Net ecosystem exchange of a disturbed and rewetted raised bog ecosystem measured by eddy covariance

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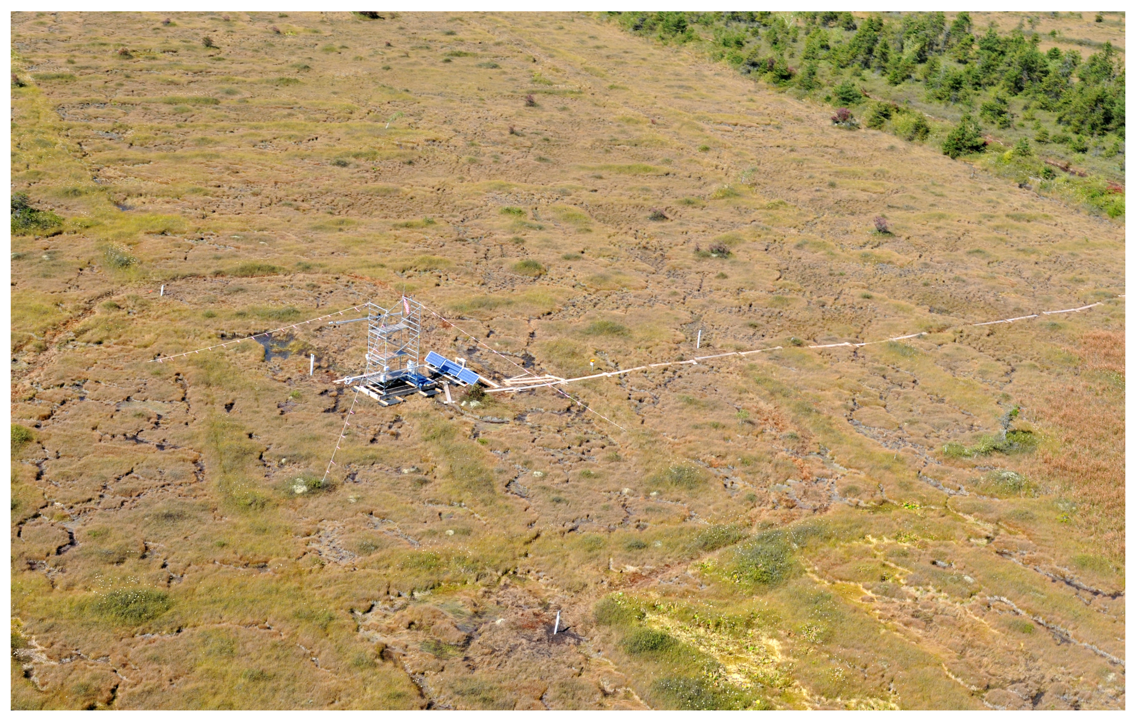
a place of mind

Introduction

Peatlands are ecosystems that can accumulate substantial amounts of atmospheric carbon dioxide (CO_2) and sequester it over time in the form of peat. However, disturbances to peatlands will expose this carbon (C), making it vulnerable to decomposition and fires. Restoring and rewetting peatlands can be a strategy to return wetlands sequestering C.

The Burns Bog Ecological Conservancy Area (BBECA) in Delta, BC is a rain-fed (ombrotrophic) domed bog ecosystem that has been disturbed by peat mining and agriculture in the 1950s and 1960s. This ecosystem is recovering from the disturbances. In this study, we quantify a year of measured net ecosystem exchange (NEE) and calculated ecosystem respiration (R_e) and gross ecosystem photosynthesis (GEP) from the BBECA. We characterize the seasonal dynamics of these exchanges. This work will guide restoration and emission management for the BBECA and Metro Vancouver.

