NOTICE

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USE OF THERMAL INERTIA DETERMINED BY HCMM TO PREDICT NOCTURNAL COLD PRONE AREAS IN FLORIDA

HCMM Data Investigation HFO-002
Contract NAS5-26453

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Preface

The objectives, approach, and anticipated results of this research contract are contained in Attachment A, STATE OF WORK: HFO-002 at the back of this report.

This text of this first quarterly report contains the following seven topics as shown in Article XII, Contract NAS5-26453.

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INTRODUCTION

This first quarterly report covers work performed during the period March 16 to June 16, 1981, of a one-year HCMM Data Investigation, Contract NAS5-26453 entitled "Use of Thermal Inertia Determined by HCMM to Predict Nocturnal Cold Prone Areas in Florida." It also reports some of the supporting information contained in the proposal for this HCMM investigation. The Objectives, Approach, and Anticipated Results are covered in detail in the attached Statement of Work (HFO-002).

This report documents progress made during the reporting period. The main items of progress reported were evaluation of HCMM transparency scenes for the available winter of 1978-1979, identification of scenes of magnetic tape processing, identification of other remote sensing supporting information, and development of a soil heat flux model with variable-depth thermal properties.

During the reporting period, we used the GE Image 100 system at NASA/KSC to compare HCMM and GOES transparent Images of surface thermal patterns. We found excellent correspondence of patterns, with HCMM obviously giving the greater resolution. One of these images showed details of thermal patterns in Florida that are attributable to difference in near surface water contents.

Our work so far demonstrates and emphasizes the wide range of surface temperatures attributable to surface thermal inertia that exist in the relatively flat Florida topography.

During the remainder of the working period, we will quantify these thermal inertia patterns under a range of soil moisture conditions, and use models to predict surface temperatures from thermal inertia information.

1. Problems:

A. Lack of 12-hour day-night sequence of HCMM satellite overflights in Florida latitudes.

Figure IV-1 (Geographical Extent of HCMM 12-hour Night Day Coverage of the Heat Capacity Mapping Mission User's Guide, Second Revision, October 1980) showed that a 12-hour day-night uninterrupted image sequence was not available between approximately 15°N and 35°N latitude because of the geometry of the orbit path and relatively narrow field of view. Day-night image sequences were available only at 36-hour intervals. This placed a limit on thermal inertia use for direct day-night sequencing. This problem was recognized in the project application, so that paired day-night overflights under similar weather patterns would be selected for analysis, as well as use of other NOAA data and satellite data such as GOES in comparing model predictions and supplying supplemental information for missing data sequences.

In overcoming these problems, we are also investigating the possibility of use of GOES, Tiros-N, or NOAA-6 data to supplement the HCMM data. GOES can give 1-hr interval data, but not at the resolution of HCMM. Tiros-N could give information on comparable crossing times as HCMM, but it is currently not functioning (1980-1981). NOAA-6 can give 12-hr sequences, but the crossing times are near sunrise and sunset, and are not desirable for yielding the most information about thermal inertia of surface.

It was found that the 1980-81 winter provided an excellent opportunity to study progressively drier and colder temperature conditions in Florida in the period from December 17, 1980, to January 19, 1981. The period from the relatively dry 1980-81 winter provided a contrast to the relatively wet winter of 1978-79. The problem was that no HCMM data were available after 1980. However, the combination of low rainfall and soil water and low temperatures was so pronounced that this period provides extreme conditions for analyses. For this reason, the period will be included for comparison. Therefore, NOAA-6 IR magnetic tapes were ordered and will be used in place of HCMM images. NOAA-6 has the same resolution (1 km) as HCMM, however, the NOAA-6 local crossing times 0730 and 1930 are not as useful as the HCMM local crossing times of 0200 and 1330. Tiros-N tapes were not available for the 1980-81 period of interest. GOES IR images were available for the period in question and will be used as needed for data analysis and interpretation.

B. Lack of clear periods during 1978-79 HCMM overflights.

The numerous periods of cloudiness during the 1978-1979 winter season has made selection of clear periods for mapping thermal inertia effects over large portions of the state more difficult than originally expected. However, there are a few periods which give almost statewide coverage that will be very useful, and there are several more periods where significant regions within the state can be investigated. These problems with cloud cover have made it necessary to select almost every suitable available period of day-night IR coverage during the 1978-1979 winter to yield satellite data for further processing. (See Section 2-C & D).

2. Accomplishments:

A. Identified wet front and dry front conditions in 1978-1979 winter season using National Climate Center Data during periods when ground truth transect data were available, and compared with HCMM coverage.

During January and February, 1979, surface transects were made for 11 overnight periods in Florida during cold night conditions by Ellen Chen and J. F. Gerber (Table 1). The data collected included radiation surface temperature, air temperature, dewpoint temperature, windspeed, and sky condition observations. The February 27-28, 1979, transects followed two routes.

Nine of the 11 nocturnal transect periods had HCMM overpasses before, during, or after the transects that were in overlapping range to give surface coverage (Table 2). The February 8-9 period had daytime coverage both before and after. Six potential day overflights and 4 potential night overflights were available. However, HCMM data for daytime overflights were missing on January 8, February 8, and February 9.

GOES maps are also available during the transect periods in Table 1 and 2. Rainfall conditions preceding the cold fronts (cold nights) are listed in Table 3. From the array of HCMM coverage, GOES maps and transect periods, rainfall conditions, and cloud problems, we are selecting suitable periods to determine the affects of surface thermal inertia on predicting nocturnal low temperatures.

B. Compared 1978-1979 winter season max-min NCC/NOAA air temperature data with surface conditions (such as soil drainage class) which affect thermal inertia.

Selected National Climate Center (NCC) maximum and minimum temperatures for 7 zones in Florida: Northwest, North, North Central, South Central, Everglades and S.W. Coast, Lower East Coast, and Keys (NCC-NOAA, 1979) were examined for January and February 1979. The monthly average minimum air temperature was subtracted from the monthly average maximum air temperature for each selected station to give the average daily temperature range. A large range indicates low surface thermal inertia, and a small range indicates high surface thermal inertia. These ranges of temperature were tabulated in decending order in Tables 4 and 5.

Northwest Zone. Station Fountain shows low thermal inertia soil effects, whereas Apalachicola shows the moderating high thermal inertia effects of the Apalachicola River wetlands and perhaps the bay.

North Zone. Stations High Springs, Cross City and Live Oak show large average daily temperature ranges indicative of well drained soils with low thermal inertia. Lake City, only about 25 miles from Live Oak, shows high thermal inertia associated with poorer drained soil. Hastings and Federal Point show higher thermal inertia associated with the St. John's River. This area was identified as a warm area by Chen *et al.* (1979).

North Central Zone. Station Ocala is in the middle of a cold prone area extending down the middle of the state. Alexander Springs is near the edge of the Ocala National Forest, an area with excessively drained soils. Inverness represents a strip of land on the west side of the state north of Tampa Bay that has been shown to be cold-prone. De Land is on an "island" of cold-prone soils. All these stations are on well drained soils. Sanford and Clermont stations have smaller temperature ranges caused by wetlands and lakes, respectively. Clermont represents the warmer area of the central lake region of Florida.

South Central Zone. Stations Bartow, Archbold and Lake Alfred are in well drained soil areas and have large average daily temperature ranges. St. Petersburg shows the very strong moderating effect of Tampa Bay and the Gulf of Mexico. Okeechobee Hurricane Gate #6 Station is adjacent to the north side of Lake Okeechobee, and shows the lake effect on the temperature range even though it is on the upwind side. Fellsmore shows the effects of a wetland region, near the St. John's marsh.

Everglades and S.W. Coast Zone. Station Belle Glade is just south of Lake Okeechobee, and represents more of a lake effect than of drained organic soil. Tamiami Trail shows the high thermal inertia of the undrained Everglades. There is no NCC reporting station within the drained Everglades that would give the sharp definition of the cold prone area shown by Chen et al. (1979) from GOES data. La Belle is in an agricultural area of somewhat poorly drained sandy soils (high water tables), but it had 5.64 inches of rain in January and only 0.46 inches of rain in February. Thus, it showed higher thermal inertia properties in January than in February.

Lower East Coast Zone. Station Miami Beach shows the extreme case of effects of an island surrounded by water. Loxahatchee is near the boundary between deep sands, drained organic soil, and an undrained organic soil water conservation area. It showed evidence of high thermal inertia during January and low thermal inertia during February.

There is some evidence in the climate records that some stations had a much larger increase in the average daily temperature range in February (a dry month) than in January (a wet month). In the North Zone, Stations Gainesville, and Usher Tower increased by +2.7 and +2.1°F, respectively. In the North Central zone, Bushnell and Ocala ranges increased by +3.5 and +2.0°F, respectively. In the South Central zone, Winter Haven, Plant City and Mountain Lake temperature ranges increased by 4.9, 3.4 and 3.0°F, respectively.* Finally, there was a general increase in the average daily temperature range in the South Central, Everglades and S.W. Coast, and Lower East Coast due to the significantly lower February rainfall.**

These air temperature data show wide ranges at different stations throughout the state. Surface temperature ranges would probably be even wid because low thermal inertia surfaces would rise higher in temperature during solar loading, and drop lower during nocturnal radiative cooling. Nevertheless, these air temperature data show clearly that thermal properties of the underlying surfaces vary considerably. These differences

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*Most of the above Stations are not shown in Table 4.

