An Interdisciplinary Analysis of Multispectral Satellite Data for Selected Cover Types in the Colorado Mountains, Using Automatic Data Processing Techniques

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MONTHLY PROGRESS REPORT

March 1975

A. Overall Status and Progress to Date

Hydrological Features

Calibration of SL-2 S192 Channel 13 Data

Introduction

The first attempt of calibration of the SKYLAB-2 S192 thermal data showed an error of 20°C, as reported in the February Monthly Report. Further investigations, however, indicated that there had been a mistake in the transformation of radiance to degrees Kelvin. This error has been corrected.

Calibration Procedures

Since the SL-2 S192 thermal data (10.2-12.5 μm band) contained two calibration reference signals in the unstraightened data (conical data tapes) for every scan line, it was possible to perform a straightforward two-point calibration as previously described by Bartolucci et al. (1973).[1] The resulting radiant temperatures for Vallecito Reservoir where ground observations were obtained at the time of the overpass are approximately 4 degrees centigrade lower than the temperatures measured by the ground crew[2] as illustrated in Figure 1. The resulting calibrated imagery showed a very pronounced banding effect (Figure 2) due to the variations (noise) in the cold and hot reference blackbody signals. This variation is shown in Figure 3.

In order to correct for the variations in the reference signals, a weighted average of the reference signals was performed. This averaging was accomplished by substituting line "n" by a line resulting from averaging line "n-1" (weighted 0.1) and line "n" (weighted 0.9). Figure 4 shows the averaged calibration signals. The smoothed calibrated imagery is shown in Figure 5.

The discrepancy between the radiant temperatures as determined from the SL-2 data and those measured by the ground truth crew were found to be caused by the "non-linearity effect" described by Bartolucci et al. (1973). In other words, this effect is due to the non-linear relationship between the amount of energy radiated by a blackbody and its temperature. Figure 6 shows the non-linear relationship between the emitted energy by a blackbody in the SL-2 thermal (10.2-12.5 μm) band for a range of temperatures between -12.8°C and 48.1°C.

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[1] Bartolucci-Castedo, L.A., R. M. Hoffer and T. R. West. (1973), "Computer-aided Processing of Remotely Sensed Data for Temperature Mapping of Surface Water from Aircraft Altitudes", LARS Information Note 042373.

[2] Ground truth data for test sites (SL-2), MSC-05531, JSC, Houston, Texas.

The cold blackbody was set at -12.8°C and the hot blackbody was set at 48.1°C at the time of the overpass. Figure 6 also shows the error that will occur when using a linear calibration function. This error is approximately 4.5°C.

In order to avoid the non-linearity error, a non-linear calibration function has been developed and it is a second degree polynomial of the form:

$$T = a_o + a_1 D + a_2 D^2 \quad \text{(Eq. 1)}$$

where T = temperature

D = digital counts of band 13

a_o, a_1 and a_2 = regression coefficients

The coefficients for equation 1 have already been computed and the implementation of the non-linear calibration function will be finished in the near future.

The temperatures obtained from the SL-2 S192 channel 13 data and using the non-linear calibration function are within 1°C from those temperatures measured by the gound truth crew.

The complete documentation of the procedures and results of the non-linear calibrations of the thermal data will be completed by next month and will be included in the final report.

Geological Assessment

During the last reporting period two classifications of the SL-3 S192 data were performed. The primary objective of the classifications was to locate areas showing evidence of hydrothermal alteration. The Exotech spectral response data of the rock samples of the area were studied and the best set of four channels for identifying altered material was chosen. The channels chosen were 4, 7, 9, 11.

Seven areas which were reasonably characteristic of the test site were chosen. These areas were then placed in three groups and each group clustered into ten cluster classes. The cluster classes were then pooled into 27 classification groups on the basis of their transformed divergence. Any class pairs with a divergence value of less than 1,000 were combined to a single class for the classification.

An area around the Platoro-Summitville Mining District was chosen on which to perform a classification. The area contained two distinct areas of known alteration and several smaller areas which were less distinct. Upon examining the results of the first classification, it was noted that

alternating rectangular patches of cloud and shadow appeared in the results printout. A detailed examination of these printouts indicated that large areas of data dropout occurred over the lower half of the run.

