VALIDATION OF MODIS FAPAR PRODUCTS IN HULUNBER GRASSLAND OF CHINA

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ABSTRACT

Fraction of absorbed photosynthetically active radiation (FAPAR) is one of key variables required in modeling primary production and global climate. FAPAR can be derived from satellite images, for example the MODIS FAPAR. However, validation of the product is a prerequisite for using it to estimate local net primary production (NPP). For this purpose, we carried out in situ measurements of FAPAR in two 2km×2km areas within the temperate meadow-steppe grassland in Hulunber during growing season in 2008. The MODIS FAPAR product reflected very well the seasonal dynamics of in situ FAPAR, but tended to overestimate the value with averaged relative error of 13.7% in the Stipa baicalensis site and 18.7% in the Leymus Chinensis site. More fieldwork for various types of the grasslands is necessary.

Index Terms—MODIS; FAPAR; NDVI; validation; Hulunber; grasslands

1. INTRODUCTION

FAPAR is one of key structural variables required in modeling primary production, global climate, hydrology, biogeochemistry, and ecology [1]. Accurate values of FAPAR in both regional and global scales with sufficient temporal frequency are important for quantifying the energy and water fluxes at the atmosphere-biosphere interface, and also for characterizing and monitoring the biosphere and its functioning [2]. Using the FAPAR values from satellites, carbon uptake in a large area could also be estimated [3].

The Moderate Resolution Imaging Spectroradiometer (MODIS) FAPAR product provides global images with 1km resolution at eight-day intervals, based on global vegetation map which is stratified into six canopy architectural types, or biomes[4]. Validation and assessment of MODIS/FAPAR products is essentially necessary to establish confidence in the use of the products [5].

There have been only a few studies on the MODIS FAPAR products [5-9]. However, only one study has so far examined the accuracy of a FAPAR product in relationship between ground-based measures in semi-arid grassland in Africa and the high resolution image estimate [5]. Extension of validation efforts to other grass type in different area of the grasslands for MODIS FAPAR products is needed. Therefore, we assessed the accuracy of the MODIS FAPAR product in the temperate meadow-steppe grassland in Hulunber of China, using high-resolution satellite imagery in conjunction with in situ measurements of canopy light harvesting during growing season, and herewith report the result.

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2. STUDY AREA

The study area is shown in figure 1.

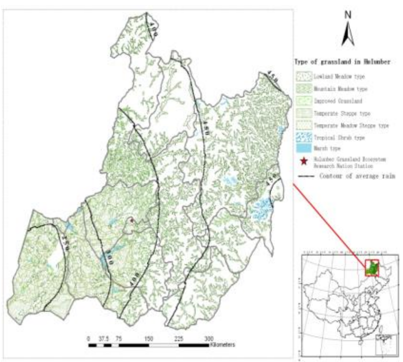

Fig.1 Types of Hulunber Grassland, and the position of the Hulunber Grassland Ecosystem State Research Station.

3. DATA

The data included in situ measured FAPAR value, and satellite data which include Beijing-1Satellite Products and three MODIS Terra Land Products.

4. METHODS

4.1 *In situ* measurements of FAPAR

Incoming PAR distributions among the vegetation are shown in Fig. 2.

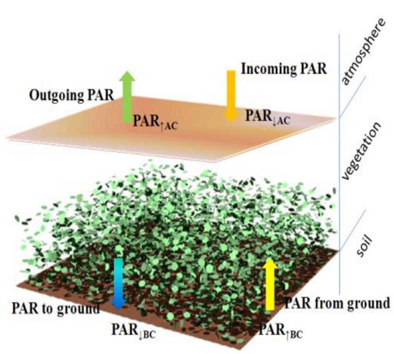

Fig.2 Distribution of incoming PAR among the vegetation

The daily total FAPAR ($FAPAR_D$) is taken as an expression for diurnal FAPAR (Goward & Huemmrich, 1992):

$$f_{par,D} = \frac{\int_{t0}^{t1}\left(PAR_{\downarrow AC}(t) - PAR_{\uparrow AC}(t)\right) - \left(PAR_{\downarrow BC}(t) - PAR_{\uparrow BC}(t)\right)dt}{\int_{t0}^{t1} PAR_{\downarrow AC}(t)\,dt} \quad (1),$$

