

The UW Cranberry Frost Forecasting System

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Introduction

Over the last two years, we have been developing an automated frost forecasting system for cranberry producing regions in Wisconsin. This system is unique in that it utilizes current weather observations from weather stations and satellites to update the initial forecast on an hourly basis. This research has been conducted as part of a project called TiSDat (Timely Satellite Data for Agricultural Management), funded by NASA under an initiative to provide increased public access to satellite data. It is a particularly timely issue now, as the National Weather Service discontinued its support of agricultural forecasts of this type in 1996.

The specific goals for this frost forecasting project are threefold. First, we strive to provide, in a timely manner, reliable forecasts of weather conditions relevant to protection against frost damage in cranberry bogs. These conditions include overnight vegetation temperatures and wind speeds. Second, we provide real-time forecast updates throughout the evening using the most recent weather measurements available. Finally, we provide easy access to these forecasts through the World Wide Web.

In this paper, we give a brief overview of the model used to make the forecasts and how it operates in practice. Forecast accuracy is compared with measurements made in two cranberry-growing regions in Wisconsin, and improvement through updates is demonstrated. We also provide a brief introduction to our cranberry forecast Web site.

Cranberry Bog Forecast Model

At the core of the TiSDat frost forecasting system is a computer model of energy transport in a cranberry bog microclimate. This model takes information from a regional forecast of weather conditions at 80 ft above the bog and scales these conditions down to bog level; conditions such as temperature, humidity, wind speed, and radiant energy from the sun and clouds. This scaling takes into account properties specific to the bog environment: the perpetually-saturated soil conditions, for example, and the thick mat of old vines beneath the new green vegetation that intercepts most of the incident radiant energy before it reaches the soil.

The model produces time traces predicting the evolution of air temperature, dewpoint and wind speed just above the bog throughout the course of the night. Most importantly, it predicts the overnight temperature course of the cranberry vines themselves. These bog forecasts yield advance warning of crop-damaging temperature

conditions, along with an approximate time when minimum temperatures will occur overnight. The bog-level wind forecast can aid in making decisions concerning appropriate frost damage prevention measures.

Model Operation and Updating

The TiSDat cranberry forecast and forecast-updating system has been set up such that it runs automatically, with little human intervention beyond standard quality control. Initial conditions and updated weather observations are downloaded over the Internet as soon as they become available to assure that the forecasts and updates appear on our Web site in a timely fashion.

Currently, the upper boundary conditions in temperature, humidity and windspeed for our cranberry bog forecast model are provided by the CIMSS Regional Assimilation System CRAS, a regional forecast model run and maintained by the Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison. The first CRAS forecast for the day is available at approximately 10:30AM CST. A cranberry bog forecast is then generated for specific cranberry-producing regions in Wisconsin; currently we are focusing on the areas around Cranmoor, Manitowish, and Shell Lake. These initial daily forecasts typically appear on our Web site by 11:00 AM.

As the day progresses, these initial bog forecasts are repeatedly compared with the most current observations of local weather conditions (obtained through the National Weather Service and the state Department of Transportation) and cloud cover conditions (obtained through the GOES weather satellite). If the forecast and observations begin to deviate, the forecast is adjusted to reflect the newly-developing conditions and new time trace plots are transmitted to our Web site.

Most important to overnight bog-level temperatures, and perhaps most difficult to forecast in the long-term, is the development and propagation of regional cloud patterns. A sudden clearing of the sky overhead can result in a rapid drop in near-surface temperature of several degrees. Assimilating cloud cover information from current satellite images significantly improves the accuracy of our minimum temperature forecast. As an extra precaution, we always generate two forecasts: one assuming our current best guess at cloud development overnight, and another assuming the skies will be completely clear. The clear-sky forecast represents the worst-case scenario in terms of minimum overnight temperatures.

Forecast Verification

To aid in assessing the accuracy of our forecasts, we installed automated weather station towers in two cranberry bogs in Wisconsin: one in Cranmoor and one outside of Manitowish. These stations record half-hourly measurements of temperature, humidity and windspeed at two heights above the bog, and temperatures within the cranberry canopy itself. They also record downwelling solar and infrared radiation, important inputs to the model; the latter quantity relates to the amount of cloud cover present.

Comparisons between model predictions and measurements taken at our bog towers over the past growing season confirm the value of the updating system we have implemented. The accuracy of our initial forecast at 11AM is comparable to that obtained by American Weather Concepts (based on their statistics from 1996). Our forecast accuracy improves steadily throughout the course of the day.

Figure 1 demonstrates the updating system in action. The input CRAS forecast predicted cloudy skies over Cranmoor on May 14th 1997, when in fact it was clear that night. The cranberry forecast therefore predicted an overnight minimum bog temperature that was approximately 3° F too high. The 6PM GOES satellite image showed that this region was much clearer than initially forecast. The input CRAS forecast was statistically adjusted to reflect these new cloud conditions, and the bog model was rerun -- this updated forecast predicted a much better minimum temperature. The forecast continues to improve as the evening progressed -- by 8PM it was virtually perfect.

