Inter-agency Northern Eurasia Earth Science Partnership Initiative (*NEESPI*) and Science Review Meeting

NEESPI Science Plan Overview

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NEESPI Science Plan Structure

1. INTRODUCTION
2. SCIENTIFIC QUESTIONS AND MOTIVATION
3. MAJOR SCIENTIFIC TOPICS
   - 3.1. Terrestrial ecosystem dynamics
   - 3.2. Biogeochemical cycles
   - 3.3. Surface energy and water cycles
   - 3.4. Land use interactions: societal-ecosystem linkages
   - 3.5. Ecosystems and climate interactions
   - 3.6. Topics of special interest
     - 3.6.1. Cold land region processes
     - 3.6.2. Coastal zone processes
     - 3.6.3. Atmospheric aerosols and pollution
4. REMOTE SENSING
5. MODELING
6. DATA AND INFORMATION TECHNOLOGY
7. EDUCATION
8. RESEARCH STRATEGY

Scientific Background Appendix

Why Northern Eurasia?

- The changes in this region have the potential to affect the entire Earth System and may already be doing so.
- The region has unique features that need to be better understood, parameterized, and accounted for. Without clear understanding of them, the description and modeling of the entire Earth system are not possible.
- The study will have benefits to the societies of the region.
- The region possesses a wealth of scientific talent that can be utilized.

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Unique features of Northern Eurasia

- **The world's largest cold region.**
- **Two thirds of the global permafrost, two thirds of the globe with seasonal snow cover, etc.**
- **The most continental climate ➔**
- **It controls the intensity of the Eurasian monsoon.**
- **The largest land area in extratropics ➔ affects global circulation of the atmosphere.**
- **More than half of terrestrial carbon.**
- **World largest forest; most of carbon is buried in bogs, soils, and, in particular, in frozen soils.**
- **Cut off from the humid tropics ➔**
- **The highest levels of climate and weather variability and highly vulnerable natural and agricultural ecosystems, and extensive and variable dry land areas.**

Accelerated climatic changes

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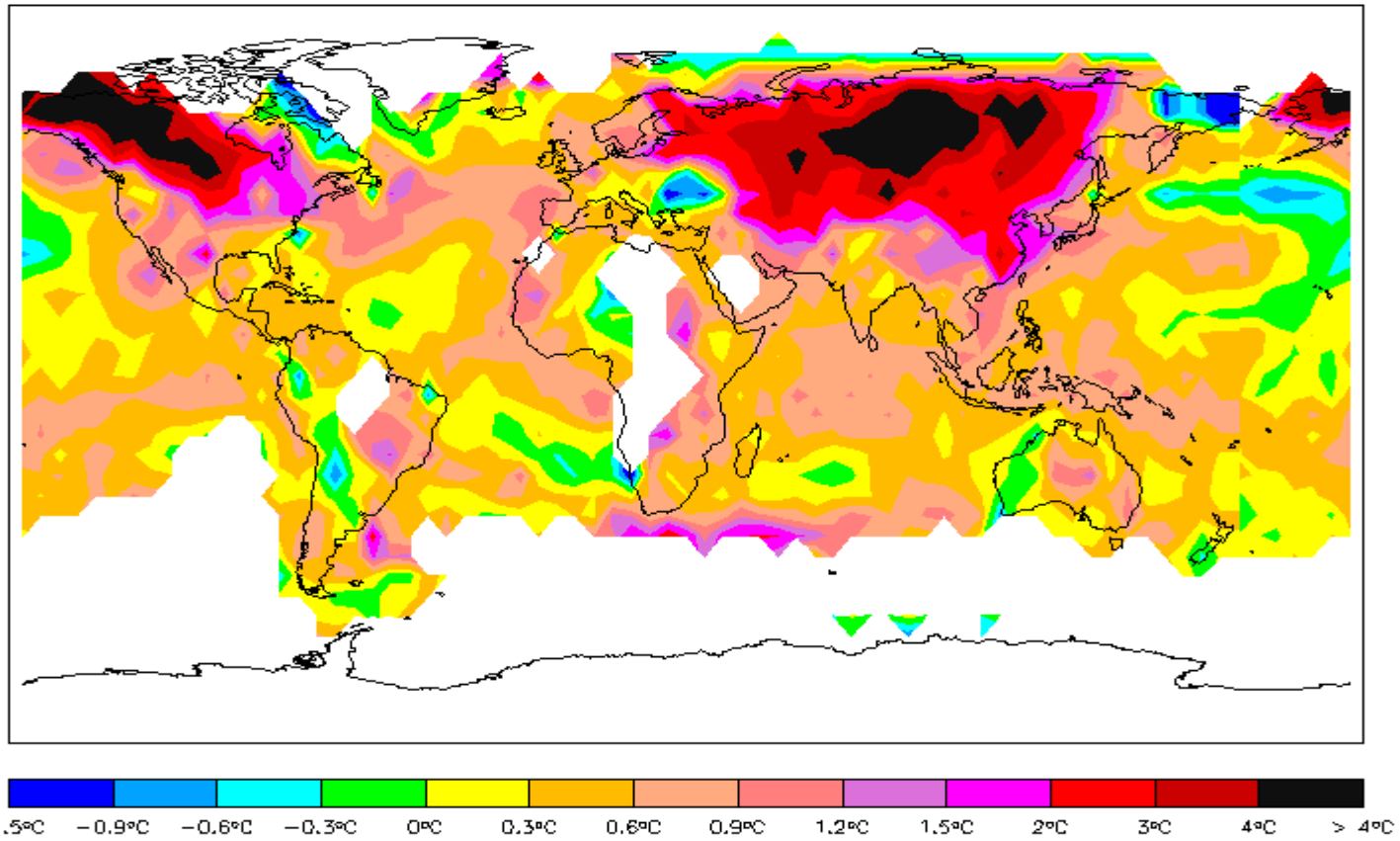
Mean Winter Temperature Change 1965 to 2004 over the globe



- Data source: (Jones and Moberg 2003). Processed by the U.S. NOAA NCDC Global Climate at the Glance Mapping System.

