

On the simultaneous estimation of Gross Primary Productivity and Evapotranspiration using the TSEB model

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Abstract

Various methods have been employed to infer gross primary productivity (GPP) from remote sensing data, which can be categorized into three main groups: empirical approaches using vegetation indices, models based on radiation use efficiency (RUE), and mechanistic models. Both empirical and RUE models have demonstrated success; however, they can exhibit significant deviations, particularly under plant stress, necessitating empirical corrections. In contrast, mechanistic models, such as Farquhar's photosynthesis model, offer a more biophysically sound approach. However, to apply the Farquhar model, stomatal conductance must be known. Earlier attempts have utilized semi-empirical equations to derive stomatal conductance for CO₂ (g_s). We propose an alternative solution where g_s is directly inferred from TSEB outputs, resulting in an analytical solution to compute photosynthesis using Farquhar's approach. This solution was tested in the GRAPEX experiment using remote sensing and eddy covariance data from the 2019 and 2020 campaigns. We used one GRAPEX parcel in 2020 for calibration and two additional parcels with the same orchard setup for validation in 2019. The parcels consisted of 1.5 by 3.35 'Merlot' grapevines arranged in a Lyre trellis system. The developed analytical solution successfully simulated GPP in the validation parcels. The comparison between predicted and observed GPP yielded an R² of 0.97, with a slope of 1.14 and an intercept of -2.89. The RRMSE was 0.29%, and Willmott's index of agreement was 0.96. This analytical solution appears to be a promising tool for simultaneously estimating orchard GPP and evapotranspiration using TSEB.