Agricultural Applications of North Dakota Agricultural Weather Network

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ABSTRACT

The North Dakota Agricultural Weather Network (NDAWN) consists of 70 automated weather stations distributed among prime agricultural locations across North Dakota, the Red River Valley, and border regions of surrounding states. The NDAWN Center is a part of the Department of Soil Science, North Dakota State University. The NDAWN stations measure wind speed and direction, air temperature, rainfall, solar radiation, pressure (32 stations), atmospheric moisture and soil temperatures under bare and turf at 10 cm (4 inch) depth. The center provides daily summaries consisting of maximums and minimums as well as time of occurrence, and various totals or averages for all variables in English or metric units. Measured and calculated variables along with complete descriptions are available. The NDAWN Center web site: http://ndawn.ndsu.nodak.edu/ allows direct access to NDAWN data in various special and temporal scales. The voice modem accommodates those who do not have internet access. The NDAWN Center has assisted many North Dakotans in making weather critical decisions concerning their crops, livestock, and livelihood. One direct benefit of NDAWN data was helping to save the 1993-94 potato crops in North Dakota. The stations provide weather data, which was instrumental in developing an agricultural model called the late blight model. This model predicts when leaf disease can occur in potato plants. Late blight doesn't occur in North Dakota every year and is prevalent during cool and moist periods of weather. In 1993-94, this model predicted that late blight would occur and growers were able to use fungicide applications to prevent the disease. Another direct benefit of NDAWN data is that it provides universities and the National Weather Service with an additional database for research and forecasting applications. Agriculture remains the number one industry in North Dakota and its success will always be dependent on the weather.

Keywords: Agricultural Weather, Automated Weather Monitoring, Agro-Climate, NDAWN , North Dakota, Weather.

INTRODUCTION

Measurement systems for agricultural applications have been implemented in many parts of the world (Sivakumar, 1994), whereas automated weather monitoring was widely published (Akyuz et. al., 2000, Snyder et. al. 1996, Sivakumar, 1994, Hubbard et al. 2000). Agriculture is the leading industry in North Dakota. Twenty-five percent of North Dakota's economic base is production

NDAWN: North Dakota Agricultural Weather Network agriculture with close to 24% of its population employed in agriculturally related fields. The North Dakota Agricultural Weather Network (NDAWN) was developed as a valuable tool for agriculture. The primary benefit of this weather station network is to use the data to develop an array of agricultural models. The models help producers make timely decisions to keep crops healthy and increase their yield. These decisions save producers both time and money.

The NDAWN was established through a grant from, and in cooperation with, the High Plains Regional Climate Center (HPRCC) , Lincoln, Nebraska in 1989. Originally the network consisted of 6 automated weather stations located at North Dakota State University (NDSU) Research and Extension Centers. Our objective was, and still is, to provide current weather data (yesterday's data today) necessary for the development of, and operational use of various crop, insect, and disease development models. However, before agricultural models could be developed detailed hourly weather data were necessary. In the early 1990s numerous Red River Valley Potato growers and some agribusinesses associated with the potato industry were the first to invest in this venture. They collectively provided grants to purchase and operate 7 more stations in the northern Red River Valley. During the mid 1990s more stations were also added to all NDSU Research and Extension Centers and other state and federal research sites. Today there are 70 identical automated weather stations distributed throughout North Dakota and its neighboring states. Figure 1 shows the location of the stations in the network as of August 2008. Station names coincide with the nearest town and are labeled with its distance and direction from the nearest town. For example, Rolla 2S is the NDAWN weather station located 2 miles (3.2km) south of Rolla, North Dakota, USA.

Since its inception in 1989, all equipment, non-labor operational costs, and some labor costs have been funded through gifts and grants from various federal and state agencies, commodity organizations, agricultural clubs, businesses, and individuals. In addition, current web site development which allows us to disseminate these valuable data free of charge was funded through a federal agency grant. North Dakota State University funds 4 full-time employees operating the NDAWN Center; the director, a network engineer, a data manager and a computer programmer.

