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Abstract

European Alpine glaciers have strongly shrunk over the last 150 years in response to climate warming. Glacier retreat is expected to persist and even intensify in future projections. This work aims at evaluating how much of the glacier retreat can be attributed to anthropogenic atmospheric forcings. For this purpose, we quantify the evolution of the Argentière glacier in the Mont Blanc area under different climate scenarios over the period 1850-present. The different scenarios are extracted from 4 ensemble experiments conducted with the IPSL-CM6-LR General Circulation Model (GCM), excluding and including natural and anthropogenic atmospheric forcings. These 6-member experiments are statistically corrected and downscaled with a quantile mapping approach that ensures consistent long term tendencies and precipitation-temperature relationship. These data feed a three-dimensional ice flow model coupled with a surface mass balance model to simulate changes in the glacier geometry over time. Over 1850-2014, historical simulations show a significant warming whereas there is no clear trend of precipitation at the annual scale. The glacier appears to be highly sensitive to individual anthropogenic forcings, with a glacier volume loss around 45% in the greenhouse gases-only experiment and a growth of about 5% in the aerosols-only experiment in 2014 relative to 1850, compared to the 32% volume loss over the same period in the historical experiment. Moreover, the natural-only experiment reveals the great impact of anthropogenic forcings with a much lower volume loss of about 10%. The latter also confirms that the end of the Little Ice Age would have occurred even without human activities. Finally, the simulations highlight a strong influence of natural internal variability and show that the front of the Argentiere Glacier definitively left its possible natural pathway only during the last decade.