ISSN 0001-4338, Izvestiya, Atmospheric and Oceanic Physics, 2013, Vol. 49, No. 1, pp. 16–32. © Pleiades Publishing, Ltd., 2013.
Original Russian Text © Yu.M. Timofeev, E.M. Shul'gina, 2013, published in Izvestiya AN. Fizika Atmosfery i Okeana, 2013, Vol. 49, No. 1, pp. 19–36.

Russian Investigations in the Field of Atmospheric Radiation in 2007–2010

Yu. M. Timofeev and E. M. Shul'gina

St. Petersburg State University, ul. Ul'yanovskaya 1, Petrodvorets, St. Petersburg, 198904 Russia
e-mail: shulgina@troll.phys.spbu.ru

Received June 19, 2012

Abstract—A short survey prepared by the Russian Commission on Atmospheric Radiation contains the most significant results of works in the field of atmospheric-radiation studies performed in 2007–2010. It is part of the Russian National Report on Meteorology and Atmospheric Sciences prepared for the International Association on Meteorology and Atmospheric Sciences (IAMAS). During this period, the Russian Commission on Atmospheric Radiation, jointly with concerned departments and organizations, ran the conference "Physics and Education," dedicated to the 75th anniversary of the Department of Physics at St. Petersburg State University (2007); the International Symposium of CIS Countries "Atmospheric Radiation and Dynamics" (2009); and the 5th International Conference "Atmospheric Physics, Climate, and Environment" (2010). At the conferences, central problems in modern atmosphere physics were discussed: radiative transfer and atmospheric optics; greenhouse gases, clouds, and aerosols; remote methods of measurements; and new measurement data. This survey presents five directions covering the whole spectrum of investigations performed in the field of atmospheric radiation.[1]

Keywords: atmospheric radiation, radiative transfer, atmospheric spectroscopy, radiation climatology, aerosol, remote sensing.

DOI: 10.1134/S000143381301009X

THEORY OF RADIATIVE TRANSFER

Numerous studies in this field were devoted to studying the processes of radiative transfer in different media and for different geometries of measurements and to the development of methods and algorithms for solving the equation of radiative transfer as applied to problems of atmospheric optics. Theoretical works in this field are devoted to an analysis of the physical foundations of the theory of transfer based on matrix Green functions [1] and to the study of continuous properties of the solution of the boundary problem for the transfer equation with generalized matching conditions at the interface [2].

Different methods of the theory of radiative transfer are being developed intensely at the Moscow Power Engineering Institute. A new approach to solving the radiative transfer equation (RTE) was formulated. This approach is based on dividing the solution into anisotropic and regular parts [3]. Based on it, the solution of the vector radiative transfer equation (VRTE) was studied for the case of a plane layer of a turbid medium [4] and compared with known methods [5, 6]. A matrix-operator approach to solving the VRTE for a stratified medium with an arbitrary substrate was proposed based on separating the anisotropic part [7]; the effect of aerosol on the radiation polarization distribution over the sky [8] and upon the angular distribution of electrons scattered by a plane target [9] was analyzed. This makes it possible to simulate satellite measurements by the highly precise tools of present-day electron microscopy.

A system of radiative transfer equations rigorously describing the process of wideband optical radiation transfer in dispersive media was formulated in the context of the theory of multiple radiation scattering at the Institute of Atmospheric Optics, Siberian Branch, Russian Academy of Sciences. Based on the equations, new algorithms of statistical modeling were pro-

[1] The materials were presented by V.N. Aref'ev and A.F. Nerushev (RPA "Typhoon"); L.P. Bass (Keldysh Institute of Applied Mathematics, Russian Academy of Sciences); L.P. Bobylev (Nansen Center); V.P. Budak (Moscow Power Engineering Institute); G.I. Gorchakov (Institute of Atmospheric Physics, Russian Academy of Sciences); T.B. Zhuravleva, S.M. Sakerin, M.V. Panchenko, and Yu.N. Ponomarev (Institute of Atmospheric Optics, Siberian Branch, Russian Academy of Sciences); V.I. Zakharov (Ural State University); I.L. Karol' and A.M. Shalamyanskii (Main Geophysical Observatory); E.N. Kadygrov (Central Aerological Observatory); Yu.Yu. Kulikov (Institute of Applied Physics, Russian Academy of Sciences); I.M. Levin (Institute of Oceanology, Russian Academy of Sciences); V.P. Ogibalov and V.A. Yankovskii (St. Petersburg State University); V.F. Radionov (Arctic and Antarctic Research Institute); S.B. Rozanov (Physical Institute, Russian Academy of Sciences); A.N. Rublev (Kurchatov Institute); A.B. Uspenskii (SRC "Planeta"); and N.E. Chubarova (Moscow State University).

posed and implemented. The algorithms made it possible to solve a series of practical problems of laser sensing of the atmosphere and vegetation cover [10, 11]. Solar radiation transfer in different atmospheric conditions was modeled and different methods for calculating atmospheric transmission functions and radiation fluxes were proposed [12–19]. A new method for determining the microphysical parameters of aerosol from spectral measurements of the optical thickness and brightness of the solar aureole was developed [20]. The effect of the quality of spectroscopic information on the simulation of radiation fluxes was estimated [21–23]. A simulation of the atmospheric radiative transfer with different spectroscopic data banks of absorption lines demonstrated that water-vapor lines that are absent in the HITRAN database (http://cfa-www.harvard.edu/hitran/) in the spectral range from 0.5 to 1 μm must be taken into account in atmospheric applications, because the contribution of these lines to the transmission calculated even with a middle spectral resolution (20 cm^{-1}) can reach 1.5% on a vertical path and up to 4% at slanted paths; the contribution of isotopic HDO modifications can reach 1% [24].

At the Keldysh Institute of Applied Mathematics, Russian Academy of Sciences, numerical methods for simulating radiative transfer in the atmosphere have been improved: a simplified algorithm was developed for calculating the brightness coefficient of solar light reflected from a spatially inhomogeneous atmosphere consisting of several large homogeneous zones; a numerical algorithm for solving the radiative transfer equation in 1D, 2D, and 3D domains was modified with a discrete representation of the scattering phase function on parallel computers with separated memory (RADUGA software); and different methods of discrete ordinates in calculations of plane albedo for an optically infinitely thick layer of sea water were compared. The following methods were considered: (a) a semianalytical method for solving the transfer equation with the small-angle approximation for the anisotropic part of the solution; (b) the iteration method for solving the transfer equation using network approximations; and (c) the iteration method for solving the Ambartsumian integral equation. The results permit one to construct an improved QSSA approximation of plane albedo for use in remote sensing problems [25–31].

Investigations into processes of nonequilibrium radiation transfer in the middle and upper atmosphere continue at St. Petersburg State University. A complete model of the photodissociation of ozone and molecular oxygen was constructed with allowance for the kinetics of the electronic-vibrational-excited products of photolysis of these components in the mesosphere and lower thermosphere (a height interval of 50–125 km). This model was used to formulate and solve new applied problems (retrieval algorithms for height profiles of ozone and water vapor, the parameterization and analysis of the accuracy of solutions of the direct and inverse problems, etc.) [32, 33]. The results were justified by analyzing the sensitivity of the complete model for the direct and inverse problems [34]. The use of this model to retrieve height profiles of H_2O concentrations from measurements of the intensity of emissions in the 6.3 μm band with the SABER infrared (IR) radiometer from the TIMED satellite was demonstrated in [35].

The fundamental problem of radiative transfer (RT) in the Martian atmosphere in vibrational–rotational (VR) bands of molecules of CO_2 (bands near 4.3, 2.7, 2.0, 1.6, 1.4, 1.25, 1.2, and 1.05 μm) and CO (bands near 4.7, 2.3, 1.6, and 1.2 μm) under the vibrational breakdown of the local thermodynamic equilibrium (BLTE) was solved for the first time with allowance for radiation absorption and scattering on aerosols. Based on the technique of accelerated lambda-iterations, an original method was developed to solve the RT problem in molecular bands under vibrational BLTE in the planetary atmosphere with allowance for the frequency overlapping of spectral lines and the reflection of radiation by the underlying surface of the planet [36, 37]. Moreover, this method permits one to take into account the aerosol scattering and absorption of radiation at frequencies of lines of VR transitions of CO_2 and CO for general phase functions. Calculations were performed for spectra both of limb radiation and of radiation outgoing at boundaries of the Martian atmosphere at different angles in VR bands of CO_2 and CO molecules in the near-IR spectral range with allowance for processes of aerosol absorption and scattering. A theoretical justification was proposed for the new method of retrieving the optical properties of Martian aerosols by measuring limb radiation in near-IR bands of CO_2 and CO.

ATMOSPHERIC MOLECULAR SPECTROSCOPY

The main direction of works on the molecular spectroscopy of atmospheric gases is the experimental study of spectroscopic parameters of atmospheric gases, the improvement of methods for calculating parameters of spectral lines and transmission functions, and the completion of spectroscopic data banks (Institute of Atmospheric Optics, Siberian Branch, Russian Academy of Sciences; Institute of Applied Physics, Russian Academy of Sciences; St. Petersburg State University; and Tomsk State University).

Spectroscopic parameters of atmospheric gases under different conditions and in different spectral ranges [38–49], as well as molecular spectra and intermolecular interactions [50–58], are actively studied experimentally and modeled at the Institute of Atmospheric Optics, Siberian Branch, Russian Academy of Sciences. The most complete and matched set of VR energy levels of $HD^{18}O$ and $D_2{}^{18}O$ molecules has been reconstructed [59–63]. The results of these studies (jointly with scientists from France, England, Belgium, and the United States) completed the HITRAN database with new and refined information [64]. In the scope of the IUPAC project (A Database of Water Transitions from Experiment and Theory), jointly with scientists from other countries, highly accurate matched energy levels of $H_2{}^{17}O$, $H_2{}^{18}O$, $HD^{16}O$, $HD^{17}O$, $HD^{18}O$, molecules satisfying the main criteria of certainty were determined proceeding from the critical expertise of all published VR transitions [65–70].

The continual absorption of water vapor for the visible part of the spectrum was detected in the experiment for the first time. The experimental results were compared with the results of calculations using the last two versions of the CKD semiempiric continuum model. A technique for calculating the line shape parameters of water vapor was developed using exact wave functions. This technique permits one to calculate the broadening and shift of lines caused by transitions to highly excited states (up to the near ultraviolet range). Mass calculations of line shape parameters and their coefficients of the temperature dependence were performed [71–76]; the obtained data were placed in the ATMOS information system and the European GEISA database [77]. The contribution of the staff of the Institute of Atmospheric Optics to the improvement of other databases and to developing data processing systems is also significant [78–80].

Highly accurate measurements of CH_4 and C_2H_4 absorption spectra were performed and the effect of features of the ethylene absorption spectrum upon indications of a laser methane analyzer was analyzed [81–84]. Based on highly accurate measurements carried out by optoacoustic and Fourier spectrometry jointly with the University of Burgundy (France) and Tomsk State University, the absorption spectrum of ethylene was analyzed for the first time in the range of 4300–6300 cm^{-1}, which is used in practice for monitoring the methane concentration in the atmosphere from satellite measurements. New data that were absent in the last version of the HITRAN database have been obtained for the ethylene absorption spectrum [85–87].

RADIATION CLIMATOLOGY AND AEROSOL

Works on these themes were performed in several directions: monitoring the radiation balance (RB) components and of atmospheric components having an effect on the radiation regime; studying the climatic trends of RB components near the land surface; and the analysis of radiation effects of atmospheric gases, aerosol, and cloudiness.

Based on actinometric observations carried out by the Meteorological Observatory of Moscow State University since 1955, the long-term regime of radiation-balance components and total radiation in wide parts of the spectrum (ultraviolet and photosynthetically active) were analyzed, as were the natural irradiance of earth surface under conditions of cloudless, broken convective clouds and all-over cloudiness of different levels. Trends of the long-term variability of optical characteristics of the atmosphere were estimated. The influence of a big city, smog, and volcanic eruptions on the income of solar radiation and transparency characteristics of the atmosphere was considered. A series of indirect methods was proposed for calculating photosynthetically active radiation and natural illumination [88]. In [89], the data of unique observations of aerosol optical thickness (AOT), integral transparency, and the moisture content of the atmosphere over 50 years (1955–2004) were systematized and generalized. A significant decrease in aerosol turbidity in Moscow at the end of the 20th century was detected. The estimate for linear trends of time series for stations with different human-induced impacts in Russia verified the global trend of the decrease in aerosol turbidity of the atmosphere. A general trend to an increase in transparency of the atmosphere was observed in the Baltic region, Central Europe, and Moscow [90]. It was shown that no significant dependence on solar activity cycles was manifested in the long-term variability of the aerosol optical thickness for different geographical regions [91].

