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Modelling of mass balance response of Glacier Fürkeleferner, Italy, with the COupled Snowpack and Ice surface energy and MAss balance model in PYthon (COSIPY)

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Glacier melt water is crucial for irrigation used for agriculture in the Martell valley, Italy. Therefore, indications of glacier development in the Ortler-Cevedale massive are of significant economic and social interest especially in the context of climate variability and climate change. In this study the "COupled Snowpack and Ice surface energy and MAss balance model in PYthon" (COSIPY) is used to investigate the state of recent mass balance of the glacier Fürkeleferner which is located at the top of Martell valley. Meteorological data of the climate station Hintermartelltal is used after adjusting to altitude by linear lapse rates. The model output is in good agreement with in situ observations during August 2016 and 2017 as well as with measured mass balances from neighboring glaciers in the European Alps. Results show a significant negative cumulative mass balance between October 2012 and September 2017. Negative mass balances throughout the total area indicate that glacier Fürkeleferner on average did not have any accumulation area left during the study period. Therefore, under present climate conditions, the glacier would completely melt away on the long run. Model runs with temperature increased by +1 K and +2 K as assumed for the European Alps between 2021 and 2050 show enhanced glacier melting. Related mass fluxes indicate a strong increase in surface melt while the decrease in solid precipitation caused by warmer temperatures is negligible. We further force COSIPY with decreased temperature and increased precipitation to reproduce a zero mass balance for the glacier surface according to glacier Fürkelen's maximum Little Ice Age (LIA) extent in 1855. Glacier area and volume for its 1855 extent were determined by mapping of terminal and lateral moraines. The model results indicate that air temperatures must have been substantially lower in the mid 19th century even if higher precipitation sums are assumed. Overall, the results are consistent with previous knowledge on paleoclimate in the Alps as reported in other studies. The study exemplifies the strong response of glacier Fürkelen's mass balance to atmospheric forcing in past, present and future. It further highlights the need of adaption of regional water management strategies in order to cope with diminishing glacier melt water in the Martell valley hydrological system in coming decades.