INTER-AGENCY COMMISSION OF THE RUSSIAN FEDERATION ON CLIMATE CHANGE

THIRD NATIONAL COMMUNICATION OF THE RUSSIAN FEDERATION

SUBMITTED IN ACCORDANCE WITH ARTICLES 4 AND 12 OF THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

MOSCOW 2002

The National Communication has been prepared under specific provisions of specially developed Federal Target Programme "Prevention of Dangerous Changes of Climate and Their Adverse Effects", authorised by the decision of the Government of the Russian Federation of October 19, 1996, No.1242, with the purposes of implementation of the commitments under the UN Framework Convention on Climate Change and prevention of negative consequences of climate change on the health of population and on the national economy.

List of the ministries, agencies, and institutions participated in the preparation of the National Communication.

Information for National Communication have been submitted by the following ministries, agencies, institutions, and institutes:

Federal Service of Russia for Hydrometeorology and Environmental Monitoring
Institute of Global Climate and Ecology under Roshydromet and RAS
Ministry for Economic Development and Trade of the Russian Federation.
Ministry for Atomic Energy of the Russian Federation
Ministry for Public Health of the Russian Federation
Ministry for Industry, Science, and Technologies of the Russian Federation
Ministry of Natural Resources of the Russian Federation
Ministry of Agriculture of the Russian Federation
Ministry of Energy of the Russian Federation
Ministry of Transport of the Russian Federation
State Committee of the Russian Federation for Standardization and Metrology
State Committee of the Russian Federation on Statistics
State Committee of the Russian Federation for Construction and Housing-Communal Complex
Federal Land Cadastre Service of Russia
Federal Mining and Industrial Inspectorate of Russia
Russian Aviation and Space Agency
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Research Institute of Hydrometeorological Information - World Data Centre of Roshydromet
Main Geophysical Observatory under Roshydromet
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International Center of Ecological Safety under the Ministry of Atomic Energy of Russia
Central Research Institute for Machine Building
Praynishnikov All-Russian Research Institute of Fertilisers and Agricultural Soil Sciences
Russian Ecological Academy

FOREWORD

The Federal Law of the Russian Federation *On the Subject of Ratification of the UN Framework Convention on Climate Change* was signed by President of the Russian Federation on 4 November 1994, after its acceptance by the Federal Assembly of the Russian Federation. The instrument of ratification was deposited on 28 December 1994 with the Secretary-General of the United Nations, Depositary of the Convention.

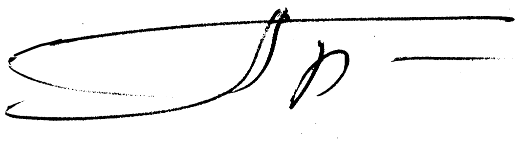
According to the provisions of the Convention, the major commitments of the Russian Federation, which belongs to the of developed countries and countries with economies in transition, are as follows:

- Implementation of national policies and appropriate measures to mitigate anthropogenic climate changes by limiting anthropogenic greenhouse gas emissions and enhancing their removal. Accordingly, measures should be implemented so that the national 2000 level of anthropogenic CO_2 and other greenhouse gas emissions does not exceed that of the 1990 base year. These policies and measures should be enhanced after 2000 so that, despite the expected economic growth, the total anthropogenic emissions of all greenhouse gases do not on average exceed the 1990 level in Russia during the first commitment period of the Kyoto Protocol from 2008 to 2012.
- Development of a national system to estimate anthropogenic emissions by source and removal by sinks of all greenhouse gases (according to the Kyoto Protocol - not later than one year prior to the start of the first commitment period). Preparation of inventories of anthropogenic sources of greenhouse gas emissions and their sinks in accordance with recommendations and methodologies developed within the framework of co-operation under the Convention. Preparation of reports on a regular basis.
- Identification of regions, sectors of activity, natural, industrial and other objects made vulnerable by climate change. Development and implementation of measures for economy branches on adaptation to climate change.
- Enhancement of scientific research on climate change issues; development of education and public awareness. Implementation of broad international co-operation in all matters related to the UN Framework Convention on Climate Change.

Considering how important it is to develop international co-operation on issues related to climate change, at the Summit of the Group of Eight in July 2001 President of the Russian Federation, Mr. Vladimir V. Putin, announced an initiative to convene the World Climate Change Conference in 2003 with participation from representatives of governments, business, the scientific community and civil society. This initiative was supported by the Summit of the Group of Eight and is reflected in the Communique of the Heads of State and Governments of the Group of Eight (section: Goals for the Future, Environment) of 22 July 2001 (Genoa, Italy).

The Third National Communication of the Russian Federation on activities under the Convention has been compiled by the Federal Service of Russia for Hydrometeorology and Environmental Monitoring (Institute of Global Climate and Ecology under Roshydromet and the Russian Academy of Sciences was the leading contributor) at the request of the Inter-Agency Commission of the Russian Federation on Climate Change. This Communication was prepared in accordance with the decisions, methodological guidelines and recommendations of the UNFCCC. Federal Ministries and Agencies participating in the Federal Target Programme “Prevention of Dangerous Changes of Climate and their Adverse Effects”, many organizations, and scientific institutions of the Russian Federation have been involved in its preparation.

The text of the Third National Communication of the Russian Federation and its Executive Summary follows hereinafter. The Executive Summary presents general information and basic data of the Communication.



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I EXECUTIVE SUMMARY

The Third National Communication has been prepared within the framework of the Federal Target Programme “Prevention of Dangerous Changes of Climate and Their Adverse Effects” (FTPC) which was adopted at 19 October 1996 by the Decision of the Government of the Russian Federation # 1242 and aimed at the implementation of the United Nations Framework Convention on Climate Change, as well as on mitigation of unfavourable effects of climate change on the health of the population and on the national economy.

National Circumstances Relevant to Greenhouse Gas Emissions and Removals

The number of population continued to decrease in the Russian Federation in 1997-2000. Macroparameters of the national economy and of the energy industries have fluctuated appreciably (Table I.1). Besides the decrease of the GDP and energy demand in 1998, the rising tendency has been observed in 1999–2000.

Table I.1
Trends in GDP and population in the Russian Federation in 1990 – 1999 (1990 = 100%)

Indicator	**Year**										
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
GDP	100.0	95.0	81.2	74.2	64.7	62.1	60.0	60.5	57.5	60.7	66.1
Population	100.0	100.1	100.1	99.9	99.8	99.6	99.3	99.0	98.8	98.2	97.7

Table I.2 presents the data on electricity production in the Russian Federation in 1990-1999.

Table I.2
Production of electric energy by power stations (in TW-hr)

Stations	**Year**									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Electric power stations, including	1082	1068	1008	957	876	860	847	834	827	846
Thermal power stations	797	780	715	663	601	583	583	567	563	563
Hydroelectric power stations	167	168	173	175	177	177	155	158	159	161
Nuclear power plants	118	120	120	119	97,8	99,5	109	109	105	122

In the near future, the main trends in the development of the Russian energy sector will be governed by the Federal Energy Strategy of Russia approved at the end of 2000 (Fundamental Provision of Energy Strategy of Russia for the Period up to 2020, approved by the Government of the Russian Federation, protocol № 39 of November 23, 2000).

Depending on the rate of economic growth, the Energy Strategy envisages the 1.14-1.36-fold increase in domestic consumption of primary energy in the period 2001-2020 (for lower and favorable variants of the economic development, respectively) with a corresponding 1.7-2.1-fold decrease in the energy intensity of the GDP.

The area of land covered with forests was 794.3 M ha or about 46.5 % of the territory of the country. Total stem stock volume was estimated as 81.6 Gm^3 in 1988, 80.7 Gm^3 in 1993 and 81.3 Gm^3 in 1998 respectively.

Forest restoration is an important activity implemented by forestry authorities. Table I.3 informs on development of forest plantations and promotion of natural regeneration over the territory of former Federal Forestry Service from 1990 to 1999.

Table I.3
Forest restoration activities over the territory of forest stock under the authority of Ministry of Natural Resources of the Russian Federation (Federal Forestry Service), kha

Year	Development of forest plantations	Promotion of natural regeneration
1990	348.1	392.7
1991	331.3	476.7
1992	334.7	574.8
1993	392.6	937.2
1994	356.2	1,111.1
1995	331.7	1,030.9
1996	274.2	761.5
1997	237.5	784.8
1998	232.0	718.1
1999	227.9	677.6

Greenhouse Gas Inventory Information

Total greenhouse gas emissions

Total anthropogenic emissions of greenhouse gases from the territory of Russia in 1999 (in CO_2-equivalent) amounted to 61.5 % of the 1990 emission. Figure I.1 and Table I.4 represent GHG emission trends in 1990 - 1999 (without CO_2 removal by forests).

Table I.4
Anthropogenic greenhouse gas emissions in the Russian Federation (Mt CO_2-eq.)

GHG	Year						
	1990	1994	1995	1996	1997	1998	1999	1999[1] (% of 1990)
CO_2	2360	1660	1590	1500	1530	1510	1510	63.9
CH_4	550	410	390	390	300	310	290	52.9
N_2O	98	49	43	41	44	34	35	35.8
PFC, HFC, SF_6	40	35	38	36	39	41	42	106.2
Total	3050	2150	2060	1970	1910	1900	1880	61.5

1) *Calculated using emission values without rounding*

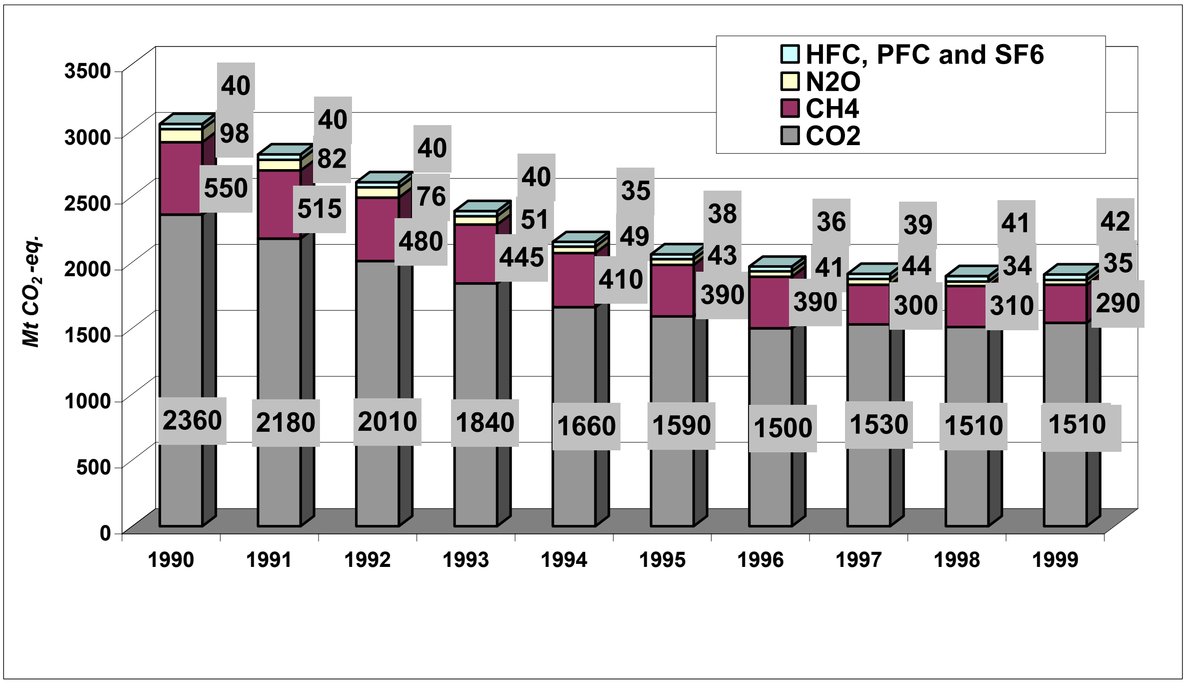

Fig. I.1 Absolute change in Russian greenhouse gas anthropogenic emissions in 1990 - 1999

Contributions of individual gases to the total emissions are presented in Table I.5. It can be seen that, despite a significant change in total emissions, the structure of emissions remains stable enough.

Table I.5
Anthropogenic GHG emissions by gas (per cent of total emission in CO_2-eq.)

Year	GHG				
	CO_2	CH_4	N_2O	HFC, PFC, SF_6	Total
1990	**77.5**	**18.0**	**3.2**	**1.3**	**100.0**
1998	**79.6**	**16.4**	**1.8**	**2.2**	**100.0**

Data presented in Table I.6 characterize the contribution of individual source categories to anthropogenic GHG emissions on the territory of the Russian Federation.

Total emissions reduction accumulated in 1990 - 1999 amounts to 7,750 Mtce (860 Mtce/yr on average). Figure I.2 illustrates annual changes of the accumulation.

Emissions of CO_2

Anthropogenic emissions of CO_2 in Russia are mainly due to the consumption of fossil fuels: coal, oil, natural gas, peat (in very small quantities), and to the use of secondary organic fuels (see Tables I.7, I.8, Figure I.1).

By 1999, total annual CO_2 emissions from the territory of the Russian Federation decreased by 850 Mt, amounting to 63.9 % of 1990 emission. More than 99 % of this decrease is due to the reduced use of fossil fuels, including decrease of 233 Mt by energy industries i.e. by general-purpose thermal power stations and boilers.

Table I.6
Anthropogenic GHG emissions in the Russian Federation by source category (Mt CO_2-eq.)

Source category	**GHG**			
	CO_2	**CH_4**	**N_2O**	**HFC, PFC, SF_6**
Primary and secondary fossil fuels, including:	1470	199	3.1	-
Fuels burned for energy	1452	2.2	3.1	-
Losses and fugitive emissions	18	197	-	-
Industrial processes	39	0.5	0.3	42
Solvents and other product use	-	-	0.6	-
Agriculture	-	51	27	-
Land-use change and forestry	-	2.9	0.3	-
Waste	-	38	3.4	-
Total	1510	290	35	42

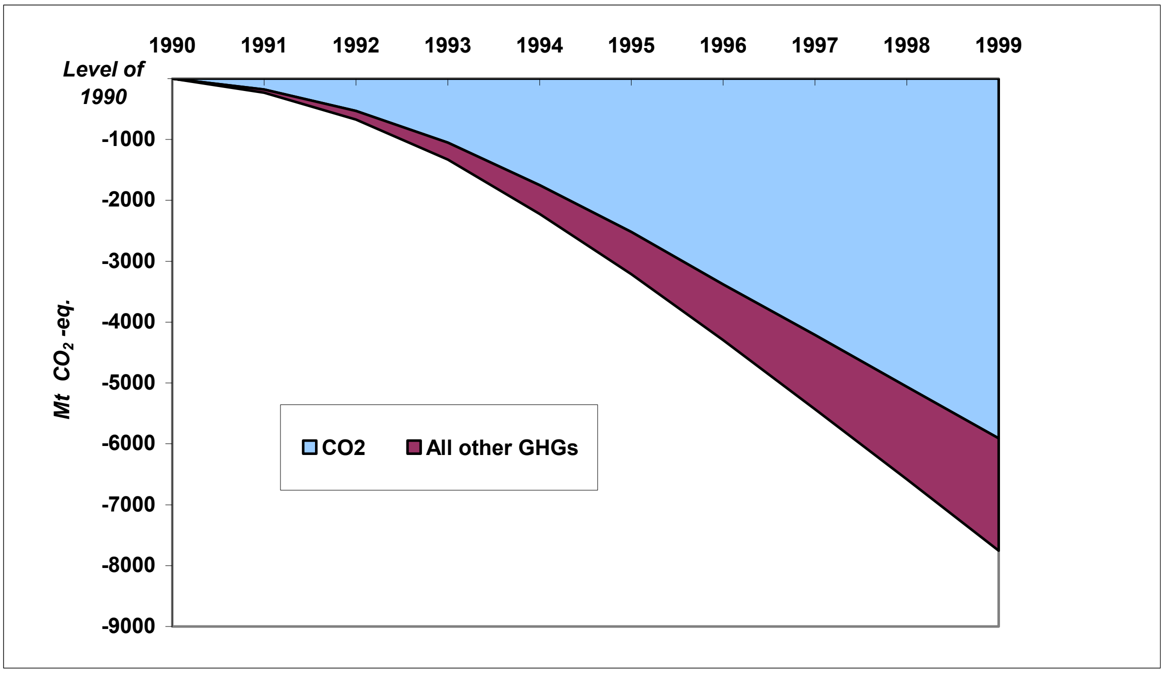

Fig I.2 Cumulative reduction of total greenhouse gas emission from 1990

Reductions in CO_2 emissions accumulated during 1991 – 1999 amount to 5,910 Mt (Figure I.2).

Emissions of CH_4

Methane emissions (Table I.9), as a whole in the period 1990 - 1999, were decreasing faster, than emissions of CO_2. The decrease is noticeable for all source categories, the only exception being emissions from forest fires. The main contribution to the reduction of emission has been brought by energy sector, including by-process emissions and leakages of methane from oil and natural gas production, transportation and consumption, and by animal husbandry (enteric fermentation by animals and anaerobic decomposition of animal waste). These two sectors were responsible for 86 % of the total reduction, or 12.4 Mt/yr CH_4 less in 1999 than in 1990.

Table I.7
Anthropogenic CO_2 emissions in 1990 – 1999 (Mt CO_2)

Emission sources	Year						
	1990	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Primary and secondary fossil fuels[1)]	2320	1640	1570	1480	1500	1470	1470
Industrial processes, including[2)]	42	20	19	15	34	35	39
Cement production	41	19	18	14	13	13	14
Total emission	2360	1660	1590	1500	1530	1510	1510

1) *Includes fuels combustion for electric, heat and mechanical energy, as well as losses and fugitive emissions: burning of associated gas and CO_2 emissions related to coal mining and coal dumps burning*
2) *From 1997 includes also emissions related to the production of lime, soda, ammonia, carbides and ferroalloys*

Table I.8
CO_2 emissions from consumption of primary and secondary fossil fuels (Mt CO_2)

Emission sources	Year						
	1990	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Power industries[1)]	708	542	517	517	493	490	475
Total emissions	2300	1600	1550	1460	1480	1450	1450

1) *Includes emissions from fuel burning by power stations and boilers of UES*

Table I.9
CH_4 emissions (Mt CH_4)

Emission sources	Year				
	1990	**1994**	**1997**	**1998**	**1999**
Primary and secondary fossil fuels,[1)] including	19.1	13.4	9.4	9.3	9.4
Oil and gas production, transportation and distribution	16.0	11.5	7.9	7.9	7.9
Coal production	2.9	1.8	1.5	1.3	1.4
Agriculture, including	5.0	3.8	3.0	2.7	2.4
Animals (enteric fermentation)	4.4	3.3	2.6	2.3	2.1
Animal waste	0.5	0.4	0.3	0.3	0.2
Rice production	0.1	0.1	0.1	0.1	0.1
Forest fires	0.1	0.1	0.1	0.9	0.1
Waste, including	1.9	2.0	1.8	1.8	1.8
Solid	1.8	1.8	1.7	1.7	1.7
Liquid	0.14	0.15	0.1	0.1	0.1
Total	26.1	19.3	14.4	14.7	13.8

1) *Includes technology-related and fugitive emissions accompanying production, transportation, storage and processing of oil, coal and gas fuels, as well as emissions from burning of all types of fuels*

Emissions of N_2O

The main factors contributing to the trend of N_2O (Table I.10) were declining emissions from agricultural soils, caused by reduction of use of organic and mineral fertilizers.

In percentage terms emissions in 1999 amounted to 35.8 % of the 1990 level. Besides, during 1990 - 1999 emissions from consumption of fossil fuels decreased by 42 %, and emission from industrial processes decreased by two thirds. As a result, the rate of decrease in N_2O emissions has exceeded the corresponding rates for CO_2 and CH_4 emissions.

Table I.10
Emissions of N_2O (kt N_2O)

Emission sources	**Year**				
	1990	**1994**	**1997**	**1998**	**1999**
Primary and secondary fossil fuels	17.4	11.1	10.6	10.1	10.1
Industrial processes	3.0	1.2	1.0	1.0	1.0
N_2O use in health care	2.0	2.0	1.7	1.7	1.6
Agriculture	280	130	114	84	88
Forest fires	1.0	0.4	1.0	6.2	1.0
Waste burning	0.3	0.3	0.1	0.1	0.1
Liquid waste treatment	12.0	11.5	12.0	11.0	11.0
Total	320	160	140	110	110

Emissions of HFC, PFC and SF_6

Table I.11 presents estimates of emissions of hydrocarbons (HFCs) and perfluorocarbons (PFCs), expressed in CO_2-equivalent units.

Table I.11
HFC, PFC and SF_6 emissions (Mt CO_2-eq.)

GHG	**Year**				
	1990	**1994**	**1997**	**1998**	**1999**
HFC	9.7	7.0	9.4	9.5	9.5
PFC	30	28	30	31	33
SF_6	-	-	0.016	0.016	0.016

Table I.11 contains calculated estimates of CF_4 and C_2F_6 emissions from aluminum smelting and emission estimates of the most widely used in the chemical industry and commercial/household refrigerating HFCs. Estimates of SF_6 emissions associated with leakages from electric equipment are also included in the Table I.11. Uncertainty of emission estimates for these chemical compounds, are generally, estimated to be high.

Emissions and Removals of Greenhouse Gases in the Forests of Russia

Annual CO_2 sequestration by live phytomass of Russian forests in 1990-1999 was estimated at 300-600 Mt CO_2/yr.

The estimates show the decrease of CO2 emissions related to wood harvesting from approximately 500 Mt CO_2/yr. in 1990 to 200-230 Mt CO_2/yr. in 1996-1999. The CO_2 emissions from forest fires were estimated at the range 10-200 Mt CO_2/yr in 1990-1999.

Table I.12 presents CO_2 net removals over the territory of forest stock in the Russian Federation.

Table I.12
CO_2 net removals in the forests of Russia from 1990 to 1999 (Mt)

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
–141.1	28.8	19.5	–27.5	242.4	337.7	175.9	133.0	3.9	212.8

Policies and Measures to Limit and Reduce Emissions and to Increase Removals of Greenhouse Gases

Due to dominance of CO_2 emissions from fossil fuels in power industry, the major provisions of emissions reduction strategy should focus primarily on reductions of CO_2 emissions in the power industry. Development of such a strategy and of a system of measures is currently based on the principles included in the following State Acts:

1. "**Basic Provisions of the Energy Strategy of Russia for the Period to 2020**" were approved by the Government of the Russian Federation (Ref. № 39, November 23, 2000). The aim and the highest priority of the national energy strategy for the period to 2020 is the most efficient utilization of natural resources and of the available scientific, technical and economic potential in the fuel-energy complex for improving the quality of life of the population.
2. "**The Energy Efficient Economy"** Federal Target Program for 2002–2005 with prospects to 2010 was endorsed by the Government of the Russian Federation on November 17, 2001 (Ref № 796). In accordance with "Basic Provisions of the Energy Strategy of Russia for the Period to 2020", wide-scale energy efficiency and saving arrangements are to be realized in the framework of this program starting in 2002.

Measures to Limit and Reduce Anthropogenic Greenhouse Gas Emissions Related to Energy Production and Use

The implementation of overall objectives of the energy strategy requires solving a number of interrelated problems including **increase of energy use efficiency,** which is of a special importance for the UNFCCC. These should be accomplished with a view to attaining a global goal of sustainable development on the basis of energy saving technologies and structural optimization of power generating facilities, while at the same time ensuring growth of energy supply and improvement in working and living standards, reduced load on the environment and improvement of national productive forces for raising economic efficiency and market competitiveness.

Substantial increase in the energy efficiency of the economy is among the core tasks for social and economic recovery of the country. The growth rates, and especially **restructuring** of the economy and technological advances, will in turn determine the dynamics of energy efficiency increase. The growth of domestic energy consumption decreases with the GDP increase and with growth of the share of services and high technology products. Thus, restructuring of the economy would compensate for more than a half of the required increment of energy consumption.

Besides the structural modification, the Energy Strategy envisions intensive institutional and technological measures to ensure saving of fuel and energy, i.e. targeted energy saving policy. Russia has a large potential for organizational and technological energy savings. Realization of domestic and world-wide (low and upper values respectively) organizational and technological measures for saving energy resources enables reducing their current consumption within the country by 40–48% or by 360–430 Mtce/yr.

As a result of anticipated GDP growth and measures planned to reduce its energy intensity, domestic consumption of power resources from 2001 to 2020 would increase approximately 1.35 times in case of positive economy development (the rate of increase is about 1.5% per annum). For lower rates of development, it would rise 1.15 times only (the increase is 0.7–0.8% per annum).

The "Energy Efficient Economy" Federal Target Program for 2002–2005 with prospects to 2010 provides for the implementation of the Energy Strategy of the Russian Federation. A considerable increase in production of electric power and renewable energy resources is envisioned within the period up to 2020 (Table I.13).

Table I.13
Production of electric power and renewable energy resources in the Russian Federation

Type of energy resources	Units	2001	2005	2010 (projection)
Total electric power production, including:	TW-hr	888.4	1,008.8	1,158.9
Heat power plants	TW-hr	576.4	665.9	765.9
Hydropower plants	TW-hr	175.1	168.9	181
Nuclear power plants	TW-hr	136.9	174	212
Production of renewable energy resources	Mtce	1	2	3–5

The implementation of measures on energy efficiency increase in fuel and energy complex will lead to GHG emission reduction to 80 Mt CO_2-eq. per annum by 2005, and to 330 Mt CO_2-eq. per annum by 2010.

The main condition for implementation of measures under the subprogram is to ensure ecological safety, including assessment of nuclear power plants impacts on the environment. Thus, new safety regulations are envisioned on the basis of national and international experience and the IAEA regulatory documents. The development of nuclear power will provide an increase in generating capacity by 33% in 2005 relative to 2000 when the electricity production amounted to 131 GW-hr. The 1.6-fold growth in the nuclear power generation relative to 2000 is projected by 2010.

Table I.14 shows the expected energy savings resulting from measures scheduled by energy consuming sectors of the national economy.

Table I.14
The projected savings of fuel and energy by power consuming sectors in 2002–2005 and in 2006-2010 (Mtce)

Consumers	Year	
	2002-2005	2006-2010
Power-consuming industries	49-52	50-54
Agriculture	5.5-6.5	6.0-7.0
Housing and communal services	35-38	38
Transport:		
Railway transport	4.0-4.6	5.0
Other transport	4.0-4.9	4.3-5.5
Federal (government-funded) institutions	4.6	8.3
Branches of energy sector	42	44

The totals for energy resources saved in consumption sphere are estimated as about 150 Mtce in 2002–2005 and 295–325 Mtce for the entire period of Program implementation.

It is envisioned that in case of positive scenario of economic growth, the arrangements under the Program would result in a decrease of GDP energy intensity by 13.4% in 2005 and by 26% in 2010 relative to 2000 level. For unfavorable scenario of economic growth, the expected decrease would be by 4.7% and 18% respectively.

A significant range of energy saving measures and mitigation of the CO_2 emissions is being realized in the frameworks of branch (sector) programs. The "Electric Power" Branch Energy Saving Program for 1999–2000 and prospects to 2005 and 2010 is aimed at increasing efficiency of fuel and energy use. It was adopted by "Unified Energy Systems of Russia" Joint Stock Company in 1999.

In 1999, the implementation of the Program resulted in improvement of parameters of fuel and energy use efficiency. The specific fuel consumption for electric and thermal power generation decreased by 1.8 and 0.7 g/kW-hr respectively. The energy consumption for internal needs reduced by 520 GW-hr (or by 2.8%). Total fuel and energy conservation in 1999 increased to 3.8 Mtce (including 1.2 Mtce from energy saving program). This amounts to 0.02 % of the total fuel consumption, compared with 1998. In comparison with 1998, the CO_2 emission reduction was 15 Mt CO_2/yr (including 2.5 Mt CO_2/yr obtained within the framework of energy saving program).

In 2000, fuel consumption increased by 4.7 Mtce due to intensified thermal and electric energy production. The GHG emission increased by 17.3 Mt CO_2/yr.

The certain reduction of the CH_4 emission in the coal mining sector was achieved as a result of considerable shift from underground to open mining. In 1990, the share of the open coal mining was 55.5 % and has already reached 64.7 % by 1999. In accordance with a program for coal branch reorganization, it should rise up to 75 % in the future.

The latest assessments show that reduction of the underground mining by 1% leads to a drop of CH_4 emissions by approximately by 2.1%. Even in case of relatively considerable increase of coal mining and lack of specific CH_4 utilization measures, the anticipated CH_4 emission from 2000 to 2010 would not exceed 70–80% of 1995 level.

Measures to Limit Greenhouse Gas Emissions and to Enhance Removals in Agriculture

The main measures to limit and reduce CO2 emissions and increase of GHG removals in agriculture are related to preservation and improvement of soil fertility in Russia and targeted on reduction of the humus loss (melioration, erosion and forest protection, introduction of the integrated mineral and organic fertilization system).

The increase of nutrition value of forages and elimination of unbalances in animal fodder rations are implemented in animal husbandry making possible the improvement of patterns and overall intensity of the CH_4 emission to the atmosphere from the enteric fermentation.

The CH_4 and N_2O emissions in agriculture can be reduced through improvement of systems for collection, storage and use of animal manure and poultry excrements. Domestic technologies and equipment for anaerobic collection, storage and processing of manure of domestic livestock and excrements of poultry have been developed. Experimental installations for thermal processing of manure and excrements have been built and currently operate in a number of poultry farms in the Moscow region.

Measures to Limit Greenhouse Gas Emissions and to Enhance Removals in Forestry

Measures targeted at increasing of the GHG removals from the atmosphere and deposition ranks highly in effective mitigation of the atmospheric increase of CO_2. Thereupon the key measures in this field should be related to afforestation and forest regeneration. Estimates show that overall effect of forest regeneration, enhancing fire resistance of forest stands, improvement of logging and deep processing technologies, reduction of harvested wood losses, as well, as implementation of the general and protective afforestation activities over few million ha could result in the additional CO_2 removal from the atmosphere by 100-200 MtCO2/yr.

Projections and the total effect of policies and measures

Projections of CO_2 emissions are based on the following average values of economic and energy macroparameters expected in the period 2001-2020.

A. Rate of the GDP growth.

An initial basis of the Energy Strategy projections is an expected increase of the GDP by a factor of 3 - 3.15 (at an annual average rate of increase 5 - 5.2 %) in case of a favourable economic development during twenty years, from 2001 to 2020. In parallel, a scenario of a lower economic development is considered with the GDP growth factor of approximately 1.5, i.e. about 3.3 % annual growth.

B. Rate of energy intensity reduction.

Two basic options for reducing GDP energy intensity are considered by the Energy Strategy, namely, an optimistic scenario and an unfavorable one. GDP energy capacity could be reduced by factor of 2.1 (at average annual rate of reduction about 3.7 %) in case of the sufficient investments to the planned measures on increase of energy sector efficiency during 2001 - 2020 (optimistic scenario). However, under unfavorable conditions the rate can decrease to 2.5 % of annual reduction.

C. Carbon intensity of energy consumption (ratio of CO_2 emissions to the total domestic energy resources consumption).

The carbon intensity of energy consumption depends upon expected evolution in fuel and energy balance of the country. According to the Energy Strategy, the share of gas in the primary energy consumption would decrease from 48 % in 2000 to 42 – 45 % by 2020, the contribution of oil is expected to be practically stable (22 – 23 %), the share of coal would increase from 20 % to 21 – 23 %, the contribution of NPP-produced electricity would increase to 5.7 - 6.0 %, and the share of non-conventional renewable energy resources would increase up to 1.1 - 1.6 %.

Thus, despite a decrease in the gas share and an increase in that of coal in the fuel and energy balance, the carbon intensity of energy consumption should remain approximately constant during all considered period due to an increase in the balance of the share of non-carbon energy resources (nuclear energy and non-conventional renewable energy).

D. Scenarios for CO_2 emissions.

Two basic scenarios of GDP increase and of GDP energy intensity reduction have been formulated in the Energy Strategy thus resulting in two scenarios for domestic energy consumption growth and two scenarios for CO_2 emissions ((Table I.15).

Table I.15
Basic scenario parameters

Macroparameters	Scenario I	Scenario II	Scenario III
GDP	+5,2 % per year	+3,3 % per year	+4,5 % per year
Energy intensity of GDP	-3,7 % per year	-2,5 % per year	-2,0 % per year
Energy consumption	+1,5 % per year	+0,8 % per year	+2,5 % per year
Carbon intensity	0	0	0
CO_2 emission	+1,5 % per year	+0,8 % per year	+2,5 % per year

As mentioned in the Second National Communication of the Russian Federation, the development of national economy and energy sector under specific conditions of the Russian Federation might, with a certain probability, result in the GDP annual rate of increase of approximately 4.5 % and in a simultaneous annual reduction of the GDP energy intensity by 2 %. Therefore, it is reasonable to consider, as an additional one, the third scenario of energy consumption and corresponding CO_2 emissions determined by above-mentioned 4.5 % GDP increase and 2 % decrease of GDP energy intensity (Scenario III).

Figure I.3 presents the calculated projections of CO_2 emissions (relative to 1990).

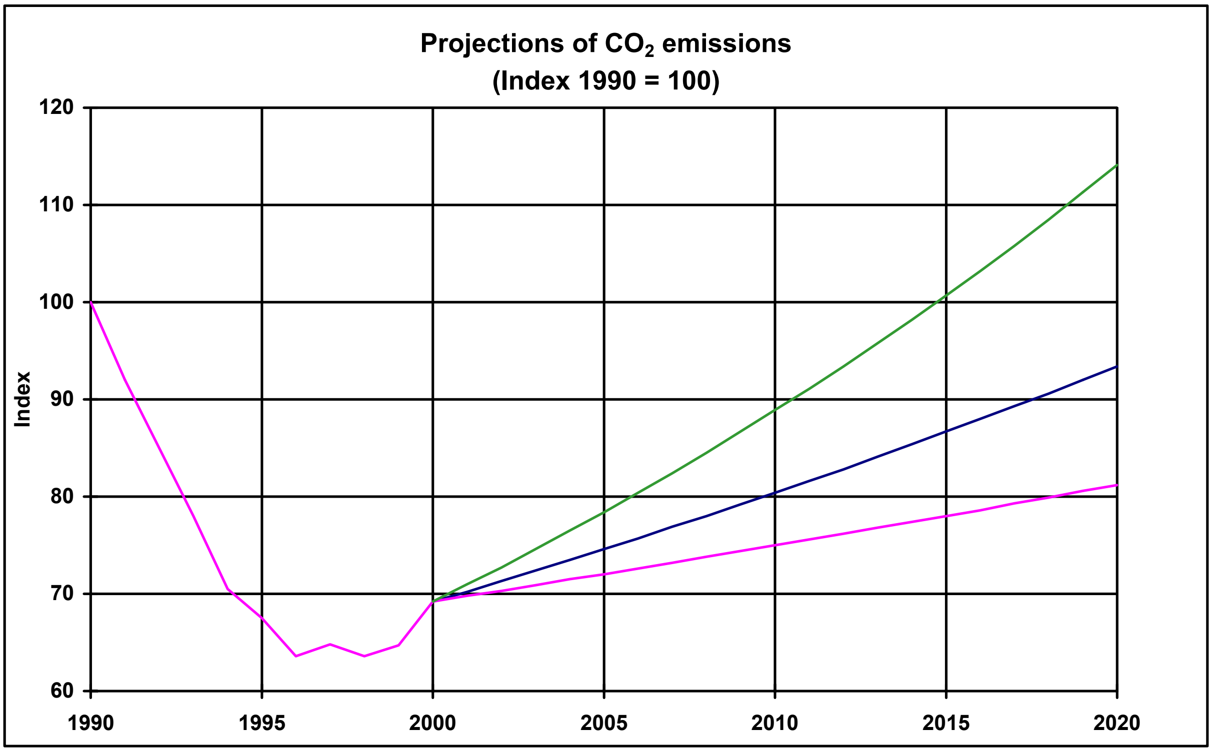

Figure I.3 Projections of CO_2 emissions.

Vulnerability Assessment, Climate Change Impact and Adaptation Measures

The most climate-dependent sectors of the economy of the Russian Federation include agriculture, forestry, and use of water resources. Some regions could be potentially affected by sea level rise, and areas of permafrost could also be affected.

Agriculture

As a result of climate change, agricultural output could improve in some regions. However, in the others it could deteriorate because of intensified desertification and an increase in unfavourable phenomena.

The potential increase in frequency of droughts and dryness on the territory of particular regions is the major negative factor of climate change for national agriculture. In general, the change of climate conditions in Russia can be characterized as “warming accompanied with increased dryness”. Based on this trend in climate change, it is reasonable to expect a reduction in the average productivity of cereal crops and sown herbs. However, rise of CO_2 atmospheric concentrations contributes to an increase in productivity, while decrease in soil fertility due to humus reserves exhaustion could adversely affect agricultural crop productivity.

The overall balance of possible consequences of climate change can be estimated as positive for national agriculture. At the same time, taking advantage of positive factors requires an advanced adaptation of agriculture to anticipated changes.

The expansion of commercial agriculture to more northern regions with sufficient moistening is one of important tasks of adaptation. Another important direction is an increase in productivity and sustainability of agriculture in steppe and forest-steppe zones of the country due to implementation of measures to fight against droughts and to develop moisture saving technologies.

To reduce the potential negative effects of climate change on the health of population, the most vulnerable regions of the Russian Federation should be selected.

Forestry

For the territory of Russia, global climate change in the next 30–40 years would not result in an abrupt deterioration of conditions required for normal growth and development of main forest forming species. Anticipated effects of climate change in this period would remain in a range of allowable changes of growth condition of these species in natural forest. However, expected changes could disrupt the interrelationship between forest species at a stage of natural forest regeneration after cuttings, fires, in the areas of impact of forest diseases and pests.

The effect of climate change would not be significant over the European territory of Russia for the next 50 years. Anticipated warming would have a positive effect on forest productivity and carbon accumulation in the Northern Siberia and Far East. Based on the calculations, it is possible to expect a stable growth in net CO_2 removals there.

An important adaptation measure is preservation over cut areas coniferous forest plantations, natural seeding and undergrowth that are subject to substitution by deciduous spices, more adaptive to new conditions of growth. The indirect impact of climate change on tree species, especially young stands, is the increased frequency of short-term extreme weather events (strong snowfalls, hails, gales, droughts, late spring frosts and etc.). In this case the adaptation measures are also indispensable. Among them the improvement of quality of planting material should be indicated that in turn, allows improving vitality of forest plantations and their resistance to unfavorable ambient environment and pathogenic factors. The major measures in forest adaptation to climate change include:

- Creation of conditions for growth and regular development of forest plantations, natural seeding and undergrowth.
- Decrease of fire risk in forests during arid season.
- Reduction of the population of pests and weakening their impact on forests. Reduction of the population of pests and weakening their impact on forests.
- Measures against fungi diseases of forest plantations and young stands.
- Enforcement of quarantine measures in silviculture within preparation of seeds and planting material in nurseries.

Water Resources and Sea Level Change

The projected changes of the climate parameters could have an essential influence on hydrological features over the territory of Russia.

In case of increase of mean annual air temperature by 3–5^0 C and precipitation by 10–20%, the annual sink in basins of the Volga and Dnieper rivers is expected to grow by 25–40%, and of the Yenisei river – by 15–20%. The annual distribution of sinks would be more even. The annual sink to the Arctic Ocean is expected to rise by approximately 15–20%.

It is highly probable that in the future the level of the Caspian Sea would decrease from its present level of -27 m to its mean position (-28.4 to -28.9 m) and would have noticeable inter-annual variations.

For many catchments global warming will cause more considerable change in extreme sink parameters than in annual and seasonal ones. The increased danger of floods is expected in many regions of Russia, where river sink is projected to grow.

The projected changes in total content, leveling, maximum and minimum consumption of water will transform erosion processes on catchments, river channels. The changes in turbidity, deposit run-off, river channel processes, and water quality are also expected. Considerable negative consequences are associated with rise of underground water and intensification of inundation, especially in zones of surplus humidity, and withdrawal of agricultural lands from rotation.

The global warming would cause an abrupt rise of water quantity as a result of snow or glacier melting that in turn, would lead to floods. The floods quite often are caused by rise of river water level due to blockage of channel by drifting ice, as it happened in Lensk, or enormous precipitation from destructive shower cyclone, as it was in Vladivostok. Frequently floods occur from winds that move sea water to river estuaries and cause its increase there because of hold up the water brought by the river.

The rise of ocean and sea level may result in flooding of low coastal areas, development of coastal erosion, changes in delta-formation processes, salinification of river lowers due to intense seawater penetration. The negative effects would occur for harbor operation.

The inundation of coastal territories and islands can be caused by tsunami originated from earthquakes or volcano eruptions in ocean. The Pacific coast of Russia, where main economy and population of Russian Far east is concentrated, is highly vulnerable to extremely destructive effect of tsunami waves.

The adaptation of water management to climate change includes implementation of water-management, bank-protection and improving preventive technical-engineering activities. To avoid emergency and extreme events, administrative measures should be adopted based on adaptive capacities of water management systems and hydraulic engineering facilities.

Regions of Permafrost

Permafrost currently covers 67% of the territory of Russia. The cryolite zone is rather sensitive to climate change. The global warming intensifies degradation of permafrost.

According to the estimates, in the next 20–25 years in Western Siberia the shift of southern border to north of solid cryolite and insular permafrost would constitute 30–80 km and 200–450 km respectively. By 2050, border of solid cryolite zone may be displaced to north by 150–200 km or more. By that time and in later years, development of hyperthermal frozen ground would be observed even in the Arctic region.

Global warming entails irreversible natural processes that may cause serious negative consequences for settlements and other managed territories.

A system of adaptation measures to prevent and limit negative consequences of particular types of technogenic impacts on sustainable social and economic development of entire region of permafrost is being developed and gradually introduced in the construction sector.

Research and Systematic Observation

A wide-ranging research of the Earth's climatic system is carried out within the framework of the following programs:

1. **“Research and Development on the Priority Directions of Progressing in Science and Civil Engineering”** Federal Target Scientific-Technical Program. The Priority Direction: "Ecology and Rational Nature Management”.
2. **“Natural Processes in Outer Shells of the Earth in Conditions of Increasing Anthropogenic Influence and Scientific Basics of Ecologically Non-Dangerous Rational Natural Management”,** the Program for Basic Research of Russian Academy of Sciences.
3. **“World ocean”** Federal Target Program. The "Study and Research of the Antarctic Region” Subprogram.
4. “**The Technology of Forecasting and Assessment of Changes in Climate, Ecosystems, and Resource Due to Anthropogenic Effect, and their Consequences**” Target Program.
5. **Federal Space Program of Russia,** the Subprogram “Remote Sensing of the Earth”. The Subprogram is aimed at development of meteorological space devices providing observations from space for real-time processing of global data on physical state of the atmosphere, land and oceans, as well as forecasting meteorological processes and climate change.

Wide-scale systematic observation programs include:

- The climatic and climate change monitoring (meteorological and atmospheric observations, oceanographic observations, terrestrial observations, and space–based observations).
- The observation systems of atmospheric components (ozone, CO_2, transboundary air pollution, and climate change oriented satellite-based background monitoring of environmental pollution)

International Cooperation

The Russian Federation actively participates in international cooperation on the problem of the anthropogenic climate change.

The President of the Russian Federation V.V. Putin at the Group of Eight summit in July 2001 proposed to convene in 2003 World Conference on Climate Change with the participation of representatives of governments, business and scientific communities as well as civil society. This proposal was supported by the summit and included in the Communiqué of Heads of States and Governments of The Group of Eight (section Future Goals, the Environment) of July 22, 2001 (Genoa, Italy). The plan of practical activities is being developed on the organization of the Conference, including international aspects and practical issues.

The Russian Federation participates actively in the Conference of the Parties and in the Subsidiary bodies of the UNFCCC. The Head of Roshydromet A.I. Bedritsky was twice elected Vice-President of the Conference of the Parties. Many scientists from the Russian Federation contributed significantly to the activities of the IPCC – the Intergovernmental Panel on Climate Change – and its working groups. Academician Yu.A. Izrael is a Vice-Chairman of the IPCC. Russian specialists participate in numerous global programs of the WMO. Mr. S.S. Lappo is a member of the Joint Scientific Committee of the World Meteorological Organization/International Council of Scientific Units (WMO/ICSU) on the World Climate Research Program (WCRP).

Russian scientists and specialists participate in programs and projects of the WCRP, supervised by the World Meteorological Organizations: Global Energy and Water Cycle Experiment (GEWEX), Experiment on Modeling the Global Climatic System, Tropical Ocean-Global Atmosphere Program (TOGA), World Ocean Circulation Experiment (WOCE), Experiment on Climate Variability and its Predictability (CLIVAR), Arctic Climate System Study (ACSYS).

Bilateral scientific and technical co-operation on the climate problems between the Russian Federation and the USA is carried-out within the framework of the Working Group RF-USA on the Climatic Politics. The Working Group defines the concept and working programs of the two countries in the field of scientific researches of the global warming.

Specialists of Roshydromet participate in the activity of the Working Group on Global and Regional Problems of Climate Change and Ozone under Interstate Council on Hydrometeorology of the CIS countries.

Active international cooperation in the field of research, protection and use of forests is carried out to increase their productivity and CO_2 sinks. The State Forest Service under the Ministry of Natural Resources of Russia established groups on the scientific and research cooperation with Sweden, the USA and China. There are long-term relations between forestry bodies of Khabarovsk and Krasnoyarsk Territories and US organizations. Activities on establishing experimental forest-seed plantations are conducted in Karelia, Yaroslavl oblast and in a number of other oblasts. Research work is conducted on Khabarovsk Territory within the framework of Canadian program International Model Forest Network. There is an agreement with the U.S. Forest Service on the monitoring of Asian form of Gypsy moth on the wooded territories adjacent to Primorye ports.

II NATIONAL CIRCUMSTANCES RELEVANT TO GREENHOUSE GAS EMISSIONS AND REMOVALS

II.1 State Structure of the Russian Federation

According to the Constitution, the Russian Federation (Russia) is a democratic federal law-bound State with a republican form of government (Article 1).

The state power in the Russian Federation is exercised by the President of the Russian Federation, the Federal Assembly (the Council of the Federation and the State Duma), the Government of the Russian Federation, and the courts of the Russian Federation (Article 11).

President of the Russian Federation is the head of the State. He is elected for four years by citizens of the Russian Federation on the basis of universal, equal, direct suffrage by secret ballot (Articles 80 and 81).

The Federal Assembly is the Parliament of the Russian Federation. It is a representative and legislative body of the Russian Federation consisting of two Chambers - the Council of Federation and the State Duma. Only two representatives from every administrative subject of the Russian Federation can be members of the Council of Federations, namely, one is elected from the legislative body, and another – from executive body of state authority. The State Duma consists of 450 deputies. They are elected for the term of four years (Articles 94 and 95).

