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Control of landscape characteristics on inter-pond water level responses to decadal climate cycles

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Ponds in the Boreal Plains (BP) of Western Canada are hydrologically dynamic and potentially vulnerable to modifications in their water budget. Water availability is governed by a long term moisture deficit (P<PET), with intermittent water surpluses occurring on a decadal cycle. Climate then interacts with Hydrologic Response Areas (HRAs), characterised by low relief, deep heterogeneous glacial deposits of differing storage capacities, which underlies a mosaic of wetland and forestland Hydrological Units (HUs), of contrasting storage and evaporative demand. These landscape characteristics cause complex and dynamic surface and groundwater interactions and variable connectivity across temporal and spatial scales. This research disentangles the complex interaction of climate, HRAs and HUs and landscape position to underpin the dominant controls on pond water level responses through climate cycles to infer the key processes driving pond persistence. We present 20 years (1998-2018) of pond stage observations at 34 sites along a 50km transect on the BP. Here we show that pond water levels in the BP exhibit spatially variable memory of climate, ranging from within-season responses to lags of multiple years. As hypothesised, ponds displayed strong decadal climatic trends, thereafter with HRAs as the overriding control on pond water level responses. However a wide range of responses within HRAs is observed due to HU and landscape position further modifying storage and hydrological connectivity and consequently memory of antecedent conditions at finer scales. Our results demonstrate the importance of storage and connectivity metrics characterised as HRAs and HUs for understanding thresholds and memory, as the pond water balance crucially incorporates the effects of antecedent moisture in a region where runoff is poorly correlated with rainfall. Unprecedented climatic warming coupled with increasing anthropogenic activity is set to modify hydrologic interactions, driving potentially critical impacts on ecosystem functioning within the BP. Therefore improving the understanding of the interactions of climate, geology and landcover and their control on pond dynamics is vital to identify thresholds for pond persistence at multiple spatial and temporal scales.