

Turbulence in katabatic and anabatic winds on steep slopes In situ observations in the european Alps

Christophe Brun

Université Grenoble-Alpes (UGA),
Laboratoire des Écoulements Géophysiques et Industriels (LEGI), Grenoble, France;
christophe.brun@univ-grenoble-alpes.fr

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Abstract

Katabatic winds are buoyancy flows generated at night by radiative cooling at the Earth's surface. They are mainly observed in winter during anticyclonic meteorological episodes associated with stratification and temperature inversion in the lower troposphere. Their counterpart consists of anabatic winds by day in summertime along alpine slope. The katabatic/anabatic wind consists of a turbulent wall jet along the slope coupled to a cooled/heated turbulent thermal boundary layer, both subject to buoyancy effects. A classical approach to coupling is given by Prandtl's (1942) model, which also includes turbulent effects, but little is known about the very close flow region below the maximum jet velocity for steep-slope configurations. There are only few in situ observations of katabatic/anabatic processes along steep alpine slopes in the mountains. I will provide preliminary results of a comprehensive observation campaign performed as part of the [European alpine project TEAMx in 2024-2026](#) in the Austrian Alps near Innsbruck and the Italian Alps in Monte Baldo and compare to observations performed in the French Alps near Grenoble since 2012. A continuous set of measurements was performed from the ground up to a height of 2 m, i.e. including the maximum jet height, using a multi-hole 3D velocity probe involving differential pressure measurements at high sampling frequency (1 KHz), mounted on a high-precision vertical displacement system (0.1 mm accuracy). Measurements taken from $z = 2$ mm close to the surface ($z^+ = 20$ expressed in wall units) to $z = 2$ m high ($z^+ = 20\,000$) allow to address the following research question: on the one hand, to deepen our general understanding of the turbulent properties of katabatic/anabatic winds in the zone very close to the surface, rarely observed in situ for technical and logistical reasons, by bringing out of the laboratory appropriately sized, high-frequency resolution 3D velocity measurement probes, on the other hand to propose and validate a set of wall laws needed to consistently define surface boundary conditions for the appropriate use of regional models in the mountains and on complex reliefs in general (e.g. Meso-NH, SURFEX from CNRM Météo-France).



Scientific contact: [Benjamin Luce](#)