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Abstract

Selected Translated Abstracts of Russian-Language Climate-Change Publications

IV. General Circulation Models

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Contents

Abstract

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This report presents English-translated abstracts of important Russian-language literature concerning general circulation models as they relate to climate change. Into addition to the bibliographic citations and abstracts translated into English, this report presents the original citations and abstracts in Russian. Author and title indexes are included to assist the reader in locating abstracts of particular interest.

Introduction

On May 23, 1972, Richard Nixon, President of the United States, and N. V. Podgorny, Chairman of the Presidium of the Supreme Soviet Socialist Republics, signed an Agreement on Cooperation in the Field of Environmental Protection Between the United States of America and the U.S.S.R. This agreement was to be implemented for the following areas: air pollution, water pollution, environmental pollution associated with agricultural production, enhancement of the urban environment, preservation of nature and the organization of preserves, marine pollution, biological and genetic consequences of

environmental pollution, influence of environmental changes on climate, earthquake prediction, arctic and subarctic ecological systems, and legal and administrative measures for protecting environmental quality.

Working Group VIII (WG VIII), which was established to address the issue of the influence of environmental changes on climate, now includes five projects: climate change; atmospheric composition; radiative fluxes, cloud climatology, and climate modeling; data exchange management; and stratospheric ozone. The office of the Deputy Assistant Secretary for International Interests of the National Oceanic and Atmospheric Administration is the U.S. coordinating agency for WG VIII projects, and the Russian Federal Agency for Hydrometeorology has been the coordinating agency within the former U.S.S.R. Since 1990, the Carbon Dioxide Information Analysis Center (CDIAC) has been active in the WG VIII project on data exchange.

CDIAC's participation in WG VIII activities has been facilitated by its participation in the Quantitative Links initiative of the U.S. Department of Energy's Global Change Research Program (USDOE/GCRP). CDIAC's role in this initiative has been to provide the quality-assured data sets needed to quantify the relationship between changes in atmospheric composition and changes in climate. In support of this role, CDIAC has collaborated with research institutions in the former U.S.S.R. to identify, quality-assure, document, and package selected data sets as CDIAC numeric data packages (NDPs). In 1991, CDIAC published the NDP *Atmospheric CO_2 Concentrations from Flask Samples Collected at USSR-Operated Sampling Sites* (ORNL/CDIAC-51, NDP-033), compiled by Thomas A. Boden of CDIAC, with data contributed by A. M. Brounstein, E. V. Faber, and A. A. Shashkov of the Main Geophysical Observatory (St. Petersburg, Russia). In 1993, CDIAC published the NDPs *Daily Temperature and Precipitation Data for 223 USSR Stations* (ORNL/CDIAC-56, NDP-040), compiled by Russell S. Vose of CDIAC, and *Six- and Three-Hourly Meteorological Observations from 223 U.S.S.R. Stations* (ORNL/CDIAC-66, NDP-048), compiled by Dale P. Kaiser of CDIAC; data for both were contributed by V. N. Razuvaev, E. G. Apasova, and R. A. Martuganov of the Research Institute of Hydrometeorological Information-World Data Center (Obninsk, Russia). In addition, CDIAC has hosted visits by Russian scientists, and CDIAC staff have visited Russian geophysical research institutions and data centers.

CDIAC sent a survey to 172 researchers in 11 countries. Participants were asked to suggest data sets (1) that would be of particular importance to the quantification of the links between changes in atmospheric chemistry, the Earth's radiative balance, and climate but (2) that were of limited usefulness because of problems with availability, documentation, or quality or (3) that did not currently exist but could be compiled from separate extant data sets. More than 100 data sets were suggested in areas ranging from climate and the cryosphere to the Earth's surface or cover and trace gas emissions and concentrations. This survey and a follow-up survey indicated that researchers in this area especially interested in the Earth's surface budget, clouds, aerosols, and general circulation models.

In response to the interest in these four areas, CDIAC and the All-Russian Research Institute of Hydrometeorological Information-World Data Center (RIHMI-WDC) in Obninsk, Russia, began a collaborative project to produce a series of dual-language bibliographies of Russian literature that had not previously been translated into English. As part of this work, CDIAC and RIHMI-WDC decided to evaluate new computer-based translation and word-processing software. The first volume in the series *Selected Translated Abstracts of Russian-Language Climate Change Publications*, published in 1992, was *Surface Energy Budget* (ORNL/CDIAC-57; Proceedings, RIHMI-WDC 158); the second volume, published in 1994, was *Clouds* (ORNL/CDIAC-64; Proceedings, RIHMI-WDC 159); the third volume, published in 1996, was *Aerosols* (ORNL/CDIAC-88; Proceedings, RIHMI-WDC 164). All three are available on request from CDIAC, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge,

Tennessee 37831-6335, U.S.A.; telephone: 423-574-3645; telefax: 423-574-2232; email: cdiac@ornl.gov.

CDIAC and RIHMI-WDC agreed that the remaining volumes in this series would be prepared in Obninsk and published in Oak Ridge. For this purpose, CDIAC transferred to RIHMI-WDC the hardware and software that had been used in the preparation of the first two volumes. The current report, on general circulation models, is the fourth volume in the series; it has been prepared by RIHM-WDC in collaboration with CDIAC.

Most of the Russian papers in this report have not been translated into English. The reader is also referred to the English-language journals *Soviet Meteorology and Hydrology* and *Atmospheric and Oceanic Physics*, which provide translations of the Russian-language journals.

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On behalf of the Carbon Dioxide Information Analysis Center (CDIAC), the Research Institute of Hydrometeorological Information-World Data Center (RIHMI-WDC), Vuacheslav N. Razuvaev, Sergej G. Sivachok, and Marvel D. Burtis, I would like to thank the following individuals who have contributed, either directly or indirectly, to the production of this report:

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Bob Etkins and Rene Tatusko of the Office of International Activities in the U.S. Department of Commerce's National Oceanic and Atmospheric Administration (Silver Spring, Maryland), who have greatly facilitated scientific exchanges and visits between Russia and the United States under the auspices of WG VIII.

Paul Kanciruk of the Environmental Information Analysis Program in the Environmental Sciences Division (ESD), at Oak Ridge National Laboratory (ORNL) and former director of CDIAC, who helped shape CDIAC's involvement in WG VIII activities and establish contacts between CDIAC and its sister institutions in Russia.

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I would like to extend my special thanks to Lina Ravina, who, in addition to translating, has had a major role in many aspects of the production of this series: collecting the literature, securing the advice of disciplinary experts, and planning the contents and appearance of the reports. Without her participation, the creation of this series would not have been possible.

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Director,
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October 1996

Bibliography

Alekseev, I. M., V. G. Turikov, and **S. S. Khmelevtsov.** 1985. Numerical test experiments with a general circulation model. Proc. Inst. Exp. Meteorol. 35(113):40-45.

A four-level general circulation model, parameterization of macroturbulent diffusion, and finite-difference approximation used for spatial and temporal derivatives are briefly described. Numerical test experiments are conducted under simplified initial and boundary conditions.

Alekseev, I. M., and **O. S. Sorokovikova.** 1987. A zonal hydrodynamic model of general atmospheric circulation. Proc. Inst. Exp. Meteor. 43(128):84-90.

A discrete zonal hydrodynamic model of general atmospheric circulation is presented. For this model, the difference analogs of laws of the conservation of mass, momentum, and full energy are valid, along with the law of the conservation of angular momentum with respect to the rotation axis. To check the selected parameterizations of subgrid-scale processes, the problem of the formation of the wind field in the fixed mean January temperature field has been solved.

Alekseev, I. M., S. S. Khmelevtsov, E. L. Podolskaya, and **L. O. Neyolova**. 1987. A general circulation model. Proc. Inst. Exp. Meteorol. 43(128):91-99.

A general circulation model is suggested that includes the radiation block and takes into account the atmosphere-underlying surface interaction. A numerical experiment to simulate January atmospheric circulation has been performed to check the methods of parameterizing the subgrid-scale processes and the radiation block.

Alekseeva, L. I., and **E. K. Semenov.** 1991. Mean zonal circulation in the free atmosphere of the tropical zone. pp. 41-55. Meteorological Conditions over the Oceans. Acad. Sci. USSR Inst. Oceanol. Moscow.

Zonal atmospheric circulation in the tropics up to 25 km in altitude is considered on the basis of data from 426 aerological stations located in the tropical zone. Diagrams of zonal wind velocity, constructed for the whole of Earth's tropical zone from data independent of the longitude of a location, are given for meridional sections. It is concluded that the existence of five belts is said to be a peculiarity of middle zonal circulation in tropical latitudes. These belts include two belts of western (anti-trade) winds in subtropical latitudes, two belts of extremely stable eastern winds in subtropical and near-equatorial latitudes of both hemispheres, and one belt of lower tropospheric western winds in near-equatorial latitudes.

Alexandrov, V. V. 1982. A general atmospheric circulation model with baroclinic arrangement. Rep. Acad. Sci. USSR 265(5):1094-1097.

The procedure for baroclinic arrangement is offered. The essence of it is that the altitude-averaged meridional temperature gradient is limited by its critical value under which baroclinical unsteadiness begins on a smooth sphere in the Phillips simple two-layer, adiabatic, quasi-geostrophic dry model. The aforementioned approach results in fairly good distributions of temperature and precipitation and allows a threefold increase in the linear dimensions of the horizontal difference grid, which makes calculations 25 times faster.

Andriatis, A. V., and **M. A. Tolstykh.** 1988. Effective realization of a difference general atmospheric circulation model. Prepr. Comp. Math. Dept. Acad. Sci. USSR 185:1-15.

The realization of a difference general atmospheric circulation model is offered. Dynamic data swapping makes it possible to bypass limits imposed by computer memory capacity and to considerably reduce overhead expenses related to exchange with external storage. It also allows parallel computation of solutions in different subareas. The way theprogram was written allows automated vectorization.

Andryuschenko, V. A., A. A. Gorbunov, M. V. Mescheryakov, and **L. A. Chudov.** 1993. Circulating and jet streams in the atmosphere appearing with the rise of two large-scale thermics. Appl. Mech. Tech. Phys. 1:75-83.

The interaction of two large-scale thermics was investigated along a vertical scale (a two- dimensional problem) and along a horizontal scale (a three-dimensional problem), and their influence on the formation of air flows in the Earth's atmosphere was numerically studied.

Astakhova, E. D., V. E. Ryabinin, and **L. V. Sidorova.** 1990. A model of nonadiabatic processes in an air column. Meteorol. Hydrol. 9:5-13.

In order to investigate parameterizations of the subgrid processes, a one-dimensional version of a spectral model of medium-range weather forecasting was developed at the U.S.S.R. Hydrometeorological Research Center. Basic characteristics of the model and results from test experiments are presented.

Astakhova, E. D. 1992. On the approximate account of the diurnal radiation cycle in a general circulation model. Meteorol. Hydrol. 9:13-20.

