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Comparisons of Linear and Nonlinear Numerical Models of Acoustic-Gravity Wave Propagation in the Middle and Upper Atmosphere.

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According to present knowledge, acoustic-gravity waves (AGWs) observed in the upper atmosphere may arise near the Earth surface due to different sources and propagate upwards. Algorithms for two- and three-dimensional numerical simulation of vertical propagation and breaking of nonlinear AGWs from the Earth's surface to the upper atmosphere were developed recently. The algorithms of the solution of fluid dynamic equations use finite-difference analogues of basic conservation laws. This approach allows us to select physically correct generalized wave solutions of the nonlinear equations. Horizontally moving periodical horizontal sinusoidal structures of vertical velocity on the Earth's surface serve as AGW sources in the model. Numerical simulation was made in a region of the Earth atmosphere with dimensions up to several thousand kilometers horizontally and 500 km vertically. Vertical profiles of the mean temperature, density, molecular viscosity and thermal conductivity correspond to standard models of the atmosphere.

Comparisons of amplitudes of wave variations of atmospheric characteristics simulated using linear and nonlinear numerical models could be helpful for testing these models and for further understanding peculiarities of AGW propagation in the atmosphere. In this study, we performed high-resolution numerical simulations of nonlinear AGW propagation at altitudes 0 – 500 km from a plane wave forcing at the Earth's surface and compared them with similar simulations using a linear AGW model. Reasonable agreements between simulated wave parameters proof adequacy of both numerical model. Significant differences between them reveal circumstances, when linear model gives substantial errors and nonlinear numerical simulations of wave fields are required. In addition, direct numerical AGW simulations may be useful tools for testing simplified parameterizations of wave effects in the atmosphere.