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COMPARATIVE ANALYSIS OF THE SURFACE OZONE CONCENTRATION IN TBILISI AND AT KISLOVODSK HIGH MOUNTAIN STATION

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Summary: *A comparative analysis of monthly average data on the surface ozone concentration in Tbilisi and at Kislovodsk High Mountain Station (KHMS) from 1989 to 2013 is carried out. In particular, it was found that the ozone content on KHMS is on average 2.6 times higher than in Tbilisi (2.2 times higher in March and April, 4.1 times higher in December). The variability of ozone concentration in different months in Tbilisi is higher than on KHMS (the coefficient of variation in Tbilisi varies from 16.5 to 32.2% in June and November, respectively, and in Kislovodsk – from 7.0 to 12.7% in February and July, respectively). Both in Tbilisi and on KHMS there is a tendency to decrease in the level of surface ozone in all months of the year. However, in Tbilisi this trend is higher than on KHMS. So, in 2002-2013, compared with 1989-2000, in Tbilisi the ozone content decreased from 10.3 to 46.8% in July and November, respectively, while on KHMS it decreased from 6.5 to 13.7% in August and November, respectively.*

Key Words: *Surface ozone concentration.*

Introduction

Atmospheric ozone is one of the most important species defining the quality of life [1-3]. Therefore, special attention in many countries of world, including in Georgia and in Russia is paid to studies of atmospheric ozone [4-11]. Special attention in the study of surface ozone variability is spared to remote sites including high mountains [2,6,8,9], and also in the strongly contaminated locality [1,3,5,7,10-12].

The ozone concentration in the lower troposphere, especially in the atmospheric surface layer, varies widely depending on photochemical processes, horizontal advection, intrusions of stratospheric air, vertical mixing, dry and humid deposition, etc. At high-altitude stations located above the planetary boundary layer, anthropogenic factors manifest themselves only slightly. Accordingly, the comparison of variations of the surface ozone concentration of under the conditions of the strongly contaminated locality and under the ecologically clean conditions (for example, high mountain region) always drew special interest [8].

In this work a comparative analysis of monthly average data on the surface ozone concentration (SOC) in Tbilisi and at Kislovodsk High Mountain Station (KHMS) from 1989 to 2013 is carried out.

Material and methods

The regular researches of surface ozone concentration in Tbilisi (41.72 °N, 44.78 °E, height – 436 m above sea level) are conducted by the Mikheil Nodia Institute of Geophysics from 1980 to present time. Thus, since 1984 there are data of the continuous series of ozone observations. The measurements of ozone were conducted by the electro-chemical ozone instrument OMG-200 [1].

At the KHMS (43.7 °N, 42.7 °E, height- 2070 m above sea level), SOC measurements have been performed since 1989 with a Dasibi 1008-AH gas analyzer described in [2, 6, 8]. This device has an

automatic correction of temperature and pressure dependence. Its sensitivity is 1 ppbv and its accuracy is 1–2 ppbv. Air was taken at a height of 3 m above the ground level.

Data about mean monthly values of SOC from 1989 to 2013 were analyzed with the use of standard statistical methods. The following designations will be used below: Mean – average values; Min – minimal values; Max – maximal values; St Dev – standard deviation; R^2 – coefficient of determination. Comparison of mean values of SOC in two period of time (1989-2000) and (2002-2013) was produced with the use of Student's criterion with the level of significance α not worse than 0.15.

Results and discussion

Results in Table 1 and Fig. 1-5 are presented.

In Table 1 statistical characteristics of mean monthly and annual values of SOC in Tbilisi and at the KHMS are presented.

