

Northern Eurasia Future Initiative (NEFI) as a Successor of Northern Eurasia Earth Science Partnership Initiative (NEESPI)

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NEESPI was launched in 2004 with its scientific horizon of 10-12 years.

During the past decade, NEESPI has included 172 individual projects and more than 1500 peer-reviewed publications. Now it is gradually discontinuing by attrition (no new projects are accepted).

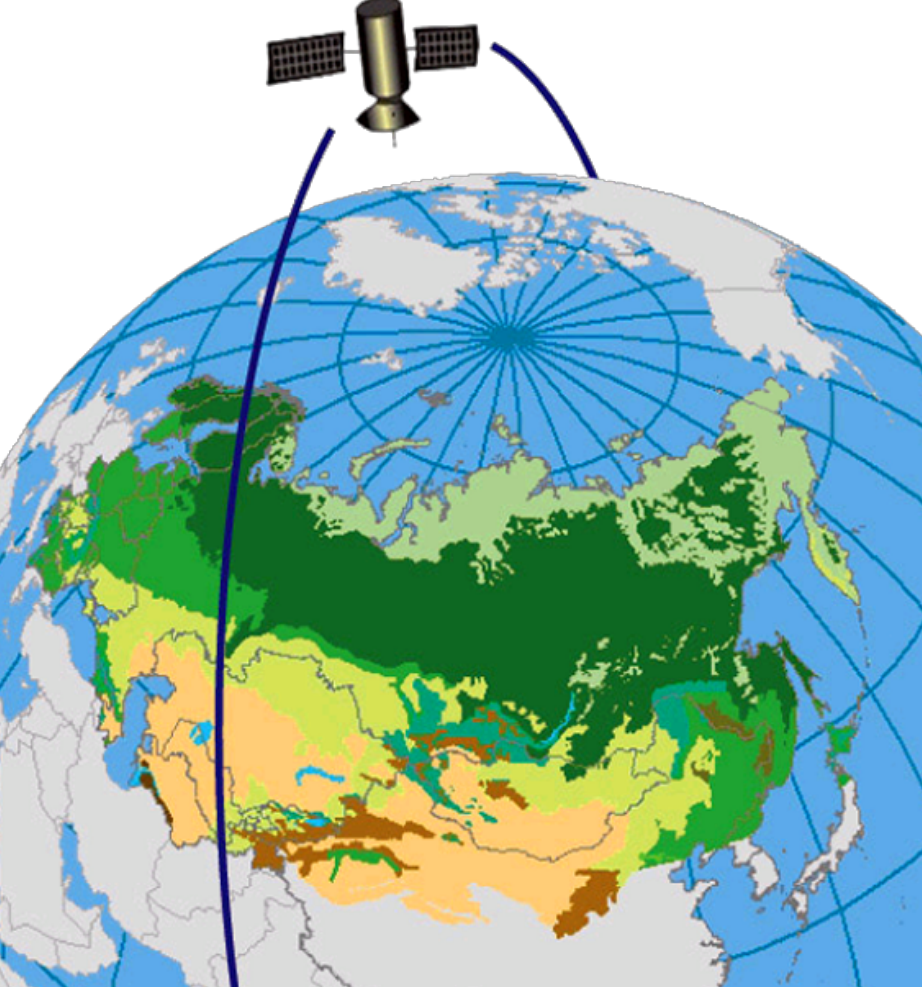
NEFI was launched in 2016.

The Science Plan of NEESPI is available at <http://neespi.org/science/index.html>

The NEFI Core Science Plan (White Paper) is available at <http://nefi-neespi.org/NEFI-WhitePaper.pdf>.

The overarching science questions:

- **NEESPI:** How do Northern Eurasia's terrestrial ecosystems dynamics **interact** with and alter the biosphere, atmosphere, cryosphere, and hydrosphere of the Earth?
- **NEFI:** How to provide in Northern Eurasia a sustainable societal development (economy well-being, activities, health, and strategic planning) in changing climate, ecosystems, and... societies?

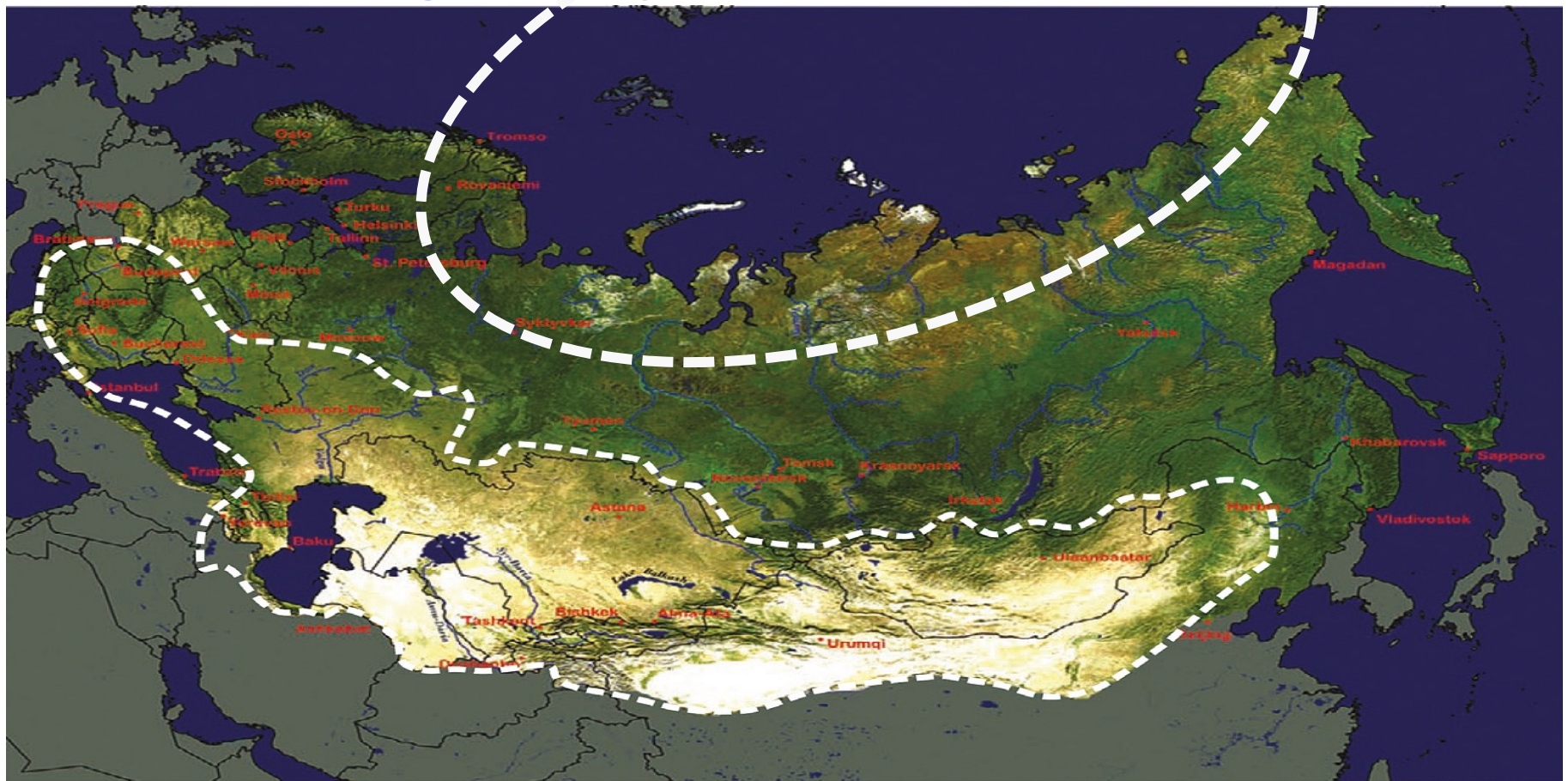


The NEESPI Study Area

<http://neespi.org>

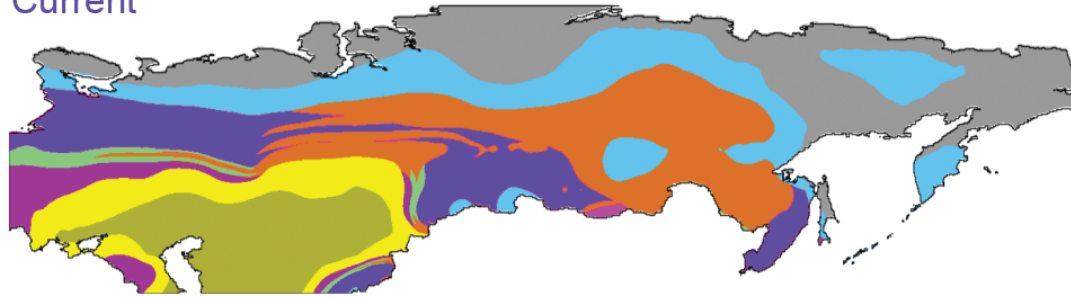
The NEFI Study Area
is the same

- Dry Latitudinal Belt (DLB) of Northern Eurasia, the largest region with acute water deficit in the extratropics.
- Boreal Forest zone northward of DLB is the largest storage of terrestrial carbon.
- The Eurasian Arctic is the region of the most prominent natural changes. Ecosystems' boundaries here are unstable.

