REPORT ON THE PROJECT "CLIMATIC AND ECOLOGICAL MONITORING OF SIBERIA" OF THE REGIONAL SCIENTIFIC AND TECHNICAL PROGRAM "SIBERIA"(1995)

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MONITORING OF THE METEOROLOGICAL (THERMODYNAMIC) STATE OF THE ATMOSPHERE

Our researches revealed the rise in the average annual temperature over the southeastern territory of Western Siberia in the last 30 years by 0.03°C. This is three times that of the last century. Warming was especially pronounced in winter. Only for three months (December, January, and February) the average annual temperature increased by 0.02°C. The temperature fields were strongly correlated with a spatial correlation length of 1500 km. Time series expansion of the temperature on different temporal scales showed that 95% of the total variance was due to intra-annual variations, 4% was introduced by circulation processes, and 1% was due to long-term trend and local features. To estimate the spatiotemporal characteristics of precipitation fields at the southeast of Western Siberia, the technique was proposed for separating the regional and local components. Our calculations showed that the regional component of precipitation fields remained unchanged in the last three decades. The long-term trend of the regional component vanished.

The main mechanism resulting in the variations of monthly precipitation sums was the circulation that was responsible for 42% of the variance; the intra-annual component contributed 30% into the variance, and 28% was due to local features. The local component played an important role in the precipitation regime. This component formed even long-term trends, which, for some areas, might differ markedly from the regional trend and varied in a wide range of values both positive and negative. Due to a major contribution of the local component to the precipitation regime, the spatial correlation between the precipitation fields was much weaker than that between the temperature fields; the correlation length was only 300 km. Such a contribution of the local component can be explained by the anthropogenic effect. Thus, in Tomsk the number of days with precipitation was, on average, by two larger than that in its surroundings.

Tomsk State University

MONITORING OF THE ATMOSPHERIC DYNAMICS

The work was done to develop a concept of an information modeling system to solve expert-prognostic problems involving evaluation of an ecological outlook for industrial regions. The experimental versions of the model complex and data base for studying changes in the climatic system and processes of pollutant transport due to joint effect of natural and anthropogenic factors were developed. The system organization of models was oriented to solve the problems of atmospheric ecological monitoring and to reveal prerequisites for ecologically adverse situations. The base models were constructed on the principles of coordination and insertion of the spatiotemporal scales from local to mesoregional.

The models and the techniques for their practical implementation were tested using the Novosibirsk industrial region, Novosibirsk, and its individual regions as an example.

To make the conception of expert estimates more specific, the ecological aspects of different variants of power and heat supply in the territory of Siberia and Far East were analyzed taking into account the specific climatic conditions and characteristic scales of regions influenced by different pollution sources that affect the quality of regional atmosphere, which were calculated based on mathematical models. As the primary power sources, we considered coal, liquid, and gaseous fuel, atomic energy, and so on. General trends were analyzed and recommendations were formulated for practical application of these results to the solution of interconnected problems of power engineering and ecology. The technique was developed for regionalizing the territory into zones by a degree of influence of different sources of anthropogenic origin. In so doing, different aspects were taken into consideration, namely, the organization of observations, control over the quality of the atmosphere, long-term ecological forecasting with the use of the scenario approach. Based on the model complex, different scenarios were modeled for different anthropogenic loads on a region.

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MONITORING OF THE ATMOSPHERIC AEROSOL, CLOUDINESS, AND PRECIPITATION

The researches carried out within the framework of this monitoring in 1993–1995 were mainly directed toward measuring and analyzing different parameters of the atmospheric aerosol. During the period under review with the use of means of ground-based, airborne, and remote lidar monitoring, the regularity in the aerosol behavior in the ground layer and the mixing layer and its integrated content in the air vertical column were studied. In the ground layer, except for the secondary maxima in July and December, the aerosol concentration was maximum in the cold season and minimum in the warm one. The mixing layer showed the opposite trend with the maximum in July and the minimum in December–January. The integrated aerosol content showed the behavior analogous, on average, to that in the mixing layer.

