The Possibility of Soil Monitoring using Satellite Remote Sensing in the Mongolian Grasslands

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ABSTRACT

Nowadays, an observation of soil condition by remote sensing on bare soil areas is a continuing project. However the observation methods have not made the clear explanation of the reflectance spectrum by soil conditions. So it is important to understand the relationship between remote sensing data and ground truth data. Soil condition includes many factors such as soil moisture, topography, soil acidity and soil grading. In this study, a ground truth reforestation study of soil conditions was carried out in Mandal-GOBI, Mongolia in August of 2000. Observed items were topography, soil moisture content, soil moisture suction and soil grading. The researchers carried out the ground truth verification. Soil moisture was unchanged according to the topography in test area. Therefore, the influence of soil moisture was disregarded in the test area for satellite imaging analysis. Consequently topographic influences could be easily derived from the original satellite image. The resulting corrected image will be helpful for using soil observation; however, the meanings of its brightness pattern need future study. And the researchers will obtain soil spectral reflectance information in the test area and compare it with the derived image which had the topographic influence removed.

1. INTRODUCTION

Soil observation using remote sensing usually uses a microwave sensor and optical sensor with a narrow short wave infrared range. Microwave is used for measurement of soil moisture content, and short wave infrared is used for classification of geology. However these observation methods have not clearly explained the reflectance spectrum corresponding to soil different conditions: soil moisture, topography, soil acidity and soil grades. Moreover land cover and atmospheric conditions make difficult analysis. Due to these errors of omission, it is important to study the relationship between satellite imaging and soil conditions. It is necessary to carry out ground truth verification of soil conditions in uniform landcover areas.

2. OBJECTIVES

This study aim is establishing observation method of soil conditions using satellite remote sensing. It is important to compare satellite image with ground truth data. As ground truth on soil conditions, topography, soil moisture content and soil grading must be observed. Test area was selected in Mandal-GOBI Mongolia because of clear atmosphere and uniform landcover. The test area size was 2 km x 2 km. After that, the results of ground truth are concluded. Finally, soil conditions will be compared with Landsat7-ETM image.

3. OBSERVATIONS RESULTS

3.1 Topography

Topography was surveyed by the kinematics method using 1cycle GPS. Numbers of observed points were 5487. DEM was generated as TIN (Triangulated Irregular Network) using all surveying points [4] (T Kadota, 2000). Figure1 shows derived contour line from the DEM.

3.2 Soil moisture contents

Soil moisture contents were measured by FDR soil moisture meter. The instrument can measure a volume of soil moisture ratio per $1m^3$. Measurement points ranged from 3 cm to 5 cm in depth. These points were selected according to topographic feature. Figure 1 shows the measurement points of soil moisture. After that, the results were compared with slope aspect and inclination that was derived from DEM. Figure 2 shows relationship between inclination and soil moisture ratio. Figure 3 shows relationship between slope aspect and soil moisture ratio. Soil moisture had no tendency with inclination and slope aspect. So it seems that soil moisture contents might not dependence on element of topography in the test area.

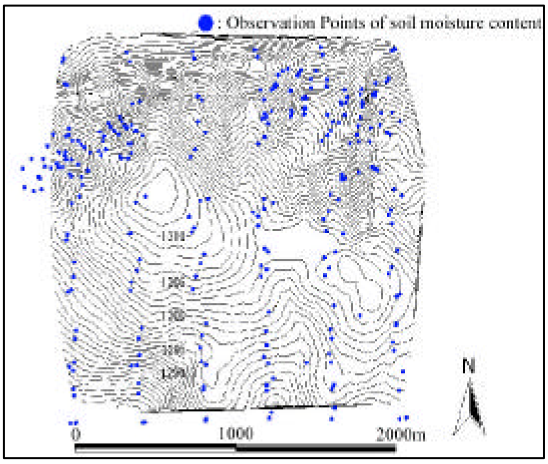

Figure 1. Observation points of soil moisture content on contour line which was derived from DEM

