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APPLICATION OF SATELLITE FROST FORECAST TECHNOLOGY TO OTHER PARTS OF THE UNITED STATES

PHASE II

FINAL REPORT

PRESENTED TO:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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15. Abstract

This is the final report of the second year's activities of a two-year effort to ascertain the application of satellite freeze forecast technology. The effort is periodically referred to as CCM II (Cold Climate Mapping Phase II). Input to this report was provided by Pennsylvania State University (C. T. Morrow) and Michigan State University (Dr. Stuart H. Gage and Dr. Jon F. Bartholic). Thermal infrared data is taken from the GOES satellite over a period of several hours and color enhanced by computer according to temperature. The varying temperatures can then be used to assist in frost forecasting.

16. Key Words

Remote Sensing, GOES, Freeze Forecasting

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CCM II

INTRODUCTION

This is the final report of the second year of activity of a two-year effort to ascertain the application of satellite freeze forecast technology to other parts of the U.S. This effort has been periodically referred to as CCM II (Cold Climate Mapping Phase II); this acronym appears in the report occasionally.

The first year's activity was accomplished under NASA Contract NAS10-9611. The final report under that contract is dated October 1980 with the final revision dated March 1981. Although the second year of activity was clearly a continuation of the first year's work (notice "Phase II" used in title), a new contract number, NAS10-9876, was designated and a lapse in the funding occurred from 05/03/80 to 07/10/80. That funding lapse included the frost period in both Michigan and Pennsylvania. The lapse left Dr. Ellen Chen, a very productive post doctorate on the first year of the contract, to be funded by other contracts during the lapse, with the result that her full attention was never returned to this effort. Communications to get Michigan State University and Pennsylvania State University back on target were time consuming and met with varied success during the period of this contract.

The Phase II contract (NAS10-9876) includes a three month period of "forebearance". This period was granted in response to a request for a no-cost extension to aid in the development of the final report to include final reports from the two subcontractors (copy of letter dated March 26, 1981 from William R. Harris is included in the 3rd Quarterly report as Appendix 1). This extension changed the end date of the contract from July 9, 1981 to October 9, 1981.

This report covers the period from July 10, 1980 through October 9, 1981. In the case of Pennsylvania, the most productive data collection period was during the lapse in funding between the two phases of the contract, i.e. the spring of 1980. Three quarterly progress reports have been submitted (see Table 1).

TABLE 1. PREVIOUS REPORTS

Quarterly Report	Dated
First	December, 1980
Second	January, 1981
Third	April, 1981

TABLE 2. List of CCM II Subcontractors
Contract NAS10-9876

Shorthand designation	Institution	Investigator	Location
PSU	The Pennsylvania State University	Dr. C. Terry Morrow	University Park, PA
MSU	Michigan State University	Dr. Stuart Gage (Dr. Jon F. Bartholic)	E. Lansing, MI

As was the case with Phase I (NASA Contract NAS10-9611), the same two subcontractors (see Table 2) are involved in Phase II (NASA Contract NAS10-9876).

Throughout the report the subcontractor's contributions are referred to as the PSU and the MSU Reports, respectively. The PSU Report may be found in Appendix 1. All references to Appendices with Roman numerals that appear in this report are referring to appendices of the PSU Report and are all contained within Appendix 1. The next 4 paragraphs appear to contain exceptions to this rule but notice that the Roman numerals refer to appendices of previous reports to NASA. Reference to the table of contents will aid in clearing up any confusion that may result from this effort to retain the contributions from the subcontractors in as near to original format as possible. The MSU Report makes up Appendix 2b of this report.

A very elaborate proposal was submitted by Dr. Stuart H. Gage of MSU and is contained in the First Quarterly Report as Appendix I of that report. While it does not directly address the Tasks as outlined in the Statement of Work, it places the CCM II effort very convincingly in the midst of the development of a broad based remote sensing capabiity that is under development at MSU. MSU's contribution to the second Quarterly report was late (arrived January 20, 1981, a few days after our Second Quarterly Report had left for KSC) and was retained for the Third Quarterly Report, becoming Appendix V of that Report. After a series of phone calls and an attempt by Dr.

John Gerber to aid in the procurement of a draft of the final report while he visited MSU in September, the draft was received on October 7, 1981. This was in time to include the MSU draft in the draft of the CCM II final report (the latter report was in the process of being mailed when the MSU draft arrived). However, there were very few cross references in the CCM II final draft that concerned the MSU report. Most of these have been added since the MSU draft arrived in October. Some modifications to that MSU draft are still expected at the time of refinement of the CCM II report, i.e. mid-November, 1981. It might be added at this point that it is our understanding that both Dr. Jon F. Bartholic and Dr. Stuart Gage worked over a weekend to get the draft to us as soon as it arrived. It is included in this report as Appendix 2b.

A phone call from MSU on October 1, 1981, passed (verbally) the data that MSU had collected to test the P-model. Mr. Robert Dillon, a programmer I, received that data and prepared it for input into the P-model evaluation programs. The results of those runs make up Appendix 2a.

