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Detection of Moisture and Moisture Related Phenomena from Skylab

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FURTHER ANALYSIS OF S-193 RADIOMETRIC TEMPERATURE AND SOIL MOISTURE CONTENT

In order to understand the relationship between S-193 radiometer temperature and soil moisture content, several plottings and analyses have been performed for the 6/5/73 Texas site. Radiometric antenna temperatures where the illuminated cone of the S-193 radiometer covered one or more soil sample sites were further analyzed. Figure 1 shows the relationship between antenna temperature and soil moisture content which was determined from one to three soil samples in the S-193 footprint. The standard error of estimate was 7.9% and the correlation coefficient .70 for these data. The average moisture content of all the samples within the S-193 footprints was 11.2% by weight.

CLOUD COVER EFFECTS

The center points of S-193 radiometer footprints were located by latitude-longitude co-ordinates and were recorded on topographic sheets. Those points lying nearest to soil samples sites were determined and elliptical boundaries 10 x 13 kilometers were drawn to show the area covered by each footprint.

Eleven by eleven enlargements of S-190A photographs (pan-x aerial B & W, band 0.6-0.7) were made of the test site areas containing soil sample data. The S-193 radiometer center points located nearest to soil sample sites were plotted on the photographs

0-25 MM ANTENNA TEMP (SOIL SAMPLE IN FOOTPRINT) EQUATION TYPE 1 OF DEGREE 1 R = .70

SCALE FACTOR ON X IS 1.00E 02 SCALE FACTOR ON Y IS 1.00E 02

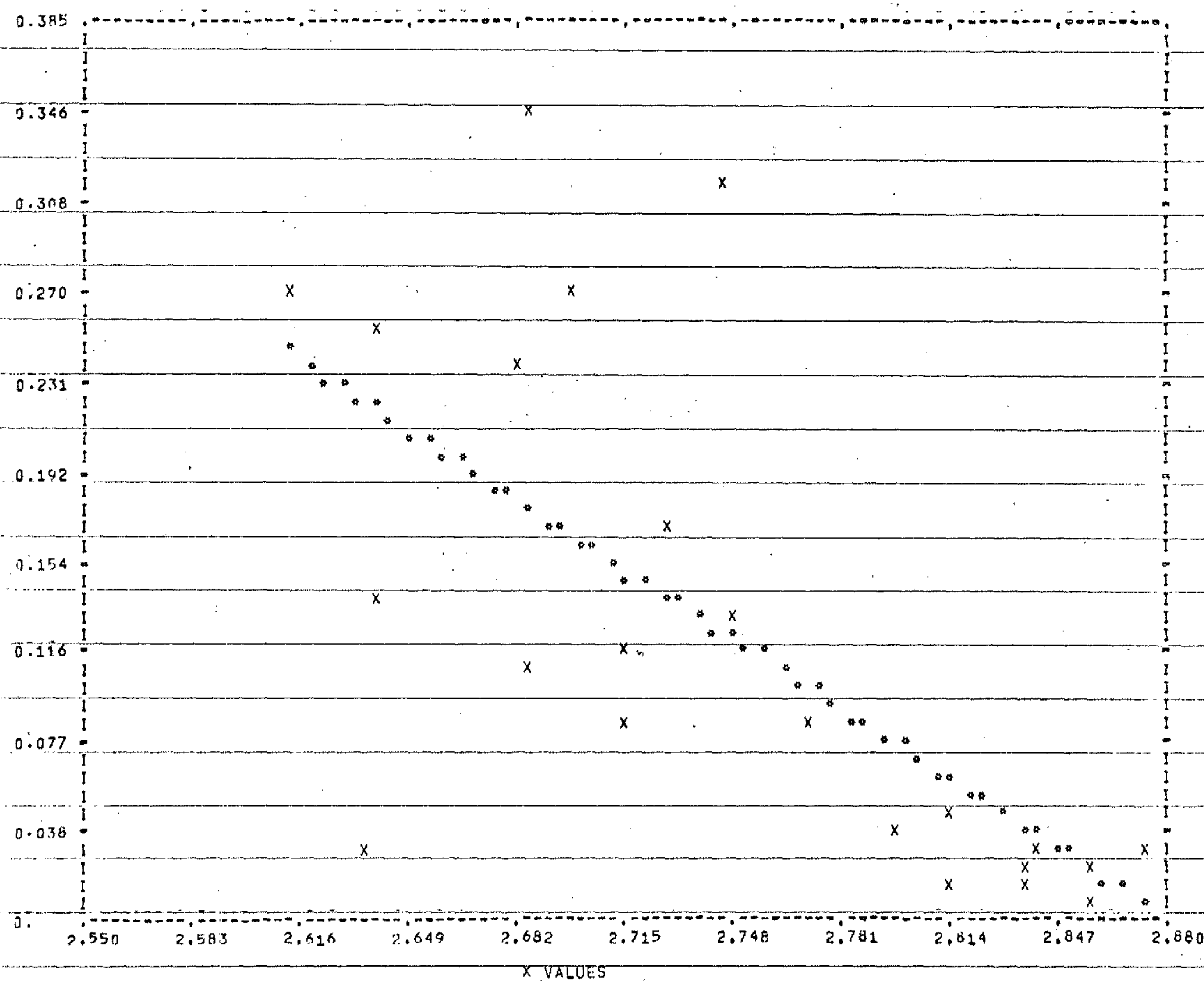

Figure 1
Correlation Between Soil Moisture Content And S-193 Radiometric Temperature

and boundaries were drawn around them. Where center points could not be located directly on the photographs due to cloud cover or poor resolution, these points were then determined by measuring distances and direction from 2 or 3 previously identified points on the photograph and by plotting a point where the lines intersected.

