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Impact of increasing temperature on snowfall in Switzerland

G. Serquet (1), C. Marty (2), and M. Rebetez (1)

(1) WSL Swiss Federal Research Institute, Lausanne, Switzerland (gaelle.serquet@wsl.ch, rebetez@wsl.ch), (2) WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland (marty@slf.ch)

The exact impact of changing temperatures on snow amounts is extremely important for mountainous regions, not only for hydrological aspects but also for winter tourism and the leisure industry in winter ski resorts. However, the impact of increasing temperatures on snowfall amounts is difficult to measure because of the large natural variability of precipitation. In addition, the impact of increasing temperatures varies, depending on region and altitude.
Moreover, the impact of the observed increasing trend in temperature on snowfall and snow cover has usually been investigated on a seasonal basis only. On a monthly basis, the relationship between this increase in temperature and snowfall is still largely unknown. Of particular concern are the autumn and spring months and variations with altitude.
In order to isolate the impact of changing temperatures on snowfall from the impact of changes in the frequency and intensity of total precipitation, we analyzed the proportion of snowfall days compared to precipitation days for each month from November to April in Switzerland. Our analyses concern 52 meteorological stations located between 200 and 2700 m asl over a 48 year time span.
Our results show clear decreasing trends in snowfall days relative to precipitation days for all months (November to April) during the study period 1961-2008. Moreover, the present conditions in December, January and February correspond to those measured in the 1960's in November and March. During the whole snow season, the snowfall ratios have been transferred in elevation by at least 300 m from 1961 to 2008. This means that with an expected temperature increase during the coming decades at least similar to the temperature rise of recent decades, we can assume an additional similar altitudinal transfer of the snowfall days relative to precipitation days ratios. The current situation in November and March could thus become the future situation in December, January and February. During the coming decades, the December, January and February snowfall days relative to precipitation days ratios for the altitude class 1101-1400 m asl would gradually shrink to only approximately 50%. For ski resorts with a base below 1400 m asl, December, January and February will be problematic, because at least one out of two precipitation days will consist of rainfall only. The beginning and end of the ski seasons (November, March-April) will also be affected by the transfer in altitude of snowfall, as currently already approximately every second precipitation day consists of rain up to 1400 m asl in November and March and up to 1700 m asl in April.