# RUSSIAN FEDERATION

## OBSERVATIONAL ACTIVITIES

The routine observations of atmospheric ozone include total ozone measurements, vertical profile and surface ozone observations.

### Column measurements of ozone and other gases variables relevant to ozone loss.

Daily measurements of column ozone are made by ozone network of Roshydromet service using filter instruments M-124 and by Roshydromet and RAS reference ozone points using Dobson, Brewer and SAOZ instruments. Network included 32 stations on the territory of the former USSR and is technically and methodically, including metrology, maintained by the Voeikov Main Geophysical Observatory (MGO). Observational data from the stations are transmitted to the Central Aerological Observatory (CAO). The CAO archives, accomplishes quality assurance of the data, analyze and monitoring daily ozone fields. The data are also transmitted to the MGO where experts responsible for the status of the network's instruments analyze them. In routine manner the ozone data are transmitted to the WMO World Ozone and UV Centre in the Environment Service of Canada. Quarterly report "Ozone amount over Russia and the neighbouring territories" are regularly published in the journal "Meteorology and Hydrology". Roshydromet publishes the status of the ozone layer in the annual edition of the "Overview of the environment pollution in the Russian Federation".

### Profile measurements of ozone and other gases variables relevant to ozone loss.

Ozone profile measurements are made daily since May 2002 by CAO using space observing system Meteor-3M/SAGE III in the frame of US-Russian cooperation, by CAO using balloon ozone sounding during the winter and spring periods at the Yakutsk and Salekhard (67N, 67E) stations, by Lebedev Physics Institute of Russian academy of Science (LPI RAS) at Moscow and Institute of Applied Optics RAS using microwave (142.2 GHz) radiometers. Institute of Optics of Atmosphere (IOA) RAS conducted the regular observations of ozone, nitrogen dioxide and aerosol profiles using lidar.

To processed Meteor-3M/SAGE III raw data CAO developed the algorithm that provide atmospheric transmission profiles for all 86 SAGE III spectral channels and then vertical profiles of ozone in the region 10-80 km, nitrogen dioxide and aerosol extinction in the region 10-40 km /*Yu.A. Borisov et al., 2005*/.

### UV measurements

The Lomonosov Moscow state University made monitoring of the surface UV radiation using the UVB-1 radiometer since 1999. The Brewer instruments located at the Yakutsk station and Obninsk were calibrated to measure the spectral distribution of the surface UV radiation. NPO "Typhoon" (Obninsk) uses Brewer instrument for regular monitoring of UV radiation.

### Calibration activities

The Dobson instrument # 107are calibrated with 4 years period, the last one was in June 2003. Calibration is conducted in the European regional centre of the calibration of Dobson's instruments, located in Hohenpeissenberg, Germany.
The three Brewer instrument were calibrated by IOS Canada in 2003 and there is a grant from Ministry of education, science and technology of Russian Federation to realize calibration of four instruments on August 2005.

## Ozone measurements in troposphere

The regular measurements of surface ozone continue at The Kislovodsk, Moscow, Dolgoprudny, Lovozero, Tomsk and Mondu stations. The most prolonged measurements are taken at the mountain scientific station Kislovodsk (2070 m above sea level) from March 1989. This station has noticeable position in the system of the global monitoring of surface ozone – it is located in the region with the steady climate (*Elansky N.F., 2004, Tarasova A.O. et al. 2003*). At the station are fixed some prolonged anomalies of the content of ozone, contrasted on the sign to the anomalies, which were being observed at the Alpine stations. This is forces to assume that long-term changes in ozone are closely related with the variability of large-scale circulation (*Elansky at al., 2002*).

The institute of physics of the atmosphere, the German Max Planck institute of chemistry and CMDL NOAA continued a series of experiments TROIKA. The railroad carriage-laboratory, that is equipped with the automated complex equipment, provides in the Russian territory measurements of surface ozone, reactive gases, greenhouse gases, ozone depleting and other volatile compounds; ; concentration and the microphysical and chemical properties of aerosol; temperature profile in layer 0-600 m, meteorological parameters, solar radiation and also remote measurements of nitrogen dioxide and ozone profiles in the stratosphere.

