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AN IMPROVED SATELLITE FROST WARNING SYSTEM[1]

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Abstract. **The Satellite Frost Forecast System (SFFS) is quite different from the one that IFAS initiated with NASA support 3 years ago. The system now entering the final stages of development is highly automated. Acquisition of satellite data from computer controlled files near Washington, D.C. is handled automatically by a Hewlett-Packard minicomputer, the heart of the system. That computer also calls through an automated telephone link and records the data from 10 key stations scattered over Florida. Microprocessors at the 10 key stations answer the telephone, interrogate wind, temperature and radiation sensors, and send the data to the calling computer without human intervention. A block diagram of the elements of the improved SFFS is shown and recent changes described.**

Products of the SFFS have until recently been viewed in real time only by forecasters at the National Weather Service forecast office in Ruskin and by the developers. Now, an experimental link with two County Extension Centers is being developed to explore solutions to problems as they are identified. Since the first concepts of SFFS were developed, it has been the goal of the developers to communicate, or to aid in the communication of, SFFS products to individual users of such information. The 1980-81 frost season should usher in the first quantum jump in the number of real time users of the SFFS products. The second jump is yet to be determined but may rest upon development of the IFAS Computer Network. This network has a 3 year completion timetable starting in late 1980.

Finally, ability of the SFFS to forecast several hours in advance what the satellite will sense rests on a physical model that forecasts future temperatures at the key stations and a space model that spreads these forecasts out into a predicted satellite view. Refinements of these models continue. As NOAA/NWS takes over the SFFS in 1981 (tentative plan), refinement of the models will probably continue in IFAS/Climatology at the University of Florida in Gainesville.

During the 3.5 years of development, SFFS has undergone numerous changes, several of which have been relatively extensive (1, 2, 3, 4, 7). Some have occurred recently and substantially improved the system. The purpose of this paper is to describe the current system and allude to how recent refinements have improved it. Most of the system changes have been responses to a rapidly changing field of computerized communications. Recent technological advances have given SFFS developers opportunities to improve the system while solving some of the problems such as these that the use of earlier versions revealed.

System Back-up. SFFS was described briefly to FSHS members in both the 1978 and the 1979 meetings (2, 4). Some appreciation for the changes that the system has undergone can be developed by reviewing those articles.

SFFS performs 2 major functions. One is the acquisition of data and the other is extrapolation of those data into the future. The system acquires both satellite and ground weather data to use in building both current and future false color thermal maps. Its functions, therefore, are both acquisition and prediction (forecasting). While it accomplishes these missions in automated fashion, it falls short of a completely automated system (so-called push-button system). The major reason it is not completely automated is substantial flexibility has been built into the system in regard to how it handles the prediction and data presentation functions.

A block diagram of the current system is shown in Figure 1. Notice there are 2 minicomputers at the heart of the system; one at the NWS weather office at Ruskin and the other at IFAS/Climatology in Gainesville. A double-headed arrow between the two computers indicates a telephone link between them through which back-up is to be provided. Other arrows in Figure 1 indicate the several telephone links over which the SFFS acquires and disseminates data.

Satellite data are acquired from NOAA/NESS through a NOAA/NWS link near Washington, D.C. The satellite

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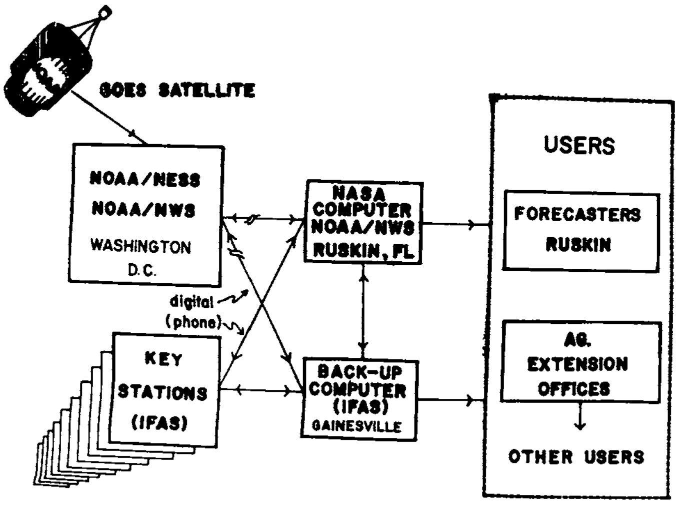

