MAN-INDUCED ENVIRONMENTAL RISKS: MONITORING, MANAGEMENT AND REMEDIATION OF MAN-MADE CHANGES IN SIBERIA*

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Кратко описывается координационная акция ИНКО РП6 проект Enviro-RISKS (Антропогенные риски для окружающей среды: мониторинг, управление и исправление антропогенных изменений в Сибири) и его состояние на сегодняшний день. Особое внимание уделено тематическим приоритетам этой акции и первым полученным результатам, в частности, недавно запущенному веб-порталу Enviro-RISKS (http://risks.scert.ru/), как основному элементу целевого объединения в сеть основных участников исследований окружающей среды.

Introduction

The very idea of this project appeared as result of authors concern with current situation in the Siberia environment itself and in basic and applied research activity devoted to it. It is well known that the Siberia environment has been influenced by serious man-made transformations during the last 50 years. Major contemporary regional level environmental risks include the following. At first, these are direct damages to environment caused by accidents during petroleum/gas production and transporting. It is also risks caused by deforestation variations in Siberian rivers runoffs and wetland regimes. Moreover, it includes influence of forest fires, flambeau lights and losses of gas and petroleum during their transportation on regional atmosphere composition as well as atmospheric transport and deposition of hazardous species leading to risks for soil, water and consequently for food-chains. Near all of the risks might be significantly enforced by regional manifestations of global change, which evolves dramatically in the

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Northern territories [1]. Regional consequences of global warming (e. g. anomalous increase of winter temperatures [2]) are strongly pronounced in Siberia. This tendency is supported by the results of climate modeling for 20–22 centuries [3]. This process not only threatens Siberia with destruction of the most part of extractive and transport infrastructure caused by the shift of permafrost borders northwards but also can change the dynamics of the natural climatic system as a whole as a result of extrication of a large mass of greenhouse gases. Similar regional problems occur in a number of Northern countries. However, Siberia is actually a place where the synergy between natural and man-induced impacts on the environment might lead to heavier environmental damage and consequences, then their separate consequences. It also includes possible strong variations of regional feedbacks to the global system, which makes relevant study important on the global scale as well.

In spite of significant research efforts of recent years the deep understanding of the dynamics of regional environment main components is not gained yet. Although many projects supported by national (SB RAS, RAS) and international (EC, IGBP-2, NEESPI, etc.) organizations are devoted to study of modern dynamics of Siberian environment, we still know little about the behavior of main components of the regional climatic system. A review on state-of-the-art in Siberian environmental research is published in the dedicated to Siberia issue of the Bulletin of Russian National Committee on IGBP [4] and available in Internet (`http://www.scert.ru/files/igbp/EngBul.pdf`). Many institutes of SB RAS also work in this direction in the frameworks of their budgets and initiative themes. But taking into account their fragmentation, these studies will not lead to the emerging of the full picture of modern natural-climatic changes in Siberia.

Siberia is one of the promising regions for the development of such basic and applied regional study of environmental dynamics [4]. In spite of significant resources used, the effectiveness of the work is not high because of insufficient funding and coordination between projects. To overcome these weaknesses a special activity is necessary. In order to gather up for now scattered regional, national and international efforts in these investigations, a sort of regional concentrated activity aimed at the both basic and applied studies is required. That is why we decided to initiate relevant project namely as FP6 co-ordination action. According to the FP6 definition the Co-ordination actions (CA) are intended to promote and support the co-ordinated initiatives of a range of research and innovation operators, in order to achieve improved integration of the European research. The co-ordination action is an instrument to network or co-ordinate research organizations, initiatives or projects for a specific purpose. It provides organizational support to achieve the networking or co-ordination of the research and innovation activities of the operators involved. Namely co-ordination activities could address tasks such as establishing a roadmap for research in specific topics and performance of required preparatory work like studies, analysis and report writing, establishment of specifications for common information systems, development of such systems and the use of common information systems to facilitate exchange and dissemination of good practices and manage common activities. Additional positives of co-ordination actions are in the fact that they may contain training activities as well.

