ATMOSPHERIC CORRECTION OF SATELLITE IMAGES OVER RUGGED TERRAIN

Yoshikazu Iikura

Faculty of Science and Technology, Hirosaki University
3 Bunkyo-cho, Hirosaki 036-8561, Japan
iikura@cc.hirosaki-u.ac.jp

1. INTRODUCTION

After having obtained a satellite image to investigate land surface properties, we sometimes find that the quality of the image is worse than we have expected. Contamination by haze and cirrus cannot be identified in advance, though the cloud cover index and the quick look image give us some information on the quality of the image and cloud positions. Moreover, atmospheric effect such as path radiance depends on the altitude of land surface even in an image taken under clear sky condition.

Although a variety of atmospheric correction techniques have been described, a few are capable of handling space-varying effects. It has been observed that the forth tasseled cap is particularly sensitive to the amount of aerosols in the atmosphere. Lavreua [1] describes one such method for removing space varying haze that subtract a portion of tasseled cap from those spectral bands requiring correction. The tasseled cap was also used to identify a haze mask in ATCOR2 [2].

It was noted that atmospheric scattering tends to affect the shorter wavelengths and thin haze has often-negligible effect in infrared bands. In the haze equalization algorithm [3], the infrared bands are used to divide the image into segments. The values of a visible band, which are averaged in a segment, are reassigned to every pixels of the segment. Liang et al. [4] estimated the spatial distribution of aerosol and its optical characteristics, which are used in their region-based atmospheric correction.

For rugged terrain, Iikura[5] showed that path radiance decreases significantly as the surface altitude increases in visible band, not only by using a radiation transfer code (6S) but also by checking shadowed pixels of actual Landsat images. He also proposed to approximate the relationship between the digital number and the surface altitude as a linear function.

In this paper, we propose a new region based method for correcting the atmospheric effects, which vary not only horizontally but also vertically. The method is applied to a Landsat TM data (p107r37) of May 29,1996 over Kitakami mountainous area. The effectiveness of the method is shown in Fig.1, where two true color composites, (a) before correction and (b) after correction, are compared.

(a) Before correctiom

(b) After correction

Fig. 1. True color Landsat TM image of the study area.

2. CORRECTION METHOD

First, the infrared bands, which are less influenced by atmospheric scattering than the visible bands, are used to divide the image into segments as Carlotto [3]. We assume that pixels in a segment have the same reflection even in the visible bands. In Fig.2, pixels in the segment are plotted with regard to the digital numbers and the surface altitude. It is seen that the digital number decreases as the altitude increases as a whole. For this purpose, Band 1 is used because it is most severely affected by the atmosphere. At the altitude of 1200m (X_0), the digital number seems to converge into 76 (Y_0).

As the deviation of the digital numbers are partly caused by the altitude, the dependence is defined by following index B:

$$B = (Y - Y_0)/(X_0 - X)$$

The index B is calculated for every pixel in each segment. This index has large deviation even in a region with same atmospheric condition. So we spatially average the index over a region of 40 x 40 pixels by using the median filter. By using the averaged index $\overline{B}$, following correction is applied to every pixels in the image,

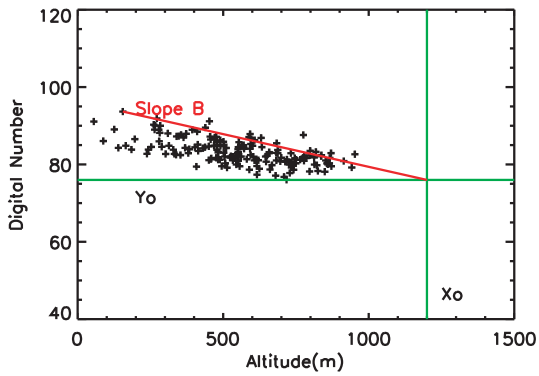

Fig. 2. Calculation of the atmoospheric effect index B : an example

$$DN_i' = DN_i - \alpha_i \overline{B}(X_0 - X)$$

where DN_i and DN_i' are an original digital number and corrected digital number of Band i, respectively. α_i is introduced to apply $\overline{B}$ to other two visible bands; 0.3 and 0.2 for Band 2 and Band 3, respectively. The corrected digital number is considered as the value if the pixel is located at the altitude of 1200 m. The result is shown in Fig.1(b), where no apparent atmospheric effect is seen. To make fair comparison, the same linear stretch function is used for image enhancement.

3. CONCLUSION

The proposed method was shown to be effective for correcting the space-varying atmospheric effects in the Landsat TM image. The method utilized the difference of the atmospheric effects between the visible bands and the infrared bands. Though we assume that the path-radiance depends on the altitude linearly, the actual vertical aerosol distribution might be different, in particular, in the case of cirrus. Physical basis of X_0 and Y_0 should be also investigated and refined.

4. REFERENCES

[1] J. Lavreau, "De-hazing landsat thematic mapper images," *Photogrammetric Engineering and Renote Sensing*, vol. 57, pp. 1297–1302, Octorber 1991.

[2] R. Richter, "A spatially adaptive fast atmospheric correction algorithm," *Int. J. Remote Sensing*, vol. 17, pp. 1201–1214, 1996.

[3] M. J. Carlooto, "Reducing the effects of space-varing, wave-length-dependent scattering in multispectral imagery," *Int. J. Remote Sensing*, vol. 20, pp. 3333–3344, 1999.

[4] S. Liang, H. Fang, and M. Chen, "Atmospheric correction of landsat etm+ land surface imagery -part i : Methods," *IEEE Trans. on Geoscience and Remote Sensing*, vol. 39, pp. 2490–2498, November 2001.

[5] Y. Iikura, "Analysis of atmospheric and topographic effects on landsat tm imagery," in *Proceedings of 22nd International Symposium on Space Technology and Science*. ISTS, 2000, pp. 87–88, Morioka, Japan.