Table 1

Statistical Characteristics of Monthly Mean Surface Ozone Concentration in Tbilisi and on KHMS in 1989-2013 (ppbv)

Location	Tbilisi					KHMS				
Month	**Min**	**Max**	**Mean**	**St Dev**	**Cv,%**	**Min**	**Max**	**Mean**	**St Dev**	**Cv,%**
Jan	4.4	22.5	13.1	4.2	32.0	34.5	46.7	40.7	3.2	7.8
Feb	10.1	23.4	16.4	4.1	25.0	39.7	51.7	44.0	3.1	7.0
Mar	11.6	30.0	20.6	4.9	23.9	37.4	56.1	46.1	4.3	9.4
Apr	14.1	30.3	21.3	4.7	22.1	36.3	53.1	47.1	4.4	9.3
May	12.1	27.0	20.4	4.4	21.8	37.4	56.3	47.5	4.8	10.1
Jun	12.9	26.7	20.2	3.3	16.5	36.8	59.0	45.7	5.3	11.6
Jul	12.6	27.7	20.5	3.6	17.6	36.4	63.1	47.3	6.0	12.7
Aug	11.9	25.8	19.3	3.9	20.3	35.9	57.9	47.5	5.7	11.9
Sep	10.2	25.1	17.7	3.4	19.3	27.8	48.4	40.8	4.8	11.8
Oct	8.0	24.2	15.4	4.1	26.6	27.7	47.7	37.6	4.7	12.5
Nov	6.9	21.3	12.9	4.6	35.2	31.2	45.6	38.3	3.9	10.1
Dec	4.5	14.8	9.5	3.1	33.0	33.2	45.5	38.8	3.3	8.4
Year	4.4	30.3	17.3	5.4	31.4	27.7	63.1	43.5	5.8	13.4

As follows from this Table monthly mean values of SOC in Tbilisi changes from 9.5 (December) to 21.3 (April) ppbv, and on KHMS – from 37.6 (October) to 47.5 (May, August) ppbv. Range of changeability (Max – Min) of monthly mean values of SOC composes: in Tbilisi – 25.9 ppbv (4.4 ppbv in January and 30.3 ppbv in April); at KHMS – 35.4 ppbv (27.7 ppbv in October and 63.1 ppbv in July). The variability of SOC in Tbilisi is considerably higher than at KHMS. Accordingly, values of Cv in Tbilisi varied from 16.5% (June) to 35.2% (December), and at KHMS – from 7.0% (February) to 12.7% (July). Mean annual value of Cv in Tbilisi is 31.4%, and at KHMS – 13.4%.

Between SOC in Tbilisi and at KHMS linear correlation and regression is observed (Fig. 1). Intra-annual variations of SOC in 1989-2013 in Tbilisi has the form of the third power polynomial, and at KHMS – the fifth power polynomial (Fig. 2).

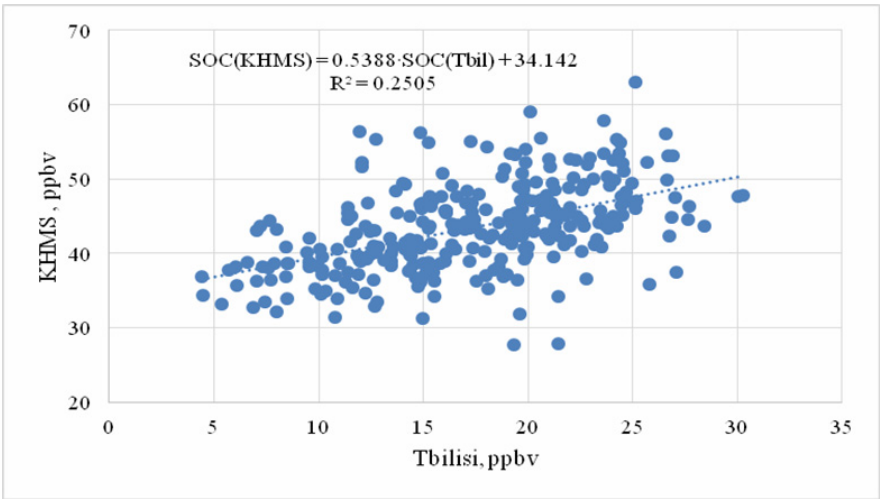


Fig. 1. Linear Correlation and Regression between SOC in Tbilisi and at KHMS (All Data).