The possibility of approximate accounting has been investigated with regard to the diurnal solar radiation cycle in a medium-range forecasting model of the Hydrometeorological Center of the Russian Federation. On the basis of preliminary experiments with a one-dimensional version of the model, the optimum method for the approximate account of the diurnal cycle has been chosen. Numerical experiments with the three-dimensional model demonstrated that in the pentad forecasts the application of the chosen method allows us to describe the time variation of the major meteorological elements and to model their time-averaged values without substantial errors. The increase in computational costs is negligible.

Bardin, G. I., and **M. P. Evseev.** 1982. Calculation of the flux divergence at 500 millibar using a global spectral atmospheric circulation model of the Southern Hemisphere and the relation of the flux divergence to the surface baric field. Proc. Arct. Antarct. Res. Inst. 365:151-155.

An algorithm is presented to calculate the flux divergence at 500 millibars in a spectral global atmospheric circulation model of the Southern Hemisphere. The relationship between the flux divergence and the characteristics of the surface baric field is studied.

Bardin, G. I., and **M. P. Evseev.** 1982. The effect of the interaction between wind flux and orography in a spectral global atmospheric circulation model of the Southern Hemisphere. Proc. Arct. Antarct. Res. Inst. 365:162-166.

An algorithm is presented to calculate the flux divergence caused by orography effects in a spectral global atmospheric circulation model of the Southern Hemisphere. The relationship between the flux orographic divergence at 500 millibars and the lifetime of specific forms of the baric relief in definite regions of the Southern Hemisphere is studied.

Batchaev, A. M. and **V. A. Dovzhenko**. 1983. Laboratory simulation of the loss of steadiness in periodic zonal flows. Rep. Acad. Sci. USSR 273(3):582-584.

The steadiness of the flat periodic flow of homogeneous incompressible viscous liquid (Kolmogorov flows) in a vertical vessel with a closed flow channel has been studied. Under experimental conditions, a stationary eddy regime that sets in after a primary periodic flow stops being steady will lose its steadiness with a further increase in the external force. As a result, a monofrequent eddying pattern appears. A further increase of the external force augments the frequency spectrum of the observed eddy fluctuations. This conclusion can shed light upon the mechanism of excitation of zonal atmospheric circulation fluctuations (the so-called "index cycle" phenomenon).

Blinkova, E. D. 1985. Preliminary results of a prolonged integration of a general circulation model based on actual data. Proc. West-Siberian Reg. Res. Inst. State Com. Hydrometeorol. 75:3-9.

Some preliminary results are presented that have been obtained in the course of a prolonged (20-30 model day) integration of the finite-difference general circulation model developed at the Computer Center of the Siberian Branch of the U.S.S.R. Academy of Sciences. FGGE level IIIa data are taken as initial information. Results of the model's integration obtained from some of the initial data (January 14-17, 1979) are compared. Dispersion and longitudinal-temporal distributions for some meteorological elements are shown.

Blinkova, E. D., N. I. Gilfer, and **L. I. Skosyrskaya.** 1986. Analyzing the results of numerical experiments with a general circulation model using FGGE data. Proc. West-Siberian Reg. Res. Inst. State Com. Hydrometeorol. 77:10-18.

Results are presented that have been obtained with prolonged (30 model day) integration of the finite-difference general circulation model developed at the Computer Center of the Siberian Branch of the U.S.S.R. Academy of Sciences. FGGE level IIIa data (January 14-20 and February 1-4, 1979) are taken as initial information. Experimental results are compared with each other and with climatic values. Statistical and zonally averaged characteristics of major meteorological elements and longitudinal-temporal diagrams are presented. The model's sensitivity is determined with respect to specification of the initial data.

Bogomolov, V. A. 1983. On the transfer mechanism of synoptical solitary eddies. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 19(12):1252-1258.

Some qualitative aspects and tendencies of the interaction between regular and singular vorticity of two-dimensional conservative flow on the plane and sphere are considered. Restrictions on the point vortex trajectory are found by using dynamical system invariants and the proved theorem on the maximum kinetic moment. A kinematic interpretation of the results obtained on the direction of meridional vortex shift at the initial stage is given. A comparison of the model results with observational data shows the determining influence of quasi-two-dimensional vorticity dynamics on the characteristics

of the transfer of large-scale solitary eddies.

Borisenkov, E. P., V. P. Meleshko, and **A. P. Sokolov.** 1981. The influence of upper-level clouds on atmospheric thermal conditions and circulation. Meteorol. Hydrol. 11:5-17.

The sensitivity of radiation budget components in the earth-atmosphere system to changes in the degree of cloudiness on different levels was determined. Numerical experiments were performed by using a general circulation model in which high clouds were absent and their formation was simulated in the region of anticyclonic disturbance. A detailed analysis of cloud-induced changes, thermal conditions, and atmospheric circulation is made. The calculations demonstrate that in the course of the formation of high clouds, atmospheric thermal conditions change, making anticyclonic disturbance in the lower troposphere weaker and making it slightly stronger in the upper troposphere and lower stratosphere.

Borisenkov, E. P., I. L. Karol, and **V. P. Meleshko.** 1988. Results of MGO studies in the field of climate theory and general atmospheric circulation. pp.18-37. Studies of 1977-1987 Dedicated to the 70th Anniversary of Soviet Power. Main Geophys. Obs. Leningrad.

Studies in the field of climate theory and general atmospheric circulation were based on the development of modern numerical general atmospheric and climate circulation models and on the mathematical simulation of climate-forming processes. Radiation, photochemical, and radiation-photochemical models were built. Basic peculiarities are presented regarding the MGO hydrodynamical general atmospheric circulation model and its application to the study of atmosphere response to various climate-forming impacts. Particular emphasis is placed on the simulation of impacts of the natural and anthropogenic factors on weather and climate. Basic results are given for monthly and seasonal forecasts of short-interval climate variation that are provided well in advance on the basis of a physical-statistical method.

Borisenkov, E. P., L. K. Efimova, and **B. E. Shneerov.** 1988. Numerical modeling of the impact of the insolation decrease on atmospheric temperature and dynamics for January and July. Proc. Main Geophys. Obs. 516:17-25.

Numerical experiments involving a general circulation model were used to evaluate probable climatic change resulting from a 5% decrease in insolation for winter and summer seasons.

Borisenkov, E. P., and **L. K. Efimova.** 1989. Simulation of climatic consequences of atmospheric aerosol pollution and heat energy from fires caused by possible nuclear war, using a general circulation model. Proc. Main Geophys. Obs. 524:115-128.

Results of numerical experiments are analyzed. The aim of the experiments is to model the impact of atmospheric aerosol pollution on climate and the joint effect of atmospheric aerosol pollution and heat emissions from fires that could be caused by a possible nuclear war. Appropriate estimates of these

effects are obtained by using a general circulation model.

Bubnov, B. M., and **G. S. Golitsyn**. 1985. Theoretical and laboratory simulation of the influence of static stability upon the structure of atmosphere general circulation. Rep. Acad. Sci. USSR 281(5):1076-1079.

The influence of parameter variations in vertical static stability upon the structure of atmosphere general circulation has been considered. An investigation is carried out by generalizing the Lorents low-parameter model to consider the external vertical temperature gradient. The two-level quasi-geostrophic model of flow in a cylindrical circular vessel with a temperature difference between the outer and inner (colder) walls of the vessel is used. The equations are expanded in Bessel functions from the radial coordinate and in harmonic functions from the azimuth. Similarly to the Lorents model, a few of the first modes of this expansion are used. The conditions of stability of this flow are investigated with respect to the following external parameters: the thermal Rossby number Ro_T; G-1; and relation $\delta T/\Delta T$, where the temperature difference, δT, is along the vertical axis. It has been found that with the increase of δT, the stability diagram shifts to the right along the axis G^{-1} (G^{-1}, the analog of the angular velocity square) and downwards along the axis Ro_T in comparison with the results of Hide and Fults [see Dolzhansky F. V., and G. S. Golitsyn 1977. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 13(8):795-819]. Theoretical conclusions are confirmed by the results of laboratory experiments performed to investigate the influence of δT on the nature of the motions arisen. The conclusions are used to explain structural variations of the Mars global atmospheric circulation in the period of global dust storms. At that time, the vertical static stability increases sharply, and circulation converts from the wave mode, with four cyclones, to the symmetric zonal flow, with no disturbances of cyclonic nature.

Degtyarev, A. I., L. A. Pavlovskaya, and **N. V. Shtyreva.** 1993. Numerical simulation of Indian summer monsoon evolution in 1979. Meteorol. Hydrol. 6:19-27.

Elements of Indian summer monsoon circulation were reconstructed in the numerical 33-day experiment by using the spectral climatic general atmospheric circulation model of the Research Hydrometeorological Center of the Russian Federation. The experimental results are considered. Wind and precipitation data are analyzed. It was shown that not only were averaged circulation characteristics for this region reconstructed but also separate phases of Indian monsoon were adequately simulated.

Degtyarev, A. I., and **L. A. Pavlovskaya.** 1992. Numerical simulation of interseasonal variation of the Indian summer monsoon. Meteorol. Hydrol. 5:42-50.

A numerical experiment was carried out with the 15-level global spectral model of general atmospheric circulation developed at the Hydrometeorological Research Center of the Russian Federation. One of the goals of the experiment was to model the summer monsoon circulation in the Indian region. The results obtained showed that the model successfully simulates the well-known large-scale features of monsoons. Phases of monsoon circulation (normal, active, and break) are considered in detail. The experiment confirmed the hypothesis of interlatitudinal interaction, which assumes that the midlatitude, ultralong Rossby waves of large amplitude penetrate the Indian region, causing disturbances of the monsoon

circulation and forming the break phase.

Degtyarev, A. I., and **E. N. Kruglova.** 1992. Annual cycle of atmospheric circulation derived from the climatic model of the Research Hydrometeorological Center of the Russian Federation. Meteorol. Hydrol. 9:5-12.

The principal experimental results of the annual cycle of atmospheric circulation reconstructed by the climatic model of the Research Hydrometeorological Center of the Russian Federation are presented. Calculations were performed for a 13-month period of model time with regard to the annual variation in solar radiation, sea surface temperature, surface albedo, and sea-ice edge. The time trend of the integral prognostic atmospheric characteristics and the surface temperature at individual grid points is shown. The diagrams of zonal wind and zone-averaged sea level pressure for January and July are given and compared with their climatological values. The precipitation fields obtained experimentally are compared with their climatological values in terms of quality. The heat balance at the underlying surface averaged for each month, as well as all of its components, is considered. In this way the radiation balance at the upper boundary of the model atmosphere is presented. It is demonstrated that the model successfully simulates the climatology of the annual variation in atmospheric circulation.

Demin, Yu. L., Yu. A. Romanov, and **N. A. Romanova.** 1985. On the reasons for the formation of the two inner-tropical convergence zones in the western part of the Pacific. Proc. All-Union Symposium on the Investigation of the interaction of Meso- and Macro-scale Processes in the Atmosphere and the Application of Statistical Methods in Meteorology. Moscow. Gidrometeoizdat. pp. 71-75.

