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Intermittent Bursting of the Wintertime Antarctic Boundary Layer

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High-resolution Large-Eddy Simulations of the very stable boundary layer from the winter at Dome C, Antarctica, reveal a mechanism for top-down intermittent turbulent bursting. Here, a non-bursting state with a boundary-layer height of just three metres is alternated by a bursting state with an elevated layer of turbulent mixing up to approximately five metres. The underlying mechanism is identified as a shear-generated Kelvin-Helmholtz-type wave instability. Such instabilities were previously observed at Dome C using sodar echograms (Petenko et al., (2019) Bound.-Layer Meteor. doi:10.1007/s10546-018-0419-6). The simulations show that an increase of shear above the boundary layer results in a local decrease of the Richardson number below its critical value. The resulting profiles of wind and temperature therefore become linearly unstable to small perturbations which is confirmed by a linear stability analysis, and waves with wavelength of approximately sixteen metres are generated. These waves rapidly grow in time, break-up and inject momentum into the boundary layer. At the same time, the underlying wind and temperature profiles are only marginally changed leading to a fast recovery and subsequent formation of the next bursting event. Furthermore, the occurrence of these bursting events is closely linked to the average thermal steady state found in our simulations over longer timescales. During the non-bursting state, boundary-layer cooling by heat flux divergence occurs below three metres and heating by subsidence is found above this height. This situation is reversed during the bursting state in which warm air heated by subsidence is transported into the boundary layer. Now, the bottom part of boundary-layer experiences warming, whereas a sharp cooling is observed above. These intermittent bursts, therefore, serve as an efficient mechanism to transport air heated by subsidence and enable the thermal steady state.