Detecting changes in the high-latitude carbon seasonal cycle with a multi-model approach

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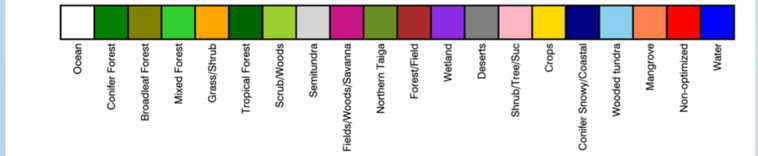
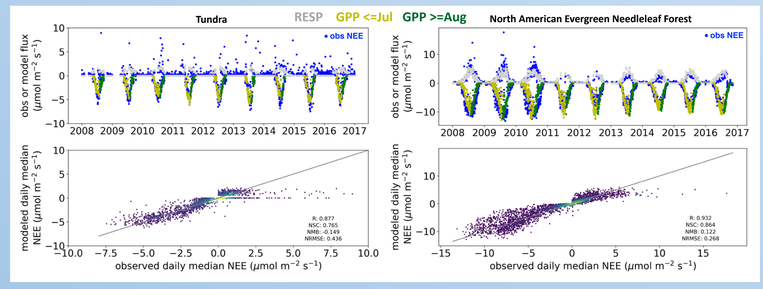
Summary

- We modified the Polar-Vegetation Photosynthesis Respiration Model and trained it using satellite-derived SIF and NEE from eddy covariance sites and CarbonTracker-Lagrange (CT-L)
- Results show significant increases in pan-Arctic GPP growing season uptake and growing season length from 2001 to 2020
- PVPRM trained by CT-L shows better agreement with optimized fluxes from an independent CarbonTracker inversion system (v2019b)



- For each ecoregion, use climatological drivers from ERA5 and NEE from flux towers or CT-L to calculate average parameters in North American boreal ecoregions
- Extrapolate parameters in space to Eurasian boreal region



- Fit using daily daytime and nighttime median values
- Split growing season due to different carbon-flux vs climatology relationships (Hu et al., 2021), designate start/end using SIF

References

Hu, L., Andrews, A. E., Thoning, K. W., Sweeney, C., Miller, J. B., Michalak, A. M., et al. (2019). Enhanced North American carbon uptake associated with El Niño. *Science Advances*, *5(6)*. https://doi.org/10.1126/sciadv.aaw0076

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Luus, K. A., Commane, R., Parazoo, N. C., Benmergui, J., Euskirchen, E. S. et al. (2017). Tundra photosynthesis captured by satellite-observed solar-induced chlorophyll fluorescence. *Geophys. Res. Lett., 44, 1564-1573.* doi:10.1002/2016GL070842

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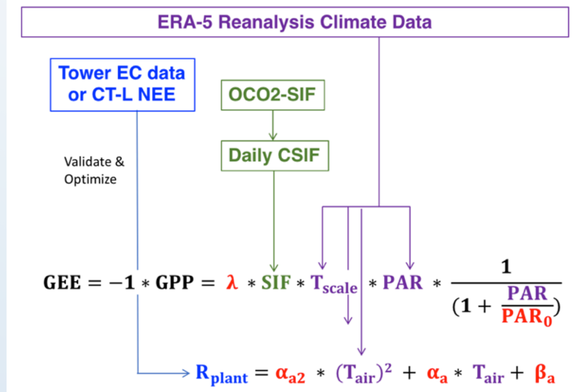
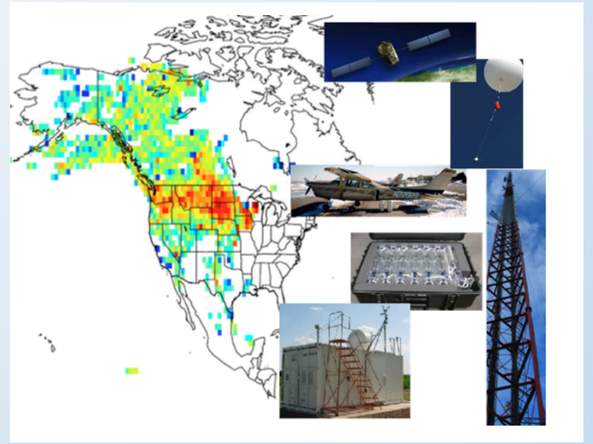
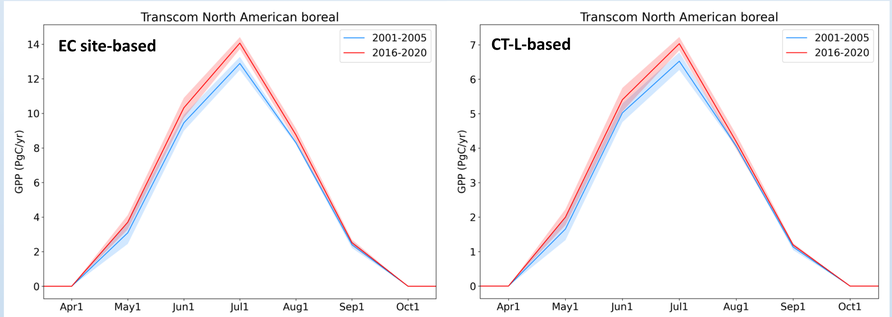
Models



