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Changes in spatiotemporal patterns of hydrological response after partial deforestation

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Predicting the effects of land use change on hydrology can be extremely challenging. It requires looking beyond the current structure and functioning of hydrological systems to predict how the system is influenced in a changed setting. Although the hydrological effects of land use change have been studied extensively, only few high resolution datasets are available to accurately describe, model and predict detailed changes in spatiotemporal patterns of hydrological fluxes and states due to land use change. The TERENO test site Wüstebach provides a unique monitoring setup to measure the major components of the water balance (evapotranspiration, discharge, precipitation) and the spatiotemporal distribution of soil moisture before and after a partial deforestation. Here, we present 5 years of measured hydrological data, including soil moisture and water budget component data 3 years before and 2 years after the partial deforestation. A data-driven investigation was used to understand changes and related feedback mechanisms in spatiotemporal hydrological response patterns. The effects of deforestation on soil moisture and evapotranspiration were analyzed by comparing states and fluxes for the control and the deforested area. The effects on discharge characteristics were analyzed using discharge metrics, including baseflow separation, peakflow rates and time to peak. Changes in preferential flow occurrence were identified using a sensor response time analysis of soil moisture measurements before and after the deforestation where preferential flow was identified as a non-sequential sequence of sensor response times within the soil. As expected from earlier studies, the partial deforestation caused a decrease in evapotranspiration and an increase in discharge. A closer look at the high resolution datasets however reveals new insights in the intra-annual variability of the water balance components. The overall decrease in evapotranspiration caused a large increase in soil water storage in the deforested region, especially during the summer period, which in turn caused an increase in frequency of high discharge in the same period. Although the evapotranspiration in the forested region was larger on average, the deforested region showed a higher evapotranspiration during part of the summer period. This could be related to water stress in the forested area, which did not occur in the deforested area because of the larger amount of water stored in the topsoil.