



Turbulent boundary layer flow over a steep 2-D hill: atmospheric stability effects

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Complex topography affects the distribution of turbulent fluxes of momentum and heat in thermally stratified boundary layers. Neutrally stratified boundary-layer flows over simplified topography (for example, blocks or sinusoidal hills) have been extensively studied by wind-tunnel experiments and numerical simulation such as Large-Eddy Simulation (LES). Atmospheric stability, however, is seldom considered due to the difficulty of physical simulation in wind tunnel. In addition, accurate prediction of separated flow induced by steep hills remains a challenge to LES modeling.

Experimental investigation of various thermal stratification effects (neutral, stable and convective) on the boundary-layer flows over a steep 2-D hill were conducted at the Saint Anthony Falls Laboratory atmospheric boundary-layer wind tunnel. The 2-D model hill has a steepest slope of 0.73 and its shape follows $h=H \cos(\pi x/L)$ for $-L/2 \leq x \leq L/2$ ($H=7\text{cm}$ and $L=14.5\text{ cm}$). The hill is fully immersed in the surface layer with a ratio of the height to the boundary layer depth (H/δ) about 0.12. High-resolution Particle Image Velocimetry (PIV) provided dynamic flow information of the onset of separation, the recirculation zone and flow reattachment location. Turbulent momentum and heat fluxes as the function of height were characterized using a triple-wire at selected stream-wise locations. Emphasis is made on the effects of atmospheric stability on the dynamics of flow separation induced by the hill as well as the flow recovery process. The present study can hopefully improve our understanding of thermally-stratified boundary layer flow behavior over a steep 2-D hill from well-controlled tests, and provide reliable database for development and validation of LES models.