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REVIEWS AND CONSULTATIONS

Ozone Content over the Russian Federation in the Second Quarter of 2019

N. S. Ivanova[a]*, G. M. Kruchenitskii[a], I. N. Kuznetsova[b], V. A. Lapchenko[c], and V. V. Shirotov[d]

[a]*Central Aerological Observatory, ul. Pervomaiskaya 3, Dolgoprudny, Moscow oblast, 141700 Russia*

[b]*Hydrometeorological Research Center of the Russian Federation, Bolshoi Predtechenskii per. 11–13, Moscow, 123242 Russia*

[c]*Vyazemskii Kara Dag Scientific Station—Nature Reserve of Russian Academy of Sciences, ul. Nauki 24, Kurortnoe, Feodosiya, Republic of Crimea, 298188 Russia*

[d]*Taifun Research and Production Association, pr. Lenina 82, Obninsk, Kaluga oblast, 249020 Russia*

**e-mail: oom@cao-rhms.ru*

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Abstract—The review is based on the results of the operation of the system of total ozone (TO) monitoring over Russia and neighboring territories that functions in the operational mode at the Central Aerological Observatory (CAO). The monitoring system uses data from the national network equipped with M-124 filter ozonometers being under the methodological supervision of the Main Geophysical Observatory. The quality of the entire system functioning is operationally controlled by the comparison with the observations obtained from the OMI satellite equipment (NASA, USA). Basic TO observation data are generalized for each month of the second quarter of 2019 and for the second quarter. Data of routine observations of surface ozone values in the Moscow region and Crimea are also considered.

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The normals (multiyear means) of total ozone (TO) over Russia and adjoining areas for the second quarter and for its months calculated for the period of 1974–1984 were presented in [1]. The quarterly mean TO values in the second quarter of 2019 were basically close to the multiyear means over the whole territory under control (Fig. 1a). The maximum deficiency of quarterly mean TO values was registered at Saint Petersburg, Arkhangelsk, and Petropavlovsk-Kamchatsky stations: it reached 6% or 1.9, 2.0, and 2.3 SD, respectively. The anomalous exceeding of the quarterly mean TO value over the normal was observed at Almaty and Heiss Island stations and made up 7 and 5% or 3.5 and 2.7 SD, respectively.

The lowest quarterly mean TO values (348–365 DU) in the second quarter were observed over the European part of Russia, the South and Central Urals, and Kazakhstan. The highest quarterly mean TO values (420–428 DU) were registered over the Arctic Ocean islands and northern Yakutia. Over the rest of the territory under control the quarterly mean TO values were 365–420 DU.

The low quality of data from Semipalatinsk, Chardzhou, Karaganda, Gur'ev, Krasnoyarsk, Samara, Nikolaevsk-on-Amur, Vladivostok, Bol'shaya Elan', Voronezh, and Pechora stations in the second quarter of 2019 does not allow their use for analyzing the ozone fields.

In April 2019, the monthly mean TO values were close to the multiyear means over the whole territory under control (Fig. 1b). The maximum deficiency of monthly mean TO values was registered at Saint Petersburg and Arkhangelsk stations and made up 10% or 1.9 SD. The TO normal was maximally exceeded in Tiksi: 7% or 1.7 SD.

In May, the monthly mean TO values were mainly close to the multiyear means over the territory under control (Fig. 1c). The anomalous deficiency of monthly mean TO values was registered in Petropavlovsk-