The highest aerosol content observed in May–June was 2–4 times higher than that for the cold season. These trends in the aerosol annual behavior were common to main regions of Siberia. The aerosol also had the diurnal behavior, which was more pronounced in summer. Two maxima were inherent in it: in the morning (9–11, L.T.) and at sunset (21–24, L.T.). In winter, only the morning maximum was observed (10–12, L.T.). An analysis showed the presence of substances of natural (terragenic) and anthropogenic origins in the aerosol chemical composition. The ratio between these two groups of substances was practically unchanged, on average, through the territory of Western Siberia. In 1994, the intercomparison was carried out between the contact (nephelometer) and remote (lidar) means of studying the aerosol characteristics. This intercomparison gave a certificate to lidars for aerosol monitoring. A nephelometer was placed onboard an aircraft that flew above the place of dislocation of LOZA, Makrel', and LISA lidars at different flight levels. Simultaneous measurements showed the good agreement between results at altitudes up to 2.5 km (lidar operation range) within the overall spread in data of 30–50%. The systematic errors were found in lidar data connected with a data processing algorithm and could be considered.

Airborne lidar experiments substantiated the use of lidars for aerosol monitoring. Periodic lidar experiments have been started to study the aerosol in the low stratosphere and high (cirrus) clouds. The correlation was revealed between the aerosol concentration in the stratosphere and the volcanic activity, which explained the origin of the Junge layer. The results of cirrus cloud sensing showed that in 20–30% of their lifetime they consisted of crystal particles with the ordered orientation.

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MONITORING OF ATMOSPHERIC GASES

According to priorities of CEMS (Climatic and Ecological Monitoring of Siberia) Project, all gaseous constituents of the atmosphere that affect the climatic and ecological situation can be divided into the following groups: (i) principal biospheric gases (O_2, N_2, H_2O, etc.), (ii) gases governing the greenhouse effect (CO_2, CH_4, H_2O, etc.), (iii) gases taking part in ozone cycle (O_2, NO_x, Freon, etc.), (iiii) molecular and atomic gaseous constituents of natural and anthropogenic origin hazardous to public health (vapors of base metals, radon, nitrogen and sulfur oxides, and fluoride- and chlorine-containing compounds).

In forecasting the trends of climatic changes, of particular importance are the long-term observations of CO_2 and CH_4 background values of concentration; the pollution of the atmosphere with vapors of base metals and nitrogen and sulfur oxides is very dangerous. The scientific groups participating in monitoring of atmospheric gases focused on the development of inexpensive and mobile devices for measuring mercury vapor concentration and values of CO_2 and CH_4 background concentration. Below we present the main results of our study.

1. Study of mercury concentration aureoles around anthropogenic sources as applied to the problems of environmental monitoring (Design and Technological Institute "Optika," SB RAS). For environmental monitoring services as well as for technological control in production of chlorine, caustic, fluorescent lamps, pure nonferrous metals, and in a number of other industrial branches, in 1993–1995 portable high-sensitive analyzers were developed for routine and current monitoring of the mercury content in media from background to maximum permissible values of concentration. In the Design and Technological Institute "Optika" the techniques for estimating the concentration of mercury and its compounds in air, water, and soil were developed and then passed to Gosstandart (State Standard) for their certification. The techniques for estimating the mercury concentration in biological objects were certified by Gosstandart (metrological certificate No. 08–47/010 of the technique for quantitative analysis of muscular tissue of fishes, human body, and animal organs for trace concentration of mercury by the method of atomic-absorption spectroscopy in cold vapor). The sensitivity of the PGA–11 atomic-absorption mercury analyzer with the Zeeman background correction, intended to measure the mercury concentration in the atmosphere, provided the measurement of concentration from 30 to 10000 ng/m for 5 s. It was sufficient to follow the dynamics of background concentration (~ 300 ng/m).

2. Development and testing of instrumentation for measuring background concentration of CO *and* CO_2 *in the atmosphere (IAO SB RAS).* The improved prototypes of nonlaser photoacoustic gas analyzers built around the commercially available device GIAM were developed to measure the background concentration of CO and CO_2 in air. The improved prototypes provided for an automatic calibration and testing for scale linearity as well as computer compatibility to process the results in real time. In 1995, the series of measurements of CO_2 background concentration were made in the atmosphere above the Atlantic Ocean during the mission of the scientific research vessel *Akademik Keldysh.* The variations in the CO_2 concentration in air were measured in the territory of Akademgorodok in Tomsk.

3. Development and testing of film semiconductor devices for measuring CO *and* CH_4 *concentration (Siberian Physical-Technical Institute at the Tomsk State University).* The prototypes of sensors for analyzing CO and CH_4 concentration in air and technological gases were developed. The sensors depend for their operation on the change in the conductance of a semiconductor film as it contacts with the gaseous constituent under analysis. The prototypes of sensor gas analyzers allowed one to measure the values of CO concentration from 0 to 1000 ppm with an error of ~15% and the methane concentration to 3 vol.% with an error of ~15%. The sensors are combined with a sampling system and an electronic display unit. For their calibration, reference gas mixtures are used. A complete cycle of metrological certification can be done with additional financial support.

