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Past and future decrease in snow in the central European rain-snow transition zone

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Mountains are referred to as water towers because they substantially affect the hydrology of downstream areas. However, snow storages will decrease in the future due to the increase in air temperature which will affect streamflow regime and water availability. Therefore, the main objectives of our research were 1) to quantify past and future changes in snow storages for a large set of mountain catchments representing different elevations and 2) to analyse how snow responds to climate variability. The snow storage was simulated for 59 mountain catchments located in six mountain regions in Czechia for the period 1965–2019 using a bucket-type catchment model. The predictions of the future climate from EURO-CORDEX experiment were considered in the model to simulate the future change in snow.

Analyses using the Mann-Kendall test identified decreasing trends in snow storages in western parts of Czechia (by up to −45 mm per decade), while no trends were detected in eastern part of Czechia suggesting the partly different climatology of both regions. In contrast to weak trends in SWE, significant trends were documented for snow cover duration, which decreased on average by 5.5 days per decade. The reason was mostly earlier snowmelt and melt-out, while trends in snow cover onset were not identified. Nevertheless, snow responded differently to climate variables across elevations. Below 900 m a.s.l., the snow was controlled mainly by air temperature, while above 1200 m a.s.l., snow responded dominantly to changes in precipitation. With the increase in air temperature in last five decades, its importance in controlling snow storage and variability increased at all elevations.

While only some significant changes in Czechia were documented in last five decades, substantial changes are expected by the end of the 21st century, such as the decrease in annual maximum SWE by 30-75%, mainly at elevations below 1200 m a.s.l. Changes are also expected for other snow-related variables, such as snow cover duration, which will be shorter, especially due to earlier start of the melting season and thus melt-out. In general, the melt-out day is projected to occur by 30-60 days earlier compared to current conditions by the end of the century. The results also showed the large variability between individual climate projections and indicated that the increase in air temperature causing the decrease in snowfall might be partly compensated by the increase in winter precipitation. Changes in snowpack will cause the highest streamflow during melting season to occur one month earlier, in addition to lower spring runoff volumes due to lower

snowmelt inputs. Additionally, the model predicted the increase in winter runoff for the future period due to the increase in air temperature and thus the shift from snowfall to rain. These changes may impose more pressure to create adaptation strategies for water reservoirs management to keep all reservoir functions, such as flood and drought protection, drinking water supply and hydropower.