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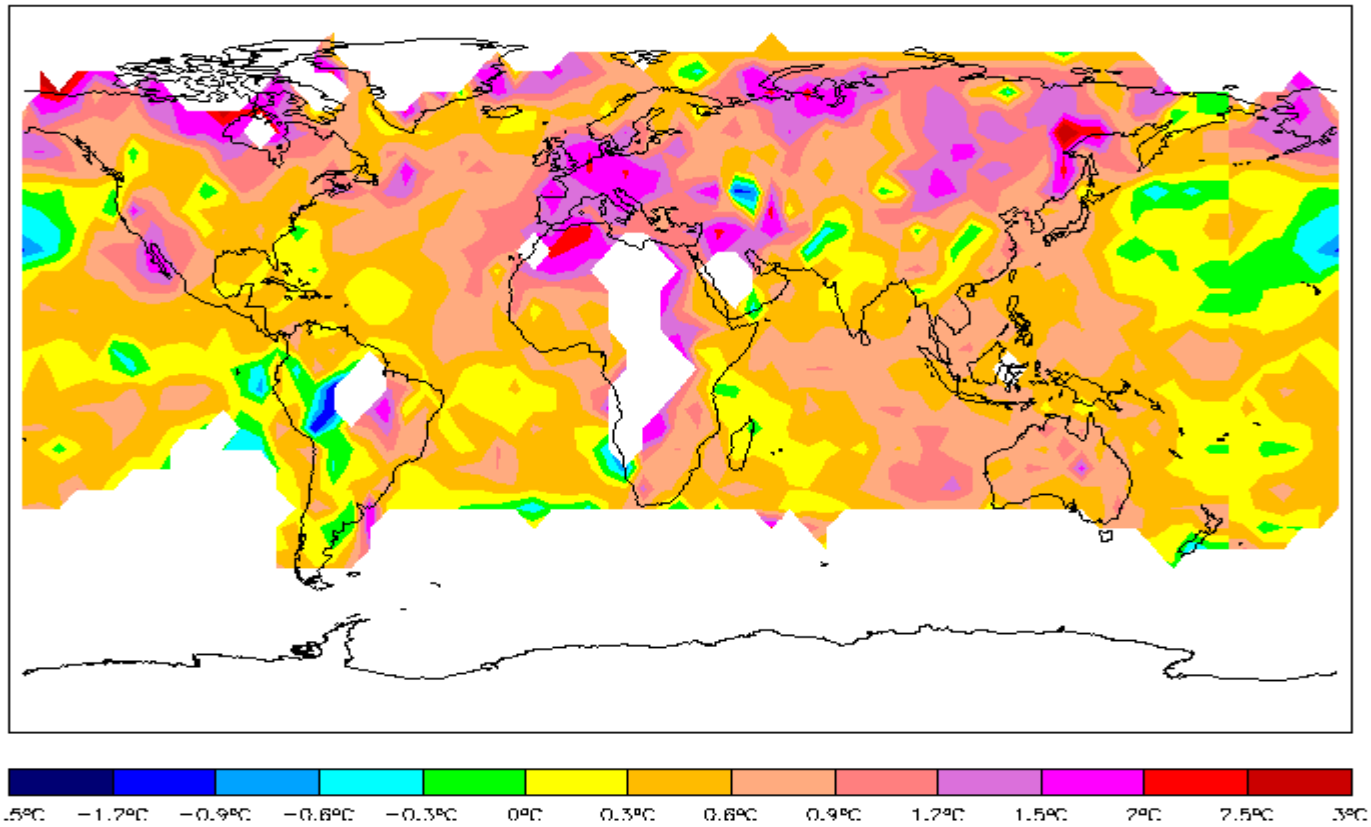
Mean Summer Temperature Change 1965 to 2004 over the globe



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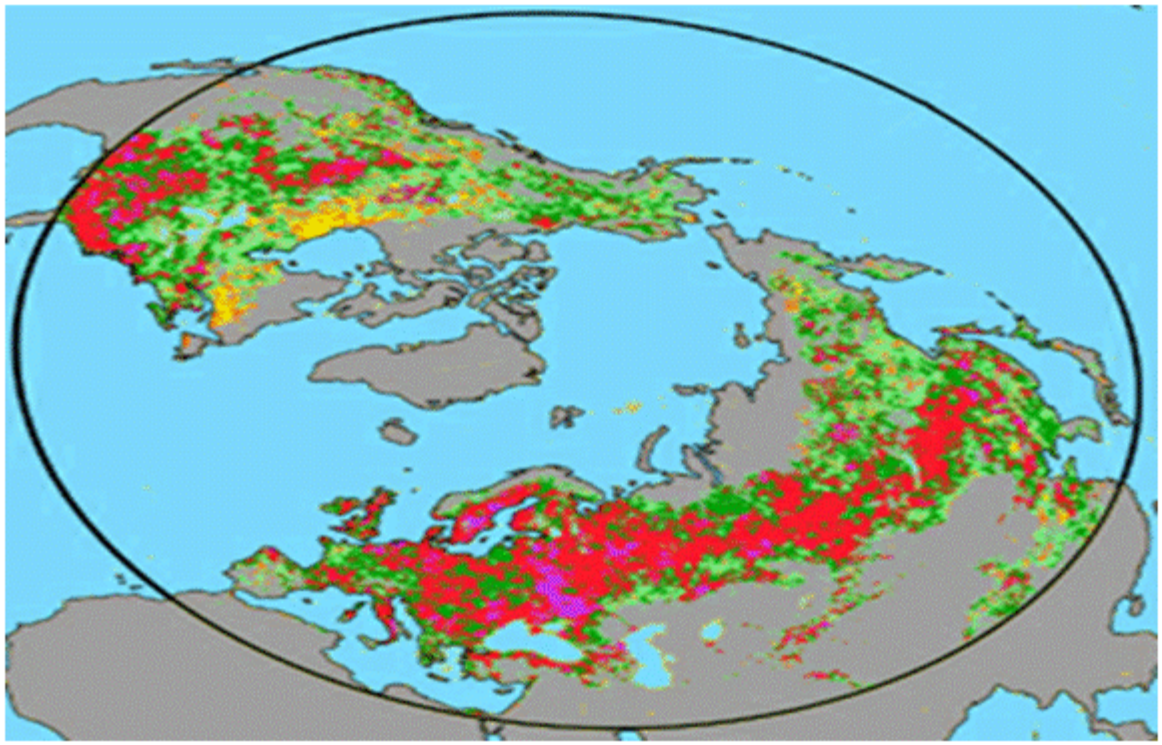
Terrestrial carbon pool may start changing

and there is a lot of carbon in this pool.