## RESULTS FROM OBSEVATION AND ANALYSIS

## Column ozone

The detailed analysis of global changes in the ozone layer was conducted, in essence, according to the data of TOMS instrument. During the period of 1979 – 2002 the reduction in the average annual value of total ozone in the region extratropical latitudes with an average speed of about 2% per annum is noted. In the northern hemisphere an increase in frequency and amplitude of the negative anomalies of the total ozone in the period 1987-1997 occurred. During this period in the high latitudes of the northern hemisphere the total ozone deficiency amounted to 40%, the duration of anomalies reached to 2 months, while into 1995 and 1997 anomalies were extended almost to half of the territory of Russia. During the last ten years practically everywhere, with exception of the high latitudes of the southern hemisphere, the slow growth of total ozone occurs to the values, close to typical ones for the middle of 1970. The process of an increase of ozone in the northern hemisphere and on the territory of Russia appeared, in particular, in the significant decrease of the basic negative ozone anomaly of the hemisphere – of "spring Yakut" which approximated to Antarctic ozone hole according to such indices as area, duration and the deficiency of ozone, in the separate years.

The mean-zonal sliding trends of total ozone were determined according to the TOMS data in the period from November 1978 through December 2003 (Fig.1).

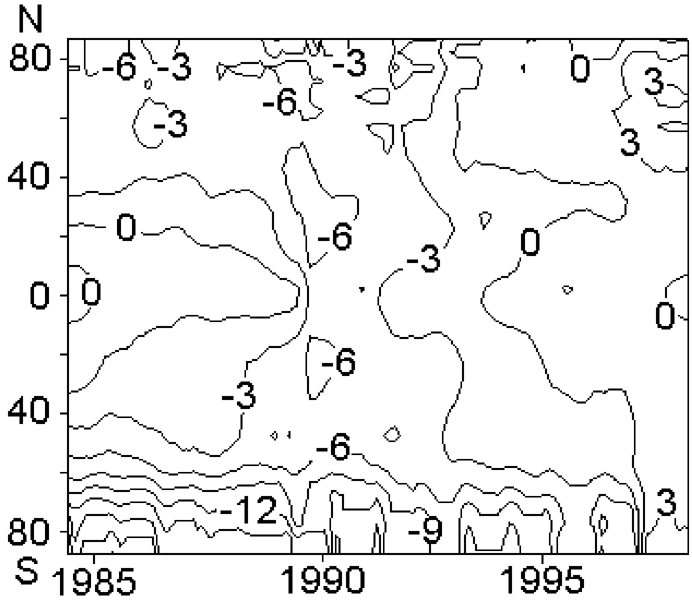


***Figure 1: The time dependence of the mean-zonal (on the 5-degree latitudinal belts) sliding trends of total ozone (in the percentages in 10 years) during the 11-year period according to the TOMS data in the period from November 1978 through December 2003. Years on the horizontal axis correspond to mean value of the 11-year period, vertical axis – latitude* /Zvyagintsev A.M. et al, 2002a/.**

**Ozone profile**

The processed Meteor-3M/SAGE III data registered powerful polar stratosphere clouds in the period from the end of December 2004 through February 2005 in the zone of 65-75 degrees of north latitude. Maximum optical cloud thickness was located at heights of approximately 20 km and was observed at temperatures below – 80°C. Under these conditions the extinction of semi-transparent stratosphere clouds exceeded the background values of the aerosol extinction for two orders. The presence of clouds was accompanied by the significant decrease of ozone concentration (*Yu. Borisov, Central Aerological Observatory*).

