1up

NASA CR-137459

Thermal Contouring of
Forestry Data-Wallops Island

by

Fred Thomson
University of Michigan

Report 010653-2-L

NAS6-2058

March 13, 1972

1

INTRODUCTION

This report discusses the contouring of 8-13.5 micrometer thermal data collected over the Forestry Site near Wallops Station, Virginia. The data were collected at an altitude of 1000 ft. above terrain on 11/4/70 at 1502-1511 hrs. The site was covered on three approximately parallel lines. The purpose of the contouring was to attempt to delineate pine trees attacked by southern pine bark beetle, and to map other important terrain categories. In addition to the routine contouring processing steps, special processing steps were required to achieve the correct aspect ratio of the thermal data. The reference for the correction procedure was color infrared photography supplied by Wallops Island personnel.

In this report, data form and quality are first discussed. Then, in successive sections, processing steps are outlined, a brief interpretation of results given, and conclusions presented.

2

FORM AND QUALITY OF ORIGINAL DATA

The thermal data were recorded on 1" magnetic tape in the C-47 aircraft. An examination of this data before processing showed that the data seemed to be of good quality. The two thermal calibration sources were registered in the data, permitting calibration of the resultant contouring steps. An examination of the temperatures of the calibration plates (as recorded on the flight record) revealed that the cold plate temperature varied slightly between the three runs, but that the hot plate temperature remained nearly constant. This variation in cold plate temperature was felt to be caused by drift in the plate controlling electronics. To avoid distortion to the video data by clamping to the varying cold plate reference, the hot plate reference was selected for clamping. (Clamping is required because the signals from the detector are AC-coupled to the preamp. Signal level thus depends not only on object temperature but on the average signal level).

3

CONTOURING PROCESSING STEPS

The several processing steps involved in the contouring are discussed in this section. Before proceeding with the contouring, we first determined the correct camera speed for printing separations which yielded the correct aspect ratio for the data.

3.1. DETERMINING CORRECT ASPECT RATIO

Because of uncertainties in aircraft true ground speed and altitude, the film speed for correct data aspect ratio cannot be precisely determined in advance. The procedure used to obtain a more precise film speed was to make trial filmstrips of video data, compare these filmstrips with color infrared photography supplied by Wallops Island personnel, and to correct the film speed to bring the video data into precise registry with the photography. This process was measurably aided by the almost identical scale of the photography and the imagery. Precise matching was obtained on the third iteration of film speeds.

Initial attempts to compute the correct film speeds by referring to topographic maps yielded inferior results. This was probably because of the relatively few landmarks in the data and on the topo maps and because of changes in some road positions since the topo map had been prepared.

3.2. CONTOURING OPERATIONS

After selection of a proper film speed for each run of data, contouring operations were begun. The hardware for performing the contouring is shown in the block diagram of Figure 1. Data from the tape recorder are first clamped to remove variations caused by AC-coupling of the detector signal. The clamping reference was the hot plate, because it was the more stable of the two references. After clamping, the signal was amplified to match its dynamic range to that of the A/D converter. Because inferior results occur when the width of one contouring interval is less than the noise level on the signal, the gain of the amplifier cannot be too large. The amplifier gain was set so that there were five contouring steps between the hot and cold plates on each run.

The A/D converter converts input voltages into digital data with up to 6 bits of resolution. A successive approximation technique is used, and conversions are made in 4 μsec, about 2/3 resolution element. Output from the A/D converter,in the form of a set of logical signals, are gated to extract information from the logical signals. Individual levels are successively printed on 70mm film as black and clear negatives. Black areas occur on the film when the incoming signal falls in the level being printed.