Persistence of Normalized Difference Vegetation Index increase: 1981-1999



(Zhou et al 2003). According to the interpretation of NDVI data by Myneni et al (2001), boreal forest might provide the net sink of 0.68 ± 0.34 Gt of C yr^{-1} of which nearly 70% is in Northern Eurasia.

Permafrost thaw

The stability of the ecosystems in more than a half of Northern Eurasia relies on the stability of ice that, so far, holds these systems together.

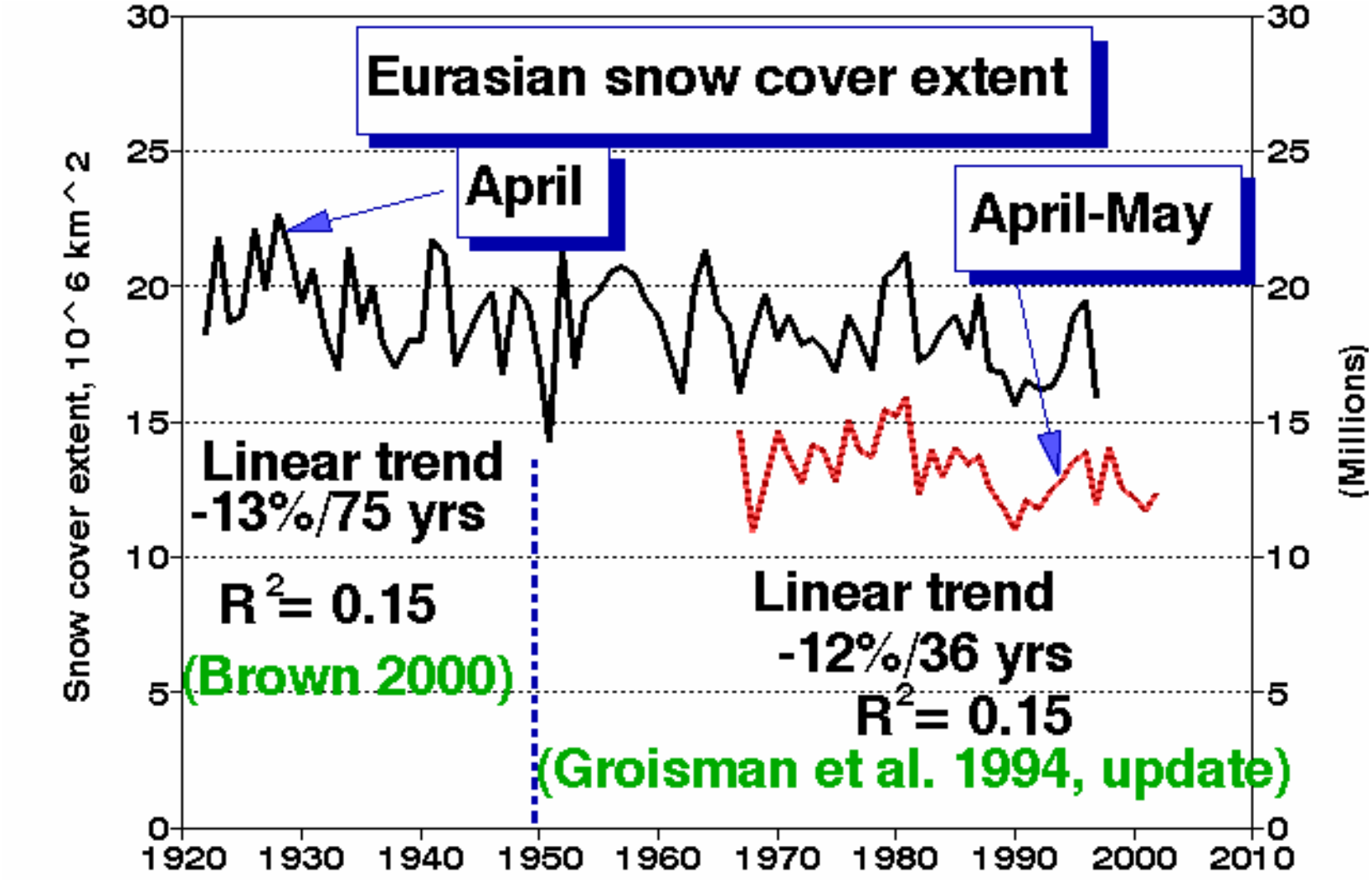
Two possible scenarios after the permafrost thaw:

Wetlands

Steppe

Changes in surface energy & water balances

Retreat of spring snow cover over Eurasia



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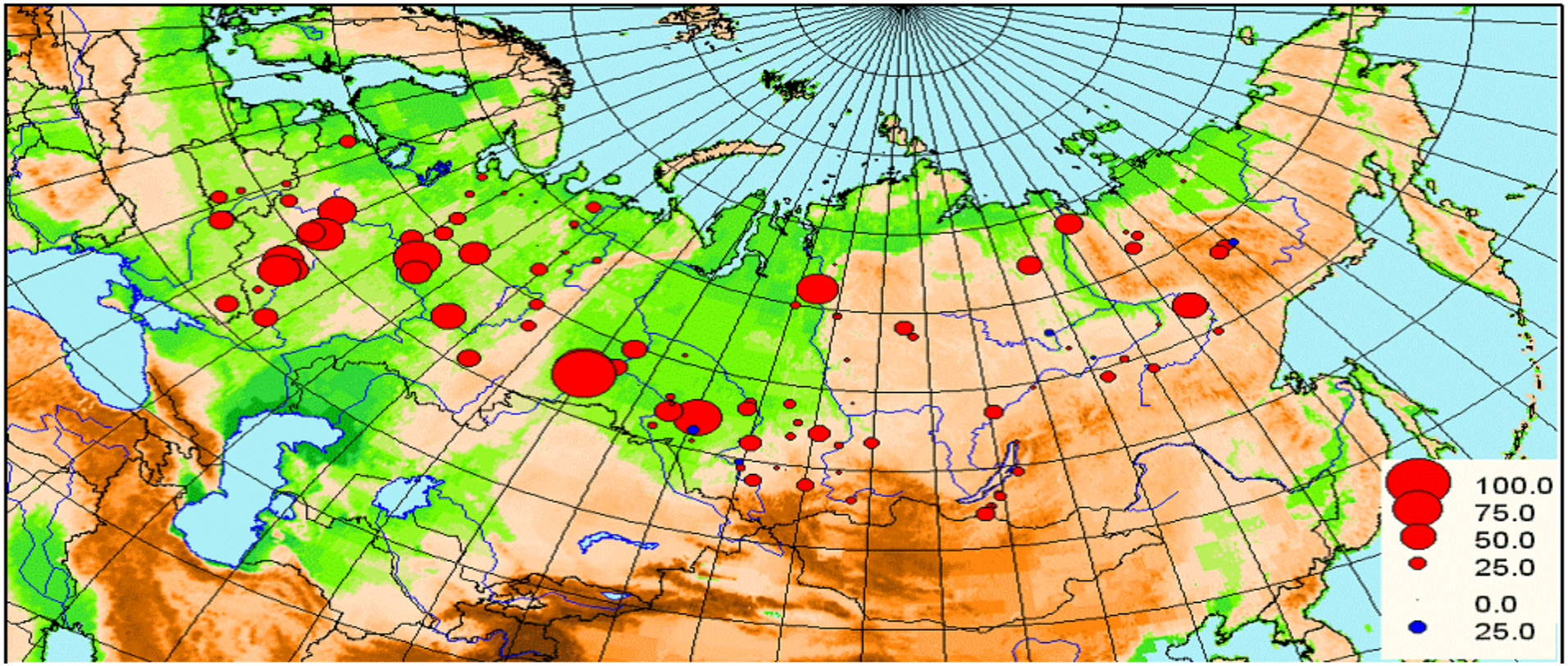
Fresh water transport to the Arctic is increasing



Winter runoff deviations for the 1978-2000 period compared to the long-term mean for ~ previous 55 years (Georgievsky et al. 2003)

Coastal zone processes

- Inundation
- Land-ocean exchange
- Impact on biota, eutrophication
- Impact on quality of life
- Coastal erosion

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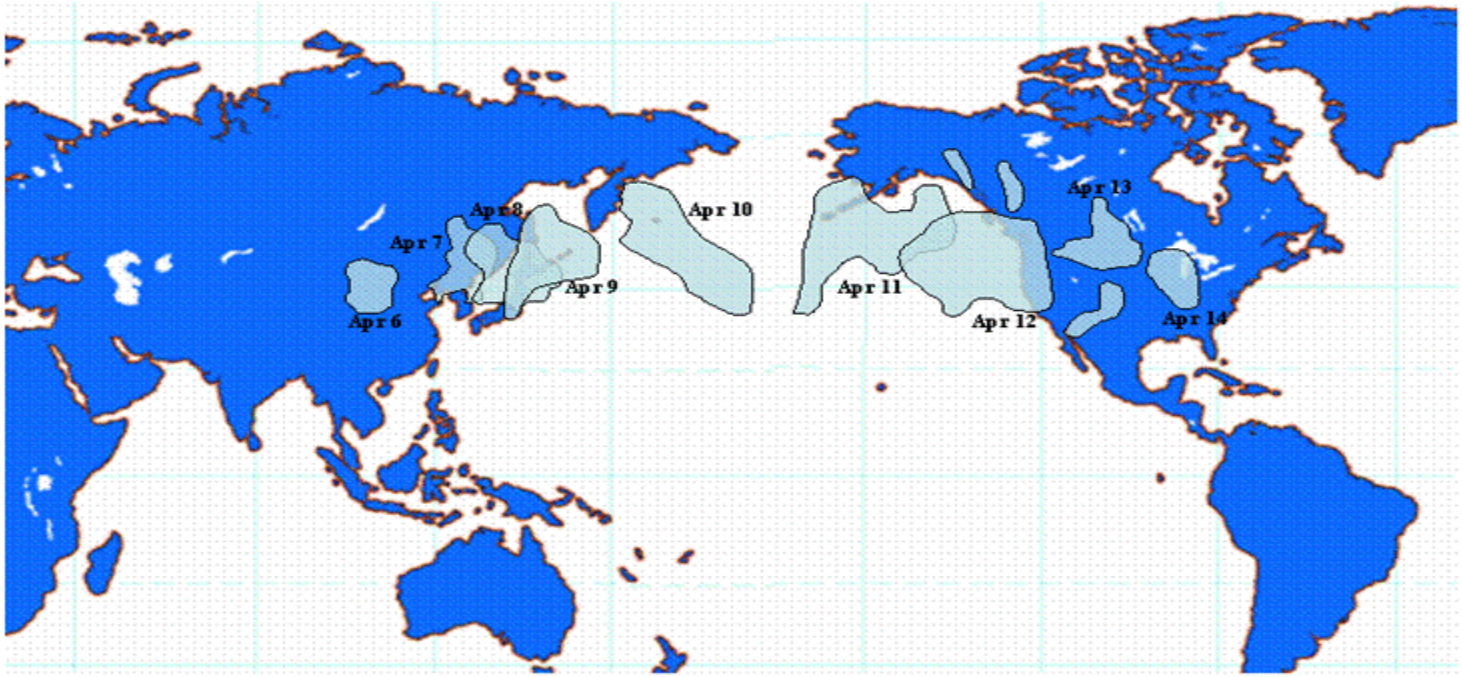
20 years ago these tanks were 60 m away from the coast of Pechora Sea (Ogorogov, 2003)

Aridization, Atmospheric Aerosol, and Air Pollution.