4. Study of plant response to the air pollution by the methods of laser gas analysis (IAO SB RAS and the Scientific Research Institute of Biology & Biophysics at the Tomsk State University). Using the methods of photoacoustic spectroscopy and biotesting, the experimental data were obtained on the dynamics of CO_2 emission under the action of enhanced values of ethylene concentration onto the plants under study. The values of ethylene concentration were found at which the plant response peaked. It was demonstrated that an increase in the ethylene concentration intensified the process of destruction of plant tissue pigments and slowed down their growth.

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MONITORING OF OZONE AND COMPONENTS OF OZONE CYCLE

By now the integrated investigations of ozone carried out in IAO SB RAS included: lidar studies of dynamics of vertical distribution of ozone and aerosol in the stratosphere and the troposphere; spectrophotometric measurements of the total ozone content (TOC), total NO_2 content and its vertical distribution; contact measurements of the near-ground ozone concentration and concentration of minor gaseous constituents (MGCs) such as CO, CO_2, and CH_4; direct airborne and balloon measurements of the ozone concentration with the use of specially developed technique and instrumentation. The measurements were mainly carried out in the regime of regular monitoring. Exceptions were airborne and balloon measurements that were very expensive and therefore were occasional.

In 1995, monitoring of the ozone concentration in the ground atmospheric layer was continued at the TOR station. The data for the period since 1989 till 1994 were generalized. It was revealed that the ozone concentration in the ground atmospheric layer regularly exceeds 2–3 MPC since 1991, and 1995 was not an exception. A distinguishing feature of the ozone annual behavior in 1995 from the other years was the later onset of its maximum observed in July. An excess of MPC was observed from February to October. The lidar measurements showed that after the abnormal pollution of the stratosphere with a volcanic aerosol due to Pinatubo eruption in 1991, the stratosphere returned to its aerosol background state by summer of 1995. Under conditions of background aerosol state of the stratosphere, no correlation between the ozone and aerosol dynamics was observed.

The observations over the total ozone content in Tomsk in 1995 revealed the significant negative deviations (up to 20–30%) of its average daily values from its average monthly value during long periods in January (for three weeks), in the first ten days of February (the maximum deviation), in the second half of March, and in the first ten days of April. The behavior of the ozone layer in the warm season also had some peculiarities. As compared to the previous years, in June the enhanced ozone content was observed, whereas in July and August the ozone content was reduced. In 1995, the deviations of the TOC average monthly values from March to October were negative: – 1% in March, – 3% in May, – 2% in July, and – 4% in August. On the whole, the observations over TOC demonstrated its gradual reduction. Thus, by the end of 1995 the total ozone content was decreased by 4.5% as compared with 1993.

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MONITORING OF THE UV, VISIBLE, AND IR RADIATION FLUXES

The complicated effect of the complex of astronomic and geophysical factors engenders a wide spectrum of oscillations – from mesometeorological to centennial and longer ones – in the variations of solar radiation fluxes. Therefore, the program of monitoring of fluxes of incoming optical radiation for 1993–1995 involved obtaining and analyzing the long-term continual series of observations. To find the short-term variability of radiation components, the measurements were carried out in different seasons in Tomsk; to estimate the long-term oscillations, the data of many-year observations at the nearest stations of the actinometric network were collected. With regard for these circumstances, the following results were obtained during a three-year period:

1. The techniques for measuring the integrated radiation fluxes (total, direct, and diffuse ones) were mastered; actinometric devices were automated with the use of a personal computer.

2. The prototype of an automated device for measuring sunshine duration was developed.

3. The preliminary series of observations over the radiation components were obtained with an overall duration of more than 2000 hours.

4. Based on the data of monitoring of the total radiation, the statistical characteristics of day-to-day variability were obtained (the variation coefficient fell within 30%), its diurnal behavior was estimated, and the data obtained were compared with the data of many-year observations at the nearest actinometric stations. It was shown in particular that for two consecutive years the monthly radiation sums in June exceeded the many-year data by about 10%.

5. From the results of simultaneous observations over the total radiation and sunshine duration, the correlation between them was estimated (the correlation coefficient was found to be 0.95) and the regression equation was derived.

6. Monitoring of the direct spectral radiation allowed us to estimate variations in its mean values and variation coefficients in different spectral ranges under the effect of variations in aerosol and water vapor content. Its diurnal behavior was asymmetric about the noon due to enhanced aerosol turbidity in the afternoon.

