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Investigation of Ozone Concentration Variability under Different Weather Conditions in the Ecologically Clean Surface Air as Exemplified by Ruispiri Village

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ABSTRACT. A study of surface ozone concentration variations under various weather conditions was conducted in Ruispiri village. It has been established that if the weather forecast is known, the SOC value during the daytime for Ruispiri and its adjoining territory can be predicted, which is of great practical significance for human health and agriculture, given that an excessive concentration or lack of ozone in the air is detrimental to the biosphere. *© 2009 Bull. Georg. Natl. Acad. Sci.*

Key words: *astmosphere, stratosphere, troposphere, near-earth ozone concentration, weather conditions.*

Ozone is not uniform in the Earth's atmosphere. The principal mass of ozone is located in the stratosphere, maximum at 20-25 km above sea level. The tropospheric ozone occupies 8-18% of the total ozone.

The concentration of ozone in the troposphere may increase as a result of natural processes: upon production of ozone by the effect of solar radiation on gases of the methane group (methane, isoprene, terpene, etc.), during thunderstorm processes, upon ascending of ozone from lithosphere by passing geological interruptions, during discontinuity of the tropopause; also an increase in the ozone concentration in the troposphere occurs during anthropogenic pollution of the air, in the case of its influence by solar radiation, upon formation of ozone as a result of a photochemical reaction.

The intensive development of industry, transport, soil mineralization, etc. has led to a dramatic deterioration of the troposphere and the stratosphere by various gases, aerosols, all this creating conditions for elevation of ozone during day hours, in the existence of solar radiation, while in nighttime the tropospheric ozone is being intensively spent in the deteriorated environment (as a result of its oxidation) without further formation owing to the absence of solar radiation. Whereas an increase in the tropospheric and surface ozone concentration can, thanks to its optical properties, cause a rise in temperature as a result of trapping by ozone of infrared radiation in the troposphere and due to the oxidation of aerosols by ozone. The tropospheric ozone trend has already been registered by scientists in a number of regions in Europe, Asia and America [1,2], who note the predictable share of ozone in the "greenhouse effect" of the troposphere.

A change in the surface ozone concentration (SOC) is associated with different weather conditions and meteorological parameters. The issue is dealt within a number of scientific works both abroad and in the former Soviet Union (FSU) countries. According to [3], the SOC has the best correlation with solar radiation. Also, it has been established that the rain and wind velocity is weakly associated with the ozone concentration variability, the wind direction playing, however, a great role in the SOC variability. A close correlation between the SOC and the potential temperature of the wet thermometer is estab-

lished in [4], the correlation factor totalling 0.95. According to [5], under conditions of high humidity, the SOC decreases. The relationship between the SOC and meteorological parameters was the subject of study by other authors as well [6-9].

The maximum permissible concentration (MPC) of ozone, or permissible exposure limit (PEL), during a single human exposure makes up 125 mcg/m^3, while during a 24-hour exposure – 28 mcg/m^3. For vegetation the PEL amounts to 60 mcg/m^3 during a 4-hour exposure, while for animals it makes up 70 mcg/m^3, also upon a 4-hour exposure.

Under definite meteorological conditions – temperature inversion, fogginess, and low cloud – the ozone concentration in the air drops dramatically, frequently down to zero. Such weather conditions contribute to the spread of various infectious diseases, because the natural disinfectant – ozone is completely absent or its concentration is rather insignificant. Such kind of weather in Georgia is more frequent during the autumn-winter period. Under the said conditions, ozone concentrations are lower in urban than in rural areas, owing to a greater extent of air pollution in towns and the resultant intensive spending of ozone.

The purpose of the present work is to study the nature of SOC variations in a relatively clear near-earth surface air taking the village of Ruispiri (Telavi district) as an example under various weather conditions. The surface ozone measurements were conducted in 2003-2005 by employees of the M. Nodia Research Institute of Geophysics under the Georgian Academy of Sciences, at the Institute's base/station located in the western part of Ruispiri, on a daily basis, from 7 AM to 12 PM inclusive. In about every hour, with a 2-minute interval, three SOC measurements were carried out, using the German-made OMG-2-type ozonometer to calculate the SOC value in the given hour.

The following types of weather were chosen to study the effects of weather on the SOC:

1. Serene or predominantly serene sky, calm;
2. Fully or predominantly cloudy sky, calm;
3. Serene or predominantly serene sky, north-westerly wind or breeze;
4. Fully or predominantly cloudy sky, south-easterly wind or breeze;
5. Serene or predominantly serene sky, north-westerly wind or breeze;
6. Fully or predominantly cloudy sky, south-easterly wind or breeze;
7. Rain (incessant), snow, fog, calm or weak, changeable breeze.

In selecting the above weather types, the prevailing wind directions (north-western and south-eastern) in Eastern Georgia, namely in Ruispiri, were taken into consideration.

