E74-10471
CR-136872

Detection of Moisture and Moisture Related Phenomena from Skylab

Joe R. Eagleman
Principal Investigator

(E74-10471) DETECTION OF MOISTURE AND MOISTURE RELATED PHENOMENA FROM SKYLAB Monthly Progress Report, Mar. 1974 (Kansas Univ. Center for Research, Inc.) 16 p HC $4.00 CSCL 08H

N74-22948

Unclas
G3/13 00471

Monthly Progress Report, March 1974

Atmospheric Science Laboratory
Center For Research, Inc.
University of Kansas

Original photography may be purchased from:
EROS Data Center
10th and Dakota Avenue
Sioux Falls, SD 57198

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Joe R. Eagleman
Principal Investigator

Ernest C. Pogge and Richard K. Moore
Co-investigators

Norman Hardy, Wen Lin and Larry League
Graduate Research Assistants

Atmospheric Science Laboratory
Space Technology Center
Center for Research, Inc.
University of Kansas
Lawrence, Kansas 66045

Ryborn R. Kirby, Technical Monitor
Principal Investigations
Management Office
Lyndon B. Johnson Space Center
Houston, Texas 77058

EREP NO. 540-A2 March 19, 1973 to August 31, 1974

Contract Number. NAS 9-13273

S 190 A Photo Interpretation

Introduction

Portionsof the S 190 A photography has been studied in detail to determine what features can be seen for each of the 6 bands. The bandwidths and related information are as follows:

Researu Serial No.	Bandwidth(μ)	Film Type	Filter
15	0.7-0.8	IR Aerographic B & W Type EK 2424	CC
08	0.8-0.9	IR Aerographic B & W Type EK 2424	DD
11	0.5-0.88	Aerochrome IR color type EK 2443	EE
02	0.4-0.7	Aerial color (high resolution) type S0-356	FF
06	0.6-0.7	Pan-X aerial B & W type S0-022	BB
10	0.5-0.6	Pan-X aerial B & W type S0-022	AA

Frame 169 for the 9-13-73 Texas site was studied using the aerial color .4-.7μ and the Aerochrome IR color .5-.88 from the transparencies. The other four filter types were enlarged to approximately 11 x 11 prints. No attempt was made to determine each and every tonal change on the photos, however, a great deal of general information was obtained. Frame 169 includes much of 9-13-73 Texas site (Figure 1). Therefore, topographic maps, field notes and aerial photography were available for identification of many features.

General Tonal Change

General color variations on the aerial color .4-.7u range from black in the north to red in the south. The lowlands appear dark gray with the south-central regions of the photo showing a lighter red color.

The IR color .5-.88u has excellent color contrast. The upland area to the north of Lubbock is a very dense red in comparison to the west and south of Lubbock which is light green with a small amount of red visible.

TEXAS SITE (9-13-73)

