

# NEESPI outstanding problems: Modeling

1.5 years after the NEESPI Science Plan release

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# NEESPI SP Chapter 5 (“Modeling”) outline

1. Science questions

2. Research approach

- Local scale modeling
- Regional scale modeling
- Global scale modeling
- Integrated assessment modeling
- Developing strategy for environmental prediction in the framework of NEESPI

4. Observational needs

5. Links with other programs

The triad of major aspects of modeling:

- Studying processes
- Filling gaps in observations
- Projecting the future

Overarching questions  
for the NEESPI modeling component

*What processes and feedbacks control energy, water and carbon fluxes over Northern Eurasia and how do the fluxes vary in space and time?*

*How do these fluxes and feedbacks affect the Earth System (particularly, on the global climate)?*

*How have these feedbacks evolved and developed during the instrumentally recorded period and in the geological past?*

*Are our models capable of simulating observed climate changes in NEA and their feedback effects on global climate?*

*Can we correlate data obtained from different fields (for example, parameters of biological turnover of carbon between forest and soil and their dependencies on climate changes) for initialization of model runs?*

*Can our models provide an operational interface between on-ground and remote sensing data for data assimilation ?*

*If the answers on the above questions are uncertain, then how must our models be improved to address them?*

*And especially, how to enhance the capability of our models to simulate the past and project future environmental and societal changes both in NEA and globally?*

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# Research approach

*Developing and validating models of different systems and scales, scaling model descriptions of different processes, reproducing Northern Eurasia natural system states and evolution observed in the past and present, and, finally, projecting the future changes.*

*The main foci are processes and feedbacks within Northern Eurasia socio-environmental system in the transient regions, and between the Northern Eurasia system and the Earth system.*

*The proposed modeling efforts are to be organized on three scales: local, regional and global:*

*Local scale – finer than 10 km<sup>2</sup>.*

*Local studies are mostly process-oriented and connected with in situ observational data sets and the most advanced fine-resolution remote sensing information.*

*Models: mainly 0- to 1D.*

## Local scale modelling priorities

- ✓ detailed parameterization of the SVAT processes ...
- ✓ advanced algorithms to describe impacts of extremes...
- ✓ sophisticated approaches (1- and 3D) to describe energy, water and carbon exchanges between surface and the atmosphere...
- ✓ parameterizations to describe exchange of atmospheric pollutants between the land surface and the atmosphere...
- ✓ sophisticated 2- and 3D permafrost models ...
- ✓ models of coastal zone evolution...
- ✓ new methods to describe spatial heterogeneity of the land cover and meteorological input parameters that allow up-scaling heterogeneity effects to the regional scale.