Project description

The three years FP6 CA Project "Man-induced Environmental Risks: Monitoring, Management and Remediation of Man-made Changes in Siberia" (Enviro-RISKS) has been started

on 1 November 2005. Its strategic objective is to facilitate elaboration of solid scientific background and understanding of man-made associated environmental risks, their influence on all aspects of regional environment and optimal ways for it remediation by means of coordinated initiatives of a range of relevant RTD projects as well as to achieve improved integration of the EU research giving the projects additional synergy in current activities and potential for practical applications.

Scientific background and foundation for the project performance is formed by a number of different levels RTD projects devoted to near all aspects of the theme but in virtue of synergy lack not resulting in improvement of regional environmental situation. The set comprise co-ordinated/performed by partners EC funded thematic international projects, Russian national projects and other projects performed by NIS partners. List of partners includes 3 leading European research organizations: Danish Meteorological Institute (Coordinator; Copenhagen, Denmark), Max-Planck-Institute for Biogeochemistry (Jena, Germany) and International Institute for Applied Systems Analysis (Laxenburg, Austria); 6 leading Russian research organizations (5 — located in Siberia): Siberian Center for Environmental Research and Training (NIS Coordinator) and Institute of Monitoring of Climatic and Ecological Systems SB RAS, (both in Tomsk), Institute for Numerical Mathematics RAS (Moscow), SB RAS Institutes Forest SB RAS (Krasnoyarsk), Institute of Computational Mathematics and Mathematical Geophysics (Novosibirsk), Ugra Research Institute of Information Technologies (Khanty-Mansiisk) as well as the KazGeoCosmos enterprise (Almaty, Republic of Kazakhstan). Additionally to the listed above partners several research organizations joined to the Project as Associated Partners. Among those are the MEDIAS-France (Toulouse, France; `http://mediasfrance.org/`), and several Russian organizations — Institute of Computational Modeling SB RAS (Krasnoyarsk), Institute of Northern Environmental Problems of Kola Science Center RAS (Apatity, `http://inep.ksc.ru/`), Tomsk State University (`http://www.tsu.ru/`), and Ural Division of RAS (Ekaterinburg).

List of performed projects, whose results will be included into dedicated studies in course of CA, comprises the following:

FUMAPEX (Integrated Systems for Forecasting Urban Meteorology, Air Pollution and Population Exposure, `http://fumapex.dmi.dk/`) Project, co-ordinated by DMI, which was aimed at improvement of meteorological forecasts for urban areas, integration and link Numerical Weather Prediction (NWP) models to Urban Air Pollution and Population Exposure models leading to an improved Urban Air Quality Information and Forecast System for application in cities in various European climates;

SIBERIA 2 (Multi-sensor concept for Greenhouse Gases Accounting in Northern Eurasia, `http://www.siberia2.uni-jena.de/index.php`), aimed at understanding the greenhouse gas budget and its interactions with climate change in the Eurosiberian region (**IIASA** and **IF** were its key performers);

TCOS-Siberia (Terrestrial Carbon Observing System — Siberia, `http://www.bgc.mpg.de//public/carboeur/web_TCOS/`), coordinated by MPI for Bio-geochemistry (Jena) and aimed at implementation of the first components of a continental scale observing system to help determine the net carbon balance of Siberia and its variation from year to year;

ISIREMM (Integrated System for Intelligent Regional Environmental Monitoring & Management), SCERT coordinated NIS Partners activity, which addressed the problem of industrial pollution, and in particular, air pollution, and its effects on the human and natural environment.

It also includes FP6 Special Support Action **ENVIROMIS-SSA** (Environmental Observations, Modelling and Information Systems, link) coordinated by **SCERT**, which formed coher-

