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

Terrestrial and Coastal Ecosystems Interactions with Climate

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Interagency NEESPI Meeting

This talk covers the following areas of the Science Plan

- **Surface energy and water cycles**
- **Ecosystems and climate interactions**
- **Topics of special interest:**

  -….

  - Coastal zone processes

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"In general, the country lacks heat. And where the heat becomes more adequate, it lacks moisture"

Paul E. Lydolph, 1977: *World Survey of Climatology.* Vol. 7. "Climate of the Soviet Union"

Changes in the surface energy budget

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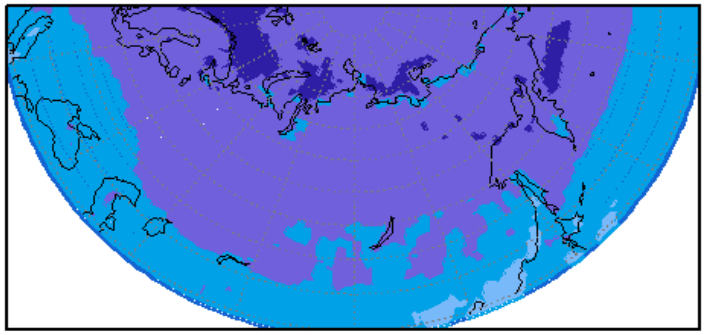
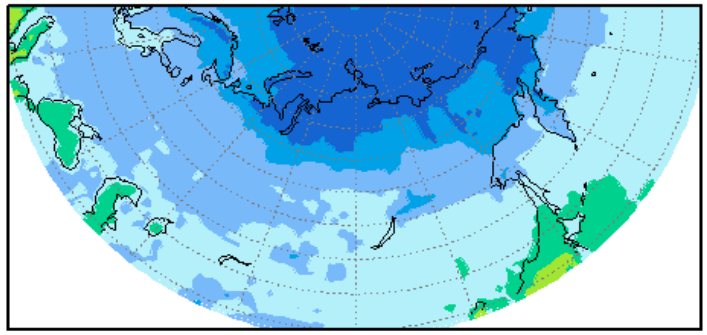
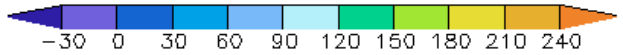
The mean seasonal total net surface radiation budget, W m^{-2}

Total Net DJF

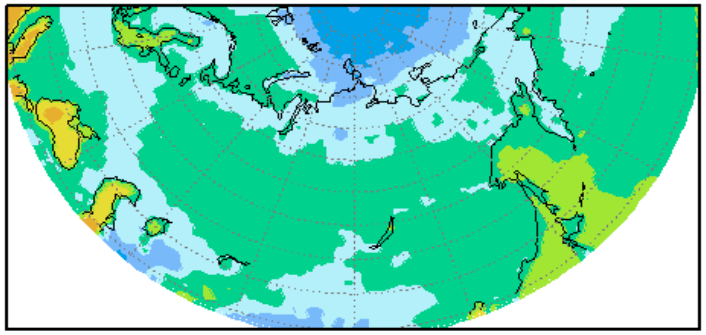


Total Net MAM

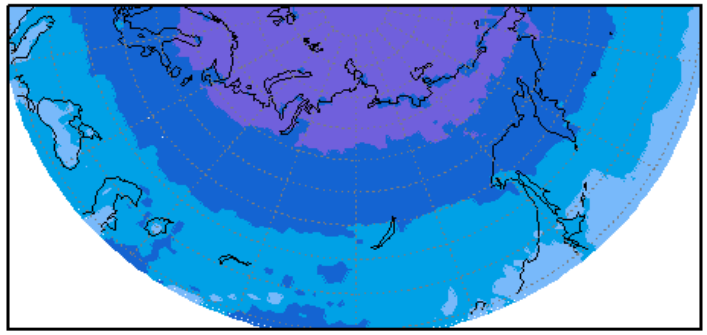




Total Net JJA



Total Net SON



Stackhouse et al. 2004

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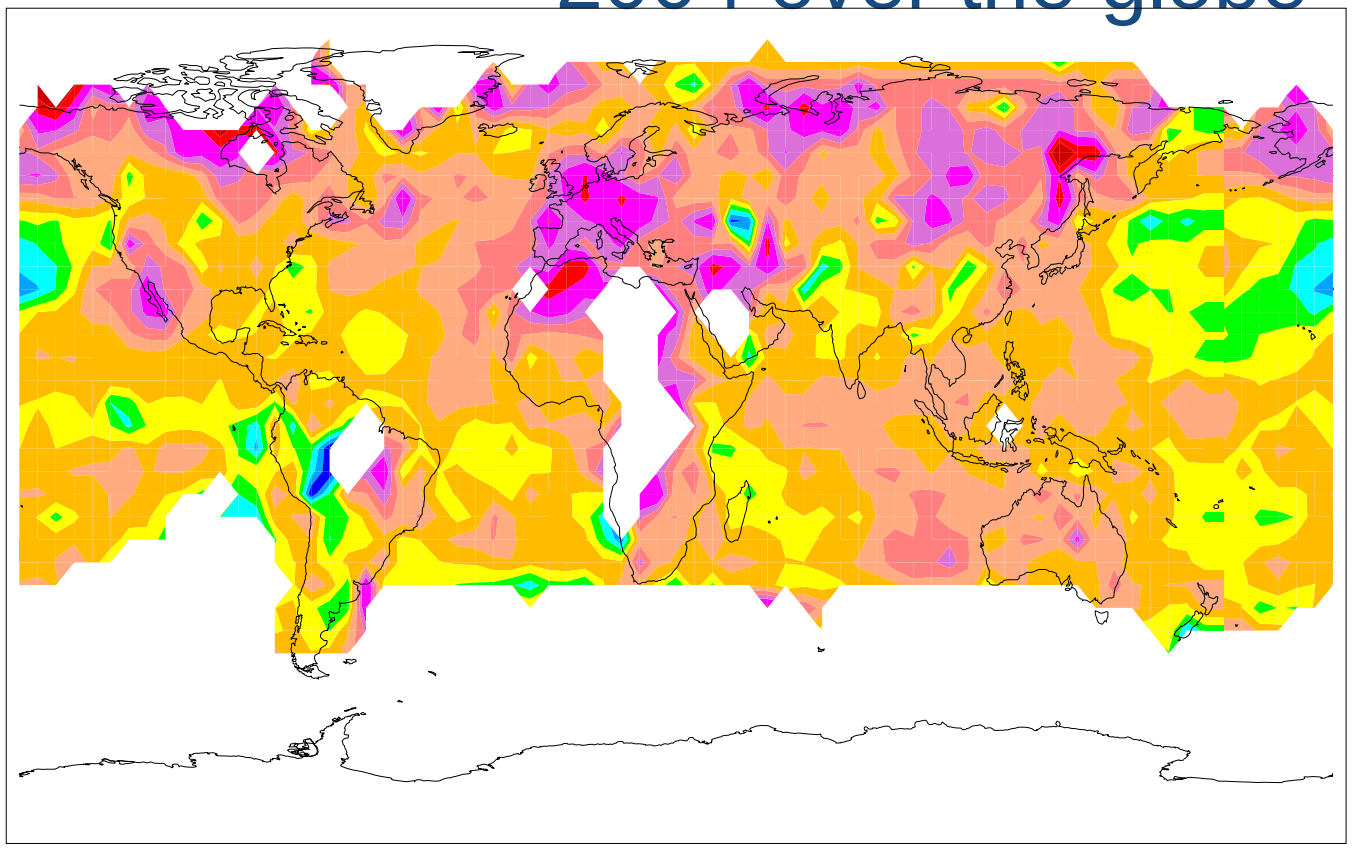
Mean Summer Temperature Change 1965 to 2004 over the globe



"First time", the summer changes are also large. This season is the most important for high-latitude' ecosystems.