*Regional scale – 10-10<sup>6</sup> km<sup>2</sup> (TBD)*

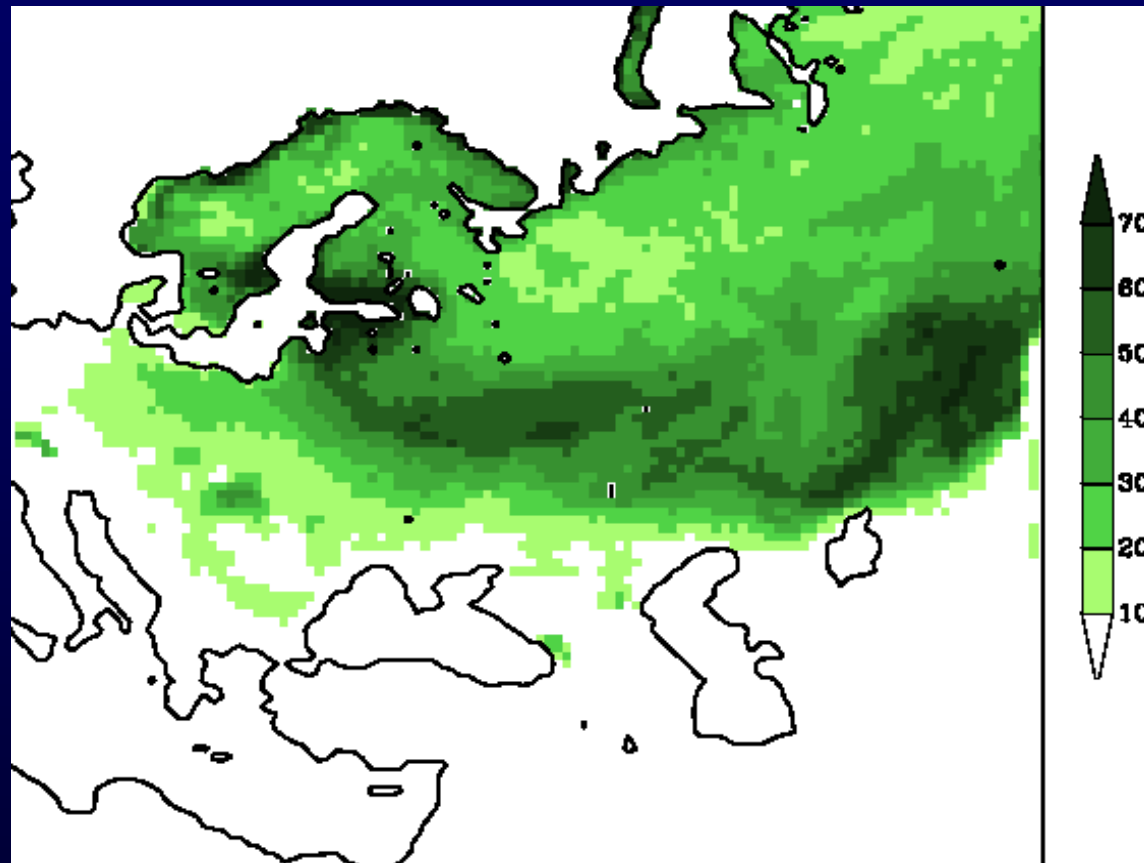
*Regional studies (most naturally – ecosystems, transition regions, river basins, administrative regions, etc.) heavily depend on fine- and moderate-resolution remote sensing information.*

*Models: mainly 2- to 3D.*

## Regional scale modelling priorities

- ✓ atmospheric regional models customized to Northern Eurasia sub-regions (including assessment of RCM skill at improving simulations for Northern Eurasia that are obtained from GCMs)
- ✓ comprehensive river routing models combined with SVAT and permafrost models
- ✓ comprehensive air pollution models
- ✓ newer permafrost modeling approach that accounts for both deterministic and stochastic (sub-grid) variability of sub-surface, vegetation, and snow properties
- ✓ advanced one-way and two-way nesting techniques for nesting hydrological, permafrost, dynamic general vegetation and other environment component models into RCMs
- ✓ data assimilation schemes that seamlessly incorporate modern satellite products and ground-based observations.

Projected change of snow cover duration (days)  
by the end of the 21<sup>st</sup> century (B2 scenario) using MGO RCM



*Global scale*

*Global scale studies presume employment of existing reanalyses and objective analyses of observational data.*