ent set of coordination, dissemination and education actions directly aimed at environment protection and stabilisation of research and development potential in Russia and other NIS countries as well as INTAS supported projects **ATMOS** (Web Portal on Atmospheric Environment, links) aimed at development a bilingual Internet portal for the domain of Atmospheric Physics and Chemistry, and the related application domain of air quality assessment and management (among key participants were **SCERT**, **INM** and **IMCES**) and "Modelling and parameterisation of the 'air-vegetation-snow-soil' system, including special aspects of the permafrost degradation" aimed at evaluation and understanding effects of the active layer of the cryosphere on climate and studying potential effects of the global climate change on the permafrost degradation (**INM** played the key role in it). Important part of the set is formed by the SB RAS Interdisciplinary Integrated Projects devoted to actual issues of Siberia environment. Among those are co-ordinated by **IMCES** projects **SGBP** ("Siberian Geosphere — Biosphere Program: integrated regional study of contemporary natural and climatic changes", `http://sgbp.scert.ru/en/about/`), in which efforts of 14 Institutes of SB RAS and RAS as well as 5 Universities were coherently joined to initiate relevant study of the region and **GVB** ("Complex Monitoring of Great Vasyugan Bog: study of modern state and development processes", link) aimed at study of development of the unique natural-climatic complex Great Vasyugan Bog (GVB) as the natural formation of planetary importance under global and regional environmental and climate change and elaboration of remediation methods for damaged by oil producing activity parts of it territory; as well as co-ordinated by **ICMMG** project "Ecological Problems of Siberian Cities", which goal was to conduct multidisciplinary scientific research of answer the basic questions: how do cities change hydrothermodynamic behaviour and composition of atmosphere and how do these changes affect the quality of life, public health and quality of environment. Complete list of the projects also comprise the Kazakhstan Ministry of Industry and Trade projects, performed by **KGC** and set of projects performed by **URIIT** for regional petroleum and gas producing companies. More detailed description of the performed by partners' projects as well as those, recently started, can be found at the Enviro-RISKS web portal (`http://risks.scert.ru/`).

One of the project tasks is facilitation to development of Siberia Integrated Regional Study (**SIRS**, `http://sirs.scert.ru/`). Accordingly to present knowledge, Siberia is the region where the most pronounced consequences of climate changes already happen and will happen. Various models have been developed to address different dimensions of this issue. Variability in space and time as well as regions of critical importance ("hotspots") have been evidenced through in situ and remote sensing measurement techniques and were forecasted by advanced climatic models. Siberia environment has been subjected to serious man-made transformations during last 50 years, whose negative consequences might be amplified by regional manifestations of global change. Say caused by deforestation (cutting and forest fires) variations in Siberian rivers runoffs and wetland regimes might interfere with change of atmospheric circulation in the region, which varies forest fires frequency, flambeau lights and losses of gas and petroleum during their transportation vary regional atmosphere composition and its radiation properties, etc. These regional problems are typical for number of NIS and for near all Northern countries.

Elaboration of solid scientific background and understanding of man-made associated environmental risks, their influence on all aspects of regional environment and optimal ways for it remediation is required to get practical results in enhancing of environment and diminish environmental risks. The region requires a new research paradigm. An overarching vision of regional aspects and its various connections to global aspects is now needed in line with the defined by the Earth System Science Partnership Integrated Regional Studies (IRS) approach,

which could lead to Siberia IRS (SIRS) program. This requires bringing together scientists from several disciplines and sub-regions into a much wider approach and setting up the relevant structures (institutions, regional and trans-regional and international networks, funding) to lead such integrative studies. Results of such studies should be bridged with and acknowledged by relevant decision policy makers in order to implement proper mitigation and remediation actions at managerial and political decision levels.

The main activities, aimed at realization of the Enviro-RISKS objective and coordination of the basic and applied environmentally oriented projects comprise:

— development and support of the Project web portal and environmental information distributed database;

— gathering and systematization of information resources obtained;

— gathering, analysis and synergy search in different level projects on Siberian environment;

— organization of conferences and experts meetings;

— search for synergy between the different projects on Siberian environment and elaboration of recommendation for new Projects;

— exchange of research personnel and postgraduates.

First results

The project **Launching Meeting**, which gathered key representatives of all Partners, took place in Copenhagen during January 30–31, 2006. Additionally to typical for such meetings management issues its agenda included a special section on Coordinated Projects, where detailed descriptions of major findings were given in more than 20 presentations/reports. Complete information on this meeting including reports delivered is available in internet (`http://project.risks.scert.ru/management/meetings/kick/`). Major result of the meeting is in allocating all to projects to selected **Thematic Focuses** and in establishing relevant **Working Groups**.

