Case studies of dynamic characteristics of atmospheric planetary waves during stratospheric warmings in winter 2008

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Abstract

This paper offers a method for investigating characteristics of propagation of wave-like temperature disturbances were observed at the height range of 20–100 km during development of the sudden winter stratospheric warmings in January–February 2008. Satellite data on vertical temperature distribution obtained by the Microwave Limb Sounder (MLS) aboard the spacecraft EOS Aura were used. In an approaching of two wave model the propagation directions of disturbances were calculated. Vorticity-like behavior of horizontal wave numbers structure was shown. Periods of disturbances vary from 11 to 27 days. Vertical wave numbers range is 35-80 km.

1. Introduction

We examined dynamic characteristics of atmospheric planetary waves observed during sudden winter stratospheric warmings (SSW) in winter 2008. Vertical temperature profiles are obtained by the Microwave Limb Sounder (MLS) aboard the spacecraft EOS Aura. Winter 2008 SSW was so strong that it effect on ionospheric characteristics. We observed high correlation between disturbances of temperature and digisonde minimum frequency of reflection. Temperatures and variations of temperature and minimum frequency of reflection in Irkutsk, Norilsk and Yakutsk are shown I figure 1.

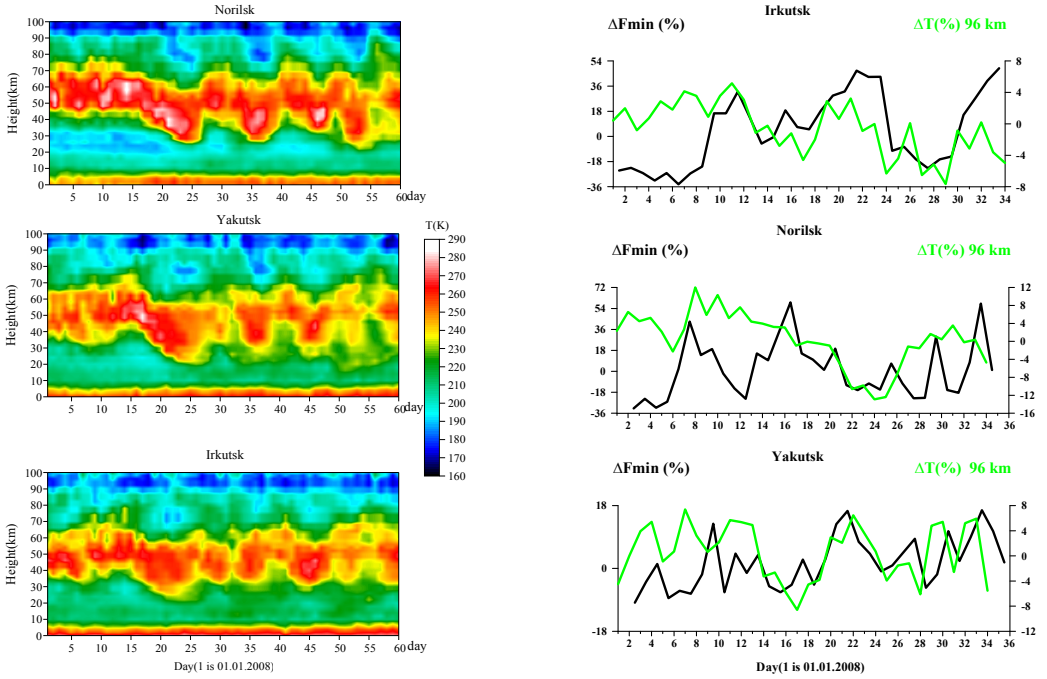

Figure 1. a) Temperatures in Irkutsk, Norilsk and Yakutsk b) Variations of temperature (green) and minimum frequency of reflection (black) in Irkutsk, Norilsk and Yakutsk

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2. Analysis method

Primarily we supposed to study disturbances propagation using the method developed for traveling ionospheric disturbances [1]. Method is based on one plane wave assumption. Dynamic characteristic are estimated by full cross-correlation technique. Unfortunately, the calculation showed high altitude-temporary variability and also for each geographic location it is seen low altitude correlation, but there is high longitude and latitude correlation (se figure 2) [2].

