8.0-10106
CR-162817

PLANT COVER, SOIL TEMPERATURE, FREEZE, WATER STRESS, AND EVAPOTRANSPIRATION CONDITIONS

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(E80-10106) PLANT COVER, SOIL TEMPERATURE, FREEZE, WATER STRESS, AND EVAPOTRANSPIRATION CONDITIONS Quarterly Progress Report, 1 Dec. 1979 - 1 Mar. 1980 (Department of Agriculture) 9 p HC A02/MF A01 CSCL 08B G3/43
N80-23733
Unclas
00106

March 1980

Type II Quarterly Progress Report
for Period December 1, 1979 to March 1, 1980

Prepared for

GODDARD SPACE FLIGHT CENTER
Greenbelt, MD 20771

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle
PLANT COVER, SOIL TEMPERATURE, FREEZE, WATER STRESS, AND EVAPOTRANSPIRATION CONDITIONS

5. Report Date
March, 1980

6. Performing Organization Code

7. Author(s)
Craig L. Wiegand, et al. HCMM

8. Performing Organization Report No.

9. Performing Organization Name and Address
Science and Education Administration
U. S. Department of Agriculture
P. O. Box 267
Weslaco, TX 78596

10. Work Unit No.

11. Contract or Grant No.
S-40198B

12. Sponsoring Agency Name and Address
GODDARD SPACE FLIGHT CENTER
Greenbelt, MD 20771

13. Type of Report and Period Covered
TYPE II Report
12/1/79 to 3/1/80

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract
Two additional procedures for editing cloud-contaminated pixels from HCMM data are described. (In the last progress report a ratio of the VIS to IR data was discussed). One is a moving window of pixels where the windows investigated have been 3x3, 5x5, 7x7, and 9x9 pixels in size, and the central pixel is ratioed to the mean for the window. This procedure can be used for night IR data. A second that is useful for daytime VIS and IR band scene pairs uses scatter diagrams of the two bands and takes advantage of the fact that earth surface features have many pairs of data points where the values in the two bands are the same. In contrast, clouds have few locations within a scene where the paired pixels have similar digital values in both bands. This procedure has been termed the clumping cloud detection scheme.

Analysis of a day thermal scene for 07 Feb 79 and a night thermal scene for 26 Feb 79 showed that temperature transects at the same latitude were near mirror images of each other for land surfaces. The vegetation cover remained static due to winter dormancy. The data suggest that day/night temperature differences measured weeks instead of hours or days apart may meaningfully characterize semi-arid land surfaces.

17. Key Words (Selected by Author(s))
Heat Capacity Mapping Mission, HCMM Soil Temperature, Freeze, Water Stress, Plant Cover, Canopy Temp., Thermal Scanner, Crop Stress, Evapotranspiration

18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
UNCLASSIFIED	UNCLASSIFIED		

*For sale by the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

TYPE II QUARTERLY PROGRESS REPORT

December 1, 1979 to March 1, 1980

A. Problems:

Six of the seven HCMM CCT that had been received by the start of this reporting period were 40 percent or more cloud covered. This necessitated our concentration on methods of machine screening so as to remove from analysis all pixels that are cloud contaminated.

A minor problem is that thermal band sometimes responds to atmospheric water vapor concentrations that are not apparent in the reflective band. Thus, the thermal emissive band is behaving as if thin clouds are present, whereas the reflective band does not detect them. Consequently, some uncertainty is introduced into procedures intended to remove cloud contaminated pixels.

Some success in detecting clouds can be achieved by ratioing Day-VIS with Day-IR data (Fig. 1 of our last Progress Report). Clouds are usually the only summertime feature that appear cool in the thermal band and bright in the reflective band. Thus, a ratio of the two bands appears to enhance the difference of clouds to water bodies, vapor, and surface. However, the ratioing scheme does not distinguish vapor effects from water bodies and land surface. Also, the ratioing scheme will not work for night data due to the absence of reflective data.

