"Physics of Auroral Phenomena", Proc. XLI Annual Seminar, Apatity, pp. 164-167, 2018

Polar Geophysical Institute

DOI: 10.25702/KSC.2588-0039.2018.41.164-167

SIMULTANEOUS MONITORING OF MIDDLE ATMOSPHERE OZONE AT APATITY AND PETERHOF IN THE WINTER 2017/2018

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Introduction

We present preliminary results of observations of the ozone emission line in winter 2017/2018 by method of microwave radiometry. Measurements of spectra of middle atmosphere ozone were executed with the help of two of mobile ozonemeters (observation frequency 110836.04 MHz). One spectrometer was installed at physical faculty in Peterhof (60N, 30E) in 28 km from the centre of Saint Petersburg [1]. Another spectrometer was installed at Polar Geophysical Institute in Apatity (67N, 33E). Both devices had identical techniques as measurement and an estimation of vertical structures of ozone. Results of joint ground-based measurements of middle atmosphere ozone content with the use microwave equipment are presented. The importance of similar observations in the studying of the influence of various disturbances on ozone layer is discussed. The comparative analysis of received results with satellite MLS/Aura data, and also with ozonesonde data at station Sodankyla (67N, 27E) and with model profiles is given.

Microwave ground-based equipment used in the experiment

Method ground-based microwave radiometry is based on measurements of thermal atmospheric radiation in vicinity the ozone line in the range of millimeter and submillimeter waves. Microwave observations are weakly dependent on weather conditions and the presence of atmospheric aerosols, and this is an advantage compared with observations in the optical and infrared wavelength ranges. In addition, the microwave ozone observations can run around the clock. In recent years it is managed to make a significant step forward towards the creation of a new generation of mobile microwave spectrometers [2]. The device consists of an uncooled heterodyne receiver tuned to a fixed frequency 110836.04 MHz corresponding to a rotational transition of ozone molecules $6_{0,6}$– $6_{1,5}$, and multichannel spectrum analyzer. In front of receiver is a module that includes an antenna (scalar horn) and a switch to calibrate accepted intensity of atmospheric ozone line radiation. The beam width (by level -3 dB) of the horn antenna is 5.4°. The SSB noise temperature of the receiver is 2500 K. The SSB receive mode is provided by evanescent filter with direct losses of 0.5 dB and the suppression of the image channel of more than 20 dB. The spectrum analyzer consists of 31 filters with a variable bandwidth from 1 MHz to 10 MHz and a full analysis bandwidth of 240 MHz. The parameters of the device allow to measure a spectrum of the emission ozone line for time about 15 min with a precision of ~ 2%. Measurement of the spectra of thermal radiation is performed by a method of calibration for two "black body" loads that are at the boiling point of liquid nitrogen and at ambient temperature. Information about the content of the O_3 is contained in the measured radio emission spectrum of the middle atmosphere. Using the inversion of the obtained spectra it is possible to obtain data on the vertical distribution of ozone in the atmosphere. The criterion of the accuracy of inverse problem solution is the best fit ozone spectral lines calculated by the retrieved profile of the O_3 concentration to the original experimental spectrum. The error of estimating the vertical distribution of ozone on the measured spectra by above described device does not exceed 20%.

The results of observations and discussion

In winter of 2017/2018 in Apatity the total duration of microwave observations was 40 days. There were three continuous series with a temporal resolution of 15 min from 22.12.2017 to 28.12.2017, from 19.02.2018 to 22.02.2018 and from 13.03.2018 to 16.03.2018. All observations in Apatity were supported by microwave measurements in Peterhof from 01.11.2017 to 31.03.2018. Unfortunately, now observation data have not been fully processed. It should be noted that continuous series were planned to reveal the influence of charged particles on the content of mesospheric ozone in the auroral zone (Apatity). The first series at the end of December was held at a very low altitude of the Sun at noon - in condition of the "polar night". Under these conditions it can be expected that sunlight does not affect the behavior of mesospheric ozone during the day.

On Fig. 1 MLS/Aura satellite measurements temperature data over Apatity at the level of 10 hPa corresponding to approximately height of 30 km for winter of 2017/2018 are given. This winter there was a sudden stratospheric warming in the middle of February, 2018. The warming lasted about a week. The maximum temperature rose to 240K on February, 16, which is higher on 50 K of the mid-temperature the January. The development of the stratospheric warming over the Apatity occurred under the classical scheme [3] from top to bottom. Experimental confirmation of this scheme can be found in [4, 5].

