

Operation of Live, Local Weather Information in Decision-Support Tools for Agriculture

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Abstract

Local, real-time weather information is important for day-to-day agronomic management of all crops. The challenge for agriculture is twofold in that local and timely weather data is not often available for farmers, and it is not integrated into decision-support tools to support agronomic planning.

Many of the traditional sources of weather information are not sufficient for agricultural applications because of the long distances between weather stations, meaning the data is not always local and applicable for on-farm evaluation and resulting operational decision processes. The second constraint with traditional weather information is the timeliness of the data. Most delivery systems are designed on a one-hour time step, whereas many decisions in agriculture are based on minute-by-minute weather conditions. This is especially true for optimizing agrichemical applications and determining the extent and severity of frost events.

This whitepaper will outline how the creation of an agricultural mesonet (weather network) can empower farmers with live, local weather information from weather stations and other sensors installed at the farm level. The real-time weather information collected from each weather station is integrated into a Web-enabled decision-support tool, providing detailed weather information affecting numerous on-farm agronomic activities such as pest management or dealing with heavy rainfall and frost events. Agronomic or decision-support tools can be used, for example, to assess the potential of disease pressure, enhance the farmer's abilities to time pesticide applications, or assess conditions contributing to crop yield and quality fluctuations. This turnkey weather system also enables farmers and industry stakeholders to view quality-assured historical weather variables at any location. This serves as a record-management tool for viewing previously uncharted agronomic weather events in graph or table form. This set of weather tools is unique and provides a significant enhancement to the agronomic decision-support process.

Some of the direct benefits for farmers can take the form of increased yield and grade potential as well as savings in money and time. Pest management strategies become more efficient due to timely and localized disease and pest modeling and the increased efficacy of pest and weed control. Examples from the Canadian Wheat Board WeatherFarm™ program integration with the Canadian WeatherBug Network will be utilized to illustrate the processes, decision-support tools and benefits to farmers.

Introduction

Environmental observations play a critical role in serving many national and regional interests. However, there are significant gaps and deficiencies on a national and regional basis worldwide for weather monitoring capabilities that expose vulnerabilities in public safety and national security as well as inhibit the realization of substantial economic benefits. Meteorological observations on the mesoscale are of greatest importance as evidenced by the fact that the vast majority of severe weather impacts and related life and property losses are associated with mesoscale events such as tornadoes, thunderstorms, fronts, squall lines, etc. The creation of a mesonet, or an integrated network of real-time weather stations, provides for timely, relevant weather information critical to the regional and local area of application.

For agriculture, the implementation of a mesonet within a particular local region of a country provides farmers with access to local surface observations, enabling more efficient operations and improved agronomic decisions. Weather stations installed directly within various field types collect live surface observations relevant to that particular growing field, enabling truly localized weather intelligence and improved decision-support tools for optimal agronomic decisions.

The Application of Agricultural Mesonet

Timely weather information over the entire growing season is crucial for many of the agronomic management decisions made on farms. The creation of a mesonet or expansion of an existing weather network through the integration of current localized weather intelligence can provide multiple benefits:

- Accurate disease and pest modeling from local and live data
- Effective timing of pest and weed control with real-time weather information and accurate forecast information
- More effective and timely soil fertility applications by monitoring weather and soil moisture conditions
- Efficient irrigation operations through improved soil moisture monitoring and irrigation scheduling

However, traditional weather data has not been integrated into decision-support tools that farmers and agricultural retailers can use. Often the sources of weather information, such as traditional weather stations, are not always local or timely, which can make the data inaccurate or irrelevant.

Agricultural Mesonet Case Study: WeatherFarm™

Weather events play a major role in the productivity and financial stability of farmers. Accurate, up-to-the-minute, local weather information had been largely unavailable to Canadian Prairie¹ farmers. For example, timely information on local weather data would help farmers assess wind conditions when applying expensive farm chemicals, improve predictions for crop yield and enhance recordkeeping for identifying weather-related farm management problems. The need for improvement and availability of agricultural mesonets for enabling decisions based on live local weather information is well documented and compelling.