The photographs were then placed on a lighted table. Cloud cover areas on the photographs were white, so more light penetrated through the photographs in clouded regions, thereby distinguishing clouded from non-clouded areas. Thus, by placing tracing paper over the photograph an outline of the clouded areas of the footprints could be drawn.

When the clouded areas of all footprints had been recorded on tracing paper then a grid containing 400 small squares (4squares equal 1% of the total area) was placed over the footprints. The squares were counted in clouded regions to obtain the percentage of cloud cover for each footprint.

For further refinement, a distinction was made between heavy (dense) and light (thin) cloud cover. This is not a function of the percent of area covered by clouds, but distinguishes whether the cloud layer is thick or thin. Dense, thick clouds show up on the photograph as a very white bright return and there is a distinct outline separating the cloud from the ground.

Light, thin clouds appear a dull white on the photograph. The ground can almost or partially be seen through the cloud. The outline between the cloud and the ground is not as sharp as in the thick cloud layer. On a lighted table dense, thick clouds can be separated from light, thin clouds by the difference in light penetrating through the photograph.

When clouds are present the liquid water content of the cloud absorbs and hence emits microwave radiation. in addition to the effects of the molecular oxygen and water vapor already present under clear sky conditions. One way to consider the effects of clouds is to use only the samples with cloud cover entirely absent or lower than one tenth. These data are plotted as in Figure 2. Unfortunately, almost all these samples were located in the north part of the test site where the soil moisture content was below 3%. The correlation coefficient was similar to the total sample, -0.70.

In Figure 3, certain adjustments can be made for cloud cover. The radiometric antenna temperatures for heavy cloud cover have been corrected according to the method described by Wu and Fung (1973, p. 84). The correlation coefficient is -0.74 and the standard error is 7.5%, indicating some improvement when the effects of cloud cover are considered.