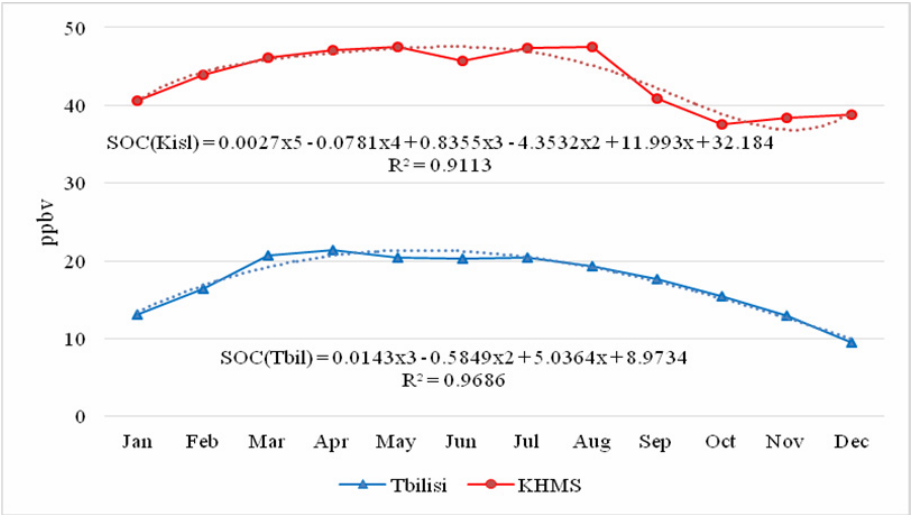


Fig.2. Intra-Annual Variations of SOC in Tbilisi and at KHMS in 1989-2013.

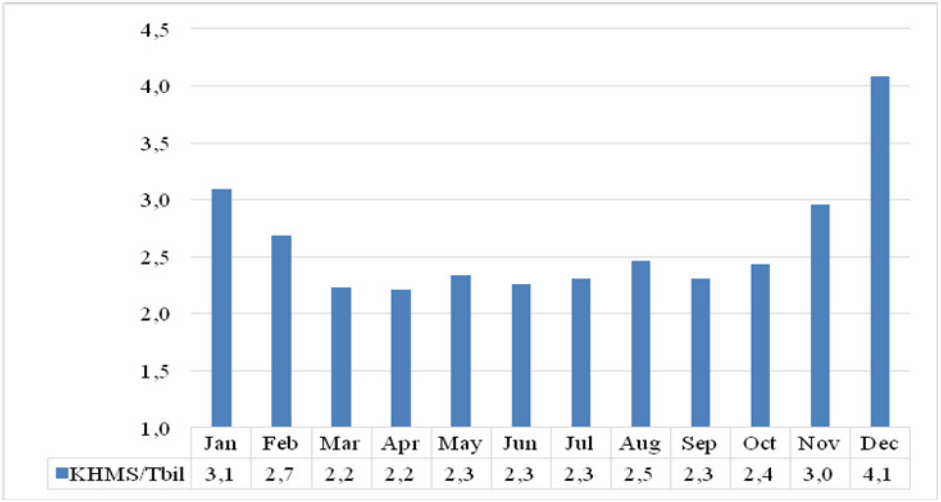


Fig. 3. Ratio of SOC at KHMS to Tbilisi

As follows from Fig.3 the ozone content on KHMS is on average 2.6 times higher than in Tbilisi (2.2 times higher in March and April, 4.1 times higher in December).