The proposal from the PSU subcontractor arrived too late to include in the First Quarterly Report even though that report was held for some time in anticipation of receiving that PSU proposal. Consequently, it became Appendix I of the Second Quarterly (Mid-term) Report. The PSU proposal followed the tasks in the Statement of Work closely and disclosed that data collected on 5 frost nights during the Spring of 1980 would be used to test P-model. Very productive communications resulted in the delivery of that data for P-model runs at UF/IFAS and the communication of the results back to PSU for evaluation. These results are covered in detail in the PSU Report that makes up Appendix 1 of this report. Note that there are nine (9) appendices to the PSU Report which are numbered in Roman numerals.

The following portion of this report entitled TASKS REPORTS is written in a format in which the individual task is first declared and then a discussion of progress toward that task follows. In the case of Task I there are four parts of the task denoted by a, b, c, and d.

TASK REPORTS

Task 1: From data bases collected, make sample runs of the P-model and/or concept and present observations/conclusions as to:

a. Can the P-model and/or concept work in that particular geographic setting;

Data from Michigan State University documenting the frost of May 6-7, 1981 were passed to IFAS/Climatology by telephone (verbally) on October 1, 1981. Mr. Robert Dillon copied the data and prepared it for input to the P-model. The results of that analysis make up Appendix 2a.

The average error made by P-model in 55 predictions made using the MSU data was -0.024°F with a standard deviation of 2.374 degrees. The worst prediction was a 6-hour forecast made at midnight that predicted a 6AM temperature 6.1°F too low. The large positive errors were all made in the 9PM forecast for the remainder of the night, i.e up to 10 hours ahead. The 10-hour forecast for 6AM was slightly over 3 deg. F too high. The P-model's performance was judged quite acceptable.

Sample runs of the P-model were made on data from Pennsylvania (see Appendix VI of PSU report for detail). Numerous phone conversations, magnetic tape exchanges, and visits by the investigators (see Table 3) improved computer to computer communications between Dr. C.T. Morrow's Lab at PSU and the Climatology Lab at UF/Gainesville to the extent that such analyses can be quite effective in the future. The visits helped clarify communication problems and resulted in the depth of interpretation that characterizes the remainder of this report (see also Appendix 6).

A copy of PSU's proposal makes up PSU Appendix I, i.e. Appendix 1, Appendix I. While it suggests that 5 nights of data are available for the Spring of 1980 and more data would be collected for the Spring of 1981. The data was first received at Gainesville in the format indicated in Appendix II. While such graphs of temperature

Table 3. Exchange visits by CCM II investigators.

Visitor	Location	Dates (1981)
J.D. Martsolf	Pennsylvania State Univ. Univ. Park, PA. Ag. Engr. Lab, Environ. Measurements	August 26-27
C.T. Morrow	University of Florida Gainesville, FL Climatology Lab, HS-PP	September 28-29

data versus time served in the selection of particular nights that qualified as typical frost nights, they did not provide input appropriate to the P-model. Consequently, a procedure to go back to the original magnetic tape records and transfer appropriate records to a tape that was later sent from Pennsylvania to Florida was developed (see PSU Appendix III). The testing data base was reduced to the first 4 nights of the 1980 data (see page 9 of PSU report, Appendix 1). Dew point temperatures were located in a hand-written log and called down from Pennsylvania to Florida (see PSU Appendix IV) and incorporated in the P-model input files (shown in PSU Appendix V). The results of the P-model input runs of the Pennsylvania data comprise PSU Appendix VI. Dr. Morrow discusses these results on page 10 through 13 of the PSU report (Appendix 1). It is possible to add to his discussion that he was surprised that the model worked as well as it did for the particular site that was used. The main criteria for choosing the site was that it was available (a rather arbitrary choice).

Conclusion: Comparisons of the PSU P-model runs with those on pages 36 through 42 of the SFFS V Mid-term report, i.e. runs on Florida Key Station data, with those of Michigan (Appendices 2, a & b) and with those of Pennsylvania (Appendix 4) indicate that the P-model seems to do as well in mountainous terrain as it does on the gentle rolling to flat Florida or Michigan terrain (c.f. pages 11 and 15 of Appendix 4). The P-model concept may be considered effectively independent of geographic setting. However, if P-model were determined by future analyses to show bias it is conceivable that such bias could be corrected by some minor modification to P-model. In other words, these studies revealed no reason to feel that the P-model will be a problem in the exportation of the SFFS concept.

b. Degree of correlation with ground truth data;

Table 3 of Appendix 2b summarizes the error analysis of the MSU data, i.e. the difference between the P-model predictions and the observations. There was a mean error by P-model of $-0.024^{o}F$ in 55 comparisons. This is very acceptable.