Tarpley in 1979 described a process for eliminating cloud-contaminated observations from GOES VISSR thermal data using standard deviations. His reasoning was that the standard deviations for cloud-contaminated data would be more variable than noncloud-contaminated data. We also have found that cloudy data are variable with high standard deviations. However, data for water body-land interfaces such as for Falcon Reservoir, the Gulf of Mexico, and the bay (Laguna Madre), also have high standard deviations; thus Tarpley's scheme would incorrectly classify these water body-land interface areas as clouds. Also, the atmospheric vapor-contaminated area does not yield a high standard deviation; thus, Tarpley's scheme would incorrectly identify this area as clear. It is possible that the Great Plains area, where Tarpley's scheme was applied, had a dry enough atmosphere and a dearth of water bodies so that neither was a problem. However, there are many other places in the world where this may be a problem.

B. Accomplishments:

1. Moving-Window Cloud Detection Scheme.

A cloud detection scheme applied to IR scenes at Weslaco, Texas uses the ratio of the center pixel value (Xc) to the average pixel value ($\bar{X}$w) of a moving n x n pixel size window (Fig. 1). What is happening is that the original data (Xc) are being ratioed to low pass-filtered-data ($\bar{X}$w). The ratio is proportional to NEDT and image information is filtered from the raw data. Variations in Xc due to clouds are treated as high frequency image detail that is partially blocked by the low pass filter. Ratio values less than Xc/$\bar{X}$w = 0.92 are assumed to be due to a partial cloud and the corresponding center pixel values are censored. This approach appears to distinguish between cloud values and surface and water body values satisfactorily. It does not censor vapor contamination. Unfortunately it causes a loss of detail because of the averaging effect. This may not be objectionable where generalized results are desired.

The same Xc/$\bar{X}$w = 0.92 ratio value was applied to all Weslaco data for cloud detection. Figure 2 shows the effect of the 0.92 ratio value for partly cloudy 27 May 78 and 12 June 78 HCMM overpass dates, and clear days 21 Oct 78 and 07 Feb 79. Note the small variability on the right side of all scenes, the Gulf of Mexico.

2. Clumping Cloud Detection Scheme.

In another cloud screening method, we have taken advantage of the fact that clouds are individualistic in scatter diagrams of visible and thermal pixel values. Clouds have few locations where pixel values of both wavebands are the same as other locations. Conversely, pixel values from the earth's surface tend to have numerous locations where both pixel values are the same as other locations. The resulting scatter from cloudy areas and the clumping of clear areas are being used to separate data with clouds from data of noncloudy areas.

3. Day Minus Night Temperature Data.

For our LRGV it is not possible to obtain Day/Night HCMM coverage 12 hours apart, nor has it been possible to obtain cloud-free 36-hour Day/Night coverage. We have received a Day-IR scene for 07 Feb 79 and a Night-IR scene for 26 Feb 79. These two scenes were clear winter scenes with typically weak atmospheric absorption characteristic for that time of year. The data in these two profiles were smoothed with a 3x3 moving window ($\bar{X}$). Air temperatures were 6° C and 21° C on the average for the night and day scene, respectively.

Figure 3 shows that the 07 Feb 79 day scene and 26 Feb 79 night scene temperature profiles across the LRGV at Latitude 26.2° N are almost mirror images; that is, high day land surface temperatures on 07 Feb 79, are generally mirrored by low night land surface temperatures on 26 Feb 79. The temperatures of water in Falcon Reservoir and the Gulf of Mexico are almost identical on both dates as expected for these deep water bodies. If 12 hour or even 36 hour day minus night HCMM coverage were available, the temperature difference between day and night land surface temperature profiles would probably have been even more pronounced. The figure indicates, however, that day/night overpasses need not be that frequent if vegetative cover has remained essentially static and little or no rain has fallen in the intervening period.