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

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Changes in temperature-derived characteristics over Northern Eurasia during the past 50 years (east of 30ºE, north of 50ºN) have already affected biosphere and human society (Groisman et al. 2003)

Characteristic	Trend, %/50 yrs
Heating-degree days	-7 to -6
Degree-days below 0ºC	-19 to -12
Degree-days above 15ºC	12 Siberia only
Duration of the growing season (T> 10ºC)	8
Frost-free period	10 Siberia only

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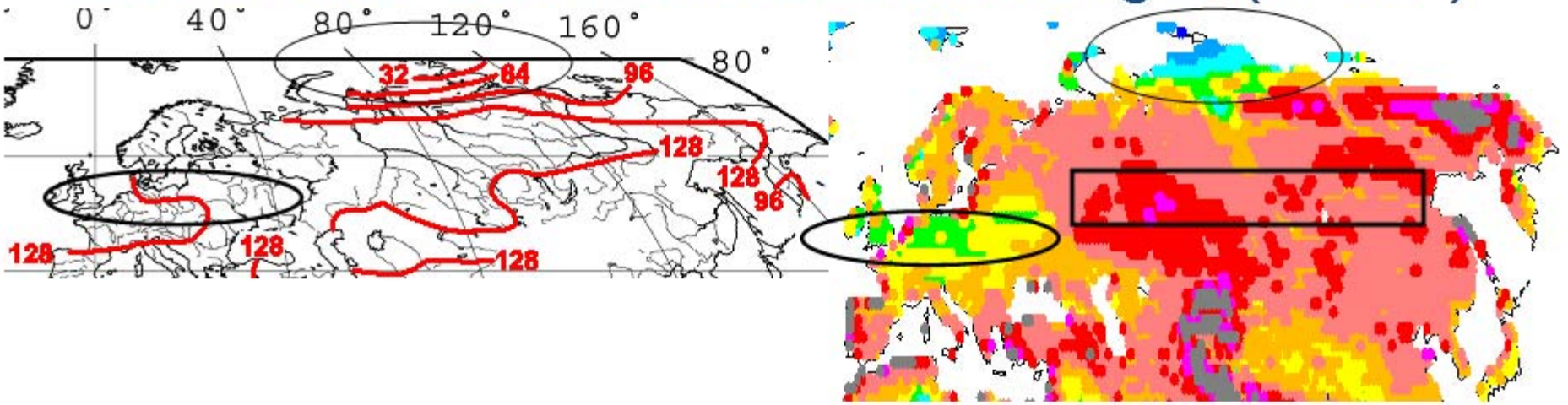
Mean June surface radiation budget (W m^{-2})



Budyko (1963)

Areas of similarity

Stackhouse et al. (2004)

Areas of large differences

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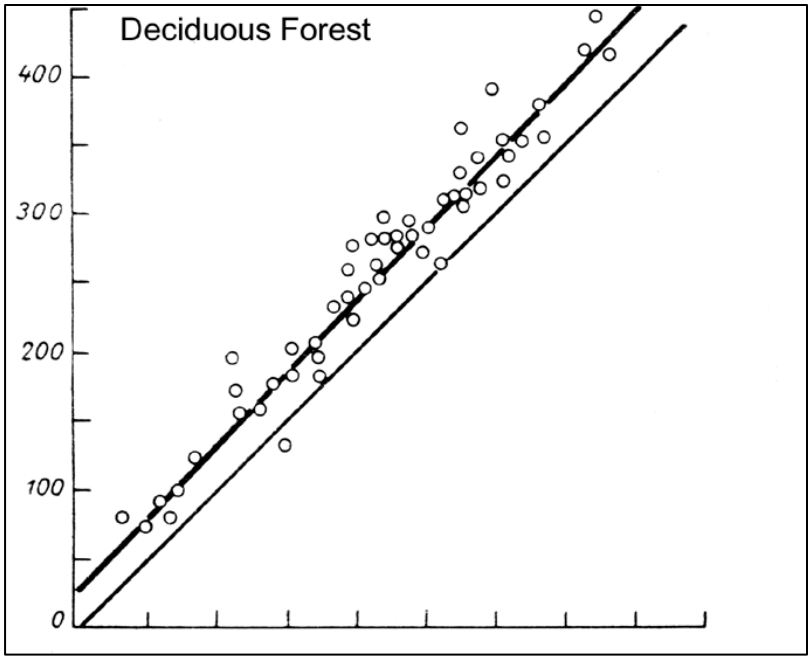
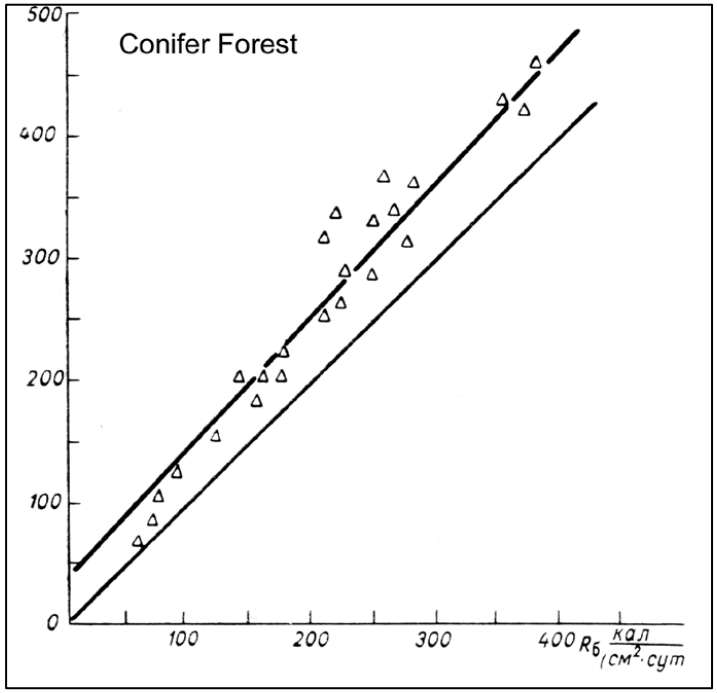
Radiation balance of forested (RB_f) versus nearby forest-free (RB_0) sites





$RB_f = a\ RB_0 + b$ (Rauner 1972)