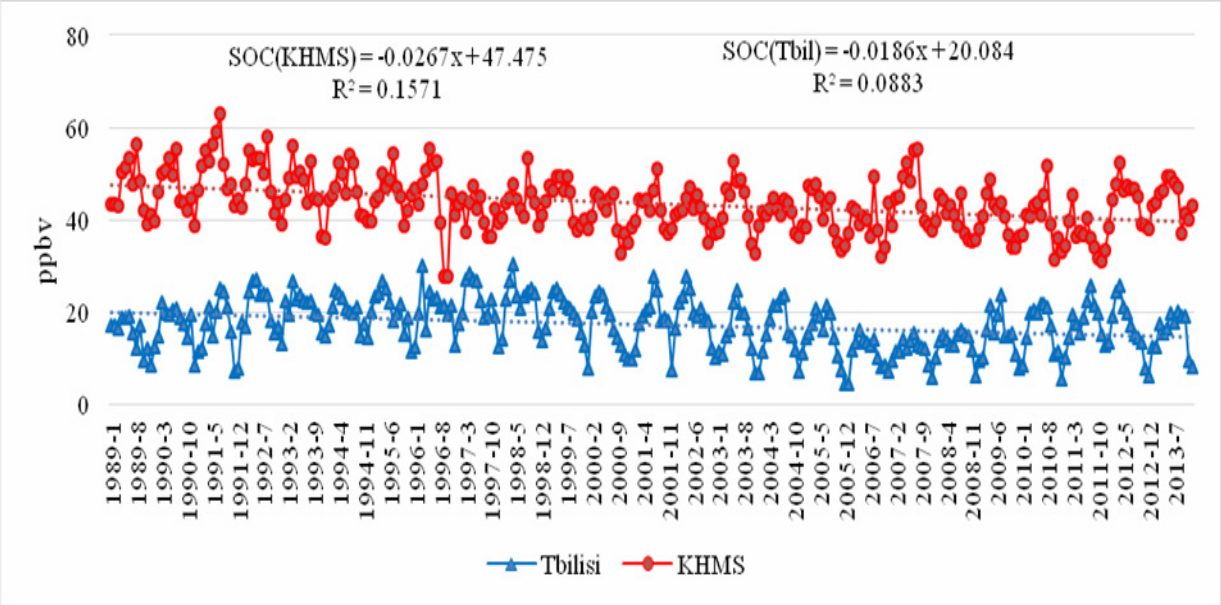
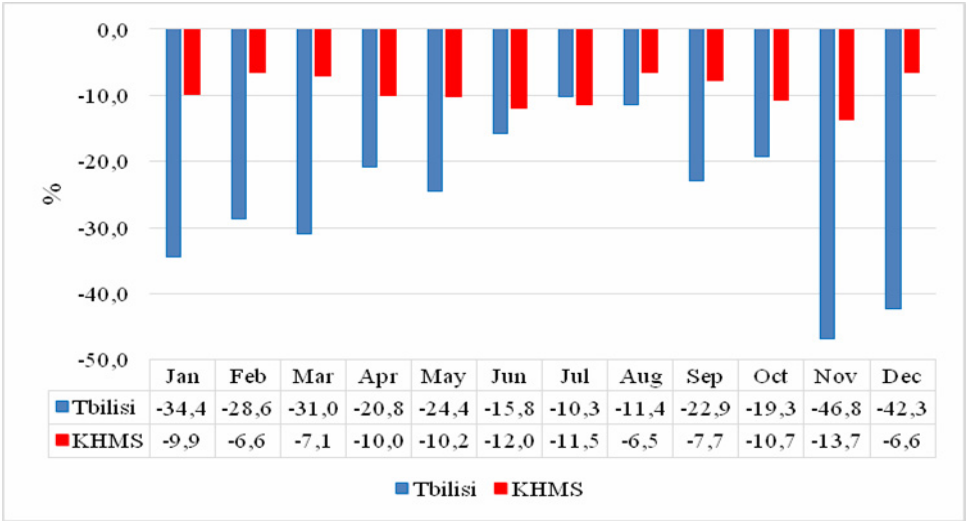


Fig. 4. Variations of monthly mean SOC in Tbilisi and at KHMS in 1989-2013

Trends of monthly mean SOC in Tbilisi and at KHMS in 1989-2013 are negative linear (Fig. 4).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tbilisi	-34,4	-28,6	-31,0	-20,8	-24,4	-15,8	-10,3	-11,4	-22,9	-19,3	-46,8	-42,3
KHMS	-9,9	-6,6	-7,1	-10,0	-10,2	-12,0	-11,5	-6,5	-7,7	-10,7	-13,7	-6,6

Fig.5. Difference between Monthly Mean SOC in 2002-2013 and 1989-2000 Relative to SOC in 1989-2013 in Tbilisi and at KHMS.

Difference between monthly mean SOC in 2002-2013 and 1989-2000 relative to SOC in 1989-2013 (Fig. 5) in Tbilisi varied from -10.3% (July) to -46.8% (November) and at KHMS – from -6.5% (August) to -13.7% (November). So, in the indicated period of time the decrease of SOC in Tbilisi occurred more intensive than at KHMS.

Conclusion

In the immediate future is planned conducting the more detailed comparative analysis of the data about SOC in Tbilisi and at KHMS with the use of statistical methods for the non accidental series of observations.

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