E82-10299
CR-168868

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

HCMM Data Investigation HFO-002
Contract NAS5-26453

L.H. Allen, Jr., Principal Investigator
University of Florida
Institute of Food and Agricultural Sciences
Building 164, Agronomy Physiology Lab.
Gainesville, FL 32611

Ellen Chen, Cooperator
J. D. Martsolf, Cooperator
P. H. Jones, Cooperator

(E82-10299) USE OF THERMAL INERTIA DETERMINED BY HCMM TO PREDICT NOCTURNAL COLD PRONE AREAS IN FLORIDA Quarterly Report, 16 Sep. - 15 Dec. 1981 (Florida Univ.) 15 p HC A02/MF A01 CSCL 04B G3/43 N82-24575 Unclas 00299

December 15, 1981
Third Quarterly Report for Period September 16-December 15, 1981

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
Greenbelt, MD 20771

Preface

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

1) Problems

2) Accomplishments

3) Significant Results

4) Publications

5) Recommendations

6) Funds Expended

7) Data Utility

8) Program for next reporting interval

LIST OF TABLES

LIST OF ILLUSTRATIONS

TABLE OF CONTENTS

INTRODUCTION

This third quarterly report covers work performed during the period September 16 to December 15, 1981, of a HCMM Data Investigation Research Contract NAS5-26453 entitled "Use of Thermal Inertia Determined by HCMM to Predict Nocturnal Cold Prone Areas in Florida."

During this period most of the CCT's were received. The supplemental list of images to evaluate the use of scenes and the location of areas for detailed study were not received until December 29, 1981.

We found the best series of day-night-day scenes to be the sequence of January 29, February 1, and February 3, 1979. Because HCMM data on CCT's were not available for analysis during this period, we performed further comparisons of HCMM image data with GOES surface temperature data. On the two dates investigated, January 10, 1979, and February 1, 1979, the HCMM-derived surface temperatures for 8 locations was about 5°C lower than the GOES-derived surface temperatures.

Since we had some diurnal data available during the severe freeze events in Florida on January 12-13, 1981, and January 18-19, 1981, we computed apparent thermal inertia (ATI) for an area of drained organic soils (the Everglades Agricultural Area) and an area of excessively drained to well-drained mineral soils south of Ocala, Florida in the west north central peninsula. These ATI values for the Everglades Agricultural Area were lower one week after the first freeze, probably due to freezing of leaves of sugarcane in the area which resulted in higher daytime temperatures less affected by evapotranspiration, and more penetration of solar radiation to the dark organic soil.

The excessively-drained to well-drained mineral soil actually had lower ATI values than the drained organic soil. This observation was based on diurnal temperature amplitudes of GOES data. In previous winters, the drained organic soils of the Everglades Agricultural Area was reported as the area with the greatest cold-prone tendency (Chen *et al.*, 1979, Jour. Applied Meteorol., Vol. 18, pp.992). Part of the reason for low ATI of the mineral soil area may be due to the extremely dry conditions during late 1980 (See Table 3, Second Quarterly Report) and early 1981.

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

1. Problems:

   A. Lag time in receipt of CCT's and images.

   During the third quarter (September 16-December 15, 1981), most of the CCT's that were ordered July 10, 1981, arrived. Table 1 and Table 2 of the second quarterly report listed the products that were ordered. However, delivery dates ranged from September 18, 1981 to November 12, 1981. Furthermore, images (transparencies and prints) listed in Table 1 of the second quarterly report were not received until December 29, 1981. We could not evaluate the usefulness of the CCT's until the images arrived. Table 1 lists these products and evaluates the utility and the region covered. This table, and Table 6 of the first quarterly report, listed information about scenes that were used to evaluate scenes during the 1978-79 winter season. These images were very necessary to provide visual information about the distribution of problem areas with cloud interference.

   B. Lack of clear periods during 1978-79 HCMM passes and lack of 12-hour day-night sequence of HCMM satellite passes over Florida.

