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Double-Nosed Low-Level Jets over Complex Terrain: Driving Mechanisms and Analytical Modeling

Luigi Brogno[1], Francesco Barbano[1], Laura Sandra Leo[1,2], Harindra Joseph Fernando[2], and Silvana Di Sabatino[1]

[1]Physics and Astronomy Department, University of Bologna, Bologna, Via Irnerio 46, Italy
[2]Department of Civil, Environmental Engineering and Earth Sciences, University of Notre Dame, Notre Dame, IN 46556

Low-level jets (LLJs) are a peculiar feature of the nocturnal Planetary Boundary Layer (PBL) and they have been extensively observed both in flat and complex terrain configurations. On the contrary, double-nosed LLJs have been rarely investigated. They essentially consist in the simultaneous occurrence of two noses (i.e. two wind-speed maxima) within the PBL vertical profile of wind speed, but their origin and mechanisms remain rather unclear.

Data collected in an open valley during the MATERHORN field experiment are used here first to demonstrate that double-nosed LLJs are frequently observed at the site during stable nocturnal conditions, and second to describe the mechanisms that drive their formation. Structural characteristics of these double-nosed LLJs are originally described using refined criteria proposed in the literature.

Two driving mechanisms for double-nosed LLJs are newly proposed in the current study. The first mechanism is wind-driven, in which the two noses are associated with different air masses flowing one on top of the other. The second mechanism is wave-driven, in which a flow perturbation generates an inertial-gravity wave. This wave vertically transports momentum causing the occurrence of a secondary nose, leading to the formation of a double-nosed LLJ. Careful examination of the temporal evolution of these events also revealed the short-lived and transitional nature of the secondary nose in both the mechanisms, as opposite to the primary nose whose evolution appeared instead driven by inertial oscillations. Application of two analytical inertial-oscillation models retrieved from the literature confirms this hypothesis. Indeed, both models satisfactorily reproduce the observed single-nosed LLJs but fail to capture the temporary formation of the secondary nose.