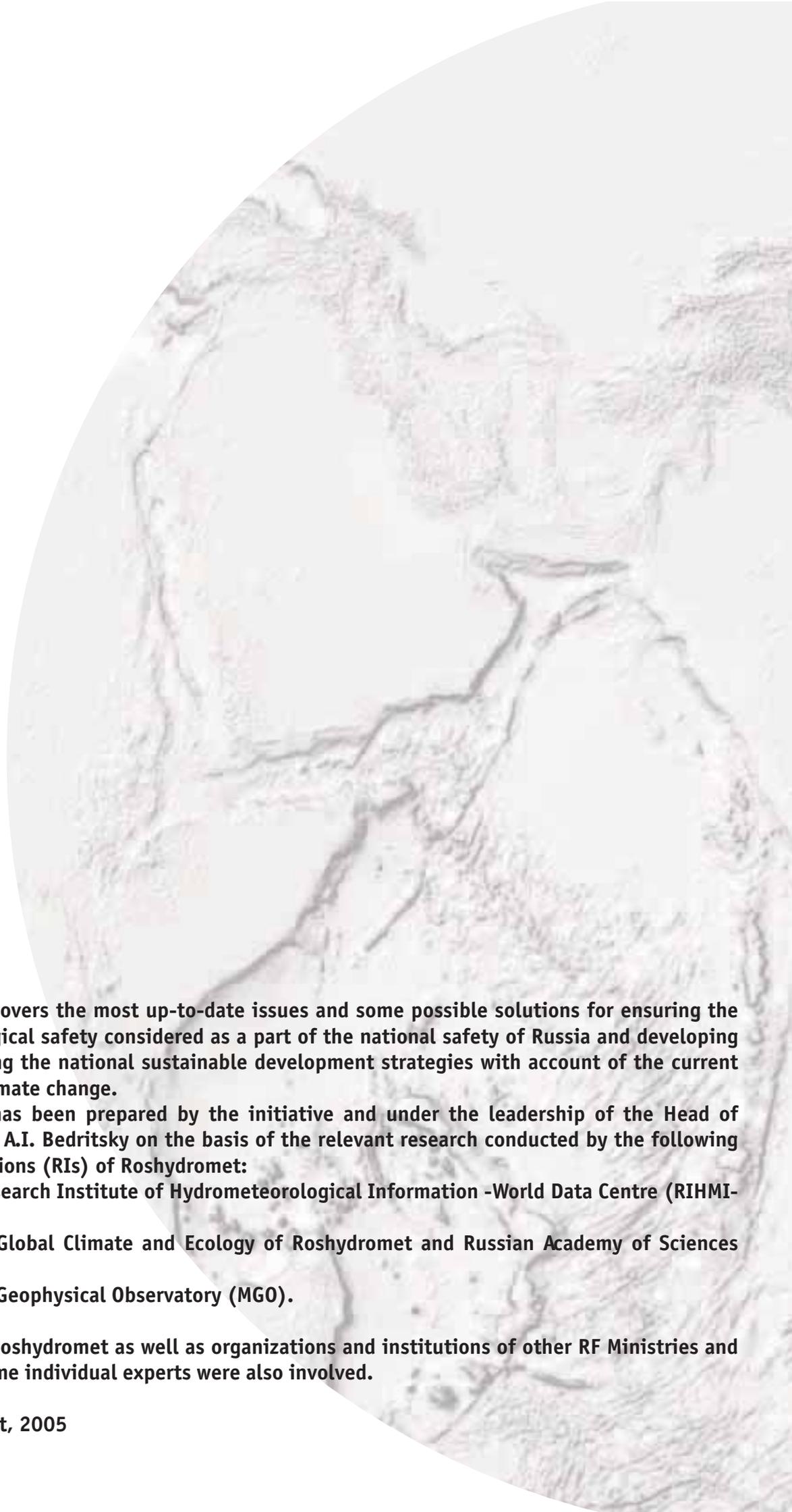
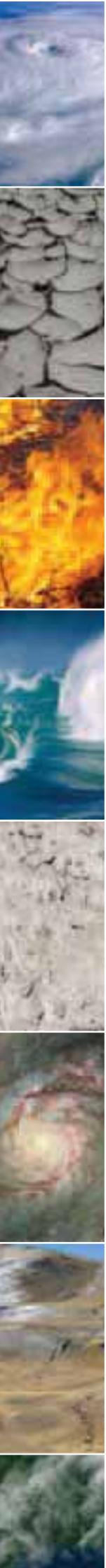




**Working out the Russian Federation
sustainable development strategies with
account of the changing climate factors**



This booklet covers the most up-to-date issues and some possible solutions for ensuring the hydrometeorological safety considered as a part of the national safety of Russia and developing and implementing the national sustainable development strategies with account of the current and expected climate change.

