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A multi-approach and multi-scale study on water quantity and quality changes in the Tapajós River basin, Amazon

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We studied the impact of the land-use change on the discharge and water quality of the Tapajós River, an important tributary of the Amazon River. Its watershed (ca. 500,000 km^2) has been drastically deforested due to construction of dams and the establishment of agro-industrial farms, which caused a loss of ca. 30% of its original forest cover as of 2016. As a consequence of these human-induced changes, studies in this region have reported increases in river discharge, which are often associated with changes in water quality and sediment transport. In this context, we analyzed changes in water quantity and quality at different scales in the Tapajós' watershed based on experimental fieldwork, hydrological modelling, and statistical time-trend analysis. At a small scale, we compared the river discharge (Q) and suspended-sediment concentrations (SSC) of two adjacent micro-catchments (< 1 km^2) with similar characteristics but contrasting land uses (forest vs. pasture) using empirical data from field measurements (2013–2014). At an intermediary scale, we simulated the hydrological responses of a sub-basin of the Tapajós (Jamanxim River watershed, 37,400 km^2), using a hydrological model (SWAT). For the setup, calibration, and validation of SWAT, we used a gradual land-use change parameterization, field assessments, and available regional data. We then simulated a land-use change scenario in order to quantify the changes in the water balance components due to deforestation. At the Tapajós' watershed scale, we investigated trends in Q, sediments, hydrochemistry, and geochemistry in the river using available data from the HYBAM Observation Service, which is maintained in collaboration with research institutions and water agencies in Brazil. The results in the micro-catchments showed a higher runoff coefficient in the pasture (0.67) than in the forest catchment (0.28). At this scale, the SSC were also significantly greater during stormflows in the pasture (579.7 $\pm$ 985.3 mg/L) than in the forest catchment (81.8 $\pm$ 148.6 mg/L). At the Jamanxim watershed scale, the hydrological modelling results showed a 2% increase in Q and a 5% reduction of baseflow contribution to total Q after a conversion of 22% of forest to pasture. At the scale of the Tapajós River, however, trend analysis did not show any significant trend in discharge and sediment concentration. Hydrological changes due to land-use change are known to be primarily manifested at smaller scales. Therefore, we ascribe this finding to the fact that most of the deforestation in this watershed has occurred in its upper portion, which produces hydrological signatures that may be buffered along the river until its outlet. However, in the Tapajós River we found upward trends in dissolved organic carbon and NO_3, which have reached an up to 10-fold increase of their outflow fluxes over the last 20 years. Although the magnitude of anthropogenic impact is likely to be scale-dependent, we found significant changes in the Tapajós watershed in river discharge, sediment concentration, and water quality across all studied scales.