According to the data of long-term measurements of erythemal UV radiation for the period from 1999 to 2006, together with the results of a reconstruction model for the period from 1968, the effect of different atmospheric parameters was analyzed [92]. It was shown that a perceptible increase in erythemal radiation is observed starting in 1980 due to ozone (2.5% per decade), effective cloud transmission (2.1% per decade), and aerosol (1.1% per decade). The effect of fires in 2002 on meteorological, radiation, and optical properties of the atmosphere in the region of Moscow was studied [93]. According to the data of the MODIS satellite device and AERONET observation network, the seasonal distribution of aerosol properties over Europe and their effect on UV radiation were estimated [94], as were the radiation effects of aerosol pollution in Moscow using the data of 3-year observations by the AERONET network [95].

In the Institute of Atmospheric Optics, Siberian Branch, Russian Academy of Sciences, long-term trends of changes in radiation balance components [96, 97], as well as in cloudiness [98] and optical and aerosol characteristics of the atmosphere (AOT) [99–104], were analyzed for the conditions of Tomsk and some other regions of Asian Russia. Based on field research, it was shown that the spring atmosphere in Primorye and the Sea of Japan is distinguished by a twofold transcendence of aerosol haziness when compared to other (marine and continental) regions of temperate latitudes. High AOT values are observed in the whole range of the spectrum (0.3–2.14 μm) and are caused by the collective effect of aerosol emissions (dust, human-induced, and smoke) from neighboring regions of the continent [105, 106]. The results of AOT measurements over oceans, comparisons with satellite data and model calculations, and the role of the Maritime Aerosol Network as a component of the AERONET network are discussed in [107, 108]

At the Kurchatov Institute, based on a mathematical simulation, quantitative estimates were obtained for errors appearing when ignoring the features of light scattering by large particles in calculations of integral solar radiation fluxes and spectral brightness temperatures of the outgoing IR radiation of the atmosphere. The estimates were found as applied to the algorithm for retrieving the aerosol characteristics of the well-known AERONET network upon different dust haziness of the atmosphere [109].

The Institute of Atmospheric Physics, Russian Academy of Sciences, carried out a cycle of complex observations of a series of the gaseous and aerosol components of the atmosphere and studied the connection between their variations and atmospheric conditions in 2007–2008 [110, 111]. The main statistical parameters of variations in mass concentrations of coarse-dispersed aerosol in Moscow were analyzed [112]. Mass concentrations of soot and submicron aerosol were jointly measured by optical methods in the near-ground layer of the air in places with different degrees of human-induced impact and under background conditions. The quantity that characterizes the relative soot content in a mass of submicron aerosol permits one to reveal the part of local and regional sources and trace the heterogenic processes of aerosol transformation [113].

The radiation regime and the specificity of long-term variability of total solar radiation and transparency characteristics of the atmosphere in polar regions are constantly studied by researchers at the Arctic and Antarctic Research Institute [114, 115]. As a result of the statistical analysis of the data of AOT measurements in polar regions by different devices and groups of researchers over 30 years, the AOT trend was estimated from –1.6% to –2.0% per year depending on the location of the measurements [116]. Results of studying aerosol characteristics of the atmosphere on board the *Akademik Fedorov* research vessel in the 52nd and 53rd Russian Antarctic expeditions were presented in [117, 118].

Many investigations were dedicated to studying the radiation effects of aerosol, including situations with fires and volcano eruptions. At the Institute of Atmospheric Optics, based on original algorithms and data obtained using satellite and long-term ground-based measurements, a study of radiation forcing and its sensitivity to a change in input parameters in the Siberian region was started [119–121]. Based on experimental and theoretical studies, the radiation characteristics of aerosol of the atmospheric thickness were determined during the time of smokes from forest fires in comparison to usual conditions. It was shown that, compared to the background conditions (0.5 μm), AOT increases on average by a factor of ~2.7 and the aerosol radiative forcing increases at the lower boundary of the atmosphere from –22 (background) to –50 W/m^2 in smoky situations [122]. It was experimentally discovered for the first time that a layer with a higher content of volcanic sulphate aerosol in the lower stratosphere leads to the appearance of an additional region of ozone depression in the middle stratosphere at heights of more than 20 km due to a deterioration in the photochemical balance, which is indicated by the behavior of NO_2 [123].

At the Main Geophysical Observatory, a series of results on estimating the value of aerosol radiative forcing in the global scale and its connection with other indices of climate warming were analyzed [124, 125]. Radiation effects of different stratospheric aerosol screens designed for global warming solutions were estimated in [126, 127].

At Ural State University, an original model for the heat equilibrium of the earth's surface was developed. This model takes into account the exponential temperature dependence in the absorption of thermal radiation in hot CO_2 and H_2O vibrational bands and predicts the existence of stationary thermal regimes of the surface of our planet in the temperature range above the boiling point of water. The regime of an explosive greenhouse effect leading to a strong overheat of the earth's surface (above 100°) when the atmospheric carbon dioxide concentration exceeds a threshold value was studied in [128–130].

In 2007–2010, specialists at the Central Aerological Observatory and the Russian Hydrometeorological Center continued their work on carrying out the Global Urban Research Meteorology and Environmental Project (GURME WMO). The vertical structure of the heat island over Moscow was studied by continuous measurements of temperature profiles of the boundary layer of the atmosphere in three points using Russian MTP-5 microwave measurers of temperature profiles [131–134]. In summer 2010, such data were obtained under conditions of anomalously high temperatures and strong smokiness. Unique data on features of the thermal stratification of the atmospheric boundary layer (ABL) in a mountain hollow and narrow mountain canyon at different synoptic situations were analyzed in [135]. In 2007, specialists at the Institute of Atmospheric Physics and the Central Aerological Observatory obtained new data on the features of ABL thermal stratification over a sea surface in a coastal zone at different synoptic situations in the scope of a complex expedition on studying the temperature-wind regime in the shore. During the full solar eclipse in Novosibirsk on August 1, 2008, specialists at the Central Aerological Observatory, the Scientific Research Radiophysical Institute, and the Institute of Atmospheric Physics, under the general superintendence of Prof. G.I. Gorchakov, obtained unique data on the effect of the solar eclipse on the meteorological regime of the atmosphere [136–138].

REMOTE SENSING OF THE ATMOSPHERE AND UNDERLYING SURFACE

Passive remote sensing of the ozonosphere and minor gaseous components of the atmosphere in the visible, IR, and microwave ranges of the spectrum; the analysis of their variability; and the improvement of measurement and interpretation techniques are carried out in a number of institutes (Institute of Atmospheric Optics, Institute of Atmospheric Physics, St. Petersburg State University, Physical Institute, RPA "Typhoon", Institute for Radiotechnics and Electronics, Main Geophysical Observatory, Arctic and Antarctic Research Institute, Institute of Applied Physics, Central Aerological Observatory, and Russian Hydrometeorological Center).

Long-term monitoring and analysis of the vertical ozone distribution (VOD) in the atmosphere over Moscow are continued using the improved low-noise spectroradiometer operating at a frequency of 142.2 GHz (Lebedev Physical Institute) [139]. Much attention is paid to the analysis of the measurement data and simulation of ozone content, as well as to studying processes of ozone destruction, at the Institute of Atmospheric Optics, the Main Geophysical Observatory, and the Central Aerological Observatory [140–145].

At the Institute of Applied Physics, the connection between variations in the stratospheric ozone content in winter Arctic and the structure of winter polar cyclones was established by the data of long-term microwave measurements. The ground-based observations were compared with data from the EOS MLS satellite device (AURA satellite) [146]. During the full solar eclipse on March 29, 2006, at the Kislovodsk high-mountain scientific site, an increase in the concentration of mesospheric ozone was detected. At a height of 60 km, its increase was 40%, which is close to the magnitude of diurnal ozone variations [147]. A new method for analyzing data on the total ozone content upon observations on moving platforms was developed [148].

Regular ground-based spectroscopic measurements of the total content (TC) of methane and carbon monoxide in the whole thickness of the atmosphere are continuing at St. Petersburg State University. The temporal variability of methane TC and its long-term trends near St. Petersburg were analyzed [149]. It was shown that methane TC trends significantly changed in recent years: the positive trend decreased and became even negative for some months. It is evident that, to obtain reliable forecasts for changes in the planetary climate in the coming decades, one needs information not only about the global trends of methane TC, but also about spatial–temporal variations of these trends. The factors that determine the anomalous variability of the total content of carbon monoxide near St. Petersburg were studied in [150].

Since 2009, solar IR radiation spectra have been measured in Petrodvorets by a Bruker high-resolution Fourier spectrometer and the TC of many climatically active gases is retrieved simultaneously [151–153]. Possibilities of using ground-based measurements of the direct solar IR radiation spectra with high spectral resolution for determining elements of vertical distributions of ozone content were studied in [154]. Based on simultaneous measurements of direct solar IR radiation with high spectral resolution and microwave spectra of downward thermal radiation, a ground-based synergetic method for determining vertical profiles of ozone was proposed [155]. This method permits one to determine the vertical ozone profile in a height range from 0 to 70 km. Comparisons of ground-based measurements of the total ozone content by different devices (Bruker Fourier spectrometer, Dobson spectrometer, and M-124 ozone meter) and satellite data from the OMI device demonstrated that the Bruker spectrometer is capable of measuring the TC of ozone with a random error of ~3 DU [156].

The data of regular ground-based measurements (using an automatic spectral complex for ground-based spectroscopic measurements of scattered solar radiation) of NO_2 (2004–2010) and CO (1995–2009) TC near St. Petersburg (Petrodvorets) were analyzed. It was shown that the data of twilight ground-based measurements of NO_2 TC agree well with the results of satellite measurements (e.g., from the SCIMACHY device): the mean discrepancy was only 0.07×10^{15} mol/cm^3 (the relative error was ~12%). The effect of forest fires on the temporal variability of the total CO content in the atmosphere was investigated. An analysis of characteristics of the annual behavior and long-term trends of CO TC for the region of St. Petersburg revealed no statistically significant long-term variations in the total CO content [157, 158].

Based on experimental data and results of numerical simulation (the CMAS model), the spatial–temporal variability of concentration fields and contents of CO, NO_2, and O_3 in the troposphere was analyzed for the northwestern part of Russia [159]. The effect of St. Petersburg emission on values of concentrations and contents of CO, NO_2, and O_3 in the troposphere was estimated. It was shown that, under certain synoptic conditions, the plume of St. Petersburg can be detected at a distance of more than 300 km, which can have an effect on the quality of the atmospheric air in neighboring states.

At the Institute of Atmospheric Optics, based on long-term airplane monitoring of the content of greenhouse gases over southwestern Siberia, it was established that CO_2 and N_2O concentrations grow in the whole thickness of the probed atmosphere (0–7 km) at a rate of 1.9 million^{-1}/year and 0.73 billion^{-1}/year, respectively. At the same time, periodic variations without a definite trend were detected in the long-term behavior of the CH_4 concentration [160, 161]. Jointly with the Limnology Institute, Siberian Branch, Russian Academy of Sciences, complex physicochemical and biological investigations of Lake Baikal were performed for the first time to study gas exchange in the "water–atmosphere" system. It was established that the flow of carbon dioxide is directed to the atmosphere in spring (May–June); in summer and autumn (August–September), carbon dioxide runs to the water surface of the lake [162–166].

At the Arctic and Antarctic Research Institute, regular measurements of minor gaseous components of the atmosphere at Antarctic stations are continued. The results of measurements of the total content of carbon dioxide and methane that were obtained by solar absorptive spectroscopy at Molodezhnaya station (1977–1978), at Mirnyi observatory (1982–1992), and at Novolazarevskaya station (2003–2006) were presented in [167]. Features of observations of the total ozone content in the northern and southern polar regions were presented in [168].

Specialists from RPA "Typhoon" continue regular measurements of minor gaseous components (MGCs) of the atmosphere in Obninsk, near Issyk Kul (jointly with the Arctic and Antarctic Research Institute, the Main Geophysical Observatory, and the Institute of Atmospheric Physics). Data from long-term monitoring made it possible to determine all the important characteristics of the variability of main radioactive gases: trends and seasonal and other variations with different periods [169–173].

At the Kurchatov Institute, the algorithm for NO_2 TC determination by AERONET data was refined. Its work was validated by comparison with estimates of NO_2 TC based on parallel measurements by the ORIEL spectrometer (Institute of Atmospheric Physics) and with SCIAMACHY satellite spectrometer estimates obtained over AERONET points in different regions of the earth. To estimate aerosol and NO_2 radiative forcing under a clear sky, an interactive (online) CSIF 2009 program was developed (Calculator of Solar Integral Fluxes, http://litms.molnet.ru/csif1/index.php). Using this program, NO_2 radiative forcing was calculated by data from 20 AERONET points in 2003–2006 [174].

A modern experimental complex, the Ural Atmospheric Fourier Station (UAFS), located in a background forest region approximately 80 km northwest of Yekaterinburg ($h = 300$ m, 57.038° N, 59.545° E) was brought into operation in Ural State University. UAFS is equipped with a Bruker IFS 125M automated Fourier spectrometer conjugated with an A547 solar tracker. It is intended for measuring atmospheric transmission spectra of solar radiation in the spectral range of 450–25000 cm^{-1} with a maximal spectral resolution of 0.0035 cm^{-1} in order to monitor greenhouse and atmosphere-polluting gases and to validate satellite data. The measurements of the atmospheric transmission spectra of solar radiation are carried out at UAFS since July 2009, mainly in the spectral range of 4000–12000 cm^{-1} with a resolution of 0.02 cm^{-1} in clear sky days, according to the requirements of the Total Carbon Observing Network (TCCON), https://tccon-wiki.caltech.edu/Sites [175]. A method for determining the relative content of heavy water (concentration ratio HDO/H_2O in water vapor) in the atmosphere from its IR high-resolution transmission spectra was proposed and approbated [176, 177].