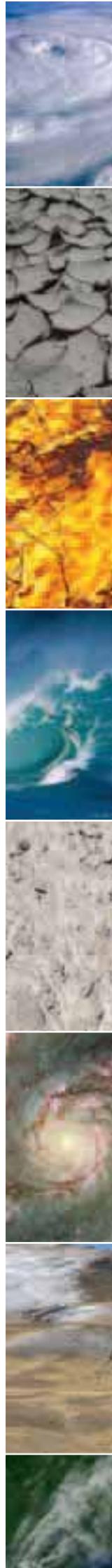
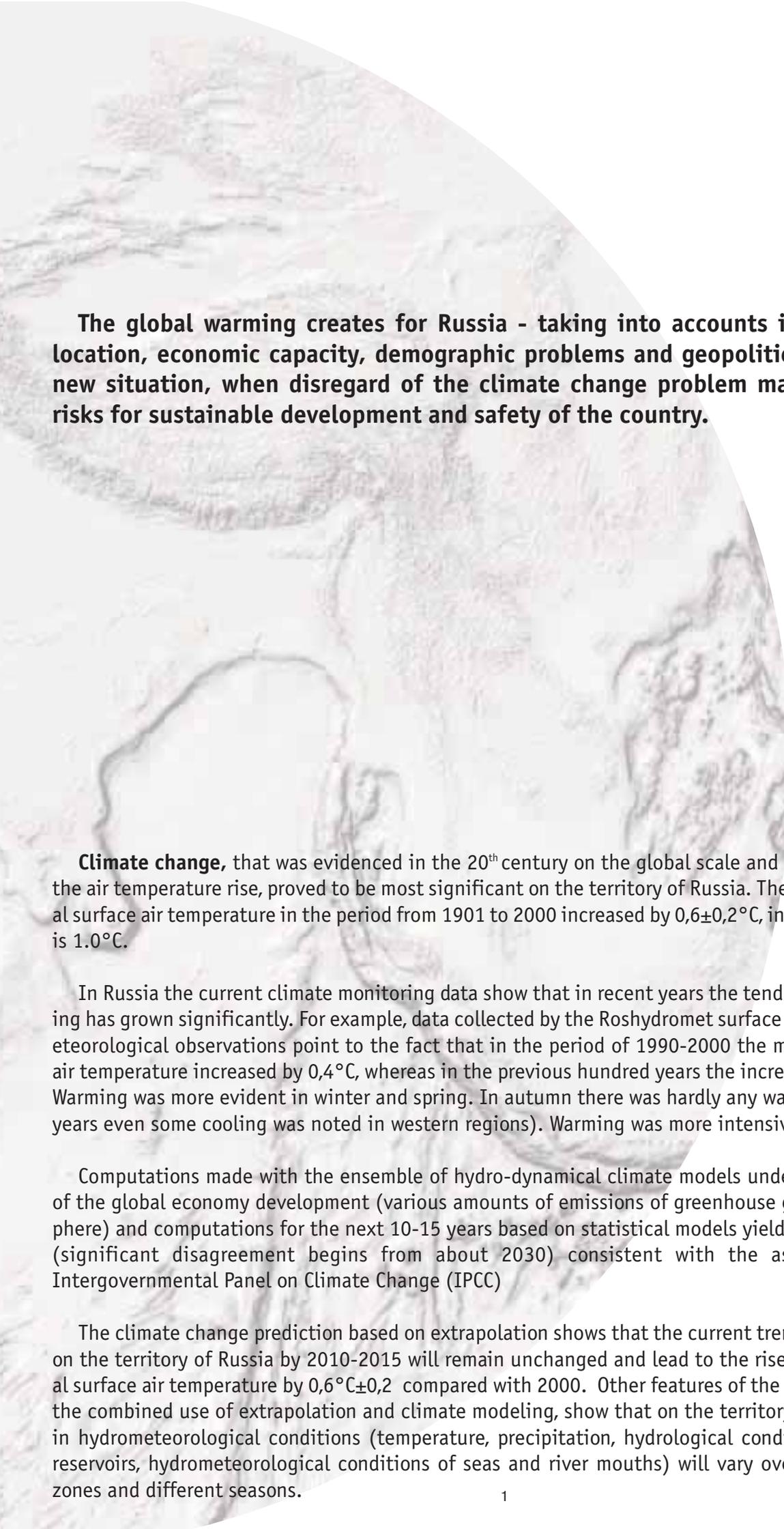
The booklet has been prepared by the initiative and under the leadership of the Head of Roshydromet Dr. A.I. Bedritsky on the basis of the relevant research conducted by the following research institutions (RIs) of Roshydromet:

All-Russia Research Institute of Hydrometeorological Information -World Data Centre (RIHMI-WDC),

Institute for Global Climate and Ecology of Roshydromet and Russian Academy of Sciences (IGCE),

Voeikov Main Geophysical Observatory (MGO).

Other RIs of Roshydromet as well as organizations and institutions of other RF Ministries and Agencies and some individual experts were also involved.



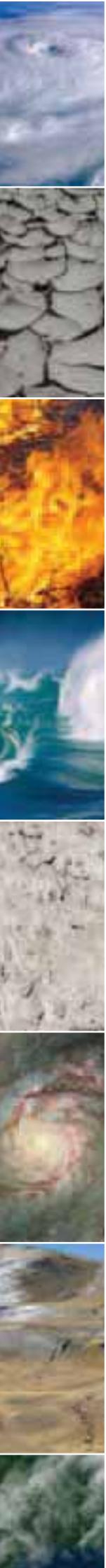
The global warming creates for Russia - taking into accounts its geographical location, economic capacity, demographic problems and geopolitical interests - a new situation, when disregard of the climate change problem may elicit serious risks for sustainable development and safety of the country.

Climate change, that was evidenced in the 20th century on the global scale and manifested itself in the air temperature rise, proved to be most significant on the territory of Russia. The global mean annual surface air temperature in the period from 1901 to 2000 increased by $0,6 \pm 0,2^{\circ}\text{C}$, in Russia the increase is $1,0^{\circ}\text{C}$.