Conifer forest: a = 1.10; b = 20 W m^{-2}

Deciduous forest: a = 1.05; b = 15 W m^{-2}

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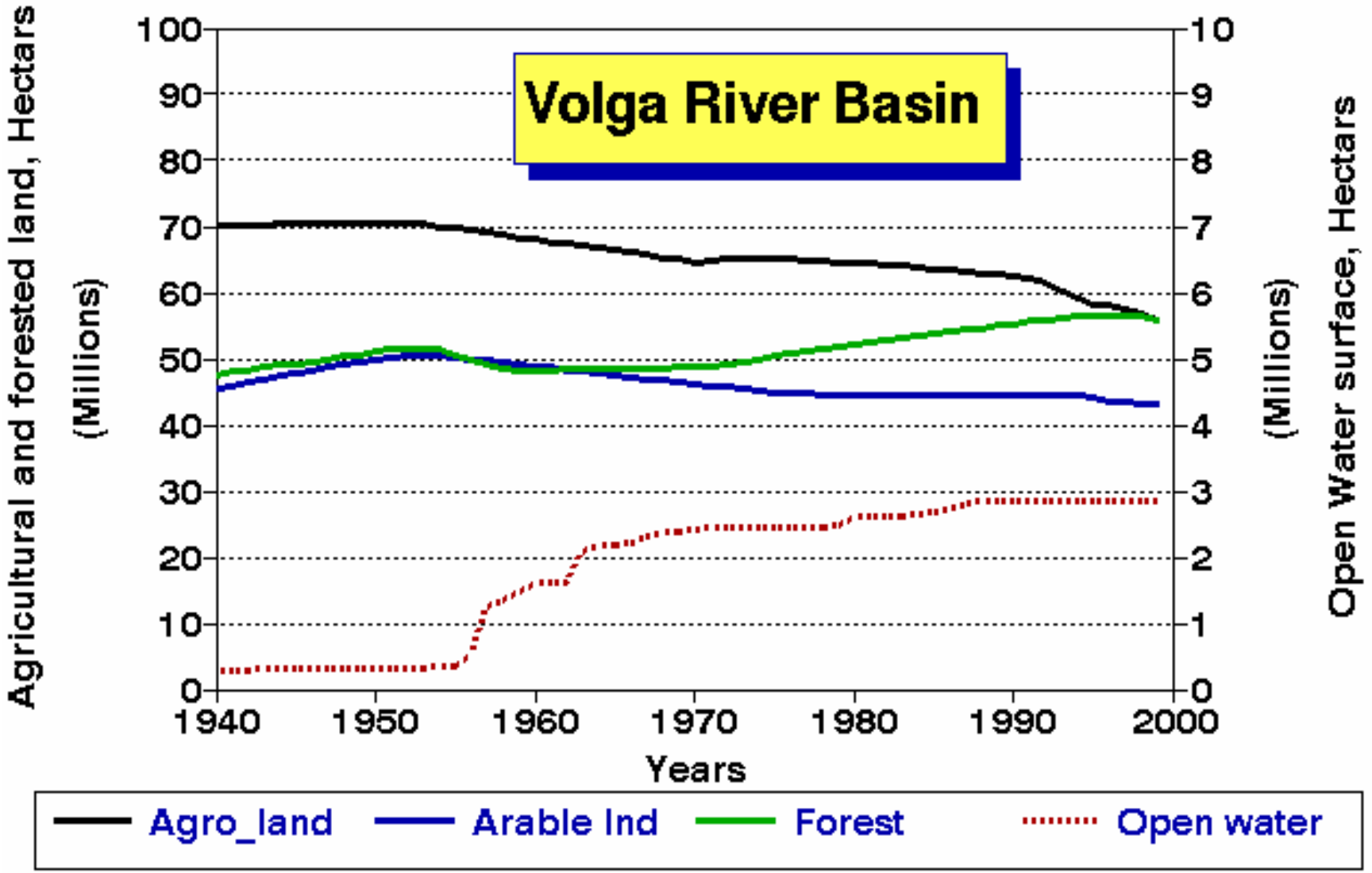
Land use dynamics in the past 60 years



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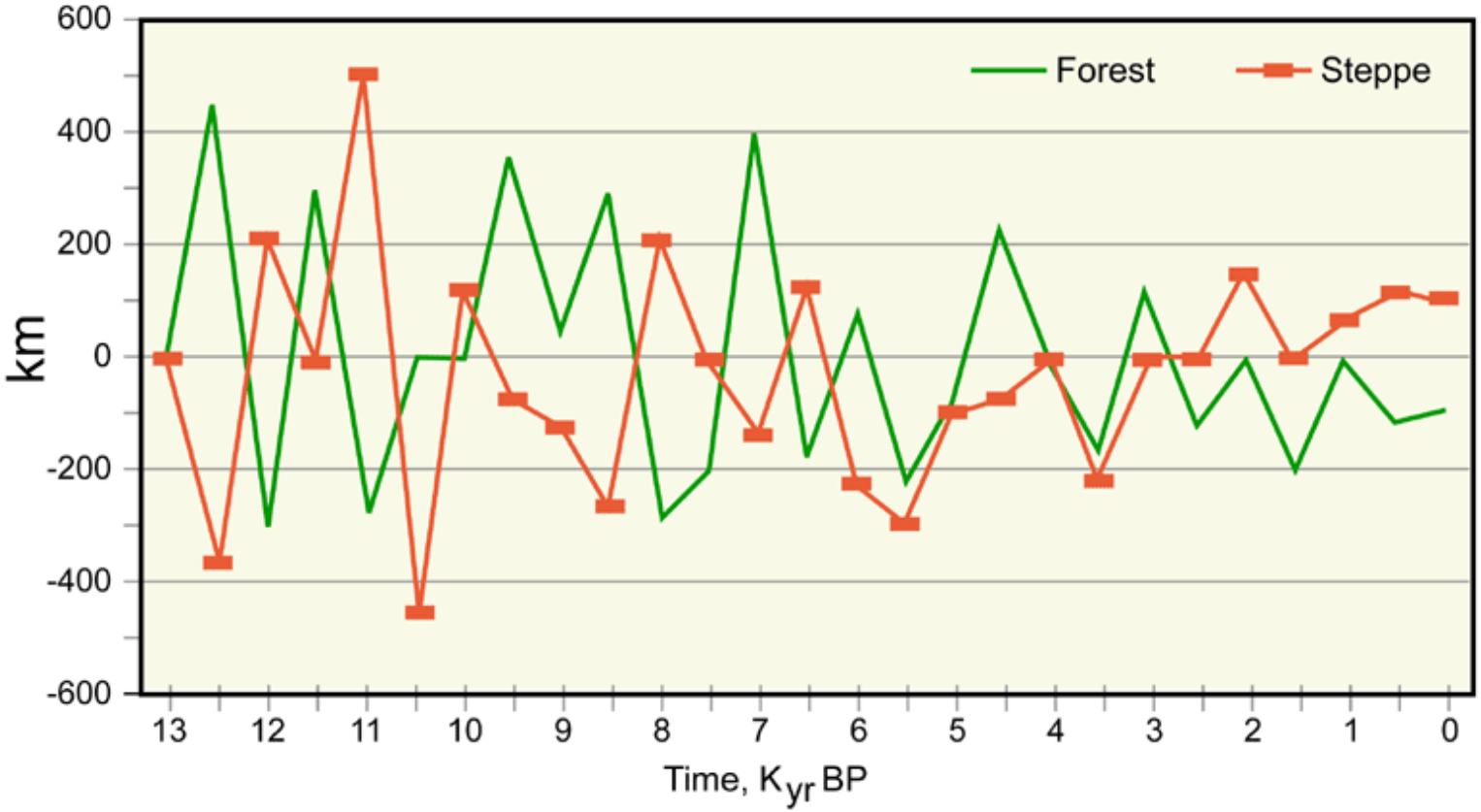
Large environmental changes in the past



Changes of the northern boundaries of forest and steppe zones along the 39°E (past 13K years)

(Kozharinov and Puzachenko 2004)

