

THE CORRELATION BETWEEN NDVI VALUE AND SURFACE TEMPERATURE MEASURED BY ASTER

K. Takemata^{a,*}, Y. Kawata^b, N. Naoe^c

^a Div. of Practical Engineering Education, Kanazawa Institute of Technology, Nonoichi, Ishikawa 921-8501, Japan - takemata@neptune.kanazawa-it.ac.jp

^b Dept. of Media Informatics, Kanazawa Institute of Technology, Nonoichi, Ishikawa 921-8501, Japan - kawata@infor.kanazawa-it.ac.jp

^c Dept. of Electrical and Computer Engineering, Kanazawa Technical College, Kanazawa, Ishikawa 921-8601, Japan - naoe@kanazawa-tc.ac.jp

Commission VII, WG VII/4

KEY WORDS: Atmospheric correction, Land cover, Vegetation, Temperature, Correlation

ABSTRACT:

The thermal environment in urban areas is characterized by the heat island phenomenon. To estimate the thermal conditions of land surfaces by satellite, it is necessary to find the relationship between the surface temperature and land cover type. The most widely used vegetation index for ecological application is the Normalized Difference Vegetation Index (NDVI). We studied the correlation between NDVI values and the surface temperature in our study area. NDVI uses radiance values or apparent reflectance values of the red and the near-infrared spectral bands. These reflectance values are influenced by the atmospheric aerosols. In order to calculate accurate NDVI values (aerosol-free NDVI), we first estimated the surface reflectance at visible bands by using our atmosphere-ground surface system based on the aerosol observation data. At the test site, we measured the aerosol optical thickness of visible bands using a sky radiometer, and we measured the air temperature and humidity by using a thermometer-hygrometer with a data logger. In this paper, we show the variations of aerosol optical thickness in the spring and summer and demonstrate the correlation between the surface temperatures of ASTER level 2B products and our observed screen temperatures.

1. INTRODUCTION

The thermal environment in urban areas is characterized by the heat island phenomenon. In the summer, the temperature of urban areas rises in comparison with the surrounding rural areas. To estimate the thermal condition of land surfaces by satellite, it is necessary to find the relationship between the surface temperature and land cover type.

ASTER spectral bands are separated into three sub-systems: visible and near-infrared radiometer (VNIR) bands, short-wave infrared radiometer (SWIR) bands, and thermal infrared radiometer (TIR) bands. VNIR has 3 spectral bands with a spatial resolution of 15 m, SWIR has 6 spectral bands with a spatial resolution of 30 m, and TIR has 5 spectral bands with a spatial resolution of 90 m.

The most widely used vegetation index for ecological application is the Normalized Difference Vegetation Index (NDVI), which uses radiance values or apparent reflectance values of the red and the near-infrared spectral bands. These reflectance values are influenced by atmospheric aerosols. In order to calculate accurate NDVI values (aerosol-free NDVI), the atmospheric effects must first be removed from the reflectance values (Karnieli et al., 2001).

The purpose of this research is to investigate the conditions of the heat island phenomenon in a Japanese city. Figure 1 shows our study area. In this paper, we show the variations in aerosol

optical thickness in the spring and summer and demonstrate the correlation between the ASTER surface temperatures (ASTER level 2B products) and our observed screen temperatures.

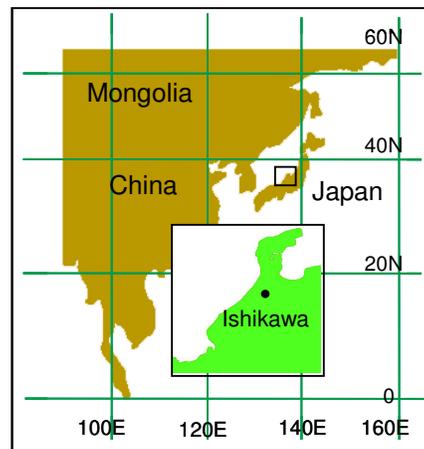


Figure 1. Map of study area

2. ANALYTIC FLOW

The analytic flow is shown in Figure 2. ASTER product 1B data were used to analyze land cover. We used ASTER level 2B products to measure surface temperatures.

* Corresponding author.

