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Influence of a valley exit jet on the nocturnal atmospheric boundary-layer at the foothills of the Pyrenees

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The evolution of the nocturnal atmospheric boundary layer in a nearly flat region at the foothills of a major mountain range is studied here. Observations at the foothills of the Pyrenees during the Boundary-Layer Late Afternoon and Sunset Turbulence (BLLAST) experimental field campaign are taken together with high-resolution mesoscale simulations of some selected Intensive Operational Periods (clear sky and no rain during evening and night). The main site of the BLLAST campaign is Lannemezan, located on a nearly flat plateau at about 10 km from the exit of the Aura valley. This 40-km long valley is oriented to the north, with a width between mountain peaks of about 5 km in the middle of the valley, diminishing to 2 km at the end.

Results show that the evolution of the nocturnal boundary-layer in Lannemezan differs from what can be expected over an isolated flat terrain region due to the presence of thermally-driven winds. Locally-generated downslope winds are observed close to sunset over the plateau and as night progresses the thermal gradient between the plain and the mountains induce mountain-plain circulations. The organization of the flow in the Aura valley generates a valley exit jet close to midnight that travels through the foothills enhanced by the thermal gradient between mountain and plain already established. Once the valley exit jet propagates through the foothills, it interacts with the locally-generated circulations and decreases its speed and height. As a result, in Lannemezan a maximum of wind speed of about 5-10 m/s from the southern sector is found between 50 m and 200 m above the ground during nighttime. All these features depend on the intensity and direction of the large-scale winds, that are different for the simulated IOPs. They can enhance or diminish the intensity of the valley exit jet and even advance or delay the arrival of the valley exit jet in Lannemezan. It is found that when large-scale winds are weak or moderate but from the south, the valley exit jet reaches Lannemezan close to midnight (or close to sunset for moderate southern large-scale winds). On the contrary, moderate large-scale winds from other directions prevent the arrival of the valley exit jet in Lannemezan. The inspection of the turbulent kinetic energy profiles in Lannemezan shows that shear is the main source of turbulence. It is maximum at lower levels and close to zero at the jet nose, with a secondary maximum above it. The presence of the valley exit jet also modifies the relative importance of the terms of the surface energy balance and the evolution of the temperature at lower levels.