In order to determine a channel similar to the least noisy channel 4, the Exotech data was again referred to and a compromise channel, channel 6, was chosen on the basis of spectral separation of rock types and data quality. The three groups of sub-training areas were again clustered and refined before the statistics for the classification were requested. Evaluation of this second classification will be completed in the next reporting period and photographs from the digital display will be made available for evaluation.

Topographic Modeling

The accuracy of the overlay of topographic data onto SL-2 S192 data was verified and the slope and aspect channels were then computed and added to the data set. Verification and completion of this June overlay was a milestone in data preparation since overlay of this large numbers of channels has never been previously accomplished. Four ERTS, 13 SKYLAB and 3 topographic channels are available for analysis. The accuracy is nominally in the 1 to 2 pixel range, however, further evaluation of accuracy needs to be done.

This completed the work on the SL-2 overlay data set. Notation of the SKYLAB August data was completed and the overlay is now in progress. Once this is completed the June and August data sets will both be in registration with the topographic data as one data set. Since all channels will not fit on one tape, certain sets of channels are located on a separate tape but they are still in registration with respect to the line and column coordinates.

Ecological Inventory

The Ecological Inventory Investigation is currently in the process of clustering and pooling the SKYLAB data. Statistics on the training fields are being obtained from the SKYLAB data only. The next step will be to classify the same test fields as were described in the previous monthly report. Results of this classification sequence will provide an objective comparison of the optimal combination of wavelength bands using SKYLAB data and LANDSAT data.

B. Recommendations

None

C. Expected Accomplishments

The documentation on the procedures and results of the non-linear calibration of the thermal data will be completed during the next reporting period. Results of this investigation will be presented in the final report.

The August overlay should be completed in the month of April. The slope channel will be rewritten to provide a calibrated slope angle rather than a uncalibrated derivational value as it now provides. Additional software is being designed that will provide elevation, slope and aspect in zones rather than in a continuous mode.

Once the SKYLAB data is clustered and a classification obtained from those statistics, wavelength bands for the LANDSAT and SKYLAB data will be compared to determine the optimum bands for the various cover types in this locale.

D. Significant Results

A data set containing SKYLAB, LANDSAT, and topographic data has been overlayed, registered and geometrically corrected to a scale of 1:24,000. The LANDSAT data (1317-17204) was collected at 9:20 a.m. on June 5, 1974 over the San Juan Mountains of Colorado. At 11:58 a.m. the same day, the SKYLAB S-192 conical multispectral scanner (13 band) obtained data over the same area. After geometrically correcting both data sets, the SKYLAB data was overlayed on the LANDSAT data. Digital topographic data was then obtained from the Defense Mapping Agency, reformatted, and a data channel containing elevation information was then digitally overlayed onto the LANDSAT and SKYLAB spectral data. Additional channels containing slope and aspect information were generated from the DMA elevation data and added to the tape containing the SKYLAB and LANDSAT spectral data.

The 14,039 sq. kilometers involving 2,113,776 LANDSAT pixels represents a relatively large data set available for digital analysis. The overlayed data set enables investigators to numerically analyze and compare two sources of spectral data and topographic data for any point in the scene. This capability is new and it will permit a numerical comparison of spectral response with elevation, slope, and aspect; and utilization of the spectral and topographic data together to obtain more accurate classifications of the various cover types present.

E. Travel

There were no travel funds expended during this reporting period for this contract.