7. The characteristics of variability of the diffuse solar radiation during a day were obtained. The variability coefficients were shown to be about 40–50%, that is, several times as high as the relative variability of the direct radiation. On average, the diffuse radiation contributed 20–24% to the total one.

8. The correlation of the radiation components and the aerosol and moisture content in the atmosphere was analyzed. The correlation proved to be significant only for the direct spectral radiation: in the visible it was correlated with the aerosol transmittance, while in the infrared it did with the atmospheric moisture content and the aerosol transmittance.

9. The work was completed on compiling the bank of many-year data on radiation characteristics of the atmosphere over the Western Siberia region.

The independent problem in the analysis of solar radiation is the study of the UV radiation in the total flux. Up to date there were no such measurements in the territory of Siberia and Far Fast because of lack of needed instrumentation. The researchers of the Tomsk State University and the Siberian Physical-Technical Institute fabricated a filter UV spectrophotometer. The regular observations over the UV irradiation of the ground from the sun and the sky have been started.

A spectral block of the device comprised three light filters with maximum transmittance at 353, 281, and 260 nm. The UV irradiation of the ground is subject to random fluctuations due to atmospheric instability, therefore to retrieve the information from the observation data, a large bulk of observations should be accumulated and the statistical methods should be used for its processing. In order to accumulate, store, and process the observation data on the UV irradiation of the ground, a computer data base was created. A table of experimental data comprises two parts: a record of experimental conditions and experimental results.

The experimental conditions include: the time of an experiment, the solar elevation angle, the cloudiness (visually measured cloud cover indices in a ten-point system, clouds in different altitude intervals, and cloud shapes), the temperature, the atmospheric pressure, the wind velocity, the intensitometer readings, and the air humidity. The observations in the three spectral ranges were recorded in 3–8 regimes. The data obtained in different regimes were then averaged. As a rule, the UV irradiation was measured once every half hour. Occasional series of observations made every 1–3 minutes showed quasi-periodicity of the data superimposed on the bell-shaped dependence of the UV irradiation on the day time. The researches carried out under cloudiness conditions showed that the quasi-periodicity was governed by the cloud type and the wind velocity. In some days, the quasi- periods were observed from several seconds to a few tens of minutes. In these cases, the amplitude of oscillations was much different and could reach 0.9 of the magnitude of irradiation. The researches carried out in cloudless days revealed no quasi-periodicity. In windy but cloudless days, the quasi-periods of 5–15 minutes were observed, with the amplitude of oscillations from 1 to 10%.

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MONITORING OF RADIO-WAVE FLUXES

For the period under review the concept of radio-wave monitoring was formulated, the measuring and computing complex was developed that allowed the electromagnetic pollution of the environment to be monitored in the range from 0.1 Hz to 32 MHz, and the experimental data of monitoring in 1993–1995 were accumulated and analyzed. The main results are listed below.

1. The diurnal and day-to-day dependence of the field level in the frequency bands occupied by resonances were studied and it was found that the frequency spectrum in the band of the Schumann resonances had a fine structure varying with the day time. The components were found to group round the

frequencies of the Schumann resonances. The main reasons for spectrum shape variations were periodic changes in the parameters of the lower ionosphere, change in the distance to a radiation source, and technogenic effect since signals of radio transmitters with monochromatic and pseudonoise radiation were detected near the resonance bands. The quasi-periodic variations of the resonant frequency and the amplitude of the first and subsequent Schumann resonances were recorded with a period of about three hours. The fluctuations with similar periods are known from measurements of a signal phase (10–20 kHz) in settled and unsettled weather connected with the enhanced radiation level near microwave links as well as with a change in the conductance of the lower atmosphere before an earthquake. In unsettled weather, the signal quasi-periodicity was more pronounced. Possible mechanisms resulting in quasi-periodic variations of electrodynamic properties of the propagation medium were considered. They are the following: variations in the sun brightness, free oscillations of the Earth, and technogenic effects.

2. The contribution of the fields with an industrial frequency of 50 Hz and its harmonics up to the 20th harmonic to the electromagnetic background in SLF range was estimated. The main regularities were revealed in energy redistribution over the components that were likely connected with the diurnal redistribution of power consumed in the city.

3. It was established that in the envelope of signals of regularly observed radio stations there were well-pronounced spectral components of the extremely low frequency (ELF) range. It was found that the spectral components of the ELF range could be recorded simultaneously in all frequency ranges: there appeared the signals at one and the same fundamental frequency with approximately identical spectral widths in the ELF range and in envelopes of signals of the LF and SW ranges. In this case, the ELF modulation was determined by variations in the electrodynamic parameters of that section of the propagation medium which was common for all above-listed ranges and lay in the D, E region of the ionosphere.

