Mesoscale dynamics and boundary-layer structure in topographically forced low-level jets

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Abstract

Stefan Söderberg: *Mesoscale dynamics and boundary-layer structure in topographically forced low-level jets*

Two types of mesoscale wind-speed jet and their effects on boundary-layer structure were studied. The first is a coastal jet off the northern California coast, and the second is a katabatic jet over Vatnajökull, Iceland. Coastal regions are highly populated, and studies of coastal meteorology are of general interest for environmental protection, fishing industry, and for air and sea transportation. Not so many people live in direct contact with glaciers but properties of katabatic flows are important for understanding glacier response to climatic changes. Hence, the two jets can potentially influence a vast number of people.

Flow response to terrain forcing, transient behavior in time and space, and adherence to simplified theoretical models were examined. The turbulence structure in these stably stratified boundary layers was also investigated. Numerical modeling is the main tool in this thesis; observations are used primarily to ensure a realistic model behavior.

Simple shallow-water theory provides a useful framework for analyzing high-velocity flows along mountainous coastlines, but for an unexpected reason. Waves are trapped in the inversion by the curvature of the wind-speed profile, rather than by an infinite stability in the inversion separating two neutral layers, as assumed in the theory. In the absence of blocking terrain, observations of steady-state supercritical flows are not likely, due to the diurnal variation of flow criticality.

In many simplified models, non-local processes are neglected. In the flows studied here, we showed that this is not always a valid approximation. Discrepancies between simulated katabatic flow and that predicted by an analytical model are hypothesized to be due to non-local effects, such as surface inhomogeneity and slope geometry, neglected in the theory. On a different scale, a reason for variations in the shape of local similarity scaling functions between studies is

suggested to be differences in non-local contributions to the velocity variance budgets.

Keywords: *low-level jets, boundary layer, turbulence structure.*