The St. Petersburg branch of the Shirshov Institute of Oceanology continues to develop techniques for remote passive and active (lidar) sensing of the thickness of the ocean and its surface [178–181]; visioning underwater objects from aerial observations in the atmosphere through a wavy sea surface [182–184]; and identifying oil pollutions of the surface, water thickness, and ice cover of the sea [185].

Devices for radiation studies and remote sensing are being developed and designed in some institutes. In the Institute of Atmospheric Optics, the SPM portative solar photometer was designed for measuring the AOT and the water content of the atmosphere in mobile conditions. The photometer excels the foreign analog (Microtops II, United States) in the spectral range (0.31–2.14 μm) and in the number of spectral channels. A new version was designed for the SP-9 solar photometer intended for the year-round automated monitoring of the AOT and the total water vapor content of the atmosphere [186, 187] and an information system was created for network solar photometers [188]. A lidar was developed for measuring the distribution of ozone concentrations in the upper troposphere–lower stratosphere. Ozone monitoring in the height range of 5–18 km was implemented using the lidar [189]. The Main Geophysical Observatory continues testing developmental prototypes of the ultraviolet ozone spectrometer intended for the reequipment of ozonometric stations in the Russian Federation [190]; equipment for direct measurements of the radiative heat influx in the atmosphere was designed based on the optoacoustic receiver of radiation, and episodic field measurements were carried out [191, 192]. In the Physical Institute, new-generation spectrometers are being designed and produced for the remote sensing of ozone, chlorine monoxide, and some other minor gaseous components of the atmosphere from the earth's surface at millimeter waves [193]. In the Institute of Applied Physics, a new-generation mobile microwave spectroradiometer was designed for studying the ozone layer of the earth. This device ensures the reception of the thermal radiation of the stratospheric ozone at the frequency of its rotational transition of 110836 MHz in a frequency band of 240 MHz. The spectral resolution in the center of the O_3 line is 1 MHz. The ozone meter is equipped with an automated control system for measurement, calibration, and preliminary data processing. This device permits one to obtain ozone distributions over a height of 20–60 km in 15–20 min [194].

INTERPRETATION OF SATELLITE MEASUREMENTS

Investigations devoted to the creation of methods for interpreting satellite measurements form the main part of developments in this direction.

St. Petersburg State University, jointly with SRC "Planeta", determined potential accuracies of satellite sensing based on numerical experiments using new Russian equipment in IR and MW spectrum ranges (Meteor satellite, IRFS-2, and MTVZA-GYa) for different parameters of the atmosphere and surface: vertical profiles of temperature and humidity, content of ozone and some greenhouse gases, temperature of oceans and land, land emissivity, moisture content of clouds, and near-water wind speed [195–198]. The new technique for determining the total ozone content (TOC) by measurement data of the SEVIRI device on geostationary satellites was improved. The proposed approach to TOC determination permits one to also determine the wind velocity in the stratosphere [199, 200]. Methodological foundations were developed and potential accuracies and the information content were determined for the satellite limb method to determining the optical and microphysical characteristics of stratospheric aerosol based on interpreting measurements of scattered solar radiation in the visible and near-IR ranges of the spectrum [201–204]. The possibilities of taking into account the horizontal inhomogeneity and nonstationarity of the atmosphere were studied in using different satellite methods with the limb geometry of measurements [205]. Based on a numerical simulation of microphysical and optical characteristics of tropospheric aerosol, statistical connections between optical characteristics in the near-IR range of the spectrum were studied. These data are necessary when interpreting satellite measurements of the total contents of carbon dioxide [206].

According to the data of the SAGE III equipment (Russian–American experiment on the Meteor international satellite), variations in the content of ozone and nitrogen dioxide were studied, as were ozone trends at different heights over the territory of Russia and optical and microphysical characteristics of stratospheric aerosol and polar stratospheric clouds [207–212]. Regional satellite monitoring of the nitrogen dioxide content in the troposphere was carried out [213].

Scientists of St. Petersburg State University took an active part in international programs on validating the data of satellite measurements. Different satellite measurements of vertical profiles of the ozone content were compared with the data of ground-based MW measurements [214]. The quality of the data of satellite measurements of the total content of nitrogen dioxide (NO_2) with the OMI equipment was studied based on comparisons with the data of ground-based spectroscopic measurements by the DOAS technique [215, 216]. The importance of allowing for daily variations in the NO_2 content in the stratosphere was demonstrated in the problem of validating the data of satellite measurement results, including measurement data from the MIPAS equipment [217]. The possibilities of improving the standard algorithm for interpreting DOAS measurements of the total ozone content were studied. This algorithm is used at stations of the NDACC international network [218].

Investigations of specialists from the Institute of Atmospheric Physics are devoted to analyzing and interpreting satellite observations of atmospheric trace gases. Satellite measurements with the MOPITT device were used for studying the global and regional effects of equatorial quasibiennial cyclicity manifested in the CO content [219]. Using the NO_2 data that were obtained by the OMI device, the tropospheric NO_2 content over the Moscow region was studied: features of its spatial distribution were analyzed; the characteristics of seasonal and weakly cycles, as well as those of interyear and long-term variability, were described; and a comparative analysis for seasonal and weakly cycles of tropospheric NO_2 content over Moscow and largest agglomerations in the world was performed [220, 221]. Including satellite observations of the optical characteristics of aerosol and of CO, NO_2, CH_2O, O_3, and water-vapor contents, an analysis of the spatial–temporal evolution of the region contaminated by combustion products and the interaction of variations of different atmospheric parameters in the course of the development of the regional weather anomaly and vast forest fires leading to smokiness in the European part of Russia in summer 2010 was performed [222]. The Kurchatov Institute, jointly with the Institute of Atmospheric Optics, developed estimation techniques for concentrations and fluxes of carbon dioxide in the atmosphere using space remote-sensing systems [223].

At SRC "Planeta", the development of automatic classification methods was continued for data from scanning radiometer-imagers of polar-orbiting and geostationary meteorological satellites (NOAA series, Meteor-M, Meteosat, and Elektro-L with AVHRR, SEVIRI, MSU-MR, and MSU-GS equipment) for determining the parameters of cloudiness and precipitations. Data processing systems (AVHRR/NOAA and SEVIRI/Meteosat-9) were developed, approbated, and brought into operation to obtain estimates of cloudiness and regional-coverage precipitation parameters (for Europe and European territory of Russia). Works on validating satellite estimates of the cloud cover were performed [224–226].

A new method was developed for the remote determination of the land-surface temperature (LST) and the land-surface emissivity (LSE) by data from SEVIRI equipment of the Meteosat-9 geostationary satellite. Radiation temperatures measured using SEVIRI under conditions of a clear sky in channels of a split window No. 9 (10.8 μm) and No. 10 (12.0 μm) for three sequential terms are used to obtain LST and LSE estimates by a combination of the "split transparency window" and "two temperatures" methods. This method was tested in experiments with real SEVIRI measurements. The satelliteLST estimates were validated by comparison with independent data: LST estimates obtained by Land Surface Analysis Satellite Application Facility (Lisbon, Portugal) and with in situ observations of the LST for summer 2009 during hours of darkness (48 stations in the Central Black Earth Region of Russia) [227, 228].

Studies on the use of the remote-sensing data about characteristics of the underlying surface in modeling the components of water and heat balance for the river discharge were continued. For this purpose, methods and algorithms of the thematic data processing of information from the AVHRR/NOAA, MODIS/Terra, and Aqua radiometers were developed and improved to estimate the temperature and emissivity of the soil, the temperature of air near the vegetative cover surface, the normalized vegetation index, the leaf-area index, and the projective vegetation cover. In addition, a version of the model of vertical heat and moisture transfer in the "soil–vegetative cover–atmosphere" system (SVAT) was developed. This model is slanted for the use of satellite data about the state of the underlying surface and some meteorological characteristics. Using the SVAT model, the total evaporation, fluxes of hidden and explicit heat, moisture and heat content of the soil, and other components of water and heat balance were calculated for the vegetation seasons of 2003–2009 [229–231].

A cycle of works on studying the possibilities of IR high-spectral resolution sounders was executed. The prospects of remote temperature-humidity sounding of the atmosphere were estimated in [232]. A series of works is devoted to remotely determining the middle-troposphere concentration of carbon dioxide X_{CO_2} and the total methane content Q_{CH_4} in the atmosphere based on the data of AIRS (EOS/AQUA) and (MetOp) IASI satellite IR high-resolution sounders. An improved scheme for X_{CO_2} determination by the AIRS data was developed and approbated by comparison with aircraft observations. A similar technique was applied for retrieving "instantaneous" X_{CO_2} quantities according to IASI data (under conditions of clear sky). The comparison of satellite estimates with quasi-synchronous aircraft observations yields an error of about 2.2 million^{-1}. An iteration physical algorithm using four CH_4 sensitive channels was developed for the retrieval of Q_{CH_4} by the IASI data. The Q_{CH_4} satellite estimates were validated by comparison with spatially matched and quasi-synchronous estimates of Q_{CH_4} by the AIRS data. The values of standard deviations between both types of estimates (averaged over 2° × 2° cells) do not exceed 3% [233, 234].

At the Nansen Center, intensive studies on the development of methods for using satellite data to monitor the underlying surface are in progress [235]. Data from a scatterometer and passive microwave observations were processed jointly, which made it possible to trace variations of multiyear ice in the Arctic. Sea ices of the Arctic Ocean were identified by data from the synthesized aperture radar [236]. The interaction between the atmosphere and ocean is studied by developing a promising new approach for the synergetic analysis of radiolocation and optical pictures, coastal upwelling is studied on the basis of satellite radiolocation pictures [237], and polar cyclones are studied using satellite microwave sensing [238]. Water ecosystems and their responses to global changes are also studied [239–241].

At RPA "Typhoon", a method for determining the dynamic characteristics of the atmosphere by data of sensing from geostationary meteorological satellites was developed. In contrast to methods applied abroad, this method permits one to determine not only the wind-velocity field, but also the coefficient of mesoscale turbulent diffusion and vorticity on a common scale of air mass motion. According to data from the SEVIRI device (Meteosat-8 and Meteosat-9 geostationary European meteorological satellites), fields of dynamic characteristics in regions of dangerous atmospheric phenomena were studied (jet flows and tropical cyclones) [242].

At Ural State University, using the neural network technique, a method for retrieving the methane content in the atmosphere by data from the AIRS sensor on the AQUA satellite was developed. Seasonal variations in the methane content in the atmosphere of western Siberia were revealed by the spectra of the AIRS sensor and the contribution of natural methane emissions from the swamp ecosystem was estimated [243]. A method was proposed for determining the associated gas-flow rate in flares by data from satellite sensing with MODIS-type sensors in IR channels [244]. Possibilities for the neural network method were studied to solve the inverse problem of determining the vertical profile of the CO_2 concentration in the atmosphere from spectral data of the TANSO-FTS sensor on a Greenhouse Gases Observing SATellite (GOSAT) satellite [245].

REFERENCES

1. V. P. Budak and B. A. Veklenko, "Boson Peak, Flickering Noise, Backscattering Processes and Radiative Transfer in Random Media," J. Quant. Spectrosc. Radiat. Transfer **112** (5), 864–875 (2011).
2. I. V. Prokhorov, "On the Structure of the Continuity Set of the Solution to a Boundary-Value Problem for the Radiation Transfer Equation," Math. Notes **86** (1–2), 234–248 (2009).
3. V. P. Budak and S. V. Korkin, "On the Solution of a Vectorial Radiative Transfer Equation in an Arbitrary

Three-Dimensional Turbid Medium with Anisotropic Scattering," J. Quant. Spectrosc. Radiat. Transfer **109** (2), 220–234 (2008).