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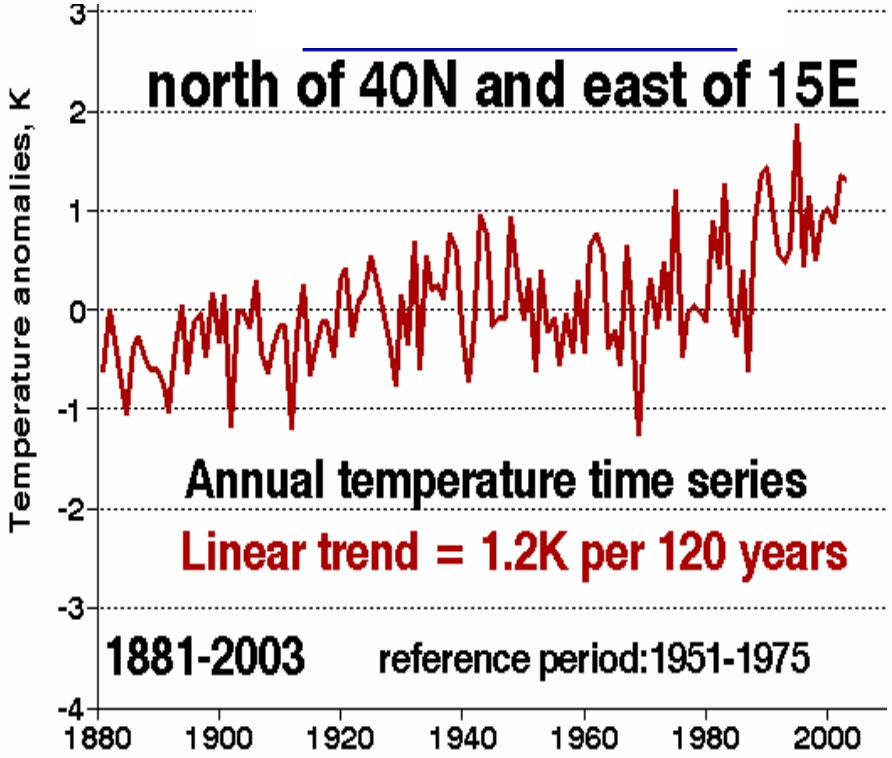
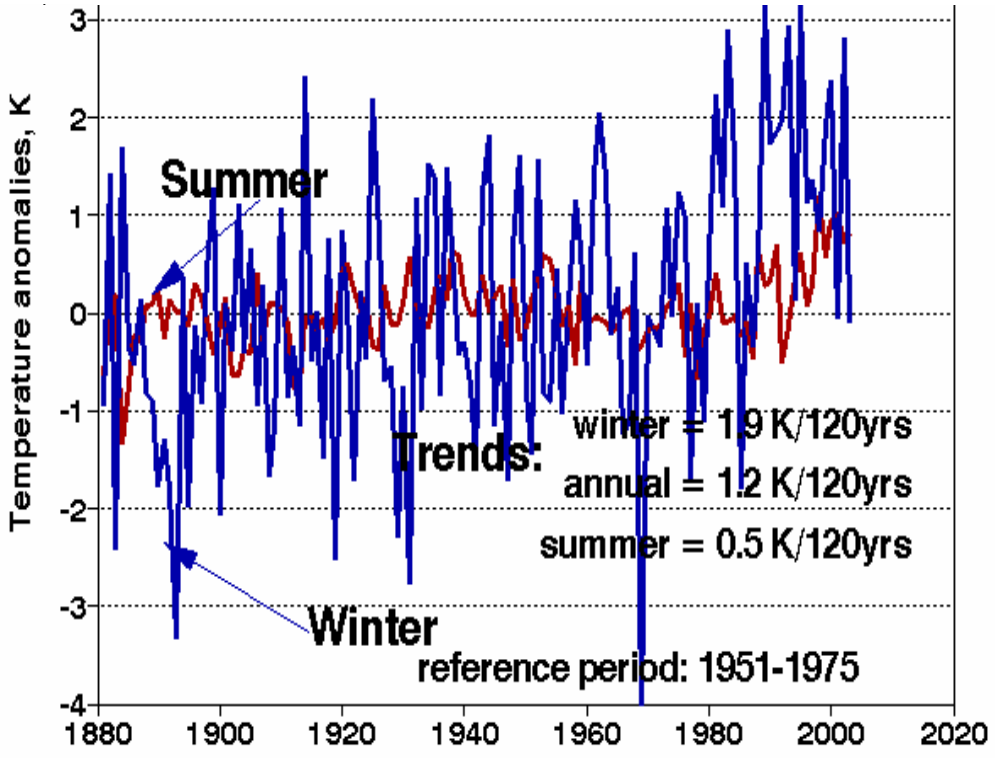
Surface air temperature changes in Northern Eurasia during the past 120 years were the largest in the world





- **Source of the data: (Archive of work of Lugina et al. 2004)**

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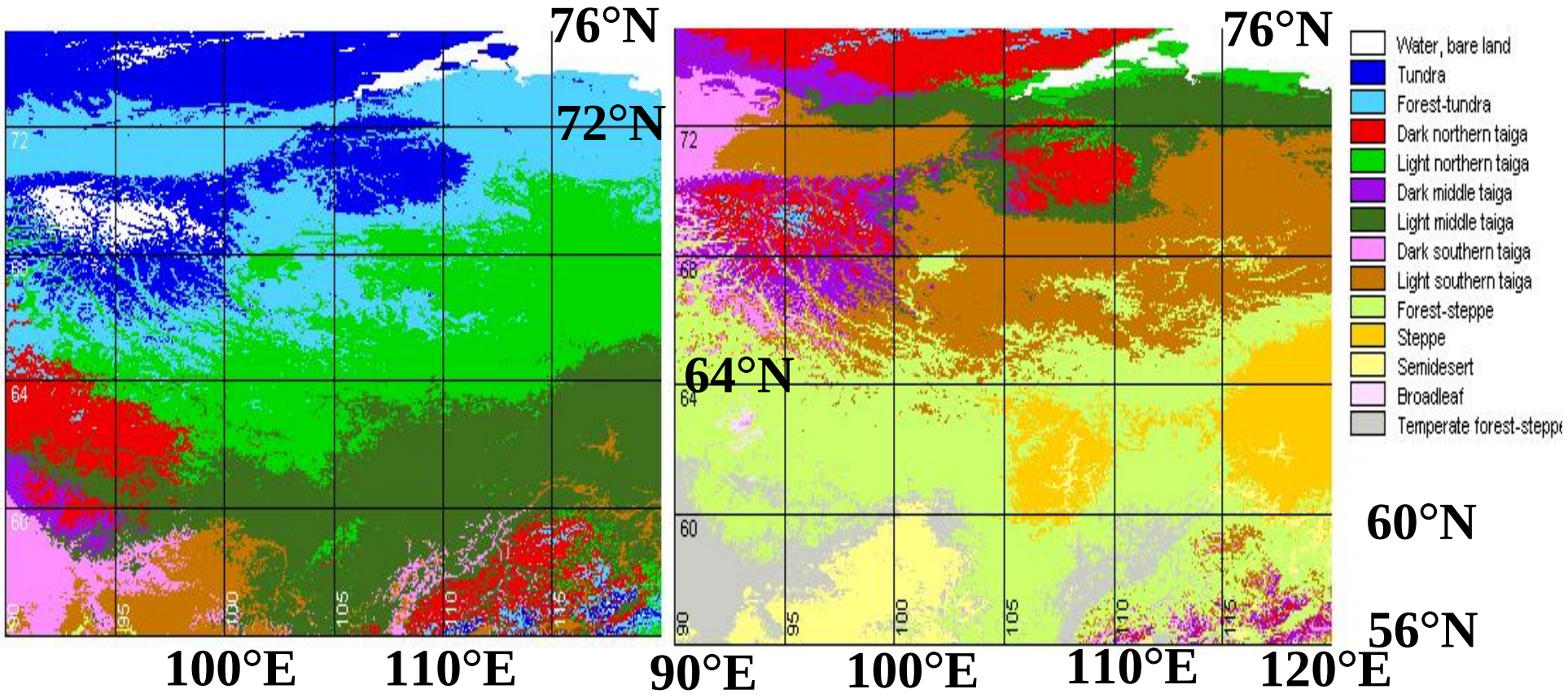
Huge possible changes projected for the future