**Table 5 does not convey the full effect. 18 out of 25 Stations showed the effect. Of the 18 stations not near a shoreline, 16 showed the effect.

are due largely to thermal inertia mediated through water content of the surfaces (soils, or complexes of soils, wetlands, and water bodies). The largest temperature ranges were associated with both higher than average maxima and lower than average minima within a climate zone. We will use early afternoon surface maximum satellite temperature patterns to predict nocturnal minimum temperature patterns. The sparce NCC climate station measurements such as these can be used to help verify satellite observations.

C. Identified, ordered, received, and evaluated (quality and coverage) of HCMM satellite images for 1978-1979 winter season.

Table 6 lists the HCMM satellite images ordered for the 1978-1979 winter season. These images were received March 27, 1981, and have been inspected for utility and region covered. This table is being used to develop an order for HCMM tapes within the constraints of problems in Section 1. Several images have been processed on the GE Image 100 at KSC. (Section 2 - F & G).

D. Identified 1978-1979 winter HCMM tapes that are needed.

Table 7 lists the HCMM CCT's that are in the process of being ordered. Of these 13 CCT's, 9 combinations are being requested for day-night scene pairs for Temperature Difference calculations and for Thermal Inertia calculations. Several tapes and pairs are needed to obtain good information over the state because of the prevalence of clouds in some part of the state in many of the HCMM scenes.

E. Reviewed 1980-1981 winter wet and dry front conditions, and ordered NOAA-6 transparencies and tapes.

NOAA-6 polar-orbiting satellite infrared (10.5 to 12.6 microns) digital data for December, 1980, and January, 1981, were ordered according to rainfall information from climatological data (Table 8). Periods of no rainfall and antecedent rainfall in Table 8 helped to determine conditions for wet and dry fronts, and hence, wet and dry periods. Geostationary satellite (GOES) infrared digital images showed that most of peninsular Florida was clear during periods of no rainfall on December 17-18, 1980, the period from the night of December 31, 1980 through the morning of January 3, 1981, the night of January 10, through the morning of January 13, 1981, and finally, from January 17-19, 1981. The period of December 17-18, was classified wet and cool, where an average of 0.63 cm or more of rain fell in each climatological region of peninsular Florida (Fig. 1). Nighttime temperatures were about 3-5°C. The clear period from December 31, 1980, to January 3, 1981, was classified intermediate dry and cool. Rainfall for the 4 days (December 28 to 31) preceding the clear period was from no rainfall to trace amounts. Nighttime temperatures in the peninsula were around 0°C and below. The period from January 10 through January 13, 1981, was classified as dry and cold. Table 8 showed that there were negligible rainfall in the period from January 4 to 9, enhancing the already dry condition in the state. Nighttime temperatures were below freezing for the entire state, with temperature of -10 to -11°C in northern and part of peninsular Florida.

NOAA-6 positive film transparencies ordered were shown in Table 9. Day-night sequence of NOAA-6 frames for the 3 periods classified as wet-cool, intermediate dry-cool and dry-cold were selected from the film transparencies and digital magnetic tapes were ordered.

Tapes ordered from the Environmental Data service (EDS) were shown in Table 9(*). The tapes ordered are not expected to arrive until August. 1981.

F. Comparison of HCMM and GOES Images using GE Image 100 and PDP 1145 System at KSC.

In order to determine feasibility of using GOES images to supplement HCMM data analysis, HCMM film transparencies were digitized by using the Image 100 computer and the resultant image (Fig. 2) compared with GOES thermal patterns. Images compared were for 0200 EST, February 1, 1979. Figure 2 showed an HCMM image digitized into eight themes (represented by colors) after eliminating grey scales not found on the surface of Florida. The black and white inset showed the coldest areas in the HCMM scene (see arrows). They corresponded well with thermal patterns of GOES coldest pixels (0, y) shown in Fig. 3. The high resolution HCMM image (Fig. 2, inset) showed clusters of cold pockets whereas the low resolution GOES image showed a large extended area of coldest pixels. Note also the similarity in the shape of the thermal patterns.

Within the remaining time of the project we will use HCMM CCT data to estimate areal size and temperature ranges of the cold areas and compare these results with cold areas. Landsat and/or aircraft photographs will be used to aid in identifying surface conditions in the coldest areas. This will help to determine surface conditions which contribute to cold surface thermal pattern. The information can be used for both predicting extremes during cold events and for potential better surface management (e.g. irrigation) to alleviate cold conditions.

G. HCMM Thermal Pattern of Organic Soil Attributable to Land Use.

HCMM nighttime IR image (Fig. 4) of January 15, 1979, showed thermal patterns of lower Florida including the original Everglades marsh. The thermal image showed that even though the soil base is the same, the different water content on or near the surface created the thermal patterns shown in Fig. 4. This pattern is also discernable in Fig. 3. The different surface water and near surface water contents were partly due to different land use in the area, for example, agricultural (3), conservation (1) and (2), and natural (4), Fig. 5. The Everglades Agricultural Area (3) generally contain the coldest areas in south Florida. The pattern of the agricultural area (Fig. 5) appears quite distinct in the HCMM image (Fig. 4).

H. Software conversion programs.

Softwares for reading TIROS types were obtained through exchanges with the Pennsylvania State University. It is being adopted to the Amdahl 470 computer at the Northeast Regional Data Center of the State University System of Florida. Softwares compatible with the Image 100 and PDP1145 computer at KSC were obtained from the Early Warning/Crop Condition Assessment Group, Agricultural Research, Southern Region, USDA, Houston, Texas.

I. Reviewed appropriate bibliography of thermal inertia models and coded a soil thermal inertia model.

As a foundation for the modelling process, a core bibliography covering microclimate, soil physics and energy budget based meteorological models has been compiled and the review process has begun. Thus far, articles on Sutherland's model (1980) used in freeze forecasting and Carlson's thermal inertia model (Carlson and Boland, 1978) have been reviewed most thoroughly. Other models by Soer (1977, 1980), Price (1980) and the "Tell-us" model (Rosema *et al*., 1978) are currently being reviewed. These and additional references are listed in a bibliography at the end of this report.

Based on information gathered so far, a fundamental numerical soil heat flux model has been developed and initial simulations performed. The model is designed to allow soil properties;

1) density,
2) specific heat, and
3) thermal conductivity

to vary with depth. The initial goal of the model is to realistically simulate the extreme cases of perfectly wet and dry sandy soils. Next the model will be coupled with a rainfall/soil moisture model to allow moisture dependent physical properties to vary as a function of moisture availability throughout a diurnal cycle. Finally, the model will be coupled to a soil surface energy budget to predict surface temperatures under different meteorological scenarios.

J. Identified local freeze severity conditions in karst topography depressions as a function of the presence or absence of water.

Freeze conditions that occurred in Florida during the January 12-13, 1981 nocturnal period caused extensive damage to citrus trees. Inspection of several karst depressions showed that depressions without water showed severe tree kills and damage, whereas trees had less damage than general where they bordered depressions that contained ponds or small lakes. Directly or indirectly, these differences were due to the higher thermal inertias of the depressions that contained water. Photographs have been obtained, but no source of post-freeze overflight images has been located.

3. Significant Results:

A. Correspondence of surface thermal inertia to soil drainage class conditions.

Chen *et al*. (1979) showed that nocturnal surface temperatures of drained organic soils of the Everglades Agricultural Area south of Lake Okeechobee were lower than those surface temperatures of the undrained Everglades and also lower than those of mineral soils somewhat north and west of Lake Okeechobee. Recent analyses of GOES data shows that cold areas correspond to well drained and excessively well drained soils in Florida.

Figure 6 shows the distribution of Florida soils by drainage class. Figure 7, 8, and 9 show patterns of cold areas that occurred during three winter seasons. These patterns will be compared in detail with HCMM data in later reports. Some comparisons were shown in Figure 2, 3, and 4 of this first quarterly report.

B. Found that GOES surface temperature can give adequate diurnal cycles of surface temperature on a scale with courser resolution.

Figure 10 shows the diurnal cycle of surface temperatures of 5 surface types within south Florida during one freeze event condition on January 12-13, 1981. This figure illustrates that frequent coverage can give a much better definition of actual time distribution of surface temperatures than a 12-hr sequence satellite system. At this time of year, at this location, the predawn minimum and midday maximum are about 6 hours apart, whereas the midday maximum and the following predawn minimum are about 18 hours apart.

These "continuous cycle" data of surface temperature will be used to compare thermal inertia data later in this research program from HCMM satellite data.

4. Publications - none.

5. Recommendations.

A. Wider swath scenes need to give frequent 12-hour sequence coverage.

For most thermal inertia uses, it appears that having frequent 12-hour sequences would be more valuable than having high spatial resolution.

B. Stationary satellite data should be used to give continuous coverage.

Preliminary work so far would indicate that frequent surface temperature data during the course of a diurnal cycle could be more important in many applications than two higher spatial resolution-lower temperal resolution data from polar orbiting satellites.

6. Funds expended to date - $ 4,638.69

7. Data Utility

A. HCMM pixel size brings out surface features in more detail than GOES.

A comparison of HCMM images in Figures 2 and 4 shows that these data yield much more detail than the GOES image of Figure 3. We have other GOES daytime IR images that also are able to distinquish between harvested and unharvested blocks of sugarcane within the Everglades Agricultural Area of South Florida. These areas are distinguishable because the plant cover surface areas remain much cooler during the daytime than the drained, black organic soils.

8. Program for next reporting interval.

   A. Order and begin analysis of HCMM day, night, temperature difference, and thermal inertia CCT's.

   B. Develop models to utilize HCMM and other satellite derived sources of thermal inertia information for mapping thermal inertia as related to surface conditions and to anticedent soil moisture conditions.