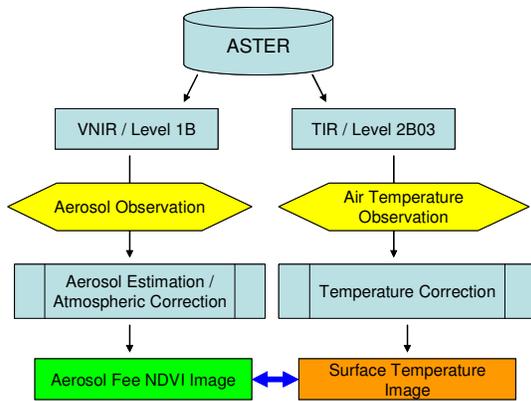


Figure 2. Analytic flow

2.1 Temperature observation on the ground

Kenrokuen Park is located in the center of Kanazawa, Ishikawa Prefecture, Japan. There are 30 schools in a 4-km radius from Kenrokuen Park. Each school has an instrument screen in its yard. Figure 3 shows a typical instrument screen in an elementary school. We installed a thermometer-hygrometer with a data logger in each instrument screen and measured the temperature and humidity at 10-minute intervals. These observation values show the air condition at a height of 1.5 m above the ground. A thermometer-hygrometer with a data logger was kept in the instrument screen from June 2003 until September 2003.



Figure 3. Instrument screen at Kanazawa Nakamura-machi Elementary School (36.56°N, 136.64°E)

Figure 4 contains the results of the observation on August 7, 2003. Even at night, the temperature at Kanazawa Nakamura-machi Elementary School, located in the business district, did not fall. At Kanazawa Yuhidera Elementary School, which is located in a pastoral area, the temperature did fall at night. This result indicates that a difference in land cover influences the air temperature.

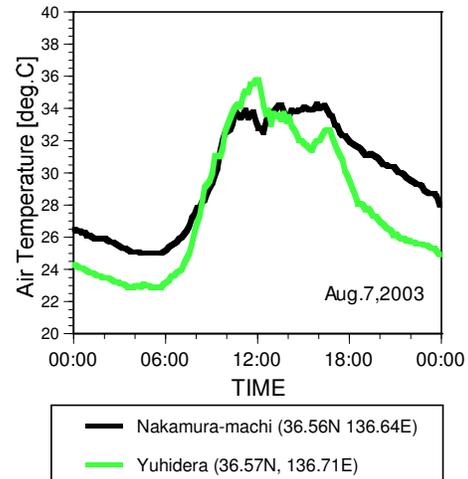


Figure 4. Air temperature at Kanazawa Nakamura-machi Elementary School and Kanazawa Yuhidera Elementary School

2.2 Atmosphere observation on the ground

A sky radiometer (POM-01: PREAD) was installed on the roof of Building No. 24 of the Kanazawa Institute of Technology (Figure 5). Atmospheric observations were taken during the day using 6 wavelength channels of 0.315, 0.40, 0.50, 0.87, 0.94, and 1.04 μm (Kawata et al., 2003). The value which was received from the sky radiometer was converted into the optical thickness of the atmospheric aerosol using the Sky Rad. Pack code (Nakajima et al., 2001).



Figure 5. Sky Radiometer at Kanazawa Institute of Technology (36.53°N, 136.63°E)

Figure 6 shows the change in the aerosol optical thickness at 0.5 μm from April 2003 to September 2003. The value of the aerosol optical thickness was high, and the change in the value from April to May was drastic. The value of the aerosol optical thickness decreased after June, and the change in the value decreased. When the NDVI value is calculated in the spring at our study site, we must be careful about the change in the aerosol optical thickness.

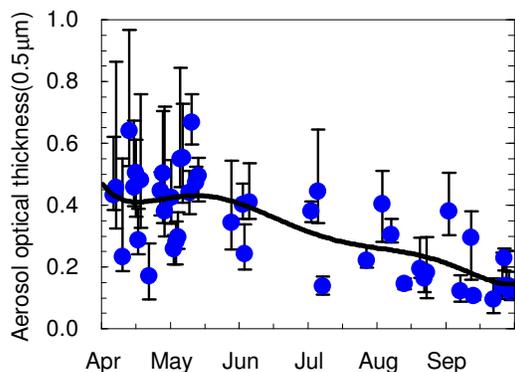


Figure 6. Aerosol optical thickness measured by the sky radiometer at Kanazawa Institute of Technology.

