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Using leaf chlorophyll observations to improve carbon cycle modelling at a temperate mixed forest

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Understanding the interactions between atmosphere and vegetation in changing climatic conditions is important so that we can predict the carbon sequestration potential of ecosystems. Helpful tools here are the terrestrial biosphere models (TBMs), since they include detailed ecophysiological process descriptions, e.g. the manifold interactions between the carbon and nitrogen cycles. However, the modelling of the nitrogen cycle poses challenges and having observational constraints on nitrogen cycle is crucial. Current remote sensing products offer estimates of leaf chlorophyll (Cab), that is related to the nitrogen cycle. In this study we want to assess how useful Cab observations are at site scale to constrain a TBM.

In this work we are studying a temperate mixed forest, Borden, located in Canada. We use a TBM QUantifying Interactions between terrestrial Nutrient Cycles, QUINCY, to model this site. From the site we have long-term (20 years) flux tower and LAI (from PAR measurements) observations together with leaf level observations of leaf chlorophyll (Cab), leaf nitrogen, and photochemical parameters of maximum carboxylation rate (Vcmax) and maximum potential electron transport rate (Jmax).

The QUINCY model was predicting too late leaf senescence, which we tuned using the site level data. The amount of leaf nitrogen was originally quite successfully simulated by QUINCY, but the amount of simulated Cab was too low. Matching the simulated Cab values with the observations did not have a pronounced effect on the GPP. Additionally, the development of LAI and Cab were originally fully coupled in QUINCY, whereas the observations showed a delayed development of Cab compared to LAI. When we implemented this decoupling between LAI and Cab, an improvement of simulated GPP compared to the observations was found. Also then the simulated

Vcmax and Jmax showed better correspondence to the observations.

Assessment of the long-term behaviour of the model at the site showed that the model was able to capture the drought-induced drawdown of carbon fluxes taking place in 2007. The observations showed an increase in the component fluxes of carbon during the time period, but this was not replicated by the model. The start of season (SOS) and end of season (EOS) were estimated from both the simulated and observed GPP and LAI using a simple threshold method. The model was more successful in capturing the changes in the growing season metrics estimated by LAI than by GPP. The model was predicting too late onset of GPP in many years, but captured largely the interannual variation of SOS in observed GPP.

This study paves the way for work using remotely sensed leaf chlorophyll in evaluation and improvement of the QUINCY model.