AN EVALUATION OF THE NOAA POLAR-ORBITER AS A TOOL FOR MAPPING FREEZE DAMAGE IN FLORIDA DURING JANUARY 1982

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INTRODUCTION

Approximately two thirds of the nation's citrus crops are grown in the state of Florida. In addition, Florida is the major producer of vegetables on the east coast. Occasionally, below freezing temperatures will cause extensive damage to these crops. In January of 1981 and again in 1982 extreme cold temperatures resulted in widespread damage to these crops. The extent of the damage was assessed and documented by the Statistical Reporting Service, United States Department of Agriculture. Previous research on the use of Landsat and Meteorological (Metsat) Satellite data has indicated that crop vigor - "greenness" can be detected in the visual and near-infrared wavelengths. The purpose of this study was to determine if damaged citrus and vegetable crops could have been detected immediately after the January 1982 freeze wtih the use of the NOAA-7 Satellite data.

TECHNICAL DISCUSSION

The NOAA-n series meteorological satellites are polar orbiting and the on-board Advanced Very High Resolution Radiometer (AVHRR) collects data for Channels: 1, 580-680 nm; 2, 725-1100 nm; 3, 3550-3930 nm; 4, 10500-11500 nm, and if so engineered, Channel 5, 11500-12500 nm. These data are collected for any given location of the world at least once each day. The pixel size of the AVHRR data is approximately (1 Km) . Channels 1 and 2 have been used to detect greenness and changes in greenness over short periods. The data selected for this experiment were closen from the

daily coverage to have few or no clouds and immediately after a cold frontage passage. Such criteria provide near minimum atmoshperic effects upon the reflected solar radiation. Thus, changes over an area, from one period to another, would be mostly attributed to the actual changes in the "greenness" of the plants.

Registration of the Metsat data has not been perfected, therefore a pixel to pixel comparison on a day to day basis is not possible. For this study it was decided to minimize the registration problems by a rectilinear system of I-J grids. This grid system circumscribes a polar stereographic projection of a hemisphere of the earth. Each square (grid) identified by a column (I), row (J) can be explicitly located on the earth as long as it is inside the equatorial circle.

Using this system, each pixel of satellite data was allocated in a specific I.J. grid. The percent of pixels from one land use category to the total number of pixels in the grid was used as areal coverage. It is known that some error will exist in this method for each I-J grid, when compared from one day to another. But using several grids together would minimize the error. For the grid which covers part of Tampa Bay, the percent of water for the three dates ranged from 19.525% to 21.865%. This would result in an error of about 4.62 square miles out of 625 sq. mi. (one grid).

The pixel data for each grid was processed using a look-up table. This table uses Channel 1 versus Channel 2 and was set up to detect the greenness, nearly bare soils, clouds and water. The values used for classification were arrived at from experience with the GMI (Gray, McCrary Index) which is the difference between Channel 2 and Channel 1 data. Different values of the GMI reflect the degree of greenness.

Changes in the percent of greenness values for the central portion of Florida were determined for three periods. A larger area of the state would have been evaluated but the non-availability of satellite data precluded it. Three dates were used, one just before the freeze, (9 January), one about a week after (16 January), and then the third (26 January) about two weeks after the freeze.

DATA

NOAA-7 satellite data was requested for the above three dates. They were found to be favorable with regard to clouds and location of the satellite with relation of Florida. Total coverage of Florida was desired but only the central portion was common on all three data sets. The satellite data was ordered from Satellite Data Service Division (EDIS/NOAA). Currently, it is difficult to obtain Metsat data once it has been placed in the archives. This is due to equipment and storage problems but funding is not available to alleviate these conditions. The processing of

the data was done on a PDP/11 computer at the Department of Aerospace Engineering and Engineering Mechanics of the University of Texas at Austin, Texas. The software was developed by the AgRISTARS Early Warning/Crop Conditions Assessment Project.

Ground truth data was obtained from U.S. Dept. of Agriculture, Statistical Reporting Service. It included a Vegetable Summary of 1980, Citrus Summary - 1981, freeze damage assessments, and Florida citrus forecast.