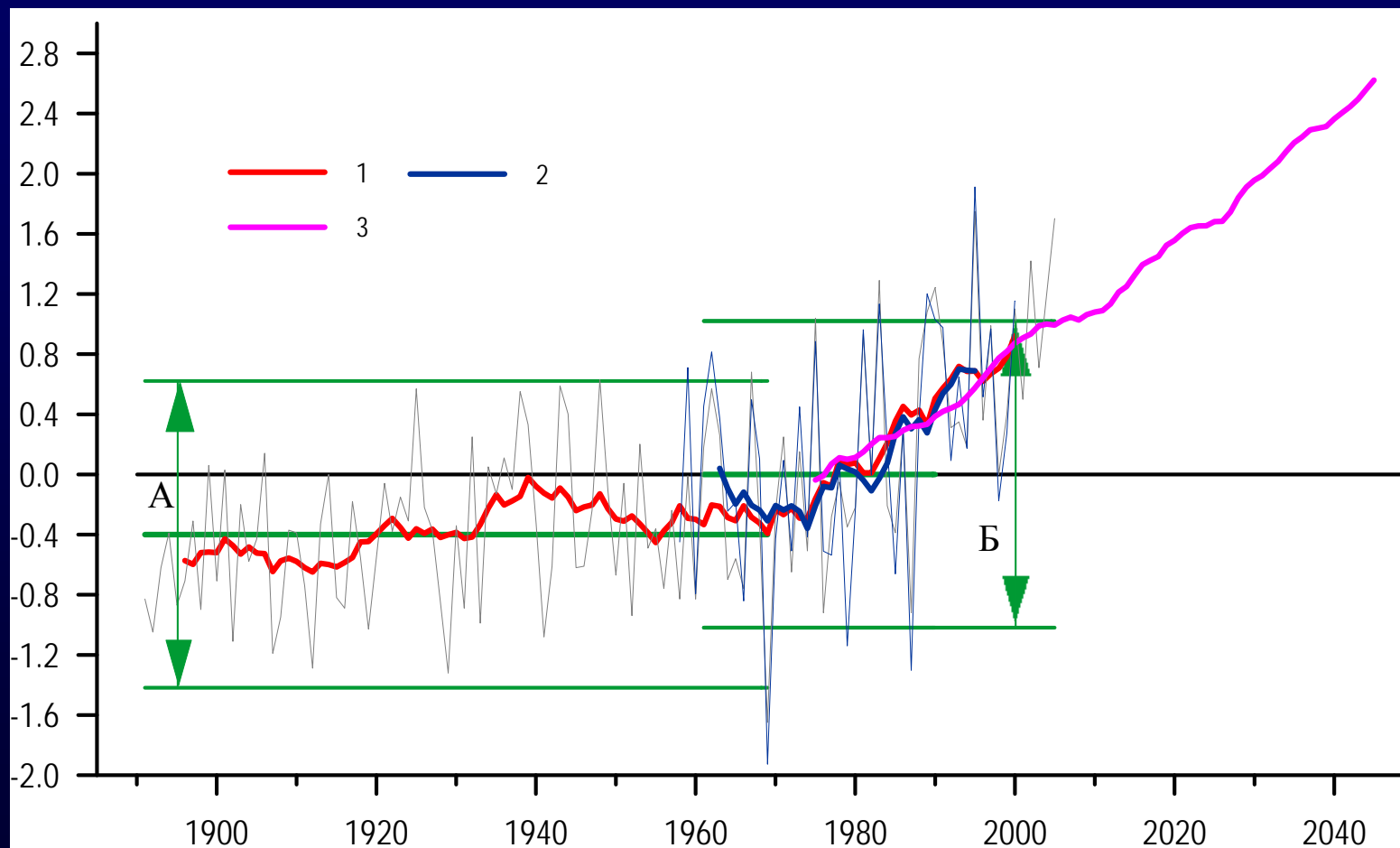
*Models: mainly Global Earth System Models (GEM) – both comprehensive and of intermediate complexity*

