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Long-term Trend Comparison of Planetary Boundary Layer Height in Observations and CMIP6 models over China

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The planetary boundary layer (PBL) plays an essential role in climate and air quality simulations. Large uncertainties remain in understanding the long-term trend of PBL height (PBLH) and its simulation. Here we use the radiosonde data and reanalysis datasets to analyze PBLH long-term trends over China, and to further evaluate the performance of CMIP6 climate models in simulating these trends. Results show that the observed long-term “positive to negative” trend shift of PBLH is related to the variation in the surface upward sensible heat flux (SHFLX) which is further controlled by the synergistic effect of low cloud cover (LCC) and soil moisture (SM) changes. Variabilities in low cloud cover and soil moisture directly influence the energy balance via surface net downward shortwave flux (SWF) and the latent heat flux (LHFLX), respectively. We have found that the CMIP6 climate models cannot reproduce the observed PBLH long-term trend shift over China. The CMIP6 results show an overwhelming continuous downward PBLH trend during the 1979-2014 period, which is caused by the poorly simulated long-term changes of cloud radiative effect. Our results reveal that the long-term cloud radiative effect simulation is critical for CMIP6 models in reproducing the PBLH long-term trends. This study highlights the importance of low cloud cover and soil moisture processes in modulating PBLH long-term variations and calls attentions to improve these processes in climate models in order to improve the PLBH long-term trend simulations.