Three Thematic Focuses/Groups consider major risks inherent to Siberia environment. These groups (with their leaders) are the following:

1. **Atmospheric Pollution and Risks** (A. Baklanov, V. Penenko).
2. **Climate/Global Change and Risks** (M. Heimann, V. Lykosov).
3. **Terrestrial Ecosystems and Hydrology and Risks** (M. Kabanov, A. Shvidenko).

The forth Focus has a generic nature and is devoted to:

4. **Information Systems, Integration and Synthesis** (Evgeny Gordov and Edige Zakarin).

The working groups also form a basis for organization of the thematic Expert Groups, which should elaborate practical recommendations for coordination of new projects on Siberia environment initiated by Partners.

The next Project event, which is the **first year Interim Meeting**, took place within frameworks of the International Conference on "Environmental Observations, Modeling and Information Systems" (ENVIROMIS-2006) held 1–8 July 2006 (Akademgorodok, Tomsk, Russia; `http://www.scert.ru/en/conferences/enviromis2006/`). Firstly, the special sessions devoted the state-of-the-art of the targeted activity were run, at which representatives of Partners and Associated Partners delivered relevant reports. This meeting description as well as presentations of the reports is available in Internet (`http://project.risks.scert.ru/management/meetings/second/`).

In between these two meetings the activities were mainly concentrated on the first and forth thematic focuses.

In particular, within the activities of the group "**Atmospheric Pollution and Risks**", the DMI performed long-term simulation of atmospheric transport and deposition patterns from sources of continuous anthropogenic sulphates and radionuclides emissions located in the Siberian, Kazakhstan, Ural, and other geographical regions [5].

The Danish Emergency Response Model for Atmosphere (DERMA) was employed to perform simulations of air concentration, time integrated air concentration, dry and wet deposition patterns resulted from continuous emissions of chemical risk sites. The geographical locations of the Siberian chemical and metallurgical enterprises situated near the cities of Kemerovo, Norilsk, Novokuznetsk, Chelyabinsk, Ekaterinburg, Nizhniy Tagil, Krasnoyarsk, Zheleznogorsk, and others were selected as representative sources of such emissions. To perform such simula-