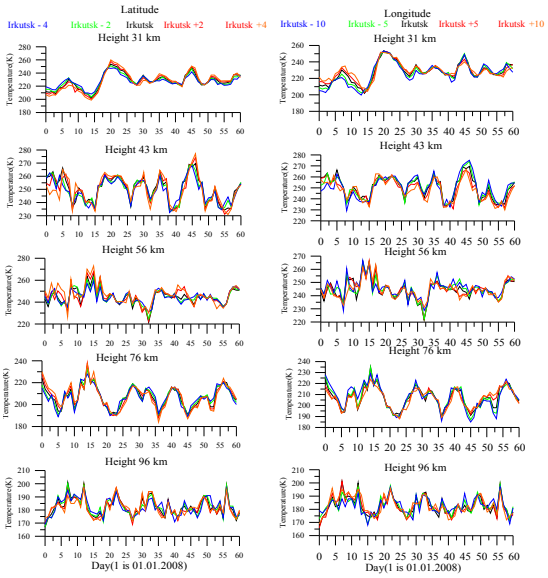

Figure 2. Temperature in different points and different altitudes

The analysis of temperature disturbances showed that complicate lozengelike altitude-temporary structure repeats itself in wide longitude-latitude sector.

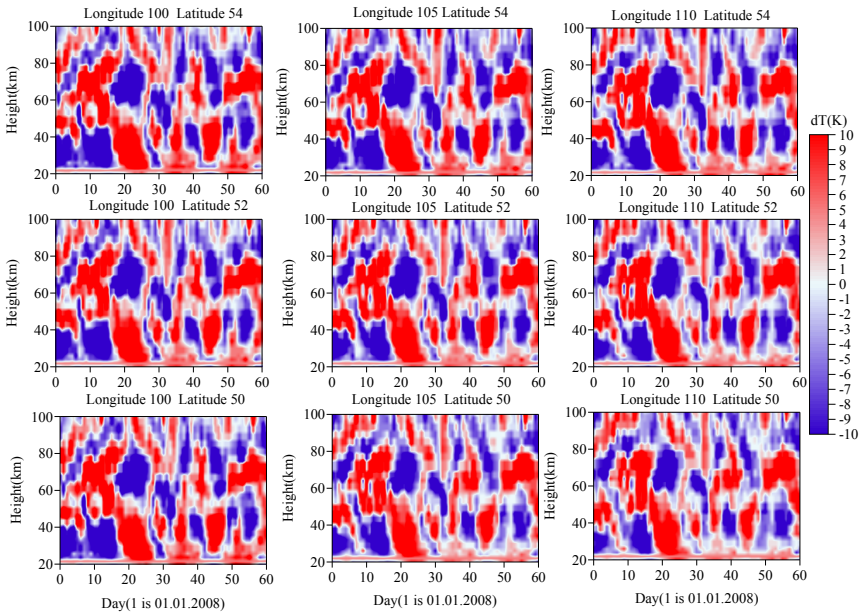

Figure 3. Temperature disturbances in different points. (we used contrast scale here).

In our opinion this structure is due to interference of several disturbances. The simplest model, which explain lozengelike altitude-temporary structure, is the model of 2 waves: upward and downward.

$$\Delta T = A\sin(\omega t - k_z z + \varphi_1) + B\sin(\omega t + k_z z + \varphi_2) \quad (1)$$

The optimal parameters: amplitudes (A, B), phases (φ1, φ2), frequency ω and vertical wave number kz were calculated for each point and its nearest neighbors(only nine points) by the RMS method. Frequency and vertical wave number are common for all of nine points, amplitudes and phases own for each point. Longitude and the latitude wave numbers were determined for a central point as derivative phases on longitude and latitude accordingly. Thus, we have received a propagation direction of disturbances for each point of space.

3. Results

In details we have studied SSW maximal phase (January 12-30 of 2008). The results are shown in figures below.

