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A theory for surface-layer scaling of thermally-driven slope flows

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Sloping terrains of any inclination favour the development, under the daily cycle of day time surface heating and night time cooling, of thermally-driven organised flows, displaying peculiar boundary layer structures, and eventually triggering the development of atmospheric convection.

The ubiquitous occurrence over the Earth of variously tilted surfaces - from gently sloping plains to steep cliffs, or valley and basin sidewalls – makes the understanding of such flows of utmost importance in view of the appropriate forecasting of the associated boundary layer transport processes. Also, they display a highly conceptual relevance, as they represent a prototypal situations for many other thermally driven-flows over complex terrain.

An appropriate surface-layer scaling for slope wind is derived extending the classical analysis for flat horizontal terrain situations to the cover inclines. In the former, momentum and heat fluxes at the surface are two independent quantities, and vertical profiles of velocity and temperature can only be connected to them by means of similiarity relationships, as fluxes are nearly invariant with height.

Instead, equations governing slope winds show that the mean wind and temperature profiles are closely connected to the flux structure normal to the slope, as this is not constant. Also, surface values of momentum flux and sensible heat flux are shown to be proportional to each other.

Based on the above relationships, suitable expressions are derived for the slope-normal profiles of velocity and temperature, both in the viscous sublayer and in the fully turbulent surface layer, as well as for the appropriate scaling factors in the two regions.