4. V. P. Budak and S. V. Korkin, "The Spatial Polarization Distribution over the Dome of the Sky for Abnormal Irradiance of the Atmosphere," J. Quant. Spectrosc. Radiat. Transfer **109** (8), 1347–1362 (2008).
5. L. G. Sokoletsky, O. V. Nikolaeva, V. P. Budak, et al., "A Comparison of Numerical and Analytical Radiative Transfer Solutions for Plane Albedo of Natural Waters," J. Quant. Spectrosc. Radiat. Transfer **110** (13), 1132–1146 (2009).
6. A. A. Kokhanovsky, V. P. Budak, C. Cornet, et al., "Benchmark Results in Vector Atmospheric Radiative Transfer," J. Quant. Spectrosc. Radiat. Transfer **111** (12–13), 1931–1946 (2010).
7. V. P. Budak, D. A. Klyuykov, and S. V. Korkin, "Complete Matrix Solution of Radiative Transfer Equation for PILE of Horizontally Homogeneous Slabs," J. Quant. Spectrosc. Radiat. Transfer **112** (7), 1141–1148 (2011). doi 10.1016/j.jqsrt.2010.08.028
8. V. P. Budak and S. V. Korkin, "The Aerosol Influence upon the Polarization State of the Atmosphere Solar Radiation," Int. J. Remote Sens. **29** (9), 2469–2506 (2008).
9. V. P. Budak and S. V. Korkin, "Space–Angle Distribution of the Reflected Charged Particles Adjusted for Spin Calculation," Radiat. Eff. Defects Solids **163**, 761–765 (2008).
10. V. V. Veretennikov, "The Method of Consequent Decomposition in the Theory of Lidar Sensing of Dense Media," Atmos. Ocean. Opt. **20** (11), 894–899 (2007).
11. G. M. Krekov, M. M. Krekova, A. A. Lisenko, et al., "Statistical Simulation of Transspectral Processes: LIF Reabsorption," Atmos. Ocean. Opt. **21** (12), 939–945 (2008).
12. S. M. Prigarin, A. G. Borovoi, I. A. Grishin, et al., "Statistical Simulation of Radiative Transfer in Optically Anisotropic Ice Clouds," Atmos. Ocean. Opt. **20** (3), 183–188 (2007).
13. T. Yu. Chesnokova, K. M. Firsov, and Yu. V. Voronina, "Application of Exponential Series in Modeling of Broadband Solar Radiation Fluxes in the Earth's Atmosphere," Atmos. Ocean. Opt. **20** (9), 730–735 (2007).
14. Yu. V. Bogdanova and O. B. Rodimova, "On Thermodynamic Dependences of Coefficients in Expansion of Radiation Characteristics into Exponential Series," Atmos. Ocean. Opt. **21** (4), 247–251 (2008).
15. T. B. Zhuravleva, "Simulation of Solar Radation Transfer under Different Atmospheric Conditions. Part 1: Deterministic Atmosphere; Part 2: Stochastic Cloudiness," Atmos. Ocean. Opt. **21** (2), 81–95; (3), 163–175 (2008).
16. S. D. Tvorogov and O. B. Rodimova, "Calculation of the Transmission Function at Low Pressures," Atmos. Ocean. Opt. **21** (11), 797–803 (2008).
17. V. V. Belov and M. V. Tarasenkov, "Statistical Modeling of the Intensity of Light Fluxes Reflected by the Earth's Spherical Surface," Atmos. Ocean. Opt. **23** (3), 197–203 (2010).
18. T. B. Zhuravleva and A. A. Kokhanovskii, "Influence of Horizontal Inhomogeneity on Albedo and Absorptivity of Snow Cover," Russ. Meteorol. Hydrol. **35** (9), 590–595 (2010).
19. S. D. Tvorogov, T. B. Zhuravleva, O. B. Rodimova, et al., "Theory of Series of Exponents and Its Application for Analysis of Radiation Processes," in *Problems of Global Climatology and Ecodynamics: Anthropogenic Effects on the State of Planet Earth*, Ed. by A. P. Cracknell, V. F. Krapivin, and C. A. Varotsos (Springer/Praxis, Chichester, 2008), Ch. 9, pp. 211–240.
20. V. V. Veretennikov, "Simultaneous Determination of Aerosol Microstructure and Refractive Index from Sun Photometry Data," Atmos. Ocean. Opt. **20** (3), 192–199 (2007).
21. T. Yu. Chesnokova and Yu. V. Voronina, "The Influence of Spectroscopic Data Quality on Modeling of Downward Solar UV Radiation Fluxes," Atmos. Ocean. Opt. **21** (7), 500–503 (2008).
22. K. M. Firsov and T. Yu. Chesnokova, "Sensitivity of Downward Long-Wave Radiative Fluxes to Water Vapor Continuum Absorption," Atmos. Ocean. Opt. **23** (6), 462–468 (2010).
23. I. A. Gorchakova, G. V. Chlenova, and A. A. Vigasin, "On the Account of Continual Absorption of Water Vapor for Computing Heat Emission Fluxes," Opt. Atmos. Okeana **22** (6), 546–551 (2009).
24. T. Yu. Chesnokova, B. A. Voronin, A. D. Bykov, et al., "Calculation of Solar Radiation Atmospheric Absorption with Different H_2O Spectral Line Data Banks," J. Mol. Spectrosc. **256** (1), 41–44 (2009).
25. O. V. Nikolaeva, L. P. Bass, V. S. Kuznetsov, et al., "A New 1D Approximation for the Solution of 2D Radiative Transfer Problems," J. Quant. Spectrosc. Radiat. Transfer **111**, 634–642 (2010).
26. O. V. Nikolaeva, L. P. Bass, T. A. Germogenova, et al., "Radiative Transfer in Horizontally and Vertically Inhomogeneous Atmospheres: Numerical Techniques," in *Light Scattering Reviews*, Vol. 2 (Springer, Berlin, 2007), pp. 295–347.
27. O. V. Nikolaeva, L. P. Bass, T. A. Germogenova, et al., "Algorithms To Calculation of Radiative Fields from Localized Sources Via the Code Raduga-5.1(P)," Transp. Theory Stat. Phys. **36** (4–6), 439–474 (2007).
28. L. P. Bass, T. A. Germogenova, O. V. Nikolaeva, et al., "Numerical Simulation of Boundary Effects in Aerosol and Cloud Optics," Atmos. Ocean. Opt. **22** (1), 102–107 (2009).
29. L. G. Sokoletsky, V. P. Budak, L. P. Bass, et al., "A Comparison of Numerical and Analytical Radiative-Transfer Solutions for Plane Albedo in Natural Waters," J. Quant. Spectrosc. Radiat. Transfer **110** (13), 1057–1206 (2009).
30. O. V. Nikolaeva, L. P. Bass, V. S. Kuznetsov, et al., "Radiation Balance in a Cloudy Atmosphere with Account for the 3D Effects," Atmos. Res. **98** (1), 1–8 (2010).
31. L. P. Bass and V. S. Kuznetsov, et al., "Parallel Algorithms for Simulation of Ultrashort Pulse Propagation in Turbid Media," Nuovo Cim. A **33C** (1), 39–46 (2010).

32. V. A. Yankovskii, V. A. Kuleshova, R. O. Manuilova, et al., "Retrieval of Total Ozone in the Mesosphere with a New Model of Electronic–Vibrational Kinetics of O_3 and O_2 Photolysis Products," Izv., Atmos. Ocean. Phys. **43** (4), 514–525 (2007).

33. V. A. Yankovskii and A. S. Babaev, "Photolysis of O_3 at Hartley, Chappuis, Huggins, and Wulf Bands in the Middle Atmosphere: Vibrational Kinetics of Oxygen Molecules $O_2(X^3\Sigma_g^-, \nu \le 35)$," Atmos. Ocean. Opt. **24** (1), 6–16 (2011).

34. V. A. Kuleshova and V. A. Yankovsky, "Model of the Electronic-Vibrational Kinetics of O_2 and O_3 Photolysis in the Earth's Middle Atmosphere: Analysis of Sensitivity," Atmos. Ocean. Opt. **20** (7), 548–556 (2007).

35. A. G. Feofilov, A. A. Kutepov, M. Garcia-Comas, et al., "Daytime SABER/TIMED Observations of Water Vapor in the Mesosphere: Retrieval Approach and First Results," Atm. Chem. Phys. **9** (21), 8139–8158 (2009).

36. V. P. Ogibalov, "Radiative Transfer in SO_2 Bands in the Near UV-Range with Radiation Absorption in the Continuum by Aerosol Particles in the Martian Atmosphere," Vestn. S.-Peterb. Univ., Ser. 4: Fiz., Khim., No. 3, 27–36 (2008).

37. V. P. Ogibalov, "Using the Transport Approximation for Accounting of Radiation Scattering by Aerosol Particles in the Problem of Nonuniform Emission in Infrared Bands of SO_2 in the Martian Atmosphere," Vestn. S.-Peterb. Univ., Ser. 4: Fiz., Khim., No. 4, 38–48 (2009).

38. O. M. Lyulin, V. I. Perevalov, J.-Y. Mandin, et al., "Line Intensities of Acetylene: Measurements in the 2.5-μm Spectral Region and Global Modeling in the $\Delta p = 4$ and 6 Series," J. Quant. Spectrosc. Radiat. Transfer **103**, 496–523 (2007).

39. O. M. Lyulin, D. Jacquemart, N. Lacome, et al., "Line Parameters of Acetylene in the 1.9 and 1.7 μm Spectral Regions," J. Quant. Spectrosc. Radiat. Transfer **109**, 1856–1874 (2008).

40. O. M. Lyulin, D. Jacquemart, N. Lacome, et al., "Line Parameters of $^{15}N_2{}^{16}O$ from Fourier Transform Measurements in the 5800–7600 cm^{-1} Region and Global Fitting of Line Positions from 1000 to 7600 cm^{-1}," J. Quant. Spectrosc. Radiat. Transfer **111** (3), 345–356.

41. S. Mikhailenko, A. Barbe, M.-R. de Backer-Barilly, et al., "Update of Line Parameters of Ozone in the 2590–2900 cm^{-1} Region," Appl. Opt. **47**, 4612–4618 (2008).

42. S. N. Mikhailenko, A. K. A. Keppler, G. Mellau, et al., "Water Vapor Absorption Line Intensities in the 1900–6600 cm^{-1} Region," J. Quant. Spectrosc. Radiat. Transfer **109**, 2687–2696 (2008).

43. A. V. Nikitin, S. N. Mikhailenko, I. Morino, et al., "Isotopic Substitution Shifts in Methane and Vibrational Band Assignment in the 5560–6200 cm^{-1} Region," J. Quant. Spectrosc. Radiat. Transfer **110** (12), 964–973 (2009).

44. N. N. Lavrentieva, T. M. Petrova, A. M. Solodov, et al., "Measurements of N_2-Broadening and -Shifting Parameters of the Water Vapor Spectral Lines in the Second Hexad Region," J. Quant. Spectrosc. Radiat. Transfer **111** (15), 2291–2297.

45. B. V. Perevalov, A. Campargue, B. Gao, et al., "New CW-CRDS Measurements and Global Modeling of $^{12}C^{16}O_2$ Absolute Line Intensities in the 1.6 μm Region," J. Mol. Spectrosc. **252** (2), 190–197 (2008).

46. V. I. Perevalov, S. A. Tashkun, K. F. Song, et al., "Global Modeling of $^{16}O^{12}C^{17}O$ and $^{16}O^{12}C^{18}O$ Absolute Line Intensities in the 1.35 μm Region," J. Mol. Spectrosc. **263** (2), 183–185 (2010).

47. I. V. Ptashnik and K. M. Smith, "Water Vapour Line Intensities and Self-Broadening Coefficients in the 5000–5600 cm^{-1} Spectral Region," J. Quant. Spectrosc. Radiat. Transfer **111** (10), 1317–1327 (2010).

48. S. A. Tashkun, V. I. Perevalov, R. V. Kochanov, et al., "Global Fitting of $^{14}N^{15}N^{16}O$ and $^{15}N^{14}N^{16}O$ Vibrational–Rotational Line Positions Using the Effective Hamiltonian Approach," J. Quant. Spectrosc. Radiat. Transfer **111** (9), 1089–1105 (2010).

49. S. A. Tashkun, T. I. Velichko, and S. N. Mikhailenko, "Critical Evaluation of Measured Rotation–Vibration Line Positions and an Experimental Dataset of Energy Levels of $^{12}C^{16}O$ in the $X^1\Sigma^+$ State," J. Quant. Spectrosc. Radiat. Transfer **111** (9), 1106–1116 (2010).

50. V. I. Perevalov, S. A. Tashkun, V. G. Tyuterev, et al., "Global Modeling of High-Resolution Spectra of Atmospheric Gas Molecules," Atmos. Ocean. Opt. **20** (5), 359–367 (2007).

51. S. D. Tvorogov, E. P. Gordov, and O. B. Rodimova, "Inter-Molecular Interaction and Molecular Spectroscopy: From Semi-Classical Representation of Quantum Theory to Line Wing Theory," Atmos. Ocean. Opt. **20** (9), 692–695 (2007).

52. B. V. Perevalov, S. Kassi, D. Romanini, et al., "Global Effective Hamiltonians of $^{16}O^{13}C^{17}O$ and $^{16}O^{13}C^{18}O$ Improved from CW–CRDS Observations in the 5900–7000 cm^{-1} Region," J. Mol. Spectrosc. **241**, 90–100 (2007).

53. B. V. Perevalov, T. Deleporte, A. W. Liu, et al., "Global Modeling of $^{13}C^{16}O_2$ Absolute Line Intensities from CW–CRDS and FTS Measurements in the 1.6 and 2.0 μm Regions," J. Quant. Spectrosc. Radiat. Transfer **109**, 2009–2026 (2008).