Soil Site Map

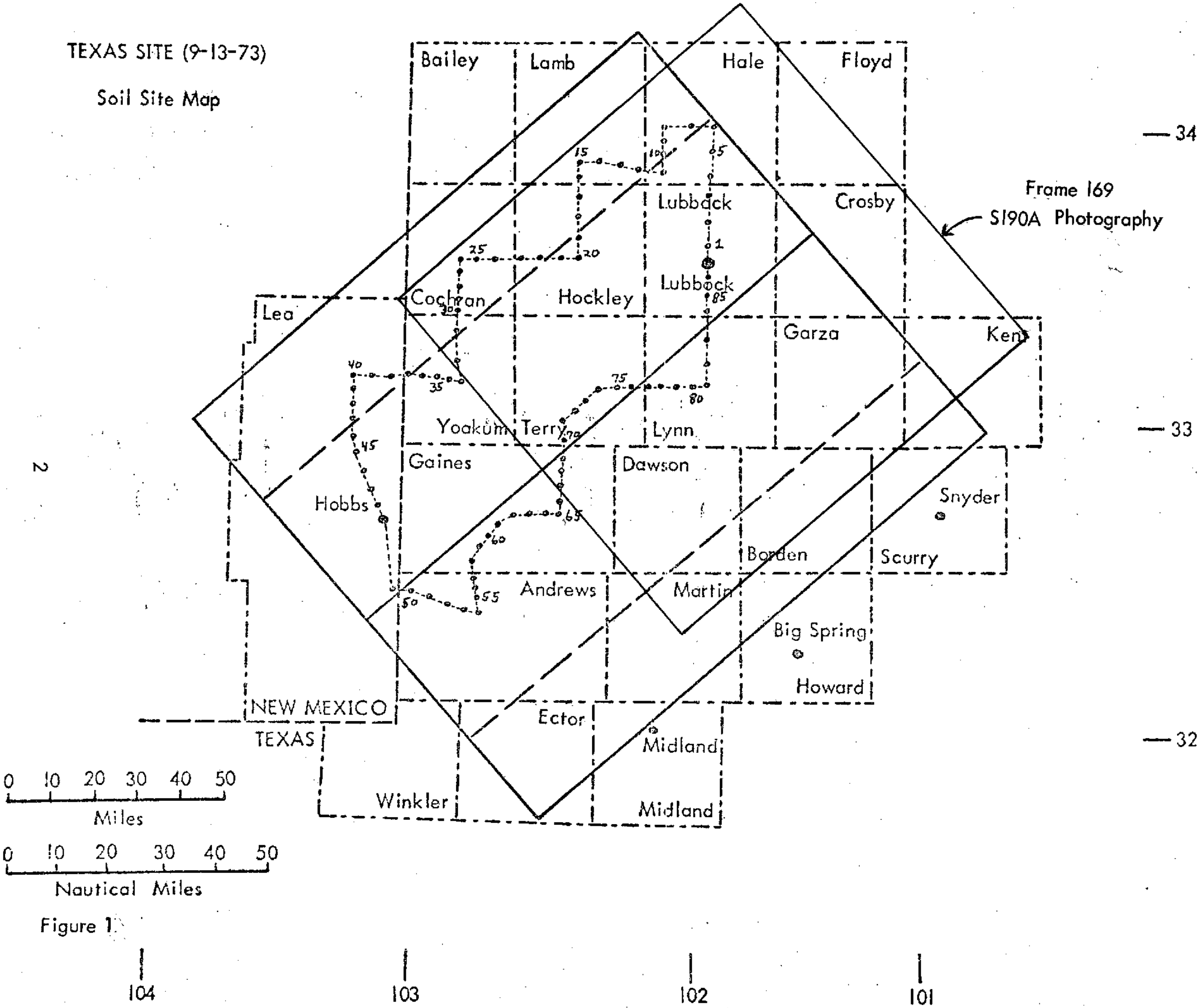

Figure 1

Excellent tonal contrast is also visible on the black and white .6-.7μ band. The area to the north and northwest of Lubbock and also immediately surrounding Lubbock appear black to dark gray. The central portion of the photo is a mixture of black and dark to light grays. The southern portion of the photo is the lightest, appearing light gray to white. The lowlands are dark gray.

The black and white .5-.6μ band shows less general contrast. The overall tonal quality is dark to medium gray with the lightest area being east of Brownfield. The lowland and the area north of Lubbock are the darkest grays.

The IR black and white (bands .7-.8 and .8-.9) are very similar to each other. The uplands are in generally light gray to almost white in contrast to the dark gray lowland. Large apparently non-cultivated areas stand out on the upland as dark gray areas.

Cities

Cities show up as a light gray color on the aerial color and the color IR. Cities ranging in size from Lubbock (130,000) to Post, Texas (4,600) may easily be seen. On the aerial color band, some of Lubbocks major streets are visible plus about ½ of the interstate loops around the city. The major streets are not visible in IR color band and only a small portion of the interstate loop can be seen.

On the B & W aerial bands cities still appear light gray. Lubbock is easily visible on both photos but smaller cities such as Staton and Levelland, Texas are more visible in the .5-.6 band as they stand out against the darker background. Some of the major streets stand out on both photos but the interstate loop is better seen in the .5-.6 band.

