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Why does the Tibetan Plateau support the highest planetary boundary layer?

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The planetary boundary layer over the Tibetan Plateau reaches an unprecedented height of 9.4 km above sea level (i.e. about 5 km above ground), therefore nearly reaching the stratosphere. This proximity facilitates exchange between the stratosphere and the boundary layer, which has important impacts for atmospheric chemistry and the transport of pollution. Both, observations from radio soundings and numerical model simulations have demonstrated that the mixed layer of the plateau planetary boundary layer (PBL) can grow to heights near the tropopause, but the underlying mechanisms responsible for this deep PBL remained uncertain. Here we explore these mechanisms using measurements of the PBL, the associated surface fluxes and regional numerical simulations. Our results indicate that the dry conditions of both ground soil and atmosphere in late winter cannot explain the development of extraordinarily deep PBLs even if wetter conditions (in summer) naturally depress PBL growth. COSMO simulations exhibit very good correspondence to the observed mean PBL structure and show realistic turbulent kinetic energy distribution throughout the full PBL depth. Modeling results demonstrate the key influence of the stability of the free atmosphere for the growth of extremely deep PBLs over the Tibetan Plateau. Weak atmospheric stability and hence deep PBLs, is found to be associated to a more southerly jet position and higher upper-level baroclinicity. This work completes a picture of the complex interplay between PBL, surface heating, stability and upper-level dynamics.