A critical analysis shows that current hypotheses about the formation of the two inner-tropical convergence zones (ICZs) in the Indian Ocean and the western part of the Pacific do not agree with a number of natural peculiarities of these zones. It is proposed that the formation of the two ICZs might be induced by peculiarities of the surface baric field in the Indian-Pacific sector of the near-equatorial zone. To check this assumption, numerical experiments are performed with a nonlinear zonal model of near-equatorial circulation, and they confirm the possibility for the formation of the two ICZs in the west of the Pacific, given the equatorial baric depression over the region of Indonesia and New Guinea.

Dobryshman, E. M., and **N. M. Saitova.** 1983. On the computational characteristics of multilevel prognostic schemes and models of general atmospheric circulation. Meteorol. Hydrol. 3:5-17.

With the growing number of levels in general circulation models and prognostic schemes, the matrix A corresponding to a finite-difference analog of the differential problem becomes ill-conditioned. The influence of boundary conditions, temperature distribution with altitude, zonal flow velocity, and scales of disturbance (Rossby waves) on three computational parameters of matrix **A** is discussed. These parameters are the conditional number, **C**(λ); quantity characteristic of independent levels, **N**; and a relative contribution of the first three modes to the total sum, δ. Calculations were first performed for test models with equidistant levels and then for 18 specific models used in various countries. A brief analysis of the structure of eigenvectors for these 18 models is given.

Dolzhansky, F. V., and **D. Yu. Manin.** 1992. Impact of the Akman turbulent layer on dynamics of large-scale motions. Rep. Russ. Sci. Acad. 322(6):1065-1069.

In framing very general suppositions about the nature of turbulence in the Akman layer, a precise formula for the force by which the planetary boundary layer acts upon the atmosphere was derived. Equations of large-scale motion dynamics with regard to turbulance in the Akman layer were formulated. Theoretical results were compared with the data from laboratory experiments with a rotating disc. It is concluded that the impact of the turbulence in the Akman layer upon the atmosphere is twofold: it modifies the beta-effect and provides quadratic atmosphere-on-Earth friction.

Dymnikov, V. P., and **A. A. Fomenko.** 1981. On the spectral distribution of the unstable mode energy in the general circulation model. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 17(7):675-679.

The growth rates of unstable waves in the wide spectral range are studied for the general circulation model of the atmosphere developed at the Computing Center of the Siberian Branch of the U.S.S.R. Academy of Sciences. The computed growth rates are compared with analytical estimates. The level of equilibrium eddy energy for each unstable mode is investigated for the model with dissipation. The equation for a comparative analysis of equilibrium levels of eddy energy is proposed for modes with different zonal wave numbers.

Dymnikov, V. P., and **V. N. Lykosov.** 1983. Spectral analysis of the quasi-stationary response of atmospheric circulation to ocean surface temperature anomalies. Prepr. Comp. Math. Dept. Acad. Sci. USSR 61:28.

A physical theory offered to explain the wave structure of the atmospheric response to eddying source anomalies is briefly outlined first. Afterwards the spectral structure of the quasi-stationary response to ocean surface temperature anomalies is analyzed. For this purpose the probable spectral structure of the stationary response to eddying source anomalies is studied with respect to the source size and location, and results are presented for numerical experiments based on a general circulation model [Marchuk, G. I., V. P. Dymnikov, V. N. Lykosov, et al. 1979. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 15(5)] and used in studies of the atmospheric circulation response to ocean surface temperature anomalies located in the middle latitude of the Northern Hemisphere in the Atlantic.The spectral structure of the response is in fairly good agreement with the results obtained from an analysis of a simple stationary linear model. Comparative analysis of model circulation responses to ocean temperature anomalies in the regions of the Bermuda energy-active zone and the Icelandic minimum showed that in the second case the response is statistically more significant. On the whole it is concluded that, in winter in the middle latitudes (the mean January circulation with the specified declination of the Sun was simulated), the model atmospheric circulation response to ocean surface temperature anomalies is weak. However it does not mean that the same response will be observed with any velocity field distribution, because the study was made only for velocity distribution close to climatic.

Dymnikov, V. P., and **M. A. Tolstykh.** 1989. Simulation of variations of interseasonal and

low-frequency atmospheric circulation and ocean surface temperature. Prepr. Comp. Math. Dept. Acad. Sci. USSR 226:1-40.

Variations of interseasonal, low-frequency atmospheric circulation and surface temperature of the Atlantic Ocean are studied by using a joint model of general atmospheric circulation and the upper mixed layer of the Atlantic Ocean. The structure of the joint model and experimental results of the simulation of January joint atmospheric and ocean upper layer circulation are presented. Interactive structures in the field of the 500-millibar geopotential surface and the ocean surface temperature, close to corresponding structures obtained from observation data, are specified.

Dymnikov, V. P., E. V. Kazantsev, and **V. V. Kharin.** 1992. Informational entropy and the local Lyapunov exponents of barotropic atmospheric circulation. Bull. Russ. Sci. Acad. Atmos. Ocean Phys. 28(6):563-573.

The idea of classifying quasi-barotropic atmospheric circulation regimes is discussed in terms of the informational entropy concept. It is shown that entropy minimums for regional circulation are associated with regimes like those of blocking and zonal flow. The hypothesis of a relationship between informational entropy and flow stability characteristics is discussed. An algorithm is formulated for calculating the local Lyapunov exponents. A strong correlation between the distribution of the total of the local Lyapunov exponents calculated for barotropic atmosphere and the distribution of informational entropy is shown for a 10-year data series. The results of calculating the total of local positive Lyapunov exponents are given. They may be used to determine the importance of barotropic instability in estimating the accuracy of 10-day weather forecasts.

Dymnikov, V. P., and **E. V. Kazantsev.** 1993. On the structure of the attractor generated by the system of equations of barotropic atmosphere. Bull. Acad. Sci. Atmos. Ocean Phys. 29(5):581-595.

It is well known that local instability of nonlinear dissipative systems could lead to chaotic behavior of their trajectories. Estimations of predictability for such systems is one of the most important problems addressed in numerical studies. Because atmospheric motion seems to be chaotic, the problem is also of interest in the context of atmospheric dynamics. Various approaches to compute the Lyapunov exponents, the Kolmogorov entropy, and the attractor dimension for the low-mode barotropic model of the atmosphere were studied and compared. The relationships between the Kolmogorov and informational entropies were also considered. The unstable equilibria points were shown to have an important influence on the attractor structure and the system behavior. Relationships between the mean time that the trajectory spends in the neighborhood of the stationary point and the stability characteristics of the equilibrium were analyzed.

Dymnikov, V. P., and **A. N. Filatov.** 1993. Introduction to the Mathematical Theory of Climate. Moscow Comp. Math. Inst. 89 p.

An attempt is made to introduce the mathematical theory of climate as it is understood by the authors. Primary emphasis is placed on the following problems: whether the climate model in question, as a

system of equations in partial derivatives of hydrothermodynamics, generates a dynamical system having the attractor or inertial diversity (by the example of barotropic and baroclinic models); whether the system, derived from the initial climatic model by transition to its finite-difference approximation, has attractors or inertial diversities; what the relation is between the attractors and inertial diversities of the derived systems and those of the initial model. Much attention has also been given to the following: proof of the presence of an invariant measure on the attractor and a search for algorithms for its computation, numerical study of the attractor structure of the equation of barotropic atmosphere on the sphere, assessment of the Housedorf dimension of the attractor and its dimension with respect to the number of spectral truncation, and study of the climatic attractors, structure by means of observation data series.

Evseev, M. P., and **E. N. Uranov.** 1982. On the consideration of the oceanic heat influx in the global atmospheric circulation model of the Southern Hemisphere. Proc. Arct. Antarct. Res. Inst. 365:145-150.

It is shown that thermal interaction between the ocean and the atmosphere in the global spectral atmospheric circulation model of the Southern Hemisphere can be taken into account. The effect of the oceanic heat influx on the wind field and geopotential at the $\mathbf{T}_{500}$ surface in different seasons is examined in terms of linear parameterization of this influx.

Evseev, M. P. 1982. Nonlinear effects of planetary dynamics in the Southern Hemisphere and the problem of forecasting the rearrangements of large-scale circulation components. Proc. Arct. Antarct. Res. Inst. 365:156-161.

An algorithm is described to calculate the nonlinear effects of planetary dynamics in the spectral global atmospheric circulation model of the Southern Hemisphere. The relationship between the divergence in the nonlinear process at $\mathbf{T}_{500}$ height and sharp rearrangements of large-scale circulation in the hemisphere is analyzed.

Filatov, S. A. 1988. Modernization of a table representation of the integral transmission function in calculating a radiant heat influx. Proc. USSR Hydrometeorol. Res. Center 298:171-177.

The need for repeated calculations of integral transmission functions (ITF) makes it difficult to parameterize radiant heat influxes in general circulation models. This paper examines one of the possible ways to optimize a computational algorithm that consists in creating, before the forecast initiation, a bank of tabulated ITF values that are selected in the course of determining the scanning index. Numerical experiments were performed on the basis of the improved segment for calculating a radiant heat influx that is included in a semispherical short-term weather forecast model of the U.S.S.R. Hydrometeorological Research Center. The use of the ITF bank reduces the time for making a forecast. From the available estimates of the model's sensitivity to radiant flux variations, the optimal number of elements in the bank was determined that ensures the required accuracy of prognostic values.

Fomenko, A. A., V. L. Perov, G. Schmitz, and **N. Grieger.** 1983. The spatial spectrum of quasi-stationary disturbances in the semisphere general atmospheric circulation model. Prepr. Comput. Cent. of Siberian Branch Acad. Sci. USSR 440:46.

The spatial spectrum of quasi-stationary atmospheric waves generated in a semisphere general atmospheric circulation model is considered. The spatial structure of quasi-stationary, ultralong waves, and non-adiabatic heat sources are studies along with spatial spectrums of eddy flows of angular momentum, heat, moisture, eddy kinetic energy and eddy available potential energy. Calculated values are compared with observation data, and conclusions about the contributions of various harmonics to general atmospheric circulation.

Fomin, V. M. 1988. Application of the splitting technique to solve the problems of calculating phase moisture transformations and precipitation in meteorological element forecasting and general circulation models. Proc. West-Siberian Reg. Res. Hydrometeorol. Inst. 85:109-117.

A technique to solve equations for forecasting meteorological elements, including different phases of atmospheric moisture, is considered. The model takes into account the averaged microphysical structure of clouds and precipitation. The second averaging of the model's equations is performed with respect to different scales of mesoprocesses.

Galin, M. B., and **S. E. Kirichkov.** 1984. A low-component spectral model of the annual variation of zonal atmospheric circulation. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 20(5):349-355.

A 14-component spectral, two-level filtered model of atmospheric circulation is considered. The annual variation of the insolation is parameterized as annual variation of zonal temperatures of radiation equilibrium. The annual variation of jet streams, zonal temperature fields, main energy components, and energy conversion rates are adequately simulated by the model.