- Polar-VPRM (Luus et al., 2017) is an empirical model with parameters optimized using SIF, 0.5-degree ERA5 climate drivers and NEE from either flux towers or CarbonTracker-Lagrange
- CarbonTracker-Lagrange is a NOAA model that uses atmospheric measurements, high-resolution meteorology and Bayesian inversion techniques to estimate regional fluxes (Hu et al., 2019)

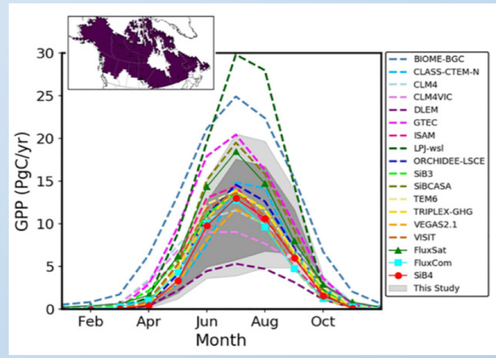


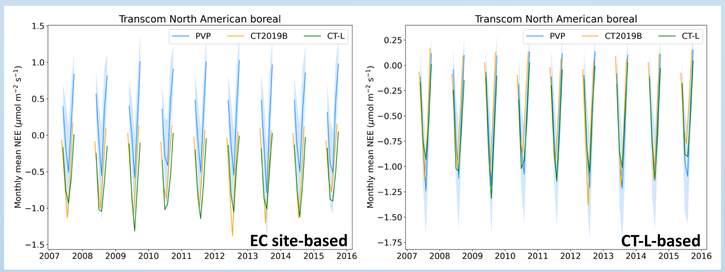
Results



20-year trend

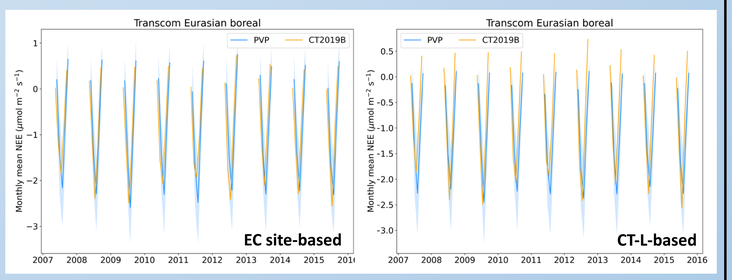
- GPP magnitudes are consistent with Hu et al. (2021) within uncertainties
- Relative change in GPP trend is higher in Eurasian boreal regions vs North America
- Growing season trends are significant for GPP, respiration & NEE for 2016-2020 vs 2001-2005

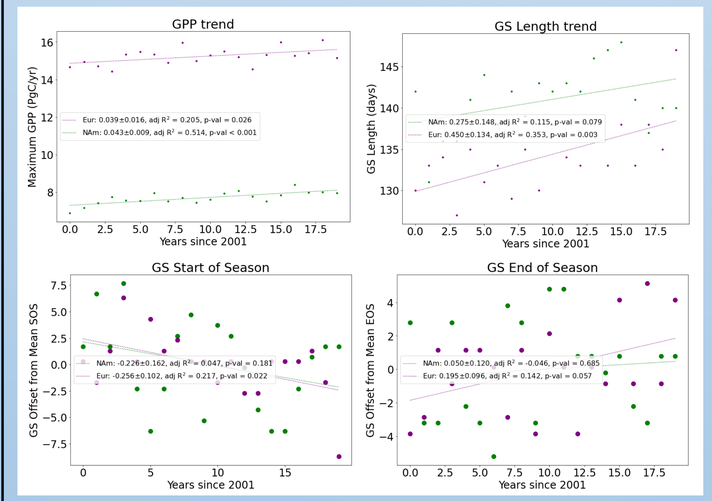




Validation with CT2019B

- Polar-VPRM trained with CT-L NEE agrees better compared to training with EC site data in North America
- Both sets produce reasonable results in the Eurasian boreal region where data is lacking





Seasonal trends & patterns

- Significant trends are seen for peak summer GPP and growing season length for both North American and Eurasian boreal regions
- Eurasian boreal region shows significant earlier growing season onset and later growing season offset
- CT-L trained PVPRM shows better spatial agreement with CT2019B
- PVPRM overestimates forest NEE and underestimates semitundra NEE