In the past, farmers have relied on weather data gathered at airports or towns that are typically not in close proximity to the farms. The farm may be 50 to 80 kilometers (km) away from an airport or town weather station, resulting in poor agronomic decisions because of the lack of local weather data. For example, a decision may be made to apply a pesticide, herbicide or fungicide to a field that may be more than 10km away from the actual farm site. If a farmer has loaded the chemical and made a trip to the field and then determines that the wind is too strong for an application, this has wasted time and money. With highly granular data from a well-placed weather station within a mesonet, the farmer will have the hyper-local information necessary to make intelligent decisions.

Weather Perils...The Day That the Frost Came

In August 2004, the Canadian Wheat Board (CWB)² reported that crops were delayed in development because of cooler than normal temperatures over much of the growing season. On 20 August 2004, a severe killing frost occurred, which was much earlier than normal. As the cereal crop was at a vulnerable stage in the growth cycle, heading to filling, this weather event led to a sharp decline in the quality profile of the crop for that year. Usually frost events of this magnitude occur in the first two weeks of September for most of the Canadian Prairies, but during this event the actual temperatures reached -6 to -8C and covered a much larger geographic area than normal. The best available information at the time indicated that temperatures reached 0 to -1C over much of the region, with pockets reaching -1 to -3C. This missed the actual minimum temperature of -3 to -8C. In addition to minimum temperatures, the duration of the frost event is important in determining the amount of damage done to a cereal crop. This information was not readily available at the time.

¹The Canadian Prairies occupy vast areas of the Manitoba, Saskatchewan and Alberta provinces.

²Controlled by Western Canadian farmers, the CWB is the largest wheat and barley marketer in the world. One of Canada's biggest exporters, the Winnipeg based organization sells grain to more than 70 countries and returns all revenue, less marketing costs, to farmers.