Siberian Physical-Technical Institute at the Tomsk State University

MONITORING OF THE ATMOSPHERIC ELECTRICITY

For the period under review, the pilot instrumentation was developed for monitoring of the atmospheric electricity. This is an automated complex for measuring the ionic conductivity and the strength of the electromagnetic field of the atmosphere. It comprises a sensor for measuring the field strengths up to 500 V/m, a storm indicator which detects the field to 5.1 V/m at distances up to 25 km, a sensor of ionic air conductivity, a microcomputer, a floppy disk drive, a floppy disk drive control unit, an analog-to-digital converter and an interface for its connection with the microcomputer, a display, and a power supply unit. To record the field strength in different city regions and near industrial complexes, the mobile version of instrumentation was developed. The cycle of measurements carried out in the International Geophysical Days in 1993–1995 yielded the following results:

1. The measured air conductivity exhibited the following properties: the ionic conductivity in good weather was $5–25\cdot10^{-15}\ S\cdot m^{-1}$ in summer and $5–15\cdot10^{-15}\ S\cdot m^{-1}$ in winter; in unsettled weather, the air conductivity reached $175\cdot10^{-15}\ S\cdot m^{-1}$ and higher.

2. The electric field strength E being measured in good weather suggested that (i) diurnal variations of the field strength were described by a smooth curve with the two maxima in the morning and at night and the magnitude of E varied from 50 to 130 V/m; (ii) the period of field variation was 10 min at night and 1–5 min in the daytime; (iii) the field strength E in winter was by 20% higher than in summer; (iiii) in most cases, the field variations started to grow in the morning (about 7, L.T.) and decreased after 16, L.T. in summer and winter.

3. In unsettled weather, the following results should be mentioned: (i) variations in the electric field strength were very complicated before and during a storm and the field often reversed its direction; E varied from −3500 to +2800 V/m; when lightning occurred, E reached more than 8500 V/m; (ii) rain-producing clouds engendered an irregular sharp change in the field with the reverse sign of its direction whereas rainless clouds caused a slight decrease in the field of good weather; (iii) snow storms engendered, as a rule, a sharp increase in the field and acted also irregularly; (iiii) in all cases of unsettled weather, field variations exceeded 60%; (iiiii) the atmospheric pollution always resulted in an increase in the field strength that varied in a complicated way. Thus, the measurements carried out near industrial enterprise at a stable wind blowing from the enterprise in good weather have shown that $E = 110–120$ V/m with variations d$E = 10–15$ V/m from $t = 0$ to 8:45, L.T. With the beginning of the enterprise operation at $t = 8{:}45$, L.T. till $t = 18{:}00$, L.T. the field varied sharply with the reverse sign of its direction, i.e., from $E = -250$ to +360 V/m with the period 2–10 min, and dE in this case reached 60%. After 18:00, L.T. the field came back to its initial value and then remained unchanged.

Design and Technological Institute "Optika," SB RAS
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MONITORING OF THE PHYSICAL STATE OF THE UNDERLYING SURFACE

In this direction of researches the Program "Climatic and Ecological Monitoring of Siberia" focuses on the compilation of the first version of the atlas of the electrophysical properties of soil and the underlying surface albedo of Siberia in different seasons. To this end, the investigations were carried out and the following results were obtained:

1. The effect of factors of the natural genesis and seasonal and annual changes including that connected with climatic changes and anthropogenic impact, which govern the electrophysical properties of soil in the 10 Hz–10 GHz frequency range was studied theoretically and experimentally. As a result, a physical-mathematical model of soil radio-wave parameters was created as well as the integrated software that allowed the electrophysical properties of soil to be forecasted for different states determined with the above-listed factors.

2. The feasibility of application of the indirect diverse long-term observational data characterizing the dynamics of the physical state of soil was analyzed. It was shown that the first version of the atlas of electrophysical properties of soil and the albedo of the underlying surface of Siberia can be realized based on the above model with the use of diverse soil-hydrological and meteorological long-term observations made at stationary ground-based stations.

3. The possibility to increase the accuracy of forecast of electrophysical properties of soil based on diverse observations made at stationary stations was analyzed. The principles were proposed for clustering the territory of Western Siberia by a set of soil, climatic, hydrological, and anthropogenic parameters determining the physical and ecological state of the underlying surface.

