Comparison of the NDVI, ARVI and AFRI vegetation index, along with their relations with the AOD using SPOT 4 Vegetation data

Gin-Rong Liu

Center for Space and Remote Sensing Research, National Central University, Taiwan 320

grliu@csrsr.ncu.edu.tw

Chih-Kang Liang

Institute of Atmospheric Physics, National Central University, Taiwan 320

Tsung-Hua Kuo

Center for Space and Remote Sensing Research, National Central University, Tawan 320

Abstract: This paper explores two such indexes----the Aerosol Free Vegetation Index (AFRI) and the Atmospherically Resistant Vegetation Index (ARVI). Comparisons were made with the NDVI (normalized vegetation index) to see if they indeed performed better. In general, the results showed that the AFRI and ARVI (with gamma=1) did indeed perform better than their NDVI counterpart study with the related channels were employed.

1. Introduction

Several indexes have been formulated with similar vegetation index function in hoping to eliminate or at least decrease the influence induced by these atmospheric particles. The Aerosol Free Vegetation Index (AFRI) was conceived by simulating the reflectance of the red band with the short-wave infrared wavelength (SWIR) because of its capacity in penetrating through the atmospheric haze [1,2,3]. The Atmospherically Resistant Vegetation Index (ARVI) uses a similar approach but by utilizing the blue band to conduct corrections on the red band [4,5]. By using data from the newer generation Spot 4 VEGETATION sensor, this study strives to compare the two indexes with the NDVI index by comparing to the aerosol optical depth (AOD) of the ground truths.

2. Theoretical basic

The ARVI index takes advantage of the different scattering responses from the blue and red band to retrieve information regarding the atmosphere opacity, and can written as follows

$$ARVI=(\rho_{NIR} - \rho_{rb})/(\rho_{NIR} + \rho_{rb})\ldots(1)$$

where ρ_{NIR} is the reflectance of the near infrared, ρ_{rb} equals $\rho_r - \gamma(\rho_b - \rho_r)$, γ (gamma value) is like a weighting function that depends on the aerosol type, and ρ_r and ρ_b refer to the reflectance of the red and blue bands, respectively.

AFRI uses primarily the short-wave infrared wavelength (SWIR) in developing its vegetation index, and can be written as follows,

$$AFRI_{2.1} = (\rho_{NIR} - 0.5\rho_{2.1}) / (\rho_{NIR} + 0.5\rho_{2.1}) \quad (2)$$

$$AFRI_{1.6} = (\rho_{NIR} - 0.66\rho_{1.6}) / (\rho_{NIR} + 0.66\rho_{1.6}) \quad (3)$$

where the subscripts 2.1 and 1.6 refer to the reflectance of different wavelengths in μm situated within the SWIR region, and ρ_{NIR} denotes the reflectance of the near infrared.

3. Vegetation analysis

In this study, three months of data from September 14 to November 26 of the year 2001 were mainly processed in constructing the various vegetation index images. A set of total 80 points (locations) where were cloud-free were chosen randomly from the 20 sets images and computed their different vegetation indexes in comparing the ARVI and AFRI indexes with the NDVI.

By first looking at the AFRI index, the average r^2 is roughly around 0.7 to 0.8. In addition to calculating the vegetation biomass over the land, an unexpected surprise was found when processing the AFRI index images. Various bright areas especially around the coastal zones could also be spotted over oceans, matching quite well with the chlorophyll distribution image from SeaWiFs. On the contrary, the NDVI image is completely incapable of doing so, as the digital counts registered are very low over oceans.

In this study, mainly the data collecting by the Aeronet station situated at a latitude of 36.5° and a longitude of 126.3°, where it is located on an islet west of South Korea, were used.

From the slope of Fig. 1, we see that the NDVI index value goes down steeply with an increasing AOD. This is consistent with the fact that a higher AOD causes the suspended particles in the atmosphere to scatter the red band more. Finally, for the ARVI index, when gamma=1, it seems nearly horizontal. The more horizontal the regression line is, the more likely it is not so easily affected by the AOD.

