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Climate change in mountains around the globe: Elevation dependencies and contrasts to adjacent lowlands

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Mountain and high elevation regions often show distinct climate trends in temperature and precipitation, which can contrast those of adjacent lowland regions. In the context of temperature, this phenomenon is known as elevation-dependent warming (EDW). Past temperature trends can increase with elevation, but this is not always so, and they may peak in a critical elevation band, or show more complex elevation profiles. This is controlled by a variety of mechanisms which may be responsible for the observed patterns, including snow albedo feedback, vegetation change, cloud and moisture patterns, aerosol forcing and their interactions.

We here present a literature-based meta-analysis of elevation profiles in recent warming rates and, in a more general context, temperature change in mountain regions around the globe. For the recent historical period (~1960-2010) we find that when comparing like with like (i.e. high elevation regions with adjacent low elevation regions) warming rates are mostly stronger at higher elevations. Warming rates have also increased over time, with more recent decades showing stronger warming. On a global scale there is no significant difference between mean warming rates in mountains and in other areas. Thus, elevation-dependency within regions can be masked by differences in geographical location in global meta-analyses. Although there have been far fewer studies on vertical profiles of precipitation changes, we extend our meta-analysis to consider this parameter, where information is available.

In addition to the meta-analysis, we compare past temperature and precipitation changes in mountain and lowland regions using global gridded observation-based and reanalysis datasets (e.g. CRU, ERA5, NCEP2) and global climate model simulations (CMIP5). Despite the uncertainties of these datasets (e.g. inhomogeneous underlying station coverage and related interpolation errors, biases, coarse spatial resolution), they allow us to compare different mountain regions globally with the same level of accuracy. There are only a few mountain areas that show distinct differences when their temperature trends are compared with lowland surroundings, but patterns vary by dataset and region. We also explore different extensions of adjacent lowlands, which may

influence the quantification of differences in temperature and precipitation trends at high and low elevation.

This historical assessment is completed by an analysis of model projections (CMIP5) for studying the expected future evolution of climate change in mountains and contrasts to adjacent lowlands