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Impact of future climatic scenarios on spring discharge signals based on an integrated numerical modelling approach: Application on a snow-governed semi- arid karst catchment area.

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Flow in a karst system in Lebanon (Important water supply source; Assal Spring; discharge 0.2-2.5 m3/s yearly volume of 22-30 Mm3) dominated by snow and semi-arid conditions was simulated using an integrated numerical model (Mike She, 2016). The calibrated model (Nash–Sutcliffe coefficient of 0.77) is based on high resolution input data (2014-2017) and detailed catchment characterization. A sensitivity analysis of individual climatic parameters (precipitation; P, temperature; T, wind, humidity, T and P lapse rates, snow degree day coefficients) shows that spring hydrograph characteristics are most sensitive to temperature. For instance, an increase of 2°C in the temperature time series yields a lengthening of the recession period by 35 days, a decrease of snow cover by 61% and a subsequent decline of the minimum flowrate without substantially affecting the total volumes observed at the spring. Linear relationships were also established between precipitation variation, and each of recession duration, water budgets, and spring flow maxima and minima.

A forward simulation using the IPS_cm5 model with the RCP6.0 scenario for future climate change (Global Climate Models GCM; daily downscaled bias and altitude corrected time series for Lebanon 2020-2099) was performed to unravel trends in discharge, recharge, and other spring hydrograph characteristics expected in the future. We find that precipitation, recharge, and discharge have moderate to highly significant decreasing trends with time over the 21st century. Moreover, recession flowrates are expected to drop drastically starting in the year 2070 to 1 L/s with shortage periods reaching up to six months. The latter is due to a temperature rise of +1.5-2.5 °C and subsequent shrinking of snow cover by almost 100% (e.g., 2073-2074). Furthermore, this is accompanied by a decline in precipitation and annual spring volume by 73% with respect to current status, with real evapotranspiration consisting of up to 50% from total water budget (currently around 12-17% in 2014-2017), thus requiring immediate attention to secure alternative sustainable resources in the area, especially during summer times.

Finally, a method is proposed to estimate future duration of water shortage periods and needed supply volumes based on modeled recession coefficients, water demand, and discharge variation during recession. Therefore the model results could be interpolated on other similar catchments and allow decision makers to implement best informed management practices, especially in complex karst systems, to overcome the impacts of climate change on water availability.