3.3 COLOR CODING AND OZALID PROCEDURES

Individual contouring separations were sent to Wallops Island for analysis and for selection of color code. Several individual separations were rendered in each of the colors chosen. At this time, it was discovered

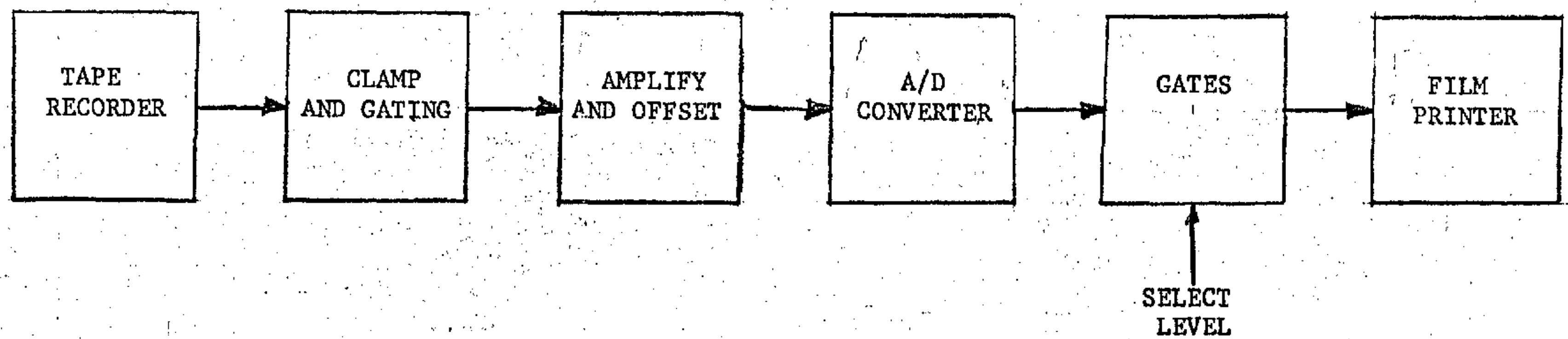

FIGURE 1

Block Diagram of Contouring Circuitry

that the original goal of two maps—a general terrain features map and a map of various stages of affected loblolly pine—could not be met. Categories were not separable in this thermal data. Accordingly, the plan was changed to prepare only one map of each line.

When separations were returned to Willow Run, we first attempted to make color ozalids at the same size as the original film. This effort was abandoned when it became clear that the fine detail in the scene could not be accurately portrayed in the color ozalid separations. It was then decided to prepare color ozalids at approximately 2.5 times the 70mm size. This required a set of high contrast negatives at the larger size. These were prepared in a two step process from the original 70mm materials.

Ozalids made at the larger size were examined to be sure that the required detail was present. Individual scan lines of data could be seen, although the rendition of fine detail was sometimes spotty. The cause of this spotty rendition is felt to be loss of some of the original film detail in the intermediate photo and/or the ozalid process.

Ozalids were overlaid and registered for each of the runs. Minor variations in film speed were magnified when the data were blown up 2.5 times, and ozalids were registered optimally at both ends of the data. This results in two negatives and two positive transparencies per line. Black marks at the top of each negative enclose the area for which the registration was optimized.

Prints were made at a scale of 1:2,000,per conversations with Dr. Oberholtzer. Prints were supplied for each of the negatives, and prints with optimum registration at both ends of the line can be mosaiced if desired.

4

CALIBRATION OF TEMPERATURE LEVELS

Calibration of the temperature range of each of the contouring levels can be accomplished by referring to the thermal calibration sources registered on the data. The most accurate calibration technique is a linear interpolation of voltage versus radiance. The radiances of the plates are modified to account for the fact that the plates are not perfect blackbodies, but have an emissivity of about 0.9, and thus reflect energy from the scanner interior. The scanner interior is assumed to be at the outside air temperature because of the flow of outside air around the scanner housing.

Calibration consists of determing the radiance of each calibration plate, relating those to contouring steps using information gathered during the contouring operation, determining the radiance of all contouring steps through interpolation and extrapolation, and finally converting these radiances to temperature. This process is summarized in Tables 1, 2, 3, and 4, where modified plate radiances and temperature ranges of each of the quantizing intervals are presented.

5

INTERPRETATION OF RESULTS

The purpose of this section is not to present a detailed analysis of results, but rather to present some factors that should be considered in the analysis of this data set. The data were collected in the middle of the afternoon, about 1-2 hours after an overcast had dissipated. For this reason, the data are not typical of mid-afternoon thermal data.