   C. Integrate sources of satellite information and verification information in order to refine patterns of nocturnal cold-prone and warm-prone areas.

   D. Use model(s) to be able to predict patterns of nighttime lows of surface temperature from daytime patterns of maximum surface temperatures and surface thermal inertia information.

TABLE 1

Dates, place, and sky condition during transects of surface temperature (Raytek radiation thermometer), 1.5 m air temperature, and dewpoint (from E. Chen and J. F. Gerber, unpublished).

NUMBER	DATE	STATE ROAD	SKY CONDITION*	SATELLITE MAPS	NUMBER OF TRUCKS***
1.	Jan. 3-4, 1979	50	Cirrus	Yes	2
2.	Jan. 8-9, 1979	24	Clear	Incomplete**	1
3.	Jan. 9-10, 1979	50	Clear	Yes	1
4.	Jan. 14-15, 1979	50	Cirrus	Incomplete**	2
5.	Jan. 22-23, 1979	24	Cirrus	Yes	1
6.	Jan. 24-25, 1979	24	Cirrus	Yes	1
7.	Feb. 1-2, 1979	40	Clouded out	Yes	2
8.	Feb. 8-9, 1979	40	Clouded out	Yes	1
9.	Feb. 10-11, 1979	40	Clear	Yes**	1
10.	Feb. 19-20, 1979	40	Clear	Yes**	2
11.	Feb. 27-28, 1979	27	Low Clouds	Yes**	2
		80	Clear, Patchy Fog		

* Sky condition refers to sky over the transect region.

** From NOAA/EDS; hours available: 0, 3, 6, 9, 12 GMT (19, 22, 1, 4, 7 EST).

*** Most of the transects were from: 10 to 11:30 p.m.
1 to 2:30 a.m.
5 to 6:00 a.m.

TABLE 2

Florida nocturnal surface temperature transects and HCMM coverage, Jan.-Feb., 1979.

Nocturnal Surface Temperature Transects (1979)		HCMM coverage						Sky Cond.	GOES/ SMS Maps	Rain[1]
		Date	Cycle Number	Reference Day Number	Day or Night	Before or After Transect	Available? (GSFC)			
Jan. 3-4	Orlando/KSC	None						Cirrus	Yes	Jan. 2-3
Jan. 8-9	Cedar Key/Archer	Jan. 8	17	0/16	Day	Before	Missing	Clear	Incompl.	Jan. 8
Jan. 9-10	Bayport/Groveland	Jan. 10	17	2	Night	During	Yes	Clear	Yes	Jan. 8
Jan. 14-15	Bayport/Groveland	Jan. 15	17	7	Night	During	Yes	Cirrus	Incompl.	Jan. 13
Jan. 22-23	Cedar Key/Archer	Jan. 23	17	15	Day	After	Yes	Cirrus	Yes	Jan. 21
Jan. 24-25	Cedar Key/Archer	Jan. 24	18	0/16	Day	Before	Yes	Cirrus	Yes	Jan. 24
Feb. 1-2	Yankeetown/I-75	None						Cloud	Yes	Jan. 31
Feb. 8-9	Yankeetown/I-75	Feb. 8	18	15	Day	Before	Missing	Cloud	Yes	Feb. 7-8
Feb. 8-9	Yankeetown/I-75	Feb. 9	19	0/16	Day	After	Missing	Cloud	Yes	Feb. 7-8
Feb. 10-11	Gulfport/SR 484	Feb. 11	19	2	Night	During	Yes	Clear	Yes	Feb. 7-8
Feb. 19-20	Ormond Beach/Ocala	Feb. 19	19	10	Day	Before	Yes	Clear	Yes	Feb. 19
Feb. 27-28	South Bay/Homestead	Feb. 28	20	3	Night	During	Yes	Lo cloud	Yes	Feb. 25-26
Feb. 27-28	Ft. Myers/Clewiston	Feb. 28	20	3	Night	During	Yes	Clear, Patchy fog	Yes	Feb. 25-26

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[1] See attached summary of rainfall preceeding transects.

TABLE 3

1/ Rainfall preceding January and February 1959 transects.

Jan. 2-3.	Generally greater than 1 inch throughout the state, mostly on Jan. 2, with some on Jan. 3.
Jan. 8-9.	Almost all rain on Jan. 8. Generally less than 0.5 inch.
Jan. 9-10.	Almost all rain on Jan. 8. Generally less than 0.5 inch.
Jan. 14-15.	Almost all rain on Jan. 13, small amount on Jan. 14. Generally less than 1.0 inch.
Jan. 22-23.	Almost all rain on Jan. 21. Generally greater than 1.0 inch N, less than 1 inch NC and SC.
Jan. 24-25.	All rain on Jan. 24, generally greater than 1 inch.
Feb. 1-2.	All rain on Jan. 31, generally less than 0.5 inch.
Feb. 8-9.	Almost all rain on Feb. 8, locally heavy, generally less than 0.5 inch.
Feb. 10-11.	No rain since Feb. 8, locally heavy, generally less than 0.5 inch.
Feb. 19-20.	Light rain in North section, generally less than .25 inch.
Feb. 27-28.	Most rain on February 25, variable, but generally greater than 1 inch. Variable rain on Feb. 26, generally less than ½ inch.

Monthly rainfall was about 7 inches for January for the North, North Central, and South Central parts of the peninsula. This amount is over twice the normal.

February rainfall was about 3, 2, and 1.5 inches in the North, North Central, and South Central zones.

TABLE 4

NCC-NOAA Climate data for selected Florida Stations that show average daily temperature ranges indicative of high or low surface thermal inertia.

Zone	Station	Range (°F)		Surface conditions
		Jan.	Feb.	
NW	Fountain 3 SSE	27.6	28.0	Well drained
NW	Apalachicola	19.8	18.8	Wetlands/Bay
N	High Springs	31.6	(28.3)	Well drained
N	Cross City	27.5	25.9	Well drained
N	Live Oak	25.8	25.2	Well drained
N	Lake City	22.7	21.5	Poor drained
N	Hastings	22.8	21.1	St. Johns R.
N	Federal Point	21.1	20.6	St. Johns R.
NC	Ocala	27.5	29.5	Well drained
NC	De Land	28.6	28.6	Well drained
NC	Alexander Springs	30.0	27.1	Ocala Nat. For.
NC	Inverness	27.3	27.6	Well drained
NC	Sanford	23.7	22.4	Wetlands
NC	Clermont	21.5	23.8	Lakes
SC	Bartow	28.7	28.3	Well drained
SC	Archbold	26.5	27.7	Well drained
SC	Lake Alfred	26.2	27.1	Well drained
SC	Fellsmere	22.3	23.0	Wetlands
SC	Okeechobee	21.0	19.2	L. Okeechobee
SC	St. Petersburg	16.8	17.8	Bay
E&SW	La Belle	23.9	28.2	High Water table[1]
E&SW	Tamiami Trail	22.2	----	Everglades
E&SW	Belle Glade	20.8	22.5	Muck/Lake[2]
LEC	Loxahatchee	23.4	27.4	Mixed[3]
LEC	Miami Beach	11.7	11.5	Island

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[1] See text for January vs February rain effect.

[2] The drained organic soil effect is probably masked by proximity to Lake Okeechobee.

[3] Confounding effects of January vs February rainfall and proximity to drained organic soil, undrained water conservation area, and well drained sandy soil.

TABLE 5

Maximum range of average daily temperature observed at climate stations within zones from NCC-NOAA Climate data, 1979.

Zone	Month	Max. Range (°F)	Min. Range (°F)	Difference (°F)
NW	Jan.	27.6	19.8[1]	9.5
NW	Feb.	28.0	18.8[1]	9.7
N	Jan.	31.6	21.1[2]	11.5
N	Feb.	(28.3)	20.6[3]	8.9
NC	Jan.	30.0	21.5	8.5
NC	Feb.	29.5	22.4[4]	7.1
SC	Jan.	28.7	20.1[5]	8.6
SC	Feb.	28.3	19.2[5]	9.1
E&SW	Jan.	23.9	19.6	4.3
E&SW	Feb.	28.2	20.6	8.6
LEC	Jan.	23.4	18.9[6]	4.5
LEC	Feb.	27.4	17.8[6]	9.6

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[1] Excludes Pensacola.

[2] Excludes Jacksonville Beach.

[3] Excludes Jacksonville Beach and Fernandina Beach.

[4] Excludes Daytona Beach.

[5] Excludes St. Petersburg.

[6] Excludes Miami Beach and Miami.

TABLE 6. Identification and evaluation of HCMM images ordered and received that cover the 1978 - 1979 winter season.