   These two problems listed in the first quarterly report were still evident even with more data. We found that the period spanning January 29, 1979 (Day IR), February 1, 1979 (Night IR) and February 3, 1979 (Day IR) gave the most complete, near cloud-free images of the whole Florida peninsula. Future work with the HCMM tapes will focus on these dates.

2. Accomplishments:

Since conditions for winters of 1978 and 1979 were not good over Florida, many frames of HCMM data apparently will not be useful. To partly compensate for lack of usable HCMM data, GOES images were used to provide information to calculate apparent thermal inertia (ATI). A large quantity of GOES winter nighttime infrared data were archived for Florida. We hope that by using the Florida data from GOES we can calculate ATI and provide information to help determine usefulness of the ATI data product. One advantage from using GOES data is that the the large amount of data allowed us to calculate ATI over the same surface within a short time period, thereby giving some assurance that thermal inertia of the soil would not have changed significantly during this period.

GOES surface temperatures were compared with calibrated HCMM night-IR data from film transparencies. Also, GOES data one week apart (January 12-13 and 18-19, 1981) were used to calculate ATI using methods in the HCMM User's Guide.

A. Comparison of GOES surface temperature with HCMM surface temperature. HCMM film transparencies for night-IR data from January 10, 1979 and February 1, 1979, were used. Film characteristics are:

January 10, 1979:
Night-IR
Contrast Range 27-76
Corresponding temperature range -1.5 to 16.6°C
°C/grey scale 1.13°

February 1, 1979:
Night-IR
Contrast Range 18-75
Corresponding temperature range -5.2 to 16.2°C
°C/grey scale 1.34°C

GOES surface temperatures used were from 0400 EST, January 10, and 2300 EST, February 1, 1979. GOES temperatures obtained from the above two images were adjusted to account for time discrepancy between GOES image time and time of passage of HCMM at approximately 0200 EST. A 0.5°C/hour drop in temperature was assumed and is a reasonably conservative amount when nights are not cold. 1°C was added to GOES temperatures obtained from January 10, 1979. 1.5°C was subtracted from GOES temperatures obtained from February 1, 1979. Results for temperature estimation for eight areas in south Florida are compared and listed in Table 2. Areas where temperatures were analyzed are shown in Fig. 1.

Average temperature difference observed from the 2 satellites is 5.9°C and 4.2°C, respectively, for the 2 nights examined. HCMM data gave temperatures lower than GOES data by approximately 5°C. Since GOES temperatures compared well with 1.5-m air temperatures (standard error of estimate, -1.6°C; correlation coefficient, 0.86, Final Report, The Development of Nocturnal GOES infrared data as a source of climate information, NOAA contract no. NA80AA-D-129, 1982). Results in Table 2 are in agreement with known HCMM results. Perhaps 5.5°C should be added back to HCMM data.

B. Calculation of Apparent Thermal Inertia (ATI) using temperatures from GOES satellite.

Equations used to calculate ATI were developed for HCMM data (Heat Capacity Mapping Mission Users' Guide, NASA, Goddard Space Flight Center, Greenbelt, MD). They are listed below:

$$ATI = NC(1 - a)/\Delta T \qquad [1]$$

where N is 1000,
C is from Table 11-3, p. 14, HCMM Users' Guide,
ΔT is obtained from GOES digital IR temperatures,

$$a = Kr/(\sin\theta \sin\phi + \cos\theta \cos\phi \cos\delta) \qquad [2]$$

θ is the latitude on earth,
ϕ is the solar declination, where

$$\phi = 0.4091 \sin\left(\frac{2\pi(\text{Day} - 80.3)}{365}\right)$$

δ is the hour angle at local noon.

$$K = 1 + 0.0167 \sin\left(\frac{2\pi(\text{Day} - 93.5)}{365}\right)^2 \qquad [2]$$

r = reflectivity

ΔT was derived from GOES diurnal surface temperatures from 2 days and nights (Jan. 12-13, and Jan. 18-19, 1981) for 1 area each in central and southern Florida (Fig. 1). Area 4 is an agricultural area of drained organic soils, known as the Everglades Agricultural Area (see Second Quarterly Report). Area 9 is in an area of excessively well-drained and well-drained sandy soils directly south of Ocala, Florida in west North Central Florida. Temperatures obtained from GOES images showed consistently that the well-drained and excessively well-drained areas are colder during winter nocturnal conditions and hence have different climate characteristics from wetland areas. Values obtained from the above equations and used to calculate ATI are listed in Table 3.