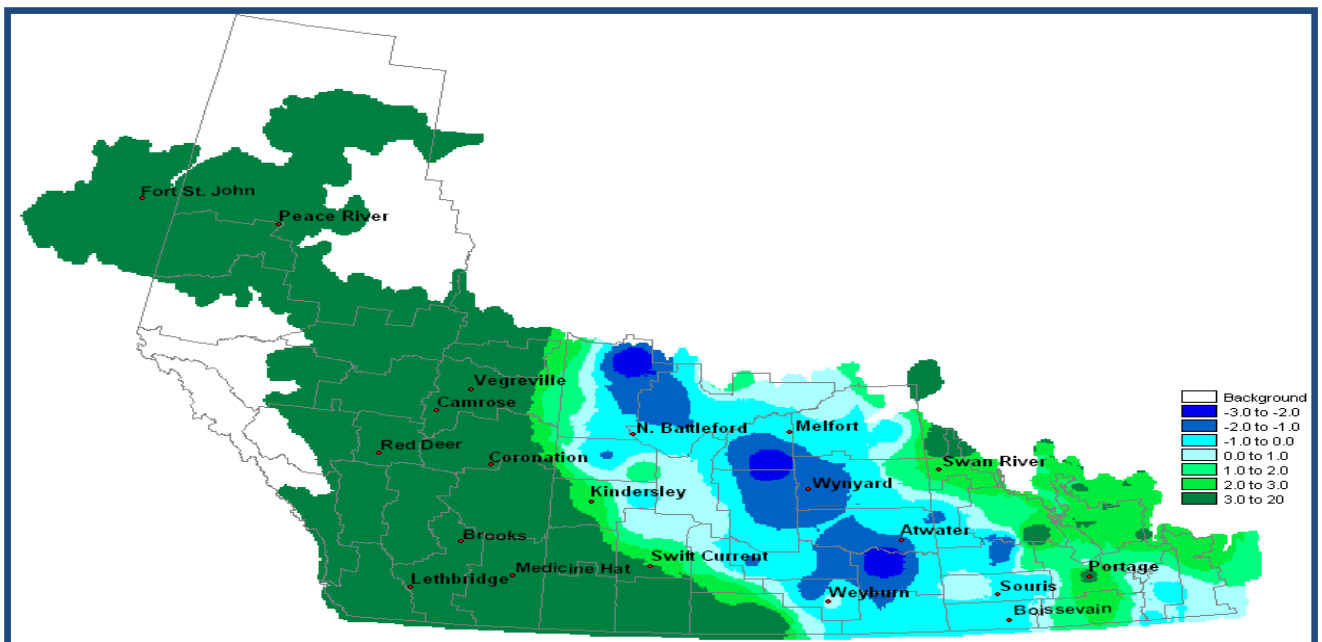


Figure 1: August 20, 2004 – Minimum temperatures reached in Western Canada region.

Lack of Information Has Critical Implications

The implication for Western Canadian farmers of this severe killing frost was a significant loss of income based on yield loss and, more important, a reduction in grade quality. Total lost income has been estimated in the tens to hundreds of million dollars at the farm gate. In field crops such as cereals, it is not possible to protect against frost damage, such as is the case in higher cash value crops. In this case, real-time local weather information would have provided the farmer with the ability to manage the crop differently based on knowing the level of damage and with a record of the weather events that could perhaps be used in a crop insurance claim.

This incident made it clear that there was a critical need for an agricultural mesonet that would deploy a higher density of live weather stations to relate screen temperatures to actual field conditions and enable farmers to be better prepared for future events. In addition, higher frequency of data transmission was needed to evaluate damage in real-time and determine its extent.

The Canadian WeatherBug Network (Mesonet)

In 2007, WeatherBug, the CWB, Richardson International and other businesses partnered to create the Canadian WeatherBug Network, the largest private weather network in Canada, designed specifically to meet the business needs of the farming and agribusiness community in Canada. This network is composed primarily of solar-powered weather stations purchased by farmers for on-farm installation. Today, the Canadian WeatherBug Network encompasses 780 on-farm live weather stations, interlinked via the Internet to other stations deployed by grain industry companies, schools, businesses and government agencies.



Figure 2: The data is provided in real-time, historical or metadata format through various feeds and through Web, mobile-enabled and desktop applications.

This Prairie-wide weather network throughout Western Canada complements the existing Environment Canada weather network with additional key elements. It forms an agricultural mesonet that transmits and integrates live weather information every few minutes and is used to power weather-based agronomic decision-support models and maps to meet the needs of farmers and agri-retailers across Western Canada.

Deploying On-Farm Weather Stations to Create Agricultural Mesonets

Traditional weather stations are 50 to 80km apart and only report once per hour, which can pose a critical issue in managing events such as spray decisions and makes it impossible to get accurate wind speed readings. Optimized spraying requires accurate updates on information including wind speed and direction; these updates should be made on a minute-by-minute basis. For many farming applications, the distance between weather stations needs to be 20km or less for accurate farm-level information.

With a solar-powered wireless weather station of ground sensors located at the edge of a field, farmers have access to current weather information beyond the shelterbelt, delivered to a dedicated display unit located in the farm office. This display provides accurate wind speed, humidity and temperature information to make operational decisions related to planting, spraying or harvesting.

A typical on-farm installation has the weather station sited away from obstacles such as trees, shelterbelts and grain bins. This is done with a wireless repeater that is usually installed in the farmyard. The weather stations have standard



installation specifications for all sensors, such as temperature measured at 1.2 meters and the wind speed/direction at 3.4 meters.

Additional sensors for factors such as soil temperature and moisture, leaf wetness, and UV and solar energy can be added. Commercial-grade stations are also available that can be combined with cameras and lightning detectors.

Figure 3: A typical on-farm installation. All sensors, including the weather station, update every 2.5 seconds utilizing the Internet; weather data is stored in servers in Washington, D.C. Photo source: Canadian Wheat Board.