Present **In year 2090**

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

Changes in the water cycle

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In Northern Eurasia, we observe:

- **Changes in the cryosphere**
- **Man-made changes**

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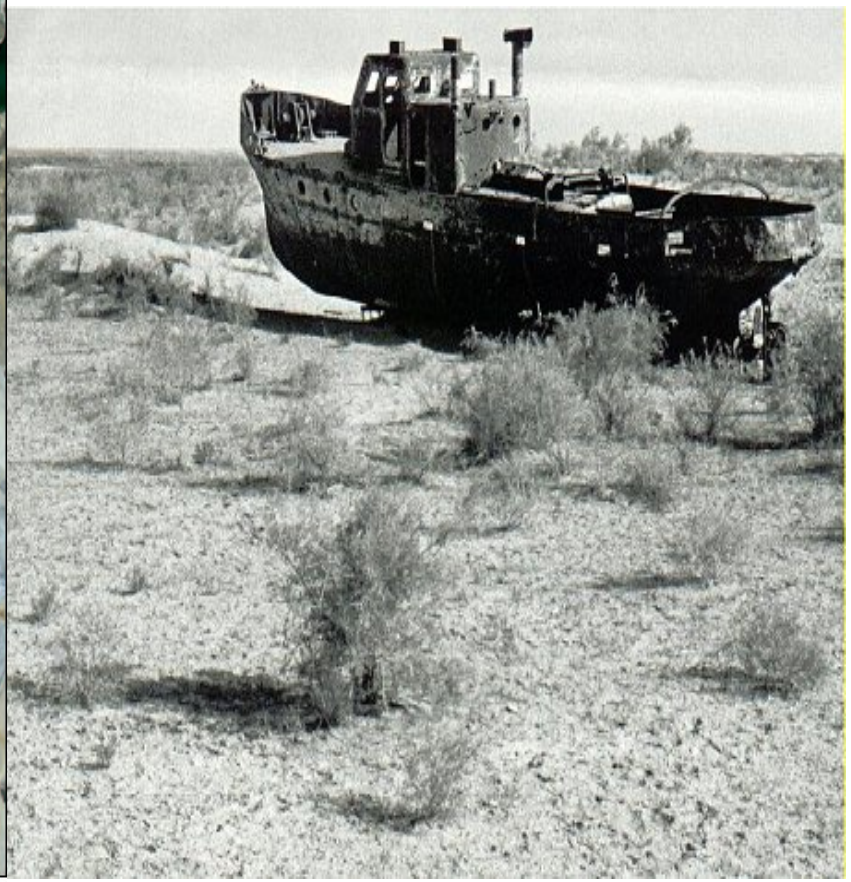
Example of man-made ecological disasters

Most of the Aral Sea will disappear in the next ten years

1989

2003



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In Northern Eurasia, we observe:

- **Changes in the cryosphere**
- **Man-made changes**
- **Changes due to the combination of direct anthropogenic and other factors**

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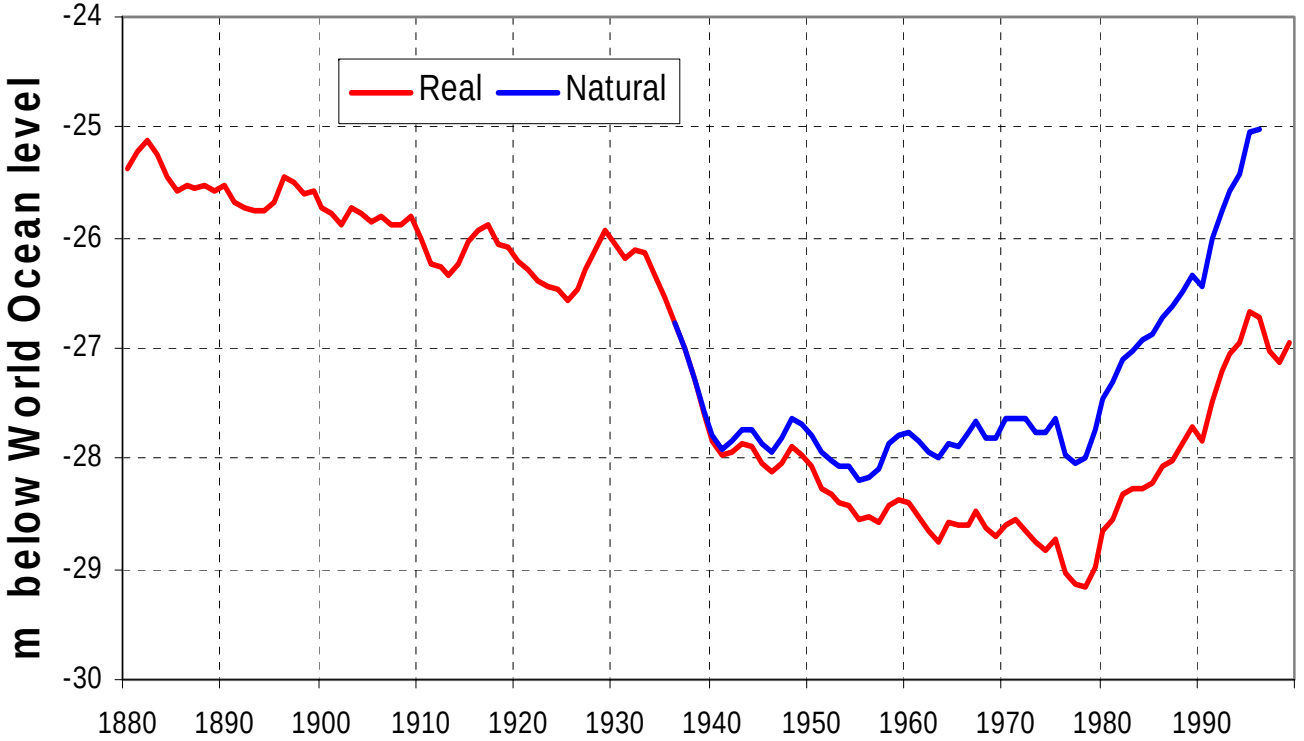
Observed and “natural” changes of the Caspian Sea level



Source: Shiklomanov (1976)

Update: Shiklomanov and Georgievsky (2003)

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In Northern Eurasia, we observe:

- **Changes in the cryosphere**
- **Man-made changes**
- **Changes due to the combination of direct anthropogenic and other factors**
- **Strong observed changes**

