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Editorial

Atmospheric and Ocean Optics: Atmospheric Physics III

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This Special Issue aimed to collect novel papers presented at the 27th International Conference on "Atmospheric and Ocean Optics: Atmospheric Physics" (AOO—21) held from 5 to 9 July 2021 in Moscow, Russia. The Special Issue comprises ten original papers and continues a series of Special Issues based on the materials of the symposia [1,2]. We invited researchers to contribute original research papers dealing with all aspects of atmospheric and ocean optics and atmospheric physics.

In the first paper of the Special Issue, S. Dolgii et al. [3] deals with the influence of absorption cross-sections on retrieving ozone vertical distribution (OVD) at the Siberian Lidar Station (SLS). The altitude range of OVD was ~5–45 km. The instrument used for the measurements was a differential absorption lidar (DIAL) device operating at the sensing wavelengths 299/341 nm and 308/353 nm. The authors analyzed OVD lidar measurements obtained in 2021 using meteorological data from the IASI/MetOp satellite at the SLS. The retrieval was performed using data from four groups concerning the absorption cross-sections: Gorshelev et al. [4], Malicet et al. [5], SCIAMACHY [6], and GOME [7]. To estimate how the absorption cross-sections influenced the OVD retrieval from lidar measurements, the authors calculated the average deviations between the profiles retrieved using different sets, both in a particular case on 2 January 2021 and throughout 2021. This study showed that, out of the four absorption cross-section sets, the data of Gorshelev et al. should be preferentially used for long-term lidar monitoring of ozone. These data show a more discrete dependence of the absorption cross-sections on the temperature values, which is a significant issue in tropospheric and stratospheric ozone measurement.

The next paper [8] is devoted to the study of the effects of climate change on the methane emissions from the Arctic shelves. V. Malakhova and E. Golubeva simulated the state of the water masses in the Arctic Ocean to analyze the transport of dissolved methane in the Arctic shelves. The authors obtained estimates of methane emissions from the Arctic seas due to the degradation of submarine permafrost and gas release at the ocean–bottom interface from 1970 to 2019. The calculated annual methane flux from the Arctic shelf seas into the atmosphere did not exceed 2 Tg CH4 year^{-1}. It was shown that the East Siberian shelves are the main contributors of methane emissions in the region. The spatial variability of the methane fluxes into the atmosphere is primarily due to the peculiarities of the water circulation and ice conditions. Only 7% of the dissolved methane originating from sediment entered the atmosphere within the study area. Most of it appeared to be transported below the surface and oxidized by microbial activity. The authors found that increasing periods and areas of ice-free water and decreasing ice concentration have contributed to a steady increase in methane emissions since 2005.

The paper by M. Dembelov and Yu. Bashkuev [9] presents the results of multiyear variations in atmospheric water vapor in the Baikal natural territory according to GPS observations. The data from GPS measurements at the permanent observation points IRKM (Irkutsk, 52°13′ N, 104°19′ E, h = 509 m), ULAZ (Ulan-Ude, 51°48′ N, 107°37′ E, h = 517 m), and BADG (Badary, 51°46′ N, 102°14′ E, h = 848 m) located within the Baikal natural area

(Eastern Siberia) were considered. A comparison was made between the time series of the tropospheric moisture content levels obtained at the IRKM site from GPS observations and radiosonde data and those obtained at the BADG site from GPS observations and measurements with a water vapor radiometer (WVR) during 2020. The average deviation in the total moisture content data during 2020, in the form of precipitable water according to GPS and WVR observations, was approximately 0.12 mm, or 1.1% relative to the average value, and the cross-correlation coefficient between the data was very high (K = 0.92). The use of GPS observations to obtain continuous data on the moisture content of the troposphere was substantiated. A series of processed data on the total moisture content based on GPS measurements using surface meteorological data for the period 1999–2020 for the IRKM and ULAZ sites and for the period 2006–2020 for the BADG site were obtained. Linear trends of total moisture content were determined for the observation points IRKM (−0.35 mm per decade, –2.7%), ULAZ (+0.47 mm per decade, +3.9%), and BADG (+1.41 mm per decade, 13.4%). Moreover, at the IRKM and ULAZ points, the surface temperature trends in the same period were positive, amounting to +0.4 K and +0.7 K per decade, respectively. The article confirms the trends identified in the work of Ross and Elliott for the territory of Eastern Siberia.

The authors of the paper [10] developed a system for detecting traveling ionospheric disturbances based on GNSS data. The large number of data that are available for ionospheric studies using the GPS TEC method, as well as the need to take into account complex atmospheric dynamics, create certain difficulties in automating the process of searching and recognizing traveling ionospheric disturbances generated by different sources. To automate the process of detecting wave disturbances, numerical criteria for assessing the level of the wave disturbance signal were proposed. The signal-to-noise ratio calculated by the proposed method was one such criterion. This work contains a description of the developed software system, which implements the proposed methodology and allows for the loading of RINEX files and processing, analyzing, and visualizing total electron content data.