54. B. V. Perevalov, V. I. Perevalov, and A. Campargue, "A (Nearly) Complete Experimental Linelist for $^{13}C^{16}O_2$, $^{16}O^{13}C^{18}O$, $^{16}O^{13}C^{17}O$, $^{13}C^{18}O_2$ and $^{17}O^{13}C^{18}O$ by High-Sensitivity CW–CRDS Spectroscopy between 5851 and 7045 cm^{-1}," J. Quant. Spectrosc. Radiat. Transfer **109**, 2437–2462 (2008).

55. H.-Y. Ni, K.-F. Song, V. I. Perevalov, et al., "Fourier-Transform Spectroscopy of $^{14}N^{15}N^{16}O$ in the 3800–9000 cm^{-1} Region and Global Modeling of Its Absorption Spectrum," J. Mol. Spectrosc. **248** (1), 41–60 (2008).

56. L. Wang, V. I. Perevalov, S. A. Tashkun, et al., "Fourier Transform Spectroscopy of $^{12}C^{18}O_2$ and $^{16}O^{12}C^{18}O$ in the 3800–8500 cm^{-1} Region and the Global Modeling of the Absorption Spectrum of $^{12}C^{18}O_2$," J. Mol. Spectrosc. **247** (1), 64–75 (2008).

57. A. V. Nikitin, F. Holka, Vl. G. Tyuterev, et al., "Vibrational Energy Levels of the PH_3, PH_2D, and PHD_2 Molecules Calculated from High Order Potential

Energy Surface," J. Chem. Phys. **130** (24), 244–312 (2009).

58. A. D. Bykov, O. V. Naumenko, E. R. Polovtseva, et al., "Fourier Transform Absorption Spectrum of $D_2{}^{18}O$ in 7360–8440 cm^{-1} Region," J. Quant. Spectrosc. Radiat. Transfer **111** (15), 2197–2210 (2010).
59. H.-Y. Ni, A.-W. Liu, K.-F. Song, et al., "High-Resolution Spectroscopy of the Triple-Substituted Isotopologue of Water $HD^{18}O$: The First Triad," Mol. Physics **106**, 1793–1801 (2008).
60. S. N. Mikhailenko, S. A. Tashkun, T. A. Putilova, et al., "Critical Evaluation of Rotation-Vibration Transitions and an Experimental Dataset of Energy Levels of $HD^{18}O$," J. Quant. Spectrosc. Radiat. Transfer **110** (9–10), 597–608 (2009).
61. S. N. Mikhailenko, S. A. Tashkun, L. Daumont, et al., "Line Positions and Energy Levels of the ^{18}O Substitutions from the HDO/D_2O Spectra between 5600 and 8800 cm^{-1}," J. Quant. Spectrosc. Radiat. Transfer **111** (15), 2185–2196 (2010).
62. O. V. Naumenko, S. Beguier, O. Leshchishina, et al., "ICLAS of HDO between 13020 and 14115 cm^{-1}," J. Quant. Spectrosc. Radiat. Transfer **111**, 36–44 (2010).
63. A. Liu, O. V. Naumenko, S. Kassi, et al., "High Sensitivity CW-CRDS of 18O Enriched Water Near 1.6 μm," J. Quant. Spectrosc. Radiat. Transfer **110**, 1781–1800 (2009).
64. L. S. Rothman, I. E. Gordon, A. Barbe, et al., "The HITRAN 2008 Molecular Spectroscopic Database," J. Quant. Spectrosc. Radiat. Transfer **110** (9–10), 533–572 (2009).
65. J. Tennyson, P. F. Bernath, L. R. Brown, et al., "IUPAC Critical Evaluation of the Rotational-Vibrational Spectra of Water Vapor. Part I. Energy Levels and Transition Wavenumbers for $H_2{}^{17}O$ and $H_2{}^{18}O$," J. Quant. Spectrosc. Radiat. Transfer **110**, 573–596 (2009).
66. J. Tennyson, P. F. Bernath, L. R. Brown, et al., "IUPAC Critical Evaluation of the Rotational–Vibrational Spectra of Water Vapor. Part II. Energy Levels and Transition Wavenumbers for HDO," J. Quant. Spectrosc. Radiat. Transfer **111**, 2160–2184 (2010).
67. B. A. Voronin, O. V. Naumenko, M. Carleer, et al., "HDO Absorption Spectrum Above 11500 cm^{-1}: Assignment and Dynamics," J. Mol. Spectrosc. **244**, 87–101 (2007).
68. B. A. Voronin, J. Tennyson, R. N. Tolchenov, et al., "A High Accuracy Computed Line List for the HDO Molecule," Mon. Not. R. Astron. Soc. **402**, 492–496 (2010).
69. S. V. Shirin, R. I. Ovsyannikov, N. F. Zobov, et al., "Water Line Lists Close to Experimental Accuracy Using a Spectroscopically Determined Potential Energy Surfaces for $H_2{}^{16}O$, $H_2{}^{17}O$ and $H_2{}^{18}O$," J. Chem. Phys. **128** (22), 1–10 (2008).
70. S. N. Yurchenko, B. A. Voronin, R. N. Tolchenov, et al., "Potential Energy Surface of HDO up to 25000 cm^{-1}," J. Chem. Phys. **128** (4), 044312 (2008).
71. A. D. Bykov, N. N. Lavrentieva, T. P. Mishina, et al., "Water Vapor Line Width and Shift Calculations with Accurate Vibration-Rotation Wave Functions," J. Quant. Spectrosc. Radiat. Transfer **109**, 1834–1844 (2008).
72. A. D. Bykov, N. N. Lavrent'eva, T. M. Petrova, et al., "Shift of Centers of H_2O Absorption Lines in the Region of 1.06 μm," Opt. Spektrosk. **105** (1), 25–31 (2008).
73. A. D. Bykov, N. N. Lavrent'eva, T. P. Mishina, et al., "Influence of Interference between Water Vapor Lines on Atmospheric Transmission of Near IR-Radiation," Opt. Spektrosk. **104** (2), 165–171 (2008).
74. J. T. Hodges, D. Lisak, N. Lavrentieva, et al., "Comparison between Theoretical Calculations and High61 Resolution Measurements of Pressure Broadening for Near-Infrared Water Spectra," J. Mol. Spectrosc. **249**, 86–94 (2008).
75. N. Lavrentieva, A. Osipova, L. Sinitsa, et al., "Shifting Temperature Dependence of Nitrogen-Broadened Lines in the ν_2 Band of H_2O," Mol. Phys. **106**, 1261–1266 (2008).
76. N. N. Lavrent'eva, T. P. Mishina, L. N. Sinitsa, et al., "Calculations of Self-Broadening and Self-Shifting of Spectral Lines of Water Vapor with the Use of Accurate Vibration-Rotation Wave Functions," Atmos. Ocean. Opt. **21** (12), 957–961 (2008).
77. N. Jacquinet-Husson, N. A. Scott, A. Chedin, et al., "The GEISA Spectroscopic Database: Current and Future Archive for Earth and Planetary Atmosphere Studies," J. Quant. Spectrosc. Radiat. Transfer **109**, 1043–1059 (2008).
78. B. V. Perevalov, S. Kassi, V. I. Perevalov, et al., "High Sensitivity CW-CRDS Spectroscopy of $^{12}C^{16}O_2$, $^{16}O^{12}C^{17}O$ and $^{16}O^{12}C^{18}O$ between 5851 and 7045 cm^{-1}: Line Positions Analysis and Critical Review of the Current Databases," J. Mol. Spectrosc. **252** (2), 143–159 (2008).
79. A. V. Nikitin, O. M. Lyulin, S. N. Mikhailenko, et al., "GOSAT-2009 Methane Spectral Line List in the 5550–6236 cm^{-1} Region," J. Quant. Spectrosc. Radiat. Transfer **111** (15), 2211–2224 (2010).
80. L. S. Rothman, I. E. Gordon, R. J. Barber, et al., "HITEMP, the High-Temperature Molecular Spectroscopic Database," J. Quant. Spectrosc. Radiat. Transfer **111** (15), 2139–2150 (2010).
81. O. Yu. Nikiforova, V. A. Kapitanov, and Yu. N. Ponomarev, "Influence of Ethylene Spectral Lines on Methane Concentration Measurements with a Diode Laser Methane Sensor in the 1.65 μm Region," Appl. Phys. B **90** (2), 263–268 (2008).
82. V. A. Kapitanov, I. S. Tyryshkin, N. P. Krivolutskii, et al., "Spatial Distribution of Methane over Lake Baikal Surface," Spectrochim. Acta, Part A **66** (4–5), 788–795 (2007).
83. V. A. Kapitanov, Yu. N. Ponomarev, I. S. Tyryshkin, et al., "Two-Channel Opto-Acoustic Diode Laser Spectrometer and Fine Structure of Methane Absorption Spectra in 6070–6180 cm^{-1} Region," Spectrochim. Acta, Part A **66** (4–5), 811–818 (2007).
84. V. A. Kapitanov and Yu. N. Ponomarev, "High Resolution Ethylene Absorption Spectrum between 6035 cm^{-1} and 6210 cm^{-1}," Appl. Phys. B **90** (2), 235–241 (2008).

85. M. A. Gonzalez, BoudonV. Lorono, M. Loete, et al., “High-Resolution Spectroscopy and Preliminary Global Analysis of C–H Stretching Vibrations of C_2H_4 in the 3000 and 6000 cm^{-1} Regions,” J. Quant. Spectrosc. Radiat. Transfer **111** (15), 2265–2278 (2010).
86. O. N. Ulenikov and G. A. Onopenko, et al., “High Resolution Study of the $\nu_5 + \nu_{12}$ Band of C_2H_4,” Mol. Phys. **108** (5), 637–647 (2010).
87. V. A. Kapitanov, A. M. Solodov, T. M. Petrova, et al., “Fourier Transform and Photo-Acoustic Absorption Spectra of Ethylene within 6035–6210 cm^{-1}. Comparative Measurements,” Int. J. Spectrosc. 203672 (2010). doi 10.1155/2010/203672
88. G. M. Abakumova and E. V. Gorbarenko, E. I. Nezval’, et al., “Fifty Years of Actinometrical Measurements in Moscow,” Int. J. Remote Sens. **29** (9), 2629–2665 (2008).
89. G. M. Abakumova and E. V. Gorbarenko, *Atmospheric Transparency in Moscow over 50 Years and Its Changes on the Territory of Russia* (LKI, Moscow, 2008) [in Russian].
90. H. Ohvril, H. Teral, L. Neiman, et al., “Variability of Atmospheric Column Transparency in the Baltic Region, 1906–2006,” J. Geophys. Res. **114**, D12 (2009).
91. S. M. Sakerin, E. V. Gorbarenko, and D. M. Kabanov, Peculiarities of Many-Yea Variations of Atmospheric Aerosol Optical Depth and Estimates of Influence of Different Factors,” Atmos. Ocean. Opt. **21** (7), 540–545 (2008).
92. N. E. Chubarova, “UV Variability in Moscow according to Long-Term UV Measurements and Reconstruction Model,” Atm. Chem. Phys., No. 8, 3025–3031 (2008).
93. N. Y. Chubarova, N. G. Prilepsky, A. N. Rublev, et al., “A Mega-Fire Event in Central Russia: Fire Weather, Radiative, and Optical Properties of the Atmosphere, and Consequences for Subboreal Forest Plants,” in *Developments in Environmental Science*, Ed. by A. Bytnerowicz, M. Arbaugh, A. Riebau, et al. (Elsevier, Amsterdam, 2009), Vol. 8, pp. 249–267.
94. N. Y. Chubarova, “Seasonal Distribution of Aerosol Properties over Europe and Their Impact on UV Irradiance,” Atmos. Meas. Tech., No. 2, 593–608, (2009). http://www.atmos-meas-tech.net/2/593/2009/
95. N. Y. Chubarova, M. A. Sviridenkov, A. Smirnov, et al., “Assessments of Urban Aerosol Pollution in Moscow and Its Radiative Effects,” Atmos. Meas. Tech. Discuss., No. 3, 5469–5498 (2010). http://www.atmos-meas-tech-discuss.net/3/5469/2010/doi:10.5194/amtd-3-5469-2010
96. T. K. Sklyadneva and B. D. Belan, “Radiative Regime Near Tomsk in 1995–2005,” Atmos. Ocean. Opt. **20** (1), 54–59 (2007).
97. B. D. Belan, G. A. Ivlev, and T. K. Sklyadneva, “Variations of UV-B Radiation in Tomsk over 2003–2007,” Atmos. Ocean. Opt. **21** (7), 535–539 (2008).
98. T. K. Sklyadneva and T. B. Zhuravleva, “Occurrence of Main Cloudiness Types over Tomsk: Data of Ground-Based Observations in 1993–2004,” Atmos. Ocean. Opt. **21** (1), 55–58 (2008).
99. M. V. Panchenko, M. A. Sviridenkov, A. S. Emilenko, et al., “Comparison of Aerosol Optical and Microphysical Characteristics in a Local Volume and on a Long Path,” Atmos. Ocean. Opt. **20** (6), 451–456 (2007).
100. S. M. Sakerin and D. M. Kabanov, “Correlations between the Parameters of Angström Formula and Aerosol Optical Thickness of the Atmosphere in the Wavelength Range from 1 to 4 μm,” Atmos. Ocean. Opt. **20** (3), 200–206, 2007.
101. S. M. Sakerin and D. M. Kabanov, “Spectral Dependence of the Atmospheric Aerosol Optical Depth in the Wavelength Range from 0.37 to 4 μm,” Atmos. Ocean. Opt. **20** (2), 141–149 (2007).
102. V. V. Zuev, O. E. Bazhenov, V. D. Burlakov, et al., “Long-Term Trends, Seasonal and Anomalous Short-Term Variations of Background Stratospheric Aerosol,” Atmos. Ocean. Opt. **21** (1), 33–37 (2008).
103. S. M. Sakerin, S. A. Beresnev, S. Yu. Gorda, et al., “Characteristics of the Annual Behavior of the Spectral Aerosol Optical Depth of the Atmosphere under Conditions of Siberia,” Atmos. Ocean. Opt. **22** (4), 446–456 (2009).
104. S. M. Sakerin, S. A. Beresnev, S. Yu. Gorda, et al., “Characteristics of the Annual Behavior of the Spectral Aerosol Optical Depth of the Atmosphere under Conditions of Siberia,” Atmos. Ocean. Opt. **22** (4), 446–456 (2009).
105. S. M. Sakerin, A. N. Pavlov, O. A. Bukin, et al., “Results of an Integrated Aerosol Experiment in the Continent–Ocean Transition Zone (Primorye and the Sea of Japan); Part 1: Variations of Atmospheric Aerosol Optical Depth and Vertical Profiles,” Atmos. Ocean. Opt. **24** (1), 64–73 (2011).
106. S. V. Afonin, M. V. Engel’, A. Yu. Mayor, et al., “Results of an Integrated Aerosol Experiment in the Continentocean Transition Zone (Primorye and the Sea of Japan). Part 2. Analysis of Spatiotemporal Variations of Aerosol Characteristics according to Satellite Data and Lidar Measurements,” Atmos. Ocean. Opt **24** (2), 198–206 (2011).
107. A. Smirnov, B. N. Holben, I. Slutsker, et al., “Maritime Aerosol Network as a Component of Aerosol Robotic Network,” J. Geophys. Res. **114**, D06204 (2009).
108. A. Smirnov, B. N. Holben, D. M. Giles, et al., “Maritime Aerosol Network as a Component of AERONET—First Results and Comparison with Global Aerosol Models and Satellite Retrievals,” Atmos. Meas. Tech. Discuss., No. 4, 1–32 (2011). http://www.atmos-meas-tech-discuss.net/4/1/2011/. doi 10.5194/amtd-4-1-20
109. A. N. Rublev, I. A. Gorchakova, and T. A. Udalova, “The Effect that Coarse Particles Have on Estimates of Both Optical and Radiation Characteristics of Dust Aerosol,” Izv., Atmos. Ocean. Phys. **47** (2), 190–200 (2011).
110. A. A. Isakov, A. S. Elokhov, and E. A. Lezina, “Synchronous Variations of the Mass Concentration of Near-Ground Aerosol, Nitrogen Oxides, and Ozone in the Moscow Region,” Atmos. Ocean. Opt. **22** (4), 428–434 (2009).
111. A. A. Isakov and A. V. Tikhonov, “On the Comparison of the Average Arrival Directions of Air Masses in the