Date	Long.	Lat.	Scene ID AAO-	Orbit	Cloud	Qual.	Plate	Type	Utility	Region Covered	GOES 1/	Transect 2/	Rain 3/
(78-79)	(W)	(N)			(%)		No.				(Z)		(Date)
17 Dec	81-18	27-54	235 - 18361	3487	30	G	088	DVIS	Good	Tam - St. J.			
"	"	"	" "	"	"	G	089	DIR	Good	Tam. - St. J.			
31 Dec	82-18	27-16	249 - 07110	3687	40	F	027	NIR	Med.	Tam. - EAA.			
10 Jan	79-03	25-01	259 - 06570	3835	30	G	130	NIR	Excel.	EAA	4/	B-G	8 Jan
13 Jan	81-50	28-26	262 - 18370	3887	40	F	132	DVIS	Med.	Tam. - EAA			13 Jan
"	"	"	" "	"	"	F	133	DIR	Med.	Tam. - EAA			13 Jan
15 Jan	77-02	25-59	264 - 06490	3909	40	G	493	NIR	Med.	EAA	5/	B-G	13 Jan
16 Jan	82-07	25-34	265 07070	2095	70	F	110	NIR	Good	Tam. - EAA			
18 Jan	80-37	31-05	267 - 18300	3961	30	F	040	DVIS	Med.	Ga. - Fla.			
"	"	"	" "	"	"	F	041	DIR	Med.	Ga. - Fla.			
18 Jan	79-08	24-59	267 - 18280	3961	30	F	042	DVIS	Good	EAA			
"	"	"	" "	"	"	F	043	DIR	Med.	EAA			
24 Jan	83-47	28-23	273 - 18410	4053	30	G	007	DVIS	Med.	EAA - St. J.	6/	CK-A	
"	"	"	" "	"	"	G	008	DIR	Med.	EAA - St. J.	6/	CK-A	
29 Jan	81-52	25-49	278 - 18350	4124	10	G	414	DVIS	Excel.	Tam. - EAA	7/		27-28 Jan
"	"	"	" "	"	"	G	415	DIR	Excel.	Tam. - EAA	7/		27-28 Jan
1 Feb	82-19	26-22	281 - 07060	4161	30	F	106	NIR	Excel.	Tam. - EAA		Y-175	31 Jan

TABLE 6. (continued)

Date	Long.	Lat.	Scene ID AAO		Orbit	Cloud	Qual.	Plate	Type	Utility	Region Covered	GOES1/	Transect2/	Pair3/
(78-79)	(w)	(N)				(%)		No.				(Z)		(Date)
3 Feb	81-36	30-17	283 -	18300	4193	30	G	010	DVIS	Excel.	Tam. - St.J.	8/		(dry)
"	"	"	"	"	"	"	G	011	DIR	Excel.	Tam. - St.J.	8/		(dry)
6 Feb	80-50	26-47	286 -	07000	4235	80	G	324	NIR	Poor	Cuba			
11 Feb	79-16	25-08	291 -	06540	4309	70	G	078	NIR	Good	Tam. - EAA	9/	G-484	
19 Feb	81-02	29-52	299 -	18280	4435	50	G	055	DVIS	Good	Tam. - St.J.	10/	OB-O	19 Feb
"	"	"	"	"	"	"	G	056	DIR	Good	Tam. - St.J.	10/	OB-O	19 Feb
28 Feb	82-14	32-03	308 -	07060	4561	30	F	231	NIR	Good	Ga. - Fla.	11/	SB-N	25-26 Feb
28 Feb	83-43	25-56	308 -	07080	4561	50	P	232	NIR	Good	Tam. - EAA	11/	FM-C	25-26 Feb

1/See Table 1 and 2
2/See Table 1 and 2
3/See Table 2 and 3
4/GOES data available at 9,10,11,12 Z
5/GOES data available at
6/GOES data available at
7/GOES data available at 1,6,9,10,11,12,13 Z
8/GOES data available at 2-18 Z
9/GOES data available at
10/GOES data available at
11/GOES data available at

St.J. = St. John's River Basin
Tam. = Tampa Bay
EAA = Everglades Agricultural Area
Ga. = South Georgia
Fla. = North Florida

Poor = generally useless
Med. = small useful regions
Good = generally useful
Excel.= completely useful

Table 7. HCMM Tapes that are in process of being ordered.

Date	Long.	Lat.	Scene ID.	Orbit No.	Cloud	Qual.	Type
(78-79)	(W)	(N)	AAO-		(%)		
15 Dec	82-14	28-14	233-07130	3450	60	G	NIR
17 Dec	81-18	27-54	235-18361	3487	20	G	DIR
10 Jan	79-03	25-01	259-06570	3835	30	G	NIR
13 Jan	81-50	28-26	262-18370	3887	40	F	DIR
15 Jan	77-02	25-59	264-06490	3909	40	G	NIR
16 Jan	82-07	25-34	265-07070	2095	70	F	NIR
18 Jan	79-08	24-59	267-18280	3961	30	F	DIR
29 Jan	83-21	31-56	278-18360	4124	40	G	DIR
29 Jan	81-52	25-49	278-18350	4124	10	G	DIR
1 Feb	80-49	32-30	281-07040	4161	20	F	NIR
1 Feb	82-19	26-22	281-07060	2161	30	F	NIR
3 Feb	80-09	24-09	283-18280	4198	20	F	DIR
3 Feb	81-36	30-17	283-18300	4198	30	G	DIR

Table 8. Average rainfall for each climatic region of Florida for the period from December 16, 1980 through January 16, 1981: Northwest (1); North (2); North Central (3); South Central (4); Everglades and SW Coast (5); and Lower East Coast (6). Data were from Climatological Data for Florida, National Climatic Center, Ashville, NC, December, 1980 and January, 1981.

		CLIMATIC REGIONS					
		(1)	(2)	(3)	(4)	(5)	(6)
Date	No. of Stations →	15	20	13	28	14	11
1980							
Dec. 16		.23	.11	.18	.15	.04	.04
17		.04	.13	.09	.37	.49	.21
22		.06	.02	.21	.30	.06	.01
23		.09	.14	.09	.09	.12	.37
24		.06	Tr	NR	.01	.10	.15
25		.10	.09	Tr	.03	.02	.01
26		.01	Tr	NR	.01	Tr	.02
27		.02	Tr	NR	.01	NR	NR
28		Tr	.01	Tr	Tr	NR	Tr
29		.06	.05	Tr	Tr	Tr	.03
30		Tr	Tr	Tr	Tr	Tr	Tr
31		NR	NR	NR	Tr	NR	NR
1981							
Jan. 7		.56	.40	.09	.01	Tr	Tr
8		NR	.03	.02	.01	Tr	Tr
14		.01	Tr	Tr	NR	NR	NR
15		.04	.11	.06	Tr	NR	NR
16		NR	Tr	Tr	Tr	.01	.02

Tr = Trace
NR = No rainfall

Table 9. Polar-orbiting NOAA-6 satellite film transparencies covering the same period as in Table obtained from Environmental Data Service. *Indicated digital magnetic tapes ordered.

Date	Time	Orbit Number	Weather Condition
Dec. 17, 1980	352:01:08:32	7655	wet, cool
Dec. 17, 1980*	352:13:29:01	7662	
Dec. 18, 1980*	352:23:10:22	7669	
Dec. 18, 1980	353:13:08:32	7676	
Dec. 31, 1980	366:00.53:20	7854	intermediate
Dec. 31, 1980*	366:13:16:01	7861	dry, cool
Jan. 1, 1981*	001:12:56:02	7875	
Jan. 3, 1981*	003:13:49:16	7904	
Jan. 10, 1981	010:00:31:30	7996	dry, cool
Jan. 10, 1981	010:12:55:02	8003	
Jan. 12, 1981*	012:13:48:11	8032	
Jan. 13, 1981*	012:23:33:28	8039	
Jan. 13, 1981	013:13:26:46	8046	

