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Mesoscale and Large-Eddy Simulations of Wave-Induced Boundary-Layer Separation

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Boundary-layer Separation (BLS) is the process by which a boundary layer, formed in a fluid at the interface with an external body, separates from it as a consequence of an adverse pressure gradient force. BLS is known to occur in the atmosphere, where it is often associated to phenomena like terrain-induced rotors and banner clouds. BLS dynamics in a stratified atmosphere is considerably more complex than in incompressible fluids: stratification in fact supports the propagation of internal gravity waves, which may be excited by flow above hills or mountains and interact with the boundary layer, favouring its separation.

The present contribution describes simulations of one particular BLS event observed on January 26th 2006 in the lee of the Medicine Bow Range in Wyoming, USA. The event was related to the breaking of a large hydrostatic wave aloft and, at lower levels, to the sharp deceleration of downslope flow followed by an intense updraft and by spots of reverse flow further downstream. Mesoscale simulations help elucidate the relationship between the ambient flow upstream of the mountain and the evolution of BLS in space and time downstream of it. Large-eddy simulations, instead, offer insight on some fine-scale properties of the flow, e.g., pulsations in the katabatic flow before separation as well as rotor and sub-rotor vortices.