We are not certain of the interpretation that should be given to the calculated ATI because it is scaled to 0-255 levels and sliced into grey scales rather than expressed in physical units. It cannot be determined whether calculated ATI is reasonably close to known values for organic and mineral soils. The difference (36.1 vs. 28.5) in value for organic soil from the same area and within a week may indicate that other factors (wind, atmospheric absorption) were neglected, that could influence surface temperatures. Rainfall was scanty during the week. It ranged from 0 to a maximum of 0.18 inch, as reported in the Clewiston and Belle Glade area (Climatological Data, Florida, 85, January, 1981). Diurnal surface temperatures for Area 4 for the 2 days (Fig. 2) showed a difference of 6°C during daytime. This difference in surface temperature for the same area over a week's period caused the difference to appear in the calculated ATI's. Wind data were found to be insufficient to determine whether wind was a significant contributing factor to the temperature difference. We did not obtain vertical moisture profiles to correct for atmospheric absorption. One factor which may also contribute to the difference (6°C) in daytime surface temperature may be the extensive damage of crops in the area from the earlier freeze (Jan. 12-13, 1981), that cause leaves of the extensive sugarcane crop to senesce and partially abscise, which would allow more solar radiation to reach the surface of the dark organic soil.

C. HCMM Computer Compatible Tapes.

A computer program to read HCMM tapes is being altered so that it can convert ASCII to EBCDIC. The North East Regional Data Center (NERDC), University of Florida, Gainesville, FL, will be used to read HCMM tapes. NERDC presently does not have a subroutine in its library which can be used to convert ASCII to EBCDIC.

3. Significant Results:

   A. HCMM surface temperatures on January 10 and February 1, 1979 appear to be about 5°C lower than GOES.

   B. Apparent Thermal Inertia for excessively-drained to well-drained mineral soils was greater than for drained organic soils, possibly because of long periods of low rainfall during late 1980 and early 1981.

   C. Organic soils cropped to sugarcane showed lower apparent thermal inertia after a severe killing freeze on January 12-13, 1981. The freeze killed leaves and resulted in less evapotranspiration and probably more solar radiation reaching the dark soil surface, which would explain the larger diurnal temperature amplitude observed.

4. Publications - none from this work. One journal article submitted to Journal of Applied Meteorology, and another journal article under preparation, both based on previous work with GOES data.

5. Recommendations:

   No new recommendations. Our experience continues to reinforce the long-term recommendations of the first quarterly report.

6. Funds expended to date (December 15, 1981) -

7. Data Utility:

   See also the first quarterly report. Our expanded attempt to gain visuals over Florida have shown thermal inertia related features outside the bounds of Florida. However, most of these observations were not part of the original objectives of the investigation, but they do directly relate to the overall mission of HCMM.

   A. The south Atlantic Coastal Plain shows features similar to Florida. Under cold air outbreak conditions, the broad floodplains of rivers are warmer than well-drained areas.

   B. The warmer Gulf Stream waters are readily apparent from the cooler coastal waters of the Atlantic, Caribbean, and Gulf of Mexico waters.

   C. Shallows of the Bahamas and Cuba are readily identified. Differences in thermal properties of Cuba were also obvious.

   D. Eddies between the Atlantic coast line and the Gulf Stream current were obvious.

8. Program for next reporting interval:

   Since data were late in arriving, the work for the next reporting interval will be similar to that listed in the second quarterly report.

TABLE 1.