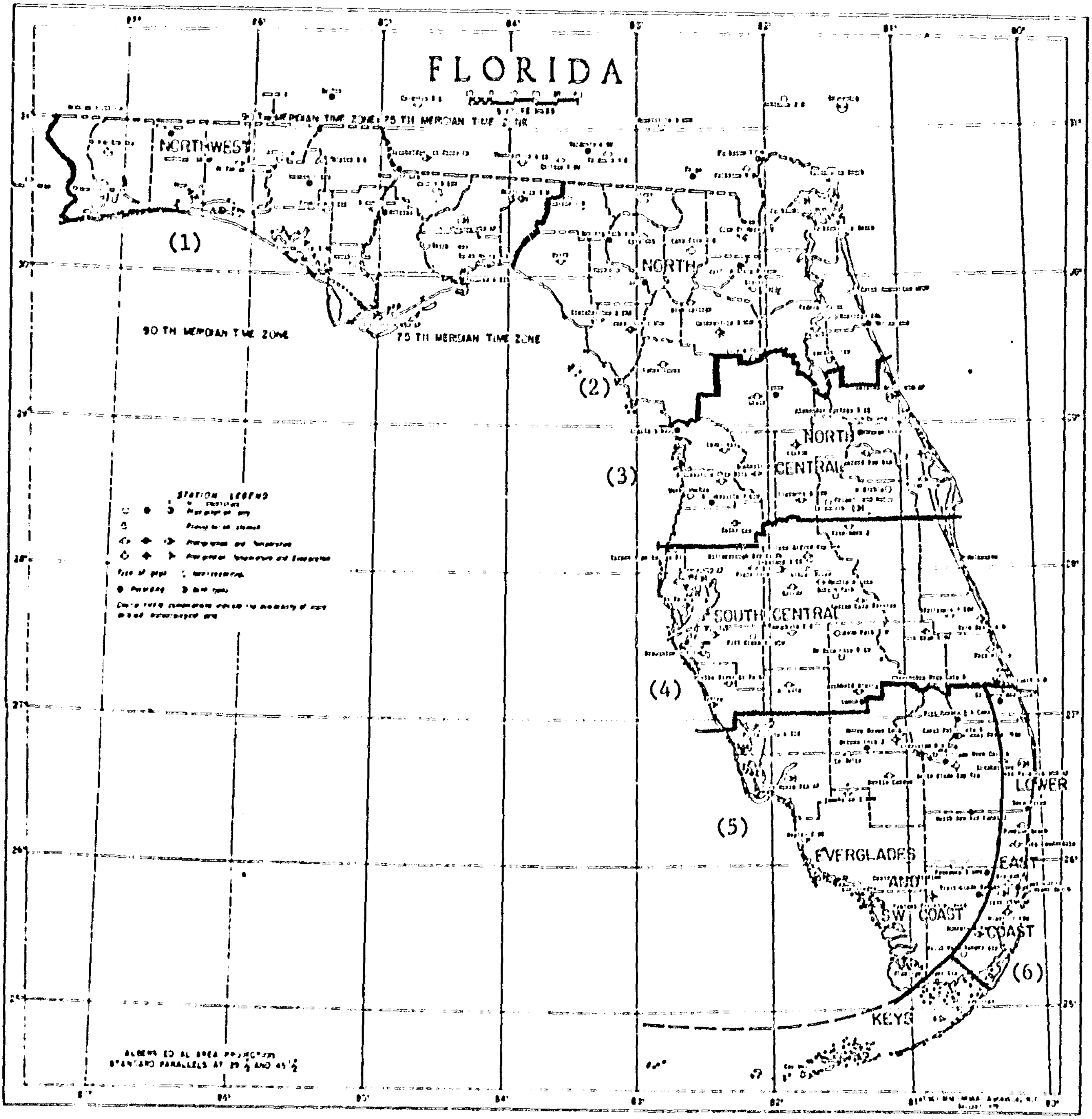
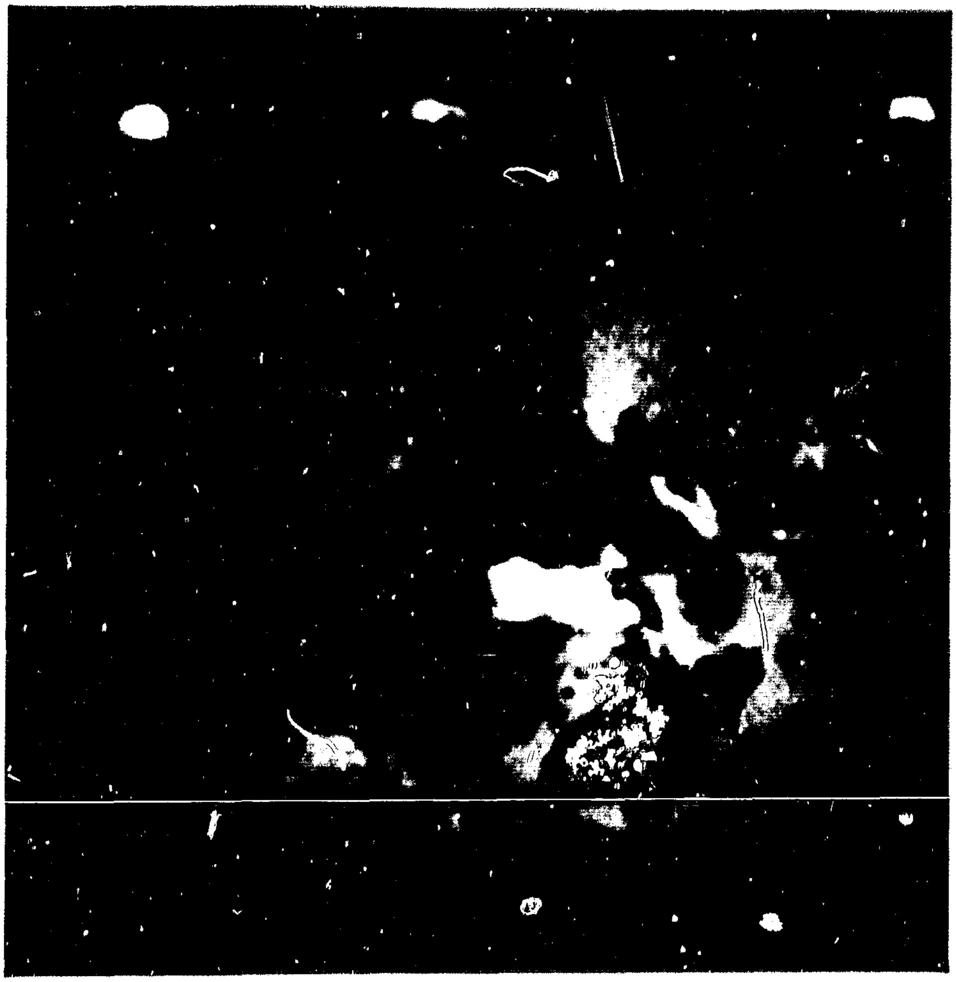


Fig. 1. Climatological regions of FLorida, showing the 6 regions where rainfall were averaged. From Climatological Data - Florida, National Climatic Center, Asheville, N.C.