Fig. 1. A block diagram of the Satellite Frost Forecast System with indications of the phone links providing paths for data acquisition and communication of system outputs to users.

data base is voluminous. It becomes possible to deal with the size of the data base by requesting only the Florida sector of the infra-red data. Sectorizing is accomplished by a file-managing computer in NOAA/NWS near Washington when interrogated by the SFFS. The NOAA/NWS computer permits sectors that have been previously separated from the large mass of data received from GOES satellite to flow at 1200 Baud (bits per second) over a voice-grade telephone line into the SFFS memory. This is digital data transmission. The basic thermal map is a matrix of characters 134 x 129, or 17,286 symbols that flow sequentially over the phone link at about 120 symbols/second (each symbol is 10 bits long). This transmission requires 2.4 minutes. Since each map is accompanied by about 6,000 characters describing its time, date, temperature code, satellite navigation, etc., the total transmission time becomes about 3.3 minutes. Acquisition of digital data by telephone from Washington is a recent change. The system, prior to the winter of 79/80, acquired satellite data in analog form over the GOES-tap circuit, necessitating the data to be re-digitized. Previously the analog data source determined the partitioning of the data into temperature ranges. With the current digital data source the partitioning is under SFFS operator control, a much more flexible and versatile option.

Acquisition of temperature, wind, and net radiation data from the 10 key stations was automated during the fall of 1979 but problems prevented the Ruskin system from utilizing those data during the 79/80 frost season. These problems have been corrected and it is expected that key station data will be available at both the Ruskin and the Gainesville computers during the 80/81 frost season. The back-up link provides hope that these data can be passed from one site to the other as well. Key station data are necessary to the prediction function, hence forecasted satellite views become available from the system only when it is possible to interrogate most of the key stations or to obtain those data from the back-up machine. So, automation of the key station data acquisition function is another recent refinement of the system and one that has yet to be tested in the Ruskin machine.

Both SFFS computers were upgraded during the last half of October to the same operating system, RTE IVB, (Hewlett-Packard's (HP) most recent operating system for their 1000 Series Minicomputers). Some ability to pass information back and forth between the 2 machines existed prior to the upgrade, but it was far from that necessary to commit one machine to back up the other. The recent upgrade permits the use of DS/1000, i.e. distributed system configuration, which is the new link between the 2 HP mini-computers which is expected to permit the transfer of both data and necessary control to provide back-up. Any system having real time operational responsibilities requires redundancy in components that may fail. Although computers have reached a high level of reliability and service contracts provide for repair within hours of their occurrence, the current development back-up capability is one of the more recent and certainly a major improvement in the SFFS, for frosts and freezes are but hours in length.

System Products. Outputs of the SFFS are thermal maps of peninsular Florida called products. These are views of the temperature distribution over the surface of the peninsula made up of colors that represent particular temperature ranges (usually from 2 to 5 deg F per range). The improved system provides the operator with control over the designation of the particular temperature ranges used in constructing the map. The outputs are primarily false color maps of the surface temperature of peninsular Florida; both observed and predicted views. While the primary user is the NWS forecaster at Ruskin, other users are anticipated and links to those users are sought.