Siberian Physical-Technical Institute
at the Tomsk State University

MONITORING OF THE PHYSICAL STATE OF THE UPPER ATMOSPHERE

At the Institute of Solar–Terrestrial Physics of the SB RAS, in accordance with the plan of work, the experimental observations were developed or improved over the parameters of the upper and middle atmosphere directly or indirectly connected with the problem of climatic and ecological monitoring. The experimental base of the Institute of Solar–Terrestrial Physics demonstrated its possibilities including ground-based sensing of the ionosphere and monitoring of the parameters of the lower atmosphere from space.

The work was done on compilation of the data base of critical frequencies of the ionosphere and indices of solar and geomagnetic activity. This data base allows a user to retrieve the needed information, to sort the data by user's request, and to print a text file of the selected data for their further processing and analysis. At present, the data base includes the results of a survey from 25 ionospheric stations of the CIS since the late 1950s till the late 1980s as well as from the stations Fort Stanley, South Uist, and Argentina Island. The indices of solar activity $F_{10,7}$ and geomagnetic activity Kp (Kp1–Kp7) and Ap (Ap1–Ap8) for the period 1964–1987 are contained in the data base, whereas the Volf numbers (of sunspots) are given since 1932.

The studies of the solar-terrestrial relationships showed a great significance of nonstationary phenomena on the sun and, especially, solar flares for the processes occurring in the near-earth space. Depending on an agent being the immediate cause of one or another geophysical phenomenon, these processes can be divided into groups and studied separately. The relationship between microwave X-ray emissions was analyzed that can be used to evaluate quantitatively proton flares from radio data and hence to grasp in advance the situation in the atmosphere. Based on the instrumentation complex of the Radio Physical Observatory of the Institute of Solar–Terrestrial Physics, the data were obtained on the dynamics of some active regions that allowed the problems of short-term forecast and quantitative diagnostics of electromagnetic and corpuscular emissions from solar flares that engendered perturbations of the near-earth space to be solved at a qualitatively new level. Simultaneous processing of spaceborne and ground-based remote sensing data allowed us to specify the effect from a certain event on the sun upon the ground layer of the atmosphere. The development of hardware and software for recording and processing of the data of remote sensing from NOAA satellites (USA) and for monitoring of the state of environment in the Baikal region was the objective of this section of the GEMS Program. Processing of information received from meteorological satellites was further improved. Now the observations of the temperature, cloudiness, ozone content, and some other parameters of the lower atmosphere can be made from these satellites. In addition, the work is being conducted on the detection of seats of large fires. The above-listed applications encompass the entire territory of Siberia and Far East.

In the Ionospheric Laboratory of the Siberian Physical-Technical Institute at the Tomsk State University, the following work was done for the period under review. By the method of vertical sensing, regular round-the-clock measurements of the ionospheric parameters (with a clock period of 15 min) were performed. The sensing results were processed by the URSI technique and were presented in the form of tables and plots. From the data of sensing for the period 1936–1994, the ionosphere response to the change in solar activity was studied. The strong correlation (~0.9) was found between the average annual values of the critical frequencies of the $F2$ layer ($f0F2$) and the number of sunspots (W) that confirmed the governing role of solar radiation in the formation of the ionosphere. The spectral analysis of the data revealed the line of maximum intensity in the spectra of both $f0F2$ and W with the quasi-period $T \simeq 10.67$ years. This value of T is close to the average duration of the solar cycle for the period 1936–1994.

Under the financial support of the Russian Foundation for Fundamental Researches, the contract was made to supply the digital ionospheric station PARUS of a new generation in 1996. This will allow us to modernize the instrumentation of the Tomsk Ionospheric Station based on the precision method of $f0F2$ measurement and hence to perform regular automated round-the-clock monitoring of the physical state of the ionosphere at a novel qualitative level.

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MONITORING OF THE ATMOSPHERIC RADIOACTIVITY

In the last few years, actively discussed are the possibilities of application of SHF pulsed radars for remote monitoring of radioactive air contamination above objects of atomic power engineering and nuclear-chemical production. Such radars record signals reflected from clouds, rain, and plumes above electric power stations, vapor above water-cooling towers, and some other atmospheric formations. It was concluded that the ionized air regions formed as a result of radionuclide decay processes could be successfully detected.

In 1993–1995, the scientists from the Scientific Research Institute of Nuclear Physics at the Tomsk Polytechnical University, the Tomsk Academy of Control Systems and Radio Electronics, and the Faculty of Atomic Power Stations of the Tomsk Polytechnical University performed a large bulk of theoretical and experimental researches aimed at elucidation of the feasibility of application of air defense radar means, airports, and meteorological services for monitoring of radioactive contamination. The results obtained allowed the justified conclusion to be drawn that standard SHF radars cannot detect signals reflected from plasma formations at long distances (a few tens of kilometers) caused by regular emissions of industrial objects dealing with nuclear technologies. Against the background of signals reflected from accompanying processes connected with emissions of warm air, atmospheric phenomena, etc. the effect of radioactive contamination processes upon radio waves is insignificant and becomes pronounced only at short distances (less than 1 km) from sources of radioactive contamination or for emergency emissions.