Example: Aeolian mineral dust transfer

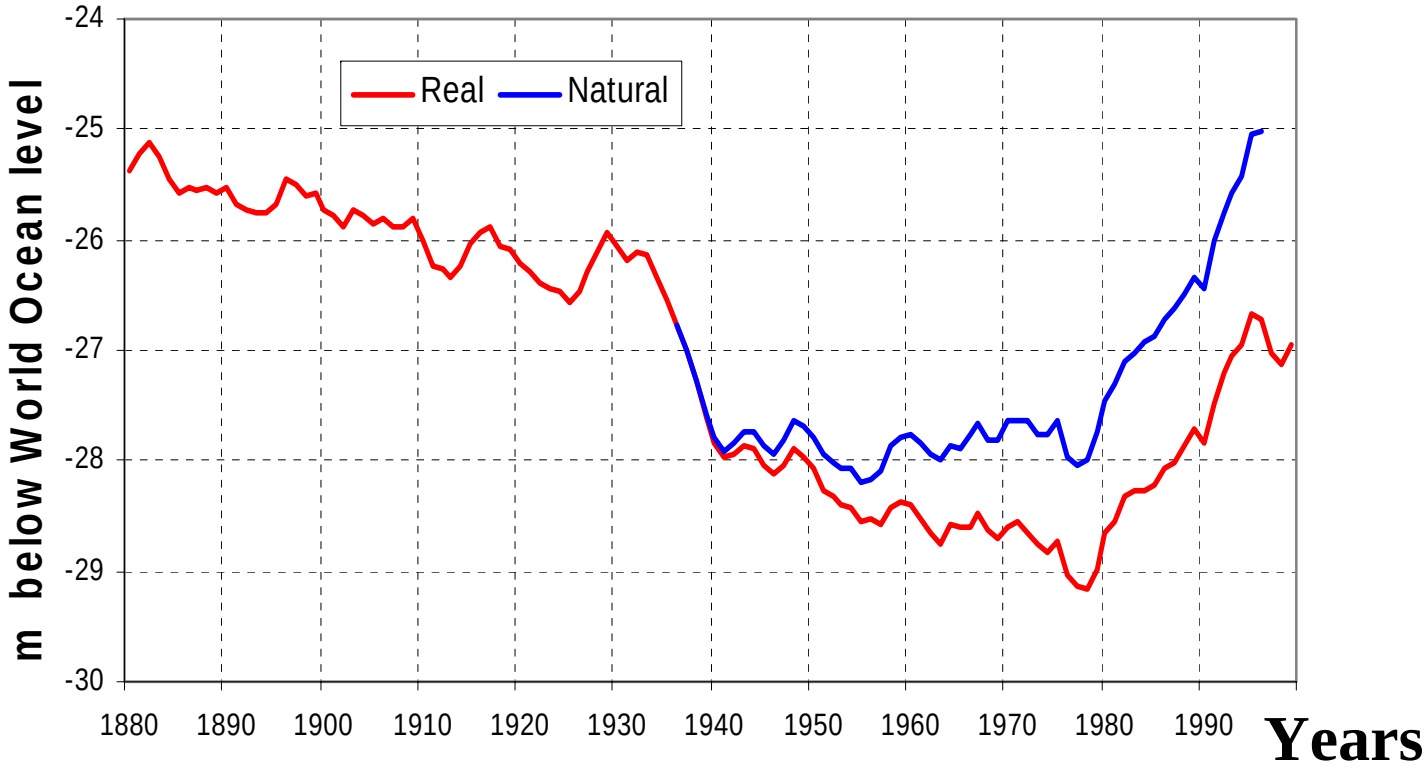


- Long-range transport of the dust storm originated over the Gobi desert on April 6th, 2001 (Darmenova and Sokolik, 2002)

Interactions with human activity

- Energy Cycle
- Water Cycle
- Ecosystems' Dynamics
- Air and Water Quality
- Regional and Global Climate Feedbacks
- Quality of Life

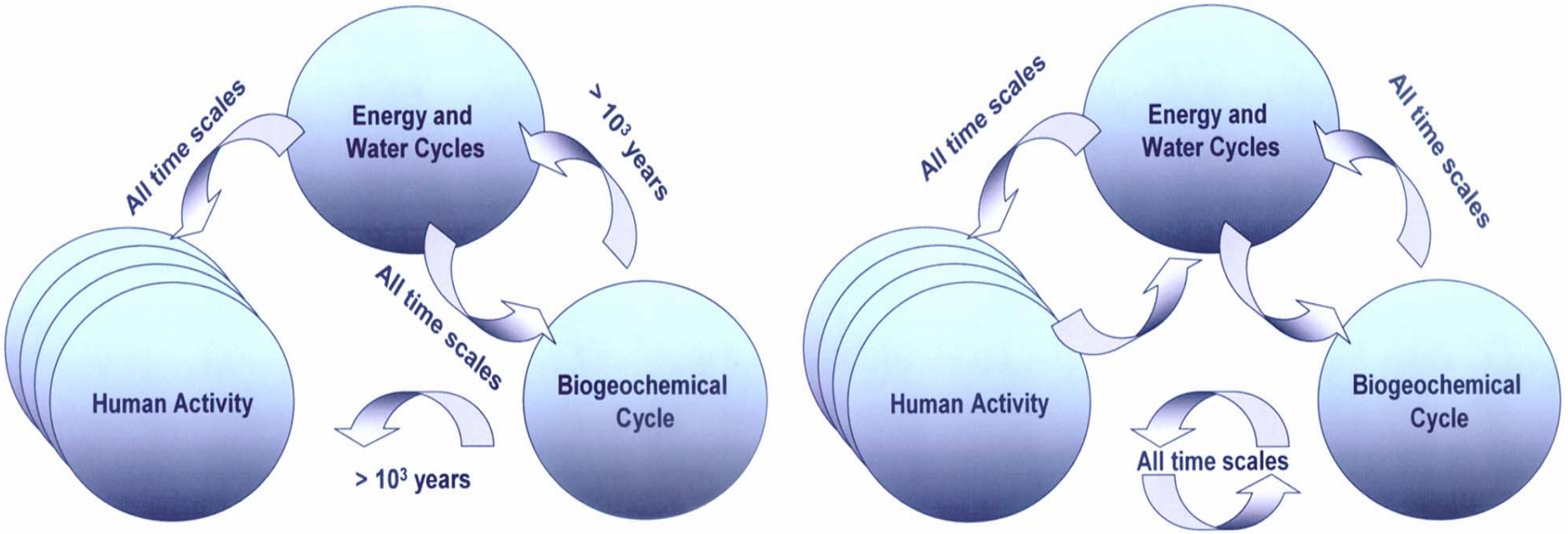
Observed and “natural” changes of the Caspian Sea level



Source: Shiklomanov (1976)

Update: Shiklomanov and Georgievsky (2003)

Pre-industrial and present interactions in the Earth Global System



- Studying any one of these cycles or activities often requires analyses of its interaction with the other two and of the transitional (non-equilibrium) character of these interactions.