WeatherFarm Online Information Center

In December 2009, the Canadian Wheat Board launched a new producer-oriented website or portal known as WeatherFarm that provides farmers with detailed local weather information gathered from the 780 on-farm weather stations that make up the Canadian WeatherBug Network. The WeatherFarm portal, which is enabled by the WeatherBug Command Centre³, provides farmers with live local weather data, growing degree days, frost reports and market information. In addition, farmers have access to historical data, forecast information and severe weather warnings from any of the on-farm WeatherBug weather stations in the established mesonet. The online information

³The WeatherBug Command Centre is a weather intelligence portal providing visualization of relevant observational values, forecasts, maps, station-by-station weather alerting, and weather-related news links and feeds. Critical operational data and custom content is integrated into the portal, providing on-line communities with a valuable resource tool for day-to-day decision making. Customized forecasting from WeatherBug Meteorological Services can also be added to the portal information. The content and design can be modified for specific business needs.

center captures additional information from the WeatherBug Network to provide intelligence from satellite and Doppler radar downloads, deliver warnings from Environment Canada, create local forecasts and plot weather variables over a period of time.

In addition, WeatherFarm applications provide critical weather intelligence that enables farmers to accurately:

- Identify optimal spray conditions using temperature, humidity and potential rainfall
- Document spray drift situations relative to wind speed and direction
- Predict crop diseases and insect infestations
- React to frost events according to their severity
- Assess conditions for seeding

Farmers also have access to a variety of data-management and decision-support tools for crop management, including pest management models, maps and modeling tools for growing degree days⁴ (GDDs), frost severity, fusarium, wheat midge, sclertonia, and more graphing and charting applications.

WeatherFarm also features the expansion of the WeatherBug Total Lightning Network™ into Western Canada. The network provides advanced forecasting of severe weather phenomena such as tornadoes, damaging downburst winds and cloud-to-ground lightning strikes. It uses advanced lightning sensors that detect not only cloud-to-ground lightning strikes but also intracloud strikes that often precede cloud-to-ground strikes.

How WeatherFarm Works

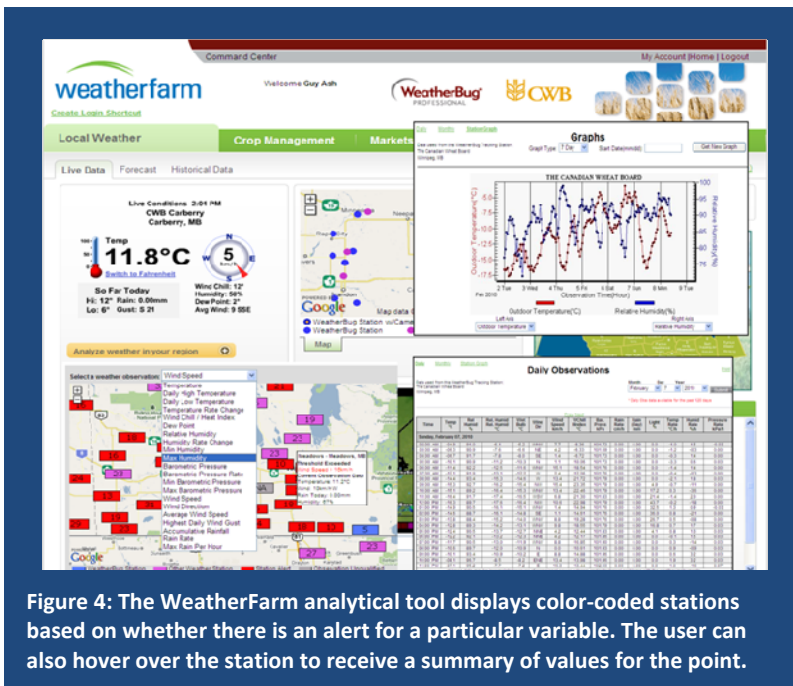


Figure 4: The WeatherFarm analytical tool displays color-coded stations based on whether there is an alert for a particular variable. The user can also hover over the station to receive a summary of values for the point.

Access to WeatherFarm is free to all farmers and agriculture retailers in Western Canada. As stated above, farmers have access to more than 780 on-farm and retail weather stations, plus an additional 200 government stations across the Prairies.