The results of the SOC variability study in Ruispiri are given in Table and Figures 1 to 3, wherefrom it is evident that the maximum SOC is observable during the 5^{th} and the 6^{th} weather types, whereas the minimal during the 7^{th} weather type. It is also evident from the Table that the key role in elevating the SOC in Ruispiri is played by the north-westerly and south-easterly winds. It is explained by the fact that the air in Ruispiri is clean and the spending of ozone transferred from the stratosphere by air turbulence and diffusion is insignificant. During the first-type weather, stratosphere-transferred ozone is less prone to destruction owing to air cleanliness in Ruispiri than during the second-type weather, when cloudiness and high humidity lead to the destruction of ozone. Because of the same reason, during the third-type weather, due to the air cleanliness, photochemical reaction does not produce ozone in Ruispiri surface air. Therefore, no great difference in the SOC during cloudless and cloudy days is observable, whereas, in Tbilisi (the Academy campus) this difference is rather noticeable [10]. During the third- and fifth-type weather, ozone displaced from the stratosphere by air turbulence exceeds ozone consumption through cloud humidity; therefore, during the third-type weather the SOC is higher than during the fourth-type weather. For the same reason, the third-type weather SOC overrides the SOC during the fourth-type weather. The least SOC is observable during the seventh-type weather, when ozone displaced from the stratosphere by air diffusion is intensively consumed owing to high air humidity.

The SOC variability under different weather conditions in Rusipiri is clearly seen in Fig. 1. The comparison of SOC under conditions of the weather type 1 to 7 has proved high humidity to be the key factor of the SOC reduction. Also seen is that under all the types of weather conditions the SOC is greater in the second half of the day than in the first half, which can be presumably explained by increased intensity of diffusion and turbulence processes in the stratosphere together with the rise in temperature and more transfer of ozone from the stratosphere to the troposphere and to the near-earth surface layer of the air.

Fig. 2 presents the daily variations of the mean SOC in Ruispiri under different weather conditions for the 2003-2005 period. It is clearly seen from the figure that during clear, serene sky the SOC is always higher than under cloudy sky conditions; for example, 1-2, 3-4, 5-6.

Table

Variability of the mean SOC during diurnal hours in Ruispiri under different weather conditions (2003-2005 period) (—) number of days

#	Type of weather	Weather symbol	SOC mean variability in time										
			10	11	12	13	14	15	16	17	Mean	Max	Min
1	Serene or predominantly serene sky, calm		41 (911)	45 (303)	50 (291)	53 (272)	56 (264)	58 (267)	56 (262)	52 (261)	51	58	41
2	Fully or predominantly cloudy sky, calm		34 (317)	38 (292)	42 (256)	46 (238)	49 (218)	48 (211)	48 (229)	43 (291)	44	49	34
3	Serene or predominantly serene sky, north-westerly wind or breeze		50 (144)	55 (151)	56 (160)	58 (163)	60 (170)	62 (166)	64 (141)	61 (142)	58	64	50
4	Fully or predominantly cloudy sky, north-westerly wind or breeze		45 (90)	49 (102)	47 (118)	51 (123)	54 (126)	55 (127)	55 (141)	55 (147)	51	55	45
5	Serene or predominantly serene sky, south-easterly wind or breeze		56 (37)	53 (51)	56 (64)	58 (79)	61 (103)	62 (116)	64 (113)	61 (111)	59	64	53
6	Fully or predominantly cloudy sky, south-easterly wind or breeze		47 (40)	41 (62)	49 (64)	51 (76)	60 (84)	54 (83)	56 (88)	58 (86)	52	60	41
7	Rain (incessant), snow, fog		31 (116)	33 (105)	37 (101)	39 (98)	40 (90)	43 (84)	43 (73)	42 (75)	38	43	31

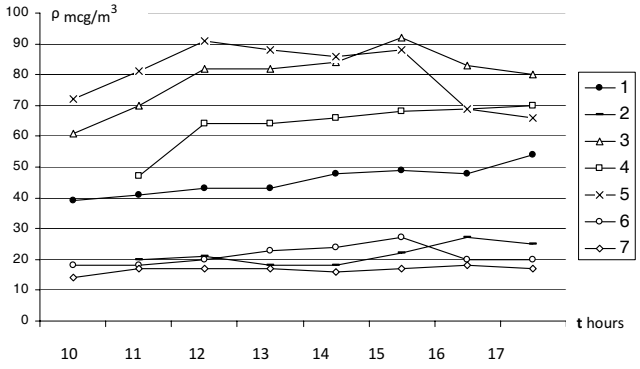

Fig. 1. Diurnal variation of the surface zone concentration under different weather conditions in Ruispiri by different days

The same figure shows that during the seventh-type weather, the SOC is the least, which can be explained by intensive destruction of the SOC under conditions of high air humidity. The figure also demonstrates an elevation in the SOC in the second half of the day, which, as mentioned above, should be caused by the rise in the intensity of air diffusion and turbulence processes together with an increase in temperature.

