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Identifying the role of human-induced land-use change while assessing drought effects on groundwater recharge

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Drought is mainly regarded as a purely natural phenomenon, driven by the natural variation in precipitation or rather the lack of precipitation. Nowadays many river catchments are, however, altered by human activities having direct effects on the catchment landscape and hydrological response. In case of the occurrence of drought events in those catchments it becomes more complex to determine the effects of drought. To what extent is the hydrological response a direct result of the natural phenomenon and what is the role of the human factor?

In this study we focus on the effects of droughts on groundwater recharge. Reliable estimation of groundwater recharge in space and time is of utmost importance for sustainable management of groundwater resources. Groundwater recharge forms the main source for replenishing aquifers. The main factors influencing groundwater recharge are the soil and topographic characteristics, land use and climate. While the first two influencing factors are relatively static, the latter two are (highly) dynamic. Differentiating between the contributions of each of these influencing factors to groundwater recharge is a challenging but important task. On the one hand, the occurrence of meteorological drought events is likely to cause direct, potentially deteriorating, effects on groundwater recharge. On the other hand, this is also the case for on-going land-use dynamics such as extensive urbanisation.

The presented methodology aims at distinguishing in space and time between climate (drought-related) and land-use (human-induced) effects, enabling to assess the effects of drought on groundwater recharge. The physically-based water balance model WetSpass is used to calculate groundwater recharge in a distributed way (space and time) for the Dijle-Demer catchments in Belgium. The key issue is to determine land-use dynamics in a consistent way. A land-use timeseries is build based on four base maps. Via a change trajectory analysis the consistency of the land-use timeseries is assured. In addition also consistent land-cover fraction maps (vegetated, impervious, bare and open water), obtained from remote sensing, are used. To account for climate variability a distributed meteorological monthly timeseries of 32 years (1980-2011) is considered. A combined drought index approach (RDI, SPI, scPDSI) is used to identify meteorological drought events during this period. WetSpass simulations are used to assess the weight of the influencing factors 'land use' and 'climate' with respect to drought effects on the recharge timeseries. Hereto WetSpass is run several times with different climate input, while the dynamic land-use timeseries (1980-2013) is considered for every scenario. Two simulation runs are used: (1) long-term average climate, representing "normal" conditions for the 32-year period and (2) dynamic climate conditions 1980-2013. The results of both WetSpass simulations enable to assess the drought effect (deviation from normal) on groundwater recharge for each monthly timestep. Results indicate that drought effects occur in the Dijle-Demer catchments and even tend to increase towards the last decade, especially during the 3rd trimester and in the south of the study area.

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