The clear and weak atmospheric absorption characteristics of the 07 Feb 79 and 28 Feb 79 Day/Night scene pair means that the temperature profiles shown are probably due to near surface soil water content and to vegetative cover.

4. Thermal Response of Land Surface Relative to Vegetative Cover and Water Stress.

Seven Day-IR, Day VIS scenes have been processed that were observed during the period 27 May to 9 July, 1978, when a number of large fields were being ground-truthed. The data have been reduced to tabulation of surface temperature for each of the fields. During the next quarter, these temperatures will be compared in detail with the ground-truth data obtained (percent ground cover, plant height, irrigation dates).

C. Significant Results:

We can not obtain HCMM day/night coverage 12 hours apart at our latitude (26° N), nor have we received any day/night scene pairs 36 hours apart. However, a day-IR scene for 07 Feb 79 and a night scene for 26 Feb 79 have been analyzed. A profile across the test site for the same latitude shows that the two profiles are near mirror images of each other over land surfaces and that the temperature of two large water bodies, Falcon Reservoir and the Gulf of Mexico, are nearly identical on the two dates. During the time interval between overpasses, the vegetative cover remained static due to winter dormancy. The data suggest that day/night temperature differences measured weeks apart may yield meaningful information about the contrast between daytime maximum and nighttime minimum temperatures for a given site.

D. Publications:

None

E. Recommendations:

Communication with other investigators is desperately needed. Exchange of knowledge on results and methods would mutually improve interpretations.

The band now described as the VIS band should be termed the "reflective" band, and the IR band should be dubbed the "emissive" band. The reason is that the VIS band on HCMM extends into the 0.75 to 1.35 μm near-infrared band where plants are highly reflective. Furthermore, bands 5 (0.5 to 0.6 μm) and 6 (0.6 to 0.7 μm) of Landsat have been extensively referred to as the visible wavelength bands; and bands 7 (0.7 to 0.8 μm) and 8 (0.8 to 1.1 μm) have been called the near-infrared or simply infrared bands.

F. Funds Expended: (through 31 Jan 1980)

Allotment for FY 78 - - - - - - - - -	$ 45,240.00
Allotment for FY 79 - - - - - - - - -	59,760.00
Allotment for FY 80 - - - - - - - - -	18,600.00
Total	$123,600.00
Location and Indirect Program Costs	$ 28,548.00
Salaries - - - - - - - - - - - - -	66,651.00
Travel and transportation- - - - -	4,441.00
Transportation of things - - - - -	44.00
Services and Supplies - - - - - -	11,716.00
Equipment - - - - - - - - - - - - -	4,392.00
Total	$115,792.00
Balance	$7,808.00

G. Data Utility:

CCT received and on order should be adequate to test the objectives of the experiment. We regret that we have not been able to identify any usable day/night scene pairs in photoproducts sent to us that are 36 hours apart.

