Effect of precipitation and stream discharge on the source composition of stream water

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The exchange of water between streams and groundwater plays an important role for hydrologic and biogeochemical processes. Along a stream the composition of stream water is modified by sequential losses of stream water with the current in-stream chemical signature to the subsurface and gains of water with another signature from the subsurface. This process has been termed hydrologic turnover. To date, most studies on hydrologic turnover have been focused on small stream networks. Moreover, the influence of hydrologic conditions on hydrologic turnover has not been systematically investigated. Taking the lower Selke River in central Germany as an example, we evaluated the evolution of stream-groundwater exchange and the source composition of stream water under different precipitation and stream discharge conditions, based on a coupled stream-groundwater model built in MODFLOW using the Streamflow-routing (SFR1) package. The results show that the stream reaches could be classified into three types: permanently gaining reaches, permanently losing reaches, and transitional reaches. Transitional reaches range from losing condition at higher stream discharge or lower precipitation to gaining condition at lower stream discharge or higher precipitation. In the lower Selke River with a length of 30 km, transitional reaches account for nearly 30% of the total river length in the studied period from 2011 to 2018. Regardless of dry or wet hydrologic condition, nearly 80% of the total groundwater contribution to stream discharge at the catchment outlet were generated over 20% of the total river length. This indicates diffuse groundwater pollution such as from agricultural nitrate may enter the stream network predominantly at a few distinct reaches. Our analysis can help to prioritize areas in a catchment where reduction of diffuse groundwater pollution would have the highest impact on improving stream water quality.