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MICROWAVE OBSERVATION OF MIDDLE ATMOSPHERE OZONE DURING POLAR NIGHT IN DECEMBER 2017 AND 2018 IN APATITY

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Abstract. We present data continuous series of microwave observations of the middle atmosphere in December 2017 and 2018. Measurements were carried out with the help of mobile ozonemeter (observation frequency 110836.04 MHz), which was established at Polar Geophysical Institute in Apatity (67N, 33E). The parameters of the device allow to measure a spectrum of the ozone emission line for time about 15 min a precision of ~ 2%. On the measured spectra were appreciated of ozone vertical profiles in the layer of 22 – 60 km which were compared to satellite data MLS/Aura and with the data of ozonesonde at station Sodankyla (67N, 27E). The microwave data on the behavior of mesospheric ozone (altitude 60 km) indicate the presence of both photochemical and dynamic components in its changes.

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 [1]. In a Fig. 1 the general view of the device is given.

Figure 1. General view of a mobile microwave ozonemeter in Polar Geophysical Institute.

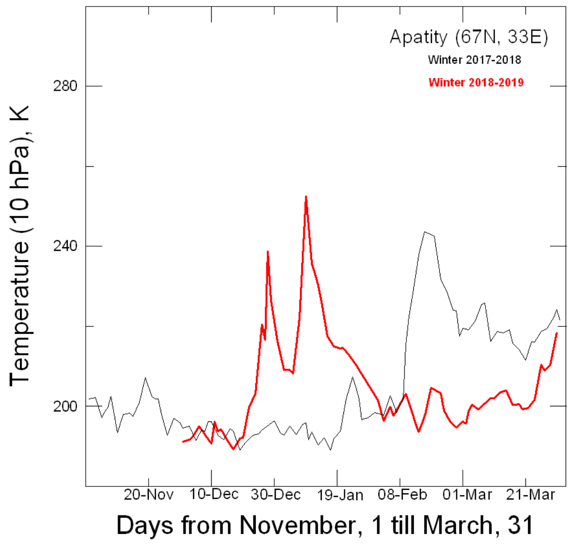

Figure 2. Changes of temperature at a level 10 hPa for winters 2017-2018 and 2018-2019 above Apatity (MLS/Aura data).

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. 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 error of estimating the vertical distribution of ozone on the measured spectra by above described device does not exceed 10-15%.

The results of observations and discussion

In Fig. 2 changes of temperature at a level 10 hPa above Apatity for two winters 2017-2018 and 2018-2019 during ground-based microwave observation of the middle atmosphere ozone were carried out are submitted. It is known, that sudden stratospheric warming (SSW) when at heights of a middle atmosphere changes of temperature on ten degrees are observed, influence on structure of terrestrial atmosphere [2, 3]. The winter 2017-2018 there was SSW in the middle of February, 2018. The warming lasted about a week. The maximum temperature rose to 240 K on February, 16, which is higher on 50 K of the mid-temperature the January. In the winter 2018-2019 SSW began December, 27 both has terminated February, 1 and there were duration almost 40 days (see Fig. 2). Prominent feature of warming was presence of two maxima of temperature at height about 30 km. The first maximum of temperature had value 239 K (28.12.2018), that has made an increment concerning average temperature of the not indignant stratosphere in December till 24.12.2018 about 45 K. Second maximum of temperature has made 252 K 09.01.2019 which had concerning average temperature for the period from 01.02.2019 up to 01.03.2019 value 54 K. Thus, development SSW for two winters had completely different character. For us that the middle atmosphere during a winter solstice in December was not indignant of dynamic processes is important. It necessary to note, that in simultaneous microwave observation in subpolar and mid-latitudes Peterhof (60N, 30E) and Tomsk (56N, 85E) the essential difference on value and durations in indignations of a middle atmosphere ozone during SSW in the winter 2013-2014 was found out [4].