3. ELEMENTARY ANALYSIS OF THE ASTER SURFACE TEMPERATURE

We measured the air temperature at 30 observation points at our study sites from June 2003 until September 2003. During that period, remote sensing data were observed by ASTER at only one site, and the observation was made at 22:00 local time on September 26, 2003. Figure 7 shows the ASTER product 2B03 surface temperature image. The trunk road which heated the area in the daytime can be seen clearly. The symbol “□” inside the figure shows the position of the instrument screen at each elementary school. Figure 8 shows the relation between the surface temperature value of the ASTER product and the air temperature value of the instrument screen. Both show high correlations, and we can estimate the air temperature from the ASTER product value.

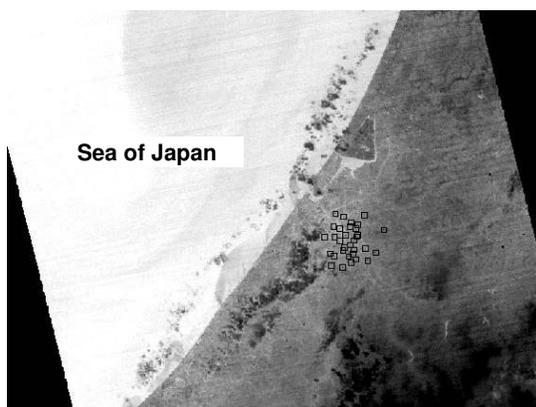


Figure 7. ASTER product 2B03 surface temperature image. The symbol “□” in the figure shows the position of the instrument screen. The center of the instrument screen is at 36.56°N, 136.66°E.

4. CONCLUSION

In conclusion, the study results can be summarized as follows:
1) The change in the atmospheric aerosol is drastic during the spring in our study area. When using remote sensing data, we

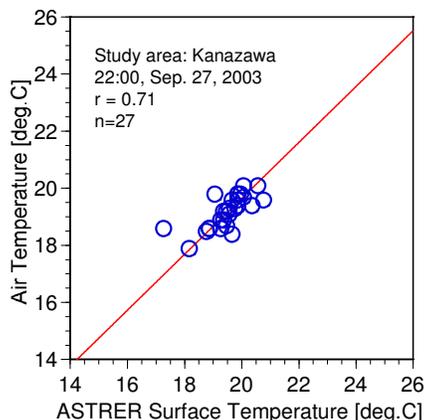


Figure 8. Scatter diagram of the ASTER surface temperature and the air temperature at the study site.

must take the influence of the daily differences in atmospheric aerosol into consideration in order to understand the effect of land cover.

2) The air temperature data recorded on the instrument screens were compared with the surface temperature data of the ASTER product, and a relation between both types of temperature data during the night in our study area was shown.

Further study will be required to determine the relation between daytime air temperature and surface temperature. We will carry out research to demonstrate the correlation between aerosol-free NDVI and surface temperature in our study area.

ACKNOWLEDGMENTS

The TERRA/ASTER data were obtained from ERSDAC, Japan. The Sky Rad. Pack code was provided by Professor T. Nakashima at CCRS, University of Tokyo. The authors would like to thank Mr. T. Inazawa at Infoserve, Inc., PCI Japanese Agency, for help in using Geomatica 9.1 in the ASTER data analysis.

REFERENCES

- ERSDAC, 2001. Level 1 data working group ASTER science team. Algorithm theoretical basis document for ASTER level 1 data processing (Ver.3.0), Japan.
- Karnieli, A., Kaufman, Y. J., Remer, J., and Wald, A., 2001. AFRI – aerosol-free vegetation index, *Remote sensing of environment*, 77, pp. 10-21.
- Kawata, Y., Fukui, H., and Takemata, T., 2003. Retrieval of aerosol optical thickness using band correlation method and atmospheric correction for Landsat-7/ETM+ image data, *IEEE international geoscience and remote sensing symposium*, Toulouse, France, pp. 2173-2175.
- Nakajima, T., Tonn, G., Rao, R., Boi, P., Kaufman, Y. J., and Holben, B., 1996. Use of sky brightness measurements from ground for remote sensing of particulate polydispersions. *Applied Optics*, 35(15), pp.2672-2686.