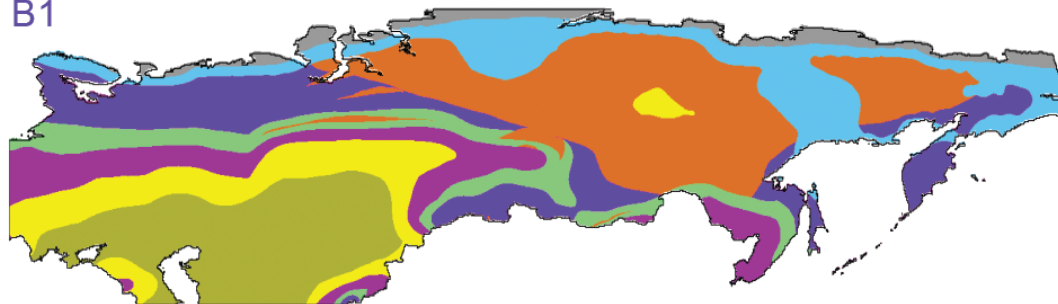


Scenarios of projected Ecosystems' Shifts to 2090

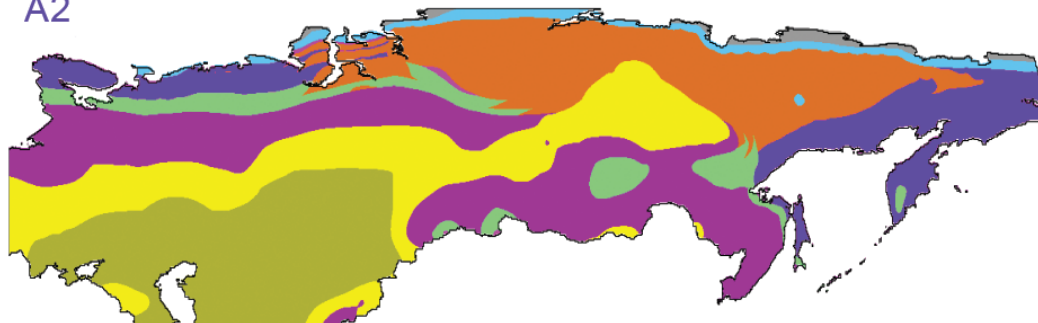
Current



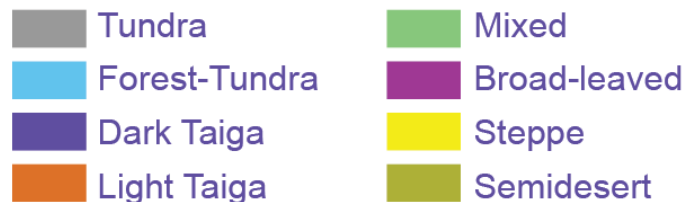
B1



A2



Vegetation classes

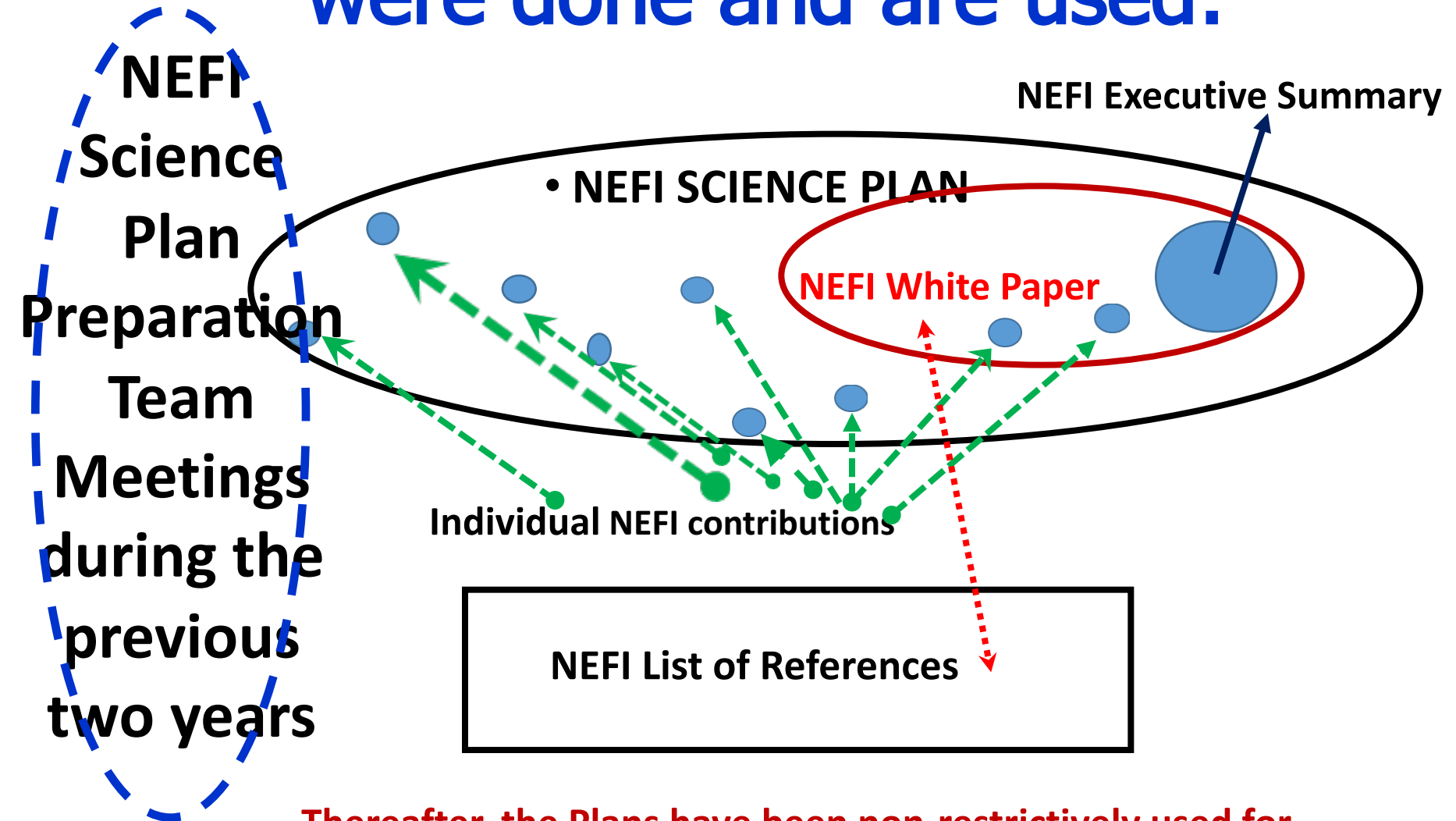


Vegetation distribution under present conditions and equilibrium vegetation distribution under future climate conditions (scenarios) over Northern Eurasia in current climate and by year 2090 (Archive of Tchebakova et al. 2016).

Background

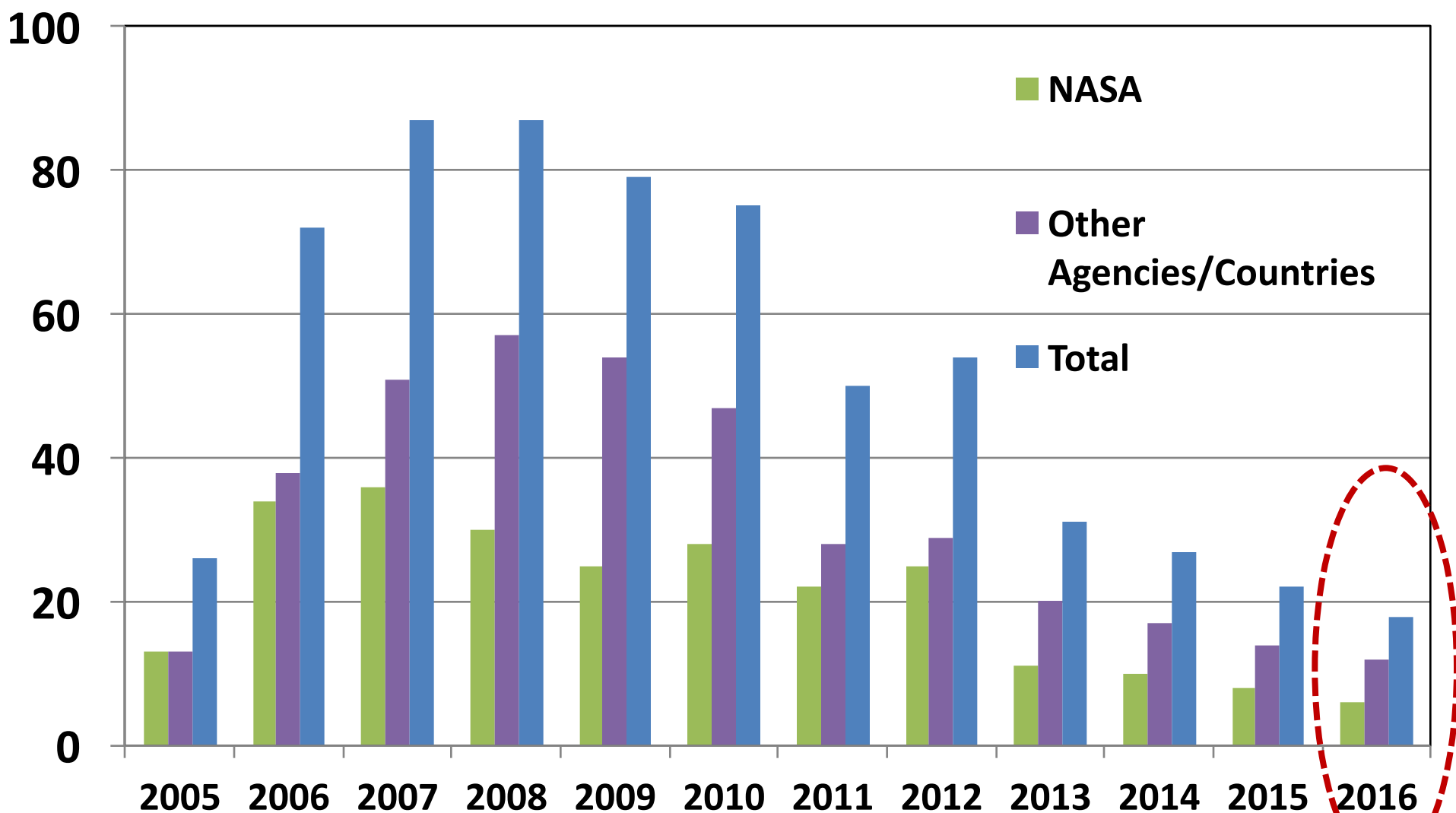
- **Northern Eurasia Future Initiative (NEFI)** has emerged as an essential continuation of the **Northern Eurasia Earth Science Partnership Initiative (NEESPI)**—an interdisciplinary program of internationally-supported Earth systems and science research—that has addressed large-scale and long-term manifestations of climate and environmental changes over Northern Eurasia and their impact on the Global Earth system.

How these Science Plans were done and are used:



Thereafter, the Plans have been non-restrictively used for proposals to funding Agencies by their authors, contributors, and everyone who share the research ideas outlined in the Plans.

Active NEESPI-NEFI Projects by year



Since The Prague Workshop in **May 2015**, we discontinued accepting new projects to the NEESP Initiative redirecting them to NEFI.

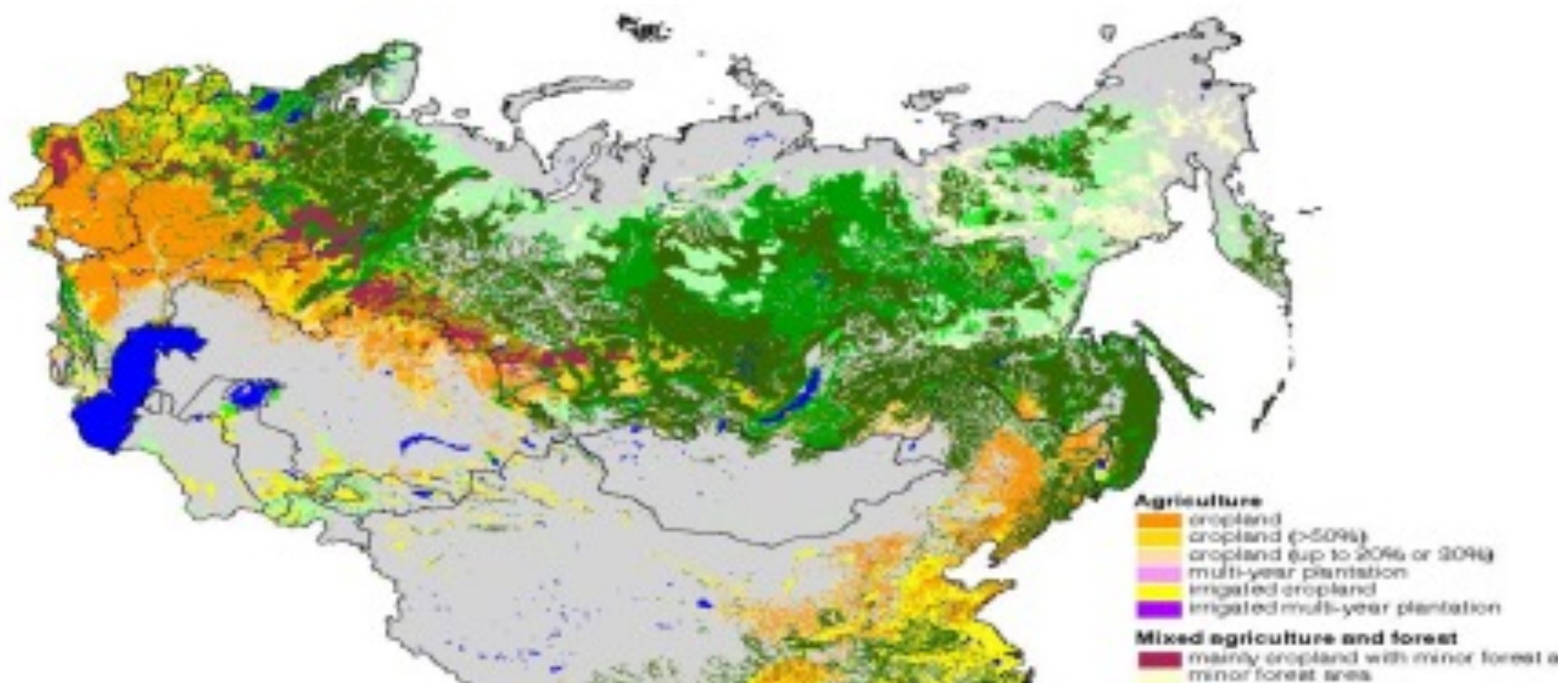
NEESPI Projects partition by topics and zones and **general statistics**

- Biogeochemical cycles 50%
 - Energy and Water cycles 30%
 - Cryosphere changes 15%
 - Atmospheric Aerosol changes/impact 5%
-
- Boreal Zone and the Arctic 75%
 - Mid-latitude Dry Land Zone 25%
 - 172 projects (27 of them were ongoing in 2014; 18 in 2016)
 - ~ 750 scientists from more than 200 institutions of 30 countries; more than 80 PhD theses defended.
 - **Insufficient number of socioeconomic foci studies**

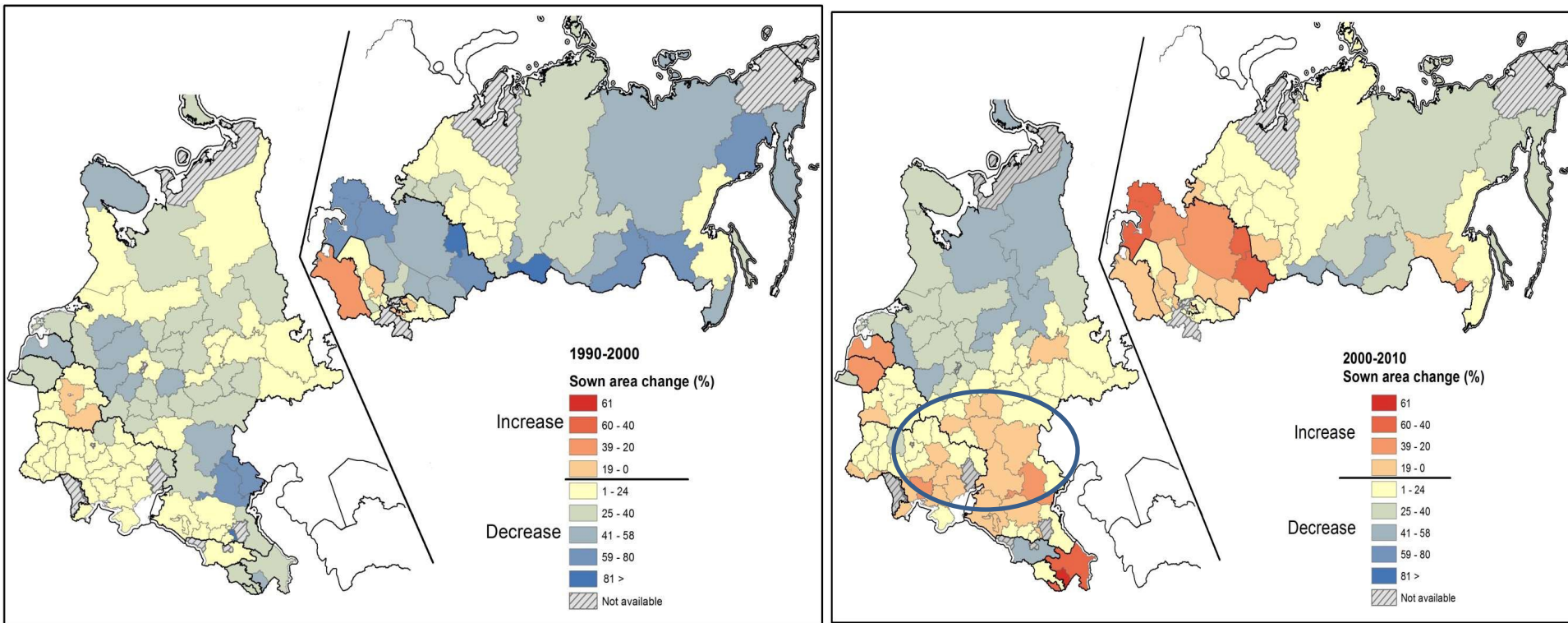
Thus, something was
overlooked

Large-scale land use changes caused by human activity:

For example: More than 90% of steppe and forest-steppe zones in Northern Eurasia is currently cropland (orange areas in the map) [Rozenzweig et al. 2003]



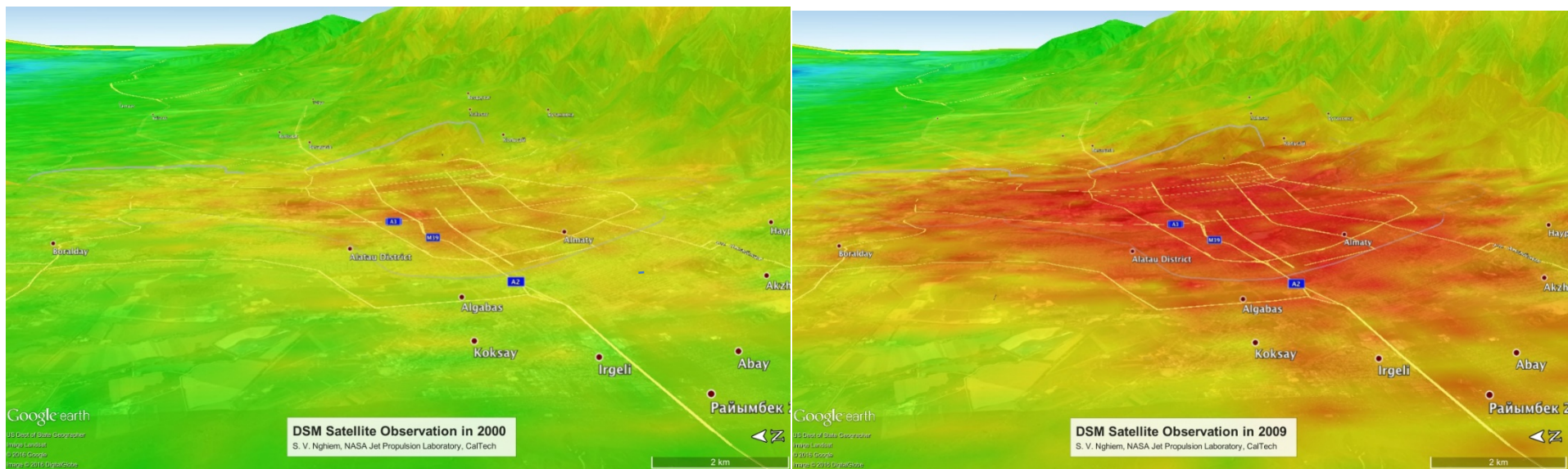
LAND ABANDONMENT DYNAMICS over the former Soviet Union since 1990



Changes (%) in sown areas (left) from 1990 to 2000 and (right) from 2000 to 2010. Areas of abandoned sown areas from 1990 to 2010 are: 40 Mha in Russia; 5.4 Mha in Ukraine; and 13 Mha in Kazakhstan (Prishchepov et al. 2017).

Intense urbanization

Almaty, Kazakhstan urban extent expansion that occurred between 2000 and 2009 (Nghiem et al. 2016)



Almaty urban region in Kazakhstan from DSM satellite observations in 2000 (left) and 2009 (right), translucently draped over 3D topography.

Red represents main urban areas, transitioned into **orange** for urban area with less development, then to **yellow** for suburban, and finally to **green** for rural/natural/wilderness areas. **Blue** indicates surface water (lakes, reservoirs, etc.).

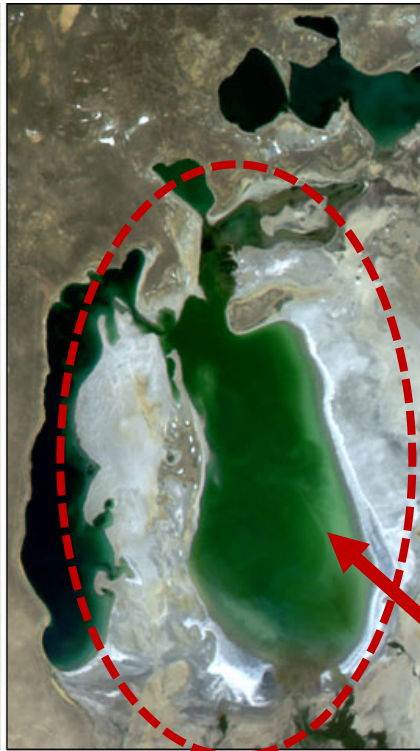
Water use that lead to ecological disasters

For example, most of the Aral Sea has disappeared in the past twenty years



July - September, 1989

1989



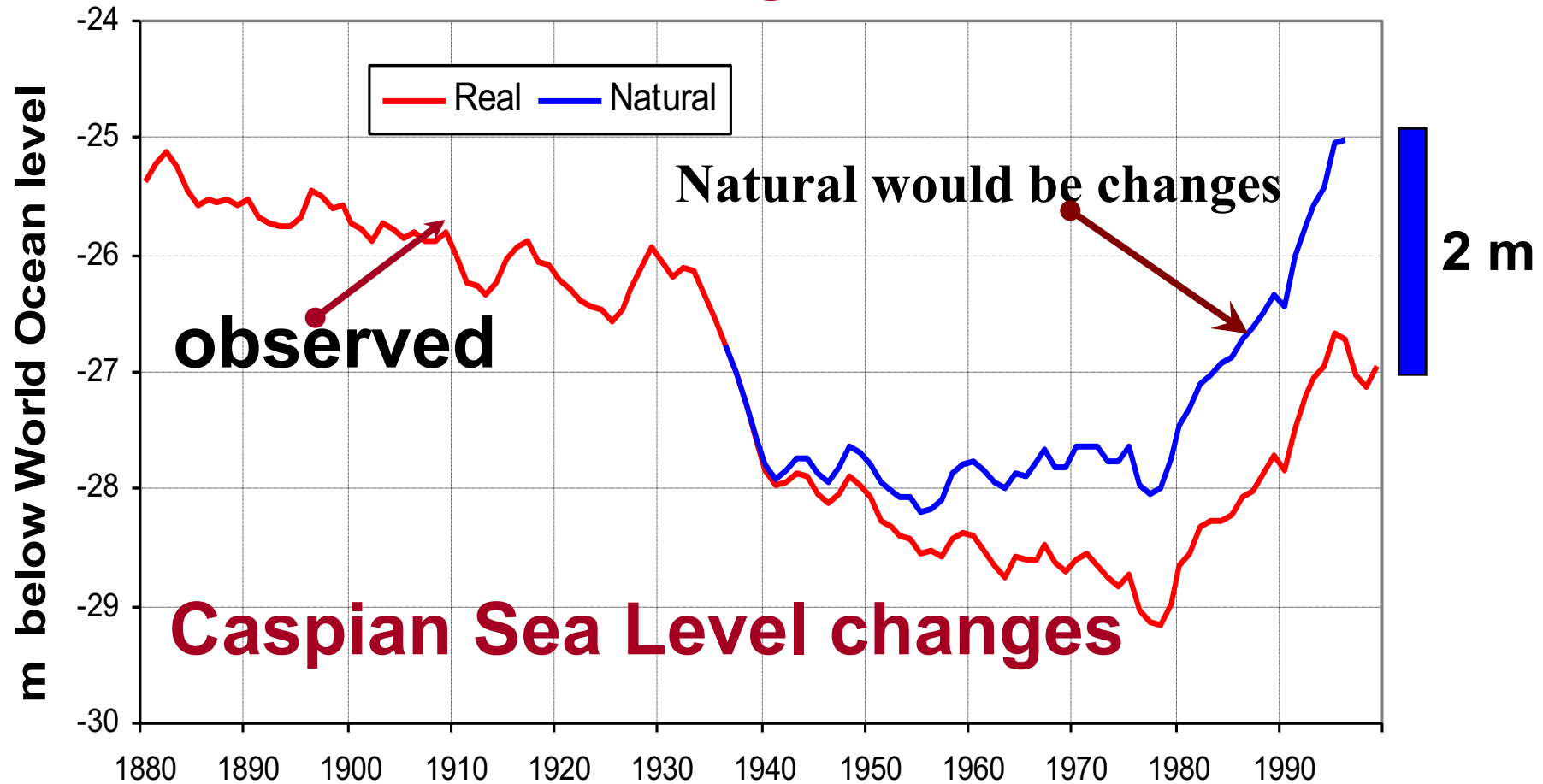
August 12, 2003

2003



**Gone in 2016; switched to
“blinking” regime**

Observed and “natural” changes in the level of the largest in the world lake are significant and of similar magnitudes



Source: Shiklomanov (1976)

Update: Shiklomanov and Georgievsky (2003)

Specific human dimension

We had “managed” societies in Northern Eurasia
and now *social shocks superimposed with
environmental changes reduce the resilience of
the societies of the region*

- Political system changed
- Land use rules changed
- Economics changed
- Infrastructure of social services unsupported

Plus

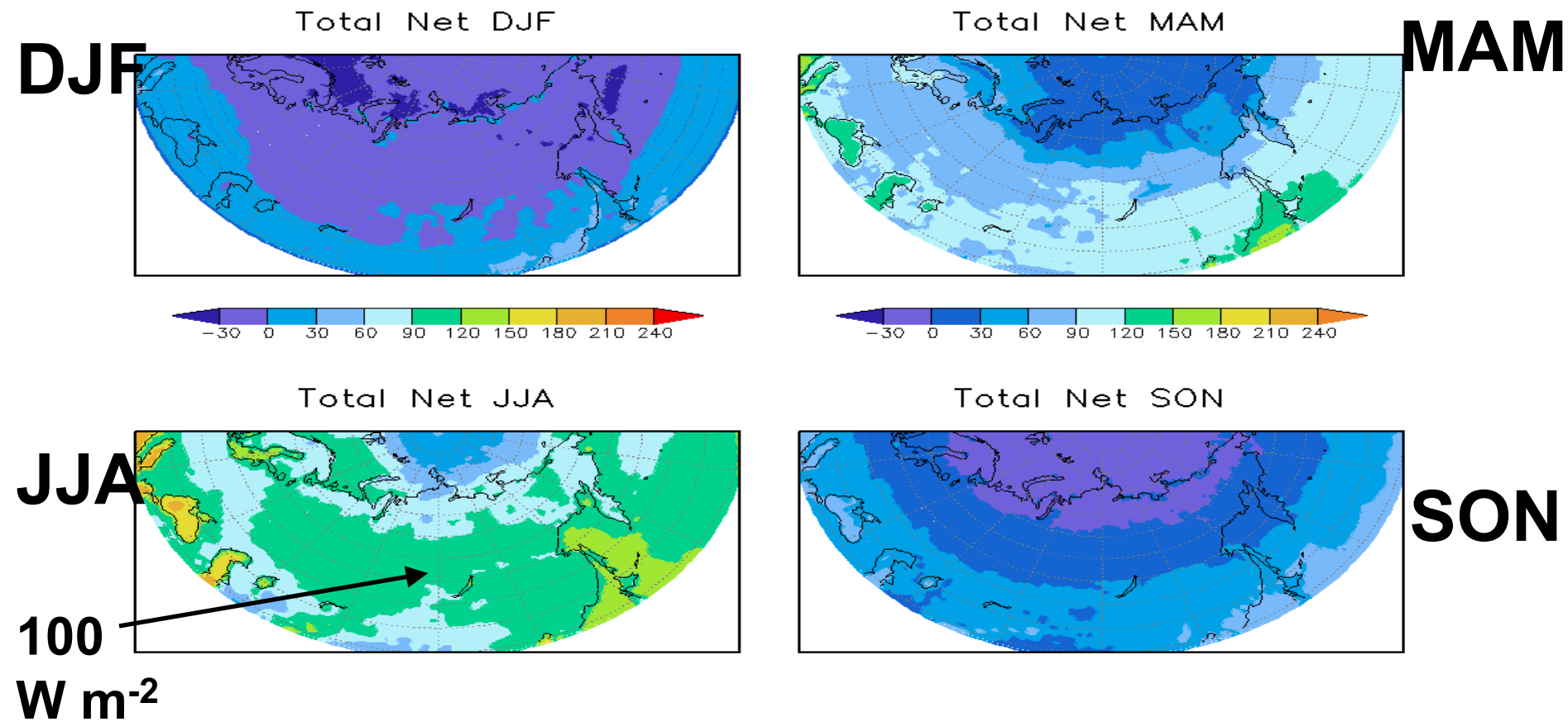
- “Hot spot” of climatic change
- Biogeochemical feedbacks changing in uncertain ways

