EDITORIAL

Siberia Integrated Regional Study: multidisciplinary investigations of the dynamic relationship between the Siberian environment and global climate change

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This is an editorial overview of the Siberia Integrated Regional Study (SIRS), which is a large-scale investigation of ongoing and future environmental change in Siberia and its relationship to global processes, approaches, existing challenges and future direction.

1. Introduction

The SIRS is a mega-project within the Northern Eurasia Earth Science Partnership Initiative (NEESPI), which coordinates interdisciplinary, national and international activities in Northern Eurasia that follow the Earth System Science Program (ESSP) approach. Under the direction of the International Geosphere–Biosphere Program (IGBP), SIRS is one of the Integrated Regional Studies (IRS) that aims to investigate environmental change in Siberia under the current environment of global change, and the potential impact on Earth system dynamics [1]. The regions of interest are those that may function as ‘choke or switch points’ for the global Earth system, where changes in regional biophysical, biogeochemical and anthropogenic components may have significant consequences for the Earth system at the global scale. Siberia is a large and significant region that may compel change [2].

Regional consequences of global warming (e.g. anomalous increases in cold season temperatures) have already been documented for Siberia [3]. This result is also supported by climate modeling results for the 20th–22nd centuries [4]. Future climatic change threatens Siberia with the shift of permafrost boundaries northward, dramatic changes in land cover (redistribution among boreal forest, wetlands, tundra, and steppe zones often precipitated by fire regime change) and the entire hydrological regime of the territory [5–8]. These processes feed back to and influence climate dynamics through the exchange of energy, water, greenhouse gases and aerosols [9]. Even though there have been a handful of national and international projects focused on the Siberian environment, scientists have minimal knowledge about the processes that control change in this understudied region, particularly those concerning the primary components that influence regional climate (i.e. cloud cover, precipitation) and responses and feedbacks to and from terrestrial and aquatic systems. This provides a strong impetus for the SIRS project.

SIRS was initiated at a boreal forest conference in Krasnoyarsk in 2002 under the auspices of the IGBP and ESSP regional strategy by Will Steffen (IGBP) and the
Siberian Branch of the Russian Academy of Sciences (SB RAS). Russian and foreign scientific activities continued under the Siberian Center for Environmental Research and Training (SCERT) in 2003. In 2005, the Siberian Branch of the Russian National Committee (SB RNC) for IGBP endorsed these activities and recommended investigations focus on four major themes:

- quantification of the terrestrial biota full greenhouse gas budget, with a focus on the exchange between biota and atmosphere;
- monitoring and modeling of regional climate change impacts;
- development of SIRS informational-computational infrastructure; and
- development of a regional strategy of adaptation to and mitigation of the negative consequences of global change.

SIRS development [10, 11] supports Siberian Earth science investigations funded by the RAS Foundation for Basic Research, the European Commission (EC), the International Science and Technology Center (ISTC) and the National Aeronautics and Space Administration (NASA). SB RNC is responsible for SIRS advances, and SCERT hosts the Committee office and houses major SIRS informational-computational infrastructure development. NEESPI (www.neespi.org/) serves as an IGBP and World Climate Research Programme (WCRP) external project, and as a NEESPI mega-project, SIRS has organized distribution centers in Krasnoyarsk and Tomsk to support NEESPI activity, and has coordinated training and educational activity aimed at young scientists.

2. SIRS approaches and outcomes

2.1. Organizational activity

The ‘Siberian Geosphere–Biosphere Program: integrated regional study of contemporary natural and climatic changes’ is one of several funded interdisciplinary projects, and it serves to unite regional studies from 14 RAS and SB RAS institutes and 5 universities. In the course of this and similar national1 and international projects, ENVIROMIS and ENVIROMIS-2 (Environmental Observations, Modelling and Information Systems) was formed, which is the SIRS professional community comprising regional, national and international specialists dealing with Siberian environmental dynamics studies. Results of those and parallel projects were analyzed in coordinated activities: ‘Enviro–RISKS-Man-induced Environmental Risks: monitoring, management and remediation of man-made changes in Siberia’ [12]. Currently, a new set of SB RAS integrated2 and international projects within the Asia-Pacific Network for Global Change Study (APN) and ISTC are under way. While a number of projects have been initiated and clustered under the SIRS umbrella and their results and data are distributed through the SIRS web portal (http://sirs.scert.ru/), the organizational SIRS infrastructure is inadequate. SIRS has neither SB RAS stable funding nor a dedicated Project Office. Both obstacles are a major concern for the SIRS governing body.

2.2. Information-computational infrastructure development

The SIRS informational-computational infrastructure, which is currently under extensive development, is designed to stimulate national and international cooperative Earth science investigations, easily exchange data and knowledge, coordinate activities, and optimize the usage of resources, services and applications [13]. The infrastructure is organized as a set of thematic, bilingual

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1 For example, ‘Complex monitoring of the Great Vasyugan Bog: modern state and development processes investigations’ and ‘Ecological problems of Siberian cities’.

