SYSTEM FOR DATA PROCESSING OF OPTICAL AND MICROPHYSICAL CHARACTERISTICS OF AERODISPERSE MEDIUM FOR ESTIMATION OF RADIANT ENERGY ATTENUATION

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СИСТЕМА ОБРАБОТКИ ДАННЫХ ПО ОПТИЧЕСКИМ И МИКРОФИЗИЧЕСКИМ ХАРАКТЕРИСТИКАМ АЭРОДИСПЕРСНОЙ СРЕДЫ ДЛЯ ОЦЕНКИ ОСЛАБЛЕНИЯ ЛУЧИСТОЙ ЭНЕРГИИ

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Аннотация. *Разработана информационно-вычислительная система, реализующая численный эксперимент по определению ослабления и пропускания оптического излучения аэродисперсной средой. В качестве моделей отдельных рассеивателей рассмотрены столбики, пластинки, сферы, а также их агрегатов. В систему включаются архивы баз данных Aeronet и Hitran оптических и микрофизических характеристик кристаллических облаков. Программный комплекс ориентирован на обработку данных по ослаблению видимого и ИК излучения. Сравнительный анализ данных численного и натурного экспериментов показал возможность оценки физико-химических параметров среды.*

Introduction. The study of the properties of aerodisperse media attracts increasing attention from the scientific community due to problems of environmental management and controlling ecological situation. Lidar system allows to scan areas in hard to reach location. However, the study of the role of the aerodisperse medium in the transformation of radiation is one of the most complex tasks in atmosphere physics. Data on the characteristics of aerodisperse media, measured by automated robotic networks around the world, are freely available on the Internet. Therefore, a system designed to study the influence of microphysical and optical characteristics of a medium on the attenuation and transmission of optical radiation, based on processing data from such an automatic network, can be a convenient tool for research.

The paper suggests a system for determining microphysical and optical characteristics of aerodisperse medium for assessing the transmission and attenuation of optical radiation. The system is implemented as a complex of interconnected applications that utilize data from Aeronet and Hitran aerosol databases. The result of the system work is the dependence of optical radiation attenuation on the chosen microphysical or optical characteristics. By conducting a numerical experiment based on a priori information, it is possible to compare the modeled results with experimental data to determine the influence of changes in various parameters.

Methods of calculation. A numerical model has been developed to study the transmission and attenuation of optical radiation. Let's consider a layer of aerodisperse medium that contains randomly oriented particles of volumetric shapes, such as cubes, spheres, plates or cylinders. The complex refraction index of a particle can be denoted as follows: $\tilde{n} = n + i\chi$, where n – refraction coefficient, χ – absorption coefficient, λ – incident radiation wavelength. The study of the attenuation of optical radiation requires the consideration of such optical parameter as extinction coefficient. If we do not take particle size distribution into consideration, extinction coefficient for a system of particles is defined as $\alpha_{ext} = C\langle S_{ext}\rangle$, where C is particle concentration, S_{ext} – extinction cross-section. Extinction cross section can be calculated via classic formulae or by using algorithms for computing radiation attenuation by a single particle.

In this work, the numerical model was implemented as a part of the program complex, a structure of which is shown in fig. 1. User query specifies the calculation parameters such as shape, size, concentration or dispersion of particles, refraction index etc. A portion of this data is stored in the internal database of the program complex – in particular, the complex refraction index spectral dependence data. The central system rearranges user query, completes it with data from the internal database, directs to the processing module, receives and processes the calculation results and, finally, returns the result in a way convenient for user.

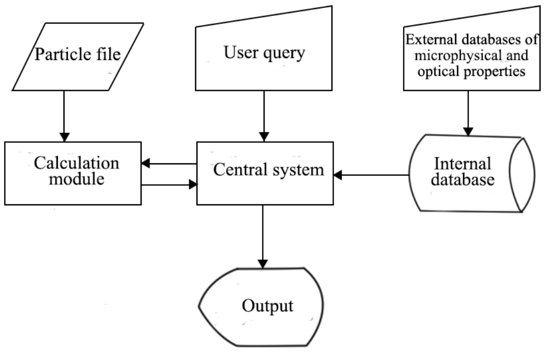

Fig. 1. Scheme of the program complex

As a source of a priori information on aerodisperse media, large and open-access databases such as Aeronet[1] and Hitran[2] were used in this work for experimental data on aerosols and refractive index spectral dependences. As a basis for calculation module, we used ADDA[3] open software for discrete-dipole approximation method for finding optical radiation attenuation by a single particle. The program complex was developed using C++ language and Qt cross-platform libraries.