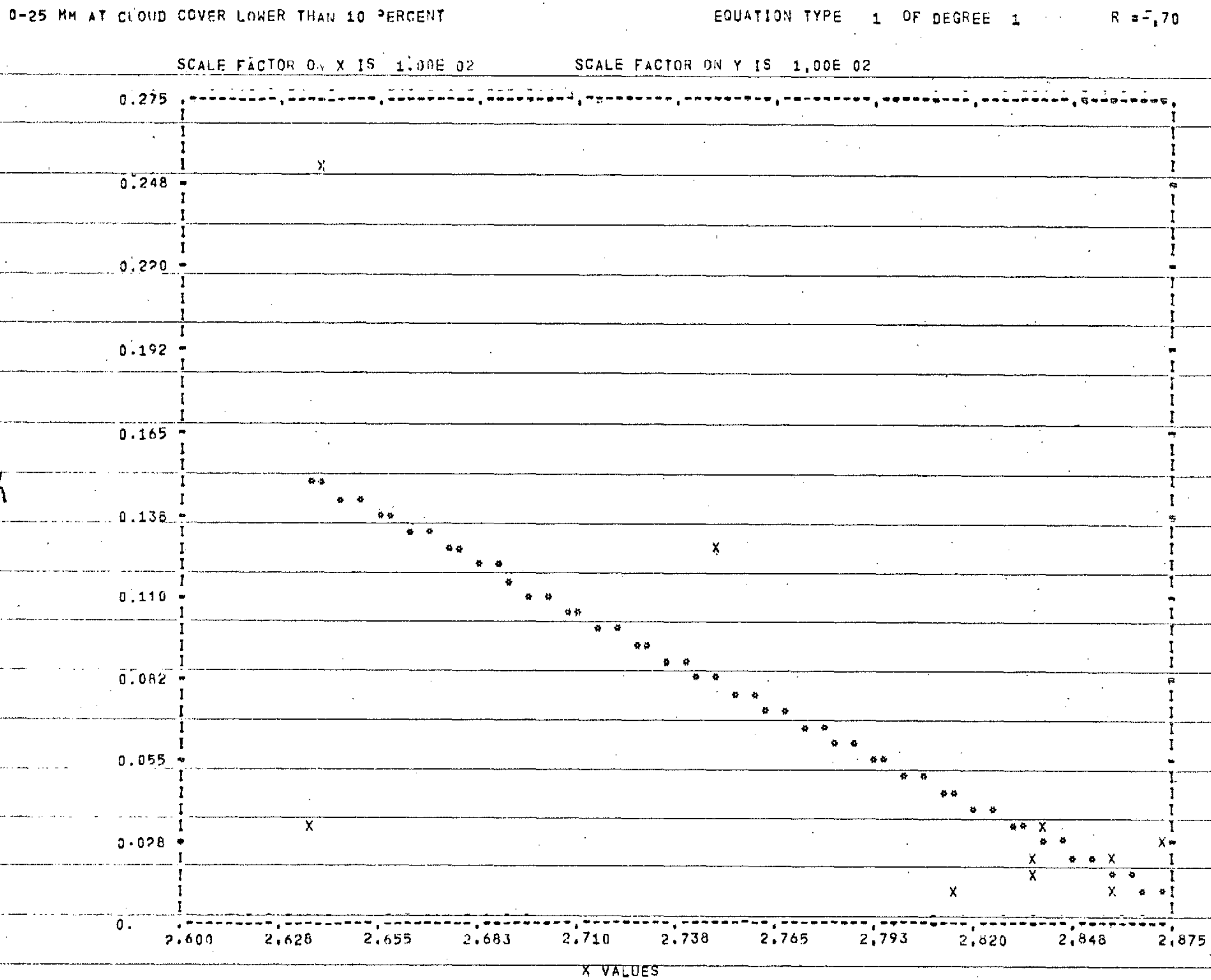

Figure 2. The Correlation Between Soil Moisture and S-193 Radiometric Temperature for Cloud Free and Cloud Cover Less Than 10%.

