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OPERATIONS OF THE JOINT USDA/OCE/WAOB AND MSU/DREC AGRICULTURAL WEATHER AND DATA CENTER

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1. INTRODUCTION

The Mississippi State University (MSU) Delta Research and Extension Center (DREC), located in Stoneville, Mississippi, is situated on one of the largest agricultural experiment stations in the world. The crop research area covers about 4,200 acres, including acreage for forest, aquaculture, and row crop research. Field plots occupy about 1,600 acres, with soil types ranging from very fine sandy loams to heavy clays. Over fifteen government, state, and public organizations are involved in agricultural research and production at DREC, whose primary area of coverage is the 18 countywide area of the state called the Yazoo Mississippi Delta. In particular, DREC cooperates with researchers at the neighboring USDA/ARS Jamie Whitten Delta States Research Center in Stoneville, to maintain a research program aimed at solving crop and aquaculture production problems.

In May 1998, a Weather/GIS Data Center was established at MSU/DREC in order to meet the local demands for adequate coverage of vital agricultural weather information required in research and production agriculture. The main mission of the Data Center is to ensure the collection and archival of vital agricultural weather data in the Mississippi Delta for local researchers and farmers.

Coincidentally, at the same time, the USDA/ Office of the Chief Economist/ World Agricultural Outlook Board (USDA/OCE/WAOB), with the support of Congress, embarked on a program to build a National Agricultural Weather Observing Network (NAWON). One of the main objectives of NAWON is to deploy weather instrumentation at carefully selected agricultural sites, especially in areas where NWS information is not available. The need for agricultural weather data and information in the Delta, along with a lack of adequate coverage of agricultural weather instrumentation, led to the establishment of a WAOB field office in Stoneville, in October 1998, as part of NAWON. A partnership between the WAOB and DREC was established, with the WAOB field office co-located with the DREC-Weather/GIS Data Center. The purpose of the joint Data Center is to collect, quality control, and manage agricultural weather data and make it available to the state, government, public, and private sector. Although the overall goals and objectives of these two institutions are similar, the primary emphasis of the DREC-Weather/GIS section is to serve the local needs for agricultural weather information and services in the Delta, while the primary emphasis of the WAOB field office is more regional in scale, relating to the goals and objectives of NAWON. As a result, WAOB partnerships with other institutions engaged in agricultural weather activities and climate services have grown to include USDA's Natural Resources Conservation Service (NRCS), the states of Missouri, Alabama, and Iowa, and the Regional Climate Centers (RCC's). At the same time, WAOB continues to work closely with the NWS to support the modernization of the crucial Cooperative Observer (COOP) Network, to ensure continuity in the national surface observation network.

The purpose of this paper is to describe the operations of the joint WAOB and DREC

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Agricultural Weather and Data Center, including: (1) the current automated weather station (AWS) network in the Delta, (2) the agricultural weather data collection and distribution process, (3) the products and services that are being provided from the joint Data Center to the various user communities, and (4) the research and education extension of the Data Center's information.

2. DELTA WEATHER NETWORK

One of the primary responsibilities of the joint Agricultural Weather and Data Center is to operate and maintain an AWS network, mainly in the Delta. The AWS network has grown from one automated site in 1998, to a total of 15 sites at the present time. The AWS network consists of eight Campbell Scientific sites, and seven sites from the Soil Climate Analysis Network (SCAN). The Data Center also collects daily COOP weather data from a National Weather Service (NWS) station that is located on the DREC site. Additional COOP data for locations in the entire state of Mississippi, including the Delta, are obtained from the Southern Regional Climate Center (SRCC). A county-level map for the state of Mississippi that displays the locations of the Delta weather network sites is shown in Figure 1. Regarding the MSU automated sites, only those five sites that report measurements on a regular basis are shown on the map.

The Campbell Scientific sites are comprised of both farmer-donated weather stations and sites purchased for special monitoring projects by Mississippi State University or one of its collaborators. All of the stations utilize data loggers designed by Campbell Scientific, Inc., but are not all identical. For example, the network contains CR10, CR10X, 21X, and CR7 data loggers. All of the sites are equipped with an ambient temperature probe, precipitation gauge, and an anemometer. Furthermore, most of the stations record humidity, solar radiation, wind direction, and soil temperature at multiple horizons. Measurements from these sites are transmitted to the Data Center through telephone lines. One additional site, located on an aquaculture pond, monitors water temperature at three depths.