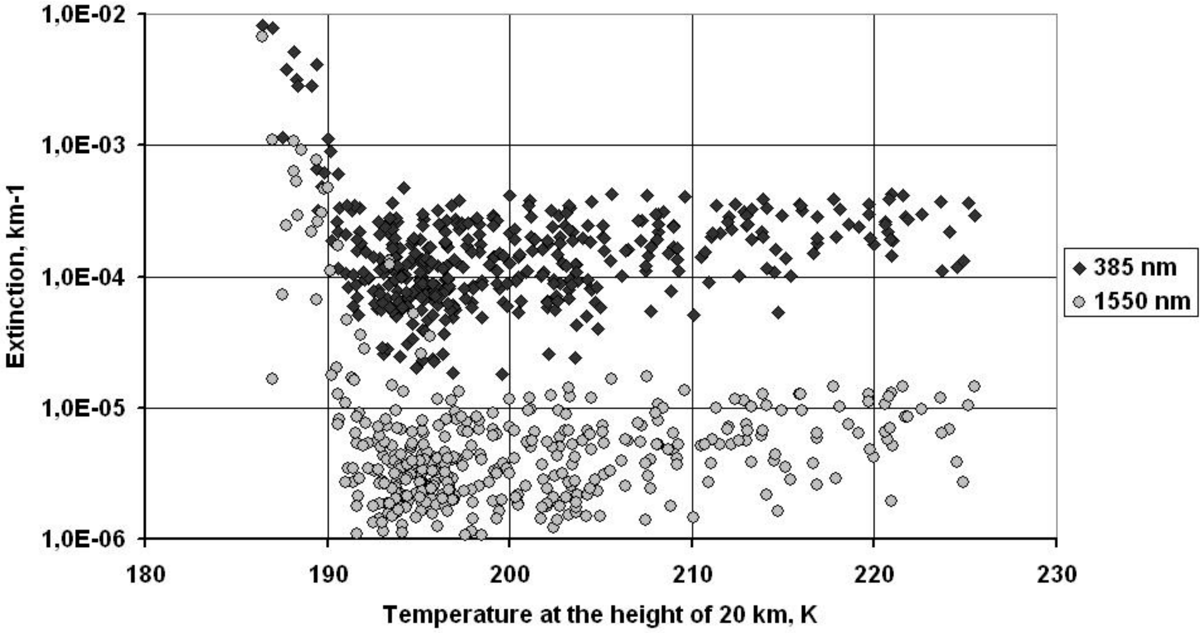


***Figure 2: Extinction of the aerosol at the height of 20 km for 385nm and 1550nm wavelength. Meteor-3M/SAGE III January-February 2005, 65-75 N.***

The analysis of long-term changes in the ozone vertical distribution by balloon sounding stations (Resolute, Cherchil, Edmonton, Goose Bay, Hohenpeissenberg, Payerne, Sapporo, Boulder, Tateno, Kagoshima, Hilo - for all period of measurements no less than 15 years) and temperature profile for the period from 1970 to 2002 was made. The method of 11-years sliding trend calculation was used. The strongest decrease of the ozone partial pressure in the North hemisphere was detected in the region directly above the tropopause in the lower stratosphere during the period from the end of the late seventies to the early ninetieth last century. The decrease of the ozone partial pressure exactly in this region of heights caused the main contribution to total ozone decrease in the North hemisphere. The correlation between ozone amount and the tropopause height indicates on the relationship between long-term changes of the ozone layer and climate change/*Zvyagintsev et al. 2005a*/.

The analysis of data of balloon ozone sounding at Yakutsk and Salekhard stations made it possible to obtain the estimation of the chemical destruction of stratospheric ozone in the winter Arctic circumpolar vortex /*Tsvetkova N.D., 2002,.2004*/. So in 2005 was fixed the record value of the chemical destruction of ozone in the stratosphere, which reached 116 Dobson units in total ozone value.

Measurements conducted by IOA RAS during 1999-2002 in the conditions of the long-term background state of the atmosphere were used for the improving the models of the ozone and aerosol vertical distributions.

**Ozone in the troposphere**

The effect of the long-range transport of ozone and its predecessors to the content of ozone at the Lovozero and Kislovodsk background stations is estimated. The influence was discovered of anthropogenic pollution from Central Europe and Western Europe on both stations and influence of the ejections of the mineral aerosol of North Africa to the content of ozone at the Kislovodsk mountain station.

According to the results of the analysis of surface ozone in the territories of Russia and Europe the conclusion is made that the changeability of ozone in Russia is defined by the same factors as in Europe, but the influence of meteorological conditions in Russia is more strong because of the smaller level of pollution /*Zvyagintsev A.M. et al, 2002*/.

The analysis is carried out of the worldwide network observations of surface ozone and vertical distribution of ozone in the troposphere during the recent several decades. The conclusion is made that the interpretation of the long-term changes of the ozone in the troposphere must carry out together with changes in the meteorological parameters, first of all in temperature /*Zvyagintsev A.M. et al, 2005b*/.