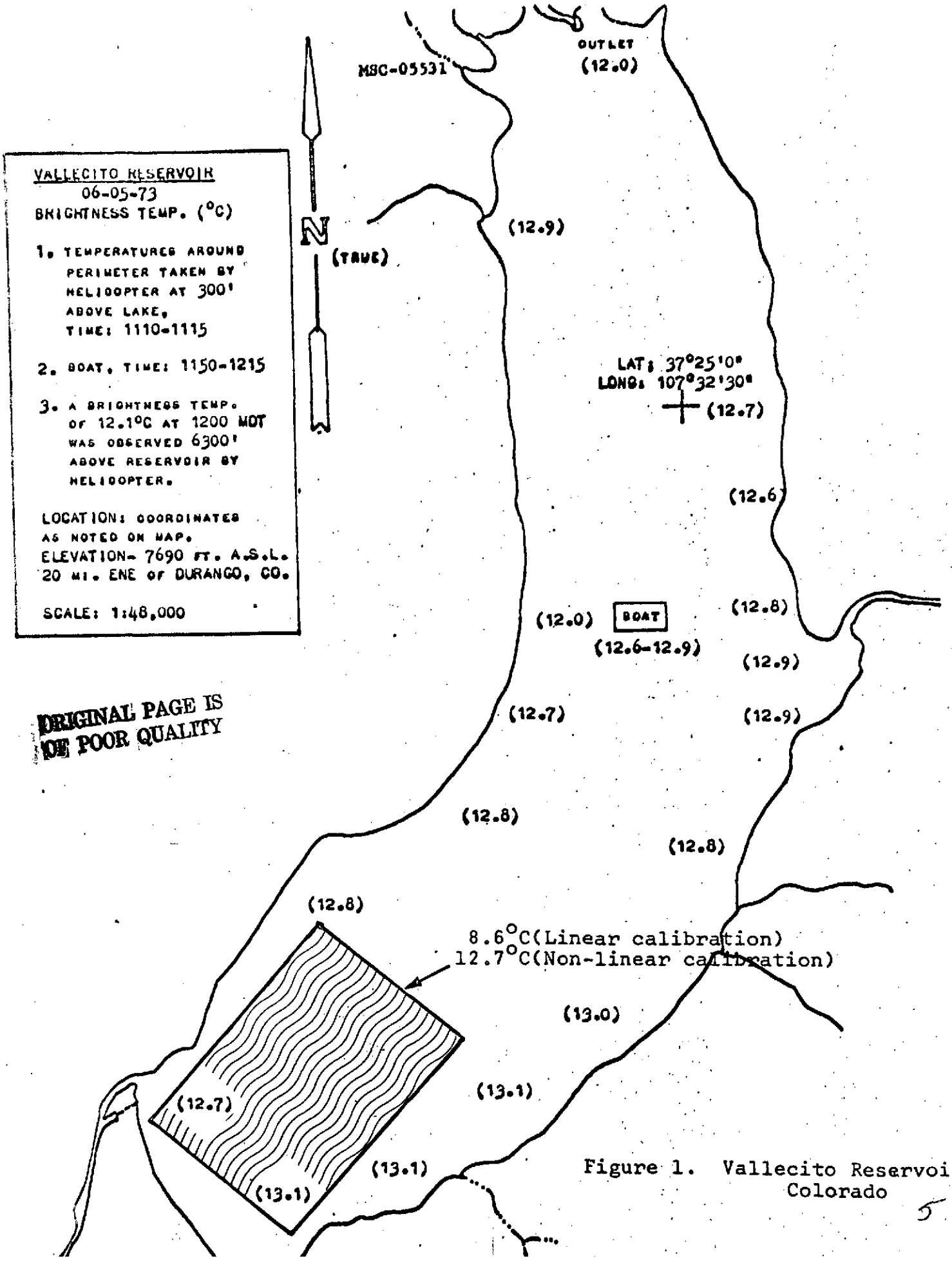
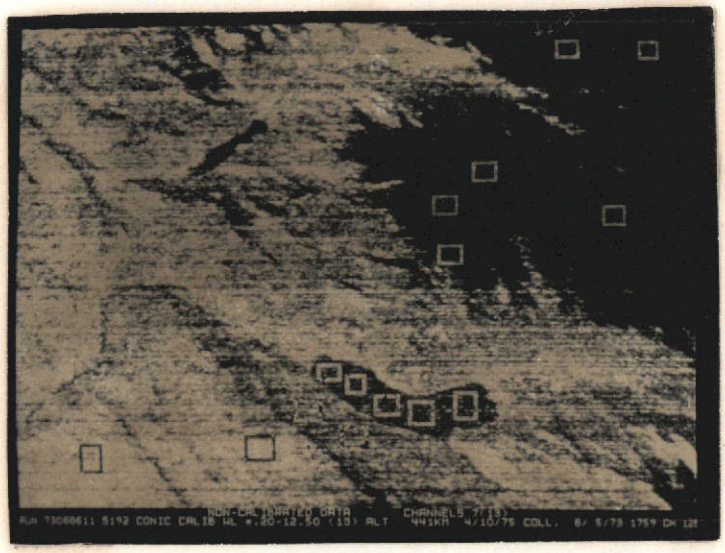


