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| **Constraining estimates of Boreal vegetation productivity in multi-source remote sensing-based models** |
| **Introduction/Aim:**  The global boreal ecosystem covers 1.9 billion hectares and is estimated to sequester 8.9 billion tonnes of carbon annually. Conventional model estimates of carbon dynamics are produced at coarse spatial resolutions leaving the heterogeneity of boreal landscapes and their carbon dynamics poorly represented. Due to rapid environmental changes in these regions, robust and comprehensive models for Gross Primary Productivity (GPP) of terrestrial vegetation in boreal environments are needed at finer spatial and temporal scales than are currently available. Advances in remote sensing technologies allow for refined representation of fine-scale patterns in GPP and offer new opportunities for improving current predictions by addressing known sources of uncertainty. Notably, key drivers of boreal GPP can now be represented through modern estimates of Land Surface Temperature from Sentinel 3, Soil Freeze/Thaw and Soil Moisture conditions from the Soil Moisture Active Passive (SMAP) platform, and vegetation vigour from Harmonized Landsat Sentinel-2 (HLS). In addition, modelling frameworks such as the National Terrestrial Monitoring System can now provide fine-scale information on boreal land cover types and disturbance histories, which allows for the stratification of model estimates across large areas while accounting for landscape heterogeneity. The focus of this work is to bring together these disparate pieces of information on the drivers of boreal productivity from innovative satellite products to improve model estimates of GPP and provide comprehensive insight into its drivers under changing future climates.  **Methods:**  Through data fusion, the spatial and temporal resolutions of the aforementioned datasets are resolved to allow for their integration into a new model of GPP. Land cover and fire disturbance history information is used to stratify relatively homogenous areas across the Canadian boreal. For these stratified areas, Land Surface Temperature, Soil Freeze/Thaw, Soil Moisture, and vegetation vigour (Enhanced Vegetation Index) are combined into an estimate of GPP. These estimates are then parameterized using a selection of reference productivity datasets and are predicted and validated across key boreal land cover types.  **Results:**  Model estimates of GPP using our new model framework were able to achieve high correlations with reference productivity datasets (r2 > 0.9) across stratified areas dominated by key boreal land cover types such as wetlands, treed-wetlands, and coniferous vegetation. Model estimates were also produced for sites representing unique fire disturbance histories, and achieved similarly high correlations with reference products. Compared to conventional remote sensing-driven model estimates generated for reference, sum of squares errors (SSE) were reduced by > 50%.  **Conclusion:**  Compared to prior work, model estimates of GPP were generated with markedly reduced seasonal biases. In addition, the use of fine-scale land cover and disturbance information allowed for more accurate parameterization of model estimates across heterogeneous land cover types than other satellite-based estimates of GPP. Overall, the new model framework provides comprehensive information on boreal vegetation productivity and its drivers with improved representation of spatial heterogeneity and seasonal trends in GPP. Through these improvements, our model provides valuable insight into the carbon dynamics of key boreal environments commonly underrepresented in existing model frameworks. |