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FUTURE FREEZE FORECASTING

J. F. Bartholic, R. A. Sutherland, *Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida*

Florida

ABSTRACT

Real time GOES thermal data acquisition, an energy balance minimum temperature prediction model and a statistical model are incorporated into a minicomputer system. These components make up the operational "Satellite Freeze Forecast System" being used to aid NOAA, NWS forecasters in developing their freeze forecasts. The general concept of the system is presented in this paper. Specific detailed aspects of the system can be found in the references cited.

INTRODUCTION

Better weather information is becoming increasingly important with high energy costs. The computerized "Satellite Freeze Forecast System" is a new forecasting tool which will aid the National Weather Service (NWS) forecasters significantly in providing better freeze forecast information for Florida and ultimately other areas in the United States. The present development activities grew out of research started in 1972. It became clear as the program progressed that remotely sensed aircraft and satellite information was an extremely valuable tool on freeze nights. In January 1976, the first nearly real time use of surface temperature satellite data was undertaken. The many groups involved NASA with financial, technical and personnel support; NOAA personnel from the Environmental Sciences Service Center at Auburn, Alabama; from the National Environmental Satellite Services (NESS); from the NWS in Ruskin, Florida and from the Institute of Food and Agricultural Sciences, University of Florida [Bartholic and Sutherland (1976), Sutherland and Bartholic (1977)]. The results of this intense satellite study on a freeze night showed clearly a potential for developing an operational satellite freeze forecast system. Development of that system officially started in May 1977 when NASA provided equipment and a contract to support development of this system at the University of Florida. The hardware was delivered to Gainesville on 1 July 1977. The system was first tested this past winter at Ruskin with the National Weather Service to aid them in developing their freeze forecasts. An updated version is being used to aid forecasters this winter.

Growers of citrus, vegetables, ornamentals, cattle, and

nearly all home owners in Florida take freeze protection action. Citrus growers alone can burn from 4 to 6 million dollars of fuel in a single, very cold night. Growers can make better decisions and frequently may fire for fewer hours on freeze nights with the improved information and, subsequently, better forecasts provided by this "Satellite Freeze Forecast System" (SFFS).

New Freeze Forecast Methods

The software (programs) used in the system to allow the computer to aid the forecaster will be discussed, then the hourly sequence of events that occur on a cold night as the satellite freeze forecast is developed will be described and finally, how this system will aid forecasters and, consequently, those needing better freeze forecast information will be discussed.

Figure 1. A photograph of the system.
A. the Hewlett-Packard 2100 MX Minicomputer
B. the random access disc storage
C. the electronic equipment that converts the amplitude modulated satellite signal as it comes over the phone lines to a voltage that can be converted by an A to D converter in the computer
D. the modem complex which allows a number of people to call the system and input to receive data over the phone lines
E. the color display which shows satellite derived temperature patterns of Florida in vivid colors
F. the terminal that allows the forecaster to interact with the system: (Jane Langford, a Computer Programmer is at the console)

Computer Programs

The system is capable of running a number of programs. Some are called up automatically on a time base such as those to handle the satellite data. Numerous others can be called easily from the terminal by the forecaster (Figure 1). These programs all reside on discs so they are rapidly accessible. The programs can be modified in real time, if necessary. This means that the system can easily continue to evolve over the next few years.

Forecasting Sequence

The system and forecaster will follow the following process during each hour from approximately 6 p.m. on. The satellite scans the surface of the earth with a heat-sensing detector. The signal that comes from that detector is sent to antennas in Washington. The signal is then taken into computers where it is corrected for temperature calibration and satellite orbit considerations. In the present case, the signal goes over phone lines from Washington to Miami, then to the freeze forecast system in Ruskin, Florida. The satellite scans over a period of approximately 20 minutes. The SFFS at Ruskin continually monitors the line to detect the signal when it starts. It then automatically keeps track of the signals that come across the phone line -- over 1,200 scan lines in all. The lines are counted until the area with Florida is obtained. Then, the signal is digitized and stored. The forecaster then sees the satellite temperautre picture of the Georgia, Alabama, and Florida area in color on his TV screen. Each color represents approximately 2°F (Sutherland, et al 1979). Thus, he has a complete temperature picture for the entire surface of the southeast at approximately 20 minutes after the hour.

The forecaster sits at the terminal and receives information from 12 key locations around the state while information is automatically going into the computer. This information from around the state includes inversion air temperatures, soil temperatures, wind speed and direction, dew point and net radiation. These are typed onto a form which automatically appears on the CRT tube of the display. These temperatures are then entered into the computer and used in a physical heat balance model. A model is used to calculate the temperatures expected for the rest of the night at each of the 12 key locations. These predictions are portrayed back on the terminal for the forecaster to get his first updated predictions at the 12 locations. Now, the system has information on the latest temperature patterns across the state of Florida, as well as the present temperature at 12 locations and predicted temperatures for the 12 locations for the rest of the night. (See Figure 2). The system predicts temperature maps of the entire surface of the state for each hour of the rest of the night, using the predicted temperatures, the last satellite temperature picture and correlation coefficients between the key stations and 3,000 locations in the state (Sutherland and Bartholic, 1977 A).

