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Interactions and Connectivity between Large Inland Lakes, Coastal Wetlands and Groundwater

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Changing climate conditions have altered sea and inland lake levels around the globe, including in the world's largest inland lake system, North America's Laurentian Great Lakes. These five lakes span the border between the United States and Canada, holding ~23,000 km3 of freshwater, including ~4,000 km3 of groundwater, which represents ~21% of the world's available freshwater. Rapid interannual changes in lake elevation of 1-2m over the last 25 years have occurred due to changing climatic conditions including precipitation, lake surface temperature and the extent of winter ice cover. Significant effort has been invested to develop predictive models for climate, runoff and lake levels in the Great Lakes region. Recent hydrologic modeling efforts have also investigated interactions between the Great Lakes and the adjacent groundwater aquifers, with a focus on groundwater as a source or sink of water to the lakes. Yet little attention has been given to the coastal hydrologic processes that control the feedback between lake levels and groundwater response. Here, we investigate the effects of lake level changes on terrestrial groundwater elevations with a coupled surface and groundwater hydrology model encompassing the entire State of Michigan, using the Landscape Hydrology Model (LHM). LHM is a gridded, process-based surface and shallow subsurface water balance model coupled to USGS MODFLOW which simulates saturated groundwater processes. We tested the effect of lake levels on terrestrial groundway by running a set of model experiments using consistent climate forcing data and different lake elevations as groundwater model boundary conditions. Results indicate the changing lake levels drive changes in terrestrial groundwater elevations of up to 2m and as far as 20 km inland. Here, we extend this study to consider how these lake-level induced changes in groundwater elevation affect the hydrologic connectivity of coastal wetlands. We explicitly consider both surface connectivity and groundwater connectivity, and how those vary in space and time. Given the predicted impacts of climate change on sea and lake levels globally, it is important to understand how feedbacks between surface and groundwater in coastal regions affect the connectivity of and ecosystem services provided by coastal wetlands.