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REVIEWS AND CONSULTATIONS

Ozone Content over the Russian Federation in 2014

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Abstract—The review is compiled on the basis of the results of the total ozone (TO) monitoring in the CIS and Baltic countries that functions in the operational regime at the Central Aerological Observatory (CAO). The monitoring system uses the data from the national network of M-124 filter ozonometers under methodological supervision of the Main Geophysical Observatory. The quality of the functioning of the entire system is under operational control that bases on the observations obtained from the OMI satellite equipment (NASA, the USA). The basic TO observation data are generalized for each month of the fourth quarter of 2014, for the quarter as a whole, and for the whole year. The results of regular observations of surface ozone content carried out in Moscow region and Crimea are also considered.

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The basic results of the total ozone (TO) observations for the first three quarters of 2014 are described in [1–3]. The low quality of data from Vladivostok, Kiev-UkrNIIGMI, Lvov, Ashkhabad, Chardzhou, Voronezh, and Nikolaevsk-on-Amur stations during the long period of time does not allow their use for analyzing the average annual TO field. However, the observational data from Vladivostok and Voronezh stations are used for analyzing the TO fields for the fourth quarter. The multiyear means of TO over Russia and adjoining areas for different months of the fourth quarter computed for 1974–1984 are presented in [4].

In the fourth quarter of 2014 the quarterly mean TO values were mainly close to the multiyear means for 1974–1984 (Fig. 1a). The maximum deficiency of quarterly mean TO values was registered at Murmansk station and amounted to 9% or 2.3 SD. The anomalous excess of quarterly mean TO values over the norm was registered in Almaty and made up 8% or 3.2 SD. The same value of the deficiency (8%) was registered at Nagaevo station but it was not anomalous because it did not exceed an anomaly threshold (made up 2.4 SD).

The lowest quarterly mean TO values (252–280 DU) in the fourth quarter of 2014 were observed over the northern regions of the European part of Russia and Urals. The highest quarterly mean TO values (360–409 DU) were registered over the Far East and Kamchatka Peninsula. Over the rest of the territory under control, the TO values were 280–360 DU.

The table contains the data on anomalous deviations of daily TO values from the norm recorded at the ozonometric network stations in the fourth quarter of 2014.

In October 2014, monthly mean TO values over the territory under control were close to the multiyear means (Fig. 1b). The maximum deficiency of monthly mean TO values was recorded in Murmansk and amounted to 8% or 1.3 SD. The norm was maximally exceeded at Omsk station (8% or 1.9 SD). In October over the most part of the territory the monthly means of TO were 280–330 DU, over the northwest of the European part of Russia, 255–280 DU, and over Yakutia, the Far East, and Kamchatka Peninsula, 330–370 DU.