Fig. 3 depicts the mean, maximum and minimum values of the SOC for all the seven types of weather. The mean, maximum and minimum values of the SOC during clear and cloudless sky are always higher than during cloudy sky, which is indicative of the destruction of ozone under conditions of high humidity. The same figure shows that the SOC during the seventh-type weather is less against other weather types (1 to 6). That is the SOC variability during the seven types of weather in Rusipiri is of the same character as in Tbilisi (Delisi, the Academy campus) [11], with the difference that the mean of the SOC in Rusipiri for the seven types of weather is higher than in Tbilisi, which can, presumably, be explained by the significant air pollution in Tbilisi, its orographic peculiarities. Tbilisi terrain represents a caldron-shaped depression, the atmosphere of which is liable to frequent temperature inversions, isothermalities, which interferes with the descending of ozone from the upper layers to the surface layer, while the available surface ozone is intensively consumed

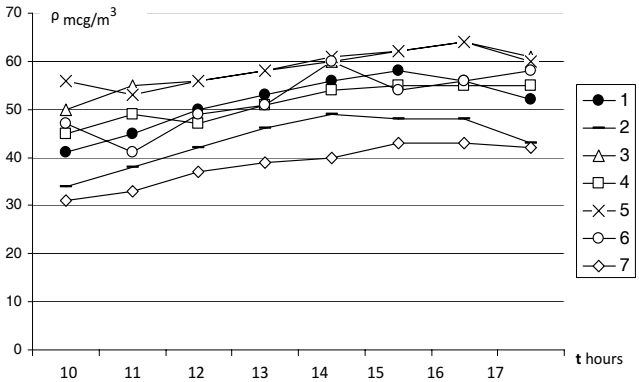

Fig. 2. Diurnal variation of the mean of the surface ozone concentration in Ruispiri under different weather conditions for the 2003-2005 period

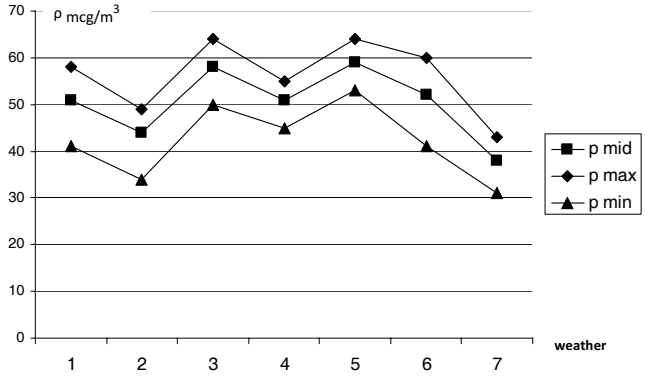

Fig. 3. Averaged values of the mean (ρ mean), maximum (ρ max) and minimum SOC observable in Ruispiri in 2003-2005 under different weather conditions (1-7) (weather types 1-7 see in Table).

against the high air pollution background, except the days when smog-like conditions are created and smog ozone is being formed in Tbilisi. It should be mentioned that neither smog ozone formation nor zero values of the SOC has been obesrved in the entire course of the SOC measurements in Ruispiri village.

The study of surface ozone concentration variations in Ruispiri has demonstrated that when the weather forecast is known, the SOC value for Ruispiri vilage and its adjoining territory can be predicted, which is of great prcatical significance for human health and agriculture, given that the excessive concentration or lack of ozone in the air is detrimental to the biosphere.

გეოფიზიკა

ეკოლოგიურად სუფთა გარემოს მიწისპირა ჰაერში ოზონის კონცენტრაციის ცვალებადობის გამოკვლევა სხვადასხვა ტიპის ამინდის პირობებში სოფ. რუისპირის მაგალითზე

ჯ. ხარჩილავა, ე. კეკენაძე, ნ. ბაგაშვილი

მ. ნოდიას გეოფიზიკის ინსტიტუტი, თბილისი

(წარმოდგენილია აკადემიის წევრის თ. ჭელიძის მიერ)

სოფ. რუისპირში ჩატარებულია მიწისპირა ჰაერში ოზონის კონცენტრაციის ცვალებადობის გამოკვლევა სხვადასხვა ამინდის პირობებში. აღნიშნული კვლევის საფუძველზე დადგენილია, რომ თუ ცნობილი იქნება ამინდის პროგნოზი, შეიძლება ვიწინასწარმეტყველოთ მიწისპირა ოზონის კონცენტრაციის სიდიდე დღის საათებში სოფ. რუისპირისა და მისი მიმდებარე ტერიტორიებისათვის, რასაც დიდი პრაქტიკული მნიშვნელობა აქვს მოსახლეობის ჯანმრთელობისთვის და სოფლის მეურნეობისთვისაც, რამდენადაც მიწისპირა ჰაერში ოზონის სიჭარბე ან დეფიციტი მავნეა ბიოსფეროსთვის.

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