Vegetation index sensitivity test based on PROSPECT+SAIL model —— a preliminary test under the UAV4VAL project

ABSTRACT

Plant canopy characteristics are important indicators of several ecological and vegetation process. Vegetation Indices (VIs) are the most common used in these biophysical parameters retrieval, in which the most commonly used are Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI). However, due to the different design of the remote sensors, the calculation for the same VI might be different for two different sensors. Under the project of UAV for validating the satellite sensors products. We tested the VI sensitivity and robust in different sensors' calculation. The results showed a high correlation (>0.9) betweent the same VI calculated from different sensors. The NDVI calculated from two sensors are ralitively the same, while the EVI calculated from Sentinel2 sensor are slightly lower than those from UAV sensor. Both the NDVI and EVI showed a larger variantion for high dense vegetation. In general, this study confirmed the robust VI relationships with biophysical parameters for sensors from different platform. The large variation for dense vegetaiton could be noticed in the further reaseach.

INTRODUCTION

Plant canopy characteristics are important indicators of plant growth status, of which the two most commonly reported are the leaf area index (LAI) and leaf chlorophyll content (LCC). They determine the interception and absorption rates of solar radiation by vegetation, thereby implying plant productivity and yield. They are also two main driving variables in several ecological and crop growth models.

Remote sensing has been reported efficient for retrieving plant canopy traits, in which the parametric regression models based on vegetation indices (VIs) are the most widely used due to their computational efficiency and simplicity. The calculation for VIs only requires a few specific spectral bands, which are easily found in handheld, drone, and satellite sensors. However, the performance of VIs in these biophysical parameter estimation applications was unstable (Figure1). One important reason might be the different band settings among the sensors. Therefore it's essential to test the Vis sensitivity among sensors.

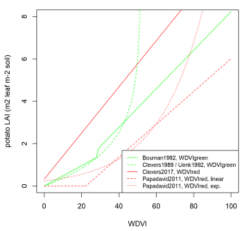

Figure 1. Five different quantitative WDVI-LAI relationships for the potato crop LAI estimation. *(sources: Bouman et al., 1992; Clevers, 1989; Clevers et al., 2017; Papadavid G, 2011)*

METHODS

Based on the background of the project, the Vis was calculated from a Sentinel 2A sensor and one drone-loaded multispectral sensor is compared and tested in this study (Figure2).

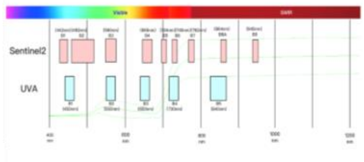

Figure 2. Band range and settings of two sensors.

The PROSAIL model, as a combination of the PROSPECT leaf optical properties model (Jacquemoud & Baret, 1990) and the Scattering by Arbitrarily Inclined Leaves (SAIL) canopy bidirectional reflectance model (Verhoef, 1984), is one of the commonly used radiative transfer models (RTM) at the leaf-atmosphere level. Based on the biophysical process in the vegetation, the PROSPECT model could generate leaf reflectance and transmittance between 400-2500 nm from given leaf optical properties, and the SAIL canopy model utilizes the PROSPECT outputs and calculates the internal canopy scattering process based on the properties of leaf angle, observation geometry, and illumination source (Figure 3). Therefore, PROSAIL could generate simulated canopy reflectance under controlled conditions, i.e., atmospheric conditions, observation geometry, canopy structure, background soil reflectance, and leaf optical properties. The three VIs were then re-calculated according to the two spectrometer settings, and Student T-test was conducted to analyze the two groups of VI calculated under different bands resampling.

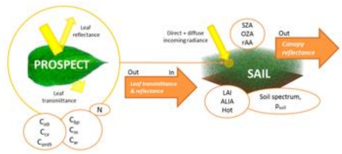

Figure 3. Canopy reflectance generation workflow of the coupled PROSPECT + SAIL models. *(source:Bergeret al., 2018).*

RESULTS

The simulated spectrum nicely visulize the changes along the wavelength. The dense vegetation has more steep increase in near infrared band. The saturation of NDVI for mid-high LAI is also revealed in the simulated dataset.

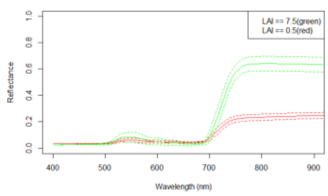

Figure 4. Simulated spectrum from coupled PROSPECT + SAIL models with different LAI input values.

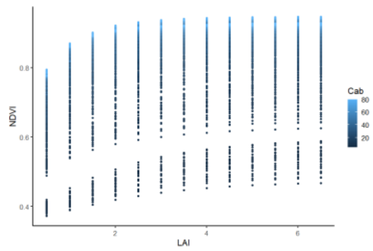

Figure 5. NDVI_LAI relationship on the simulated dataset.

In general, both the two VIs are robust and stable in calculation from different sensors with high pearson correlation coefficient. Under the situation with the less dense vegetation with lower LAI, the UAV deduced vegetation indices are more likely to overestimate than those based on Sentinel2 sensor. Likewise, for the dense vegetation with higher LAI, the Sentinel2-deduced VIs are slightly higher than those from UVA sensor. Though NDVI and EVI both have high correlation between the two sensors, EVI has more difference for extreme low and high values. The EVI values of the two sensors shows an exponential relationship. For dense vegetation, the difference between EVI could up to 0.5.

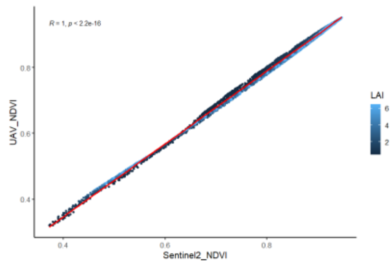

Figure 7. NDV Icalculation comparison between two sensors.

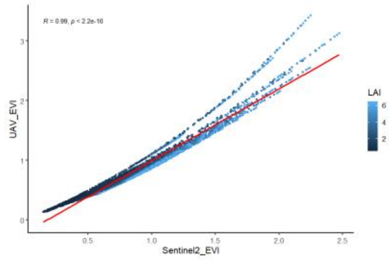

Figure 6. EVI calculation compariso between two sensors.

CONCLUSION

This study confirmed the robust VI relationships with biophysical parameters for sensors from different platform, conducted a prior test for the validation of the UAV platform as satellite inversion product. However, for the high dense vegetation area, the large variation of the VI calculation was found in EVI calculation. In the further VI-based inversion application, these sensor-deduced variation could be explained in advance.