Galin, M. B., and **S. E. Kirichkov.** 1985. Stability of zonal atmospheric circulation in the model with orography and a blocking problem. Bull. Acad. Sci. USSR. Atm. and Ocean Phys. 21(6):563-572.

The stability of a zonal flow is examined by using a 20-component spectral general circulation model with orography. It is shown that different types of instability (orographic, baroclinic, and combined baroclinic-orographic) may develop as a function of a wave number, orography height, and external forcing intensity. Different types of instability are discussed in terms of their relation to stationary nonzonal disturbances.

Galin, M. B., and **S. E. Kirichkov.** 1985. Orographic influence on nonzonal atmospheric circulation and blocking phenomena. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 21(7):691-698.

The results of integrating the equations of a 20-component low-parameter nonlinear model discussed.

Integration is performed unless an asymptotic circulation regime is formed. It is shown that different zonal flow instabilities are connected with different asymptotic regimes. Some regimes have atmospheric blocking characteristics.

Galin, M. B., and **S. E. Kirichkov.** 1987. A low-component model of the influence of sea-surface temperature anomalies on atmospheric circulation. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 23(9):899-905.

The influence of temperature anomalies influence is studied based on a two-level quasi-solenoidal model. The radiation heating is calculated with transmission coefficients. The underlying surface is treated as ocean with a specified temperature. Because of spectral truncation, the surface temperature anomaly and the atmospheric response at every latitude take the form of a single wave with the prescribed wave number. Stationary and nonstationary regimes are formed in the atmosphere as a function of the underlying surface zonal temperature distribution, nonzonal anomaly intensity, and the prescribed wave number. The intensity of the atmospheric circulation and the phase shifts of meteorological fields with respect to the temperature anomaly of the underlying surface are found as a function of latitude, wave number, and external forcing. Maps of the stream function, temperature, vertical velocity, and heating rate are presented. In a typical case, the anticyclonic vorticity is found at the upwind side of the positive temperature anomaly.

Grakhovsky, G. N., and **M. P. Evseev**. 1989. On the diagnosis and prediction of large, ten-day air temperature anomalies in the Western Arctic using a spectral hydrodynamic model. Proc. Arct. Antarct. Res. Inst. 416:88-96.

Data are presented on the frequency of large air temperature anomalies in the Western Arctic in transition periods of the year. A procedure is suggested for analyzing and predicting considerable warming up and cooling off by means of a heat-influx equation in a global spectral hydrodynamic general circulation model.

Grieger, N., V. L. Perov, A. A. Fomenko, and **G. Schmitz.** 1985. A study of January atmospheric circulation using a six-level hemispherical model. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 21(4):374-382.

This work examines the results of numerical modeling of January atmospheric circulation over the Northern Hemisphere obtained by using a hemispherical version of the global model. Zonally averaged characteristics of meteorological elements are presented; the relation of these elements to the planetary wave-induced transfer is studied; amplitudes and phases of stationary ultra-long waves are shown; the behavior of turbulent kinetic and available potential energies is studied.

Gushchina, D. Yu., and **E. K. Semenov**. 1993. Planetary reconstruction of vertical cells of tropical atmospheric circulation in the period of the 1982-1983 El Niño culmination. Meteorol. Hydrol. 10:5-13.

Data from the objective analysis of wind fields of the European Center for Medium-Range Weather Forecasting were used to calculate the velocity potential of divergent wind and the stream function in the free tropical atmosphere during the culmination of the 1982-1983 ENSO event. New data are discussed pertaining to the macroscale reconstruction of the vertical cells of the zonal circulation that caused the anomalous distribution of the planetary zonal flows in the lower and upper troposphere of low latitudes.

Kamenetz, F. F., V. I. Petviashvili, and **A. M. Pukhov.** 1993. Simplified dynamics of shallow baroclinic atmosphere. Bull. Sci. Acad. Atmos. Ocean Phys. 29(4):457-463.

Simplified equations for perturbations of horizontally baroclinic atmosphere are obtained. Perturbations are of synoptical scales with frequencies lower than the Coriolis frequency, so geostrophic approximation is valid. Exact nonlinear solutions of these equations in the form of dipole vortices are found. It is shown that, contrary to the barotropic case, the baroclinic vortices may have velocities lower than the Rossby velocity. The nonlinear phase of the baroclinic instability is simulated numerically for the atmosphere with large-scale gradients of pressure and potential temperature.

Kazakov, A. L., and **V. N. Lykosov.** 1986. On the problem of the sensitivity of general circulation models to boundary layer parameterization. Proc. West-Siberian Reg. Res. Inst. State Com. Hydrometeorol. 77:22-32.

Major methods of atmospheric boundary layer parameterization with regard to problems of general circulation are reviewed, with emphasis on the peculiarities of calculating vertical turbulent fluxes at the Earth's surface. Some well-known experiments for estimating the models' sensitivity to different schemes of boundary layer parameterization are described. General methodological issues for conducting similar research are formulated.

Kazantsev, E. V. 1990. On the applicability of instability indices of quasi-stationary atmospheric circulation regimes for describing low-frequency variation of the atmosphere. Prepr. Comp. Math. Dept. Acad. Sci. USSR 265:1-27.

The applicability of instability indices to problems of long-range weather prediction is studied. The behavior of unstable modes of atmospheric conditions under actual regime progression and the response of calculated indices to variations of the model parameters are investigated.

Kharitonenko, V. M. 1986. A three-level nonlinear atmospheric circulation model with orographic inhomogeneities of the surface. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 22(12):1260-1268.

A three-level baroclinic spectral atmospheric model with orography is constructed. For the maximum spectral truncation, the interaction of a single wave with zonal flow and orography is considered. A transition from simple to more complicated, up to irregular, circulation regimes is followed as a function

of the external forcing amplitude. The character of the flow depends on the type of instability of zonal circulation. It is shown that there are two nonstationary nonzonal flow regimes with different amplitudes of steady periodic variations of the wave and zonal flow for the same external forcing.

Kharitonenko, V. M. 1991. The influence of the surface friction and turbulent heat transfer on the structure of the stationary planetary waves. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 27(3):227-233

To study the influence of surface friction and turbulent heat transfer on the structure of the stationary planetary waves in the atmosphere, a three-level, low-component model of the atmospheric response to the large-scale orographic and thermal inhomogeneities of the underlying surface is considered. In the case of a single wave, the analytical dependencies of the amplitude and the phase of the planetary waves upon the parameters of the turbulent exchange, zonal flow, and spectral extension are reproduced.

Kirichkov, S. E. 1982. A six-component zonal atmospheric circulation model. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 18(6):579-584.

A six-component, two-level hemispheric model of zonal circulation of the atmosphere with energy sources and sinks is considered. The model is based on quasi-solenoidal baroclinic approximation and allows a satisfactory description of the observed zonal atmospheric circulation.

Kislov, A. V. 1989. Dynamic statistical general circulation model. Bul. Moscow State Univ. Ser. 5: Geography 4:23-29.

A dynamic statistical general circulation model whose equations are written in a spherical coordinate *p*-system is suggested. A vertical structure of the atmosphere is described by variables at isobaric surfaces of 250, 675, and 925 hPa. A horizontal grid interval is 10° in latitude and 15° in longitude. A time step is equal to one day. Model calculations involving a different insolation distribution over the upper atmospheric boundary and constant sea-surface temperatures show that the equilibrium level ("model climate") is achieved in about 30 days. Results of numerical experiments to simulate a climatic regime appropriate to July conditions of the Northern Hemisphere are presented. The simulated thermal conditions are shown to adequately account for large-scale peculiarities of the temperature field. The model adequately simulates the position of the zones of maximum mean zonal velocities of westerlies. The resulting spatial distribution and amounts of absolute precipitation show satisfactory agreement with climatic data.

Kislov, A. V. 1991. A three-dimensional atmospheric circulation model with completely described physical processes and simplified dynamics. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 27(4):353-361.

The first climate simulation results from a three-level general circulation model are presented. Temperature and specific water content are prognostic variables; wind is calculated from quasi-geostrophic relations. The model includes parameterization of synoptic-scale disturbances,

convection, large-scale condensation, evaporation, clouds, radiation transfer, and some orographic effects. The surface albedo is a function of the surface type and the snow cover predicted by the model. With reasonable accuracy, the model simulates large-scale features of July climate, including temperature and precipitation. The largest errors are represented by very low wind speeds in the tropics.

Kislov, A. V. 1992. Simulation of holocene and late glaciation climate on the basis of a simplified general atmospheric circulation model. Bull. Sci. Acad. Atmos. Ocean Phys. 28(7):705-713.

A simplified general atmospheric circulation model is used to study climate response to variations of insolation at the external atmospheric boundary, albedo distribution, ocean surface temperature, orography, and CO_2 content. These boundary conditions correspond to those of late glaciation and the Holocene. It is shown that temperature deviation (averaged for all continents of the Northern Hemisphere) reproduced by the simplified model is in good agreement with similar data obtained from the general atmospheric circulation model. The greatest positive deviations of precipitation amount, as compared with current values, are observed in the equatorial zone and associated with an intensification of the inner-tropical convergence zone under warm climate conditions. It is concluded that the model performs well enough to justify its application as an exploratory tool for paleoclimatic problems.

Kislov A. V. 1994. Study of the genesis of Holocene warm climates on the basis of simplified general circulation model simulations. Bull. Sci. Acad. Atmos. Ocean Phys. 30(4):443-450.

Experiments were carried out using a simplified general circulation model (GCM) to estimate climate sensitivity to changes in insolation distribution at the outer atmosphere boundary (according to conditions that existed 6 and 9 kiloyears BP) and the surface characteristics (albedo, ice, ocean temperature) for the boreal and the Atlantic minimums of the Holocene. The reproduced anomalies correlated well with the paleoreconstruction data. It was shown that warm climates are said to be the reaction of global climate to the Milancovich mechanism and to the feedback "modification of the landscape's climate variation" (in arid zones). A comparison was made between the numerically retrieved climatic characteristics and similar numerical data obtained by different GCMs.

Kislov, A. V. 1994. On the theory of climate fluctuations in the post-glaciation epoch. Bull. Moscow State Univ. Ser. 5(1):24-31.

The 15000-year dynamics of climate during the post-glaciation period has been simulated by using a simplified global atmospheric circulation model. The Holocene climate fluctuations result from interactions within the atmosphere-ocean- land system, evolving at the background of climate regime peculiarities, caused by the Milancovich effect.

Kislov, A. V., and **G. V. Surkova.** 1995. On a regional climate model. Meteorol. Hydrol. 5:23-31.

A climate model is described which is intended for simulating climatic fields near the Earth's surface

with a high spatial resolution in some regions. The model incorporates an atmospheric general circulation model (GCM) (constructed with simplified dynamics and full consideration of physical processes) and a regional model (RM) (incorporating the active layer of the Earth's surface and the atmospheric boundary layer). The GCM/RM has been implemented for the Caspian and Aral regions. The model has been tested by comparing the reconstructed fields with the climatic averages. It is shown that the near-surface temperature is reconstructed at each point of the calculation domain with an error of 3° C, the evaporation 0.9 mm/day, etc. The correlation coefficients of the simulated and observed values are approximately 0.75.

