Gravity Wave Instability Dynamics in Mesospheric Stratification and Shear Environments

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An anelastic numerical model is used to explore gravity wave instability dynamics in variable stratification and shear environments in the mesosphere and lower thermosphere (MLT). Recent computational advances facilitate the characterization of localized gravity wave packets in a deep atmosphere, enabling realistic amplitude evolution and enhanced sensitivity to transient nonlinear dynamics. The results reveal that gravity wave packets impinging on a sheet of high stratification and shear enable local Kelvin-Helmholtz instabilities (KHI) where gravity wave vertical displacements approach their maxima and mean and gravity wave shears combine. The KHI arise at smaller scales and evolve to larger scales with time, as seen in lidar, radar, and airglow observations. Such events tend to be highly localized and thus yield local energy and momentum deposition expected to have strong influences throughout the mesosphere, thermosphere, and ionosphere (MTI) region. These simulations illuminate one of the major mechanisms driving turbulence and mixing in the MLT at scales that are challenging or impossible to describe quantitatively with existing measurement capabilities.

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