Boreal Forest Springtime Variability in Solar Induced Fluorescence and Spectral Reflectance

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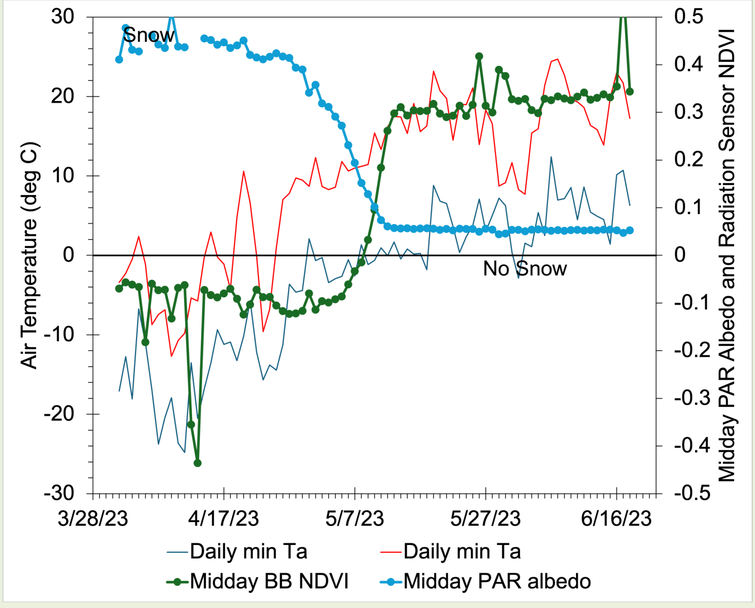
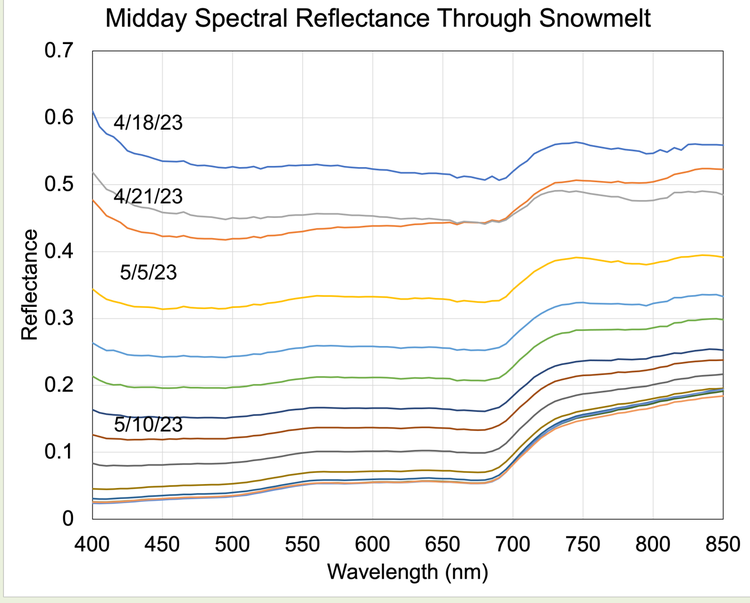
Introduction

Signals from vegetation chlorophyll fluorescence (F) can improve the assessment of growing season length and ecosystem productivity, providing new insights into the relationships between productivity, carbon balance, and other critical feedback processes across the boreal biome. To improve the understanding of how F vary across spatial scales and can be upscaled from leaf to canopy level through the 2023 growing season we deployed automated systems to measure diurnal and seasonal variation in leaf and canopy reflectance and solar induced fluorescence (SIF) of the boreal forest at the Caribou Creek (BONA), AK NEON flux tower. In addition to the CO_2 flux from eddy covariance, the Monitoring-PAM (MoniPAM) made active measurements of leaf level chlorophyll fluorescence (ChlF) providing relative electron transport rates and photochemical yields of photosystem II (PSII), while the FLoX (Dual FLuorescence boX) sensors provided proximal measurements of canopy Solar Induced Fluorescence (SIF) and spectral reflectance. The collection captures seasonal and diurnal variation in reflectance, ChlF, SIF in the O2A (SIFA) and O2B (SIFB) atmospheric bands.

