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Effects of Measurement Uncertainties of Meteorological Data on Estimates of Site Water Balance Components

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Numerical water balance models are widely used in ecological and hydro sciences. However, their application is related to specific problems and uncertainties. The reliability of model prediction depends on (i) model concept, (ii) parameters, (iii) uncertainty of input data, and (iv) uncertainty of reference data. How model concept (i) and parameters (ii) affect the model performance is an often treated problem. On the contrary, the effects of (iii) and (iv) are seldom tackled although their effects are of similar magnitude. It should be considered that uncertainties of input data and reference data do not only affect the prediction accuracy but also the parameter identification (calibration and validation).

The uncertainty has two different reasons: (a) actual measurement uncertainties and (b) limitations of representativeness as consequence of a scale gap between meteorological measurement and hydrological modelling. A separate analysis of both aspects is often not possible as most hydrological investigations operate on catchment scale where both effects interfere with each other. Our study is focused on site scale (< 1.5 km^2). Thus, the scales of measurement and modelling are similar, and effects due to regionalisation and generalisation can be neglected.

At site scale we take the micrometeorological perspective: primary reference is the evapotranspiration measured via the eddy covariance technique instead of runoff. Because of the use of evapotranspiration as a reference, it is possible to limit the investigations to the upper parts of the soil that are influenced by root water uptake. Thus, also the parameter uncertainty is significantly reduced as most parameters can be directly quantified.

The analyses of effects due to input uncertainties are based on Monte-Carlo-Simulations with perturbated input series. The Monte-Carlo-Simulations were done for two water balance models of different complexity (HPTFs: black box model; BROOK90: process based complex model) and for different sets of parameterisation. Our results show that seemingly small uncertainties in daily measurements can lead to significant discrepancies on annual scale. Uncertainties in precipitation but also in radiation measurements are especially serious. E.g., a small offset of 5 W m^{-2} in measured daily radiation sum up to an uncertainty of 160 MJ m^{-2} (equivalent to 65 mm) on annual scale. The uncertainty of radiation measurements is thereby the main reason for uncertainties in calculated potential but also actual evapotranspiration.

It is also demonstrated that effects of input uncertainties are similar for both model types and all variants of parameterisation. The typical spread of simulation results (here defined as the range between median and upper/ lower percentile) being caused by uncertainties of meteorological measurement is on average $\pm$ 25 mm (5 %) for annual actual evapotranspiration and $\pm$ 30 mm (10 %) for annual seepage. However, the maximum spread can be significantly higher particularly in years being affected by rare and extreme weather conditions. In summary, our study shows clearly: uncertainties in meteorological data are not negligible. Input uncertainties must be considered in the same way as effects of parameterisation and shortcomings of the model concept.