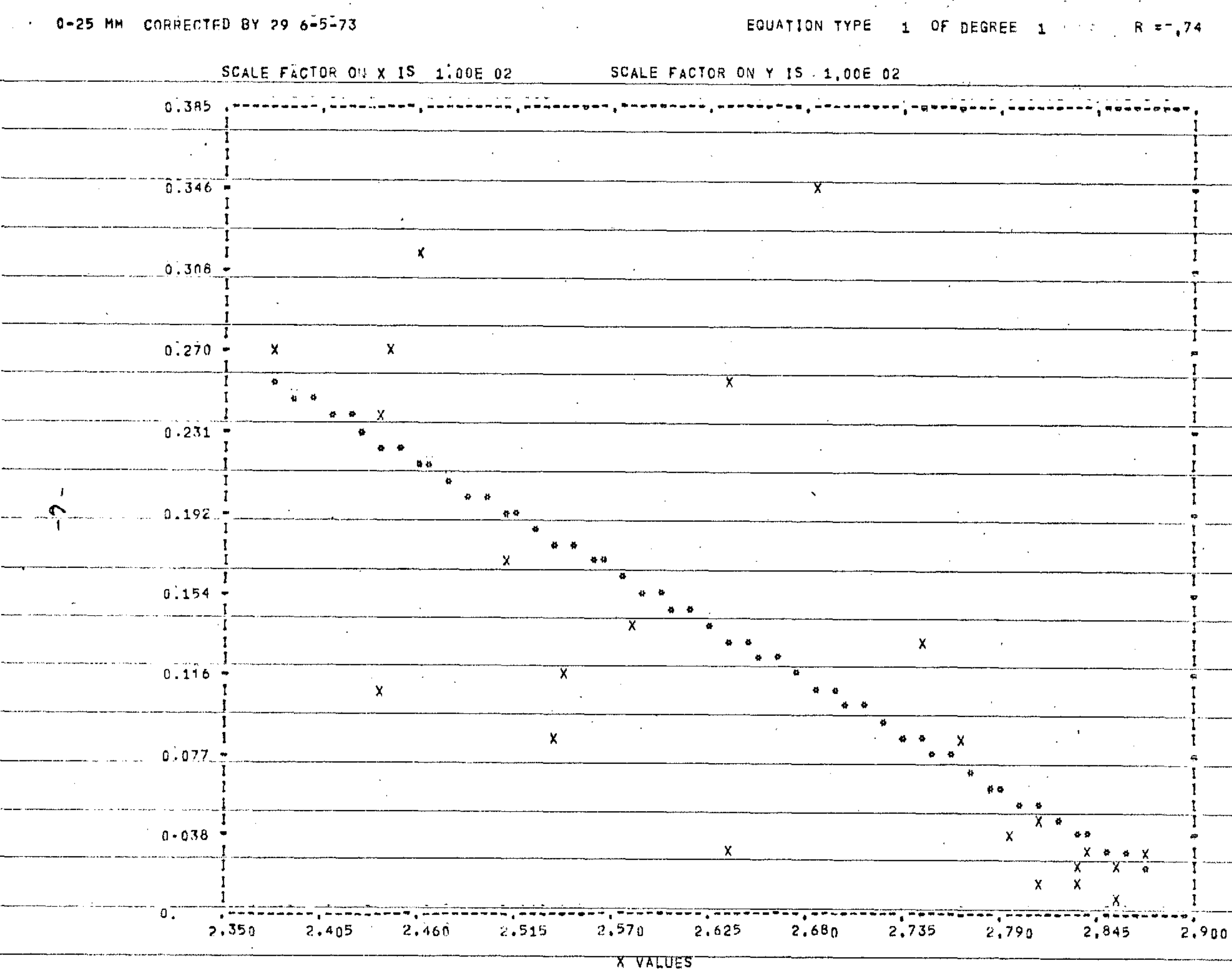

Figure 3.
Correlation Between Soil Moisture and S-193 Radiometric Temperature Corrected For Effects of Heavy Cloud Cover.

One additional adjustment was made because of the nature of the distribution of the soil sample sites. Just before the Skylab data collection there were several local showers in the southern part of the test site, therefore, the variation of soil moisture content was great in some areas. One or two soil moisture samples in areas where large variations occurred were apparently not able to represent the whole S-193 return area. In these cases the soil moisture content of additional sample sites just outside the return area were also included to determine the average moisture content. These results are plotted as in Figure 4. which does not include the cloud cover adjustment. The standard error of estimate is 5.84% and the correlation coefficient is -0.75. Thus, the correlation is improved by using some of the soil sample sites just outside the footprints.