The stations measure air temperature, relative humidity, wind speed, wind direction, solar radiation, station air pressure at 32 stations (not adjusted to sea level), rainfall, and soil temperature under a bare soil surface and under a turf covered surface. The stations also keep track of maximum and minimum air temperature, maximum wind speed, and the times they occur. Calculated variables include potential evapotranspiration, dew point temperature, wind chill temperature, heating and cooling degree days, and numerous growing degree days. Departure from normal (1971-2000 average) temperature or rainfall data are also available. The normal temperature and precipitation values were

HPRCC: High Plains Regional Climate Center
NDSU: North Dakota State University

interpolated from National Weather Service (NWS) Cooperative stations. A complete list of variables can be seen from the following link: http://ndawn.ndsu.nodak.edu/help.html?topic=datainfo#vardefs

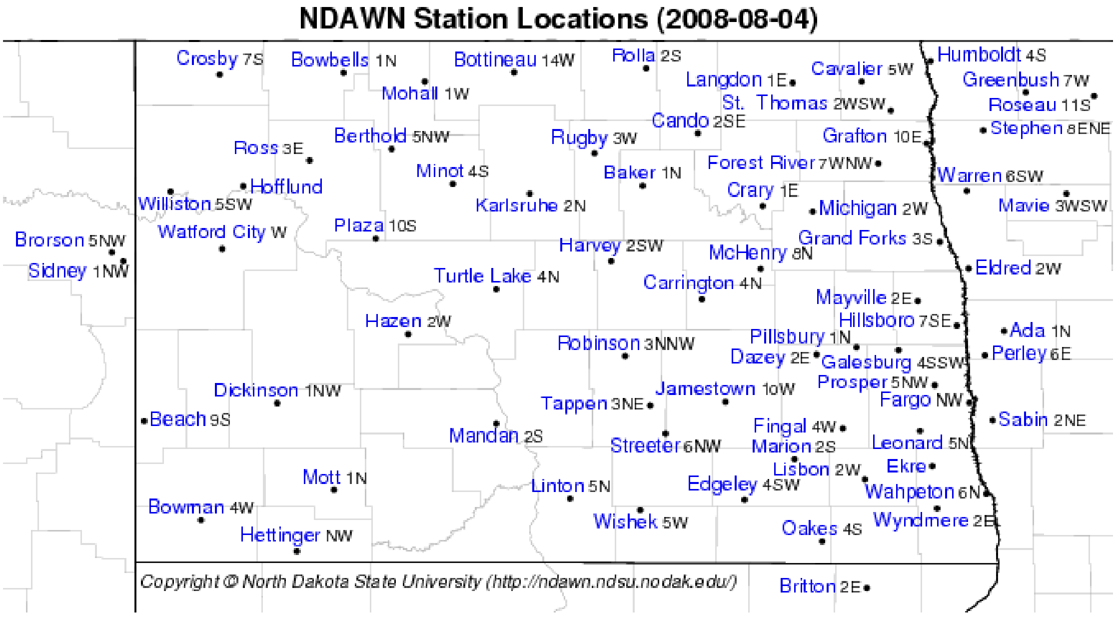

Figure 1. North Dakota Agricultural Weather Network (NDAWN) station locations in North Dakota, USA.

MATERIALS and METHODS

Data Access: The data is accessed each morning daily by a central computing system in the High Plains Regional Climate Center (HPRCC), Lincoln, Nebraska via telephone line. Each weather station has its unique telephone number. In addition to daily downloading of the data, users can call the weather station via dedicated number to get latest (last 10-min) weather conditions from the station's voice modem. The voice modem converts the data in text format into speech format for the end-user to hear.

Quality Assurance: Data quality has the highest priority in the operation of the North Dakota Agricultural Weather Network. In order to prevent erroneous data from being released to the public, two data quality control procedures are completed daily. There are several ways the data from an automated weather network can be checked in an automated fashion (Akyuz et. al. 2001).

Once the daily data is downloaded by the HPRCC computing system, it goes through a series of automated Quality Checking (QC) algorithm (Hubbard et. al., 2005). If erroneous data is detected, it is flagged for further action. The data manager can decide whether to accept the data or replace it with an estimated value. If the data is estimated, its value is displayed preceding a letter "E" indicating that

NWS: National Weather Service
QC: Quality Checking

the value is estimated. After the data is QC'd in HPRCC, it is transferred to the NDAWN Center for a secondary QC and eventually to input for agricultural applications.

