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We investigated spatial and temporal dynamics of climate associated with late Holocene water-level fluctuations in Lakes Michigan and Superior. Sedimentological studies show water-level variability in the upper Great Lakes at millennial to sub-centennial timescales during the late Holocene. A spatial array of high-resolution records of peatland paleohydrology was used in conjunction with other proxy-climate records to reconstruct patterns of late Holocene moisture variability in the region. These records were compared directly to the water-level histories of Lakes Michigan and Superior. At centennial timescales, peatland paleohydrology shows a close correspondence with lake-level history. Paleoclimate records also document increased moisture during the Algoma highstand (~3200-2300 BP) and a later unnamed highstand (~1900-1300 BP). Moisture increases during the unnamed highstand were synchronous across the western Great Lakes region. However, moisture increases associated with the Algoma highstand were spatially and temporally variable, with increasing moisture occurring later in southern portions of the region. A denser network of proxy-climate records would potentially help reconstruct the atmospheric circulation patterns that drove Great Lakes water-level fluctuations.