Table 6.3 of the PSU Appendix VI summarizes the error analysis performed on the PSU data. There was a mean error by P-model in 264 comparisons of only $0.6^{o}F$ (see Table 6.1, PSU Appendix VI) which is quite acceptable (page 11, PSU report, Appendix 1).

c. Appropriateness to agricultural/meteorological environment;

Pages 8 and 9 of the MSU Report (Appendix 2b) describes 5 reasons that the P-model seems appropriate to the Michigan environment. These point primarily to the similarity in the expected energy transport mechanisms, i.e. both radiative and convective, during freezes in both Florida and Michigan.

Page 13 of the PSU Report (Appendix 1) initiates a discussion by Dr. C.T. Morrow of the appropriateness of the P-model to the agricultural needs of Pennsylvania and by inference to the fruit growing areas of Northwestern U.S. He concludes that the model has quite a bit of applicability (see pages 15 and 16 of PSU Report, Appendix 1; and also Appendix 6).

It seems to this author (who feels somewhat qualified to speak to this question by virtue of 13 years of experience in frost protection research in Pennsylvania) that two characteristics of fruit production in temperature zones have permitted growers to register less concern about frost or cold damage in comparison to those who grow tropical plants in sub-tropical climates, e.g. citrus. One of these is that the production areas in the temperate zones are generally more scattered over the total area and consequently when frost damage occurs its localized effects define a minority of affected growers. Secondly, only the crop is in jeopardy; the trees live on to potentially bear another year. However, while producer pressures may not be as high in deciduous fruit areas for frost warning services the total extent of the damage is large. The consumer pays for the losses in higher fruit prices and some of the transportation and marketing mechanisms suffer greater fluctuations in their volume, leading to operations inefficiencies and finance problems.

Regarding the appropriateness of the P-model to the meteorological environment there are no apparent reasons that the large scale weather is significantly different from that in Florida, i.e. the frosts occur primarily in the presence of a large high pressure dome. On the micrometeorological scale there seems to be some reason for concern because the P-model is a one-dimensional model, i.e. the vertical components of the energy budget are primarily involved. Cold air drainage, horizontal flow of heat, would seem to be ignored except for the wind speed indicators that have the opportunity of tipping off the model that down slope flow is occurring. The resulting mixing is likely to forestall as rapid a temperature drop as would otherwise occur. This mechanism is apparently handled quite effectively because the model seems to have predicted the temperatures at the Rock Springs site in Pennsylvania rather well; That site is on the West slope of Mt. Tussey, i.e. very much in a cold air drainage pattern.

d. If feasible, discuss parameters important to the location of key weather stations, i.e. numbers, settings, etc.

The MSU Report (Appendix 2b) does not directly address this question but contains a statement on Page 9 that indicates there has been a persistence of temperature differences between stations in the MOSS product analysis. They interpreted this as an indication that there are good correlations between key (weather forecasting sites) locations and agricultural weather measuring locations. While it is not explicit in Appendix 2b it should be noted that Michigan already benefits from one of the largest and most effective network of agricultural weather stations in the nation.

Dr. C.T. Morrow discusses a computerized dissemination network that PSU is planning (see pages 16-18, PSU Report, Appendix 1). There are possibilities that the communication network may include automatic weather stations to support integrated pest management programs as well as to facilitate a warning system similar to the Satellite Frost Forecasting System. The Meteorology Department of PSU has had an automated weather station in operation for some time on top of the 5-story building in which their department is housed. There have been negotiations underway to move that station off the building roof and onto agricultural lands of the Agricultural Experiment Station that are likely to remain in similar service for years to come in order to make the observations more characteristic of the surrounding countryside. This has immediate implications in the feasibility of the acquisition of ground data for the Nittany Valley.

The National Weather Service has provided frost warning services from a station in Kearneysville, West Virginia, but under the manpower reductions this position has remained vacant in recent years. The previous weather service provides some tradition around which an automated station might be located since the University of West Virginia operates a branch station of their Agricultural Experiment Station there. The branch station at Biglerville is another possibility. Several possibilities exist to represent the concentration of fruit production in what is referred to as the Cumberland-Shenandoah production region. The region is well represented by a meeting of researchers and extension specialists serving the fruit industry in a group called the Cumberland- Shanandoah Fruit Worker's Conference. There is a good possibility that this group would play a very active part in the placement of automated stations in the event of the implementation of a SFFS-like program.

Task 2: Give observations/conclusions as to the applicability of the S-model and/or concept from the data base at the two areas. This portion of the study must be general as this subject cannot be covered comprehensively without substantial work in statistical evaluation of temperature correlations which is beyond the scope of this contract.

Recent developments with the S-model indicate that there are good possibilities that the coefficients for the model may be produced by the minicomputer system supporting a SFFS-like system. This certainly could be the case for areas like Pennsylvania and Michigan. However, this possibility was not sufficiently apparent at the time that the subcontracts were drawn up to attempt to test the concept through the subcontracts.