## Global scale modeling priorities

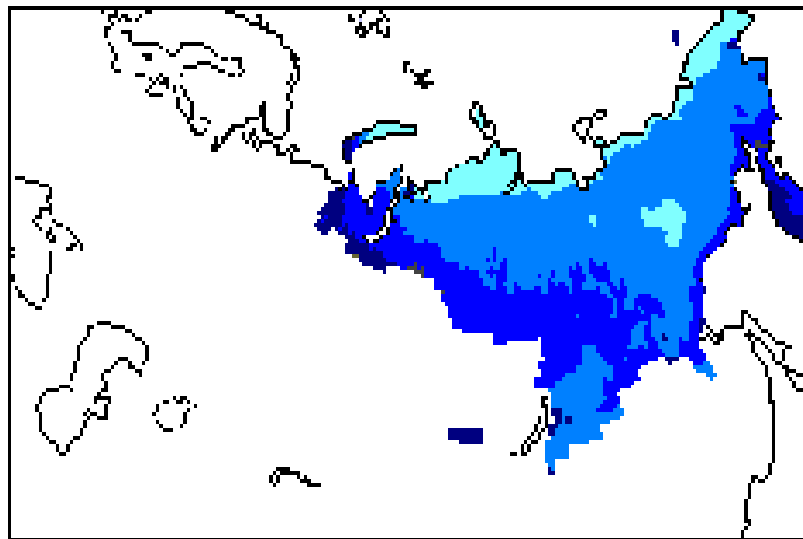
- ✓ incorporation of improvements in process understanding at local and regional levels into comprehensive hydrological, vegetation, cryospheric components of GEMs
- ✓ studying effects and feedbacks of environmental changes in Northern Eurasia in the global context at the decadal, centennial, and millennial time scales and comparison with instrumental, historical, and palaeo data
- ✓ estimates of extreme ranges in climate change impacts in past and in present for the entire Northern Eurasia
- ✓ assessing the predictive skill of GEMs and projecting the future.

*Direct effects of climate change on land surface  
hydrology, terrestrial cryosphere and vegetation...*

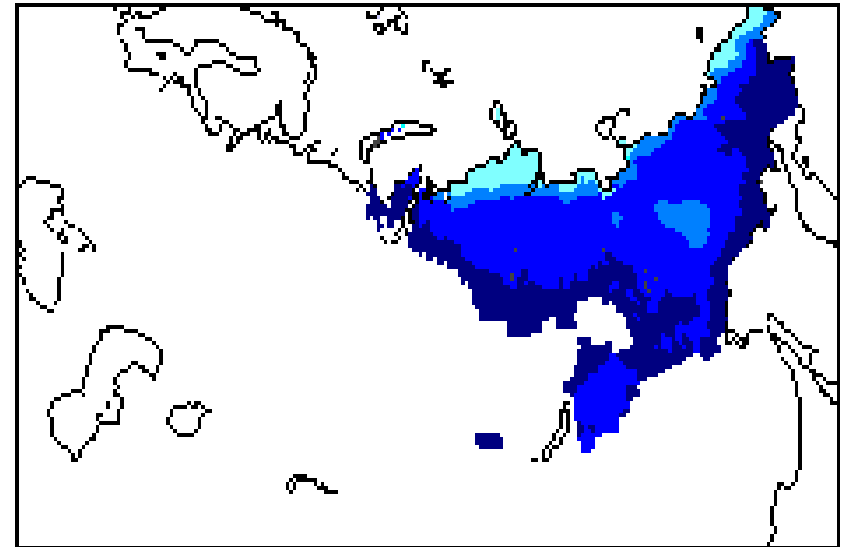
# Surface air temperature anomalies over Russia: observed (station data), reanalyzed (ERA40) and simulated/projected (17-member ensemble of IPCC AR4 AOGCMs, A2 emission scenario)



Permafrost region active layer increase projected by 2011-30 (left) and 2071-90 (right): 9-member ensemble of IPCC AR3 AOGCMs, B2 emission scenario.

