ATMOSPHERIC CORRECTION FOR ESTIMATION OF ABOVE-GROUND CROP BIOMASS – A COMPARISON

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Abstract: Water vapor content and aerosol from Earth’s surface and atmosphere contribute significantly to optical remotely sensed data. Thus, removing atmospheric effects plays an important role in preprocessing image which is the input for further applications. Atmospheric correction methods including relative and absolute methods have been developing sine 40 years ago. In this paper, we perform a comparison of three widely used methods nowadays; they are the improved dark object subtraction (DOS), Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) and the Second Simulation of Satellite Signal in the Solar Spectrum (6S). DOS is an absolute image-based method, while FLAASH which incorporates the MODTRAN4 and 6S are absolute modelling methods. The comparison is analyzed based on Landsat TM image acquired in July 2011. Atmospheric profile including Atmospheric Optical Depth (AOD) and Water Vapor Column is MODIS product; they are MOD04 and MOD05, respectively. These atmospheric corrected images were investigated in above-ground corn dry biomass estimation using *k*-Nearest Neighbor (*k*NN). Overall, in term of spectral curve 6S performed better slightly than FLAASH and DOS, however for estimating crop biomass using FLAASH images seems to be better accuracy.

Keyword: 6S, FLAASH, DOS, Atmospheric Correction

I. Introduction

Above-ground crop dry biomass information can be used in monitoring crop growth, predicting potential yield and estimating crop residues (Liu et al., 2004). Remote sensing based method has been proven to be very powerful tool for estimating dry phytomass, however, uncertainty of satellite imagery such as atmospheric effects may reduce accuracy of these estimation models. The objective of this study is to evaluate some atmospheric correction models for agricultural biomass estimation purpose. Four cases of atmospheric effect removing are of concern: 1) top of atmosphere (TOA) reflectance (Chander & Markham, 2003); 2) The improved Dark Object Subtraction (Chavez, 1988); 3) Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH) (ENVI, 2009) and 4) The Second Simulation of Satellite Signal in the Solar Spectrum (6S) (Vermote, Tanre, Deuze, Herman, & Morcrette, 1997; Zelazowski, 2014). All processed images are then analyzed by using *k*-Nearest Neighbours (*k*NN) algorithm (Gjertsen, 2007; Magnussen, McRoberts, & Tomppo, 2009; Soenen, Peddle, Hall, Coburn, & Hall, 2010; Tomppo, Gagliano, Natale, Katila, & McRobert, 2009; Zheng et al., 2004) to estimate biomass. Ten fold validation is used to assess accuracy of the model. Yucheng commune, Shangdong province, China is chosen as a studied site, it is covering by two Landsat ETM scenes acquired in 11th July 2011.

II. Materials and methods

Study area: Yucheng commune, Shangdong province, Eastern of China with 62% out of 138817.75 ha was covering by corn at the study time is located between 36^{o}32’39”N – 37^{o}4’57”N and 116^{o}27’16”E – 117^{o}5’2”E. Yucheng belongs to continental climate with distinct seasons even Shangdong has a long coastal line. Studied site is flat and is an agricultural area with full of corn at the time of study.

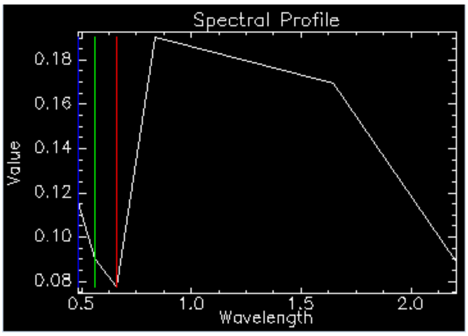
Data sets: Above-ground corn dry biomass was performed by Remote Sensing group, Department of Geographical Information Science, Nanjing University, China. The field trip was around August 2011. The number of sample are18, and in each sample there are 9 subplots. Corn trees within each subplot was collected and dried. Two Landsat ETM acquired in 11 July, 2011 was investigated. Their path is 122; and rows are 34 and 35.

Processing data: Firstly, Landsat image DN value was converted to TOA reflectance. Then, atmospheric correction using DOS and FLAASH was performed within ENVI software. About 6S running, a Matlab routines was used (Zelazowski, 2014). Atmospheric profile for 6S model including Atmospheric Optical Depth (AOD) and Water Vapor Column is MODIS product; they are MOD04 and MOD05, respectively. After each atmospheric correction approach, the two scenes were stacked together and subset fitting to studied area.

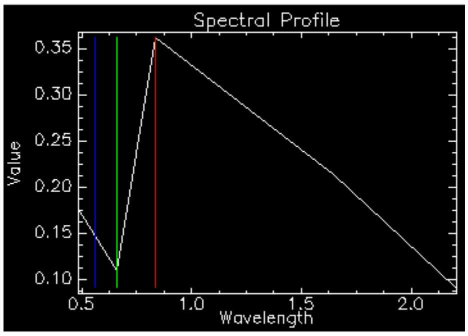
Secondly, 17 band ratios for each cases were created as independent variables for *k*NN model. About accuracy assessment, 10 fold validation method was involved, and Root Mean Square Error (RMSE) and Relative Root Mean Square Error (%RMSE) are parameters using to compare those atmospheric correction options.

