# MODELS FOR ESTIMATING DIFFERENT CROPS LEAF AREA INDEX USING HYPERSPECTRAL DATA*


*Heng Dong*, Qiming Qin*, Lin You*, Xinxin Sui*, Jun Li*, Hongbo Jiang*, Jinliang Wang*, Haixia Feng*, Hongmei Sun***

**Institute of Remote Sensing and Geographic Information System, Peking University, Beijing, 100871, China*

***Beijing Forestry University, Beijing, 100083, China*

Corresponding author: Qiming Qin. Tel: +86-10-62751965. Fax: +86-10-62751962.

E-mail address: qmqin@pku.edu.cn.



## ABSTRACT

As a parameter of researching plant groups and cluster analysis, leaf area index (LAI) is closely related to a variety of biological processes, such as transpiration, photosynthesis and respiration. Now LAI has become a key parameter in researching the eco-system. There are two ways to get the LAI data, one is from the ground-based measurement, the other way is based on retrieval from remote sensing. A large range of continuous data can be acquired from RS images. So it is possible to obtain accurate LAI of large area, and now LAI retrieval by remote sensing has become a hot issue in quantitative remote sensing [1].

At present there are two methods of LAI retrieval by remote sensing: one is the empirical method, primarily through the use of LAI and vegetation index empirical relationship; another is physical model approach, mainly geometric optics model and radiation transfer model, from which inversion of LAI, this kind of methods have a strong physical basis, but is difficult to obtain some parameters, and model calculations consume a large amount of time. It is very hard to retrieve LAI from this kind of models[2]-[4]. Now most of the current studies focus on the use of empirical models.

The experiment site is located at a proving ground of Wulateqianqi of Inner Mongolia. To explore whether the crop type is an impact factor of LAI retrieval, soybean, corn, potato and sunflower which are the main crops in the site were chose. We measured the Hyperspectral Data and leaf area index of soybean, corn, potato and sunflower. With use of the measured LAI data, we research the relations between LAI and Vegetation indexes. The best quantitative model for each type of crop is established.



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ASD FieldSpec HandHeld Portable spectrometer is used to get the Hyperspectral Data. LAI is measured by SUNSCAN plant canopy analysis system. This article selects three vegetation indexes (VI), which are normalized differential vegetation index (NDVI), simple ratio (SR) and modified second soil-adjusted vegetation index (MSAVI2) to do some research. NDVI is applied most widely in vegetation remote sensing, and is closely related to LAI, which is shown in many studies. SR is sensitive to vegetation stage changes. The linear relationship between SR and bio-physical parameters is obvious. SR is most suitable to LAI retrieval [5]. MSAVI2 is a good index to estimate LAI. It can reduce the impact on the spectral reflectance that is caused by different types of soil [5]. Three vegetation indexes need the near-infrared reflectance and red-band reflectance. We choose 750nm and 670nm reflectance. Then for soybean, corn, sunflower and potato, linear, quadratic polynomial, power exponent, logarithmic and exponential functions five kinds of models were established. (Results as shown in Table 1)

| Soybean | Fitting formula | $R^2$ |
|---|---|---|
| NDVI | $y = 19.098x - 12.862$ | 0.332 |
| | $y = 550.17x^2 - 913.6x + 381.15$ | 0.785 |
| | $y = 0.0506e^{4.8814x}$ | 0.315 |
| | $y = 15.701Ln(x) + 5.962$ | 0.314 |
| | $y = 6.2126x^{4.0051}$ | 0.296 |
| SR | $y = 0.2999x - 1.2495$ | 0.616 |
| | $y = 0.0309x^2 - 0.7446x + 7.1924$ | 0.733 |
| | $y = 1.0041e^{0.0755x}$ | 0.566 |
| | $y = 4.5465Ln(x) - 8.9313$ | 0.541 |
| | $y = 0.1417x^{1.1533}$ | 0.505 |
| MSAVI2 | $y = 6.9475x - 4.333$ | 0.394 |
| | $y = 6.9738x^2 - 9.1337x + 4.8328$ | 0.399 |
| | $y = 0.3713e^{1.9348x}$ | 0.444 |
| | $y = 7.9142Ln(x) + 2.5972$ | 0.391 |
| | $y = 2.5497x^{2.2245}$ | 0.448 |
| Corn | | |
| NDVI | $y = 41.138x - 30.014$ | 0.548 |
| | $y = 323.62x^2 - 541.97x + 232.56$ | 0.558 |
| | $y = 0.0365e^{5.831x}$ | 0.536 |
| | $y = 37.001Ln(x) + 10.916$ | 0.547 |
| | $y = 12.078x^{5.2443}$ | 0.534 |
| SR | $y = 0.1822x + 3.2917$ | 0.518 |
| | $y = -0.0212x^2 + 1.1158x - 6.5622$ | 0.600 |
| | $y = 4.0998e^{0.0258x}$ | 0.506 |
| | $y = 4.0067Ln(x) - 4.9955$ | 0.544 |