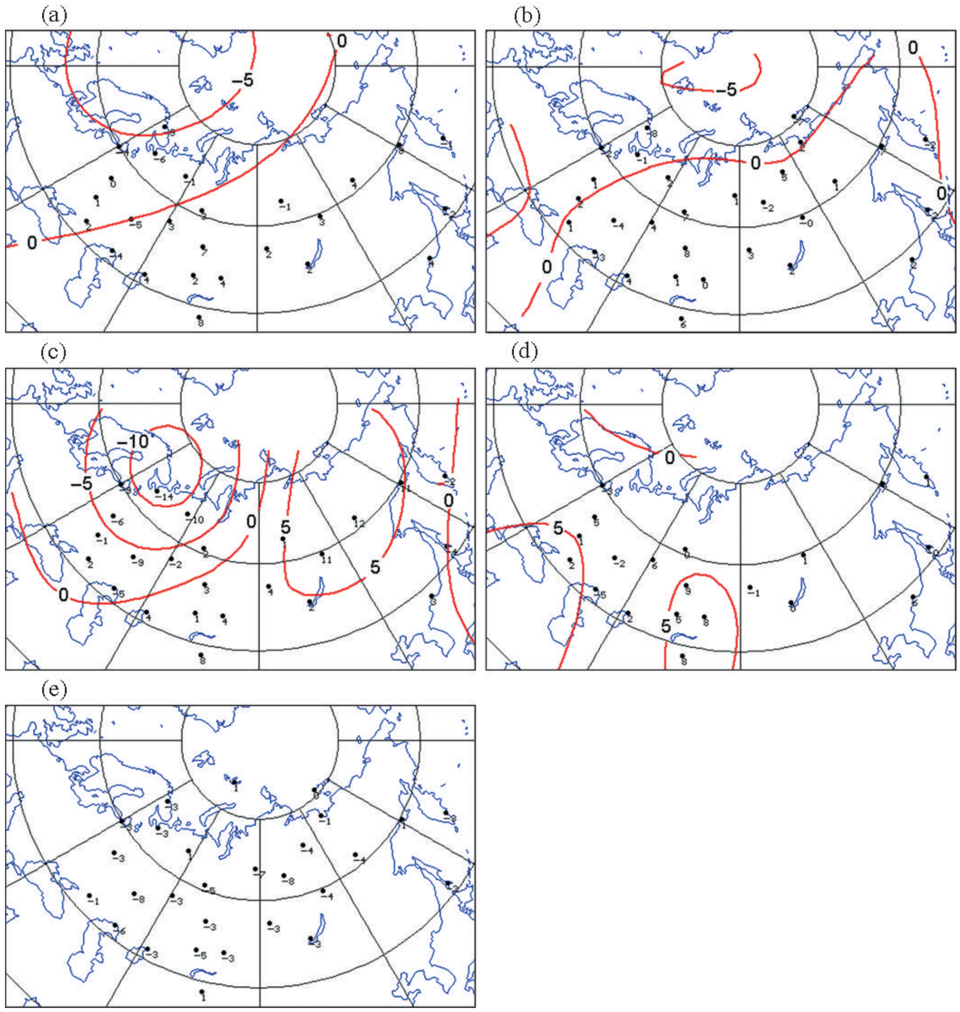

Fig. 1. The field of deviations (%) of the total ozone content from the multiyear mean in (a) October–December, (b) October, (c) November, and (d) December as well as (e) for the whole year 2014.

In November over the most part of the territory under control the monthly mean TO values were close to the multiyear means (Fig. 1c). The maximum deficiency of monthly mean TO values was recorded in Arkhangelsk (14% or 2.1 SD). The norm was maximally exceeded at Yakutsk station: 12% or 1.9 SD. The decreased (by 10%) but not anomalous TO values were registered over the northern regions of the European part of Russia (234–258 DU). In November over the most part of the territory the monthly means of TO were 265–360 DU, over the north of the European part of Russia, 234–265 DU, and over Yakutia, the Far East, and Kamchatka Peninsula, 360–420 DU.

Over the most part of the territory under control in December 2014 monthly mean TO values were also close to the multiyear means (Fig. 1d). The maximum deficiency of monthly mean TO values was recorded in Gur'ev and amounted to 5% or 1.1 SD. The maximum exceeding of the norm was observed at Omsk station (9% or 1.5 SD). Over the most part of territory in December the monthly means of TO were 330–400 DU, over the European part of Russia and over the north of West Siberia, 309–330 DU, and over the Far East and Kamchatka Peninsula, 400–435 DU.

The field of deviations of annual mean TO values from the norm in 2014 (Fig. 1e) is rather smooth and the values are mainly negative (from –8 to 1%). The maximum deficiency of annual TO means (8%) was registered at Samara and Tura stations. The maximum exceeding of annual mean TO values over the norm (1%) was observed at Heiss Island, Pechora, Ashkhabad, and Nagaevo stations.

During the year 2014, some considerable deviations of daily TO values from the norm were registered in March and April. For example, the TO values were below the norm:

Total ozone deviations from the norm in the fourth quarter of 2014

Station	October			November			December		
	Date	TO		Date	TO		Date	TO	
		%	SD		%	SD		%	SD
Below the norm									
Karaganda				3	23	2.8			
Above the norm									
Almaty	9	18	2.7	10	20	2.6	8	27	3.2
	10	18	2.8	18	35	4.2			
	12	21	3.2						
Aral Sea	26	24	3.4	5	23	3.0			
	27	19	2.7	7	21	2.8			
Bol'shaya Elan'	10	21	2.8						
Irkutsk	9	26	3.4						
Krasnoyarsk	28	30	3.3						
Nagaevo	22	23	2.7						
	23	23	2.6						
Omsk							7	30	2.6
Semipalatinsk	27	21	2.7	28	31	3.2			
Turukhansk	2	24	2.7						
Khanty-Mansiysk				27	36	2.9			
Tsimlyansk				2	28	3.6			
				3	21	2.7			

—by 28–35% on March 18–22 over the north of Krasnoyarsk krai and Yakutia (296–347 DU);

—by 24–29% on April 1–3 over West and Central Siberia (288–327 DU);

—by 25–37% on April 15–18 over Siberia (262–336 DU).