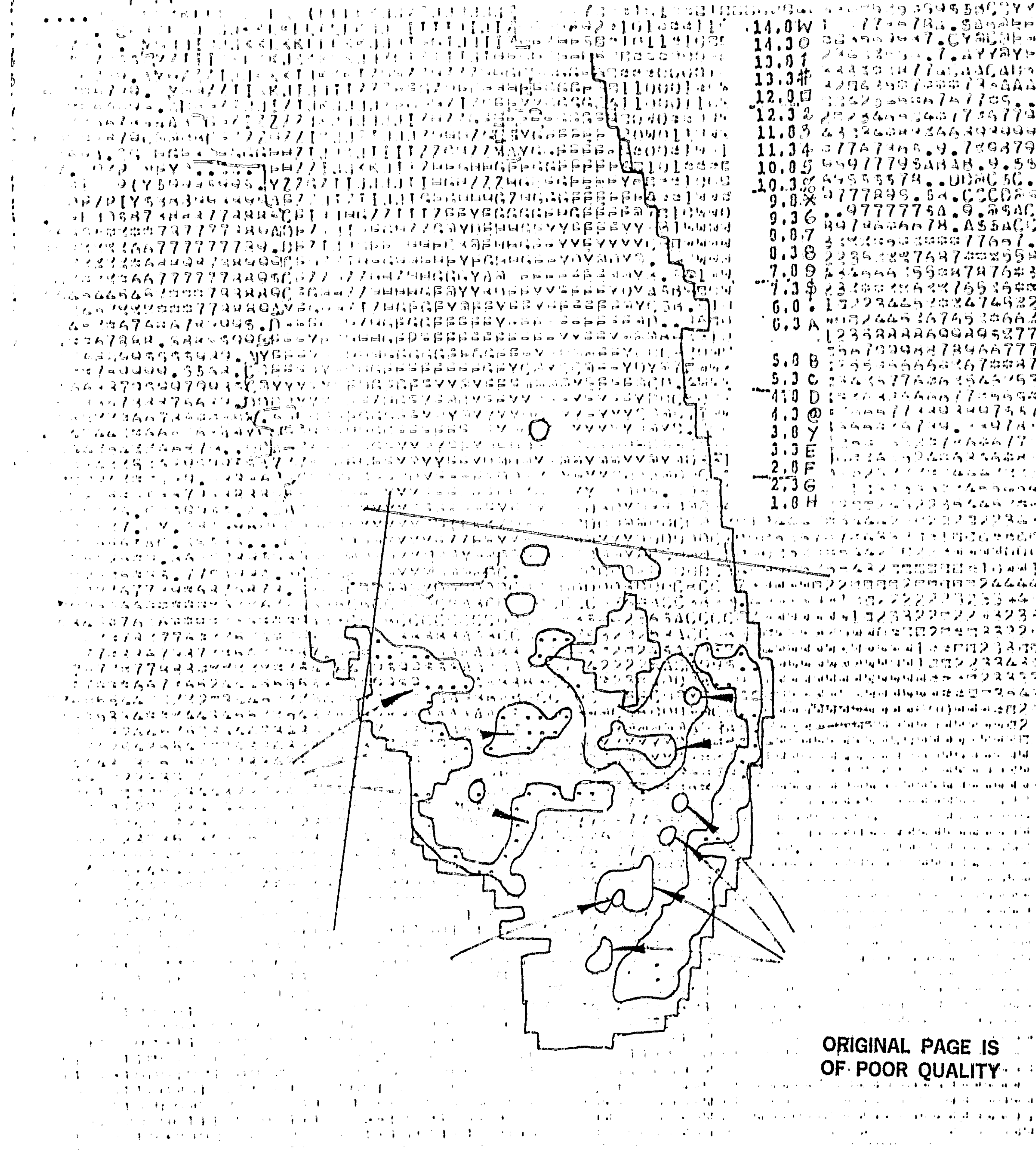


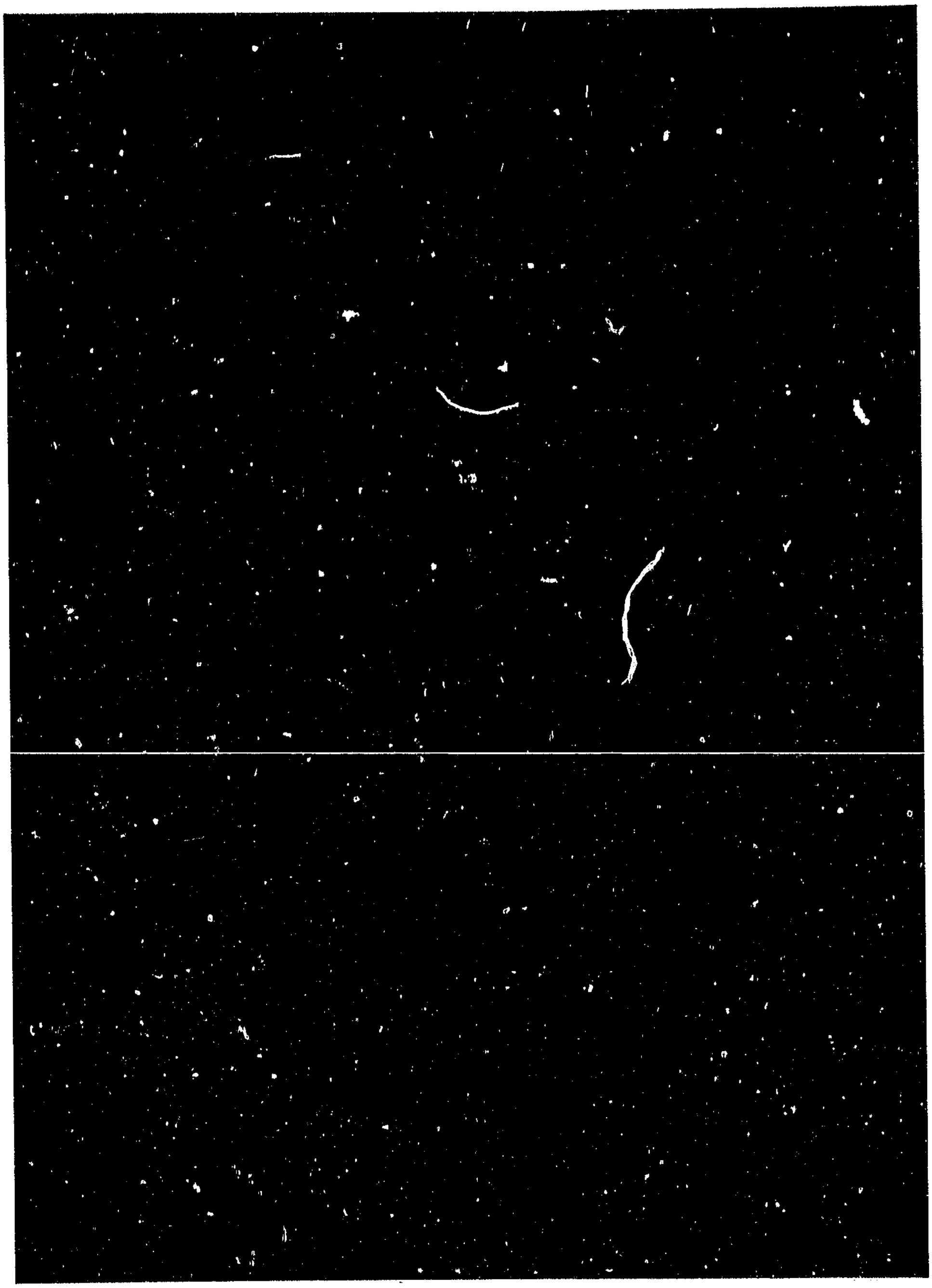
Key

1. Green (coldest)
2. Orange
3. Dark blue
4. Yellow
5. Magenta
6. Light blue
7. Black
8. White (warmest)

Fig. 2. HCMM infrared (IR) image of lower Florida at approximately 0200 EST Feb. 1, 1979, obtained by digitizing HCMM film transparency using the Image 100 computer at Kennedy Space Center. Inset shows the coldest areas in the scene (arrows).

Fig. 3. GOES infrared (IR) image at 0200 EST, Feb. 1, 1979. Thermal patterns are outlined to show correspondence to HCMM image shown in Fig. 2.





Key

1. Green (coldest)
2. Orange
3. Dark blue
4. Yellow
5. Magenta
6. Light blue
7. Black
8. White (warmest)

Fig. 4. HCMM nighttime IR image on Jan. 15, 1979, obtained by digitizing HCMM film transparency using the Image 100 computer at Kennedy Space Center. The image illustrates thermal patterns which can be generated due to different land use.

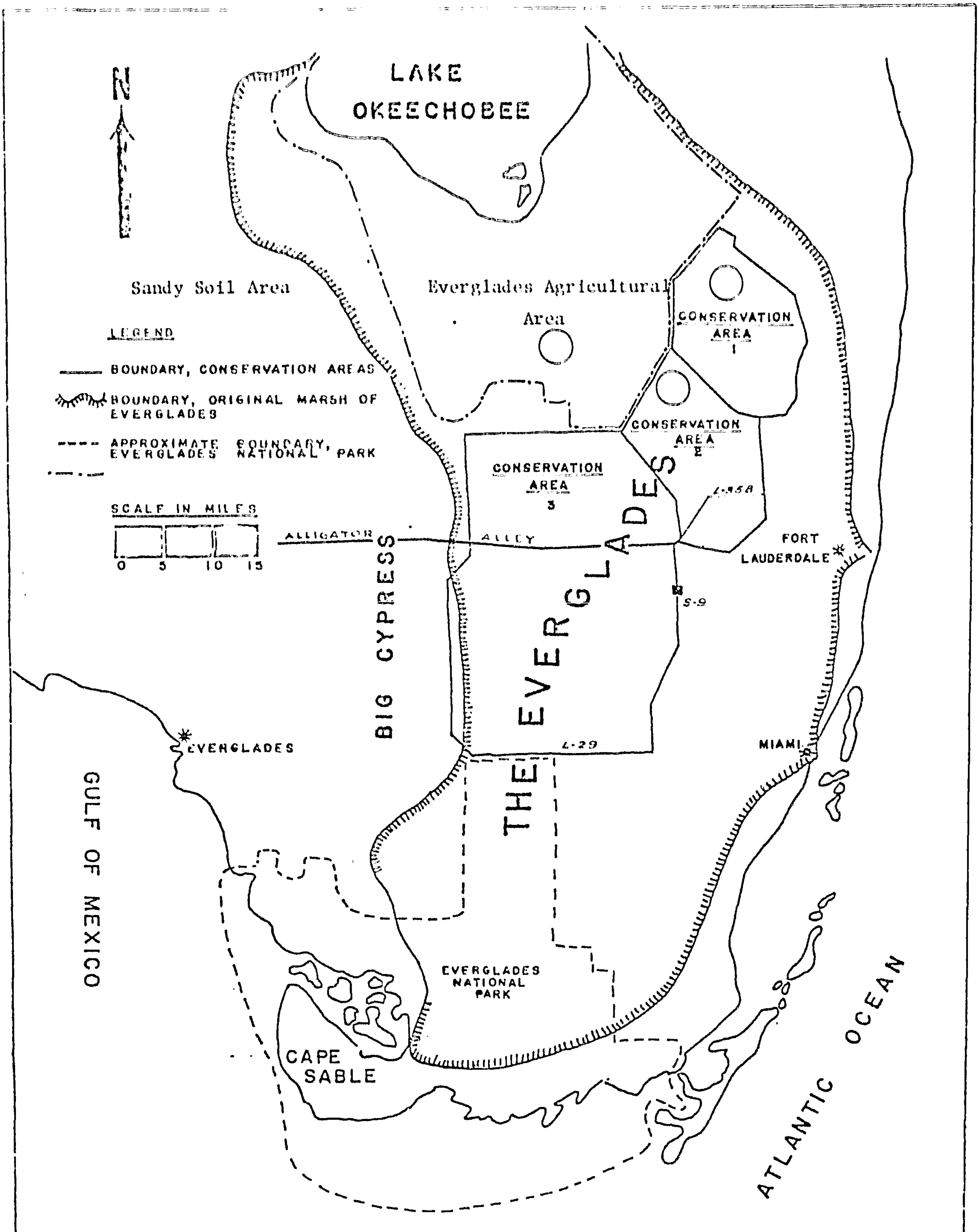


Fig. 5. MAP OF LOWER FLORIDA SHOWING LOCATION OF THE CONSERVATION AREAS AND EVERGLADES NATIONAL PARK, AND ORIGINAL EXTENT OF THE EVERGLADES MARSH. (from Central and South Florida Flood Control District, Vol. 1, No. 5, 1972).