The raw digital satellite data (Channels 1-2) were first allocated to a grid location, then the allocated raw data for Channels 1 and 2 were processed by a classifier (Fig. 1) and printed on a dot matrix printer. The printer plots were then fitted together, forming a map of Florida. The water, clouds and "greenness" were analyzed for changes with time.

DATA ANALYSIS

The changes in greenness were plotted for four grid values that corresponds to the location of counties with heavy production of citrus fruit. These counties each produced more than 10,000 boxes of citrus in the 1980-81 season. (Fig. 2). Some cloudiness was present on the January 16 date which had a major affect on the grid values. High readings of Channel 1 were labeled with a negative index (2-1) as clouds.

The minimum temperatures that were observed on the morning of January 12, 1982 averaged 22°F but ranged between 26° and 16°F. Temperatures at or below 26°F were sustained for about 10 hours. The shortest was seven hours and the longest was 12 hours (Fig. 3). This freeze was very similar to the freeze that occured on January 14, 1981. The January weekly Weather and Crop Bulletins published by NOAA/USDA Joint Agricultural Weather Facility reported the following:

- That 84 percent of the oranges sampled had internal ice.
- The extent of the damage to fruit resulting in lost production could not be directly inferred by their survey icing percentages.
- Cold weather since mid-November placed trees in good condition to withstand the cold.
- However, unseasonably warm weather during the last two weeks had begun to bring out some new growth. The condition of foliage indicates severe wilt and burning, with some defoliation likely.

This new growth was severly damaged by the freeze. Florida Weather and Crop News, dated January 18, 1982, reported that there was considerable leaf curl on the citrus trees, and in early Februry the USDA projected a decrease of about

20 percent in citrus production as a result of the freeze. The classifier shows the percent of total pixels in each classification category. (Fig. 4) is a plot of these percentages plotted for each of the three days, January 9, 16 and 26. An index number of eight is highest with greenness decreasing with index values.

The percentage of pixels in each of the categories against the total pixels was plotted for each of the three days, January 9, 16 and 26. This plot reveals few readings as high as an eight. Most of the values were sixes and fours.

Values of six for four counties which are very high producers of citrus were examined. About 50 percent of the total area had readings of 6. This was reduced to about 25 percent immediately after the freeze. This would represent about one fourth of the area. The values for about two weeks after the freeze shows a rapid increas in index values to about 40 percent with readings to 6 again.

In addition to the counties that were mostly citrus producers, two grids that cover major vegetable producing counties were analyzed. The higher index of 8 or above represented about 18 to 20 percent of the total area. The values of 6 about 60 percent of the total pixels. After the freeze the number of pixels with readings of 8 and 6 fell sharply. The data analyzed two weeks after the freeze displayed almost no recovery in the 8 or 6 greenness categories on one grid. The other grid displayed a partial recovery. The difference in recovery was because the area was mixed citrus and vegetables.

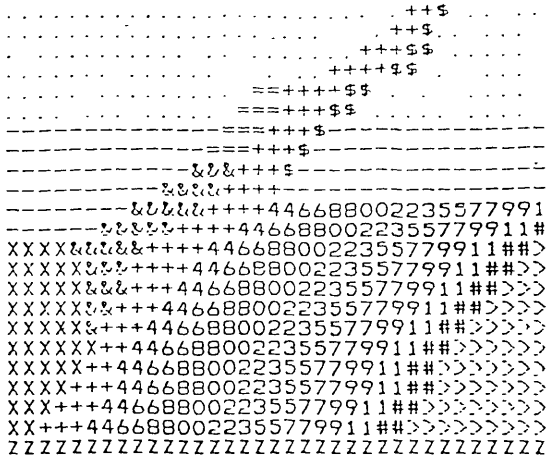
CONCLUSION

The NOAA-n Satellite is capable of detecting changes in greenness that occur over short periods of time and an estimation of the area of damage can be made. The severity of the damage was not evaluated in this experiment.