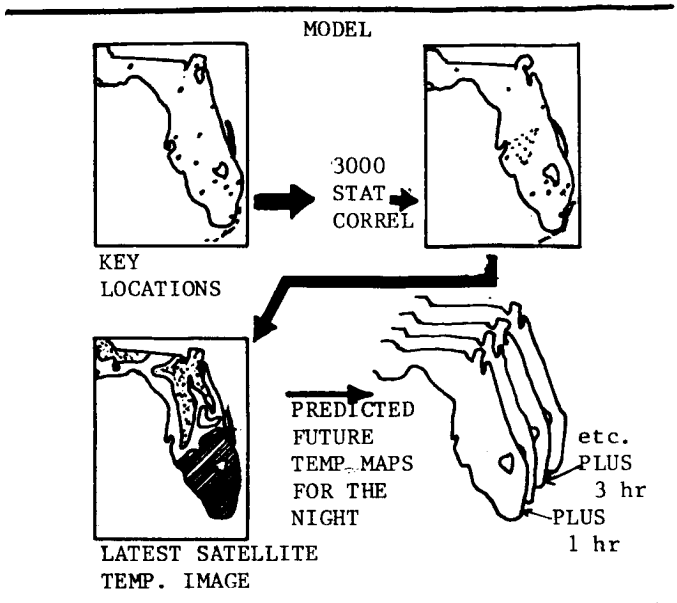

Figure 2. Flow diagram showing the sequence of steps required to develop predicted temperature maps.

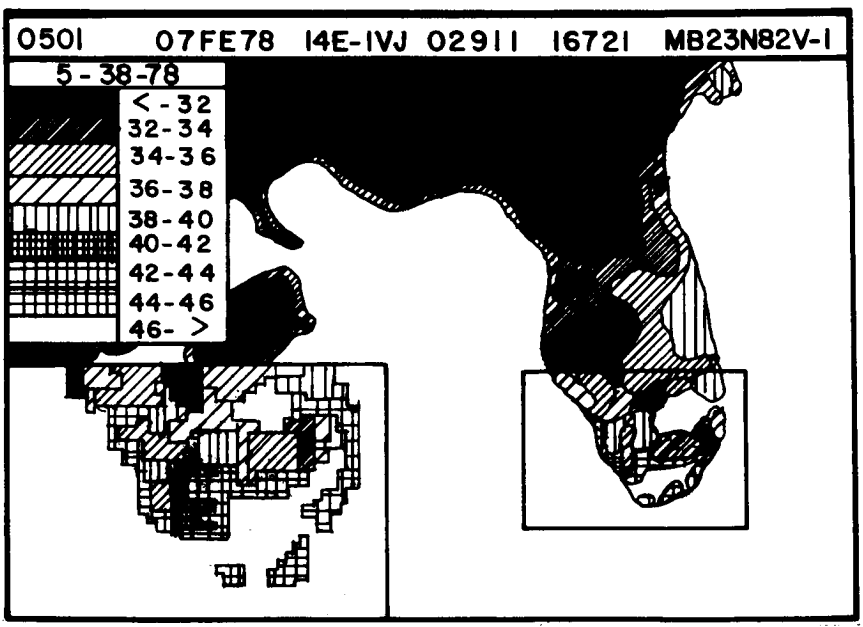

Figure 3. Black and white rendition of GOES Thermal Data from the Satellite Freeze Forecast System color TV screen.

The system develops a new forecast each hour for the entire surface of the state for the remaining hours of the night and thus, vital information needed by growers and those making freeze protection decisions is provided.

The physical model (for the 12 key stations) was operational during this past winter and was run on many of the cold nights by the forecasters. Evaluation of the 152 runs for the 1977-78 winter showed:

96% of predicted minimum temperature values were within $\pm$ 5°F
91% " " " " " " " $\pm$ 4°F
83% " " " " " " " $\pm$ 3°F
64% " " " " " " " $\pm$ 2°F
42% " " " " " " " $\pm$ 1°F

of the actual minimum measured. The second model was run but enough data has not yet been collected to produce satisfactory statistical coefficients relating the 3000 points to the 12 key locations. Work is continuing to develop new coefficients. A larger GOES data base from cold nights is being acquired from which to develop the new coefficients for use in the system.

The color data, of course, cannot be reproduced in this paper, so a black and white rendition is shown. Geostationary Orbiting Environmental Satellite (GOES) thermal data acquired and displayed by the SFFS is shown in Figure 3. These GOES data are obtained with the system every hour. Thus, temperatures, temperature trends, and cloud movement can be easily determined and followed.

Forecast Output

This winter the satellite freeze forecast system will be run in parallel with the traditional way of forecasting freeze temperatures. More frequent updates of the forecast and more detailed forecasts of the areas of the state are now available from the forecast office because of the SFFS. This improved frequency and smaller resolution information is of assistance in itself. However, certainly the written description of the color picture loses much in its translation.

TV stations and new means for communicating present temperature prediction pictures will be seen in coming years. Certainly, a grower could quite easily pick out his particular area with a satellite picture in front of him. He would have the most detailed temperature information technically possible at this time by observing the changes taking place.

CONCLUSION

Freezing temperatures can completely destroy a crop in a few hours. There are a number of possible methods for moderating these minimum temperatures but most methods are relatively costly and they are energy intensive. The grower needs to know detailed present temperatures and future temperature predictions for his specific area to make the best use of freeze protection devices.

The "Satellite Freeze Forecast System" will provide this type of information for the grower so that he can make better decisions for protecting the valuable food resource he has responsibility for providing.

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