Investigation of Atmospheric Boundary Layer Dynamics in Alpine Valleys
Massimiliano de Franceschi
Supervisor: Prof. Dino Zardi

The Atmospheric Boundary Layer (ABL) is the subject of both theoretical and experimental studies since many decades. This shallow region of the atmosphere close to the Earth's surface, where exchanges of momentum, heat and moisture take place, is important for its strong interactions with all the relevant biological processes and in particular with anthropogenic activities. This is particularly true in the Alpine region which is a very densely populated area and also a valuable heritage of environmental and natural resources.

This has been the starting point of this work in designing the investigations reported herein, because in such a complex scenario like the Adige Valley (Northern Italy) meteorological data and consequent understanding of atmospheric dynamics are in many cases insufficient for a suitable evaluation of proposed infrastructure development, analysis of the potential risks or even management of pollutants from existing sources.

The analysis of the orography as well as the typical meteorological conditions was the first step in planning the field campaigns. In particular preliminary indication about phenomena under investigation available before starting the measurements, allowed to adopt the most suitable approach to the problem. During the eight different field experiments, various sensors and instruments have been used, but in this work the attention is focused on the single-point turbulence measurements obtained from an ultrasonic anemometer, while the other information have been mainly used as a control of the boundary conditions.

One of the most delicate issues our attention was turned on, was indeed the reliability of the *standard* analysis techniques (developed and adopted in the literature for cases of flat-uniform terrain) over complex orography. In this phase the effects of the analysis techniques have been tested, resulting in a revision of the recursive filter proposed by McMillen (1988) along with the streamwise alignment for extending the eddy-correlation technique over complex terrain (de Franceschi and Zardi, 2003).
The data analysis has specifically involved the diurnal cycle of mean quantities, turbulent fluxes, as also the nondimensional standard deviations in the Monin-Obukhov Similarity Theory (MOST) framework. At a first glance, limiting the attention only to the aforementioned quantities could seem somewhat limited, especially when considering the amount of information acquired during the eight field campaigns considered here. This choice is although justified by the main objective of this research which is focused on the characterization of ABL dynamics in a valley context. In this sense the comparison of a restricted set of information from all the measurements has been considered more relevant instead of a very detailed description of one single campaign. In fact carrying out of field measurements in the same valley but in different seasons, at two different sites, and with different boundary conditions (i.e. surface roughness, measuring height, weather conditions, etc.), allows for extending some of the results to the more general context of the *valley environment* instead of each single specific location.

Considering the typical circulations pattern of the target areas, it has been confirmed the relevance of valley orientation and shape in redistributing the energy input along the day: beside the evidence of the response of the whole system to the energy input in accordance with earlier descriptions of the phenomenon (valley-winds system), an interesting feedback effect has been outlined. In fact, a minimum in the sensible heat flux due to the combined effect of site shadowing and persistence of up-valley winds has been clearly reported for both target areas.

Also from the analysis of the nondimensional standard deviations specific features have been outlined. Horizontal components seems to organize well into MOST framework, and even in unstable conditions the driving parameters seem to be the measuring height z and the friction velocity u* for both ? u and ? v. The meandering of the valley, along with its continuous widening and narrowing is the most probable responsible for the overall identity of the longitudinal and lateral near-neutral values. The evaluation of the nondimensional turbulent kinetic energy for neutral conditions and its comparison with the same quantity for the flat-uniform terrain suggests that the along-valley winds carry the same amount of energy as on a plain, but differently redistributed among the three wind components.