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Numerical Modeling of Nonlinear Acoustic-Gravity Wave Propagation from the Earth's Surface to the Upper Atmosphere

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Three-dimension algorithm for numerical simulation of vertical propagation and breaking of nonlinear acoustic-gravity waves (AGWs) from the Earth's surface to the upper atmosphere is developed. The 3D algorithm for hydrodynamic equation solution uses finite-difference analogues of basic conservation laws. This approach allows us to select physically correct generalized wave solutions of hydrodynamic equations.
Horizontally moving periodical horizontal sinusoidal structures of vertical velocity on the Earth's surface serve as AGW sources in the model. The numerical simulation covers altitudes from the ground up to 500 km. Vertical profiles of the mean temperature, density, molecular viscosity and thermal conductivity are specified from standard models of the atmosphere. Calculations are made for different amplitudes, horizontal wavelengths and speeds of wave sources at the bottom of the atmosphere. When AGW amplitudes increase with height, waves may break down in the middle and upper atmosphere.
After activating tropospheric wave sources, AGW very quickly (in a few minutes) may reach high altitudes up to 100 km and above. Instability and dissipation of wave energy may lead to formations of wave accelerations of the mean winds and to creations of wave-induced jet flows in the middle and upper atmosphere. Nonlinear interactions may lead to instabilities of the initial wave and to the creation of smaller-scale structures. These smaller inhomogeneities may increase temperature and wind gradients and enhance the wave energy dissipation. Thus, the increase in AGW amplitudes in the upper atmosphere may occur at a much slower pace than the increase in amplitudes of tropospheric wave sources.
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