The Russian Federation consists of 89 subjects of the Russian Federation (Article 65). There were 21 republics, 6 territories, 49 regions, 2 cities of federal value, 1 autonomous oblast, and 10 independent districts, as of January 1, 2001. The subjects of the Russian Federation are incorporated in 7 Federal lands.

There were 1,097 cities and towns in Russia. The largest cities (in brackets population is given in thousands) were Moscow (8,305), Saint - Petersburg (4,628), Novosibirsk (1,393), Nizhni Novgorod (1,343), Ekaterinburg (1,257), Samara (1,146), Omsk (1,138), etc. There were 1,864 settlements of an urban type. All above cited data were as of January 1, 2001. The capital of the Russian Federation is Moscow.

As of January 1, 2002, there were 1,098 cities and towns; the largest of them (in brackets a population is given in thousands) were Moscow (8,300), St.-Petersburg (4,596), Novosibirsk (1,388), Nizhni Novgorod (1,333), Ekaterinburg (1,251), Samara (1,134), Omsk (1,127) etc., and 1,850 settlements of an urban type.

II.2 Demographic information

The Russian Federation is the sixth largest country in the world in terms of population. The data on a population are presented in Table II.1. The values of 148.5 million and 148.3 million have been used for calculations of per capita statistical values for the 1990 (base) year and for 1994, respectively.

Population density was 8.5 persons per km^2. in 2000 and 8.4 persons per km^2 in 2001.

The number of engaged in economy has increased and the number of unemployed has reduced in 2000 compared with 1999.

Economically active population amounted to 71.0 million at the end of 2000.

Russia is multiethnic state. More than 100 nationalities and nations are represented on its territory. The Russians constitute more than 4/5 of the whole population (the number was 119,866 thousand in accordance with the 1989 general census data). There is a significant share of Tatars (5,522 thousand), Ukrainians (4,363 thousand), Chuvashes (1,774 thousand), Bashkirs (1,345 thousand), Byelorussians (1,206 thousand).

Table II.1
Population of the Russian Federation in 1985 - 2000 (million)

Year (End of year)	Population in millions of people			
	Total population	Urban population	Rural population	Average annual number of economically active population
1985	143.6	103.7	39.9	74.9
1990	148.2	109.4	38.8	75.3
1995	147.6	107.7	39.9	66.4
1996	147.1	107.3	39.8	66.0
1997	146.7	107.1	39.6	64.7
1998	146.3	106.8	39.5	63.8
1999	145.6	106.1	39.5	64.0
2000	144.8	105.6	39.2	64.3
2001	144.0	105.1	38.9	-

II.3 Geographic Profile and Natural Resources

The territory of the Russian Federation occupies the larger part of the Eastern Europe and Northern Asia. Russian territory equals 17,075.4 thousand km^2 (the largest territory in the world). Longitudinal extent is in the range of 2.5-4.0 thousand km; latitudinal one is 9.0 thousand km. The State borders with:

Norway and Finland in the northwest;
Poland, Estonia, Latvia, Lithuania and Byelorussia in the west;
Ukraine in the southwest;
Georgia, Azerbaijan and Kazakhstan in the south;
China, Mongolia and the Democratic People's Republic of Korea in the southeast;
USA and Japan in the east (sea border).

Russia is washed by the seas of the Arctic Ocean (the Barents Sea, the White Sea, the Kara Sea, the Laptev Sea, the Eastern-Siberian Sea, the Chuckchee Sea), by the seas of the Pacific Ocean (the Bering Sea, the Sea of Okhotsk, the Sea of Japan), and by the seas of the Atlantic Ocean (the Baltic Sea, the Black Sea, and the Sea of Azov).

The following natural zones occur on the territory of Russia: a polar-tundra zone occupying up to 30 % of the country's area, a zone of coniferous forests (taiga) - 50 %, zone of a deciduous forests - 8 % and a forest-steppe zone - 12 %.

Wide-ranging plains occupy about 70 % of the territory. The East-European plain outstretches to the west. Its eastern border is the Ural mountain system. The West-Siberian plain is located to the east from the Urals. Further to the east the Central Siberian plateau is located between the Yenisei and Lena rivers. It continues by the Central Yakutian plain on its eastern border.

The mountain areas prevail in the eastern and southern parts of the country. These are the northern chains of the Great Caucasus in the European part. Here is the highest point of the Russian Federation - a mountain of Elbrus, of 5,642 meters above the sea level. Mountains of Southern Siberia extended along the State border include: Altai, Kuznetsky Alatau, Western Sayan, Eastern Sayan, mountains of Tuva, Baikal-side, Transbaikalia, and Stanovoe Nagorie. Medium-altitude mountain chains prevail in the north-eastern part of Siberia, and in the Far East. The mountains of Kamchatka and Kuril Islands are extended along the Pacific coast of Russia.

There are about 120 thousand rivers with a length over 10 kilometres on the territory of the country, and the overall length of them is 2.3 million kilometres. The longest rivers are: the Lena (4,400 km), the Irtish (4,248 km), the Yenisei (4,102 km), the Ob (3,650 km), the Volga (3,530 km), the Amur (2,824 km).

About 2 million fresh and salt-water lakes are located on the territory of the Russian Federation. The largest ones are the Lake Baikal (31.5 thousand km^2), the Lake Ladoga (18.1 thousand km^2), and the Lake Onega (9.7 thousand km^2).

The huge area amounting to more than 67 % of the territory of Russia is occupied by permafrost or by many years frozen grounds (MFG). MFGs are stretched out to the north-eastern European part; in Western Siberia they occupy its northern half. MFGs are spread almost everywhere in the Eastern Siberia and at the Far East. Zones of continuous, block-island, island, and rare-island MFGs succeed one another in the north to south direction. A broad spectrum of cryogenic processes causing wide spread disturbances of natural and technogenic complexes is typical on the territory of permafrost, especially in zones of continuous MFGs.

Active exploitation of mineral resources is carried out in a zone of the continuous permafrost where the huge deposits of oil, combustible gases, and coal are concentrated, especially in the European part and in Western Siberia. Focal agriculture exists in Southern Siberia. The appropriate infrastructure has been created there: cities, settlements, transport communications, means of communication, electricity transmission lines, pipelines, etc. Economic activity is accompanied by significant adverse effects on nature and by strengthening of cryogenic destructive processes in the permafrost zone.

According to the data of Roszemcadastre, 147.4 M ha or 8.6 % of the country's territory is occupied by bogs, as on January 1, 2001.

The total area of bogs (peat layer > 30 cm) and wetlands (peat layer < 30 cm) is 369.1 M ha or 21.6 % of the territory of the country (Table II.2). The most of the peat-covered wetlands are located in the Asian part of the country (84 %), in the area of permafrost (73 %), and the taiga zone (71 %).

Table II.2
Peat covered wetlands of Russia

Territory (zone)	Area (Mha)	Territory (zone)	Area (Mha)	Territory (zone)	Area (Mha)
European part	58.8	Tundra and forest-tundra	106.2	Permafrost zone	270.6
Asian part	310.3	Taiga and other zones	262.9	Western Siberian low land	99.1

The area of land covered with forests was 794.3 M ha or about 46.5 % of the territory of the country according to the data of Roszemcadastre as on January 1, 2001. Agricultural lands occupy 13 % of the territory of Russia.

All kinds of mineral fuels are extracted in Russia, with oil (including gas condensate) and natural gas having the largest share. . The main production of oil and gas has been developed in the Western Siberia. There is abundance of iron ores; there are also significant ore deposits of various non-ferrous and rare metals. The deposits have been found out of precious, semiprecious and ornamental stones, as well as of marble, granite, basalt and other building and decorative stone materials in many mountain areas of Russia, especially the Urals, the Altai, Transbaikalia and at the Kola peninsula.

II.4 Climatic conditions

The major part of the territory of the Russian Federation is situated in a moderate climatic zone. Climate is continental almost everywhere (in extreme northwest - maritime), in

Siberia and in the northern areas of the Far East it is sharply continental, in the south of the Far East moderate monsoon climate prevails.

Average January monthly temperatures vary between 0 and -5°C (Northern Caucasus) and between –40 and -50°C (Republic Saha, Yakutia) where the minimal temperatures reach -65-70 °C. Average monthly temperatures of July vary from 1°C at northern coast of Siberia to 24-25°C in Prikaspijskaya lowland.

The greatest amount of precipitation falls out in mountains of Caucasus (up to 2,000 mm per year), in the south of the Far East (up to 1,000 mm), and also in a forest zone of East European plain (up to 700 mm). The minimum precipitation falls at semiarid areas of Prikaspijskaya lowland (about 150 mm per year).

II.5 Economic reference data

The GDP growth in 2000 (in monetary terms) was predetermined by the growth in the industrial production and in the construction sectors.

Table II.3
Trends in gross domestic product (1990 = 100%)

	Year								
	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total GDP	81	74	65	62	60	61	58	61	66
GDP per capita	81	74	65	62	60	61	58	62	67

The main factors for the increase in the industrial production and construction were the expansion of domestic investment and consumer demand and the growth of export (Tables II.3 and II.4)

Table II.4
Trends in the real produced GDP (percentage relative to a corresponding period of the previous year)

Branch of economy	1998	1999	2000[1)]
GDP	- 4,9	5,4	8,3
Production of goods	- 7,4	10,7	10,7
Industry	- 5,2	10,8	12,1
Agriculture	- 18,8	17,1	5,0
Building	- 6,5	6,1	11,5
Production of services	- 2,5	1,8	6,2
Market services	- 3,5	1,9	7,2
Transport	- 4,6	5,9	5,2
Trade and public catering	- 5,5	- 2,4	10,4
Non-market services	0,4	1,4	1,8

1) Estimated

II.6 Energy industry

Russia, with its 2.8 % of the world population and 12.8 % of the world territory, has 12-13 % of the world unexplored resources and about 12 % of explored reserves of oil, 42 % resources and 34 % reserves of natural gas, about 20 % reserves of coal and 32 % reserves of brown coal. The total volume of the extracted fuels for the whole history amounts to 17 % of potential extractable resources for oil and 5 % for gas. Reserves-to-production ratio is estimated as some dozens years for oil and gas, and much more – for coal. The uranium mineral base can meet the requirements of developing nuclear energy.

Tables II.5 and II.6 present the data on production of energy resources in the Russian Federation in 1990-1999.

In the near future, the main trends in the development of the Russian energy sector will be governed by the Federal Energy Strategy of Russia approved at the end of 2000 (Fundamental Provision of Energy Strategy of Russia for the Period up to 2020, approved by the Government of the Russian Federation, protocol № 39 of November 23, 2000).

Table II.5.
Primary energy supply (Mtce)

Production	Year									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total, including	1862	1758	1656	1539	1438	1402	1396	1359	1367	1388
Oil and gas condensate	738	661	571	506	454	439	431	437	434	436
Natural gas	739	742	740	713	698	685	694	659	682	683
Coal	270	241	230	209	186	181	171	164	154	170
Fuel peat (nominal humidity)	1,8	1,6	2,7	0,9	1,0	1,5	1,4	1,1	0,6	0,6
Shale	1,3	1,2	1,1	0,9	0,9	0,7	0,5	0,6	0,5	1,2
Fuel wood	17,2	17,5	13,4	13,7	8,5	8,1	7,0	6,0	5,2	5,1
Electrical energy produced by hydro-nuclear and geothermal power plants	94,7	93,7	97,8	95,5	89,0	86,2	91,1	91,6	90,6	92,1

Source: Russian Statistics Yearbook, 2000

The Energy Strategy provides a basis for the development of a long-term power policy of Russia aimed at ensuring energy security under the conditions of transition of the country to a market economy, long-term sustainable public supply of energy, and protection of energy independence of the country.

Table II.6
Production of electric energy by power stations (in TW-hr)

Stations	Year									
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Electric power stations, including	1082	1068	1008	957	876	860	847	834	827	846
Thermal power stations	797	780	715	663	601	583	583	567	563	563
Hydroelectric power stations	167	168	173	175	177	177	155	158	159	161
Nuclear power plants	118	120	120	119	97,8	99,5	109	109	105	122

The aim of the energy policy and the highest priority of the Energy Strategy of Russia for the period up to 2020 is the most effective use of natural energy resources and of available scientific, technology and economic potential of the fuel-energy complex to increase the living standard of the population. Accordingly, the Energy Strategy stipulates the ways of creating the conditions for safe, effective and sustainable functioning of the energy sector of Russia.

Realization of the main goal of the Energy Strategy requires solving the whole complex of interrelated problems, among which one of the most important is increasing the effectiveness of the energy use on the basis of energy saving technologies and optimization of the structure of power generating facilities under the conditions of an increase in the energy supply of the economy, labor and everyday life of the population and the decrease in ecological load on the environment, taking into account the global concept of sustainable development, as well the power and technological improvement of the productive forces of the country to raise their economic effectiveness and market competitiveness.

The main way of achieving the goals and realizing the provisions of the Energy Strategy is the state participation in creating the civilized energy market and economic relations within it. The state regulation will be carried-out with the help of:

- Correlated price, tax, customs and competition policies;
- Implementation of anti-monopolistic policy and institutional and administrative reorganizations in the fuel-power complex;
- Improvement of the legal and normative base of the energy sector functioning, standardization, certification and guaranteeing the uniformity of all types of measurements, licensing activity of the energy market participants.

Depending on the rate of economic growth, the Energy Strategy envisages the 1.14-1.36-fold increase in domestic consumption of primary energy in the period 2001-2020 (for lower and favorable variants of the economic development, respectively) with a corresponding 1.7-2.1-fold decrease in the energy intensity of the GDP.

II.7 Transport

The volume of the rail traffic of goods in 2000 was 110.5 % as compared to 1999 level, the commercial turnover being increased by 14 % as compared with 1999.

The amount of commercial road transportation of goods in 2000 was 109.2 % as compared to 1999 level, and the turnover increased by 10.7%.

The amount of commercial shipping of goods by sea transport of general use continued to decrease in 2000, being less by 14.0 % as compared to 1999 level, and the turnover decreased by 17.1 %.

Positive tendencies in the economic development of the country observed in 1999-2000, influenced to a certain degree the activity of civil aviation. In 2000 the passenger turnover remained at the 1999 level. Commercial carriers (transport aviation) transported 21.83 mln passengers on regular lines in 2000 (101.7 % as compared to 1999).

II.8 Industry

For the whole year of 2000 the industrial production index exceeded that of the corresponding period of the previous year, amounting to 112 % on an annualized basis.

The most increase in the industrial production (as compared to the previous year level) was achieved in non-ferrous metal industry, light industry, building materials industry, machinery and metal working, food industry.

II.9 Housing fund and municipal structure

The housing fund of the Russian Federation constitutes more than 20 % of the total reproducible capital facilities of the country, i.e. 2,786.6 M sq. m of the total area, including:

Municipal - 739.6 M sq. m (26,6 %);
State-owned - 176.5 M sq. m (6,3 %);
Private - 1,818.7 M sq. m (65,3 %);
Mixed property - 50.2 M sq. m (1,8 %);
Communal - 1.6 M sq. m (0.1 %).

The total number of individual apartments in the Russian Federation is 55.2 mln, among them 23 % one-room, 41 % – two-room, 29 % – three-room, 6 % – four-room.

Table II.6a[*]
Trends in the structure of housing fund by property type (% of total)

Year	Type of property			
	Private	State	Municipal	Other
1990	33	42	25	0
1997	57	7	31	5
1999	63	6	29	2
2000	65	6	27	2

Of the total amount of the housing fund 73 % are equipped with water supply lines, 69 % – with sewerage, 74 % – with central heating, 64 % – with baths, 59 % – with hot water supply, 70 % – with gas supply, 16 % – with floor-mounted electric cooking appliances. These are the evidences of the increase in the level of equipment of dwelling houses with the main types of services and amenities.

While the average living area is 19.3 sq. m per capita, 5.4 mln families are on a waiting list to improve their living conditions, one third being registered for 10 and more years. In the last year 252.6 thousand families (or 4.6 % of the total number of the registered ones) improved their living conditions. Under the existing rates, it will take more than 20 years to provide all the needy with dwellings.

Every year the unserviceable housing fund with depreciation of more than 65-70 % and subject to demolishing, increases (1995 – 37.7 M sq. m, 1996 – 40.3 M sq. m, 1997 – 42.3 M sq. m, 1998 – 45.5 M sq. m, 1999 – 49.6 M sq. m, 2000 – 65.4 M sq. m). Just in the last few years about 50 M sq. m became unusable because of decrepitude, including 4.4 M sq. m of the total area last year, or about 14 % of the new dwelling construction in the country. About 20 % of municipal housing fund is not yet supplied with all amenities, and in small towns every second house does not have plumbing.

II.10 Agriculture

In 2000, certain measures were taken to stabilize the production in the agricultural complex of the Russian Federation, providing agriculture of the country with state support and strengthening the financial situation of agricultural producers, developing the food market and securing reliable food supply of the population.

As a result of these measures, in 2000 harvest has increased, exceeding the 1999 level: of bread grains – by 20 %, of flax fiber – more than twice (2.2 fold), of potatoes – by 8.4 %, and of a number of other agricultural plants.

Positive shifts took place in the forage production. There were stored up 27.4 Mt of coarse and rich fodder (normalized to forage units). This number exceeds those of the previous year by 3.5 Mt, or 15 %.

Animal production has stabilized in many regions of the Russian Federation. Production of cattle and poultry intended for slaughter (in live weight) and egg production increased by 3 % as compared to 1999. Milk production remained at the level of 1999.

However, the total situation in this branch remains unstable because of the decrease in the cattle population.

The continuous demand of population for domestic-produced provision, more favorable weather conditions, and the improvement of production and economic results of the activity of certain agricultural producers promoted the improvement of a number of

[*] The Table number was introduced by interpreters

economic indexes characterizing the activity of agricultural complex of the Russian Federation in 2000.

On the basis of the data from the Ministry of Agriculture of Russia, the number of profitable agricultural enterprises increased by 5.8 %, and the share of profitable agricultural enterprises amounted to 46.6 % in 2000 compared to 45.0 % in 1999.

II.11 Forestry Sector

The balanced utilization of forest stock on the basis of sustainable forest management is a national priority for the Russian Federation. The forest stock comprises all forest lands in the country including those not covered by forest vegetation with exception of forests on lands of Ministry of Defense and urban territories. National forestry legislation regulates utilization, conservation and reforestation of forests both included in and excluded from forest stock as well as of lands within the territory of forest stock that are not covered by vegetation.

In the Russian Federation, State Census of Forest Stock is implemented once every 5 years. The latest censuses were conducted in 1988, 1993 and 1998. In 1988, the territory of forest stock was 1,182.6 Mha. In 1993 and 1998, it changed to 1,180.9 and 1,172.3 Mha respectively. Total stem stock volume was estimated as 81.6 Gm^3 in 1988, 80.7 Gm^3 in 1993 and 81.3G m^3 in 1998 respectively. Table II.7 presents the structure of the national forest stock and lands not included in it over the territory of subjects of the Russian Federation as for January 1, 1998 (the data of the last State Census of Forest Stock).

Table II.7
The lands included and not included in forest stock within the territory of the Russian Federation as for January 1, 1998

The national managing authority for forests included and not included in the forest stock	Total area, Mha	Total stock volume, Gm^3
Forest stock, including:	1,172.3	81.33
Federal Forestry Service	1,110.6	74.32
State Committee for Environment	18.9	1.40
Ministry of Agriculture	42.5	5.56
Ministry of Education	0.4	0.052
Forests not included in the forest stock, including:	6.2	0.53
Ministry of Defense	4.9	0.42
Forests of urban territories	1.3	0.11
Total for the territory of the Russian Federation	1,178.6	81.86

As follows from Table II.7, the largest areas and volume occupy the territory of national forest stock that previously was under the responsibility of the Federal Forestry Service. Now it is part of Ministry of Natural Resources of the Russian Federation.

In accordance with national Forestry Code, the basic responsibilities of the Russian Federation in the field of utilization, conservation, protection and reproduction of forest resources include:

- Ownership, use and management of the forest stocks, determination of the guiding principles of the state forest management policy and implementation of unified investment policy for utilization, conservation, protection and reproduction of forests;
- Subdivision of forests into management groups; demarcation of first-group forests by conservation categories and conversion of forests into various groups;
- Elaboration, endorsement and implementation of state programs for utilization, conservation, protection and reproduction of forests;

- Establishing rates, rules and payments for use of forest stock, allocation of allowances and determination and approval of allowable cuts;
- Authorization and regulation of state census, cadastre, monitoring and inventory of forests;
- Sanction and implementation of state control on utilization, conservation, protection and reproduction of forests and etc.

Thus, state administration, registration and control cover all the territory of national forest stock. The management of forest is organized on the basis of its economic, environmental and social role, geographical location and specific functions. That is important for planning measures for mitigating climate change impacts. Based on the above factors, national forest stock is subdivided into 3 groups. The forests of the First Group ensure water protection, conservation, sanitary-hygienic, recreation and other functions. This group also includes stands of especially protected natural areas. Management activities in the forests of the First Group primarily aim at conservation and restoration of growing stock. The Second Group includes stands in highly populated regions and ground transportation networks. Limited harvesting operations are allowed there. This group also includes regions with insufficiently forested areas that require specific limitations in utilization regime for forest protection purposes. The Third Group of forests includes regions with vast forest areas of commercial value. These are subdivided into developed and reserve parts. Federal forest management authority sets differentiation criteria for reserve forests. It should be noted that maintaining environmental functions is mandatory for any utilization operations implemented in the national forest stock.

In the Russian Federation, forest stock includes forest and non-forest lands. Non-forest land comprises territories with no forest vegetation that are allocated for other management purposes. Forest land is subdivided into territories actually covered and temporarily not covered by forest vegetation. CO_2 removals were estimated over actually covered by forest lands as they were at the moment of State Census of Forest Stock. The most complete and reliable series of data on volume, age, species composition and other functional properties of actually covered by forest lands have been accumulated for 94.2% of national forest stock that was previously under the authority of the Federal Forestry Service of Russia. Table II.8 presents areas and volumes of main stock-forming species on actually covered by forests lands of the former Federal Forestry Service that were taken from the state forest censuses.

Table II.8
Area and stock volume of dominant forest-forming species over actually covered by forests lands (taken from the state censuses of forest stock)

Years	**Area, Mha**			**Stock volume, Mm^3**		
	Conifers	**Hardwood**	**Softwood**	**Conifers**	**Hardwood**	**Softwood**
1988	506.0	15.2	107.4	58,608.33	1,645.76	11,188.94
1993	507.7	17.3	113.2	57,677.48	1,860.41	12,103.7
1998	508.7	17.5	119.7	57,787.58	1,912.76	13,095.02

Age distribution is important for estimates of CO_2 removals in forests. In Russia, more than a half of forests have mixed age structure, whereas forest plantations occupy relatively small territories. This results in noticeable decrease in accuracy of estimates. Age distribution of forests of the former Federal Forestry Service is shown on Figure II.1. It should be noted that since the state census of 1993, the changes in the age structure were minor.

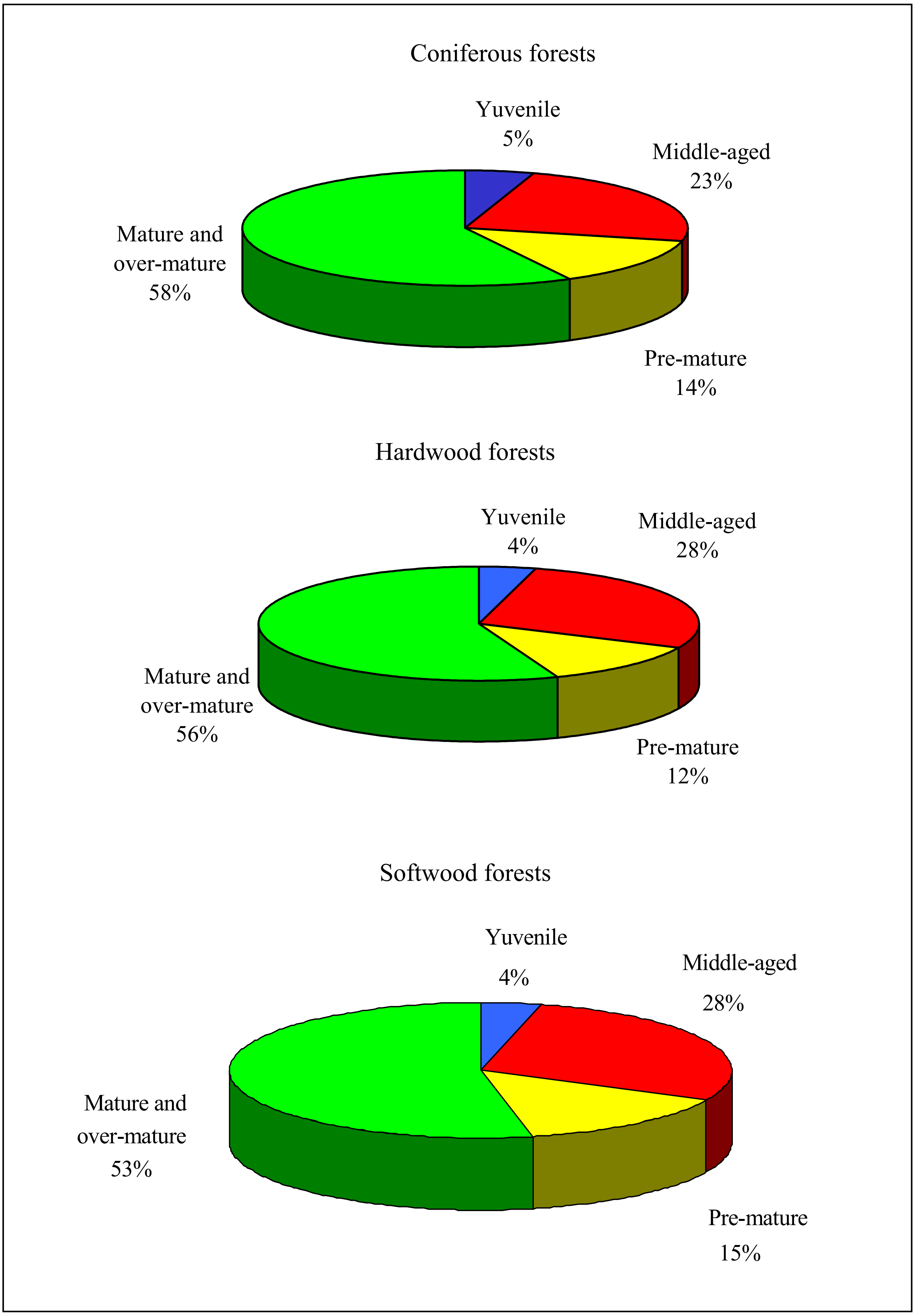

Fig. II.1 Age distribution of stock volume of State Forest Stock as for January 1, 1998

Forest utilization is a key factor that influences total net carbon sequestration by forests. In Russia, the notions "estimated allowable cut" (permissible forest cut determined on the basis of environmental capacity of forest ecosystems) and "actual cut" are used. From 1990 to 1998, estimated allowable cut within the country was higher than 500 Mm^3/yr. The data on actual forest cuts from 1990 to 1999 are provided in Table II.9.

Table II.9
Actual forest cuts within the territory of national forest stock, Mm^3
(the data of Ministry of Natural Resources of the Russian Federation)

Year	Main cuts	Transitional cuts
1990	283.5	27.5
1991	251.7	24.7
1992	227.5	24.0
1993	174.2	19.9
1994	130.4	20.7
1995	134.1	22.6
1996	110.5	22.7
1997	103.4	23.0
1998	98.0	22.0
1999	121.6	22.7

As follows from Table II.9, from 1990 to 1999 actual cuts were significantly lower than the annual allowable values.

Forest restoration is another activity implemented by forestry authorities. Silvicultural technologies over lands allocated for forest plantations are set based on objectives of newly developed forests, specific features of tree species used, forest types and technical and economic capacities of forestry units. Promotion of natural regeneration is another important restoration measure. It is carried out to develop favorable conditions for intensive growth of a new generation of economically valuable tree species. More than 60% of total promotion is implemented by conservation of young undergrowth during harvesting. The rest promotion measures are realized through mineralization of upper soil layer. Low-value stands are reconstructed by development of forest plantations. This measure intends to improve composition, productivity and enhance other benefits of forests. Table II.10 informs on development of forest plantations and promotion of natural regeneration over the territory of former Federal Forestry Service from 1990 to 1999.

Table II.10
Forest restoration activities over the territory of forest stock under the authority of Ministry of Natural Resources of the Russian Federation (Federal Forestry Service), kha

Year	Development of forest plantations	Promotion of natural regeneration
1990	348.1	392.7
1991	331.3	476.7
1992	334.7	574.8
1993	392.6	937.2
1994	356.2	1,111.1
1995	331.7	1,030.9
1996	274.2	761.5
1997	237.5	784.8
1998	232.0	718.1
1999	227.9	677.6

As follows from the table, silvicultural activities noticeably dropped after 1995. The promotion of natural regeneration was the highest in 1994-1995 and somewhat decreased thereafter.

Forest fires are a serious problem for the Russian Federation. Regular fire control covers the area of active forest protection that is about 2/3 of the total area of forest stock. It includes almost entire European part of the country, southern and partly central regions of Siberia and the Far East. Fire extinguishing activities over rest territory (about 400 Mha) are incidental, and registration of fires is practically lacking. The data on forest fires over controlled territories of forest stock is shown in Table II.11.

Table II.11
Forest fires within the controlled territory of forest stock under the authority of Ministry of Natural Resources of the Russian Federation

Parameter	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Fire events, thousands	11.7	13.0	21.0	16.9	18.6	24.3	29.3	27.6	24.0	31.8	18.9
Area of fires, kha	965	569	522	733	520	352	1,826	669	2,458	679	1,281

As follows from table, the areas of forest fires were abnormally high in 1996, 1998 and 2000. Figure II.2 shows the total volume of wood combusted in forest fires (the data of the Ministry of Natural Resources of the Russian Federation).

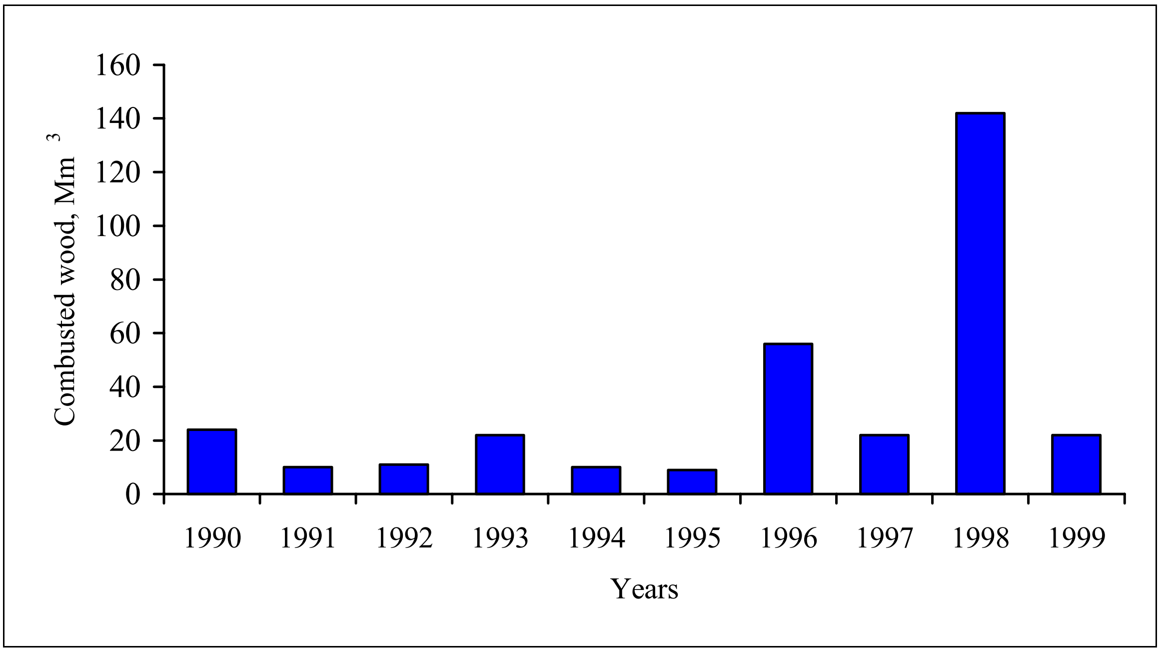

Fig. II.2 Volume of wood combustion from forest fires (the data of the Ministry of Natural Resources of the Russian Federation)

III GREENHOUSE GAS INVENTORY INFORMATION

First systematic estimates of GHG emissions and removals on the territory of Russia were conducted in the second half of the 1980-s. Estimates of emissions and removals for 1990, determining the obligations of Russia as an Annex I Party to the UNFCCC, were included in the First National Communication submitted in 1995. The Second National Communication (1998) contained additional and updated estimates for 1990, as well as estimates for 1991-1994 and, partially for 1995. In 1999 – 2000 estimates for 1995 and 1996 were developed and submitted to the UNFCC Secretariat.*

The emissions and removals inventory data for 1997, 1998 and 1999, developed in 2001, are provided in Annex 1 to the present National Communication.

Methodology used for the preparation of inventories has been based on the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines), as well as on national studies and research. While developing inventories for 1997 - 1999 data and methodologies contained in the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000) were also used to some extent. Starting in 2002 a more extensive introduction of the Good Practice Guidance in national inventory process is planned in the Russian Federation.

During the whole period of developing national GHG inventories in the Russian Federation in accordance with requirements of the UNFCCC and national requirements, work on improvement of the inventories' methodical basis, completeness and disaggregation level, including expansion the scope of emission source categories, was carried out.

To ensure data comparability and consistency in time series, relative emission data in percentage terms included in this chapter were corrected in order to exclude effects of methodological changes introduced in different years for individual source categories, emission factors and other parameters. Such corrections were not applied to absolute emissions data expressed in mass units or CO_2-eq.

For that reason, in some tables emissions data are rounded, and total emissions can differ slightly from the sum of the corresponding individual values and from emissions data presented in Annex 1.

III.1 Total Greenhouse Gas Emissions

Total anthropogenic emissions of greenhouse gases from the territory of Russia in 1999 (in CO_2-equivalent) amounted to 61.5 % of the 1990 emission. Figure III.1 and Table III.1 represent GHG emission trends in 1990 - 1999 (without CO_2 removal by forests). Figure III.2 illustrates annual changes in total CO_2-equivalent emissions.

Contributions of individual gases to the total emissions are presented in Table III.2. It can be seen that, despite a significant change in total emissions, the structure of emissions remains stable enough. Some increase in a CO_2 contribution to the total emissions can be attributed to the increase in energy intensity of the GDP in the 1990-s and to the accompanying increase in fuel-related CO_2 emissions per unit of production output.

Data presented in Table III.3 characterize the contribution of individual source categories to anthropogenic GHG emissions on the territory of the Russian Federation.

Table III.4 and Figure III.3 present the results of estimates of specific GHG emissions (per unit of GDP and per capita).

* Estimates of emissions and removals for the whole 1990 – 1996 period submitted by Russia were included in the official documents of the UNFCCC.

Table III.1
Anthropogenic greenhouse gas emissions in the Russian Federation (Mt CO_2-eq.)

GHG	Year							
	1990	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**1999[1)] (% of 1990)**
CO_2	2360	1660	1590	1500	1530	1510	1510	63.9
CH_4	550	410	390	390	300	310	290	52.9
N_2O	98	49	43	41	44	34	35	35.8
PFC, HFC, SF_6	40	35	38	36	39	41	42	106.2
Total	3050	2150	2060	1970	1910	1900	1880	61.5

1) Calculated using emission values without rounding

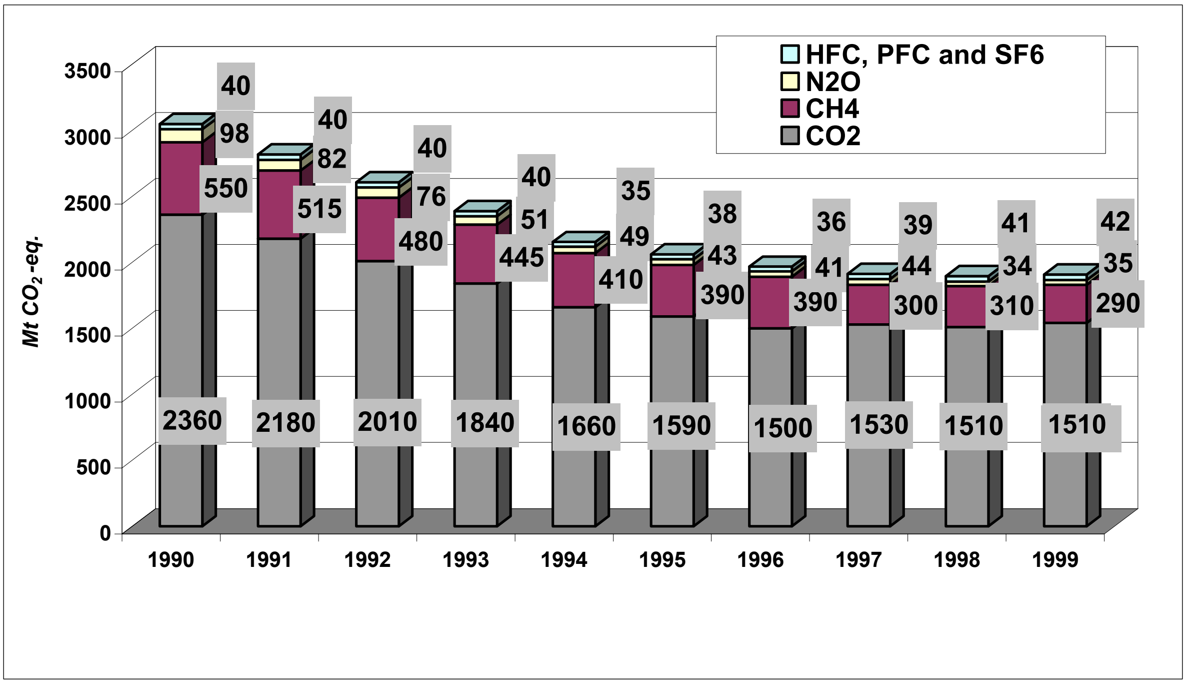

Fig. III.1 Absolute change in Russian greenhouse gas anthropogenic emissions in 1990 - 1999

Data on annual changes of the GDP and population of the Russian Federation for 1990 - 1999 used as a basis for these calculations are included in Table III.5. Taking into account data provided in Table III.4, it can be seen that by the end of the 1990-s an increasing trend in emissions per unit of the GDP was reversed and stabilization and even some decrease can be observed. Notwithstanding that, emissions per unit of the GDP are still well above the 1990 level.

Table III.2
Anthropogenic GHG emissions by gas (per cent of total emission in CO_2-eq.)

Year	GHG				
	CO_2	**CH_4**	**N_2O**	**HFC, PFC, SF_6**	**Total**
1990	77.5	18.0	3.2	1.3	100.0
1998	79.6	16.4	1.8	2.2	100.0

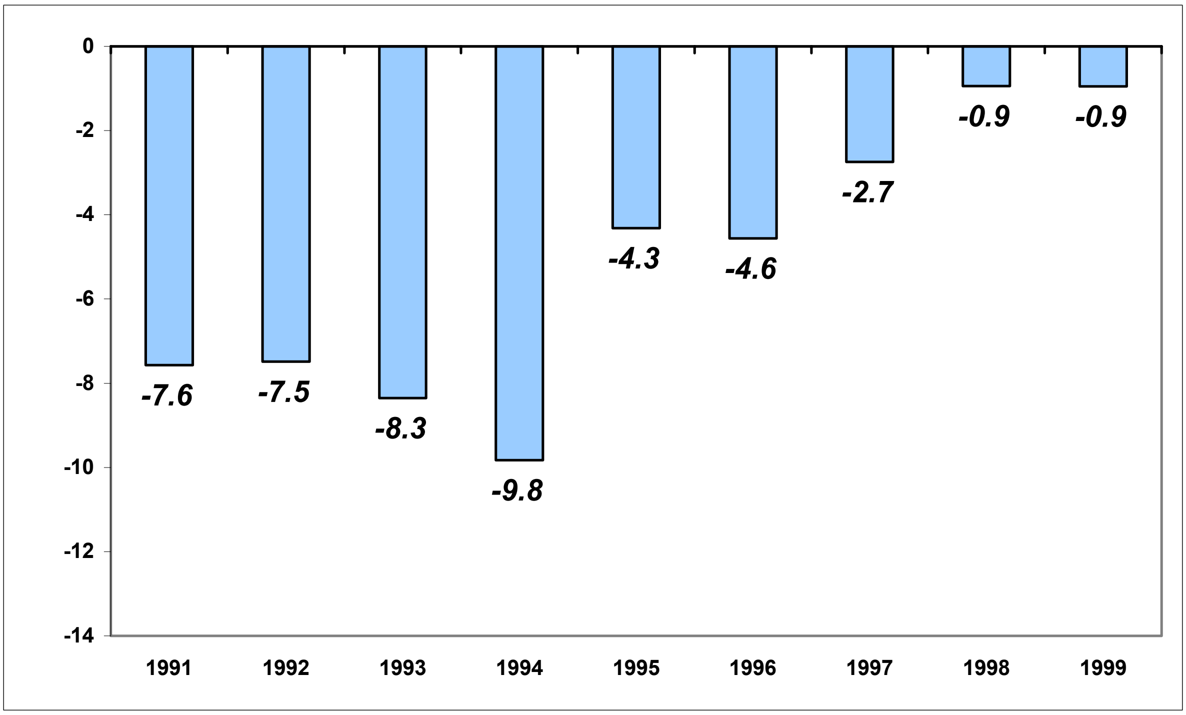

Fig. III.2 Annual percent change in total greenhouse gas emissions in 1990 - 1999

Table III.3
Anthropogenic GHG emissions in the Russian Federation by source category (Mt CO_2-eq.)

Source category	**GHG**			
	CO_2	**CH_4**	**N_2O**	**HFC, PFC, SF_6**
Primary and secondary fossil fuels, including:	1470	199	3.1	-
fuels burned for energy	1452	2.2	3.1	-
losses and fugitive emissions	18	197	-	-
Industrial processes	39	0.5	0.3	42
Solvents and other product use	-	-	0.6	-
Agriculture	-	51	27	-
Land-use change and forestry	-	2.9	0.3	-
Waste	-	38	3.4	-
Total	1510	290	35	42

Total emissions reduction accumulated in 1990 - 1999 amounts to 7,750 Mtce (860 Mtce/yr on average). Figures III.4 and III.5 illustrate annual changes of the accumulation.

Table III.4
Trends in greenhouse gas emissions per unit of GDP in 1990 – 1999 (1990 = 100%)

Emissions	**Year**						
	1990	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
CO_2 Emissions	100.0	108.7	108.5	105.9	107.2	111.1	105.4
Total GHG emissions	100.0	109.0	108.8	107.7	103.5	108.2	101.5

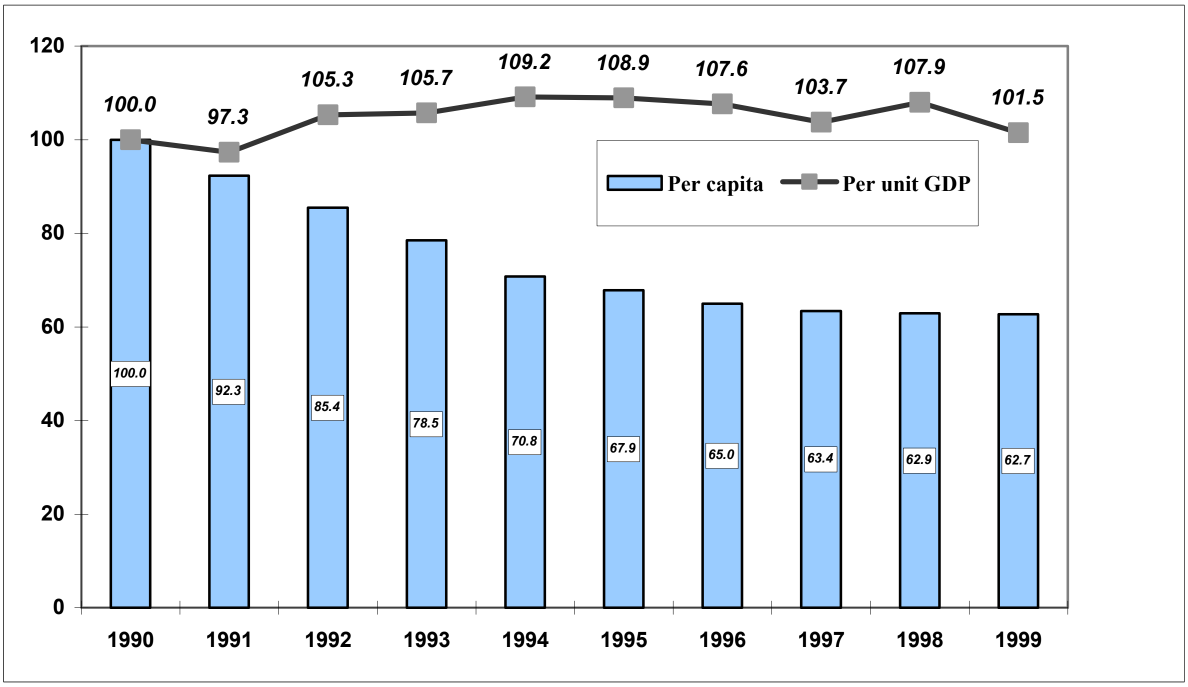

Fig III.3 Greenhouse gas emissions per capita and per unit of GDP in 1990 – 1999 (1990 = 100%)

Table III.5
Trends in GDP and population in the Russian Federation in 1990 – 1999 (1990 = 100%)

Indicator	**Year**										
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
GDP	100.0	95.0	81.2	74.2	64.7	62.1	60.0	60.5	57.5	60.7	66.1
Population	100.0	100.1	100.1	99.9	99.8	99.6	99.3	99.0	98.8	98.2	97.7

Estimates of GHG emissions from international aviation and marine bunker fuels are presented in Table III.6. Due to lack of data, only indirect estimates were made with a high degree of uncertainty. All GHG emissions related to bunker fuels were estimated to be due to the use of liquid fuels.

Table III.6
Emissions of CO_2, CH_4 and N_2O from international bunker fuels

Year	**GHG**		
	CO_2 (Mt)	**CH_4 (kt)**	**N_2O (kt)**
1990	12.4	0.7	0.2
1999	8.3	0.6	0.1

III.2 Emissions of CO_2

Anthropogenic emissions of CO_2 in Russia are mainly due to the consumption of fossil fuels: coal, oil, natural gas, peat (in very small quantities), and to the use of secondary organic fuels.. Contribution of industrial processes is less significant. Among them cement production, aluminum smelting, production of nitric acid, soda and other industrial processes accompanied by oxidation of carbon-containing raw materials can me mentioned (see Tables III.7, III.8, Figures III.6 and III.7).

