A Resonant Instability of Steady Mountain Waves

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When density-stratified air is forced by winds over elevated terrain, the vertical displacement of the flow results in a downstream pattern of dispersing waves. The effects of these gravity waves can often be visualized through clouds which do not drift with the winds, but remain stationary with respect to the topography. Such vertical disturbances to the flow are important in the understanding of the microscale variations in cloud and precipitation patterns for alpine communities (and ski resorts). Intense wave activity is also an aviation hazard when encountered as in-flight turbulence. R. Long (1953) made the remarkable discovery that, in a special case of twodimensional steady, stratified flow, the nonlinear streamfunction satisfies the linear Helmholtz equation. Surprisingly, it is only recently that very careful flow simulations for multiply-peaked terrain have revealed that these steady solutions can be unstable. The nonlinear mechanism behind this instability is a parametric resonance of counter-propagating gravity waves. This result determines that the critical topographic height required for the onset of turbulent flow is in fact considerably lower than the overturning condition as traditionally established by steady flow theory.

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