Very frequent coverage by satellite is necessary to obtain short period changes in greenness. With daily coverage it would be possible to monitor changes of less than one week in most instances.

Resolution afforded by the NOAA-n Satellites is sufficient to monitor changes in areas as small as the I.J. grid. Changes in smaller areas such as moderate size lakes, large fields and large rivers could also be detected.

CLASSIFICATION TABLE



X	Water
+	Wet soil
=	Shallow water or wet soil
>	Highest GMI
#	Very high GMI
4	GMI = 4
6	GMI = 6
8	GMI = 8
0	GMI = 10
2	GMI = 12
3	GMI = 13
5	GMI = 15
7	GMI = 17
9	GMI = 19
1	GMI = 21
.	Cloudy
-	Partly cloudy
$	Sand
&	Partly water or flood water
Z	Shadow or very dark area

Figure 1

DISTRIBUTION OF PRODUCTION
BY COUNTIES, 1980-81

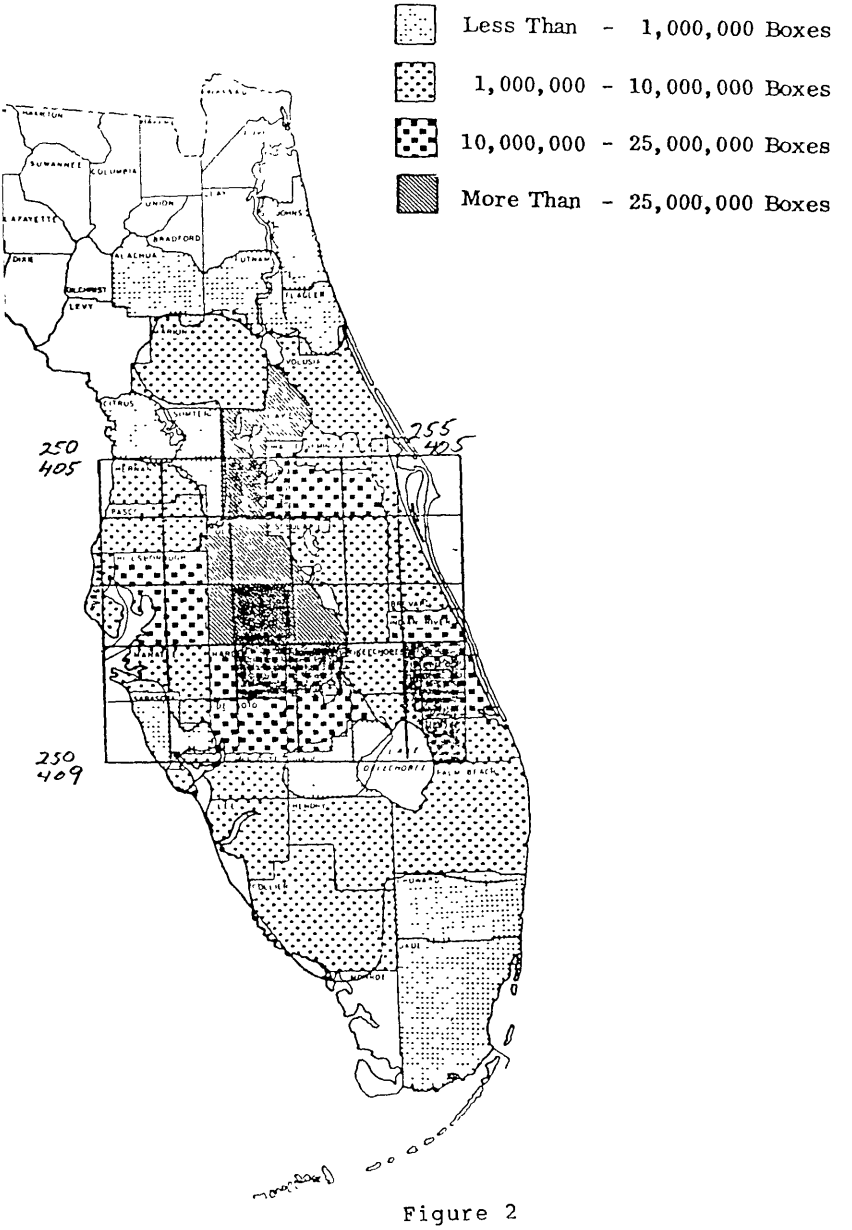


Figure 2

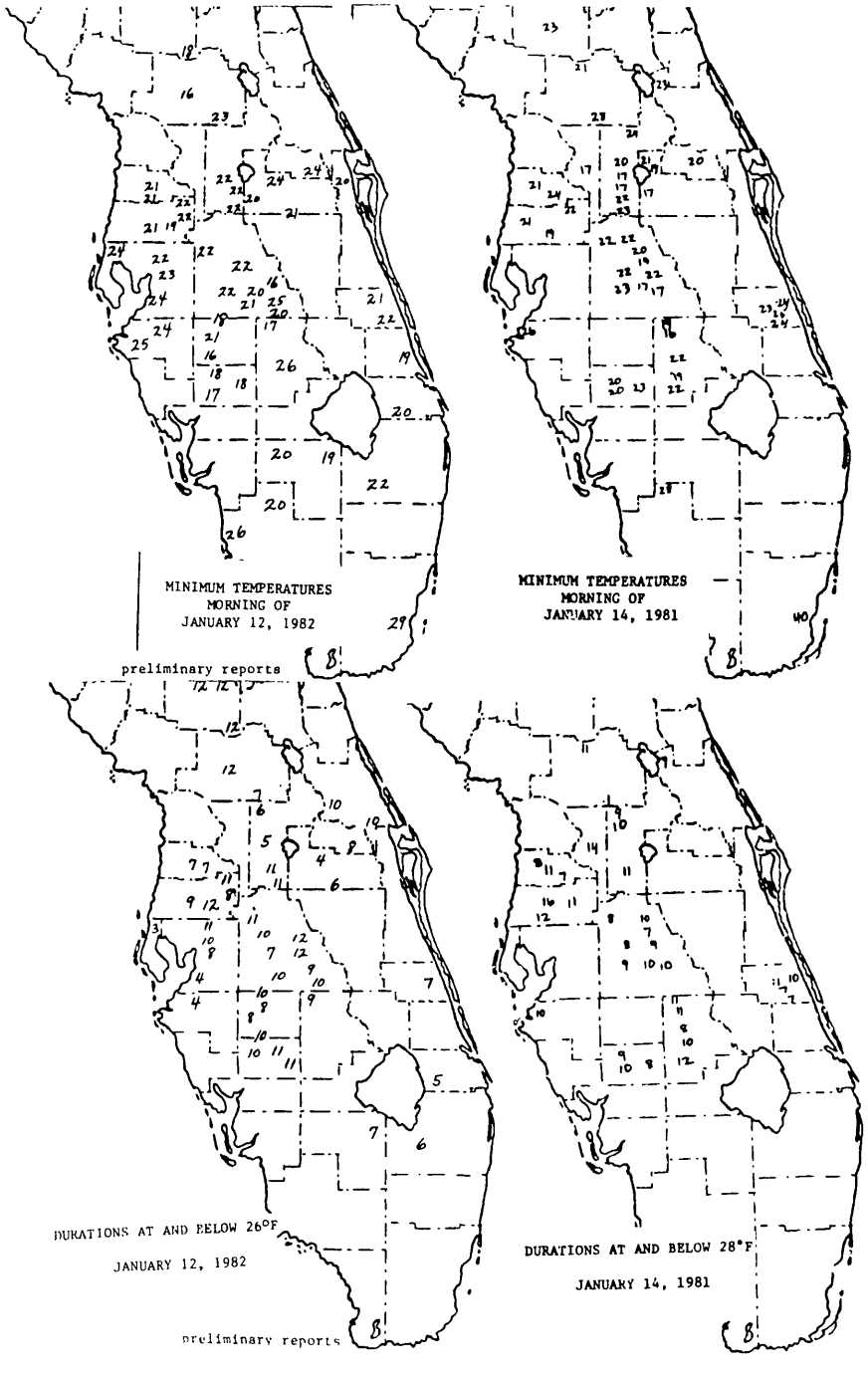

MINIMUM TEMPERATURES
MORNING OF
JANUARY 12, 1982
preliminary reports
MINIMUM TEMPERATURES
MORNING OF
JANUARY 14, 1981
DURATIONS AT AND BELOW 26°F
JANUARY 12, 1982
preliminary reports
DURATIONS AT AND BELOW 28°F
JANUARY 14, 1981