Black and white IR bands show cities as medium gray. Where cities are surrounded by a light background they are easily visible but next to medium or dark gray backgrounds they can no longer be seen. On both bands the major street patterns in Lubbock show up well. Seven east-west and seven north-south streets are visible but the interstate loop does not show up. The Texas Tech campus is visible as a dark gray rectangle in both photos.

Roads

Roads are not easily visible in the aerial color and color IR bands but some major roads such as west of Lamesa and southwest of Brownfield can be detected. The aerial B & W bands have the same problem. Some major roads can be followed for a shortdistance then they fade out as the background changes, however, the Lubbock airport is visible as well as an air strip between Brownfield and Levelland. A major road in the dissected lowland southeast of Post, Texas can easily be seen. Secondary roads can be traced as section lines in some areas.

On the B & W IR bands some major roads such as Highway 82 from Brownfield to Lubbock and Highway 84 running NW-SE through Lubbock stand out better than in any of the other bands. The roads are dark gray and therefore fade out on the dissected lowland. Secondary roads and section lines are not as clear as in the B & W aerial bands.

Lakes and Streams

On the aerial color band two lakes (White River Lake and Illusion Lake) appear very black but most lakes are hard to see. More easily seen are the color changes of the landscape surrounding the lakes. Two areas appear very white and are apparently areas of high salt content (Mound Lake and an area near Cedar Lake). Major streams on the dissected lowland show up as light brown but tributaries can not be seen.

The IR color band shows White River Lake, Illusion Lake and Rich Lake as dark blue with other lakes being medium blue. The same two white areas with other lakes being medium blue. The same two white areas also appear in IR color bands. Major streams show up as light green to white in color.

The B & W aerial bands show the same three lakes as in the color IR band except the lakes are black. The other lakes are medium gray generally with white borders around them. The two white areas are easily seen in the .5-.6μ band but in the .6-.7μ band they are less distinct due to other very light areas in the photo. Major streams appear white and many tributaries can be seen in both aerial B & W bands.

Almost all lakes appear black in IR B & W bands. Many more smaller lakes can be detected than in the other bands. Streams, however, do not show up as well but the major streams can be traced. Few if any tributaries can be seen.

Cultivated and Non-Cultivated

In the aerial color band, cultivated areas range from black in color in the north to various shade of red farther south. Field work indicated the predominate crops in this region are cotton, grain sorghum and corn. Non-cultivated areas appear medium to dark gray and are predominately grassland or grassland and shrubs. Aerial photos revealed that some very light red areas such as around Mound Lake are sand dunes.

The color IR band shows cultivated regions ranging in color from deep red north of Lubbock to medium and light green throughout the rest of the photo. Non-cultivated areas are dark green in color. Frame 028 of the June 6, 1973 mission also provides an excellent opportunity to examine fields of cotton and grain sorghums in the color IR and B & W IR bands. Figure 2 shows the spectral reflectance characteristics for cotton under conditions of moderate and high soil moisture. It is readily seen that reflectance in the red and near infrared is extremely high. This is observable on the color IR where cotton fields show up as intense reds and on the B & W IR bands where cotton appears as brighter fields. Similarly, on the Pan-X band (0.5 - 0.6) cotton is seen as very black fields, which from the curve is what would be predicted.

Cultivated areas range from black to almost white in the B & W pan-X aerial band and therefore smaller tracts of non-cultivated land are more difficult to detect. The non-cultivated lowlands and uplands are dark gray. Large upland tracts can be separated from cultivated areas but not as easily as in the aerial color and color IR.

Since the B & W aerial band (.5 - .6μ) is an overall medium to dark gray, although some non-cultivated areas can be seen, this band is not as good for distinguishing between cultivated and non-cultivated areas. However, the IR B & W bands are excellent for distinguishing the two. Non-cultivated areas appear as smooth dark gray tones in contrast to a medium to light gray cultivated area.

