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A new approach for estimating northern peatland gross primary productivity using a satellite sensor derived chlorophyll index

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Long-term studies of ecosystem carbon dioxide (CO_2) exchange improve our understanding of the links between carbon and climate. Despite their important role in the global carbon cycle, the effect of large-scale environmental changes on peatland carbon dynamics has been little studied compared to other ecosystems. To improve our understanding of peatland-atmosphere carbon exchanges, more information is required regarding the annual and seasonal CO_2 budget in peatland ecosystems. Carbon flux models that are largely driven by remotely sensed data can be used to estimate gross primary productivity (GPP) over large areas, but despite the importance of peatland ecosystems in the global carbon cycle, relatively little attention has been given to determining their utility in these ecosystems. Data from the Earth observation sensor MODIS (Moderate Resolution Imaging Spectrometer) are commonly used to drive remote sensing-based carbon models. However, with the continuity of MODIS still uncertain, there is the motivation to extend the knowledge acquired from modelling efforts with the MODIS datasets to other sensors data.

Here, we focus on exploring new ways of estimating peatland GPP from the European Space Agency (ESA) sensor MERIS (Medium Resolution Imaging Spectrometer), which can potentially provide additional information about carbon exchange processes by deriving information directly related to vegetation functional properties. The MERIS Terrestrial Chlorophyll Index (MTCI) is a vegetation index that provides information concerning chlorophyll content and is a promising index for assessing peatland carbon fluxes. We use several years of carbon flux data from two contrasting Canadian peatlands, to explore the relationships between the MTCI and GPP within and across sites. We also develop and test a series of MTCI-based models to determine whether the inclusion of environmental variables, thought to be important determinants of peatland carbon flux, improve upon direct relationships. For context, we compare the newly developed GPP models with the MODIS GPP product.

Our results show that simple MTCI-based models can be used for estimates of inter- and intra annual variability in peatland GPP. The MTCI is a good indicator of peatland GPP and compares favorably with more complex products derived from the MODIS sensor on a site specific basis. The incorporation of MTCI into a light use efficiency type model, by means of partitioning the fraction of photosynthetic material within a plant canopy, shows most promise for peatland GPP estimation, outperforming all other models. However, our results also show differences in model relationships with GPP, both between sites and when water availability is reduced. Research in order to predict the variations in the slope of the relationship between MTCI-based models and GPP, and to fully account for the down regulation in carbon uptake under moisture limiting conditions, is ongoing. Nevertheless, the current results show great promise and demonstrate that satellite data specifically related to vegetation chlorophyll content may ultimately facilitate quantification of the temporal and spatial dynamics of peatland carbon fluxes.