2 For example, ‘Models of biosphere change based on the boreal ecosystems’ carbon balance using field and satellite data observations’ and ‘Information technologies, mathematical models and methods for monitoring and control of ecosystems intended for stationary, mobile and remote observations’.
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Russian and English), internet-accessible informational-computational systems, the first of which is the scientific web portal ATMOS (http://atmos.iao.ru/). ATMOS is an integrated set of distributed topical websites, combining standard multimedia information with research databases, models and analytical tools for on-line use and visualization, designed primarily for atmospheric physics and chemistry (http://risks.scert.ru)/3 [12, 14]. These powerful tools have already promoted understanding of the interactions between Siberian ecosystems, the atmosphere and human dynamics, under the impact of global climate change. For example, the climate site of the Enviro–RISKS portal (http://climate.risks.scert.ru/) processes unique data sets, from monitoring and modeling regional meteorology, atmospheric pollution transformation/transport and climate, all of which are significant for dynamic regional assessments. This is a user-friendly, interactive web system that can be used for regional climate change assessment and visualization based upon standard meteorological data. All major reanalysis and climatic characteristics are provided (surface air temperature, pressure, humidity, precipitation, soil moisture, and geopotential height), and the users can (but do not need to) access the data files directly but freely receive the results of their analyses through the Grid Analysis and Display System (GrADS; www.iges.org/grads/) or Interactive Data Language (IDL; www.itvis.com/idl/). Specific spatial and temporal domains can be selected, as well as a wide range of statistical analyses, data manipulations, and visualization tools (including animation) that may be required for global, continental, and regional climate change assessments. The SIRS infrastructure has become an indispensable tool, providing researchers with an open platform (portal plus tools) that may be used, adapted, enriched or altered on the basis of the specific scientific applications in regions of Siberia, the Russian Federation, and the northern exatropics.

2.3. SIRS capacity building/young scientists’ education/training

The SIRS educational capacity building programme includes ENVIROMIS biannual Multidisciplinary Conference, CITES (Computational and Information Technologies for Environmental Sciences) biannual Young Scientists’ School (YSS) and international conferences [15]. These include lecture courses for young scientists, training sessions, invited lectures and thematic workshops (www.scert.ru/en/conferences/). The first event was organized in 2000, and thereafter each year 50–70 young scientists from Russia and the Commonwealth of Independent States participate in CITES and ENVIROMIS conferences. These events are organized to support multidisciplinary education, contain no parallel sessions, are composed of about 50% students, and all presentations are posted to assist future professional activity. In the first years, these activities were supported internationally (INTAS, the EC International Cooperation Program within FP5 and FP6); however, recent activities have been supported by the Russian Foundation for Basic Research, the RF Ministry of Education and Science and the SB RAS.

2.4. Some results gained in the course of SIRS projects being carried out, and current challenges

While some findings on regional climate dynamics were reported in the EGU 2009 NEESPI session and in manuscripts listed on the NEESPI website (www.neespi.org/science/NEESPI_publications.pdf), a majority of them have been published in Russian journals and are still unknown in the international climatic community. However, additional reports can be found in the

3 ‘Environmental observations, modeling and information systems’ (http://enviromis.scert.ru/) and ‘Man-induced environmental risks: monitoring, management and mitigation of man-made changes in Siberia (Enviro–RISKS)’. 
Enviro–RISKS final scientific report [16], mainly in the third volume devoted to climate change, terrestrial ecosystems and hydrology (www.dmi.dk/dmi/sr08-05-3.pdf). We have already established that temperatures have increased, particularly in the winter in Eastern Siberia (0.5°/decade), and the number of frost days (∼ 1 day yr⁻¹) and growing season length has also increased (∼ 1 day yr⁻¹) [17, 18]. Even more troubling is the potential for these transient phenomena to manifest themselves as nonlinear reactions to ongoing climatic change [19].

There are three main scientific research challenges to the SIRS community, which are also very important from a regional socio-economic point of view and for the global carbon cycle.

• Permafrost fate, especially its border shift, seriously threatens infrastructure and might form a significant carbon and methane source to the atmosphere. Climate-related drying would alter biogenic emissions in peatlands that have been deposited over millennia and would increase the potential for peat fires which cannot be extinguished.

• Temperature/precipitation/hydrology regime change, which might increase risks of forest and peat fires, thus changing significantly the carbon, terrestrial and hydrologic cycle of the region.

• Desert–steppe–forest–tundra ecosystem borders northward shifts, which will also change regional input into the global carbon and radiation balance and give rise to serious socio-economical consequences for local populations (i.e. alter potential agricultural lands).

New in situ instrumentation, data sets, models and research are required to address these challenges. The SB RAS has adopted a long-term integrated project ‘Development of the basic network for monitoring of natural and climatic processes in Siberia’ to establish a network of dedicated sites and stations equipped with modern instrumentation to monitor environmental changes in the region. One example is the Zotino tall tower observatory (ZOTTO) launched a few years ago (www.sfu-kras.ru/science/achievement/zotto/public) [20]. It is anticipated that together with ZOTTO, the future SB RAS network will serve as an important source of reliable environmental data for analyses. Another important SIRS objective is the development of a high-resolution regional climate model that properly takes into account specifics of this region (e.g., presence of permafrost, interaction of the biosphere and terrestrial hydrology, etc). Development of an integrated model was recently discussed at the NEESPI Workshop (www.scert.ru/en/conferences/cites2009/) by leading SIRS specialists and their German and US partners.

3. Conclusions

Devoted to regional–global linkages, understanding, monitoring and assessment of global change impacts on a regional level, SIRS targets provide substantiated recommendations for regional decision makers to understand and work towards mitigating the negative effects of climate change for Siberia and its population. This approach will allow the Siberian Branch of the Russian National Committee for IGBP to perform its mission, ensuring the growth of scientific knowledge of the dynamic Siberian environment and its subsystems, and to develop a solid basis for mitigation and adaptation strategies for the negative consequences of global change.

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