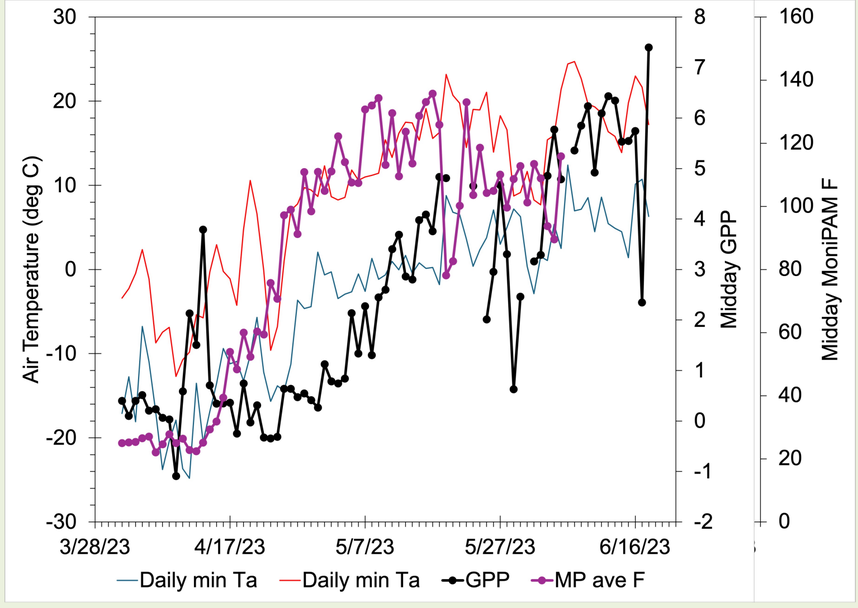
Results



PAR albedo is an indicator of snow cover, with snow cover beginning to decrease once daily maximum air temperatures are consistently above freezing. NDVI increase lags snowmelt, with the start of NDVI green-up occurring when about half of the snow cover has melted.

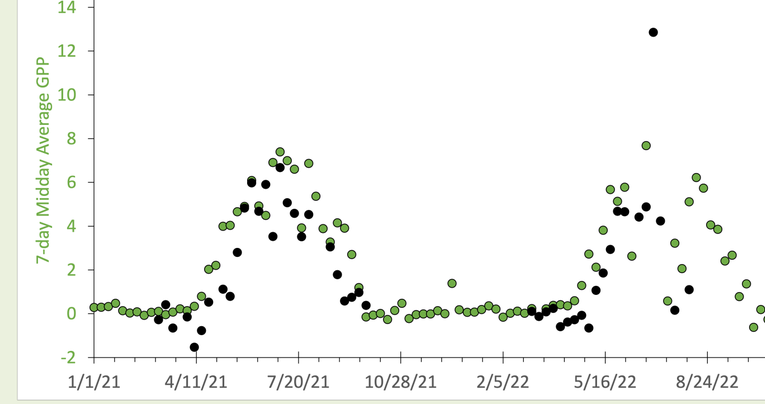


Midday (12:30) visible-near IR spectral reflectance through the snow melt period.

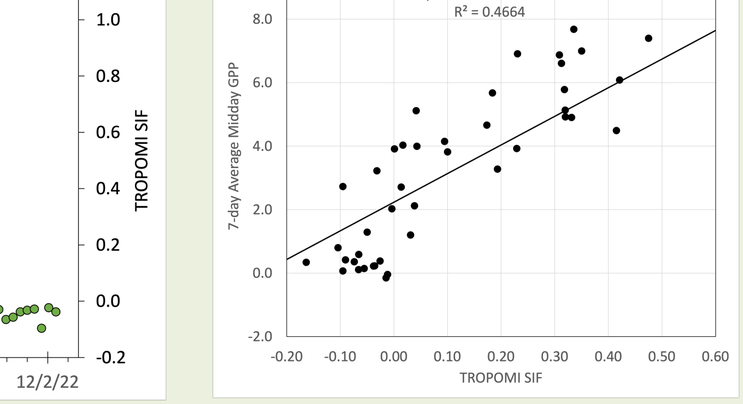


Midday leaf level fluorescence from MoniPAM rapidly increases with daily maximum air temperature through the early spring, while canopy level midday average gross primary productivity (GPP) from the eddy covariance flux tower lags the increasing temperature.