In Russia the current climate monitoring data show that in recent years the tendency towards warming has grown significantly. For example, data collected by the Roshydromet surface network of hydrometeorological observations point to the fact that in the period of 1990-2000 the mean annual surface air temperature increased by $0,4^{\circ}\text{C}$, whereas in the previous hundred years the increase was only $1,0^{\circ}\text{C}$. Warming was more evident in winter and spring. In autumn there was hardly any warming (in recent 30 years even some cooling was noted in western regions). Warming was more intensive east of Urals.

Computations made with the ensemble of hydro-dynamical climate models under various scenarios of the global economy development (various amounts of emissions of greenhouse gases to the atmosphere) and computations for the next 10-15 years based on statistical models yield very similar results (significant disagreement begins from about 2030) consistent with the assessments of the Intergovernmental Panel on Climate Change (IPCC)

The climate change prediction based on extrapolation shows that the current trend towards warming on the territory of Russia by 2010-2015 will remain unchanged and lead to the rise of the mean annual surface air temperature by $0,6^{\circ}\text{C} \pm 0,2$ compared with 2000. Other features of the prediction based on the combined use of extrapolation and climate modeling, show that on the territory of Russia changes in hydrometeorological conditions (temperature, precipitation, hydrological conditions of rivers and reservoirs, hydrometeorological conditions of seas and river mouths) will vary over different climate zones and different seasons.



By 2015 on most of the territory of Russia air temperature in winter is expected to further rise by about 1°C with some variations over different regions of the country. In summer in general the expected warming will be not as pronounced as in winter. temperature will rise by 0,4°C.

The mean annual amount of precipitation is expected to further increase, mainly due to the increase in the cold period. On most of the territory of the country the predicted amount of precipitation will exceed that received at present by 4-6%. The most significant precipitation increase is expected in the north of Eastern Siberia (by up to 7-9%).

It is common practice to divide a variety of climate change factors into internal (i.e. processes within the climate system, which includes the atmosphere, oceans, active land layer and cryosphere) and external to the climate system. The latter in turn are divided into natural (time variations in the energy flow from the Sun to the Earth, concentrations of volcanic aerosols in the atmosphere, etc.) and anthropogenic (on the global scale these are basically changes in active component concentration in the atmosphere as well as changes in the landscape, vegetation, hydrological cycle etc. caused by economic activities).

It is very important and very difficult to determine the overall cause of the climate change experienced today. At present the most wide-spread opinion is that it can be explained by the combination of two main factors: long-period fluctuations of atmospheric circulation and global warming induced by the increase of greenhouse gases in the atmosphere. Studies on the contribution of the anthropogenic factors are continued providing an increasingly convincing evidence of the fact that the warming experienced in the late 20th and early 21st century cannot be attributed only to natural processes. The further increase of the anthropogenic factor should therefore be expected as far as the on-going climate change is concerned.

For the moment the main hypothesis remains unchanged. It holds that the significant part of the warming experienced in the late 20th and early 21st century is accounted for by the additional greenhouse effect resulted from anthropogenic emissions of active gases (primarily carbon dioxide - CO₂). Data of observations show a very significant growth of CO₂ concentrations in the second half of the 20th century (about 50 parts per million). It is more than a half of the CO₂ concentration growth in the period of transition from the glacial to interglacial conditions. The growth of methane (CH₄) concentration, which is another important greenhouse gas, in the industrial period is even more intensive: from about 700 ppb (parts per billion) in the early 18th century (mean value for the interglacial periods) to 900 ppb in the early and 1700 ppb in the late 20th century. However, radiation forcing caused by the observed change in methane concentration is about three times lower than that caused by carbon dioxide.

The greenhouse potential of ozone, fluorocarbons and nitrogen (in the form of nitrogen oxide) is even lower. The impacts of the most active greenhouse gas - water vapor -are not studied adequately; the impact of direct changes in water vapor concentrations caused by economic activities (irrigation, clear-cutting of a forest etc.) is not likely to be high. The assessments of the effect caused by the changes in moisture content in the atmosphere include numerous feedback (including cloud feedback) and are highly uncertain. In general the growth of moisture content in the planetary boundary layer (1-2 lower kilometers of the atmosphere) caused by the increase in the moisture-holding capacity of the atmosphere and evaporation during warming is expected to be equivalent to the effect in the radiation balance caused by the growth of carbon dioxide concentration. However, very little is known on the changes and effects of water vapor in the higher layers of the atmosphere.

But serious uncertainties resulting from the inadequacy of observations, difficulty in understanding of physical processes and numerous feedback within the climate system, reliability of climate models, difficulty to detect low anthropogenic signal amid high natural climate variability still **do not allow clear conclusions on the contribution of greenhouse gases anthropogenic emissions to the warming being observed.**

In Russia most of the climate studies are traditionally conducted by the institutions of the Hydrometeorological Service (now - Roshydromet), Academy of Sciences and Higher Education System.

Climate in Russia is studied intensively, and the achievements of Roshydromet scientists, in particular, are significant (1980-85: Scientific Application Reference Book on Climate of the USSR was produced; 2002: Monograph "Climate of Russia" was published; 2005: Encyclopedia of Climate Resources of the Russian Federation was prepared and a number of climate-related publications were issued).

However it should be noted that in the last decade of the 20th century Russia began to fall behind the world standards in climate study. To a considerable extent it was due to the prolonged crisis in research activities caused by inadequate funding. Young people are no more interested in science as they used to be and due to the ageing of personnel a scientific capacity of Roshydromet, Academy of Sciences and Higher Education System is continuously decreasing. In the field of climate study the situation is aggravated because of the inappropriate coordination. In conditions of inadequate funding waste and duplication of efforts is not permissible. At the same time to date there is no mechanism to effectively coordinate inter-agency research activities.