Unique features of Northern Eurasia

- The most continental climate that is cut off from the humid tropics →
 - The highest levels of climate and weather variability
 - Highly vulnerable natural and agricultural ecosystems, and
 - Extensive and variable dry land areas
- The world's largest cold region
- Significant source of terrestrial carbon
- All the above => Potential for large climate change feedbacks of global importance => International interest

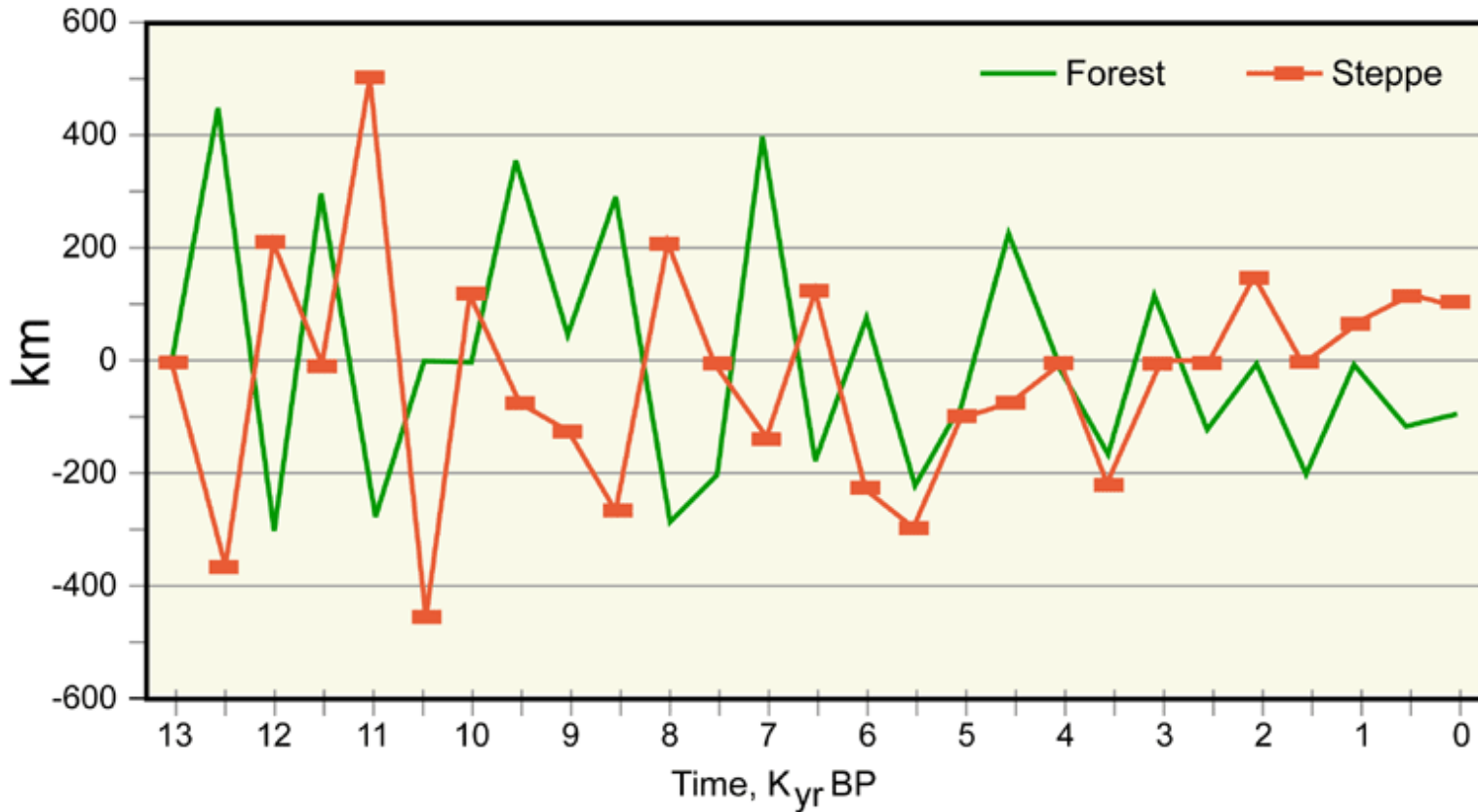
Short but intense warm season

The mean seasonal total net surface radiation budget, W m^{-2}



Stackhouse et al. 2017

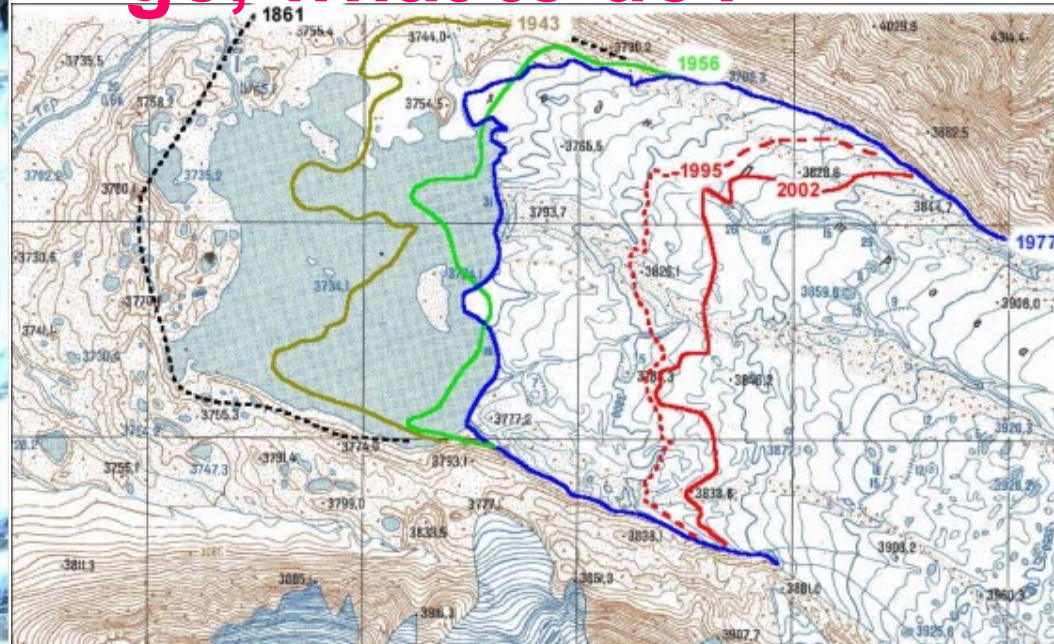
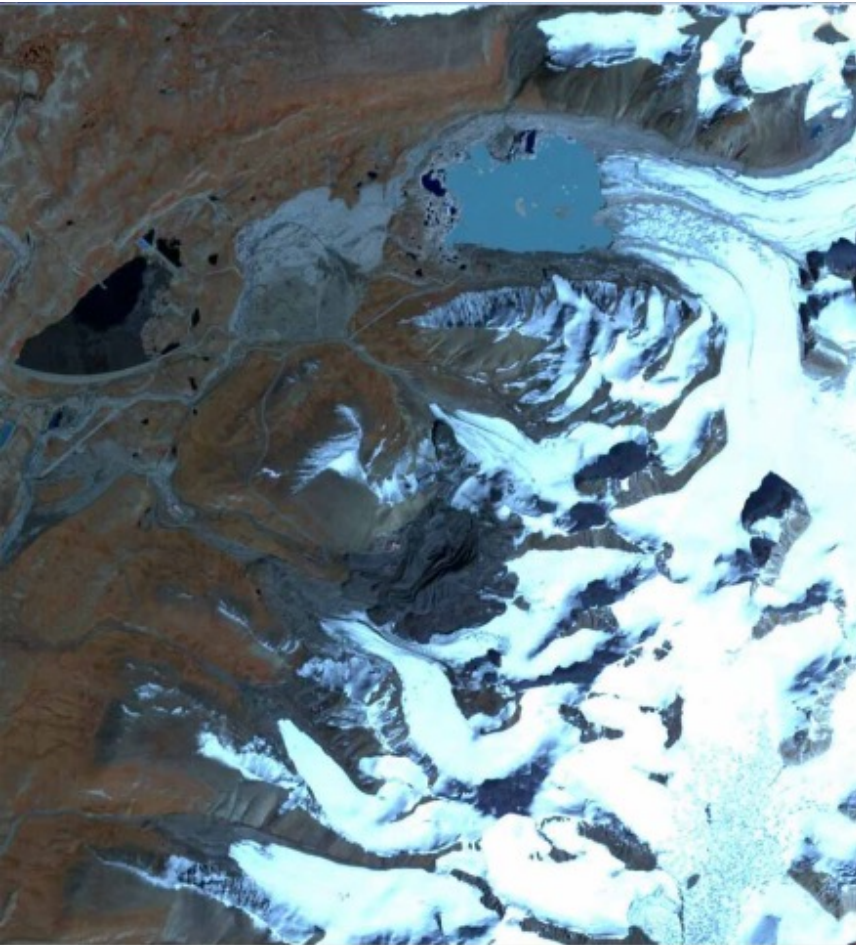
Changes in the past...



Changes of the northern boundaries of forest and steppe zones along the 39°E (past 13×10^3 years)
(Kozharinov and Puzachenko 2005)

Changes are affecting water supply...

When the millenium-old water storage will go, what to do?



Example. Central Asia .Example of a central Tien Shan glacier recession. Petrova Glacier in the Akshiyarak area, ASTER image, September 2002 (A), and instrumental topographic data (B) (Aizen and Kuzmichonok, 2003)

...land cover...

Two possible
scenarios after
the permafrost
thaw:

Wetlands

Steppe



... the carbon cycle over land...

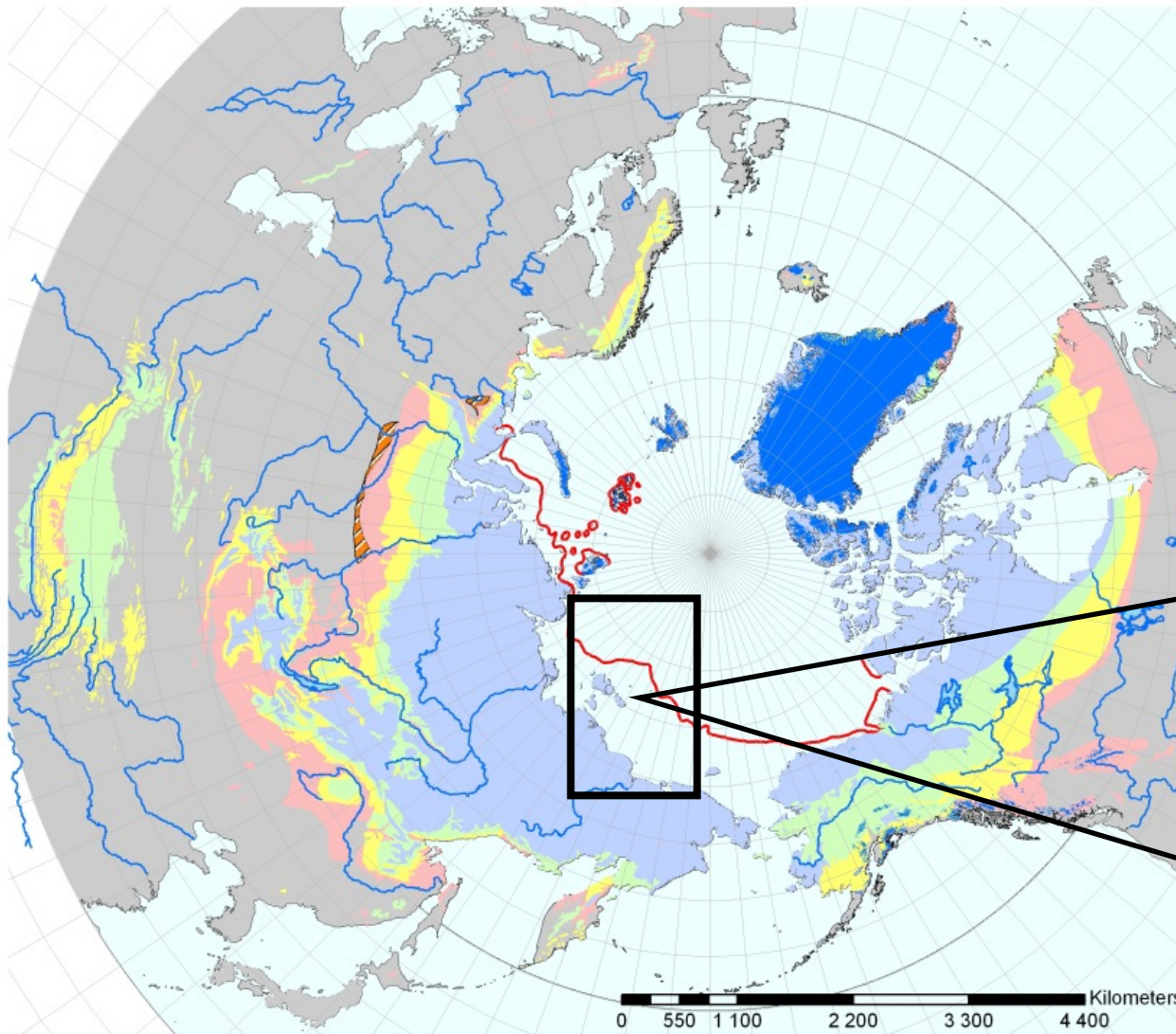


In the area of “wet thermokarst” formation, new and significant sources of CH₄ production are developing.

