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DYNAMICS OF THE GROUND-LEVEL OZONE IN THE KOLA PENINSULA AT DIFFERENT LEVELS OF ANTHROPOGENIC POLLUTION

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Abstract

Results of surface ozone monitoring in the Kola Peninsula (Lovozero, Apatity) are discussed. During all seasons the ground-level ozone concentrations in the Kola Peninsula never exceed of the typical ozone concentrations at the upper level boundary of the mixed layer. As a rule, episodes of the higher ozone concentrations are accompanied by the higher nightly concentrations (correlation coefficient between the day maximum and the night minimum ozone concentrations are 0.6-0.7). During winter months in the Kola Peninsula there is practically no diurnal cycle of ozone concentration in rural site, while in the center of Apatity city in working hours there is a regular decrease of ozone concentration (up to 100 percent on some days). This decrease is caused by chemical destruction in reaction with NO, which is accumulated in the boundary layer in conditions of the surface inversion. This effect is not observed on weekends, when motor transport number is considerably cut down, or with the wind velocity exceeding 2 m/s, which provides turbulence dispersion of ozone destruction substances and the in-flow of fresh air from suburbs.

Introduction

The ground-level ozone concentration in the Kola Peninsula has been monitored at the geophysical observatory "Lovozero" since 1999 by UV-ozonometer "DASIBI 1008AH" (made in USA).

In addition, since 2002 the monitoring of the surface ozone concentration is done at some other two points: in the center of Apatity city (population about 75000 people), in its suburbs (2 km from the city limits). Here we used chemiluminescence ozonometer (made in PGI /1/) and UV-ozonometer "ML9810B" (made in England).

Experimental data and discussion

During all seasons the ground-level ozone concentrations in the Kola Peninsula never exceeds the typical ozone concentrations at the upper level boundary of the mixed layer, which determines apparently the upper limits of background concentrations by intensive turbulence exchange (according to data of the ozone sounding in observatory Sodankyla, which is placed 300 km in south-west direction). For over 90 % of the time (and more 99% during summer months) the background ozone concentrations are less than 40 ppb (Table).

The cases of the summer ozone concentrations above 55 ppb are never observed, but there take place spring increases of the background ozone concentrations under 63 ppb (probability is 0.04%).

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The maximal diurnal ozone concentrations at all monitoring points are correlating well (for all months correlation coefficients they are 0.8-0.9) and are closely approximating (± 2 ppb) in spite of different levels of anthropogenic emissions of ozone precursors. This is an argument in favour of the same mechanism form of the ground-level ozone field.

The frequency of the higher ozone concentration (> 25 ppb) in Lovozero and in Apatity city are practically the same (during summer 38.6 and 39.6% respectively). At the same time the frequency of the lower ozone (<10 ppb) concentrations in Apatity city is larger, than in Lovozero, because additional ozone destruction in condition of the man-made pollutions (during winter is 13.6 and 3.8 % respectively).

During winter months in the Kola Peninsula in conditions of low light and polar night (November-February), when the synoptic situation is preserved, there is practically no diurnal cycle of ozone concentration in rural site, while in the center of Apatity city in working hours there is a regular decrease of ozone concentration (up to 100 percent on some days) (Fig.1a). This decrease is caused by chemical destruction in reaction with NO, which is accumulated in the boundary layer in conditions of the surface inversion. This effect is not observed on weekends, when motor transport number is considerably cut down, or with the wind velocity exceeding 2 m/s, which provides turbulence dispersion of ozone destruction substances and the in-flow of fresh air from suburbs.

During spring and autumn months the ozone concentration decrease takes place in the morning and evening hours in conditions of surface inversion (fig 1b). In the midday hours, when the surface inversion is destroyed and turbulence exchange is becoming stronger, NO is taken out from the surface layer and the daily maximal ozone concentrations in Apatity and Lovozero are closely approximating.

Table. Background ozone frequency distributions in rural and urban sites.

	Lovozero					Apatity city				
Ozone, ppb	Winter	Spring	Summer	Automn	Year	Winter	Spring	Summer	Automn	Year
0…..5	0.42	0.0	0.49	1.6	0.53	6.0	0.17	2.3	4.2	3.6
5…10	3.4	0.18	3.6	6.4	3.1	7.5	0.58	5.3	9.8	5.8
10…15	8.4	1.3	8.9	13.7	7.5	13.2	1.0	10.0	15.6	10.1
15…20	15.4	3.7	20.6	22.1	14.7	17.9	4.8	17.8	21.3	15.6
20…25	20.2	7.5	27.8	29.0	20.3	19.2	7.9	25.0	24.4	19.0
25…30	24.6	16.6	18.2	19.6	19.9	16.6	16.1	24.1	19.1	18.8
30…35	18.9	29.8	11.7	6.4	18.0	11.7	23.1	10.0	5.3	12.8
35…40	8.3	28.3	6.5	1.1	11.9	5.5	27.4	4.5	0.33	9.2
40…45	0.47	9.8	1.5	0.14	3.2	2.4	15.3	0.83	0.0	4.4
45…50	0.0	2.2	0.75	0.0	0.78	0.0	3.5	0.10	-	0.77
50…55	-	0.53	0.0	-	0.15	-	0.0	0.0	-	0.0
55…60	-	0.14	-	-	0.0	-	-	-	-	-
60…65	-	0.0	-	-	-	-	-	-	-	-
65…70	-	-	-	-	-	-	-	-	-	-
70…75	-	-	-	-	-	-	-	-	-	-
75…80	-	-	-	-	-	-	-	-	-	-
80 ppb	**Maximum allowed concentration**									

