A MODEL FOR INSTANTANEOUS FAPAR RETRIEVAL: THEORY AND VALIDATION

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1. INTRODUCTION

The Fraction of Absorbed Photosynthetically Active Radiation (FAPAR, sometimes also noted fAPAR or fPAR) is the fraction of the incoming solar radiation in spectral range of solar light from 400 to 700 nanometers that is absorbed by plants. FAPAR can be derived from remote sensing measurements and a number of algorithms have been proposed to estimate this important environmental variable [1-5]. Currently most algorithms only consider parameters like normalized differential vegetation index (NDVI), leaf area index (LAI), leaf chlorophyll, and construct the empirical relationships between FAPAR and these parameters [1-3]. However, it is known that the sun also affects the FAPAR, and thus a disadvantage for such empirical method is that the relationship varies at different time of a day. To overcome this disadvantage, this paper focuses on the construction of a FAPAR model, accounting for the sun zenith change besides some known parameters.

2. MODEL FOR FAPAR RETREIVAL

The model is derived by analyzing the interaction processes of photons and canopy (figure 1). In the light incoming path, we mathematically expressed the transmission (T_0) and directional reflectance ($\rho_{\theta v,\lambda}$) of canopy. Thus, the absorption of canopy in the incoming path can be calculated. Similarly, we calculated the absorption of canopy in the outgoing path of photons reflected from the background. The two parts of absorption constitute the FAPAR of single band and single direction ($FAPAR^{t}_{\theta v,\lambda}$). The FAPAR in the 2π space and the Photosynthetically Active Radiation (PAR) spectral region is the integral of $FAPAR^{t}_{\theta v,\lambda}$. The final formula is a function of Nilson parameter (λ_0), G function (G_s, G_v), sun zenith angle (θ_s), leaf area index (LAI), background reflectance (ρ_g), and directional reflectance ($\rho_{\theta v,\lambda}$) of canopy.

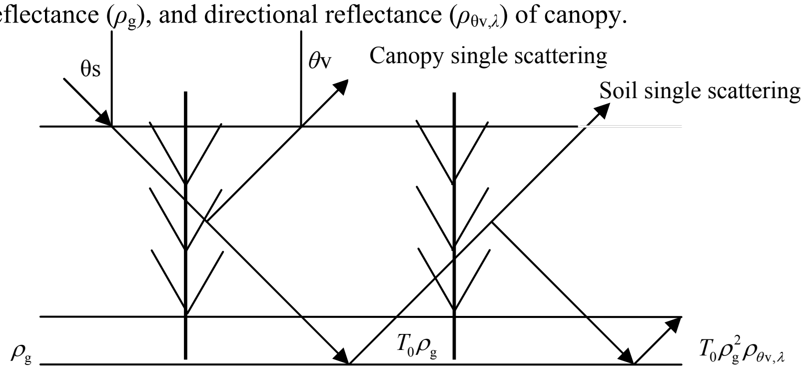

Fig. 1. Interactions of photons with canopy and soil background

3. COMPARISIONS WITH MONTE CARLO SIMULATIONS

We conducted the Monte Carlo simulations of FAPAR [6-8] and compared the results by model and by simulations. The FAPAR for different LAI (figure 2), sun zenith angle (figure 3), and leaf angle distribution (LAD) is calculated by the model and simulated by Monte Carlo method. We also analyzed the contribution of background to canopy FAPAR. Results show that canopy absorption in the outgoing path of photons reflected from the background cannot be neglected. The above model considers this contribution and the error is less than 2% compared with Monte Carlo simulation results.

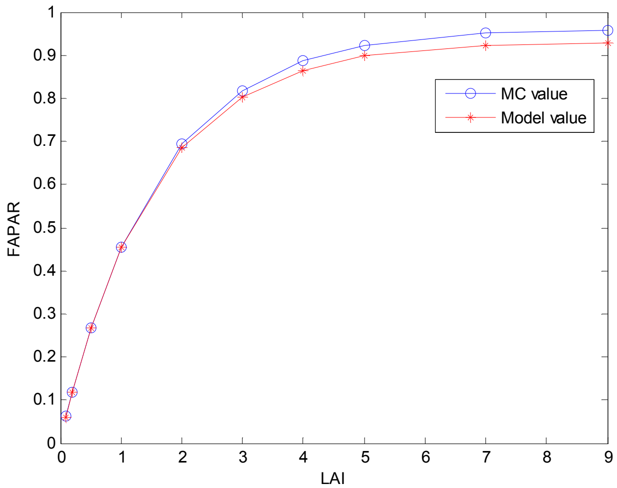

Fig. 2. Relationships between FAPAR and LAI

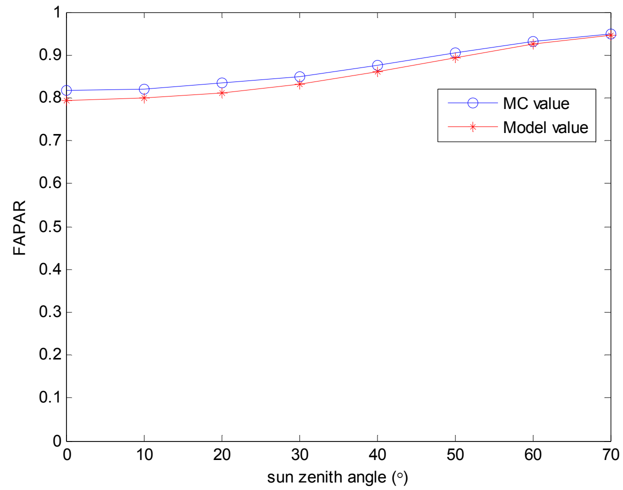

Fig. 3. Relationships between FAPAR and sun zenith angle

4. VALIDATION WITH FIELD DATA

We also further validate the algorithm with field data of daily FAPAR for some crops, such as wheat and corn. Results show that the algorithm, the Monte Carlo method, and the field data share the same daily change trend and similar scale. The error is small and acceptable, improving the feasibility of the proposed model.

5. CONCLUSION

A model for the FAPAR retrieval is proposed, compared with Monte Carlo method and validated by field data. The new model considers the effect of sun and thus successfully explains the daily change of FAPAR. It is useful for accurately calculating FAPAR at a specific time of a day. It also forms the foundation for other research, like the scaling effect of FAPAR.

6. REFERENCES

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