Figure 1. Vallecito Reservoir, Colorado

Uncalibrated Thermal Band



Calibrated Thermal Band

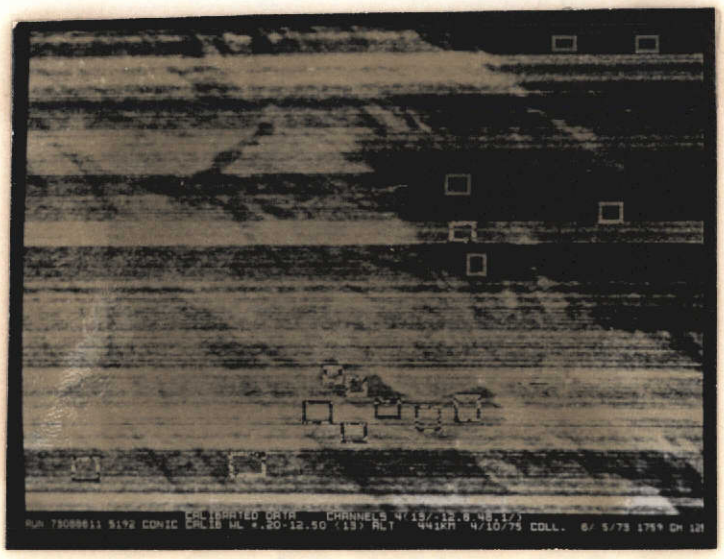


Figure 2.

RUN NUMBER..... 73388611 DATE DATA TAKEN... JUNE 5,1973
FLIGHT LINE... S192 CONIC CAL18 TIME DATA TAKEN..... 1759 HOURS
DATA TAPE/FILE NUMBER.. 3100/ 1 PLATFORM ALTITUDE..1449822 FEET
REFORMATTING DATE. JAN 8,1975 GROUND HEADING..... 125 DEGREES

