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Combination of distributed water balance modelling and isotope methods to determine recharge areas in high-alpine karst massifs

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In this paper an approach of distributed hydrological modelling of water balance components in a karstic mountainous region is presented. In karstic regions hydrological catchment boundaries are usually not known a priori. The idea is to combine water balance modelling results based on the orographic catchment boundaries with disparate sources of information in an iterative way to identify hydrographic catchment boundaries and subsurface water ways. The additional data and information are derived by region-wide point measurements of discharge, field surveys, isotope data, tracer tests, electric conductivity data, soil and (hydro-)geological surveys and mapping, snow depth data, etc.. These data sources are complementary to the usually used rainfall and runoff data and assist in model building, parameter calibration and interpreting the results. Also, to get information about the meteorological input in a high-alpine region comprehensive regionalisation and correction methods are assessed and applied. The study is set up in the mountain range Kaisergebirge in Tyrol/Austria, using the well known model MIKE SHE. Based on the additional information the original model structure is adjusted to the specific situation in the karst, e.g. by introducing a bypass-flow, and the parameters are selected. Calibration of the model parameters to runoff volume at the stream gauges is limited due to the large uncertainties in the catchment boundaries. The results are evaluated in terms of closing and – equally important – non-closing the water balance, and spatial patterns of simulated state variables, such as soil moisture and snow water equivalent, and runoff components are interpreted in the light of the different sources of information. In one gauged sub catchment, for example, simulation of the runoff dynamics is improved compared to gauge observations by introducing the bypass flow. Complementary data of spring discharge and electric conductivity are analysed and confirm the bypass concept. In a second sub catchment, the spatial pattern of the simulated snow water equivalents is analysed and the melting dynamics are compared qualitatively to the simulated runoff at the catchment outlet. Taking into consideration additional complementary data of isotope analyses, conclusions about the runoff contributing areas during snow melt and about the average altitude of the contributing recharge area can be drawn. As an overall result, a map of surplus and deficit on sub catchment scale is drawn to form a general conceptual model of karst water flow directions in the high-alpine region.