Farmers are not required to own a weather station in order to use WeatherFarm, but may simply select a weather station closest to their location as their home station. The interface is tab-driven, utilizing intuitive major tabs and subtabs to organize information such as forecast or historical data. Users can also change their home station at any point, which is important since this is what the decision-support tools are based on. Some other features include geo-targeted watches and warnings from Environment Canada, news feeds, and maps.

⁴ Growing degree days are a measure of heat accumulation used by farmers and agronomists to predict crop growth and stage of development

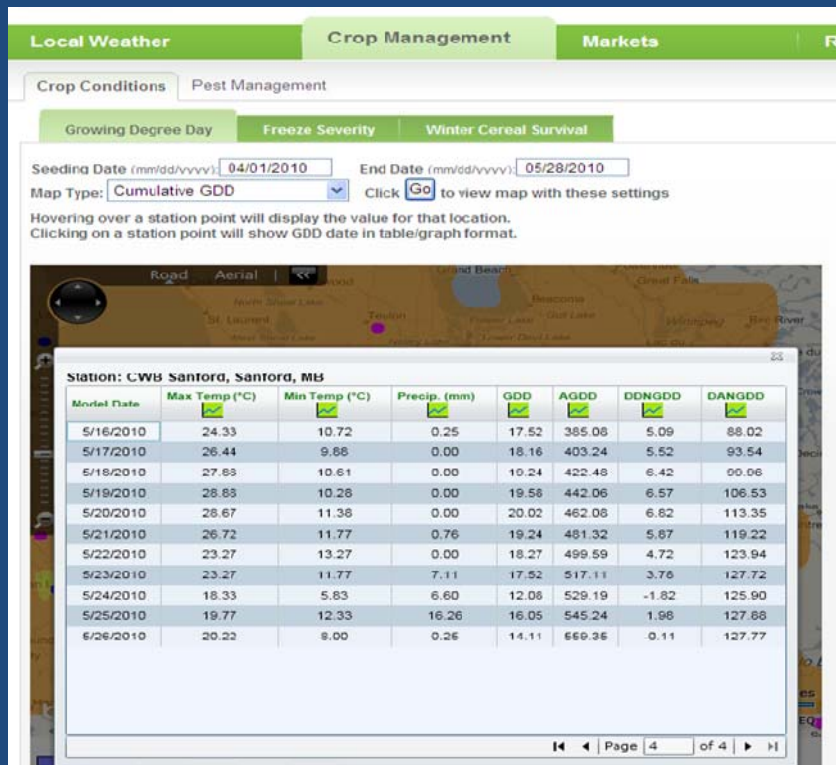


Figure 2: This table provides a daily summary of information from the user-defined seeding date and includes the maximum and minimum temperature, precipitation, daily GDDs, accumulated GDDs, departure from normal GDDs and departure from accumulated normal GDDs.

WeatherFarm Analytical Tools

With the ability to access any one of the 950-plus weather stations across the Prairies, farmers can view graphs for any station and select one of 21 variables to plot that information instantaneously on a map – the map is centered based on the home station. See Figure 4.

WeatherFarm Decision-Support Tools for Agronomic Models

The first model in WeatherFarm to have field-level functionality is the local cumulative growing degree model. The Prairie-wide GDD map still remains, but the user has an option to choose the local GDD map, which is centered around a home station.

WeatherFarm also has models for fusarium, wheat midge and sclerotinia that are based on a Prairie-wide view.

The farmer can choose from the cumulative GDD or departure from normal GDD map for his or her region. The farmer may also input seeding date and end date, typically the most recent day, and simply click the GO button to generate the local map. The GDD model is based on work from Agriculture and Agri-Food Canada and the University of Montana and is a base 0C model.

The farmer can hover over each station and see the accumulated GDDs to date. The user can also zoom out on the local map to view the entire Prairie region, which can be based on any seeding date. See Figure 5. If a user clicks on the station, a table of data is presented. See Figure 6.

