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Quadrant Analysis of the Heat and Momentum Fluxes at the Transition Layer between the Marine Atmospheric Boundary Layer and the developed Internal Boundary Layer close to the coastline

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The purpose of this work is to study the main characteristics and the micro-structure of the Transition Layer between the Marine Atmospheric Boundary Layer (MABL) and the developed Internal Boundary Layer (IBL), which is created downwind close to the coastline. The dynamics and the structure of this Transition Layer, which could be defined as the region where the growing IBL perturbations enter the MABL and mix the air, are of major interest affecting a variety of MABL' parameters.

For this study data collected from CBLAST field campaign, conducted during summer 2003 at Nantucket Island USA, were used. More specifically data from sonic anemometer measurements at 20 Hz sampling frequency, at 10m height and 80m distance from the coastline were studied. According to our measurements during the night the recorded characteristics of the surface layer at 10m height had the behavior of the MABL, while during the day in most cases the developed IBL was recorded. Thus a diurnal cycle was noticed with the mechanically generated IBL during the night, being lower than the height of our instruments (10m) while a thermally generated IBL during the day was easily observed with characteristic perturbations. In many cases an intermediate state was observed, indicating the existence of the Transition Layer. In order to identify the layers and their characteristics, a conditional analysis was developed using multiple criteria, based mainly on values of the heat and momentum fluxes estimated by the eddy covariance method.

We used the quadrant analysis method to study the coherent structures and compare the results under different atmospheric conditions. This method decomposes shear stress into four quadrants, separating the events that contribute to the downward and upward momentum fluxes. Events in quadrants 2 (ejections) and 4 (sweeps) compose the coherent turbulent structures while events in quadrants 1 and 3 compose the incoherent structures. The parameters γ and exuberance provide info on the relation between the ejection and the sweep mechanisms and coherent/incoherent structures accordingly. Within the IBL layer the ejections are the governing state, implying that they are the dominant mechanism of the growing layer, where the more powerful eddies are sweeping mass from the overlaying layer. Within the MABL layer a more balanced state between ejections/sweeps is observed implying that the MABL is more stable energy is more equilibrated and there are more incoherent motions. At the Transition Layer, we recorded more ejections than sweeps, but less than within the IBL. In that case it seems that an invasion of strong eddies from the underlying layer to the stable layer is the main mechanism.

By concluding, the Transition Layer features significantly different behavior compared with the pure MABL and IBL layers, thus a separate study of the structure of this zone could enhance the knowledge of the turbulent processes of a growing layer and explain the complicated states observed in field experiments.