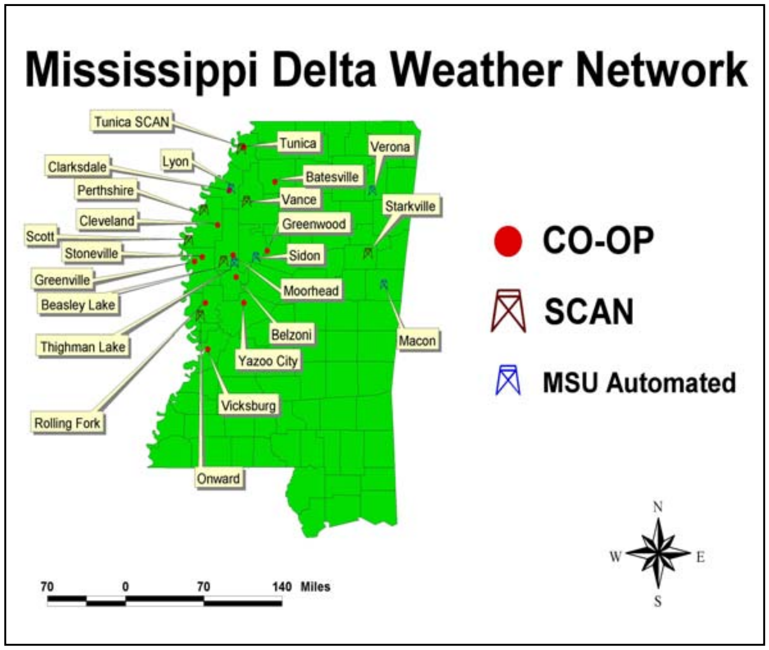

Figure 1. Mississippi Delta Weather Network.

Since September 1999, six SCAN weather stations have been installed in the Delta, as well as one additional site on the main campus of Mississippi State University in Starkville. These SCAN sites were installed through partnerships between the USDA/WAOB, USDA/NRCS/National Water and Climate Center (NWCC), DREC, and local producers. Data loggers enable the use of a variety of sensors at each site. The automated SCAN weather stations measure precipitation, temperature, relative humidity, wind speed and direction, solar radiation, atmospheric pressure, and soil moisture and soil temperature at various depths (Figure 2). The SCAN network uses meteor burst communication technology to transmit data in near real-time from the remote SCAN sites. The USDA/NRCS/NWCC administer the SCAN network. The Delta SCAN sites are part of a national automated soil-climate monitoring network currently being developed by the NWCC. The SCAN focuses on agricultural areas in the United States, where coverage of agro-meteorological data such as soil moisture and soil temperature data is sparse or non-existent.

3. DATA COLLECTION AND DISSEMINATION

The methods for collecting the agricultural weather measurements from the various remote automated weather sites vary, depending on the communication type. The Campbell scientific sites

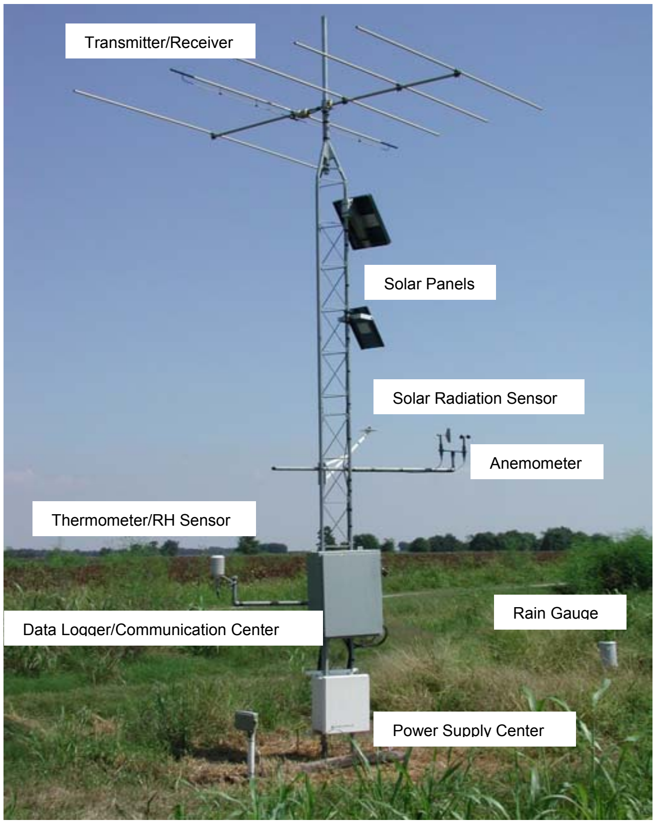

Figure 2. SCAN Site.

are equipped with standard telephone modems that are contacted automatically with the use of Campbell Scientific, Inc. (CSI) software PC208W. The data collection process starts a little after midnight, and the data are stored as a comma delimited file. Once the data are downloaded, a SAS program, set to run automatically, picks up the data files, manipulate the files, and save each of the data sets to two servers in a set format designed to be picked up by the MSU-Extension Service (MSU-ES) server around 4:00 a.m.

