Appendix

Most important achievements of the Institute of Optical Monitoring SB RAS reported by the RAS and SB RAS in 1993–2001

1993

From the Report "Activity of Siberian Branch of the Russian Academy of Sciences in 1993"

The Institute of Atmospheric Optics in cooperation with the DTI "Optika" completed formation of the instrumental system for an airborne laboratory based on AN-30 aircraft. This system provides for climate and ecological monitoring of the atmosphere and surface and includes a wide spectrum of tools for both direct and remote measurements (spectrometers, lidars, television and thermal vision equipment).

The data of long-term airborne sensing of the lower troposphere above the territory of Western Siberia have been analyzed. This analysis revealed, in particular, the interannual cycles of variability of the aerosol content.

The periods of maximum atmospheric content of aerosol coincide with powerful emissions from volcanoes: El Chichon (Mexico) in 1982 and Mt. Pinatubo (Philippines) in 1991 (Fig. 1).

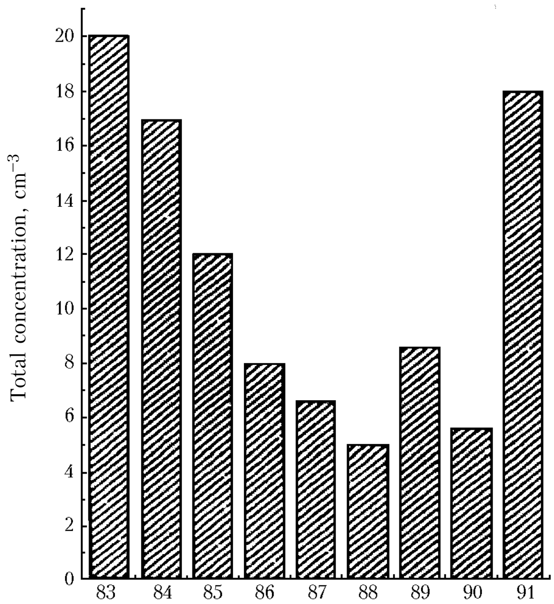

Fig. 1. Histogram of the annual mean total concentration of aerosol particles with the radius larger than 0.2 mm in the atmospheric layer from 0 to 3 km.

On the regional scale, the effect of atmospheric turbidity (because of transport of volcanic particles) on the climate is most pronounced in the annual amplitude of temperature of the low atmospheric layers: at maximum turbidity occurred, winters were warmer and summers colder and, inversely, at minimum of the aerosol overburden, the temperature contrast between winter and summer is the highest, that is, the climate becomes more continental.

1994

From "Report on Activity of Siberian Branch of the Russian Academy of Sciences in 1994. Vol. I. Main Results of Basic Research in Priority Fields of Science and Technology"

1. An Ecological-Meteorological Observatory has been created. This Observatory makes it possible combined studies of the atmosphere and the effect of natural and anthropogenic factors on the air composition and climate. The Observatory is equipped with unique instrumentation, including laser and radio wave stations for remote sensing of the atmosphere. It is both the center of basic research into the Earth's atmosphere and a testing ground for new ecological-meteorological devices (Design and Technology Institute "Optika").

2. Development of industrial laser interferometer for testing large-size optical parts has been completed. The interferometer is based on original technological solutions in a power unit (aperture diameter of 1 m), compensator unit, and interferogram processing unit that distinguish it from the existing device (MARK-IV made by ZIGO, USA). (Design and Technology Institute "Optika").

1995

From the Report "Activity of Siberian Branch of the Russian Academy of Sciences in 1995"

In May 1995, the first Russian lidar BALKAN-1 was launched for three-year operation at the MIR space station (Spektr module). The BALKAN-1 lidar was developed at the Institute of Atmospheric Optics in cooperation with the Design and Technology Institute "Optika". BALKAN-1 is designed for sensing of cloud fields and the Earth's surface from space (Fig. 2).

In July–October the first series of experiments with the BALKAN-1 lidar confirmed the correctness of scientific and technological solutions used.