**THEORY, MODELLING AND OTHER RESERCH**

MGO developed the 3D transport-photochemical model of the stratosphere. The ozonosphere changes caused by Montreal Protocol realization were estimated The model calculations demonstrate that during period of 1992-2002 the ozone layer evolution depends of the current meteorological situation for the most part and only 1-2% was caused by implementation of the Montreal Protocol /*Egorova T.A. et al., 2003*/.

The estimations of the ozone decreasing during spring 1993-1996 and 2002 over the Antarctic are conducted. For calculation the assimilated meteorological reanalyzed UKMO data were utilizes. Successful description of the heterogeneous photochemical processes allow to achieve a good agreement with the results of observations made at the Syowa (Japan), Marambio (Argentina) and Amoodsen-Scott stations and also render the unique behaviour of the ozone hole in 2002 /*Ozolin Yu.E. et al., 2003*/.

At the Novosibirsk State University the calculation of natural and anthropogenic factors to long-term changes in the ozone layer in the last decades of the $20^{th}$ century is studied using a numerical two-dimensional ozonosphere model with self-consistent calculation of photochemical, radiative, dynamic, and microphysical processes. Changes in the ozone layer calculated from data in anthropogenic pollution, 11-year solar UV flux variations, and volcanic eruption agree quite well with the global ozone trends observed in the last 25 years of the 20$^{th}$ century (*Demidov I.G. et al., 2005*).

Studies are carried out on the development of the methods of processing and analysis of data of IR- sounder IASI of high spectral resolution. This instrument is intended to launch on the future European meteorological satellite. The method of evaluating the vertical distribution of ozone according to information IASI is proposed (*Uspensky A.B. et al., 2003*)

Within the framework of project TRIDES it is shown that the predecessors of the toxic chlororganic connections, which are formed with the participation of ozone, are not only the anthropogenic pollution, but also the products of the vital activity of the halo-bacteria, that live in salt waters of Caspian and Aral Seas and lakes of Central Asia /L. Weissflog et al., 2005/.

The estimation was carried out of the emission of ozone depleting substances in the territory of Russia according to observations of the TROIKA experiment. It is shown that the emissions of such substances are small, with exception of Freon -12 /D.F. Hurst et al.,2004/.

## DISSEMINATION OF RESULTS

### Data reporting

The M-124 network observations of the total ozone are daily transmitted to the WOUDC. The results of observations by Dobson instrument #107 (Dolgopruny) and by Brewer (Yakutsk) instrument are monthly transferred in WOUDC. Total ozone data base of Brewer observation at the Kislivodsk station was transferred in WOUDC. Observational data of SAOZ instrument located at the Salekhard are transferred once a week to the French centre of SAOZ data collection. Data of balloon ozone sounding at the Salekhard and Yakutsk stations during the winter-spring period of 2003, 2004 and 2005 are represented into the NILU data base.

### Information to the public

A technology for UV forecasting on the Russian territory was developed. The technology utilizes the M-124 network observations, satellite (METEOSAT) cloud cover and surface albedo data to retrieve current and forecast the next day UV-B surface radiation. Technology is used irregularly, only in the case of the strong negative anomalies of total ozone.

### Relevant scientific papers


*Egorova T.A., Rozanov E.V., Zubov V.A., Karol I.L. Model for ozone trend investigations: brief description and validation //Proceedings of the RAS. Atmospheric and Oceanic Physics, 2003, V39 Suppl.3, P.310-326 (In Russian).*

*Ozolin Yu.E., Karol I.L., Kiselev A.A., Zubov V.A. Trajectory modeling of transport and photochemistry of the air masses in the Antarctic stratospheric polar vortex// Proceedings of the RAS. Atmospheric and Oceanic Physics, 2003, V39 Suppl.4, P.492-504 (In Russian).*

*Demidov I.G., Zadorozhny A.M. Contribution of Natural and Antropogenic Factors to Long –Term Changes in the Earth's Ozone layer zt the End of the 20$^{th}$ Century// Proceedings of the RAS. Atmospheric and Oceanic Physics, 2005, V41 Suppl.1, P.51-65 (In Russian).*

*Zvyagintsev A.M., Kruchenitsky G.M., Chernikov A.A. Changes of the vertical ozone distributions in the stratosphere and there correlation with tropopause height changes// Proceedings of the RAS. Atmospheric and Oceanic Physics, 2005a, V41 Suppl.4, P.1-10 (In Russian).*