Data from the SCAN sites are collected in near-real time with the use of a master station communications facility. Meteor burst communications was first developed by the U.S. military in the 1950's and was implemented by NRCS in mid-1970 for use in the SNOWpack TELemetry (SNOTEL) network. The SNOTEL network, also operated by NRCS/NWC, is a high elevation climate monitoring system in the West, used to forecast stream flow volumes to assess water availability. Meteor burst communications uses the ionized gas trails that are left behind by the billions of small meteoroids that quickly vaporize as they enter the earth's atmosphere each day. These ionized particles reflect radio signals that can be bounced off the gas trail and reflected back to earth (see Figure 3). This technique allows for communication between a remote site and a master collection station up to 1200 miles away (Schaefer and Peatzold, 2000). There are a total of seven master stations that are located throughout the country that receive data from the SNOTEL and SCAN networks. In a cooperative effort between USDA, DREC, and Meteor Communications Corporation, Inc., a meteor burst master communication facility was established on DREC land in Stoneville. This master communications facility (meteor burst master station) is currently operational, and is being used to collect weather data transmitted from the Delta SCAN sites as well as other SCAN sites nationwide.

SCAN sites transmit data every hour by VHF radio signals that are bounced of the gas trail and reflected back to the master station in Stoneville. At the master station, the data are checked for completeness. If complete, an acknowledgement message is sent back to the remote site instructing it not to transmit again until its next schedule time. All three transmissions take place in less than a tenth of a second. From the master station, the data are sent via telephone line to the NWCC Central Computer Facility. The NWCC decodes the hourly data and places it on a MSU server and also posts the data on the NWCC web site at www.wcc.nrcs.usda.gov/scan/.

DREC begins processing the archived SCAN data on the MSU server around 2:00 am, similar to the way it processes the data that is collected by the Campbell Scientific sites. The SCAN data on the

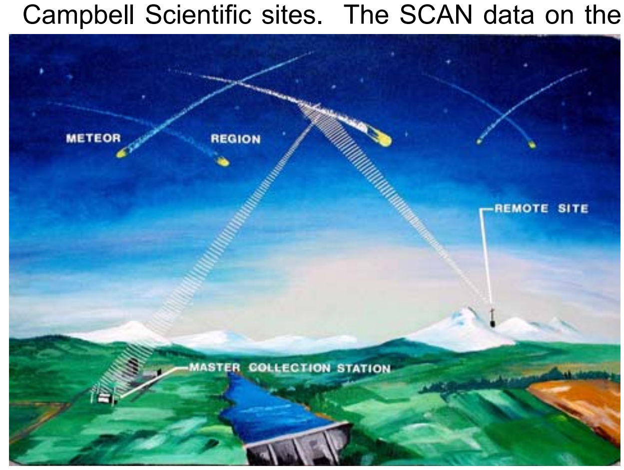

Figure 3. Meteor Burst Communications.

MSU server contains thirty days worth of 24-hour data for each SCAN site. Once the files are located on the archive server, PC208W initiates the batch processing of the SAS program that summarizes the data into one daily file for each SCAN site and saves it on the two servers located at DREC. These files are then placed on the DREC web site www.DeltaWeather.MsState.Edu.

The weather data collected from the Stoneville Cooperative Observer site is collected both manually, and using the AWS format with telephone connections. The manual collection format requires the data to be collected each day at 7:00 a.m. central standard time (CST), including weekends and holidays. The data is sent to the NWS using a touch-tone telephone and the Remote Observation System Automation (ROSA) system. Each of the manual weather instruments on the COOP site is complemented with an electronic instrument that records data at several intervals with the aid of a CSI CR7 Data logger. The collected daily data is recorded and downloaded in order to supplement and backup the manually read weather observations. The portions of the AWS data that are sent to the NWS in the monthly COOP data include solar radiation and humidity data. A majority of the hourly data is not available on the Internet, but archived locally. Through cooperation with the Southern Regional Climate Center (SRCC) in Baton Rouge, Louisiana, the past 10 days worth of 24-hour (COOP) data for the state of Mississippi are sent to the Data Center by e-mail around 11:00 am each day. These data include the morning's 7:00 a.m. readings from the Mississippi Delta area COOP stations that include maximum and minimum air temperature, and total precipitation. Also, the University of Missouri provides weather data for eight automated stations in the Missouri Bootheel.