... and in the Arctic coastal zone

Circumpolar permafrost extent

Permafrost Lab., GI UAF, 2003



Coastal erosion and sub-sea permafrost degradation is a new and potentially very important issue for the global change.

... and put society wellbeing and human health in harm way

Increasing frequency of dust storms and increasing rate of soil erosion.



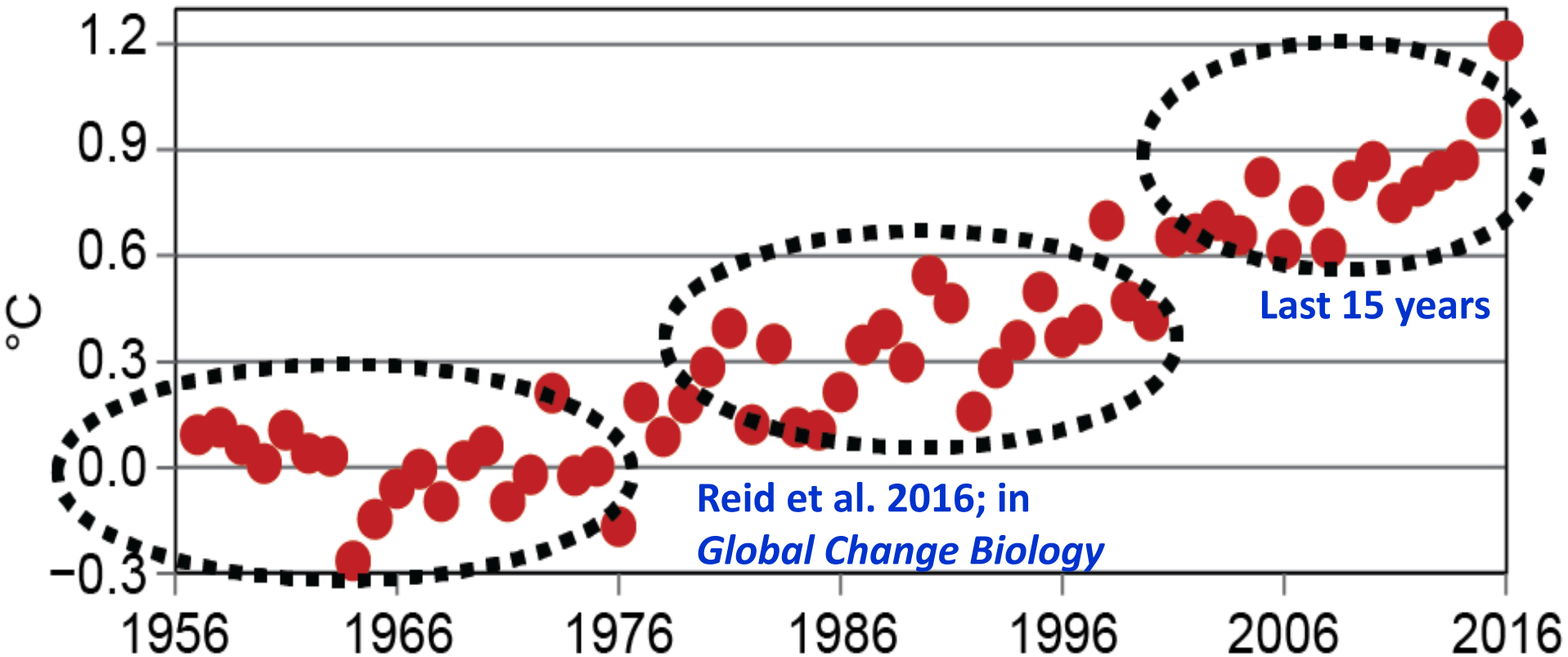
Air pollution. Fine aerosol particles are responsible for causing the greatest harm to human health.



URGENCY:

**SOME CHANGES HERE HAVE BEEN ALREADY
BEYOND THOSE SET BY THE PARIS
AGREEMENT OF DECEMBER 2015**

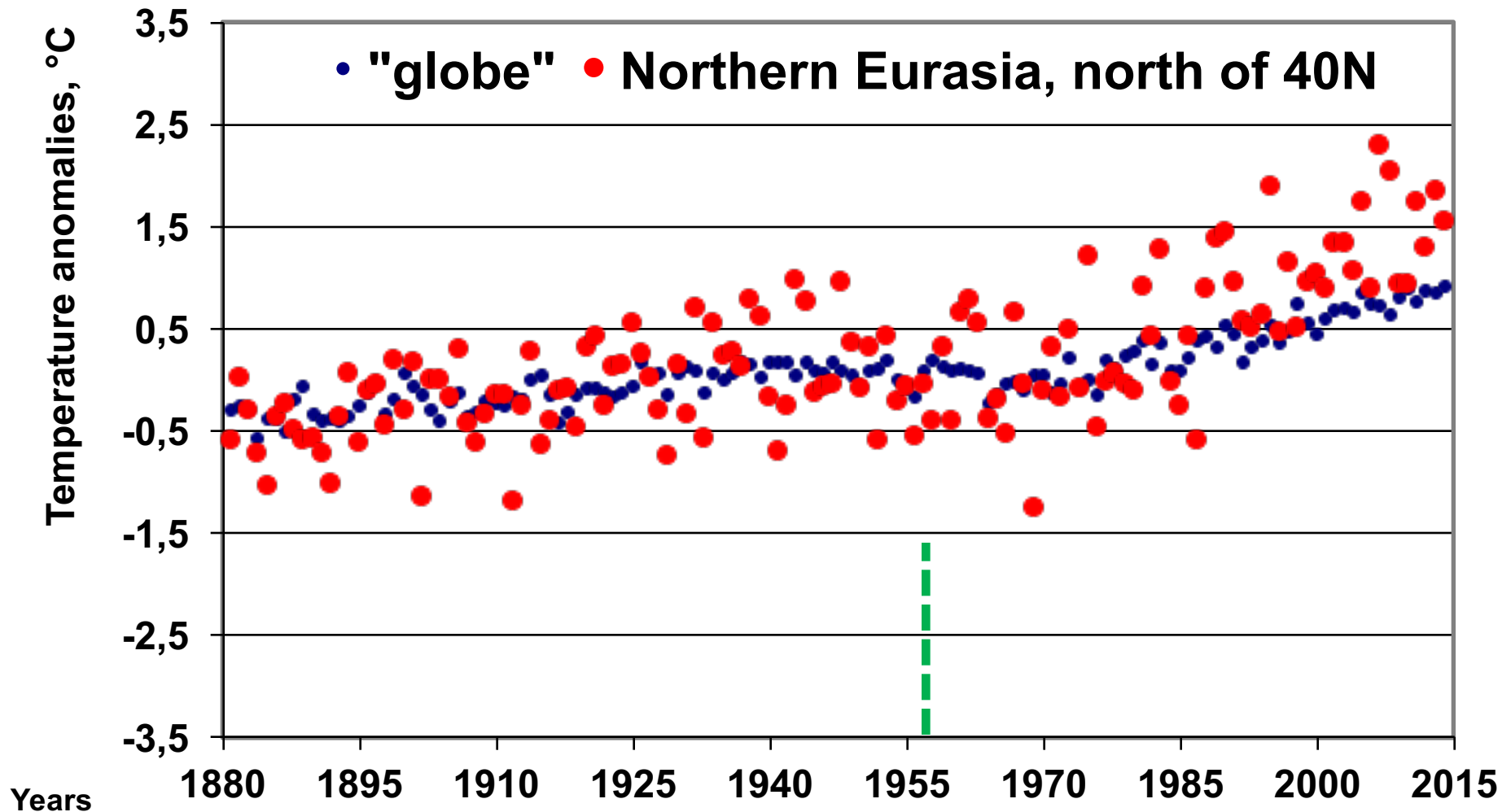
Global Annual Surface Air Temperature Anomalies, °C



Lugina et al. 2006, updated.

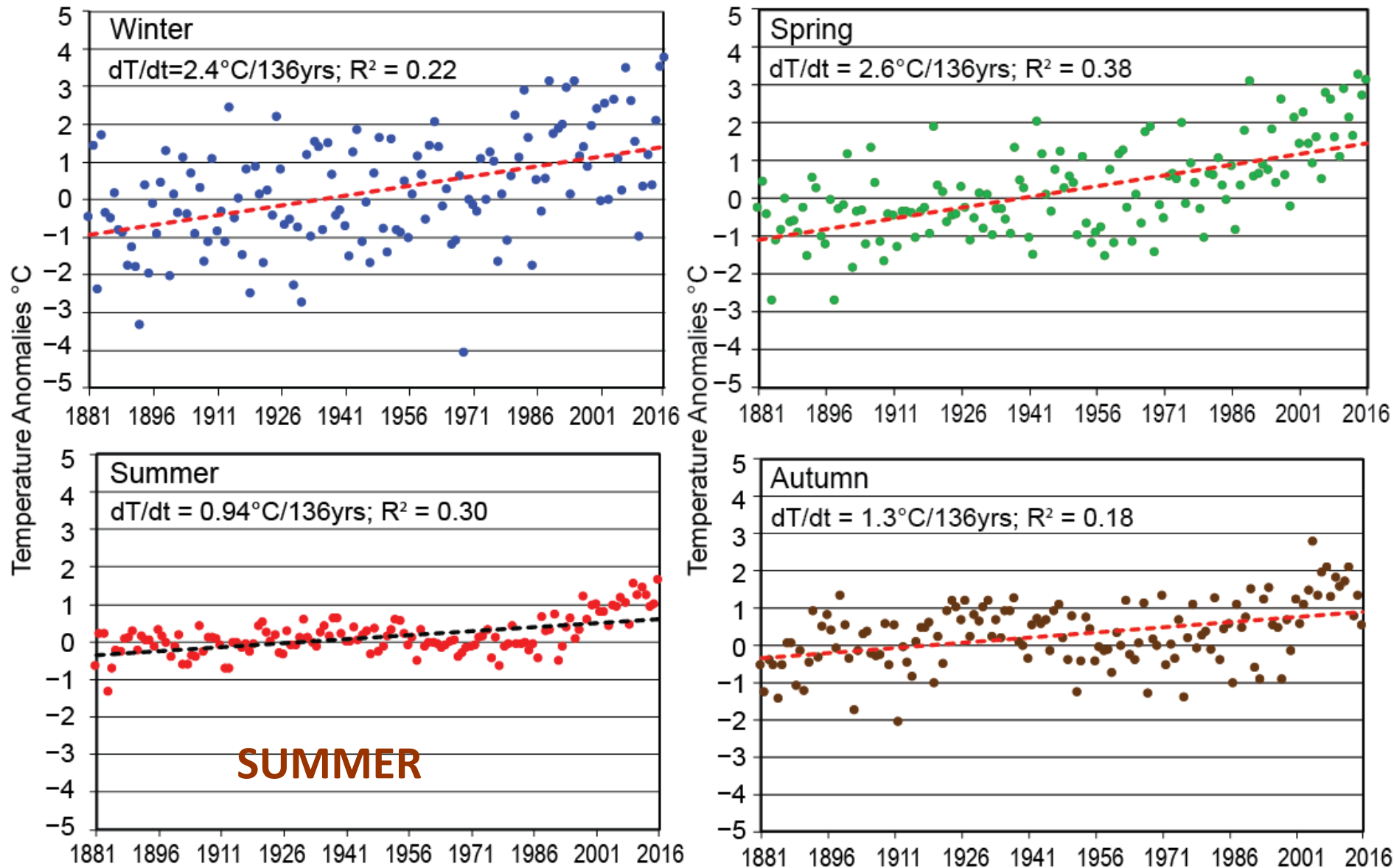
Anomalies from the long-term mean values for 1951-1975

Global Annual Surface Air Temperature Anomalies, °C



Rates of increase of annual temperature for the “globe” (60°S to 90°N) and Northern Eurasia are **0.96 °C/130 yr** and **1.6°C/130yr** respectively (Lugina *et al.* 2006, updated).

Temperatures in Northern Eurasia since 1881



Regional warming here is well above than the average temperature increase over the Globe

NEFI ADD-ON TO THE NEESPI CONCEPT

We are living in the epoch of large changes in **Climate, Environment, and Human Activities**. All these changes now have become intertwined and affect each other => they have to be studied in a synergetic manner.

This has been the NEESPI concept. However, the socio-economic impacts of variability and/or systematic changes in climate and environment are still poorly covered making it difficult to effectively plan future (and to accurately interpret already performed) model experiments.

=>

- The Northern Eurasia Future Initiative (NEFI) objective is to bridge climate and environmental studies with the economic consequences of the observed changes and societal development.
- NEFI will provide the synergy between them and spurring the advances of physical sciences in quantifying observed and projected climate and environmental changes and the advances of the economic analyses and the impacts.

