TOWARDS THE OPTIMAL MODIS-BASED PHOTOCHEMICAL REFLECTANCE INDEX FOR ARID AREAS

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1. INTRODUCTION

The diagnostic modeling of gross primary productivity is complicated by a variety of regulatory mechanisms acting at different time scales, e.g. variations in leaf area, chlorophyll content, rubisco activity, and stomatal conductance. A model formulation that can–theoretically–comprise all these variations was first described by [1, 2]: gross primary productivity (GPP) is computed as the product of the amount of absorbed photosynthetically active radiation (aPAR) and a light use efficiency term. Present-day diagnostic models have the light use efficiency (LUE) term implemented either as a constant (sometimes stratified according to plant functional type) or as a (biome-specific) maximum LUE reduced by scalars that represent environmental stress [3]. This look-up table approach is unable to represent the complete range of productivity dynamics, especially at shorter time scales [4, 5], primarily due to inaccurate maximum LUE estimates [6]. Global scale estimations of environmental drivers reducing maximum LUE cause more uncertainty [7]. Besides, current remote-sensing based models have difficulties to detect drought stress unless soil water content is accounted for [8], which is difficult on a global scale. So, we need an alternative approach for cases in which LUE and leaf area/ chlorophyll content do not vary synchronously.

Another option to estimate LUE employs a narrow wavelength range centred around 531 nm [9]. Reflection there decreases as plants protect their photosynthetic system from excess sunlight trough xanthophyll pigment interconversion. The photochemical reflectance index (PRI) combines reflectance at this wavelength (ρ_{531}) with a reference wavelength insensitive to short-term changes in light energy conversion efficiency (usually 570 nm, ρ_{570}) and normalises it [10]:

$$PRI = (\rho_{531} - \rho_{570})/(\rho_{531} + \rho_{570}) \quad (1)$$

To be useful for global or regional scale applications, PRI must be be estimated from spaceborne sensors. Although the originally proposed 570 nm reference band is missing, MODIS based PRI was successfully used to estimate LUE in temperate and boreal forests [11, 12, 13], also in Mediterranean evergreen oak forests [14, 15]. From previous studies it is not clear whether there is one optimal way to use MODIS-based PRI for all applications (i.e. with only one reference band and viewing geometry) or whether regional/global studies will require a stratified approach, e.g. different reference bands according to plant functional type or vegetation density. In this study we investigate this question with focus on arid areas.

2. DATA AND METHODS

In this study we use MODIS reflectance data (MOD21KM) after atmospheric correction with 6S to compute PRI. We tested which of the potential reference bands 1 (620-670 nm), 4 (545-565 nm), 12 (546-556 nm), 13 (662-672 nm), and 14 (673-683 nm) is most suitable, i.e. where the resulting PRI yields the strongest relationship with LUE.

LUE used for the evaluation is calculated as the ratio of GPP and aPAR (incident PAR multiplied by faPAR). Halfhourly GPP and incident PAR are routinely obtained at Fluxnet eddy covariance towers. We tested 3 different faPAR products (MOD13A2, Cyclopes, and JRC-Seawifs) to investigate the influence of this product choice on the PRI-LUE relationship. Furthermore, we tested the influence of viewing geometry on the PRI-LUE relationship.

Sites investigated in this study include several evergreen broadleaf forest with different coverage, savannah, and deciduous broadleaf forest under drought stress for comparison.

3. REFERENCES

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