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Importance of shaded leaf contribution to the total GPP of high latitude ecosystems: evaluation of MODIS GPP

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The Moderate Resolution Imaging Radiometer (MODIS) is a primary instrument in the NASA Earth Observing System (EOS) which was designed for monitoring global terrestrial vegetation. MODIS provides global estimates of 8-day mean gross primary productivity (GPP) at 1-km spatial resolution. In this study, the MODIS GPP algorithm using light use efficiency (LUE) approach and the Integrated Carbon-Canadian Land Surface Scheme (IC-CLASS) based on Farquhar photosynthetic model and a sunlit and shaded leaf separation scheme was evaluated against eddy covariance (EC) measured GPP in a variety of ecosystems in Canada. Although GPP simulated by the two models agreed well when they were averaged over Canadian landmass, there were systematic differences between them in spatial distribution patterns. These differences were due to inherent shortcomings of the LUE modeling approach. When a constant maximum LUE value is specified for each biome type, this simplification cannot appropriately deal with the shaded leaf contribution to total canopy GPP. When GPP was simulated by IC-CLASS with the separation of sunlit and shaded leaves, the biases were minimized. Compared with daily and annual GPP derived from EC flux data at 7 Fluxnet Canada sites, IC-CLASS performed better than the MODIS GPP algorithm. The differences between IC-CLASS and MODIS GPP were larger in more clumped canopies (i.e. forests), resulting from the increase in the fraction of shaded leaves. Thus, the LUE models should be improved to consider different LUEs in sunlit and shaded portions of the canopy for their effective and reliable estimation of GPP at regional scale.