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Centennial observed snowfall trends and variability in the European Alps

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Climate change significantly affects snow, emphasizing the urgency to comprehend the temporal and spatial variations in snowfall trends. Analysing historical snowfall data across large areas is often impeded by the lack of continuous long-term time series. This study investigates snowfall trends (HN) by examining observed time series from 46 Alpine sites at various elevations spanning the period 1920-2020. In addition to HN, the analysis focuses on key parameters such as precipitation (P), mean temperature (TMEAN), and large-scale synoptic descriptors — the North Atlantic Oscillation (NAO), Arctic Oscillation (AO), and Atlantic Multidecadal Oscillation (AMO) indices — to discern patterns and variations in HN over the years.

The study reveals that over the past century, below 2000 m a.s.l., there has been a decline in HN across the Alps, particularly in southern and low-elevation sites, despite a slight increase in winter precipitation. The South-West and South-East regions experienced average losses of 4.9% and 3.8% per decade, respectively, while the Northern region showed a smaller relative loss of -2.3% per decade. The negative HN trends are primarily attributed to a TMEAN increase of 0.15 °C per decade. The majority of the HN decrease occurred between 1980 and 2020, as a result of a more pronounced increase in TMEAN. This is reinforced by changes in the running correlation between HN and TMEAN, NAO, AO over time; before 1980, there was no correlation, while in later years, the correlation increased. This suggests that in recent times, the right combination of temperature, precipitation, and atmospheric patterns has become crucial for snowfall. On the other hand, no correlation was found with the AMO index.