Modeling Climate/Global Change and Assessing Environmental Risks for Siberia

MAN-INDUCED ENVIRONMENTAL RISKS: MONITORING, MANAGEMENT AND REMEDIATION OF MAN-MADE CHANGES IN SIBERIA
enviroRISKS
FP6 EC project

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A central direction of climate models development is associated with an increasingly accurate description of all physical processes participating in climate formation. At the same time, it is quite urgent now to use modern mathematical models in studying regional climate and ecological peculiarities, in particular, that of Northern Eurasia. It is related with the fact that, according to modern ideas, natural environment in mid- and high latitudes of the Northern hemisphere is most sensitive to the observed global climate changes. One should consider such tasks of modeling regional climate as detailed reconstruction of its characteristics, investigation of the peculiarities of hydrological cycle, estimation of the possibility of extreme phenomena to occur, and investigation of the consequences of the regional climate changes for the environment and socio-economic relations as its basic tasks.
Changes in nature and climate in Siberia are of special interest in view of the global change in the Earth system. Siberia is undoubtedly a ponderable natural territorial region, which is characterized by the various combinations of climate-forming factors. Forests, water, and wetland areas are situated on a significant part of Siberia. They play planetary important regulating role due to the processes of emission and accumulation of the main greenhouse gases (carbon dioxide, methane, etc.). Evidence of the enhanced rates of the warming observed in the region and the consequences of such warming for natural environment are reasons for integrated regional investigations in this region of the planet.
Reported is an overview of some results obtained in course of carrying out recently finished EC FP6 **Enviro-RISK** project (www.dmi.dk/dmi/sr08-05-3.pdf).

Introduction

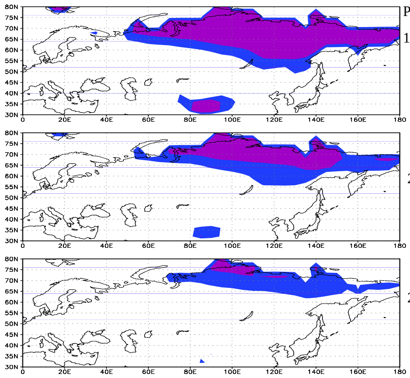
The central problem of the modern theory of climate is the prediction of its changes caused by anthropogenic activities. The principal methodological basis for solving this problem is numerical simulation of the climate system with the aid of climate models based on global atmosphere–ocean general circulation models. It is clear that the formulation of the climate models requires a comparison with real data and special-purpose field experiments in addition to observations carried out on a continuous basis. Analysis of the results of these experiments must enable the construction of increasingly more accurate models of specific physical processes determining the dynamics of the climate system.

It is quite urgent now to use modern mathematical models in studying regional climate and ecological peculiarities, in particular, that of Siberia. It is related with the fact that, according to modern ideas, natural environment in mid- and high latitudes of the Northern hemisphere is most sensitive to the observed global climate changes. One should consider such tasks of modeling regional climate as detailed reconstruction of its characteristics, investigation of the peculiarities of hydrological cycle, estimation of the possibility of extreme phenomena to occur, and investigation of the consequences of the regional climate changes for the environment and socio-economic relations as its basic tasks. The vast continental territory of Siberia (about 10 million km2) is undoubtedly a ponderable natural territorial region of Eurasian continent, which is characterized by the various combinations of climate-forming factors. Forests, water, and wetland areas are situated on a significant part of Siberia, which play planetary important climate regulating role due to the processes of emission and accumulation of the main greenhouse gases (CO_2, CH_4, etc.).

Permafrost and seasonally frozen ground in most regions (and, especially, in Siberia) show large changes in recent decades. Accordingly to Pavlov (2003), permafrost temperature increased approximately 1 ˚C at depths between 1.6 and 3.2 m from the 1960s to the 1990s in East Siberia, and about 0.3 ˚C to 0.7 ˚C at a depth of 10 m in northern West Siberia.

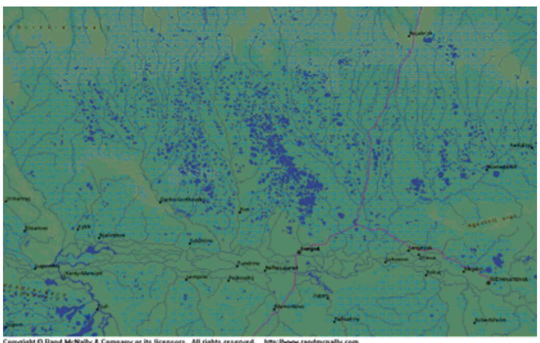
RESULTS

The IPCC scenarios for future concentration of greenhouse gases were used to estimate possible both global and regional (in particular, for Siberia) consequences. Accordingly to the INM climate model results, the global warming to the end of 21st century will be, depending on scenario, of value from 2.0oC to 3.5oC. The most pronounced warming is expected in Arctic and in middle latitudes, especially, in Russia. For example, under scenario A1B the global warming is expected to be about 3.3oC, while the winter warming in Russia is estimated from 4-6oC in southern part to 8-10oC in northern regions. In summer, the warming in Russia is estimated from 5-6oC in south to 3-4oC in north. Thus, one can expect essential consequences of this warming to the Siberia environment. Below possible catastrophic shortage of the permafrost area in Siberia to the end of 21st century are shown.

