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Turbulence, Atmosphere and Climate Dynamics: the International conference dedicated to the centenary of the birth of A.M. Obukhov

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Abstract. The International Conference dedicated to the centenary of the birth of Academician Alexander Mikhailovich Obukhov «Turbulence, Atmosphere and Climate Dynamics» held in Moscow from May 16 to 18, 2018. The topics of the conference covered the following scientific areas: turbulence; geophysical hydrodynamics; atmospheric and climate system dynamics; physics and composition of the atmosphere; air-sea interaction; wave propagation. The conference showed a high scientific level of almost all the presentations. Studies of turbulent, climatic and atmospheric processes are traditionally conducted in our country at the highest level, as evidenced by the publication in high-ranking scientific journals and the active participation of Russian scientists in international programs.

The development of the turbulence theory was one of the main directions of the 20th century science. Continuing interest in the problem of turbulence is associated with the prevalence of this phenomenon: most of the motions of fluids, gases and plasmas found in nature and technology are turbulent. Jet streams in the upper troposphere, clouds of the lower levels are also in turbulent motion. Ocean currents, the upper layer of the ocean exhibit turbulent fluid dynamics. And if one looks into space, one will find turbulence there – the photosphere of the Sun and other stars, interstellar medium, gas nebulae, solar and stellar winds, magnetospheres of the Earth and other planets. Most combustion processes involve turbulence and often depend on it. The water flows in rivers and canals, the motion of natural gas and oil in pipelines, air and water traces of the ships, cars, submarines, aircraft wings - all of this is turbulence. Turbulence plays a very significant and diverse role in the physical processes that determine the state of the surface and boundary layers of the atmosphere - the habitat of humanity. Its theoretical research is needed to solve the problems of climate modeling, the transfer of aerosols and the assessment of air pollution, remote sensing, signal propagation and flight safety.

The theory of atmospheric turbulence was developed in the middle of the last century, and one of its main developers was an outstanding scientist, Academician of the USSR Academy of Sciences Alexander Obukhov (05.05.1918-03.12.1989). The theory of a turbulent boundary layer created by A.M. Obukhov together with A.S. Monin, is still the most cited work in the atmospheric science and the basis for modeling processes in the atmospheric boundary layer. The international conference “Turbulence, Atmospheric and Climate Dynamics” was dedicated to the centenary of A.M. Obukhov. The first conference with this title was held 5 years ago, and the interest of the scientific community to its topics showed that the tradition should be continued.

The topics of the conference, held from May 16 to 18, 2018, covered the following scientific areas: turbulence; geophysical hydrodynamics; atmospheric and climate system dynamics; physics and composition of the atmosphere; air-sea interaction; wave propagation.

Of course, the main topic of the conference was the development of ideas laid by Alexander Obukhov. This determined the topics of the sections, and the direction of most reports.

The basis of the turbulence theory were developed using specialized experiments and theoretical constructs, and work in this area is actively continuing. But at the same time, the theory of turbulence is called the last unsolved problem of classical theoretical physics. And, despite the development of modeling methods, it is still far from a complete solution of this problem. Therefore, the main presentations were devoted to the fundamental and general questions of the theory of turbulence; observations, instrumental base and theoretical problems in atmospheric turbulence; laboratory and numerical experiments; modelling and practical approaches to its study. The section “Geophysical Fluid Dynamics” was devoted to the theoretical description of various geophysical processes, including the theory of turbulence. The greatest interest was aroused by the presentation devoted to quasilinear and nonlinear mechanisms of flow formation, processes in a stratified rotating fluid, theoretical description of shallow water movements on a sphere. Also a number of presentations were presented demonstrating the experience of applying theoretical constructions to the forecast of meteorological phenomena (tropical cyclones, tornadoes, rapid convective phenomena).

The largest number of presentations was presented at the sections “Dynamics of the Atmosphere and Climate System” and “Physics and Atmospheric Composition”. And this is not surprising, since the theoretical description of small-scale atmospheric processes is the basis for developing models of weather forecast and climate dynamics, as well as studying the distribution of atmospheric impurities and atmospheric composition. And the problem of climate change and the state of the atmosphere is currently attracting the attention of specialists from various scientific fields.

