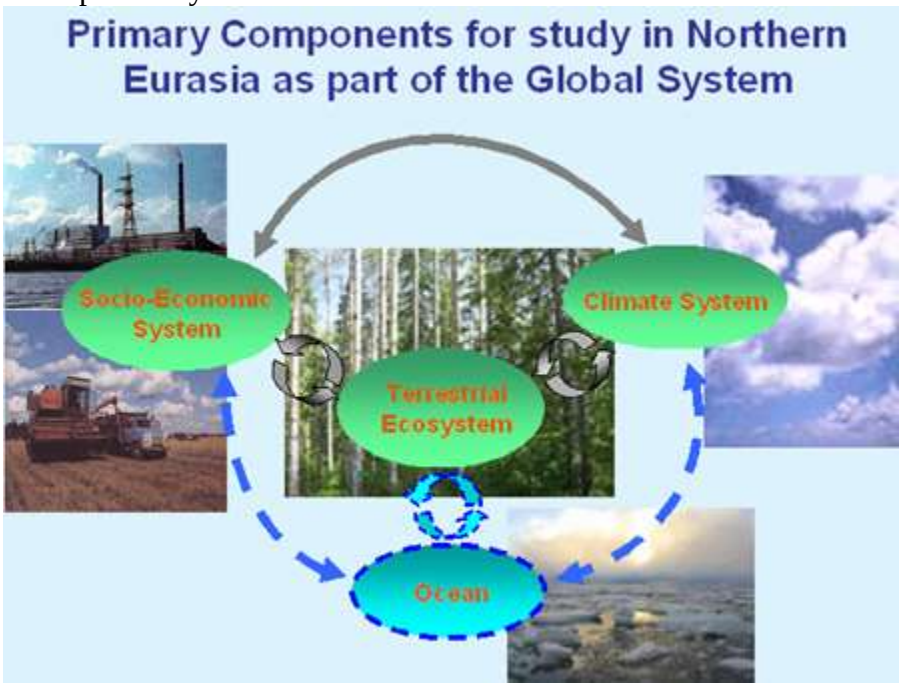
Summary of the Northern Eurasia Earth Science Partnership Initiative (NEESPI) Workshop, Petrozavodsk, Russia, 1-5-September 2013 devoted to ***Current Status and Future Earth System Studies in Northern Eurasia***

Background.

Among four major components of the Earth Global System, NEESPI is addressing three of them leaving the oceanosphere beyond the Initiative foci.



Northern Eurasia is a sensitive and rapidly changing area with the signal of climate change effects already observed in many components of the Earth's system. The surface warming in the NEESPI domain since the commencement of extensive instrumental observations (around 1881) is 1.5˚C. During the past 50 years the rate of the annual temperature increase here was 0.33˚C per decade which is substantially larger than for the globe. Additionally, this region experienced a shock impact of the abrupt institutional and economic changes in the former Soviet Union countries as well as in East Europe, Mongolia, and China. The goal of the Initiative launched nine years ago is to study climate-ecosystem interactions and societal impacts in boreal and non-boreal zones of Northern Eurasia (http://neespi.org/science/science.html). The current version of the NEESPI Science Plan was finalized in December 2004. Designed for the decade, nine years later, NEESPI is in its concluding stage as a focused activity. NEESPI became an international program involving 30 countries and more than 200 institutions. Over 750 scientists have been working in about 160 individual NEESPI projects. NEESPI was implemented by assembling international teams of scientists, reaching out to local scientists to build partnerships and combine local data/knowledge with international science. The legacy of the Initiative is in its established connections, ongoing synthesis of the previous studies and a new generation of scientists that emerged from the NEESPI projects, with over 75 Ph.D. students defending their theses in the NEESPI framework. Twenty nine books and over 1200 peer-reviewed articles have been published or are now in press. It is a right time to reassess the NEESPI Science Plan and put forward a new set of science questions that (a) are based upon the

Initiative past findings and (b) account for new challenges, Earth Science advances, and opportunities that have emerged during the past decade since the NEESPI Science Plan release.

Objectives of the Workshop.