CHANNEL 13 SPECTRAL BAND 10.20 TO 12.50 MICROMETERS DISPLAYED AS.. D CALCODE = 7

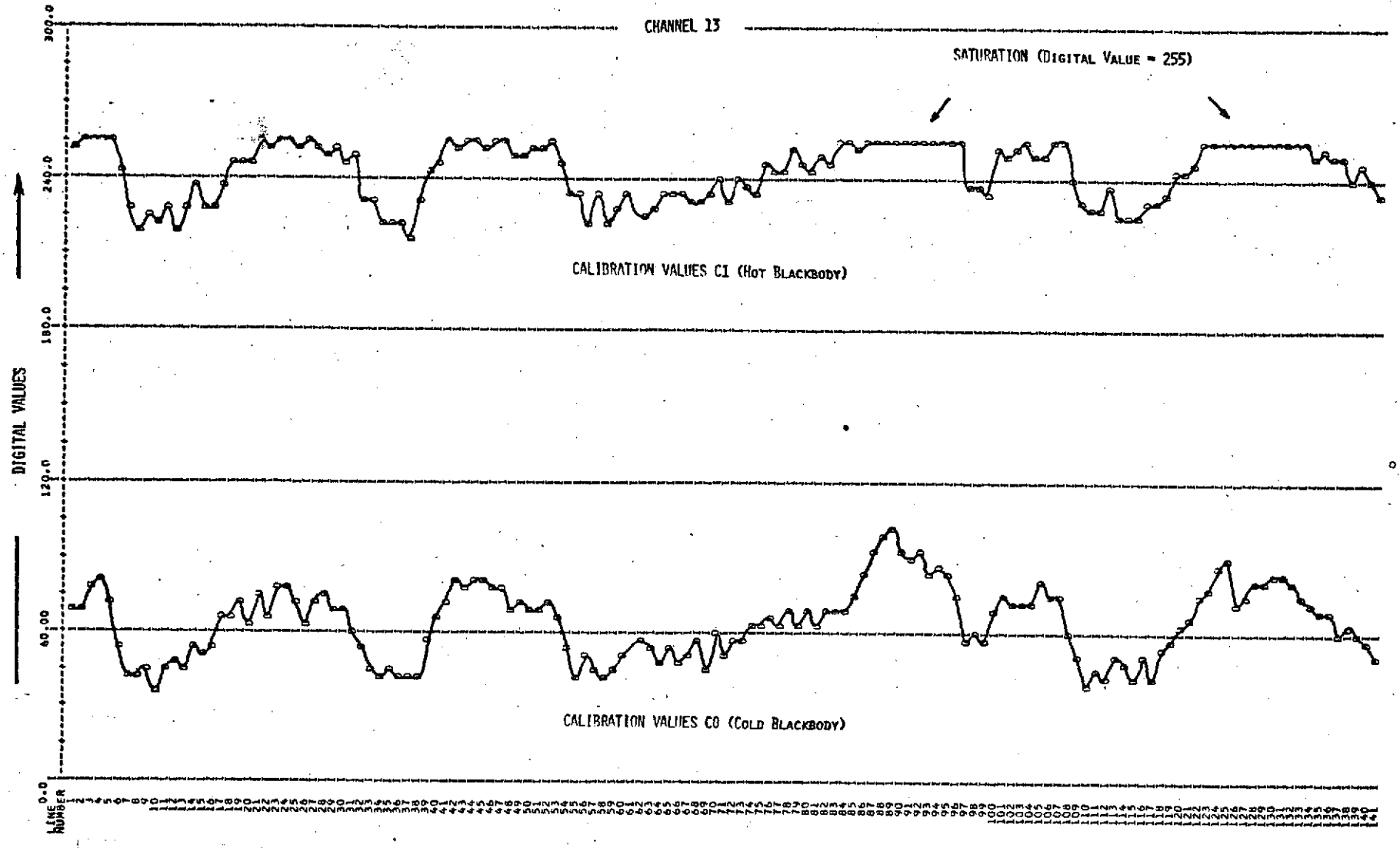


Figure 3. Blackbody Calibration Signals

ORIGINAL PAGE IS
OF POOR QUALITY

RUN NUMBER..... 73088613
FLIGHT LINE... S192 CALIBRATION
DATA TAPE/FILE NUMBER.. 3100/ 2
REFORMATTING DATE. JAN 9,1975

DATE DATA TAKEN... JUNE 5,1973
TIME DATA TAKEN..... 1759 HOURS
PLATFORM ALTITUDE..1449822 FEET
GROUND HEADING..... 125 DEGREES

