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Turbulence spectral-characteristics of pure katabatic flow over a steep Alpine slope.

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Katabatic flows develop over every – even slightly – tilted terrain when a surface cooling occurs. These downslope buoyancy-driven flows have the shape of an asymmetric wall jet with a wind maximum height (z=zj) of the order of a few meters, as it is generally observed in mountainous areas. This complex boundary-layer process does not respond to the classical Monin Obukov Similarity Therory (MOST) except, may be, in the lowest thin layer between the surface and zj/10. This flow configuration prevents from any MOST-applicability to fit field observations and even more to represent such processes in atmospheric models. As a similarity law for katabatic flows is yet to be formulated, it is of paramount importance to seek a deeper understanding of the physics of the processes involved.

In this work we analyse a turbulence dataset collected during a field campaign held in November 2012 over the Grand Colon mountain slope (Belledonne ridge, French Alps). The main device consisted in 4 sonic anemometers installed at different heights at 1.0, 1.8, 4.0 and 6.3 m above the surface along a unique measuring mast. This mast was placed in the upper part of the slope, just below the summit, to capture the local generation of the flow. The gathered wind and temperature high-frequency measurements allowed us to carry out an in-depth analysis of the turbulence spectral characteristics within a katabatic flow.

The analysis of both spectra and co-spectra reveal some specific turbulence characteristics of the katabatic flow. The spectral analyses confirmed that the frequency of the local energy injection generated by shear rely on height above the ground, except for heights close to zj. At these heights, since the shear vanishes, a deficit of local energy injection is observed on the spectra through an intermediate slope at the corresponding frequency. This does not respond to any known theory. The co-spectral analyses revealed that the distribution of the energy contribution per frequency, at each height of the wall jet, resulted from both positive and negative cross-correlations. The analysis of this distribution revealed a zone of progressive overlapping of these cross-correlations, which depends on z. It was further observed that small turbulent structures move up the wall jet from its lowest zone towards its highest zone. This phenomenon may result from a varying turbulent diffusivity that depends on the turbulent scale considered. Both the spectral and co-spectral analysis highlight the complexity of the turbulent processes within katabatic flows.