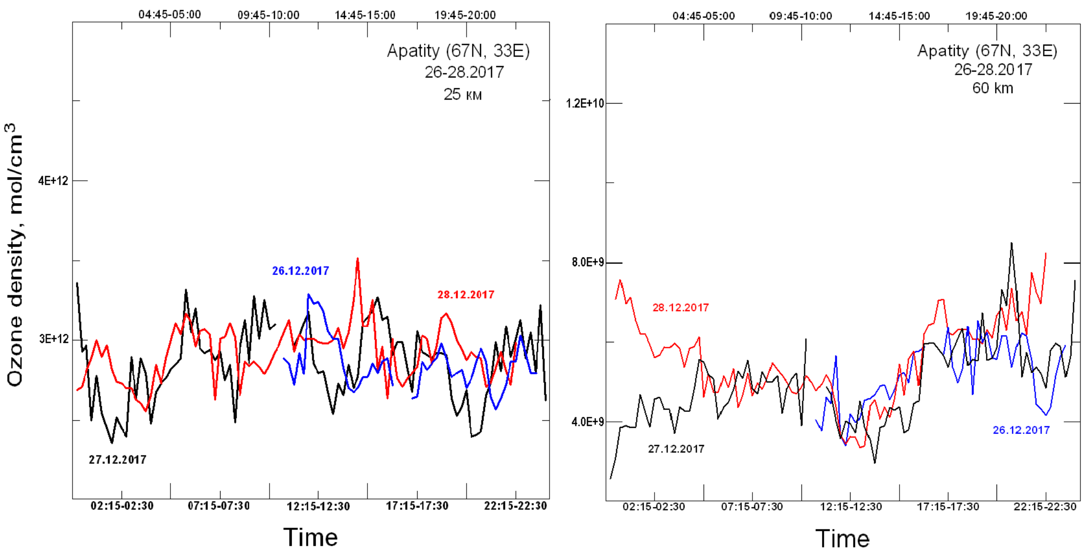

Figure 3. Diurnal variations of ozone density at 25 km (*left panel*) and 60 km (*right panel*) from ground-based microwave observation 26-28.12.2017 during polar night. Maximal height of the Sun over horizon in midday - 1°.

In Fig. 3 changes of ozone at heights of 25 and 60 km which were received from continuous microwave observations in December, 2017 with of temporal resolution 15 min are shown. Well appreciably that of ozone concentration at height of 25 km changes within day a little. Daily variations of mesospheric ozone (60 km) find out characteristic decreasing of its concentration in area of local midday practically on a constant for three days. Decreasing of ozone concentration in midday concerning midnight has made 25%. The values of the O_3 concentration increase at night, mainly due to the absence of O_3 photodissociation and the changing $[O]/[O_3]$ ratio [5]. The attention a significant divergence (in 1.5-2 times) in ozone concentration at night for 27.12.2017 and 28.12.2017 pays to itself. Probably, it is caused by horizontal carry of air in mesosphere.

In Fig. 4 daily variations mesospheric ozone (60 km) which were received from two series of continuous microwave measurements near to a winter solstice in December 2017 and 2018 are resulted. The scale of diurnal variations O_3 connected to photochemistry in different years in December has close values. The average value of diurnal fluctuations of ozone in December 2018 has made 26%. The attention gradual growth of mesospheric ozone at polar night within 4 day more than on 30% in December 2018 involves in itself.

The numerical data on an average daily course of mesospheric ozone which is connected to rising and sunset are collected in the Table at the end of the text for December 2017 and 2018.