4. Conclusion

Finally it is still too premature to make any conclusions if the differences of different AOD can be employed to retrieve other aerosol information. As there were only twenty-four sets of data to test our procedure, more data must be processed and analyzed. In addition, one of the main inaccuracies might be attributed by scattered cirrus clouds in the atmosphere that are not easily detected. More efforts to provide reliable cirrus cloud screening are strongly encouraged. On the contrary, the theoretical basis of the ARVI index is complex and not direct enough than AFRI. It’s probably that eventually the AFRI index will attain a more important role in future studies. Its physical interpretations are clear and more direct. When devising an index, it must be both simple and resistant to various influences. In addition, its potential in assessing the chlorophyll over the ocean and in calculating the AOD with the NDVI index should be further explored. Perhaps a whole new index could be devised with the new method. Lastly, with the recent launch of the SPOT 5 spacecraft in 2002, which carries onboard the second-generation VEGETATION instrument, more precise measurements can also be made of our home planet's surface. As the spectral resolution of satellites continues to improve, and new innovative ways being invented to remotely sense our planet, there is still much more to be learned of our beautiful planet.

References

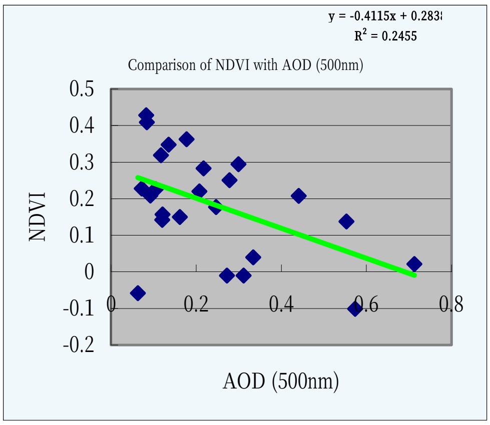
[1] Ångström A. K., 1929: On the atmospheric transmission of sun radiation and on dust in the air. Geogr. Ann., vol. 11, pp. 156-166.

[2] Buschmann, C. and Nagel, E., 1993: In vivo spectroscopy and internal optics of leaves as basis for remote sensing of vegetation. *International Journal of Remote Sensing*., **17**, 845~862.

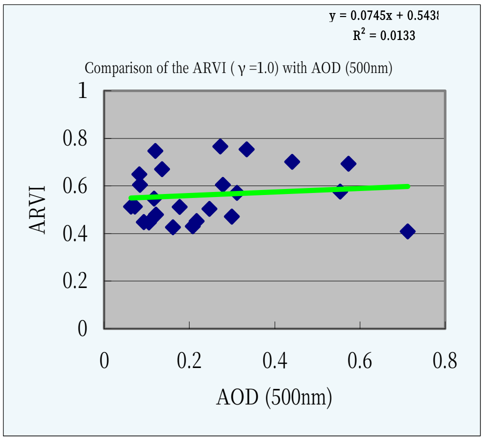
[3] Lin, T.-H., A. J. Chen, G.-R. Liu, and T.-H. Kuo, 2002: Monitoring the Atmospheric Aerosol Optical Depth with SPOT Data in Complex Terrain. International Journal of Remote Sensing,

[4] Kaufman, Y. J. and Tanre, D., 1992: Atmospherically Resistant Vegetation Index (ARVI) for EOS-MODIS. *IEEEE Trans. Geosci. Remote Sensing*., **30** (2), 261~270.

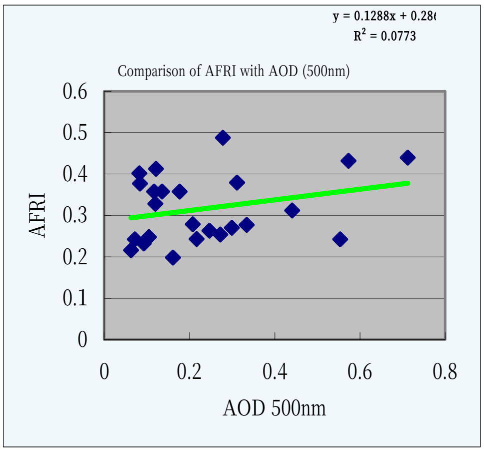
[5] Liu, G.R., Chen, A.J., Lin, T.H. and Kuo, T.H., 2002: Applying Spot data to estimate the aerosol optical depth and air quality. *Environ Modelling &Software*., **17**, 3-9.



(a)



(b)



(c)

Fig. 1 (a) Comparison of the NDVI index and AOD -500nm, (b) but for ARVI (γ =1.0), (c) but for AFRI.