The problem under study can be solved only based on current advances in SHF electronics and novel high-informative radar methods. In particular, super-high-power relativistic sources of SHF radiation can be used to construct radars capable not only to obtain the information about the structure and the geometry of plasma formations, but also to affect actively the electronic component of the plasma. For physical justification of application of modern super-high-power sources of SHF radiation to radar monitoring, new experimental and theoretical data on the interaction of high-power SHF radiation with slightly ionized plasma resulting from the radioactive decay in air at atmospheric pressure are required. The laboratory work planned in the near future is focused on obtaining the data on the effective cross section of SHF electromagnetic wave scattering by air plasma formed upon exposure to ionizing radiation. It is the main parameter that will allow us to formulate the specifications of radars built around SHF oscillators and to evaluate their possibilities as well as to provide a basis for guiding the development of systems of radar monitoring of the environment from the viewpoint of diagnostics of radioactive contamination.

Scientific Research Institute of Nuclear Physics at the Tomsk Polytechnical University

MONITORING OF ASTROPHYSICAL AND GEOPHYSICAL FACTORS

For the period under review the work was done to implement the novel information technology for studying the environment into practice. The technology is based on the methods of remote satellite sensing. Up to date, the reception of five information channels of the Advanced Very High Resolution Radiometer and twenty channels of the High Resolution Infrared Sounder installed onboard the NOAA satellites (USA) has been realized. In 1995, the work was done on the development of special software to keep the station of space monitoring of the environment operating in the regime of information reception. The programs were written for computing the satellite trajectory for packing and visualizing the data, and for thematic processing, namely, for temperature charting of the earth's surface. The second direction of our work for this period was connected with the forecast of solar activity and its terrestrial manifestations on the basis of measuring the intensity of sun's radio emission. Based on the data of radio sensing of the near-sun space with the use of *Venera*-15 and *Venera*-16 spacecrafts as well as on the data of vertical sensing of the ionosphere and the data on average diurnal values of the index of solar activity, it was shown that the solar activity, manifesting itself through variations of the electron concentration of sun's supercorona, was transferred to the earth with the speed of solar wind, and its geoeffective manifestations could be forecasted for period of 7–11 days.

An analysis of influence of different astrophysical and geophysical factors upon the climate, ecology, and biological processes shows that most significant among them and suitable for monitoring are the solar–terrestrial and lunar–terrestrial relationships oscillating with different periods (ranging from a day to several tens of years). The manifestation of these relationships (especially, lunar–terrestrial one) is specific in different earth's regions. For the period 1993–1995, the following results were obtained:

1. The technique and software were developed to conduct a search for the empirical relationships between the near-ground values of temperature and pressure at particular meteorological stations and the indices of solar activity and its cycles on the basis of many-year series of observations with regard for quasi-two-year variations. A start has been made on the collection of meteorological information in the form of series of average diurnal temperature and precipitation. The series for five stations with the length from 19 to 112 years have been already obtained.

2. The algorithms and software were developed for computing the coordinates and phase angle of the moon, i.e., the characteristics of the relative positions of the moon and the sun about the earth.

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METROLOGICAL AND METHODICAL SUPPORT FOR CLIMATIC AND ECOLOGICAL MONITORING

The work in this direction was mainly aimed at integrated regional monitoring of the basic processes in the atmosphere. To this end, in 1994 the basic meteorological station was put into operation. This station was included into the hydrometeorological network as the second class station. Since October 26, 1994, the regular measurements have been carried out of the following meteorological parameters: temperature of air and soil at different levels, wind speed and direction, amount of precipitation, and cloud height and type. In addition, we measured (at long intervals) the radioactivity and the electric characteristics of the atmospheric air, the snow cover width, and the actinometric characteristics. The background polygons were in Kireevskoe, Kazanka, Baturino (Tomsk Region), and Lomachevka (Kemerovo Region) villages. To form the organizing structure of the project, a number of meetings were held and the Climatic and Ecological Observatory was established to provide scientific-methodical and technical support for the base complex and the background polygons. In April of 1995, the Siberian Meeting on Climatic and Ecological Monitoring was held at the observatory. About 70 reports were presented at this meeting. Different problems of monitoring of the physical state of the atmosphere, the underlying surface, the atmospheric gaseous composition, the aerosol, the fluxes of electromagnetic radiation, and some others were discussed. Abstracts of reports presented at the meeting were published. Much planned work was not completed due to insufficient financial support.