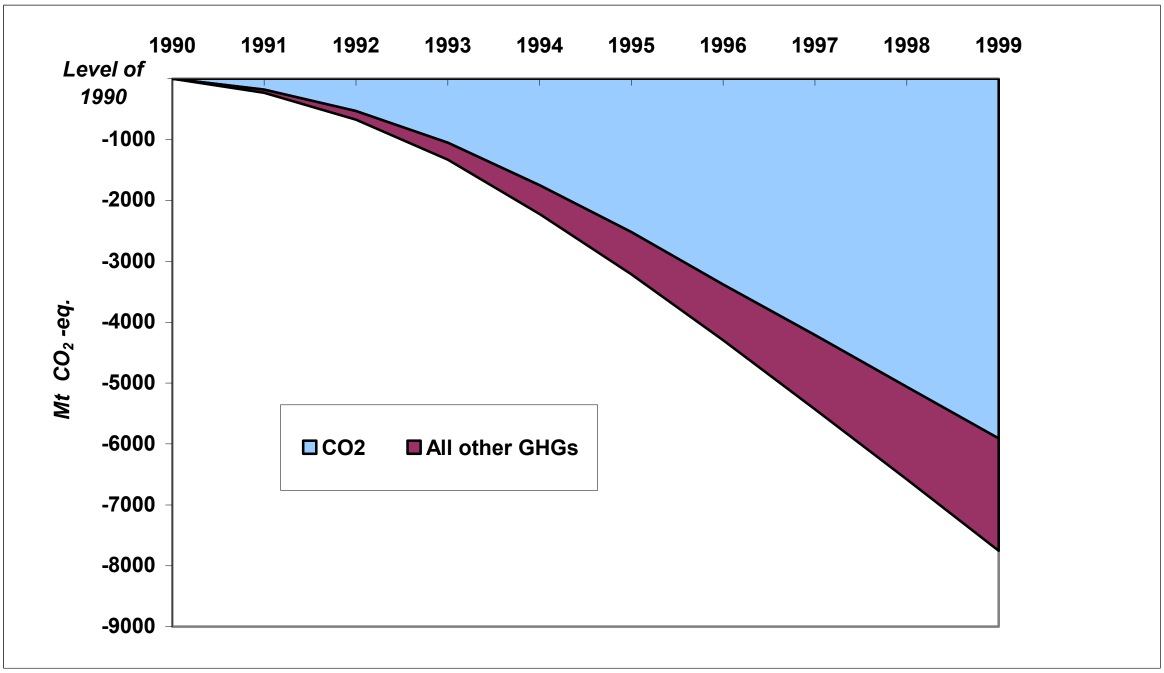

Fig III.4 Cumulative reduction of total greenhouse gas emission from 1990

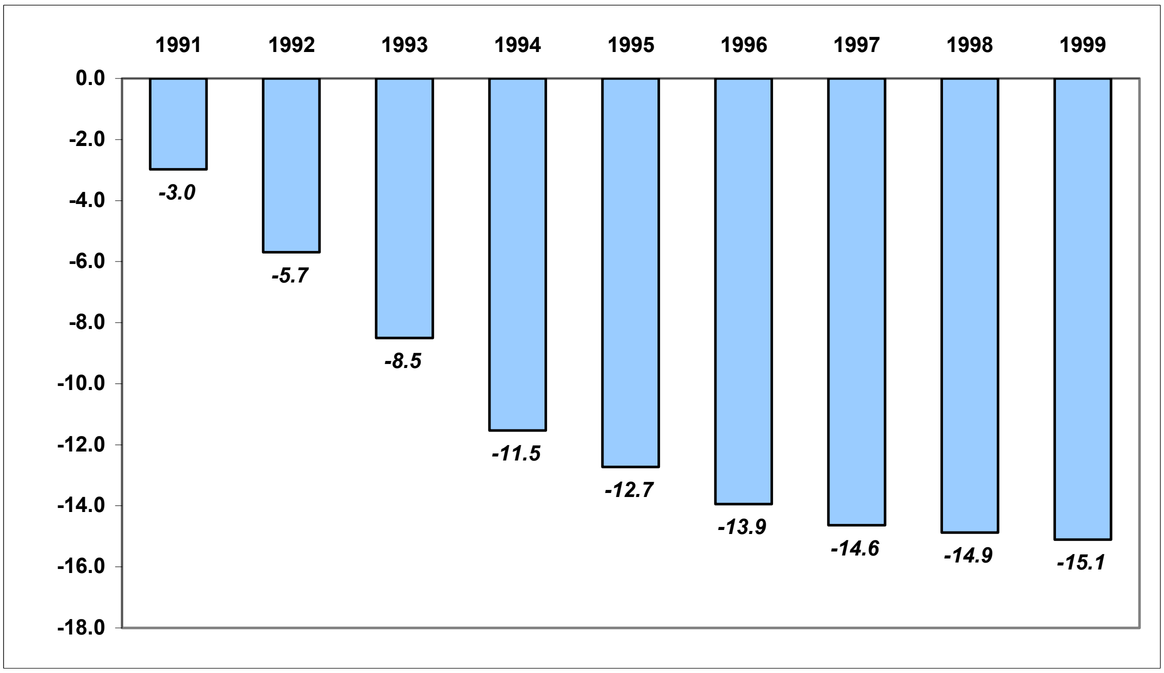

Fig III.5 Annual rate of accumulation of GHG emissions reduction (percent of total cumulative GHG emission reduction in CO_2-eq. in 1990 – 1999)

By 1999, total annual CO_2 emissions from the territory of the Russian Federation decreased by 850 Mt, amounting to 63.9 % of 1990 emission. More than 99 % of this decrease, is due to the reduced use of fossil fuels, including decrease of 233 Mt by energy industries i.e. by general purpose thermal power stations and boilers.

Table III.7
Anthropogenic CO_2 emissions in 1990 – 1999 (Mt CO_2)

Emission sources	Year						
	1990	1994	1995	1996	1997	1998	1999
Primary and secondary fossil fuels[1)]	2320	1640	1570	1480	1500	1470	1470
Industrial processes, including[2)]	42	20	19	15	34	35	39
cement production	41	19	18	14	13	13	14
Total emission	2360	1660	1590	1500	1530	1510	1510

1) Includes fuels combustion for electric, heat and mechanical energy, as well as losses and fugitive emissions: burning of associated gas and CO_2 emissions related to coal mining and coal dumps burning
2) From 1997 includes also emissions related to the production of lime, soda, ammonia, carbides and ferroalloys

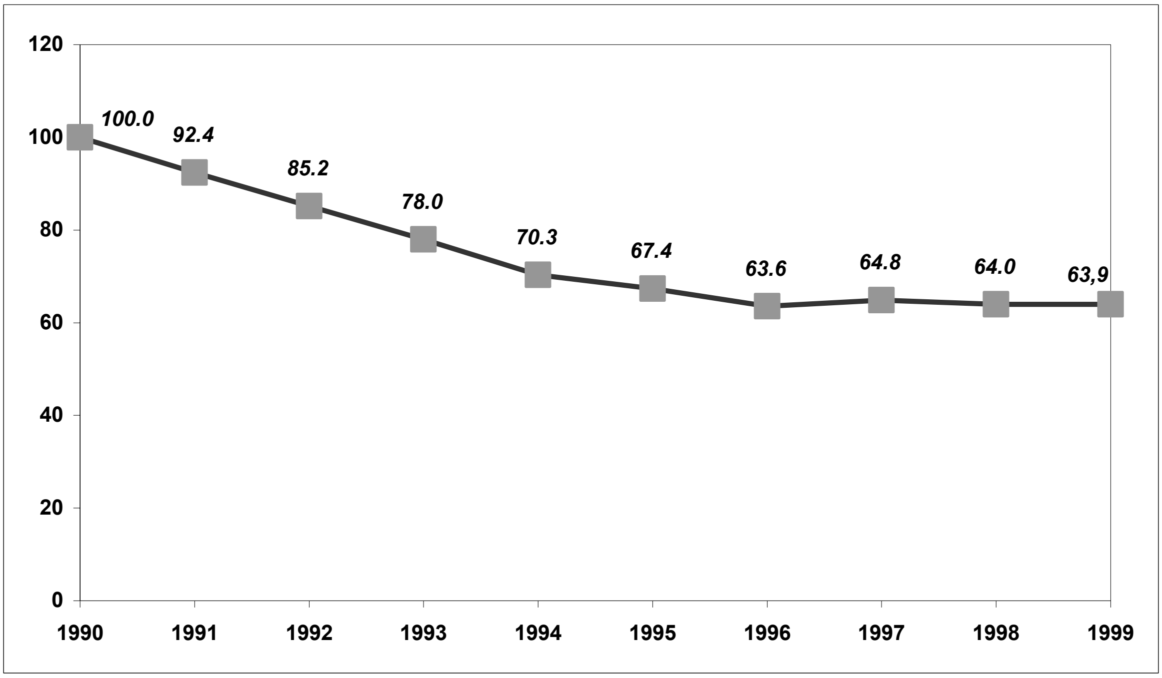

Fig III.6 Trends in CO_2 anthropogenic emissions in 1990 – 1999 (1990 = 100%)

Reductions in CO_2 emissions accumulated during 1991 – 1999 amount to 5,910 Mt (Figures III.4 and III.8.). Similar to 1990, consumption of fossil fuels remains the main source of CO_2 emission to atmosphere, contributing more than 98 % to the total emissions.

Apart from the overall decrease in the energy consumption in the country caused by economic recession in the early and mid-1990-s, reductions of CO_2 emissions are also partially related to the structural change in primary energy consumption in the same period. In particular, the share of natural gas in the total national consumption of fossil fuels has increased in 1990 - 1999 from 43.7 % up to 53.1 %, and the share of nuclear and hydroelectric power stations in electricity generation has also markedly increased. These structural changes resulted in reduction of 105 Mt of annual CO_2 emissions by 1997 (6.9 percent). These processes affected CH_4 emissions, resulting in their additional reductions related to the decrease in coal mining activities. At the same time, some slowdown in reduction of emissions accompanying production and use of natural gas was observed. The overall effect of these processes led to a growth of the total CH_4 emissions (to about 0.6 Mt in 1997), in contrast with a scenario based on an unchanged structure of energy consumption in the 1990 - 1997. In terms of CO_2-equivalent emissions, that amounts to a growth of 12.6 Mt. Thus, overall reduction of all GHG emissions due to changes in the structure of energy consumption amounted to about 92 Mt CO_2-eq. (in 1997).

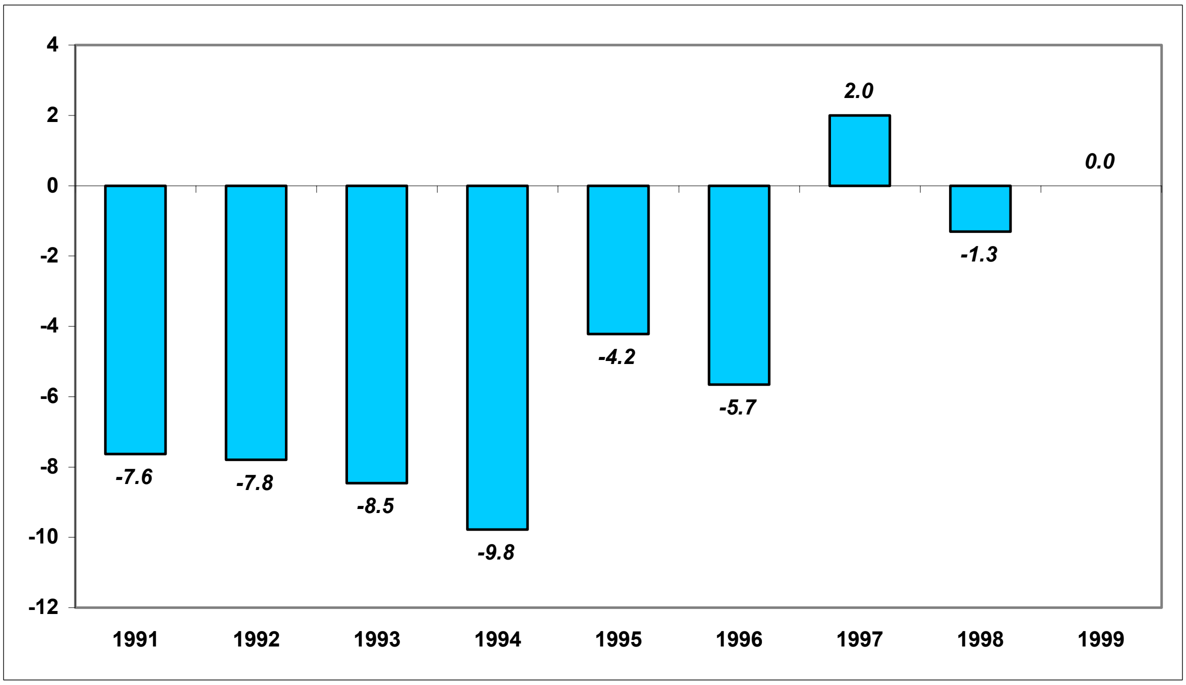

Fig III.7 Annual changes in CO_2 emissions (per cent)

Figure III.9 shows the contribution of individual fossil fuels to the total emissions of CO_2.

Table III.8
CO_2 emissions from consumption of primary and secondary fossil fuels (Mt CO_2)

Emission sources	Year						
	1990	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Power industries[1)]	708	542	517	517	493	490	475
Total emissions	2300	1600	1550	1460	1480	1450	1450

1) Includes emissions from fuel burning by power stations and boilers of UES

III.3 Emissions of CH_4

Methane emissions (Table III.9), as a whole in the period 1990 - 1999, were decreasing faster, than emissions of CO_2. The decrease is noticeable for all source categories, the only exception being emissions from forest fires. The main contribution to the reduction of emission has been brought by energy sector, including by-process emissions and leakages of methane from oil and natural gas production, transportation and consumption, and by animal husbandry (enteric fermentation by animals and anaerobic decomposition of animal waste). These two sectors were responsible for 86 % of the total reduction, or 12.4 Mt/yr CH_4 less in 1999 than in 1990.

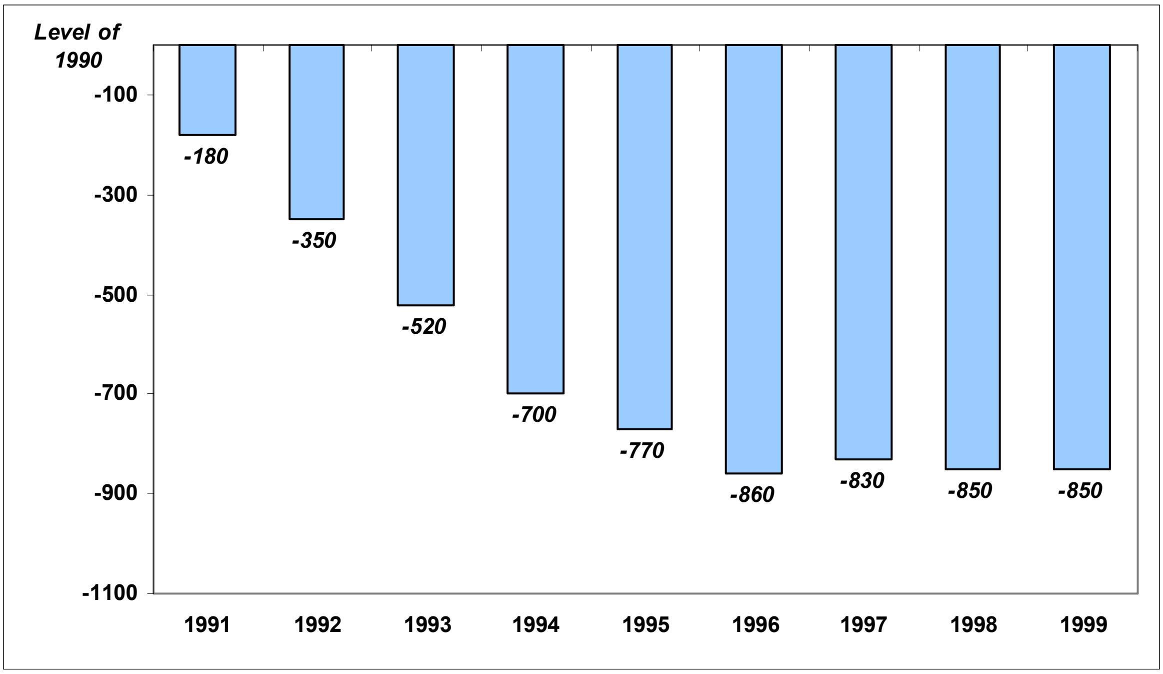

Fig III.8   Annual decrease in CO_2 emissions in 1990 – 1999 (Mt CO_2)

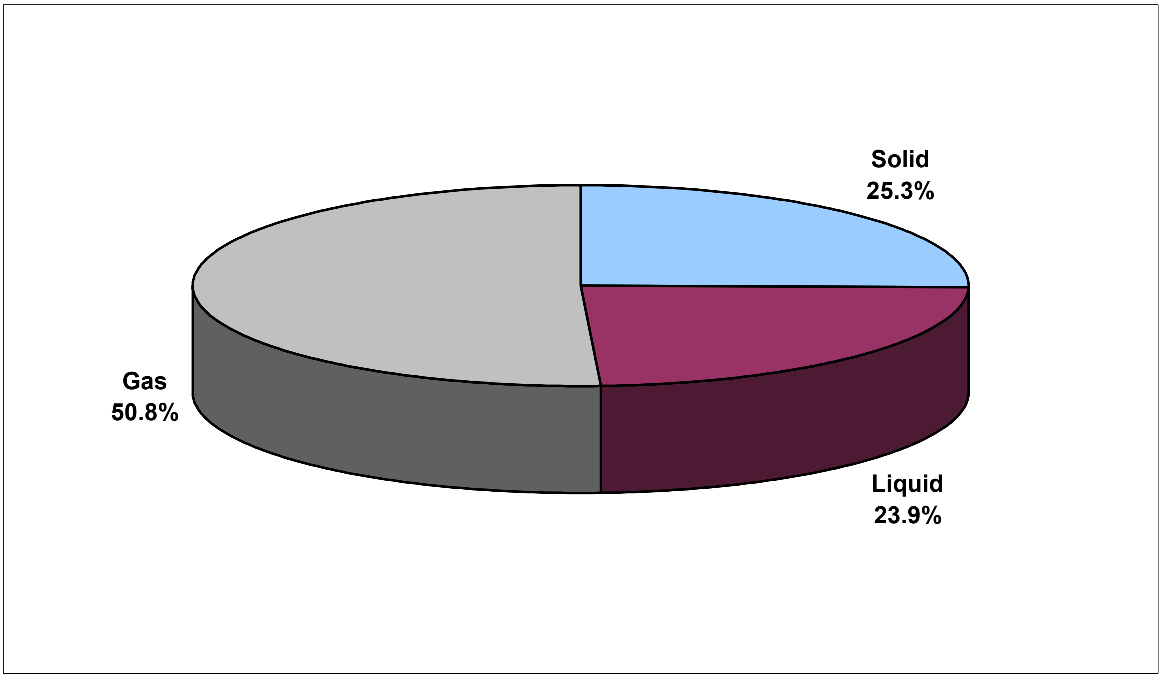

Fig III.9 CO_2 emissions from consumption of primary and secondary fossil fuels by fuel type in 1998 (per cent)

Figure III.10 shows the CH_4 emissions by source. It should be noted, that emission estimates for such a major source category as oil-and-gas industries are still highly uncertain, despite a limited use of national emission factors.

Table III.9
CH_4 emissions (Mt CH_4)

Emission sources	Year				
	1990	1994	1997	1998	1999
Primary and secondary fossil fuels,[1)] including	19.1	13.4	9.4	9.3	9.4
oil and gas production, transportation and distribution	16.0	11.5	7.9	7.9	7.9
coal production	2.9	1.8	1.5	1.3	1.4
Agriculture, including	5.0	3.8	3.0	2.7	2.4
animals (enteric fermentation)	4.4	3.3	2.6	2.3	2.1
animal waste	0.5	0.4	0.3	0.3	0.2
rice production	0.1	0.1	0.1	0.1	0.1
Forest fires	0.1	0.1	0.1	0.9	0.1
Waste, including	1.9	2.0	1.8	1.8	1.8
solid	1.8	1.8	1.7	1.7	1.7
liquid	0.14	0.15	0.1	0.1	0.1
Total	26.1	19.3	14.4	14.7	13.8

1) Includes technology-related and fugitive emissions accompanying production, transportation, storage and processing of oil, coal and gas fuels, as well as emissions from burning of all types of fuels

III.4 Emissions of N_2O

Total annual N_2O emissions in 1990 – 1999 have decreased by more than 200 kt (Table III.10, Figure III.11). The main factors contributing to this decrease were declining emissions from agricultural soils, caused by reduction of use of organic and mineral fertilizers.

Table III.10
Emissions of N_2O (kt N_2O)

Emission sources	Year				
	1990	1994	1997	1998	1999
Primary and secondary fossil fuels	17.4	11.1	10.6	10.1	10.1
Industrial processes	3.0	1.2	1.0	1.0	1.0
N_2O use in health care	2.0	2.0	1.7	1.7	1.6
Agriculture	280	130	114	84	88
Forest fires	1.0	0.4	1.0	6.2	1.0
Waste burning	0.3	0.3	0.1	0.1	0.1
Liquid waste treatment	12.0	11.5	12.0	11.0	11.0
Total	320	160	140	110	110

In percentage terms emissions in 1999 amounted to 35.8 % of the 1990 level. Besides, during 1990 - 1999 emissions from consumption of fossil fuels decreased by 42 %, and emission from industrial processes decreased by two thirds. As a result, the rate of decrease in N_2O emissions has exceeded the corresponding rates for CO_2 and CH_4 emissions.

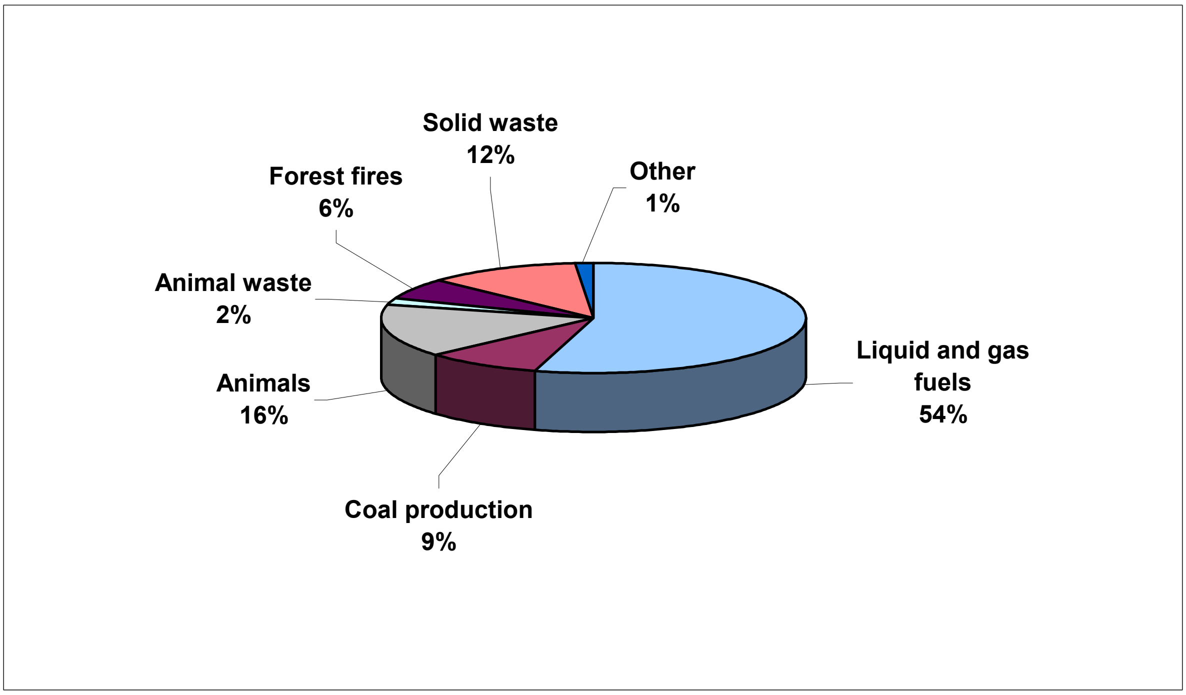

Fig III.10   1998 emissions of CH_4 by source

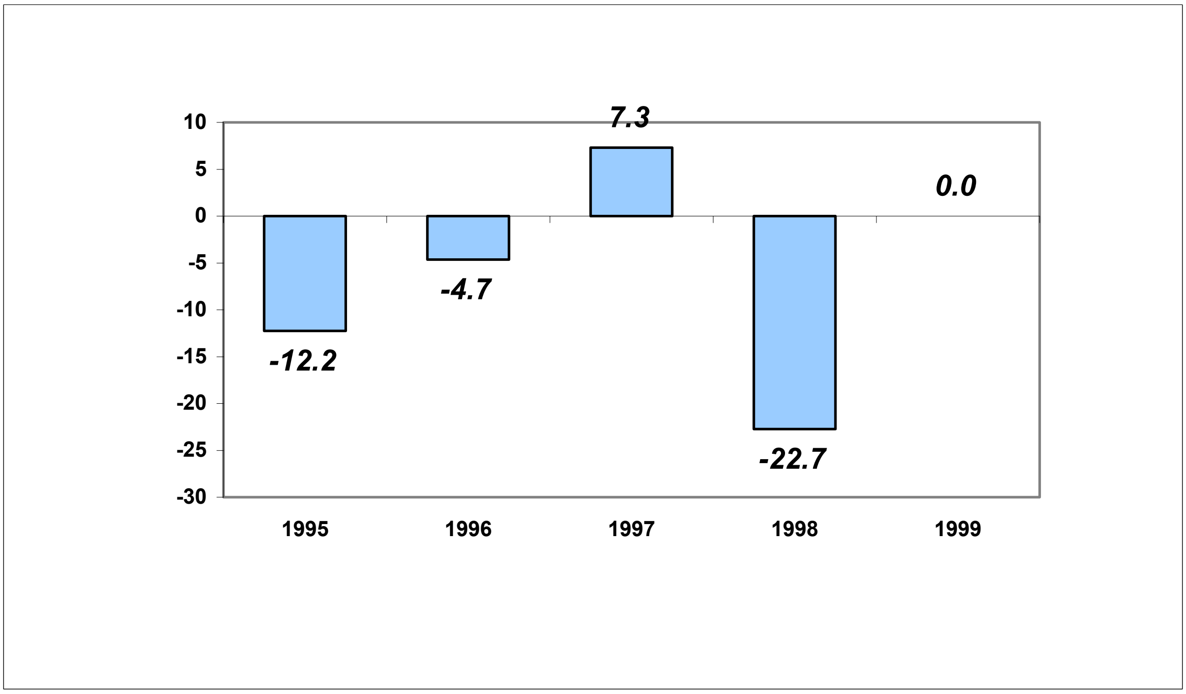

Fig III.11   Annual change in N_2O emissions in 1995 – 1999 (previous year = 100 %)

III.5 Emissions of HFC, PFC and SF_6

Table III.11 presents estimates of emissions of hydrocarbons (HFCs) and perfluorocarbons (PFCs), expressed in CO_2-equivalent units.

Table III.11
HFC, PFC and SF_6 emissions (Mt CO_2-eq.)

GHG	Year				
	1990	**1994**	**1997**	**1998**	**1999**
HFC	9.7	7.0	9.4	9.5	9.5
PFC	30	28	30	31	33
SF_6	-	-	0.016	0.016	0.016

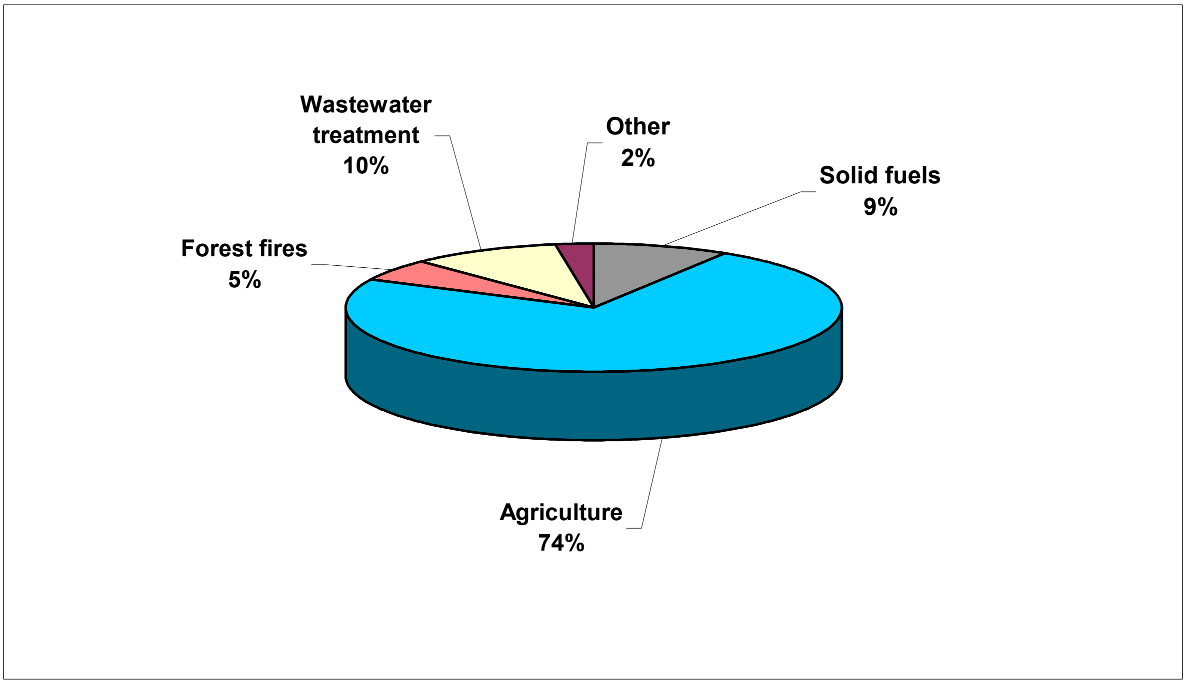

Fig III.12 1998 emission of N_2O by source

Table III.11 contains calculated estimates of CF_4 and C_2F_6 emissions from aluminum smelting and emission estimates of the most widely used in the chemical industry and commercial/household refrigerating HFCs. Estimates of SF_6 emissions associated with leakages from electric equipment are also included in the table. Uncertainty of emission estimates for these chemical compounds, are generally, estimated to be high.

III.6 Emissions of Indirect Greenhouse Gases

Emissions of indirect greenhouse gases are presented in Table III.12 according to the national statistics of pollutant emissions to the atmosphere.

Table III.12
Emissions of NO_X, CO and SO_2 (Mt)

GHG	Year						
	1990	**1994**	**1995**	**1996**	**1997[1)]**	**1998[1)]**	**1999[1)]**
NO_X	3.0	2.1	2.0	1.9	4.1	4.2	3.7
CO	8.1	5.1	5.0	4.9	13.5	13.8	13.9
SO_2	9.4	6.5	6.4	6.2	6.3	6.0	5.8

1) As of 1997, includes emissions from mobile sources

III.7 The Greenhouse Gas Emissions and Removals in Agricultural Sector

The greenhouse gas emissions from agriculture were calculated in accordance with the IPCC Guidelines that treat agricultural sector as a source of methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO) and nitrogen oxides (NO_x) emissions. The only source of CO and NO_x emissions is field burning of agricultural residues. In Russia, burning of agricultural residues on fields is not performed. Hence, the data on CO and NO_x emissions could not be provided. In what follows, the release of CH_4 and N_2O from 1990 to 1999 is considered in detail. In addition, agricultural activity may be associated with changes in soil carbon stocks, and therefore, may result in carbon dioxide (CO_2) emissions or removals.

The changes in carbon stocks of agricultural soils

The IPCC estimates indicate that soil is a major reservoir of organic carbon that contains about 80% (2,000 Gt) of its total content in terrestrial ecosystems. With regard to a type of agricultural land use (arable lands, pastures, hayfields, etc.), fertility and cultivation technologies, the soils could be both source and sink of CO_2. In Russia, agricultural activity currently results in minor CO_2 emission to the atmosphere. In 1995, according to model estimates by All-Russian Scientific and Research Institute of Agricultural Meteorology, it was about 44.1 Mt C or 9.5% of industrial emissions in the country. The data for later years are not available yet. Positive balance of soil humus is typical for arable lands of Northern and Northwestern economic regions with an area of 2.4% of total plough lands in the country. The negative balance of soil organic carbon occurs over the rest of the territory of plow lands. It results in CO_2 emissions to the atmosphere. Estimates of the Federal Land Cadastre Service of Russia indicate an average decrease in humus content of arable lands by 0.4–0.6% in the last 25 years. Rates of carbon loss have recently increased. The major cause of CO_2 emissions growth is a reduction by 72% from 1993 to 2000 of an input of organic fertilizers and a decrease in intensive land reclamation activities. At the same time, a decrease in the area under crops as well as a decrease in total agricultural land areas in recent years resulted in a declining trend in CO_2 emissions from agriculture. Natural regeneration over abandoned and converted managed lands contributes to a CO_2 sink that could partly or entirely compensate for emissions described above. CO_2 removals could be further enhanced owing to the change in crop rotations towards the increased introduction of perennial herbs, wider application of green manure, erosion-preventive measures and other activities.

According to the IPCC Guidelines, soil liming and cultivation of unmanaged (virgin) lands are also sources of anthropogenic CO_2 emissions from agriculture. There was no cultivation of virgin lands after 1970 in Russia. CO_2 emissions from application of limestone and other lime materials to agricultural soils are shown in Table III.13.

As follows from Table III.13, CO_2 emission from liming gradually decreased. In 1990, the emission was 14 Mt of CO_2, and in 1999, it dropped to almost 8% of the 1990 level. The decrease in lime use from 1990 to 1999 is associated with economic depression in national agricultural production.

Thus, agricultural activity may cause insignificant CO_2 release to the atmosphere. But it is not possible to produce a complete quantitative estimate of these losses.

CH_4 emission

The sources of CH_4 emissions in the Russian agricultural sector are enteric fermentation of domestic livestock, waste management systems of domestic livestock and poultry and rice cultivation. Rice fields occupy relatively insignificant area that is about 0.2% of arable land of the country. Table III.14 presents CH_4 emissions from rice cultivation that was calculated for continuously flooded fields in accordance with the IPCC Guidelines.

Table III.13
CO_2 emission from liming of agricultural soils within period from 1990 to 1999 (Mt)

Years	Amount of limestone and other lime materials applied	CO_2 emission
1990	31.4	13.82
1991	29.0	12.76
1992	25.4	11.18
1993	18.3	8.05
1994	9.8	4.31
1995	6.2	2.73
1996	4.4	1.94
1997	3.3	1.45
1998	2.3	1.01
1999	2.5	1.10

Rice fields contribute to 2.5% of total CH_4 emission from national agricultural sector. Significant reductions in CH_4 emissions from this category sub-source are due to a decrease in the area of rice fields since early 1990s.

Table III.14
CH_4 emissions from rice cultivation from 1990 to 1999 (Gg)

Years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CH_4 emissions	114.8	106.8	106.0	104.4	77.2	68.4	68.8	60.4	58.4	69.2

Figure III.13 shows CH_4 emissions from enteric fermentation of domestic livestock, animal waste management systems and their totals for national agricultural sector for the period 1990 to 1999. As follows from the figure, enteric fermentation is a priority source of methane emissions, while the contribution of waste of domestic livestock and poultry is insignificant. In 1990, CH_4 emissions from domestic livestock were 4,890 Gg. Later they dropped and accounted for less than 48% of the 1990 level (2,350 Gg) in 1999. The observed decline in CH_4 emissions is associated with a decrease in livestock and poultry in the country as a result of a crisis in the agricultural sector.

Methane release from enteric fermentation depends on the type, age, weight, productivity, diet and orientation of breeding of agricultural animals. The intensity of CH_4 flux also depends on manure storage technologies and keeping regime applied for domestic livestock and poultry. Table III.15 presents a comparative distribution of CH_4 emissions from enteric fermentation and animal waste management systems by particular categories of animals for 1990 and 1999.

As shown in that table, almost 90% of CH_4 emissions from enteric fermentation come from dairy and non-dairy cattle that has the most intensive fermentation. Animal waste management systems of swine farms also substantially contribute to emissions from this sub-source.

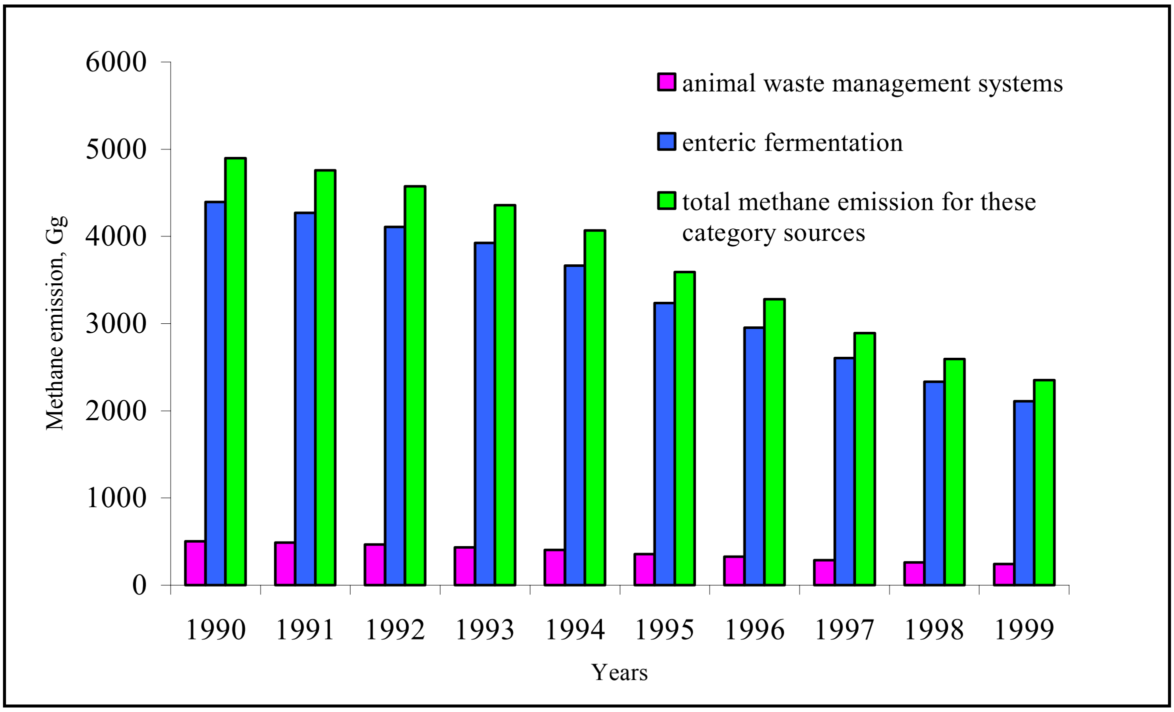

Fig. III.13 The methane emissions from domestic livestock and poultry in national agricultural sector from 1990 to 1999

Table III.15
Distribution of 1990 and 1999 CH_4 emissions by animal categories (%)

Animal category	CH_4 emission by year					
	Enteric fermentation		Animal waste management systems		Total emission	
	1990	1999	1990	1999	1990	1999
Dairy cattle	38.4	51.8	24.8	33.3	37.0	49.8
Non-dairy cattle	48.4	39.9	30.2	24.7	46.6	38.3
Sheep	10.0	5.1	2.1	1.1	9.2	4.7
Goats	0.7	0.5	0.2	0.1	0.6	0.5
Horses	1.1	1.5	0.7	1.0	1.0	1.5
Swine	1.4	1.2	31.8	28.4	4.5	4.0
Poultry	0.0	0.0	10.2	11.4	1.1	1.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

The uncertainty in CH_4 emissions is estimated as relatively high. It is mainly associated with specific uncertainty of methane emission factors. Other features such as animal diet modification, changes in the average storage period of waste and redistribution of livestock population between state and private farms, affect accuracy of assessments to a lesser extent.

N_2O emissions

In Russia, agricultural sector is a key source of anthropogenic nitrous oxide emissions. N_2O originates from manure of domestic livestock and poultry during its storage in various animal waste management systems. But the major sources of N_2O emissions are agricultural soils including cultivated organic ones. The data on the use of organic soils in agriculture are not available now, and it is not possible to estimate N_2O release from cultivated histosols.

Country-specific activity data on nitrogen content in manure of domestic livestock and poultry were used to estimate N_2O emissions from animal waste management systems. The calculations showed that solid storage and pasture range and paddock determine summary N_2O emissions from this category source being widely used within the country. Figure III.14 presents totals for N_2O emissions from domestic livestock and poultry together with those from solid storage and pasture range and paddock for the period from 1990 to 1999. Because of a decreased numbers of livestock and poultry, summary N_2O emissions decreased from 0.21 Gg in 1990 to 0.1 Gg in 1999 (Figure III.14).

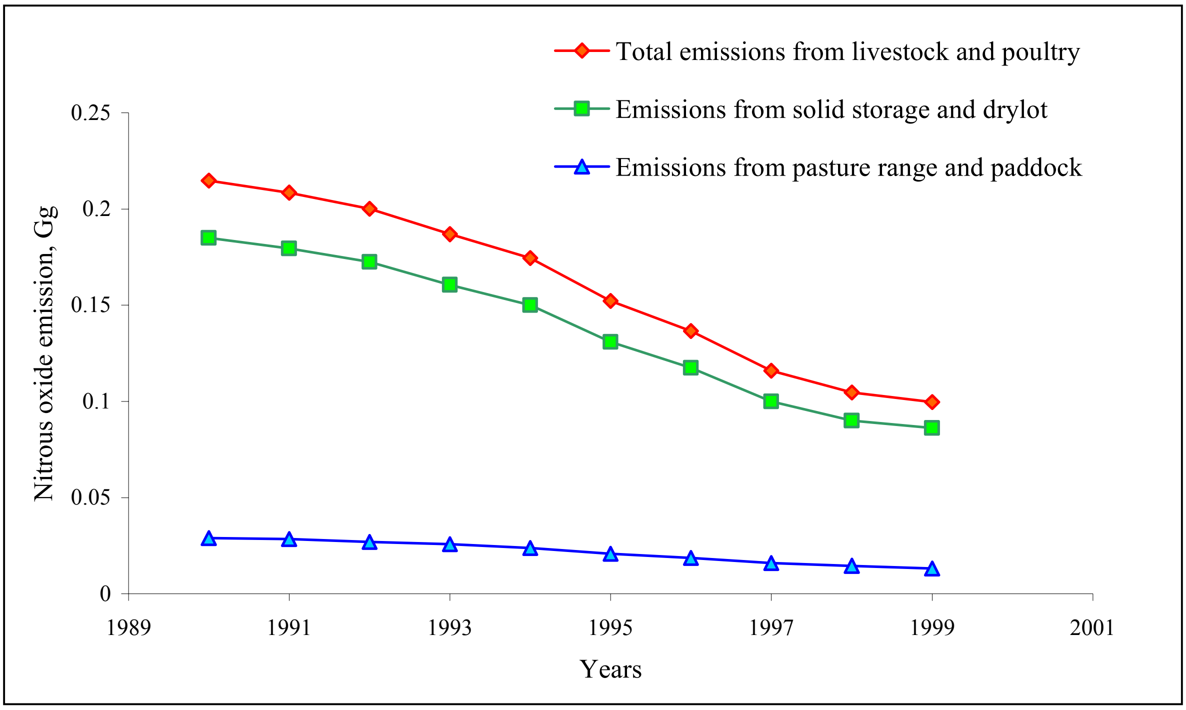

Fig. III.14 N_2O emissions from livestock and poultry in Russia from 1990 to 1999

Annual input of synthetic nitrogen fertilizers and yearly production of nitrogen-fixing and other crops within the country formed the basis for estimation of N_2O emissions from agricultural soils. Figure III.15 presents N_2O release from the use of synthetic nitrogen and organic fertilizers, decomposition of agricultural crop residues left on fields and cultivation of nitrogen-fixing crops together with total emissions from agricultural soils of Russia from 1990 to 1999. The decomposition of above- and belowground parts of crop residues accounts for 60 to 80% of annual input of anthropogenic nitrogen to agricultural soils, and is a major source of N_2O emissions in the agricultural sector of Russia. After 1990, the abrupt decrease in synthetic nitrogen fertilizer input resulted in a reduction of N_2O emissions from this entire category source. Thus in 1990, the release of N_2O to the atmosphere caused by the application of fertilizer nitrogen was almost 83 Gg. In 1999, it amounted to no more than 19.5% of the 1990 level (16 Gg N_2O). Emissions from organic fertilizers (manure) and cultivation of nitrogen-fixing crops were about 3% of the total N_2O released from agricultural lands.

Secondary transformations of anthropogenic nitrogen compounds through atmospheric deposition of NO_X and NH_3, leaching and runoff from fields induce N_2O formation and its subsequent release from agricultural soils. This was also taken into account in the calculations. Indirect emissions of nitrogen used in agriculture are given in Table III.16 together with total N_2O emissions from agricultural sector of the country.

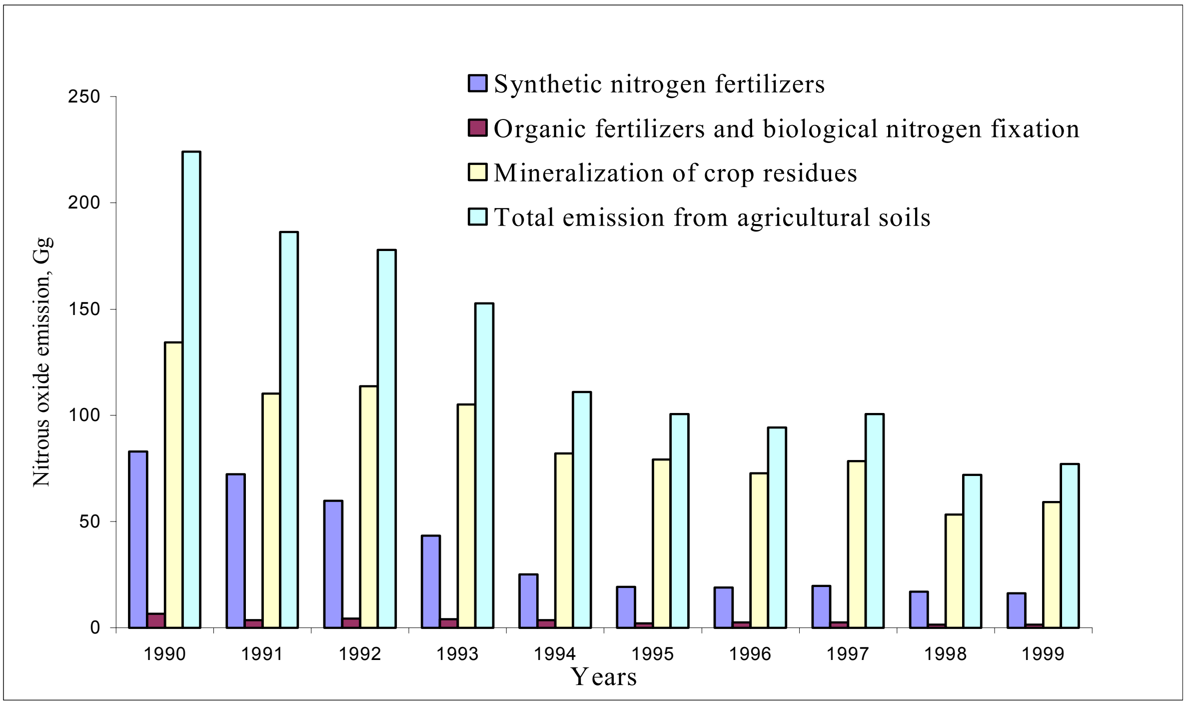

Fig. III.15 N_2O emissions from agricultural soils of Russia from 1990 to 1999

From 1990 to 1999, total nitrous oxide emissions from the agricultural sector were gradually decreasing (Table III.16). The decrease is due to a reduced input of nitrogen fertilizers, decline in the area of cultivated crops and a reduction of domestic livestock and poultry as a result of depression in agricultural production in the country.