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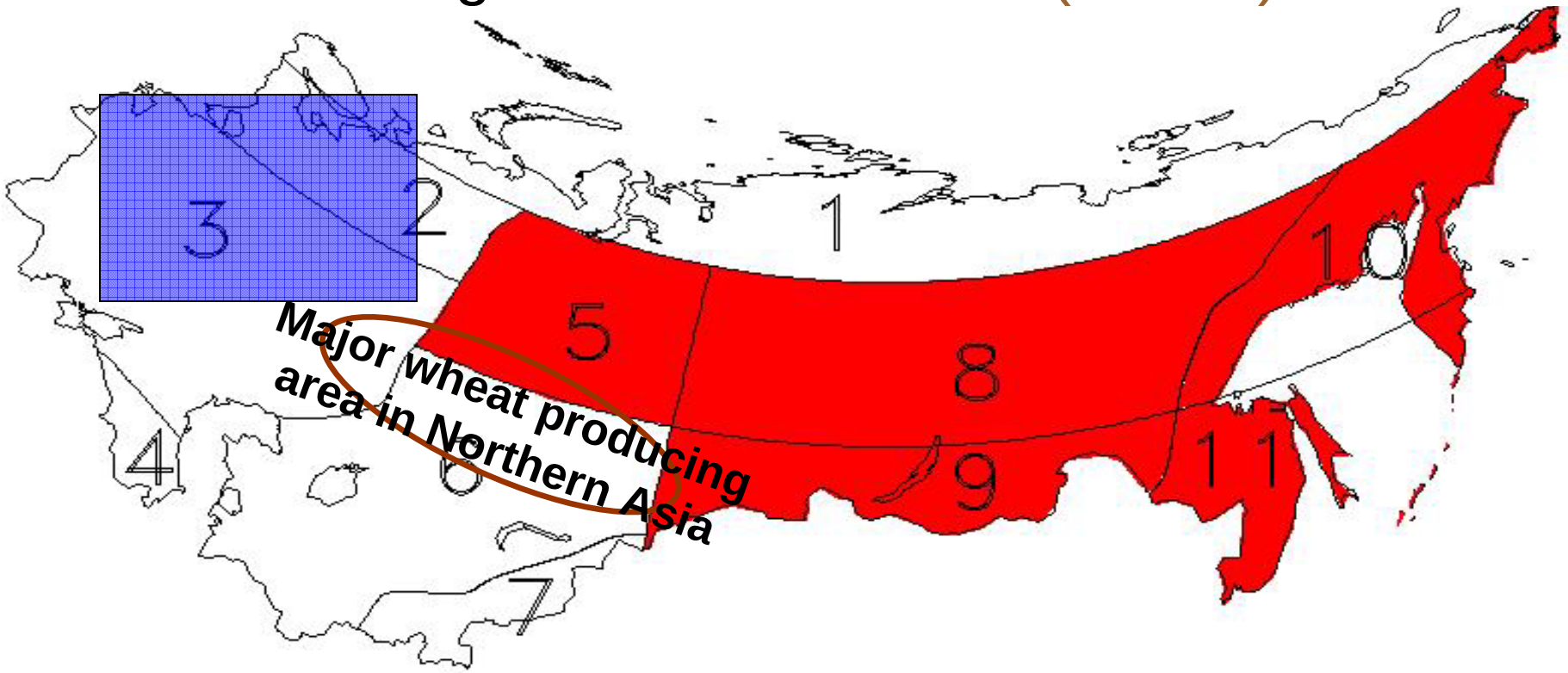
Regions with more humid conditions (blue), regions where potential forest fire danger has increased in the 20th century (red), and the region where agricultural droughts have increased (circled)



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In Northern Eurasia, we observe:

- Changes in the cryosphere
- Man-made changes
- Changes due to the combination of direct anthropogenic and other factors
- Strong observed changes
- All of these changes are important regionally and some of them feedback to the global energy, water, and biogeochemical cycles

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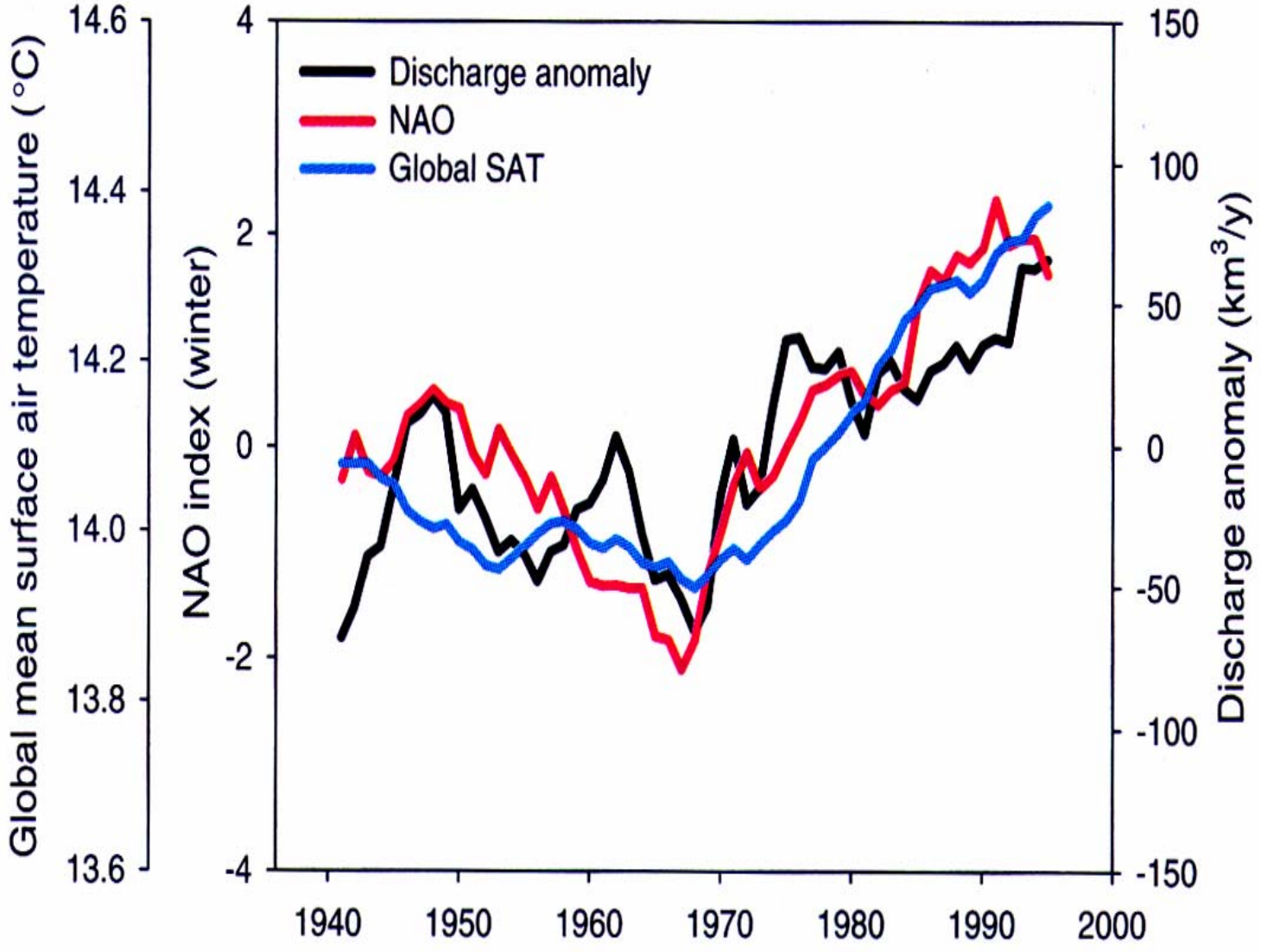
Eurasian Arctic river discharge anomalies (Peterson et al. 2002)



Ecosystems and climate interactions

- **The biogeochemical feedbacks** are associated with changes of terrestrial biomass, soil chemical properties, and microbiology and, thus, with changes of the chemical composition of the atmosphere.
- **The biogeophysical feedbacks** directly affect surface and near-surface energy, water, and momentum fluxes via changes in surface albedo, roughness, moisture availability for evapotranspiration, etc.