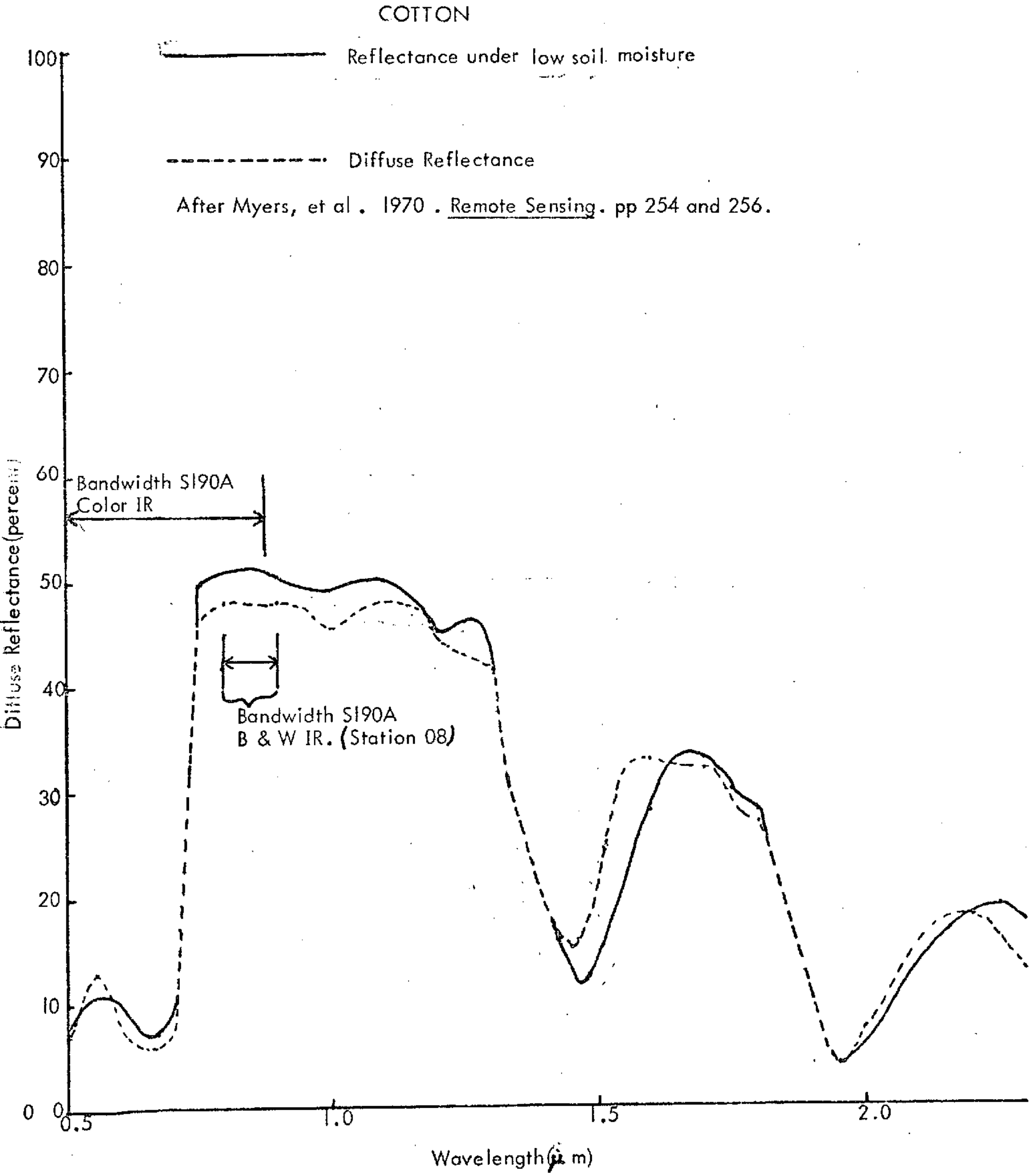
COTTON
Reflectance under low soil moisture
Diffuse Reflectance
After Myers, et al. 1970. Remote Sensing. pp 254 and 256.
Bandwidth S190A
Color IR
Bandwidth S190A
B & W IR. (Station 08)
Diffuse Reflectance (percent)
100
90
80
70
60
50
40
30
20
10
0
0.5
1.0
1.5
2.0
Wavelength (µm)

Figure 2

Local Relief

Local relief is not easily detected on the aerial color band. The escarpment separating the cultivated upland and the dissected lowland is visible as a color change from light red to medium gray but the exact dividing line is often hard to see. Local relief on the dissected lowland does not stand out very well but due to color changes from gray to black the circular depressions on the northern upland are easily seen.