(a)



(b)

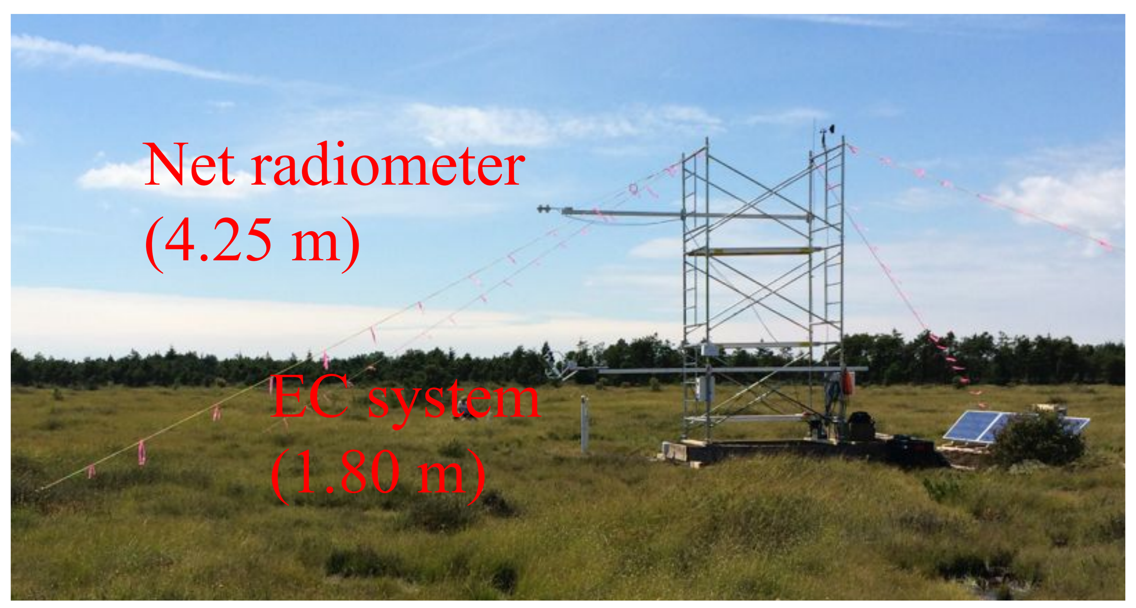


Fig. 1. Aerial photographs of the **(a)** study site and **(b)** flux tower established on a floating platform to measure CO_2 fluxes using an eddy-covariance (EC) system.

