Geophysical Research Abstracts
Vol. 14, EGU2012-812-1, 2012
EGU General Assembly 2012

Study on Mixed-Pixel Clumping Index Calculation and Validation

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Clumping index is an important vegetation structure parameter to describe the foliage clumping in canopy quantitatively. The effect of foliage clumping is generally considered at the canopy and below canopy scale in pure vegetation pixel. The mixed-pixel clumping index (MPCI) is an equivalent clumping index. In previous studies, it is usually equal to the clumping index of the dominated vegetation type in the mixed pixel. However, this calculation method cannot consider the effect of mixed pixels and it is almost impossible to get an accurate clumping index of mixed pixels. We propose a new method to calculate the clumping index of mixed pixels by combining the medium-spatial resolution image. The method coupled the linear mixture model and the directional gap fraction formula, and the formula of the mixed-pixel clumping index is deduced (Eq. 1). The scale difference caused by the inhomogeneity of fractional vegetation of cover, clumping index and leaf angle distributions inside the mixed pixel can be better considered in the method.

$$\Omega_c = -\frac{\cos(\theta_c)\cdot \ln[\frac{1}{n}\sum_{i=1}^{n} P_{f,i}(\theta_c)]}{\cos(\theta_f)\cdot G_c(\theta_c)\cdot \frac{1}{n}\sum_{i=1}^{n}\frac{\ln[P_{f,i}(\theta_f)]}{\Omega_{f,i}\cdot G_{f,i}(\theta_f)}} \quad (1)$$

where the subscripts f and c correspond to the medium- and coarse-resolution of satellite data respectively. Ω is clumping index, θ is view zenith angle, P is gap frequency and G is the projection of unit leaf area in the θ direction. It is assumed that $n$is the number of medium-resolution pixels covered inside the coarse-resolution pixel. And the end-member gap fraction and clumping index inside mixed pixels are known. They are obtained from medium-resolution images.

To analyze the influence of the inhomogeneity inside mixed pixels to the equivalent clumping index, we made the analysis in two cases: one is that the pixel is mixed with the same vegetation type but different fractional cover; the other is that the pixel is mixed with different vegetation types. The result shows that the inhomogeneity of vegetation type and fractional vegetation of cover inside mixed-pixel has an important influence on the mixed-pixel clumping index and according to the above analysis we found that in some area the clumping index difference before and after the mixed pixel correction is obvious.

At present there is no a direct way to measure the large scale clumping index. We validate the method by indirect method, which is we employed it to VALERI (VAlidation of Land European Remote sensing Instruments) datasets. Then we correct the coarse resolution effective LAI (Leaf Area Index) with MPCI and compare the results to the true LAI. The Preliminary validation shows good accuracy. The correlation coefficient, R^2 is above 0.90; the root-mean-square error (RMSE) is about 0.1, and the average relative error is below 10%. Based on the MPCI method, we employ HJ-1A/1B CCD data to make 1km x 1km MPCI product over Heihe area of China. Through the analysis and validation, the method of MPCI is capable of correcting the scale difference caused by the inhomogeneity of the vegetation cover inside mixed pixels and has more accuracy, which is significant for LAI inversion of coarse spatial resolution and the precision accuracy application of carbon cycle model.