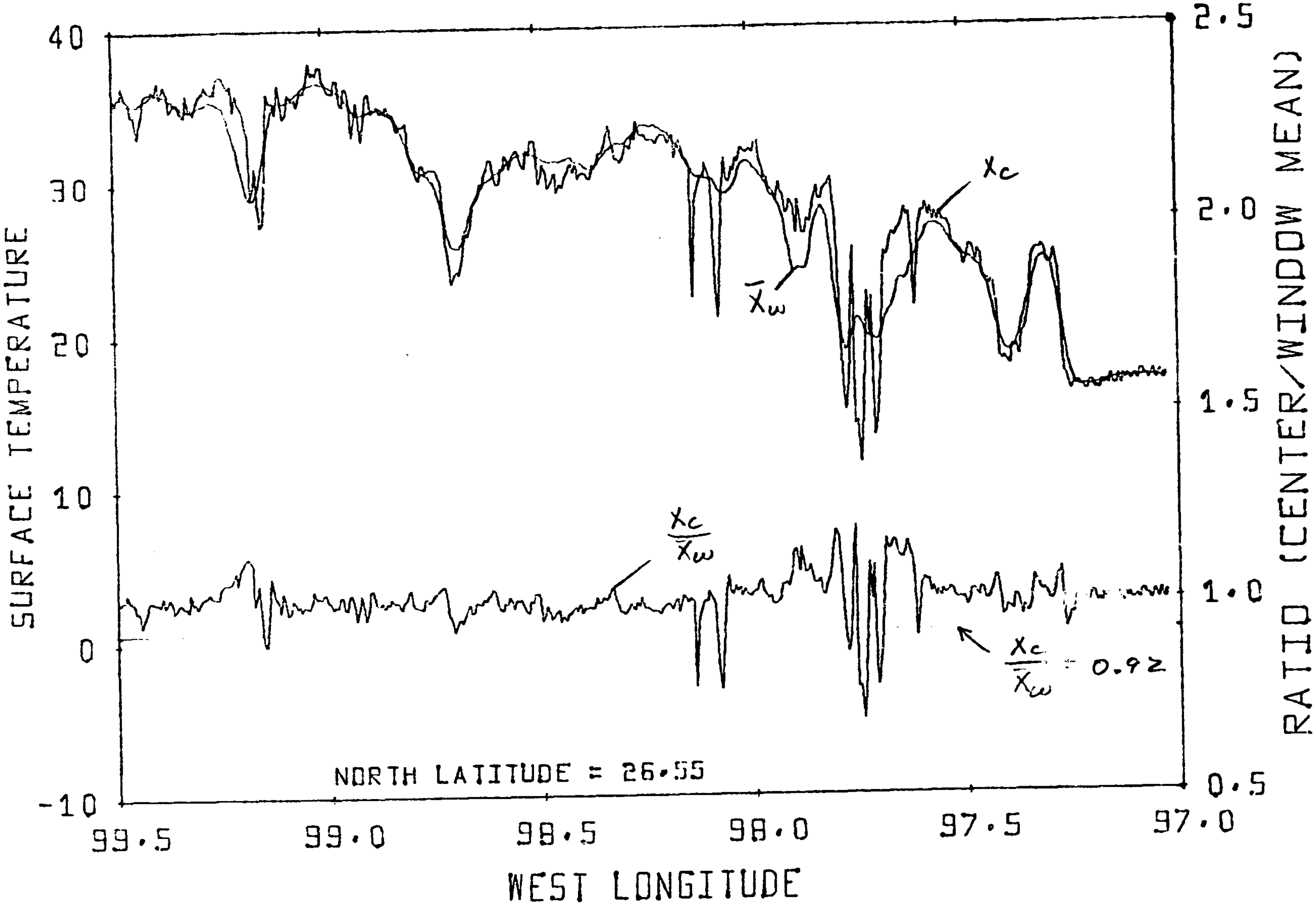

Fig. 1. Upper curves show unfiltered (Xc) and filtered ($\bar{X}w$) temperature profiles of an east-west transect across the LRGV test sites on latitude 26.55° N during a relatively clear day, 15 Aug 78. The lower curve (Xc/$\bar{X}$w) shows the ratio of the temperature of the center pixel to the mean temperature of a 9 pixel by 9 pixel moving window. Areas falling below the 0.92 ratio line (Xc/Xw=0.92) are considered to be cloud contaminated.