The state control of the most important areas of climate change study might be a reasonable way out. This will make the whole range of scientific findings available to the relevant decision making and planning bodies. Such approach will make it possible to incorporate more effectively the national priority areas of climate study into international programmes, to make bilateral and corporate contacts, to increase the international visibility of national commitments.

Attention should be paid to the role of Roshydromet as a body that can better than any other agency perform as a coordinator of climate change study activities carried out under state control.

Obtaining reliable information on the state of climate system and on current climate conditions on the territory of specific regions of the country is one of the most important tasks in the field of climate study. Special attention should be given to the quality and processing of information coming via the Global Telecommunication System (GTS) of the World Meteorological Organization. The problem of receiving and applying satellite information becomes increasingly important. At the same time to assess the extent to which the current conditions are abnormal and probability of their recurrence, the reliable data for the longest possible period, sometimes longer than the period of instrumental observations are required. A large amount of work should be done on the check of data homogeneity using all the available information on the station history and on the change of instruments and methods of observations (the so-called metadata) to create baseline data sets. Until recently investigation of climate variability on the territory of Russia was encumbered by the lack of time series on computer-compatible media required for the statistical analysis. Today due to advances in computer facilities and information technologies the situation is changing. Significant volumes of data become available. The integrated processing of these data may and should result in new climate knowledge. **Data objectively reflecting the current status and nature of changes in the climate system are the essential basis for climate study and a simplified idea of data accumulation, analysis and use may eventually produce wrong conclusions on the state of the climate system.**

Requirements to the quality of data form the basis of the whole set of climate study activities and application of climate knowledge. An integrated approach to the problem of data dictates the need of developing a sequential multi-phase procedure of data obtaining, beginning from the data of observations and ending with homogenous high-quality meteorological data series. Consistent requirements to the data quality should be met at each phase of the procedure. It is therefore necessary to take measures to improve the quality of data obtained by the network of meteorological stations, to develop up-to-date software to control data at the stage of their incorporation into the State Data Fund and to col-





lect and place on computer compatible media all the information on the history of each station. Only after that it is possible to create an efficient system of monitoring the current state of the climate system (climate monitoring) as well as to obtain reliable information on climate change during the historical period, which should be used for making decisions on adaptation and applied in various sectors of the economy.

It is appropriate as a matter of priority in the field of climate science to speed up the development of the unified data sets to be used for research, to ensure their reliable storage, to extend a range of users of such data including users from various social and economic sectors, to establish creative teams for the joint analysis of the newly developed data sets.

In recent years owing to the international cooperation in the field of model intercomparison and easier access to the Internet in the Russian Federation, the emphasis in model studies performed in Russia has shifted to the analysis of climate computations made predominantly with foreign models and the use of the outcome in applied research. As for the most technologically complicated and resource-consuming activities related to the **development of physico-mathematical atmosphere and ocean models** there is some falling behind the world standards. In the coming decade the development of new and improvement of existing models will remain a priority area of fundamental science in the most developed countries. With this in view the development of the national models meeting the world standards as well as the use of these models in climate prediction and other fundamental research should a high priority task for the climate science in Russia. Without national models and the appropriate infrastructure for their further development it will be difficult for Russia to maintain its independent and scientifically based position in the process of taking various political and economic decisions.

To ensure reliability and sustainability of economic sectors in the Russian Federation, it is required that all natural resources, including climate, be effectively used. This approach imposes special requirements on climate information and provision of climate and climate change information in the form that can be used in different social and economic sectors. Our objective is to develop specialized indices that describe as completely as possible the dependence of a specific sector on climatic conditions. Among these is a bioclimatic potential determining a relation of the crop yield to heat and moisture indices, as well as specialized indices used in wind and solar energy.

The ongoing and potential impacts of changing climate on national socio-economic sectors make it necessary to develop climate change adaptation measures for the sustainable development of the country. Adaptation calls for a number of measures to ensure adaptability of the system to the actual or anticipated change.

As applied to a climatic system, this implies a set of economic, social, administrative and even political measures allowing a creation of public infrastructures and flexible socio-economic systems that are resistant to the ongoing and anticipated climate change. To develop adaptation measures, it is necessary to assess the vulnerability of different ecological and technological systems to climate variability and climate change, which is to be followed by integrated monitoring of changes occurring within the climate system. Of particular importance are the warnings of hazardous climate change events. Adaptation issues are given much emphasis in implementing recommendations of the UN Framework Convention on Climate Change. A five-year programme of climate change adaptation is now being developed. In this case it is very important to prepare national adaptation programmes that, while being connected with the integrated programme, reflect national priorities and measures to prevent climate change consequences. In the Russian context of adaptation, one of the first priorities is to obtain reliable and comprehensive information on the ongoing and predicted climate change on the Russian territory. It is obvious that the solution of this problem depends on a number of measures to be taken to improve the meteorological network and quality of observations, as well as to improve data processing and presentation methods. This will provide the opportunity to identify the first-level actions that are to be taken immediately in individual regions of Russia.

In this case strategic problems to overcome long-term effects of climate change are also to be solved. **The necessity of developing the Russian national programme on climate change adaptation is beyond question.**

In 2005, Roshydromet issued the Strategic Prediction of Climate Change in the Russian Federation for the period to 2010-2015 and its impact on the economic sectors in Russia. From analyzing long-term instrumental climate observations on the Russian territory and summarizing national and foreign studies to assess probable climate change in the near future, the Prediction evaluates the changes in the climate system components which are expected to occur until 2015 on the Russian territory. Recommendations were prepared for socio-economic sectors to take into account climate change in the next decade.

