

OBSERVATION OF THE TOTAL OZONE CONTENT IN THE ATMOSPHERE OVER THE ARCTIC DURING THE POLAR NIGHT OF 1991

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Results of observations of the total ozone content over the Arctic (Heiss Island, 81°N, 58°E) in the winter of 1991 are presented. An increase in the total ozone by 14% was observed in January, 1991 compared to January, 1989.

INTRODUCTION

Recently a statistically representative data on the depletion of the total ozone content (TOC) in the atmosphere have been recorded in the middle and higher latitudes of the Northern Hemisphere. An analysis of the TOC data obtained in the 1969–1986 has shown¹ that the mean annual value of the total ozone content in the 30–64° N latitude belt decreased within the limits from 1.7 to 3.0%, in addition, depletion of the TOC during winter was 2.3–6.2% with an intensification of the TOC depletion in the high Northern latitudes. The TOC depletion was associated, in particular, with a strong effect of the emissions of chemical substances, containing chlorine and bromine, into the atmosphere which upset the stable conditions of ozone existence in the atmosphere.

The expeditions to measure the TOC over Heiss Island (81° N, 58° E) were first undertaken in the winter of 1988–89 and were continued in the winter of 1990–91. For high-precision measurements of the TOC over Heiss Island in 1990 we together with specialists of the Canadian Environmental Protection Agency (EPA, Canada) used the new MK–IV modification of the Brewer spectrophotometer No. 049. Results of the TOC observations were regularly delivered at the Soviet ozonometric databank of the Central Aerological Observatory and at the World Center for ozonometric data in Canada.

THE TOC MEASUREMENT METHOD

The MK–IV Brewer spectrophotometer produced by the Canadian company SCI–TEC is a modification of the Brewer MK–II device. The device is designed for consecutive measurements of the TOC, SO₂, and NO₂ according to the given program. The TOC values were determined from the results of spectrophotometric measurements of the lunar radiation in the wavelength range 310–320 nm (Ref. 2).

The Brewer spectrophotometer No. 049 was preliminary calibrated and attached to the triad of the standard Brewer devices in Toronto, Canada in 1990. At present the quality of the measurements of the spectrophotometer is checked out using the regular readings of the built-in halogen lamp, whose stability characterizes the stability of the working parameters of the spectrophotometer. Analysis of a set of the readings

of a standard halogen lamp of the device No. 049 obtained for 8 months revealed the agreement of their values with the initially set values within the limits of 0.4%, which indicates a normal mode of the device operation and a high quality of the ozonometric data obtained over Heiss Island in 1991.

RESULTS OF THE TOC OBSERVATIONS

The TOC measurements over Heiss Island during the polar night of 1990–91 were begun when the moon appears on December 27, 1990. The lowest reading of the TOC was equal to 232 Dobson units (D.u.) and was observed in that day of December over this high-latitude region. During next week, a rapid increase in the ozone content up to 440 D.u. occurred. The increase in the TOC (Fig. 1) correlates well with a sudden increase of the atmospheric temperature, which was at the 30, 50, and 100 mbar levels. The TOC value averaged over the December series of observations was 311 D.u.

The average monthly value of TOC in January, 1991 was 386 D.u. The temperatures in the stratosphere during the second half of January, 1991 at the 30 and 50 mbar levels were sufficiently stable and did not drop below –80°C. At that time, the noticeable variations in the TOC were not observed. The TOC value changed insignificantly from 348 D.u. on January 24 to 369 D.u. on January 28, 1991. For comparison, we give the results of the ozone measurements over Heiss Island in January, 1989.³ For that observation series, the temperature of the stratosphere often reached –85°C, in addition, the values of the TOC were lower and lay within the interval from 314 to 345 D.u. This indicates that the observed variations in the TOC over Heiss Island are, to a considerable degree, related to the variations of the temperature in the stratosphere and, as the latter decreases, as a rule, depletion of the TOC values, recorded by the spectrophotometer, is observed.

Figure 2 shows the results of the TOC measurements over Heiss Island in the winter observation series of 1989 and 1991 and a curve of the TOC variation in accordance with Fioletov's empirical model⁴ for the given latitude. The TOC values in January, 1991 were, on the average, higher than those in January, 1989 by 14%, in addition, they were higher by 5% than the average value of the TOC during the second half of January, 1989.