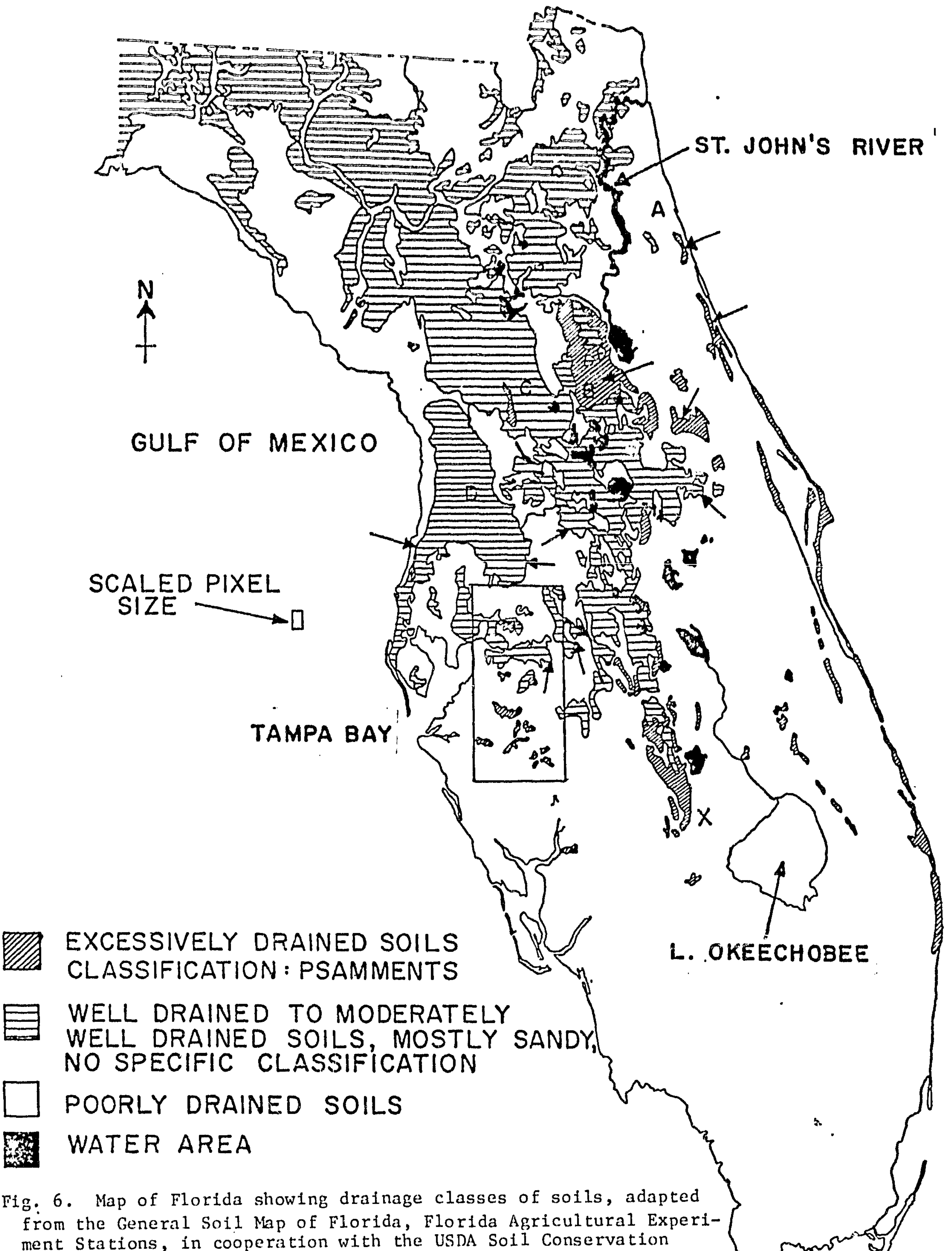


Fig. 6. Map of Florida showing drainage classes of soils, adapted from the General Soil Map of Florida, Florida Agricultural Experiment Stations, in cooperation with the USDA Soil Conservation Service, 1962.

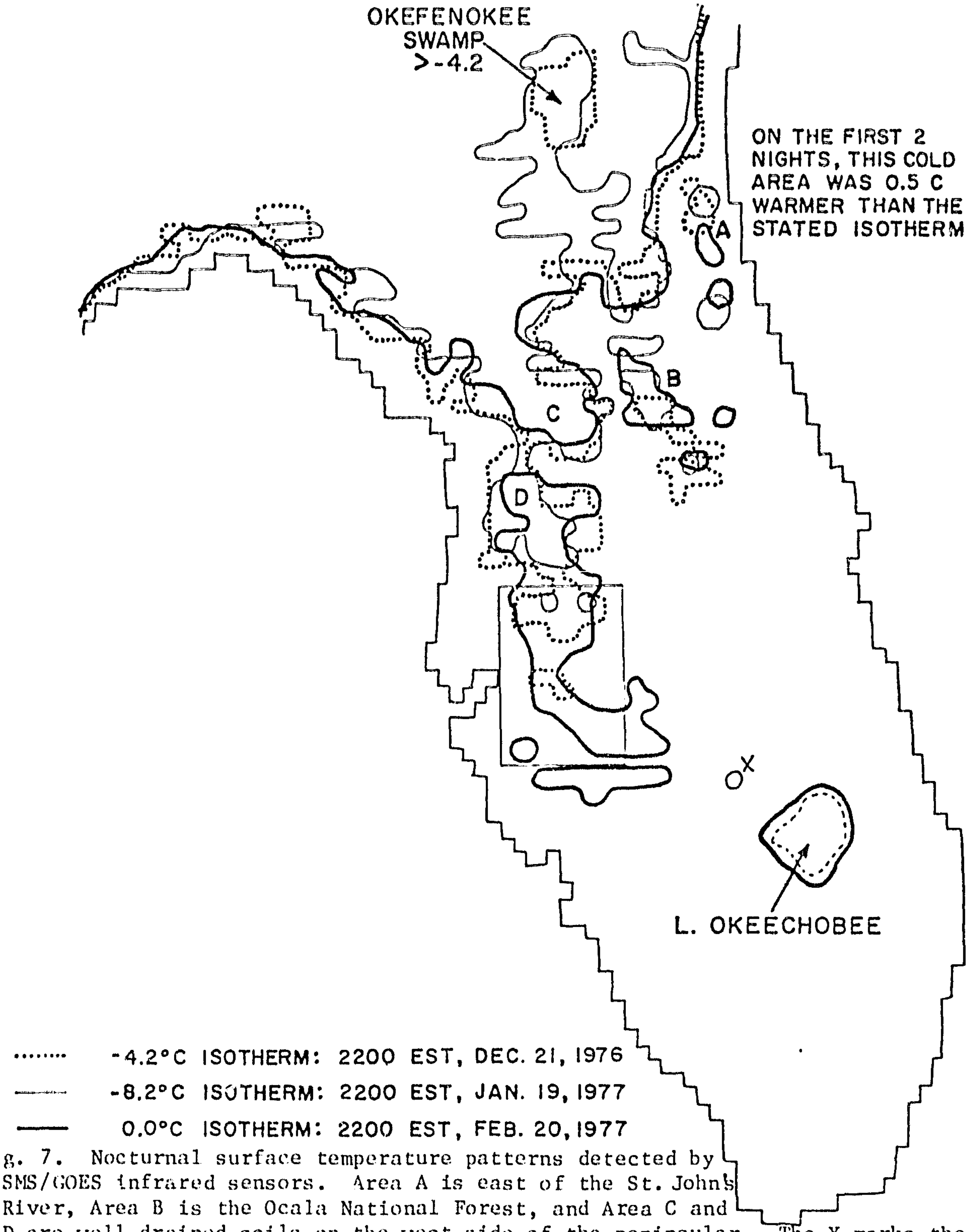


Fig. 7. Nocturnal surface temperature patterns detected by SMS/GOES infrared sensors. Area A is east of the St. John's River, Area B is the Ocala National Forest, and Area C and D are well-drained soils on the west side of the peninsular. The X marks the location of a cold pixel associated with a small area of excessively drained soil. The area within the box is a poorly defined area that frequently in colder than on the east side of the Peninsula. (Adapted from Chen et al., 1981)

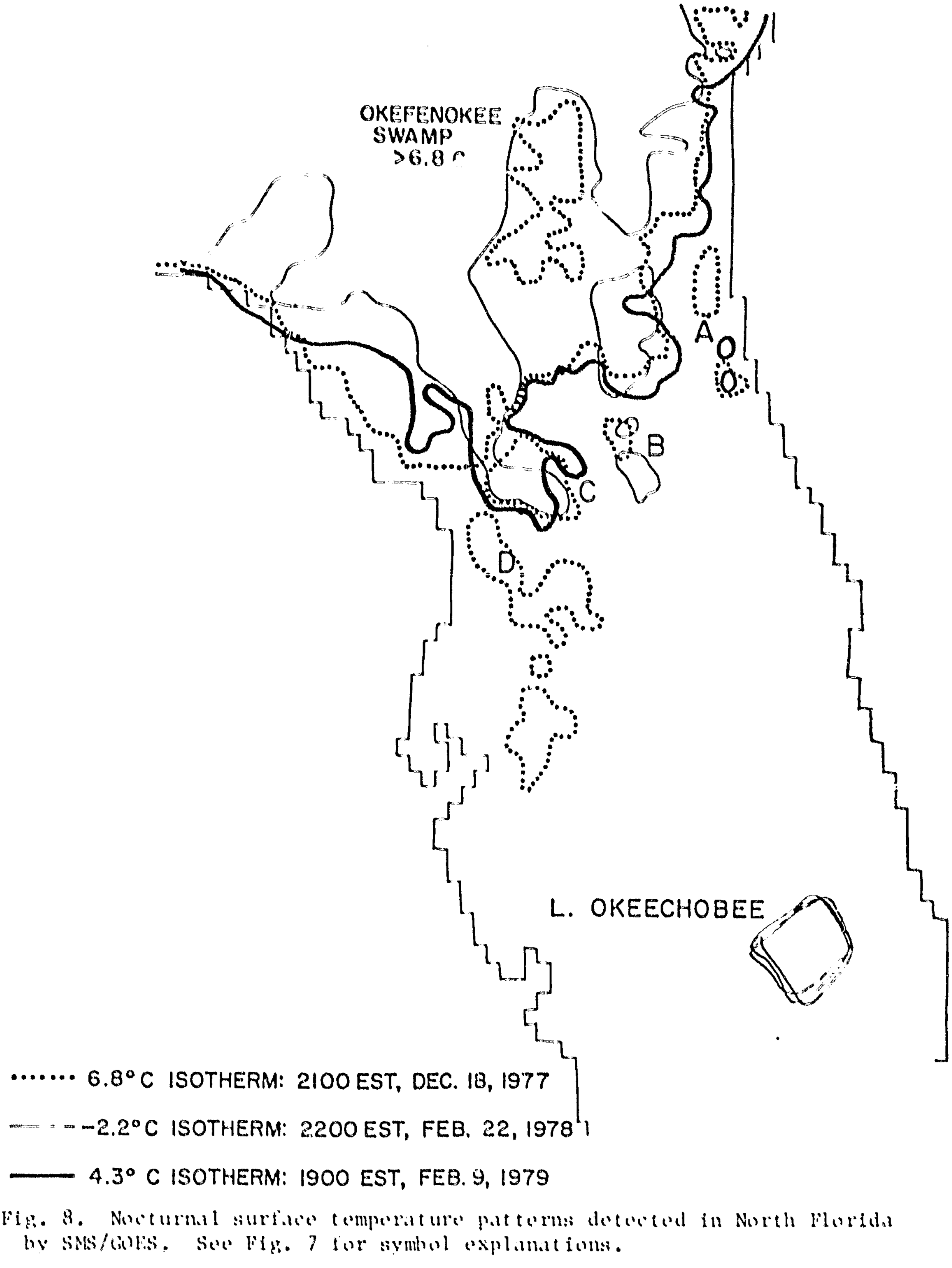


Fig. 8. Nocturnal surface temperature patterns detected in North Florida by SMS/GOES. See Fig. 7 for symbol explanations.