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MEDICAL AND BIOLOGICAL CONSEQUENCES OF CLIMATIC AND ECOLOGICAL CHANGES IN THE ENVIRONMENT

Within the framework of the CEMS Project, in 1995 the main attention was given to an analysis of many-year observations over a forest tick, a carrier of dangerous human diseases – encephalitis and Lyma. The results of monitoring of the tick population at two polygons near Tomsk were systematized. At the first polygon, the observation period covered 30 years (1963–1992), while at the second polygon it was 11 years (1983–1993). Ticks were collected by the standard technique (onto a white material once every 10 days during one hour since the first ten days of April till the end of August). In addition, the statistics on tick activity in 1983–1995 was collected from the data on the number of people in Tomsk and the Tomsk Region who appealed for an inoculation against attached tick. From the dates of their appeal, the periods of tick activity were determined. The results of analysis allowed us to conclude that the tick population on both polygons peaked from May 15 to the end of June. In different years, the population peak was different in magnitude but practically did not shift in time. At the first polygon, the maximum population was observed in 1981–1982 and a decrease in population was most pronounced in 1970–1975 and 1984–1987. At the second polygon, the average tick population decreased smoothly from 20 to 12 ticks per hour for one person with a trap in 1983–1985, and from 1986 to 1992 it increased exponentially up to 84 ticks. In 1993, the average population decreased down to 55 ticks per hour for one person with a trap. Judging from the number of people who appealed for inoculation, the index of tick activity in 1985–1988 was relatively low (about 5300 tick attacks on men). Since 1989, the number of people who appealed for inoculation against tick began to grow and reached the peak in 1992 (23443 events). By 1994, the tick activity reduced markedly (down to 13054 inoculated people). Based on the result of analysis, we concluded that the period of tick activity being monitored during the last 16 years becomes longer. In 1980, it lasted 136 days, whereas in 1995 it lasted already 190 days. At the early 1980s, the first ticks appeared in the third ten days of April or at the beginning of May; in the mid-1980s, the beginning of tick activity shifted toward mid-April; since 1990s, ticks awoke from the hibernation in the first ten days of April. In 1995, people first appealed for inoculation on March, 25. The apparent elongation of the period of tick activity is indicative of a smooth change of some limiting factor, likely the temperature.

Summarizing the work on some biological aspects of the problem of climatic and ecological monitoring for the period 1993–1995 done within the framework of the CEMS Project of the Regional Scientific and Technical Program "Siberia," the main result should be noted, namely, the systematization of many-year field observations over the dynamics of different components of the biota (forest ticks and circular-web spiders, hollow nesting birds, and herpetobionts) and the search for biota relationships with changes in an anthropogenic load and trends of climatic factors.

The independent section within the framework of this monitoring is the study of response of the main human functional systems to the change in external physical factors, including those monitored in different sections of the CEMS Project. To carry out such a study, its method and technique were developed. Its essence lies in an analysis of the known tenets of the effect of electromagnetic fields on a human body, in elucidation of the key aspects of their influence on the nervous system, and in an analysis of rhythmic processes in a cerebrum and the construction of a qualitative model of biorhythmic organization of functional processes of different hierarchy levels. On the one hand, this allowed us to set up a working hypothesis that the natural electromagnetic background affects the psychosomatic processes in a human body and to put forward an assumption about its correcting role to balance biorhythms of a body. On the other hand, we managed to substantiate the choice of the psychophysiological parameters reflecting the dynamics of processes in main functional systems (central nervous, cardiovascular, respiratory, thermoregulating, and sensorimotor ones) and the psychic state of a man. The experimental studies allowed us to evaluate the dynamics of significant variables and functional states of the main human subsystems for observation intervals during the International Geophysical Days in 1993–1995. Under conditions of simultaneous monitoring of the parameters of the "man–electromagnetic background" system, the fundamental characteristics of this system were determined, namely, the correlation between variations in fluctuations of the cardiointerval parameters and the electromagnetic background in the 0.8–2.5 Hz frequency range. In this case, the change in the level of functioning of the cardiovascular system resulted in corresponding shifts in the dynamics of states of some other functional systems of a body. Coordinated character of changes in the parameters of electrocardiogram and the electromagnetic background has demonstrated that the ELF electromagnetic fields are among significant ecological factors even in days without magnetic storms.

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