Klimenko, L. V. 1994. Atmospheric circulation over the European territory of the former USSR during the cold season. Meteorol. Hydrol. 5:94-100.

The dynamics of large-scale atmospheric processes, classified by the author, have been analyzed for the cold season. Century-long fluctuations of these processes and their importance in climate formation were defined. The latter is evident in the formation of warming and cooling periods and warm and cold seasons. Reasons are cited for climate warming, which is particularly intensive during the cold period of the year.

Kondratyev, A. V. 1981. On the interaction of long waves in the western flows of mid-latitudes with waves in the eastern flows of the tropical zone. Bull. Leningrad State Univ. 18:91-95.

The interaction of long planetary waves in the western flows of mid-latitudes with the eastern waves of the tropical zone is studied on the basis of GATE data by using correlation and spectral analyses. It is discovered that the above-mentioned interaction occurs with the distinguishing interval of approximately 6 days.

Koppelmaa, I. V. 1989. General atmospheric circulation model response to ocean surface temperature variation. Prepr. Comput. Math. Dept. USSR Acad. Sci. 237:1-16.

The response of a general atmospheric circulation model that is used in Computational Mathematics Department of the U.S.S.R. Academy of Sciences for climatological studies to ocean surface temperature variation is analyzed. The impact of cloudiness on the response parameter is assessed. It is concluded that convective cloudiness should be considered in the model.

Krupchatnikov, V. N. 1982. On the semi-implicit method of integration in numeric general atmospheric circulation models. Prepr. Comput. Cent. Siberian Branch USSR Acad. Sci., No. 340, 20 p.

When atmospheric circulation is simulated by using spectral models, semi-implicit methods are said to be convenient. With such methods of integration, the terms of equations responsible for gravitational oscillations are linearized in relation to the predetermined temperature profile and are considered implicitly; other terms are described explicitly. The gravitational mode makes the results highly

responsive to the temperature profile and generates noticeable distortions of high frequencies. The proposed method to extract barotropic mode with subsequent initialization allows the above-mentioned deficiency to be eliminated.

Krupchatnikov, V. N., and **O. F. Savchenko.** 1991. Frequency-wave spectrum of interseasonal atmospheric circulation fluctuations in low latitudes based on simulation data. pp. 90-100. In System Simulation of Ecological Processes. Comput. Cent. Siberian Branch USSR Acad. Sci., Novosibirsk

The results of a frequency-wave analysis of interseasonal fluctuations of summer climate tropical circulation in the Northern Hemisphere are presented as reproduced by an atmospheric general circulation model without considering the interaction of the atmosphere and the ocean or radiation and cloudiness. Spectral analysis, in which disturbances were divided into eastern and western directions of wave propogation, was used. It was shown that Kelvin waves, having small wave numbers and propogating to the east, make the major contribution to fluctuations of zonal velocity in periods ranging from 15.4 to 46.0 days. The contribution of Rossby waves grows with the increase of wave numbers. The signal, propogating to the east, prevails in the spectrum of heating sources; thus, the hypothesis that the forced Kelvin waves are supposed to be dominant in interseasonal fluctuations of tropical atmospheric circulation is indirectly confirmed.

Krupchatnikov, V. N., and **G. P. Kurbatkin.** 1991. Simulation of the large-scale dynamics of the atmosphere: Numerical methods. Comput. Cent. Siberian Branch USSR Acad. Sci., Novosibirsk 169 p.

This monograph is dedicated to the investigation of atmospheric dynamics. Fundamental theoretical principles of nonstationary, quasi-geostrophic wave motions and midzonal circulation are considered. Current prognostic systems for midrange forecasting of large-scale atmospheric motions are described. The necessary numerical algorithms used as a basis for constructing a general circulation and weather forecast model are presented.

Krupchatnikov, V. N., and **G. P. Kurbatkin**. Simulation of the Large-Scale Dynamics of the Atmosphere. Methods of General Circulation Diagnosis. Comput. Cent. Siberian Branch USSR Acad. Sci., Novosibirsk 114 p.

Some methods of hydrodynamical diagnosis of general atmospheric circulation are presented. The theories of geophysical flow instability and quasi-stationary, large-scale tropospheric disturbances form the basis of these methods. Both theories are outlined in the first two chapters of the monograph. Results of the theory of nonstationary, quasi-geostrophical motions are also used for hydrodynamical diagnosis.

Krupchatnikov, V. N., and **A. G. Yantsen.** 1994. Parameterization of the atmosphere-Earth surface interaction in a general atmospheric circulation model. Prepr. Comput. Cent. Siberian Branch Russian Acad. Sci., Novosibirsk 1013:1-15.

A new scheme is developed for parameterizing surface processes, which appears to be considerably more advanced in comparison with the one employed by the previous version of the general atmospheric circulation and weather prediction model. This scheme will be a component of the new version of a general atmospheric circulation and weather prediction model being developed for a broad spectrum of climatic problems and in particular for estimating climate variation on the basis of mathematical simulation.

Kurazhov, V. K., and **S. A. Chaikina.** 1984. On the contribution of large-scale orography to the transformation of major forms of atmospheric circulation in the middle troposphere. Proc. Arct. and Antarct. Res. Inst. 397:116-121.

A procedure for taking into account large-scale orography in transforming H_{500} geopotential fields given major forms of atmospheric circulation is described. Orographic divergence fields were analyzed at meridional and eastern forms of circulation.

Kurazhov, V. K. 1984. An account of ozone heat influxes in the baroclinic zonal circulation model. Proc. Main Geophys. Obs. 471:15-20.

The effect of ozone heat influxes on vertical velocities in the lower and middle atmosphere is studied by using a baroclinic zonal circulation model. In the layer of the maximum ozone content, ozone heat influxes are shown to have a considerable effect on the vertical velocities in the stratosphere.

Kurbatkin, G. P., A. I. Degtyarev, V. D. Kaznacheeva, and **I. V. Trosnikov.** 1990. Analysis and modeling of the extreme blocking situation over the European USSR in October 1987. Meteorol. Hydrol. 8:5-13.

The principal feature of the development of atmospheric processes in October 1987 is analyzed: an evolution of the blocking situation over the European U.S.S.R. Numerical experiments were carried out to simulate this situation by means of the U.S.S.R. Hydrometeorological Research Center spectral model. Results from numerical experiments ignoring the orographic and nonadiabatic factors are presented.

Kurgansky, M. V. 1993. Introduction to Large-Scale Atmospheric Dynamics: Adiabatic Variants and Their Application. Gidrometeoizdat, St. Petersburg. 168 p.

The aim of the book is to introduce large-scale dynamics of atmospheric processes (thousands of kilometers). Vortices of large-scale horizontal dimension are continuously observed in the atmosphere and determine weather and climate. Modern atmospheric dynamics is based on two principles: the principle of close correspondence between actual and geostrophic winds and the principle of potential vortex and energy conservation. These two principles and fundamentals of invariants theory of atmospheric processes as well as their lab application are described in the book. Mid-scale and

small-scale atmospheric motions that appear to be three-dimensional are not considered. The table of contents of the book is as follows: motion equations and conservation principles, reduced equations of atmospheric motion, hydrodynamical instability of conservative motions, isentropic analysis of motions, and dissipative processes.

Kutsenko, B. Ya., and **S. P. Mukhin.** 1989. An account of non-adiabatic factors in modeling mezoscale atmospheric processes. Proc. Cent. Aerol. Obs. 174:46-53.

A scheme is presented that accounts for turbulent processes and effects of the underlying surface inhomogeneity in a numerical three-dimensional model of mezoscale atmospheric processes. Experimental results are compared with field observations. Results of modeling the diurnal trend and breeze circulation are shown as an example of the scheme's efficiency.

Lykosov, V. N., and **A. L. Kazakov.** 1983. On atmospheric circulation response to the processes of microscale turbulent interaction with the underlying surface. Prepr. Comput. Cent. Siberian Branch USSR Acad. Sci. No. 495, 35 p.

Model mean January general atmospheric circulation response to the processes of turbulent interaction with underlying surface is studied. GCM model-based numeric experiments have been performed using two schemes for parameterizing the steady flow layer. Mainly, these schemes differ with low wind velocities (i.e., under conditions) typical for some regions of the tropical zone. It is shown that changing the parameterization variant causes considerable variation of fundamental parameters of the climate system and as a result changes the energetic and dynamic characteristics of circulation. Calculations allowed the following to be obtained: relationships between friction and heat exchange coefficients and between wind velocity and stratification over the ocean (for altitude of 10 m), a relationship between the turbulence coefficients for momentum and heat and between wind velocity and stratification over the ocean (at an altitude of 70 m), time dependence of the mean surface temperature of the Northern Hemisphere continent (for one of experiments), and zone-averaged flows of evident and latent heat, zone-averaged monthly values of precipitation amount and other characteristics, all of which are presented in the form of tables and diagrams. Experiments confirmed the importance of energy-active zones for the formation of general atmospheric circulation, especially in the tropical World Ocean. Practical conclusions, following from the analysis of experimental results, show the importance of both research activities in the regions of the ocean mentioned and mathematical simulation techniques for [determining] processes of momentum, heat and moisture transfer to the overlying atmosphere layers, and parameterization of these processes for subsequent incorporation into GCMs. Numerical experiments were performed on the basis of the Cray-1 computer at the European Centre for Medium-Range Weather Forecasting, in Reding (England).

Lykosov, V. N., and **I. M. Bobyleva.** 1984. On the problem of parameterizing the steady stratified boundary layer in an atmosphere general circulation model. Preprint. Comput. Cent. Siberian Branch USSR Acad. Sci. No. 529, 29 p.

Results are given for numerical experiments performed to evaluate the influence of the steady stratified

boundary layer upon the atmosphere thermodynamical regime. A global three-level GCM with a resolution of 10° longitude and 6° latitude is applied. The scheme of the boundary layer parameterization is reduced to direct inclusion of near-surface turbulent flows (with the relevant attenuation coefficient, proportional to the boundary layer depth) into prognostic equations at the estimated level, nearest the Earth's surface. Mean January circulation was simulated (the sun declination, ocean surface temperature, and pack ice location were assumed to be climatical). It is shown that a neglect of processes related to vertical turbulent transfer of motion amount, heat, and moisture under conditions of steady stratification causes statistically significant local variations of the lower atmosphere thermodynamic regime in temperate and high latitudes of the Northern Hemisphere. It leads to a weakness of intensity in stationary centers of action, such as the Siberian anticyclone and the Aleutian depression. In contrast, excessive turbulent exchange between the atmosphere and underlying surface with steady temperature stratification in the boundary layer causes excessively intensive formation of anticyclones in middle latitudes.

Marchuk, G. I., V. P. Dymnikov, and **V. B. Zalesny.** 1987. Mathematical Models in Geophysical Hydrodynamics and Numerical Methods of Their Realization. Gidrometeoizdat, Leningrad. 296 p.