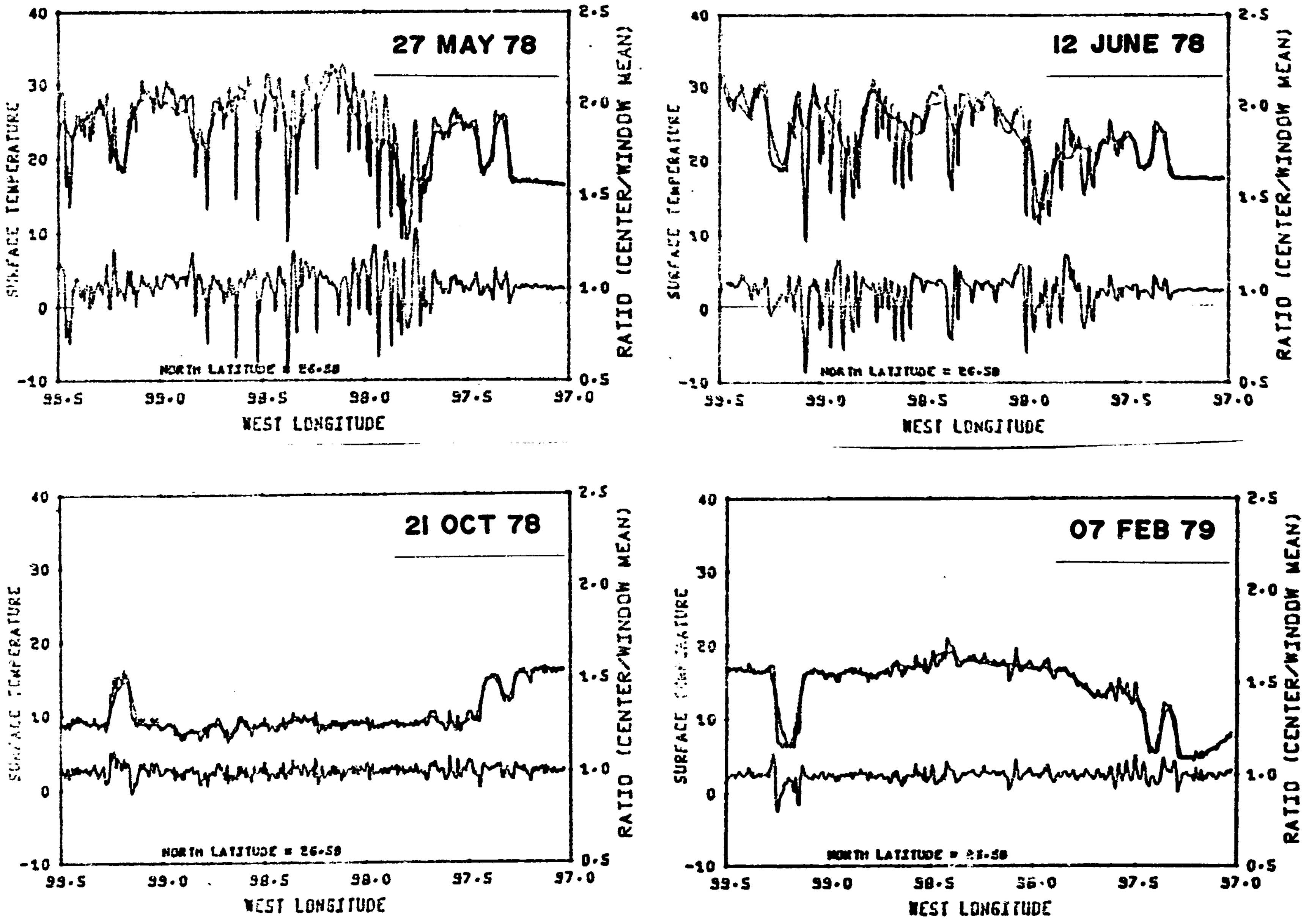

Fig. 2. The upper curves of each graph show the unfiltered and filtered daytime temperature profiles of east-west transects across the test site on latitude 26.55° N. Two partly cloudy and two clear dates are illustrated. The lower curve of each graph shows the ratio of the temperature of the center pixel to the mean temperature of a 9 pixel x 9 pixel moving window.