Results

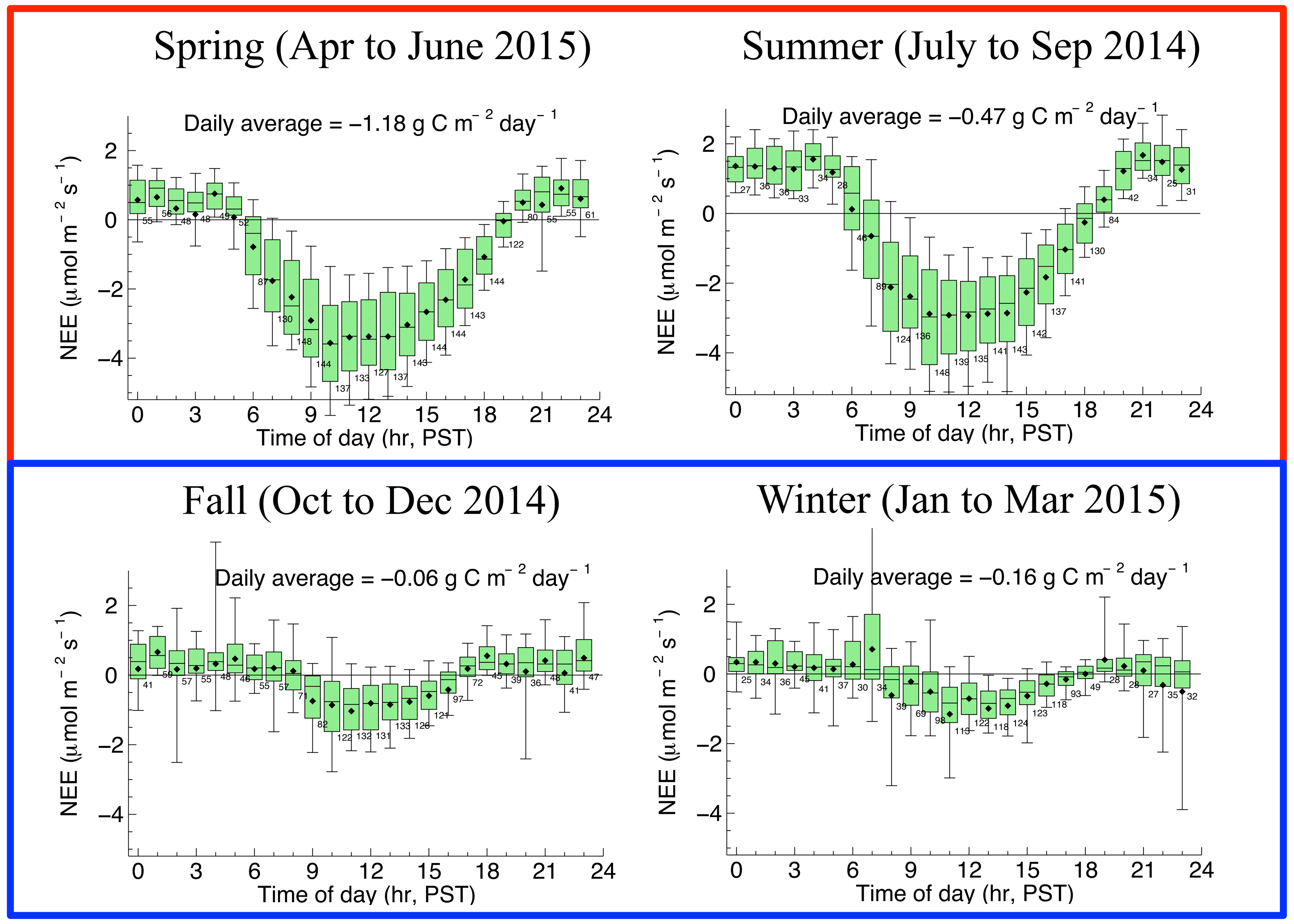


Fig. 2. Diurnal course of EC-measured NEE in each of the four seasons where boxes display interquartile range and whiskers are 10 and 90% percentiles. Lines inside the boxes are medians and diamonds are class averages.