The S-model represents the possibility of developing a SFFS that can recall the distibution of temperatures during previous freezes in a particular area and bring that cold climate climatology to bear upon present forecasts. Since compouters have excellent memories, the concept of recalling such information from memory and influencing the forecasts with it is good climatology and very likely will be attracive to any who adapt SFFS to their locations. However, the S-model in its current configuration fails to live up to these expectations. It may not be a trivial matter to bring past freeze information to bear readily upon current freeze events until the navigational problems with the satellite data from one year to another are resolved. That problem is defined well enough to declare it nontrivial. This line of thought is discussed in more detail under Task 5.

Certainly, there will be pressure on SFFS developers and adapters to lengthen the period over which the system can be expected to successfully or usefully forecast. The possibility of using the excursion of temperatures above a common base during the day previous to the freeze as convincingly related to the amount that temperatures may be expected to drop below that base on the subsequent clear night gives hope of lengthening the forecast period. Drs. Hartwell Allen and Ellen Chen have been perfecting a method of determining the heat capacitance of soils by observing the temperature excursions through clear days using day and night IR image sequences after the fact. The moisture conditions in a particular locality have been found by Dr. Ellen Chen to be clearly involved in the amount that one may expect that locality to cool under radiant frost conditions. It is likely that the development of this heat capacitance mapping technology will spin-off into the SFFS development with the possibility of extending the points in time from whence the system will forecast into the previous day, i.e. develop forecasting periods approaching 20 hours, double the current capability. Without the present limitation on the range of temperatures that can be acquired via 1200 Baud link with Suitland, Maryland has prevented the acquisition of daytime IR maps in sequence with nighttime IR maps due to over or under ranging problems at NOAA/NWS. This program is discussed in more detail under Task 4.

Pages 10 and 11 of the MSU Report (Appendix 2b) describe in some detail the conviction that similar temperature patterns persist from one frost night to the next indicating a stong dependence on surface vegetation and soil characteristics. Figures 1 through 4 of Appendix 2b were submitted as evidence of such persistence.

Task 3: Identify and discuss any peculiarities of the Michigan and Pennsylvania sites which might limit conclusions from being applied elsewhere in the United States as a general case.

a. Michigan: A peculiarity of Michigan under frost conditions is that the wind speed seems to be less likely to go to zero during the event, making wind machines and other frost protection methodology difficult to adopt without some qualification. This peculiarity in the case of a SFFS-like system works in favor of the system when used in Michigan. The more the wind tends to mix up the air near the surface the more likely the pixel temperatures determined by the satellite are to very closely represent the temperature of the whole area. If other areas of the Midwest were thought to have greatly different frost conditions than Michigan has there would be a problem in extrapolating the experience from Michigan to Ohio, Indiana, Illinois, Kentucky, Missouri, Wisconsin, Minnesota, Iowa, Nebraska, etc. However, all of this area of the United States seems to have high pressure domes that continue to move with the westerlies across the country during the frost season (both spring and fall) so that the periods of dead calm under the center of the high are relatively short. The further south one goes, the more likely the high pressure domes are to become stalled between the westerlies and easterlies, resulting in longer periods of cold, clear and calm weather.

Since the paragraphs above were developed the MSU Report (Appendix 2b) arrived with an explicit statement concerning Task III (see pages 11 and 12 of that report). It declares the Florida and Michigan cases to be very similar but an earlier statement (item 3 on page 8) indicates that Ceel Van Den Brink had interpreted in earlier work that approximately 70% of Michigan's frosts were radiational and 30% were advective. Since this ratio would be more like 90:10 in Florida the author of this report has let the following conclusion stand.

Conclusion: The Michigan case provides a good example for the remainder of the Midwest. The Florida experience is more likely to be a good example for the southern U.S.

b. Pennsylvania: The PSU site is on the slope of one of the narrow ridges that separates the broad fertile valleys of the fruit growing portion of the Appalachian Mountains. The diagram that makes up Figure 2 in Appendix 3 demonstrates two points:

1) the variations in temperature under frost conditions in mountain-valley topography are very similar from

one frost to another.

2) these variations closely follow the topography and have distance scale very similar to the intervalley topographical features.

Figure 1 relates this situation to a typical pixel from GOES, i.e. approximately 25 square miles in area. If the pixel location is known, i.e. the pixel is oriented relative to the geography of the covered area there is an excellent possibility that the relationship between the pixel temperature and that of particular sites covered by the pixel will become known and used with reliability.

Conclusion: small scale (relative to pixel size) variations in topography and hence in temperature distribution may not pose a serious limitation to the usefulness of a SFFS-like system in mountainous terrain. However, in order for the products to be convincing it is likely that a period of time is necessary during which the product users become calibrated or convincing research must be accomplished for each area that relates individual site temperatures to pixel temperatures. Finally, it is assumed in this discussion that it will become possible in these systems to orient the pixels with respect to the location they actually cover.