New/Old Science Questions

- How can we quantify and project the ecosystems dynamics in Northern Eurasia that:
 - i. *are internally unstable (e.g., operate in narrow temperature ranges);*
 - ii. *are interrelated with highly variable components of the cryosphere and/or are vitally controlled by components that have been systematically changing (greenhouse gases; land use, atmospheric circulation) and,*
 - iii. *have a potential to impact the global Earth system with unprecedented rates of change over few decades, e.g., due to, for example, catastrophic forest fires, dust storms, and hotly debated future methane release from the frozen ground in high latitudinal land and shelf areas.*
- **What are the major drivers** of the ongoing and future changes of the water cycle in Northern Eurasia and how will their changes affect the regional ecosystems, society and feedback to the Global Earth system and economy
- **How to secure the sustainable development of societies of Northern Eurasia** in the near future overcoming the “transitional” nature of their economics, environmental and climatic change challenges, and untying institutional legacies?

Foci of new research

- 1. Global change, particularly the warming of the Arctic**
- 2. Increasing frequency and intensity of extremes and changes in the spatial and temporal distributions of inclement weather conditions**
- 3. Retreat of all components of the cryosphere**
- 4. Changes in the terrestrial water cycle**
- 5. Changes in the biosphere**
- 6. Pressure on agriculture and pastoral production**
- 7. Changes in infrastructure**
- 8. Societal actions to mitigate negative consequences of the environmental change and to benefit from positive consequences**
- 9. Quantification of the role of Northern Eurasia in the global Earth and socioeconomic systems to advance research tools with an emphasis on observations and models.**

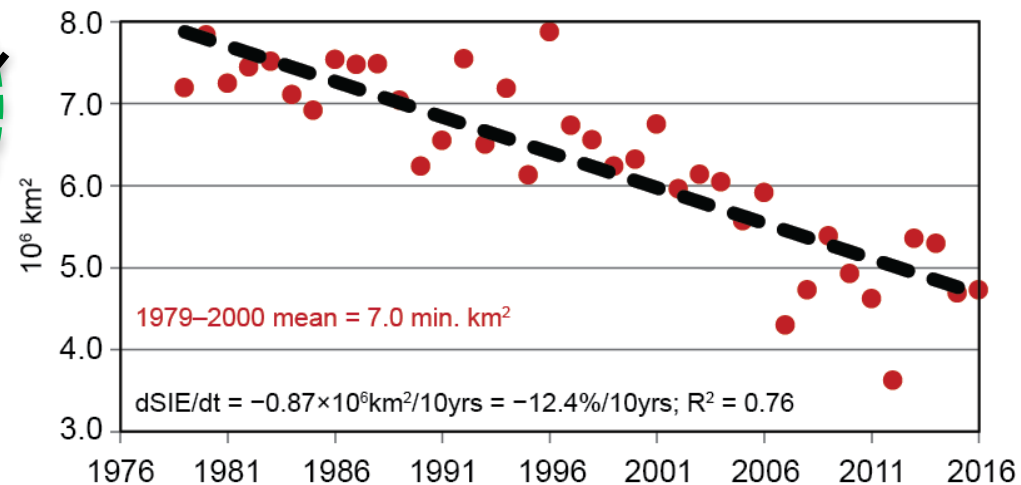
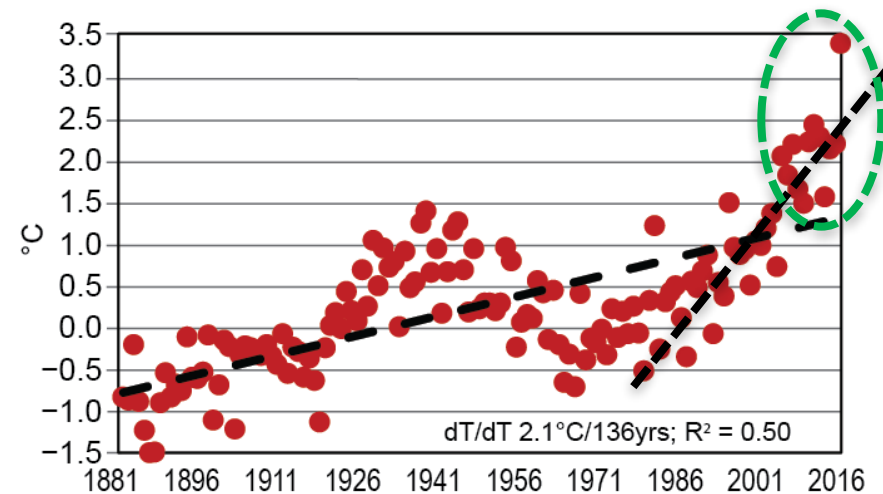
Research Focus: Global Impact of the Arctic Warming

- Direct regional warming/cooling
- Changes in atmospheric circulation
- Social and economic consequences



*One of the first UCMO GCM sensitivity experiments with polar ice replaced by water at 0°C. Changes in January surface air temperature, °C (**Newson 1973**).*

Annual surface air temperature anomalies area-averaged over the 60°N - 90°N latitudinal zone



Northern Hemisphere September sea ice extent

Summer and annual maximum daily precip at Krymsk station, mm/day

Black Sea June-July SST, °C

Research Focus: Extremes frequency and intensity in changing climate.



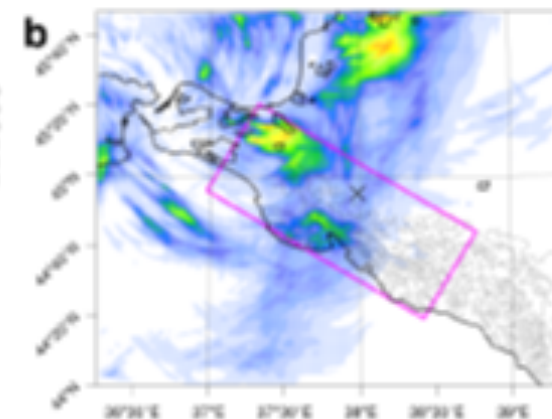
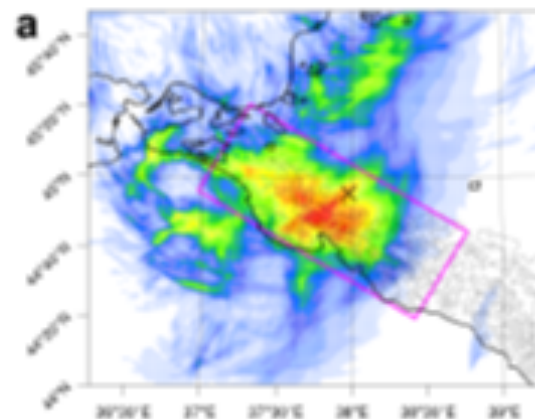
(Groisman et al. 2013)

Krymsk Flood Russia, July 7, 2012 (Meredith et al. 2015)

Total simulated precipitation from 6th July at 03Z to 7th July 2012 at 12Z

Realistic SST at the course of the event

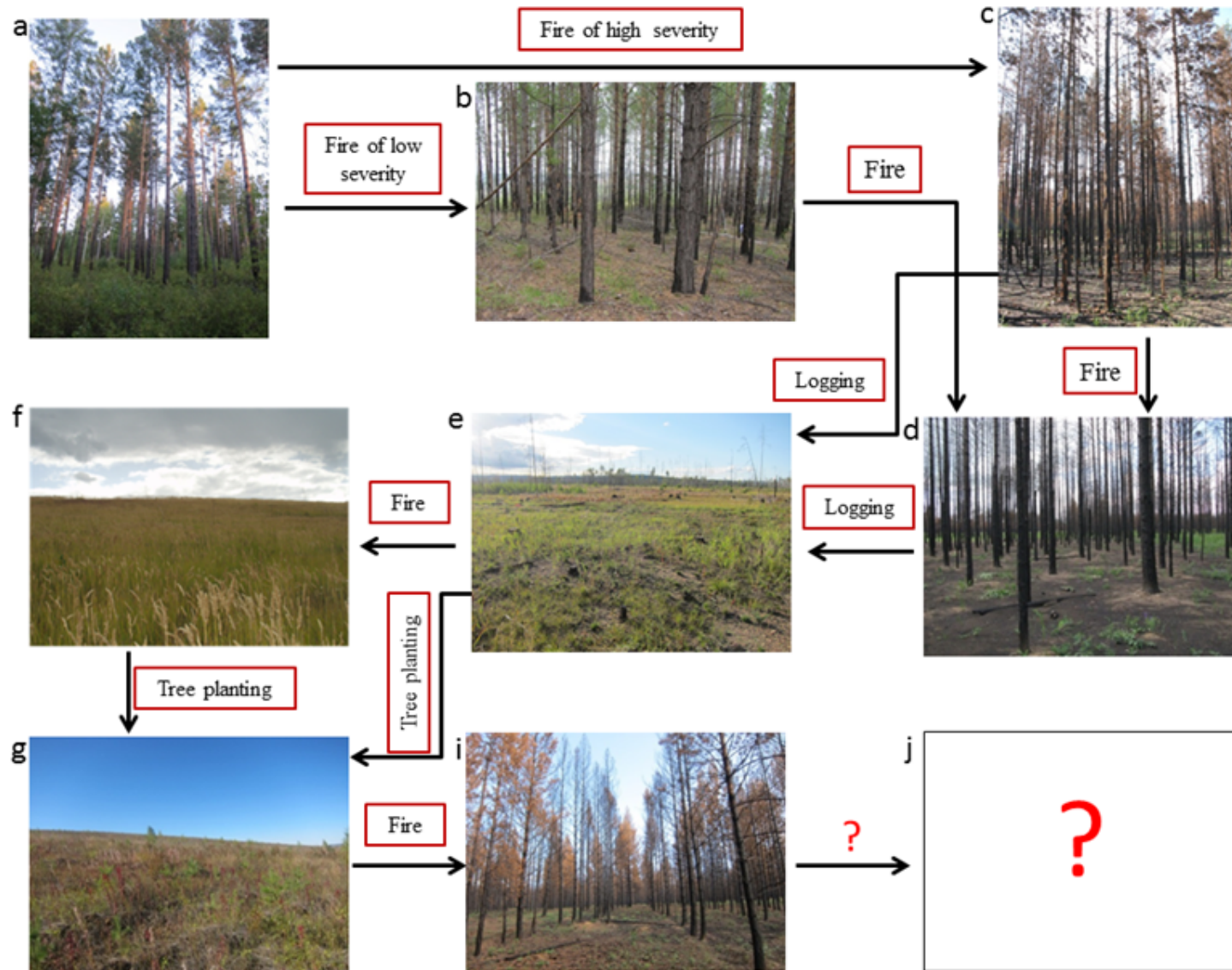
Reduced SST with subtracted clim trend



186 mm (171 mm observed)

23 mm

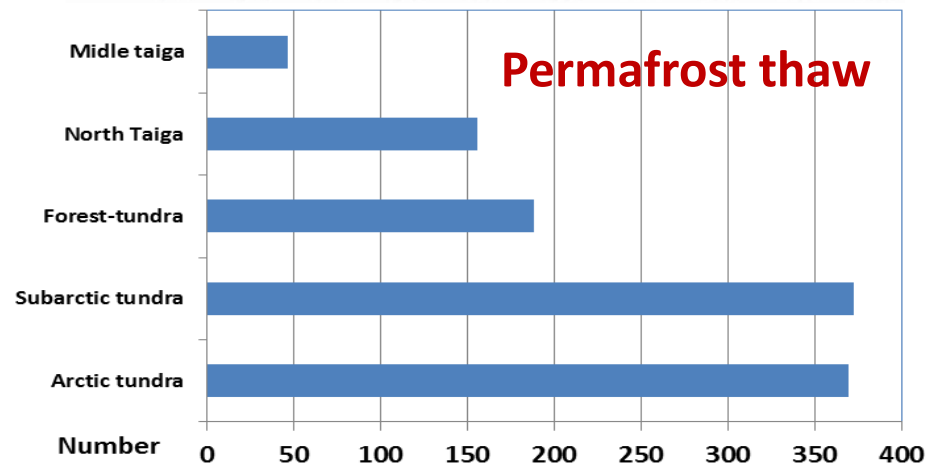
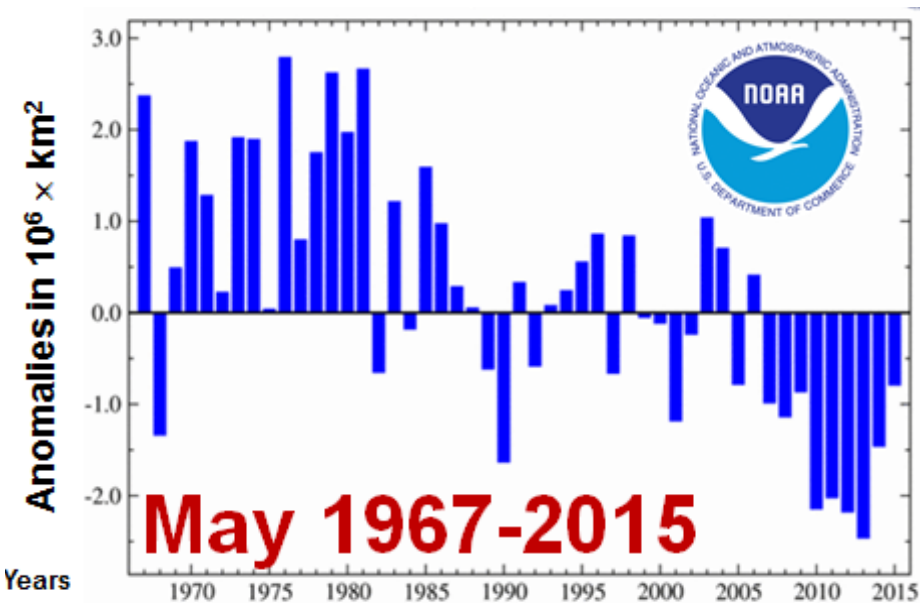
Research Focus: Extremes frequency and their intensity in changing environment