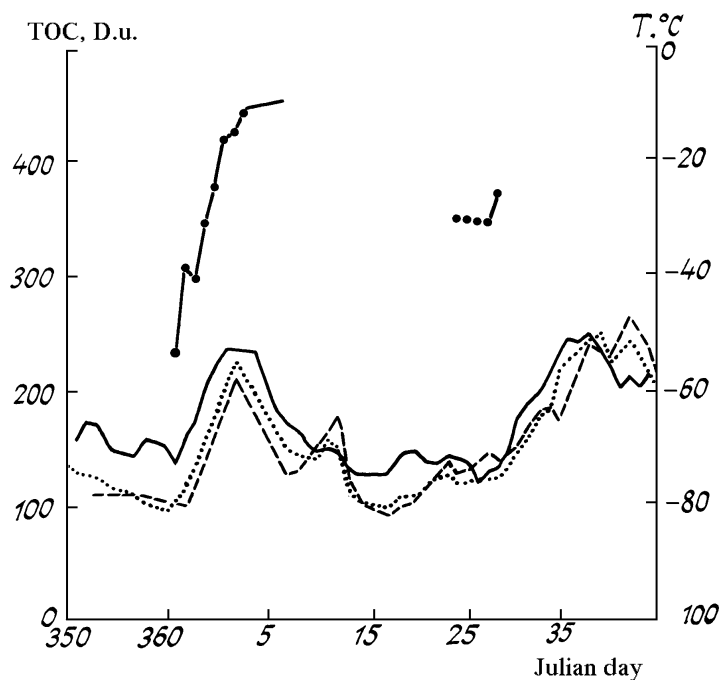


FIG. 1. The TOC variation and the temperature time-course over Heiss Island in winter of 1990–91: the TOC (curve with dots); the temperature at the 100 mbar (solid curve), 50 mbar (dots), and 30 mbar (dashed curve) levels.

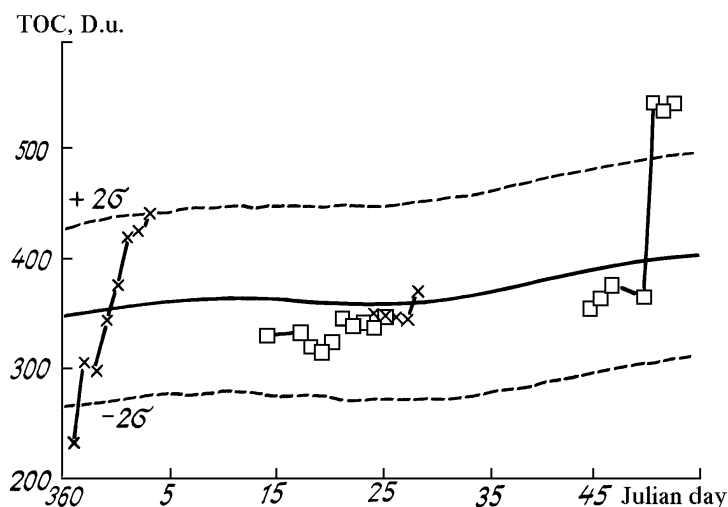


FIG. 2. Comparison of the results of observations over Heiss Island in 1989 and 1991 with the empirical model data⁴: the model (solid curve), 1989 (squares), and 1990–91 (crosses).

The TOC value which was equal to 232 ± 4 D. u. on December 27, 1990 (seven observations) can be referred to as anomalously low value of the total ozone content. Analysis of the TOC data observed in the high latitudes of the Arctic in 1987–90 shows that the TOC close in value which was equal to 241 ± 6 D.u. (19 observations) was recorded only once at the Canadian station Alert (82° N) on December 21, 1988.⁵ In the region neighbouring to Heiss Island, at the station Longuear (78° N), Spitzbergen, the TOC varied from 315 to 345 D.u. in December, 1989.⁶ Low TOC values, as a rule, were observed at the Northern Scandinavian station Tromsø (70° N). Thus in December, 1989 the minimum value of the TOC was 190 D.u. Comparison of those data with the readings of the Brewer spectrophotometer at the

Sodankylä observatory (67° N), Finland,⁶ which is only 500 km apart from the Norwegian station, indicates that, to all appearance, the Dobson spectrophotometer at the Tromsø station regularly underestimates the TOC values (up to 20%) when measuring ozone at large solar zenith angles in late fall and in winter. This dependence disappears in the summer months, which is confirmed by the last international intercomparisons of the Dobson spectrophotometers at Aros (Switzerland, 1990), when the Dobson device No. 14 (Norway) was in agreement with the second standard Dobson device No. 65 (USA). The discrepancy was within the limits of 1% when observing the TOC at intermediate solar zenith angles.

The results of the TOC measurements over Heiss Island are listed in Table I.

TABLE I. The average daily values of the TOC over Heiss Island in December, 1990 and in January, 1991. Measurements of the lunar radiation.

Date	Average daily values of the TOC (D.u.)	Standard deviation (D.u.)	Number of observations
December 27	232	4	7
December 28	306	5	5
December 29	298	16	18
December 30	344	19	14
December 31	376	21	12
January 01	419	9	5
January 02	424	1	2
January 03	440	15	8
January 24	348	1	2
January 25	347	9	20
January 26	346	4	17
January 27	344	8	14
January 28	369	6	4

CONCLUSIONS

1. The results of the TOC observations over Heiss Island in winter 1991 did not show the substantial deviations in their values, predicted by the model calculations.

2. The TOC values over Heiss Island in winter 1991 were higher than those observed in this region in winter 1989.

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