Task 4: Give recommendations as to whether the concept should

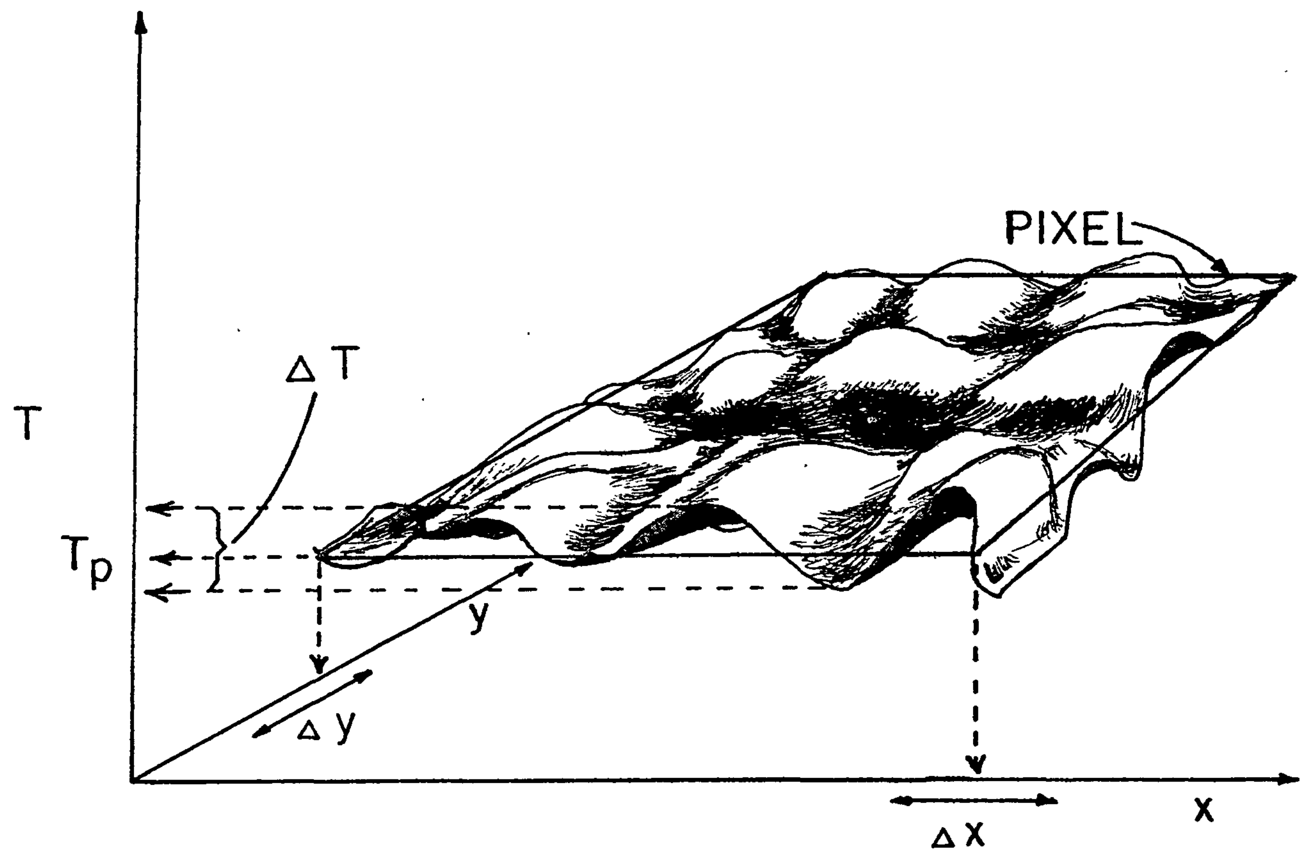

Fig. 1. Sketch of pixel with dimensions larger than elements of temperature fluctuation implying that if the pixel remains constant relative to the topography ($\Delta Y = \Delta X = 0$) and the temperature distribution remains constant relative to the topography for post events (a well documented horticultural observation) then given locations will have predictable ΔT with respect to the pixel temperature (Tp).