Results of calculations. For testing the functionality of the program complex a numerical investigation was carried out. We simulated the incident radiation attenuation by particles of sea salt aerosol at low humidity. The obtained values of attenuation were compared to the experimental data from Aeronet logged at NY_Alesund station in 2006. Due to incomplete experimental data, we've made the following assumptions: planetary boundary layer H = 1.5 km, aerosol particle concentration in accumulation mode $C = 150{*}10^6\ l^{-1}$.

Figure 2 below shows the dependence of the extinction coefficient $\alpha_{ext}(a)$ on average size of a particle for modeled and experimental data. Modeled curves 1-3 display a similar behavior and their values are close to the experimental. Small inconsistences can be explained by assumptions we've made. Fig. 3 shows the dependence of the extinction coefficient on incident radiation wavelength at different real parts of the complex refractive index values. The increase in real part leads to increase in amplitude values and oscillation frequency of $\alpha_{ext}(\lambda)$.

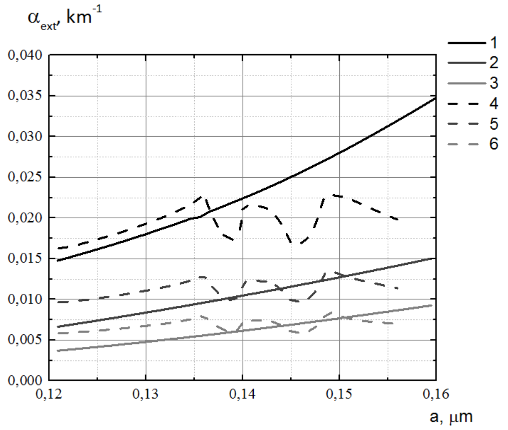

Fig. 2. Extinction coefficient $\alpha_{ext}(a)$ for sea salt aerosol, humidity $\varphi = 0\%$, $C = 150*10^3\ l^{-1}$; $1 - \lambda = 675$ nm, modeled; $2 - \lambda = 675$ nm, experimental; $3 - \lambda = 871$ nm, modeled; $4 - \lambda = 871$ nm, experimental; $5 - \lambda = 1020$ nm, modeled; $6 - \lambda = 1020$ nm, experimental

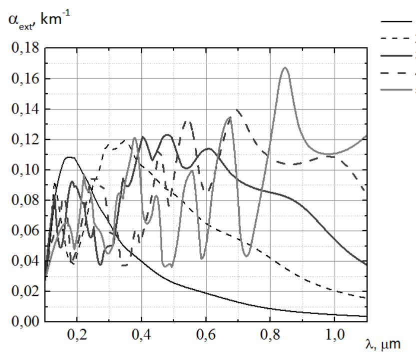

Fig. 3. $\alpha_{ext}(a)$ for cube particles, $\chi = 10^{-6}$, $\bar{a} = 0.2\ \mu m$, $C = 200*10^3\ l^{-1}$; $1 - n = 1.25$; $2 - n = 1.5$; $3 - n = 1.75$; $4 - n = 2.0$; $5 - n = 2.5$

Conclusions. This paper presents a program complex that implements a system for processing optical and microphysical characteristics data of aerodisperse media for estimation of radiant energy attenuation. Compared to the experimental data, modeled data show similar behavior and close values. It is possible to use the developed program complex to estimate the influence of given microphysical and optical characteristics on radiant energy attenuation. In addition, a promising direction of the development of this work is the analysis of the spectral dependences of the extinction coefficient for assessing the properties of the medium, i.e. solution of the inverse problem.

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