Moscow Region Versus the Average Hanel Parameters and Average Particle Refractive Indices," Atmos. Ocean. Opt. **23** (3), 169–173 (2010).

112. G. I. Gorchakov, B. A. Anoshin, and E. G. Semoutnikova, "Statistical Analysis of Mass Concentration Variations of the Coarse Aerosol in Moscow," Atmos. Ocean. Opt. **20** (6), 461–464 (2007).

113. A. S. Emilenko and V. M. Kopeikin, "Comparison of Synchronous Measurements of Soot and Submicron Aerosol Concentrations in Regions with Different Anthropogenic Loadings," Atmos. Ocean. Opt. **22** (4), 421–427 (2009).

114. V. F. Radionov, E. N. Rusina, and E. E. Sibir, "Specific Features of Long-Term Variability of Total Solar Radiation and Characteristics of Atmospheric Transparency in Polar Areas," Probl. Arkt. Antarkt., No. 76, 131–136 (2007).

115. V. F. Radionov, E. N. Rusina, and E. E. Sibir, "Radiation Regime and Long-Term Variability of Total Solar Radiation at Barents Sea Stations," Trudy AANII **450**, 81–90 (2009).

116. C. Tomasi, V. Vitale, A. Lupi, et al., "Aerosols in Polar Regions: A Historical Overview Based on Optical Depth and in situ Observations," J. Geophys. Res. D **112**, d16 205 (2007). doi 10.1029/2007JD008432

117. S. M. Sakerin, D. M. Kabanov, V. F. Radionov, et al., "About Investigation Results on the Atmosphere Aerosol Optical Depth in Circumnavigation around Antarctica (the 53d RAE)," Atmos. Ocean. Opt. **21** (12), 900–904, (2008).

118. S. M. Sakerin, D. M. Kabanov, V. S. Kozlov, et al., "Results of Aerosol Characteristics Investigations during the 52th RAE," Probl. Arkt. Antarkt., No. 77, 65–75 (2007).

119. T. B. Zhuravleva, D. M. Kabanov, S. M. Sakerin, et al., "Simulation of Aerosol Direct Radiative Forcing under Typical Summer Conditions of Siberia. Part 1. Method of Calculation and Choice of Input Parameters," Atmos. Ocean. Opt. **22** (1), 63–73 (2009).

120. T. B. Zhuravleva and S. M. Sakerin, "Simulation of Aerosol Direct Radiative Forcing under Typical Summer Conditions of Siberia. Part 2. Variability Range and Sensitivity to the Input Parameters," Atmos. Ocean. Opt. **22** (1), 74–83 (2009).

121. T. B. Zhuravleva, D. M. Kabanov, and S. M. Sakerin, "On Daytime Variations of Atmospheric Aerosol Optical Depth and Aerosol Radiative Forcing," Atmos. Ocean. Opt. **23** (6), 528–537 (2010).

122. S. M. Sakerin, V. V. Veretennikov, T. B. Zhuravleva, et al., "Comparative Analysis of Radiative Characteristics Aerosol in Fire Smokes and Cloudy Conditions," Opt. Atmos. Okeana **23** (6), 451–461 (2010).

123. V. V. Zuev, O. E. Bazhenov, V. D. Burlakov, et al., "On the Effect of Volcanic Aerosol on Variations of Stratospheric Ozone and NO_2 according to Measurements at the Siberian Lidar Station," Atmos. Ocean. Opt. **21** (11), 825–831 (2008).

124. I. L. Karol', V. A. Frol'kis, and A. A. Kiselev, "Radiative and Thermal Regime of the Atmosphere and the Climate System: External Forcing Indices and Their Evaluation," Trudy GGO, No. 560, 33–50 (2009).

125. I. L. Karol, V. A. Frolkis, and A. A. Kiselev, "Radiative and Thermal Regime of the Atmosphere and the Climate System: External Forcing Indices (Metrics) and Their Evaluation," in *IPCC Expert Meeting on the Science of Alternative Metrics*, Ed. by G.-K. Plattner, T. Stocker, P. Midglaey, et al. (Univ. of Bern, Bern, 2009), pp. 37–38.

126. V. A. Frol'kis and I. L. Karol', "Simulation of the Effect of Stratospheric Aerosol Dimming Parameters on the Efficiency of Offsetting Global Greenhouse Climate Warming," Atmos. Ocean. Opt. **24** (1), 74–87 (2011).

127. V. P. Meleshko, V. M. Kattsov, and I. L. Karol', "Is Aerosol Scattering in the Stratosphere a Safety Technology Preventing Global Warming?," Russ. Meteorol. Hydrol. **35** (7), 433–440 (2010).

128. V. I. Zakharov, K. G. Gribanov, and S. A. Beresnev, "Role of Gas and Aerosol Components of the Atmosphere in the Model of Greenhouse Explosion," Atmos. Ocean. Opt. **22** (2), 162–172 (2009).

129. V. I. Zakharov, "Regarding Greenhouse Explosion," in *Global Climatology and Ecodynamics—Anthropogenic Changes to Planet Earth*, Ed. by A. Cracknell, V. Krapivin, C. Varotsos (Springer/PRAXIS, Chichester, 2008), Ch. 6, pp. 107–132.

130. V. I. Zakharov, R. Imasu, K. G. Gribanov, et al., "Free Energy Balance at the Upper Boundary of the Atmosphere," Atmos. Ocean. Opt. **21** (3), 211–218 (2008).

131. E. N. Kadygrov, A. V. Koldaev, E. A. Miller, et al., "Study of Urban Heat Island Inhomogeneity in Nizhni Novgorod on the basis of a Mobile Atmospheric Temperature Profiler," Russ. Meteorol. Hydrol. **32** (2), 110–118 (2007).

132. E. N. Kadygrov, "Microwave Radiometry of Atmospheric Boundary Layer—Method, Instrumentation, Measurement Results," Opt. Atmos. Okeana **22** (7), 697–704 (2009).

133. E. A. Miller, E. A. Vorob'eva, and E. N. Kadygrov, "Analysis of Seasonal and Annual Peculiarities of the Temperature Stratification of an Urban Heat Island," Atmos. Ocean. Opt. **22** (4), 435–440 (2009).

134. V. A. Gladkikh, A. E. Makienko, E. A. Miller, et al., "Study of the Atmospheric Boundary Layer Parameters under Urban Conditions with Local and Remote Diagnostics Facilities. Part 1. Interlevel Wind Speed Correlations," Atmos. Ocean. Opt. **24** (3), 271–279 (2011); "Part. 2. Air Temperature and Heat Flux," Atmos. Ocean. Opt. **24** (3), 280–287 (2011).

135. E. A. Vorob'eva, A. N. Shaposhnikov, V. V. Folomeev, et al., "Measurement Results of Thermal Stratification of Atmospheric Boundary Layer in Canyons and Troughs of the Guam Ridge," Opt. Atmos. Okeana **23** (6), 505–509 (2010).

136. G. I. Gorchakov, E. N. Kadygrov, A. A. Isakov, et al., "Influence of a Solar Eclipse on Thermal Stratification and the Turbulence Regime," Dokl. Earth Sci. **417** (8), 1243–1247 (2007).

137. G. I. Gorchakov, E. N. Kadygrov, Z. V. Kortunova, et al., "Eclipse Effects in the Atmospheric Boundary Layer," Izv., Atmos. Ocean. Phys. **44** (1), 100–106 (2008).

138. G. I. Gorchakov, A. K. Petrov, A. A. Isakov, et al., "The Influence of Solar Eclipse on the Processes in the Atmospheric Boundary Layer," Atmos. Ocean. Opt. **23** (6), 433–440 (2010).

139. S. V. Solomonov, A. N. Ignat'ev, E. P. Kropotkina, et al., "Spectral Instruments for Monitoring of Atmospheric Ozone at Millimeter Waves," Prib. Tekh. Eksp., No. 2, 138–144 (2009).

140. A. M. Zvyagintsev, I. B. Belikov, N. F. Elanskii, et al., "Statistical Modeling of Daily Maximum Surface Ozone Concentrations," Atmos. Ocean. Opt. **23** (4), 284–292 (2010).

141. E. A. Titova, I. L. Karol', A. M. Shalamyanskii, et al., "Statistical Analysis and Comparison of External Factor Effects on the Total Ozone Field over the Russian Territory in 1973–2007," Russ. Meteorol. Hydrol. **34** (7), 442–453 (2009).

142. B. D. Belan, "Tropospheric Ozone. 3. Mechanism and Factors Determining the Ozone Content in Troposphere," Atmos. Ocean. Opt. **21** (7), 520–534 (2008).

143. B. D. Belan, "Tropospheric Ozone. 6. Ozone Cycle Components," Opt. Atmos. Okeana **22** (4), 358–380 (2009).

144. B. D. Belan, "Tropospheric Ozone. 7. Ozone Sinks in the Troposphere," Opt. Atmos. Okeana **23** (2), 108–126 (2010).

145. B. D. Belan, G. N. Tolmachev, and A. V. Fofonov, "Ozone Vertical Distribution in the Troposphere over South Regions of Western Siberia," Atmos. Ocean. Opt. **24** (2), 181–187 (2011).

146. M. I. Beloglazov, V. M. Demkin, A. A. Krasil'nikov, et al., "Microwave Measurements of the Ozone Content in Winter Arctic Stratosphere," Geomagn. Aeron. **50** (2), 256–262 (2010).

147. Yu. Yu. Kulikov, A. A. Krasil'nikov, V. M. Demkin, et al., "Variations in the Concentration of Mesospheric Ozone duringthe Total Solar Eclipse of March 29, 2006, from Microwave Radiometric Data," Izv., Atmos. Ocean. Phys. **44** (4), 486–490 (2008).