Mathematical models of specific dynamic processes responsible for the formation of atmospheric and ocean circulation are formulated and analyzed. The following are studied: processes of admixture transport in the atmosphere and ocean, nonlinear energy transfer along the spectrum in quasi-two-dimensional and quasi-geostrophical approximations, large-scale wave dynamics and stability, formation of boundary jets, etc. Numerical algorithms for solving the main problems of geophysical hydrodynamics, satisfying a number of a priori requirements, are constructed from the analysis performed. Problems in efficiently implementing these algorithms on modern computers are studied.

Marchuk, G. I., and **Yu. N. Skiba.** 1990. A contribution of adjoint functions to the study of the sensitivity of a model of atmosphere-ocean thermal interaction to small perturbations. Bull. USSR Acad. Sci. Atmos. Ocean Phys 26(5):451-460.

A method is suggested for studying the sensitivity of a model of the atmosphere-ocean thermal interaction to small perturbations. The method employs adjoint equations. The values of some linear functionals of a perturbed solution are considered as indicators of the model's sensitivity. A space-time structure of the solutions of adjoint problems (influence-functions) allows a better understanding of the system's response to external perturbations. This is associated with the fact that the value of the functional characterizing the system's response is crucially dependent on the structure and amplitude of the heat-source perturbations and on the initial data in the vicinities of the influence-function local maximums. As an example, the influence functions for mean December surface temperature anomalies over the European U.S.S.R. and the U.S.A. are analyzed. The great contribution of energy-active zones of the World Ocean to the formation of these temperature anomalies is demonstrated. For any time period selected, particular energy-active zones involved in this process are determined by the location of the influence-function local maximums.

Meleshko, V. P., and **A. P. Sokolov.** 1982. The effect of a North Atlantic water-temperature anomaly on circulation, thermal conditions, and hydrological cycle in the Northern hemispheric atmosphere.

Meteorol. Hydrol. 2:51-62.

The effect of a North Atlantic water-temperature anomaly on general circulation, thermal conditions, and the hydrological cycle in the atmosphere is studied by using a general circulation model. A positive anomaly is specified in the zone of the active thermal atmosphere- underlying surface interaction in the northeastern Atlantic. The state of the Northern hemispheric atmosphere in January is calculated by a two-month integration of a set of equations with and without regard for the water temperature anomaly. This paper provides a detailed comparative analysis of atmospheric characteristics for the Northern Hemisphere and individual regions of the European continent.

Meleshko, V. P., B. E. Shneerov, and **G. V. Parshina**. 1982. Calculation of circulation, thermal conditions, and hydrologic cycle in the atmosphere for July using a general circulation model. Proc. Main Geophys. Obs. 459:3-23.

A new version of a hydrodynamic general circulation model is described. The model takes into account major processes of heat and moisture exchange: i.e., radiation transfer, interaction between underlying surface and atmosphere, large-scale condensation and convection, hydrologic conditions of the continental active soil layer, and horizontal diffusion. A 60-day numerical experiment was performed to calculate circulation, thermal conditions, and hydrologic cycle in the atmosphere for July. Atmospheric characteristics are compared with observations.

Meleshko, V. P., S. V. Bogachenko, and **B. E. Shneerov.** 1982. On the calculation of radiation heat influxes in the general circulation model. Proc. Main Geophys. Obs. 459:56-64.

A modified version of a radiation scheme used in a general circulation model developed in the Main Geophysical Observatory is examined. Some sources of errors in the previous radiation scheme are discussed and ways to remove them are suggested. Radiation balance components at the atmospheric boundaries were calculated by using the old and new schemes. Estimated data are compared with measurements and computational results obtained from other radiation schemes.

Mokhov, I. I., V. Ya. Galin, A. I. Degtyarev, E. N. Kruglova, V. P. Meleshko, A. P. Sokolov, P. V. Sporyshev, G. L. Stenchikov, I. V. Trosnikov, and **D. A. Sheinin.** 1994. Intercomparison of general circulation models: Diagnostics of intra-annual cloudiness evolution. Bull. Sci. Acad. Atmos. Ocean Phys. 30(4):527-542.

An intercomparison of general circulation models (GCMs) was carried out. The evolution of cloudiness fields in the annual cycle has been evaluated for GMCs of the Main Geophysical Observatory (St. Petersburg), the Computer Mathematics Institute (Moscow), the Russian Research Hydrometeorological Center (Moscow), and the Computer Center of Russian Academy of Sciences (Moscow) in comparison with observational data. Clouds in different layers were considered as well as total cloudiness. Sources of differences were analyzed.

Mokhov, I. I., O. P. Skrotskaya, and **I. G. Ostapenko.** 1994. The overlap between clouds of different layers in general circulation models. Bull. Sci. Acad. Atmos. Ocean Phys. 30(4):558-563.

An analysis is conducted concerning the patterns of overlap between clouds of different layers and types in general circulation models in comparison with data from satellite and ground-based observations. Peculiarities are noted with regard to cloudiness overlapping coefficients in different latitudinal belts over land and over ocean for different seasons. Estimates for the uncertainty range of the total cloud amount variations in general circulation models are made using different patterns of overlap cloudiness.

Monin, A. S. 1987. On negative viscosity in global circulations. Rep. USSR Acad. Sci. 293(1):70-73.

A negative viscosity mechanism responsible for maintaining a differential rotation on the Sun and the solar system's planets is described. It is likely to be universal and each gas sphere with internal heat sources must be in a state of differential rotation with equatorial acceleration. For the Sun, this mechanism represents barotropisized waves that are in its convective zone and that have a prevailing latitudinal wave number equal to six. A differential rotation of the Earth's atmosphere manifests itself as strong subtropical jets generated by negative viscosity. The latter is connected with the axes of the Rossby-Blinova wave crests inclined toward the jets. All intensive currents in the oceans are of narrow-jet nature. This can be accounted for only by negative viscosity generated by the ensemble of synoptical eddies. The relation between global circulation peculiarities and negative viscosity on the solar system's planets (Jupiter, Saturn, Venus) is considered.

Murav'ev, A. V. 1994. Visualization of atmospheric general circulation model data using correlation characteristics of the attractor. Meteorol. Hydrol. 3:10-19.

The possibility of visualizing the process generated by the barotropic T2ILI model using autocorrelation characteristics of the attractor is discussed. The Grassberger- Procaccio algorithm is used. The stability of characterics, the dependence of estimates upon autocorrelation, and the peculiarities of calculations with probabalistic space postulated are studied. It is shown that qualitative conclusions about predictability using terms of ordinal statistics may be well derived on the basis of more stable characteristics of autocovariations of the time series.

Nikitin, A. E. 1992. Conditions for the formation and sustentation of the blocking system stability over Eastern Europe in October 1987. Meteorol. Hydrol. 7:35-44.

The atmospheric circulation characteristics in the period of formation and existence of the outstanding (in terms of duration and intensity) blocking system over Eastern Europe in October 1987 are studied. It is shown that blocking should be considered a global phenomemon, the development of which is associated with the structure of the planetary circulation and the static equilibrium of the atmosphere. The stability of the circulation pattern with blocking is ensured by a balanced energy exchange between the blocking system and the zonal flow, the compensation of dissipation by heat advection into the system, and the suppression of the vortex activity in the atmosphere outside the blocking area.

Nikitin, A. E. 1991. The nature of general atmospheric circulation in the Northern Hemisphere during the different phases of the Indian monsoon. Bull. USSR Acad. Sci. . Atmos. Ocean Phys. 27(10):1161-1171.

To investigate the probable causes of variations in intensity of the Indian monsoon, the distribution of meteorological elements and of energetic characteristics in the atmosphere of the Northern Hemisphere during the active phase and the break of the monsoon in June-July of 1979 is studied. Variations in the monsoon evolution may be associated with the change of the circulation pattern in the atmosphere of the Northern Hemisphere on the whole. The lower frequency pattern corresponds to the break phase. Vorticity advection and variations in the rate of energy exchange between the zonal flow and the eddies within the system of quasi-stationary troughs associated with the blocking systems in the North of Euroasia might appear to be the cause of the break. However, changes in the tropical zone that are associated with the monsoon break, owing to the changes of flow over Tibet, might lead to a redistribution of sources and sinks of energy in the eastern part of Euroasia, changes in intensity and position of the Pacific storm-track, and consequently substantial changes of circulation conditions in middle latitudes.

Panarin, A. V. 1982. Heat-and-moisture exchange model of the spherical Earth. Prepr. Comput. Cent. Siberian Branch USSR Acad. Sci. No. 377, 13 p.

To study the influence of disturbances induced by natural and antropogenic factors, a mathematical model based on equations of heat inflow and the equation of water vapor transfer has been developed to describe heat-and-moisture exchange within the atmosphere-continent-ocean system. Dynamic factors are considered through variational agreement of meteorological element fields by means of data from observation or by solving the global atmospheric circulation problem. A definition and integral formulation of the problem are given. Integral formulation of the model allows a natural agreement between the heat-and-moisture exchange conditions in the atmosphere, ocean, and soil at the interface. Thermal atmospheric regime models formulated without regard for the ocean influence might appear to be considerably more sensitive to variations of external parameters. Climatic variations of global atmospheric temperatures with regard to differences in the time scales of motion should be studied in combination with ocean temperature variations.

Parkhomenko, V. P. 1992. Global climate models and their application in numerical experiments. pp. 87-101. In Theory and Methods of Geographical Prediction: Possibilities and Ways. Russian Acad. Sci. Scientific Council on Biosphere Problem. Moscow.

Energy balance, radiation convective, general atmospheric circulation models and the model of the U.S.S.R. Academy of Sciences Computer Center are described in general terms. Maps of the geographical distribution of calculated and observed sea level pressure for January are presented. Air temperature distributions near the underlying surface are shown, derived on the basis of the Academy of Sciences model. Calculations are given based on a joint application of a general atmospheric circulation model and a thermodynamical model of the active layer of the ocean. The field of ocean surface

temperature calculated by the Academy of Sciences model is presented. Results of calculations for determining the possible climatic consequences of nuclear war are given. The map of isolines of the optical depth of atmospheric pollution on the 7th and the 30th days of a war conflict is shown.

Penenko, V. V. 1981. Methods of Numerical Simulation of Atmospheric Processes. Gidrometeoizdat, Leningrad. 351 p.

The book contains a methodical description of numerical simulation methods of atmospheric hydrothermodynamics. The main emphasis is on the constructive algorithmic aspects of the problem. Discrete models are constructed based on a variational principle and a splitting method. Finite difference and spectral difference models, methods of analyzing the sensitivity of discrete models to the input data variation, and methods of model parameter identification, are considered, as well as methods of assimilation and adjustment of observational data

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Perevedentsev, Yu. P., and **K. M. Shantalinsky.** 1984. On the interlatitudinal exchange of relative eddying in the atmosphere of the Northern Hemisphere. Proc. West-Siberian Reg. Sci. Res. Inst. Goskomgidromet. 64:3-10.