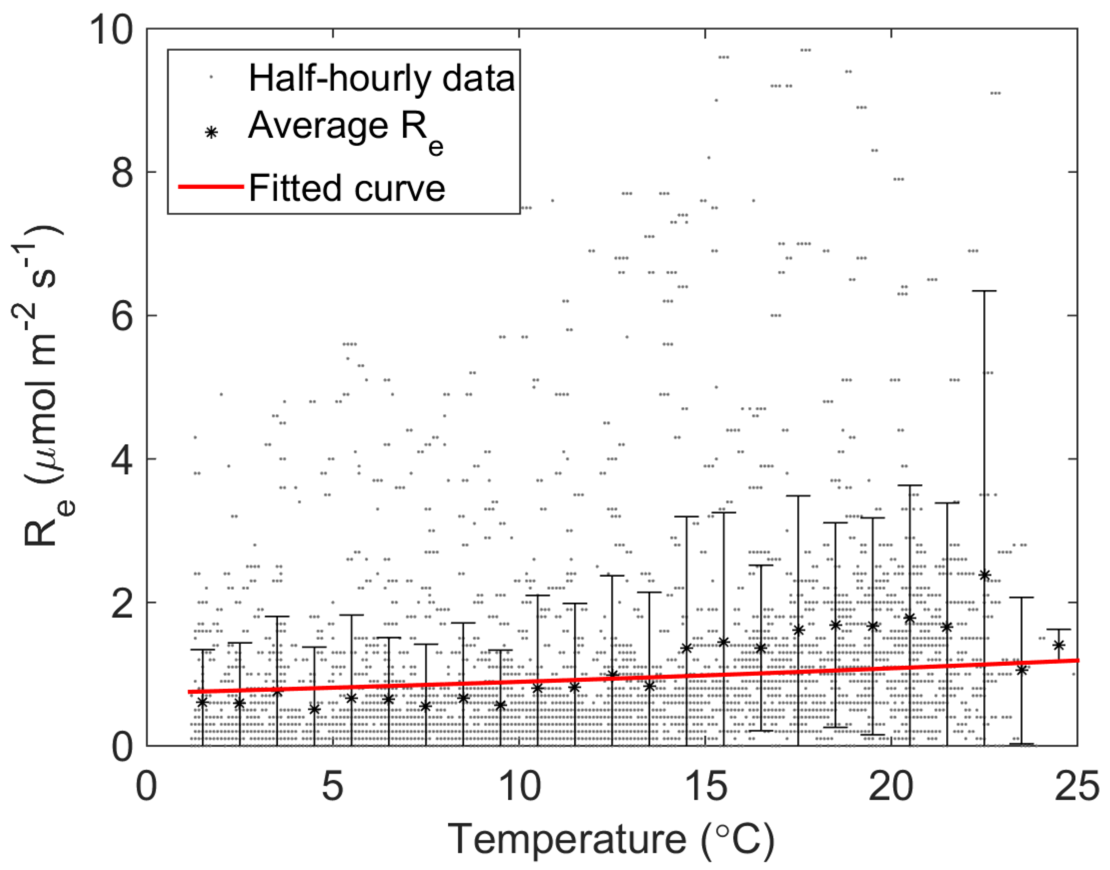


Fig. 3. Relationship between R_e (nighttime 30-minute NEE measurements) and soil temperature at 5cm depth. The u_* threshold was 0.08 m s^{-1}. The fitted curve is the Van't Hoff (exponential) equation. Average values are shown for 1 K bins showing the standard deviations (vertical bars).