Classical biogeochemical feedback

- **In a warmer climate, there will be an intensification of bioproductivity, B+∆B, and thus a sequestration of some fraction of the anthropogenic CO_2 will occur.**
- **For example, boreal forest located in the regions of greatest warming *and* a general surface heat deficit is a primary candidate for this *negative* feedback. But, what if ...**

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… the area of the boreal forests changes with climatic change? This alone makes the summarized sign of this particular feedback undefined.

… with the temperature increase, the rates of respiration, transpiration, decomposition of dead biomass and soil organic material, and the rate of release of methane and CO_2 from soil increase? This may generate a potential runaway scenario of a strong positive biogeochemical feedback.

… with time, the influence of some of these factors saturate while others enhance? This raises the temporal factors (dynamics) as a critical issue of actual changes in this feedback.

… the forthcoming changes affect biomass and biodiversity of microbiota and trophic links that control the biogeochemical cycle and thus interfere with the major biogeochemical feedback? These controls are poorly known.

…other ecosystems' changes associated with climate change, human activity, and biogeophysical feedbacks interfere?

Example of biogeophysical feedbacks associated with effects of forest on:

- **Surface radiation balance, RB_f/RB_0**
  - **Deciduous: 1.25-1.27**
  - **Conifer: 1.31-1.37**
- **Precipitation, P_f/P_0**
  - **60°N ~1.12**
  - **50°N ~1.21**
- **Evaporation, E_f/E_0**
  - **~1.05 to 1.20**

Rauner (1972)

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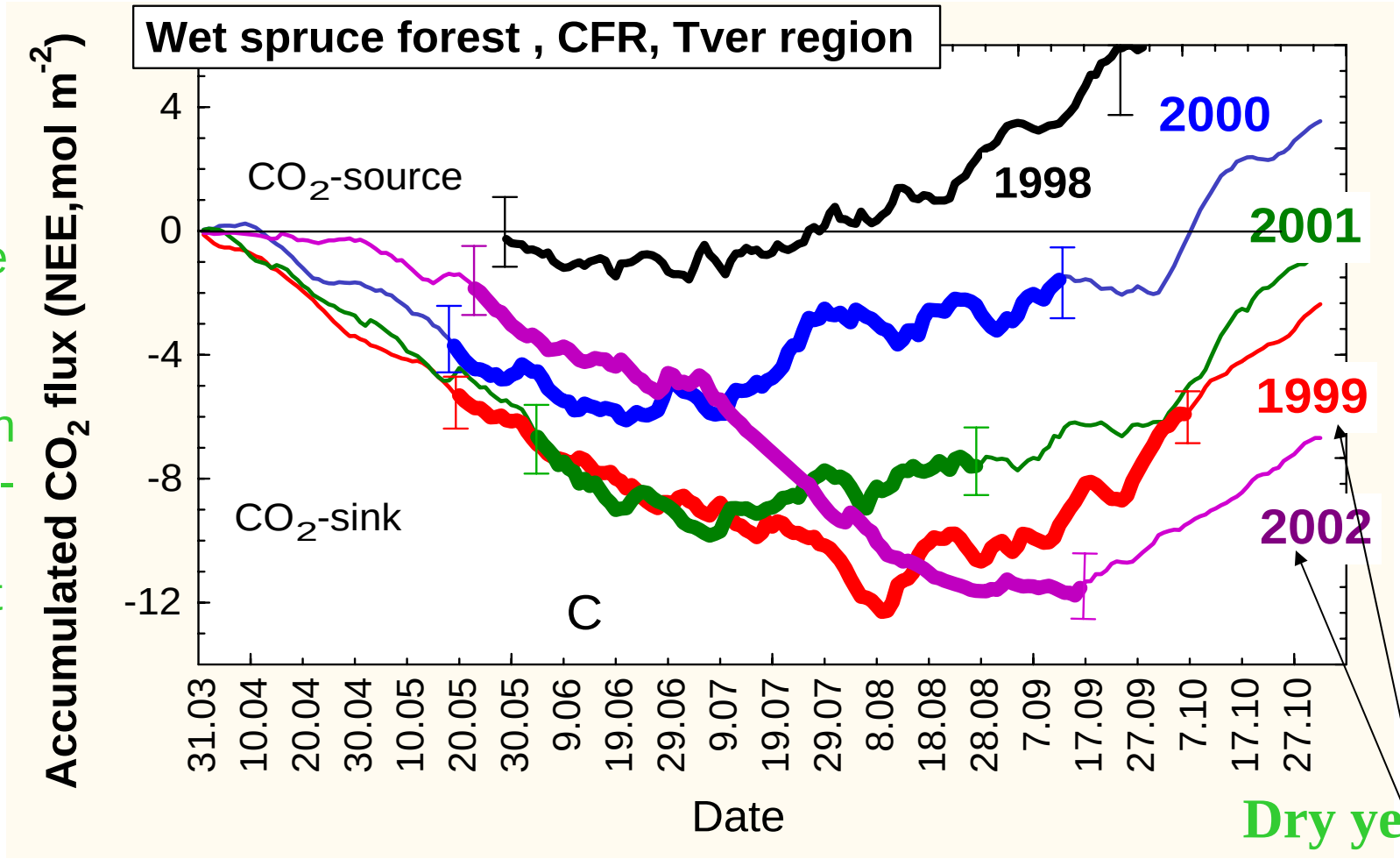
Example of hydrology-vegetation feedback.

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

From the Archive of the Euro-Siberian Carbon-flux Project



Coastal Zone Processes

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Coastal zone of Northern Eurasia with the regions most affected by past, present and projected changes