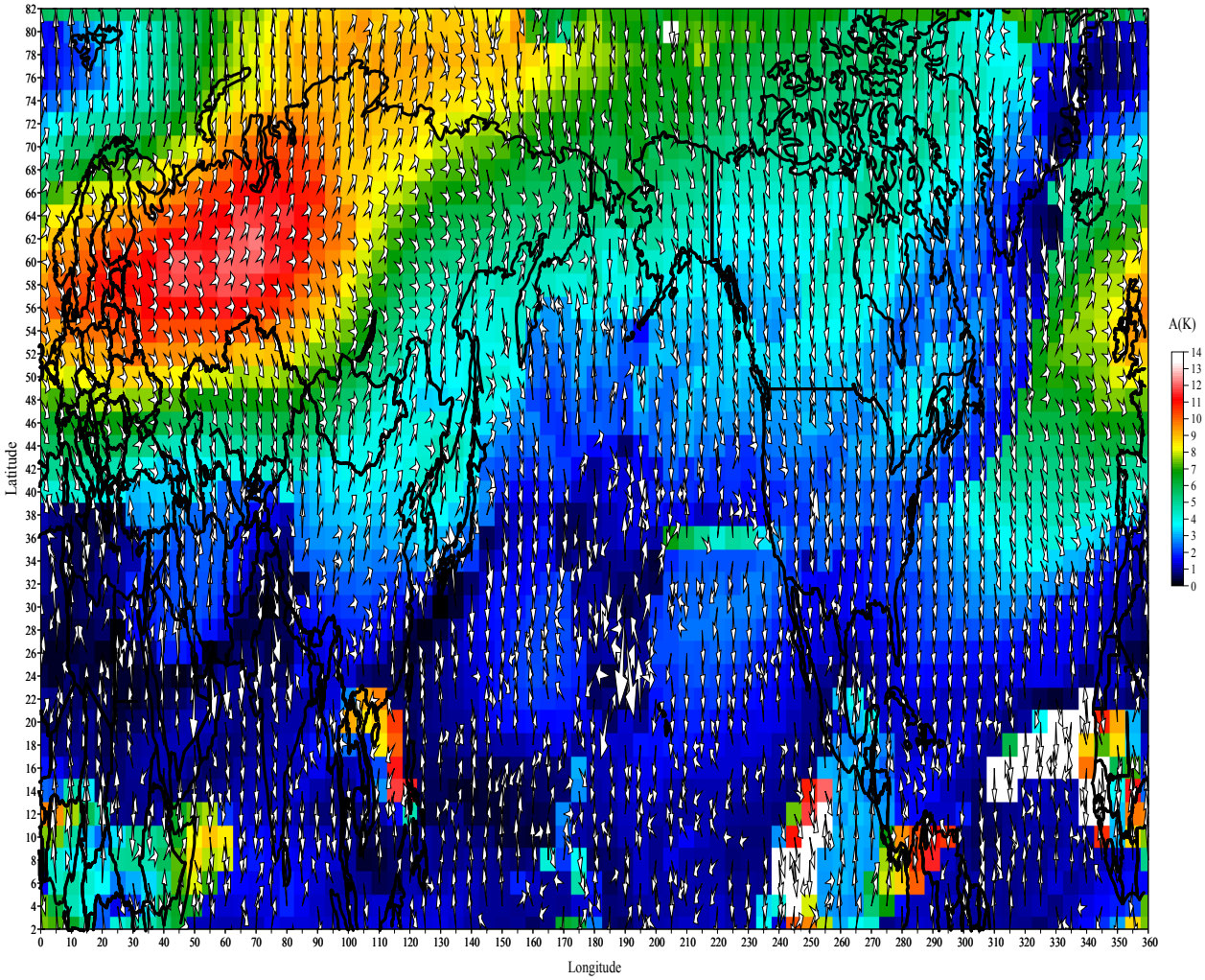

Figure 4. Upward wave: Horizontal wave numbers structure on amplitude upward wave