The accuracy of the estimates obtained depends on accuracy of both activity data and emission factors. In the majority of cases, the activity data were taken from national statistic reports that have high reliability (the error of estimates is no more than 5%). The emission factors were mainly taken from the IPCC Guidelines. Their errors are ±20%. Therefore, the overall error of estimates is considered to be 20%.

Table III.16
N_2O emissions from agricultural sector of Russia from 1990 to 1999 (Gg)

Years	**N_2O emission by category source**			
	Domestic livestock and poultry	**Agricultural soils**	**Leaching of nitrogen compounds and atmospheric deposition of NO_X and NH_3**	**Summary N_2O emission**
1990	0.21	224.2	55.3	279.5
1991	0.21	186.4	48.0	234.4
1992	0.20	177.9	39.8	217.8
1993	0.19	152.8	28.9	181.8
1994	0.17	111.1	16.8	128.0
1995	0.15	100.7	12.9	113.6
1996	0.14	94.3	12.7	107.1
1997	0.12	100.7	13.2	113.9
1998	0.10	72.0	11.4	83.4
1999	0.10	77.2	10.9	88.1

III.8 Emissions and Removals of Greenhouse Gases in the Forests of Russia

The forests of the Russian Federation are a tremendous reservoir of carbon in living biomass of plants, plant residues at various decomposition stages, soil humus, and peat-lands. The anthropogenic activity on management and utilization of forests may result in both increase and reduction in total reserves of forest ecosystem biomass. This is complemented by net CO_2 removals or emissions. Emissions of other greenhouse gases are associated with forest fires. The IPCC data indicate that on a global scale, forests of temperate and northern latitudes are net removals of carbon dioxide.

To achieve the highest transparency in the national inventory, the greenhouse gas emissions in the forestry sector were calculated with the use IPCC Guidelines that provide accounting methodology for CO_2, CH_4, N_2O, CO and NO_x emissions and removals. In accordance with the IPCC Guidelines, the sources of CO_2 emissions in forestry are wood harvesting operations, biomass combustion, entire or partial withdrawal of biomass due to land conversion and biomass decay within conversion. The emissions of CH_4, N_2O, CO and NO_x are calculated only from woody biomass combustion. CO_2 removals are determined by carbon accumulation in biomass of forests and on other lands converted from agricultural use.

Changes in forests and other woody biomass stocks provide the highest contribution among the major components of greenhouse gas emissions and removals in forest sector identified by IPCC (changes in forests and other woody biomass stocks (1), forest and grassland conversion (2), abandonment of agricultural lands and re-growth of forests on them (3)). The land-use change data (abandonment and conversion of agricultural lands) and a complete or partial withdrawal or decay of biomass due to conversion are not available, and therefore, the accounting for greenhouse gas emissions and removals form conversion of lands was not implemented. It should be noted that the absolute contribution of these constituents is minor and consequently they cannot significantly affect total values of CO_2 emissions and removals in forestry sector.

The structure of the IPCC Worksheets has been adjusted to slash-burn system of land use that foresees deforestation and subsequent expansion of arable lands as a result of it. This system is not applied in Russia. The section on greenhouse gas emissions in agriculture indicates that land management systems used in the country are quite adequate, and they do not cause CO_2 emissions from cultivated soils. Instead the chemical transformation, changes in soil carbon of agricultural lands are mainly associated with mechanical transfer (wash-out and erosion). Therefore, it was not possible to fill all the IPCC Worksheets. The only Worksheets filled are those that correspond to traditional national practices of management and utilization of forests as well as of land use where the most complete data are available.

CO_2 absorption through removals in phytomass

As shown in Section II, the most complete data on changes in forest areas and volume stocks are available only for the territory of the former Federal Forestry Service of Russia that is currently under the auspices of the Ministry of Natural Resources of the Russian Federation. This territory covers more than 94% of the total area of forests of the country. CO_2 removals in the forest sector were estimated based on the data of 1988, 1993 and 1998 State Censuses of Forest Stock. The calculations of annual CO_2 sequestration by live phytomass were carried out for lands actually covered by forest taking into account dominant forest-forming species and their age structure. Since the forest census was carried out once every 5 years, the data for intermediary years were obtained by linear interpolation. Based on special researche carried out by the Center for Ecology and Forest Productivity Problems of the Russian Academy of Sciences in collaboration with the Institute for Forestry, the volume stock and annual sequestration of carbon in phytomass of forest ecosystems of Russia were estimated as for January 1, 1988. The research also resulted in the development of country-specific conversion factors for carbon in total phytomass of growing stock that were used for calculation of annual CO_2 sequestration for the period from 1990 to 1999. It was assumed that carbon content in 1 kg of dry weight of stems, branches and roots is 0.5 kg, while 1 kg of needles, leaves and undergrowth accumulates 0.45 kg of carbon. Figure III.16 presents summary data on CO_2 removals in phytomass of forests of the Russian Federation.

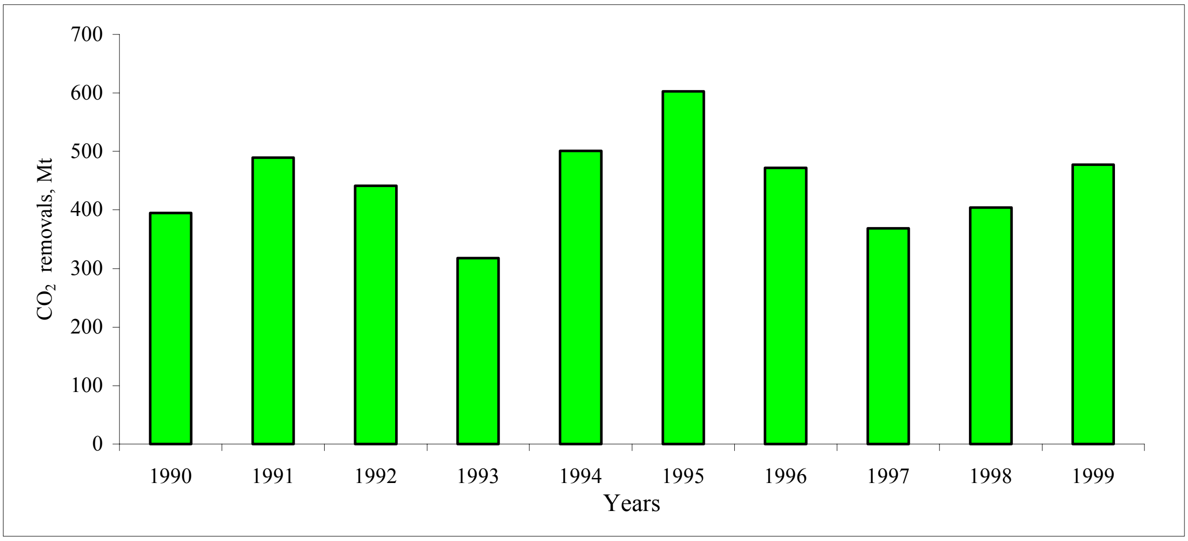

Fig. III.16 CO_2 removals in phytomass of forest stock of the Russian Federation

CO_2 emissions associated with wood harvesting

The data of the Ministry of Nature Resources of the Russian Federation on main and intermediate cuttings formed the basis for the calculation of CO_2 emissions from wood harvesting. These data are presented in Section II.11. The values of conversion factors for calculating the total phytomass from harvested wood were taken from the IPCC Guidelines. Figure III.17 presents estimates of CO_2 emissions from wood harvesting. As can be seen from the figure, the decrease in wood harvesting since 1990 resulted in a reduction of CO_2 emissions from this activity.

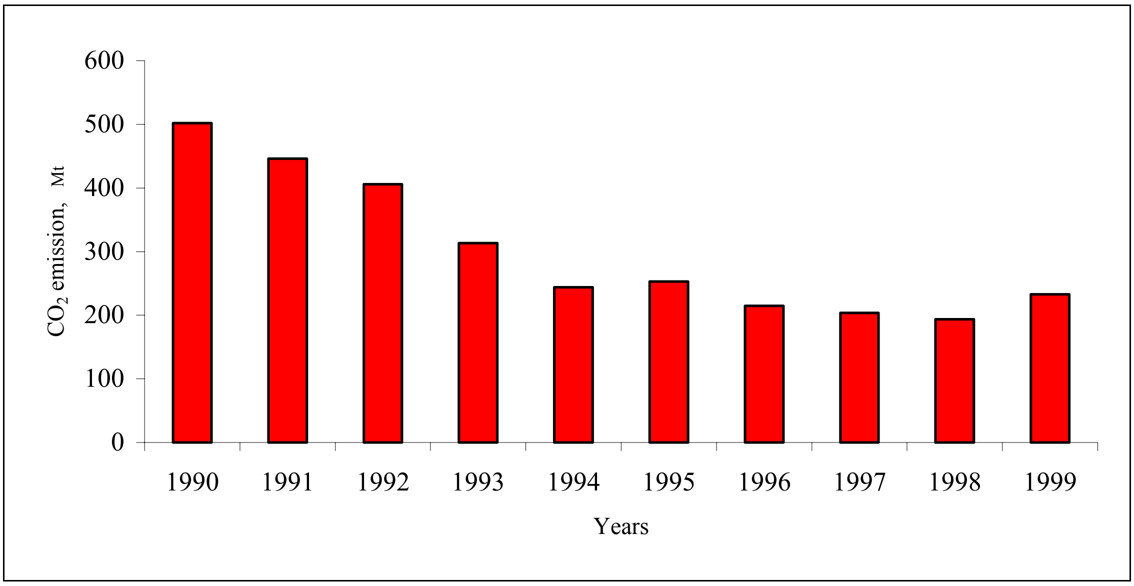

Fig. III.17 CO_2 emissions from wood harvesting

In 1989, the Center for Ecology and Forest Productivity Problems carried out a study of amount, composition and utilization categories of harvested wood including fuel-wood and slash. The study also included detailed analysis of decay of organic matter left over cut areas. The results obtained showed that about 85% of harvested wood was removed, whereas 15% were parts of stems that were left. This value should be increased to take account of other woody biomass also left over cut areas. This study was described in detail in the Second National Communication. For 1989, overall release of CO_2 due to the commercial use of forests was estimated to be almost 450 Mt CO_2/yr. The CO_2 estimates for 1990 and from 1993 to 1997 in the Second National Communication were made using a similar methodological approach. For 1990 and 1993, emission flows of 400 and 270 Mt CO_2/yr were obtained. The estimates for 1994 to 1997 indicate that CO_2 emissions varied between 220 and 240 Mt CO_2/yr. It should be noted that the values of CO_2 emissions calculated using the IPCC Guidelines are rather close to those provided in the Second National Communication. However, the estimates obtained on the basis of the IPCC Guidelines seem to be preferable from the point of view of transparency, accuracy and consistency with international accounting methodology and consequently, comparability of the results obtained, because they are based on actual data of wood harvesting and conventional conversion factors.

Greenhouse gas emissions from forest fires

Greenhouse gas emissions from forest fires could be subdivided into two components: rapid release of CO_2 and other greenhouse gases from biomass combustion and continuous CO_2 emissions due to decay of post-fire residues on burnt out places. Under climatic conditions of Russia, the rate of decay is very low, and it may continue for several decades or more. The amount of combusted biomass strongly depends on the type of forest, reserves of inflammable materials and inclusion of various tree layers in a fire event. However, these factors make it almost impossible to make accurate estimates of biomass combusted over large areas. Natural climate conditions, size and composition of residues seriously affect the rate of post-fire decay. Hence, only preliminary estimates could be made for this case.

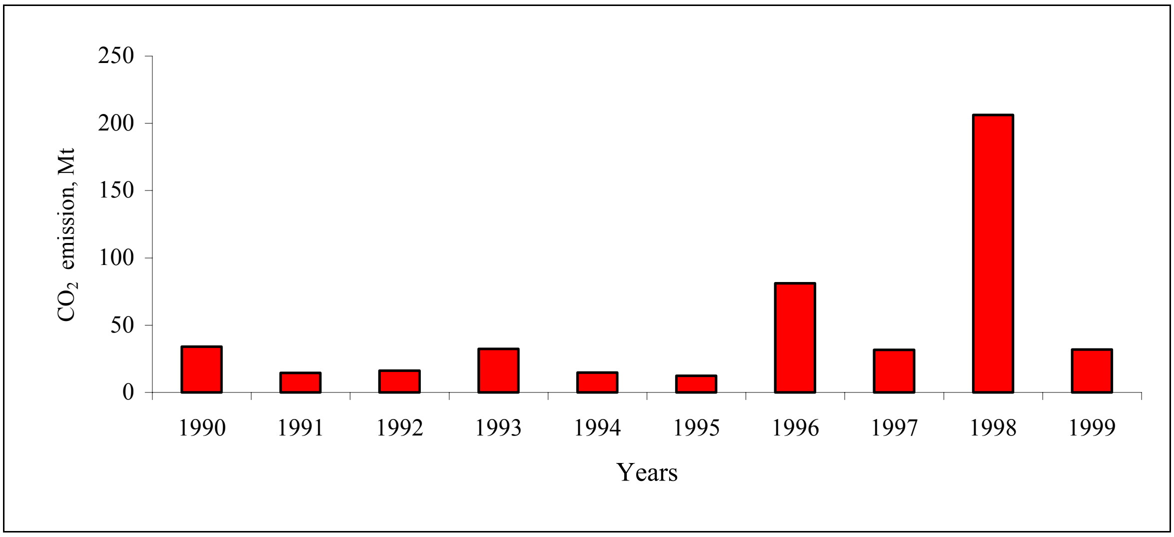

Fig. III.18 CO_2 emissions from forest fires the territory of forest stock of the Russian Federation

Recently, the data on amount of combusted wood were unavailable. Therefore, the estimates of greenhouse gas emissions from forest fires were made on the basis of scientific studies by research institutes of the former Federal Forestry Service of Russia and Russian Academy of Sciences. The results of these studies and estimates derived from them were provided in First and Second National Communications. In the present communication the estimates of greenhouse gas emissions from forest fires are carried out with the use of the methodology and appropriate conversion and emission factors of the IPCC Guidelines. The Ministry of Nature Resources of the Russian Federation provided the data on wood combusted during forest fires for the period 1990 to 1999. It should be noted that according to the IPCC Guidelines, CO_2 release from forest fires is not included in total emissions from the forest sector, because it is assumed that loss of carbon from wood combustion would be fully compensated for in the same year by post-fire regeneration. In climatic conditions of Russia, amounts of carbon accumulated annually on burnt areas due to post-fire regeneration is significantly lower than its release during fire. That is in contradiction with the IPCC assumptions. Hence, CO_2 emissions from forest fires were included in the summary balance of CO_2 emissions and removals in forests of Russia.

Figure III.18 presents the values of CO_2 emissions from forest fires from 1990 to 1999. The emissions of other greenhouse gases are presented in Table III.17.

The Second National Communication presents annual CO_2 emissions from forest fires for the period from 1988 to 1994 that vary from 90 to 240 Mt CO_2/yr. They were derived from scientific research. The calculations on the basis of actual data on wood combustion are significantly lower than the estimates in the Second National Communication. However, in 1996 to 1998 the emission has notably increased due to wood loss.

Table III.17
Emissions of CH_4, N_2O, CO and NO_x from forest fires (Gg)

Years	**Emission by gas**			
	CH_4	**N_2O**	**CO**	**NO_x**
1990	148.9	1.02	1,302.8	37.0
1991	63.4	0.4	554.4	15.7
1992	70.3	0.5	615.4	17.5
1993	141.3	1.0	1,236.3	35.1
1994	64.6	0.4	565.5	16.1
1995	53.9	0.4	471.2	13.4
1996	354.2	2.44	3,099.1	88.0
1997	138.1	1.0	1,208.6	34.3
1998	900.4	6.2	7,878.0	223.7
1999	138.8	1.0	1,214.1	34.5

Estimates of the total net CO_2 removals in the forests of Russia

The CO_2 net removals were calculated as the difference between annual sequestration in total phytomass and emissions from forest fires and wood harvesting. Table III.18 presents CO_2 net removals over the territory of forest stock.

Table III.18
CO_2 net removals in the forests of Russia from 1990 to 1999 (Mt)

1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
–141.1	28.8	19.5	–27.5	242.4	337.7	175.9	133.0	3.9	212.8

It should be noted that CO_2 net removals in this table are underestimated. The estimates performed in various years indicate a 7–8% increase in net removals, if all lands of forest stock are included in the accounting. Additional CO_2 removals could be obtained, if the forests of the Ministry of Agriculture, former State Environment Committee (currently Ministry of Natural Resources), other ministries and agencies and urban forests are included in the accounting. However, reliable data on these forests are currently unavailable, and these values were not included in the calculations.

Net removals in Table III.18 differ from those presented in the Second National Communication (average values of CO_2 net removals for 1990, 1994 and 1995 were 392, 568 and 585 Mt CO_2 respectively). To identify the cause of differences in the estimates, repeated calculations of CO_2 net removals were undertaken in accordance with methodological approaches used in the preparation of the Second National Communication. Results of calculations were compared with those performed in accordance with the IPCC Guidelines and data on forest stock, wood harvesting and forest fires provided by the Ministry of Natural Resources (Figure III.19).

The comparison demonstrated that the difference was due to the fact that only the data on State Forest Census of 1988 and 1993 were available at the time of the preparation of the Second National Communication. The complete data on wood harvesting and combustion that form debit of CO_2 net balance in forests were unavailable. Because available data were insufficient, the calculations were made using information from scientific publications and reference books (yield tables for growing stock), which included the values different from the actual ones.

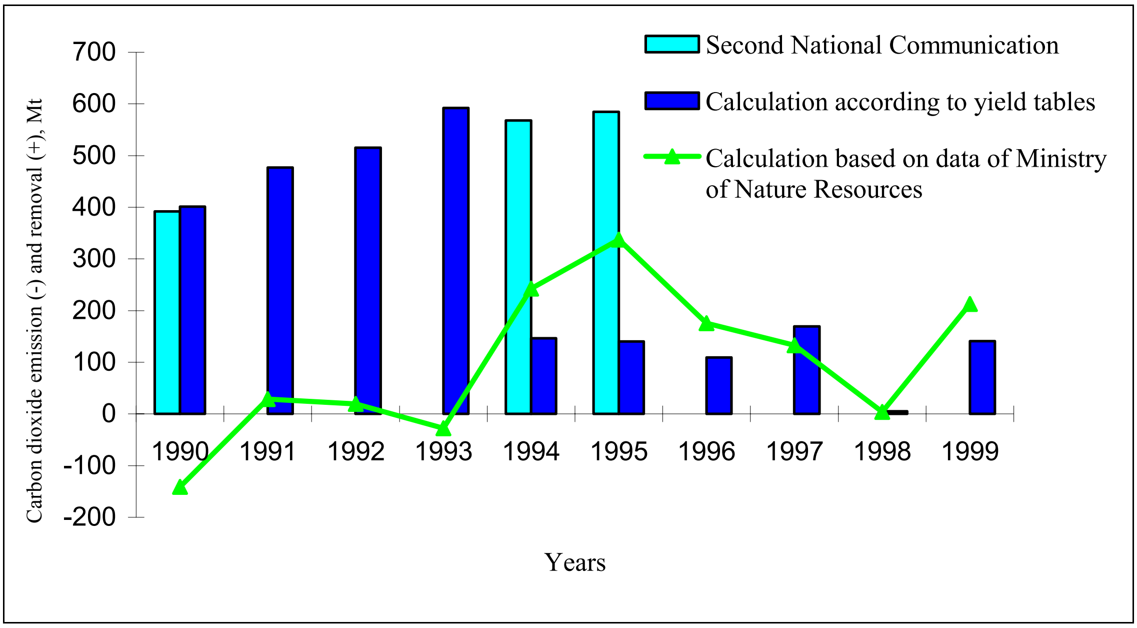

Fig. III.19 Estimates of CO_2 net removals over the territory of forest stock of the Russian Federation

The actual data of the State Census of Forest Stock for 1988, 1993 and 1998 were used for the preparation of the present National Communication. That provided for a more accurate estimation of spatial and temporal dynamics of forest stock. The use of the data of the Ministry of Natural Resources on wood harvesting and losses due to forest fires for the period from 1990 to 1999 enabled to obtain more reliable estimates for debit part of the CO_2 balance in the forests.

The accuracy of estimates depends on accuracy of initial data and conversion factors. Estimation error for parameters of State Census of Forest Stock should not be higher than 20%. The calculations were performed with the use of conversion factors taken from the IPCC Guidelines and literature data. Their errors are also close to 20%.

IV POLICIES AND MEASURES TO LIMIT AND REDUCE EMISSIONS AND INCREASE REMOVALS OF GREENHOUSE GASES

IV.1 Strategic Approaches Aimed at Limiting Anthropogenic Greenhouse Gas Emissions and Enhancing Sinks

A relative contribution to atmospheric warming of various anthropogenic greenhouse gases depends on their CO_2 equivalent emissions. In Russia, as well as worldwide, carbon dioxide emissions are especially important among the greenhouse gases (1998):

Carbon dioxide	– 79.9 %
Methane	– 16.5 %
Nitrous oxide	– 1.9 %
Hydrofluorocarbons and perfluorocarbons	– 1.7 %
Total equivalent emission	– 100 %

In the Russian Federation (in 1998), fossil fuels accounted for 98.5% of direct anthropogenic CO_2 emission. The remaining 1.5% came from the so-called “technological” emissions due to cement production and some other industries. Fuel combustion accounted for almost 98% of total CO_2 emissions associated with the use of fossil fuels (the rest comes from flaring and dumps).

In 1999, power-related shares of national CO_2 emissions from the main fossil fuels were 48.7%, 22.6% and 28.7% for natural gas, oil and coal, respectively. That is noticeably different from the numbers for world in general, which are correspondingly 20.1%, 41.7% and 38.2%.

Due to dominance of CO_2 emissions from fossil fuels in power industry, the major provisions of emissions reduction strategy should focus primarily on reductions of CO_2 emissions in the power industry.

Enhancement of quality of greenhouse gas removals and sinks is another important aspect of efficient limitation of anthropogenic GHG emissions. Russia has almost a quarter of the world wood reserves. Therefore, the increase of atmospheric carbon dioxide sequestration by forest ecosystems is an extremely important measure.

Implementation of measures for reduction and limitation of GHG emissions is based on the provisions of a unified national policy aimed at the most effective responses to anticipated climate change and its adverse effects.

Main requirements for the implementation of these provisions are as follows:

1) National climate change response measures should be coordinated with the goals of sustainable national social and economic development to avoid adverse social effects.
2) The priority measures should ensure fulfillment of commitments of the Russian Federation under the UNFCCC at minimum costs.
3) National actions to limit and reduce GHG emissions should be closely coordinated with activities related to assessment of climate change impacts on managed and natural ecosystems, national economy and human health, as well as with development of preventive adaptation measures. Besides, it is necessary to prepare in advance a set of measures to take maximum advantage of the positive effects of climate change (for example, in hydropower).
4) In the Russian Federation, limitation of emissions and enhancement of sinks are implemented under the conditions of an economy in transition with a depressed production output a resulting decrease in greenhouse gas emissions. For the period up to 2010, when recovery and intensive growth of the national economy are expected, commitments of the Russian Federation under the Protocol to the

UNFCCC (Kyoto, December 1997) seem to be adequate. The Russian Federation should undertake considerable efforts (especially in securing required investments), in order not to exceed average 1990 CO_2-equivalent emission levels in 2008–2012. To fulfill this commitment, it is essential to develop and implement a wide-range program of measures to limit GHG emissions to the atmosphere.

Taking into account the general requirements mentioned above, some basic principles for development and implementation of measures to limit and reduce anthropogenic GHG emissions can be formulated.

A decrease in GHG emissions in the Russian Federation after 1990 formed the basis for implementation of a low-cost national strategy for meeting commitments under the UNFCCC and the Kyoto Protocol in 2001–2010. Existing "reserves" of GHG emission reductions should contribute positively to a progressive sustainable development of the national economy and power industry at this initial stage without diverting large investments to high-cost emission reduction measures in power generation and in industry. Under these circumstances, the main thrust of the GHG emission control strategy should be to implement measures aimed at increasing overall energy efficiency and ensuring energy saving in all sectors, including public utilities, industry, transportation, agriculture and fuel-energy complex. Thus, in the medium-term, implementation of the UNFCCC provisions related to the limitation of GHG emissions generally corresponds to the national policy and strategy of development and improvement of the national energy system.

The limitation of emissions growth and enhancement of removals should be implemented through coordinated technical, economic and institutional arrangements and activities in all key sectors of economy with priority consideration given to the government-set energy saving requirements, indispensable to ensure economic growth (Statement of the Prime-Minister of the Russian Federation in the State Duma on May 17, 2000).

The actual energy policy includes numerous measures to ensure energy savings and to advance efficiency of the utilization of resources. Implementation of these measures will noticeably reduce consumption of primary energy resources, especially fossil fuels. In turn, this will result in the decrease in GHG emissions.

An optimum way to reduce GHG emissions in the power sector is to implement a range of multipurpose economically viable measures to save energy, to renovate and improve efficiency of the energy system as a whole. As a result, significant reductions in GHG emissions, in particular CO_2 and methane, could be achieved.

This includes the following main groups of activities:

II. An extensive program of energy efficiency improvement and energy saving based on the latest know-how and economic incentives for fuel-energy complex, industry, transportation, municipal services and other sectors.

III. Optimizing the structure of energy consumption through increased contribution of renewable energy sources and fuels with less carbon content comprising:
   - Extended application of traditional (hydropower) and non-traditional renewable (solar, wind, geothermal, biomass) energy sources;
   - Optimization of the share of nuclear power in the total consumption of primary energy resources.

Despite the significant drop of national emissions (approximately by 35% for CO_2) due to economy depression under transit conditions after 1991, in the next few years, GHG emissions are expected to grow as a consequence of prospective systematic yearly increases in economic activity and energy resources consumption. It is the time, when strategically justified and carefully technically and economically tested system of measures (programs and projects) on emissions reduction and limitation will be required. Development of such a strategy and of a system of measures is currently based on the principles included in the following State Acts:

1. "**Basic Provisions of the Energy Strategy of Russia for the Period to 2020**" were approved by the Government of the Russian Federation (Ref. № 39, November 23, 2000). The aim and the highest priority of the national energy strategy for the period to 2020 is the most efficient utilization of natural resources and of the available scientific, technical and economic potential in the fuel-energy complex for improving the quality of life of the population.
2. **"Energy saving"** Federal Law is in force since April 3, 1996. It defines major national policy principles on energy saving and efficiency increase.
3. **"Prevention of Dangerous Changes of Climate and Their Adverse Effects",** Federal Target Program was endorsed by the Government of the Russian Federation on October 19, 1996. The Program is aimed at ensuring implementation of international commitments of the Russian Federation under the UNFCCC and taking necessary measures to prevent adverse effects of climate change on national economy and human health.
4. **"Energy Saving in Russia for 1998–2005"** Federal Target Program was approved by the Government of the Russian Federation on January 24, 1998. The ultimate objective of the Program is to accelerate integration of energy saving into the national economy.
5. "**The Energy Efficient Economy"** Federal Target Program for 2002–2005 with prospects to 2010 was endorsed by the Government of the Russian Federation on November 17, 2001 (Ref № 796). In accordance with "Basic Provisions of the Energy Strategy of Russia for the Period to 2020", wide-scale energy efficiency and saving arrangements are to be realized in the framework of this program starting in 2002.
6. **"The Basic Orientations of Social and Economic Development of the Country for Long-term Outlook"** provide projections of fundamental macro-economy parameters of country development for the period up to 2010.

The measures to improve GHG absorption and storage quality are highly important. Major actions in this area are related to forest restoration (reforestation) and development of new forests (afforestation). The estimates show that activities on forest rejuvenation, decrease in forests fire numbers, improved harvesting technologies and timber use and planting new forests and shelter belts on several million hectares could result in a prospective increase in CO_2 removals of 100–200 Mt CO_2/yr.

IV.2 The Measures to Limit and Reduce Greenhouse Gas Emissions and Increase Removals and Their Expected Outcomes

IV.2.1 Power industry

Basic Provisions of Energy Strategy of Russia for the Period to 2020
The implementation of overall objectives of the energy strategy requires solving a number of interrelated problems including **increase of energy use efficiency,** which is of a special importance for the UNFCCC. These should be accomplished with a view to attaining a global goal of sustainable development on the basis of energy saving technologies and structural optimization of power generating facilities, while at the same time ensuring growth of energy supply and improvement in working and living standards, reduced load on the environment and improvement of national productive forces for raising economic efficiency and market competitiveness.

Substantial increase in the energy efficiency of the economy is among the core tasks for social and economic recovery of the country. The growth rates, and especially **restructuring** of the economy and technological advances, will in turn determine the dynamics of energy efficiency increase. The growth of domestic energy consumption decreases with the GDP increase and with growth of the share of services and high technology products. Thus, restructuring of the economy would compensate for more than a half of the required increment of energy consumption.

Structural policy and restructuring of the energy industry envision evolutionary improvement of national fuel and energy balances to achieve optimum ratios between basic fuels as well as to ensure optimum balance between centralized and decentralized heat and of energy supply. The main directions of the structural energy improvement are as follows:

- Attaining optimum ratio of different economic forms, improvement of quality and degree of state regulation, reduction of production costs in the energy sector;
- Reforming housing and municipal sectors to achieve at least a two-fold increase in efficiency of fuel and energy consumption within the period under consideration;
- Advanced development of electric power supply as a basis for production efficiency growth and high living standards for population;
- Stabilization of the consumption of natural gas and an increase in coal consumption in power industries.
- Improvement of power industries through advanced development of nuclear power plants, large steam-gas installations to replace existing gas-based electricity generation plants, a broad use of gas-turbines in heat power plants, development of "small-capacity" and non-traditional power industry (including use of non-fuel expansion turbines and modernization of large urban (district) boilers to small heat power plants);
- Increase of production of high-quality refined oil products through improved and intensive oil refinement;
- Ensuring required volumes of production of coal taking into account economic, social and environmental factors, further development of coal enrichment and complex processing technologies to obtain environmentally acceptable and competitive products, including high-quality household fuel;
- Intensive development of local power resources (hydropower, peat, small-size hydrocarbon fields and etc.) and increased use of renewable energy sources (wind, geothermal, solar energy, coal-bed methane, biological resources etc.);

In future, structural policy should ensure a broad use of both traditional and new energy resources.

Table IV.I
The potential for organizational and technological measures for saving energy resources (2000)

Sectors	Electric power, T W-hr	Central heating, P cal	Fuel, Mtce	Total	
				Mtce	%
Total for fuel and energy complex, including:	29–35	70–80	99–110	120–135	33–31
Power and heat supply	23–28	67–76	70–77	90–100	25–23
Industry and construction	110–135	150–190	49–63	110–140	31–33
Transport	7–11	–	22–26	23–30	6–7
Agriculture	4–5	5	9–11	12–15	3
Communal	70–74	120–135	51–60	95–110	27–26
Total	220–260	345–410	230–270	360–430	100

Besides the structural modification, the Energy Strategy envisions intensive institutional and technological measures to ensure saving of fuel and energy, i.e. targeted **energy saving policy**. Russia has a large potential for **organizational and technological**

energy savings. Table IV.1 shows expert estimates based on the state of national industry by the beginning of 2000. Realization of domestic and world-wide (low and upper values respectively) organizational and technological measures for saving energy resources enables reducing their current consumption within the country by 40–48% or by 360–430 Mtce/yr. Fuel and energy complex has almost a third of this saving potential. The other third refers to industry and construction. The communal sector has more than a quarter, while transport and agricultural sectors have 6–7% and 3% respectively.

The Energy Strategy envisions development of economic and administrative terms for a prompt implementation of the economically viable components of organizational and technological potentials in energy saving. These components will be determined by **price and taxation policy** implemented in the country**.**

The main prerequisite for increased energy saving is to bring domestic prices for energy carriers as soon as possible to a level that is sufficient for self-financing of fuel and energy producers (including forthcoming investments).

Correct pricing policy is absolutely necessary but not sufficient for increased energy savings. The Energy Strategy anticipates realization of integrated system **of legal, administrative and economic measures** stimulating efficient energy use. The frameworks of this system include:

- Intensification of administrative and legislative measures, including revision of acting fuel and energy consumption norms and regulations to strengthen saving requirements; improvement of accounting and control norms for energy consumption, establishing standards for energy consumption and losses together with mandatory certification of energy consuming installations and equipment in common use to conform to power consumption requirements; regular energy audit of enterprises;
- Additional economic incentives for energy saving that will make it efficient for business such as: income tax exemption for investments into organizational and specific technological fuel and energy saving activities; accelerated paying back of energy saving equipment; tax or other financial support for energy saving measures, including leasing of energy efficient equipment; tax sanctions for non-achieving the prescribed energy efficiency parameters etc.;
- Broad popularization of efficient energy use among population: extensive training of personnel; accessible databases on energy saving activities, technologies and equipment, regulatory and technical documentation; conferences and workshops to share experience, popularization of energy saving in mass media etc.

The anticipated dynamics of the GDP growth and decrease in GDP energy intensity in 2001-2020 determine the level of **domestic energy consumption.**

The rise of living standards will substantially change the level and structure of **per capita energy consumption**. From 1990 to 1999 this indicator decreased from 9.0 to 6.3 tce (or by 30%). Under the favorable conditions of the economic development per capita energy consumption would grow substantially – up to 1.3 times in the period up to 2020. Thus by 2020 per capita energy consumption would be 8.3–8.4 tce, closely approaching but still not reaching the pre-crisis level. Under a lower scenario of the GDP growth, per capita energy consumption would increase by 2020 to 7.6 tce.

The consumption of **electric power** would grow most dynamically in the forthcoming period. It would increase by 21–35% by 2010 and 1.4 to 1.8 times by 2020, compared to 1995 level. After 2000, electric energy intensity of the GDP would steadily decline.

A very moderate increase in **central heating** is projected. Even in case of an optimistic scenario, it would exceed the 1995 level only by 11–12% by 2020. This is explained by structural shifts in economy, accomplishment of accumulated heat savings and preferential development of individual sources.

The demand for **liquid motor fuel** within considered period would exceed the 1995 level by 25 to 62%, but still would not reach pre-crisis level despite an increased use of cars especially by the population. The liquefied and compressed natural gas would be widely used as engine fuel in forthcoming period (up to 5 Mt of secondary liquid fuel equivalent by 2010 and 10–12 Mt by 2020). Hydrogen engines and cell fuels would be used in transport.

The Energy Strategy identifies the following priority directions for the use of main energy carriers:

- Natural gas: for non-fuel purposes (production of mineral fertilizers, raw material for gas chemistry etc.), energy supply of communal sector and power heating and for engine fuel on transport**;**
- Oil: for provision the needs in motor fuels and raw material for petrochemical industry;
- Coal: for electric power generation, coke production and supply of individual household consumers;
- Uranium: for electricity and heat generation.

The priority directions for gas and oil utilization for the period to 2010–2012 also include exports as the main source of hard currency revenues to the country.

As a result of anticipated GDP growth and measures planned to reduce its energy intensity, domestic consumption of power resources from 2001 to 2020 would increase approximately 1.35 times in case of positive economy development (the rate of increase is about 1.5% per annum). For lower rates of development, it would rise 1.15 times only (the increase is 0.7–0.8% per annum).

"Energy Efficient Economy" Federal Target Program for 2002–2005 with prospects to 2010

The objectives of the Program include:

- Increased efficiency of the use of fuel and energy resources and creating necessary conditions for transfer of the economy to energy saving course of development;
- Sustainable supply of population and economy with energy careers:
- Creation of reliable base of raw materials and ensuring sustainable development of fuel and energy complex under market economy being established;
- Maintaining sufficient levels of export potential of the fuel and energy complex and increasing the efficiency of fuel and energy resources exports;
- Mitigating adverse environmental impacts of fuel and energy complex;
- Ensuring energy security of the Russian Federation.

It is the interagency Program, which will be implemented in two stages:

I stage: from 2002 to 2005;

II stage: from 2006 to 2010.

The Program includes three subprograms:

- "Energy Efficiency of Fuel and Energy Complex";
- "Safety and Development of Nuclear Power" and
- "Efficiency of Energy Consumption"

Implementation of the Program will require the following financial resources (in 2001 prices):

2,958.7 billion Rubles for 2002–2005 and

4,046.0 billion Rubles for 2006–2010.

The Subprogram "Energy Efficiency of Fuel and Energy Complex"

This program is designed to resolve a range of scientific and technology problems and to develop a new generation of national technologies, equipment and installations for modernization of particular branches of fuel and energy complex.

To expand the use of non-traditional renewable energy sources it is envisaged to develop equipment for micro-hydropower and geothermal plants, small- and high-power wind generators, transformation of solar radiation, efficient utilization of organic solid waste for power generation, hydrogen production and its use as an energy source, utilization of solid oxide fuel cells and combined energy systems on the basis of block and block-modular approaches.

A considerable increase in production of electric power and renewable energy resources is envisioned within the period up to 2020 (Table IV.2).

Table IV.2
Production of electric power and renewable energy resources in the Russian Federation

Type of energy resources	Units	2001	2005	2010 (projection)
Total electric power production, including:	TW-hr	888.4	1,008.8	1,158.9
Heat power plants	TW-hr	576.4	665.9	765.9
Hydropower plants	TW-hr	175.1	168.9	181
Nuclear power plants	TW-hr	136.9	174	212
Production of renewable energy resources	Mtce	1	2	3–5

The implementation of measures on energy efficiency increase in fuel and energy complex will lead to GHG emission reduction to 80 Mt CO_2-eq per annum by 2005, and to 330 Mt CO_2-eq per annum by 2010.

The subprogram "Safety and Development of Nuclear Power"

The main condition for implementation of measures under the subprogram is to ensure ecological safety, including assessment of nuclear power plants impacts on the environment. Thus, new safety regulations are envisioned on the basis of national and international experience and the IAEA regulatory documents.

At the first stage (2002–2005), the development of nuclear power will provide an increase in generating capacity of 3 GW by 2005. This would be achieved due to new and reactivated construction (by 2005 the electric energy production should be 174 TW-hr).

At the second stage (2006–2010), an increase in nuclear power generation would reach 4.81 GW by 2010, and the energy production would increase to 212 TW-hr.

In the longer term, by 2020, the nuclear power plants are expected to provide up to 25% of electricity for the country as a whole, and about 40% for the European part of Russia.

The subprogram "Efficiency of Energy Consumption"

The subprogram includes 6 sections related to the main consumers of energy resources:

1) Power-intensive branches of industry
   The intended measures in industry (iron and steel and non-ferrous metallurgy, chemistry and petrochemistry, engineering and metal working, construction materials, timber and wood-processing, pulp and light industries, and food-processing) would lead to saving of 49–52 M tce in 2002–2005 and 50–54 M tce in 2006–2010.
2) Agriculture
   Energy saving would be 5.5–6.5 M tce in 2002–2005 and 6–7 M tce in 2006–2010.
3) Communal services
   It is planned to save 35–38 M tce in 2002–2005. In 2006–2010, the saving fuel and energy resources for country as a whole could reach almost 38 M tce.
4) Transportation
   Scheduled for railway transportation measures would allow savings of energy resources of 4–4.6 Mtce in 2002–2005 and of 5 Mtce in 2006–2010. For other types of transport under the authority of the Ministry of Transport of the Russian

Federation (air, marine, river, motor, urban electric and industrial carrier, as well as that within territories of enterprises and road construction), savings of fuel and energy resources would be 4.0–4.9 Mtce in 2002–2005, and 4.3–5.5 Mtce in 2006–2010 respectively.

5) Federal budgetary institutions

The federal executive bodies have been required to ensure economy of fuel and energy resources of about 4.6 Mtce for 2002 to 2005, and about 8.3 Mtce for 2006 to 2010 respectively.

6) The branches of fuel and energy complex

The economy of energy resources would be 42 Mtce for 2002 to 2005 and 44 Mtce for 2006 to 2010.

The totals for energy resources saved in consumption sphere are estimated as about 150 Mtce in 2002–2005 and 295–325 Mtce for the entire period of Program implementation.

It is envisioned that in case of positive scenario of economic growth, the arrangements under the Program would result in a decrease of GDP energy intensity by 13.4% in 2005 and by 26% in 2010 relative to 2000 level. For unfavorable scenario of economic growth, the expected decrease would be by 4.7% and 18% respectively.

The “Energy Saving in Russia for 1998–2005” Federal Target Program

A significant range of energy saving measures is being realized in the frameworks of “Energy Saving in Russia for 1998–2005” Federal Target Program. The Program is commissioned by the Ministry of Energy of the Russian Federation.

It is planned that the Program would result in economy of primary energy resources from 365 to 435 Mtce during the 8 years. Besides the great economic benefit, it results in substantial reductions of CO_2 emissions (approximately by 780–830 Mt CO_2 for 8 years).

The Program is to be implemented in two stages. The provision of customers with equipment for registration and regulation of energy resources consumption and saving is mainly to be completed at the first stage. The investment program on extended use of energy saving technologies, energy efficient production and construction is intended for this period. The financial and economic procedure and legislative basis for federal and regional energy saving would be created.

Table IV.3
The description of “Energy Saving in Russia for 1998–2005” Federal Target Program subprograms

Branches of economy	**2005 (compared with 1995)**		**Total for the period from 1998 to 2005**	
	Energy saving, Mtce/yr	**Emission reduction, Mt CO_2/yr**	**Energy saving, Mtce**	**Emission reduction, Mt CO_2**
Fuel and energy complex	33–37	75–80	136–155	310–330
Communal sector	22–25	40–45	93–110	170–190
Energy intensive branches of industry	33–40	70–75	136–170	300–310
Total	88–102	185–200	365–435	780–830

The second stage of the Program envisions a broad-scale implementation of energy saving in various sectors of economy, development of an advanced energy market and accomplishment of the outputs of the first stage.

Table IV.3 shows the most important parameters of the Program.

Table IV.4 presents the aggregate parameters of investment projects planned for implementation in branches of economy during 1999–2005.

Table IV.4
The aggregate parameters of investment projects planned for implementation in branches of economy during 1999–2005

Branches of economy and investment projects	**2005 (compared with 1995)**	
	Energy saving, M tce/yr	**Emission reduction, Mt CO_2/yr**
Total for fuel and energy complex, including:	**39.6**	**79**
Oil industry		
Data measuring devices for gas and oil producing complexes	0.19	**0.4**
Production of block–module installations of complete utilization of associated petroleum gas	0.14	**0.3**
Production of installations on processing attendant gas	1.1	**2.2**
Creation of autonomous container 1.5 MW thermal heating plants working on associated gas	0.89	**1.8**
Block–module diesel 5.5 MW power plant working on associated gas	0.32	**0.6**
Oil processing industry		
Waste-heat recovery system on oil refining enterprises (10 units)	0.26	**0.5**
Creation of block-module installation on processing of condensate, compressate, oil refuse to engine motor fuels	2.4	**4.8**
Gas industry		
Production of 1.0 and 2.0 MW heat generators for radiate heating systems	1.3	**2.6**
Production small thermal heating plants (up to 2 MW) on the basis of gas turbines	5.7	**11.4**
Creation of 150 kW aggregate gas electric power generators (10 units) working on pressure differentials	0.9	**1.8**
Improvement of gas compressors	6	**12.0**
Production of oven recuperates	1.4	**2.8**
Coal industry		
Production of equipment for intensified coal bed methane extraction	0.6	**1.2**
Creation of drifting complex for unmanned shaft boring	0.7	**1.4**
Creation of a complex for colliery waste utilization for electric and thermal power generation	3.8	**7.6**
Introduction of a complex for automated mine working	0.4	**0.8**
Electric power and heat supply		
Introduction gas turbine and steam gas installations in building new power plants	6.4	**12.8**
Installation of production of automated 1–3 Gcal/hr small-size boilers	1.6	**3.2**
Production of automated systems for central heat supply	2.4	**4.8**
Production of new heat-insulating fine-fibroid materials	0.46	**0.9**
Creation of automated 500 kW turbo-expander power generating complex	0.9	**1.8**
Application of compensation devices in energy supply systems	1.7	**3.4**
Total for communal sector, including:	**21**	**40**
Transfer of boilers and generators to qualified fuel combustion	2.2	**4.2**
Closure of low-efficient boilers (up to 20 Gcal/hr) with transition to high-power boilers	1.3	**2.5**

Branches of economy and investment projects	2005 (compared with 1995)	
	Energy saving, M tce/yr	Emission reduction, Mt CO_2/yr
Application of panels with improved heat protective features in new house building	1.7	**3.2**
Production of economy light sources	5.7	**10.8**
Automation of central and individual heat devices	3	**5.7**
Application of new freezers and refrigerators	1.8	**3.4**
Introduction of efficient heat generators	0.7	**1.3**
Provision energy consumers with energy control and regulation devices	4.6	**8.7**
Total for energy intensive branches of industry, including:	**34**	**73**
Metallurgy		
The extended application of continuous cast of steel	2.4	**5.2**
Increased use of oxygen-converter and electric processes in steel smelting	6.2	**13.3**
Improvement of energy utilization in large industrial centers with metallurgical enterprises	1.8	**3.9**
Reduction of electric energy consumption in aluminum production	1.9	**4.1**
Industry of construction materials		
Transition to dry process of cement production	4.8	**10.3**
Introduction of new roasting devices and improvement of operative equipment in construction material production	1.9	**4.1**
Modernization of gas burner devices for mines and rotating furnaces	2.1	**4.5**
Pulp and wood industry		
Creation of small 1.5 MW thermal heating plants working on harvesting residues and waste of wood processing	4.1	**8.8**
Utilization of sulfite and sulfate of leaches	2.2	**4.7**
Introduction of thermal pumps in water recycling facilities of enterprises	6.4	**13.8**

The "Electric Power" Branch Energy Saving Program

The "Electric Power" Branch Energy Saving Program for 1999–2000 and prospects to 2005 and 2010 is aimed at increasing efficiency of fuel and energy use. It was adopted by "Unified Energy Systems of Russia" Joint Stock Company in 1999.

