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Abstract

With an average elevation of 4000 m, High Mountain Asia (HMA) and the Tibetan Plateau (TP) are hosting the third largest reservoir of glaciers and snow after the two polar ice caps, and trigger strong rates of orographic precipitation. Climate studies over HMA are related to serious challenges concerning the exposure of human infrastructures to natural hazards and the water resources for agriculture, drinking water and hydroelectricity to whom several hundred million inhabitants are depending. However, temperature, precipitation, and snow cover in this region are poorly described in global climate models because their coarse resolution is not adapted to the complex topography of this area. Since the first CMIP exercises, a cold model bias has been identified in HMA, however, its attribution is not obvious and may be different from one model to another. Our study focuses on a multi-model comparison of 27 CMIP6 models over 1979-2014. A cold bias is still present in near-surface air temperature over HMA reaching an annual value of -2.0 °C (± 3.2 °C), associated with an over-extended relative snow cover extent of 53 % (± 62 %), and a relative excess of precipitation of 139 % (± 38 %). Precipitation biases are uncertain because of the undercatch of solid precipitation in observations. Higher-resolution models do not systematically perform better than the coarse-gridded ones, suggesting that the development of more realistic physical parameterizations over complex topography areas is still needed. We implemented new snow cover parameterizations taking into account the sub-grid topography in the IPSL general circulation model. This model shows a strong cold bias and an excess of snow cover over HMA. These new parameterizations were calibrated over HMA using a high-resolution snow reanalysis and compared to a deep learning algorithm. Preliminary results show improvements in simulated snow cover and reduced cold bias over HMA. The residual biases suggest that other factors must be involved (e.g., tropospheric cold bias, precipitation biases, aerosol forcing uncertainties, orographic drag), and raise the potential limitation of the implemented parameterizations over permanent snow areas. Nevertheless, taking into account the sub-grid topography in the snow cover parameterization is essential to properly represent snow cover dynamics over mountainous areas.