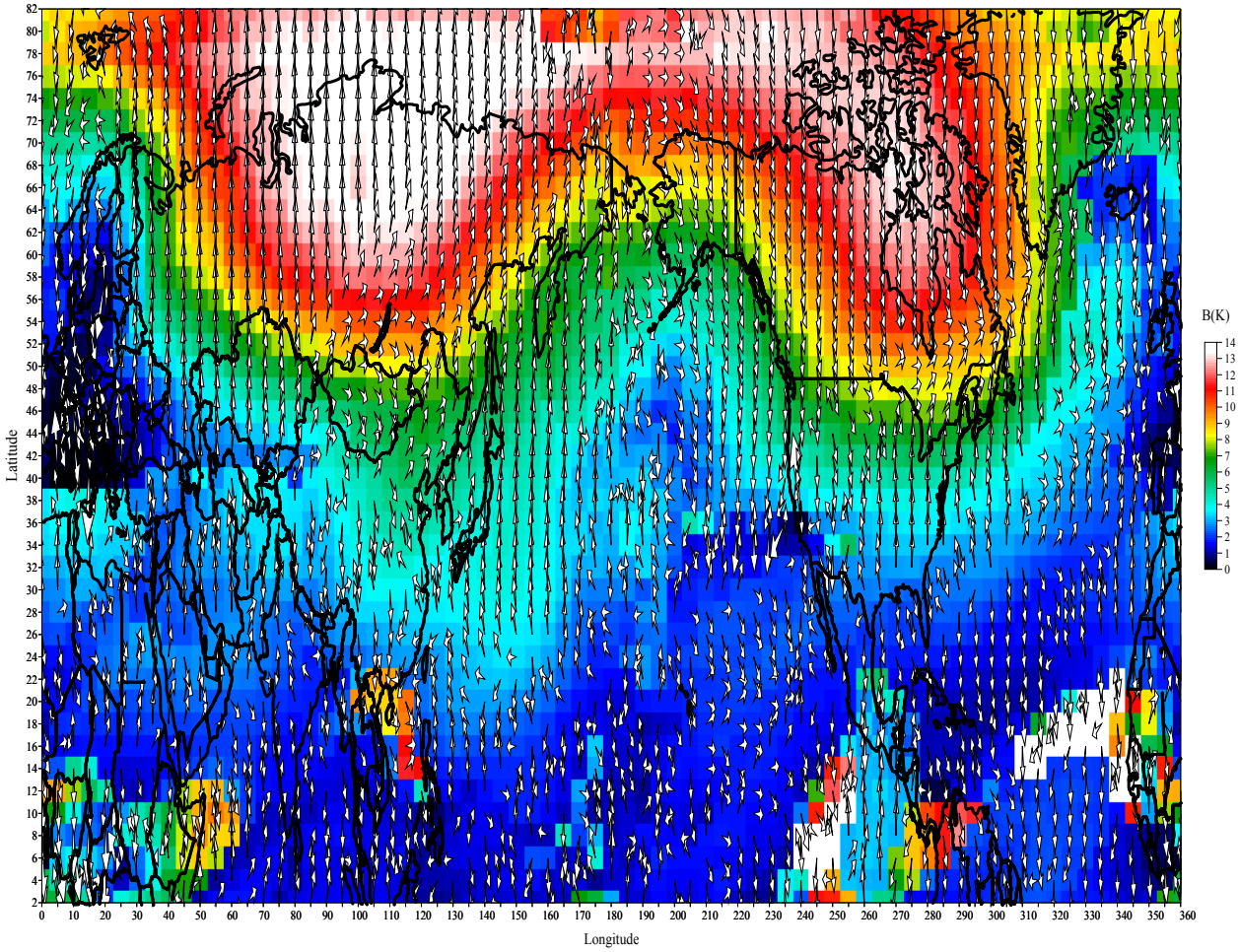

Figure 5. Downward wave: Horizontal wave numbers structure on amplitude downward wave

4. Conclusion

1) Method based on one plane wave assumption does not give adequate dynamic characteristics of SSW disturbances.
2) Method based on 2 waves gives the follows results:
   a) Horizontal wave numbers structure shows vorticity-like behavior
   b) Periods of disturbances vary from 11 to 27 days
   c) Vertical wave numbers range is 35-80 km .

5. Acknowledgments

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6. References

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2) Marina Chernigovskaya, Andrey Medvedev, Maxim Tolstikov, Irina Medvedeva, and Konstantin Ratovsky Dynamic characteristics of atmospheric planetary waves during stratospheric warmings in winter 2008 // Geophysical Research Abstracts Vol. 12, EGU2010-7610, 2010 EGU General Assembly 2010