During summer months (June – July) diurnal cycle of ozone concentration in Apatity, its suburbs and Lovozero is similar as there exists unstable stratification during the most part of day and there are no conditions for accumulation of the ozone-destruction substances.

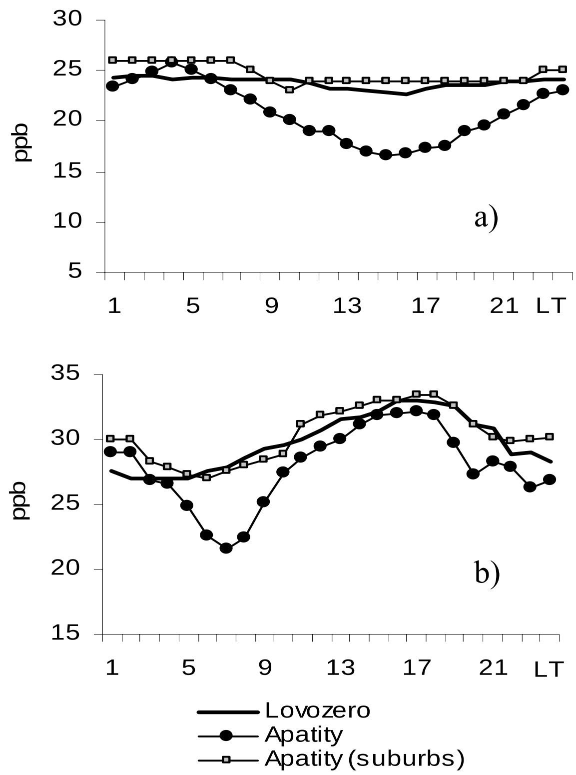

Fig.1. Average diurnal cycles of the ground-level ozone concentration in Lovozero, center Apatity city and Apatity suburbs in December (a) and April 2003 (b).

Separately, we consider 20 cloudless summer days, when the Kola Peninsula has been in anticyclon conditions and when in the mixed layer the wind velocity was less than 4 m/s. However even under such best conditions for photochemical production ozone in surface layer there was not found any difference either between maximum concentrations ground-level ozone in rural site and center city, or in the specific features of diurnal ozone dynamics (Fig.2), such as the hour of maximum concentration or its velocity of the day variations.

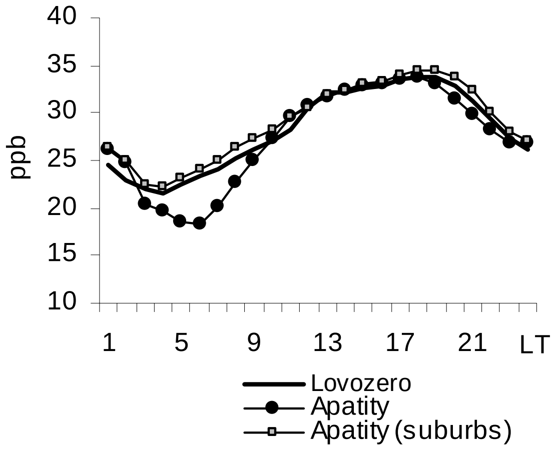

Fig.2. Average diurnal cycles of the ground-level ozone concentration in Lovozero, center Apatity city and Apatity suburbs in June-July in conditions clear sky and the average wind velocity in mixed layer less than 4 m/c.

In spring, the presence of ozone precursors in the urban air even during the polar day practically has no effect on the maximum concentration of the ground-level ozone. The diurnal variations of background ozone are described best by using generally accepted notions about the diurnal dynamics processes in the boundary layer. This may give evidence about insignificant role of processes photochemical generation of the ground-level ozone in the high altitude atmosphere because of unfavorable meteorological conditions (scarcity of ultraviolet radiation, low temperatures etc.).

The anthropogenic influence on the background ozone at the Kola Peninsula is reduced to the decrease of its concentration and is, in fact, limited by the city territories.

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