The primary products consist of both observed and predicted thermal maps. The observed map is the view transmitted from the satellite during the previous hour. The predicted map is the view that the satellite is expected to transmit at some time in the future. Thermal maps are depicted in false color which requires a color monitor that will accept separate red-green-blue (RGB) inputs. More commonly used color TV receivers require a composite signal of all three primary colors. Consequently, communication of the output signal to other TV displays beyond the system monitor itself is rather complicated. A system monitor at Ruskin serves the forecasters (Fig. 1) while the other at Gainesville serves the developers. Products delivered to the monitors have undergone extensive refinement and improvement since the beginning of the system development. One of these refinements is the result of the acquisition of digital data mentioned earlier. This permits the operator to select the particular temperature ranges to be displayed. It is possible to rerun the map building program with a different selection if desired. Another refinement is interpolation of the raw data into an appropriate number of pixels to provide correct length and width relationships in the image of the peninsula displayed. This refinement has been referred to as geometric correction of the data. It results in some data smoothing and as such is a compromise. However, this refinement can be removed easily if it is found undesirable at any point in the future. Several additional refinements have been termed enhancements. One of these is split screen capability where 2 maps can be displayed simultaneously, e.g. the observed map for the previous hour and the predicted map for three hours in the future. All combinations are possible and under operator control. One possibility is to display the current view with one of a similar hour in the historical record of previous freezes, i.e. a climatological function. Another enhancement is to provide an enlarged section of the map up in one corner. The selection of the area to be enlarged as well as the enlargement factor (multiplication factor) is under operator control. Finally, geographic check points can be plotted on the maps to provide geographic reference for user orientation.

There has been an intent since the initial conception of SFFS to communicate the products to users beyond the forecaster, such as, to county extension workers, to growers, and perhaps to the media. The possibility that the products would be valuable to marketing and financial interests in their assessment of freeze damage within a few hours of the damage has been realized. But the development of communication links with these so-called "other users" remains to be realized in the future.

An exception to the observation above is the development of an experimental link with 2 County Extension Offices (Figure 2). Link 2 provides a path for the raw map data to travel from the SFFS computer to an APPLE II microcomputer in the Climatology Laboratory of IFAS at Gainesville. That APPLE may be called by similar APPLE microcomputers in Lake and/or Polk County Extension Offices to obtain the maps (Link 3). The links (2, 3 and 4) require operators at both ends of the link to provide the transmission of the string of characters from which the thermal maps are built. This is only an experimental system and not intended to be a solution for many growers or organizations that wish to obtain the SFFS products. See Figure 3 for such a system. Software has also been developed to permit agents in Lake and Polk counties to call the Climatology APPLE and obtain map data. These APPLE to APPLE links are voice-grade telephone line links and they are transmitted at 300 Baud. It requires almost ten minutes to transmit one map at this rate. One APPLE can in turn serve one or 2, permitting users beyond the County Extension Office. It should be quickly emphasized in this discusion that the APPLE network is but a temporary solution to the problem. This is an experimental link made only to study the communication of SFFS products to other users. The APPLE is a home computer and the map that it is able to build is inferior to that available to users of the SFFS monitors. However, many of the same features or enhancements have been made available through the APPLE map building program which is very similar to the one on the HP system.

The system or one system similar to that which will probably be used to communicate SFFS products as well as many other weather agricultural information products to users is depicted in Figure 3. The network is envisioned as a hierarchical system with the information feeding up and down the links through nodes and from level to level. Growers may communicate with county extension computers in this network with "green thumb"-like memory boxes that plug into their telephone systems (5). Such systems permit the user to dial the local office and interrogate the computer there for a menu of products available for transmission on a page by page basis. The local source will permit retrieval of a given number of pages with a single call. The user may then display at will the pages or views one by one on his TV set. One such page may be the current observed satellite view and another may be one of the predicted maps. The likelihood an IFAS Computer Network will come into existence in the next three to five years is quite high, but the precise nature of such a network, i.e. what type of equipment will be used and how it will be funded, is yet to be determined. There is little doubt that SFFS will be linked to such a system. SFFS products may be communicated to users over such a system in a superior format to that currently available through the experimental APPLE link.

