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Peatland wetness and the inter-annual variability of net ecosystem exchange: comparison of multi-year records from two different types of northern peatlands

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Two continental northern peatlands have had the net ecosystem exchange (NEE) measured continuously for over a decade: Mer Bleue (MB) is a raised bog in the cool-temperate ecoclimatic region of central Canada and Degerö Stormyr (DS) is a minerogenic oligotrophic 'poor' fen in northern Sweden. The published multi-year net ecosystem carbon balance for each of these peatlands is approximately – 20 to 30 g C m^{-2} yr^{-1} based on measurements of all the major carbon exchanges, and is remarkably similar to other published balances and to the original analysis E. Gorham published for peatlands in 1991. However, while the NECB are similar the net ecosystem exchange (NEE) is very different between MB and DS. Most of the annual variance comes from the growing season - May to October. The growing season accumulated NEE for MB and DS for the period of measurements (10 years for MB and 9 years for DS) was -129.4 and -78.8 g C m^{-2} t^{-1}, respectively, and the standard deviation and range around the mean at MB was 50.8 and 135.7 versus at 30.0 and 108.5 g C m^{-2} t^{-1} at DS. Both peatlands are nutrient poor. MB has a continuous cover of *Sphagnum* with a near complete cover of ericaceous shrubs. DS is covered by *Eriophorum*, shrubs, and sedges, and *Sphagnum* where the water table is below the surface. The main difference between these two peatlands is in the variation of moisture storage. MB has a much lower mean growing season water table depth (WTD) than DS, -42.3 versus -14.4 cm and the growing season range and standard deviation are greater at MB than DS (16.2 and 5.7 versus 13.4 and 4.8 cm). Further, the WTD is fairly normally distributed at DS but at MB on about half the years there is a longer tail towards WTDs $>$ -50 cm. These growing seasons correspond to lower cumulative NEEs. At MB there is a significant inverse relationship between cumulative growing season NEE and mean WTD (r^2 = 0.42) but not at DS. However, at DS a weak significant relationship arises if one anomalously large cumulative growing season NEE (-149 g C m^{-2} t^{-1} which is 2 σ $>$ the mean) is removed (r^2 = 0.22). Further, the change in growing season cumulative NEE for a given change in WTD is 3.5 times greater for MB than DS (-5.8 versus -1.6 g C m^{-2} t^{-1} cm^{-1}). Most inter-comparisons of peatland carbon exchange (e.g. Lund et al. 2009) have found the WTD to be either insignificant or relatively unimportant. However, based on the comparison of MB and DS it appears to be a significant factor with a greater impact on the NEE at MB where WTD is deeper and variability within and between years is greater than at DS. We hypothesize that it is the structure of the growing season variance in moisture storage within the peatlands between years, and between the peatlands over the years that is key to explaining a portion of the variance in NEE. It is critical to be able to test this hypothesis across a diversity of peatlands to establish the link between hydrology and carbon exchange over time if we want to be able to project how peatland carbon stores might change with climate change.