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Controls on water table depths and fluctuations in peatlands: a balance between meteorological conditions and hydrogeological setting

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Peatlands are ecosystems characterized by a near-surface water table controlled by a combination of internal and external processes influenced by short-term meteorological variations and long-term climate change. Site-related conditions such as peat hydrodynamic properties, vegetation patterning and hydrogeological setting in which peatlands developed are also important controls of water table dynamics. The objective of this research was to characterize the controls exerted by meteorological conditions and hydrogeological settings on water table depths (WTD) and water table fluctuations (WTF). Seven peatlands located in or near the St. Lawrence Valley (southern Quebec, Canada) and positioned in different hydrogeological settings were characterized and monitored over a two-years period. On each site, different areas were monitored with wells and piezometers in which water tables were recorded hourly. These areas were located up-gradient, mid-gradient, and down-gradient of the peatland flow, in the minerotrophic zone within the peatland, as well as in the adjacent superficial aquifer. In each area, the hydraulic conductivities (K) were measured in situ using slug tests. For all the studied peatlands, WTD varied between 1 cm (above peat surface) and -54 cm (below peat surface). Aquifer K values in areas where peatlands feed the aquifer (outflow zone) ranged between 1.4*10-7 and 8.5*10-3 cm/s whereas that of the areas where the aquifer feeds peatlands (inflow zone) ranged between 5.6*10-7 and 3.9*10-6 cm/s. Strong correlations were found between mean peatland WTD and the aquifer K, suggesting that some control is exerted by the outflow zones on peatland WTD. Changes in peatland water storage capacity during low evaporative periods were found using autocorrelation functions. Evapotranspiration was shown to be the dominant factor controlling monthly cumulative water table decreases while precipitation dominated the monthly cumulative water table increases. The results show that a 1°C change in monthly air temperature leads to a decrease between 7 and 13 mm in monthly decreases, while a decrease of 1 mm in monthly precipitation induces a monthly decrease between 1 and 2 mm. This study sheds new light on aquifer-peatland connections, suggesting that while WTF is strongly influenced by meteorological conditions, WTD is controlled both by direct (flux) and indirect (pressure) connections with the aquifers. This study confirms that the connectivity between peatland and aquifer influences the vulnerability of peatlands to climate change in different ways depending on their hydrogeological setting.