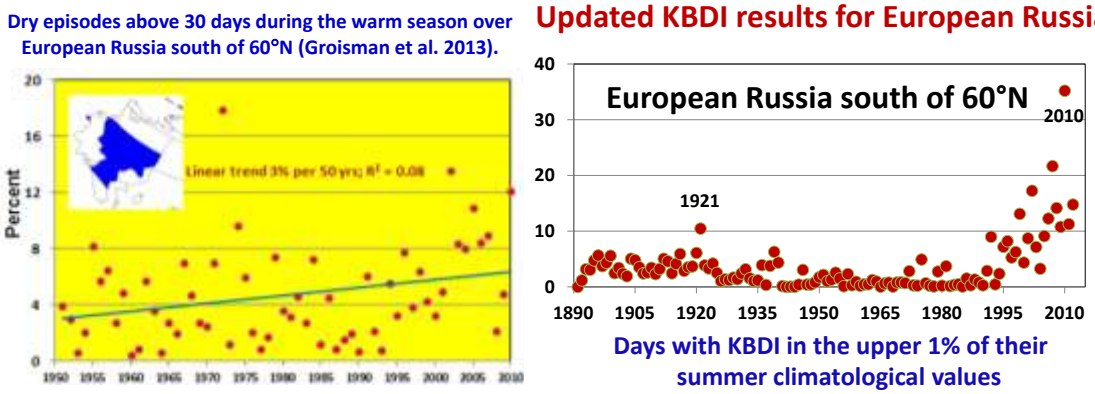
- To assess the present state of regional Earth System modeling capabilities in providing the knowledge required for societies in the region and beyond to face risks posed by global environmental change and to seize opportunities in a transition to global sustainability.
- To accumulate the new set of scientific ideas for regional projects that succeed the NEESPI Science Plan under a tentative title "*FUTURE Northern Eurasia*"

Workshop Summary.

The latest NEESPI research foci was on integrated assessments and projections and includes summation of all knowledge in books and overview papers, expanding and maintaining of the regional observational data base, and developing regional Earth System modeling capabilities to provide the knowledge required for societies in the region and beyond to face risks posed by global environmental change and to seize opportunities in a transition to global sustainability. This is a prelude to a new initiative by ICSU/ISSC *Future Earth*.

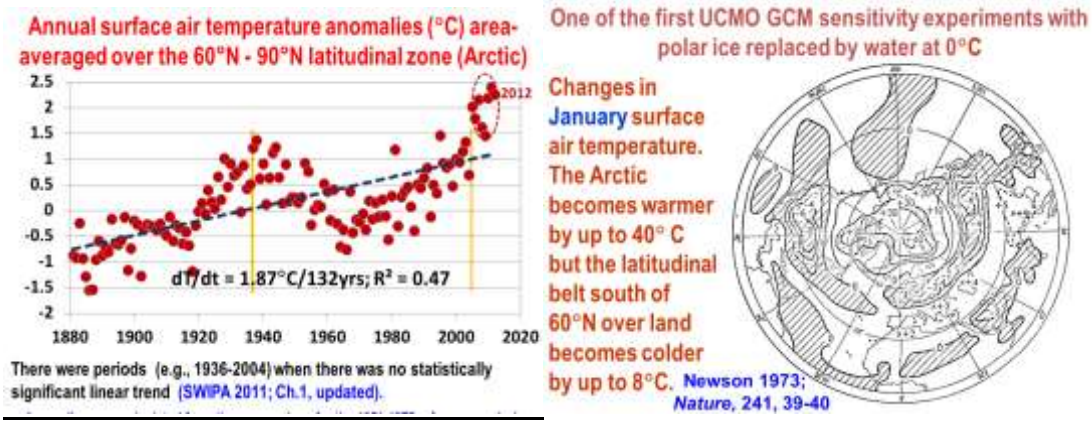
The Workshop concluded that the Major NEESPI Science question: "How do Northern Eurasia's terrestrial ecosystems dynamics interact with and alter the biosphere, atmosphere, and hydrosphere of the Earth?" remains intact. However, new challenges and science foci emerge. Among them are urgent needs to understand and project:

1. Dynamics of **extreme events** in Northern Eurasia in changing climate and environment;



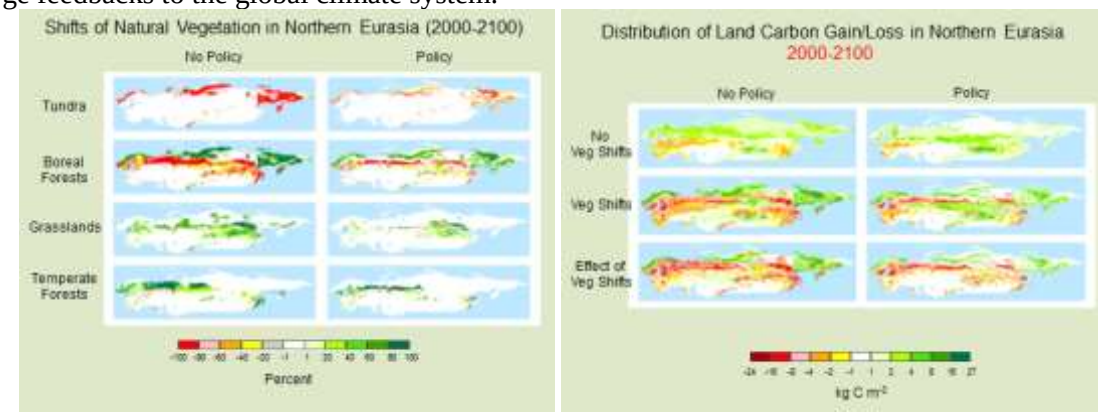
Figures that illustrate the first challenge (Groisman et al. 2013). Changes of the frequency of unusually dry summers in European Russia. ***Left:*** Prolonged no-rain events in the past 60 years and ***Right:*** Time series of the region-wide frequency of unusually high values of the Keetch-Byram Drought Index (KBDI, which is a combination of high temperatures and low rainfall totals) responsible for intensification of the fire weather. Being brought together, these two characteristics clearly show that the disastrous extreme summer of 2010 in this part of the world was not only a manifestation of rainfall deficit but also a function of high temperatures. In fact, July-August mean regional temperature over this region was 2˚C higher than in any year during the period of large-scale instrumental observations (i.e., during the past 130 years).