The WeatherFarm unique growth-stage model is an improvement over current growing-degree-day tools, which are not customizable by seeding date and region. The growing-degree-day models will continue to be enhanced in future releases with the

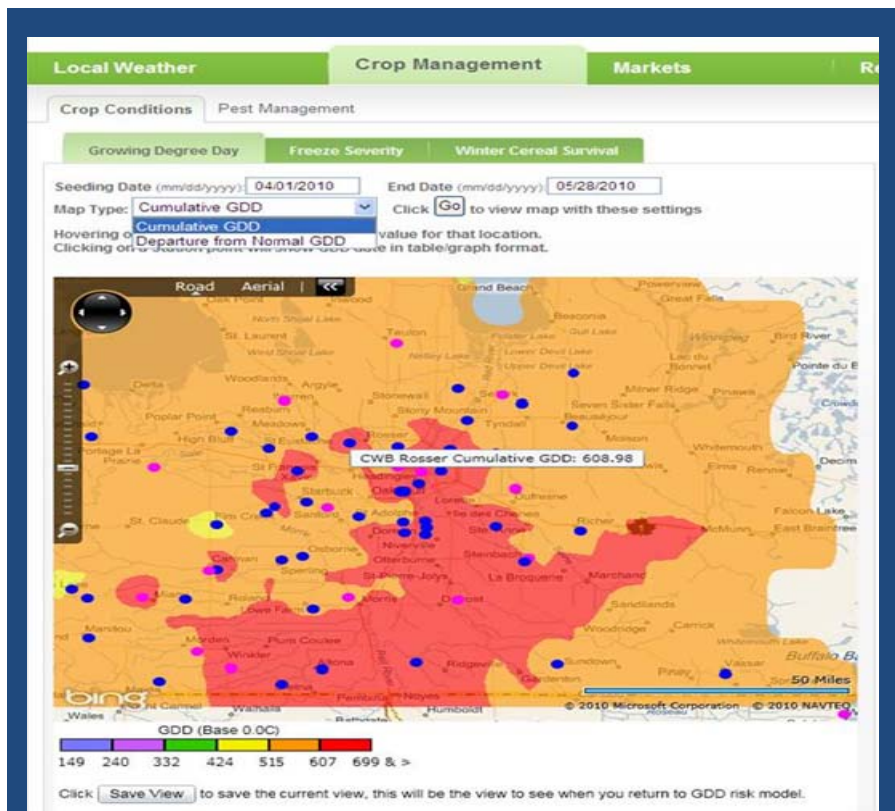


Figure 6: When a farmer clicks on the local GDD map, he or she is presented with a 60km by 60km region around the home station – this represents the typical growing region and area of interest for a farmer.

addition of more crops and increased functionality.

WeatherFarm development will continue with additional agronomic support tools to help farmers manage pests and disease, and to increase the effectiveness of their agronomic decision-support process. Upcoming features include enhancements to models for wheat midge and fusarium.

The Canadian WeatherBug Network and WeatherFarm are now on track to revolutionize the way weather information is gathered, shared and used in Canada by farmers, media, businesses, government and the public. It is not intended to replace Environment Canada; it is meant to enhance the services of the agency. The Prairie-wide scope of the CWB has made this possible, along with the technology and innovation of WeatherBug. Farmers and the agricultural industry have worked together to build a weather network that is specifically focused on the needs of the wheat growers — this is the future of weather information.

The WeatherFarm community continues to expand quickly, with more than 8,500 farmers and agri-retailers registered as users since its launch in December 2009.

Conclusion

Few occupations depend more on having timely and accurate weather information than farming. A whole set of agronomic decisions that growers need to make every day are highly weather dependent. Whether spraying, seeding or making countless other agronomic decisions, growers need the ability to integrate live weather intelligence into pest models, integrated pest management practices, yield/quality models and precision farming practices.

The creation of an agricultural mesonet (weather network) with integrated online tools can equip farmers with live, local weather information from weather stations installed in farm/field locations, resulting in tremendous cost savings and direct benefits to growers such as the potential to increase yield and increase efficiencies. Pest and weed management strategies become more efficient through delivery of timely and localized disease and pest modeling. With weather stations installed at a field level, growers have access to 27 different measurements of local, real-time information including air temperatures, precipitation, wind speed and direction, and humidity, which are vital for day-to-day management decisions.