Extreme forest fire affect the biosphere (Kukavskaya et al. 2016)

Research Focus: Cryosphere retreat

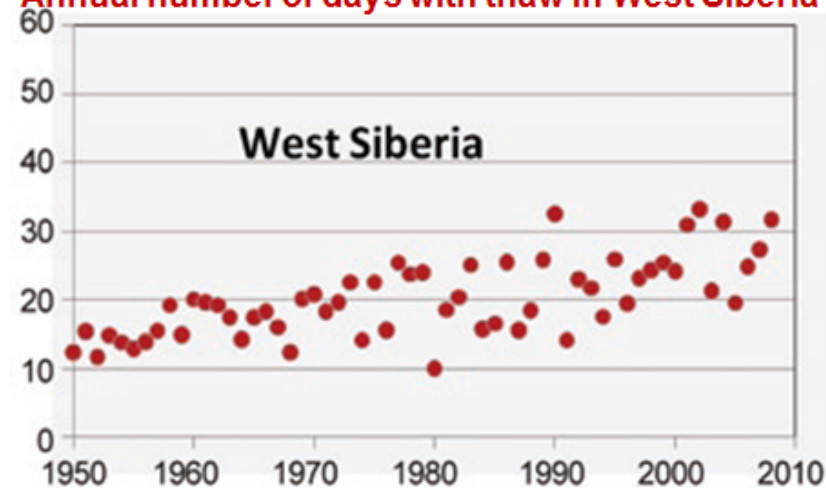
May snow cover over Eurasia



Number of newly emerging thermokarst lakes in W. Siberia, 1973-2013 period, Polishchuk et al. 2015

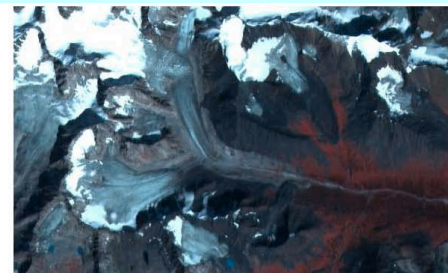
We define “days with thaw” as the days when the mean daily temperature is above -2°C while snow on the ground is above 5 cm.

Annual number of days with thaw in West Siberia



Upper Khovd River Basin

Photo by V.V. Sapozhnikov



River Discharge within three neighboring valleys in the Tian Shan Mountains (Zailiyskiy Alatau)

River Basin	Level of glaciation	Discharge tendency
Kaskelen	Low glaciation	Decrease
Malaya Almaatinka	Moderate glaciation	Moderate increase
Bolshaya Almaatinka	Extensive glaciation and buried ice	Very strong increase

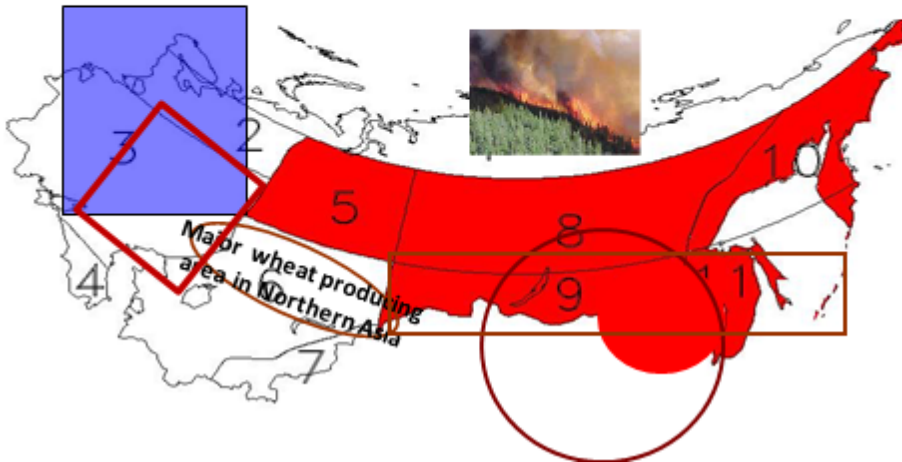
Prof. Maria Shahgedanova, Walker Institute for Climate System Research, The University of Reading, United Kingdom, Personal Communication



Research Focus: Water supply deficit

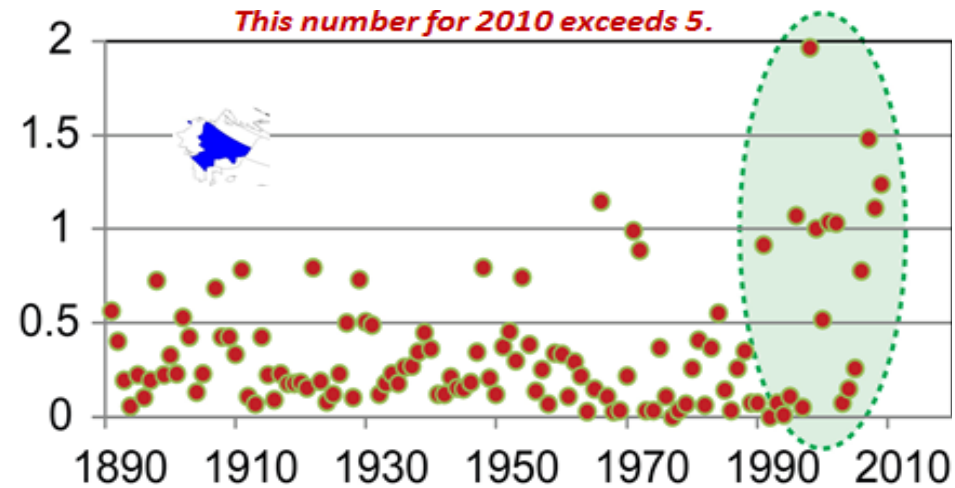
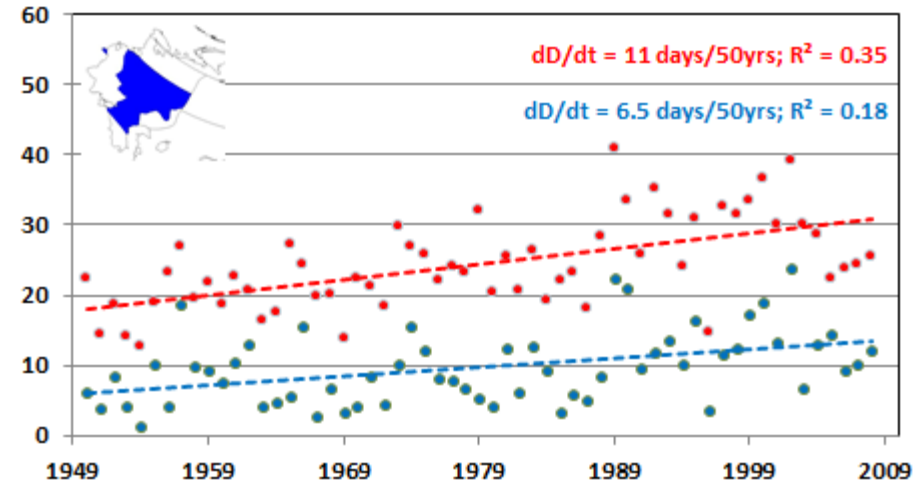
1. Mild winters with frequent thaws
2. Earlier spring onset
3. Longer vegetation season
4. Warmer summers and
5. No significant change in precipitation

All the above lead to summer dryness and promote extremely dry episodes



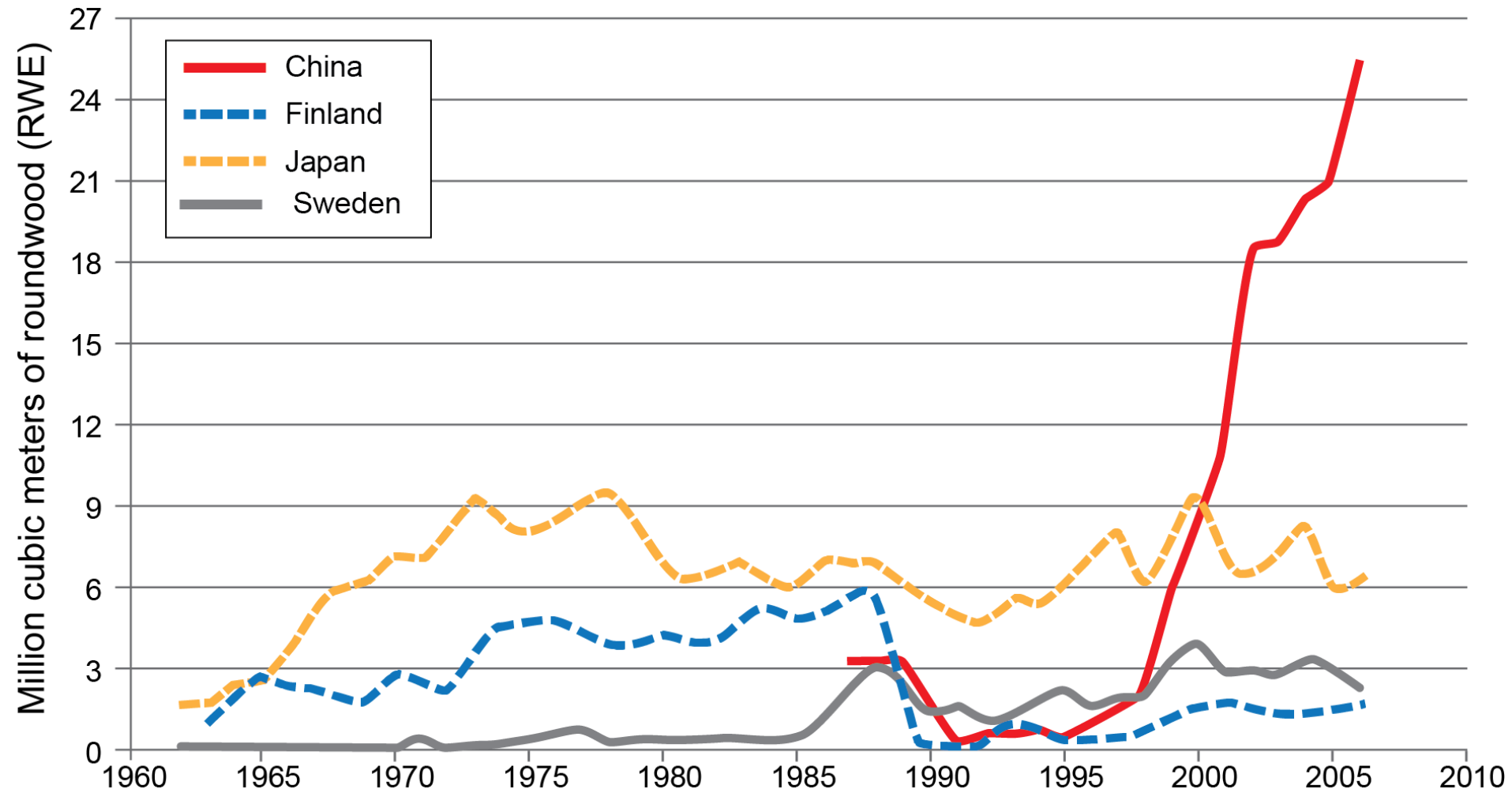
Changes in the surface water cycle over Northern Eurasia in the 20th century; areas with more humid conditions (**blue**), with more dry conditions (**red**), with more agricultural droughts (**circled**), and with more prolonged dry episodes (**rectangles**).

