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Boundary-layer similarity in a numerically simulated oscillatory turbulent katabatic flow

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In mountain meteorology, it is common to distinguish between anabatic flows (winds), which are driven by the slope surface heating, and katabatic winds, which result from the slope surface cooling. These flows often incorporate long-period oscillations of velocity and buoyancy fields with observed frequency being approximately equal to the product of the environmental buoyancy frequency and the sine of the slope angle. One of outstanding questions regarding structural aspects of slope winds is the degree to which they may be considered as boundary-layer flows subject to the formal simplifications associated with the boundary-layer approximation of flow motion.

Structure of the governing slope-flow equations in the boundary-layer form – which is hypothetically a valid approximation for a katabatic flow along a shallow slope – has been examined. For this approximate flow case, the scaling laws have been deduced that involve only two non-dimensional parameters: the Prandtl number and a modified Reynolds number. The slope angle, which is an additional parameter in the original scaled slope-flow problem, appears in the approximate boundary-layer problem only as a factor in the modified Reynolds number. This feature could mean considerable savings of computer resources in parametric slope-flow studies. The validity of the proposed scaling hypothesis has been assessed using direct numerical simulation data.