Total fuel conservation for 10-year period should be 83 Mtce. The CO_2 emission reduction by 2010 would reach 20 Mt CO_2/yr.

The implementation of this Program started from relatively inexpensive technological measures, such as: increase of efficiency of equipment and reduction of losses of electric power in grids primarily through introduction of automated power control and registration systems. Besides, the Joint stock Company "Unified Energy Systems of Russia" implemented a set of organizational measures in 1999–2000.

In 1999, the implementation of the Program resulted in improvement of parameters of fuel and energy use efficiency. The specific fuel consumption for electric and thermal power generation decreased by 1.8 and 0.7 g/kW-hr respectively. The energy consumption for internal needs reduced by 520 GW-hr (or by 2.8%). Total fuel and energy conservation in 1999 increased to 3.8 Mtce (including 1.2 Mtce from energy saving program). This amounts to 0.02 % of the total fuel consumption, compared with 1998. In comparison with 1998, the CO_2 emission reduction was 15 Mt CO_2/yr (including 2.5 Mt CO_2/yr obtained within the framework of energy saving program).

In 2000, fuel consumption increased by 4.7 M tce due to intensified thermal and electric energy production. The GHG emission increased by 17.3 Mt CO_2/yr.

The "Energy Saving in Transport of Russia (1998–2005)" Branch Program

The main objective of “Energy Saving in Transport of Russia” Branch Program is to establish the stages and introduction of major and priority orientations of science technology advance that provide economy and replacement of oil fuels in transport.

The measures for saving motor fuels in transport are classified as follows:

I. Introduction of energy efficient rolling stock, optimizing of transportation facilities park by tonnage (bearing capacity), specific orientation, type of energy devices and service life.

   Compared with motor transport currently in use within the country, the introduction of modern energy efficient rolling stock reduces fuel consumption by motor transport by 30–40% (particularly due to wide use of diesel cars) together with decreased consumption for other transportation types by 18–20%.

II. Introduction of advanced energy saving fuels and oils for minimizing losses due to delivery, storage and distribution of fuel and lubricant products.

   The modern oil additives and increased shares of high-octane gasoline would allow to reduce consumption of motor fuels up to 10–12%. The increase of gasoline stations network will reduce idle runs, decrease evaporation losses from overflows thus resulting in economy of 3–5%.

III. Improvement of technical operation, organization of transportation, providing incentives for energy saving and staff qualification. The operation in most cost-effective mode together with improved professional skills of workers and their interest in fuel saving totally provide up to 8–11% economy of energy and fuel resources.

IV. Replacement of liquid motor fuels with alternative fuels. In the near perspective (5–10 years) alternative fuels and energy could replace up to 30 % of liquid motor fuels.

In general, it is envisaged that energy saving measures would account for a decrease in fuel and energy demand of 3.5% by 2000 and 9.5% by 2005 relative to 1998.

The “Increase in Efficiency of Energy Resource Use by the Entities of Russian Academy of Science and Reduction of Costs for These Purposes” branch Program for Energy Saving in the Entities of Russian Academy of Sciences

The mandatory energy reviews on accomplishment of energy saving measures are conducted in enterprises and entities with annual energy resource consumption more than 6 k tce or more than 1 kt of motor fuel (or less if appropriate decision of executive bodies of subjects of the Russian Federation is made) irrespective of property rights. They are implemented in accordance with the Federal Law “On Energy Saving” (Ref. no. 28 of 03.04.96), the Decree of the Government of the Russian Federation “On Additional Measures to Intensify Energy Saving in Russia” (Ref. no 588 of 15.06.98) and the Orders of the Ministry of Energy of the Russian Federation (Ref. no. 161 of 18.05.99 and Ref. no. 324 of 05.10.99). The reviews are aimed to evaluate the efficiency of energy resources utilization and to reduce customer costs for fuel and energy supply.

As a rule, the energy saving potential of enterprises of various branches of economy differs insignificantly and is estimated to be about:

- 15–25 % for heating power and
- 10–20% for electric power.

From 1999 to 2000, numerous energy saving measures were implemented in the institutions of the Russian Academy of Science on the entire territory of the Russian Federation.

Measures on Methane Emission Limitations in Coal Mining

The share of open mining in total coal mining in Russia has considerably increased in the last decade. In 1990, that share was 55.5 % and has already reached 64.7 % by 1999. In accordance with a program for coal branch reorganization, it should rise up to 75 % in the future (“Plan of Actions on Coal Branch Stabilization”, Ministry of Energy of the Russian Federation, 1998.)

The latest assessments show that reduction of the underground mining by 1% leads to a drop of CH_4 emissions by approximately by 2.1%. Based on these rates and projections for total coal production, the likely CH_4 emission has been estimated for 2000–2010 (Table IV.5). The potential direct measures to decrease emission mainly relate to utilization of energy potential of methane extracted by degassing and vent systems. They can provide for additional decrease in emission.

Table IV.5
Levels of CH_4 emission at coal mining[1)]

Sources of emission	Years			
	1995	**2000**	**2005**	**2010**
Total coal mining, Mt	263	258	294	308
Open mining, %	57.8	65.2	75.0	75.0
CH_4 emission, Mt	1.75	1.38	1.25	1.31
CH_4 emission if 62.1% of coal is produced by open mining, Mt	–	1.59	1.78	1.86

1) Including methane emission from the coal extracted and stored on the surface

Thus, even in case of relatively considerable increase of coal mining and lack of specific utilization measures, the anticipated CH_4 emission from 2000 to 2010 would not exceed 70–80% of 1995 level. In a hypothetical case, if the ratio between open and underground mining is maintained at the present level, the 2010 emission would exceed the 1995 level by 6–7%.

IV.2.2 Agriculture

The balance in plant cultivation is formed when CO_2 absorption within the growth of agricultural crops is compensated by carbon loss during harvesting and decomposition of agricultural crop residues on fields. CO_2 emissions to the atmosphere from domestic livestock are due to metabolism of agricultural animals and poultry, primarily, by their respiration. According to expert estimates of the Ministry of Agriculture of the Russian Federation, this flow amounts to about 190 Mt CO_2 per year.

The main measures to limit and reduce CO_2 emissions and increase of GHG removals in agriculture are: increase in energy consumption efficiency, decrease in energy intensity, energy resources savings and direct emission limitation. The major activities to limit emission and increase of removals of greenhouse gasses in agriculture are currently implemented in the framework of several Federal Target Programs.

The “**Federal Target Program for Stabilization and Development of Agricultural Production in the Russian Federation for 1996–2000**” was approved by a Decree of the President of the Russian Federation (Ref. no. 933, June 18, 1996) and endorsed by Decision of the Government of the Russian Federation (Ref. no. 798, July 12, 1996).

The Ministry of Agriculture of the Russian Federation has commissioned this Program. It is implemented by 10 ministries and agencies of the Russian Federation, Russian Academy of Agricultural Sciences and executive bodies of subjects of the Russian Federation.

The following measures are envisioned under the Program:

- Realization of legal, institutional, financial and economic measures for overcoming the crisis in agricultural production, its stabilization and sustainable development;

- Establishment of efficient multi-structure agrarian economy, improvement of sectoral structure and of regional specialization of agriculture;
- Increase of investments;
- Intensification of industrial and social structure;
- Improvement of social status of rural citizens; and
- Implementation of environmental conservation measures.

Within the framework of the Program, it is planned to restore integrated mineral and organic fertilization system to prevent fertility decrease and to raise organic matter reserves in arable lands. Besides, the necessary erosion-protection, forest protection and land reclamation activities have been undertaken. The landscape agriculture systems are being developed to ensure high productivity of agricultural lands, resource and energy saving and safe application of mineral fertilizers and chemicals for plant protection. The increase of nutrition value of forages and elimination of unbalances in animal fodder rations are implemented. The improved forage production will enable to change intensity and nature of atmospheric CH_4 emissions from internal fermentation of agricultural animals. The priority orientation in plant cultivation is the transition to efficient energy saving and low cost technologies together with introduction of highly productive species and hybrids of agricultural crops resistant to overlying, extreme environmental factors, diseases and pests.

Favorable economic conditions for foreign and domestic investments in the development of agricultural industry complex and related sectors created by the State form a crucial activity course within the framework of the Program. The investments in land reclamation aim at qualitative improvement of existing land reclamation stock. An important part of a set of measures to prevent soil erosion is of precautionary nature. Terracing of sharp slopes and ravines was done in 1996–2000 to protect soils against water erosion. Waterproof locks, dams, guides, catchments reservoirs and bottom constructions have been built together with reconstruction of existing hydraulic engineering facilities.

The "**Recovery of Environmental Conditions of Volga River and its Affluents, Restoration and Preventing a Degradation of Natural Complexes of Volga Basin for the Period to 2010**" Federal Target Program (Volga Revival Program) was approved by Decision of the Government of the Russian Federation (Ref. no. 414, April 24, 1998). It includes "**Environmentally Safe Development of Agriculture**" subprogram. It identifies measures to restore environmental conditions of agricultural industry complex in the Volga basin. Implementation of the Subprogram envisions assimilation of environmentally safe highly efficient and energy saving tools for utilization of waste of agricultural industry production, increase in efficient use of agricultural lands, provision of population with high-quality food products through transition to environmentally safe technologies, and establishment of network of enterprises for biological processing livestock and poultry waste.

The "**Federal Integrated Program for Increase of Soil Fertility in Russia**" envisions the following phases:

1 phase (1992–1995) was approved by Decision of the Government of the Russian Federation (Ref. no. 879, November 17, 1992) and

2 phase (1996–2000) was endorsed by Order of the Government of The Russian Federation (Ref. no. AZ-P1-06174, February 27, 1996)

The Decision of Government of the Russian Federation (Ref. no. 1034, December 30, 2000) extended the period of implementation of the 2nd phase of the Program to 2001.
The "**Increase of Soil Fertility in Russia for 2002–2005**" Federal Target Program was approved by Decision of the Government of the Russian Federation (Ref. no. 780, November 8, 2001). The Program stipulates a range of measures ensuring preservation and improvement of soil fertility in Russia and an increase in the output of agricultural

production on the basis of introduction of environmentally safe and energy saving technologies.

The CH_4 and N_2O emissions in agriculture can be reduced through improvement of systems for collection, storage and use of animal manure and poultry excrements.

A system for protection of livestock farms against adverse natural and climatic phenomena and technogenic disasters is under development in the frameworks of the Federal Target Program for Stabilization and Development of Agricultural Production in the Russian Federation.

Domestic technologies and equipment for anaerobic collection, storage and processing of manure of domestic livestock and excrements of poultry have been developed. Experimental installations for thermal processing of manure and excrements have been built and currently operate in a number of poultry farms in the Moscow region. Based on existing technology, highly efficient and environmentally safe systems for utilization of agricultural animals and poultry waste are under development now.

IV.2.3 Forestry

The plant life on our planet is an effective absorber of greenhouse gases. Boreal forests make an especially high contribution to carbon sequestration. Owing to a relatively slow growth intensity and oxidation of biosynthetic by-products, boreal forest ecosystems absorb and accumulate significant amounts of atmospheric carbon and retain it for 80 to 120 years until achieving the age of cutting. The forest stock of Russia consists predominantly of boreal zone forests and consequently, has considerable potential for greenhouse gas removals. Within 10 years (1990–1999), total CO_2 net removals by forests in the country reached 985.4 Mt. Therefore, reforestation, afforestation and forest reconstruction projects and programs rank highly in a national policy of preventing adverse effects of climate change.

National priority is the balanced use of the area of forest stock on the basis of sustainable forest management. The conservation of forests has been stipulated in legislative and regulatory acts, primarily in the “Forest Code of the Russian Federation”, a new law adopted in 1997. State Forestry Service of the Ministry of Natural Resources of the Russian Federation is responsible for development and consistent implementation of the forest policy including practical application of the Forest Code, as well as for creating organizational and economic conditions for sustainable management of forests.

The forests of northern Siberia and Far East are currently utilized mostly as the resource base. The evaluation of their potential in increase of GHG removals shows that their rational use taking into account environmental and climatic requirements can result in substantial effect. This is a special issue for consideration within the strategy of forest management in Russia, as it requires large financial expenditures and development of a complex of specific measures.

Nowadays, a considerable reduction of CO_2 emissions to the atmosphere from national forest sector is achieved through improvement of control and protection against fires, insects and diseases, as well as enhancement of logging and deep processing technology together with utilization of harvesting residues over areas of cuts, temporary storage and loading for subsequent transportation (cut areas and upper stocks), as well as at wood-processing enterprises. Within the framework of the “**Forests of Russia**” Federal Target Program (1997–2000), the measures related to forest regeneration, drainage, management cutting and protection against insects and fires were implemented. They resulted in a higher forest cover growth, increase in forest productivity and enhanced carbon removal over the territory of forest stock.

“**Protection of Forest Against Fires for 1999 to 2005**” Federal Target Program includes system of measures to improve fire prevention awareness, to enhance fire resistance of forest stands (creation of green zones and slips, fire prevention gaps, barriers, water reservoirs etc.), and to introduce institutional and technical arrangements.

Within the section "Forest Reclamation" of the Federal Complex Program on soil fertility improvement carried out under the auspices of the Ministry of Agriculture of the Russian Federation, forest service established from 1996 to 2000 112.2 kha of forest shelter belts to protect agricultural lands and pastures from erosion. As for January 1, 2000, area of all types of protective stands established by forestry institutions on the territory of the Russian Federation was 3.2 Mha. The stands are located in regions with dangerous scale of soil erosion and desertification.

A special attention should be paid to the enhancement of CO_2 removals in Russian forests owing to the implementation of forest management activities, such as creation and maintenance of forest plantations (sown and planted stands), provision of natural regeneration and reconstruction of low valuable stands. Table IV.6 presents the scope of the measures that have been undertaken in the last decade (1990–1999).

Table IV.6
Measures to increase GHG removals on the territory of State Forest Stock within the period from 1990 to 1999

Measures	**Total area of measure implementation, kha**
Establishment of forest plantations	3,066.2
Promotion of natural regeneration	7,465.4
Reconstruction of low valuable forest stands	244.8
Maintenance of forest plantations (recalculated for one-fold treatment)	18,182.8

The conservation of forest undergrowth during wood harvesting has recently accounted for 46–54% of total measures on promotion of natural regeneration (in 1997 it was 54.3%, in 1998 – 52.4%, and in 1999 and 2000 – 45.8% and 48.4% respectively). Mineralization of upper soil layer is implemented on approximately 30% of areas (30.9% in 2000). The other promotion activities are also applied.

The reconstruction of highly productive, but sparse forest stands with crown density less than 0.5, as well as formation of forest plantations on sites not suitable for natural regeneration (mining excavation and dumps, slopes of ravines, areas of communal waste dumped storage and etc.) are among other measures to enhance GHG removals in forests. The estimates show that afforestation and reforestation activities can be implemented in the Russian Federation over the area of 35–40 Mha, while reconstruction of forest stands for their productivity improvement – over 20–25 Mha. It should be noted that reconstruction is an integrated measure that includes reconstruction cutting and development of forest plantation.

The introduction of modern technologies to forest management and wood industry can provide essential contribution to reduction of CO_2 emissions and increase its removal in forests. The practical activities related to introduction of new know-how could be as follows:

- Application of advanced forest harvesting equipment notably reducing wood losses over cutting areas (currently these losses are 20–30%) together with full utilization of wood from transitional cuts;
- Increase in the level of automation of logging operations, application of machinery with specific ground pressure 0.4–0.5 kg/cm^2 allowing to preserve almost 70% of self-sowing and undergrowth over cutting areas; and

- Introduction of deep mechanic and chemical processing of softwood species to enable more complete utilization of harvested wood and consequently, to reduce emissions from decomposition of harvest residues.

IV.2.4 Waste

State Committee of the Russian Federation on Construction, Housing and Municipal Complex in collaboration with sectoral institutes consistently implements policy on introduction of low-waste and non-waste technologies in production of construction materials that meet the most recent technical, economic and environmental requirements.

Nowadays, the industry of construction materials is a substantial branch capable to implement efficient utilization of technogenic waste and resolve the tasks of resource saving and environmental protection.

The problem of application of technogenic waste in construction industry has been intensively studied by Russian scientists. Technologies for production of a long list of construction materials on the basis of different industrial waste have been developed. The major construction and technical properties have been studied and vast regulatory and technical documentation is available for utilization of waste in heating, metallurgy, chemical and other industries, as well as for production of cements, concrete, fillers, walls and other construction materials.

Meanwhile, it should be noted that there is still a considerable gap between waste utilization in construction industry and scientific and practical potential accumulated.

Based on importance of waste processing and utilization, it is essential to:

- Invest into development and production of machinery required for processing waste for energy, metallurgy, chemical and other industries for conversion into construction materials;
- Develop appropriate taxation and investment policy to provide incentives to producers and customers for industrial waste processing and utilization;
- Introduce mandatory certification and prepare required documentation for waste processing products and construction materials on their basis to correspond to the requirements of environmental safety;
- Establish an environmental fund financed by payments from the rent of land used for waste dumps, waste transportation to dumps and their maintenance to invest in the introduction of non-waste technologies in waste processing; and
- Introduce tax incentives for waste processing enterprises and those using processed waste products.

V PROJECTIONS AND THE TOTAL EFFECT OF POLICIES AND MEASURES

V.1 Energy Strategy of Russia to 2020: Projections of Domestic Energy Consumption, Reduction Energy Intensity of GDP and Expected Trends in CO_2 Emissions

Projections of CO_2 anthropogenic emissions have been carried out on the basis of a multiplicative model relating expected CO_2 emissions to macro parameters of economy and energy development:

$$CO_2 = GDP \times E/GDP \times CO_2/E ,$$

where: CO_2 - CO_2 emissions,
GDP - Gross Domestic Product,
E - total domestic energy consumption,
E/GDP - GDP energy capacity,
CO_2/E - carbon intensity of energy consumption.

The following projections of CO_2 emissions are based on the current programs of social and economic development of the country and on the General Provisions of the Energy Strategy of Russia for the Period until 2020. Realisation of the key provisions of the above-mentioned documents should finally allow Russia to emerge from an economic crisis of the 1990-s and to achieve a sustainable growth of all components of social and economic development.

It is obvious that there is no basis for preparing any “baseline scenario” or a “business as usual scenario” for CO_2 emissions under the specific circumstances of the economy and energy growth in Russia. Projections of CO_2 emissions are directly dependent on the specific values of expected macro parameters of progressive development of the economy and energy sector. In other words, the ways of development of economy and energy sector envisaged by the official program documents can at the same time be considered as the large-scale integrated measures on regulation of CO_2 emissions.

Projections of CO_2 emissions are based on the following average values of economic and energy macroparameters expected in the period 2001-2020.

A. Rate of the GDP growth. An initial basis of the Energy Strategy projections is an expected increase of the GDP by a factor of 3 - 3.15 (at an annual average rate of increase 5 - 5.2 %) in case of a favourable economic development during twenty years, from 2001 to 2020.

In parallel, a scenario of a lower economic development is considered with the GDP growth factor of approximately 1.5, i.e. about 3.3 % annual growth.

B. Rate of the GDP energy intensity reduction. The radical increase in energy efficiency of the economy is one of the key objectives of the social and economic revival of Russia. A corresponding reduction of the GDP energy intensity will be related to the two groups of measures:

- **Restructuring of economy and energy sector** in line with the **technological progress** should compensate for more then a half of required energy consumption increase, since an increased share of services and high technology industries in the GDP would lead to a reduced need for growth in the domestic energy use;

- Pursuing a targeted **policy of energy saving** based on a vigorous implementation of organisational and technological **saving fuel and energy** measures would lead to a realization of up to one-third of the available potential in savings of energy resources by 2010 and allow to completely utilize this potential within economically effective limits to 2020 (Table V.1).

As a result of implementation of the whole large-scale complex of measures on reduction of the GDP energy intensity it is expected that 70 – 75 % of reduction would be related to structural reorganisation of the economy, and 25 - 30 % - to organisational and technological energy saving measures.

Table V.1
Projections of energy resource savings (relative to 2000)

Year	Energy resource savings (M tce/yr)	Expected CO_2 emission reduction (Mt CO_2/yr)
2005	30 - 55	55 – 100
2010	105 - 140	200 – 270
2015	185 - 200	350 – 380
2020	300 - 420	570 – 800

Note: The lower values correspond to implementation of measures readily available domestically, the higher values correspond to introduction of the best available world practices.

Two basic options for reducing GDP energy intensity are considered by the Energy Strategy, namely, an optimistic scenario and an unfavourable one. GDP energy capacity could be reduced by factor of 2.1 (at average annual rate of reduction about 3.7 %) in case of the sufficient investments to the planned measures on increase of energy sector efficiency during 2001 - 2020 (optimistic scenario). However, under unfavourable conditions the rate can decrease to 2.5 % of annual reduction.

C. Carbon intensity of energy consumption (ratio of CO_2 emissions to the total domestic energy resources consumption).
The carbon intensity of energy consumption depends upon expected evolution in fuel and energy balance of the country. According to the Energy Strategy, the share of gas in the primary energy consumption would decrease from 48 % in 2000 to 42 – 45 % by 2020, the contribution of oil is expected to be practically stable (22 – 23 %), the share of coal would increase from 20 % to 21 – 23 %, the contribution of NPP-produced electricity would increase to 5.7 - 6.0 %, and the share of non-conventional renewable energy resources would increase up to 1.1 - 1.6 %.

Thus, despite a decrease in the gas share and an increase in that of coal in the fuel and energy balance, the carbon intensity of energy consumption should remain approximately constant during all considered period due to an increase in the balance of the share of non-carbon energy resources (nuclear energy and non-conventional renewable energy).

D. Scenarios for CO_2 emissions.
Combination of considered options of evolution of basic affecting factors (GDP, energy intensity of GDP, carbon intensity of energy consumption) allows formulating corresponding possible scenarios of CO_2 emissions in the period 2001 - 2010.

Two basic scenarios of GDP increase and of GDP energy intensity reduction have been formulated in the Energy Strategy thus resulting in two scenarios for domestic energy consumption growth and two scenarios for CO_2 emissions ((Table V.2).

As mentioned in the Second National Communication of the Russian Federation, the development of national economy and energy sector under specific conditions of the

Russian Federation might, with a certain probability, result in the GDP annual rate of increase of approximately 4.5 % and in a simultaneous annual reduction of the GDP energy intensity by 2 %. Therefore, it is reasonable to consider, as an additional one, the third scenario of energy consumption and corresponding CO_2 emissions determined by above-mentioned 4.5 % GDP increase and 2 % decrease of GDP energy intensity (Scenario III).

Table V.2
Basic scenarios of economic development

Macroparameters	Scenario I	Scenario II
GDP	Favourable economic development Annual increase ≈ 5-5.2 %	Lower economic development. Annual increase ≈ 3.3 %
Energy intensity of GDP	Optimistic variant. Annual decrease ≈ 3.7 %	Unfavourable variant Annual decrease ≈ 2.5- 2.6 %
Energy consumption	Annual increase ≈ 1.5 %	Annual increase ≈ 0.7- 0.8 %
CO_2 emission	Annual increase ≈ 1.5 %	Annual increase ≈ 0.7- 0.8 %

Thus, the basic initial and resulting parameters of the key affecting factors (i.e. their increase or decrease rates during 2001-2020) and energy consumption and CO_2 emissions determined by these parameters are formulated as follows for all three considered scenarios. (Table V.3)

Table V.3.
Basic scenario parameters

Macroparameters	Scenario I	Scenario II	Scenario III
GDP	+5,2 % per year	+3,3 % per year	+4,5 % per year
Energy intensity of GDP	-3,7 % per year	-2,5 % per year	-2,0 % per year
Energy consumption	+1,5 % per year	+0,8 % per year	+2,5 % per year
Carbon intensity	0	0	0
CO_2 emission	+1,5 % per year	+0,8 % per year	+2,5 % per year

Figure V.4 and Table V.1 presents the calculated projections of CO_2 emissions (relative to 1990).

Table V.4.
Projections of CO_2 emissions (1990 = 100%)

Year	Scenario I	Scenario II	Scenario III
2000	69,2 %	69,2 %	69,2 %
2005	74, 6%	72,0 %	78,4 %
2008	78,0 %	73,8 %	84,5 %
2010	80,4 %	75,0 %	88,9 %
2012	82,8 %	76,2 %	93,4 %
2015	86,7 %	78,0 %	100,7 %
2020	93,4 %	81,2 %	114,1 %

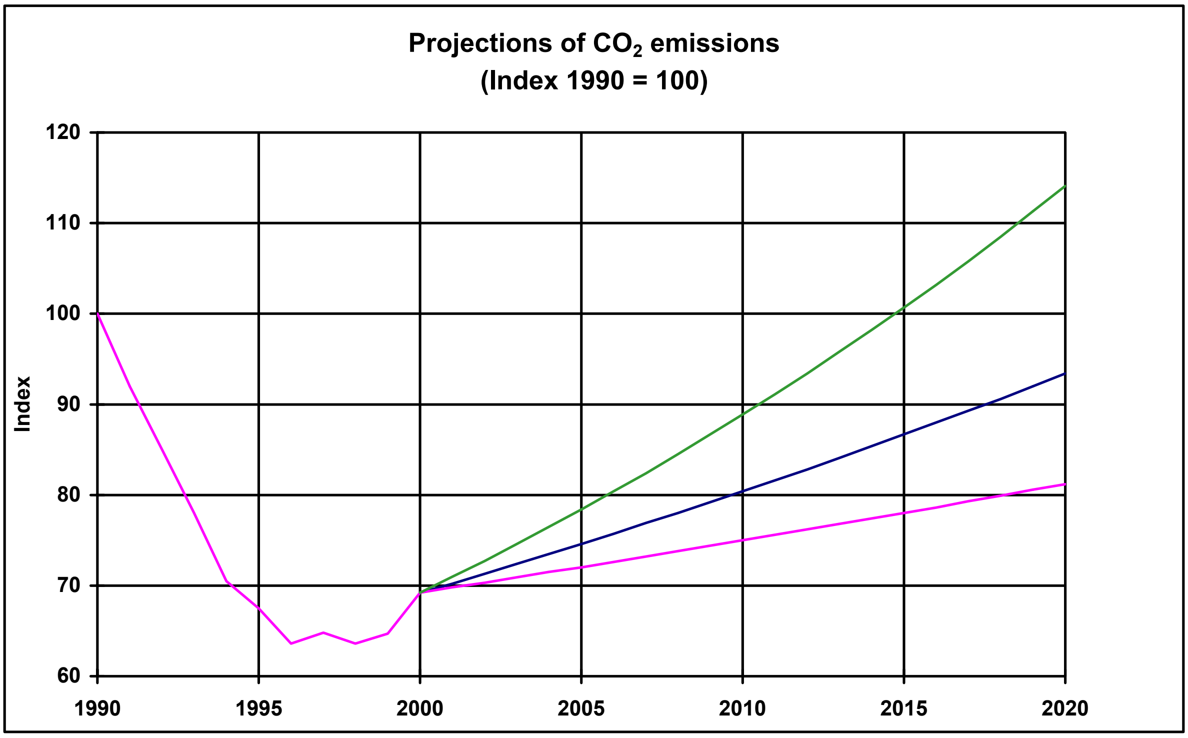

Figure V.1 Projections of CO_2 emissions.

VI Vulnerability Assessment, Climate Change Impact and Adaptation Measures

The most climate-dependent sectors of the economy of the Russian Federation include agriculture, forestry, use of water resources. Some regions could be potentially affected by sea level rise, and areas of permafrost could also be affected.

To mitigate possible effects of climate warming on human health of the population of Russia, it is necessary to identify highly vulnerable regions. This information is important for sanitary and epidemiological services of the Ministry of Public Health of the Russian Federation for monitoring changes in hygienic and epidemiological situations, and for the Ministry of Emergencies of the Russian Federation for prevention and liquidation of consequences of emergencies related to rise of groundwater, technogenic disasters in coal and ore mines, inundation of territories due to annual precipitation increase.

VI.1 Agriculture

Russia is among the countries, whose agriculture strongly depends on fluctuation and variability of climatic conditions. The analysis of currently available regional climate scenarios gives a rather uncertain view of climate change parameters within the territory of the country. It is possible to expect displacement of boundaries of vegetation zones along with change in climate conditions. Agricultural output could improve in some regions. However, in the others it could deteriorate because of intensified desertification and an increase in unfavorable phenomena. For example, a decrease in productivity of factor 1.5–3.0 in some regions due increased frequency of droughts could result in a reduction of total productivity of agricultural production of 20 to 25%.

The improvement of agricultural climate conditions of productivity formation, decrease of climate-related risk for agricultural production and growth of bioclimate potential have been identified during the last decades over European part of the country. The positive effects of anticipated climate change on plant cultivation include the following:

- Increase in area of land suitable for agriculture,
- Longer vegetative periods,
- Increase in heat supply of agricultural crops, and
- Improvement of wintering conditions for field crops and horticultures.

The increase in CO_2 concentrations in the atmosphere is a main positive factor for productivity. The analysis shows that with sufficient moisture and nutrition doubling of carbon dioxide concentrations would lead to an increase in productivity of cereal crops by 34% on the average. The anticipated rise of CO_2 concentrations may largely compensate for negative effects of climate change on agriculture of Russia. However, this assumption is relevant for only a portion of plants, and it does not cover such crops as corn and millet. Besides, increased concentrations of ground ozone and other contaminants may greatly reduce the efficiency of CO_2. Table VI.1 shows results of calculations of the effects of climate change.

The potential increase in frequency of droughts and dryness on the territory of particular regions is the major negative factor of climate change for national agriculture. In general, the change of climate conditions in Russia can be characterized as "warming accompanied with increased dryness". Based on this trend in climate change, it is reasonable to expect a reduction in the average productivity of cereal crops and sown herbs by 15 and 3% correspondingly. However, this projection may not come true, as rise of CO_2 atmospheric concentrations contributes to an increase in productivity, while decrease in soil fertility due to humus reserves exhaustion could adversely affect agricultural crop productivity. To obtain objective information on CO_2 flows in agriculture, it is necessary to set a system of monitoring CO_2 emissions and removals in agriculture as well as sectoral inventory of greenhouse gases on the basis of a permanent geographically-relevant grid of experimental plots. The system should include experiments with fertilizers and other agrochemical agents together with technological methods for their effective application.

In a view of a positive influence of atmospheric enrichment with CO_2, expected results climate change are generally favorable for development of cereal crop cultivation and livestock fodder base. However, in some regions a drop in grain productivity may occur in the next decades because of increase of droughts. Thus, there was a tendency for a decrease in cereal crop productivity in Siberia for the last 10–15 years that has been associated with climate. Due to further warming, this decrease could exceed 20% and become critical for regional economies. Apparently, the intensive growth of plants as well as CO_2 absorption induced by the temperature would not compensate for accelerated decomposition of organic matter. This may result in a decrease in soil fertility.

The overall balance of possible consequences of climate change can be estimated as positive for national agriculture. At the same time, taking advantage of positive factors requires an advanced adaptation of agriculture to anticipated changes.

The basic measures on adaptation of agriculture to climate change include:

- Assimilation of highly productive cultivars of cereal crops with the aim of the most efficient use of vegetation periods;
- Cultivation of agricultural crops with short vegetation period in the southern regions of the country to enable for growing the second harvest within one year for example, of vegetables with shortened period of vegetation.
- Earlier spring sowing of summer crops for more efficient use of soil water reserves and increase possibility of cultivation of second harvest;
- Assimilation of environmentally safe agricultural technologies through increased productivity of agricultural crops under increased CO_2 atmospheric concentration and increased rates of fertilization.
- Expansion of areas of agricultural lands under winter cereal crops, subject to assumed increased adaptation to anticipated climate change and global warming;
- Development of field protection forest shelter belts in arid regions to increase soil moisture reserves and reduce the effects of dry winds;
- The extension of irrigation systems in arid areas to provide for increase in moisture content in soil through artificial sprinkling additional areas of agricultural crops to improve their productivity; and
- Development of adaptive system of agricultural management.

The expansion of commercial agriculture to more northern regions with sufficient moistening is one of important tasks of adaptation. This corresponds to the program of intensification of agriculture in non-chernozem zone of the country, that envisions an increase in the mean productivity of cereal crops and concurrent significant reduction of their areas. The increase in thermal resources due to warming, could contribute to extension of full-season normally more productive cultivars. The expansion of areas of stubby crops will enable to replace summer crops with more productive winter ones in regions, where they previously had limited distribution because of severe winters.

Another important direction is an increase in productivity and sustainability of agriculture in steppe and forest-steppe zones of the country due to implementation of measures to fight against droughts and to develop moisture saving technologies. A set of measures includes: decrease in arable land area and development of pasturing in highly arid regions, application of drought-resistant cultivars in agricultural systems; use of fallows; reduction of non-efficient evaporation; shift sowing of summer crops to earlier dates, and of winter – to later for the best use of moisture resources. For forest-steppe and steppe regions where sufficient moistening is envisioned, the main orientation of adaptation is optimized use of increasing thermal resources through expanding areas under thermophilic and economically valuable agricultural crops.

In addition to general directions of national agriculture, a number of specific measures should be pointed out:

- *For fruit-farming and wine growing*: increased thermal resources and reduced winter severities provide prerequisites for extending the areas of fruit species and grape cultivation together with considerable advance of thermophilic and productive cultivars to north and east;
- *For irrigated agriculture*: the irrigation strategy should be reconsidered due to growth of productivity of irrigated lands due to increased bioclimatic potential and rise of costs of water because of increased evaporation.
- *For cattle breeding*: due to reduced stabling period and subsequent decline in farm heating costs, and mainly, increase of fodder base, cattle breeding conditions will improve in forest zone. In arid steppe zone, the rise of livestock productivity is possible due to expansion of pasture areas due to a decrease in arable lands.

Table VI.1
The response of crop productivity to possible climate change and CO_2 concentration increase in the atmosphere

Region	**Per cent of the modern level of crop productivity with regard to the period of scenario realization**			
	30–40 yrs	**60–70 yrs**	**30–40 yrs**	**60–70 yrs**
	Forage crops cultures		**Grain-crops cultures**	
Northern	22	32	26	24
Northwestern	21	24	22	12
Kaliningrad	22	22	34	25
Central	19	24	27	25
Volga–Vyatka	21	30	20	26
Central Chernozem Area	20	24	15	15
Northern Volga	24	30	16	19
Southern Volga	5	14	7	30
Northern Caucasus	2	3	-6	-7
Ural	14	28	11	16
West Siberian	6	19	-7	-1
East Siberian	0	0	-12	-18
Far Eastern	6	13	10	12
Russia	**13**	**21**	**11**	**14**

VI.2 Forestry

The climate change can exert a strong impact on complex multi-level ecosystems, such as forest, various components of which have different rates of response to the change. This could lead to irregularities in their functioning and, accordingly, to an increase of instability. The forests of Russia are a tremendous reservoir of carbon stored in above- and belowground biomass of plants, their oddments, humus and peat. Therefore, any alteration of tolerance of forest ecosystems due to anticipated climate change may result in irreversible changes in a global cycle of main biogenic substances. The latter in turn, would disrupt functioning of the biosphere as a whole.

The investigations of relationship between photosynthetic intensity and carbon dioxide content give grounds to assume that the global increase in CO_2 concentration in the atmosphere could lead to more favorable conditions for photosynthesis and, accordingly, to growth of the highest plants due to their biological potential and more effective utilization of solar energy. Thus, the growth of CO_2 atmospheric concentration can strengthen photosynthetic activity of plants and, therefore, improve increment of forest biomass. At the same time, an increase in ground air temperature could be accompanied by increased frequency of droughts and hot periods, reduced precipitation, alteration of soil-hydrological regime, permafrost melting and other adverse effects on plants.

For the territory of Russia, global climate change in the next 30–40 years would not result in an abrupt deterioration of conditions required for normal growth and development of main forest forming species. Anticipated effects of climate change in this period would remain in a range of allowable changes of growth condition of these species in natural forest. However, expected changes could disrupt the interrelationship between forest species at a stage of natural forest regeneration after cuttings, fires, in the areas of impact of forest diseases and pests. For example, due to its biological features as a luciphile species, larch at the higher limit of its natural habitat could be replaced by fir or spruce, as the less luciphile species. The replacement of conifers with deciduous tree species is also possible, because the latter are less sensitive to climate change.

The investigations and model estimates conducted in the Institute of Global Climate and Ecology showed that the effect of climate change would not be significant over the European territory of Russia for the next 50 years. Anticipated warming would have a positive effect on forest productivity and carbon accumulation in the Northern Siberia and Far East. Based on the calculations, it is possible to expect a stable growth in net CO_2 removals there.

At the same time, changes in forest species structure have been noted in the Central Chernozem Reserve in the forest-steppe zone of the country that is linked to the change in amount of precipitation. Drying of oak forests is observed over the territory of reserve, and according to the IPCC, degradation of forest ecosystems is considered to be a specific indicator of their vulnerability to climate change. The expansion of upper forest boundary in alpine areas is also considered as one of consequences of climate change. The replacement of vegetation cover by upper forest border has been already identified for highlands in the Southern Urals.

The majority of researchers agree that in a long-term outlook predicted temperature variations could result in shifting climate zone boundaries to the north. Even relatively minor temperature variations in this century have already caused changes in distribution boundaries of specific species. But in general, these changes are slow. An average speed of displacement of habitat for woody spices is about a dozen kilometers in a century. Thus, the shift of vegetation zones would lag behind the climate change. Therefore, only continuous and constant impacts could result in quantitative and qualitative changes in their state. The initial changes will originate at microstructure (cell-like) level of plants located in conditions of the most favorable effects of climatic parameters.

An important adaptation measure is preservation over cut areas coniferous forest plantations, natural seeding and undergrowth that are subject to substitution by deciduous spices, more adaptive to new conditions of growth. The indirect impact of climate change on tree species, especially young stands, is the increased frequency of short-term extreme weather events (strong snowfalls, hails, gales, droughts, late spring frosts and etc.). In this case the adaptation measures are also indispensable. Among them the improvement of quality of planting material should be indicated that in turn, allows improving vitality of forest plantations and their resistance to unfavorable ambient environment and pathogenic factors. The major measures in forest adaptation to climate change include:

- Creation of conditions for growth and regular development of forest plantations, natural seeding and undergrowth. The Forest Service recommends a careful selection of terms of planting, quality planting material, opportune maintenance and management cutting in young stands (lightening and thinning).

- Decrease of fire risk in forests during arid season: propagation, development of fire-prevention barriers, building roads, undertaking preventive fires, creation of fire control system, introduction of technical devices for fire detection and other activities. These measures are outlined in the Federal Target Program "Protection of Forest Against Fires for 1999 to 2005".
- Reduction of the population of pests and weakening their impact on forests. Detection and elimination of forest pest outbreaks.
- Measures against fungi diseases of forest plantations and young stands (farinaceous dew, snow shutte, root jaw and etc.).
- Enforcement of quarantine measures in silviculture within preparation of seeds and planting material in nurseries.
- Introduction of adaptive measures in forestry carried out to take account of climate change.

VI. 3 Water resources and sea level change

High sensitivity and immediate response of hydrological regime to climate change specify vulnerability of water resources.

It is known that climate warming and increase in precipitations in recent decades over the territory of Russia have exerted essential influence on hydrological features. The growth of low (winter–summer–autumn) sink by 20–40% above the standard rates has been observed for basins of the Volga, Don and Dnieper rivers in the last 15–20 years as a result of an increase in underground water resources. The annual river sink has increased, while the spring tide has diminished.

The increase of the Volga sink and of the amount of precipitation proved to be the major factors for the Caspian Sea level rise of almost 2.5 m in 1978–1995. In the Caspian area, more than 320 k ha were flooded and withdrawn from land use in recent years. Significant damages to settlements, ports and roads were caused, and thousands of people were resettled.

The level of Lake Baikal has risen by more than 1.5 m above its original level by 1998 due to the construction of a dam for Irkutskaya hydropower station. Now it is controlled in accordance with provision of the Decree of the Government of the Russian Federation "On the Highest Values of Water Levels of Lake Baikal Under Implementation of Economic and Other Activities" (Ref. no. 234 of 26.03.2001). Its maximum level is set to be 457 m of Pacific Altitude System. The serious consequences of water level rise include destruction of spawning areas and damage to food base of valuable Baikal fish species, inundation of settlements and destruction of parts of Trans-Siberian Railway.

Presently, there is a lack of reliable regional projections of climate change. Therefore, quantitative assessments of hydrological consequences were performed using different scenarios based on general atmospheric circulation models and reconstruction of past paleoclimate. All scenarios project considerable rise of air temperature and precipitation. In case of increase of mean annual air temperature by $3–5^0$ C and precipitation by 10–20%, the annual sink in basins of the Volga and Dnieper rivers is expected to grow by 25–40%, and of the Yenisei river – by 15–20%. The annual distribution of sinks would be more even.

The annual sink to the Arctic Ocean is expected to rise by approximately 15–20%.

It is highly probable that in the future the level of the Caspian Sea would decrease from its present level of -27 m to its mean position (-28.4 to -28.9 m) and would have noticeable inter-annual variations.

For many catchments global warming will cause more considerable change in extreme sink parameters than in annual and seasonal ones. The increased danger of floods is expected in many regions of Russia, where river sink is projected to raise.

The projected changes in total content, leveling, maximum and minimum consumption of water will transform erosion processes on catchments, river channels. The changes in turbidity, deposit run-off, river channel processes, and water quality are also expected. Considerable negative consequences are associated with rise of underground water and intensification of inundation, especially in zones of surplus humidity, and withdrawal of agricultural lands from rotation.

The global warming would cause an abrupt rise of water quantity as a result of snow or glacier melting that in turn, would lead to floods. The floods quite often are caused by rise of river water level due to blockage of channel by drifting ice, as it happened in Lensk, or enormous precipitation from destructive shower cyclone, as it was in Vladivostok. Frequently floods occur from winds that move sea water to river estuaries and cause its increase there because of hold up the water brought by the river.

The global warming will change water use by different consumers, especially irrigation. A decrease in sprinkling rates for yearly crops by 10–30% is expected. On the contrary, the rates for perennial herbs may rise by 10–40%.

The rise of ocean and sea level may result in flooding of low coastal areas, development of coastal erosion, changes in delta-formation processes, salinification of river lowers due to intense seawater penetration. The negative effects would occur for harbor operation.

The inundation of coastal territories and islands can be caused by tsunami originated from earthquakes or volcano eruptions in ocean. The Pacific coast of Russia, where main economy and population of Russian Far east is concentrated, is highly vulnerable to extremely destructive effect of tsunami waves.

The adaptation of water management to climate change includes implementation of water-management, bank-protection and improving preventive technical-engineering activities. To avoid emergency and extreme events, administrative measures should be adopted based on adaptive capacities of water management systems and hydraulic engineering facilities.

The adaptation measures to insufficient water resources include development and use of water saving and accumulation technologies on the basis of annual sink distribution, technical and engineering measures on raising the efficiency of water use. These include introduction of water recycling, low water-consuming processes, snow retention, water saving agricultural and forest reclamation measures, building water reservoirs in lowlands.

For extra humid regions, a range of engineering measures are recommended to adjust and reallocate river sink together with development of open and closed drainage channels, water receivers and building of water-detention dams and other facilities.

The system of adaptive measures is developed with consideration of relationships between water management and other branches of economy, needs for water supply of population and environmental protection requirements.

VI.4 Regions of permafrost

Permafrost currently covers 67% of the territory of Russia. The cryolite zone is rather sensitive to climate change. The global warming intensifies degradation of permafrost.

The estimated increase of annual mean air temperature in the last 25–30 years in northern areas of Russia is of 1.0–1.2 °C. However, in some regions (Yeniseysk, Lensk, Touroukhansk, Tchul'man, Yakoutsk), an increase by 1.4–2.3 °C was identified. The highest air temperature increase by 0.9 °C for summer was observed in the north of Western Siberia, and by 3.6 °C for winter – in Yakutia.

From 1960 to 1995 on the territory of cryolite zone of Russia, significant variations in the mean annual air temperature trend were observed: from 0.01 °C up to 0.09 °C/yr. The highest positive regional trend of the mean annual temperature was identified for the north of Western Siberia and Yakutia (Table VI.2). The regional estimates demonstrate that in the north of Russia, the increase of air temperature during long cold period was much higher, than for short warm one. The average ratio between cold and warm seasonal air temperature trends for entire northern territory of the country is 1.4.

Table VI.2
The parameters of mean annual regional trends of air temperature rise in the north of Russia for 1960–1995

Region	Air temperature trend, °C/yr
North of the European part of the country	0.03
North of Western Siberia	0.06
Yakutia	0.06
North–Eastern part of the country	0.02

Due to an increased depth of seasonal thawing in the southern regions of the cryolite zone, melting of top of permafrost strata may be identified. The thawing of frozen rocks from bottom with a rate up to 4 cm/yr is also observed all over Western Siberia, except for the far northern regions.

Based on anticipated increase of ground air temperatures in the XXI century, thermal monitoring of cryolite zone, and geo cryolite modeling, projections for ground temperature rise at 10-meter-depth together with the moves of cryolite borders and changes in seasonal thawing depth were elaborated. The projected increase in temperature of top soil layer in different natural zones on the territory of the cryolite region of Russia is shown in Table VI.3.

In the next 20–25 years in Western Siberia, the shift of southern border to north of solid cryolite and insular permafrost would constitute 30–80 km and 200–450 km respectively. By 2050, border of solid cryolite zone may be displaced to north by 150–200 km or more. By that time and in later years, development of hyperthermal frozen ground would be observed even in the Arctic region.

The bedrock temperature variations would entail the change in their solidity, carrying capacity and compressibility, as well as result in deformation of melting deposits, formation of thermokarst, thermal erosion and in other cryogenic processes.

Table VI.3
Projected rise of temperature of top soil layer over the cryolite zone of Russia in the XXI century, °C

Region	2020			2050		
	Tundra	Forest-tundra	Taiga	Tundra	Forrest-tundra	Taiga
North of the European part of the country	0.8	–	–	1.6	–	–
Western Siberia	1.1	1.0	0.9	2.4	2.6	2.4
Yakutia	1.4	1.0	0.8	2.8	2.6	2.5
North–Eastern part of the country	–	0.6	0.5	–	1.5	1.5

The degradation of cryolite would lead to negative consequences for such branches of economy as ground construction (communal, industrial, linear, hydraulic engineering), gas industry, mining industry and underground excavations. But on the other hand, it would facilitate expansion of agriculture to the North.

Global warming entails irreversible natural processes that may cause serious negative consequences for settlements and other managed territories.

A system of adaptation measures to prevent and limit negative consequences of particular types of technogenic impacts on sustainable social and economic development of entire region of permafrost is being developed and gradually introduced.