NASA/GSFC Contract No. NAS5-26453 "Use of Thermal Inertia Determined by HCMM to Predict Nocturnal Cold Prone Areas in Florida"

Images - Ordered July 10, 1981 (page 1 of 4)
- Received Dec. 29, 1981

Plate #	Date	Type	Utility	Region Covered
046	15 Dec 78	NIR	Poor	Tam.-Oke
080	20 Dec 78	NIR	Poor	Tam.-St.J.
081	20 Dec 78	NIR	Med	EAA-Cuba
412	29 Jan 79	DVIS	Poor	Fla-GA-SC
413	29 Jan 79	DIR	Poor	Fla-GA-SC
105	01 Feb 79	NIR	Good	Su-St.J.
012	03 Feb 79	DVIS	Excell	EAA-Cuba
013	03 Feb 79	DIR	Excell	EAA-Cuba

046 - Cloud streak over Taylor Creek.
080 - Fog??
081 - Cuba excellent. EAA may be OK.
105 - Generally good.
412/413 - S. Carolina good.
012/013 - Cuba excellent. EAA may be OK.

TABLE 2.

Comparison of surface IR temperatures derived from HCMM film transparencies with GOES surface IR temperatures for 8 areas in South Florida. Temperature is in °C.

Area Compared	January 10, 1979			February 1, 1979		
	HCMM	GOES[1]	Δ	HCMM	GOES[2]	Δ
1. Lake Okeechobee	9.0	13.0[3]	4.0	6.6	13.0[3]	6.6
2. Lake Kissimmee				5.6	8.8	2.7
3. Blue Cypress Lake				5.6	7.3	1.7
4. EAA	-1.6	8.5	10.1	-1.2	4.8	6.0
5. Cons. Area #1	6.2	11.0	4.8	4.2	10.0	5.8
6. Cons. Area #2	7.9	11.5	3.6	5.9	10.5	4.6
7. Everglades	5.7	11.5	5.8	3.7	9.5	1.7
8. EAA, West	2.0	9.3	7.3	2.2	7.0	4.8
Average Δ			5.9			4.2

Δ = GOES temperature - HCMM temperature.

1 Temperature was estimated by adding 1.0°C to the temperature obtained from the 0400 EST GOES image in order to bring the GOES temperature closer to the time of passage of HCMM (≈ 0200 EST).

2 Temperature was estimated by subtracting -1.5°C to the temperature obtained from the 2300 EST GOES image to bring the GOES temperature closer to the passage of HCMM (≈ 0200 EST).

3 Water temperature of Lake Okeechobee was allowed to stay the same because it had been shown that GOES water temperature decreases ≈ 2°C throughout the night (Final Report, NOAA Contract No. NA80AA-D-00129).

TABLE 3.

Values used in calculation of apparent thermal inertia (ATI) for 2 areas in Florida: Area 4, the drained organic soils of the Everglades Agricultural Area (EAA) in South Florida, and Area 9, the area classified as excessively drained and well-drained mineral soils 25 km directly south of Ocala in the west North Central Florida peninsula. Data used were from January, 1981.

Area where ATI is calculated	Area 4 Organic Soil		Area 9 Mineral Soil	
Date (January, 1981)	12-13	18-19	12-13	17-18
N	1000	1000	1000	1000
θ (latitude)	26.5°	26.5°	29.0°	29.0°
ϕ (solar declination)	-21.63°	-20.58°	-21.63°	-20.58°
δ (hour angle)	-6°	-6°	-6°	-6°
C (Table 11-3, HCMM User's Guide)	0.981	1.004	0.926	0.950
ΔT (GOES), °C	19.3	25.0	24.6	23.1
r (reflection, from Geiger)	0.2	0.2	0.35	0.35
K (calculated from Eq. [3])	0.967	0.968	0.967	0.968
a (calculated from Eq. [2])	0.2014	0.2016	0.5370	0.5375
ATI (calculated)*	36.07	28.51	17.42	17.56

* Unit for ATI is scaled to 0-255 rather than to physical units (HCMM User's Guide, p. 10).