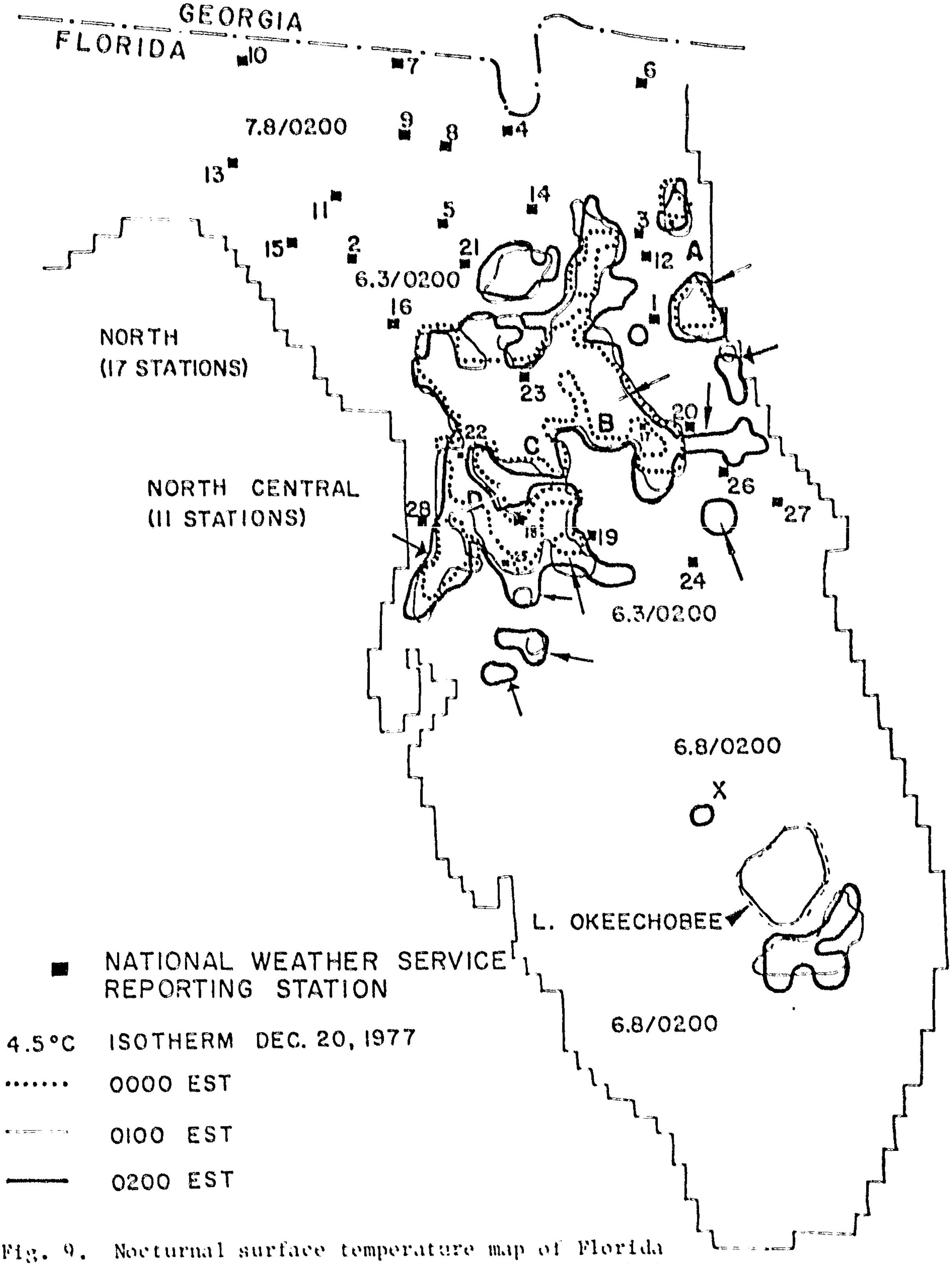


Fig. 9. Nocturnal surface temperature map of Florida from SMS/GOES data showing a large cold area with low rainfall in north central Florida.

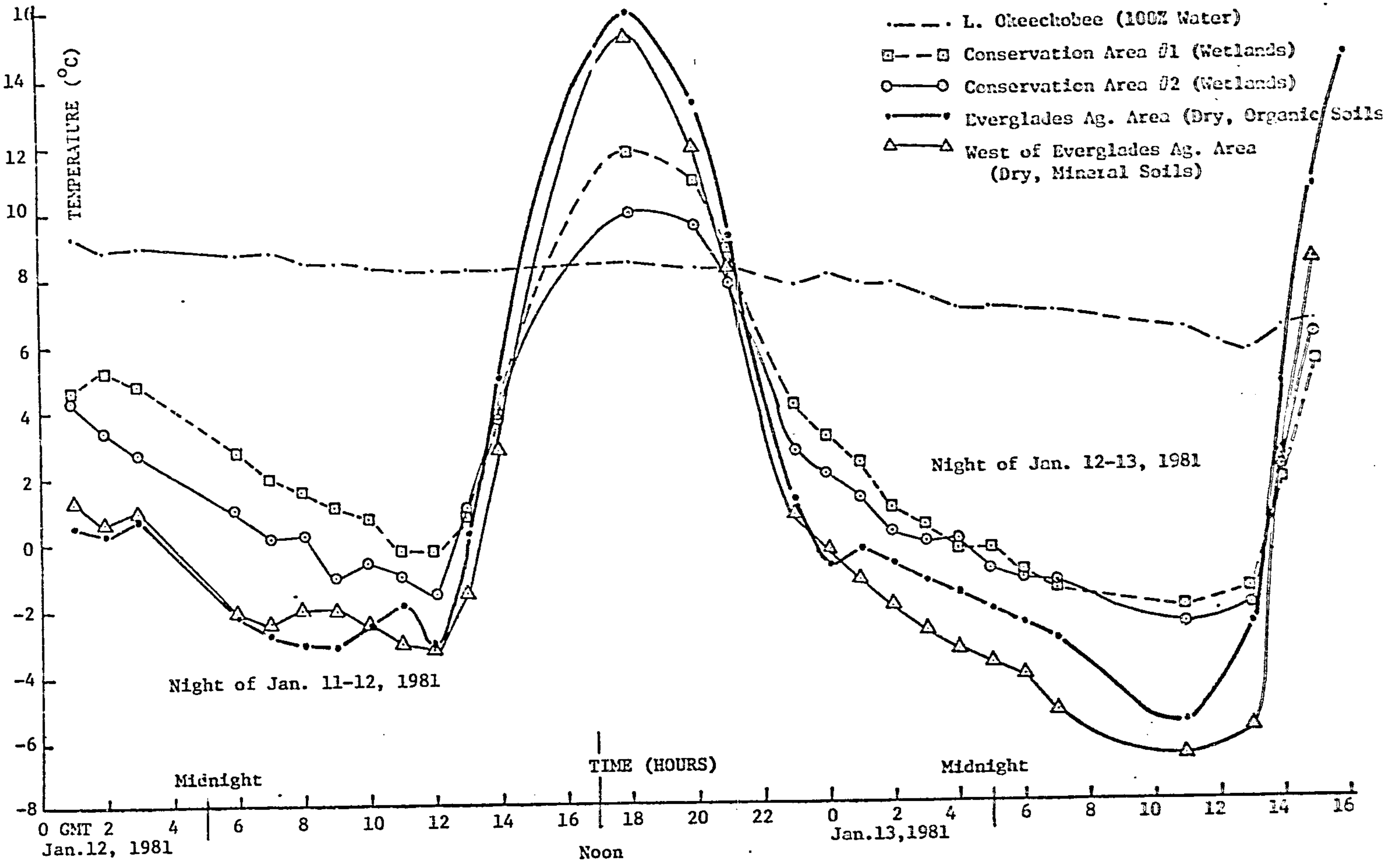


Fig. 10 Diurnal surface temperatures from GOES for L. Okeechobee, Conservation Area #1, Conservation Area #2, Everglades Agricultural Area, and an area west of the Everglades Agricultural Area (see Fig.5). The period covers Jan. 11 to Jan. 13, 1981.

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