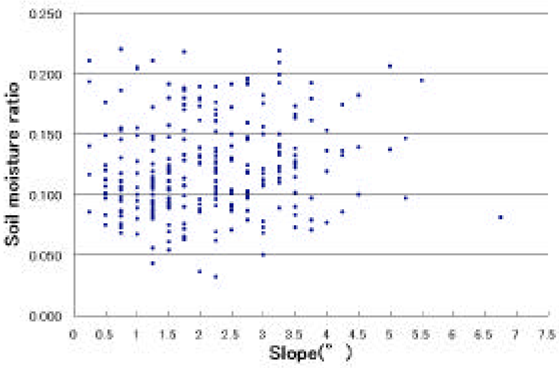

Figure 2. Relationship between inclination and soil moisture ratio

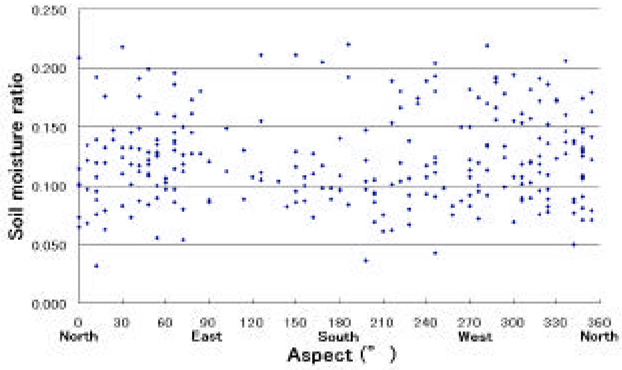

Figure 3. Relationship between slope aspect and soil moisture ratio

3.3 Soil moisture suction

Soil moisture suction relates a drying degree within soil. When the suction is indicating high value, the drying degree also shows high. This instrument was set up in surface, 30 cm and 60 cm in depth. Measurement period was two weeks from August 7 to August 18. Figure 4 shows soil moisture suction and the change in time series. In this figure, Soil moisture suction shows the highest value at noon in almost day [1] (A Yoshino, 1999). So it seems that soil moisture was influenced by sun elevation rather than topography.

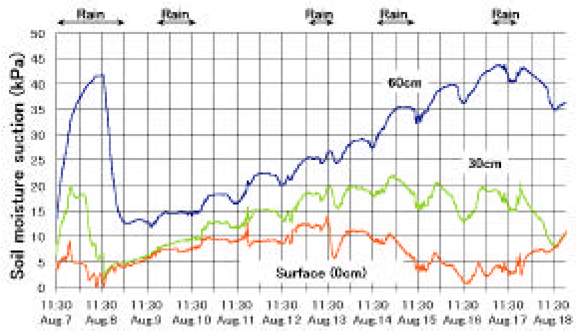

Figure 4. Soil moisture suction changing in time

4. RELATIONSHIP BETWEEN SATELLITE IMAGES AND TOPOGRAPHIC RESULTS FEATURE

The results of soil moisture observation will be uniform at same time in the test area. It means that soil moisture has almost same status regardless with topographic feature in gentle slope. And the landcover also showed uniform, in the test area where is thin grassland. Therefore satellite image will be deeply influenced by topography because of shading. The hill shading will be related with spectral reflectance. In this chapter the shading image will be compared with the satellite image.

4.1 Hill shading

DEM was converted to grid type in 30m spatial resolutions same as Landsat7. Shading value in each grid was calculated using Lambert's equation with use of DEM. Strictly, this equation needs the parameters of reflection ratio on surface and optical atmospheric thickness. However these parameters did not use in this study. Because generated shading image will just compare with satellite image statistically. Cosine value between light source vector and normal vector of the surface was used for shading image generation. Figure 5 shows derived shading image. Sun elevation and azimus were used same parameters as acquired period of Landsat7 image.