*Tsvetkova N.D., H.Nakane, Luk'yanov A.N., Yusjkov V.A., Dorokhov V.M., Zaitsev L.G., and Sitnikova V.I. Estimation of the winter-spring rates of ozone depletion within the Stratospheric Arctic Cyclone in Siberia in 1995-200 from balloon measurements// Proceedings of the RAS. Atmospheric and Oceanic Physics, 2002, V38 Suppl.2, P.211-219 (In Russian).*

*Tsvetkova N.D., H.Nakane, Yusjkov V.A., Luk'yanov A.N., Dorokhov. Estimation of the contribution of the chemical destruction of ozone to its total amount in Arctic polar vortex in the winter- spring period of 2000//Meteorogy and hydrology, 2004, No 10, P.56-63 (In Russian).*

*Borisov Yu.A., Bankova T.V., Ivanovsky A.I., Chayanova E.A., Glazkov V.N. METEOR-3M/SAGE III: Algorithm, Results & Validation//Proceeding of the 31 International Symposium on remote Sensing of Environment, St. Petersburg, 2005.*

*Elansky N.F. Atmospheric ozone studies in Russia in 1999-2002// Proceedings of the RAS. Atmospheric and Oceanic Physics, 2004, V40 Suppl.4, P.567-576 (In Russian).*

*Tarasova O.A., Elansky N.F., Kuznetsov G.I., Kuznetsova I.N., Senic I.A. Impact of air transport on seasonal variations and trends of surface ozone at Kislovodsk high mountain station // J. Atm. Chem. 2003, Vol. 45, P.245-259.*

*Uspensky A.B., Romanov C.V., Trotsenko A.N. Simulation of remote measurements of the vertical distribution of ozone in the atmosphere according to the data of the satellite IR sounder of highly spectral resolution. Exploration of the Earth from space, 2003, Vol.1, P.49-57 (In Russian).*

*Zvyagintsev A.M., Kuznetsova I.N. Changeability of surface ozone in the environments of Moscow: the results of ten-year regular observations // Proceedings of the RAS. Atmospheric and Oceanic Physics, 2002, V38 Suppl.4, P.486-495 (In Russian).*

*Zvyagintsev A.M., Kruchenitsky G.M., Chernikov A.A. Long-term changes in the content of ozone in the troposphere //Proceedings of the RAS. Atmospheric and Oceanic Physics, 2005b, V41 Suppl.1, P.47-58 (In Russian).*

*L. Weissflog, C.A. Lange, A. Phenningsdorff, K.Kotte, N. Elansky, L. Licitzyna, E. Putz, G. Krueger,Sediments of salt lakes as a new source of volatile highly chlorinated C1/C2 hydrocarbons //J.Geoph. Res.Lett. Vol. 32. L01401, 2005.*

*D.F. Hurst, P.A. Romashkin, J.W. Elkins, E.A. Oberlander, N.F. Elansky, I. B. Belikov, I.G. Grandberg, G.S. Golitsyn, A.M. Grisko, C.A.M. Brenninkmeijer and P.J. Cruzen. Emissions of ozone-depleting substances in Russia during 2001 //J.G.Res.V.109, D14303, 2004.*

**PROJECTS AND COLLABORATION**

US-Russian Meteor-3M/SAGE III project.
European project QUOBI.
European project SCOUT-03.
TRIDES Project.

Agreement between Roshydromet and Finnish Meteorological Institute (item 2. Stratospheric ozone and UV radiation measurements)

**FUTURE PLANS**

To continue monitoring the total ozone and vertical distribution of ozone with the use of ground-based, balloon and satellite observation facilities.

To develop together with the Belarus' country satellite spectrophotometer SFM -2M intended for the measurements of the vertical profile of ozone in the upper troposphere, the stratosphere and the mesosphere.

In order to equip ozone network stations with the instruments of contemporary level, MGO developed and prepared the experimental sample of ozone UV- spectrometer for measuring the column ozone, the spectral composition of the UV radiation, the optical density of aerosol, etc. Spectrometer is developed on basis of diffraction grating and CCD and it separates the spectrum of radiation in the range 230-420 nm with the 0.9 nm resolution.

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