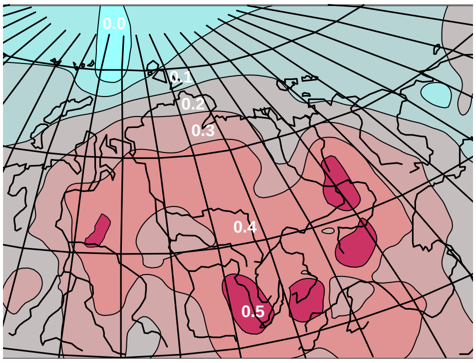


PERMAFROST
1981-2000
2081-2100 B1
2081-2100 A2

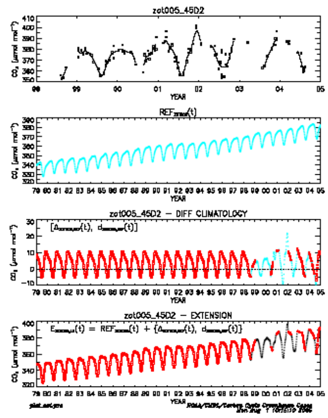
Crucial importance is the interaction of the atmosphere with hydrologically heterogeneous land – the territory, occupied by a dense network of water bodies (lakes, rivers, wetlands, etc.), covering a significant fraction of the total area. Under conditions of strong synoptic flow, the breeze circulation is almost negligible, but even in this case lakes still considerably affect the structure of the boundary layer (Stepanenko et al., 2006). Thus, it is possible to suggest that the further improvement of land-surface schemes might be done by taking into account effects of the land surface heterogeneity, including the methane emissions from thermokarst lakes (in particular, in Siberia, see: http://knb.ecoinformatics.org/knb/metacat/nceas.891/nceas).



Map of linear trends of annual mean near-ground temperature during the period from 1965 to 2000 (data taken from the NCDC site (Ashvill, USA, http://www.ncdc.noaa.gov) Contours on this map show the regions with different value of the trend (different gray scales) in 0.1°C step of warming during 10 years. As is seen from this figure, the rates of warming on the entire territory of Siberia in the second half of XX-th century were quite high (more than 0.2°C per 10 years), and in some regions they reached the value of the linear trend of 0.5°C/10 years.



From the data obtained from the Terrestrial Carbon Observation System Siberia (TCOS-Siberia) project the expected high inter-annual variability of terrestrial carbon fluxes became clearly obvious, that is driven by the large variability of climate and fire occurrence. A very interesting finding was that Siberia seems to be a smaller sink than generally assumed: the amount of the carbon sequestration of Siberia is only less than 20% of the fossil fuel emissions from the Russian Federation. Thus, the question if Siberia acts on a long-term scale as source or sink for carbon is still unsolved. In consequence, the continuation of measurements is mandatory, with broadening the focus on additional effects due to climate change for example on permafrost and ecosystem migration, and on effects of local and regional anthropogenic impacts. Globally effective anthropogenic influences are affecting directly the local scale, while local contamination and exhaustive cultivation are responsible vice versa for global impacts. Max-Planck-Institute for Biogeochemistry (MPI-BGC) conducts several projects focusing on Siberian key ecosystems and atmospheric research with respect to climate change (Sabine et al., 2003, Canadell et al., 2004). An example given presents CO_2 data from the lowest flight level at Zotino profile site (~60°N / ~90°E).



CO_2 data from the lowest flight level at Zotino profile site (implemented in NOAA/CMDL GLOBALVIEW-CO2 database). [Panels from top to bottom : top - Time series of CO_2 mixing ratios; middle - Reference marine boundary layer time series; bottom - Difference between measurement and reference (blue circles; interpolated *red circles* and extrapolated *red squares* differences) and extended record including smoothed measurement data and interpolated and extrapolated values derived from data extension procedure].

Concluding remarks

At present, the challenge facing the weather and climate scientists is to improve the prediction of interactions between weather/climate and Earth system. The World Modelling Summit for Climate Prediction was held at the European Centre for Medium-Range Weather Forecasts on 6 – 9 May 2008 with the aim to develop a strategy to revolutionize prediction of the climate, in particular, at the regional level (http://wcrp.ipsl.jussieu.fr/Workshops/ModellingSummit/). It was recognized that considerably improved predictions of the changes in the statistics of regional climate (especially, of extreme events) are required to assess the impacts of climate change and to develop adaptive strategies to ameliorate their effects on environment and society.

Thus, one can hope to arrive to kilometre-scale modelling of the global climate system, which will enable scientists to advance understanding and representation of the physical and biogeochemical processes responsible for climate variability and predictability and determine related risks on regional and local levels.
Such activity at regional Siberian scale has been recently started by informal consortium comprising groups from INM RAS, IMCES and ICMMG SB RAS, SCERT and MPI Institutes. First results are expected to be presented next year.