The temporal variations of TO values in some latitudinal zones over the territory of Russia correlate well with the variations of corresponding average zonal TO values retrieved from the satellite data. Figure 2 presents the long-term TO variations in different latitudinal zones retrieved from the results of satellite observations since 1979 (i.e., since the moment when, as believed, considerable changes in the ozone layer caused by the anthropogenic impact of chlorofluorocarbons started to be manifested). In 2014 in the latitudinal zone of 35 –70 N TO values were approximately the same as in the previous year and by about 3% lower than in the 1970s; the same situation was observed at Russian stations. In general, it can be stated from the data of the ground-based stations of the ozonometric network and from the satellite data that after the dramatic decrease in TO caused by the Pinatubo volcano eruption in 1991 and after the considerable increase in TO in the second half of the 1990s, no strongly pronounced unidirectional long-term variations have been registered in the ozone layer over the midlatitudes of the Northern Hemisphere in recent 15 years. In 2014 the number of foreign papers were published [5, 6, 8, 9] which described long-term TO variations and noted the comparability of the impact of anthropogenic and natural factors on the changes in the ozone layer; also, these papers point at uncertainties impeding the forecasting of the future variations of the ozone layer. If the rate is kept of the increase in TO that has been observed since the beginning of the current century, appreciable changes in TO can be expected in 15–25 years only.

The observations of the spring Antarctic ozone anomaly (SAZA or "the ozone-hole") under the methodological guidance of the WMO are carried out by the specialists of many countries including Russia (at Mirnyi, Novolazarevskaya, and Vostok stations). Ground-based observations carried out by the Arctic and Antarctic Research Institute are used as reference ones for satellite observations. The basic volume of data on SAZA characteristics (maximum area, minimum TO value in it, and total ozone deficiency during the lifetime of SAZA) is received from satellite observations using the equipment produced in the USA and

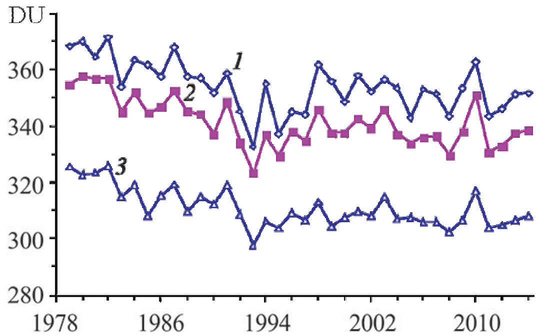

Fig. 2. The course of annual mean TO values in the latitudinal zones of (*1*) 50 –60 , (*2*) 40 –50 , and (*3*) 30 –40 N retrieved from the TOMS, OMI, and SBUV satellite instrument data.

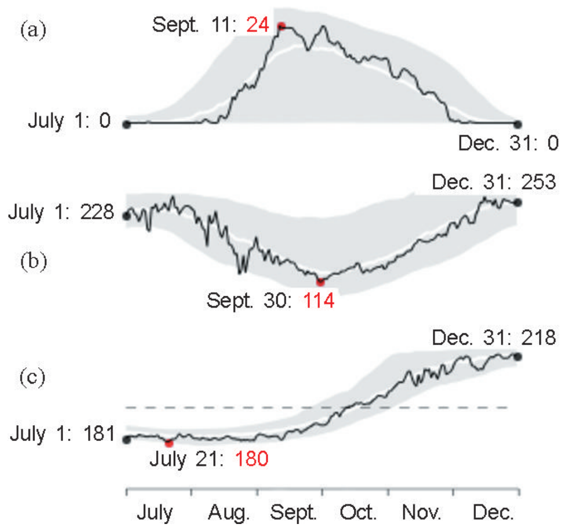

Fig. 3. Major characteristics of the spring Antarctic ozone anomaly in 2014 according to the data of the NASA (the USA) satellite observations: (a) area occupied by the territory with TO of 220 DU (10^6 km^2), (b) minimum TO value (DU), and (c) minimum temperature in the stratosphere (K). The areas between the minimum and maximum values observed in 1979–2013 are grey-colored; the light lines within these areas indicate the mean values for this period.

Western Europe. The area of the territory where TO < 220 DU, is considered as the area occupied by SAZA. Main quantitative parameters of SAZA in 2014, namely, the time of the beginning and end of the anomaly, the maximum area, and minimum TO values are close to the means for the recent 10 years. Its steady manifestation started in the middle of August and ended in early December. The major characteristics of SAZA in 2014 taken from the website of NASA (USA) (http://ozonewatch.gsfc.nasa.gov) are presented in Figs. 3 and 4. They yield considerably to the record parameters of SAZA observed in the late 1990s. The maximum total deficiency of the ozone mass (computed for the territory with the TO values below 220 DU) in 2014 was by about two times lower than in 2006 and in the late 1990s. The content of so called ozone-depleting substances in the atmosphere has been decreasing rather slowly and, although more and more signs are observed of the trend towards the SAZA decrease, it is early so far to talk about the beginning of the ozone layer recovery over the Antarctic [7]; probably, we will be able to state such recovery reliably in several decades only.