The detection of local relief on the color IR band is about the same as on the aerial color band, however, the escarpment is more easily seen as a dividing line between the light green upland and the dark green lowland. Local relief is poor on the dissected lowland and only a few upland circular depressions stand out and only then as color changes from gray centers to the red fields surrounding the depressions.

The B & W aerial bands have the best visible local relief. The actual boundary between the upland and lowland is not as clear as in the B & W IR bands but the dendritic drainage pattern leading off the escarpment is very visible. The depressions stand out as pocket marks all over the northern part of the photo.

The B & W IR bands show little or no local relief. The depressions are not visible nor the dissected lowlands. The escarpment is seen as a color contrast from a light gray upland to a dark gray lowland. Some streams can be seen leading away from the escarpment on the lowland side.

Clouds

Only a few scattered cumulus clouds appear in the photos. On the aerial color, color IR bands clouds are about the only white objects, therefore, they stand out quite clearly. They also stand out well in the aerial B & W band (.5 - .6 μ) since the background is medium to dark gray, however, they are not as easily seen as in the aerial color and color IR bands.

The aerial B & W band (.6 - .7μ) and the two IR B & W bands are not good for detecting small scattered cumulus clouds. There are some scattered and apparently thin clouds in the south-central portion of the photos. In these three bands only the shadows of the clouds show up on the landscape, however, in the south-west portion of the photos the individual scattered cumulus clouds are larger in diameter so the clouds as well as the shadows may be seen.

Soil Types

June 6, S 190 A photography (Frame 09-27 & 28 of the Texas and New Mexico border areas displays a significant amount of soil information. Included on these photos are Roosevelt, and Lea Counties, New Mexico, and Cochran, Yoakum, Hockley, and Terry Counties in Texas. These particular counties are of interest since certain soil associations tend to be well delineated on the color and B & W IR bands (Figure 3). Essentially, on this imagery, Amarillo loamy sands and sandy loams are well delimited with respect to adjacent deep sand associations. Information from the U.S.D.A., S. C. S., soil surveys indicates that certain essential variations are present between soil associations. (Various soil characteristics are shown in Table 1.) From Table I it can be seen that essential variations do exist, however, it is immediately apparent that these variations are quite small, and significant overlap in variable values is present.

Soil Moisture and Precipitation Analysis On S 190A Imagery (0.7-0.9 Microns)

Two Skylab photos have been analyzed for their moisture detectability. Soil moisture should be detectable in the reflective IR portion of the spectrum. This moisture should appear as dark swaths on the photo resulting from local thunderstorm precipitation.

Figure 4 was taken on 8-5-73 over south-central Kansas using the 0.7-0.8 micron band. Figure 5 was taken on 6-5-73 over the Lubbock, Texas area using the 0.8-0.9 micron band. Both photos show the amounts of precipitation that occurred during the 5 days prior to overflights and the average moisture content for the first inch of soil along the soil sample route.

For the June 5 Texas site all the precipitation values shown occurred on June 2. Precipitation values range from .08 inches at Tahoka to .83 inches at Lorenzo. None of these locations reveal any detectable tonal changes caused by precipitation. The Slaton area with .50 inches is darker than most areas of the photo. yet the Abernathy and Lorenzo areas received more precipitation, .58 and

TABLE I

Soil	Surface Depth	U.S.D.A Texture	Permeability	Water Available	Natural Vegetation
Amarillo fine sandy loam	0-10 in.	Fine sandy loam	Inches/hr. 0.75 - 2.0	Inches/inch. 0.125	Blue-grama, side-oats grama, Buffalo grass, windmill grass
Amarillo Loam	0-8 in.	Loam	0.5 - 1.5	0.150	Blue-grama, side-oats grama, vinemesquite, Buffalo grass
Amarillo loamy fine sand	0-12 in.	Loamy fine sand	1.0 - 2.0	0.83	Indian grass, Switch grass, Bluestem, Giant dropseed, blue-grama
Brownfield fine sand	0-14 in.	Fine sand	1.5 - 3.0	0.67	See Amarillo loamy fine sand.
Tivoli fine sand	0-72 in.	Fine sand	1.0 - 4.0	0.67	Indian grass, sand bluestem, switchgrass, Hairy grama, Blue-grama

After: (1) U. S. D. A. S. C. S. Survey Series 1960, No. 17, March, 1964.