CHANNEL 13 SPECTRAL BAND 10.20 TO 12.50 MICROMETERS DISPLAYED AS.. C CALCODE = 7

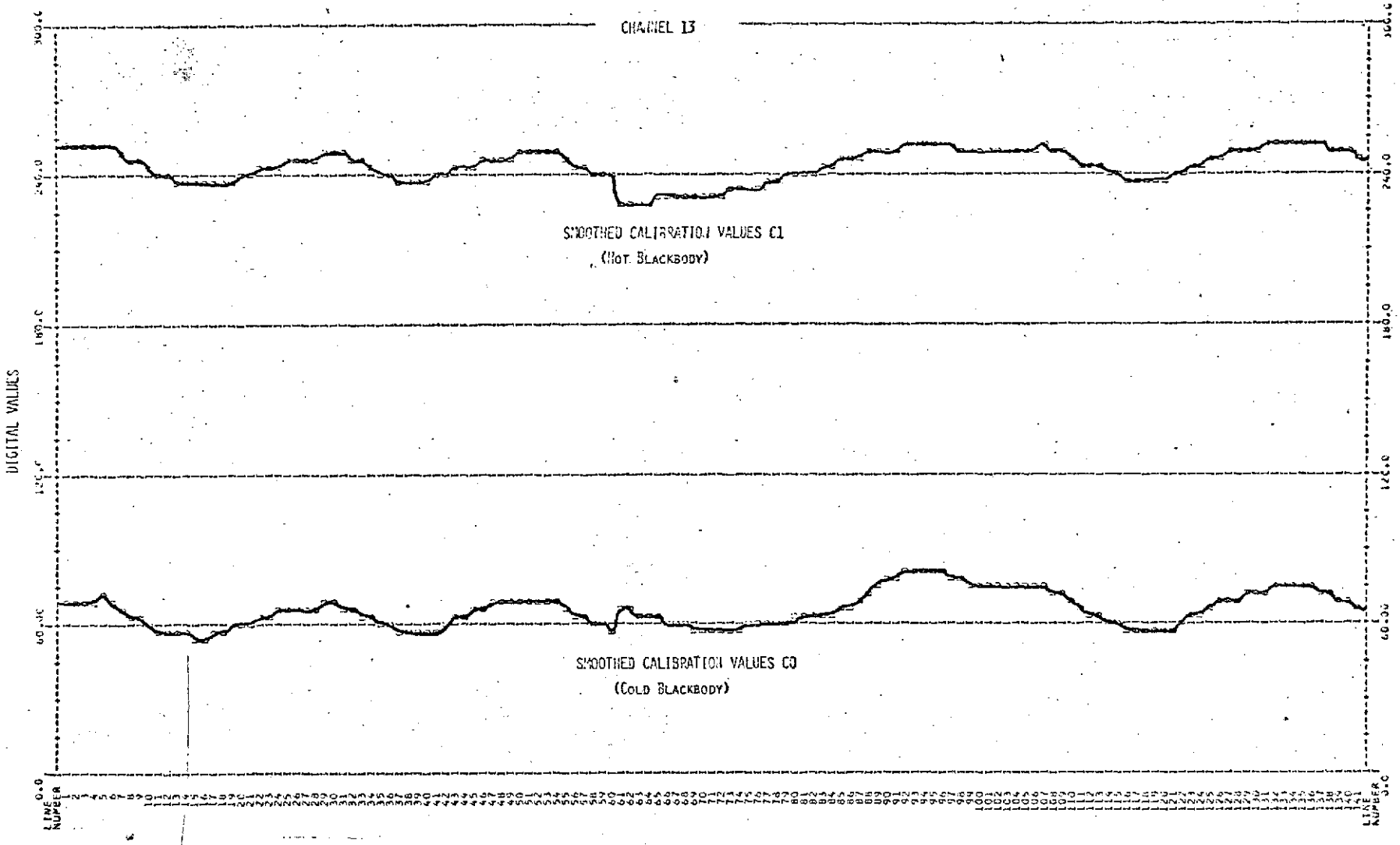


Figure 4.

