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Customization of a hydrological model for the estimation of water resources in an alpine karstified catchment with sparse data

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The main objective of the MontanAqua transdisciplinary project is to develop strategies moving towards a more sustainable water resources management in the Crans-Montana-Sierre region (Valais, Switzerland) in view of global change. Therefore, a detailed assessment of the available water resources in the study area today and in the future is needed.
The study region is situated in the inner alpine zone, with strong altitudinal precipitation gradients: from the precipitation rich alpine ridge down to the dry Rhône plain. A typical plateau glacier on top of the ridge is partly drained through the karstic underground formations and linked to various springs to either side of the water divide. The main anthropogenic influences on the system are reservoirs and diversions to the irrigation channels. Thus, the study area does not cover a classical hydrological basin as the water flows frequently across natural hydrographic boundaries. This is a big challenge from a hydrological point of view, as we cannot easily achieve a closed, measured water balance.
Over and above, a lack of comprehensive historical data in the catchment reduces the degree of process conceptualization possible, as well as prohibits usual parameter estimation procedures.
The Penn State Integrated Hydrologic Model (PIHM) (Kumar, 2009) has been selected to estimate the available natural water resource for the whole study area. It is a semi-discrete, physically-based model which includes: channel routing, overland flow, subsurface saturated and unsaturated flow, rainfall interception, snow melting and evapotranspiration. Its unstructured mesh decomposition offers a flexible domain decomposition strategy for efficient and accurate integration of the physiographic, climatic and hydrographic watershed. The model was modified in order to be more suitable for a karstified mountainous catchment: it now includes the possibility to punctually add external sources, and the temperature-index approach for estimating melt was adjusted to include the influence of solar radiation. No parameter calibration in a classical sense was used as sufficient observations are missing.
Hence, parameters are estimated with values obtained from the literature, catchment boundaries were determined basing on tracer experiments, as well as the relationship between precipitation, spring- and river-discharge.
Historical data such as river discharge, infiltration experiments and snow and glacier mass balance measurements were used to validate simulations.
Here some case studies are presented, illustrating the difficulty of estimating snowmelt and icemelt parameters, of judging their correctness, as well as the consequent sensitivity of the regional water balance.

REFERENCES

Kumar, M. 2009: Toward a hydrologic modeling system. PhD Thesis, Departement of civil and Environmental engineering, Pennsylvania State University, USA.