Table 1

Modified Plate Radiances For
Forestry Contouring-Wallops Island

Line 13

Plate	Temp	Radiance*	Scanner Temp.	Scanner Radiance	Mod. Radiance
cold	52.3°F	3.868	281°K	3.647	3.846
hot	56.2	4.009			3.973
			Line 14		
cold	52.6	3.875	281°K	3.647	3.853
hot	56.2	4.009			3.973
			Line 15		
cold	53.3	3.902	281°K	3.647	3.877
hot	56.6	4.029			3.991

* in mw/cm^2-ster

Table 2

Temperatures For Line 13

Binary Level	Wallops Designation	Temperature Range(°F)	Comments
01000		49.4-50.0	not coded
01001		50.0-50.7	not coded
01010		50.7-51.4	not coded
01011	13-11	51.4-52.1	black
01100	13-12	52.1-52.8	black
01101	13-13	52.8-53.5	black
01110	13-14	53.5-54.1	black
01111	13-15	54.1-54.8	orange
10000	13-16	54.8-55.5	orange
10001	13-17	55.5-56.2	red
10010	13-18	56.2-56.9	red
10011	13-19	56.9-57.6	brown
10100	13-20	57.6-58.2	brown
10101	13-21	58.2-58.9	brown
10110	13-22	58.9-59.6	blue
10111	13-23	59.6-60.3	blue

Table 3

Temperatures for Line 14

Binary Level	Wallops Designation	Temperature Range(°F)	Comments
01001	14-9	50.3-51.0	not coded
01010	14-10	51.0-51.6	not coded
01011	14-11	51.6-52.3	black
01100	14-12	52.3-52.9	black
01101	14-13	52.9-53.6	black
01110	14-14	53.6-54.2	orange
01111	14-15	54.2-54.8	red
10000	14-16	54.8-55.5	red
10001	14-17	55.5-56.1	blue
10010	-	56.1-56.7	not coded

Table 4

Temperature For Line 15

Binary Level	Wallops Designation	Temperature Range(°F)	Comments
01011	15-11	52.3-52.9	black
01100	15-12	52.9-53.5	black
01101	15-13	53.5-54.1	black
01110	15-14	54.1-54.7	orange
01111	15-15	54.7-55.3	red
10000	15-16	55.3-56.0	red
10001	15-17	56.0-56.6	brown
10010	15-18	56.6-57.2	brown
10011	15-19	57.2-57.8	brown
10100	15-20	57.8-58.4	brown
10101	15-21	58.4-59.0	blue
10110	15-22	59.0-59.6	blue

Typically, mid-afternoon thermal data portray water as the coolest and bare soil, roads, and concrete as the warmest scene constituents. This arises because the absorbtion of solar energy heats the asphalt and concrete. Water is heated too, but far less because of its high thermal inertia. Healthy, transpiring vegetation also appears cool, although not as cool as water, because of the loss of energy through transpiration.

The data processed here are more typical of early morning data, because the solar input had only been effective since the dissipation of the overcast. Early morning data are characterized by rapid variability of object temperature caused by solar energy absorbtion. At some time early in the morning, a "crossover" point is reached when the roads and bare soil (destined to be the warmest scene objects in mid-afternoon but coolest in predawn) and the water (warmest in predawn and coolest in midday) have nearly the same temperature. This point is well illustrated in the data from Line 13, where the pond and the road have nearly the same temperature.

Thermal shadows are very prominent in this data. These shadows occur in all thermal data because objects sheltered from the sun do not heat as rapidly as those exposed to the sun.

In forested areas, the thermal signal is quite variable because of the shadowing of one tree by others. It is not unusual to see sunlit and shaded halves of the tree crown in thermal data, and the rapid variation of signal caused by alternately scanning sunlit and shaded portions of crowns must be contended with in analysis.

6

CONCLUSIONS

This report has discussed the contouring of three lines of forestry data collected near Wallops Station, Virginia in November 1970. The display of this contoured data was made difficult by the abundance of five detail in the contoured results. An acceptable display was generated by enlarging each contouring separation 2.5 times before going to the color ozalid display process. Calibration of each of the contouring levels was accomplished by referring to hot and cold reference plates, correcting the radiance of these plates for their 0.9 emissivity. Because of the conditions of data collection, these mid-afternoon data resemble closely typical mid-morning data.