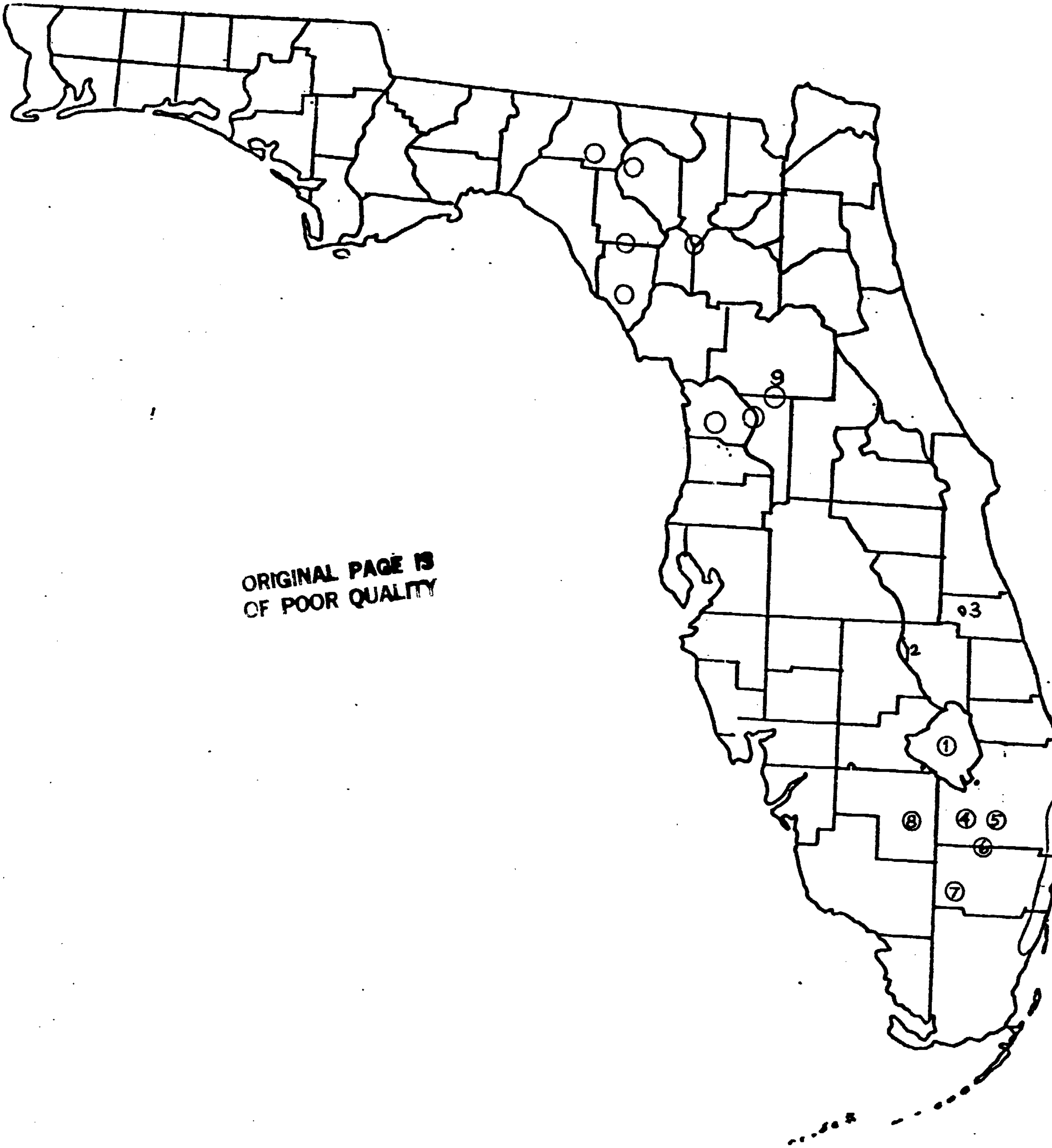

Fig. 1. Map showing the eight areas (1 to 8) where HCMM derived surface temperatures were compared with GOES surface temperatures. ATI was calculated using T obtained from GOES from Area 4 and Area 9. County lines are shown on the map.