Further improvement in the correlations are obtained if the adjustment for cloud cover is included (Figure 5.). The correlation coefficient is -0.80 and the standard error of estimate is 5.3%. These refinements represent considerable improvement in the initial correlation (-0.56) reported in the April Progress Report. One further refinement is possible because of some influence from vegetation. The vegetation distributions have been determined for this test site from the S190A and S190B color photography. We are now in the process

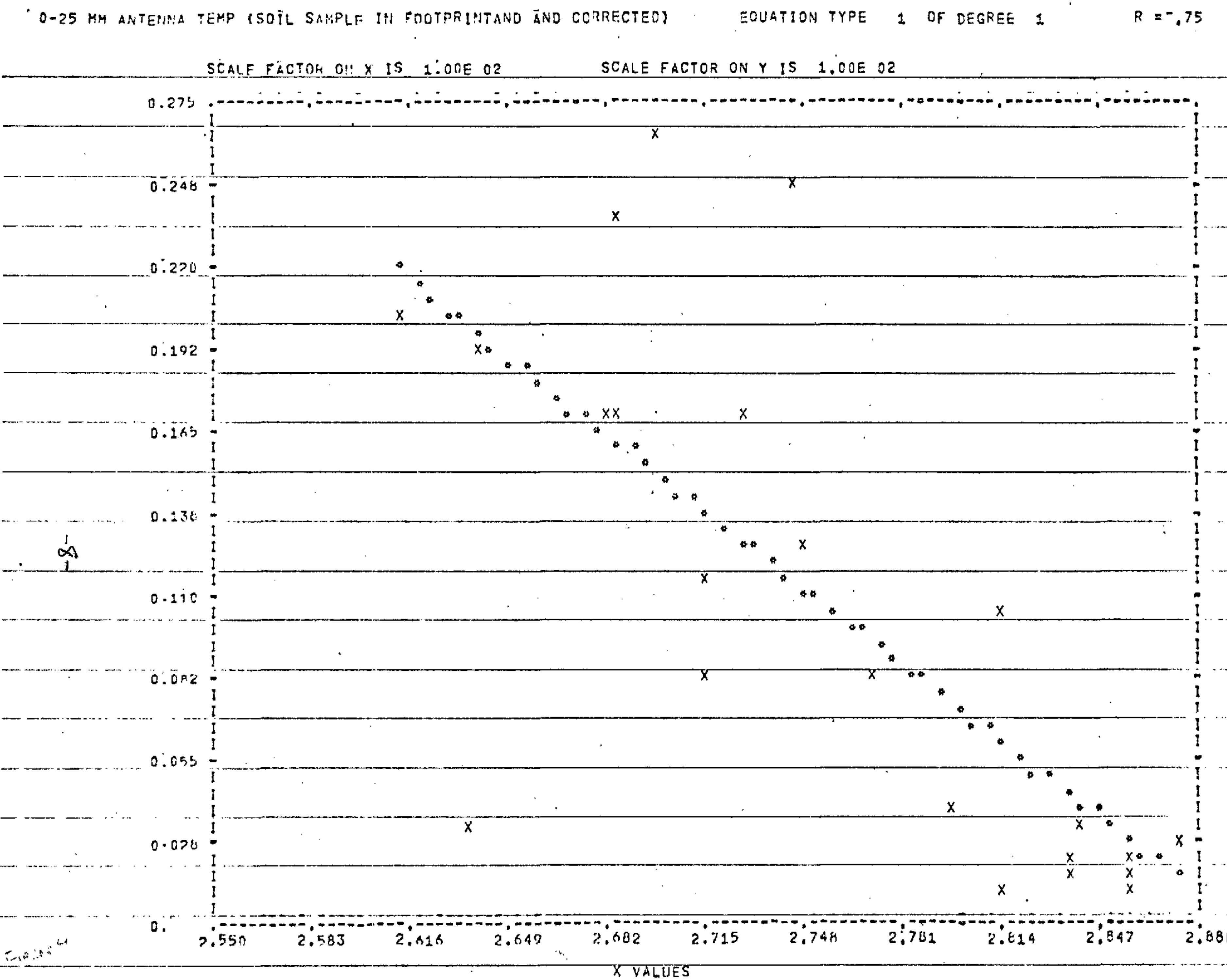

Figure 4. Correlation Between Adjusted Soil Moisture and S-193 Radiometric Temperature Unadjusted For Effects of Heavy Cloud Cover.

