LEE VORTICES IN AN EVOLVING SYNOPTIC-SCALE FLOW

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Abstract: Most previous studies of lee vortices have assumed that large-scale flows evolve slowly enough so that transient effects are negligible. In this paper, we explore the life cycle and behavior of lee vortices induced by an isolated mesoscale mountain of height h in a slowly evolving synoptic-scale flow. The cross-mountain flow accelerates from rest to 20 m/s at 25 hours and then decelerates back to zero at 50 hours. The large-scale static stability N is constant throughout the domain. The nonlinearity parameter, e = Nh/U, ranges from infinity at the outset and conclusion of the model run, to order unity at 25 hours, and is symmetric about this minimum value. Despite the symmetry in the local nonlinearity parameter, the mountain-induced disturbances exhibit different behavior in the accelerating and decelerating phases of the large-scale flow. Lee vortices are produced in the large-e flow regimes at both the beginning and end phases of the roughly two-day period. The structure and distribution of these vortices is, however, rather different in each phase. Well-defined lee vortex dipoles or continuous vortex shedding (depending on the specific situation) tend to occur only in a decelerating large-scale flow; in the accelerating phase the vortices are smaller and not as well defined. Two factors are identified that might induce such asymmetry: 1) background flow acceleration/deceleration and 2) large-scale difluence/confluence (which must accompany large-scale acceleration and deceleration in dynamically consistent synoptic systems). To determine the relative importance of these factors, we compare the vortices in simulations with steady fields of confluence or difluence with the vortices appearing in a time-dependent horizontally uniform background flow that evolves in the same manner as the flow at the ridge crest in the dynamically consistent synoptic system. These comparisons show that even though large-scale difluence and confluence can alter the wake and vortex structures, the acceleration and deceleration of the background flow plays a much larger role in modulating the strength and character of the lee vortices.