Turbulence, Atmosphere and Climate Dynamics

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Abstract. The conference "Turbulence, Atmosphere and Climate Dynamics" dedicated to the memory of the Alexander M. Obukhov was held in Moscow from November 10 to 12, 2020. 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 conference "Turbulence, Atmosphere and Climate Dynamics" dedicated to the memory of the outstanding scientist, Academician of the USSR Academy of Sciences Alexander M. Obukhov (05.05.1918–03.12.1989) was held in 2020 for the third time. The founder and director of the Institute of Atmospheric Physics, A.M. Obukhov, together with A.N. Kolmogorov, created the foundations of turbulence theory, which determined one of the main vectors of development in many branches of scientific research, both natural phenomena of different scales, and various applied problems in the second half of the last century and up to the present time.

The wide interest of the scientific community and active participation in the first and second conferences "Turbulence, Atmosphere and Climate Dynamics" in 2013 and 2018 showed the need to organize these conferences regularly. At the third conference from 10 to 12 November 2020 in Moscow 86 oral reports and 70 posters were presented. The conference was attended by scientists from Moscow, St. Petersburg, Ufa, Perm, Tomsk, Novosibirsk, Irkutsk, Kazan, Nizhny Novgorod, Obninsk, Sevastopol with representatives from Great Britain, Finland, Cyprus. Significant number of reports made by young scientists. The topics of the third conference covered the following scientific areas: turbulence in the atmosphere and ocean, geophysical hydrodynamics, general circulation of the atmosphere and dynamics of the climate system, structure and composition of the atmosphere and transport of impurities, propagation and interaction of waves in the atmosphere, physics of the atmospheric boundary layer.

The key topics of the conference were related to the development of scientific studies initiated under the leadership of A.M. Obukhov, including the first section “Turbulence in the atmosphere and ocean”. Turbulence plays a very significant and diverse role in the physical processes that determine the regime of the surface and boundary layers of the atmosphere, in particular. Its theoretical study is necessary to solve the problems of atmospheric diffusion, momentum transfer and eddy transport, transport of impurities and assessment of atmospheric pollution, remote sensing, signal propagation (scattering and transformation), flight safety, climate modeling. The main presentations were related with fundamental topics of the theory of turbulence; observations, instrumentation and theoretical
problems in atmospheric turbulence; laboratory and numerical experiments; model and practical approaches in the research of turbulence.

The section "Geophysical hydrodynamics" was devoted to theoretical problems, numerical and laboratory modeling arising in the description of various geophysical processes, including those using the theory of turbulence. The greatest interest was aroused by the reports devoted to quasilinear and nonlinear mechanisms of flow formation, processes in a stratified rotating fluid, baroclinic and barotropic instabilities at large and meso scales, convection, development of geophysical flow modeling in the shallow water approximation on the sphere. A number of reports was presented at this section, demonstrating the experience of applying theoretical constructions to forecasting different meteorological phenomena.

A large number of reports were presented at the sections "General circulation of the atmosphere and dynamics of the climate system" and "Structure and composition of the atmosphere and transport of impurities". Problems of atmospheric structure and composition and climate change are attracting the attention of specialists in various scientific fields. The main tool for reproducing the climate conditions and their changes, including extreme weather and climate situations, is climate modeling. A number of reports of the section "General circulation of the atmosphere and dynamics of the climate system" were devoted to the development, improvement and application of modern weather forecast and climate models. Model approaches developed for operational weather forecasting systems, the results of modeling of future climate changes using global climate models, analysis of the response of the climate system to external influences, as well as natural climate fluctuations, analysis the current state of the climate system, including polar regions, were presented. Series of reports were devoted to the diagnosis and forecasting of dangerous mesoscale meteorological phenomena - tornadoes, squalls, polar cyclones. In a number of presentations, the problems of interaction of phenomena of various scales were considered. Particular attention was paid to the urban climate. The presented reports once again confirmed that to improve the predictability of extreme atmospheric phenomena and climate anomalies at various spatial scales it is necessary to combine results of ground-based measurements, satellite observations and mesoscale modeling.

The section "The structure and composition of the atmosphere and the transport of impurities" represents the direction of atmospheric physics and chemistry that has been most actively developing in recent decades. This is due to the fact that the dynamics of the composition of the atmosphere is not only an indicator of climatic changes and the anthropogenic impact, but also an indicator of the quality of the human environment. Processes and changes in state in different layers of the atmosphere were considered - from the troposphere to the thermosphere. The results of experimental studies, the results of model simulations and new theoretical models of the propagation of atmospheric pollutants were presented. A number of reports considered the aerosol composition of the atmosphere and the influence of external (volcanic activity) and internal (turbulent transfer) processes. A number of reports was devoted to aeroelectric and aerophysical observations focused on the development of numerical models of electricity in the atmospheric boundary layer. Special reports were devoted to the change in the composition of the atmosphere of the Moscow region during the quarantine measures in spring 2020.

One of the most important applications of the theory of turbulence is to describe the processes of propagation of waves of various ranges in the atmosphere. in the reports of the section "Propagation and interaction of waves in the atmosphere" the propagation of different waves in the atmosphere, including radio waves, acoustic waves, infrasound, was considered. Results of lidar observations of atmospheric structure, theoretical and laboratory modeling of wave propagation in various media were presented. Several reports were devoted to the physical foundations of the acoustic sounding method using the scattering of sound waves by small-scale turbulent inhomogeneities, initiated by A.M. Obukhov.

The section "Physics of the boundary layer atmosphere" was organized for the first time. The reports presented the results of the development of parametrizations of processes in the atmospheric boundary layer, theoretical and experimental studies on various landscapes, the results of modeling of mesoscale circulations. One of reports was related with the studies of the foehn effect at the Spitsbergen archipelago. The section included a special subsection “Study of the structure and
dynamics of the atmospheric boundary layer using unmanned aerial vehicles”. This subsection was
attended by representatives of the Moscow Institute of Physics and Technology, Moscow Aviation
Institute, Central Aerological Observatory, A.M. Obukhov Institute of Atmospheric Physics RAS
(Moscow), Moscow State University, Arctic and Antarctic Research Institute (St. Petersburg), as well
as representatives of the V.E. Zuev Institute of Atmospheric Optics SB RAS (Tomsk), Institute for
Monitoring of Climatic and Ecological Systems SB RAS (Tomsk) and SA Khristianovich Institute of
Theoretical and Applied Mechanics SB RAS (Novosibirsk). As part of the sectional discussion,
possible ways to combine the technical and methodological efforts of various initiative groups and
options for future joint field experiments using unmanned aerial vehicles were discussed.

A distinctive feature of the conference in 2020 was a significant poster section. Posters were
presented in all areas of the conference and were actively discussed both in person and online. All
sections of the conference were interconnected, taking into account the topics of the reports presented.
The organizers even had problems with what section to place a number of reports. This demonstrates
the close connection between the various topics of the conference. The work of the conference showed
the general high scientific level of the reports presented. A number of topical problems were specially
discussed at the conference. In particular, to improve the description of interaction of the atmosphere
with the surface and the transfer of impurities it is necessary to improve corresponding
parameterizations for the atmospheric boundary layer based on the theory of similarity and the
coefficients of turbulent transport. New approaches should be adequate for simulations in extreme
conditions of stratification and in conditions of complex surfaces, in particular in the Arctic. A wide
range of scientific issues discussed at the conference and the attention of the scientific community
showed the importance of topics of the “Turbulence, Atmosphere and Climate Dynamics”.

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