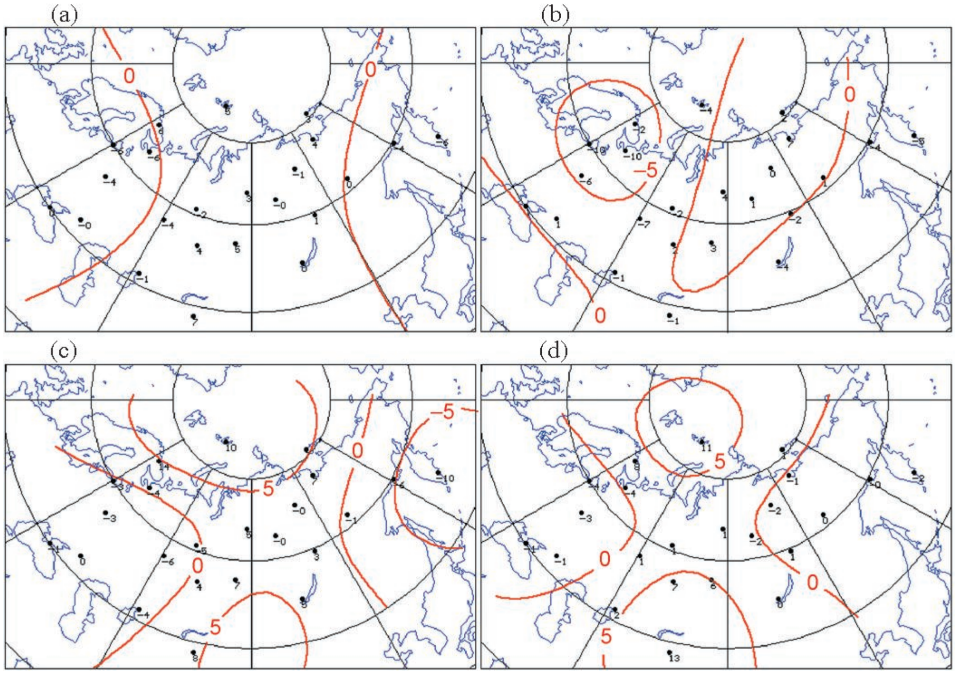

Fig. 1. The field of deviations (%) of total ozone values from the multiyear mean in (a) April–June, (b) April, (c) May, and (d) June in 2019.

Kamchatsky (10% or 2.6 SD). The anomalous exceeding of TO values over the normal was observed in Murmansk and on Heiss Island: 14 and 10% or 3.1 and 2.6 SD, respectively. On May 1–2, the monthly mean TO values (522–528 DU) above the normal (by 31–34%) were observed over the south of Western Siberia and northeast of Kazakhstan.

In June 2019, the monthly mean TO values were close to the normal over most of the territory under control (Fig. 1d). The maximum deficiency of monthly mean TO values was registered at Saint Petersburg and Arkhangelsk stations (4% or 1.0 SD). The anomalous exceeding over the normal was observed at Almaty and Heiss Island stations: 13 and 11% or 4.4 and 3.1 SD, respectively.

The table presents data on anomalous deviations from the normal of daily TO values registered at the ozonometric network stations in the second quarter of 2019.

The calculations of ultraviolet index (UVI) for the center of the European part of Russia based on TO and cloudiness data for Moscow and the Moscow oblast [3, 4] revealed that the monthly mean value of UVI was 4.1 for May and 5.2 for June. In May, the maximum values of UVI exceeded 5.5 (the threshold above which population should use UV-radiation protection means) during two days. In June, 14 such days were registered, during four of them UVI exceeded 6.5. According to UVI measurement data for Saint Petersburg (Voeikovo), the monthly mean value was equal to 2.8 in May and 3.7 in June. The values of UVI above 5.5 were not registered in Saint Petersburg in May and June.

According to the data of surface ozone monitoring stations in the center of the European part of Russia (Moscow, Obninsk) and in the south of the Crimean Peninsula (Nature Reserve of the Russian Academy of Sciences, Kara Dag), in the second quarter of 2019 surface ozone values were basically within the range of seasonal long-term values [2, 5].

As often, the episodes of significant increase in surface ozone values were observed in Crimea and the Moscow region in April. In the Kara Dag Nature Reserve, the maximum daily surface ozone value (162 g/m^3) was observed at 18:00 local time on April 26, 2019, it exceeded $MPC_{m.s}$ (160 g/m^3). The exceeding over the criterion of safe surface ozone values recommended by the World Health Organization (WHO) (the running average 8-hour concentration is 100 g/m^3 [6]) was registered in the Kara Dar Reserve on April 25–28. It was supposed that the increase in surface ozone values on the Crimean coast could partly be formed under conditions of TO growth in the atmosphere caused by the propagation of high TO values from the area of the Siberian High to the south of the European part of Russia on April 21–24. According to the observations at Feodosiya stations, the TO values above 400 DU (by 8–14% above the normal) were registered on those days.

Total ozone deviations from the normal in the second quarter of 2019

Station	April			May			June		
	Date	TO		Date	TO		Date	TO	
		%	SD		%	SD		%	SD
Below the normal									
Arkhangelsk	21	24	2.6	12	23	2.7			
	23	26	2.8						
	24	24	2.6						
Petropavlovsk-Kamchatsky				31	22	3.0			
St. Petersburg	17	27	2.8						
Turukhansk							8	18	2.7
Above the normal									
Almaty							7	18	3.0
							8	17	2.8
							9	15	2.6
							14	16	2.8
							18	15	2.6
							20	17	2.9
							22	15	2.7
							24	16	2.8
							25	15	2.7
							26	18	3.2
							28	15	2.7
							30	18	3.2
Aral Sea							9	16	2.6
Murmansk				5	27	3.3			
				6	32	3.9			
				7	21	2.6			
				9	26	3.2			
Omsk	18	27	2.8	1	31	3.4	7	22	3.2
	27	31	3.3	2	32	3.4	22	18	2.6
Tiksi	18	22	2.8	1	18	2.6			
	23	29	3.8	2	21	3.1			
Tomsk	18	28	3.0	1	29	3.2	24	21	3.1
	27	32	3.5	2	34	3.8			
	28	29	3.2	3	23	2.6			
Tura	29	22	2.8						
Turukhansk				1	21	2.7			
Feodosiya							30	20	3.3
Khanty-Mansiysk	27	42	4.6						
Heiss Island				19	19	3.0	5	17	3.0
				22	17	2.8	6	15	2.6
				23	18	3.0	19	15	2.6
				27	17	2.9	27	20	3.4
Tsimlyansk							30	18	2.8
Yakutsk							19	19	3.0

