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Photochemical Reflectance Index (PRI) can estimate seasonal variations of ecosystem gross radiation use efficiency for different forest types

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Carbon uptake by vegetation is one of the most important fluxes between the ecosystems and the atmosphere. To estimate the carbon uptake by vegetation, namely gross primary productivity (GPP), its temporal and spatial variability and to understand the controls of their changes, are one of the most important endeavors in current ecosystem ecology. However, estimating fluxes in ecosystems has been a difficult task. Remote sensing tools emerged as a very interesting complement to explicit carbon fluxes estimates made with other techniques. Different ground based measurements of carbon uptake by the vegetation have been extrapolated using spectral indexes derived from sensors on board of satellites or airborne platforms. The radiation use efficiency model proposed that the GPP can be estimated from the radiation absorbed by the vegetation and the radiation use efficiency (RUE) term that transforms the absorbed radiation into plant biomass. Satellite information was most frequently used to estimate the fraction of the incident radiation absorbed by the vegetation (fPAR) using spectral indexes such as the Normalized Difference Vegetation Index (NDVI). RUE has been a more difficult to estimate variable and, moreover, previous results showed that the seasonal variation of gross RUE is only weakly influenced by vapor pressure deficit (VPD) and temperature, contrary to what is frequently assumed by different GPP models. One of the most promising ways to make these estimations independent from climatic data is to remotely estimate RUE. The reflectance of leafs and plants of narrow bands centered in 531 nm has been shown to be closely related to the activity of the xanthophyll cycle which is linked to heat dissipation of the excess of radiation. The Photochemical Reflectance Index (PRI), which takes advantage of this relationship and related carotenoid/chlorophyll relationships, is a normalized spectral index that was related to spatial and temporal variations of the RUE and was proposed as a possible way to scale up the changes in the photosynthetic performance. In this study we evaluated the PRI as a remotely sensed surrogate of the ecosystem RUE in different forest sites. We analyzed GPP from eddy covariance data of carbon fluxes and MODIS (Moderate Resolution Imaging Spectroradiometer) data for different forest sites across Europe. The GPP was estimated from the total CO2 fluxes from eddy covariance towers. An average for the 8-days period of the GPP and PAR half-hour values was used for days having MODIS NDVI and the EVI. The PRI = (band 11- band 12)/(band 11 + band 12), was calculated from the MODIS daily calibrated radiance for bands 11 (526-536 nm) and 12 (546-556 nm) for the pixels that included the towers. We evaluated the PRI as a seasonal estimator of the RUE (RUE = GPP/APAR) by linear and non linear correlations of the complete dataset. Our results showed that the PRI derived from freely available satellite information (MODIS sensor) presented a positive relationship with the RUE for the different forest sites. Thus, we show that it is possible to estimate RUE in real time and therefore actual carbon uptake of forests at ecosystem level using the PRI. The use of PRI can directly assess the changes in RUE or in photosynthetic performance previous to more drastic decays in leaf area or other structural parameters. This conceptual and technological advancement avoids the need to rely on either the sometimes unreliable maximum RUE, hard-to-obtain climate data, or on imprecise land-use/land-cover data.