Geophysical Research Abstracts
Vol. 17, EGU2015-4148-1, 2015
EGU General Assembly 2015

Dissipation of atmospheric waves in the vicinity of a caustic

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Wave energy dissipation through irreversible thermodynamic processes is a major factor influencing propagation of acoustic and gravity waves in the Earth's atmosphere. Accurate modeling of the wave dissipation is important in a wide range of problems from understanding the momentum and energy transport by waves into the upper atmosphere to predicting long-range propagation of infrasound to the acoustic remote sensing of mesospheric and thermospheric winds. Variations with height of the mass density, kinematic viscosity, and other physical parameters of the atmosphere have a profound effect on the wave dissipation and its frequency dependence. Recently, an asymptotic theory has been developed, which quantifies the dissipation of acoustic-gravity waves without resorting to traditional but unrealistic assumptions regarding spatial variation of the kinematic viscosity and thermal conductivity in the atmosphere. The theory assumes that air temperature and wind velocity vary gradually with height and horizontal coordinates and is valid under the same conditions as the ray theory of acoustic-gravity waves. Wave amplitude increases significantly in the vicinity of turning points of quasi-plane waves and, more generally, in the vicinity of caustics, where the ray theory does not apply. Dissipation of acoustic-gravity waves in the middle and upper atmosphere is expected to be at maximum in the vicinity of their turning points. In this paper, we extend the asymptotic theory of the atmospheric wave dissipation to include caustics. The atmosphere is modeled as a neutral, three-dimensionally inhomogeneous, moving ideal gas of variable composition. We study physical processes in the vicinity of simple caustics to quantify the contribution of this region into the overall dissipation of acoustic-gravity waves and infrasound and to describe the competition between the focusing due to diffraction and the attenuation due to dissipation. The importance of the interplay between the diffraction and the dissipation is evaluated by comparing the predictions of the ray and diffraction theories.