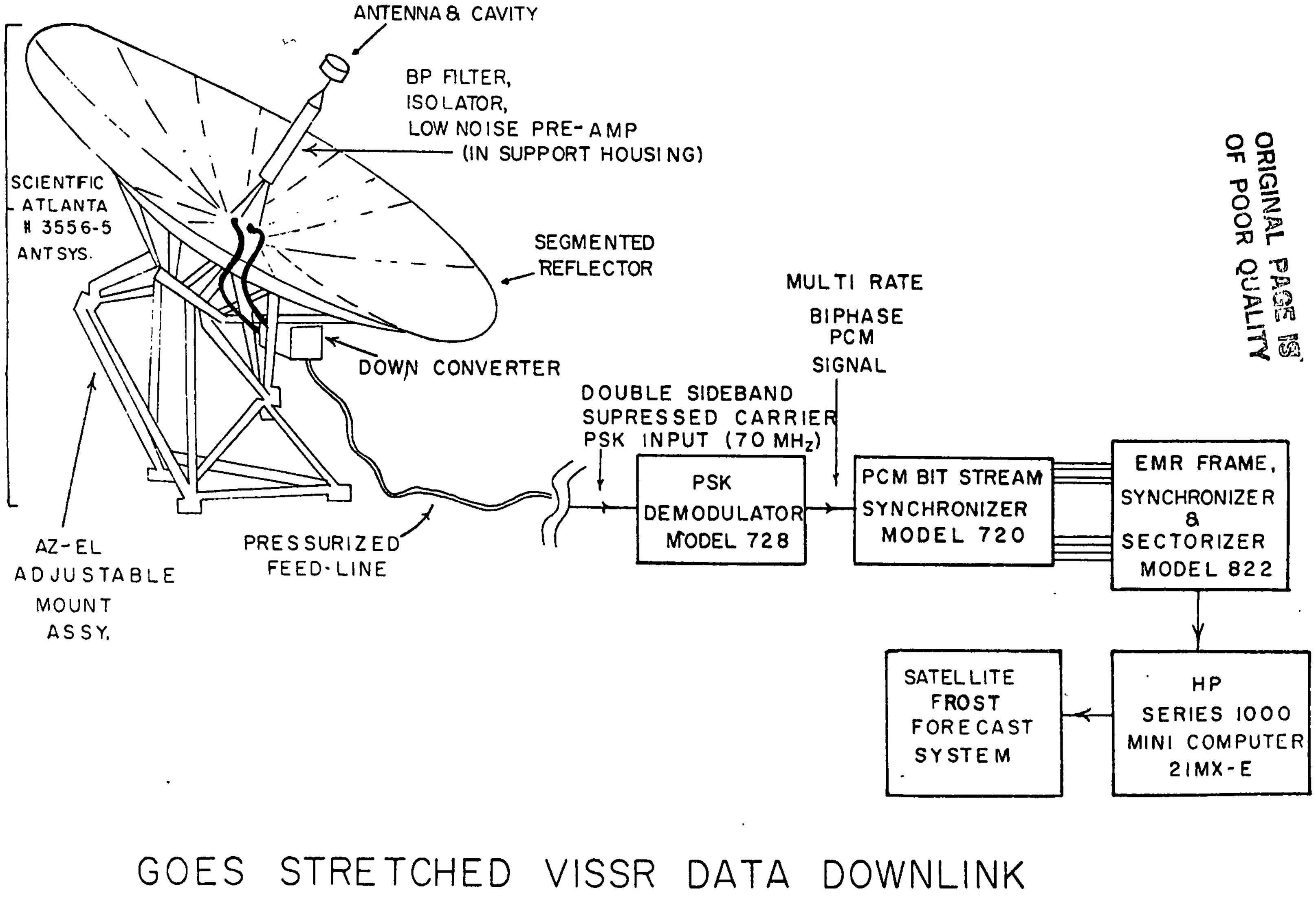

Figure 2. Diagram of the GOES Satelite downlink system that has been proposed to capture and sectorize the satellite data necessary to operate SFFS in Florida. This system is expected to become operational about December 1, 1981, in Gainesville, Florida, near the IFAS Climatology Lab in the Fruit Crops Department.

be pursued further and if so, what specific studies should be performed.

On pages 20 and 21 of the PSU Report (Appendix 1), Dr. Morrow makes six recommendations regarding the future of this type of study. These might be summarized to have indicated that while there is additional work that is identifiable, the concept is useful and is likely to be pursued (see Appendix 6). Communications with Dr. Morrow along these lines permits this author to indicate that a joint effort between the Pennsylvania State University and some private company is the likely future developer of this sort of service in the Northeastern U.S.

The Department of Meteorology of INPE, Brazil, is down linking GOES-East IR data to document the location and intensity of freezing temperatures during very cold nights in the coffee and citrus producing areas of Brazil. Mr. Michael Allan Fortune made contact with IFAS/Climatology when he was visiting NOAA/NESS in Suitland, MD on Oct. 5, 1981, to describe the Brazilian acquisition system and request information about SFFS. At our suggestion he also made contact with NASA/KSC and NASA/HQ (Mr. James M. Dodge, in the latter case). We have exchanged some information and it is apparent that both parties would probably benefit from closer communications concerning the nature of the efforts.

Appendix 2b contains MSU's recommendations for additional work in the following areas: P-model performance when Michigan soils are frozen in the early Spring; collection of GOES data from NOAA/NESS on a real time basis; correlation of temperature patterns with general surface conditions during freeze events. On page 12 of Appendix 2b indicates that, "Clearly, the conceptual theme of using GOES data to aid in characterizing the thermal regimes in a state both in non-real and real time, need to be further prusued. The data proves to be very accurate, particularly during freeze events and correlations of temperarture patterns with general surface conditions would indicate more information could be obtained."

Appendices 4 and 5 contain manuscripts that describe the SFFS system as reported to a group of scientists having responsibilities for the communication of agricultural weather data and to an international symposium on citriculture in Japan. Both manuscripts describe SFFS as a rapidly developing methodology that has potential application in horticulture when the industry experiences frost hazard. Most horticultural industries are climatically temperate or subtropical and consequently experience frost hazards.