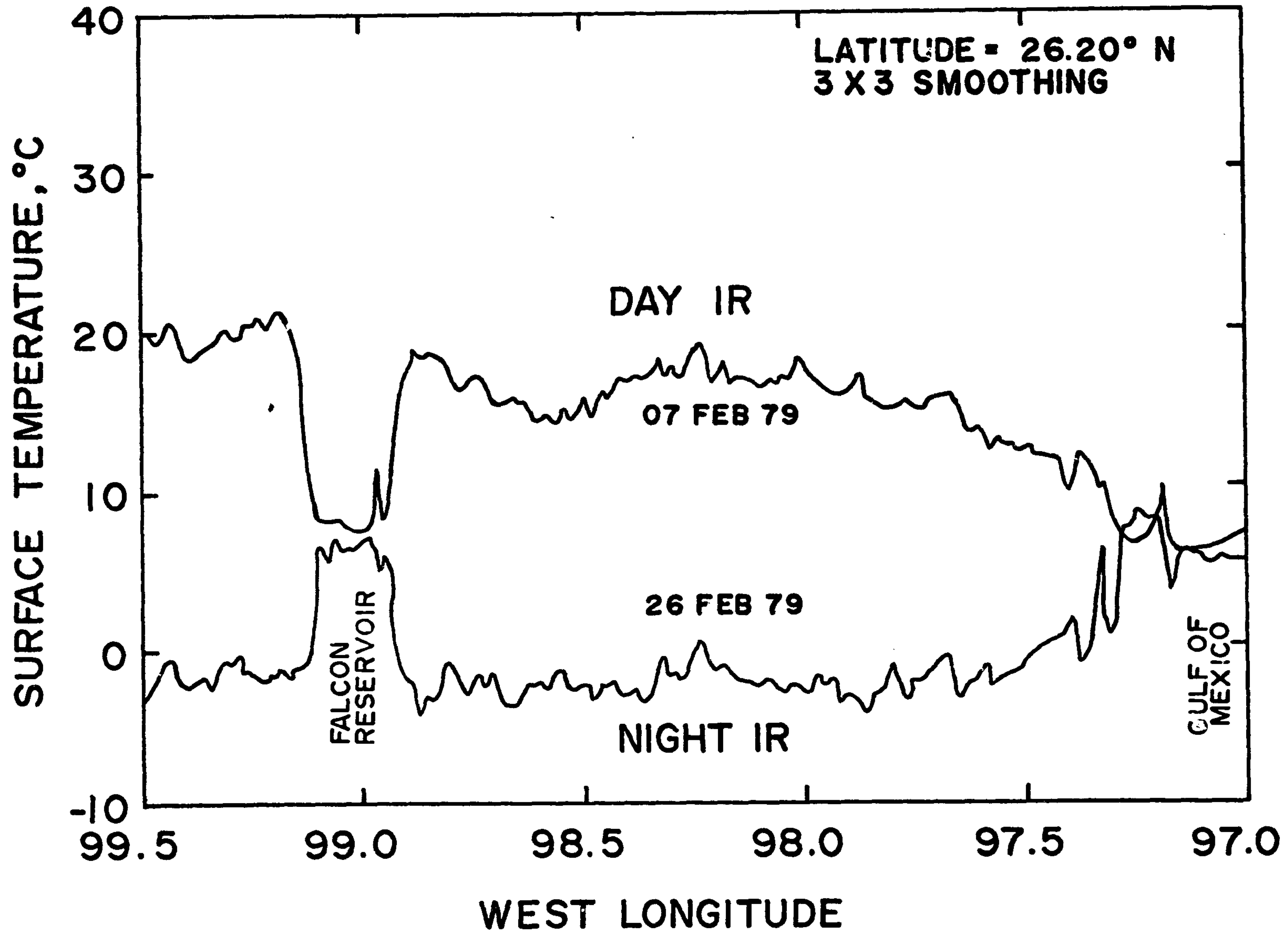

Fig. 3. Daytime (07 Feb 79) and nighttime (26 Feb 79) Surface temperature profiles across the Lower Rio Grande Valley test sites on latitude 26.20° N.