Web Access to the TiSDat Cranberry Forecast

Cranberry growers in Wisconsin can access the TiSDat cranberry forecast on the World Wide Web through our home page at <http://www.soils.wisc.edu/wimnext/>. Follow the link here labeled "Cranberry Bog Temperatures" and select the growing region of interest. We hope to expand this list of supported regions in the near future.

You are now on our cranberry forecast page. At the top of the page we let you know when the current forecast was produced and when you can expect our next update. Directly below this is a plot showing the current temperature forecast. The plot shows time traces of predicted temperature in the bog and at 5 ft above the bog. You have the option to overlay all measurements that have been collected up to the time of the current update.

Below this, you can view a forecast of an additional weather variable. Currently, you can choose between wind speed and dewpoint. By displaying wind speed, for example, you can easily determine what the winds will be like during the times a critical temperature threshold will be exceeded.

Conclusions

In conclusion, the UW frost forecasting system is unique in that it uses real-time surface and satellite weather observations to provide hourly improved forecasts of overnight frost conditions. The model outputs a full time trace of predicted temperatures and wind speeds throughout the evening, rather than just one, isolated minimum overnight temperature prediction. This should help growers in scheduling their frost protection activities. Access to the forecasts is fast and easy -- all forecasts and updates are published on the World Wide Web. User feedback on our homepage format is most welcome and encouraged! Send comments via the email link on the cranberry forecast page.

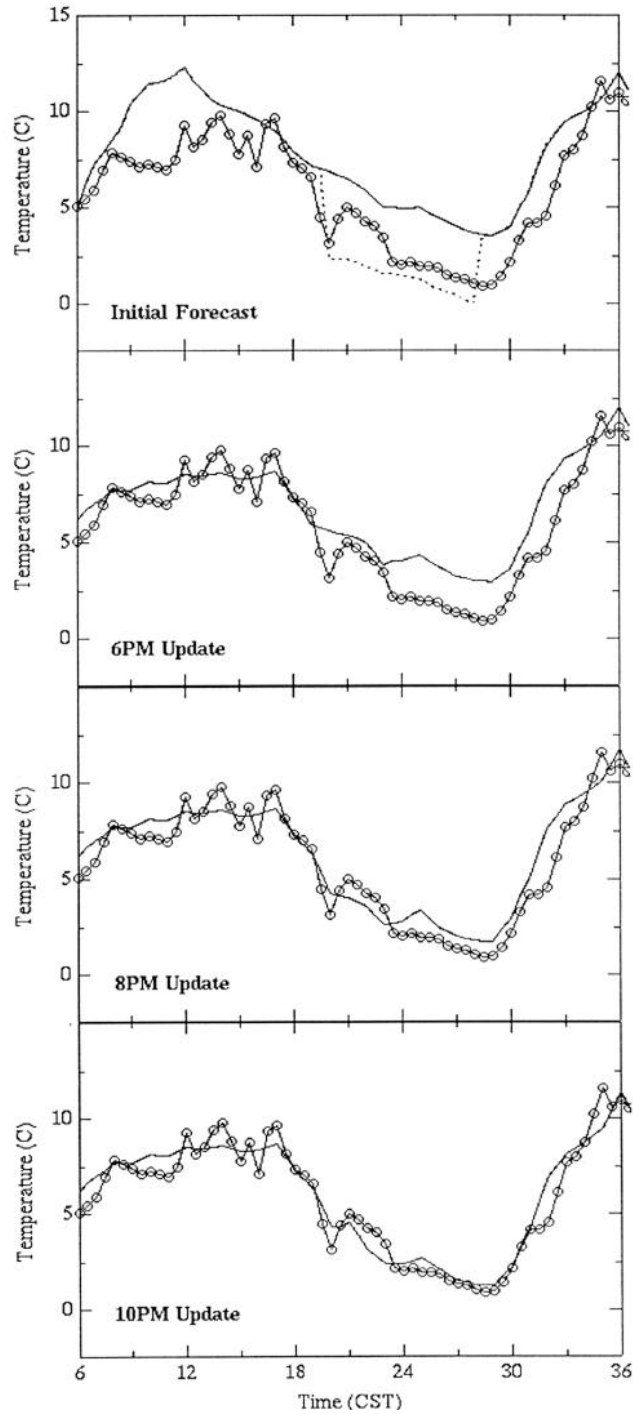


Figure 1: Effect of updates on minimum temperature forecast accuracy. Circles indicate measurements of bog temperature made with our automated weather station at Cranmoor; solid lines indicate the updated forecast at the time specified. The dotted line in the first frame shows a forecast assuming the skies will be clear overnight.