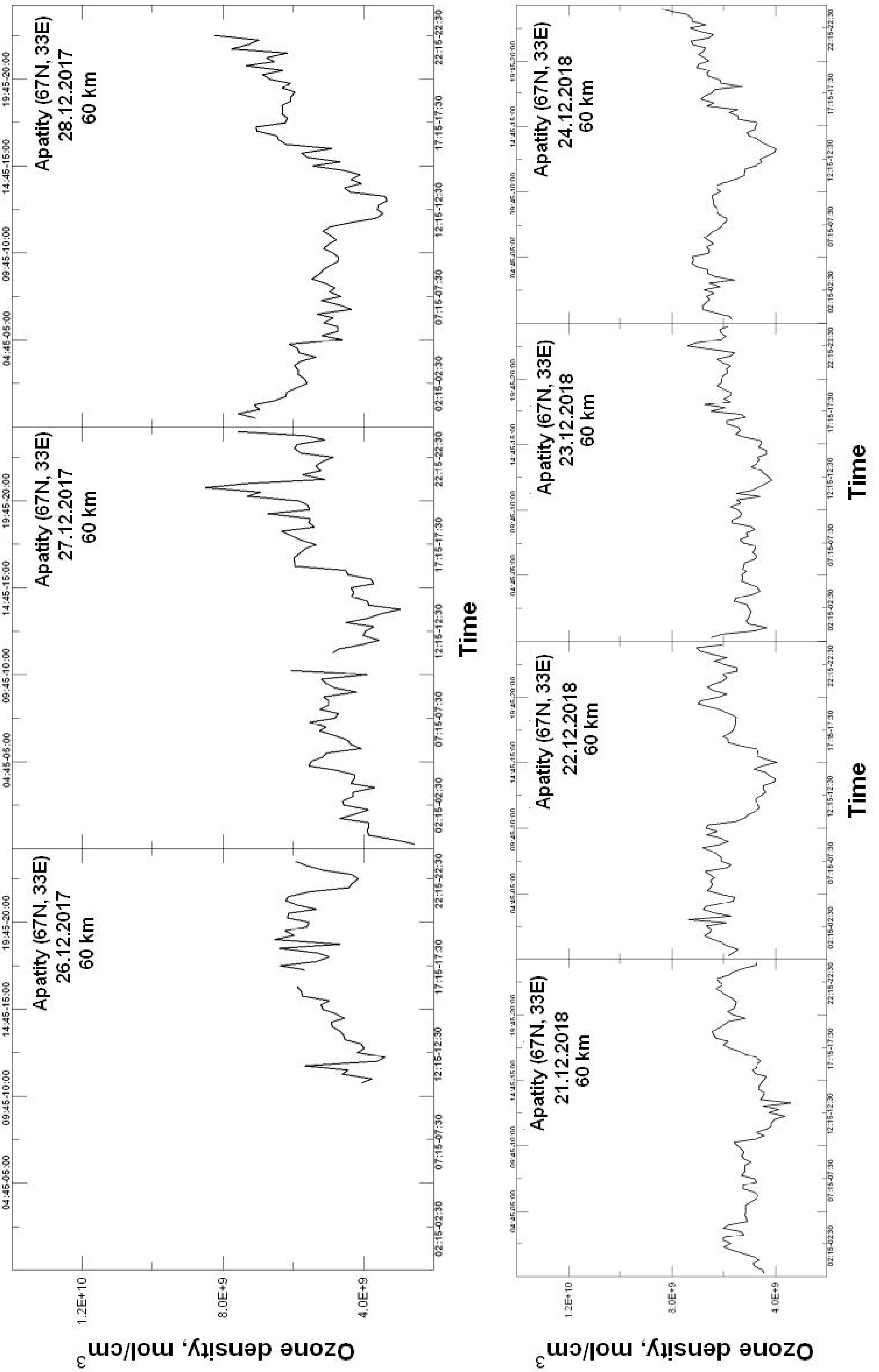

Figure 4. Diurnal variations of mesospheric ozone density (60 km) from MM-measurements in 26-28 December, 2017 and 21-24 December, 2018 at polar latitude

Table

Diurnal variations of mesospheric ozone (60 km)

	10:00 – 14:00	22:00 – 02:00	
26.12.2017	(4.32±0.15)(09)		
		(4.25±0.23)(09)	
27.12.2017	(4.12±0.20)(09)		
		(6.24±0.22)(09)	
28.12.2017	(4.28±0.16)(09)		25%
20.12.2018	(4.35±0.12)(09)		
		(5.30±0.13)(09)	
21.12.2018	(4.34±0.12)(09)		
		(5.84±0.14)(09)	
22.12.2018	(4.77±0.15)(09)		
		(5.76±0.19)(09)	
23.12.2018	(4.81±0.12)(09)		
		(6.44±0.12)(09)	
24.12.2018	(4.95±0.18)(09)		26%

Conclusion

1. The important result of the present work is renewal of microwave monitoring of the middle atmosphere ozone in Arctic.
2. For the first time the data on behaviour mesospheric ozone are received during a polar night in continuous observations with temporal resolution oh 15 min.
3. Variability mesospheric ozone (60 km) is determined both photochemistry, and dynamic processes.

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