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Quantifying catchment water balances and their uncertainties by expert elicitation

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The increasing demand on water resources necessitates a more responsible and sustainable water management requiring a thorough understanding of hydrological processes both on small scale and on catchment scale. On catchment scale, the characterization of hydrological processes is often carried out by calculating a water balance based on the principle of mass conservation in hydrological fluxes. Assuming a perfect water balance closure and estimating one of these fluxes as a residual of the water balance is a common practice although this estimate will contain uncertainties related to uncertainties in the other components.

Water balance closure on the catchment scale is also an issue in Denmark, thus, it was one of the research objectives of the HOBE hydrological observatory, that has been collecting data in the Skjern river catchment since 2008. Water balance components in the 1050 km^2 Ahlergaarde catchment and the nested 120 km^2 Holtum catchment, located in the glacial outwash plan of the Skjern catchment, were estimated using a multitude of methods. As the collected data enables the complex assessment of uncertainty of both the individual water balance components and catchment-scale water balances, the expert elicitation approach was chosen to integrate the results of the hydrological observatory. This approach relies on the subjective opinion of experts whose available knowledge and experience about the subject allows to integrate complex information from multiple sources.

In this study 35 experts were involved in a multi-step elicitation process with the aim of (1) eliciting average annual values of water balance components for two nested catchments and quantifying the contribution of different sources of uncertainties to the total uncertainty in these average annual estimates; (2) calculating water balances for two catchments by reaching consensus among experts interacting in form of group discussions. To address the complex problem of water balance closure, the water balance was separated into five components: precipitation, evapotranspiration, surface runoff, recharge and subsurface outflow. During the study, experts first participated in individual interviews where they gave their opinion on the probability distribution of their water balance component of interest. The average annual values and uncertainty of water balance components and catchment-scale water balances were obtained at a later stage by reaching consensus during group discussions.

The obtained water balance errors for the Ahlergaarde catchment and the Holtum catchment were -5 and -62 mm/yr, respectively, with an uncertainty of 66 and 86 mm/yr, respectively. As an advantage of the expert elicitation, drawing on the intuitive experience and capabilities of experts to assess complex, site-specific problems, not only the uncertainty of the water balance error was quantified, but the uncertainty of individual water balance components as well.