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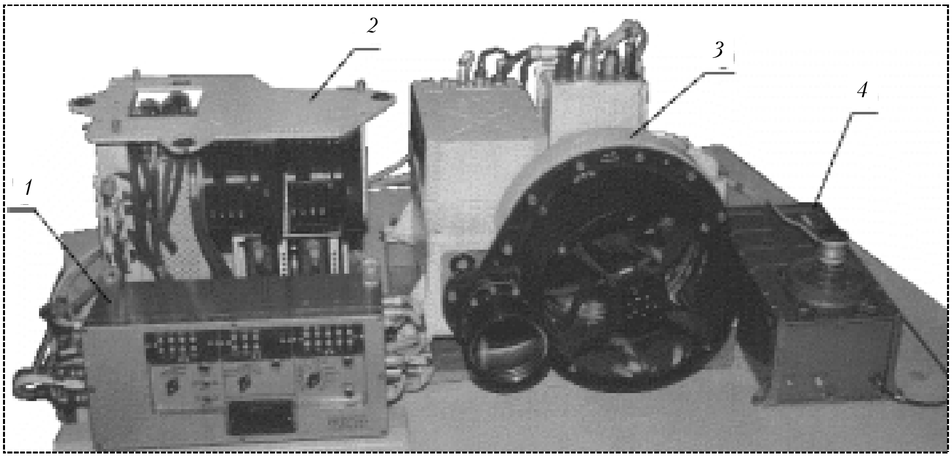

Fig. 2. Components of BALKAN lidar: control unit *1*, telemetry unit *2*, transmitting/receiving system *3*, lidar signal unit *4*.

1998

From the Report "Activity of Siberian Branch of the Russian Academy of Sciences in 1998"

1. The Institute of Optical Monitoring developed a high-reproducibility (up to 50%) technology of growing $ZnGeP_2$ single crystals and an annealing technology providing for the controlled optical properties of crystals (absorption coefficient of less than 0.1 cm^{-1}) in the wavelength range of 3–8 μm (Fig. 3). This significantly increased the efficiency of IR frequency converters made of these crystals and intended for use in the systems of remote sensing of the atmosphere. (Earth Sciences. Geochemistry, Mineralogy, Petrography).

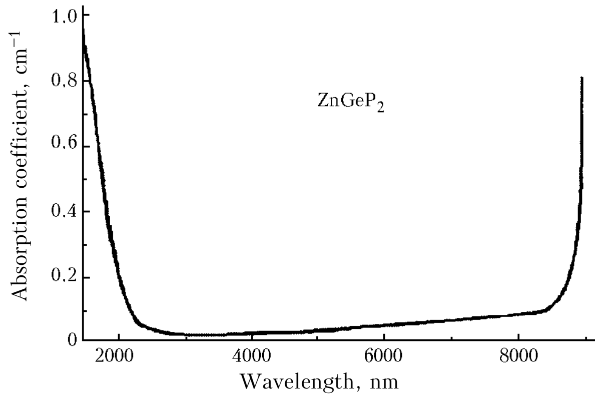

Fig. 3. Absorption spectrum of $ZnGeP_2$ crystals.

2. Through processing the data obtained during several decades at 114 meteorological stations in the Northern Hemisphere, the Institute of Optical Monitoring in cooperation with the Faculty of Meteorology and Climatology of Tomsk State University revealed high correlation between the annual mean values of the surface air temperature (T) and the amplitude of its annual behavior (A_T). The latter was determined as the annual mean half difference of monthly mean temperatures in the coldest and hottest months for each station. As is seen from Fig. 4, high correlation between T and A_T reveals a common regularity for different climatic zones of the Northern Hemisphere.