The following are specific studies that it would seem from our experience to be necessary to the utilization of a SFFS-like thermal map display and forecasting system:

1) Navigation of the Satellite Data

The user of the information in real-time must know where his fruit is located in relation to the thermal map or the value of the information is greatly reduced in his decision-making process. While survey results published in NAS10-8920 Reports indicate that Florida growers can find their location within a couple of pixels on thermal maps of the entire peninsula, the growers are quick to expect geographic references that have some reliability. It should be noted at this point that if the information is to be valuable to the real-time user it must be available to him within a matter of minutes after it becomes available from the satellite.

The use of the data in the assessment of damage and subsequent planning of transportation and marketing scenarios is a near real-time operation and seems even more dependent on good geographical orientation of the data in order to couple the data with densities of crops for which the critical temperatures are known. The Jan. 13, 1981 freeze in Florida demonstrated this use of SFFS products convincingly. At this point the need for some standardized pixel location becomes apparent. The data bases upon which assessment programs will depend will undoubtedly be fixed in space and require that some interpolation of the satellite data be made to line up the temperature fields directly on top of the areas for which the crop densities have been determined.

Finally, the long-term user of the temperatures for climatological studies which we have been terming, "cold climate mapping," or CCM, must be able to relate thermal maps one with another over extended periods of time, i.e. years. Consequently, not only do the navigational studies need to deal with orientation on the face of the globe but with the software that seems necessary to develop time series of data that have acceptable space orientation. It is becoming apparent that this includes stretching and rotation as well as the simple x and y offsets of the rectangular coordinate system.

The navigation or orientation of the satellite data was indicated under Task 2 to be critical to the successful operation of S-model as it currently exists. But fairly sophisticated tools to study this problem are becoming available in the SFFS software. Consequently, there is hope that the goal of developing a system that will have a recollection of past freezes and be able to bring such information not only into display to remind the forecaster of the scenario but also to incorporate the patterns into the forecasted product through the S-model is realistic. The effort would seem to be dependent upon the ability of the system to stack the pixels in time over a particular geographical location. The changes in temperatures of these pixels (even during the previous day) become the principal ingredient upon which the model forms its predicted product. The memory of past events comes into play by the development of software that can relate the current happening with a similar one of the past, either automatically or with aid from the user. In its present configuration, the potential power of SFFS is far from its zenith.

This is an emphatic recommendation that the effort with S-model development continue.

2) The Dissemination of SFFS products

This is viewed as a continual process that is necessary to achieve the maximum value from the observed and forecasted products. We appear to be on the threshold of an era of the home computer controlled communication device that brings in all manner of information from which the user can make decisions in finance, purchasing, services such as transportation, lodging, etc. Opportunities to interface with these various private, quasi-public and public service communication networks should be investigated and capitalized upon where appropriate. Funding from the USDA/SEA-Extension has been requested and some obtained (Agreement 12-05-300-535, Amendment 1) for this purpose. Further efforts along this line are anticipated by UF/IFAS. These include the pursuit of contacts with television firms. So far there have been two promising contacts in this latter area, one from Ft. Myers, and the second from St. Petersburg.

3) Satellite Data Acquisition

Currently, the satellite freeze forecast system (SFFS) is dependent on a 1200 Baud link to a NOAA/NWS queue in Suitland, Maryland, that in turn is dependent upon the successful operation of at least two batch programming operations to transfer the data from the antenna to a data base from which it is sectorized for the Florida queue. While this experimental link worked rather well in the 79-80 frost season, it was quite unsatisfactory during the 80-81 season and little hope has been provided by NOAA/NESS, or for that matter NOAA/NWS, that much better performance can be expected from an experimental link on a system that has as much operational pressure as theirs. The MSU Report (Appendix 2b) indicates on Page 7 that the method of obtaining GOES data from NESS in Suitland was no longer operative and that they should use the historical archiving system at Wisconsin. MSU on pages 13 and 14 of Appendix 2b describes difficulties and frustration in acquiring satellite data due to a rapid change in NESS policy. IFAS attempts to acquire the data on MSU's behalf were disrupted by the declaration of center of sector being within the NOAA/NESS program at Suitland and not under IFAS control.

The direct downlink described in Figure 2 has been proposed and largely funded by IFAS to be operational during the 81-82 season. Since there is no redundancy in the system, it will serve simply as a back-up to the current method of satellite data acquisition described earlier in the paragraph.

Initially, SFFS acquired satellite data from the GOES-TAP link, an analog linkage through the NOAA/NESS field station in Miami. The analog data was digitized at the SFFS site in Ruskin, Florida, for use in the SFFS display and forecast software. Presently, the digital data in the NOAA/NWS queue in Suitland, Maryland, is in the form of ASCII characters.

The number of characters in the ASCII set is 95, restricting the temperature range over which data can be transmitted to 95/2 or 47.5°C (85.5°F) since the infrared temperature resolution of GOES is 0.5°C. Actually the data is downlinked in binary and the complete range 000 through 255 (256 temperature divisions from -110.2°C to 56.8°C or -165.3°F to 134.3°F). If the data could be passed from NOAA/NWS to SFFS in binary instead of translation to ASCII, it is much more likely that most of the full scale would be available (some combinations become illegal due to control character assignment through the various software interfaces involved). Mr. Art Bedient at NOAA/NWS is presently trying to develop the binary data transfer possibility. IFAS/Climatology is trying to ready SFFS to accept binary data input since the antenna link will transmit in binary format.