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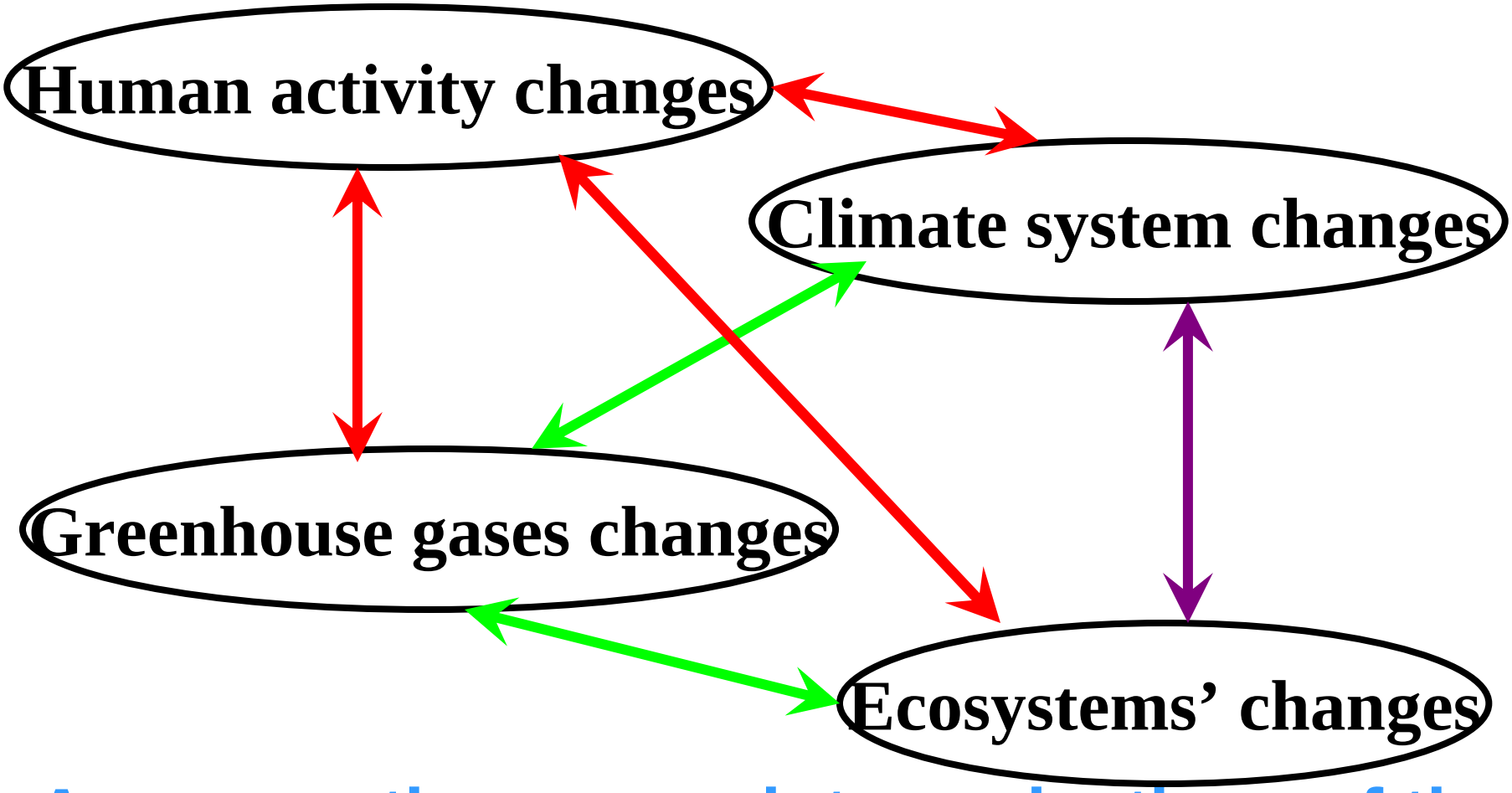

A synergetic approach to projections of the future changes

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Scientific Background Appendix

Tools

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The overarching NEESPI science question:

- **How do Northern Eurasia's terrestrial ecosystems dynamics interact with and alter the biosphere, atmosphere, and hydrosphere of the Earth?**

This question can be reformulated in a pragmatic way as:

- **How do we develop our predictive capability of terrestrial ecosystems dynamics over Northern Eurasia for the 21st century to support global projections as well as informed decision making and numerous practical applications in the region?**

Scientific topics

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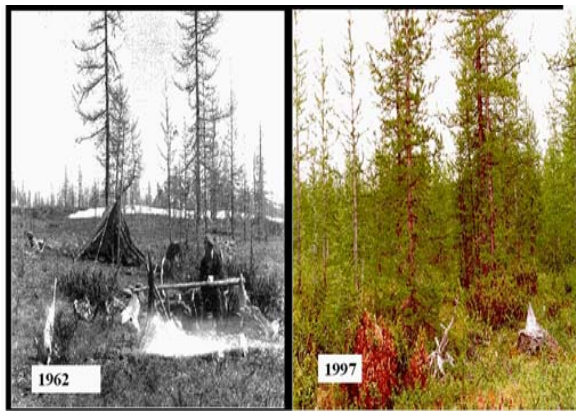
Biogeochemical cycles. Science questions:

What are the current geographical and temporal distributions of the major stores and fluxes of carbon and other elements in Northern Eurasia?

What are the major drivers and feedback mechanisms that control the dynamics of the biogeochemical cycles at local, regional, and continental scales?

What are the likely future dynamics of biogeochemical cycles that are important to the functioning of the Earth system and the human society?



What points of intervention and windows of opportunity exist for society to manage biogeochemical cycles in order to mitigate adverse consequences?

