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Tracing water through a bog: $\delta^{18}O$ and $\delta^{2}H$ signatures detail seasonal hydrology and bog response to precipitation events

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Stable water isotopes, $\delta^{18}O$ and $\delta^{2}H$, are natural tracers that provide valuable information on hydrologic processes without disturbing sensitive or protected environments, like bogs. A bog is a rainfed peatland with inhibited organic matter decomposition and large organic carbon stores. As hydrological cycles shift due to climate change, it is necessary to define residence times and identify the stream water sources to compare water and chemical fluxes from degraded and undisturbed bog systems. We used $\delta^{18}O$ and $\delta^{2}H$ to trace water through an undisturbed, degraded, and deforested bog in northwest Ireland. Samples from stream water, bog porewaters, and bog pools were collected by hand and by autosampler during two hydrological summer campaigns and four hydrological winter precipitation events from 2022–2024. Event samples were collected via remotely triggered autosamplers every 2 hours during hydrological events and compared to surface pool and peat porewater $\delta^{18}O$ and $\delta^{2}H$ signatures. The range of $\delta^{18}O$ and $\delta^{2}H$ in bog stream water was -8.90 to -3.79‰ for $\delta^{18}O$ and -61.7 to -25.8‰ for $\delta^{2}H$. The shifts in stream $\delta^{18}O$ and $\delta^{2}H$ show the temperature driven seasonal shifts in precipitation isotopic composition (summer bulk, -5.70‰, -39.2‰ and winter bulk, -9.65‰, -67.0‰). The range of peat porewaters throughout the year for $\delta^{18}O$ (-6.22 to -4.46‰) and $\delta^{2}H$ (-37.1 to -28.8‰) were smaller. Event sampling captured the bog hydrologic response to rain and snow events. Stream water $\delta^{18}O$ and $\delta^{2}H$ values resembled porewater prior to the event and were depleted in response to event precipitation. The magnitude of stream depletion was dependent on precipitation isotopic composition and water volume. Preliminary mixing model results from a snow event suggest that event water contribution was ≤13% during melt, and most stream flow was sourced from bog porewaters and groundwater. The magnitude of isotopic depletion from winter rain events was greater, and we anticipate that these events contribute larger volumes of water via overland and shallow subsurface flow. These data demonstrate that $\delta^{18}O$ and $\delta^{2}H$ provide qualitative and quantitative understanding of water source to streams and will continue to be useful tools in quantifying event response as climate changes.