Long-term projections of geocryolite conditions in relation to anticipated air temperature rise should be taken into consideration in calculations of strength and deformations of basements within construction and reconstruction activities in the cryolite zone. Introduction of global warming considerations in construction projections would lead to an increase of depth of piles for basement location in accordance with standard I (preservation of frozen bedrocks) and the depth of pre-building ground thawing in accordance with standard II (allowance for bedrock thawing). The choice of building approaches should also be made taking into account long-term projections of ground temperature regime.

Adaptation measures for present construction include:

- Geological and engineering monitoring of thermal properties of ground of basements and sites of construction and
- Protection of basements of buildings by the use of additional options for temperature lowering.

VI.5 Impact on human health

A crucial problem is health care of population of northern regions that comprise 68% of the territory of Russia. 12.2 million of people live in extreme climatic conditions, and children constitute a third of them.

A set of cosmic, heliophysics, climatic and anthropogenic factors affect morbidity of the population.

Increased amounts of anthropogenic greenhouse gases in the atmosphere contribute to destruction of stratospheric ozone layer and to an increase in penetrating ultraviolet radiation (290–320 nm) that reaches the Earth surface. Satellite monitoring detected ozone hole above considerable part of the territory of Siberia. Within it, the ozone concentration decreased by 15–30%, but in some periods the decrease was by 40–45%.

A retrospective study of consequences of ultraviolet effect on human health is required. According to the data of the Ministry of Public Health of the Russian Federation, depletion of the ozone layer by 1% may cause an increase of morbidity from melanoma, none-melanoma cancer and cataract by 2%, 3% and 0.6–0.8% respectively.

Extreme climate of northern areas imposes higher demands on organism and becomes a limiting factor for human adaptation. Due to specific weather and climatic features, the respiratory diseases, neuropathy, sensory and blood circulation diseases dominate in the structure of population morbidity. The occurrence of cardio-vascular and respiratory diseases among northern inhabitants is 1.2 times higher than among those from the central regions of the country. A considerable mental and functional tension and misbalance of cardiac rhythm vegetative regulation have been identified among underground mine workers, who constitute a considerable part of the northern inhabitants.

The reproductive capacity of women living in the north is estimated as being unfavorable. Being twice higher than that for the country as a whole, the level of maternal mortality is considered to be critical, and high distribution of gynecological and extragenital pathologies has been identified. The unbalanced structure of food and deficiency of basic nutrition substances results in the loss of body weight and reduced productivity.

Health care of young people is especially complicated. Due to a limited adaptive capacity and lower plasticity of the functional system, infantile organism is extremely vulnerable in the north. The risk of haematogenic organ pathology, and blood and urine-genital diseases has reached its maximum among the infantile and teenager population.

The uncertainty of possible climate change assessments and restriction of predicted parameters by air temperature and amount of precipitation only justify the need for specific integrated research over northern areas of the country.

To implement this research the following national projects are recommended:

- Establishment of an interagency prognostic center for evaluation of sanitary–epidemiological health status of the population in the northern areas; and
- Organization of a federal database of retrospective statistical data on the health of population and environmental factors affecting it.

VII RESEARCH

VII.1 The basic programs

*VII.1.1 "**The Technology of Forecasting and Assessment of Changes in Climate, Ecosystems, and Resource Due to Anthropogenic Effect, and their Consequences**" Target Program*

The program is aimed at development of technologies maintaining climatic research, including:

- Prediction of anthropogenic climate change on the basis of modeling and observed data;
- Detection of climate change and estimation of climate variability of anthropogenic and natural origin;
- Assessment of impacts of large-scale environment and climate change on ecosystems and socio-economic structures;
- Estimation of critical (permissible for terrestrial ecosystems) anthropogenic interference with the climate system.

*VII.1.2 The "**Prevention of Dangerous Changes of Climate and Their Adverse Effects**" Federal Target Program*

The Program is aimed at creation of both, information systems about occurring and future climate changes, their consequences, and the anthropogenic climate change and enforcing human-induced factors that affect it; and also on development of a set of preventive measures for adaptation of economy of the Russian Federation to climate change and preventing dangerous climate changes and their negative consequences for the period to 2020.

*VII.1.3 The "**World ocean**" Federal Target Program*

"Study and Research of the Antarctic Region" Subprogram is directed at studies of formation of current climate and forthcoming climate change taking into account numerous factors and interferences in Antarctic "atmosphere-ice-ocean-continent" system and their effect on global climatic processes.

"Research on the Nature of World Ocean" Subprogram, project "The Diagnosis and Prediction of the World Ocean Climate for Maintenance of Economical Activity, National Defense Capability and Sustainable Development".

*VII.1.4 The"**Researche and Development on the Priority Directions of Progressing in Science and Civil Engineering**" Federal Target Scientific-Technical Program. The Priority Direction: "Ecology and Rational Nature Management"*

"Global Changes of the Environment and Climate" Subprogram, project "Monitoring and Simulation of Climate Changes: Impact Assessment for Russia" includes monitoring of climate change as such, and besides, monitoring critical effects on climate system, their sources (greenhouse gases etc.) and consequences, and also formulation of overall concept of dangerous anthropogenic influence on climatic system.

"Integrated Researches of Oceans, Seas and Arctic and Antarctic Regions" Subprogram, project "Monitoring of Ocean-Atmosphere Interaction for Forecasting Climate Changes and Maintenance of Marine Activity"

VII.1.5 ***"Natural Processes in Outer Shells of the Earth in Conditions of Increasing Anthropogenic Influence and Scientific Basics of Ecologically Non-Dangerous Rational Natural Management"*** *the Program for Basic Research of Russian Academy of Sciences*

The Program is supervised by the Department on oceanology, atmospheric physics and geography of the Russian Academy of Sciences.

VII.1.6 The ***Federal Space Program of Russia****, the Subprogram "****Remote Sensing of the Earth****"*

The Subprogram is aimed at development of meteorological space devices providing observations from space for real-time processing of global data on physical state of the atmosphere, land and oceans, as well as forecasting meteorological processes and climate change.

VII.1.7 The Russian Foundation for Basic Research supported researches on nitrous oxide emission by agricultural lands of Russia (project no. 99-05-64130) and both emission and removal of carbon dioxide in land-use and in forestry (project no. 01-05-64079).

VII.2. Regional climate change on the territory of Russia

The most reliable assessment of climate change can be obtained from the data of instrumental observations on a network of hydrometeorological stations. Datasets of long records at 455 meteorological stations over the former USSR (of which 359 stations are located in the Russian Federation) were used as a basis for climate change estimates presented in this study.

The most pronounced feature of climate records in the XX century was the evident increase in surface air temperature (SAT) from the beginning to the end of the century, almost everywhere and for the globe as a whole. This phenomenon has received a title of "global warming". The global surface temperature (spatially averaged over the Globe) show the increase over the twentieth century about 0.6 °C ± 0.20 °C. However, time series of SAT show that climate changes highly non-homogeneously in time and space. Thus, from 1910 to 1945 and from 1976 to 2000 there were periods of greatest global warming, and between them some cooling even occurred. A spatial pattern of global warming is also highly inhomogeneous – especially, over such large territories as Russia.

Time series of annual mean anomalies of surface temperature and monthly precipitation totals, spatially averaged over the Russian Federation territory are presented in Figure VII.1. The anomalies are calculated as deviations from the averages over the base period 1961-1990 (normal). Trends are shown in each time series for two periods: century as a whole and the last 50 years. The linear trend was estimated by the method of least squares (as a slope of a linear approximation), applied to the period under consideration, and scaled to centenary period, which thus indicates a rate of change of considered variable in dimensional units per 100 years. It should be noted here, that records in datasets used are much less representative up to mid 1940-s and from mid 1990-s.

For Russia as a whole, the warming per century (1901–2000) was about 1 °C. In the last 50 years the rate of warming has increased up to 2.7 °C/100 yrs, and after 1970 the increasing trend was estimated already as about 4 °C/100 yrs. The percentage of total variance of regionally averaged temperature (over the territory of the country), explained by the linear trend, is 33%, 30% and 24% respectively. The maximum of warming in Russia was observed in 1995: about 2 °C deviation from the norm (average over the base period 1961–1990). In 2000, annual temperature anomaly over Russia has averaged 1.1 °C.

Warming is more pronounced in winter and spring, but is almost not observed in autumn. The largest positive trend occurred to the east from Urals, whereas weak cooling was found near the Black Sea and in some western (autumn) and polar regions.

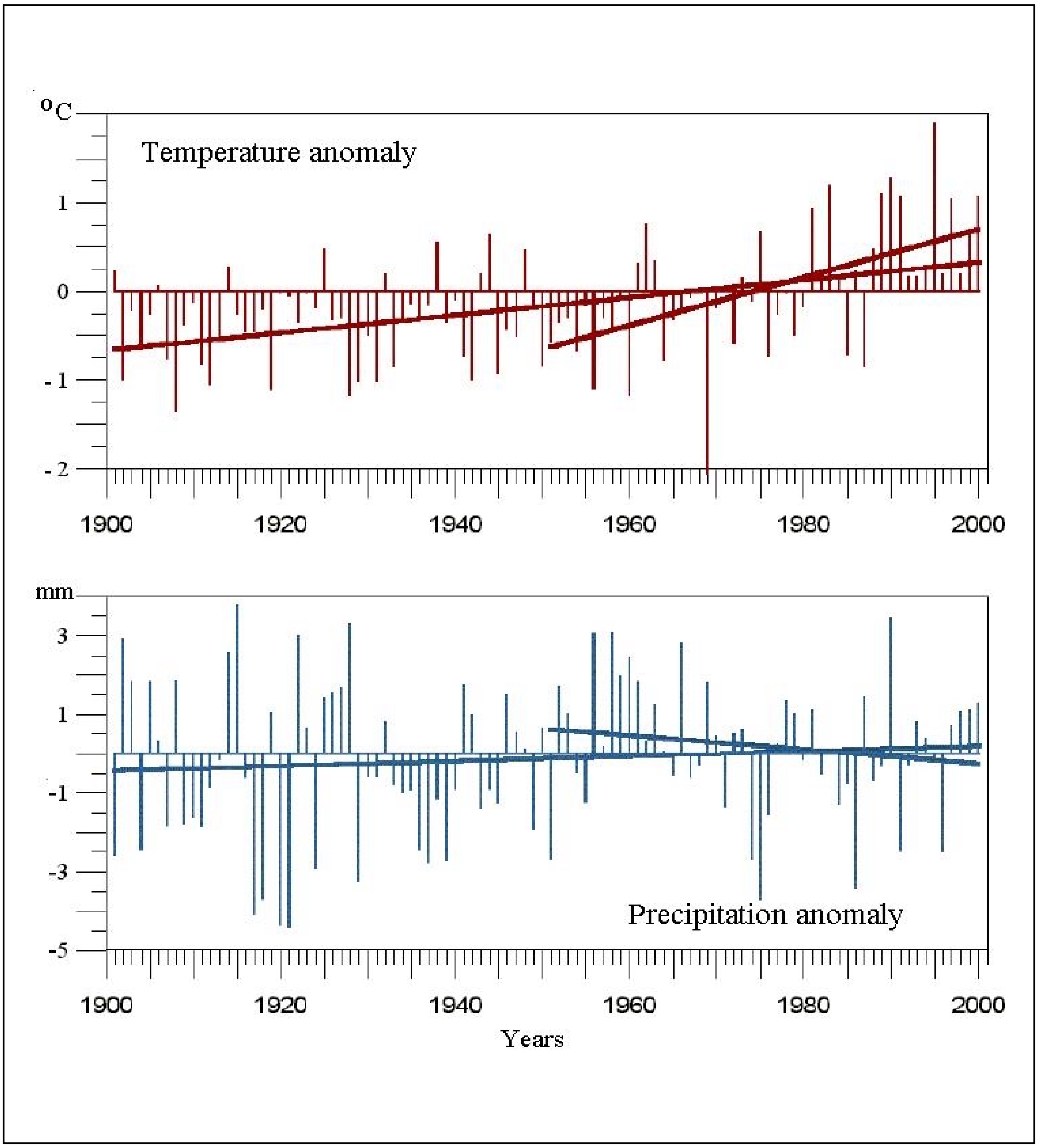

Fig. VII.1 Time series of mean annual anomalies of the surface air temperature (above) and monthly precipitation totals (below) for the territory of Russia as a whole. Base period: 1961-1990. The linear trends are shown for periods: 1901-2000 and 1951-2000. The anomalies are calculated as deviations from 1961-1990 means

The secular time series of mean monthly precipitation totals (averaged over the territory of Russia and within each year) exhibited a weak trend of 0.6 mm/100 yrs, responsible for 0.9% of total variance. In the last 50 years the downward trend in precipitation totals has amounted to -1.8 mm/100 yrs, with the percentage of the total variance 2.5%. Thus, there were some increases during the last 100 years, but certain decreases in the last 50 years occurred in precipitation over the territory of Russia as a whole.

Figures VII.2 and VII.3 provide more complete information on current tendencies of climate change in temperature and precipitation over the territory of the country in the second half of the XX century. Spatial distributions of linear trend coefficients are presented here for the year as a whole and for cold and warm periods of the year. The trends are shown on sites of stations considered. Trends are calculated for the period of 1951–1998 and scaled to the percentage of norms (1961–1990 mean monthly totals) per 100 years.

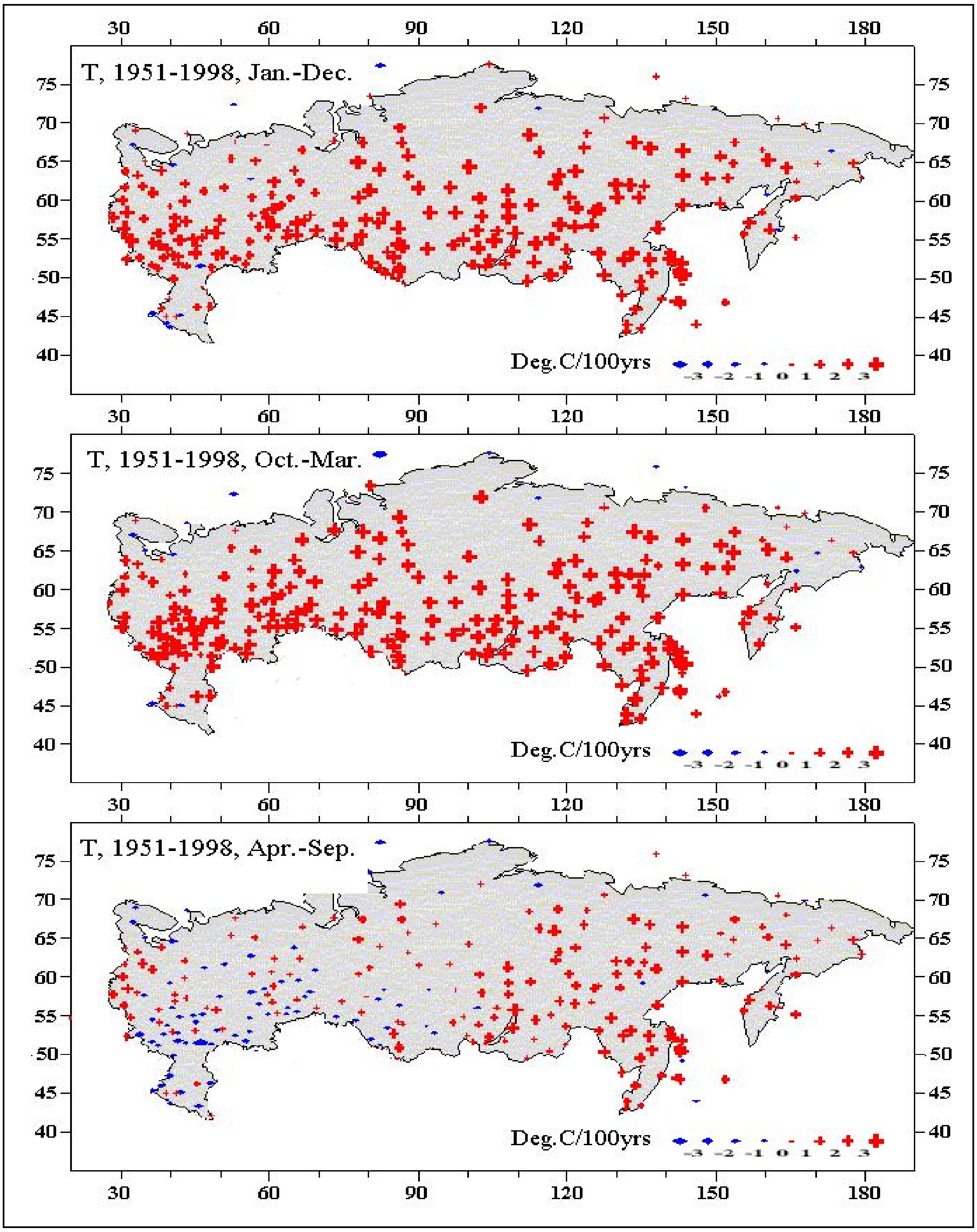

Fig. VII.2 Linear trend coefficients of surface air temperature over the territory of Russia. The trends are estimated for 1951-1998 and scaled to °C/100 yrs. The plus (red) and diamond (cyan) symbols represent warming and cooling respectively. The size of a symbol corresponds to trend intensity (more than 1, 2 and 3 °C/100yrs). The data were previously averaged for the indicated seasons.

As follows from Figure VII.2, global warming occurs in all regions of Russia. However, the areas of descending trend are revealed nearer to the Black Sea and also in isolated parts of the polar region of the country.

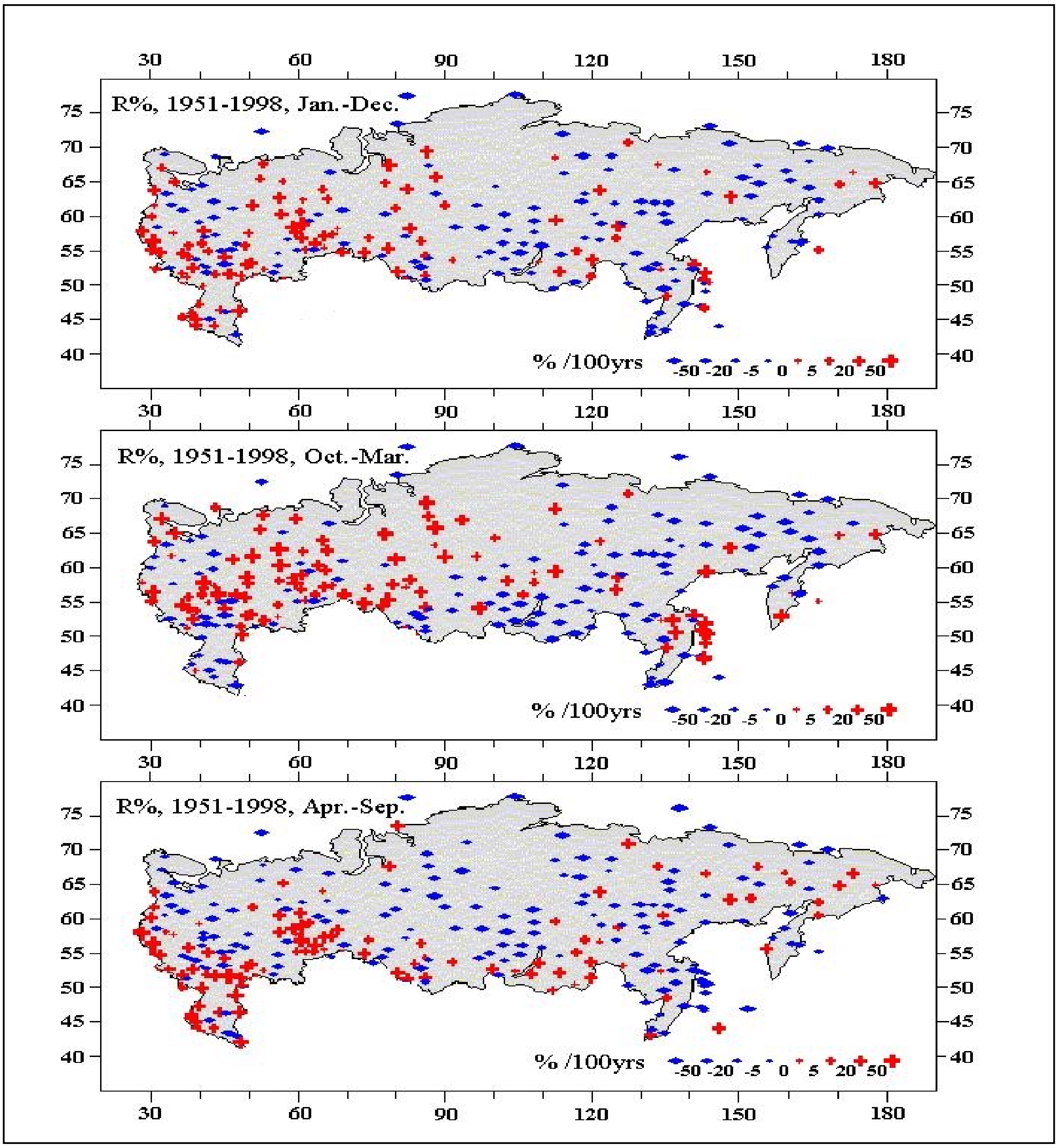

Fig. VII.3 As in Fig. VII.2, except for monthly precipitation totals, averaged for the indicated season and expressed in percents of the 1961-1990 norms. Levels of trend intensity shown are for more than 5, 20 and 50 %.

Warming expressed in terms of annual means is mainly due to substantive increases of temperatures in the colder periods. In warm periods, the increase in temperature trend is typical only for the Eastern Siberia and the north-western regions of Russia (except for the White Sea region). Minor cooling or no clear tendency is observed for the remaining territory.

The spatial pattern of precipitation trends over the territory of the country in the second half of century is not so uniform (Figure VII.3).

The cold period precipitation tends to decrease practically in all eastern regions of the country, except for the coastal areas (Chukotka, south of Kamchatka and coast of Okhotsk Sea, including Sakhalin and lower Amur). The decrease in precipitation occurs also in the northwestern region (Kareliya) and everywhere in the southern European part of the country, starting from the Voronezh region. Thus, a clear tendency of cold period precipitation to increase is observed only in the Western Siberia and adjacent eastern sector of European part of Russia, including a few central regions.

In warmer periods the picture is almost the opposite. The area of positive trends covers Far East (Chukotka), Trans-Baikal region, Southern Urals, and also southwestern part of European Russia (including Volgograd area). On the remaining territory practically everywhere a decreasing precipitation trend is exhibited.

For the year as a whole, the growth of precipitation dominates over Western Siberia and the European part of Russia (except for Kareliya, Altai, southern Urals), while in eastern regions a declining trend is dominating (Cis- and Trans-Baikal regions, Central and Eastern Siberia and Far East), with a few small areas of ascending trend for Sakhalin, Chukotka and upper Amur.

Thus in Russia, the main regional features of climate change for the second half of the XX century are as follows:

- Pronounced areas of cooling (region of the Black Sea and polar areas) at the background of a general global warming;
- Lack of warming in warmer periods over considerable part of the European territory of Russia; and
- Decrease in precipitation over the eastern regions of the country and increase in the west of the European territory and in Western Siberia.

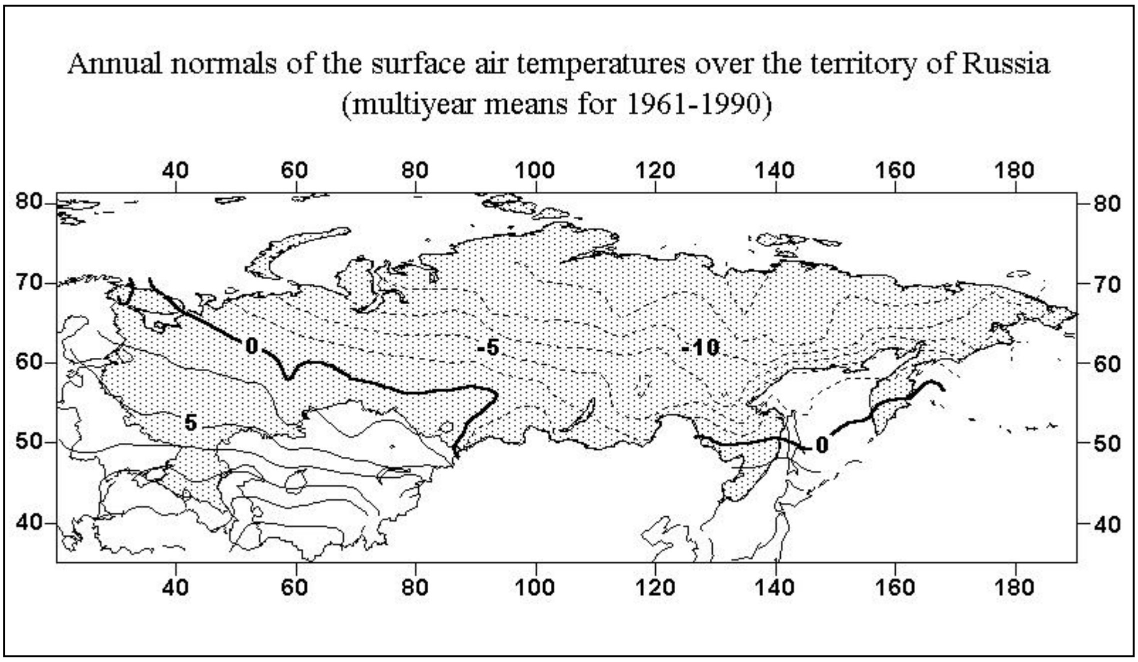

Fig. VII.4 The multiyear mean surface air temperature over the territory of former USSR. The norms are calculated on the basis of monthly mean temperature over 455 stations of the USSR for the base period of 1961-1990

The problems of climate and its change are of special importance for the territory of the Russian Federation, because for most of it mean annual temperature is less then +5°C (Figure VII.4) and thus, requires special costs for energy resources for heating and creating acceptable living conditions. Particularly, in the European part of the country (where the majority of the population lives) to the north from 55 N (more than 50% of the region considered) mean annual temperature is less then +5°C, and for most of the Asian territory it is less then 0°C.

VIII SYSTEMATIC OBSERVATION

VIII.1 Climate

The present section presents brief information on observations over the climate system within the framework of operational programs of the Federal Service of the Russian Federation on Hydrometeorology and Environmental Monitoring (Roshydromet) and other institutions and agencies of the Russian Federation. The detailed description of operational programs and observation systems pursuant to the UNFCCC Guidance (developed by GCOS: Annex 1 to Decision 5/CP.5, FCCC/CP/1999/7) is provided in Annex 2.

VIII.1.1 Meteorological and atmospheric observation

VIII.1.1.1 The existing national plans: availability, time frames for implementation and specific commitments under GCOS requirements

The basic regular climatic observations in the Russian Federation are implemented within the framework of primary activities of Roshydromet which are stipulated in the following Federal Target Programs:

- "Development of a System of Hydrometeorological Maintenance of National Economy of the Russian Federation in 1994–1996 and for the Period to 2000"
- "Prevention of Dangerous Changes of Climate and Their Adverse Effects"
- "World ocean"

The Russian side has undertaken commitments to ensure operation of 129 ground-based hydrometeorological stations for the purposes of GCOS. At present, 119 of these stations are operational, including 102 conforming to the standards of GCOS. For GUAN aerological network, the corresponding numbers are 10, 8, and 6, respectively. The refinement of the structure of reference GCOS and GUAN networks is also envisaged, so that by 2005 the number of operational stations should correspond to the commitments of the Russian Federation.

VIII.1.1.2 The responsibilities of ministries and agencies responsible for implementation of the plans

Roshydromet provides the management of observational network, logistics, financing of activities on its operation, planning and financing of scientific research and experimental design activities for measurement methods, observation methodology, data collection and processing.

VIII.1.1.3 International data exchange; submission of metadata to international data centers; participation in international programs of quality control and archiving

The All-Russian Institute of Hydrometeorological Information–World Data Center participates in the program of international data exchange.

All-Russian Institute of Hydrometeorological Information–World Data Center and Main Geophysical Observatory implement documentation of the history of stations on the territory of the former USSR.

The quality control of climatic data is conducted by All-Russian Institute of Hydrometeorological Information–World Data Center, the Main Geophysical Observatory, and the Institute for Global Climate and Ecology. Data archiving is done within the framework of the Federal Target Program "Prevention of Dangerous Changes of Climate and Their Adverse Effects" with participation of the All-Russian Institute of Hydrometeorological Information–World Data Center, Main Geophysical Observatory and the Institute for Global Climate and Ecology.

VIII.1.1.4 Conformity to GCOS/GOOS/GTOS climatic monitoring principles

Since data requirements for GCOS are higher than those for common climatic stations, the existing Russian GSN network does not completely correspond to the principles of climate monitoring both in terms of the choice and the number of stations regularly transmitting data to the World Data Center, including information on metadata change (i.e. description of observation sites, equipment used, history of stations etc.).

Primarily this relates to transmission of CLIMAT reports, as not all Russian GSN stations transmit them to World Data Centers. Besides, not all the stations are part of the International Data Exchange, i.e. they are not included in the list of stations published in Climatic Monthly, Part I.

VIII.1.2 Oceanographic observations

VIII.1.2.1 The data of oceanographic observation

Sea-surface temperature

Observations of a sea-surface temperature are conducted by a network of coastal and marine island hydrometeorological stations (in Russia, there are 180 observation plots), and under Ship of Opportunity (SOOP) (the number is currently insufficient) and Voluntary Observing Ship (VOS) Programs using uniform techniques (Annex 2).

Sea-level

Sea-level measurements are implemented by a network of coastal and island hydrometeorological stations 4 times per day at 0, 6, 12 and 18 h UTC using sea gauges. The sea-level is recorded continuously at the stations with automatic tide gauges, and hourly sea-level values are calculated on the basis of the records.

Oceanographic observations in the Arctic and Antarctic regions

In the Russian Federation, oceanographic observations in polar regions are conducted by the Arctic and Antarctic Research Institute. Formally, the Institute does not participate in global systems of oceanographic observations in Arctic and Antarctic regions (in the Southern ocean). Nevertheless, the oceanographic observations are carried out and data are provided to the National Oceanographic Data Center of the All-Russian Institute of Hydrometeorological Information–World Data Center. The reference data on sea temperature and salinity are available from National Oceanographic Data Center of the All-Russian Institute of Hydrometeorological Information–World Data Center.

The following programs are being implemented:

- "World ocean" Federal Target Program including Subprograms:
  - **"Creation of a Unified Information System on the State of the World Ocean"** and
  - **"Research on the Nature of World Ocean"**
- **"The Researches and Developments on the Priority Directions of Progressing in Science and Civil Engineering**" Federal Target Scientific-Technical Program including Subprograms:
  - **"Global Changes of the Environment and Climate"** and
  - **"Integrated Researches of Oceans, Seas and Arctic and Antarctic Regions"**

The on-going international programs with participation of the Russian Federation include:

- World-Climate Research Program (WCRP);
- Global Ocean Observation System (GOOS);
- Global Sea Level Observing System (GLOSS)

- The International Program of Research of the Caspian sea; and
- The International Program of Research of the Black Sea.

VIII.1.2.2 The international data exchange; submission of metadata to World Data Centers; participation in international programs of quality control and archiving

The international data exchange, submission of metadata to the World Data Centers; participation in international programs of quality control and archiving in Russia is implemented by ARIHMI-WDC (NODC) with the status of the World Data Center.

VIII.1.2.3 Conformity to GCOS/GOOS/GTOS principles of climatic monitoring

The research on observational techniques is conducted. Ground-based and ship observations are made based on uniform techniques and at fixed times.

VIII.1.3 Terrestrial observations

VIII.1.3.1 Participation in global networks of land observations - glaciers (GSN-G); permafrost (GSN-P); carbon cycle (FLUXNET)

Glaciers

The Institute of Geography of the Russian Academy of Sciences, the Moscow State University, the Tomsk State University, the Institute of Volcanology of the Russian Academy of Sciences, the Northern Caucasus Hydrometeorological Service Administration are involved in the program of World Glacier Monitoring Service.

The Arctic and Antarctic Research Institute conducts research and monitoring of glaciers in the Arctic and Antarctic regions (see also *VIII.1.3.2*).

Permafrost

The monitoring-type research of permafrost are conducted by the institutions of the Russian Academy of Sciences, and research institutes and bodies the Ministry of Natural Resources of the Russian Federation.

VIII.1.3.2 Participation in other land observations

Land-use and general surface monitoring

The observations include a systematic census of agricultural lands, data acquisition on the areas of swamps, peat accumulation rates and methane emission to the atmosphere. These activities are implemented with participation of the institutions of Roshydromet, the Federal Service for Land-Survey of Russia and the Russian Academy of Sciences.

The Institute for Global Climate and Ecology of Roshydromet and the Russian Academy of Sciences and the Institute of Forestry of the Russian Academy of Sciences carry out systematic research on impact of climatic factors on terrestrial ecosystems.

Forestry and distribution of forest-fires

Systematic census and monitoring of forests are conducted over entire territory of the country. They are implemented by the State Forest Service of the Ministry of Natural Resources of the Russian Federation. Data on forest fires are collected by "Avialesookhrana" special enterprise. However, currently they encompass only 2/3 of the territory of forest stock. The satellite data are the only available information on fires over unprotected forests of the north and tundra.

Fluxes of CO_2

The detailed surveys of specific components of the carbon cycle and estimates of carbon reserves in forest ecosystems are conducted by the International Forestry Institute of the Russian Academy of Natural Sciences and by the Center on Problems of Forest Ecology and Productivity of the Russian Academy of Sciences.

The Russian Academy of Agricultural Sciences carries out research under the Federal Target Program *Increase of Soil Fertility in Russia*. The increase of soil fertility results in a subsequent rise of soil carbon reserves and therefore, CO_2 removals from the atmosphere.

Observations on snow and ice cover in the Arctic Region are conducted by the Arctic and Antarctic Research Institute in cooperation with Alfred Wegener Institute for Polar and Marine Research (Germany) on the example of Severnaya Zemlya archipelago and by Institute of Geography of Russian Academy of Sciences on the example of Spitzbergen island.

Monitoring of ice sheet temperature and snow survey at the Vostok Russian Antarctic Station are conducted by the Russian Antarctic Expedition. Temperature measurements in wells drilled at the Vostok Station have been carried out on the non-regular basis since 1957. High-precision thermograms of deep wells (depth of the 5G-1 well is currently 3,623 m) form the basis for reconstruction of temperature variations due to global climate change in the last 500,000 years.

In January 1970, a snow survey ground for observation of the increment rate of the snow-cover thickness was established 1.5 km north from the Vostok Station. In December 1998, a new identical ground was established to the west from the old one. Observations on both grounds are carried out simultaneously. Officially, these observations are not a part of any monitoring program.

VIII.1.3.3 The programs for hydrological systems

The observations on hydrological systems are conducted on a regular basis by Roshydromet and institutions of the Russian Academy of Sciences and the Ministry of Nature Resources.

VIII.1.3.4 Participation in the programs of international data exchange; metadata; quality control and archiving

The Russian Federation participates in international program of glacier monitoring and submits data to bulletins issued by the World Glacier Monitoring Service.

VIII.1.3.5 Conformity to GCOS/GOOS/GTOS principles of climatic monitoring

The majority of land observing systems are of the exploratory nature. It was not planned that these systems should meet the requirements of the GCOS/GOOS/GTOS climate monitoring principles. However, the data obtained can be used in research. Some systems conduct regular observations.

The development of systems for monitoring permafrost and biotic component of the Earth climatic system were envisioned in the frameworks of the Federal Target Program *Prevention of Dangerous Changes of Climate and Their Adverse Effects*. The methodological basis for monitoring has been designed and inventory of data sources was implemented. However, financing the Program after 2001 is not planned currently.

VIII.1.4 The space–based observation programs

Roshydromet operates national remote sensing space systems including meteorological systems, *Okean–01* oceanographic satellites and *Resurs–01* satellites for natural resources analysis. Customer functions for the above systems are assigned with Russian Aerospace Agency (*Rosaviacosmos*) which is in charge of elaboration and development of remote sensing satellites under Federal Space Program of Russia. Alongside with Rosaviacosmos, Roshydromet is appointed customer of the systems developed for acquisition of hydrometeorological information, survey of natural resources of the Earth and environmental monitoring, as well as modernization of Ground Data Receiving and Processing Complex for satellite information.

VIII.1.4.1 A brief description of space series, flights and instruments

The state of space segment

The national meteorological space system is a two-level system consisting of *Meteor* satellites for medium-height near-polar orbits and high-orbital (geostationary) *Elektro* satellites at sub-satellite point 76° 50' E. The *Meteor–2* and *Meteor–3* weather satellites on near-polar orbits have exhausted their resource. In 2002, a new generation of *Meteor* satellites, *Meteor–3M* series, should start operating. Starting from the second in the series, these should approximate NOAA (USA) satellites with respect to information parameters. The first *Elektro* geostationary weather satellite was launched in 1994 to serve the needs of Roshydromet and in accordance with international commitments under the World Meteorological Organization (WMO). It functioned with some irregularities and by now has also exhausted its resource. The launch of the next one has been postponed till 2005. The *Okean–01* satellite was launched in 1995, and currently it has almost stopped functioning. The No. 3 *Resurs–01* satellite (1994) operates with some limitations.

For detailed information on perspective satellites, measuring equipment and launch program see Annex 2.

Ground Data Receiving and Processing Complex

The Ground Data Receiving and Processing Complex of Roshydromet comprises 3 large regional centers in Moscow–Obninsk, Novosibirsk (West Siberian) and Khabarovsk (Far-Eastern) and a network of autonomous data receiving plots. The Moscow Center with branches in Moscow and Obninsk is the most advanced. It performs all major functions such as planning, receiving, processing, archiving and distribution among the users of information from national and some foreign operational satellite systems.

Obninsk Branch can receive dataflows at a rate of 61.44 M bit/s. The ultra high frequency range (466.5 M Hz) data from *Resurs–01* No. 3 and *Okean–01* can be received in Obninsk, Novosibirsk and Khabarovsk. The reception zones of the above centers cover the whole territory of the country.

Moscow Center pre-processes and archives information from meteorological, oceanographic and environmental and resource satellites. Besides, the possibility for data retransmission through *Elektro* satellite (when operational) and transmission via INTERNET and on magnetic, optic and magnetic-optic carriers is foreseen.

VIII.1.4.2 The programs of archiving, quality assurance and quality control

1) The main scale of global observations of cloud cover and atmospheric motions (wind and cloud evolution) are provided by polar-orbital and geostationary weather satellites. Part of the output data (parameters of wind and cloud cover) are transmitted to GTS and fed into numerical prognostic models. Thus, about 4,000 SATOB reports on wind data, cloud cover and sea surface temperature are received through GST by the Hydrometeorological Centre of Russia on standard observation terms.
2) The data on temperature and humidity sounding of the atmosphere are important information produced on the basis of NOAA satellite information and regularly transmitted to GTS. More than 4,000 SATEM reports on atmospheric temperature and humidity are daily transmitted to the Main Radiometeorological Center and to the Hydrometeorological Centre database. Due to a limited accuracy, these data are only partially used in prognostic schemes. Their quality should increase with development of more informative measuring devices such as Infrared Atmospheric Sounding Interferometer and Fourier Infrared Spectrometer. This would enable to supplement data from ground-based aerological network and considerably reduce their volume.

3) The system of data collection and transmission is a rather important element of satellite systems. It allows collecting and transmitting information on observations from platforms and stations that are difficult to access.

The above mentioned data retransmission systems on the basis of geostationary weather satellites form a valuable addition to GTS. These are intended for exchange with meteorological and other information between meteorological centers of different level.

VIII.1.4.3 The main fields of application (atmosphere, ocean and land surface)

Global monitoring of environment and climate change is one of the main orientations for use of information from remote sensing space systems. Both existing and prospective satellite observation systems are the major GCOS components that enable to achieve its basic purposes. On the one hand, satellite information fills the gaps in sparse network of ground-based observations. On the other hand, ground-based *in-situ* data allow for calibrating satellite instruments and receiving valid information matched with ground measurements.

The key data parameters for environmental monitoring and climatic research are:

- Vertical temperature profiles in troposphere and stratosphere;
- Vertical distributions and total content of principal tropospheric and lower stratospheric gases and aerosols;
- Cloudiness;
- Precipitation;
- Wind data based on motion of tracer clouds;
- Components of Earth–atmosphere radiation balance;
- Wind at ocean surface and wind stress;
- Fluxes of charged particles and electromagnetic fields in the near space;
- High accuracy sea surface temperature and chromaticity and surface topography of the ocean;
- Parameters of land surface, including temperature, albedo, vegetation cover and etc.;
- Sea ice, snow and ice cover of land.

The analysis of structure of satellite metering equipment and remote sensing products shows that the information for a range of primary task of global monitoring of environment and climate change is provided by:

1) Existing and scheduled to launch solar-synchronous orbit operational satellites (such as *Meteor–3M*, NOAA, DMSP, EPS/ *Meteor*),
2) Polar-orbital satellites for Earth sensing (*Rosaviacosmos*: *Resurs* and *Okean*; ESA: *ERS* and *Envisat*; NASA: *EOS*; NASDA: *ADEOS*).
3) Operating weather geostationary satellites (*Elektro*, *Meteosat*, *GOES*, *GMS*).

VIII.2 Observation Systems of Atmospheric Components

Regular observations of climate-affecting atmospheric components are conducted in the framework of the main activities of Roshydromet and are developed under *Prevention of Dangerous Changes of Climate and Their Adverse Effects* (1996-2001) and *Development of a System of Hydrometeorological Maintenance of National Economy of the Russian Federation* (1998-2001) Federal Target Programs.

Roshydromet is the leading institution responsible for observations of climate-active atmospheric components. The Russian Academy of Sciences conducts researche on global and regional changes in climate-active atmospheric components as well as migration and transformations of greenhouse gases and aerosols in the atmosphere. Gosstandart implements metrological support of measurements, development of state standards and verification apparatus.

The activities on systematic observation on atmospheric components and research under the framework of Federal Target Programs are financed from the federal budget.

In accordance with Federal Target Program implementation plans, the methodology has been developed and experimental measurements of entire methane concentration in the atmosphere (at 1 station) and its content in the ground air layer (at 1 station) have been carried out since 1996.

The systems of atmospheric components monitoring are a part of the State System for Environmental Condition Observation. Roshydromet and its scientific and research institutions and local bodies perform management, coordination and provision of scientific and methodical support for observations under the System.

The results of measurements of entire ozone concentration in the atmosphere and transboundary air pollutant transport, as well as carbon dioxide observation data are regularly transmitted to international data centers of Global Atmospheric Watch (GAW), Co-operative Program for Monitoring and Evaluation of the Long-Range Transmissions of Air Pollutants in Europe (EMEP), WMO World Ozone and Ultraviolet Data Centre (WOUDC) and World Data Centre on Greenhouse Gases (WDCGG).

VIII.2.1 The system for observation of total ozone content in the atmosphere

Nowadays, the systematic observations of atmospheric ozone are carried out in Russia at 24 ozone stations equipped with M-124 filter ozonmeters, 2 stations equipped with Dobson spectrophotometers (Dolgoprudny and St-Petersburg) and in two observation plots equipped with Brewer spectrophotometers (Obninsk and Yakutsk).

The observation data are transmitted daily to the Central Aerologic Observatory maintaining the *Ozonometry* data bank. The Main Geophysical Observatory monitors the quality of measurement data and develops new ozone observation methods. Information is transmitted daily by e-mail to the WMO World Ozone and Ultraviolet Data Centre (WOUDC) in Toronto (Canada) and to the Daily Ozone Measurement Centre (DOMC) in Thessalonica (Greece). The atmospheric ozone data from Russia are used to compile daily maps of ozone distribution in the atmosphere of Northern Hemisphere that are available on Internet (http://exp-studiestor.ec.gc.ca/cgi-bin/select.Map).

The data on the state of atmospheric ozone field aggregated over 28 monitoring stations located on the territory of the country are published in the *Ozone Data WMO Reviews*.

VIII.2.2 Carbon dioxide observations

Regular measurements of the CO_2 content in the boundary layer of the atmosphere have been made in Russia since 1986 under the framework of the Global Carbon Dioxide Monitoring System of the WMO Global Atmospheric Watch. Until 1994, the measurements were conducted at 3 monitoring stations: Bering Island, Kotelny Island, and Teriberka (Kola Peninsula). Since 1995 and up to now, the measurements are being conducted only at Teriberka station because of reduction in financing of these activities.

The Main Geophysical Observatory implements scientific and methodical leadership of the measurements, monitors quality of data, analyzes the information available and submits it for publication.

The CO_2 data obtained from 1986, have been transmitted to the Carbon Dioxide Data Analysis Centre in Oak Ridge (USA) and the WMO World Data Centre on Greenhouse Gases in Tokyo (Japan).

Recently, the efforts have been undertaken in the framework of *Prevention of Dangerous Changes of Climate and Their Adverse Effects* Federal Target Program to establish carbon dioxide monitoring stations in Western Siberia.

VIII.2.3 The system for transboundary air pollutants monitoring

Monitoring of transboundary transport of air pollutants was established in early 1980s in the framework of the Convention on Long-range Transboundary Air Pollution. The system of monitoring was established over the territory of the former USSR to implement the Co-operative Program for Monitoring and Evaluation of the Long-Range Transmissions of Air Pollutants in Europe (EMEP) designed by the UN Economic Commission for Europe and WMO. In 1990, the system included 11 observation stations. Nowadays in Russia, 4 EMEP stations are operating. Also they are a part of WMO GAW regional station network. In Russia, EMEP/GAW observations are carried-out in accordance with *Development of a System of Hydrometeorological Maintenance of National Economy of the Russian Federation* Federal Target Program.

The observation program at EMEP/GAW stations includes systematic measurements of ozone, sulfur dioxide, nitrogen dioxide and aerosols of sulfate, nitrate and ammonia in boundary air layer, as well as measurements of ion composition in precipitation. After data quality control and processing, the results of measurements are transmitted to the EMEP Coordination Chemical Centre in Norwegian Institute for Air Research (Oslo, Norway).

Institute of Global Climate and Ecology provides scientific and methodological management, analytical treatment and generalization of the information available. The observation results are published in reports of EMEP Co-ordination Centre, Annual Review of Environmental Pollution in the Russian Federation and Review of Background State of the Environment Over the Territory of CIS Countries.

VIII.2.4 The System of Integrated Background Monitoring of Environmental Pollution

The System of Integrated Background Monitoring of Environmental Pollution was established over the territory of the former USSR in late 1970s—early 1980s. It was aimed at obtaining systematic information on the state of environmental pollution, assessment of trends and projecting changes in the content of dominant pollutants and their influence on the environment in regions distant from impacted and urbanized zones.

A network of observation stations in biosphere reserves is the basis for the System. WMO recommendations for regional stations of background atmospheric pollution monitoring (BAPMON/GAW) were taken into consideration, when the locations of stations were chosen.