where $PAR_{\downarrow AC}$ *(t)* and $PAR_{\uparrow AC}$ *(t)* are the downwards and upwards incident PAR at time *t* above the canopy, and $PAR_{\downarrow BC}$ *(t)* and $PAR_{\uparrow BC}$ *(t)* represent the incident PAR at time *t* below the canopy, respectively ; t_0 and t_1 are the times (min) of sunrise and sunset, respectively. In this study, we set t_0 = 6:00, ie, 360, and t_1=19:30, ie, 1170.

One 2km×2km size of grassland block within the *Leymus chinensis + mesophilic forbs* site and the *Stipa baicalensis* site was respectively used for the *in situ* PAR measures. In the actual measures, the block was gridded as illustrated in **Fig.3**. The order of measuring incident PAR was as follows: initially the measure was carried in grids A, C, G, I, and E, on randomly selected 3-5 1m^2 quadrat at 20-50m intervals in each grid, the next measure was in grids B, D, H, F and E, followed by grids J, L, M, K, and E, and so on, until the whole block was completely measured.

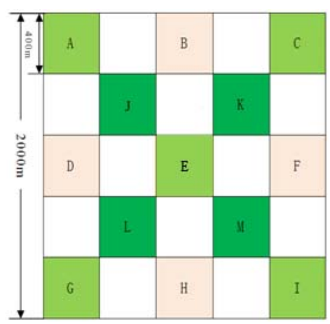

Fig. 3 Illustration of the sampling order for measuring PAR in grids. Measures were conducted in order of light green, pink, and dark green grids.

Daily average FAPAR from 6:00 (t_0) to 19:30 (t_1) was calculated using formula (1).

4.2 Assessing representativeness of MODIS 1km pixel data for the *in situ* sites using Beijing-1 32m pixel images

The results showed that the fieldwork sites were highly homogenous in general. Interpixel variance was very low, indicating that the grass density in both the 2km × 2km blocks was very homogeneous. Based on this heterogeneity analysis, in situ measured FAPAR value in two sites is found to be directly comparable to MODIS FAPAR value of 1km pixel.

5 RESULTS

5.1 Relationships between *in situ* measured FAPAR, NDVI, LAI and height of the canopy

Fig.4. showed that a linear relationship between FAPAR and height of the canopy was significant, but a polynomial fitting was more significant (R^2 ranging from 0.81 to 0.86). An exponential relationship between FAPAR and LAI was found to be more significant than a linear fitting, and the relationships had a little difference between the *Leymus Chinensis* site and the *Stipa baicalensis* site.

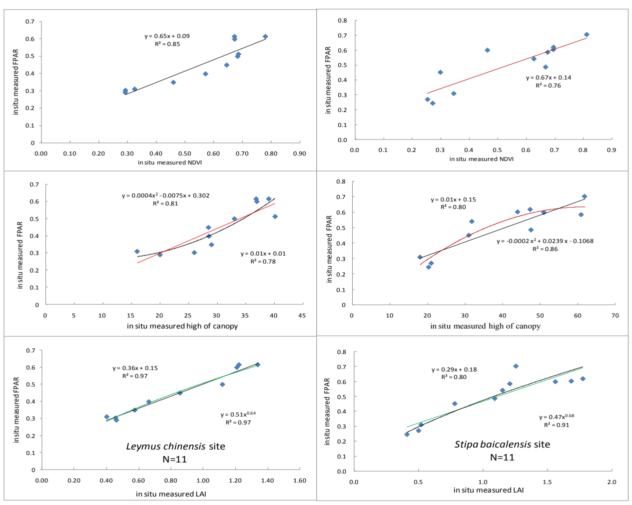

Fig.4 Relationships between in situ measured FAPAR, NDVI, LAI and height of the canopy in *Leymus Chinensis + mesophilic forbs* and *Stipa baicalensis* sites.

5.2 Comparing *in situ* measured FAPAR and MODIS FAPAR

The seasonal variation of the *in situ* measurements was generally captured very well by the MODIS FAPAR products during growing season in both the sites (Fig.5).

