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Coupling urban expansion models and hydrological models: how important are spatial patterns?

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It is well known that urban expansion has a significant impact on the surface water balance by transforming vegetated covers into sealed surfaces, such as buildings, roads and parking spaces. These changes alter several hydrological processes at various spatial and temporal scales and thus cause changing fluxes of evapotranspiration, surface runoff and groundwater recharge. In order to estimate the impact of urban expansion on the surface hydrology, hydrological models are often 'loosely' coupled with different types of urban expansion models. It is, however, not clear to what extent spatially-explicit urban expansion scenarios provide an added value in comparison with non-spatial urban expansion models at different scale levels. The objective of this study is to acquire a better insight in the importance of scale effects involved in the loose coupling of urban expansion scenarios and hydrological models. The relative importance of using different projections of both (i) quantity and (ii) spatial patterns of urban expansion was analysed at four different scale levels. The highly urbanised Flanders-Brussels region was taken as an example application. A number of urban expansion scenarios for 2025 and 2050, that varied in terms of quantity and spatial pattern of urban expansion, was developed and subsequently used as an input in the hydrological model WetSpass. WetSpass is a physically based spatially-distributed water balance model for simulating seasonal and yearly groundwater recharge, actual evapotranspiration and surface runoff. The results obtained suggest that at the level of the Flanders-Brussels region, an accurate estimation of the quantity of urban expansion should get priority over an accurate projection of the spatial patterns. The quantity uncertainty related to the use of different urban expansion scenarios resulted in a 17% uncertainty on the assessed runoff values, 1.5% on the evapotranspiration values and 4.5% on the estimated groundwater recharge. Comparable uncertainty values could be observed on all four analysed scale levels. On the other hand, the importance of using accurate projections of the spatial pattern of urban expansion increased systematically with an increasing spatial resolution. At the level of individual subcatchments the uncertainty related to the spatial patterns of urban expansion equalled the uncertainty related to the quantity assessment. At the level of individual pixels, an accurate projection of the spatial patterns was even found to be more important than an accurate assessment of the quantities of urban growth. Based on the results from this study it can be concluded that a uniform strategy for coupling urban expansion models and hydrological models seems inappropriate. The smaller the area under investigation, the more effort should be put in an accurate simulation of the spatial patterns of land cover change. These findings are highly relevant for water management and spatial planning policymakers that typically operate at different administrative levels.