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Estimation of Gross Primary Productivity of a raised bog ecosystem using satellite models and eddy covariance techniques under exceptional climatic conditions

Ruchita Ingle, Saheba Bhatnagar, Bidisha Ghosh, Laurence Gill, and Matthew Saunders
Trinity College Dublin, Ireland (ingler@tcd.ie)

Peatlands are vital to the global carbon (C) cycle as they act as a significant C store and these systems in Ireland store between 1064 –1503 Gt C on ~20% of the land area. However, around 90% of this area has been drained and degraded by various anthropogenic activities and the emissions from these activities are approximately 3 million t C per year. A better understanding of the land-atmosphere C and greenhouse gas (GHG) dynamics is vital to halt these emissions and enhance the C sink strength of these ecosystems. Gross Primary Productivity (GPP) is a major part of the peatland carbon cycle and detailed knowledge of the spatial and temporal extent of GPP is imperative for improving our predictions of peatland ecology, biogeochemistry and carbon balance in response to global change. Eddy covariance (EC) techniques are widely used to measure carbon fluxes but can only account for fluxes within the flux footprint of the tower, and it is challenging to scale up data from EC towers to regional and global scales due to the limited number of towers and their geographic locations. This research assesses the relationship between remote sensing and ground-based measurements for a near-natural raised bog in Ireland using EC techniques and high-resolution Sentinel 2A satellite imagery. Vegetation indices (VIs) are one of the key input parameters for satellite-based GPP and most of the existing VIs have been developed for grassland, agriculture, and forest ecosystems. This study developed a hybrid index for raised bogs using multiple linear regression and six widely practiced conventional vegetation indices. Two approaches have been used in this study for estimating GPP using the LUE model. Initially, all the individual indices have been used to model the GPP, which was subsequently compared with the EC GPP to determine the performance of each index against the EC data. The model was run with meteorological data and satellite-derived vegetation indices. During the 2018 study period, the weather was exceptionally dry which made it challenging and rewarding at the same time as the hybrid index was developed for an exceptional year. It was crucial to test the performance of the hybrid index under more normal weather conditions with limited clear sky satellite imagery. Therefore, the hybrid index was validated for the year 2019 which had normal weather conditions. The hybrid index based modelled GPP showed a significant correlation with the EC GPP for both the years with an $R^2 > 0.95$. Overall, this research has demonstrated the potential of combining EC techniques and the hybrid index along with satellite-derived models to better understand and monitor key drivers and patterns of GPP of raised bog ecosystems under different climate scenarios.