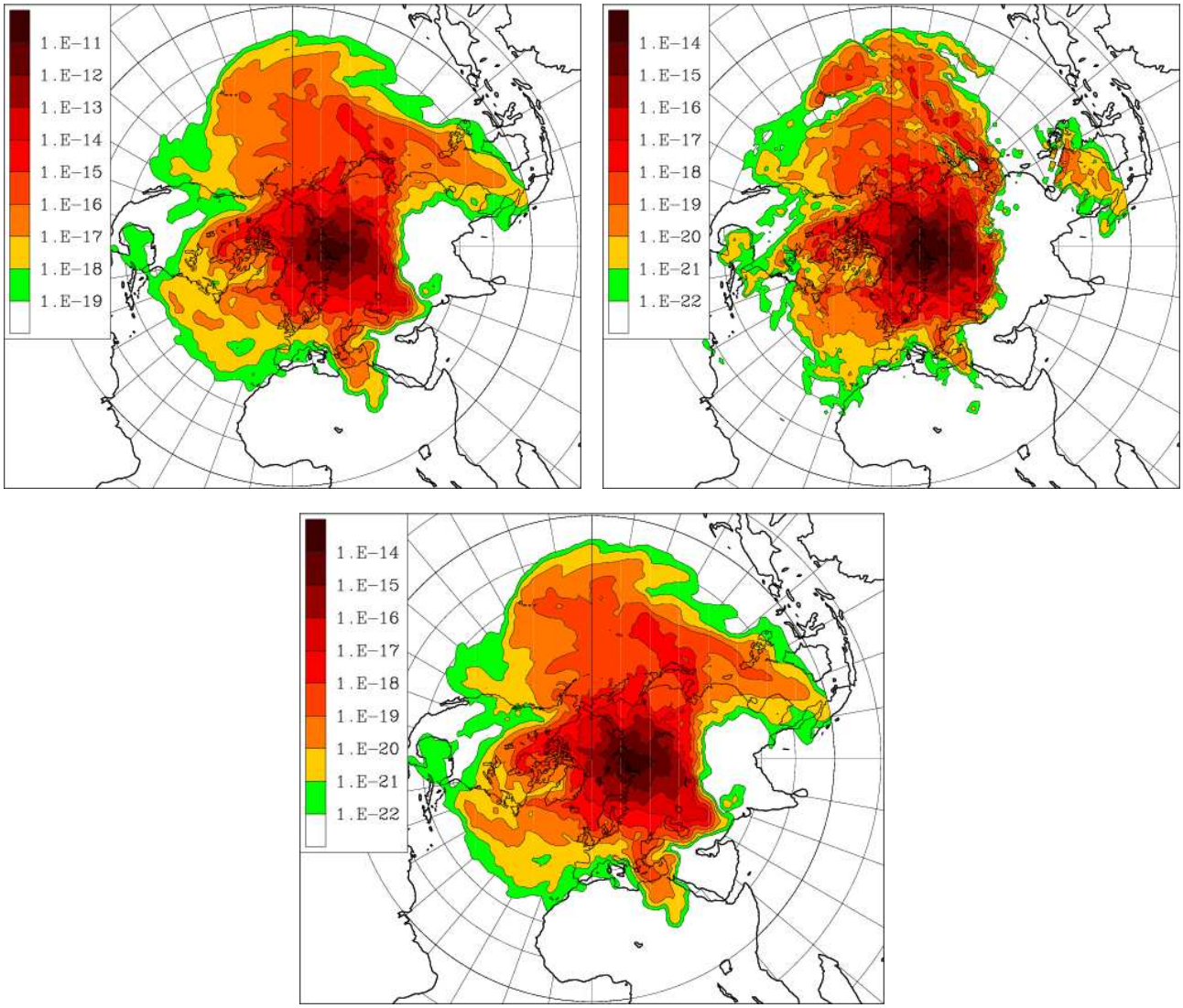


Fig. 1. DERMA model results of the long-term dispersion modelling: annual time integrated air concentration, dry and wet deposition patterns from the Norilsk nickel plant [5].

tions the European Center for Medium-Range Weather Forecasts (ECMWF) 3D meteorological fields (for years of 1985 — as climatologically typical year, and 1983 — as year with a significant deviation of atmospheric circulation patterns for the North Atlantic Oscillation) were used as input by the DERMA model. Several assumptions were applied. In particular, the hypothetical daily unit releases of sulphates at a constant rate were considered from each site. For each daily release the followed transport through the atmosphere and deposition on the underlying surface due to dry and wet removal processes were estimated on an interval of 2 weeks.

Detailed analyses of simulated concentration and deposition fields for each site allow evaluating spatial and temporal variability of these resulted patterns on regional and hemispheric scales (example is given in fig. 1). The results of these simulations are also applicable for GIS integration as well as essential input for further evaluation of doses, impacts, risks, short- and long-term consequences for population and environment from potential sources of continuous emissions.

Within the group "**Information Systems, Integration and Synthesis**" the SCERT team developed and launched the Project web-portal (`http://risks.scert.ru/`). The bilingual (Russian and English) Enviro-RISKS web-portal is aimed at dissemination of the CA results as well as relevant projects results and approaches. The portal is organized as a set of interrelated scientific sites, which are open for external access information-computational systems realized by means of Internet technologies. It is also an information resource on general environment issues adjusted also for usage in education process and giving an access to environmental information and basics on environmental monitoring and management to regional administrators, researchers, students and general public thus giving rise the environmental concern in NIS management bodies and general public. The Portal engine employs middleware designed in course of the INTAS project ATMOS performance results [6, 7]. Since till now there is no international standards on relevant middleware technological choices are based of W3C recommendations. In particular, Apache web server is used as well as PHP script language and MySQL DBMS. The linguistic service is providing multi-language information presentation on site and in the dialogue system. Among the information resources there are also gathered and systemized environmental information resources obtained in process of environmental studies in Siberia and results of relevant expert groups studies. The portal is also aimed at exchange and dissemination of good practices examples of practically important results obtained in course of projects implementation, especially those obtained in area of remediation.