The Strategic Prediction can be used by governmental authorities and other organizations involved in policy making and planning of specific measures for the development of economic sectors, as well as in preparing the programmes of sustainable development of territories and regions.

According to the Strategic Prediction, under changing climate, its manifestations and impacts on different economic sectors and living conditions are of clearly pronounced regional character. This is to be taken into account in developing and implementing the programmes of medium- and long-term socio-economic development of Russia and its regions and constituents. Special attention is to be given to: (1) further specification of assessments of the climate change impact as applied to each of the Russian Federation constituents, (2) identification of economic sectors most sensible to sharp adverse weather and climate changes, and (3) improvement of the national system of early detection of hazardous hydrometeorological events (HE) and forecasting of their evolution.

Given the increasing number and the intensity of HEs, one of the most important lines of activity to protect human, society and state against hazardous extreme weather and climate events is to improve hydrometeorological safety which is to be considered as a factor of sustainable economic development.

The efficiency of the hydrometeorological safety strategy is connected with minimization of economic and social losses. Efforts to realize the strategy should primarily focus on the creation and improvement of information activity related to HE early detection and forecasting, as well as making society and decision-makers aware of these events. Of importance here is the technical improvement of environmental monitoring on the Russian territory.

Early adaptation measures, which are to be considered as one of the ways of implementing the hydrometeorological security strategy, will make it possible to make economy and production more resistant to the ongoing climate change and sharp manifestations of weather and climate variability, to avoid (or, at least, to decrease as much as possible) the losses caused by HEs and adverse effects of climate variability, and to improve production efficiency by taking into account favourable climate changes.

Uncertainties in our knowledge of the climate character and trends are still very high, which is clearly demonstrated by research results, including those mentioned here. Nevertheless, along with the necessity of giving proper attention to the further development and improvement of our knowledge of the processes in question, decisive actions for mitigation of climate change effects and adaptation of economy to these effects are to be taken right now.

The use of conclusions and recommendations of the Strategic Prediction in taking national actions will also be a major and valuable contribution of the Russian Federation to the fulfillment of international commitments as to climate and climate change, risk reduction and mitigation of natural disasters, and commitments related to other international conventions, contracts, protocols and agreements.





The benefit from using climate information receives increasing attention at the international level, too. One of the WMO priority projects is CLIPS, climate information and prediction services. Under this project, great progress has been achieved in the development of methods for climate information use which are largely applied to tropical countries. It is advisable to more actively participate in the meetings held within WMO and WMO Regional Associations (RA VI and RA II), which are dedicated to current methods of using climate information, as well as to promote the distribution of these methods and their introduction into practice.

The success in future climate change assessments is primarily related to the development of climate research and the accessibility of computational resources. In climate forecasting, future changes in concentrations of greenhouse gases and other radiation active substances are the most important model inputs. These substances modify the radiation impact on the planet and cause climate change on very long time scales. Therefore, in modelling the probable state of future climate, the term "prospective assessment", rather than "forecast" or "prediction", is to be applied.

Physical processes, which are not important in general circulation prediction models for five to seven days and even in long-term weather forecasts, become determining in climate modelling. This is particularly related to the ocean circulation dynamics, the change in the underlying surface landscape, and the evolution of the snow and ice cover. Considerable efforts will be required to study these processes, before many climate aspects can be simulated realistically. Nevertheless, despite the complexity of physical processes, there is no doubt that the existing climate models provide a helpful prospective assessment of climate change.

Many of the current models allow a satisfactory climate modelling. Moreover, current modeling is capable of simulating large-scale changes in surface temperature observed in the 20th century. This large-scale agreement between modelling results and observations improves the accuracy in warming rate assessments computed for the century to follow. The modelling of the observed natural variability (e.g. El Niño, monsoon circulation, North Atlantic Oscillation) also improved.

On the other hand, systematic errors remain too high. One of the factors throwing doubt upon a prospective assessment of climate change is uncertainty of the external impact (e.g. future concentrations of atmospheric carbon dioxide and other greenhouse gases and aerosols). For the Russian Federation to achieve success in assessing future climate change, it is necessary to bridge a gap in the science of physical processes in the climate system, to improve the information support of this activity and, finally, to do away with the lag in the application of computer and communication facilities. Of importance is also the interaction between the centre and the regions in making regional prospective climate change assessments.

At present, there are a large number of international and regional programmes to study climate of different regions in the Northern Hemisphere (the Arctic, Northern Eurasia, Western Europe, South-Eastern Asia, etc.). Some of the programmes are dedicated to the study of global atmospheric and oceanic processes. At the same time it seems necessary to draw particular attention **to the integrated study of climate changes occurring in the mid-latitude zone of the Northern Hemisphere**. Programmes focused on the above subject, which would integrate regional and national research efforts, are not available, despite the fact that the level of regional and national climate research conducted by countries of high scientific potential for mid latitudes of the Northern Hemisphere is much higher, as compared to research conducted for the other regions of the world.

Mid-latitude climate research conducted under the joint scientific programme involving a number of developed countries, which was initiated by Russia, can serve as a basis for joint efforts to analyze the impact of the climate change, particularly the change in the climate extreme frequency, on the fuel and energy sector in the states located in this zone, i.e. all G-8 states, **which is particularly important in the context of the global energy security initiative put forward by Russia**.

