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Improving Gross Primary Production Estimates by Integrating Eco-Evolutionary Optimality Modelling with High-Resolution Sentinel-2 Observations

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The terrestrial biosphere constitutes a major component of the global carbon cycle, absorbing a substantial fraction of anthropogenic CO_2 emissions and thereby mitigating climate change. Terrestrial vegetation governs the largest carbon flux in biosphere - gross primary production (GPP), the total carbon uptake through photosynthesis - making accurate quantification of GPP critical to projection of land-atmosphere carbon exchange. However, it remains challenging due to uncertainties in observations and model representations. Advances in high-resolution satellite remote sensing products now enable detailed monitoring of vegetation changes, while process-based models could offer mechanistically robust characterization of plant biophysical and biochemical processes. Here we integrate quality-controlled and corrected Sentinel-2 leaf area index (LAI) with eco-evolutionary optimality-based P model to simulate GPP at eddy covariance flux sites. Model performance is evaluated against site observations to assess the ability of this framework to reproduce observed spatial patterns and temporal dynamics. Our results demonstrate that such hybrid approaches combining Earth Observation data with a theoretically grounded, parameter-sparse model greatly improved GPP simulation, highlighting a promising pathway for advancing ecosystem carbon flux modelling and evaluation.