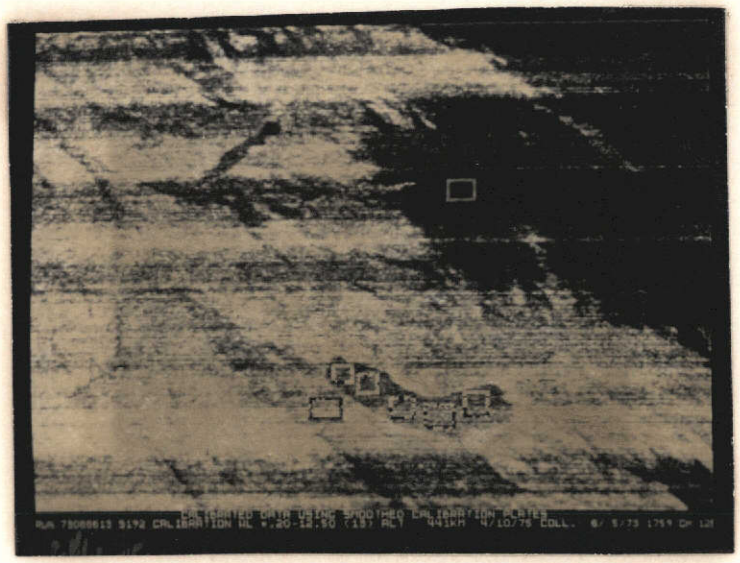


Figure 5. Smoothed Calibrated Imagery

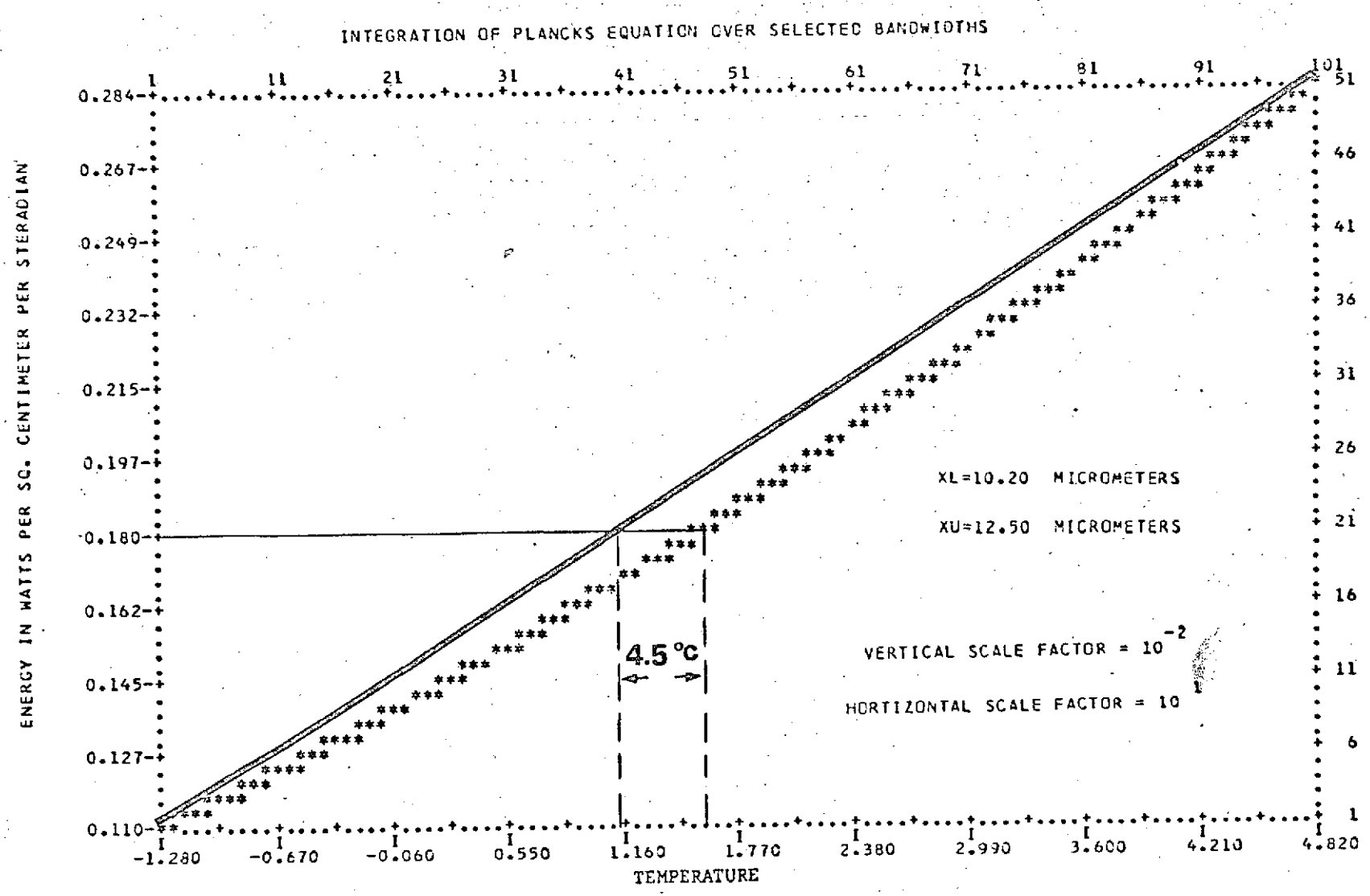


Figure 6.