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New insights into the Elevation Dependent Warming in the Tibetan Plateau-Himalayas from CMIP5 models

Elisa Palazzi, Luca Filippi, and Jost von Hardenberg
ISAC-CNR, Torino, Italy (e.palazzi@isac.cnr.it)

We use the output of twenty-seven Global Climate Models (GCMs) participating in the Coupled Model Intercomparison Project phase 5 (CMIP5) to investigate Elevation Dependent Warming (EDW) in the Tibetan Plateau, Himalayan and Karakoram mountains and surrounding areas in historical model simulations and in future projections.

The model data indicate enhanced warming with elevation in the past decades and an intensification of the EDW in the future decades under a high-range IPCC emission scenario (RCP 8.5), particularly for the minimum temperature in winter and spring and for the maximum temperature in summer and autumn, which corroborates previous observational and model studies focused on the Tibetan Plateau region. However, our study suggests that the relationship between the warming rates and the elevation (for both the minimum and maximum temperature and with some seasonal differences) is far from being linear. In particular, two clearly distinct regimes emerge such that regions with temperatures below the freezing level of water show a stronger warming than regions above, suggesting that the phase of water and/or the presence of snow play a key role.
This bimodal response is very robust and it is captured by the multi-model mean as well as by all individual GCMs. The mechanisms for enhanced warming trends with elevation are investigated using a multiple regression model which incorporates five predictors, associated with the variables that are expected to be important for the EDW: surface downwelling longwave radiation, surface downwelling shortwave radiation, near-surface specific humidity, albedo, and orography. We find that inclusion or exclusion of the orography as a predictor does not change significantly the amount of explained variance for the prediction of either the minimum temperature change in winter or the maximum temperature change in summer, in particular if one regression model already includes albedo and specific humidity. The albedo emerges as one variable playing a significant role, in some cases more important than, in others comparable to downward longwave radiation and specific humidity that previous studies indicated as leading mechanisms for the EDW in the Tibetan Plateau region.