The interlatitudinal exchange of relative eddying is considered within the following systems: middle meridional circulation, long stationary waves, and mobile eddies (i.e., cyclones and anticyclones). Eddying inflows caused by the convergence of meridional flows are estimated.

Perevedentsev, Yu. P., K. M. Shantalinsky, and **V. V. Guryanov.** 1986. On the interlatitudinal exchange of relative vorticity in the Southern Hemisphere's atmosphere. pp. 222-223. In Meteorological Research in Antarctica: Selected Papers of the 2nd All-Union Symposium, Leningrad, Oct. 19-22, 1981. Part 1. Gidrometeoizdat, Leningrad.

The transfer of relative vorticity in the system of mean meridional circulation is considered. This is produced by the circulation Gadley and Ferrel cells and by the direct Antarctic cell. In the Southern Hemisphere, the eddy transfer is shown to be more efficient in the mean circulation system than in the system of long stationary waves. The importance of the large-scale interlatitudinal exchange of vorticity for maintaining atmospheric jets is emphasized. It is assumed that the intensive transfer of relative vorticity caused by mobile baric formations is observed as a result of the increased cyclonic activity near the Antarctic coast.

Perevedentsev, Yu. P., N. V. Ismagilov, and **K. M. Shantalinent.** 1994. Atmospheric centers of action in the Northern Hemisphere. pp. 4-15. In Atmospheric Circulation, Climate, Air Pollution. Kazan Univ., Kazan.

Long-term monthly values, anomalies, mean square deviations, and correlation coefficients were calculated for parameters of atmospheric centers of action and circulation indices (climatic norms).

Correlations between [a] parameters of atmospheric centers of action and [b] atmospheric circulation and weather characteristics are considered.

Pichugin, A. M. 1986. On the stability of zonal circulation in a low-component general atmosphere circulation model. Proc. West-Siberian Reg. Sci. Res. Inst. Goskomgidromet. 77:32-36.

The problem of the zonal Gadley stream is solved by numerical means. The influence of spectral truncation parameters in the model upon the solution is considered. Dependence upon the statistical stability parameter is defined. Examples of neutral stability curves are given.

Poroshin, A. Yu., and **V. F. Romanov.** 1990. Simulation of eddy exchange in climatic models of the large-scale atmospheric dynamics. Bull. USSR Acad. Sci. Atmos. Ocean Phys. 26(3):234-247.

A semiempirical description of the effects of spatial and spectral synoptic-scale eddy exchange in climatic models of large-scale atmospheric dynamics is developed. It allows one to describe the geographical distribution of climatic parameters, taking into account longitudinal inhomogeneities and the effects of the dynamic interaction between mean circulation and synoptic processes. For this purpose, spatially smoothed equations are used instead of the zonally averaged ones, with spectral maxima of synoptic and climatic variability estimated by means of the appropriate dynamic equations. Coefficient values are determined from the diagnostic study by using climatic data. Comparing the obtained results with the experimental data shows a qualitatively correct description of the main features of mean circulation and climatic eddy dynamics and energetics. Considering the longitudinal distribution of the eddy exchange parameters makes it possible to avoid difficulties in describing the resulting mean zonal values of eddy transfer and mean zonal circulation. It is shown that it is important to take into account such longitudinal features when considering a latitudinal structure. The problems of universal estimates of coefficients in a semiempirical description of eddy dynamics and energetics effects are also covered.

Prokh, L. Z., and **O. E. Tkalich.** 1982. Characteristics of atmospheric circulation during the outbreak of the southwestern cyclones, causing strong winds in the south of Ukraine. Proc. Ukraine Reg. Sci. Res. Inst. Goskomgidromet. 189:32-37.

Outbreaks of southern and south-western cyclones are caused by a disturbance of the west-eastern troposphere transfer. To quantify these disturbances, the Blinova and Kats circulation indices are considered for the period of outbreaks of 115 southern and southwestern cyclones, which caused considerable wind strengthening in the Ukraine. Mean values of the Blinova indices during such periods are close to long-term means for the given season and month; however, their variations from daily values are considerable and reach 15-20%. Deviations of the Blinova indices from monthly and long-term means vary in a range from -9.9 to 10.3 for various types of the southwestern and southern cyclones trajectories.

The Kats indices indicate that meridional circulation prevails over Europe and the European U.S.S.R. In the period of outbreak of the cyclones considered, the general index means which are equal to 1.26, exceed the critical value considerably, $I' > 0.75$.

Rivin, I. G. 1985. Small-parametric general circulation model in the channel on the -plane. Proc. West-Siberian Reg. Res. Inst. State Com. Hydrometeorol. 75:78-86.

A nonadiabatic general circulation model is described. The integration domain is bounded by the channel without regard for spherical geometry. The heat influx is parameterized in the Newton form. Results of numerical experiments using slip and adhesion boundary conditions at the lateral boundaries of the channel are presented. The correctness of these aforementioned boundary conditions in the barotropic estimate is analyzed.

Romanov, V. F. 1987. On a climatic model of the atmospheric dynamics and experimental data assimilation. Rep. USSR Acad. Sci. USSR. 296(4):821-827.

The problem of developing climatic general circulation models is discussed. This includes the following: averaging the equations of the general circulation theory, parameterizing the statistical effects of synoptic eddy dynamics and the energetics of the atmosphere, [and] quantitatively determining unknown coefficients. The last is suggested to be solved on the basis of diagnostic modification of climatic circulation problems by using climatic data to determine parameters of the dynamics. The problem of determining the coefficients is stated as a diagnostic problem with the minimized discrepancies between the estimated and observed fields. A climatic hemispheric model of the vertically averaged atmospheric dynamics is examined as an example. Data assimilation has been performed, and the coefficients have been determined. The contribution of the eddy momentum exchange to the formation of climatic features of the circulation is studied with regard to the eddy-produced energy provided to the average flows. This contribution is shown to be important, making it possible to explain essential features of the dynamics and provide a better agreement between the solutions and climatic data.

Romanov, V. F. 1988. On the parameterization of the effects of synoptic eddy processes in climatic general circulation models. Bull. USSR Acad. Sci. Atmos. Ocean Phys. 24(4):367-380.

The atmospheric general circulation is described for climatic time scales by a set of equations including an explicit description of the averaged dynamics of eddy modes and the dynamic interaction of synoptic-scale eddy modes and mean fluxes. The system parameterizes the effects of shear and eddy viscosity, associated mass effect, the friction of large-scale and eddy motions at the underlying surface, diffusive eddy motions, eddy exchange, barotropic instability, and a dynamic effect of the eddy pressure anomaly. Eddy motions are shown to transfer energy to mean fluxes, with total kinetic and mechanical energy being conserved. To simplify the model of the zonally averaged plane atmosphere, the problem of large-scale circulation was solved analytically. The results are in good agreement with climatic data and describe a concentration of the zonal jet. A numerical experiment with a three-dimensional global climatic model explains the formation of jet flows in the eddy peripheral zones by the effects of eddy exchange.

Rykov, V. V. 1981. Numerical simulation of atmospheric motions in a restricted area. Moscow. Comput. Cent. USSR Acad. Sci. 31 p.

The problem of a local increase of spatial resolution when atmospheric motions are calculated is considered. This problem is associated with the need for detailing small-scale processes, which are not approximated by a general atmospheric circulation model. Atmospheric motions are described in the shallow water approximation at the surface and on the rotating sphere. Nonreflexive boundary conditions for motions in an internal area, considering the impact of an external large-scale solution, are offered. A possibility is shown for calculating hydrodynamical processes in regional areas with spatial resolution increased by time considerably exceeding the time of the signal pass (sound and gravitational signals) through the specified area.

Samrov, V. P. 1987. A low-parameter model for a qualitative study of long-term general circulation variations. Proc. USSR Hydrometeorol. Res. Cent. 278:76-81.

A spectral baroclinic, quasi-geostrophic general circulation model in spherical geometry is described. The model has the minimum number of waves required to describe nonlinear interactions between the motions of planetary and synoptic scales; this allows it to be used in a qualitative study of long-period general circulation variations without consuming a lot of computer time.

Semyonova, I. V. 1983. Estimates of the parameterization of radiant fluxes in large-scale atmospheric circulation models. Proc. Arct. Antarct. Res. Inst. 392:74-80.

The values of long-wave updrafts and downdrafts at upper and lower atmospheric boundaries are examined. A comparison is made between the parameterization of these long-wave fluxes in low-parameter. large-scale atmospheric circulation models with clouds specified with respect to their levels and to the total number of octas only. Climatic data for the Northern Hemisphere are used. Some estimates as to the "accuracy" of model representations of radiant fluxes are given.

Sergin, V. Ya., and **A. P. Oreshko.** 1987. A time-averaged global circulation model. Meteorol. Hydrol. 7:13-22.

A time-averaged, three-dimensional hydrodynamical model of the atmosphere is constructed to simulate the smoothed seasonal variations of meteorological elements and their climatic evolution. The model includes heat and moisture transport equations and takes into account all major nonadiabatic heat influxes and a global water cycle. Dynamical equations are split into zonally averaged and three-dimensional, quasi-stationary nonzonal deviations. The transports of angular momentum, heat, and moisture by nonstationary synoptic eddies are parameterized in macroturbulence terms. Numerical experiments show that the time-averaged model satisfactorily simulates the climatic atmospheric fields and reduces computer time considerably.

Sidorenkov, N. S. 1982. On the nature of zonal atmospheric circulation. Proc. USSR Hydrometeorol. Res. Cent. 248:66-75.

Annual mean zonal atmospheric circulation is shown to be generated by the equalization of the absolute angular momentum under the influence of macroturbulent mixing. Dissimilarities of the concept from current ideas about atmospheric transfer processes are shown and accounted for. A semiempirical differential equation of the specific angular momentum balance in the atmosphere is derived.

Sidorenkov, N. S. 1991. Physics of mean annual atmospheric circulation. Proc. USSR Hydrometeorol. Res. Cent. 316:3-18.

Mean annual zonal atmospheric circulation appears to be the result of a leveling off of the absolute angular momentum induced by macroturbulent mixing. Microturbulent viscosity attenuates circulation. Circulation becomes stationary only when the specified positive angular momentum is accumulated in the atmosphere. The atmosphere borrows this angular momentum from the Earth. A semi-empirical differential equation is derived for the distribution of specific angular momentum in the atmosphere. Its analytical solution is obtained for the case in which turbulence coefficients are assigned according to the simplest model. It is asserted that theory and observations are in good agreement. The mechanism of the formation of subtropical pressure maximums is explained.

Sidorenkov, N. S. (ed.). 1992. Monitoring of general atmospheric circulation. Proc. Hydrometeorol. Res. Cent. of the Russian Federation. No. 322, 93 p.

Results of monitoring basic parameters of general atmospheric circulation are generalized for the period 1986-1990. An analysis of the time trends and estimates of anomalies are presented for such atmospheric characteristics as circulation intensity, mass, temperature, angular momentum, kinetic energy, and quasi-two-year cyclicity, as well as for southern oscillation, Earth rotation velocity, and the motion of the poles.