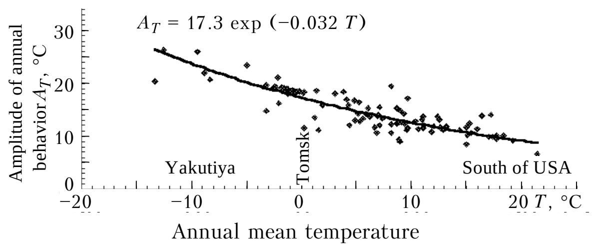

Fig. 4. Amplitude of the annual behavior of temperature for the Northern Hemisphere vs. the annual mean temperature.

Analysis of long-term temperature variations shows that global warming leads to the gradual decrease of the amplitude of the annual behavior. One of the manifestations of this regularity is the smaller increase of temperature in summer months as compared with winter months at global warming. (Earth Sciences. Geochemistry, Mineralogy, Petrography)

1999

From "Report on Activity of the Russian Academy of Sciences in 1999. Earth Science. Oceanology. Atmospheric Physics. Geography"

1. An unparalleled algorithm for calculation of fluxes of thermal radiation in radiative blocks of climatic models was developed. The optimized reference algorithm and its parametric modification based on Laplace transformation significantly decreased the computation time at the error no higher than 0.5% (IOM SB RAS).

2. A method was developed for estimation of physical properties of a new class of mixed-type nonlinear-optical crystal (IOM SB RAS).

3. An analytical three-flux model was developed for successive calculation of the fluxes of direct and scattered solar radiation with justified applicability limits in the cloudless atmosphere and under the overcast conditions. This model provides for rigorous description of variations of the radiative fluxes under the effect of natural and anthropogenic factors (IOM SB RAS).

From the Report "Activity of the Siberian Branch of the Russian Academy of Sciences in 1999"

For the first time, the Institute of Optical Monitoring succeeded in growing mixed-type crystals and in obtaining frequency conversion in this type of nonlinear-optical crystals, namely, generation of the second harmonic of CO_2 laser in $AgGa_{0.6}In_{0.4}Se_2$ crystals being a mixture of the initial $AgGaSe_2$ and $AgInSe_2$ crystals (Fig. 5).

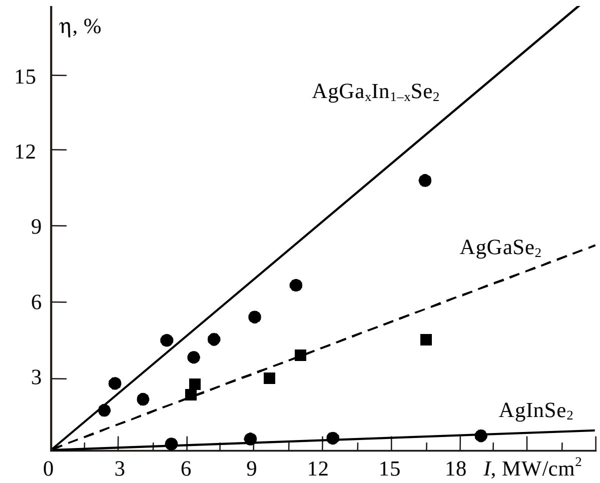

Fig. 5. Efficiency of second harmonic generation of CO_2 laser in the initial $AgInSe_2$ [theory (lower solid line) and experiment (circles)] and in $AgGaSe_2$ crystals [theory (dashed line) and experiment (squares)], and in the mixed $AgGa_xIn_{1-x}Se_2$ crystal 11 mm in length at $x = 0.6$ [theory (upper solid line) and experiment (circles)].

Selection of the proper composition provided for fulfillment of the conditions of noncritical phase matching, what caused about three times higher efficiency of mixed crystal as compared with the maximum efficiencies of the initial crystals. The further increase in the efficiency will be proportional to the square length of the crystals used. (Earth Sciences. Petrology, Geochemistry, Mineral Resources).

2000

From the Report "Activity of the Siberian Branch of the Russian Academy of Sciences in 2000"

1. The Institute of Optical Monitoring performed statistical analysis of the temperature conditions in Northern Asia based on the data of 134 meteorological stations for the period since 1955 till 1998. This analysis revealed local character of warming with the maximum trend exceeding 0.5°C/10 yr (Fig. 6). At the same time, the interseasonal amplitude of fluctuations of the monthly mean temperature decreases with the increase of the annual mean temperature for Northern Asia as a whole except for the region of Verhoyansk pole of cold, where the corresponding dependence has just the opposite character. (Earth Sciences. Geology of the Environment, Geoecology).