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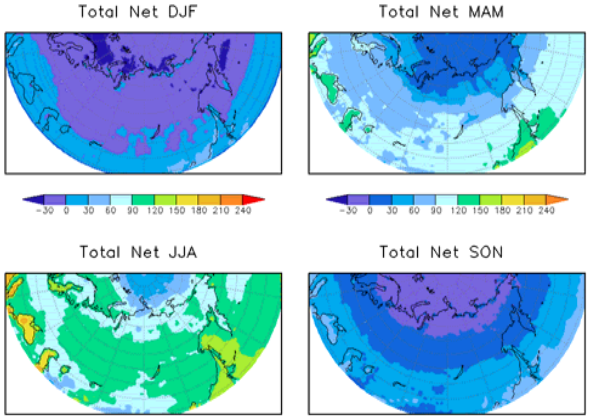
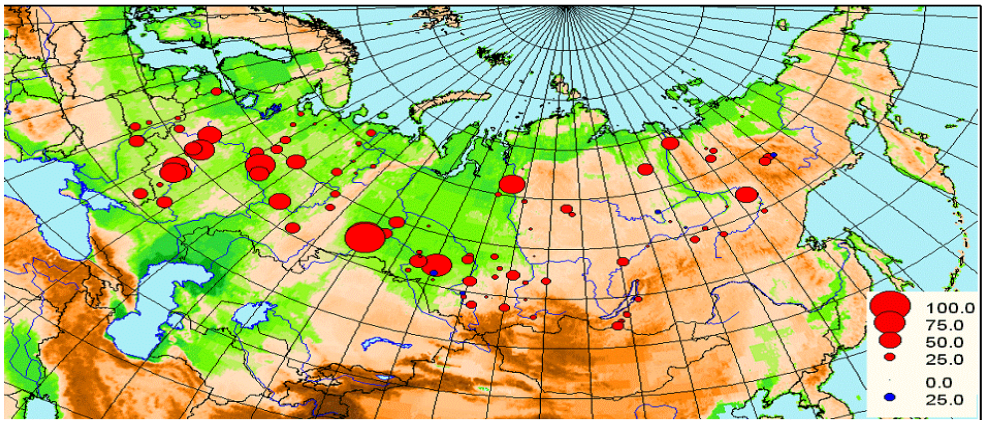
Surface energy and water cycles. Science questions:

- What is the relative importance of the major drivers and feedback mechanisms that control the variability and changes of the surface energy and water cycles at local, regional, and continental scales?
- What are the details of surface energy and water cycle dynamics in Northern Eurasia, and how do they improve our understanding of how this region interacts with global cycles?





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- These science questions will be addressed by:
- development of an interactive suite of the land surface models that can interactively feed back to regional and global climate, environmental, and economic models and
- performing all necessary studies to make this suite of models a viable working tool
- using modern tools of environmental monitoring
- integration the results from historical data sets, present observational systems, and process studies into a unified knowledge base

GEWEX

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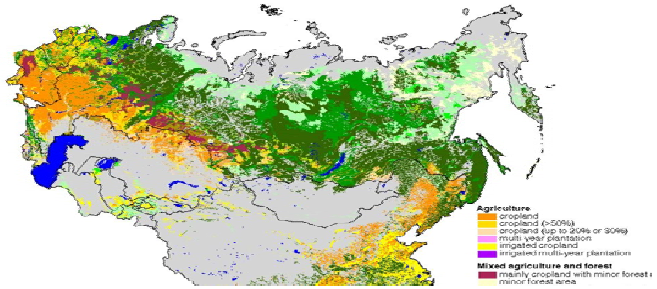
Land use interactions: societal-ecosystem linkages. Science questions:

- What land use changes are taking place in Northern Eurasia and what are their impacts on the environment and society?
- What lessons can be learned from the responses to dramatic land-use modifications during the "planned" economy period for future sustainable natural resource management?
- What will be the consequences of socio-economic changes in Northern Eurasia on the environment?
- How can science contribute to development of environmental strategies for society (societies)?



Cropland (orange areas) occupies currently more than 90% of steppe and forest-steppe zones of Northern Eurasia (Rozenzweig et al. 2003)

The Aral Sea from an "in-situ" observation

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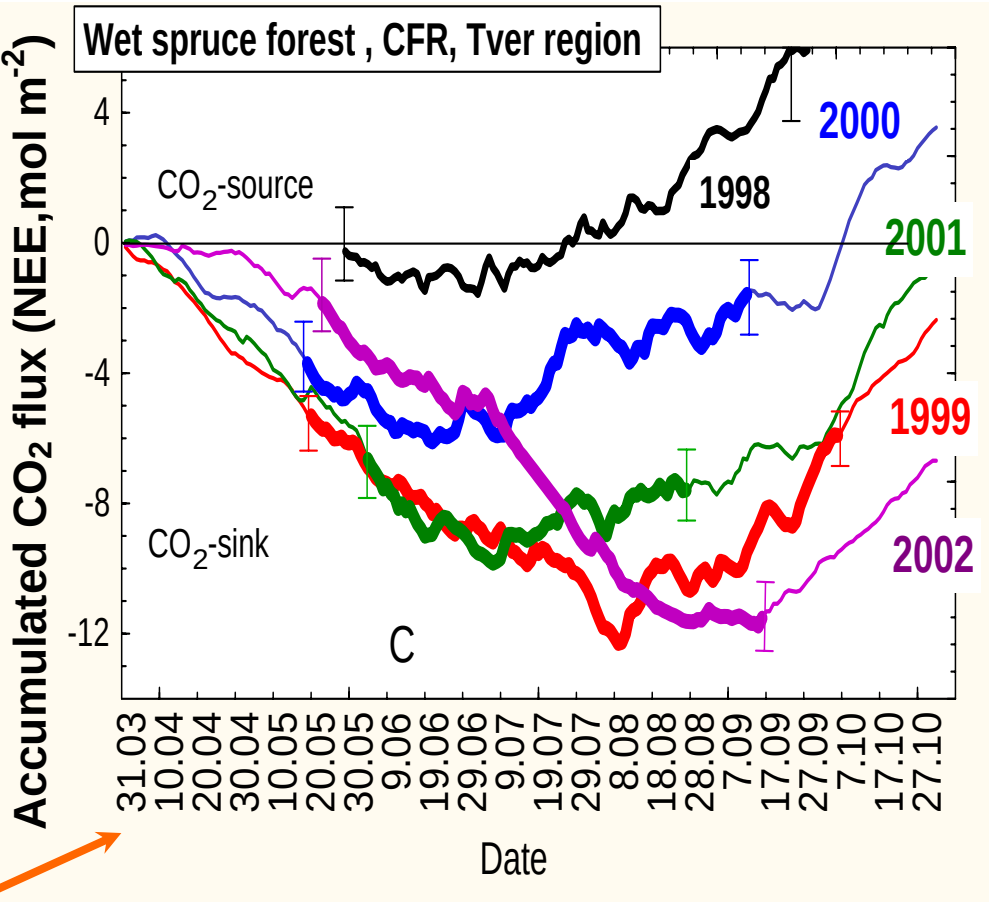
Ecosystems and climate interactions. Science question:

- How do we account for the synergy of feedbacks of major processes within the regional terrestrial ecosystems, climate, cryosphere, and hydrosphere of Northern Eurasia and their interactions with society?



BAHC, IGBP

Sign of annual Net Ecosystem Exchange depends upon weather conditions [positive CO_2 flux stands for source to the atmosphere].

Major focuses

- **Focus on transient zones that are most vulnerable in the future changes**
  - **Coastal zone**
  - **Tundra-forest**
  - **Forest-steppe**
  - **Steppe-desert**
  - **Mountains**
- **Focus on feedbacks that make the projection of the future changes uncertain**
  - **Biogeochemical feedbacks**
  - **Biogeophysical feedbacks**
  - **Human activity**

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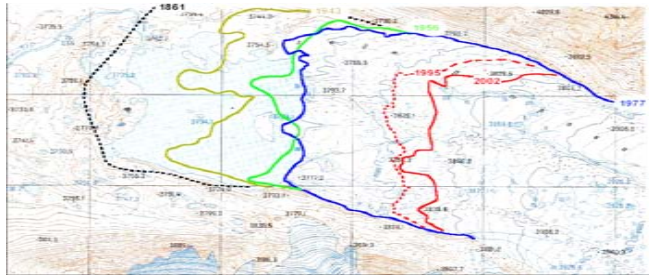
Topics of special interest

- **Cold land processes:**
  - Permafrost
  - Glaciers
  - Snow cover
- **Coastal Zone:**
  - Erosion
  - Impact of changes
- **Atmospheric aerosols:**
  - Pollution, smoke
  - Mineral dust



Example of a central Tien Shan glacier recession

Phytoplankton distribution in the Dnepr Estuary demonstrates eutrophication processes

Forest fires and smoke across the Baykal Lake

Dust storm in Northern China

Tools

Modeling. Science questions:

- How do we reduce the uncertainty of regional and global Earth System modeling related to poor knowledge of major processes and feedbacks in Northern Eurasia?
- How do we secure a societal feedback loop in our models that allows simulation of various scenarios of human activity and, in particular, land use in the region?

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- The NEESPI modeling efforts will be organized on three scales: local, regional, and global.
- The three-scale approach implies using or developing a wide range of models, including atmospheric boundary layer models, soil-vegetation-atmosphere transfer models of different levels of complexity, permafrost models, air pollution models, data assimilation schemes, regional 3-D atmospheric models coupled to comprehensive land surface components, regional high-resolution hydrologic models, models of primary and secondary successions in vegetation and soils, dynamic general vegetation models, global climate models, including, general circulation models and Earth system models of intermediate complexity, socio-economic models, and integrated assessment models.

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Remote sensing, data & technology. Science questions:

- How can we characterize and improve the accuracy and availability of current remotely sensed data products to meet the needs of the NEESPI science community and resource managers?
- How do we improve the capability of present and future observation systems as well to capture climatic and environmental characteristics and change in the unique conditions of Northern Eurasia?

IGOS

To answer these questions we need:

- better understanding of the underlying processes;
- stabilization (rescue) of existing (past) data; and
- new products specifically tailored for high latitudes.

Education

- The presence of an education component will be among the funding requirements of *successful* NEESPI projects
- Additionally training will be implemented at the levels of elementary and secondary school, undergraduate education, graduate professional education, graduate Ph.D. education, continuing education, and re-training
- Example: GLOBE's International Plan represents the program of partnership between the USA and more than 100 other countries. More than one million children of elementary and middle schools at more than 12000 schools take part in this program

Objectives: to have in ~10 years

- **A suite of process –oriented models for each major terrestrial process in all its interactions (including those with the society)**
- **A suite of global and regional models that seamlessly incorporate all regionally specific feedbacks associated with terrestrial processes in Northern Eurasia and serve as a major tool for both future environmental change projections and for informed decisions on land use and environmental protection policies**
- **An integrated observational knowledge data base for environmental studies in Northern Eurasia**
- **A system in place that can serve the emergency needs of the society (early warning / management / mitigation of floods, fire, droughts, and other natural disasters)**

Science Plan Key Words

- **Understanding of Interactions Affecting the Globe and Processes of Major Societal Importance**

IGBP, GEWEX

Tools:

- **Modeling**
- **Modern Integrated Knowledge Base & Monitoring**

IGOS

Regional processes of major societal importance

- **Extreme meteorological and hydrological events (e.g., droughts, floods, heat/cold waves)**
- **Natural hazards (e.g., dust storms, inundation, desertification, and forest fires)**
- **Thaw of permafrost**
- **Snow and river ice cover factors**
- **Glaciers impact on hydrology**
- **Atmospheric/water pollution**
- **Soil erosion**
- **Water supply deficit**
- **Declines in agricultural and forestry production**

Cryo-sphere

Quality of life

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Summary

- The NEESPI research strategy plans to capitalize on a variety of remote sensing and other tools and implement a general modeling framework linking socio-economic factors, crop, pollution, land use, ecosystem, and climate models with observational data to address key research questions within Northern Eurasia
- As an integral part of these activities, a set of educational activities is suggested as well as interaction with appropriate components of the related ongoing scientific and operational programs
- A major objective of NEESPI will be to provide information, which empowers society and decision-makers to plan and react wisely, to mitigate the negative and to benefit from the positive consequences of environmental changes