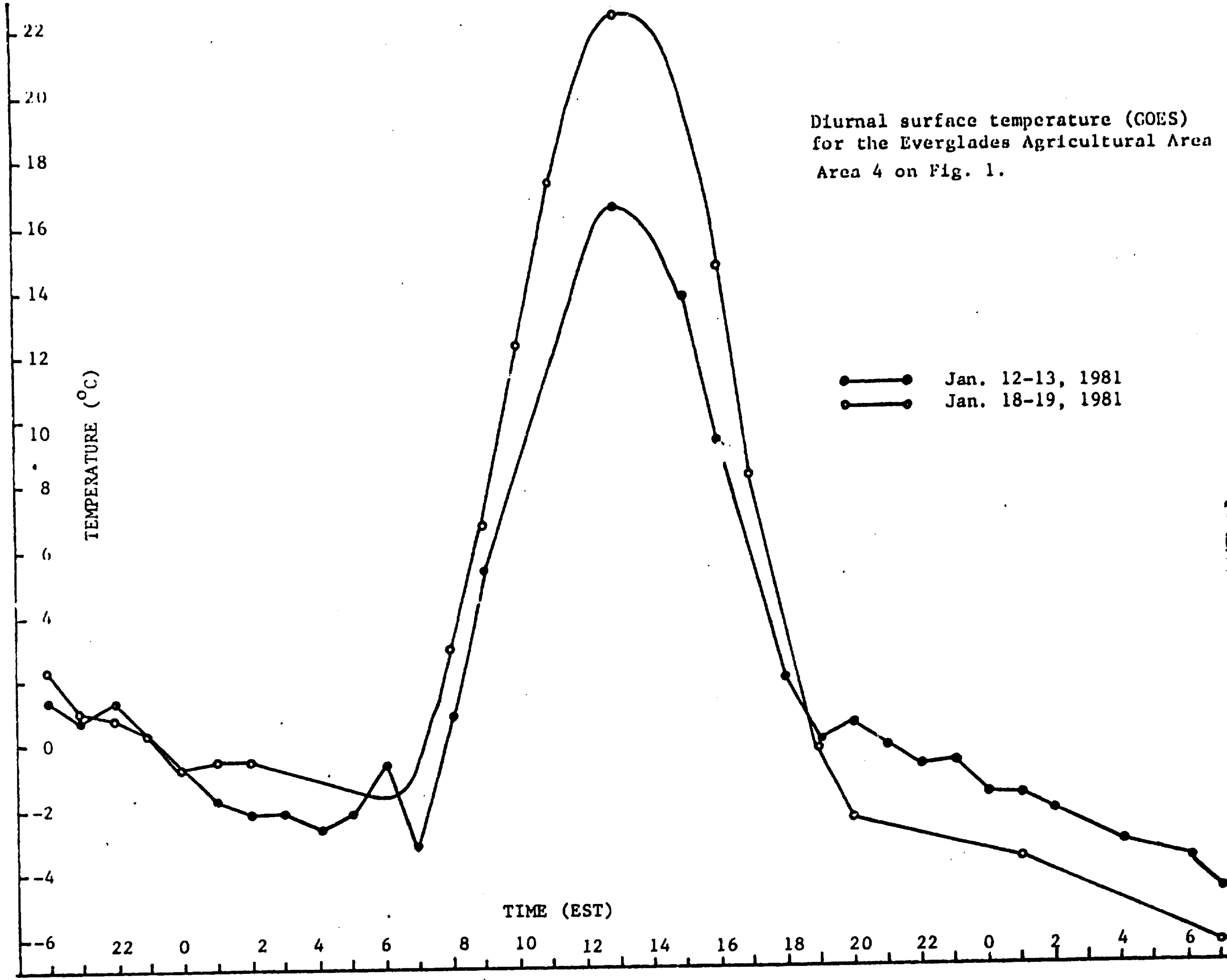
Diurnal surface temperature (GOES)
for the Everglades Agricultural Area
Area 4 on Fig. 1.
Jan. 12-13, 1981
Jan. 18-19, 1981
TEMPERATURE (°C)
TIME (EST)
22
20
18
16
14
12
10
8
6
4
0
-2
-4
-6
22
0
2
4
6
8
10
12
14
16
18
20
22
0
2
4
6

Fig. 2.