148. E. N. Rusina and E. L. Genikhovich, "A Method for Analyzing Data on Total Ozone Content in Observations on Mobile Platforms," Trudy GGO, No. 562, 61–75 (2010).

149. M. V. Makarova, A. V. Poberovskii, K. N. Visheratin, et al., "Time Variability of the Total Methane Content in the Atmosphere over the Vicinity of St. Petersburg," Izv., Atmos. Ocean. Phys. **45** (6), 723–730 (2009).

150. M. V. Makarova, V. S. Kostsov, and A. V. Poberovskii, "Study of the Factors Determining Anomalous Variability of Carbon Dioxide Total Column Amount over St. Petersburg," Izv., Atmos. Ocean. Phys. **43** (4), 497–504 (2007).

151. A. V. Poberovskii, "High-Resolution Ground Measurements of the IR Spectra of Solar Radiation," Atmos. Ocean. Opt. **23** (2), 161–163 (2010).

152. A. V. Poberovskii, A. V. Polyakov, and Yu. M. Timofeev, "Measurements of the Hydrogen Fluoride Total Column Amount in the Atmosphere over the Vicinity of St. Petersburg," Izv., Atmos. Ocean. Phys. **46** (2), 261–263 (2010).

153. A. V. Poberovskii, M. V. Makarova, A. V. Rakitin, et al., "Variability of the Total Column Amounts of Climate Influencing Gases Obtained from Ground-Based High Resolution Spectroscope Measurements," Dokl. Akad. Nauk **432** (1), 656–659 (2010).

154. Ya. A. Virolainen and Yu. M. Timofeev, "Determination of Elements of the Vertical Structure of Ozone Content from Ground-Based Measurements of Solar Radiation with High Spectral Resolution," Issled. Zemli Kosmosa, No. 3, 3–10 (2008).

155. Ya. A. Virolainen and Yu. M. Timofeev, "A Combined Method for Determining the Vertical Profiles of Ozone Content to Validate Satellite Measurements," Issled. Zemli Kosmosa, No. 4, 61–66 (2010).

156. Ya. A. Virolainen, Yu. M. Timofeev, D. V. Ionov, et al., "Ground-Based Measurements of Total Ozone Content by the Infrared Method," Izv., Atmos. Ocean. Phys. **47** (4), 480–490 (2011).

157. A. V. Poberovskii, A. V. Shashkin, D. V. Ionov, et al., "NO_2 Content Variations Near St. Petersburg as Inferred from Ground-Based and Satellite Measurements of Scattered Solar Radiation," Izv., Atmos. Ocean. Phys. **43** (4), 505–513 (2007).

158. M. V. Makarova, A. V. Poberovskii, and S. I. Osipov, "Time Variations of the Total CO Content in the Atmosphere Near St. Petersburg," Izv., Atmos. Ocean. Phys. **47** (6), 739–746 (2011).

159. M. V. Makarova, A. V. Rakitin, D. V. Ionov, et al., "Analysis of Variability of the CO, NO_2, and O_3 Contents in the Troposphere Near St. Petersburg," Izv., Atmos. Ocean. Phys. **47** (4), 468–479 (2011).

160. M. Yu. Arshinov, B. D. Belan, D. K. Davydov, et al., "Spatial and Temporal Variability of CO_2 and CH_4 Concentrations in the Surface Atmospheric Layer over West Siberia," Atmos. Ocean. Opt. **22** (1), 84–93 (2009).

161. M. Yu. Arshinov, B. D. Belan, D. K. Davydov, et al., "Vertical Distribution of Greenhouse Gases above Western Siberia by the Long-Term Measurement Data," Atmos. Ocean. Opt. **22** (3), 316–324 (2009).

162. M. V. Panchenko, V. M. Domysheva, D. A. Pestunov, et al., "Experimental Study of CO_2 Gas Exchange in the System "Atmosphere–Water Surface" of Lake Baikal (Statement of Experiment)," Atmos. Ocean. Opt. **20** (5), 408–417 (2007).

163. M. V. Sakirko, M. V. Panchenko, V. M. Domysheva, et al., "Diurnal Rhythms of Carbon Dioxide Concentration in the Sea-Level Air Layer and in the Surface Water of Lake Baikal in Different Hydrological Seasons," Russ. Meteorol. Hydrol. **33** (2), 112–116 (2008).

164. M. V. Sakirko, V. M. Domysheva, O. I. Belykh, et al., "Estimation of the Spatial Variability of Carbonic Acid Stream Direction in Different Hydrological Seasons at Lake Baikal," Atmos. Ocean. Opt. **22** (4), 478–482 (2009).

165. V. M. Domysheva, M. V. Sakirko, D. A. Pestunov, et al., "Seasonal Behavior of the CO_2 Gas Exchange Process in the "Atmosphere–Water" System of the Littoral Zone of Southern Baikal. 1. Hydrological Spring," Atmos. Ocean. Opt. **24** (3), 253–260 (2010).

166. V. M. Domysheva, M. V. Sakirko, D. A. Pestunov, et al., "Experimental Assessment of the Carbon Dioxide Flow in the Atmosphere–Water System of the Lit-

toral and Pelagic Zones of Lake Baikal during Hydrological Summer," Dokl. Earth Sci. **431** (2), 541–545 (2010).

167. F. V. Kashin, V. F. Radionov, and E. I. Grechko, "Variations in the Total Column Amounts of Carbon Monoxide and Methane in the Antarctic Atmosphere," Izv., Atmos. Ocean. Phys. **43** (4), 490–496 (2007).

168. V. F. Radionov, E. N. Rusina, E. E. Sibir, et al., "Specific Features of Total Ozone Content in Northern and Southern Polar Areas," Probl. Arkt. Antarkt., No. 75, 64–72 (2007).

169. F. V. Kashin, V. N. Aref'ev, N. E. Kamenogradskii, et al., "Carbon Dioxide Content in the Atmospheric Thickness over Central Eurasia (Issyk Kul Monitoring Station)," Izv., Atmos. Ocean. Phys. **43** (4), 480–489 (2007).

170. F. V. Kashin, V. N. Aref'ev, V. K. Semenov, et al., "Structure of Time Variations in Carbon Dioxide in the Atmospheric Thickness over Central Eurasia (Issyk Kul Monitoring Station)," Izv., Atmos. Ocean. Phys. **44** (1), 90–99 (2008).

171. V. N. Aref'ev, F. V. Kashin, A. V. Krasnosel'tsev, et al., "Structure of Time Variations in the Atmospheric Transparency in Central Eurasia (Issyk Kul Monitoring Station)," Izv., Atmos. Ocean. Phys. **44** (5), 615–620 (2008).

172. V. N. Aref'ev, F. V. Kashin, V. K. Semenov, et al., "Variations in Nitrogen Dioxide in the Atmosphere over Central Eurasia (Issyk Kul Monitoring Station)," Izv., Atmos. Ocean. Phys. **45** (5), 575–582 (2009).

173. F. V. Kashin, R. M. Akimenko, V. N. Aref'ev, et al., "Carbon Oxide in the Surface Air (Obninsk Monitoring Station)," Izv., Atmos. Ocean. Phys. **46** (1), 45–55 (2010).

174. A. N. Rublev, A. N. Trotsenko, T. A. Udalova, et al., "Determination of NO_2 in the Surface Layer of the Atmosphere," RRC Kurchatov Institute, Preprint IAE-6506/16 (2008).

175. V. I. Zakharov, M. S. Blagodareva, and K. G. Gribanov, "The Method of Remote Sensing of $^{13}CO_2/^{12}CO_2$ Ratio in the Atmosphere using High Resolution Transmittance IR Spectra," Atmos. Ocean. Opt. 21 (5), 342–344 (2008).

176. K. G. Gribanov, V. I. Zakharov, S. A. Beresnev, et al., "Sensing HDO/H_2O in the Ural's Atmosphere Using Ground-Based Measurements of IR Solar Radiation with a High Spectral Resolution," Atmos. Ocean. Opt. **24** (4), 369–372 (2011).

177. A. Yu. Toptygin, K. G. Gribanov, V. I. Zakharov, et al., "Determination of the Vertical Profile of HDO/H_2O from High-Resolution Atmospheric Transmission Spectra," Atmos. Ocean. Opt. **24** (4), 369–372 (2007).

178. I. M. Levin and O. V. Kopelevich, "Correlations between the Inherent Hydrooptical Characteristics in the Spectral Range Close to 550 nm," Okeanologiya **47** (3), 344–348 (2007).

179. I. M. Levin, "Advanced Lines of Progress for Optical Remote Methods of Ocean Study," in *Fundamental and Applied Hydrophysics,* Ed. by A. A. Rodionov (Nauka, St. Petersburg, 2008), No. 1(6), pp. 14–47 [in Russian].

180. I. M. Levin, L. S. Dolin, O. N. Frantsuzov, et al., "Depth Profiles of Hydrophysical Parameters in the Barents Sea as applied to the Problem of Lidar Sounding," in *Fundamental and Applied Hydrophysics*, Ed. by A. A. Rodionov (Nauka, St. Petersburg, 2008), No. 4(6), pp. 16–24 [in Russian].

181. I. S. Dolina, M. A. Rodionov, and I. M. Levin, "Reconstruction of the Characteristics of Hydrophysical Fields in the Sea from Hydro-Optical Measurement Data," Morskoi Vestn., No. 4, 62–64 (2010).

182. V. V. Savchenko, V. Yu. Osadchii, and I. M. Levin, "Correcting Underwater Images Distorted by Surface Waves," Okeanologiya **48** (6), 780–783 (2008).

183. I. Levin, V. Savchenko, and V. Osadchy, "Correction of an Image Distorted by a Wavy Water Surface: Laboratory Experiment," Appl. Opt. **47** (35), 6650–6655 (2008).

184. I. M. Levin, L. S. Dolin, and T. M. Radomysl'skaya, "Visibility Range of Large Submarine Objects in Visual Observation from the Air through Wavy Sea Surface," in *Fundamental and Applied Hydrophysics*, Ed. by A. A. Rodionov (Nauka, St. Petersburg, 2008), No. 1(3), pp. 4–15 [in Russian].

185. I. V. Aleshin, V. K. Goncharov, I. M. Levin, et al., "Modern Remote Methods for Studying the Ecological State of the Marine Environment under Ice Conditions," Morskoi Vestnik, No. 2 (26), 69–74 (2008).

186. S. M. Sakerin, D. M. Kabanov, A. P. Rostov, et al., "Mobile Solar Photometer," Prib. Tekh. Eksp., No. 2, 181–182 (2009).

187. S. M. Sakerin, D. M. Kabanov, A. P. Rostov, et al., "Solar Photometer SP-9 for Aerosol Monitoring," Prib. Tekh. Eksp., No. 5, 165–166 (2010).

188. D. M. Kabanov, V. V. Veretennikov, Yu. V. Voronina, et al., "Information System for Network Solar Photometers," Atmos. Ocean. Opt. **22** (1), 121–127 (2009).

189. V. V. Zuev, V. D. Burlakov, S. I. Dolgii, and A. V. Nevzorov, "Differential Absorption Lidar for Ozone Sensing in the Upper Troposphere and Lower Stratosphere," Atmos. Ocean. Opt. **21** (10), 765–768 (2008).

190. A. A. Solomatnikova, "Calculation of Total Ozone Content with Automated Measurements by Light from Zenith of Clear and Cloudy Sky," Trudy GGO, No. 560, 255–267 (2009).

191. A. A. Eliseev and V. I. Privalov, "Characteristics of Radiative Heat Transfer in the Atmospheric Surface Layer from the Results of Direct Measurements," Izv., Atmos. Ocean. Phys. **43** (5), 586–591 (2007).

192. A. A. Eliseev, D. V. Rumyantsev, and V. A. Frol'kis, "Substantiation of the Possibility of Direct Measurements of Radiative Heat Influx in the Atmosphere," Atmos. Ocean. Opt. **22** (3), 359–364 (2009).

193. A. N. Ignat'ev, K. P. Gaikovich, E. P. Kropotkina, et al., "Simulation of Calculations Chlorine Oxide Content in the Atmosphere by Ground-Based Observation Data at Millimeter Waves," Radiotekh. Elektron. **52** (5), 538–544 (2007).

194. A. A. Krasil'nikov, Yu. Yu. Kulikov, V. G. Ryskin, et al., "New Small-Size Microwave Spectroradiometer–

Ozonometer," Prib. Tekh. Eksp., No. 1, 127–133 (2011).

195. A. V. Polyakov, Yu. M. Timofeev, and A. B. Uspenskii, "Temperature–Moisture Sounding of the Atmosphere by data of IKFS-2, a Satellite IR Sensing Device with High Spectral Resolution," Issled. Zemli Kosmosa, No. 5, 3–10 (2009).

196. Ya. A. Virolainen, Yu. M. Timofeev, A. V. Polyakov, et al., "Optimal Parameterization of the Spectra of Outgoing Thermal Radiation with the Data of the IKFS-2 Spaceborne IR Sensing Device Taken as an Example," Atmos. Ocean. Opt. **23** (3), 215–221 (2010).