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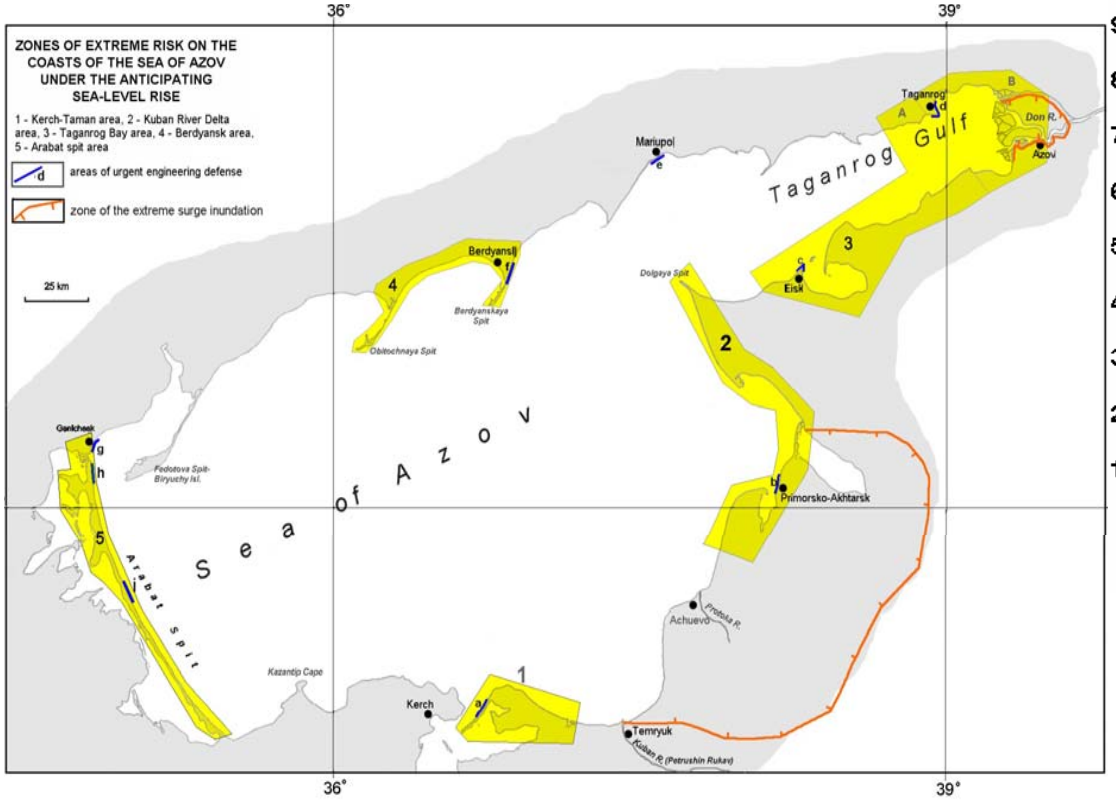
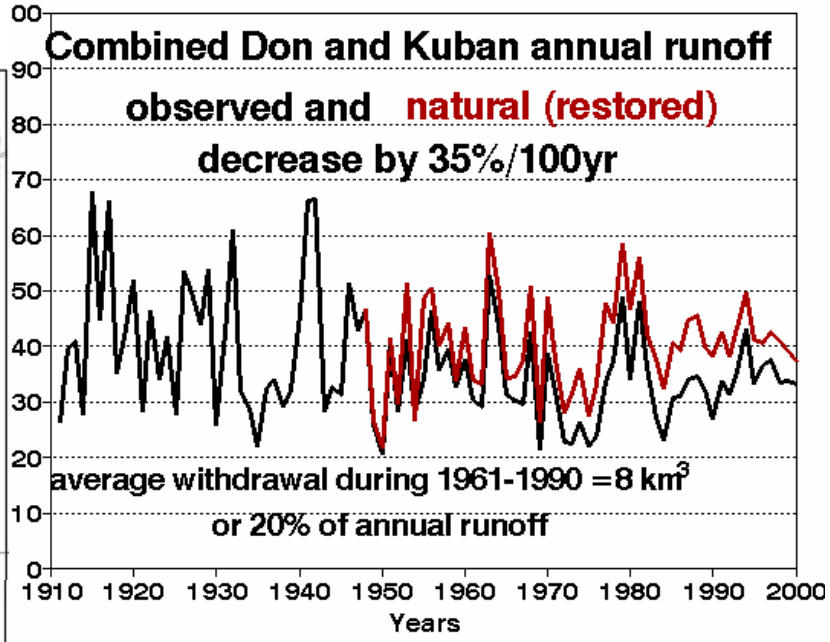
Sea of Azov





Coastal zones at extreme risk

Variations of actual and natural (estimated without human impact) runoff into the Sea ($km^3\ yr^{-1}$).

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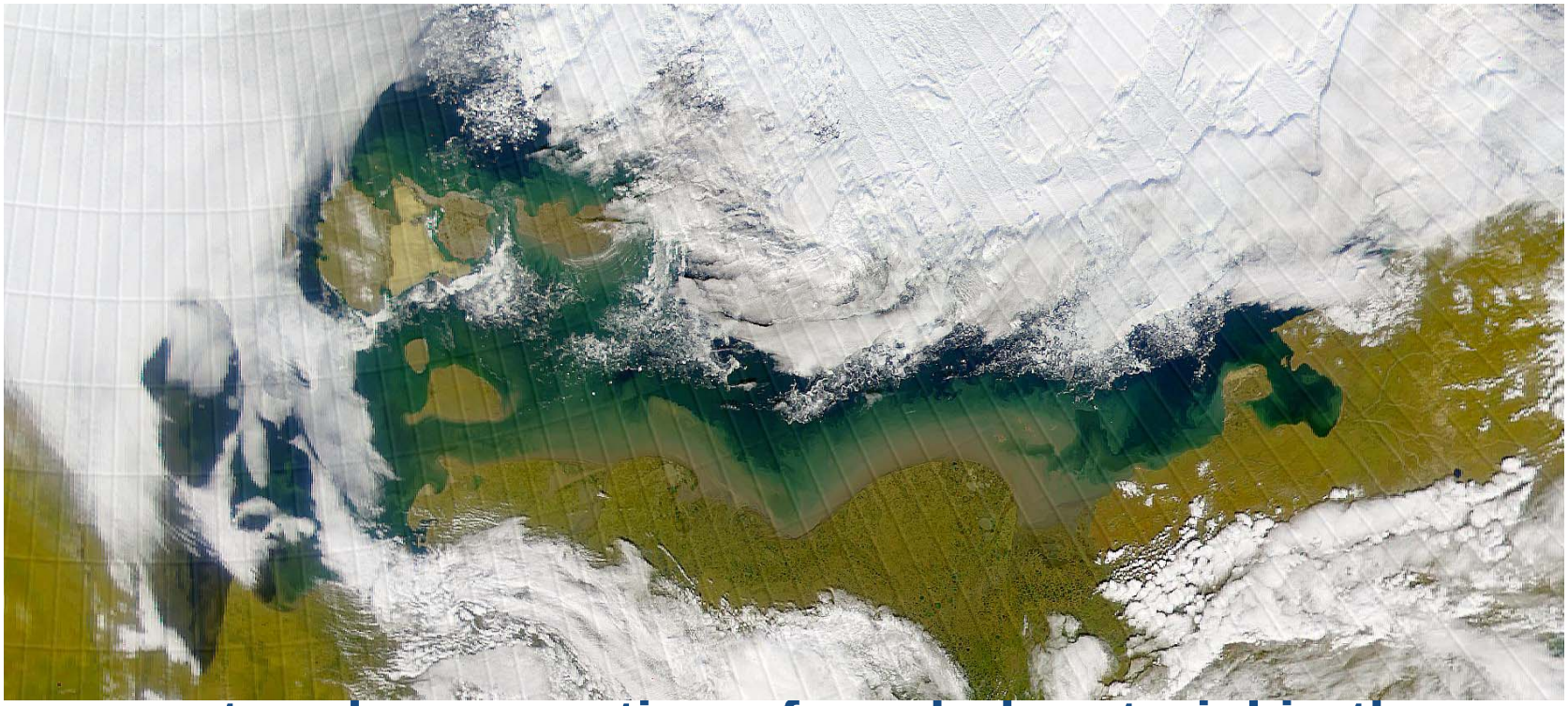
Coastal Zone in Central Siberia



- **Transport and propagation of eroded material in the East-Siberian Sea and the eastern Laptev Sea plays a significant role in mass balance, water optical properties, carbon cycle, and hydrochemistry of the region**

[NASA satellite image, Sept. 2000; Semiletov et al. 2003].

Science Plan Key Words

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

Tools:

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