The secondary QC occurs every Monday through Friday morning, except holidays. The NDAWN data manager compares all estimated data to the original erroneous or dubious data to determine the cause of the problem so it can be fixed as soon as possible. At the same time data from all stations are visually compared to those from nearby stations in order to identify suspicious or erroneous data that the computer program cannot detect. In addition, average weekly and monthly data are similarly compared to identify possible calibration or other problems. If these checks identify erroneous or dubious data, they are estimated.

NDAWN stations are visited at least once each year for preventive maintenance, inspection, and calibration. All sensors are checked and/or replaced for refurbishment or recalibration according to manufacturer specifications and/or our strict preventive maintenance schedule. When daily quality control identifies a malfunctioning sensor the station is visited as soon as possible to repair or replace it.

Agricultural Applications: NDAWN was developed to collect weather data to be used in the development and implementation of certain agricultural applications such as; crop, insect, disease, irrigation scheduler and other models. Many models are currently available on the NDAWN web site: http://ndawn.ndsu.nodak.edu/help.html?topic=homepage.The crop related models include applications for barley, canola, corn, potato, sugarbeet, sunflower, wheat, and small grains. General agricultural and other applications available on the web site are crop water use, insect development, heating/cooling degree day, and the irrigation scheduler. As research continues, more models will be developed and added as a valuable resource for all.

Specific Applications:

Canola: Menu expands to "Sclerotinia Risk" and "Degree Days" and "Growth Stage".

Sclerotinia Risk: Link to web site for sclerotinia risk maps and more;

Degree Days & Growth Stage: Displays data request page for a "Table" or "Map" of canola growing degree days and estimated growth stages.

Corn Degree Days: Displays data request page for a "Table" or "Map" of corn growing degree days.

Potato Late Blight: Displays maps or tables of potato late blight severity values, favorable days, or "P-Days".

Sugarbeet: Expands to "Degree Days" and "Growth Stage" and "Cercospora Infection Values".

Degree Days & Growth Stage: Displays data request page for a “Table” or “Map” of sugarbeet degree days and estimated leaf stage.

Cercospora Infection Values: Displays data request page for “Map” of “Cercospora Infection Values” or “Tables” of “Favorable Days” and “Cercospora Infection Values”.

Sunflower Degree Days: Displays data request page for a “Table” or “Map” of sunflower degree days and/or estimated growth stage.

Wheat: Menu expands to “Degree Days” and “Growth Stages”, “Disease Forecaster”, and “Wheat Midge Degree Days”.

Degree Days & Growth Stages: Displays data request page for “Tables” or “Maps of “Wheat Degree Days”, and “Estimated Haun Growth Stages”.

Disease Forecaster: Link to “Small Grain Disease Forecast” system for scab, septoria, rust, and tan-spot diseases.

Midge: Displays data request page for a “Table” or “Map of “Midge Growing Degree Days”, “Wheat Growing Degree Days”, or “Estimated Haun Growth Stage”.

Small Grains: Link to “Small Grain Disease Forecast” system for scab, septoria, rust, and tan-spot diseases.

Crop Water Use: Provides options to view maps or tables of crop water use for potato, corn, dry beans, wheat, barley, sugarbeets, soybeans, sunflower, alfalfa, and turf grass for a number of preset emergence dates. Other page options include a total rainfall map since April 15th and a crop water deficit map.

Insect Degree Days: Displays data request page for an Insect degree day table with base temperatures of 40, 45, 50, 55, 60, and 65°F (4, 7, 10, 13, 16, and 18°C).

Heating/Cooling Degree Days: Displays data request page for a Table of heating and cooling degree days with base temperature of 65°F (18°C).

CONCLUSION

NDAWN has become a valuable regional resource and so far only a fraction of its potential has been realized. These data have become part of the North Dakota climatological archive and will become more valuable as the period of record grows and/or new applications are discovered by scientists in all fields. Timing of these applications is a direct economic gain and environmentally friendly. The authors encourages adaptation of networks with similar applications be implemented to assist farmers and decision makers throughout the world so that agricultural applications are all scientific and not guess-work.

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