The portal operation will be supported by a distributed information system with main server in Tomsk and nodes Krasnoyarsk, Moscow, Khanty-Mansiisk and Almaty thus providing easy access to structured information resources on Siberia environment, its management under anthropogenic environmental risks and methods of its remediation. Additionally its Intranet part is used as an instrument for exchange and dissemination of information between the project partners. The Portal start page is shown on fig. 2.

The Portal functionality allows an access to gathered and analyzed detailed information on all coordinated Projects, gathered and systemized results and finding obtained including relevant observation data and information resources, distributed database, which will give an access to data on characteristics of Siberian environment to the Project Partners and an access to relevant metadata to all interested professional community. The basic thematic sites currently integrated into the Enviro-RISKS web-portal are Air Quality Assessment and Management, which compiles basic aspects of air pollution and environmental impact assessment and West Sibera site, which provides basic information on Siberia environment characteristics. Figure 3 shows it in more details.

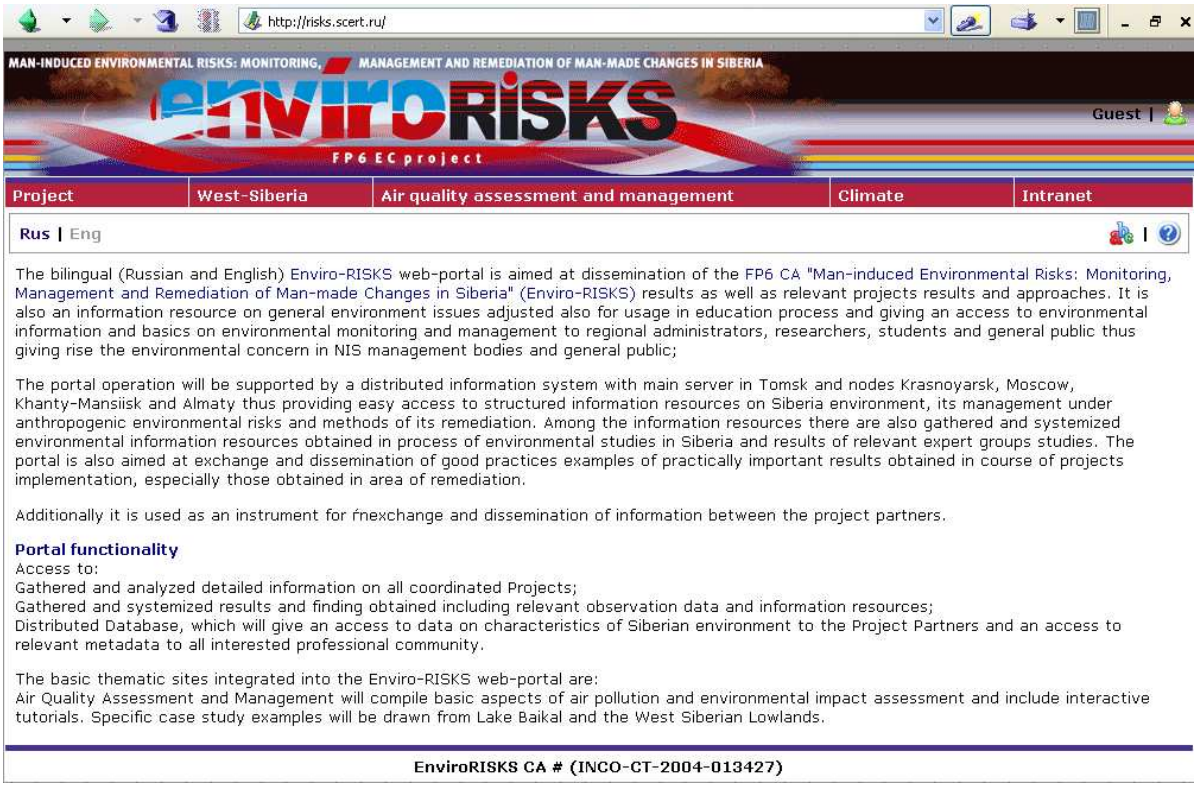
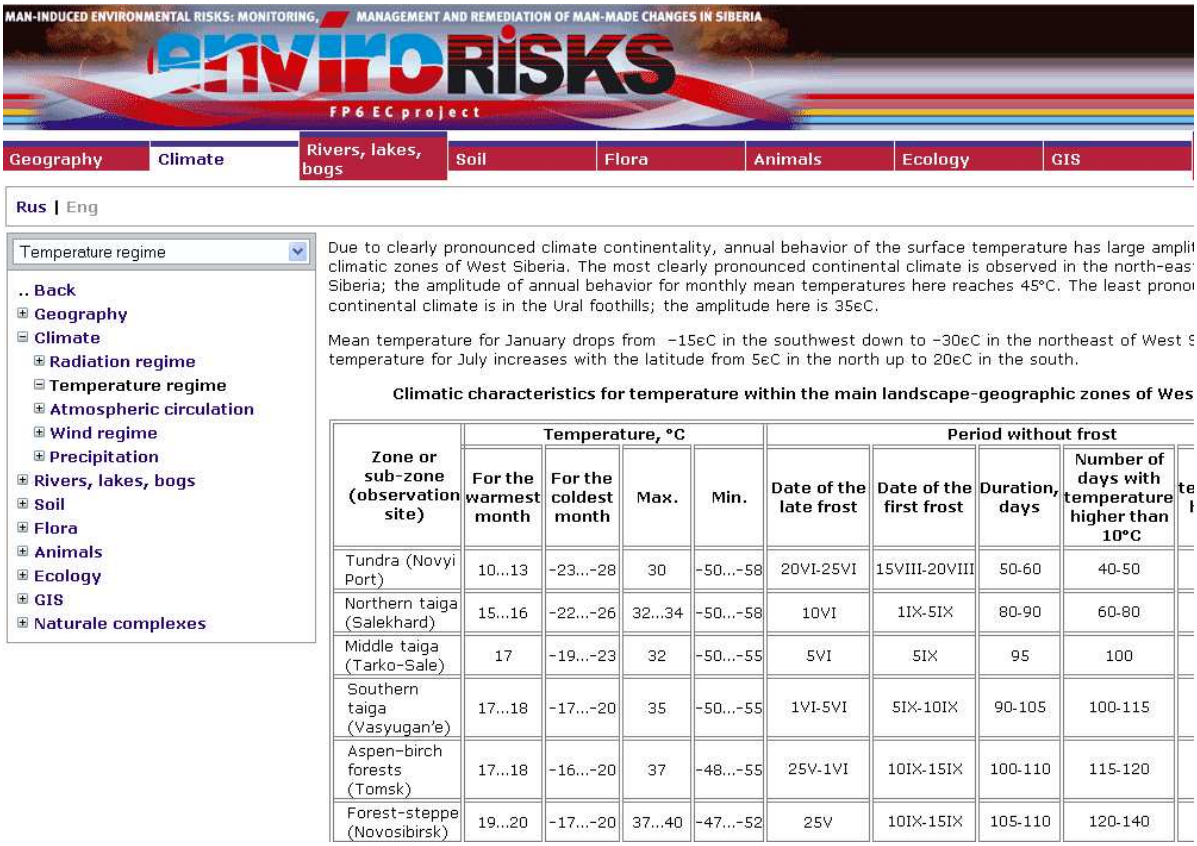