The spring episode with high surface ozone values in Moscow and Obninsk (the Kaluga oblast) was more durable and was observed with small deviations during April 21–26 (Fig. 2). On those days, in Obninsk surface ozone values increased in the afternoon to 142 μg/m^3 (April 22) and 137 μg/m^3 (April 26); in Moscow, surface ozone values reached 144–152 μg/m^3 in some districts. Abnormal warm weather with the daytime temperature above 20°C set in the center of the European part of Russia at the beginning of the

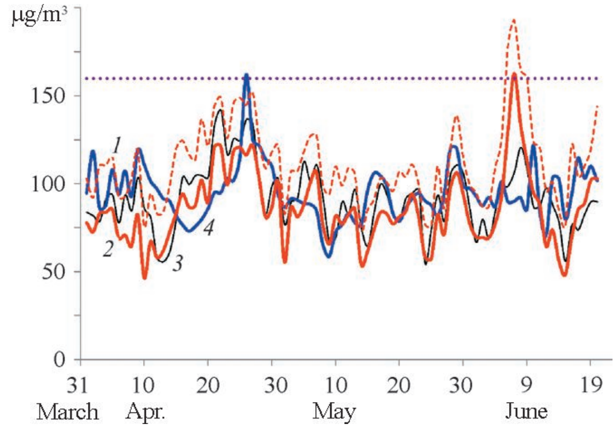

Fig. 2. The daily maxima of surface ozone values in April–June 2019: (*1*) maximum surface ozone values at separate stations in Moscow; (*2*) surface ozone values averaged over Moscow; (*3*) Obninsk; (*4*) Crimean coast. The horizontal dotted line marks the value of $MPC_{m.s}$ = 160 g/m^3.

first ten days of April temperature reached 23–25 C on April 24–27. The increase in surface ozone values was observed against a background of prevalence of light wind in the lower atmosphere (when wind strengthened to 10–12 m/s on April 23, surface ozone values decreased throughout the city). Evidently, nighttime temperature inversions accompanying the anticyclonic situation also affected the formation of the analyzed episode and impeded urban air purification from pollutants (ozone precursors).

No cases of $MPC_{m.s}$ exceeding were observed in May–June in the Kara Dag Reserve, unlike the Moscow region, where the episode with an extremely rare duration and daily surface ozone maxima was registered in early June. At most monitoring stations in Moscow (http://mosecom.ru/), on June 6–9 surface ozone values increased to 130–155 g/m^3 (in some districts of the city, to 160–195 g/m^3 in the forenoon). The peculiarity of this episode was the maintenance of high ozone values in the daytime during 5–6 hours (13:00 to 18:00). The increase in surface ozone values being dangerous due to its potential negative consequences was accompanied by calm hot dry weather, while daytime air temperature rose to 30 C. It is notable that in the remote background area (Obninsk) during the period of abnormal high ozone values in Moscow, total ozone values remained much below $MPC_{m.s}$ (Fig. 2).

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REFERENCES

1. A. M. Zvyagintsev, N. S. Ivanova, G. Kakadzhanova, G. M. Kruchenitskii, and I. N. Kuznetsova, "Ozone Content over the Russian Federation in the Second Quarter of 2008," Meteorol. Gidrol., No. 8 (2008) [Russ. Meteorol. Hydrol., No. 8, **33** (2008)].
2. A. M. Zvyagintsev, I. N. Kuznetsova, I. Yu. Shalygina, E. A. Lezina, V. A. Lapchenko, M. P. Nikiforova, and V. I. Demin, "Investigation and Monitoring of Surface Ozone in Russia," Trudy Gidromettsentra Rossii, No. 365 (2017) [in Russian].
3. N. S. Ivanova, *Methods for Total Ozone and UV Index Forecasting* (2010), http://method.meteorf.ru/ methods/pollut/uv/uv.html.
4. N. S. Ivanova, "An Empirical Model of Ultraviolet Index Calculation," Trudy Gidromettsentra Rossii, No. 365 (2017) [in Russian].
5. I. Yu. Shalygina, I. Yu. Shalygina, and V. A. Lapchenko, "Surface Ozone Regime at Kara Dag Station in Crimea According to Observations in 2009–2018," Gidrometeorologicheskie Issledovaniya i Prognozy, No. 2 (2019) [in Russian].
6. *Air Quality Guidelines: Global Update 2005—Particulate Matter, Ozone, Nitrogen Dioxide and Sulphur Dioxide* (World Health Organization, Geneva, 2006).