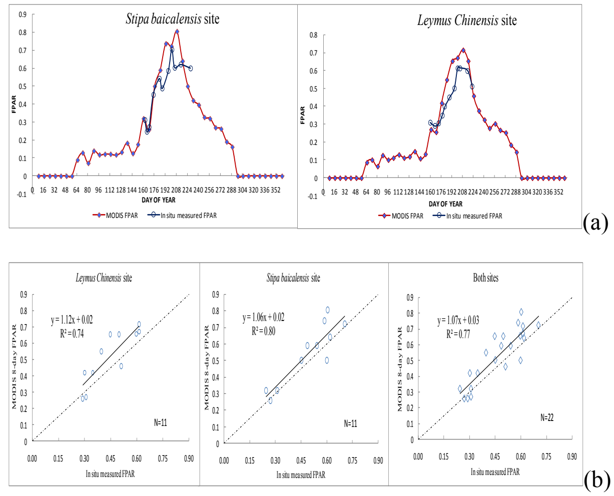

Fig.5 Time series of in situ measured FAPAR and MODIS 8-day FAPAR in the two fieldwork sites (a), and correlation analyses (b).

As shown in **Fig.5**, the MODIS values overestimated slightly the *in situ* measure, particularly from day 182 to day 208 of the year, and the error (the difference divided by the *in situ* value) was 13.7% on average in the *Stipa baicalensis* site and 18.7% in the *Leymus Chinensis* site.

5.3 Comparing FAPAR and NDVI between Beijing-1 and MODIS

A regression model was used to derive the relationship between the *in situ* FAPAR and NDVI, and the results are as follows:

FAPAR = 0.860 * NDVI + 0.002, R^2 = 0.841 N=59 (for *Stipa baicalensis* site); FAPAR= 0.630 * NDVI + 0.075, R^2 = 0.509, N = 139 (for *Leymus Chinensis* site).

These regression relationships were then applied to the Beijing-1 image for the field sites to convert NDVI to FAPAR. The FAPAR image was then degraded to the exact MODIS FAPAR products pixel size using the nearest-neighbor algorithm. The generated Beijing-1 FAPAR was compared to MODIS FAPAR; the results showed that Beijing-1 FAPAR was higher than the MODIS values.

MODIS 1km NDVI product and Beijng-1 1km NDVI were compared. The results showed that the Beijing-1NDVI was consistently higher than the MODIS value in the fieldwork sites, though the correlation was high (R^2 = 0.468). This may explain why the Beijing-1 FAPAR was higher than the MODIS FAPAR at 1 km resolution.

6. DISCUSSIONS

Numerous authors have studied the relationship between FAPAR and NDVI using satellite data or using radiation transfer models and generally agreed that the relationship is linear for green vegetation; they also tested the robustness of the relationship between FAPAR and NDVI for different types of vegetation using *in situ* measured data [5]. Even so, few studies have verified the relationship for temperate meadow-steppe grasslands using *in situ* measurements. The data presented here are thus only one obtained from the vegetable growing season which is also the phase of interest in modeling NPP.

Our result that the Beijng-1 1km FAPAR was higher than the MODIS 1km FAPAR in the both fieldwork sites is different from the report by[9] where the MODIS products generally overestimated FAPAR relative to both ground-based measurements and Landsat-derived estimates of FAPAR. Partly this may be due to the higher value of Beijing-1 NDVI than the MODIS NDVI. Another reason could be attributed the difference in the wavelength between MODIS NDVI (Red: 620-670nm; NIR: 841-876nm) and Bejing-1NDVI (Red: 630－690nm, NIR: 760－900nm).

The land cover map separates global vegetation into eight biomes: grasses and cereal crops, shrubs, broadleaf crops, savannas, deciduous broadleaf forests, evergreen broadleaf forests, deciduous needleleaf forests and evergreen needleleaf forests. The MODIS FAPAR algorithm is based on the land cover map for the global, and probably too broad for local areas. We found a little different in FAPAR between the two fieldwork sites in the temperate meadow-steppe type in the Hulunber grassland, so validation of MODIS FAPAR in the grassland is ongoing work.

7. REFERENCES

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