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The Ability of a General Circulation Model to represent the Atmospheric Boundary Layer over the Antarctic Plateau

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In a General Circulation Model (GCM), the turbulent mixing parametrization of the atmospheric boundary layer (ABL) over the Antarctic Plateau is critical since it affects the continental scale temperature inversion, the katabatic winds and finally the Southern Hemisphere circulation. The aim of this study is to evaluate the representation of the Antarctic Plateau ABL in the Laboratoire de Météorologie Dynamique-Zoom (LMDZ) GCM, the atmospheric component of the IPSL Earth System Model in preparation for the sixth Coupled Models Intercomparison Project. We carry out 1D simulations on the fourth Gewex Atmospheric Boundary Layers Study (GABLS4) case, and 3D simulations with the 'zooming capability' of the horizontal grid and with nudging. Simulations are evaluated and validated using in-situ measurements obtained at Dome C, East Antarctic Plateau, and satellite data.
Sensitivity tests to surface parameters, vertical grid and turbulent mixing parametrizations led to significant improvements of the model and to a new configuration better adapted for Antarctic conditions. In particular, we point out the need to remove minimum turbulence thresholds to correctly reproduce very steep temperature and wind speed gradients in the stable ABL. We then assess the ability of the GCM to represent the two distinct stable ABL regimes and very strong near-surface temperature inversions, which are fascinating and critical features of the Dome C climate. This leads us to investigate the competition between radiative and turbulent coupling between the ABL and the snow surface in the model. Our results show that the new configuration of LMDZ reproduces reasonnably well the Dome C climatology and it is able to model strong temperature inversions and radiatively-dominated ABL. However, they also reveal a strong sensitivity of the modeling of the different regimes to the radiative scheme and vertical resolution. The present work finally hints at future developments to better and more physically represent the polar ABL in a GCM.