Special attention should be given to the problem of changing climate of large cities. At present, developed countries in the mid-latitude zone of the Northern Hemisphere conduct such studies; however, coordination of efforts and the use of the world experience to solve the problem of megacity climate have not reached the proper level yet. Megacities in the mid-latitude zone account for a significant part of the population of developed countries exposed to weather and climate extreme events (heat and cold waves, sharp temperature gradients, extraordinarily intensive precipitation, etc.). The experience in analyzing and mitigating the effects of these events is extremely important and is worth studying and using. High population density makes these regions sensitive to infections caused by climate change, which makes it necessary to develop specific methods of analysis and to inform people of the expected climate change in advance.

The climate of Russian large cities, compared to that of west European cities (located at the same latitudes), due to low air temperatures, continentality, seasonal fluctuations and a long snow period, is much more severe and less auspicious for the production development, as well as for the life and prosperity of people. Permafrost east of the Urals aggravates these features.

The severity of climate affects the efficiency of investments and primarily the two- or four-fold appreciation of construction and maintenance of productive and social facilities, especially in emergencies caused by hazardous events. The above factors have a particular effect on the "energy comfort" and prosperity of people.

Despite a general decline in production, ecological conditions in the Russian cities continue to degrade, which is primarily connected with the development of motor traffic and automotive pollution. Thus the problems of climate change, energy saving and environmental monitoring, as applied to large Russian cities, are to be jointly solved.

It should be borne in mind that despite the expected significant effects of warming, climate in Russia, including its large cities, will remain severe, contrasting and relatively unfavourable, compared to the climate at the same latitudes in Europe and North America.

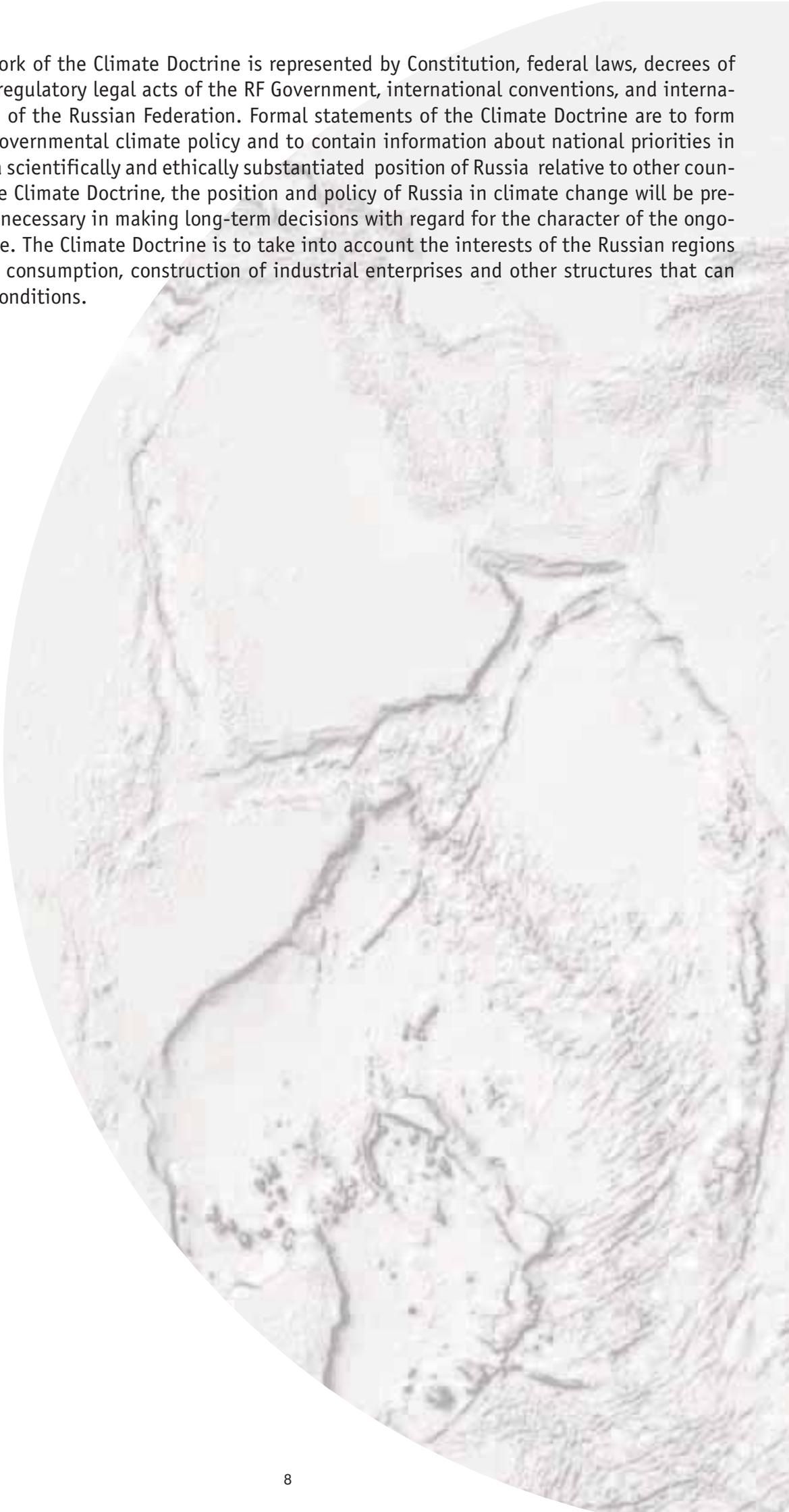
According to the experience of the developed foreign countries, specifically, the EC states and the USA, **the governmental policy as to the climate change is to be based on the major principles and priorities that are clearly formulated and adopted at the highest governmental level.**

It is necessary for Russia to create **the Climate Doctrine of the Russian Federation** and to work out the strategy for climate change. Russia, owing to its vast territory, variety of probable climate warming consequences, and a status of a large exporter of hydrocarbon fuel that allows it to become a leading power-producing country in the 21st century, is one of the key constituents of international relations with respect to climate change problems. The official view of Russia to this problem is to be expressed in the Climate Doctrine of the Russian Federation, the fundamental document to be used in making national and international political and economical decisions concerning climate and the related problems.