4. PRODUCTS AND SERVICES

The joint DREC and WAOB Agricultural Weather Data Center provides numerous products and services to researchers, producers, county extension agents, and agricultural industries in the Delta and nationwide. Such products and services include: weather and climate data, geographic queries, crop progress information, products developed using Geographic Information Systems, and weekly weather briefings. Weather data and products are provided to the user community in several ways. The primary mechanism used to disseminate the Delta weather data is through the DREC – Weather/GIS web site, while the WAOB field office web site is used to disseminate the table of weekly "Weather Data for Mississippi and the Missouri Bootheel". To date, over 350,000 users have visited the DREC Web site to access Delta weather data and products. The Data Center also handles numerous requests for information related to climate services, including temperature and precipitation data, wind data, average first and last frost or freeze dates, solar radiation, and pan evaporation data. A contribution to the monthly MSU-Extension Service (ES) agriculture newsletter also distributes data and information to users.

The DREC web site allows users to interactively select Delta weather data by selecting the station of interest, and entering the desired time period. The period of record for which data are available varies by individual station. Weather data for those stations that have a 30-year normal is also available for comparison. Once a station and date are selected, the user is given the choice to view individual data parameters, or the entire summary data set. There are also several pre-set reports available for selection such as a degree-day heat unit report.

The DREC - Weather/GIS Data Center also produces several agro-meteorological products that are derived from weather data and prior research on crop phenology. Crop growth simulation models are available for rice and cotton. A Rice DD50 model is a program that interactively "grows" a rice crop based on accumulated heat units (derived from temperature data) that are related to the crop's phenological development. From the web site, growers can choose their individual counties and varieties of rice to obtain information on stages of crop development as well as crop management recommendations. For future dates, the program uses 30-year normals to finish growing out the crop until a predicted harvest date. This helps farmers anticipate growth stages for planning future management decisions in order to increase revenues and/or decrease losses. Researchers and Extension personnel also use this program to complete comparative variety studies and aid in diagnosing problems in clients' fields.

Research experiments from 1993 through 1996 resulted in a new MSU recommendation being introduced into the cotton production industry in the Mississippi Delta. This MSU-ES recommendation, called the "Node Above White Flower Five Rule" (NAWF5), calls for the collection of DD60 heat unit data after a cotton plant reaches a certain growth stage. When a field of cotton reaches NAWF5, this denotes the last effective bloom population that will significantly increase yield, thus the last bloom population that is economically feasible to protect from insects. This recommendation requires watchful monitoring of the cotton plants when nearing maturity by researchers and producers to identify that date at which a flower blooms on the fifth node (branch) from the top of the plant (terminal). From that date, the cotton boll that is made from that flower needs 350 Degree Day Heat Units based on 60 degrees Fahrenheit (DD60s) to become large enough to be safe from certain insect damages. At the point in which a certain amount of heat units are accumulated, certain crop damaging pests are no longer a threat and thus no longer in need of being controlled. As a result, applications of pesticides for certain pests can be terminated (Harris, et al., 1997), thus saving the producer as well as the environment an average of two insecticide applications. Since the benefits from this recommendation require a researcher or producer to keep a watch of each field and variety, the recommendation suggests obtaining data from a nearby weather station or extension office (Cochran, et al., 1998) to aid in the determination of cotton development.

Planting recommendation reports are also available on the DREC - Weather/GIS Data Center's web page. The MSU-ES recommends time windows for planting crops. Some of their recommendations are base on weather scenarios. Planting recommendations for corn and soybeans are based on 30-year normals, and are used for the timing "trigger" as when to plant. MSU-ES's current recommendation is plant as early as you want depending on the amount of risk you want to accept for the chance of frost or freeze each crop can withstand. Available on the DREC web site are 10%, 50%, and 90% chance of frost/freeze maps.