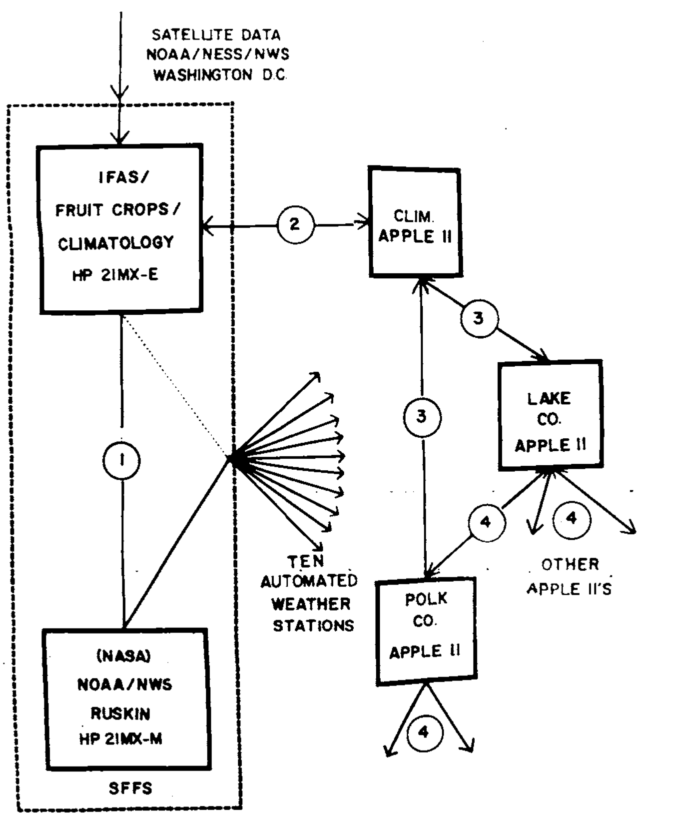

Fig. 2. SFFS product links in the experimental APPLE network. Link 2 passes the raw SFFS map from the SFFS HP computer in Gainesville to an APPLE in the same lab.

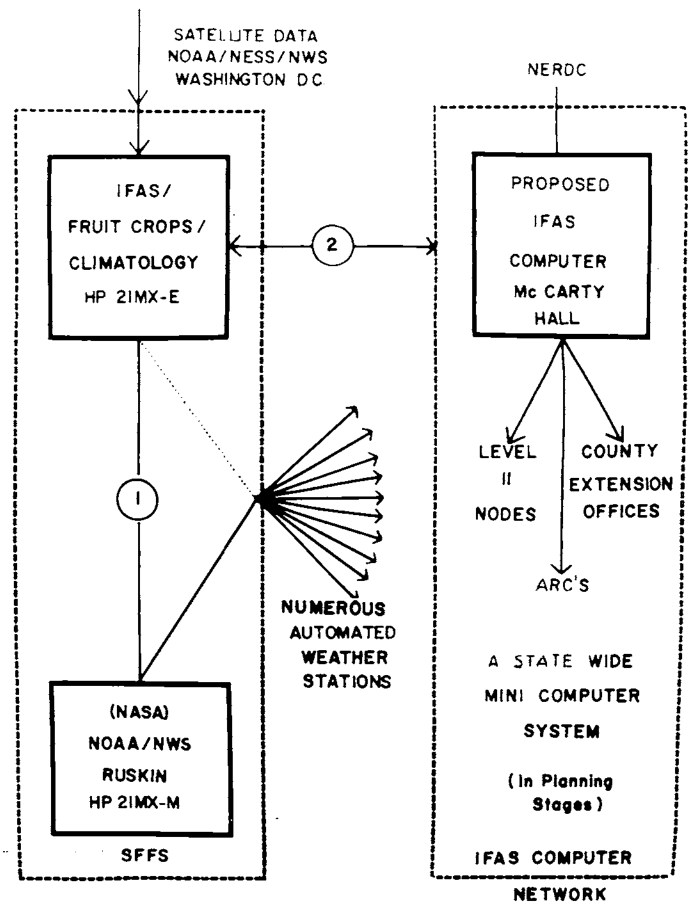

Fig. 3. A very probable link of the current SFFS with the proposed IFAS Computer Network.