Scientific substantiation of the Climate Doctrine's concept is to be built on Russian and foreign research of climate change and its effects on different economic and social sectors. A great variety and a magnitude of climate change in different regions of Russia, as well as its diverse impact on the environment, is a result of a large territory of the country and a wide variety of natural conditions. Of this variety it is necessary to identify the conditions that place Russia in a position of inequality before other countries, specifically, in terms of demands for incinerated fuel amount. **The Climate Doctrine is to ensure national hydrometeorological safety in initiating the international and regional programmes and investment projects and to promote sovereignty in making and implementing the climate policy.**



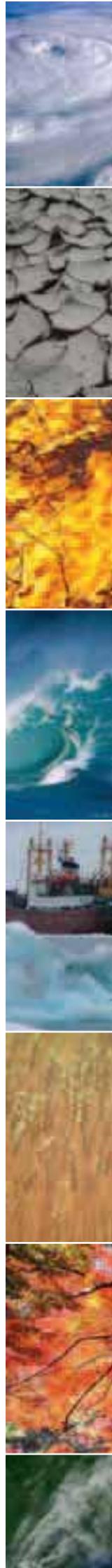
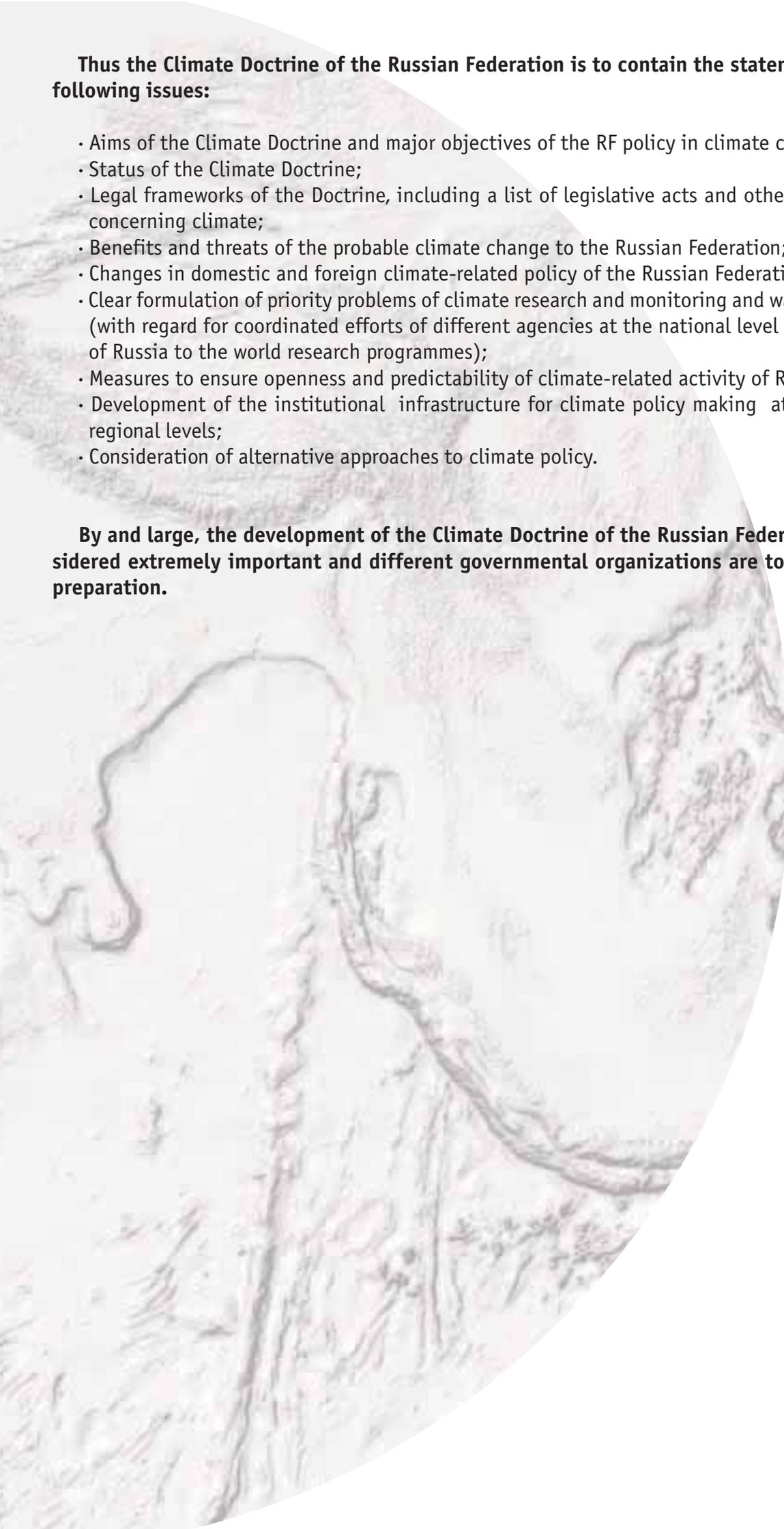
A legal framework of the Climate Doctrine is represented by Constitution, federal laws, decrees of the RF President, regulatory legal acts of the RF Government, international conventions, and international agreements of the Russian Federation. Formal statements of the Climate Doctrine are to form the basis of the governmental climate policy and to contain information about national priorities in the framework of a scientifically and ethically substantiated position of Russia relative to other countries. Owing to the Climate Doctrine, the position and policy of Russia in climate change will be predictable, which is necessary in making long-term decisions with regard for the character of the ongoing climate change. The Climate Doctrine is to take into account the interests of the Russian regions in terms of power consumption, construction of industrial enterprises and other structures that can affect the living conditions.