| | | |
|---|---|---|
| | $y = 1.2686x^{0.5673}$ | 0.531 |
| MSAVI2 | $y = -8.2089x + 15.022$ | 0.582 |
| | $y = 18.454x^2 - 44.641x + 32.861$ | 0.599 |
| | $y = 22.009e^{-1.1817x}$ | 0.587 |
| | $y = -8.0977Ln(x) + 6.7815$ | 0.588 |
| | $y = 6.7209x^{-1.1654}$ | 0.593 |
| Potato | | |
| NDVI | $y = 5.4333x - 1.7166$ | 0.445 |
| | $y = 16.741x^2 - 16.544x + 4.6621$ | 0.492 |
| | $y = 0.1629e^{3.1748x}$ | 0.531 |
| | $y = 3.2725Ln(x) + 3.4615$ | 0.419 |
| | $y = 3.3468x^{1.9022}$ | 0.495 |
| SR | $y = 0.1857x - 0.1453$ | 0.66 |
| | $y = 0.0012x^2 + 0.1559x - 0.0099$ | 0.661 |
| | $y = 0.434e^{0.1042x}$ | 0.727 |
| | $y = 1.5744Ln(x) - 1.3855$ | 0.548 |
| | $y = 0.2168x^{0.8828}$ | 0.602 |
| MSAVI2 | $y = 3.871x - 1.6092$ | 0.322 |
| | $y = -8.1012x^2 + 19.268x - 8.4176$ | 0.359 |
| | $y = 0.154e^{2.3721x}$ | 0.422 |
| | $y = 3.6286Ln(x) + 2.3814$ | 0.338 |
| | $y = 1.7788x^{2.1995}$ | 0.434 |
| Sunflower | | |
| NDVI | $y = 27.071x - 20.059$ | 0.715 |
| | $y = -272.44x^2 + 496.24x - 221.99$ | 0.728 |
| | $y = 23.329Ln(x) + 6.7436$ | 0.716 |
| | $y = 0.0022e^{8.4605x}$ | 0.736 |
| | $y = 9.5969x^{7.2958}$ | 0.738 |
| SR | $y = 0.2452x - 0.0804$ | 0.718 |
| | $y = -0.0262x^2 + 0.9727x - 5.071$ | 0.738 |
| | $y = 3.4017Ln(x) - 5.604$ | 0.731 |
| | $y = 1.1526e^{0.0756x}$ | 0.720 |
| | $y = 0.2069x^{1.0545}$ | 0.740 |
| MSAVI2 | $y = -0.0472x + 3.4034$ | 0.00005 |
| | $y = -134x^2 + 332.78x - 203.1$ | 0.120 |
| | $y = 2.326e^{0.2837x}$ | 0.005 |
| | $y = 0.0135Ln(x) + 3.3415$ | 0.000002 |
| | $y = 3.0495x^{0.3763}$ | 0.006 |

**Table 1**

From the table, it is obvious that leaf area index of soybean is linear and quadratic polynomial correlated to SR. The $R^2$ are 0.616, 0.737. For leaf area index of corn, MSAVI2 quadratic polynomial, exponential

estimation model are better. The $R^2$ are 0.599, 0.590. SR quadratic polynomial estimation model fit better for leaf area index of potato. The $R^2$ are up to 0.727, 0.661. The power exponent of NDVI, SR are very suitable to sunflower leaf area index retrieval and the $R^2$ are 0.738, 0.740.

From the results, the conclusion can be made that the relationships between the three vegetation indexes and leaf area index are close, except the relationship between the LAI of sunflower and MSAVI2. So LAI can be retrieved from the vegetation index. However, for different crops, the best model is not the same. When retrieving LAI from low spatial resolution RS images, more attention should be paid to mixed pixels.

***Key words***: LAI retrieval; Remote sensing; Hyperspectral Data

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