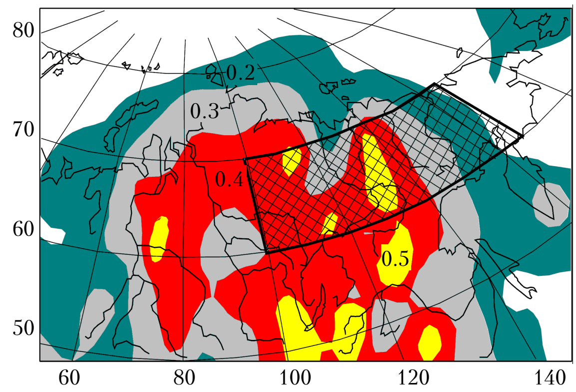

Fig. 6. Levels of warming trends in Northern Asia, in °C/10 yr. Shading shows the region, in which the amplitude of the annual behavior of temperature increases with the growth of the annual mean temperature.

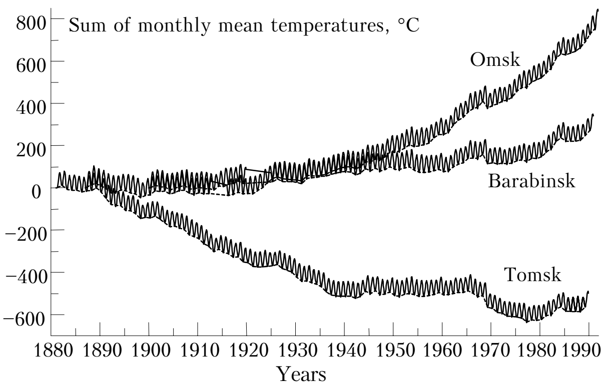

Fig. 7. Evolution trajectories of temperature conditions for three regional natural-climatic zones of Siberia.

2. The Institute of Optical Monitoring proposed and tested for the first time the system-evolutionary approach to the study of current changes in regional natural and climate systems and to multifactor simulation of the processes of energy and mass transfer in the Earth's atmosphere with the allowance for consistency of intersystem relationships. Based on this approach, new methods were developed for processing and analysis of monitoring results for estimating regional climate changes. These new methods are not distorted by smoothing averaging. As an example, Fig. 7 shows the results of processing meteorological data for three Siberian cities that demonstrate regional peculiarities of the evolution of temperature conditions, sharp turns of

the evolution trajectory, in particular, the marked turn in the 60s that was observed everywhere in the Northern Hemisphere. (Earth sciences. Geology of the Environment, Geoecology).

3. The Institute of Optical Monitoring developed the differential lidar absorption (DIAL) method for overlapping bands in the UV spectral region and completed development of computer-controlled gas analyzer for nitrogen monoxide and sulfur dioxide in the exhaust gas emissions with the threshold sensitivity of 1 mg/m^3 (Fig. 8).

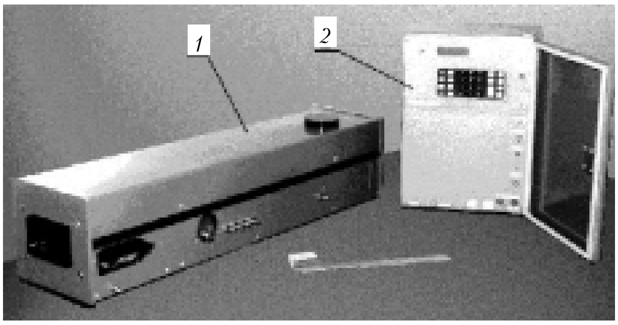

Fig. 8. DOG-2 gas analyzer.