(2) U. S. D. A S. C. S. Soil Survey Series 1960, No. 15, March, 1964.

Figure 3

S190A IR B&W PHOTOGRAPHY (0.7-0.8 microns)
FRAME 226 (8-5-73 KANSAS SITE)

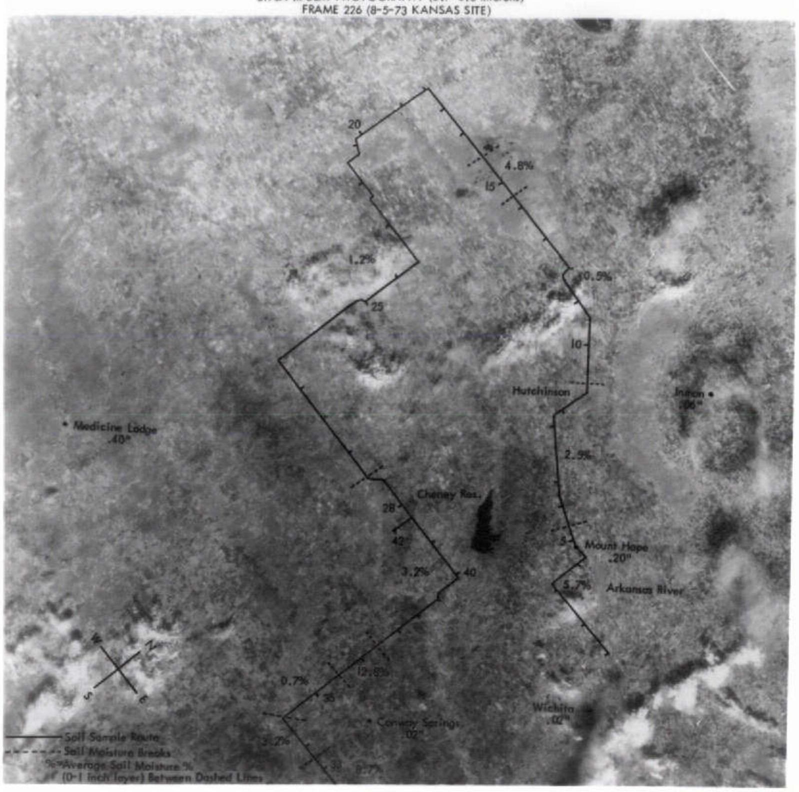

Figure 4

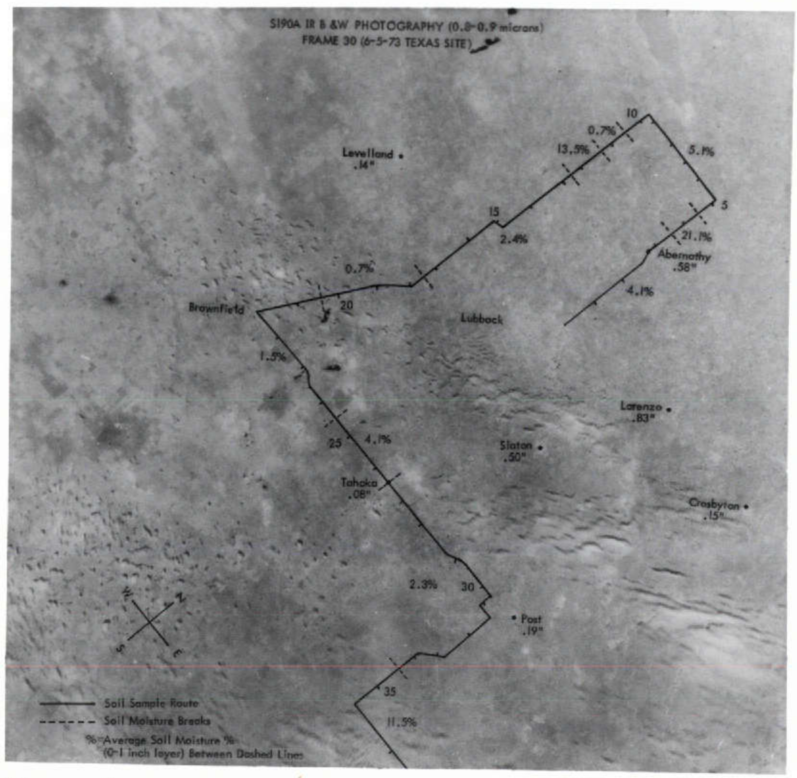

Figure 5

.83 inches respectively, but have a lighter tone. Although moisture swaths are not visible one should take into account that the rain gauge stations are widely scattered and that the precipitation occurred 3 days prior to overflight.

Thirty-six soil samples taken within 24 hours of overflight reveal a moisture range in the first inch of soil from 0.7% to 21.1%. Where the moisture changes significantly, break points are shown as dashed lines. Looking north of Lubbock the average moisture values are 4.1%, 21.1%, 5.1%, 0.7%, 13.5% and 2.4% yet there is little detectable tone variation in this area. Similarly throughout the photo moisture changes do not coincide with tonal changes. This may be due in part to the low moisture contents observed. Most of the moisture values are less than 5.0%. However, this does not account for the lack in tonal change for the 13.5% and 21.1% values.

For the August 5 Kansas site all of the precipitation values shown occurred on August 2 with the exception of the Medicine Lodge value which occurred on August 1. Precipitation values range from .02 inches at Wichita and Conway Springs to .40 inches at Medicine Lodge. As on the Texas photo none of these locations reveal any detectable tonal changes caused by precipitation. The Medicine Lodge area with .40 inches is lighter in tone than the Conway Springs area with 0.2 inches. Once again, although moisture swaths are not visible one should take into account that most of the precipitation was negligible and occurred 3 and 4 days prior to overflight.