Figure 3

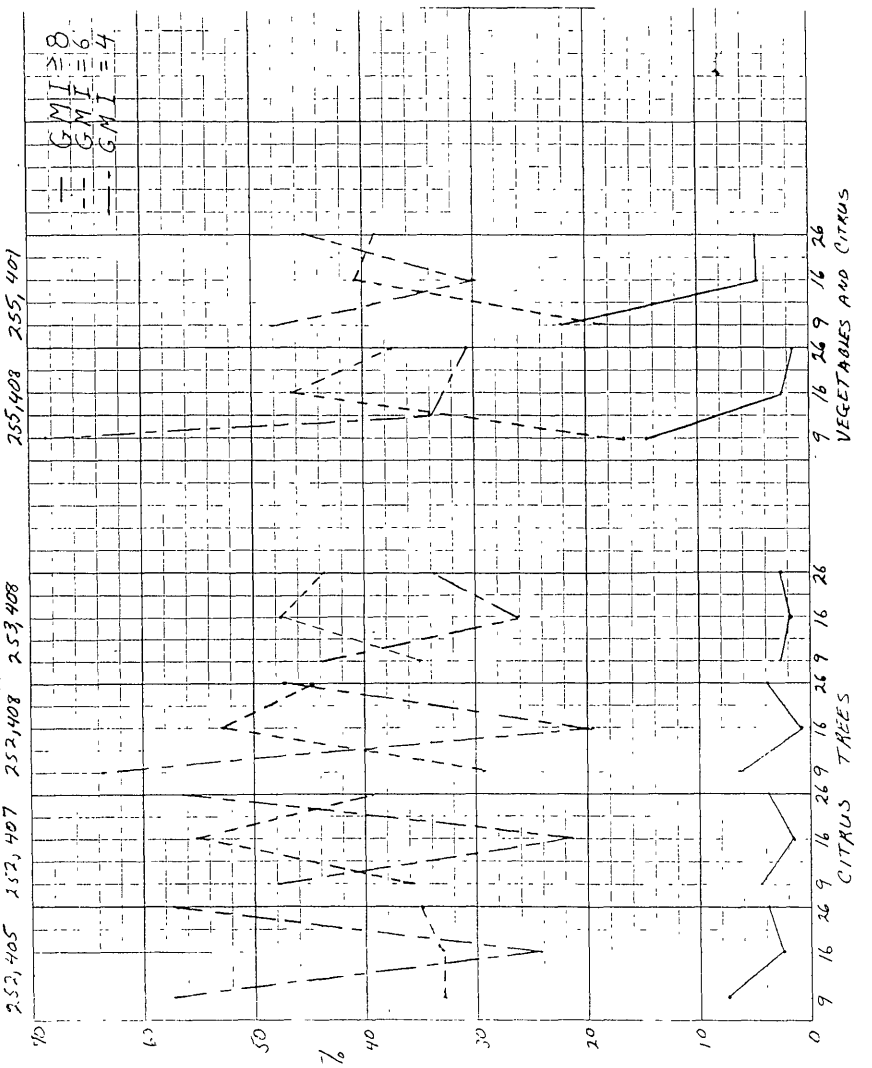

GMI ≥ 8
GMI = 6
GMI = 4
GRID
252,405
252,406
252,407
252,408
253,408
255,408
255,407
%
0
10
20
30
40
50
60
9
16
26
CITRUS TREES
VEGETABLES AND CITRUS

Figure 4