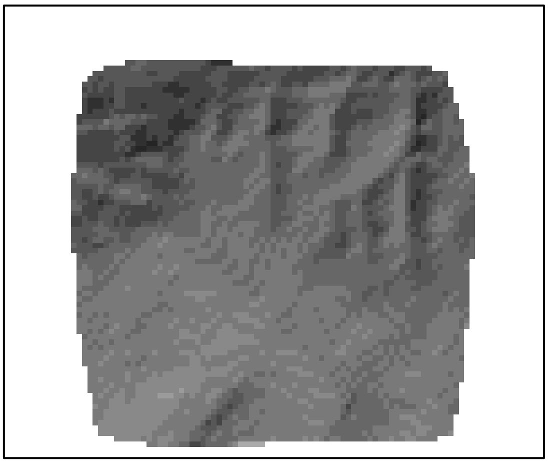

Figure 5. Shading image

Table 1. Correlation coefficients between shading value and ETM value in each band of Landsat7

Band Num.	Correlation Coef.
Band 1	0.40
Band 2	0.53
Band 3	0.65
Band 4	0.76
Band 5	0.78
Band 7	0.75

4.2 Geometric correction of satellite images

In this study, systematically corrected Landsat7 images were used. Because selecting the ground control points was difficulty in test area. This image can be corrected in high accuracy using correlation with shading data, when position where the correlation indicates the highest was found by shifting the satellite image. Table 1 shows the highest correlation between shading and each band. The results showed band 5 and 7 indicate high correlation. Figure 6 and 7 show the geo-corrected image.

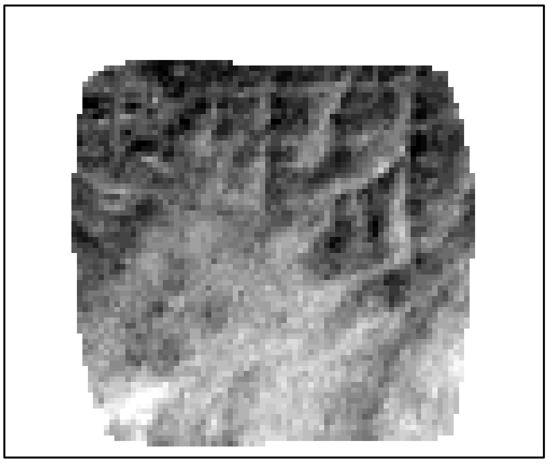

Figure 6. Geo-corrected Landsat7-ETM (Band 5)

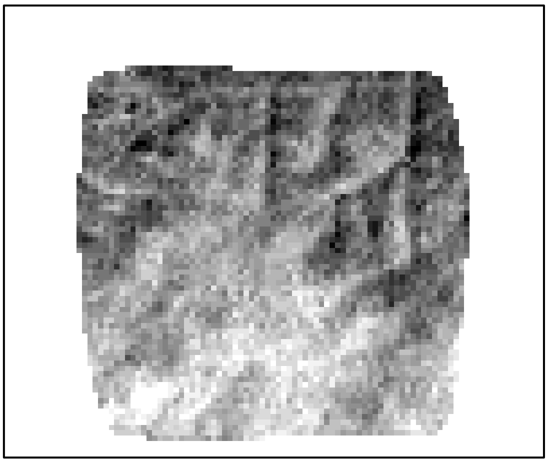

Figure 7. Geo-corrected Landsat7-ETM (Band 7)

4.3 Removing effects of topography

Satellite images are influenced by Topography. Figure 8 and 9 show relationship between the shading value and each band value. An equation of the fitting line was calculated by regression analysis . Correlation coefficients showed 0.78 (band5) and 0.75 (band7). Therefore, band value can be estimated by shading value using following equation.

X = A * S + B ------------------------------- (Equation 1)

S: shading value

X: Estimation values of band 5 or band 7.

A: Gradient of regression line 3.48651(band 5), 2.815579 (band 7)

B: Interception of regression line -200.868 (band 5), -159.81 (band 7)

By using previous equation 1, topographic influence in Landsat7 images might be eliminated. Transform can be established by following the first order equation, which uses gradient and interception in previous regression analysis.

Yij = Cij * Xij ------------------------------- (Equation 2)

Cij = Xmax / (A * Sij + B) ------------------------------- (Equation 3)

Yij: After transform value in each pixel

Cij: Transform coefficient in each pixel

Xmax: Maximum value estimated

Xij: value of satellite image in each pixel

Smax: Maximum value of shading

Sij: Shading value in each pixel

Figure10 and 11 show the image removed topographic influence by using previous transform Equation 2.