2. Near-future and long-term regional and **global impact of the rapid Arctic warming**;



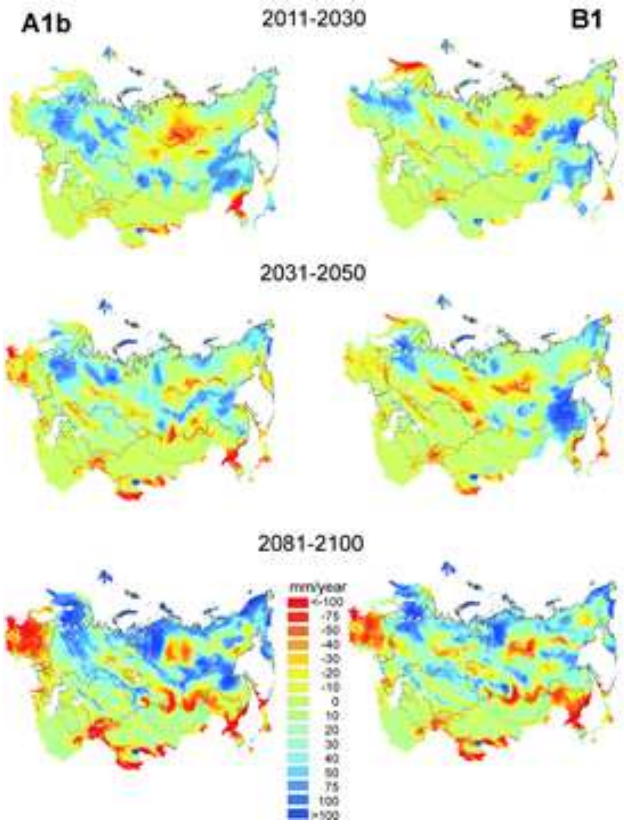
Figures in support of the second challenge. Unprecedented warming in the Arctic has already caused a significant sea ice retreat in the end of the warm season. As a result, increasing of the open water areas in the Arctic Ocean, thinning of the sea ice cap, and additional influx of the water vapor and heat into the Arctic atmosphere may change atmospheric circulation in the northern extratropics as we know it (up to extremes shown in the 40-yrs-old modeling result).

3. **Regional carbon cycle and land cover changes** and their feedbacks to the Global Earth System. Northern Eurasia contains large areas of peatlands, boreal forests, grassland and tundra, which stores a large amount of organic matter and carbon in their vegetation, soils, and permafrost. The fate of this organic matter and carbon is uncertain under the future climate conditions and human activities. The biogeochemical cycles of carbon, nitrogen, ozone as well as phosphorous could exert large feedbacks to the global climate system.



Figures that illustrate the third challenge (Zhuang et al. 2013). Biospheric models indicate major changes in the biogeochemical cycle in Northern Eurasia and show our ability to mitigate them to some extent.

4. It was concluded that global and **regional food and water security** can be at risk with observed and projected changes because most fertile lands of the densely populated southern half of the NEESPI domain are in the areas of risky agriculture due to the increasing water deficit. This raises demand for further studies of **societal feedbacks to detrimental changes across Northern Eurasia (i.e., adaptation and mitigation problems).**



Future projections of the hydrological cycle in the NEESPI domain

The figure shows mean annual anomalies in annual river runoff estimated for ECHAM5 GCM climate projections for SRES emission scenarios (A1b left column and B1 right column) versus base scenario 20C3m over 1961-1991. Most significant runoff increases are projected along the Arctic Ocean coastline, in Northern Europe and the Russian Far East. **A decrease in runoff is expected in most southern regions of the NEESPI domain.**

Figures that illustrate the fourth challenge (Shiklomanov et al. 2013).