The DOG-2 two-component gas analyzer is designed for ecological monitoring of emissions and on-line regulation of fuel burning conditions at heat-and-power plants. The developed scientific background and new technological solutions provide for high performance of the gas analyzer (continuous work for up to one year), multiple technological capabilities, and high operation rate (time needed for one measurement is 8 s). (Earth Sciences. Geology of the Environment, Geoecology).

4. The Institute of Optical Monitoring developed a new technology for production of crystals with improved optical quality for highly efficient frequency converters of laser radiation to be used in the systems for remote monitoring of the atmosphere in the mid-infrared spectral region. It is based on the results of many-year experimental studies on how the absorption coefficient of $ZnGeP_2$ is affected by the conditions of compound synthesis, crystal growth, and doping, as well as thermal processing and dosed e-beam irradiation.

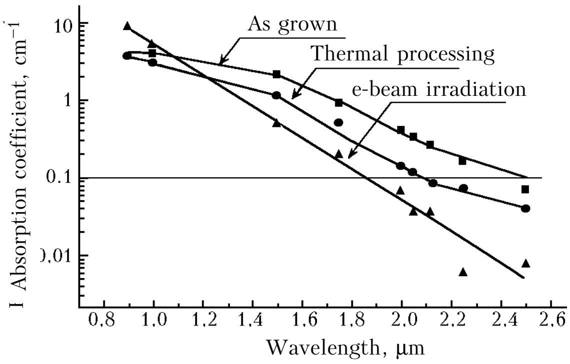

Fig. 9. Absorption spectra of $ZnGeP_2$ crystals at different stages of their production.

As can be seen from Fig. 9, the thermal processing of crystals markedly improves their optical properties, and the following irradiation by fast electrons (with the energy higher than 5 keV) leads to further decrease of the absorption coefficient in the mid-infrared (< 0.05 cm^{-1} at the wavelength of 2 μm).

The achieved level of the optical quality of crystals obtained by the developed technology provides for production of parametric light oscillators with the increased efficiency in the region of 3–10 μm at laser pumping with different active elements (LiYF4: Ho, parametric light oscillator based on KTP-crystals with pumping by a YAG:Nd laser). (Earth Sciences. Geology of the Environment, Geoecology).

1997–2001

From "Summary Report on Activity of the Presidium of RAS in 1997–2001. Earth Sciences. Oceanology, Atmospheric Physics, and Geography"

Statistical analysis of the temperature conditions in Siberia based on the data of 134 meteorological stations for the period from 1955 to 1998 revealed the focal character of warming with the maximum trend exceeding 0.5°C/10 yr. Interseasonal fluctuations of the monthly mean temperature decrease with the increase of the mean annual temperature for Siberia as a whole except only for the region of the Verhoyansk pole of cold, where the corresponding dependence has the opposite character (IOM SB RAS).

From the Report "Siberian Branch of the Russian Academy of Sciences. 1997–2001"

1. The Institute of Optical Monitoring developed a series of gas analyzers for monitoring of NO and SO_2 content in smoke emissions with the threshold sensitivity of 1 mg/m^3. One- and two-component gas analyzers passed certification and are produced now for ecological monitoring of smoke emissions and optimization of fuel burning conditions at heat-and-power plants (Earth Sciences. Instrumentation).

2. Based on the results of statistical analysis of temperature conditions of the surface air in Southern Siberia for the last decades, the Institute of Optical Monitoring revealed a stable local accelerated warming in some regions with the maximum trend of more than 0.5°C/10 yr (see Fig. 6) against the backgrounds of the systematic increase of the annual mean temperature. The amplitude of the annual behavior of the monthly

mean temperature in the surface atmosphere A_T that characterizes the stability of the climatic system keeps, on the average, a nearly linear dependence on the annual mean temperature T (in K): $A_T = \alpha\,(300 - T)$, where α for the Northern Hemisphere as a whole equals 0.56, and for different climatic zones of Siberia it takes the values from 0.4 to 0.8 (Earth Sciences. Prediction of Global Changes in the Environment and Climate, Geography).

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