197. A. V. Polyakov, Yu. M. Timofeev, and A. B. Uspenskii, "Possibilities of Determination of the Content of Ozone and Other Trace Gases by Data of IKFS-2, a Satellite IR Sensing Device with High Spectral Resolution," Issled. Zemli Kosmosa, No. 3, 3–11 (2010).

198. A. V. Polyakov, Yu. M. Timofeyev, and A. B. Uspensky, "Possibilities for Determining Temperature and Emissivity of the Land Surface from Data of Satellite IR Sounders with High Spectral Resolution (IRFS-2)," Izv., Atmos. Ocean. Phys. **47** (9), 1092–1096 (2011).

199. A. V. Polyakov and Yu. M. Timofeev, "The Accuracy of the Calculation of Total Ozone ContenUsing the SEVIRI Instrument on the Geostationary Satellite Meteosat-8," Issled. Zemli Kosmosa, No. 2, 3–9 (2007).

200. A. V. Polyakov and Yu. M. Timofeev, "Determining the Total Ozone from Geostationary Earth Satellites," Izv., Atmos. Ocean. Phys. **44** (6), 745–752 (2008).

201. S. G. Semakin, A. V. Polyakov, and Yu. M. Timofeev, "Comparison of Measured and Calculated Transmission Functions in the *A*-Band of Oxygen at 0.76 mcm," Issled. Zemli Kosmosa, No. 1, 37–43 (2008).

202. S. G. Semakin, Yu. M. Timofeev, A. V. Polyakov, et al., "Potential Accuracies of the Retrieval of Stratospheric Aerosol Scattering Coefficient by Limb Measurements of Scattered Solar Radiation," Issled. Zemli Kosmosa, No. 4, 54–63 (2009).

203. S. G. Semakin, Yu. M. Timofeev, A. V. Polyakov, et al., "On the Determination of the Stratospheric Aerosol Microstructure from Limb Scatter Measurements," Atmos. Ocean. Opt. **23** (4), 334–338 (2010).

204. S. G. Semakin, Yu. M. Timofeev, A. V. Polyakov, et al., "Error Analysis for Retrieving the Optical Characteristics of Stratospheric Aerosol by Limb Scatter Satellite Method," Issled. Zemli Kosmosa, No. 3, 71–76 (2010).

205. A. V. Rakitin, V. S. Kostsov, and A. V. Polyakov, "Account of Atmospheric Nonstationarity in Sounding Its Composition by the Occultation Method," Issled. Zemli Kosmosa, No. 2, 1–11 (2008).

206. Ya. A. Virolainen, "The Correlation between Aerosol Optical Parameters in Near IR Molecular Absorption Bands," **21** (3), 201–205 (2008).

207. V. S. Kostsov, A. V. Polyakov, A. V. Rakitin, et al., "The Results of Determination of NO_2 Content in the Stratosphere by SAGE III Experimental Data," Issled. Zemli Kosmosa, No. 5, 16–28 (2008).

208. A. M. Chaika, Yu. M. Timofeev, and A. V. Polyakov, "Stratospheric Aerosol by SAGE III Experimental Data," Issled. Zemli Kosmosa, No. 2, 10–18 (2007).

209. A. M. Chayka, Yu. M. Timofeev, and A. V. Polyakov, "Integral Microphysical Parameters of Stratospheric Background Aerosol for 2002–2005 (the SAGE III Satellite Experiment)," Izv., Atmos. Ocean. Phys. **44** (2), 193–206 (2008).

210. A. V. Polyakov, Yu. M. Timofeev, and Ya. A. Virolainen, "Polar Stratospheric Clouds from Satellite Observational Data," Izv., Atmos. Ocean. Phys. **44** (4), 448–458 (2008).

211. A. V. Polyakov, K. Rendall, L. Kharvei, et al., "New Improved Algorithm of Interpretation of SAGE III Occultation Measurements," Issled. Zemli Kosmosa, No. 1, 31–36 (2008).

212. D. V. Ionov, "Vertical Structure of the Long-Term Trend of Stratospheric Ozone by Satellite Measurement Data over Southern Regions of Russia," Issled. Zemli Kosmosa, No. 4, 1–6 (2009).

213. D. V. Ionov and Yu. M. Timofeev, "Regional Space Monitoring of Nitrogen Dioxide in the Troposphere," Izv., Atmos. Ocean. Phys. **45** (4), 434–443 (2009).

214. K. Hocke, N. Kampfer, D. Ruffieux, et al., "Comparison and Synergy of Stratospheric Ozone Measurements by Satellite Limb Sounders and the Ground-Based Microwave Radiometer SOMORA," Atmos. Chem. Phys., No. 7, 4117–4131 (2007).

215. D. V. Ionov, Y. M. Timofeyev, V. P. Sinyakov, et al., "Ground-Based Validation of EOS-Aura OMI NO_2 Vertical Column Data in the Midlatitude Mountain Ranges of Tien Shan (Kyrgyzstan) and Alps (France)," J. Geophys. Res. **113**, D15S08 (2008). doi 10.1029/2007JD008659

216. E. A. Celarier, E. J. Brinksma, J. F. Gleason, et al., "Validation of Ozone Monitoring Instrument Nitrogen Dioxide Columns," J. Geophys. Res. **113**, D15S15 (2008). doi 10.1029/2007JD008908

217. G. Wetzel, A. Bracher, B. Funke, et al., "Validation of MIPAS-ENVISAT NO_2 Operational Data," Atmos. Chem. Phys., No. 7, 3261–3284 (2007).

218. F. Hendrick, J.-P. Pommereau, F. Goutail, et al., "NDACC UV-Visible Total Ozone Measurements: Improved Retrieval and Comparison with Correlative Satellite and Ground-Based Observations," Atmos. Chem. Phys. Discuss., No. 10, 20405–20460 (2010). doi 10.5194/acpd-10-20405-2010

219. S. A. Sitnov, "Analysis of the Quasi-Biennial Variability of Carbon Monoxide Total Column," Izv., Atmos. Ocean. Phys. **44** (4), 459–466 (2008).

220. S. A. Sitnov, "Analysis of Spatial–Temporal Variability of Tropospheric NO_2 over Moscow Megapolis Using OMI Spectrometer (Aura Satellite) Data," Dokl. Earth Sci. **429** (9), 1511–1517 (2009).

221. S. A. Sitnov, "Analysis of Satellite Observations of the Tropospheric NO_2 Content over the Moscow Region," Izv., Atmos. Ocean. Phys. **47** (2), 166–185 (2011).

222. S. A. Sitnov, "Satellite Monitoring of Atmospheric Gaseous Species and Optical Characteristics of Atmospheric Aerosol over the European Part of Russia in

April–September 2010," Dokl. Earth Sci. **437** (1), 368–373 (2011).

223. A. N. Rublev, G. Yu. Grigor'ev, T. A. Udalova, et al., "Regression Models for the Estimation of Carbon Exchange in Boreal Forests," Atmos. Ocean. Opt. **23** (2), 111–117 (2010).

224. E. V. Volkova and A. B. Uspenskii, "Detection of Clouds and Identification of Their Parameters from the Satellite Data in the Daytime," Russ. Meteorol. Hydrol. **32** (12), 723–732 (2007).

225. E. V. Volkova and A. B. Uspenskii, "Estimation of Cloud-Cover Parameters in Daylight Time by Data of the METEOSAT-8 Geostationary Meteorological Satellite," Sovr. Prob. Dist. Zond. Zemli Kosmosa **5** (1), 441–450 (2008).

226. E. V. Volkova and A. B. Uspenskii, "Comparative Analysis of Estimates for the Height of the Upper Boundary of Cloudiness by AVHRR MIS3 NOAA Radiometer and Meteorological Radar Data," Sovr. Prob. Dist. Zond. Zemli Kosmosa **6** (11), 104–110 (2009).

227. V. I. Solov'ev and S. A. Uspenskii, "Monitoring of Soil Surface Temperature by Data of New-Generation Geostationary Meteorological Satellites," Issled. Zemli Kosmosa, No. 3, 79–89 (2009).

228. V. I. Solov'ev, A. B. Uspenskii, and S. A. Uspenskii, "Derivation of Land Surface Temperature Using Measurements of IR Radiances from Geostationary Meteorological Satellites," Russ. Meteorol. Hydrol. **35** (3), 159–167 (2010).

229. E. L. Muzylev, A. B. Uspenskii, Z. P. Startseva, et al., "Determination of Characteristics of Underlying Surface by AVHRR and MODIS Data and Their Use in the Model of Vertical Heat and Moisture Transfer for River Watershed," Sovr. Prob. Dist. Zond. Zemli Kosmosa **5** (1), 142–154 (2008).

230. E. L. Muzylev, A. B. Uspenskii, Z. P. Startseva, et al., "Use of Estimates for Temperatures of Underlying Surface and vegetation Characteristics by High-Resolution Satellite Data in Models of Vertical Heat and Moisture Exchange for River Watershed," Sovr. Prob. Dist. Zond. Zemli Kosmosa **6** (11), 400–410 (2009).

231. E. L. Muzylev, A. B. Uspenskii, Z. P. Startseva, et al., "Modeling Water and Heat Balance Components for the River Bsin Using Remote Sensing Data on Underlying Surface Characteristics," Russ. Meteorol. Hydrol. **35** (3), 225–235 (2010).

232. A. B. Uspenskii, "Current State and Prospects of Remote Temperature–Moisture Sensing of the Earth's Atmosphere," Issled. Zemli Kosmosa, No. 2, 26–36 (2010).

233. A. V. Kukharskii and A. B. Uspenskii, "Determination of Tropospheric Mean Carbon Dioxide Concentration from Satellite High Spectral Resolution IR-Sounder Data," Russ. Meteorol. Hydrol. **34** (4), 202–211 (2009).

234. A. V. Kukharskii and A. B. Uspenskii, "Monitoring of Carbon Dioxide Content in the Troposphere over Boreal Ecosystems of Siberia," Sovr. Prob. Dist. Zond. Zemli Kosmosa **7** (4), 204–211 (2010).

235. V. V. Melentyev and V. Chernook, "Multi-Spectral Airborne and Satellite Survey as Component of the Spatial Information System for Monitor and Management of Wildlife Ecology," in *Spatial Information Management in Wildlife Ecology*, Ed. by F. Huettman (Springer, Tokyo, 2009), pp. 324–356.

236. G. V. Alekseev, F. I. Danilov, V. M. Kattsov, et al., "Changes in the Climate and Sea Ice of the Northern Hemisphere in the 20th and 21st Centuries from Data of Observations and Modeling," Izv., Atmos. Ocean. Phys. **45** (6), 675–586 (2009).

237. V. N. Kudryavtsev and V. K. Makin, "Model of the Spume Sea Spray Generation," Geophys. Res. Lett. **36**, L06801 (2009). doi 10.1029/2008GL036871

238. L. M. Mitnik, M. L. Mitnik, and E. V. Zabolotskikh, "Microwave Sensing of the Atmosphere–Ocean System with ADEOS-II AMSR and Aqua AMSR-E," J. Remote Sens. Soc. Japan **29** (1), 156–166 (2009).

239. A. A. Korosov, E. A. Morozov, D. V. Pozdnyakov, et al., "Identification and Mapping of Blooming Areas of Coccolithophores in the Biscayne Bay by Satellite Data," Issled. Zemli Kosmosa, No. 3, 67–78 (2009).

240. D. V. Pozdnyakov, A. A. Korosov, N. A. Petrova, et al., "Investigation of the "Hysteresis" Character of the Return of Lake Ladoga from the Mesotrophic State," Issled. Zemli Kosmosa, No. 1, 45–59 (2009).

241. A. A. Korosov, D. V. Pozdnyakov, A. Folkestad, et al., "Semi-Empirical Algorithm for the Retrieval of Ecology-Relevant Water Constituents in Various Aquatic Environments," Algorithms **2**, 470–497 (2009). doi 10.3390/a2010470

242. A. F. Nerushev, E. K. Kramchaninova, and V. I. Solov'ev, "Determination of Characteristics of Atmospheric Motions from Satellite Multiwave Remote Sensing Data," Izv., Atmos. Ocean. Phys. **43** (4), 442–450 (2007).

243. K. G. Gribanov, R. Imasu, A. Yu. Toptygin, et al., "Method and Results of Retrieval of the Methane Content in the Atmosphere of Western Siberia from AIRS Data," Atmos. Ocean. Opt. **20** (10), 805–809 (2007).

244. K. G. Gribanov, V. I. Zakharov, K. S. Alsynbaev, et al., "Method for Determination of the Casing-Head Gas Outcome in Flares Using Data of Satellite Sounding in IR Channels by MODIS-Type Sensors," Atmos. Ocean. Opt. **20** (1), 60–64 (2007).

245. K. G. Gribanov, R. Imasu, and V. I. Zakharov, "Neural Networks for CO_2 Profile Retrieval from the Data of GOSAT/TANSO-FTS," Atmos. Ocean. Opt. **23** (1), 42–47 (2010).