Integration of models that describe different aspects of the regional Earth System is occurring but has to be further intensified. In the past, the outputs of the Global climate models (GCMs) were used as an input for regional climatic and hydrological models (RCMs and HMs) that were thereafter used for impact assessments. Currently, RCMs and models of the surface block: HMs, biospheric models, cryospheric models, dust formation models, and socio-economic models began interacting among themselves, use the output of each other and are moving together towards a suite of integrated models comprehensively describing natural and anthropogenic terrestrial processes. This suite eventually will be able to explain and project the processes in context of the Earth System change.

Finally, it was noted new opportunities that are emerging in the Earth Systems studies including **new generation of the Global Earth System models and new remote sensing products** that have been already delivered to the scientific community and/or those that are just on the horizon (e.g., Global Precipitation Mission, GPM, that for the first time will cover high latitudes where the NEESPI domain resides).

Workshop attendees capitalized on participation of a representative group from the modeling community involved in climate, weather, hydrology, biosphere, and land use modeling. **A special suite of statements and recommendations was compiled regarding the role of modeling in the comprehensive assessment of contemporary and future changes in Northern Eurasia:**

1. GCMs are not designed for regional assessments. Therefore, only GCMs with adequate spatial resolution (i.e., the resolution that allows to describe key regional processes) should be used for the region if we need to account for its specifics. We would like to use those GCMs that meet certain criteria regarding consistency with observations, to show major large scale patterns that directly or indirectly impact the NEESPI domain from all directions beyond its boundaries.
2. In addition, most existing GCMs and Earth System Models do not include representations for number of processes, such as dust storms, forest fires and land use, which are likely to have large impact on the climate change in the NEESPI domain.. Changes in snow cover, permafrost, glaciers, biosphere, and Arctic shelf sea ice all have special impact to Eurasia. Therefore, parameterizations of the physical processes governing changed in these components should be improved. When needed, the use of regional models should be promoted.
3. It was specifically noted that only two GCMs are available in the Russian Institutions that can capitalize on local knowledge; other modeler groups should seek international collaboration to better address the regional specifics (land cover species specifics, permafrost and soil distributions, etc.). Most of the climate models do not include the detailed land surface model or the biological/hydrological cycle model. The stand-alone specific models are not suitable for the regional analysis. Therefore, sharing observational data with different modeling groups for climate model assessment and analysis should be considered mandatory and encouraged on the international level (a good example is the collaboration between NASA and the Russian Academy of Sciences). These days, many observational data can be found through the networking.
4. In the NEESPI domain, the socio-economic issues are very closely connected with the climate change problems. Therefore, Earth System Models (ESMs) are needed that incorporate the above mentioned specifics of the domain and incorporate the controls (by decision makers) and economic (socio-economic) models directly into the ESMs. Generally, the regional studies in the NEESPI domain require models that are "larger" and more complicated than climatic models. They might include biospheric, meteorological, hydrological, and permafrost models as well as socio-economic model and/or decision-makers considerations. So, these ESMs should include anything that can change the Earth System and affect the **society well-being**.
5. Methods for the data processing and analysis of the CMIP5 results should be further developed. From CMIP5 models we have to select the so-called trusted climate models, e.g. the models that simulate reasonably well the regions we are interested in. It is necessary to define the rules for model selection, such as their ability to simulate (in addition to climatology and major tendencies) the prime modes of variability (NAO, ENSO, PDO, North Atlantic Multidecadal Oscillation, etc.).

6. A bias correction approach should be further explored. This means to correct the modeling results for the historical period (20^{th} century) and then apply the same correction for the future climate scenarios.
7. While we hope to use mostly a "feedback approach" (when regional changes interact with large-scale climatic, environmental, and societal processes), impact models are still required that
    a. are seamlessly linked to GCMs and
    b. address specific concerns of the regional societies.
8. Negative experience with NCEP/NCAR reanalyses was mentioned. These products are not quite good enough for the Eurasian continent because few synoptic data were provided by the Meteorological Agencies for reanalysis data production and ERA40 reanalysis data are also not quite suitable for the model inter-comparison. ERA40interim reanalysis data are much improved and may be useful for regional research. When "locals" prevent modelers from access to their terrestrial information, they "shoot themselves in the foot" with respect to their future ability to use the models' output.
9. We have to emphasize an attention to the **processes that can produce the issues in the future**, such as the permafrost thaw, change of the snow cover characteristics, and other changes that may affect different components of the Earth environment, human life, and economic activity.
10. It is suggested to set up some projects for early career scientists (ECS). Experience of the present NASA and RFBR dedicated Calls for ECS Proposals should be explored and improved as possible.