III. Results and conclusions

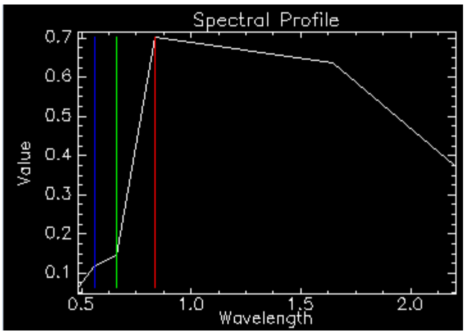
Figure 1 shows spectral curves of corn area in 4 cases of atmospheric correcting. From the figure, it can be seen that 6S model is more efficient to remove atmospheric effect. At figure 1.a, spectral curve reflects about the pure value captured by satellite sensor, spectral value at 0.483µm (blue area) is more than 0.56 µm (green) and 0.662µm (red), it is caused and affected by scattering of atmosphere, so earth surface looks more blue when observing from sky. Also, reflectance values at all bands are quite small, it is because of absorption of atmosphere's molecular (water vapor, aerosol, CO_2 etc). In DOS, the issue in visual band wavelength is still the same, even values of reflectance increase significantly, around 2 times at NIR. In FLAASH, radiance reflected from corn area was corrected more exactly compared to DOS, it is double than DOS in NIR, however, this corn area is likely to be more red because it removes blue scattering problem but reflectance value at red is more than green. In case of 6S, the values of radiance reflectance are similar to FLAASH result except for red area, so corrected image looks more green than others (real color composition).



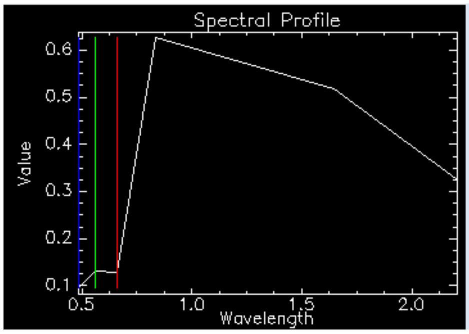
a



b



c



d

Figure 1. Spectral curves of corn area of atmospheric correction results: a. TOA reflectance; b. DOS; c. FLAASH and d. 6S

Table 1. Accuracy assessment of *k*NN algorithm with TOA reflectance (no atmospheric correctio), DOS, FLAASH and %RMSE (unit of RMSE in mg/m^2)

k	No atmospheric correction		DOS		FLAASH		6S	
	RMSE	%RMSE	RMSE	%RMSE	RMSE	%RMSE	RMSE	%RMSE
1	174.79	21.25	174.79	21.25	128.57	15.65	193.90	23.72
2	148.85	18.14	148.85	18.14	127.07	15.50	143.88	17.64
3	126.82	15.47	126.91	15.48	108.17	13.17	140.97	17.25
4	123.65	15.09	123.74	15.10	105.20	12.84	134.07	16.42
5	117.72	14.39	117.87	14.40	96.92	11.84	133.07	16.30
6	116.12	14.19	116.23	14.20	98.74	12.05	128.26	15.72
7	115.15	14.07	115.26	14.09	97.59	11.92	125.51	15.38
8	114.60	14.01	114.71	14.02	97.06	11.85	126.60	15.52
9	113.06	13.82	113.17	13.84	95.41	11.67	122.99	15.07
10	112.69	13.78	112.81	13.79	93.81	11.47	120.88	14.81
11	112.59	13.77	112.70	13.78	92.73	11.34	121.05	14.83
12	112.83	13.80	112.94	13.81	92.62	11.32	121.00	14.82
13	112.57	13.77	112.68	13.78	92.22	11.28	119.88	14.69
14	111.94	13.69	112.05	13.71	92.16	11.27	119.29	14.61
15	111.93	13.69	112.05	13.71	92.07	11.26	118.98	14.58

Finally, all the corrected images were involved in *k*NN algorithm to estimate above-ground corn dry biomass, *k* was tested from 1 to 15. Table 1 shows accuracy assessment of the algorithm in 4 cases, it shows that the more number of *k*, the higher accuracy achieved (when *k* runs from 1 to 15). Interestingly, these results reveal a different story, FLAASH seems to be a suitable atmospheric correction method for biomass application when 6S corrected image was not good as TOA reflectance and DOS's. RMSE of TOA reflectance, DOS, 6S and FLAASH were 111.93mg/m2, 112.05 mg/m2, 92.07 mg/m2 and 118.98 mg/m2, respectively.

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