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Relating temperature, snow height and glacier characteristics to streamflow trends in Western Austria

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The results of streamflow trend studies are often characterised by mostly insignificant trends. This applies especially for trends of annually averaged runoff: In our study region, Western Austria, we found that there is a trend gradient from high-altitude to low-altitude stations, i.e. a pattern of mostly positive annual trends at higher stations and negative ones at lower stations. At mid-altitudes, trends are mostly insignificant. The trends were most probably caused by the following two main processes: On the one hand, melting glaciers produce excess runoff at high-altitude watersheds. On the other hand, increasing evapotranspiration results in decreasing trends at low-altitude watersheds. However, these patterns are masked at mid-altitudes because the resulting positive and negative trends balance each other. To verify these theories, we attributed the detected trends to specific causes. For this purpose, we analysed trends on a daily basis, as the causes for these changes might be restricted to a smaller temporal scale than the annual one. The daily trends were assessed by calculating 30-day moving average subsets and then estimating significance and magnitude. This allowed for the explicit pointing out of the exact days of year (DOY) when certain streamflow trends emerge and then relating them to the according DOYs of trends and annual cycles of other observed variables, e.g. the DOYs when snow height trends occur or the DOY when temperature crosses the freezing point in spring. Concerning trends caused by increased glacial melt, we applied correlation analyses between glacier area and trend magnitudes during the corresponding DOYs. As a result, the positive trends in spring were attributed to an earlier and more intense snow melt. The ones that follow in late spring at upper stations could be related to increased glacial melt. The negative trends in summertime that turn up earlier at low-altitude stations and later at high-altitude stations are most probably an effect of earlier and increased melt-out and evapotranspiration. The negative trends at upper stations in late summer were linked to decreased melt due to decreasing glacier surface area. Finally, the original hypothesis concerning annual trends was confirmed with a high level of confidence.