Annual and **winter** number of days with thaw over European Russia south of 60°N

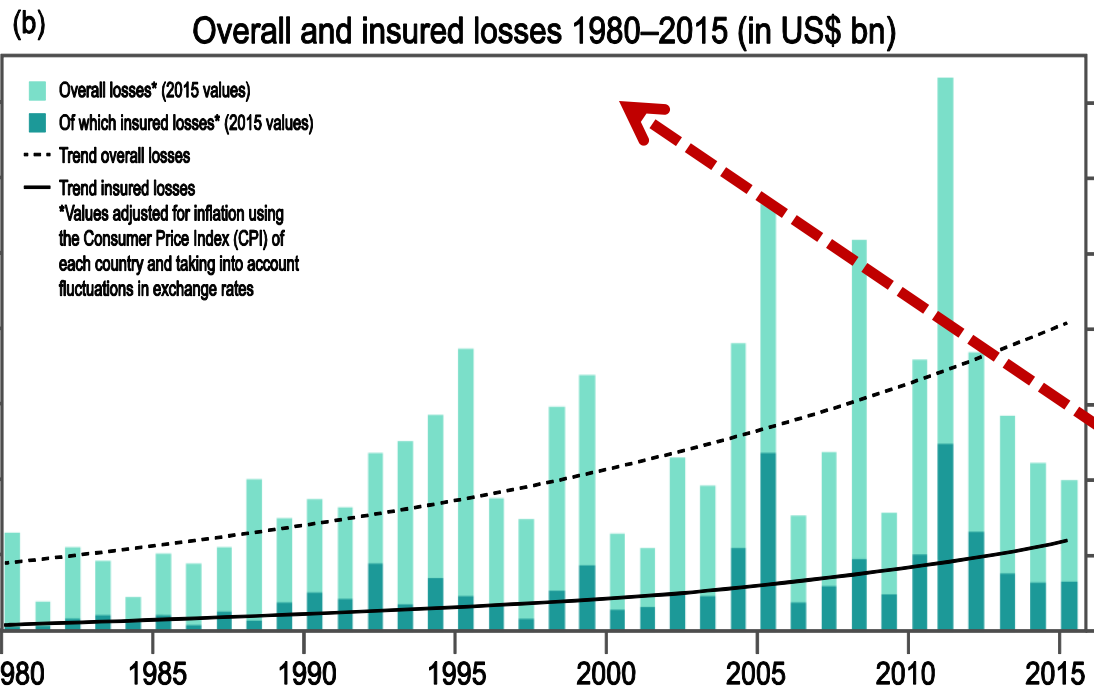
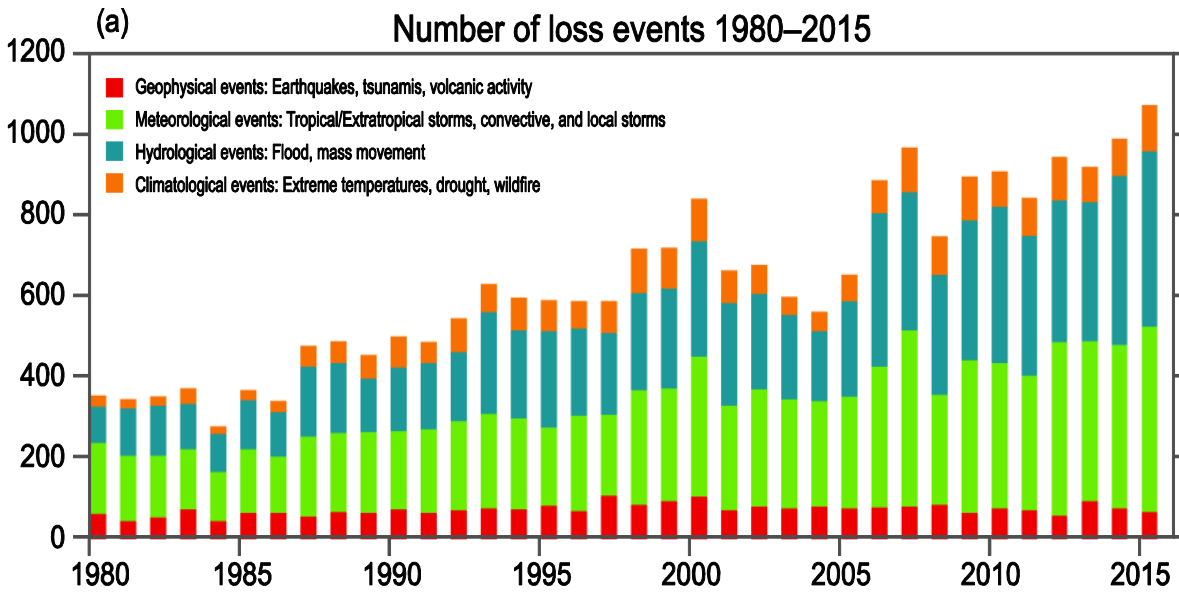


Number of "hot" nights, $T_{\min} > 23.9^{\circ}\text{C}$ over European Russia south of 60°N

Growing commodities trade (here, round-wood between Russia and its four neighbors)



Research Focus: Societal feedbacks in response to environmental changes



Planning in order to be prepared for risks related to the **increasing possibility of changes** and to reduce the adverse impact of disasters and increase resilience of the communities at risk is needed. . *Future studies within this focus should be concentrated on development of appropriate models that account for direct social feedbacks.*

The frequency and damage of the major natural and environmental disasters. **Source: Munich Re-insurance**

BARROW AK, USA
Population 4,212
71°17'44"N 156°45'59"W



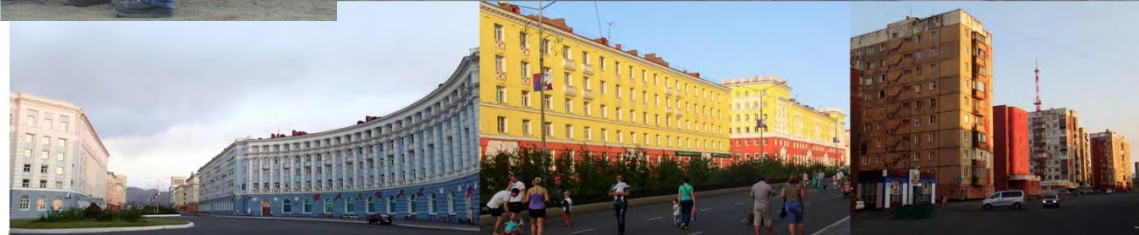
New foci:
f. Transformation of
environment by man
and our need to survive
in this environment

NORILSK, RF
Population 175,365
69°51'N 88°13'E



TWO FACES OF THE ARCTIC

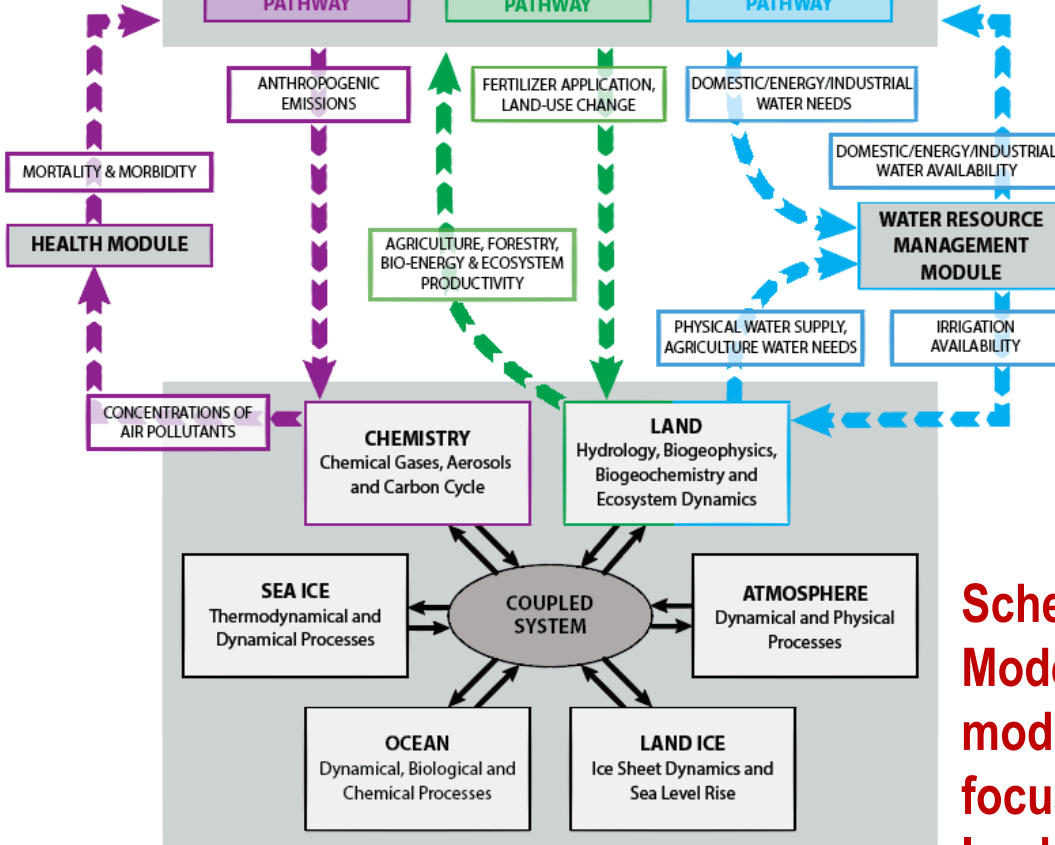
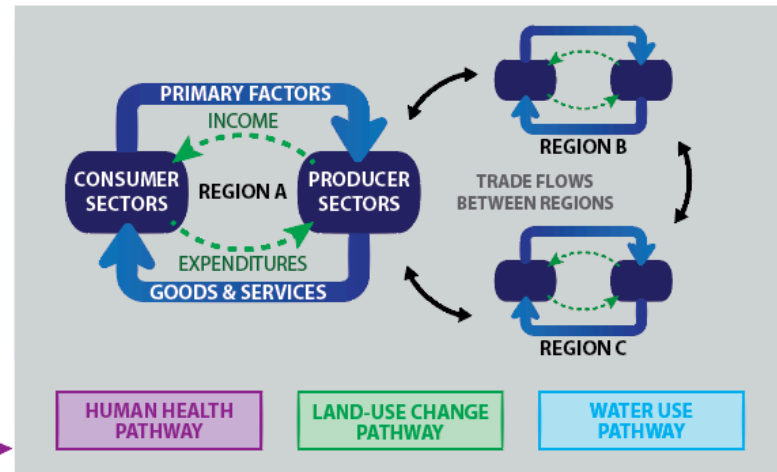
Courtesy of Prof. Nikolay
Shiklomanov, George
Washington University, DC, USA



FOCUS ON INTERDISCIPLINARY MODELING

- 1. Development of regional process-oriented models, the Earth System models, and Integrated Assessment Models that can be used for assessments of future changes under different environmental and socioeconomic change scenarios**
- 2. Studying the role of Northern Eurasia in the global Earth and socioeconomic systems**

HUMAN SYSTEM



EARTH SYSTEM

Research Focus: Role of Northern Eurasia in the global Earth and socioeconomic systems (Monier et al. 2017).

Future studies within this focus should be concentrated on exploitation of a suite of regional process-oriented models, the Earth System models, and Integrated Assessment Models under different environmental and socioeconomic change scenarios with tracking the changes beyond the Northern Eurasia domain, i.e., teleconnections

Schematic of an Integrated Assessment Model (IAM) that couples a human activity model and an Earth system model with a focus on three feedback pathways: health, land-use change, and water resources.

The latest NEFI events:

- **May 2016:** The NEFI White Paper (Science plan) has been completed and exposed for public comments at the NEESPI web site
- **December 2016 - January 2017:** Two programmatic papers were submitted to *ERL* and *PEPS* (the second paper is currently in review).
- **The first NEFI Special Issue of *Environ. Res. Lett.* was launched in March 2017** <http://iopscience.iop.org/1748-9326/focus/NEFI>
- **We convened the NEFI Sessions at the AGU (Dec. 2016) and JpGU-AGU (May 2017) Annual Meetings. Two more sessions in Zvenigorod, Russia (Sept. 2017) and New Orleans, USA (Dec. 2017) have been planned.**

Present NEFI programmatic papers *in review and published*

- **Groisman et al. 2017: Northern Eurasia Future Initiative (NEFI): Facing the Challenges and Pathways of Global Change in the 21st Century. *Problems of Earth and Planetary Sciences, PEPS*. Submitted in December 2016**
- **Monier et al. 2017: A Review of and Perspectives on Global Change Modeling for Northern Eurasia. *Environ. Res. Lett.*, 12, <http://iopscience.iop.org/article/10.1088/1748-9326/aa7aae/meta>.**
- **Chen, Y.Z et al., 2017: "Quantitative assessment of carbon sequestration reduction induced by disturbances in Temperate Eurasian Steppe. *Environ. Res. Lett.*, 12, [doi: iopscience.iop.org/article/10.1088/1748-9326/aa849b](http://iopscience.iop.org/article/10.1088/1748-9326/aa849b).**

Ongoing and future NEFI steps

- Existing NEESPI projects have been coopted to NEFI.
- New Projects that will be joining to NEESPI/NEFI may have the affiliation of their choice; international nature of NEFI/NEESPI Projects (with researchers from 2+ nations) will be preserved.
- NEFI Science Plan will be broadly distributed among the researchers who have research interests in Northern Eurasia.
- Support of perspective proposals to Funding Agencies will be provided on behalf of NEESPI (up to 2017) and NEFI.
- Next NEFI /NEESPI Research Session and Meeting has been scheduled at the AGU Annual Meeting, New Orleans (December, 2017) [*There are plans for 2 more Meetings*].
- Taking into account that two largest regional research communities (in China and Russia) are somewhat discriminated by the US funding Agencies, more attention have been devoted to other national and international Agencies (Belmont Forum, AMAP, BRICS, APN, and to Bilateral Collaboration Research Calls).

Why international community

should study 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 and without clear understanding of them, the description and modeling of the entire Earth system are not possible**
- **The studies will have benefits to the societies of the region**
- **The region possessed a wealth of scientific talent that can be utilized.**

The NEFI Challenge

How to provide in Northern Eurasia a sustainable societal development (economy well-being, activities, health, and strategic planning) in changing climate, ecosystems, and... societies?

Thank You!