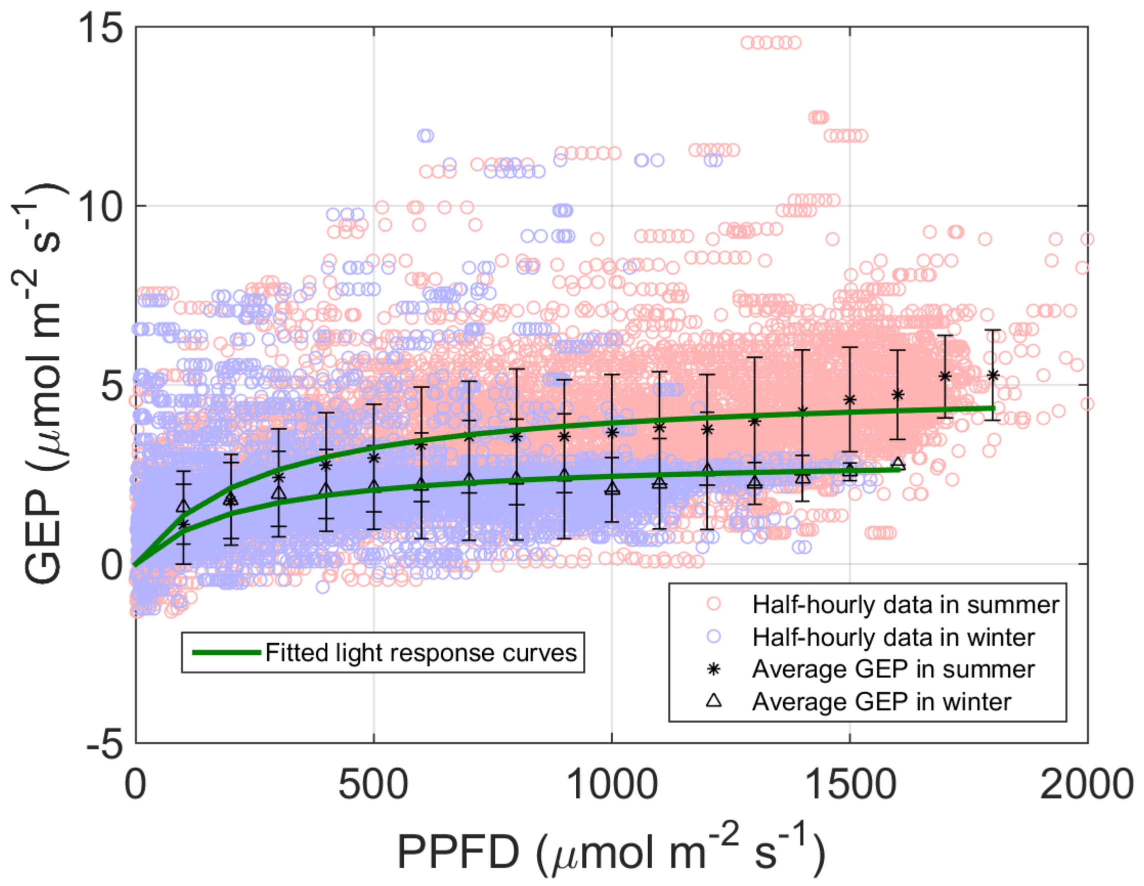


Fig. 4. Summer and winter light response curves determined from the daytime 30-minute NEE measurements and nighttime R_e, i.e., GEP = R_e – NEE. The curves are best fit of the Michaelis–Menten equation. Average values are shown for 100 µmol m^{-2} s^{-1} bins showing the standard deviations (vertical bars).