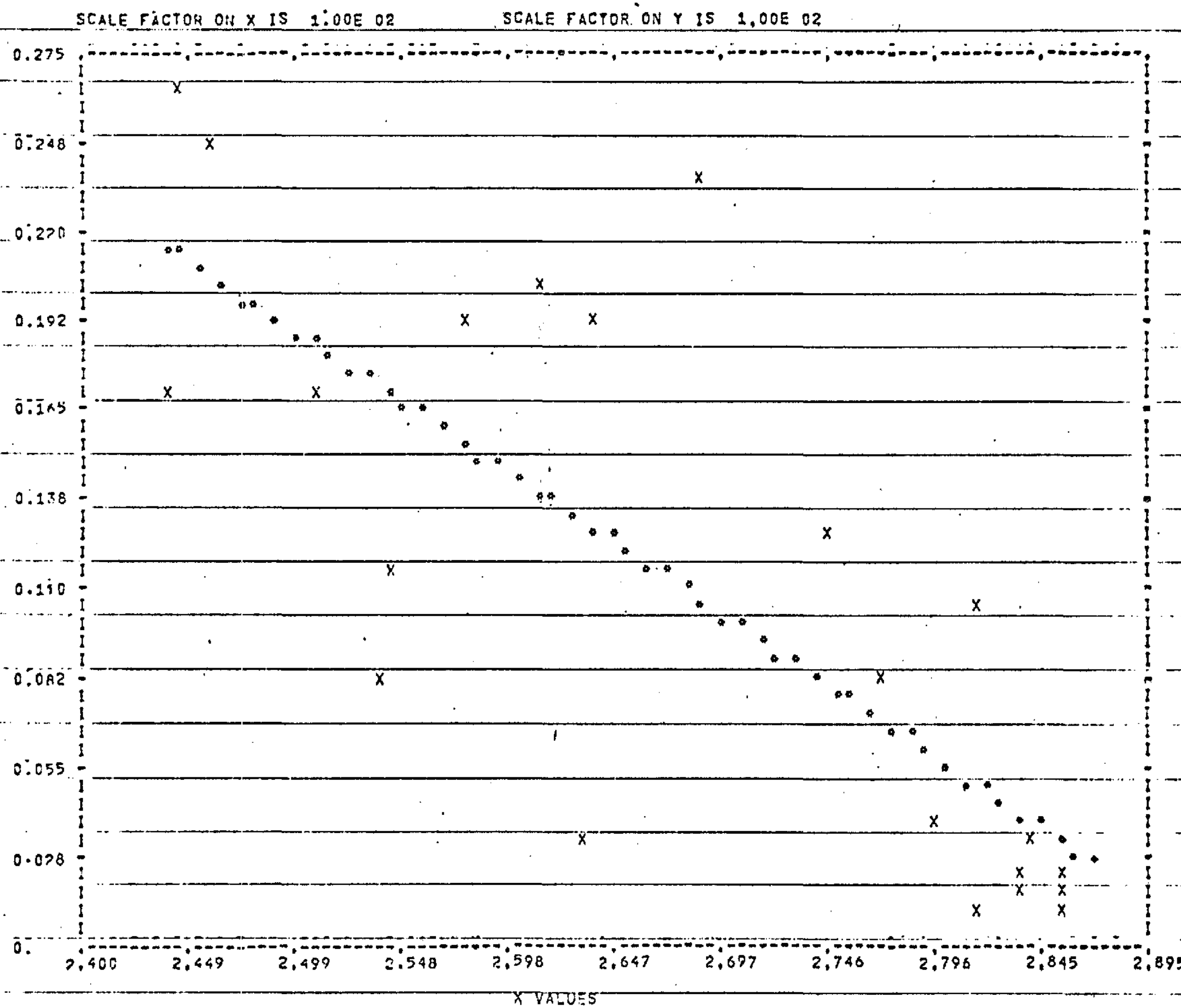

Figure 5. Correlation Between Adjusted Soil Moisture and S-193 Radiometric Temperature Corrected for Effects of Heavy Cloud Cover

of making adjustments for the effects of vegetation and the results will be reported next month.

REFERENCES

Wu, S. T. and Fung, A. K., 1973. "A Theory of Microwave Apparent Temperature over the Ocean". NASA Contractor Report, NASA CR-2329. 146 pp.