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Hyporheic expansion and contraction due to hydrologic forcing

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The hyporheic zone is dynamic in both space and time providing a critical zone for stream metabolism and biogeochemical cycling. In considering the extent and volume of the hyporheic zone, geomorphology is considered the primary control in many settings. However, superimposed on top of these geomorphologic features are dynamic hydrologic forcing from the stream, groundwater, and hillslope, which cause the hyporheic zone to expand and contract. In some setting, hydrologic forcing alone can produce the same extent and volume of the hyporheic zones in the absence of any geomorphologic feature. The research presented here explores the temporal role of hydrologic forcing on the expansion and contraction of the hyporheic zone. Using a coupled numerical surface and groundwater model we analyze the transient drivers that control the volume of the hyporheic zone by simulating daily, annual, and storm induced stream and groundwater fluctuations. Results show annual groundwater forcing is the dominant control on the volume of the hyporheic zone but this response can be modified by in phase and out of phase surface water dynamics due to storm events. By removing all geomorphologic features we explore the impact of a suite of in phase and out of phase hydrologic forcing on the magnitude and extent of the hyporheic zones. Results show these hydrologic forcing can produce hyporheic flow path lengths and residence times that span orders of magnitude. The span of path lengths and residence times, simply controlled by the superposition of hydrologic signals, are equivalent to those produced by geomorphic features. These results stress the importance of quantifying dynamic hydrologic forcing from the stream, groundwater, and hillslope in future efforts of upscaling to stream networks.