SFFS's acquisition of digital satellite data from GOES has been taking place in parallel with an effort connected with with a much more sophisticated (and consequently expensive) acquisition system known as McIDAS. The development of McIDAS has reached a stage in which a private company, Control Data Corporation, appears to be in the process of producing systems that used to be available in limited numbers through the University of Wisconsin. Both SFFS and, we understand, McIDAS are NASA developments. There may be some mutually beneficial exchanges of information between the developers. Certainly SFFS would benefit from increased reliability in satellite data acquisition and aid in the navigational aspects of the data orientation. Contact has been made with Control Data Corporation (CDC) to identify several possibilities that SFFS may benefit from the presence of a McIDAS in Florida and that CDC may benefit from the incorporation of an additional application, i.e. the frost warning products, into McIDAS.

4) Development of Alternative Forecasting Models

There is every reason to believe that with time the forecasting models, i.e. the P-model and the S-model, will be improved. Certainly there is a need to develop simpler models that will operate on less expensive computer systems, e.g. the APPLE II+ system that is being used by 6 counties currently interfacing to the SFFS/Florida system. One much simplified S-model uses coefficients that simply relate the pixels to changes in key station temperature as weighted by the distance of the pixel being forecasted from the particular key station.

With increased use of the SFFS systems there is little doubt that various research efforts will find it both convenient and advisable to experiment with new models and test their performance against the present models. As the users of the system become more sophisticated in their demands for options on the system, there will be continued pressure to develop additional features as justified by need.

5) SFFS's potential role in rapid communication of weather data

Currently, SFFS products are communicated to users in the following manner: first the NWS forecasters at Ruskin see the products displayed on the color monitor and, in the case of the key station data, on a clip board on their data board. They make their forecasts and communicate them to radio stations and other media by the same procedures that they have used before having SFFS. SFFS may be mentioned in this process but it is more likely that the users of the NWS frost warnings will not be aware that such a tool exists and is influencing the forecasts.

Secondly, SFFS products are beginning to be linked to other display systems from both the Ruskin and the Gainesville components of SFFS. Last winter, APPLE II computers at the Lake County and the Polk County Agriculture Extension Centers received satellite maps from a third APPLE in Gainesville, and built displays for the agents, John Jackson and Tom Oswalt. The impressions they gained from viewing the thermal maps were relayed through the tapes they played to subscribers of phone links to electronic secretaries. These agents carry out very effective educational programs in frost protection on freeze nights through these verbal telephone links with growers. Largely because of the popularity of the concept, this APPLE II+ network has been increased to six county offices this year. Four are in counties with citrus and two in peaches (see Table 4).

The rate at which the ASCII character string can be communicated from queues in the Hewlett-Packard minicomputers that service them has been increased this year to 1200 Baud. It requires about 3 minutes to transmit a thermal map to a user by the new network.

In addition to serving the new APPLE II+ network from Ruskin the HP mini is expected to acquire the dew point information it needs to make its P-model forecast through a port in the NWS/AFOS mainframe. Once this link is established it seems possible and quite likely that other weather data available in the AFOS system will become available to SFFS and be transmitted by the APPLE II+ Network to users. Digitized radar maps are likely to be targets for this link as well as many of the text formated weather summaries that are not communicated by AFOS.

Finally, SFFS in Florida, may have additional opportunities to support similar efforts in other states. For example, PSU outlines an attractive possibility in a letter dated October 6, 1981, which

Table 4. Listing of members of the 81-82 APPLE II+ Network using products from SFFS.

Location	Agent	County	Crops	Connection
Homestead	Seymour Goldweber	Dade	Avocados, limes, vegetables, etc.	Ruskin
Ft. Pierce	Pete Spyke	St. Lucie	Citrus ornamentals	Ruskin
Bartow	Tom Oswalt	Polk	Citrus	Ruskin
Tavares	John Jackson (Francis Ferguson)	Lake & Orange	Citrus	Gainesville
Madison	Jacque Breman	Madison	Peaches	Gainesville
Quitman	Henry Carr	Brooks	Peaches	Gainesville

is attached to this report as Appendix 6. The letter proposes to explore the possibility of submitting a proposal to help fund the goals of the proposal. Another example is the Brazilian Frost Warning System described earlier.

In summary, there are possibilities that the SFFS computer equipment will be called upon in the future to support a much larger menu of products than simply the SFFS products. To accomplish this there is a need to develop some very flexible software to handle the link between SFFS and AFOS. Secondly, the link into AFOS may permit other areas of the United States to capitalize on SFFS products by picking up summaries or renditions of them off the AFOS schedule. However, this possibility is clearly in the domain of NOAA/NWS and will be explored at their instigation.