In Fig. 2 shown the temporal variations of ozone density (ground-based microwave data) and temperature MLS/Aura data (thick continuous line) at 25, 40 and 60 km in the winter 2017/2018. On the lower panel shown the variations of ozone density (open rhombuses) at altitude 25 km. In addition, here direct measurements of ozone density (balloon probe data) at an altitude of 25 km in the meteorological station of Sodankyla marked by black squares are given. This station is located in close proximity to the Apatity station at the same latitude. On the middle panel Fig. 2 the O_3 density variations at an altitude of 40 km (thin line) according to MLS/Aura are shown.

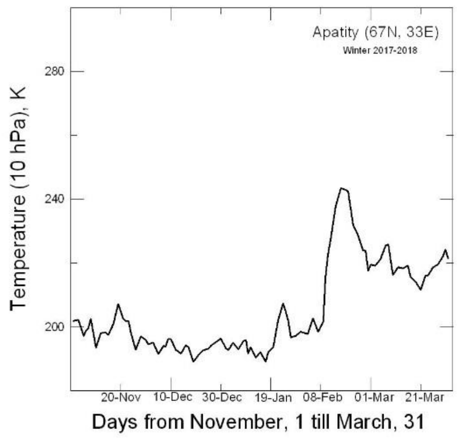

Figure 1. Change of temperature in the course of time at a level 10 hPa over Apatity in the winter 2017/2018 (MLS/Aura data)