In 1991, the observation network consisted of 14 stations over the territory of the former USSR. At present, 4 stations are operating in Russia.

The measurements of gas and aerosol atmospheric components (nitrogen dioxide, sulfur dioxide, sulfate aerosols, total aerosol content in the air, heavy metals and polyaromatic hydrocarbons) are an important part of the program for background monitoring. The program of observations also includes measurements of chemical composition of precipitation.

The results of observation over the network of System of Integrated Background Monitoring of Environmental Pollution are transmitted to the Institute of Global Climate and Ecology, which implements scientific, methodical and information monitoring in Russia and CIS countries in the frameworks of Interstate Council on Hydrometeorology of CIS Countries. The measurement data of background atmospheric content of gases and aerosols for 1980–2000 are included in the *Background Monitoring* database that also includes information from EMEP/GAW monitoring for the territory of Russia.

The investigations on integrated background monitoring are also carried out in the framework of co-operation between the CIS countries on the basis of multilateral and bilateral agreements. The cooperating countries exchange results of observations. These are stored in the *Background Monitoring* database and are included in an annual Review of Background State of the Environment Over the Territory of CIS Countries published in the Russian Federation.

For further development of the System over the territory of the country, it is planned to resume observations at stations in Central Siberia and Lake Baikal area that were interrupted in 1998 due to the lack of financing, and to equip stations and laboratories with modern analytical and measurement equipment and data processing, archiving and transmitting devices. It is envisioned to establish a regular data exchange with the World Data Centre on Atmospheric Components and to ensure participation in regular WMO intercalibration tests for atmospheric component measurement tools undertaken in the framework of GAW.

Currently operating in the country observation systems of climate-active atmospheric components are not enough to provide a full scope of information required to solve global and regional climate change problems. Except the network of atmospheric ozone observation, the stations for monitoring of gaseous and aerosol atmospheric components are located only on the European territory of the country.

To improve systematic observation of atmospheric components, activities have been currently undertaken to establish observation stations in the Asian part of the country, modernize analytical base of monitoring systems and provide co-ordination centers with modern means of data processing, storage and transfer.

Taking into account difficult economic situation in Russia nowadays, financial support from the Global Environment Facility and WMO could in many respects assist to increase the efficiency of measures aimed at developing atmospheric observations in the framework of climate change problem.

VIII.3 The Atmospheric and Near Space Observations by Remote Sensing Weather Satellites to Investigate Climate Problems

The weather satellite system is designed to expeditiously receive global data on the physical state of the atmosphere, land, and ocean. These are necessary to forecast weather formation and climate change, control the state of near space, as well as estimation of total content and vertical distribution of ozone, atmospheric concentrations and composition of minor gas constituents and radiation fluxes.

In Russia, the weather satellite system has been in operation since 1967. It consists of 3 *Meteor* satellites with equipment for estimating main hydrometeorological parameters necessary for weather forecasting: state and dynamics of cloudiness, surface and top cloud temperatures, total atmospheric ozone content and ionizing radiation fluxes in near space.

From 1992 to 1997, the measures have been undertaken to maintain weather satellite system in operation and to continue its development. Two medium-height orbit satellites *Meteor–3* No. 25 (1993) and *Meteor–3* No. 7 (1994) and a geostationary *Elektro* satellite (1994) were launched.

Nowadays, national space weather system in operation includes medium-height orbit satellites *Meteor–3* No. 25 at the height of 950 km and inclination of 81.5° and *Meteor–3* No. 7 at the height of 150-1250 km and inclination of 82.6°.

At the end of 2001, it was planned to launch a medium-height orbit *Meteor–3M* satellite No. 1. It will have the following equipment aimed at investigating climate change: *Climat* infrared system for global and local survey; SFM-2 spectrophotometer to estimate vertical distribution of ozone and other minor gas constituents; and 5AOE-3 American device to estimate vertical distribution of minor gas constituents in the atmosphere.

The Federal Space Program of Russia for the period up to 2005 has been elaborated and approved, and a draft Federal Space Program of Russia up to 2010–2015 has been developed. Both programs envision further development of high technology weather satellites. The satellite scientific equipment will be supplemented with high spectrum resolution infrared Fourier spectrometers providing estimations of atmospheric concentrations of greenhouse gases, ozone and various aerosols.

The data from ground-based and satellite measurements are archived in the Central Aerologic Observatory. The Main Geophysical Observatory is responsible for scientific and methodological processing of space data.

IX EDUCATION, TRAINING AND PUBLIC AWARENESS

IX.1 Education and Training

The initial training of future specialists, necessary for successful work in such a multidisciplinary field of knowledge as modern climatology, is carried-out by corresponding departments (of meteorology and climatology, atmospheric physics, oceanology) of Russian higher educational institutions and universities (St-Petersburg Hydrometeorological University; Lomonosov Moscow State University; Moscow Physical and Technical Institute; The Far East University; Kazan, Tomsk, Perm, Omsk, Saratov, Irkutsk universities).

There are three training levels corresponding to the standards of bachelor, specialist and master. About 20 students graduate annually from each department.

Although nominally Russian higher education institutions do not train specialists in the field of climatology (the main specialities are meteorology, hydrology, oceanology, atmospheric physics, digital methods), many students specialize in the field of climate in their third-fifth years, doing practical work in research institutes under Roshydromet and RAS. There they prepare their course and diploma thesis devoted to actual climatic problems under the supervision of actively working researchers-climatologists.

Subsequently, deeper knowledge in the field of climate can be obtained by specialists in the system of postgraduate studies at the university departments and leading scientific and research institutes. As a rule, on graduating from the postgraduate course, a researcher-climatologist stands for a degree of candidate of science (specialities Meteorology, Climatology and Agro-Meteorology and Atmospheric and Hydrosphere Physics).

Practical workers can expand their understanding of the problems of modern climatology at professional courses, annually established by Institute of Skill-Improvement under Roshydromet.

Training of medium-level technical personnel is carried-out by Moscow Hydrometeorological Technical School.

IX.2 Public Awareness

The problem of climate change is widely elucidated by All-Russian specialized newspapers such as Zeleny Mir (Green World), Spaseniye (Salvation), Prirodno-Resursnye Vedomosti (Natural Resources Bulletin), NG-Nauka (NG-Science, supplement to Nezavisimaya Gazeta), as well as practically by all mass editions, national and regional TV and radio channels. Leading scientists and specialists are involved in explaining these problems in mass media. Scientific and popular editions by Roshydromet and other publishing houses provide for deeper understanding of the problems of climate change for interested part of general public – non-specialists. There are scientific and technical magazines for specialists: Meteorology and Hydrology (translated into English and distributed in many countries), Proceedings of the Russian Academy of Sciences, Proceedings of RAS - Geographical Series, Proceedings of RAS - Physics of Atmosphere and Ocean, etc.

Since 1985 a monthly bulletin *Climate Monitoring Data: Northern Hemisphere* is being published in the USSR and later - in the RF. Since 1998 a new bulletin *Climate Change in Russia* is being prepared by the Institute of Global Climate and Ecology under Roshydromet and RAS. It contains information on current anomalies and changes in temperature and precipitation at the background of the global climate change, change of snow cover, indices of climate anomality and extremality and dangerous natural events. It is available on the web site of Information System on Climate Change Affected by

Anthropogenic Factors (ISCCAAF): *www.climate.mecom.ru*. On the web-site there are also data on large observed climatic anomalies, as well as special materials on the state of the climate system, prepared by scientific and research institutions under Roshydromet participating in the establishing and support of ISCCAAF (IGCE, Hydrometeocenter of the RF, RIHMI-WDC, MGO, AARI). These institutes also prepare specialized bulletins (the atmospheric circulation, Arctic climate, etc.) The corresponding materials are arranged on the web site of ISCCAAF and home pages of the institutes.

IX.3 International Cooperation

The Russian Federation actively participates in international cooperation on the problem of the anthropogenic climate change.

The President of the Russian Federation V.V. Putin at the Group of Eight summit in July 2001 proposed to convene in 2003 World Conference on Climate Change with the participation of representatives of governments, business and scientific communities as well as civil society. This proposal was supported by the summit and included in the Communiqué of Heads of States and Governments of The Group of Eight (section Future Goals, the Environment) of July 22, 2001 (Genoa, Italy). The plan of practical activities is being developed on the organization of the Conference, including international aspects and practical issues.

The Russian Federation participates actively in the Conference of the Parties and the Subsidiary bodies of the UNFCCC. The Head of Roshydromet A.I. Bedritsky was twice elected Vice-President of the Conference of the Parties. Many scientists from the Russian Federation contributed significantly to the activities of the IPCC – the Intergovernmental Panel on Climate Change – and its working groups. Academician Yu.A. Izrael is a Vice-Chairman of the IPCC. Russian specialists participate in numerous global programs of the WMO. Mr. S.S. Lappo is a member of the Joint Scientific Committee of the World Meteorological Organization/International Council of Scientific Units (WMO/ICSU) on the WCRP.

Russian scientists and specialists participate in programs and projects of the WCRP, supervised by the World Meteorological Organizations: Global Energy and Water Cycle Experiment (GEWEX), Experiment on Modeling the Global Climatic System, Tropical Ocean-Global Atmosphere programme (TOGA), World Ocean Circulation Experiment (WOCE), Experiment on Climate Variability and its Predictability (CLIVAR), Arctic Climate System Study (ACSYS).

Bilateral scientific and technical co-operation on the climate problems between the Russian Federation and the USA is carried-out within the framework of the Working Group RF-USA on the Climatic Politics. The Working Group defines the concept and working programs of the two countries in the field of scientific researches of the global warming.

Specialists of Roshydromet participate in the activity of the Working Group on Global and Regional Problems of Climate Change and Ozone under Interstate Council on Hydrometeorology of the CIS countries.

Active international cooperation in the field of research, protection and use of forests is carried out to increase their productivity and CO_2 sinks. The State Forest Service under the Ministry of Natural Resources of Russia established groups on the scientific and research cooperation with Sweden, the USA and China. There are long-term relations between forestry bodies of Khabarovsk and Krasnoyarsk Territories and US organizations. Activities on establishing experimental forest-seed plantations are conducted in Karelia, Yaroslavl oblast and in a number of other oblasts. Research work is conducted on Khabarovsk Territory within the framework of Canadian program International Model Forest Network. There is an agreement with the U.S. Forest Service on the monitoring of Asian form of Gypsy moth on the wooded territories adjacent to Primorye ports.

ANNEX 1 SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1997 - 1999)

Data below are presented in the unified format of the United Nations Framework Convention on Climate Change and cover the period of 1997 – 1999.

Data on emissions and removals of greenhouse gases in 1990 – 1994 were included into the Second National Communication of the Russian Federation (1998). Inventory data for 1995 and 1996 submitted by the Russian Federation to the UNFCCC in the period following to the Second National Communication could be found in the official documents of the Convention, e.g. *FCCC/SBI/2000/11*.

Emissions and removals of CO_2, CH_4, N_2O, NO_X, CO, non-methane volatile organic compounds (NMVOCs) and SO_2 are reported in units of mass. According to the UNFCCC Guidelines, emissions of hydrofluorcarbons (HFCs) and perfluorcarbons (PFCs), as well as sulphur hexafluoride (SF_6) are expressed in CO_2 equivalent terms using 1995 IPCC GWP values, based on the effects of greenhouse gases over a 100-year time horizon.

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1997)
(Sheet 1 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC [1]		PFC [1]		SF_6 [1]	
									P	A	P	A	P	A
Total National Emissions and Removals	**1 529 465**	**-131 557**	**14 379**	**141**	**4 143**	**13 490**	**1 000**	**6 312**	**NE**	**9449**	**NE**	**30 487**	**NE**	**16**
1 Energy [2]	**1 495 183**	**NA**	**9 464**	**11**	**NE**	**NE**	**NE**	**NE**						
A Fuel Combustion (Sectoral Approach)	493 318	NA	9	4	2 343	8 790	NE	312						
1 Energy Industries [3]	492 973	NA	9	4	NE	NE	NE	NE						
2 Manufacturing Industries and Construction	NE	NA	NE	NE	NE	NE	NE	NE						
3 Transport	NE	NA	NE	NE	1 656	8 633	NE	289						
4 Other Sectors	NE	NA	NE	NE	NE	NE	NE	NE						
5 Other (Waste Incineration)	345	NA	NE	0	NE	NE	NE	NE						
B Fugitive Emissions from Fuels	15 767	NA	9 349	NE	NE	NE	NE	NE						
1 Solid Fuels	6 600	NA	1 480	NE	NE	NE	NE	NE						
2 Oil and Natural Gas	9 167	NA	7 869	NE	NE	NE	NE	NE						
2 Industrial Processes	**34 282**	**NE**	**20**	**1**	**NE**	**NE**	**NE**	**NE**	**NE**	**9449**	**NE**	**30 487**	**NE**	**16**
A Mineral Products	19 380	NE	NO	NO	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA
B Chemical Industry	10 989	NE	20	1	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA
C Metal Production	3 911	NA	NO	NO	NE	NE	NE	NE	NA	NA	NE	30 487	NA	NA
D Other Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E Production of Halocarbons and Sulphur Hexafluoride	NA	NA	NA	NA	NA	NA	NA	NA	NE	9358	NE	NE	NE	NE
F Consumption of Halocarbons and Sulphur Hexafluoride	NA	NA	NA	NA	NA	NA	NA	NA	NE	91	NE	NE	NE	16
G Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

1) *In CO_2 equivalent*
2) *According to the reference approach (row 1 is not the sum of rows 1A and 1B)*
3) *Thermal power stations and boiler-plants of Unified Energy System*

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1997)
(Sheet 2 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)														
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC [1]		PFC [1]		SF_6 [1]	
									P	A	P	A	P	A
3 Solvent and Other Product Use	**NE**	**NA**	**NE**	**2**	**NE**	**NE**	**NE**	**NE**						
4 Agriculture	**IE [4]**	**IE [4]**	**2 951**	**114**	**NE**	**NE**	**NE**	**NE**						
A Enteric Fermentation	NA	NA	2 606	NA	NA	NA	NA	NA						
B Manure Management	NA	NA	285	NA	NA	NA	NA	NA						
C Rice Cultivation	NA	NA	60	NA	NA	NA	NA	NA						
D Agricultural Soils	IE [4]	IE [4]	NE	114	NA	NA	NA	NA						
E Prescribed Burning of Savannas	NO	NA	NO	NO	NO	NO	NO	NO						
F Field Burning of Agricultural Residues	NE	NA	NE	NE	NE	NE	NE	NE						
G Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE						
5 Land-Use Change & Forestry	**IE**	**-131 557**	**138**	**1**	**34**	**1 209**	**NE**	**NE**						
A Changes in Forest and Other Woody Biomass Stocks	IE	-164 663	NA	NA	NA	NA	NA	NA						
B Forest and Grassland Conversion	31 654	NA	138	1	34	1 209	NE	NE						
C Abandonment of Managed Lands	NE	NE	NA	NA	NA	NA	NA	NA						
D CO_2 Emissions and Removals from Soil	1 452	NE	NA	NA	NA	NA	NA	NA						
E Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE						
6 Waste	**NE**	**NA**	**1 806**	**12**	**NE**	**NE**	**NE**	**NE**						
A Solid Waste Disposal on Land	NE	NA	1 681	NA	NA	NA	NA	NA						
B Wastewater Handling	NE	NA	125	12	NA	NA	NA	NA						
C Waste Incineration	IE [5]	NA	IE [5]	NE	NE	NE	NE	NE						
D Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE						
7 Other (please specify)	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**						

(4) Accounted for in the Sector 5
(5) Included under IA5

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1997)
(Sheet 3 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)														
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC [1]		PFC [1]		SF_6 [1]	
									P	A	P	A	P	A
MEMO ITEMS														
International Bunkers	**8 293**	NA	**1**	**0**	**NE**	**NE**	NE	**NE**						
Aviation	NE	NA	NE	NE	NE	NE	NE	NE						
Marine	8 293	NA	1	0	NE	NE	NE	NE						
CO_2 Emissions from Biomass	**19 274**													

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1998)
(Sheet 1 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)														
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC (1)		PFC (1)		SF_6 (1)	
									P	A	P	A	P	A
Total National Emissions and Removals	**1 504 600**	**-2 927**	**14 722**	**114**	**4 168**	**13 777**	**900**	**6 007**	**NE**	**9458**	**NE**	**31 411**	**NE**	**16**
1 Energy (2)	**1 469 736**	**NA**	**9 352**	**10**	**NE**	**NE**	**NE**	**NE**						
A Fuel Combustion (Sectoral Approach)	490 203	NA	8	4	2 368	9 177	NE	307						
1 Energy Industries (3)	489 858	NA	8	4	NE	NE	NE	NE						
2 Manufacturing Industries and Construction	NE	NA	NE	NE	NE	NE	NE	NE						
3 Transport	NE	NA	NE	NE	2 368	9 177	NE	307						
4 Other Sectors	NE	NA	NE	NE	NE	NE	NE	NE						
5 Other (Waste Incineration)	345	NA	NE	0	NE	NE	NE	NE						
B Fugitive Emissions from Fuels	17 993	NA	9 245	NE	NE	NE	NE	NE						
1 Solid Fuels	6 223	NA	1 320	NE	NE	NE	NE	NE						
2 Oil and Natural Gas	11 770	NA	7 925	NE	NE	NE	NE	NE						
2 Industrial Processes	**34 864**	**NE**	**19**	**1**	**NE**	**NE**	**NE**	**NE**	NE	**9458**	**NE**	**31 411**	NE	**16**
A Mineral Products	18 984	NE	NO	NO	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA
B Chemical Industry	12 064	NE	19	1	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA
C Metal Production	3 816	NA	NE	NE	NE	NE	NE	NE	NA	NA	NE	31 411	NA	NA
D Other Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E Production of Halocarbons and Sulphur Hexafluoride	NA	NA	NA	NA	NA	NA	NA	NA	NE	9360	NE	NE	NE	NE
F Consumption of Halocarbons and Sulphur Hexafluoride	NA	NA	NA	NA	NA	NA	NA	NA	NE	98	NE	NE	NE	16
G Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

1) *In CO_2 equivalent*
2) *According to the reference approach (row 1 is not the sum of rows 1A and 1B)*
3) *Thermal power stations and boiler-plants of Unified Energy System*

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1998)
(Sheet 2 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)														
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC [1]		PFC [1]		SF_6 [1]	
									P	A	P	A	P	A
3 Solvent and Other Product Use	**NE**	**NA**	**NE**	**2**	**NE**	**NE**	**NE**	**NE**						
4 Agriculture	**IE [4]**	**IE [4]**	**2 650**	**84**	**NE**	**NE**	**NE**	**NE**						
A Enteric Fermentation	NA	NA	2 334	NA	NA	NA	NA	NA						
B Manure Management	NA	NA	258	NA	NA	NA	NA	NA						
C Rice Cultivation	NA	NA	58	NA	NA	NA	NA	NA						
D Agricultural Soils	IE [4]	IE [4]	NE	83	NA	NA	NA	NA						
E Prescribed Burning of Savannas	NO	NA	NO	NO	NO	NO	NO	NO						
F Field Burning of Agricultural Residues	NE	NA	NE	NE	NE	NE	NE	NE						
G Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE						
5 Land-Use Change & Forestry	**IE**	**- 2 927**	**900**	**6**	**224**	**7 878**	**NE**	**NE**						
A Changes in Forest and Other Woody Biomass Stocks	IE	-210 268	NA	NA	NA	NA	NA	NA						
B Forest and Grassland Conversion	206 329	NA	900	6	224	7 878	NE	NE						
C Abandonment of Managed Lands	NE	NE	NA	NA	NA	NA	NA	NA						
D CO_2 Emissions and Removals from Soil	1 012	NE	NA	NA	NA	NA	NA	NA						
E Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE						
6 Waste	**NE**	**NA**	**1 801**	**11**	**NE**	**NE**	**NE**	**NE**						
A Solid Waste Disposal on Land	NE	NA	1 676	NA	NA	NA	NA	NA						
B Wastewater Handling	NE	NA	125	11	NA	NA	NA	NA						
C Waste Incineration	IE [5]	NA	IE [5]	NE	NE	NE	NE	NE						
D Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE						
7 Other (please specify)	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**						

4) Accounted for in the Sector 5

5) Included under IA5

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1998)
(Sheet 3 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)														
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC [1]		PFC [1]		SF_6 [1]	
									P	A	P	A	P	A
MEMO ITEMS														
International Bunkers	**8 293**	**NA**	**1**	**0**	**NE**	**NE**	**NE**	**NE**						
Aviation	NE	NA	NE	NE	NE	NE	NE	NE						
Marine	8 293	NA	1	0	NE	NE	NE	NE						
CO_2 Emissions from Biomass	**16 704**													

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1999)

(Sheet 1 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)														
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC [1]		PFC [1]		SF_6 [1]	
									P	A	P	A	P	A
Total National Emissions and Removals	**1 508 921**	**-211 742**	**13 846**	**113**	**3 707**	**13 938**	**830**	**5 793**	**NE**	**9466**	**NE**	**32 982**	**NE**	**16**
1 Energy [2]	**1 470 383**	**NA**	**9 463**	**10**	**1 987**	**9 238**	**NE**	**283**						
A Fuel Combustion (Sectoral Approach)	475 125	NA	8	4	1 987	9 238	NE	283						
1 Energy Industries [3]	474 780	NA	8	4	NE	NE	NE	NE						
2 Manufacturing Industries and Construction	NE	NA	NE	NE	NE	NE	NE	NE						
3 Transport	NE	NA	NE	NE	1 987	9 238	NE	283						
4 Other Sectors	NE	NA	NE	NE	NE	NE	NE	NE						
5 Other (Waste Incineration)	345	NA	NE	0	NE	NE	NE	NE						
B Fugitive Emissions from Fuels	18 005	NA	9 357	NE	NE	NE	NE	NE						
1 Solid Fuels	5 867	NA	1 430	NE	NE	NE	NE	NE						
2 Oil and Natural Gas	12 138	NA	7 927	NE	NE	NE	NE	NE						
2 Industrial Processes	**38 538**	**NE**	**23**	**1**	**NE**	**NE**	**NE**	**NE**	**NE**	**9466**	**NE**	**32 982**	**NE**	**16**
A Mineral Products	20 069	NE	NE	NE	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA
B Chemical Industry	14 086	NE	23	1	NE	NE	NE	NE	NA	NA	NA	NA	NA	NA
C Metal Production	4 383	NA	NE	NE	NE	NE	NE	NE	NA	NA	NE	32 982	NA	NA
D Other Production	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
E Production of Halocarbons and Sulphur Hexafluoride	NA	NA	NA	NA	NA	NA	NA	NA	NE	9360	NE	NE	NE	NE
F Consumption of Halocarbons and Sulphur Hexafluoride	NA	NA	NA	NA	NA	NA	NA	NA	NE	106	NE	NE	NE	16
G Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

1) *In CO_2 equivalent*
2) *According to the reference approach (row 1 is not the sum of rows 1A and 1B)*
3) *Thermal power stations and boiler-plants of Unified Energy System*

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1999)
(Sheet 2 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)														
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC [1]		PFC [1]		SF_6 [1]	
									P	A	P	A	P	A
3 Solvent and Other Product Use	**NE**	**NA**	**NE**	**2**	**NE**	**NE**	**NE**	**NE**						
4 Agriculture	**IE [4]**	**IE [4]**	**2 421**	**88**	**NE**	**NE**	**NE**	**NE**						
A Enteric Fermentation	NA	NA	2 108	NA	NA	NA	NA	NA						
B Manure Management	NA	NA	244	NA	NA	NA	NA	NA						
C Rice Cultivation	NA	NA	69	NA	NA	NA	NA	NA						
D Agricultural Soils	IE [4]	IE [4]	NE	88	NA	NA	NA	NA						
E Prescribed Burning of Savannas	NO	NA	NO	NO	NO	NO	NO	NO						
F Field Burning of Agricultural Residues	NE	NA	NE	NE	NE	NE	NE	NE						
G Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE						
5 Land-Use Change & Forestry	**IE**	**-211 742**	**139**	**1**	**34**	**1 214**	**NE**	**NE**						
A Changes in Forest and Other Woody Biomass Stocks	IE	-244 641	NA	NA	NA	NA	NA	NA						
B Forest and Grassland Conversion	31 799	NA	139	1	34	1 214	NE	NE						
C Abandonment of Managed Lands	NE	NE	NA	NA	NA	NA	NA	NA						
D CO_2 Emissions and Removals from Soil	1 100	NE	NA	NA	NA	NA	NA	NA						
E Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE						
6 Waste	**NE**	**NA**	**1 800**	**11**	**NE**	**NE**	**NE**	**NE**						
A Solid Waste Disposal on Land	NE	NA	1 673	NA	NA	NA	NA	NA						
B Wastewater Handling	NE	NA	127	11	NA	NA	NA	NA						
C Waste Incineration	IE [5]	NA	IE [5]	NE	NE	NE	NE	NE						
D Other (please specify)	NE	NE	NE	NE	NE	NE	NE	NE						
7 Other (please specify)	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**						

(4) Accounted for in the Sector 5
(5) Included under IA5

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1999)
(Sheet 3 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)														
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC [1]		PFC [1]		SF_6 [1]	
									P	A	P	A	P	A
MEMO ITEMS														
International Bunkers	**8 300**	**NA**	**1**	**0**	**NE**	**NE**	**NE**	**NE**						
Aviation	NE	NO	NE	NE	NE	NE	NE	NE						
Marine	8 300	NO	1	0	NE	NE	NE	NE						
CO_2 Emissions from Biomass	**16 383**													

TABLE 7B SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1997)
(Sheet 1 of 1)

SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC (1)		PFC (1)		SF_6 (1)	
										P	A	P	A	P	A
Total National Emissions and Removals		**1 529 465**	**-131 557**	**14 379**	**141**	**4 143**	**13 490**	**1 000**	**6 312**	**NE**	**9449**	**NE**	**30 487**	**NE**	**16**
1 Energy	Reference Approach	**1 495 183**													
	Sectoral Approach (2)	**509 085**	**NA**	**9 358**	**4**	**2 343**	**8 790**	**NE**	**312**						
A Fuel Combustion		493 318	NA	9	4	2 343	8 790	NE	312						
B Fugitive Emissions from Fuels		15 767	NA	9 349	NE	NE	NE	NE	NE						
2 Industrial Processes		**34 282**	**NE**	**20**	**1**	**NE**	**NE**	**NE**	**NE**	**NE**	**9449**	**NE**	**30 487**	**NE**	**16**
3 Solvent and Other Product Use		**NE**	**NA**	**NE**	**2**	**NE**	**NE**	**NE**	**NE**						
4 Agriculture		**IE (3)**	**IE (3)**	**2 951**	**114**	**NE**	**NE**	**NE**	**NE**						
5 Land-Use Change & Forestry		**IE**	**-131 557**	**138**	**1**	**34**	**1 209**	**NE**	**NE**						
6 Waste		**NE**	**NA**	**1 806**	**12**	**NE**	**NE**	**NE**	**NE**						
7 Other (please specify)		**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**						
Memo Items:															
International Bunkers		**8 293**	**NA**	**1**	**0**	**NE**	**NE**	**NE**	**NE**						
Aviation		NE	NA	NE	NE	NE	NE	NE	NE						
Marine		8 293	NA	1	0	NE	NE	NE	NE						
CO_2 Emissions from Biomass		**19 274**													

(1) In CO_2 equivalent;
(2) Sectoral estimates are partial
(3) Accounted for in the Sector 5

TABLE 7B SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1998)
(Sheet 1 of 1)

SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC (1)		PFC (1)		SF_6 (1)	
										P	A	P	A	P	A
Total National Emissions and Removals		**1 504 600**	**- 2 927**	**14 722**	**114**	**4 168**	**13 777**	**900**	**6 007**	**NE**	**9458**	**NE**	**31 411**	**NE**	**16**
1 Energy	Reference Approach	**1 469 736**													
	Sectoral Approach (2)	**508 196**	**NA**	**9 253**	**4**	**2 368**	**9 177**	**NE**	**307**						
A Fuel Combustion		490 203	NA	8	4	2 368	9 177	NE	307						
B Fugitive Emissions from Fuels		17 993	NA	9 245	NE	NE	NE	NE	NE						
2 Industrial Processes		**34 864**	**NE**	**19**	**1**	**NE**	**NE**	**NE**	**NE**	**NE**	**9458**	**NE**	**31 411**	**NE**	**16**
3 Solvent and Other Product Use		**NE**	**NA**	**NE**	**2**	**NE**	**NE**	**NE**	**NE**						
4 Agriculture		**IE (3)**	**IE (3)**	**2 650**	**84**	**NE**	**NE**	**NE**	**NE**						
5 Land-Use Change & Forestry		**IE**	**- 2 927**	**900**	**6**	**224**	**7 878**	**NE**	**NE**						
6 Waste		**NE**	**NA**	**1 801**	**11**	**NE**	**NE**	**NE**	**NE**						
7 Other (please specify)		**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**						
Memo Items:															
International Bunkers		**8 293**	**NA**	**1**	**0**	**NE**	**NE**	**NE**	**NE**						
Aviation		NE	NA	NE	NE	NE	NE	NE	NE						
Marine		8 293	NA	1	0	NE	NE	NE	NE						
CO_2 Emissions from Biomass		**16 704**													

(1) In CO_2 equivalent;
(2) Sectoral estimates are partial
(3) Accounted for in the Sector 5

TABLE 7B SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (1999)
(Sheet 1 of 1)

SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	HFC [1]		PFC [1]		SF_6 [1]	
										P	A	P	A	P	A
Total National Emissions and Removals		**1 508 921**	**-211 742**	**13 846**	**113**	**3 707**	**13 938**	**830**	**5 793**	**NE**	**9466**	**NE**	**32 982**	**NE**	**16**
1 Energy	Reference Approach	**1 470 383**													
	Sectoral Approach [2]	**493 130**	**NA**	**9 365**	**4**	**1 987**	**9 238**	**NE**	**283**						
A Fuel Combustion		475 125	NA	8	4	1 987	9 238	NE	283						
B Fugitive Emissions from Fuels		18 005	NA	9 357	NE	NE	NE	NE	NE						
2 Industrial Processes		**38 538**	**NE**	**23**	**1**	**NE**	**NE**	**NE**	**NE**	**NE**	**9466**	**NE**	**32 982**	**NE**	**16**
3 Solvent and Other Product Use		**NE**	**NA**	**NE**	**2**	**NE**	**NE**	**NE**	**NE**						
4 Agriculture		**IE** [3]	**IE** [3]	**2 421**	**88**	**NE**	**NE**	**NE**	**NE**						
5 Land-Use Change & Forestry		**IE**	**-211 742**	**139**	**1**	**34**	**1 214**	**NE**	**NE**						
6 Waste		**NE**	**NA**	**1 800**	**11**	**NE**	**NE**	**NE**	**NE**						
7 Other (please specify)		**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**						
Memo Items:															
International Bunkers		**8 300**	**NA**	**1**	**0**	**NE**	**NE**	**NE**	**NE**						
Aviation		NE	NA	NE	NE	NE	NE	NE	NE						
Marine		8 300	NA	1	0	NE	NE	NE	NE						
CO_2 Emissions from Biomass		**16 383**													

(1) In CO_2 equivalent;
(2) Sectoral estimates are partial
(3) Accounted for in the Sector 5

STANDARD INDICATORS

Data				Type of Emissions Estimates	
Indicator	**Interpretation**	**Indicator**	**Interpretation**	**Indicator**	**Interpretation**
NO	Emission or removal do not occur	IE	Emission or removal has been estimated but included elsewhere in the inventory	P	Potential Emissions
NE	Emission or removal have not been estimated	C	Data are not included to avoid disclosure of confidential information	A	Actual Emissions
NA	Activities that do not result in emissions or removals	0	Emission or removal is estimated to be less than one half of the unit being used to record the inventory table		

ANNEX 2: SYSTEMATIC OBSERVATION OF CLIMATE SYSTEM

A2.1 Climate

A2.1.1 Meteorological and atmospheric observation

Table A2.1.1
Participation in the global atmospheric observing systems

	GSN[1)]	GUAN	GAW[2)]	Other
How many stations are the responsibility of the Party?	129	10	7	
How many of those are operating now?	119	8	5	
How many of those are operating to GCOS standards now?	102	6	5	
How many are expected to be operating in 2005?	129	10	7	
How many are providing data to international data centres now?	85	6	5	

1) see A2.1.1.5
2) see A2.2

A2.1.1.1 Existing national plans and their availability, time frame for their implementation and specific commitments to address GCOS requirements

- Federal target program (FTP) "Development of a system of hydrometeorological maintenance of a national economy of the Russian Federation in 1994 - 1996 and on period till 2000"
  Subprograms:
  1.2. Hydrometeorological Observation System (Target scientific and technology program TSTP- 2)
  1.11.4. Science and Methodology management of network operation
- FTP "Prevention of Dangerous Changes of Climate and Their Adverse Effects" Federal Target Program, (FTPC)
  Subprogram:
  3.1. Creation and Support of Operation of the Information System on Climate Change and Influence of Anthropogenic Factors
- FTP "World ocean"
  Subprogram:
  "Studies and Researches of the Antarctic" (planned till 2012). Studies conducted by the Russian Antarctic Expedition (RAE) of Roshydromet.

A2.1.1.2 The responsibilities of ministries and agencies responsible for implementing the plans

Roshydromet provides management of an observational network, logistics, financing of activities on network operation, planning and financing of research and experimental design works on the measurement methods, observational practice, data collection and processing.

A2.1.1.3 International data exchange; submission of metadata to international data centers; participation in international programs of quality control and archiving

Data

All-Russia Institute of Hydrometeorological Information – World Data Center (ARIHMI-WDC) shares in the program of international data exchange. The program includes support of the archive:

- *meteorological observation data at 223 stations of the former USSR.*

Metadata
ARIHMI-WDC, MGO conduct activities on documenting of the history of stations on the territory of the former USSR.

Programs of quality control and archiving
The activities on quality control of climatic data are conducted in ARIHMI-WDC, MGO, Institute for Global Climate and Ecology (IGCE). The activities on data archiving are conducted within the framework of FTPC with participation of ARIHMI-WDC, MGO, IGCE.

A2.1.1.4 Conformity to GCOS/GOOS/GTOS climatic monitoring principles

Items 1-3: conformance is ensured by the procedures management of the network based on necessary researches and experimental design works.

It is worth noting that insufficient financing resulted in the change of the number of observation terms at some stations. Presently Roshydromet takes steps to update the data on observations at the stations.

Item 4 is under development now. The criteria of hazardous weather events have been approved and experimental monitoring is being implemented.
Item 5 is ensured by FTPC (see A2.1.1.1).
Item 6 is the basic priority for hydrometeorological network of the Russian Federation. It is partially limited by financing. Presently the assessment of monitoring of data acquisition from the network stations is performed.
Item 7: More than 30 stations of Russian GSN network operate in polar regions (including the islands of the Arctic Ocean) and close regions with arduous conditions. In the Antarctic, 4 stations operate. By 2005, one more station is planned to put into operation.
Item 9: is primarily applicable to GAW.
Item 10: is FTPC priority.

Summary. Considering that data requirements for GCOS are higher than those for common climatic stations, the presently existing RF network for GSN does not completely satisfy climate monitoring principles with respect to the choice of stations and to the number of stations regularly transmitting data into the World Data center, including information on change in metadata (such as information on observation site, instrument, history of station etc.).

In the first place this concerns transmission of the CLIMAT reports, as not all GSN stations of the Russian Federation transmit CLIMAT reports in the World Data Centers. Besides, not all GSN stations of the Russian Federation are the stations of International data exchange, i.e. enter in the list of stations published in a Climatic Monthly, part I.

A2.1.1.5 National terrestrial network of meteorological observation (GSN RF) for GCOS

Terrestrial network of meteorological observation of the Russian Federation, the territory of which is greater than 17 million km^2 (17.104) and embraces 11 time zones, presently includes 1618 stations that conduct the range of observations corresponding to climatic stations since 1966 at 8 terms: 00, 03, 06, 09, 12, 15, 18 and 21 hr Coordinated Universal Time (UTC). This provides a possibility to describe the diurnal cycle of principal meteorological elements (air temperature and humidity, characteristics of wind, atmospheric pressure, soil temperature, visibility, cloud amount, type and height of the lower boundary) with required accuracy.

The measurements of precipitation are performed at the closest to 07 and 19 hr of winter zone time terms. Over I and II time zones, additional measurements at 03 and 15 hr UTC are made.

The observations on intensity and development of atmospheric phenomena are carried out continuously.

Since 1966, on the territory of the Russian Federation there are no climatic stations in WMO sense (i.e. those performing observations at 01, 07, 13 and 19 hr of mean solar time).

Initially, 129 of the above stations were included in the Global Surface Network (GSN). Some of them never transmitted CLIMAT reports even on national level. As for May, 1997, only 85 stations of GSN network transmitted CLIMAT reports. Roshydromet notified WMO on that by the letter (Ref. No. 90-74/75 of 05/05/1997).

For a number of reasons in last years 10 stations were closed, and the GSN network of RF has somewhat decreased. Presently it includes only 119 stations, the distribution of which over the territory of RF is presented in Fig.A2.1.

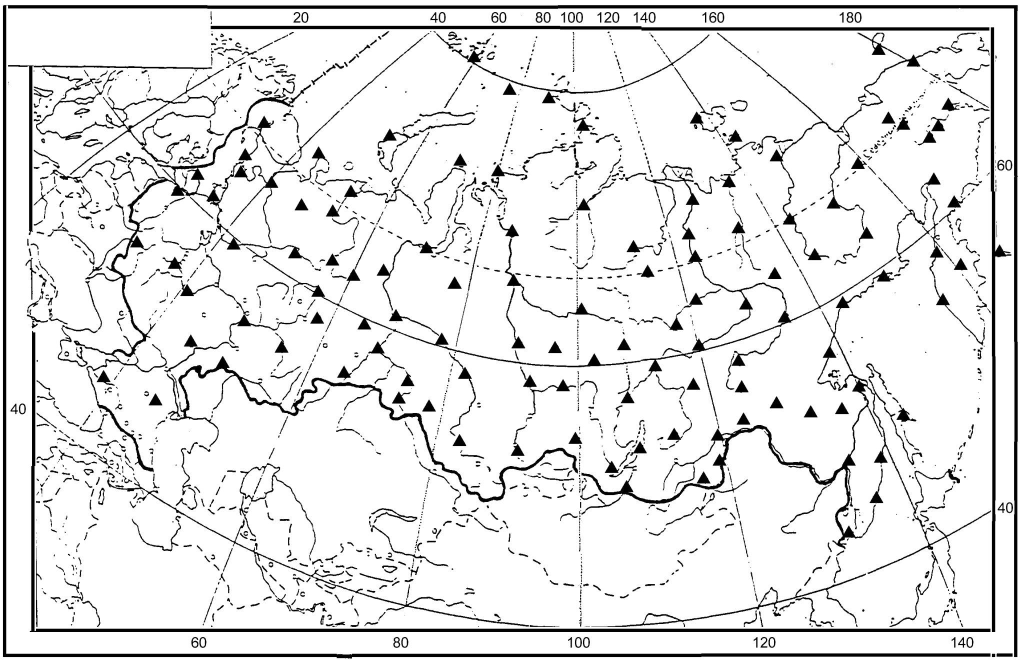

Fig. A2.1 The GSN network of the Russian Federation

GSN network of RF includes 106 reference stations (analogous to those of the Reference Surface Network (RSN)), 18 hard-to-reach stations, i.e., those located in difficult geographic and severe climatic conditions, or on the small island (peninsula), far from large settlements, or with no regular transportation links.

Among the 119 presently operating GSN stations of the Russian Federation:

- The following stations were urbanized:
  KAMENNYJ MYS
  HANTY-MANSIJSK
  ICA
  NIZNEUDINSK

NERCINSKIJ ZAVOD
KYRA
HABAROVSK
VYTEGRA
ALEKSANDROV GAJ

- The following stations lost specific character:
  BUHTA PROVIDENJA
  TARKO - SALE
- The following stations were covered with trees:
  SYKTYVKAR
  ERBOGACEN
  ALTAJSKIY BARNAUL
  IRKUTSK
  BOMNAK
- The following station temporarily do not operate:
  ESSEI.

All Russian GSN stations transmit SYNOP reports.

CLIMAT reports are transmitted in Hydrometeorological Centre of Russia by 111 stations. The following stations included in the GSN of the Russian Federation do not currently transmit CLIMAT reports:

KOJNAS
REBOLY
NJAKSIMVOL'
HANTY-MANSIJSK
KAMENSKOE
USTVAJAMPOLKA
KLJUCI
NIKOL'SKOE

85 stations of Roshydromet, included in GSN of RF transmit CLIMAT reports in World Data Centers. This was reported to WMO by the Roshydromet letter №90-74/75, 05.05.1997.

Presently 4 stations operate in Antarctica. This number is planned to be increased to 5 by 2005.

A2.1.2 Oceanographic observations

Table A2.1.2
Participation in the global oceanographic observing systems

	VOS	SOOP	TIDE GAUGES[1)]	SFC DRIFTERS	SUB-SFC FLOATS	MOORED BUOYS	ASAP
For how many platforms is the Party responsible?	**500**	**10**	**50**	**-**	**-**	**-**	**-**
How many are providing data to international data centres?	**500**	**10**	**7**	**-**	**-**	**-**	**-**
How many are expected to be operating in 2005?	**600**	**50**	**100**	**-**	**-**	**5**	**5**

1) Tide level recorders

A2.1.2.1 Oceanographic observation data

Sea surface temperature (SST)

Observations of a sea-surface temperature are conducted on a network of coastal and marine island hydrometeorological stations (180 points of observation in Russia). At each station SST measurements are performed 4 times daily (observation terms 00, 06, 12, and 18 hr UTC). Mercury thermometers or electronic thermometers are used as a main instrument. The indicating scale provides the measurement accuracy of 0.1^{o}C. Ship SST measurements (VOS, SOOP) are conducted at the same terms and using the same technique.

Sea level

The sea-level measurements are executed on a network of marine coast and insular hydrometeorological stations 4 times per day at 00, 06, 12 and 18 hr. At the stations provided with tide level recorders the sea-level is recorded continuously, and on the basis of this record hourly values of a sea-level are calculated. All heights are determined relative to a unified datum level with elevation number -5.00 m relative to the Baltic reference system. For the Caspian Sea a unified datum level with elevation number -28.00 m relative to the Baltic reference system is used.

Oceanographic observations in the regions of Arctic and Antarctic

In the Russian Federation oceanographic observations in polar areas are conducted by the Arctic and Antarctic Research Institute (AARI). AARI formally does not participate in global systems of oceanographic observations in the Arctic Region and Antarctic Region (the Southern ocean), nevertheless oceanographic observations are executed and data transmitted to ARIHMI-WDC (NODC).

Arctic

In the last decade about 30 oceanographic expeditions with participation of AARI conducted researches of the seas of the Russian and Central Arctic. Most of these were conducted within frameworks of international projects.

Within frameworks of the Subprogram "*Creation of a Unified Information System on the State of the World Ocean*" (FTP "World ocean") AARI compiles and presents at the web-site metadata on different subjects (ice, the ocean, atmosphere). Presently more than 10 metadata sets may be accessed free on the web-site of AARI. In 2001 the Russia-USA project "*Hydrochemical Atlas of the Arctic Ocean*" was completed. Within the framework of this project the international Arctic Ocean database was created, which became available that year to the world community. The database of generalized oceanographic data (temperature, salinity, density, hydrochemical characteristics) for the Arctic basin was created. Each year within the framework of an international project 3 drifting meteorological buoys are built in AARI and located in basins of the Arctic Ocean and Arctic seas.

Antarctic

Work is conducted by the Russian Antarctic Expedition (RAE) within the framework of the research line "*Fundamental research of the Southern Polar Region*" of the subprogram "*Studies and researches of the Antarctic*" (FTP "World Ocean"). Subprogram is planned till 2012. Oceanographic surveys are funded as "other costs" of the RAE budget. Observations are performed using modern instruments in conformity with principles and standards of GCOS. Marine meteorology data (including SST) from the research vessel "Academician Fedorov" (which provides RAE activities in the Southern Ocean) are regularly transmitted as standard reports. Till 2000 research vessel "Academician Fedorov" performed ctandard aerological observations, which are now ceased. Between 1997 and 2001 in the Antarctic seas 141 stations were completed (temperature, salinity, standard hydrochemical characteristics). In 1999 a Russian tide gauge was installed near the observatory "Mirny", and sea-level measurements were resumed. Unfortunately, in September 2000 the tide level recorder failed. However, for the first time for many years a year-long sea-level record was collected at the Russian station. Also in 1999, the coastal oceanographic observations were resumed from the fast ice near "Mirny" and conducted during the Antarctic winter of 1999-2000. These data were obtained independent of any international project and have not been presented anywhere outside AARI.

The reference data on temperature and salinity of the seas are available in ARIHMI-WDC (NODC).

The programs implemented are:

- FTP "World ocean":
  Subprogram "Creation of a Unified Information System on the State of the World Ocean" and *"Research on the Nature of World Ocean"*
- Federal Target Scientific-Technical Program including **"**Researches and Elaborations on Priority Lines of Development in Science and Engineering for Civil Purposes"
  Subprograms:
  - **"***Global Changes of the Environment and Climate***"** and
  - **"***Integrated Researches of Oceans and Seas, Arctic Region and Antarctic Region***"**

Current international programs in which the Russian Federation participates:

- World-Climate Research Program (WCRP);
- Global Ocean Observation System (GOOS);
- Global Sea Level Observing System (GLOSS)
- The International Program of Research of the Caspian sea; and
- The International Program of Research of the Black Sea.

A2.1.2.2 International data exchange; submission of metadata to World Data Centers; participation in international programs of quality control and archiving

The international data exchange, submission of metadata in World Data Centers; participation in international programs of quality control and archiving in Russia is implemented by ARIHMI-WDC (NODC), having the status of the World Data Center.

A2.1.3 Terrestrial observation

A2.1.3.1 Participation in global networks of land observations - glaciers (GSN-G); permafrost (GSN-P); carbon cycle (FLUXNET)

Glaciers

The Institute of Geography of Russian Academy of Sciences, Moscow State University, Tomsk State University, Institute of Volcanology of Russian Academy of Sciences, the Northern Caucasus Hydrometeorological Service Administration are involved in the program of World Glacier Monitoring Service.

Arctic and Antarctic Research Institute implements research and monitoring of glaciers in Arctic and Antarctic regions (see also *VIII.1.3.2*).

Permafrost

By the early 1990s there were about 400 meteorological stations and 25 geocryological stations that operated in the North of Russia. Each station had 8-10 observation sites (including background and technogenic) and profiles, and about 20-30 thermometric boreholes of 10-15 m depth. This provided relatively high level of the permafrost-climate monitoring in the country. In the last 4-6 years the observation network has significantly reduced: in different regions of the cryolithozone about 30% of stations or more were closed. Efforts of individual experts and agencies made it possible to keep only several geocryological stations. It should be noted that most accurate and comprehensive data on the thermal regime of the ground may be obtained at geocryological stations.