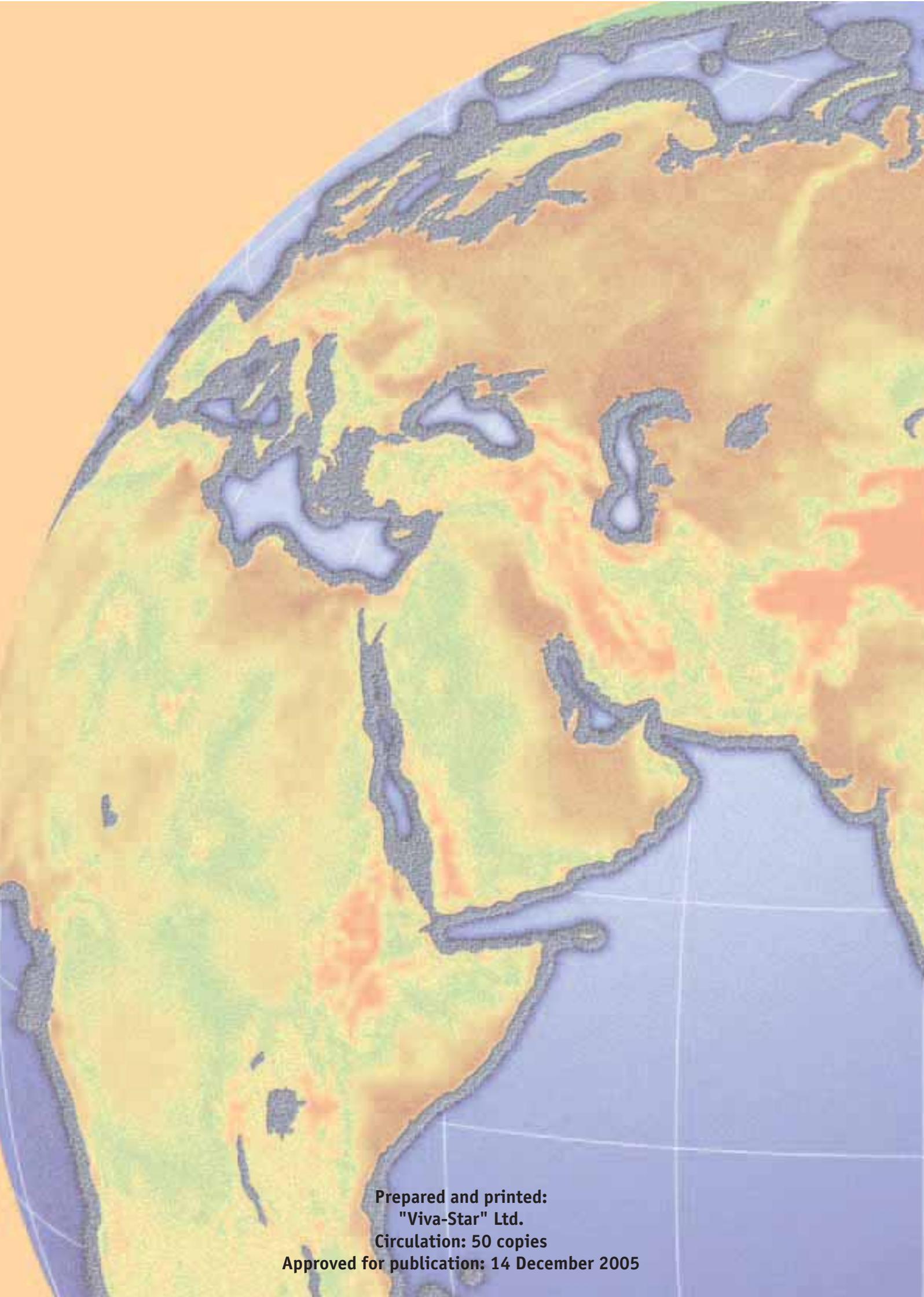


Thus the Climate Doctrine of the Russian Federation is to contain the statements covering the following issues:

- Aims of the Climate Doctrine and major objectives of the RF policy in climate change;
- Status of the Climate Doctrine;
- Legal frameworks of the Doctrine, including a list of legislative acts and other formal documents concerning climate;
- Benefits and threats of the probable climate change to the Russian Federation;
- Changes in domestic and foreign climate-related policy of the Russian Federation;
- Clear formulation of priority problems of climate research and monitoring and ways of their solution (with regard for coordinated efforts of different agencies at the national level and the integration of Russia to the world research programmes);
- Measures to ensure openness and predictability of climate-related activity of Russia;
- Development of the institutional infrastructure for climate policy making at governmental and regional levels;
- Consideration of alternative approaches to climate policy.

By and large, the development of the Climate Doctrine of the Russian Federation is to be considered extremely important and different governmental organizations are to be involved in its preparation.





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