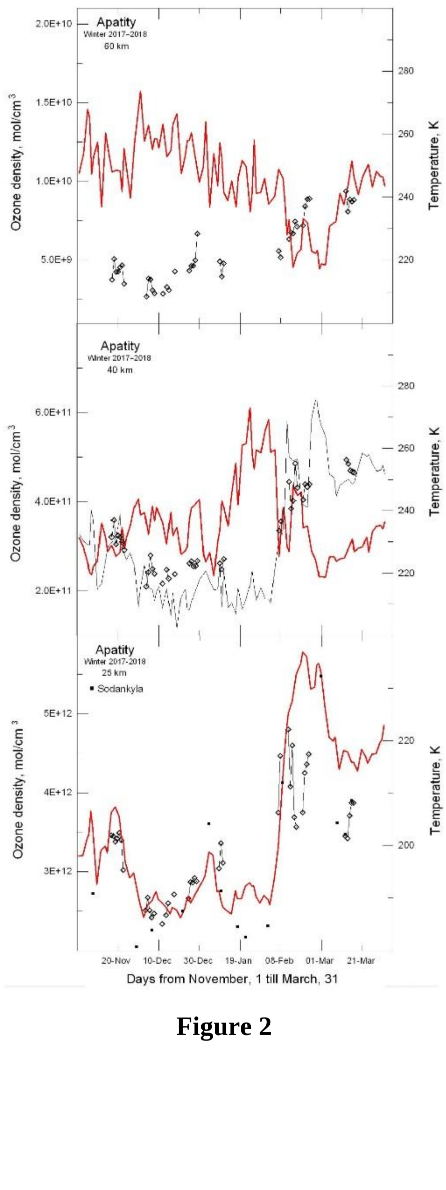

Figure 2

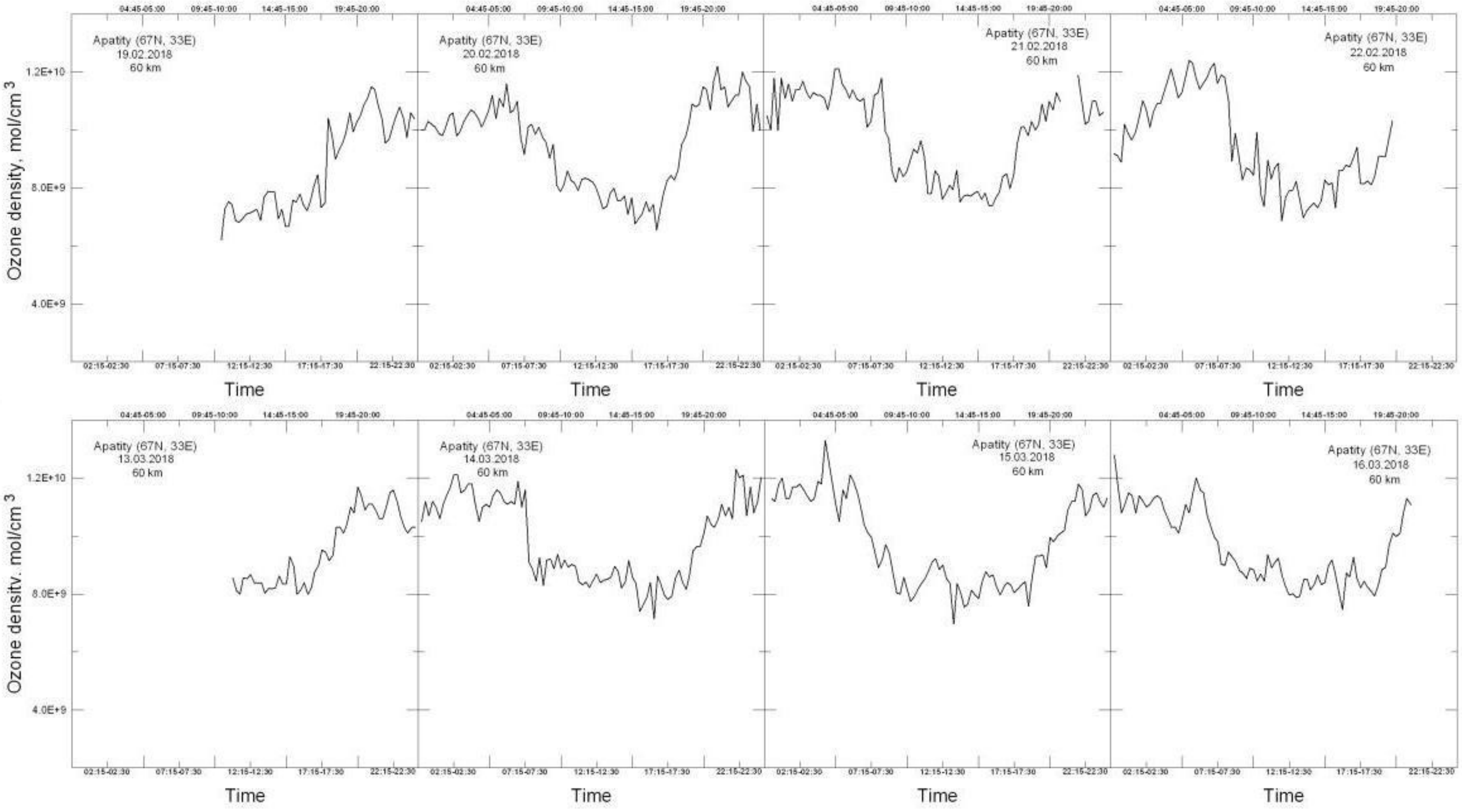

Figure 3. Diurnal variations of ozone at height 60 km in continuous series of microwave measurements from 19.02.2018 till 22.02.2018 and from 13.03.2018 till 16.03.2018. The temporal resolution of 15 min.

On the Fig. 3 changes in mesospheric ozone at an altitude of 60 km for two continuous observation series in February and March 2018 are presented. The average amplitude of diurnal variations of O_3 was about 30%.

On the Fig. 4 the diurnal changes in mesospheric ozone at an altitude of 60 km during the polar night 28.12.2017 are shown. Note the significant variations in the O_3 density, which apparently are not associated with sunrise and sunset. The amplitude of changes in ozone density reached 80%. Nevertheless the variations in the O_3 density correlate with the diurnal changes in O_3 concentrations at the altitudes of the mesosphere modeled by *Rodrigo et al.* [6,7] for mid- latitudes.

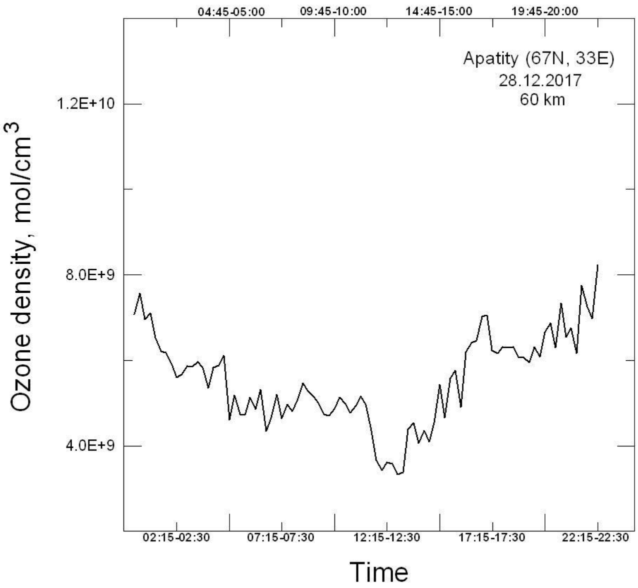

Figure 4

Conclusion

1. We show the new results of studying the dynamics of ozone content in the middle atmosphere over Apatity (67N, 33E) during the winter 2017/2018 by the microwave radiometry method.
2. Microwave results (vertical distribution of ozone) were compared with satellite data – altitude profiles of ozone and temperature in the layer of 20-60 km (MLS/Aura), and also with ozonesonde data at stations Sodankyla (68N, 27E).
3. Unusual diurnal variations in ozone at altitude 60 km, which were caused by polar night in December 2017, were observed over Apatity.

Acknowledgments. The work was supported the RFBR grant 15-05-04249.

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