The cotton planting recommendation is based on soil temperature. When soil temperatures reach a certain level in the spring, producers are advised to plant cotton when there is an accumulation of fifty DD60s in the next 5 days. These calculations of future heat units are needed to ensure that soil temperatures will remain at favorable levels for seed germination. To calculate these future heat units, forecasted model output of temperature data from the National Weather Service's medium range forecast model is used for locations in Mississippi as well as surrounding states. The 5-day forecasted maximum and minimum temperatures from the model are downloaded and placed into a database. The DD60 data are calculated from the forecast temperature and stored in the database. Using Geographical Information System (GIS) software, contour maps of the DD60 data are then generated on a map of the state of Mississippi. The data are separated into three gradations as to "Favorable", "Marginal", and "Unfavorable" to plant cotton for the day. The map is re-drawn nightly and the gradations move from south to north as the temperatures increase in the spring until statewide soil temperatures reach favorable levels for cotton planting.

Data from the automated and manual weather stations in the Delta are disseminated though the DREC web site. In addition, the WAOB Stoneville field office routinely compiles a table of regional "Weather Data for Mississippi as well as the Missouri Bootheel" for weekly publication in the *Weekly Weather and Crop Bulletin* (*WWCB*), a joint effort between the USDA and the U.S. Department of Commerce. The table provides station data from 8 automated weather stations in the Missouri Bootheel, 12 NWS CO-OP stations in the Delta, 5 Campbell Scientific automated stations in the Mississippi (3 in the Delta), and 7 SCAN stations in Mississippi (6 in the Delta). Data parameters in the table include average maximum and minimum temperature (in degrees Fahrenheit) for the week, average temperature, extreme high and extreme low temperature, cumulative precipitation (in inches) for the week, quarter, and year, weekly average maximum and minimum 4" depth soil temperatures, and episodic events. Furthermore, average temperature departures from normal as well as percent of normal precipitation are computed for those stations that have 30-year normals. A brief summary of Delta weather and crop conditions is also included in the table. This table is also provided through the WAOB field office web site at www.usda.gov/oce/waob/mississippi/fieldoffice.html

In September 2001, USDA's PC-based version of the Advanced Weather Interactive Processing System (AWIPS) was implemented (Rippey et al. 2000) at the field office. The field office uses the PC-AWIPS system to provide weather information to local researchers and farmers. Furthermore, the AWIPS system is used to supply valuable input into a weekly weather briefing that is e-mailed each Thursday to about 130 local users in the Delta. The briefing contains weather and crop information for the local Delta region, including local rainfall, air and soil temperature data, USDA/National Agricultural Statistics Service (NASS) crop condition reports, and NWS forecast information.

5. RESEARCH AND EDUCATION

Researchers at both DREC and the neighboring USDA/ARS Research Center use the Delta agricultural weather data and climate information to determine the agronomic and environmental factors that influence crop yield and development. Some recent examples are research on the yield benefits of early cotton planting (Pettigrew, 2002), and research on weed management systems for soybean production (Heatherly et al. 2002). The knowledge obtained from such research is transferred to the producers in the Delta through the Extension Service, in the form of recommendations on crop production. The information from the Data Center is also vital to research on irrigation scheduling and planting recommendations. In addition, to collecting and providing agricultural weather data from the AWS network, the Data Center helps set-up instrumentation to collect microclimate weather variables in research fields. Examples are measurements of soil temperature to correlate with weed and wild host plant emergence and measurements of within-canopy air and soil temperature as it relates to cotton grown under different irrigation and tillage environments. Producers are educated on the results of this research through newsletters, publications, "Field Day" demonstrations, and personal contact by extension county agents and specialists, as well as through products developed by the DREC – Weather GIS Data Center. Furthermore, the Data Center has a strong working relationship with MSU's Department of Geosciences, routinely exchanging weather data and ongoing research. The Department provides input into the weekly weather briefings prepared at the Data Center.

6. CONCLUSION

The joint USDA/WAOB and MSU/DREC Agricultural Weather Data Center provides agricultural weather data and services that are vital to the local Delta community. The growth of the AWS network of Campbell Scientific and SCAN sites has helped to fill some of the gaps in the weather data requirements of both researchers and producers. By providing the agricultural weather data and derived products over the Internet in near real-time, The Data Center assists producers in making timely management decisions to help mitigate the effects of adverse weather on crop production, or to lower production costs due to untimely use of crop promotion and protectant applications. The Data Center also has a regional focus, through existing partnerships with other state, public, and government institutions engaged in agricultural weather activities and climate services.

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