The main tool for simulations of climatic conditions, including extreme weather and climate events, is climate modeling. Therefore, a large number of presentation from the “Dynamics of the Atmosphere and Climate System” section were devoted to the development, improvement and application of modern weather and climate forecast models. Model approaches developed for operational weather forecasting systems in the Hydrometeorological center of Russia, the results of modeling future climate changes using modern global climate models, including the model of the Institute of Numerical Mathematics of the Russian Academy of Sciences, analysis of the climate system response to external influences, and natural climate variations, analysis, current state of the climate system, especially including the polar regions were presented. Of particular interest was the series of reports devoted to the diagnosis and prediction of dangerous mesoscale meteorological phenomena - tornadoes, squalls, polar lows. In a number of talks the problems of interaction of phenomena of various scales were touched upon, including in the study of urban climate. Discussion of the reports presented at the section contributed primarily to the development of methods for studying atmospheric and climatic processes. The presented reports once again confirmed that the forecast of catastrophic atmospheric phenomena and climatic variability, both regional and global, is possible only with the joint use of data from ground-based measurements, satellite data and mesoscale modeling.

The section “Physics and Atmospheric Composition” represents the direction of atmospheric physics that has been most actively developed in recent decades. This is due to the fact that the dynamics of the composition of the atmosphere is not only an indicator of climate change and the anthropogenic human impact on nature, but also an indicator of the quality of the human environment. The processes and state changes in different layers of the atmosphere, from the troposphere to the ionosphere, were considered. The results of experimental studies, the results of model calculations and new theoretical models of the distribution of atmospheric impurities are presented. A number of reports considered the aerosol composition of the atmosphere, the influence of external (volcanic activity) and internal (turbulent transfer) processes on it. And a series of talks was devoted to aeroelectric and aerophysical observations, focused on the development of numerical models of atmospheric electricity in the boundary layer.

One of the most important factors in the formation of weather and climate is the oceans. It is obvious that without taking into account the real characteristics of atmosphere and ocean interactions, it is impossible to successfully develop neither the models of the atmospheric circulation or the methods of long-term and long-term weather and climate forecast based on it. Therefore, the study of the hydrosphere and atmosphere interactions is becoming increasingly necessary to understand the nature of the processes occurring on our planet, and the further development of the sciences of hydrology, meteorology and oceanology. In general the problem of energy exchange between the ocean and the atmosphere, small-scale (turbulent) interaction takes a special place, being crucial in the exchange of heat, momentum and moisture directly across the interface of interacting media. The theoretical description of such an interaction is difficult because of the extreme complexity of the physical processes under consideration. The suitability of the laws and theoretical positions, obtained mainly for flows in wind tunnels and for near-wall turbulence, under conditions of a moving sea-atmosphere interface requires careful testing. Therefore, the “Atmosphere and Ocean Interaction” section attracted both a sufficient number of interesting talks and the attention of listeners. The work of the section was conducted in the following areas: modeling of climatic and regional variability of atmospheric and oceanic processes, small-scale interaction of the atmosphere and the ocean, interaction of the atmosphere and the ocean in the polar regions

One of the most important applications of the theory of turbulence is to describe the processes of propagation of waves of different ranges in the atmosphere. The section "Propagation of radio waves" presented the traditional activity of the Institute of Atmospheric Physics. For example, the physical foundations of the method of acoustic sounding, to which several reports were devoted, using the scattering of sound waves by small-scale turbulent inhomogeneities, were laid by A.M. Obukhov. The reports also considered the propagation of infrasound, lidar observations of the state of the atmosphere, theoretical and laboratory modeling of wave propagation in various media.

The conference showed a high scientific level of almost all the presentations. Studies of turbulent, climatic and atmospheric processes are traditionally conducted in our country at the highest level, as evidenced by the publication in high-ranking scientific journals and the active participation of Russian scientists in international programs.

The traditional parametrization of the atmospheric boundary layer is based on the similarity theory and the coefficients of turbulent transport, which describe the interaction of the atmosphere with the earth's surface and the diffusion of tracers. But with the improvement of models, the rejection of the hydrostatic approximation and, especially, with achieving high spatial resolution, the traditional parameterizations of the atmospheric boundary layer are no longer applicable. Their main drawbacks - inapplicability to the extreme conditions of stratification and to flows over complex surfaces, cannot be eliminated while remaining within the framework of the classical theory, i.e. by introduction of more accurate similarity functions or further corrections to the traditional turbulent closures of Reynolds-averaged equations. Consequently, new approaches to the development of parametrizations are needed, which should be based both on the results of eddy-resolving and direct numerical modeling of turbulent processes in the atmospheric boundary layer, and on data from specialized field and laboratory experiments.

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