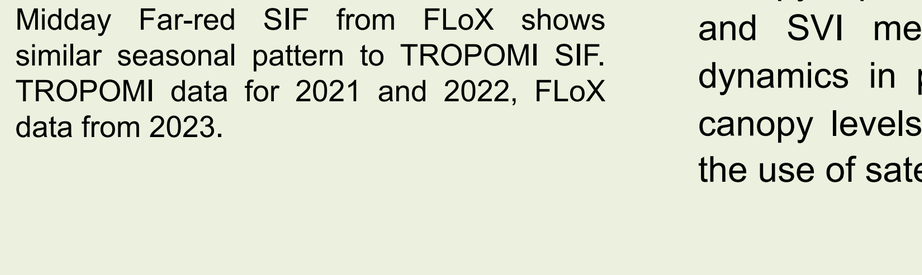
Left: Caribou Creek NEON flux tower, Right top: FLoX mounted on top of tower, Right middle: Field of view of FLoX shown by red circle, Right bottom: a MoniPAM sensor head attached to spruce branch

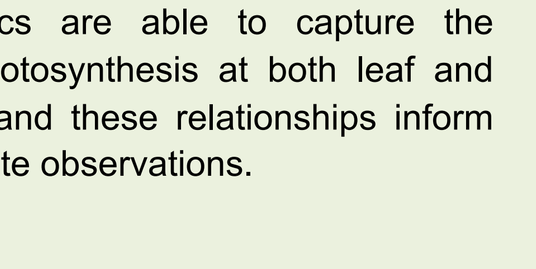


Leaf level midday PSII Yield from MoniPAM tracks increase in GPP from eddy covariance tower.

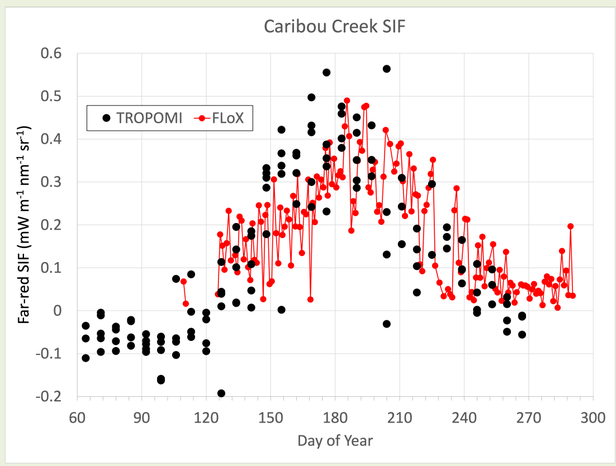


Midday Modified Chlorophyll Absorption in Reflectance Index [MCARI = ((R700−R670)−0.2(R700−R550))*(R700/R670)] from the FLoX spectral reflectance strongly tracks midday GPP from eddy covariance





SIF from TROPOMI tracks 7-day average GPP for this site, although the relationship appears to be nonlinear



Midday Far-red SIF from FLoX shows similar seasonal pattern to TROPOMI SIF. TROPOMI data for 2021 and 2022, FLoX data from 2023.

Conclusions

The springtime period of boreal forest development is a critical period that is particularly sensitive to climate change while being important in determining seasonal productivity. The instrumentation provides a temporally dense dataset from snowmelt to early summer. Our findings demonstrate that canopy optical measurements including SIF and SVI metrics are able to capture the dynamics in photosynthesis at both leaf and canopy levels, and these relationships inform the use of satellite observations.

Acknowledgements

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