Forecasting Ability. A unique feature of the SFFS is its ability to create predictions of what the satellite will see in the future (1, 2, 6, 7, 8). This ability has not yet been evaluated in detail due to the youth of the system and consequent dearth of comparative data but there is much interest in this feature (1, 4).

The forecasting ability of SFFS depends upon the quality of data collected from the key stations and just as heavily upon the use of those data in the *physical* model

(P-model). The P-model uses knowledge of the physics of the lower atmosphere to set up cooling equations and solve these for future temperatures at the key stations. The P-model extrapolates from the past through the present into the future. The forecaster can help the P-model by forecasting changes in some of the inputs and asking the model to take these into consideration in its forecast. The P-model promises with such refinements and more experience to become a more interesting component of SFFS.

The space model (S-model) uses these data and the current satellite view to build the future or predicted map after the P-model predicts the future temperatures at key stations. The S-model uses historical data concerning the tendency for the cold temperature patterns to be similar from one frost to another (3) to construct the predicted map. The S-model promises to become more refined as more maps are collected and archived in the SFFS memory banks.

IFAS/Climatology has a great interest in continued refinement of the models that provide the predictive feature of SFFS; consequently, it will continue to seek ways to improve the models.

The Key Stations. Ten key stations are operated over the peninsula during the frost season. These now have microprocessors that automate the communication of their sensings to SFFS. Currently, the sensings consist of 3 air temperatures, 3 soil temperatures (one being the surface), and an average wind speed. Net radiation is sampled on 4 of the 10 towers. Shielded net pyrradiometers were used prior to this frost season and required frequent maintenance. Ventilated pyrradiometers of the Gier-Dunkle type will be used in their stead in many locations this season.

Lack of uniformity in the quality of the telephone lines and switching mechanisms through which data flow from key stations to SFFS computer reduces reliability of data acquisition. Automated acquisition remains superior to that of formerly used voice communications and dependence upon volunteer observers.

Automated communication of data from the key stations to the HP computer controlling SFFS and instruments at the stations have problems yet to be solved but the concept of acquiring weather data for predictive models in agriculture has been convincingly demonstrated. It is only a matter of time (and perhaps some additional effort) until key stations of this type will remain in place throughout the year and support several programs in addition to the SFFS, not the least of which are the IPM (Integrated Pest Management) programs.

Changes in SFFS over 3.5 years of development have cost time but resulted in improvement. Recent changes have added flexibility and reliability. Extension of the thermal maps beyond the NWS forecasters, while part of the SFFS concept from its beginning, is one of the most recent improvements.

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TEMIK ALDICARB FOR CONTROL OF PESTS ON FLORIDA CITRUS[1]

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Abstract. **The efficacy of 5 and 10 lb. AI rates per acre (5.6 and 11.2 kg/ha) of granular aldicarb chiselled in or broadcast and disked into the soil was evaluated for control of mite and insect pests of citrus. Its effectiveness against citrus rust mite, spider mites, aphids, whitefly, and mealybug suggests that aldicarb would provide the Florida grower with multiple pest control benefits.**

Various formulations of Temik™ aldicarb had been evaluated in the United States for a decade prior to 1976 to determine its effectiveness for control of insects and mites attacking citrus (2, 3, 4, 5, 6, 8, 11, 12, 13, 14, 15).

The decision, in that year, to manufacture a single granular formulation plus the development of a mechanical method of applying the granules provided a standardized treatment procedure for all investigators to use in their test work.

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