The basic parametrs of cryolithozone monitoring include: ground temperature, depth of seasonal melting, and development of cryogenic geological processes.

The following stations of cryolithozone monitoring are currently operating:

1) circumpolar–tundra zonal station, 30 km from Vorkuta with regional observation sites "*Rogovoy*", "*Karataikha*" and others. The station is operated by "*Polyarnouralgeologiya*" Open Joint-Stock Company, Vorkuta.
2) "*Tyurinto*", "*Marre-Sale*", "*Kharasovey*", "*Parisento*" geocryological stations with observation sites "*Sklonovy*", "*Tadibe-Yaha*", and "*Bovanenkovo*". It is envisioned that they would be basis for Yamal-Gydan polygon to be established in the north of Western Siberia. The station and sites are operated by All-Russian Research Institute of Hydrogeology and Engineering Geology (Postal address: 142452, Moscow, *VSEGINGEO*);
3) "*Nadym*" geocryological station, 30 km south from Nadym. The station is located in the northern taiga subzone of Western Siberia. The station is operated by the Institute of the Earth Cryosphere of the Russian Academy of Sciences, Siberian Branch (Postal address: 625000, Tyumen, P.O. Box: 1230);
4) "*Chabyda*" geocryological station in central taiga subzone, 20 km southwest of Yakutsk. The station is operated by Melnikov Institute of Permafrost Studies of the Russian Academy of Sciences, Siberian Branch (Postal address: 677010, Yakutsk, 10).
5) Observation sites near "*Tiksi*" and "*Chersky*", polar region of Yakutiya. The sites are operated by Melnikov Institute of Permafrost Studies of the Russian Academy of Sciences, Siberian Branch (Postal address: 677010, Yakutsk, 10).
6) "Dionisiya" geocryological station in tundra zone, 15 km south of Anadyr. The station is operated by Chukotka Branch of North-East Complex Research Institute, of the Russian Academy of Sciences, Far Eastern Branch (Postal address: 686710, Anadyr).

A2.1.3.2 Participation in other land observations

Monitoring of land-use and of terrestrial surface

Institute of Land Monitoring of the Federal Land Cadastre Service of Russia undertake research and systematic inventory of agricultural lands. Data on the areas of swamps and decennary rates of peat accumulation are available from the State Hydrological Institute of the Roshydromet.

The Institute for Global Climate and Ecology of Roshydromet and the Russian Academy of Sciences conduct systematic studies of climatic factor impacts on terrestrial ecosystems that include processing of data on climate change impacts and development of models and methods of calculation. The Institute of Atmospheric Physics of the Russian Academy of Sciences investigates impacts of warming on tundra and methane emissions in the atmosphere.

In 1996-2000, Russian Academy of Agricultural Sciences in cooperation with the Ministry of Agriculture implemented "*The Emergency Events in Agricultural Sector*" research and experimental program that included the measures to mitigate the risk from abnormal environmental and climatic events.

Forestry; distribution of forest fires

The systematic forest inventory and monitoring are conducted over all territory of the country. These activities are directed by the All-Russian Scientific and Information Center on Forest Resources of the Ministry of Natural resources of the Russian Federation. The regional authorities of the Ministry also play important role in this work. The detailed forest census was performed once in every 5 years (1983, 1988, 1993, and 1998). The next census is planned for 2003. The data on forest fires collected by "*Avialesookhrana*" special enterprise however, now they encompass only 2/3 territories of forest fund. The satellite data is the only accessible information on fires i1n unprotected northern forests and tundra.

The fluxes of CO_2

The International Forestry Institute of the Russian Academy of Natural Sciences and the Center of Forest Ecology and Productivity Problems of the Russian Academy of Sciences implement detailed surveys of specific components of carbon cycle and estimates of carbon reserves in forest ecosystems.

The Russian Academy of Agricultural Sciences carries out surveys under *Increase of Soil Fertility in Russia* Federal Target Program. The increase in soil fertility results in subsequent raise of soil carbon reserves and therefore, CO_2 removals from the atmosphere.

Observations on snow and ice cover in the Arctic Region

Arctic and Antarctic Research Institute in cooperation with Alfred Wegener Institute for Polar and Marine Research (Germany) investigate the current state of glaciers and paloeclimatic changes in the central part of Arctic based on the example of Severnaya Zemlya archipelago. In 2001, the through boring of "*Academiya Nauk*" ice cap on the *Komsomolets* Island was completed. The 724-meter-deep ice core was extracted, and a set of geophysical studies was performed in the well. According to approximate estimates, the age of ice at the basement rock is about 9,500 years, i.e. the paleoclimatic curve embraces almost the whole Holocene. The stratigraphic and geochemical studies of the upper snow layer were performed in the neighborhood of the field camp, and refined mass balance data were obtained. In 2000, similar observations of the snow-cover were performed over *Ushakov* and *Uyedineniya* islands in the Kara Sea.

Ice-sheet temperature monitoring and snow cover observations at the Vostok station, Antarctica

The non-regular measurements of temperature in wells drilled at the Vostok station are carried since 1957. The results of 100-meter-depth measurements made in different years are used for studies of surface temperature trends in Central Antarctica for the last 200 years. High-precision thermograms of deep wells (the deepest 5G-1 well is 3,623 m now) are used for the study of temperature variations due to global climatic changes in the last 500 thousand years. In January of 1970, 1.5 km north of Vostok station the snow survey polygon was established for snow cover increment observations. The polygon includes two orthogonal profiles oriented from north to south and from west to east. Each profile includes 40 landmarks set every 25 m. One landmark is common for both profiles making the total number of them 79. From 1970 to 1995, monthly measurements of landmark heights and of upper 20 cm snow layer density at each fifth mark were performed enabling for assessment of interannual variability in snow accumulation near Vostok station. Since 1996, the measurements are performed once in each year in the end of December.

In December, 1998, a new completely identical polygon was established to the west from the old one. The observations over both polygons are carried out simultaneously.

These observations are not a part of any official monitoring program.

A2.1.3.3 Participation in the programs of international data exchange; metadata; quality control and archiving

The Russian Federation participates in the international program of glacier monitoring and submits data to bulletins issued by the World Glacier Monitoring Service.

A2.1.3.4 Conformity to GCOS/GOOS/GTOS principles of climatic monitoring

The majority of land observing systems is of the exploratory nature. It was not planned that these systems should meet the requirements of GCOS/GOOS/GTOS climatic monitoring principles. However, the data obtained can be used in research. Some systems conduct regular observations.

The development of monitoring of permafrost and biotic component of the Earth climatic system were envisioned in the frameworks of *Prevention of Dangerous Changes of Climate and Their Adverse Effects* Federal Target Program. The methodological basis for monitoring has been elaborated and the inventory of data sources was implemented. However, financing of the Program after 2001 is not planned.

A2.1.4 Space-based observation programs

Roshydromet operates national remote sensing space systems including meteorological systems, *Ocean–01* oceanographic satellites and *Resurs–01* satellites for natural resource analysis. The national meteorological space system develops as a two-level system consisting of *Meteor* satellites for medium-height near-polar orbits and high-orbital (geostationary) *Elektro* satellites at sub-satellite point 76° E. Functions of the customer of the listed SS are assigned to the Russian aerospace agency (Rosaviacosmos) that is in charge of activities on creation and development of SS ERS pursuant to the Federal Space Program (FSP) of Russia. The development of space- and land based systems of this branch of the Federal Space Program ought to ensure the acquisition of information on the state of the atmosphere, seas and oceans, land surface, including the snow and ice cover on the operational basis, which will increase the reliability of weather forecasts (including the long-range ones) and help to solve other climatic study problems, as well as to monitor the Earth's ozone layer and the radiation situation in the near-Earth space and assess the anthropogenic impact on the environment. Roshydromet, alongside with Rosaviacosmos, is appointed a customer of space complexes for the collection of hydrometeorological information, analysis of the Earth's natural resources and ecological monitoring, produced according to the FSP; and also the activities on modernization of the Ground Ddata Receiving and Processing Complex (GDRPC).

Below sections briefly describe national weather space systems (including remote and ground-based sections) and plans for development of two-level weather space system (*Meteor–3M* and *Elektro*). The prospects of their use in climatic monitoring and research are considered.

A2.1.4.1 A brief description of space series, flights and instruments

State of space segment

The *Meteor–2* and *Meteor–3* weather satellites on near-polar orbits has worn out. The Federal Space Program of Russia has provided for construction of an updated *Meteor–3M* satellite, whose information characteristics, beginning with the second spacecraft in a series, should approach those of the NOAA (USA) satellites. The first *Elektro* geostationary weather satellite was launched in 1994 in accordance with interests of Roshydromet and in pursuance of international commitments under World Meteorological Organization (WMO). It operated with deviations from normal mode and by now has also worn out. The start of the next satellite of this series was postponed till 2005. The oceanographic *Ocean–01* satellite was launched in 1995, and currently it has virtually ceased working. The No. 3 *Resurs–01* satellite (1994) operates with limitations.

The domestic MSP is a constituent of the global space subsystem of hydrometeorological observations which was formed on the basis of the national space systems under the WMO supervision and consists of two levels: satellites of the main operators of the USA, the European community, Japan, India, the Peoples Republic of China working on the geostationary orbit (GOES-E, GOES-W, Meteosat, GMS, Insat, FY-2) and the system of operational American satellites of the NOAA series at medium-height near-polar solar synchronous orbits (the orbital group consists of at least two satellites – morning and afternoon ones).

In accordance with the experience gained the operational polar orbiting weather satellites should be equipped with a multispectral scanner working in visible and infra-red bands; atmospheric sounding equipment; a space borne radio engineering complex for data acquisition from ground-based stations. The NOAA satellites carry the listed equipment. The similar set of equipment is to be installed at *Meteor–3* satellite (starting from the second satellite in the series). The output information for the operational meteorology and hydrology, and climatic studies should provide multispectral images of cloudiness and the Earth's surface, data on air temperature and humidity, sea surface temperature and regional and global cloudiness.

The onboard instrument package of operational geostationary weather satellites includes:

- Scanning devices allowing to acquire images of the Earth with the 30-min image session frequency in visible and infra-red bands; and
- Radio-engineering complex for data collection and transmission. These devices are the permanent part of the onboard instrumental package of both the foreign satellites and the Russian *Elektro* satellite.

<u>Ground Data Receiving and Processing Complex of the Roshydromet</u>

The primary task of the GDRPC of Roshydromet is to provide public authorities, the federal ministries and offices subjects with all the information available from the Russian and foreign operational satellite systems necessary for solving the tasks of the hydrometeorological maintenance, monitoring of natural and technogenic disasters, climate monitoring.

The GDRPC of Roshydromet consists of three large centers: Moscow - Obninsk, Western Siberian Regional Data Receiving Center (WS RDRC, Novosibirsk), and Far-Eastern Regional Data Receiving Center (FE RDRC, Khabarovsk), and also a network of Stationary and Mobile users' Direct Receiving Stations (SMDRS). The Moscow center with divisions in Moscow and Obninsk is the most advanced. It implements all major functions such as planning, receiving, processing, archiving and distribution among the users of information from national and some foreign operating satellite systems.

The center in Obninsk is now unique. It can receive complete dataflows at a rate of 61.44 M bit/s. The ultra high frequency range (466.5 M Hz) data from *Resurs–01* No. 3 and *Ocean–01* can be received in Obninsk, Novosibirsk and Khabarovsk. The reception zones of the above centers cover the whole territory of the country.

Moscow Center preprocesses and archives information from meteorological, oceanographic and environmental and resource satellites. Besides, the possibility for data retransmission through *Elektro* satellite (if operational) and transmission via INTERNET and on magnetic, optic and magnetic-optic carriers is foreseen.

Below is presented the information on perspective satellites, measurement equipment and launching schedules.

<u>*Meteor–3M* weather satellite</u>

In 2002, a new generation of *Meteor–3M* polar orbital satellites should start operation (Table A2.1.4).

These satellites have more informative than *Meteor–3M* instrument package with modernized 1.7 GHz radio links and will be launched into solar-synchronous orbit. The lack of advanced multispectral scanners, infrared and microwave atmospheric sounding devices and data transmitters similar to High Resolution Picture Transmission at previous *Meteor* satellites reduced their information efficiency and hindered integration with foreign weather space systems. These "weak points" will be consistently removed in *Meteor–3M* series (a complete set of equipment and a new radio link will be installed at the second satellite of the series).

Table A2.1.4

Orbital characteristics of Meteor-3M spacecraft

Satellite	Date of launching	Inclination (deg)	Altitude (km)	Period of revolution (min)	Equator crossing time
Meteor–3M No. 1	December, 2001	99.6	1024	105.3	9:15 a.m.
Meteor–3M No 2	2005	99.6	1024	105.3	10:30 a.m. (4:30 p.m.)

The *Meteor–3M* No.2 will be equipped with an multispectral scanner (MSS) working in visible and IR bands, whose characteristics are similar to those of the AVHRR on NOAA satellites (channels 1-4 of the MSS are similar to the channels of the AVHRR device; the spatial resolution in nadir is about 1 km).

The development and installation of the microwave atmospheric temperature and humidity radiometer (MATHR) and the infrared Fourier-transform scanning spectrometer (IRFS) working in microwave and infra-red bands is an important development in the modernization of the *Meteor* spacecrafts.

The microwave atmospheric temperature and humidity radiometer was developed by Rosaviakosmos Central Engineering and Design Institute. It is 20-channel microwave scanner for "all-weather" atmospheric temperature and humidity sounding with working frequencies in spectral windows 18.7, 23.8, 31.5, 36.7, 42.0, 48.0, 89 GHz and also in 52-57 GHz oxygen and 183.31 GHz water vapor absorption bands. Table A2.1.5 gives the main parameters of the radiometer. The swath width is about 2,600 km. The equipment is designed for the acquisition of information necessary for the estimation of the vertical profiles of temperature and humidity (similar to the AMSU on the NOAA-15 satellite). Besides, the measurements of the MATHR include atypical channels near 42 and 48 GHz for the needs of oceanographic studies, specifically, for the detection of changes in the subsurface oceanic layer. It will be installed on both *Meteor–3M* No. 1 and No. 2 satellites.

The onboard infrared Fourier-transform scanning spectrometer (IRFS) is an important part of the future atmospheric sounding system. Its development was started in the Russian Federation in 1993 by Keldysh Center of Rosaviakosmos, Institute of Space Studies of the Russian Academy of Sciences and by other agencies. The first test model (sounding in nadir) will be installed at *Meteor–3M* No. 2. The second device in dial mode will be installed at the Russian segment of Alpha International Space Station. The spectrometer is designed for more accurate temperature and humidity sounding in the troposphere and low stratosphere under minimal cloudiness and for obtaining data on cloudiness parameters. The measurements should also provide for:

- Remote sounding of sea surface temperature with accuracy higher than 0.5 ºK and land surface temperature with accuracy about 1 ºK;
- Total ozone concentration measurements with accuracy about 5-10% and the data on its vertical distribution;
- Estimates of total methane and nitrous oxide content in the troposphere with accuracy 10%; and
- Estimation of aerosol optical thickness with accuracy 20%.

General characteristics of the IRFS are given in Table A2.1.6.

The combined data from microwave atmospheric temperature and humidity radiometer and infrared Fourier-transform scanning spectrometer will provide for deriving the all-weather atmospheric soundings of temperature and humidity profiles with accuracy 1 ºK, 1-km vertical troposphere resolution (temperature) and accuracy 10%, troposphere resolution 1-2 km (humidity).

Table A2.1.5
Main characteristics of the MATHR

Frequency, GHz	18,7	23.8	31.5	36.7	42.0	48.0	52-57	89	183
Polarization, V/H	V, H	V	V, H	V, H	V, H	V, H	V	V, H	V
Spatial resolution (km)	75	68	45	41	36	32	30	18	15
Conical scan, period (s)	2.52								
Scan angle (deg)	51.3								
Swath width (km)	2600								
Weight (kg)	80								
Power consumption, W	90								

MATHR Channel characteristics

Channel No	Central frequency, GHz	Channel bandwidth, MHz	Height of the weight function maximum, km
1	18.7	200	-
2	23.8	400	-
3	31.5	400	-
4	36.7	400	-
5	42.0	2000	-
6	48.0	2000	-
7	52.28	400	2
8	52.85	300	4
9	53.33	300	6
10	54.40	400	10
11	55.45	400	14
12	56.9682	50	20
13	56.9682	20	25
14	56.9682	10	29
15	56.9682	5	35
16	56.9682	3	40
17	89	4000	-
18	183.31 ±7.0	1500	1.5
19	183.31 ±3.0	1000	2.9
20	183.31 ±1.0	500	5.3

Table A2.1.6
Key characteristics of the IRFS device

No	Parameter	Units of measurement	Short-wave channel	Long-wave channel
1.	Spectral range: Wavelength Wave number	 micrometers cm^{-1}	 2-4.5 5000 - 2200	 5-16 2000 - 625
2.	Reference channel wavelength	micrometers	1.06	1.06
3.	Maximum optical length difference: High resolution 0.1 cm^{-1} Low resolution 0.5 cm^{-1}	 mm mm	 64 13	 64 13
4.	Angular width of sight: Resolution 0.1 cm^{-1} Resolution 0.5 cm^{-1}	 mrad mrad	 14 24	 25 43
5.	Duration of interferogram measurement: High resolution 0.1 cm^{-1} Low resolution 0.5 cm^{-1}	 s s	 4 0.8	 4 0.8
6	Dynamic range		2^{18}	2^{16}
7	Number of points in two-side interferogram		2^{18}	2^{18}

Basic provisions for development and future prospects of national observational space system are based on:

1) Russian space system being developed as the national operational system of hydrometeorological spacecrafts (SHS).
2) National SHS is a component of global space hydrometeorological observation subsystem based on national space systems functioning under the WMO guidance.
3) In-orbital grouping and payload of spacecrafts within the two-level system are determined from the following priorities in the employment of satellite data:
   - On-line meteorology and hydro-meteorological information;
   - Monitoring of climate and global climate changes;
   - Environmental atmospheric monitoring;
   - Scientific problems of atmospheric physics and chemistry.
4) The orbital group of the Russian operative MSS consists of a system of one or two spacecrafts at medium-height solar-synchronous orbits (satellites of the *Meteor-3M* series) and a spacecraft at geostationary orbit (*Elektro* series; sub-satellite point 76 ºE is approved by the WMO).
5) The main goal of *Meteor-3M* national system is to gain information about global distribution of cloudiness, snow and ice fields, detect special hydrometeological phenomena (SHP) and transmit SST and atmospheric temperature and humidity sounding data to be used in hydrometeorological and climatic studies. The data from *Meteor-3M* spacecraft will be an almost sole source of operational global and regional information about state and development of atmospheric processes for wide ocean areas and remote land sites, especially with regard to continuing reduction of the land-based observational network. The global data coverage is due to the direct data transmission mode (DDT mode) and recording mode available on *Meteor* satellites. This necessitates the launching of *Meteor* satellites as auxiliary to NOAA satellites that do not provide operational global information to Russian

users (regional information is available only within the reception range of data receiving centers).

6) With regard to above-mentioned principles of formation of national MSS and requirements to hydro-meteorological measurements, the measuring equipment of medium-height *Meteor-3M* spacecrafts is divided into three groups:
   - The equipment for collecting satellite hydrometeorological information (SHI) to be used on operational basis and helio-geophysical information;
   - Equipment for global environment and climate monitoring;
   - Experimental equipment for development of remote sensing methods of the surface and realization of international programs and experiments.

The most important devices to be used for providing hydrometeorological information and monitoring of global climate changes on spacecrafts working on solar-synchronous orbits are:

- Multispectral scanner (MSS) for obtaining images of the cloud cover and the Earth's surface, temperature monitoring;
- Infrared Fourier-transform scanning spectrometer (IRFS) for collection of data on the vertical temperature and humidity distribution and for sounding of the gaseous composition of the atmosphere;
- Radiometric equipment working in the microwave band (MRE) for monitoring of temperature and humidity of the underlying surface and the atmosphere;
- Complex of helio-geophysical measurement devices (GGM) for monitoring particle fluxes and electromagnetic fields in the near-Earth space;
- System for data collection and transmission from ground-based centers.

The second group of equipment should consist of:

- Complex for monitoring of the Earth radiation balance (RB): RB scanning radiometer, solar constant meter;
- Complex for monitoring gaseous composition of the atmosphere (ozonometry complex – TOMS, near-UV spectrometer, Fourier-transform spectrometer in nadir and dial mode).

The instruments of the third group are chosen proceeding from propositions of home industry and foreign partners.

7) The onboard instrument package for the climate and environmental monitoring, studies in atmospheric chemistry and physics is formed according to the industrial offers and the participation in international research programs and projects. Good examples of international cooperation are joint Russian-French-German development of SCARAB radiation balance scanner, and experiments in radiation balance data collection aboard *Meteor-3* No.7, *Resource-01* No.4 satellites (launched in 1998); launching and operation of TOMS equipment jointly with NASA (1991, *Meteor-3*, No.5), preparations for launching of SAGE-III equipment (2001, *Meteor-3M*, No.1). Such practice is efficient means for implementation of research projects and programs, build-up of international cooperation for solution of problems of atmospheric remote sensing.
8) Transmission of information via *Elektro* (GOMS) satellite communication lines should become the main means of information exchange and distribution. Besides, modem communication lines and the web network are to be used.

<u>*Meteor-3M* satellite on solar-synchronous orbit. Planned development of MSS.</u>

The recommendations given and the experience in operation of meteorological satellites of the *Meteor*, NOAA, and *Elektro* series were in some degree incorporated in the program of development of space systems for remote sensing of Earth in Russia. To solve the hydrometeorological, climatic, ozone layer and radiation monitoring tasks in the near-Earth space. The Federal Space Program provided for the construction and flight tests (FT) of the medium-height meteorological satellite of a new generation *Meteor-3M* (in 2001, spacecraft No. 1, in 2005 spacecraft No. 2) for the period before 2005, and also the launching and operation of the geostationary satellite *Elektro* (GOMS) No. 2 (after 2005). Roshydromet has been appointed the customer of these space systems (together with Rosaviakosmos) and the main user of satellite data.

Elektro geostationary spacecraft

Visible- and IR-scanners producing the images of the Earth every 0.5 hours, SEM instruments for monitoring of the near-Earth space (NES) and obtaining heliogeophysical information, radio engineering system for data collection and retranslation are the main part of the onboard instrument package of operational geostationary meteorological satellites.

To meet objectives of hydrometeorological maintenance and fulfill international obligations to WMO, *Elektro* No. 2 spacecraft with equipment similar to described above will be launched after 2005. The decision on creation and launching *Elektro* No. 2 spacecraft was adopted in spring of 2001, after the tender held by Rosaviakosmos.

A2.1.4.2 Programs of quality control and archiving

Possibilities for data collection and distribution grow rapidly with development of satellite telecommunication networks (based on geostationary and polar-orbiting satellites), see above. The World Wide Web network is becoming widely used for this purpose.

During the period beginning from the 1970s, operational hydrometeorological and resource satellite observational systems have been developing dynamically. Satellite observational systems became and integral part of existing and projected systems of World Weather Watch, GCOS and GOOS. We should also note the role of satellite observational systems in the global observational network:

1) The bulk of global observations of the cloud cover, atmospheric motions (wind, evolution of cloud systems) are provided by the operational polar-orbiting and geostationary meteorological satellites; some of the output data (data on the wind and cloud cover parameters) arrive at the GTS and assimilated in by numerical prognostic models. Specifically, the Hydrometeorological Center of the Russian Federation receives via the GTS about 4000 SATOB telegrams with the data on the wind, cloudiness, SST by standard terms (00 h, 12 h UTS).
2) Atmospheric temperature and humidity sounding data derived from the NOAA satellite information and arriving regularly to the GTS are an important information product. More than 4000 SATEM telegrams with the atmospheric temperature and humidity sounding data are transmitted daily to the MRMC and Hydrometcenter database. These data, due to their limited accuracy are only partially assimilated in prognostic schemes. As measurement systems develop and progress (instruments with greater information yield of the IASI and IRFS type) the quality of the atmospheric temperature and humidity sounding data will grow which will make it possible to supplement the information from the land-based aerological sounding network and significantly reduce this network.
3) The SDCT system is a very important element of satellite systems. It makes it possible to collect and transmit data of observation platforms and out-of-the-way stations. The systems of data retranslation based on the geostationary meteorological satellites mentioned above are a useful addition to the GTS. These systems are designed to exchange meteorological information and output products between meteorological centers at different levels.

A2.1.4.3 The main fields of application (atmosphere, ocean and land)

The global monitoring of climate and environmental changes is one of the main applications of space information from Space Systems of the Earth Remote Sensing. Climate changes are a manifestation of global changes on the Earth.

A major component of GCOS, permitting to achieve its basic purposes, are the satellite observation systems, both existing, and perspective. A necessary condition of the GCOS realization is the maximum coordination of plans of national space agencies and meteorological services of the leading countries for development and maintenance of operational and experimental satellite systems. The existing national programs of satellite system development grant a significant volume of satellite information (mainly the measurements from meteorological satellites – polar-orbital and geostationary) that allows solving the GCOS tasks and can supplement (or replace) the data of other observing systems. A major component of GCOS, permitting to achieve its basic purposes, are the satellite observation systems, both existing, and perspective. The satellite data, on the one hand, fill "gaps" in the space network of ground-based observations; on the other hand, the ground-based *in-situ* data allow to conduct calibration of satellite instruments and to receive matched with ground-based measurements valid data.

The objectives monitoring of climate and changes in the environment (an independent line according to the WMO classification) may be classified into a number of specialized applications:

1) Global and regional climatology of cloudiness and precipitation, monitoring of radiation balance components;
2) Vegetation, biomass, and desertification monitoring;
3) Detection and monitoring of forest and bush fires;
4) Monitoring of inundation boundaries at floods;
5) Monitoring of volcanoes, dust clouds and aerosol content in the atmosphere;
6) Monitoring of ozone layer and concntration of minor atmospheric constituents;
7) Monitoring of emergencies and hazardous natural and anthropogenic phenomena and their consequences;
8) Monitoring of water pollution (seas and inland water reservoirs), soil, and snow cover;
9) Monitoring and forecasting of heliogeophysical situation in near-Earth space.

General outlines of the GCOS are provided in Table A2.1.7.

Table A2.1.7
General outlines of the GCOS

The Earth	Main system	Goals of the global climate observation system	Key observations
	Global	Global radiation	Cloud amount. Droplet size distribution. Heat and moisture fluxes at the surface. Solar flux. Surface radiation flux. Radiation balance of the Earth. Spectral albedo. Aerosols.
	Oceans	Characteristics of oceans. Ocean-atmosphere interface	Color of the ocean. Oceanic topography. Geoid. Sea ice. Sea surface temperature. Salinity. Sub-surface ocean temperature. Wind speed and direction. Ice cover (as a tracer). Spectrum of waves. Atmospheric pressure at the sea surface
	Atmosphere	Thermodynamics of the atmosphere. Composition and chemistry of the atmosphere. Atmosphere-land interaction.	Temperature profile. Clouds. Wind profile. Liquid water/ice. Precipitation. Humidity (profile/total content). Gaseous components (total content/profile). Vegetation characteristics. Soil moisture. Snow and ice. Land temperature. Fires. Evaporation.
	Land	Climate response to the biosphere-land interaction	Changes in vegetation. Changes in land use.

Requirements for satellite data

The key parameters and types of information for the environmental monitoring and climate research are:

- Vertical profiles of temperature in troposphere and stratosphere;
- Vertical distributions and total contents of principal tropospheric (H_2O) and lower stratospheric (O_3) gases and aerosols; profiles and content of minor atmospheric constituents (CH_4, N_2O, CO, CO_2, NO_X, SO_2) and aerosols;
- Cloudiness;
- Precipitation;
- Wind data based on the motion of tracer clouds;
- Components of radiation balance of the Earth–atmosphere system;
- Wind at the ocean surface, wind stress;
- Fluxes of charged particles and electromagnetic fields in the near space;
- SST (with high accuracy), chromaticity of the ocean, topography of the ocean surface;
- Characteristics of land surface, including surface temperature, albedo, vegetation cover, etc.;
- Sea-ice, snow- and ice- cover of land.

General requirements to the satellite information for the monitoring of the global climate change are: availability of long observation records, continuity, compatibility and homogeneity of satellite information (which assumes the use of sensors of the same type, or cross-calibration of instruments). Requirements to immediacy of satellite data transmission are less stringent than those for on-line meteorology; moreover, for some parameters and elements the absolute continuity of measurements is not necessary, in contrast with the on-line meteorology.

The analysis of structure of metering equipment of satellite systems and of output products of remote sensing demonstrate that a number of primary goals of the monitoring of global environmental and climatic changes are provided with information by:

1) Existing and scheduled to launch operational satellites, at solar-synchronous orbits (such as *Meteor – 3M*, NOAA, DMSP, *EPS*/*METEOR*),
2) Polar orbiting satellites for the Earth remote sensing (*Rosaviacosmos*: *Resource* and *Ocean* satellites; ESA: ERS and *Envisat* satellites; NASA – EOS satellites; NASDA: ADEOS satellites).
3) Operational meteorological geostationary satellites (GOMS, *Meteosat*, GOES, and GMS).

A2.2. Observation Systems of Atmospheric Components

Regular observations of climate-effecting atmospheric components were conducted within the framework of Federal Target Programs "*Federal Target Programme "Prevention of Dangerous Changes of Climate and their Adverse Effects*" (1996-2001) and "*Development of the System for Hydrometeorological Support of Economy of the Russian Federation*" (1998-2001).

The leading agency responsible for conducting observations of climate-active atmospheric components within the framework of the above Target Programs is Federal Service of Russia on Hydrometeorology and Environmental Monitoring (Roshydromet).

The Russian Academy of Science conducts research on the global and regional changes in the climate-active atmospheric components (AC), as well as migration and transformation of greenhouse gases and aerosols in the atmosphere.

The metrological support of these measurements, development of state standards and verification apparatus is carried out by State Committee of the Russian Federation on Standardization, Metrology, and Certification (Gosstandart of Russia).

Federal budget finances the activities in the field of systematic observation of the atmospheric components within the framework of the Federal Target Programs.

Measurements of AC influencing climate on the territory of Russia the are carried out by ground-based systems of monitoring the total ozone atmospheric content of transboundary transport of environmental pollutants (EMEP)*, system of complex background monitoring (SCBM). Carbon dioxide observations at present are conducted at one monitoring station.

In accordance with the working plans of Federal Target Programs and based on the measurement methods developed, experimental observations of total atmospheric methane content are carried out (one station) together with its contrent in the surface air layer (one station).

The AC monitoring systems are included in the state environment observation system. Roshydromet (together with its scientific and research organizations and local bodies) is the leading agency coordinating activities of the AC monitoring systems and providing scientific and methodical support for the measurements.

The results of measurements conducted by the observation systems of the total atmospheric ozone content and of transboundary transport of pollutants, as well as the carbon dioxide observation data are regularly transmitted to data centers of international programs Global Atmospheric Watch (GAW), Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP), WMO World Ozone and Ultraviolet Data Centre (WOUDC), and World Data Center on Greenhouse Gases (WDCGG).

The generalized data on the present AC concentrations and on the tendencies of its change over the territory of Russia are published annually in the "*Review of the Background State of the Environment on the Territory of the CIS Countries*", and in the "*Review of the Environmental Pollution in the Russian Federation*".

A.2.2.1. Observation system of the total atmospheric ozone content

At present, the systematic observations of atmospheric ozone (the total ozone content – TOC) are carried out in Russia at 24 ozone stations equipped with filter ozonometers M-124; at 2 stations equipped with Dobson spectrophotometers (Dolgoprudny and St-Petersburg), as well as in two observation points equipped with Brewer spectrophotometers (Obninsk and Yakutsk).

The TOC data are daily transmitted to the Central Aerologic Observatory under Roshydromet compiling the "Ozonometry" data bank The quality control of measurement data as well as development of new TOC observation methods is carried out by the Main Geophysical Observatory (MGO) under Roshydromet.

Roshydromet is the leading agency responsible for the TOC monitoring in Russia. It also carries-out the functions of coordinating and scientific-methodological center within the framework of co-operation of the CIS countries on the problem of atmospheric ozone.

The data on estimates of the main statistical characteristics of the TOC field are used to compile daily maps on the TOC field on the base of developed techniques.

Operative data obtained at 24 Russian stations (equipped with filter ozonometers) are daily transmitted by e-mail to World Ozone and Ultraviolet Data Centre (WOUDC) under WMO in Toronto (Canada) and to Daily Ozone Measurement Cantre (DOMC) in Tessaloniki (Greece). The TOC data from Russia are used to compile daily maps on ozone

* *EMEP stations are also included into regional GAW network of the WMO.*

distribution in the atmosphere of the Northern Hemisphere. They are presented in Internet (http://exp-studiestor.ec.gc.ca/cgi-bin/select.Map).

The generalized data on the state of the TOC field over the territory of Russia obtained from 28 monitoring stations are published in WMO Reviews *OZONE DATA*.

The information obtained from ground-based observation system in Russia and other countries, satellite ozone measurement data (in the framework of bilateral co-operation with the USA) is used in scientific researches on the influence of anthropogenic and natural factors on change in the Earth ozone layer.

A2.2.2 Carbon dioxide observations

Regular measurements of carbon dioxide content in the boundary layer of the atmosphere have been carrying-out in Russia since 1986 in the framework of Global Carbon Dioxide Monitoring System and GAW under WMO. Until 1994 the measurements had been conducted at three monitoring stations:

1) Bering Island (Commander Islands, the Far East);
2) Kotelny Island (New Siberian Islands, Eastern Siberia);
3) Teriberka (Kola Peninsula, Western Arctic).

The geographical coordinates of monitoring stations and the periods of systematic observations of carbon dioxide are presented in Table A2.2.1.

As a result of reduced financing since 1995 up to now, the carbon dioxide measurements are conducted only at Teriberka station.

The Main Geophysical Observatory (MGO) under Roshydromet gives scientific and methodical leadership to the carbon dioxide measurements, controls the quality of the measurement data, analyzes the information available, and presents it for publication.

The data on CO_2 measurements obtained from 1986 have been transmitted to Carbon Dioxide Data Analysis Centre (Oak Ridge, USA) and World Data Centre on Greenhouse Gases under WMO (WDCGG, Tokyo) and were published in their editions.

Table A2.2.1
The geographic location of observation stations for background content of climate-active components in the boundary layer

Background station, observation period	**Observation system**	**Coordinates**			
		Latitude		**Longitude**	
		deg	**min**	**deg**	**min**
Astrakhan BR* (1985-2000)	SCBM	53	00	70	15
Barguzin BR (1983-1997)	SCBM	54	12	109	30
Voronezh BR (1985-2000)	SCBM	51	54	39	36
Caucasinn BR (1984-2000)	SCBM	43	42	40	12
Prioksko-Terrasny BR (1985-2000)	SCBM	54	54	37	48
Central-Forest BR (1983-1995)	SCBM	56	36	32	48
Danki (1997-2000)	EMEP/GAW	54	54	37	48
Pinega (1990-2000)	EMEP/GAW	64	42	43	23
Shepelevo (1994-2000)	EMEP/GAW	59	58	29	06
Yaniskoski (1983-2000)	EMEP/GAW	68	56	28	51
Teriberka (1988-2000)	GAW	69	12	35	06
Bering Island (1986-1994)	GAW	55	12	165	59
Kotelny Island (1986-1994)	GAW	76	06	37	54

*- *Biosphere reserve*

In the framework of bilateral co-operation on the problem of greenhouse gas monitoring, information exchange is carried-out with American and Canadian organizations. Inter-calibration is conducted of carbon dioxide measurement methods and the observation results in Russian and Canadian Arctic (GAW station *Alert*), and in the Arctic zone of the USA (GAW station *Barrow*).

To develop carbon dioxide observations in Russia, it is necessary to establish not less than two monitoring stations on the Asian territory of the country, as well to equip the MGO analytical laboratory with modern improved methods of carbon dioxide measurements and means of data processing and transfer.

At present, certain efforts are made in the framework of Federal Target Program *Prevention of Dangerous Changes of Climate and Their Adverse Effects* to establish carbon dioxide monitoring stations in Western Siberia.

A.2.2.3 Transboundary air pollution monitoring system

The system of monitoring transboundary transport of air pollutants was established in early 1980-s under the Convention on Transboundary Long-Distance Air Pollution. It was established on the territory of former USSR to fulfill the Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe designed by UN European Economic Commission (EEC). In 1990 the system included 11 observation stations. At present, 4 EMEP stations are operating in Russia. They also constitute a part of WMO network of regional GAW stations. Geographical location of the EMEP/GAW stations and their observation periods are shown in Table A2.2.1.

The EMEP/GAW observations are carried-out in Russia according to Federal Target Program *Development of the System for Hydrometeorological Support of the Economy of the Russian Federation*.

Formally, EMEP/GAW system is a component of State Observation Service of the Environment. Roshydromet is an agency giving the leadership to systematic EMEP observations in the Russian Federation.

The observation program at the EMEP/GAW stations includes systematic measurements of the boundary layer ozone, sulphur dioxide, nitrogen dioxide, sulphate, nitrate and ammonia aerosols, as well as measurements of ion composition of the precipitation. Air samples collected at the observation network stations are analyzed in the special laboratory of the IGCE. Measurement results after quality control and processing are transmitted to EMEP Coordinating Chemical Centre (Institute for Atmospheric Research, Oslo).

Data produced by the observation system in Russia are included in the EMEP European database.

Institute of Global Climate and Ecology (IGCE) gives scientific and methodical leadership to the EMEP measurements, analyzes and summarizes the information available. The observation results are published in reports of EMEP Co-ordination Centre (EMEP/CCC), as well as in annual *Review of Environmental Pollution in the Russian Federation* and *Review of Background State of the Environment in the CIS Countries*.

A2.2.4 System of complex background monitoring of the environment pollution

The system of complex background monitoring on the territory of former USSR (SCBM) was established in the late 1970-s – early 1980-s. It was targeted to obtain systematic information on pollution in different media, estimate the tendencies and forecast changes in the content of prevailing pollutants in the environment and influence on the state of the environment in regions distant from impacted, urbanized zones.

The SCBM is based on the network of observation stations located in biosphere reserves. When choosing the regions to locate the stations, the WMO recommendations were taken into consideration for regional stations included in the system of background atmospheric pollution monitoring (BAPMON/GAW).

In 1991 the SCBM observation network consisted of 14 stations on the territory of the former USSR. At present, 4 SCBM stations are operating in Russia (Table A2.2.1).

An important part of the SCBM program is measurements of gas and aerosol atmospheric components (nitrogen dioxide, sulfur dioxide, sulfate aerosols, total aerosol content in the air, heavy metals, and polyaromatic hydrocarbons). The observation program also includes measurements of chemical composition of the precipitation.

The observation results from SCBM network are transmitted to the Institute of Global Climate and Ecology under Roshydromet and RAS (IGCE) which carries-out the functions of scientific-methodical and information monitoring in Russia and CIS countries (within the framework of Interstate Council on Hydrometeorology of the CIS Countries). The measurement data on background atmospheric content of gases and aerosols for the period of 1980-2000 are a component of Background Monitoring database, which also includes information from EMEP/GAW monitoring systems on the territory of Russia. IGCE performs compilation of databank, generalization of information for its further presentation in agreed formats, as well preparation of reference and information materials.

The investigations on the complex background monitoring are also carried-out within the framework of co-operation between the CIS countries on the base of multilateral and bilateral agreements. In particular, the co-operation plans provide for carrying-out of systematic observations according to uniform program with the use of unified measuring means of AC background content on the territory of the CIS countries. The observation results are subjects of exchange between the countries participating in the co-operation. They are kept in databank Background Monitoring and published in annual *Review of the Background State of the Environment in the CIS Countries* printed in Russia.

To develop SCBM on the territory of Russia it is planned: to restore observations at stations located in Central Siberia and in the vicinity of the Baikal Lake (were interrupted in 1998 because of lack of finance); to supply SCBM stations and analytical laboratories with modern analytical equipment, means of measurement data processing, storage and transfer; to arrange regular data exchange with World Data Centre on Atmospheric Components; to ensure participation in regular intercalibrations of atmospheric component measurement equipment carried-out by WMO in the framework of GAW.

The generalized information on conducted in Russia observations of the climate change related gas and aerosol atmospheric components are provided in Table A2.2.2, according to recommendations of the UNFCCC Secretariat.

Observation systems of climate-active atmospheric components operating in Russia at present, cannot ensure the full scope obtaining of the information sufficient to solve the problems of the global and regional climate change. The monitoring stations of gaseous and aerosol atmospheric components are situated on the European territory of the country (except for the network of observation stations of the total atmospheric ozone content).

At present, certain activities are carried-out to develop systematic observations of the atmospheric components: establishing the observation stations on the Asian territory of the country, modernizing the analytical base of the monitoring systems and supplying the co-ordination centers with modern means of data processing, storage and transfer.

Taking into account the serious economic situation in modern Russia, the financial support from Global Ecological Facility (GEF) and WMO could in many respects favor to increase the effectiveness of measures aimed at the development of atmospheric observations in the framework of climate change problem.

Table A2.2.2
Systems for atmospheric components observation

Atmospheric component	Total number of stations	Correspondence to the characteristics of national climate			Observation period, total number of stations (digital stations)			Correspondence to the data quality control procedures			Availability of additional data. Total number of stations (percentage of digital stations)	Projected number of operating stations in 2005
		Complete	**Partial**	**No**	**10-20 years**	**20-30 years**	**30-50 years**	**Complete**	**Partial**	**No**		
Carbon dioxide	1		+		1 (1)			+			1 (100)	3
Ozone (surface)	3		+		3 (3)				+		3 (100)	3
Ozone (total)	28	+			28 (28)				+		28 (100)	28
Aerosols:												
Sulfate	8		+		8 (8)			+			8 (100)	8
Nitrate	4		+		4 (4)			+			4 (100)	4
Ammonia	4		+		4 (4)			+			4 (100)	4
Sulfur dioxide	8		+		8 (8)			+			8 (100)	8
Nitrogen dioxide	6		+		6 (6)			+			6 (100)	6

The Principles of Climatic Monitoring

GCOS/GOOS/GTOS[2]

1. The assessment of effect of the new systems or of changes in existing systems should be completed prior to their introducing.

2. It is necessary to provide reasonable period of parallel using of the new and existing observing systems.

3. The outcomes of data calibrating, quality control and uniformity assessments as well as estimations of changes in treatment procedures should be based on the same datasets.

4. It is necessary to provide capabilities for regular assessing of the data quality and uniformity with respect to the extreme phenomena data, including high-resolution data and their descriptive information.

5. It is necessary to incorporate considerations of the ecological (climate) monitoring assessments, such, as IPCC, into global priorities in the field of observations.

6. It is necessary to provide a continuous operation of observing stations and systems.

7. Prime attention must be given to additional observations in regions of poor data, and in regions experiencing climatic changes.

8. The long-term requirements for new system should be informed to its developers, as well as to networks operators and engineers on equipments on initial stage of the system development and implementation.

9. It is necessary to encourage transformation of research observing systems into long-term operations.

10. Data management systems, which support data access, data use and interpretation, should be incorporated into climate observing systems as their most important elements.

[2] GCOS-39(WMO/TD-No.87) (UNEP/DEIA/MR.97-8) (GOOS-ll) Report of the GCOS/GOOS/GTOS Panel, Third session (Tokyo, Japan, 15-18 July, 1997).

ABBREVIATIONS

AARI	Arctic and Antarctic Research Institute of Roshydromet
ACSYS	Arctic Climate System Study
ARIHMI-WDC	All-Russia Institute of Hydrometeorological Information – World Data Center of Roshydromet
ASAP	Automated Ship Aerology Program
ASD	Artificial space devices
BAPMON	Background Atmospheric Pollution Monitoring
CIS	Commonwealth of Independent States
CLIVAR	Experiment on Climate Variability and it’s Predictability
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe
eq.	Equivalent
ERS	Earth remote sensing
FE	Far East Region
FLUXNET	Global Surface Network - Carbon
FSP	Federal Space Program
FTP	Federal Target Program
FTPC	Federal Target Programme “Prevention of Dangerous Changes of Climate and their Adverse Effects”
GAW	Global Atmospheric Watch
GCOS	Global Climate Observing System
GDP	Gross domestic product
GDRPC	Ground data receiving and processing complex
GEF	Global Environmental Facility
GEWEX	Global Energy and Water Cycle Experiment
GHG	Greenhouse gas
GLOSS	Global Sea Level Observing System
GOOS	Global Ocean Observing System
GTOS	Global Terrestrial Observing System
Gosstandart	State Committee on Stadardization, Metrology, and Certification
GSN	Global Surface Network
GSN-G	Global Surface Network - Glaciers
GSN-P	Global Surface Network - Permafrost
GST	Ground surface temperature
GUAN	Global Upper-Air Network
H	Horizontal
IAEA	International Atomic Energy Agency
ICSU	International Council of Scientific Unions
IGCE	Institute of Global Climate and Ecology
IPCC	Intergovernmental Panel on Climate Change
MFG	Many years frozen grounds
MGO	Main Geophysical Observatory
MRMC	Main Radiometeorological Center of Roshydromet
MSS	Meteorological space system; multispectral scanner system
NODC	National Oceanographic Data Center
NPP	Nuclear power plant
RAE	Russian Antarctic Expedition
RAS	Russian Academy of Sciences
RF	Russian Federation

RIHMI-WDC	Research Institute of Hydrometeorological Information – World Data Center
Rosaviacosmos	Russian Aerospace Agency
Roshydromet	Federal Service of Russia for Hydrometeorology and Environmental Monitoring
Roszemcadastre	Land Cadastre Service of the Russian Federation
SC	Spacecraft
SHS	System of hydrometeorological spacecrafts
SOOP	Ship of Opportunity Program
SS	Space system
SST	Sea surface temperature
TOGA	Tropical Ocean-Global Atmosphere Program
UES	Unified Energy System
UN	United Nations
UNFCCC	UN Framework Convention on Climate Change
USA	United States of America
USSR	Union of Soviet Socialist Republics
V	Vertical
VOS	Voluntary observing ship
WCRP	World Climate Research Program
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
UTC	Coordinated Universal Time

UNITS

B	billion
°C	degrees Celsius
G	giga (10^9)
H	henry
Hz	Hertz
J	joule
K	Kelvin
M	mega (10^6)
P	peta (10^{15})
T	tera (10^{12})
V	Volt
W	Watt
cal	Calorie
cm	centimeter
deg. (˚)	degree
g	gram
hr	hour
k	Kilo (10^3)
kg	kilogram
km	kilometer
km^2	square kilometer
l	liter
m	meter
min	minute
ml	milliliter
mln	million
mm	millimeter
n	nano (10^{-9})
ppm	parts per million
rad	radian
Rubl.	Rubles
s	second
tce	tons of coal equivalent
t	metric ton
W-hr	Watt-hour
yr	year