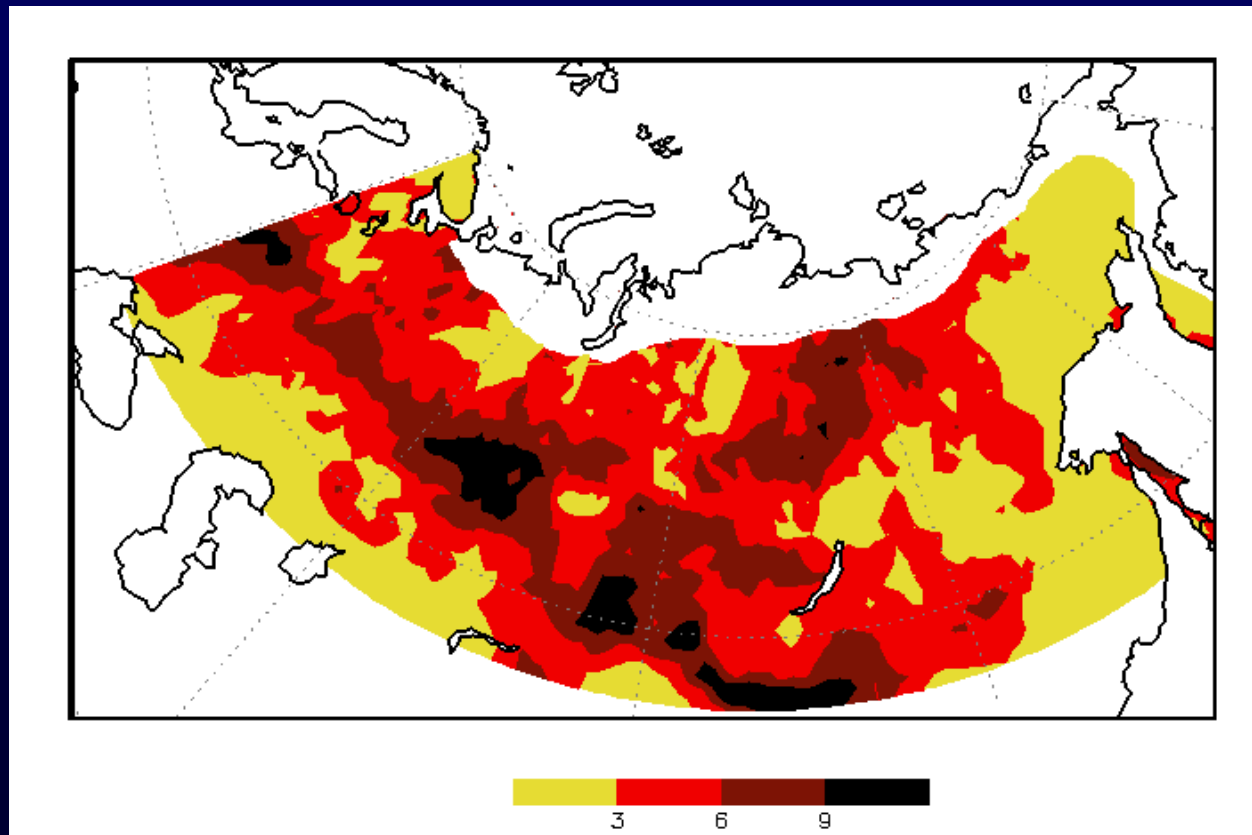


0 20 40 60 80 cm



0 20 40 60 80 cm

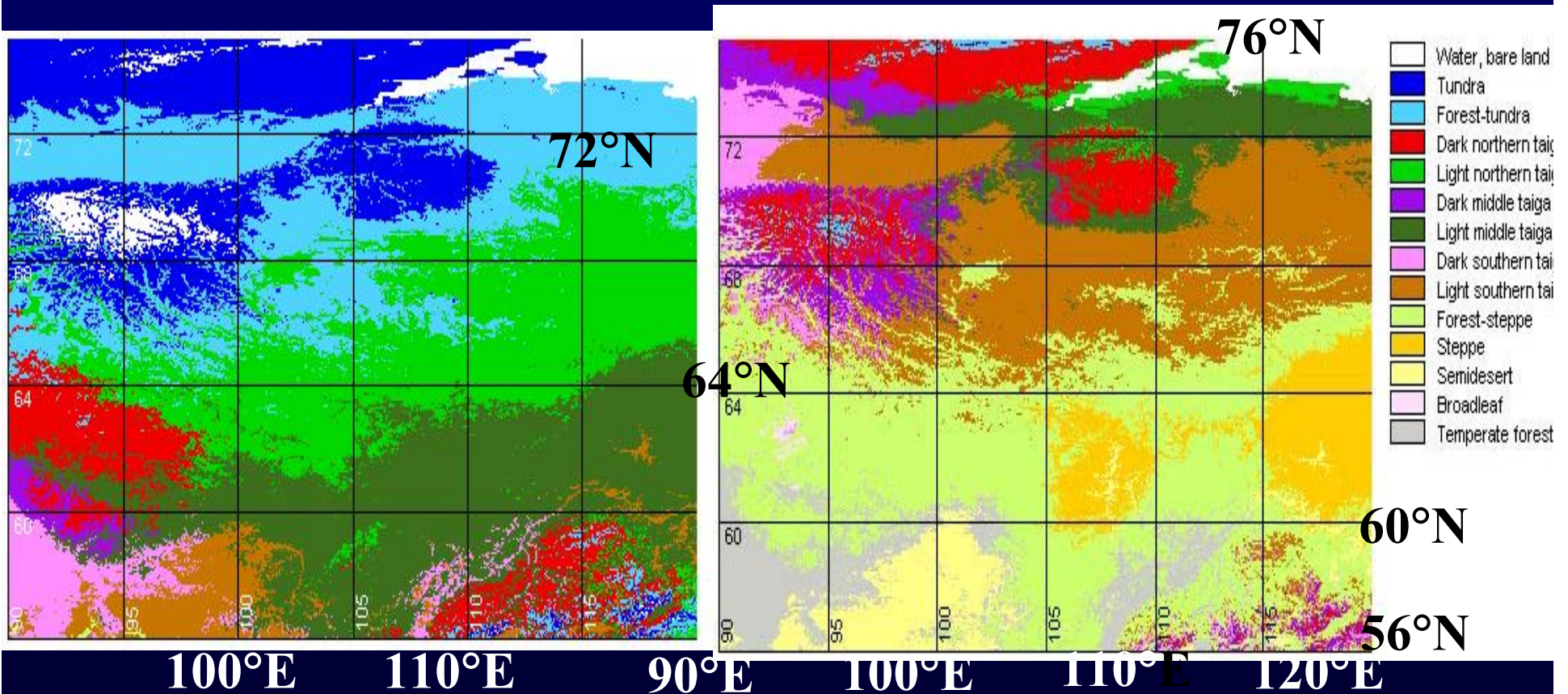
Projected change of the number of days with highest probability of forest fire by the end of the 21<sup>st</sup> century: 9-member ensemble of IPCC AR3 AOGCMs, B2 emission scenario.



*... however, IPCC WG1 AR4 considers couplings between changes in climate system and biogeochemistry in a set of AOGCMs and there is a billion-dollar question:*

*What if we 'll need to re-do all assessments when the interactive biosphere will be included?*

# Ecosystems' changes projected for the future using HAD3 GCM



Present

In year 2090

Major ecosystems distribution in central and eastern Siberia  
(Tchebakova et al. 2003)

## Integrated assessment models

The ultimate goal of an integrated assessment study is to represent the climate change problem within the framework of a quasi-closed system so that the social and environmental consequences of policies to adapt to or to limit global warming are seen in their totality.

**The topic will be covered in the next talk by Sergey Venevsky**

## Issues for discussion

Reanalyses: is a regional reanalysis for Northern Eurasia (NEARR) possible?

In order to efficiently integrate all levels of NEESPI modeling component developments at the local scale level need to be implemented in regional scale models and further in GEMs.

For this purpose we need:

- ✓ Models' interaction (coupling).

- ✓ A universal environmental data product driving regional hydrological, vegetation, biogeochemical, cryospheric and other models at regional (up to the entire Northern Eurasia) scale. This data product should have sufficiently high spatial/temporal resolution and provide sufficient areal coverage.

These are challenges of the NEESPI modeling component and we put them forward to further discussion. Implementation aspect of this discussion is important.

So, let us talk...

How to secure integration of the  
NEESPI studies?