Sitnikov, I. G., and **M. N. Titov.** 1988. Dynamics, energetics, and wave processes of the tropical zone in a general circulation model. Meteorol. Hydrol. 8:5-19.

This article describes numerical experiments on analyzing features of the tropical zone in a prognostic version of the atmospheric general circulation model developed by I.V. Trosnikov and other authors at the U.S.S.R. Hydro-meteorological Research Center. A four-level version of hemispheric and global models is used. The characteristics averaged over the integration period are compared with FGGE data and some climatic distributions for the tropics. The zonal distributions of wind, temperature, transfer of heat, and angular momentum across the circles of latitude, as well as some energetics characteristics are computed. A spectral analysis of model-generated disturbances is carried out, and major wave types are revealed. The diagnostic distribution of convective precipitation is obtained from the model fields. It is shown that the model simulates the structure and energetics of the tropical atmosphere correctly enough. Possible causes of discrepancies between the results and observation data are examined.

Skrotskaya, O. P. 1988. Numerical simulation of the formation and evolution of large-scale nonconvective clouds in a weather forecast model. pp. 132-137. In Numerical Simulation of Stratiform Clouds and Their Modification. [Rep. All-Union Seminar (Kiev, 1985)]. Gidrometeoizdat.

The paper is devoted to the problem of numerically simulating stratiform cloud evolution in weather forecasts and general circulation models. The function Ψ transfer equation is used to predict moisture and water content of the cloud atmosphere, the function Ψ being a combination of the dew point deficit and water content. Additional relationships that make it possible to take into account the features of large-scale processes are also introduced. Some results of numerical experiments for large-scale condensation modeling are presented.

Skrotskaya, O. P., and **I. G. Ostapenko.** 1994. Parameterization of some cloudiness characteristics for general circulation models. Bull. Sci. Acad. Atmos. Ocean Phys. 30(4):564-571.

A method is proposed for parameterizing the threshold conditions of condensation. The method is based on a statistical representation of humidity and temperature inside an integration cell. Relationships for statistical characteristics of variables are given. Suggestions are made concerning the applicability of the results to general circulation models.

Sokolov, A. P. 1986. Simulation of the January atmospheric circulation using a global spectral model. Meteorol. Hydrol. 2:12-21.

A short description is given of an atmospheric general circulation model based on a numerical integration of the hydrothermodynamic equations expressed in spherical coordinates. The horizontal weather element fields are expanded on a spherical function series; in the vertical direction, the finite-difference approximation of variables is performed. The employed parameterizations of nonadiabatic processes are described. Results of two experimental simulations of January atmospheric circulation indicate that the model simulates the general features of the observed atmospheric circulation quite well. The results are compared with findings from other studies.

Sonechkin, D. M. 1987. Some methodical problems to study and model long-term variations of general atmospheric circulation. Proc. USSR Hydrometeorol. Res. Cent. 278:3-27.

The problem of predictability in numerical weather forecasting is discussed. The importance of using concepts and methods of dynamic system theory in studying predictability is shown. Using a single-wave, spectral, quasi-geostrophic atmospheric model as an example, it is shown how predictability deteriorates when the forecast has inaccurately specified initial conditions. With a two-wave model taken as an example, a new form of equations of atmospheric dynamics involving a division into "fast" and "slow" motions is constructed. Owing to the averaging technique, this form is shown to be promising in developing new methods of numerical weather forecasting for terms that exceed the predictability limits of the present forecasting models.

Sonechkin, D. M. (ed.). 1987. Statistics of general atmospheric circulation and its models. Proc. USSR Hydrometeorol. Sci. Res. Cent. No. 278, 135 p.

Problems of simulation, description, and prediction of long-period oscillation in the system of general atmospheric circulation are discussed on the basis of a dynamical-statistical approach. Various characteristics of long-term oscillations in low-component models are presented, as well as results of computing the statistical characteristics of actual meteorological fields and fields of sea surface temperature in the Northern Hemisphere.

Sonechkin, D. M., I. L. Vlasova, and **N. E. Zimin.** 1993. Long-period oscillations of zonal flow and wave amplitudes in the 500-hPa geopotential field. Meteorol. Hydrol. 8:28-36.

The search has been continued for regularities in the long-period oscillation of atmospheric circulation that result from qualitative studies of strange-attractor, low-component atmospheric models. It has been found that time oscillations of principal zonal modes and wave amplitudes having the same zonal and similar meridional wave numbers are synchronous.

Stenchikov, G. L., and **D. V. Turkov.** 1988. Computing the seasonal patterns of atmospheric circulation. Moscow. Comput. Cent. USSR Acad. Sci. 27 p.

Stationary atmospheric circulation patterns for January and July are computed by using a two-level climate model, and the impact of the underlying surface on them is assessed. Results of computations are compared with observation data in terms of both quantity and quality. For July, climate variations induced by the decrease in the sea ice area are studied. For January, climate variations induced by the substitution of Antarctic continental ice for the continental surface area free from ice and snow are studied.

Tarnopolsky, A. G., and **V. A. Shnaydman.** 1984. Modeling the interacting atmospheric and oceanic boundary layers. Meteorol. Hydrol. 5:48-56.

A closed set of equations that incorporate equations of motion, balance, and dissipation of kinetic energy of turbulence are solved, and the processes in the boundary layers of the atmosphere and ocean with regard for their interaction are simulated. The formulated algorithm takes into account the effect of wind waves on the vertical structure of atmospheric and oceanic turbulence. Vertical profiles of turbulence parameters are presented as a function of external factors. It is demonstrated that with the wave height growth, the maximum of the turbulence coefficient shifts to the ocean surface. Dependencies of dynamic velocity, roughness, and its ratio to the wave height upon the sea surface wind speed are derived and are in conformity with experimental data. Typical examples of model calculations using weather ship observations are given.

Trosnikov, I. V., and **A. V. Murav'ev.** 1993. Possibilities of statistical filtration of trends in general atmospheric circulation models. Meteorol. Hydrol. 11:22-31.

Characteristics are given for the global trend that arises in the 500-hPa isobaric surface fields with prolonged integration of the spectral hydrodynamic model T21LI5 of the Research Hydrometeorological Center of the Russian Federation. A significant difference in the trend characteristics for the Northern and Southern hemispheres is found. The capabilities of the aposteriori filtration of trends with the polynomial local moving approximation are demonstrated.

Vereshchagin, M. A., and **Yu. P. Perevedentsev.** 1982. Interlatitudinal heat exchange in the troposphere and lower stratosphere in the system of the mean meridional circulation in the Northern Hemisphere in the winter. Proc. West-Siberian Reg. Res. Inst. State Com. Hydrometeorol. 54:74-84.

An internal and spatial structure of heat fluxes (HF) in the system of the mean meridional atmospheric circulation at 1000-30 mb in the Northern Hemisphere in winter (January) is analyzed. Advective heat fluxes (AHF), stationary macroturbulent heat fluxes (SMTHF) going through the full latitudinal circles, and heat fluxes determined by their convergence are calculated from aeroclimatic data in the 10-80° N zone for both individual heights and the whole 1000-30 mb layer. AHFs are one or two orders of magnitude larger than SMTHFs. The SMTHFs' contribution to the meridional heat transfer attains the largest values at temperate and high latitudes. Heat fluxes determined by the convergence of AHFs and SMTHFs are comparable with other atmospheric heat balance components. Advective heat exchange contributes to greater meridional temperature contrasts in the subtropical planetary height frontal zone and weaker temperature contrasts in the portion of the height frontal zone related to the stratospheric (western) jet. Heat exchange in the system of stationary eddies promotes a leveling of the meridional temperature contrasts in the subtropical height frontal zone.

Vilfand, R. M. 1983. On atmospheric waves. Proc. USSR Hydrometeorol. Res. Cent. 257:35-39.

Spectra of large-scale atmospheric circulation indices are calculated. A statistically significant 2.3-month harmonic has been revealed.

Vlasova, I. L., N. E. Zimin, and **D. M. Sonechkin.** 1989. Relaxation oscillations and phase synchronization of planetary waves. Meteorol. Hydrol. 11:33-42.

Based on a model of general atmospheric circulation as an assemblage of interacting nonlinear oscillators, an analysis is conducted concerning the dynamics of planetary waves of the northern hemispheric 500-hPa geopotential field. Two alternating patterns of wave motion are found to be typical: "oscillatory," when the wave phase oscillates around a mean position for about a month, and "rotating," when the wave phase changes fast and monotonically in 2 π times during a week or so. In the "oscillatory" pattern the phases of waves corresponding to the same zonal wave number are synchronized in pairs. The results are of interest in developing methods for numerical long-range forecasts of weather.

Volkov, Yu. N., and **E. V. Karasev.** 1987. Numerical experiments with a two-level general circulation model. Proc. Far-East Reg. Res. Hydrometeorol. Inst. 127:101-116.

A quasi-geostrophic, low-component general circulation model is studied with regard to heat influx and kinetic energy dissipation. Results of numerical experiments to modify parameters characterizing the spatial inhomogeneity of heat influx velocity ("equator-pole," "ocean-continent") are examined. The atmospheric model adequately describes specific major features of the general circulation model: seasonal atmospheric centers of action, west-easterlies at temporate latitudes, and low- and high-latitude easterlies. A wide range of variations of atmospheric characteristics is observed at the heat flux constant in time.

Volkov, Yu. N., E. V. Karasev, G. I. Anzhina, and **B. M. Kalashnikov.** 1988. Statistical analysis of data from the numerical realization of a low-component general circulation model. Proc. Far-East Reg. Res. Hydrometeorol. Inst. 139:68-75.

Data from the numerical realization of a low-component general circulation model are statistically processed. Regression and analog methods of statistical analysis are tested from model data.

Zhikharev, G. M. 1986. Multiple equilibra and the role of topography in low-order atmospheric circulation models. Bull. Acad. Sci. USSR Atmos. Ocean Phys. 22(7):691-700.

The effect of topography and external driving are considered in a low-order, quasigeostrophic model of barotropic atmosphere. Topography is represented by one nonzonal wave mode. In case I, when external driving is represented by the zonal mode *X*, three stationary regimes may exist with the supercritical amplitude of topography *H*. Variation of *X* allows transitions between two stable solutions with high and low zonal indices. These transitions have the form of a hysteresis event. In case II, when external forcing is represented by the wave mode *Y*, β-effect provides periodic instability of the solution with a western zonal flux (*Y* is slightly supercritical). The stabilizing effect of *Y* depends on *H*. With *H* approaching 0, when the energy flux from wave modes to the zonal mode is negligible, physically significant values of *Y* cannot suppress instability. But the solution becomes stable as *H* grows, with *Y* being large enough.

Zolotokrylin, A. N., L. V. Khemelevskaya, and **N. L. Shuvaeva.** 1992. A study of circulation extremes in the Northern Hemisphere. Cont. Meteorol. Stud. 15:151-156.

Results are presented from studies of long-term circulation dynamics in the Northern Hemisphere using typification of elementary circulation mechanisms according to B. A. Dzerdzeevky.