Peatland hydrology across scales: seasonal and interannual controls of water table and carbon emissions

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Our project aims to guide future representations of peatland hydrology and water-carbon feedbacks within Earth System Models, by improving process understanding and developing parsimonious models that elucidate the effects of hydroclimatic variability and spatial heterogeneity. Our research questions are centered on the three key drivers of peatland hydrology: (1) seasonal and interannual hydroclimatic fluctuations, (2) spatial heterogeneity of bog microtopography, and (3) hydrological connectivity across landscape units within a peatland watershed. Our analyses and model development use existing long-term datasets within the Marcell Experimental Forest (MEF), with new data collected whenever necessary.

To date, we have demonstrated the strong influence of water table elevations on the temperature sensitivity of CH_4 emissions, using a newly developed eddy covariance dataset spanning eleven years at MEF (Feng et al. 2020). Specifically, higher water tables dampen the springtime increases in CH_4 emissions as well as their subsequent decreases during the fall, resulting in hysteresis. These results imply that any hydroclimatological changes in peatlands that shift seasonal water availability from winter to summer will increase annual CH_4 emissions, even if temperature remains unchanged. To further investigate seasonal hydrological changes, we installed automated water table gauges across four bog-forest boundaries (the “lagg”) in two watersheds at MEF, which are hotspots of intense biogeochemical activity. These measurements will give us new information about the extent of lagg expansion and contraction during high intensity rainfall and snowmelt events. Finally, the hydrological connectivity between upland forests and low-lying bogs are investigated during the snowmelt period using existing data for snow and frost depth, water table elevations, and streamflow. Preliminary results show decrease in water table elevation and annual streamflow despite an increase in precipitation, due to the dominant role of evaporative demand that decrease surface water storage in snowpack and bogs.

References:

Feng, Xue, M. Julian Deventer, Rachel Lonchar, GH Crystal Ng, Stephen D. Sebestyen, D. Tyler Roman, Timothy J. Griffis, Dylan B. Millet, and Randall K. Kolka. “Climate sensitivity of peatland methane emissions mediated by seasonal hydrologic dynamics.” *Geophysical Research Letters* 47, no. 17 (2020): e2020GL088875.