Peatland hydrology across scales: wintertime controls of spring water table and streamflow

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BER Program: TES

Project: Peatland hydrology across scale: a probabilistic framework for confronting variability, heterogeneity, and uncertainty (University award)

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, we investigated the hydrological connectivity across the peatland watershed complex during early spring – a critical period where water table is elevated from snowmelt – using extended hydrological records from MEF (e.g., snow and frost depths, water table elevations, streamflow). Results show that (i) streamflow has decreased over decades due to increased evapotranspiration rates (despite no detectable trends in precipitation), (ii) the timing of spring water table recharge and streamflow is decoupled from shifts in snowmelt, and (iii) frost depth is a key explanatory variable for the timing and magnitude of streamflow. These results suggest that frost plays an important role in connecting surface water storage in peatlands to stream outlets, and that the hydrological connectivity across the peatland watershed complex can mediate the sensitivity of hydrological responses to climate variations.

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.