Fig. 2. The Enviro-RISKS Portal start page.



Zone or sub-zone (observation site)	Temperature, °C				Period without frost				
	For the warmest month	For the coldest month	Max.	Min.	Date of the late frost	Date of the first frost	Duration, days	Number of days with temperature higher than 10°C	te
Tundra (Novyi Port)	10...13	-23...-28	30	-50...-58	20VI-25VI	15VIII-20VIII	50-60	40-50	
Northern taiga (Salekhard)	15...16	-22...-26	32...34	-50...-58	10VI	1IX-5IX	80-90	60-80	
Middle taiga (Tarko-Sale)	17	-19...-23	32	-50...-55	5VI	5IX	95	100	
Southern taiga (Vasyugan'e)	17...18	-17...-20	35	-50...-55	1VI-5VI	5IX-10IX	90-105	100-115	
Aspen-birch forests (Tomsk)	17...18	-16...-20	37	-48...-55	25V-1VI	10IX-15IX	100-110	115-120	
Forest-steppe (Novosibirsk)	19...20	-17...-20	37...40	-47...-52	25V	10IX-15IX	105-110	120-140	

Fig. 3. An example of West Siberia climate description.

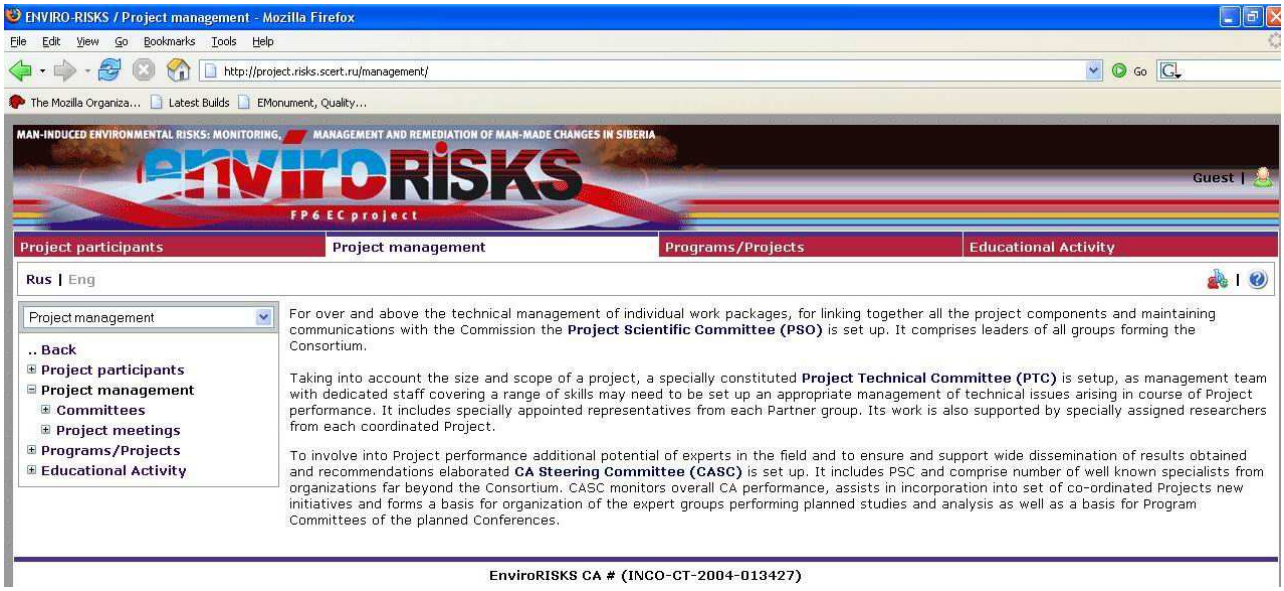


Fig. 4. The Project management page.

The Portal site Climate, which is under development now, is aimed at an access to specially designed analytical tools allowing to get spatial pattern of selected Siberia climatic characteristics from measured or simulated data sets.

Special site is devoted to the Project management. It comprise information on the Project Partners, Project management, Projects/Program coordinated and give an access to gathered by Partners educational recourses. Figure 4 shows the page devoted the Project management.

One can see in the menu that it contains Project participants' descriptions, Project Committees as well as provides with detail description of the Project Meetings.

Conclusions

Direct impact of the Project will be in elaboration of on the base of dedicated studies of the expert groups practical recommendations for regional level activities in basic and applied environmental problems solving. It should include based on satellite remote sensing methods, local measurements and numerical modeling early detection and monitoring of accidents in process of petroleum/gas production and transporting including their influence on water, soil, vegetation and animals; appearance of new forest fires and flambeau lights, variations in Siberian rivers runoffs and wetland regimes; best approaches to mitigate environmental risks in process of industrial activity in the region and modern technologies for remediation of damaged territories.

Anticipated strategic impact of the CA is in yet started via the Project Portal dissemination of effective approaches and tools for monitoring, management and remediation of man-made environmental risks in Siberia and in suffering from similar problems regions of NIS. Due synergism and synchronization in performance of recently started by the Partners projects it also should improve the state-of-the-art of Environmental Science and applications in Russia, NIS and EU. We hope that elaborated by the expert groups practical recommendations being implemented at the Siberian federal District will lead to improvement of well being and security of local population as well.

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