The next two articles are devoted to the study of Lake Baikal. The paper by N. Abasov et al. [11] is concerned with a methodological approach to monitoring the state of atmospheric parameters in the catchment area of Lake Baikal, including real-time analysis of actual distributed data with the determination of analog years according to the preset proximity of comparative indicators and the most probable long-term predictive distributions of surface temperatures, precipitation, pressure, and geopotential with a lead time of up to 9–12 months. The authors developed the information-analytical system GeoGIPSAR [12] to conduct real-time analysis of spatial and point data using various processing methods and to obtain long-term prognostic estimates of water inflow into the lake.

M. Taschilin et al. [13] present the spatiotemporal distribution and seasonal variability of the aerosol optical depth (AOD) of the atmosphere at the 0.55 μm wavelength over the Baikal region of Russia based on long-term data (2005–2019) from satellite observations (MODIS/AQUA). A comparison of satellite AOD values with the AERONET record at the Geophysical Observatory of Institute of Solar-Terrestrial Physics was performed. The results show that interannual AOD variability is mainly due to forest fires. The highest atmospheric transparency was seen in 2010, 2013 and 2016, and the lowest was observed in 2008, 2012 and 2014. It is noted that AOD decreased with latitude with a gradient of ΔAOD = 0.002 ÷ 0.001 per degree of latitude. The mean seasonal variations in AOD at the six satellite overpass points were characterized by spring (April) and summer (July) highs and low AOD values in autumn. From June to November, the AOD monthly means dropped by more than 60%.

The next four papers in the Special Issue focused on numerical modeling and assessment of the impact of changes in meteorological conditions, aerosol, and gas composition of the atmosphere on the current climatic conditions. Air quality monitoring systems differ in composition and accuracy and their temporal and spatial coverage. A monitoring system's performance can be assessed by evaluating the accuracy of the emission sources identified by its data.

In the inverse modeling approach of A. Penenko et al. [14], a source identification problem is transformed into a quasi-linear operator equation with a sensitivity operator. The sensitivity operator is composed of sensitivity functions evaluated on the adjoint ensemble members. The members correspond to the measurement data element aggregates. Such ensemble construction allows for working harmoniously with heterogeneous measurement data in a single-operator equation. The quasi-linear structure of the resulting operator equation allows for both solving the inverse problem and predicting solutions. Numerical experiments for the Baikal region scenario were carried out to compare accuracy estimates for different inverse problem solutions. In the considered scenario, the projection to the orthogonal complement of the sensitivity operator's kernel allowed for predicting the source identification results with a higher accuracy than the other estimate types. The authors developed and tested a sensitivity-operator-based set of tools for analyzing heterogeneous air quality monitoring systems. They propose this technology be used for assessing and optimizing observational systems and experiments.

T. Zhuravleva et al. [15] present the first box model simulation results aimed at identifying possible effects of the atmospheric photochemical evolution of the organic component of biomass burning (BB) aerosol on the aerosol radiative forcing (ARF) and its efficiency (ARFE). The simulations of the dynamics of the optical characteristics of the organic aerosol (OA) were performed using a simple parameterization developed within the volatility basis set framework and adapted to simulate multiday BB aerosol evolution in idealized isolated smoke plumes from Siberian fires (without dilution). The results indicate that aerosol optical depth can be used as a proxy for studying the effect of the OA evolution on the ARF, but variations in the scattering and absorbing properties of BB aerosol can also affect its radiative effects, as evidenced by variations in the ARFE. Changes in the single-scattering albedo (SSA) and asymmetry factor, which occur as a result of the BB OA photochemical evolution, may either reduce or enhance the ARFE as a result of their competing effects, depending on the initial concentration OA, the ratio of black carbon to OA mass concentrations, and the aerosol photochemical age. The simulation results also reveal that (1) the ARFE at the top of the atmosphere is not significantly affected by the OA oxidation processes compared to the ARFE at the bottom of the atmosphere, and (2) the dependence of ARFE in the atmospheric column on the BB aerosol photochemical age almost mirrors the corresponding dependence of SSA.

The method developed by M. Tarasenkov et al. [16] for estimating the cloud adjacency effect on the reflectance of ground surface areas reconstructed from passive satellite observations allows one to estimate gaps in cloud fields in which the cloud adjacency effect can be considered small (the increment of the reflectance $\Delta r_{surf} \leq 0.005$). The algorithm is based on statistical simulation by the Monte Carlo method of radiation transfer in stochastic broken cloudiness with a deterministic cylindrical gap. An interpolation formula was obtained for the radius of the cloud adjacency effect that can be used for the reconstruction of ground surface reflectance in real time without the need for Monte Carlo-based calculations.

R. Kostromin et al. [17] propose a new microservice-based approach for organizing simulation modeling in heterogeneously distributed computing environments. Within the proposed approach, all operations related to data preparation, executing models, and analyzing the obtained results are implemented as microservices. The main advantages of this approach include the ability to apply parameter sweep computing within simulation modeling and possibility of integrating resources from publicly accessible supercomputer centers with cloud and fog platforms. Moreover, the authors provide automated microservice web forms using special model specifications. They developed and applied the service-oriented tools to study the environmental friendliness of the equipment used in various buildings in the Baikal natural territory, including recreational tourist centers, children's camps, museums, exhibition centers, etc. The authors evaluated the possible cost of heat pumps used in different operational and meteorological conditions. The provided comparative analysis confirmed the aforementioned advantages of the proposed approach.

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