Soil sample sites 1-28 and 33-42 appear in the Kansas photo. Soil samples taken from these sites within 24 hours of overflight reveal a moisture range in the first inch of soil from 0.7% to 12.8%. Tonal variation is greater than in the Texas photo yet these variations do not seem to coincide with the moisture changes. Once again the moisture content is generally less than 5.0%. However, in the bottom portion of the photo the moisture values are 12.8%, 0.7%, 3.2% and 8.7% yet there is no noticeable tone change as these moisture values change.

Significant Conclusion

Soil moisture and precipitation variations were not detectable as tonal variations on the S 190 A IR B & W photography. Some light tonal areas contained high precipitation .83 inches and high moisture content 21.1% while other light tonal areas contained only .02 inches precipitation and as little as 0.7% moisture. Similar variations were observed in dark tonal areas. This inconsistancy may be caused by a lapse of 3 to 4 days from the time precipitation occurred until the photographs were taken and the fact that in the first inch of soil the measured soil moisture was generally less than 5.0%.

For overall tonal contrast, the aerial color, color IR and aerial B & W (.6-.7 μ) appear to be the best. Cities stand out from the landscape best in the aerial color and color IR, however, to see major street patterns a combination of the two aerial B & W bands (.5-.6μ & .6-.7μ) and the two IR B & W bands (.7-.8 μ & .8 - .9μ) may be desirable. For mapping roads it is best to use all 6 bands. Where roads fade out in one photo, they generally can be picked up and continued in another band. For lake detection, the IR B & W bands (.7-.8 μ & .8-.9 μ) would be the best but for streams the aerial B & W band (.6-.7μ) would be better. The aerial color, color IR, and the two IR B & W bands are best for distinguishing cultivated and non-cultivated areas, whereas the two aerial B & W bands are better for seeing local relief. Clouds may be best seen in the aerial color & color IR bands.

References

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Myers, V. I., et al: 1970. Soil, Water, and Plant Relations. Remote Sensing With Special Reference to Agriculture and Forestry. N. A. S. . Washington, D. C., 424 pp.