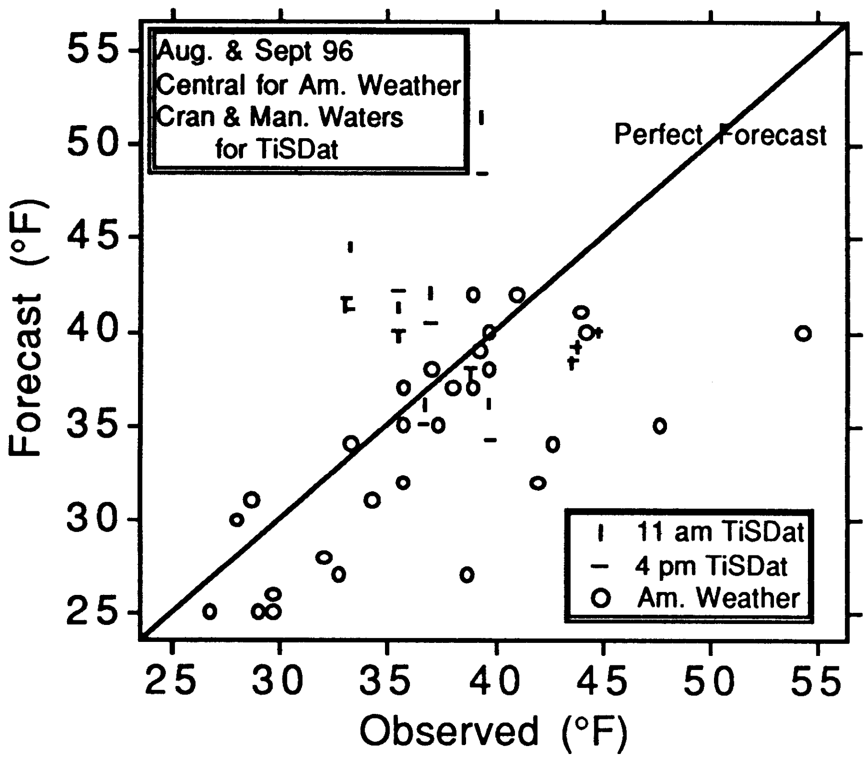

Figure 4. Comparison of TiSDat automated forecasts with convention forecasts made by American Weather Concepts (AWC). The diagonal line is where a point representing a perfect forecast would fall.

Figure 4 shows that AWC did a good job on many days, and tended to be conservative on other days--that is they sometimes predicted colder temperatures than were observed. In contrast, TiSDat tended to make the opposite and more dangerous mistake often--not predicting cold enough. On some occasions the updated forecasts made later in the day were closer to the observed than the first forecasts. The updating system in use during this period was only a portion of the final system that we envision.

In summary, the current TiSDat system cannot do any better than conventional forecasts, which AWC does well. We believe that the great virtues of our experimental system are in correcting the situations in which conditions changed substantially after the conventional forecast was made. Updates will be possible through use of automated observations, both on Earth and from space, and the speed and convenience of the World Wide Web.