The ozone values in the atmospheric surface layer over the Moscow region in the fourth quarter of 2014 were caused by the peculiarities of atmospheric processes, were typical of the season, and were considerably below the maximum permissible concentration of ozone for the air of populated areas. For the year 2014 as a whole, according to the data of Dolgoprudny station and Mosecomonitoring automatic stations of air pollution control, only several short episodes were registered during the hot periods of summer and spring (May 24–25, June 6–7, and July 14–19). Then the surface ozone values approached closely the

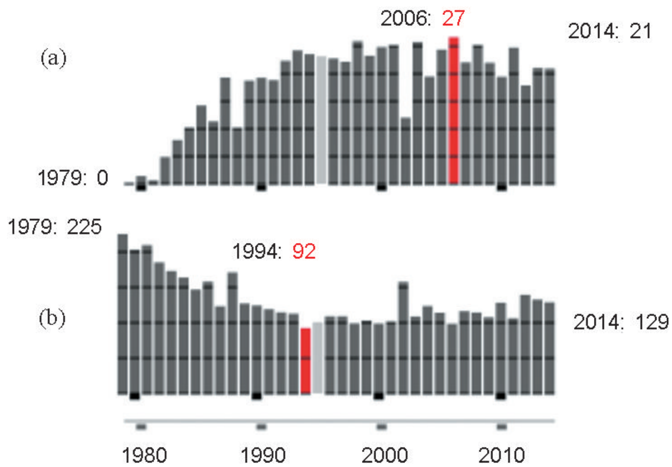

Fig. 4. (a) The mean area of the spring Antarctic ozone anomaly (10^6 km^2) from September 7 to October 13 and (b) the mean value of the minimum TO in it (DU) from September 21 to October 16 according to the data of NASA (the USA) satellite observations from 1979 to 2014. Figures 3 and 4 are taken from the NASA website http://ozonewatch.gsfc.nasa.gov. Extremes of mentioned variables reached in previous years are marked separately (the data for 1995 are absent).

maximum permissible single concentration ($MPC_{m.s}$) of 160 g/m^3 in 1–6 hours after the local noon. The most significant episode was observed on July 31–August 2 but even at that time the exceeding over $MPC_{m.s}$ made up not more than 20%. The inhomogeneity of the surface ozone field on the territory of Moscow and neighborhood was clearly observed during these episodes; the movement was registered of the zone of the maximum values of surface ozone on the territory of the Moscow region from (south)east to (north)west. No hazardous ozone values for the population health were observed in 2014 on the Black Sea coast of the Crimea: the maximum concentration was registered on August 14 on the territory of Kara Dag Nature Reserve and amounted to 138 g/m^3.

REFERENCES

1. A. M. Zvyagintsev, N. S. Ivanova, G. M. Kruchenitskii, et al., “Ozone Content over the Russian Federation in the First Quarter of 2014,” Meteorol. Gidrol., No. 5 (2014) [Russ. Meteorol. Hydrol., No. 5, **39** (2014)].
2. A. M. Zvyagintsev, N. S. Ivanova, G. M. Kruchenitskii, and I. N. Kuznetsova, “Ozone Content over the Russian Federation in the Second Quarter of 2014,” Meteorol. Gidrol., No. 8 (2014) [Russ. Meteorol. Hydrol., No. 8, **39** (2014)].
3. A. M. Zvyagintsev, N. S. Ivanova, G. M. Kruchenitskii, et al., “Ozone Content over the Russian Federation in the Third Quarter of 2014,” Meteorol. Gidrol., No. 11 (2014) [Russ. Meteorol. Hydrol., No. 11, **39** (2014)].
4. A. M. Zvyagintsev, N. S. Ivanova, G. M. Kruchenitskii, et al., “Ozone Content over the Russian Federation in 2008,” Meteorol. Gidrol., No. 3 (2009) [Russ. Meteorol. Hydrol., No. 3, **34** (2009)].
5. W. Chehade, M. Weber, and J. P. Burrows, “Total Ozone Trends and Variability during 1979–2012 from Merged Data Sets of Various Satellites,” Atmos. Chem. Phys., **14** (2014).
6. E. W. Chiou, Bhartia, R. D. McPeters, et al., “Comparison of Profile Total Ozone from SBUV (v8.6) with GOME-type and Ground-based Total Ozone for a 16-year Period (1996 to 2011),” Atmos. Mea. Techn., **7** (2014).
7. A. T. J. de Laat, R. J. van der A, M. van Weele, “Tracing the Second Stage of Ozone Recovery in the Antarctic Ozone-hole with a “Big Data” Approach to Multivariate Regressions,” Atmos. Chem. Phys., **15** (2015).
8. S. M. Frith, N. A. Kramarova, R. S. Stolarski, et al., “Recent Changes in Total Column Ozone Based on the SBUV Version 8.6 Merged Ozone Data Set,” J. Geophys. Res., **119** (2014).
9. T. G. Shepherd, D. A. Plummer, J. F. Scinocca, et al., “Reconciliation of Halogen-induced Ozone Loss with the Total-column Ozone Record,” Nature Geoscience, **7** (2014).