P1.1-115

The influence of acoustic and internal gravity waves from atmospheric storms on the parameters of the upper atmosphere

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INTRODUCTION AND MAIN RESULTS

This presentation provides numerical modeling results of the propagation of atmospheric waves before atmospheric storms in the Moscow region. Experimental observations from a network of four microbarographs located in the Moscow region were taken as a source of disturbances.

It was obtained wave characteristics of disturbances in the upper atmosphere caused by the generation of acoustic and internal gravity waves from atmospheric storms. Numerical calculations showed the formation of local heating areas form in the upper layers of the atmosphere, which affects wave propagation.

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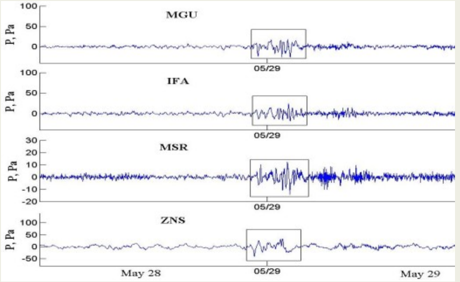
Introduction

This work proposes a new approach to account for AGWs and IGWs generated by a tropospheric meteorological source in a large-scale model: modeling of AGWs propagation using a high-resolution nonlinear hydrodynamic model of the atmosphere with a perturbation source specified on the basis of experimental data; calculation of the local spectral characteristics of the observed waves; calculation of the heat flux due to the propagation of the calculated waves; inclusion of the calculated heat flux as an additional source in the large-scale model [1].

Methods/Data



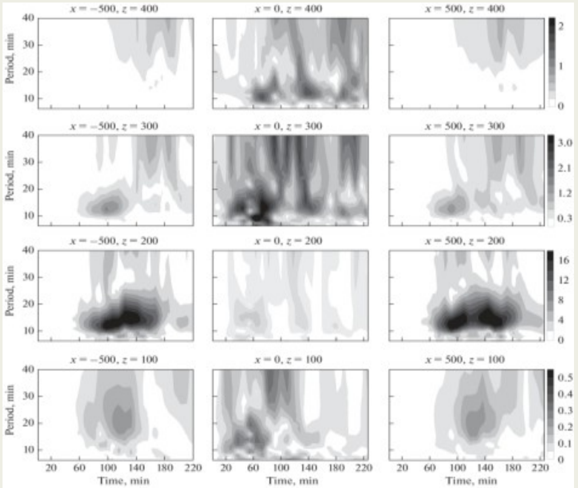
- Atmospheric pressure variations on the Earth's surface, recorded on a network of four microbarographs located in the Moscow region on May 29, 2017, during the passage of an atmospheric storm.

Pressure variations were used as a source of disturbances at the lower boundary.

[1] Kurdyaeva, Y., Borchevkina, O., Golikova E., Karpov I. Bulletin of the Russian Academy of Sciences: Physics, 2024, Vol. 88, No. 3, pp. 412–418.
[2] Gavrilov, N.M. and Kshevetskii, S.P., Earth, Planets Space, 2014, vol. 66, no. 1, p. 88.
[3] Kshevetskii, S., Borchevkina, O., Kurdyaeva, Y., et al., Pure Appl. Geophys., 2020, vol. 177, no. 11, p. 5567.

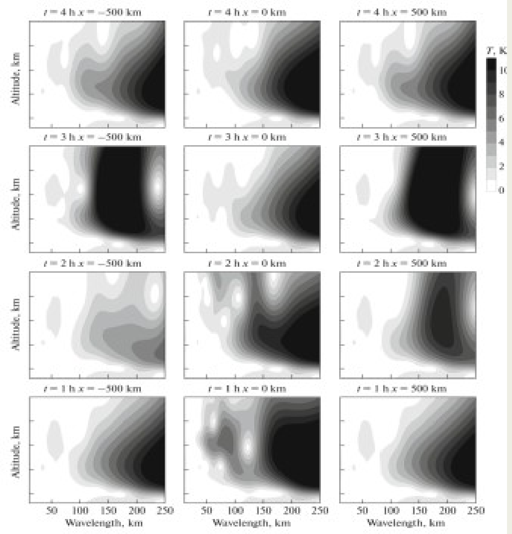
- A three-dimensional version of the high-resolution nonlinear numerical model AtmoSym [2]. was used for the simulation. The model is based on the solution of a system of nonlinear hydrodynamic equations and is adapted to solve problems of the wave propagation from pressure variations on the Earth's surface [3].

Results



Frequency characteristics of fluctuations in wave temperature at different altitudes and points (x and z are the horizontal and vertical coordinates, respectively). The center of the source was determined at the lower boundary in the area of point x = 0 km.

- The results of the spectral analysis showed that already 30 minutes after the start of the source operation at an altitude of 100 km, waves with periods of 10-15 minutes are observed, waves with periods of 15-30 minutes are observed 120 minutes after the start of the source operation at a distance of 500 km from the source.



Wavelet analysis of the vertical structure of temperature disturbances, obtained with numerical calculations to distinguish the characteristics of waves in the thermosphere. The center of the source was determined at the lower boundary in the area of point x = 0 km.

Conclusions

Results from numerical modeling showed that our meteorological source generated mainly small-scale IGWs with frequencies close to the Brunt–Väisälä frequency. At altitude, however, they can propagate as infrasonic waves since the values of the Brunt–Väisälä frequency and the acoustic cutoff in a non-isothermal atmosphere change. Local heating regions form in the upper atmosphere over time, affecting the propagation of waves and complicating the interpretation of possible experimental results on the considered atmospheric waves.