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Improving drainage representation in distributed groundwater models with information from hydrologic signatures

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Intensively used agricultural land in humid climates frequently is artificially drained to prevent flooding and increase crop yield. Drains have a profound effect on groundwater flow patterns, consequently affecting the associated transport of chemicals and particles. Hence, knowledge of the amount and dynamics of drain flow and its interplay with recharge and overall groundwater flow is essential to, for example, understand the transport and retention of nitrate in agriculturally dominated catchments.
We investigated the impact of drainage on streamflow, to improve modelled drainage in large-scale hydrological models. We work with distributed integrated groundwater-surface water models in the DHI MIKE SHE software with model grid sizes of 100 m and 500 m, covering two Danish catchments of about 1,000 km2. Modelling drainage systems on a large scale is challenging, due to the mostly unknown distribution of the actual drain pipes, and difficulties representing finely resolved phenomena in such models. Furthermore, direct observations of drain flow are limited. As flow generation from drain is different from flow generation through normal groundwater-stream interaction, drainage is assumed to have an impact on hydrographs, also in (small) natural streams where drain flow only constitutes a part of the total flow. We extracted such information in the form of meaningful hydrologic signatures. Those signatures can be derived from streamflow observations at discharge stations (about 500 across Denmark) and compared to simulated signatures. Or, as observed signatures show correlations to different explanatory variables (topography and derived indicators, geology, soil type, etc.), the signatures can be used in a regionalization approach.
By informing these large-scale models with hydrological signatures, instead of the use of conventional metrics in calibration, the drain description in the model can be improved. Eventually, the insight gained from this work will be transferred to the national Danish hydrological model, and help improving national targeted regulation of nitrate in agriculture to protect surface and groundwater.