Incorporating satellite-retrieved canopy nitrogen content into the biophysical process model for estimating crop yield and N fertilizer recommendation

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Remote sensing-based biophysical process models (RSBPM) are powerful and indispensable tools for estimating crop productivity over field and landscape scales. However, due to the lack of regional fertilization data, nitrogen stress is often poorly parameterized in these models, which may lead to considerable biases in crop yield simulation. To address this issue, current study improves the representation of nitrogen constraints on photosynthetic capacity in the RSBPM. Canopy nitrogen content retrieved from the newly available high-resolution Sentinel-2 spectral bands is integrated into the model to constrain nitrogen availability in the vital photosynthetic enzyme. And a two-leaf upscaling scheme is used to account for the vertically varying nitrogen content inside canopies and the associated physiological differences between leaves. Measurement data was collected for 32 field-years that spans major crops including wheat, maize, soybean and rice from 2016 to 2017 in China. The satellite-retrieved canopy nitrogen content partially reflects the field fertilization, and identifies seasonality of Rubiso-limited photosynthetic capacity. The new representation of nitrogen constraints significantly reduces the bias of estimated crop yields, and improves the temporal correlations between the simulated and the measured biomass, relative to the commonly employed cases of using specified constant nitrogen stress factor, default fertilization schemes, and the big-leaf nitrogen-constrained model. The improved RSBPM also enables the remote estimation of nitrogen nutrient index, which indicates the status of actual N absorbed versus critical N requirement in the crop. This model improvement on nitrogen constraints has significant implications for better assessment and prediction of crop yield and nitrogen use efficiency and for studying human-environment interactions.

Keywords: canopy nitrogen content, crop yield, biophysical process model, Sentinel-2, fertilization, nitrogen nutrient index