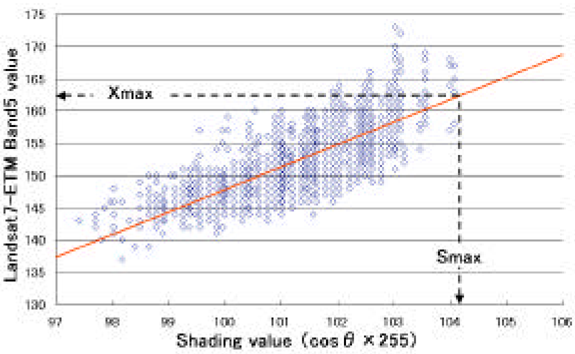

Figure 8. Relationship between shading value and Band 5 value

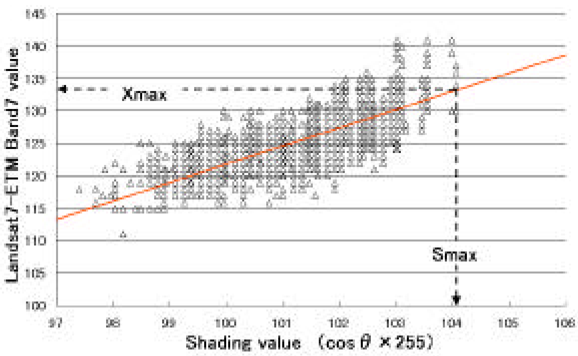

Figure 9. Relationship between shading value and Band 7 value

4.4 Relationship between the image removing topographic influence and soil condition

In figure 10 and 11, there were bright areas in southern part. These situations might be come from soil condition. Because, soil moisture was estimated a random value and topographic influence was removed. Unfortunately the reason could not find by ground truth. The spectral reflectance must be observed as further study.

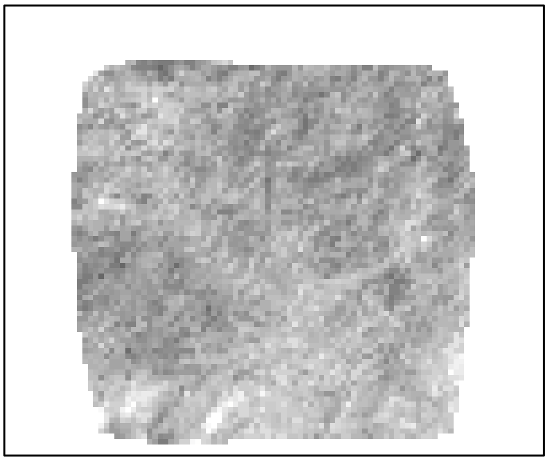

Figure 10. Removing topographic influence on band 5 image

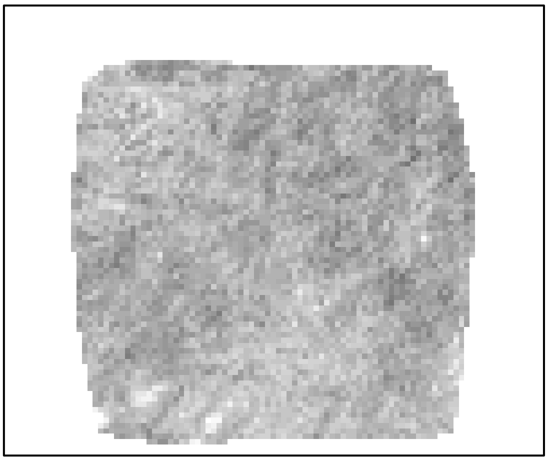

Figure 11. Removing topographic influence on band 7 image

5. CONCLUSIONS

Ground truth was succeeded to carry out. The soil moisture has no tendency according to topography in the test area. The influence of soil moisture can disregard in the test area for satellite image analysis. Therefore topographic influence could be easily removed from original satellite image. This image will be helpful for soil observation. However meaning of brightness pattern in the removed image was not understood. As future study, the soil spectral reflectance information in the test area will be acquired and it must compare with the derived image which was removed topographic influence.

6. ACKNOWLEDGMENTS

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