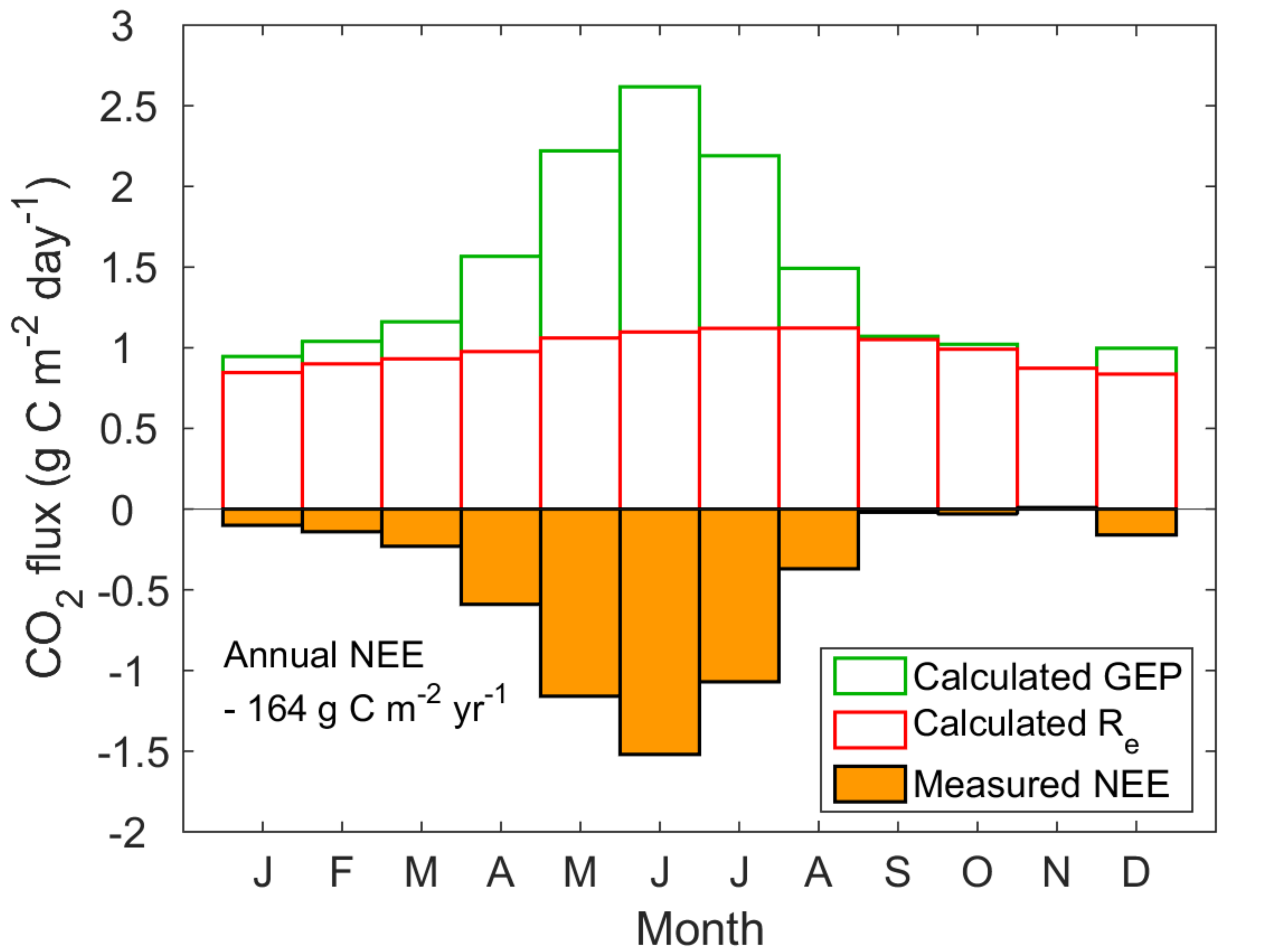


Fig. 5. Monthly EC-measured NEE, R_e calculated using nighttime NEE measurements, and GEP calculated using daytime NEE measurements and R_e.

Conclusions

1. Annual NEE, R_e and GEP were -164, 354 and 518 g C m^{-2} yr^{-1}, respectively; the magnitude of NEE was lower than in previous studies of pristine temperate peatlands. Burns Bog is not a highly productive ecosystem; yet the considerably limited R_e due to oxygen limitation permits C sequestration even during the winter.
2. The magnitude of GEP in summer months reached 5 µmol m^{-2} s^{-1}. The lower light response in winter was due in part to the loss of leaves from the deciduous plants.
3. During the wet winter, NEE was low but also R_e was small. This means the rewetting procedure currently applied in the BBECA will help sequester CO_2 year around.

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References

Coursolle, C., Margolis, H.A. , et al., 2006. Late-summer carbon fluxes from Canadian forests and peatlands along an east–west continental transect. *Can. J. For. Res.* 36(3), 783-800.

Knox, S.H., Sturtevant, C., Matthes, J.H., Koteen, L., Verfaillie, J., Baldocchi, D., 2015. Agricultural peatland restoration: effects of land-use change on greenhouse gas (CO_2 and CH_4) fluxes in the Sacramento-San Joaquin Delta. *Glob. Chang. Biol.* 21(2), 750-765.

Lafleur, P.M., Roulet, N.T., Bubier, J.L., Frolking, S., Moore, T.R., 2003. Interannual variability in the peatland-atmosphere carbon dioxide exchange at an ombrotrophic bog. *Glob. Biogeochem. Cycles.* 17(2), 1036.

Ögren E, Evans JR (1993) 'Photosynthetic light-response curves, 1. The influence of CO_2 partial pressure and leaf inversion'. *Planta* 189, 182-190.

Sonnentag, O., Van Der Kamp, G., Barr, A.G., Chen, J.M., 2010. On the relationship between water table depth and water vapor and carbon dioxide fluxes in a minerotrophic fen. *Glob. Chang. Biol.* 16(6), 1762-1776.

Sulman, B.N., Desai, A.R., Saliendra, N.Z., Lafleur, P.M., Flanagan, L.B., Sonnentag, O., Mackay, D.S., Barr, A.G., van der Kamp, G., 2010. CO_2 fluxes at northern fens and bogs have opposite responses to inter-annual fluctuations in water table. Geophys. Res. Lett. 37(19), L19702.

Syed, K.H., Flanagan, L.B., Carlson, P.J., Glenn, A.J., Van Gaalen, K.E., 2006. Environmental control of net ecosystem CO_2 exchange in a treed, moderately rich fen in northern Alberta. *Agric. For. Meteorol.* 140(1–4), 97-114.

Long, K.D., Flanagan, L.B. and Cai T., 2009. Diurnal and seasonal variation in methane emissions in a northern Canadian peatland measured by eddy covariance. *Glob. Chang. Biol.* 16(9), 2420-2435.