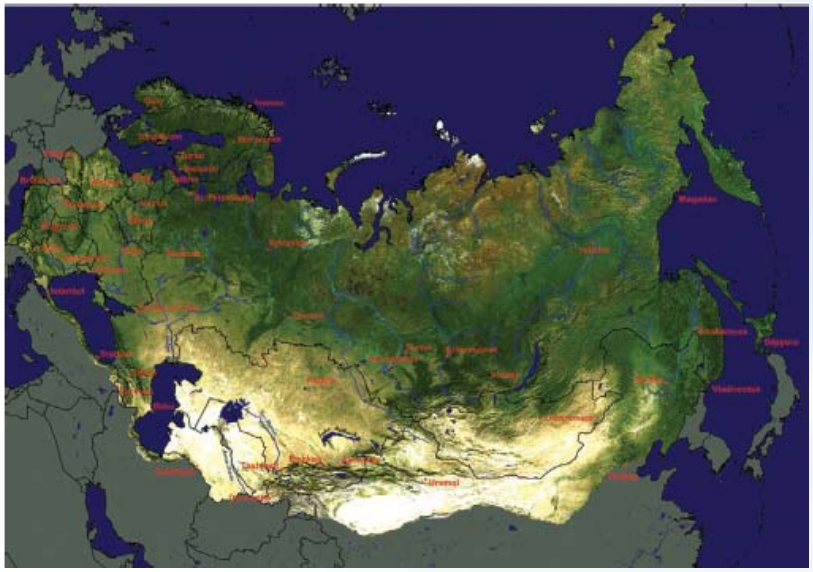

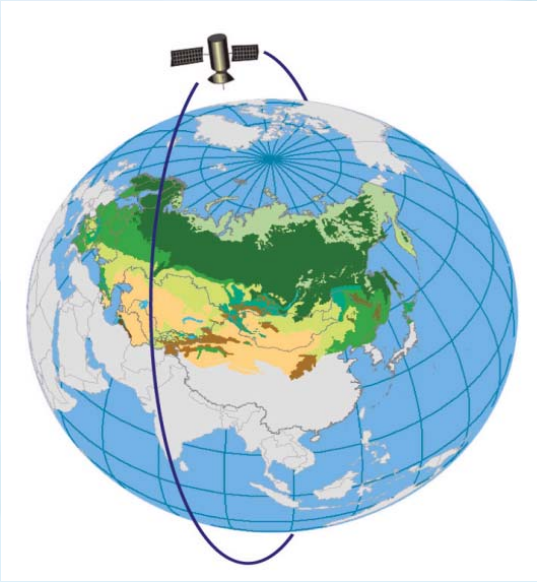

Northern Eurasian Arctic: Impact of Climate Change on Ecosystems

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Ecosystem Services and Management Program,
IIASA, Laxenburg, Austria

IIASA Seminar 19-20 May 2014

Specifics: One of the most vulnerable regions of the globe

The coldest land mass of continental scale including all bioclimatic zones of the Northern Hemisphere

Fragile ecosystem which evolutionary developed under cold climate

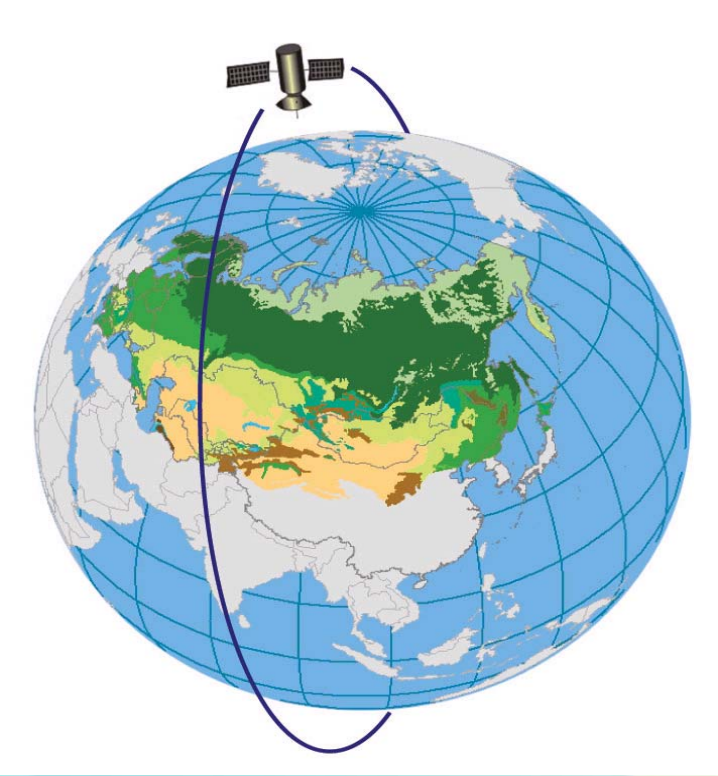
The biggest bog-forest ecosystems globally

About two-third of the area is represented by permafrost which contains from 500-900 Pg C in permafrost and bogs (methane, hydrates)

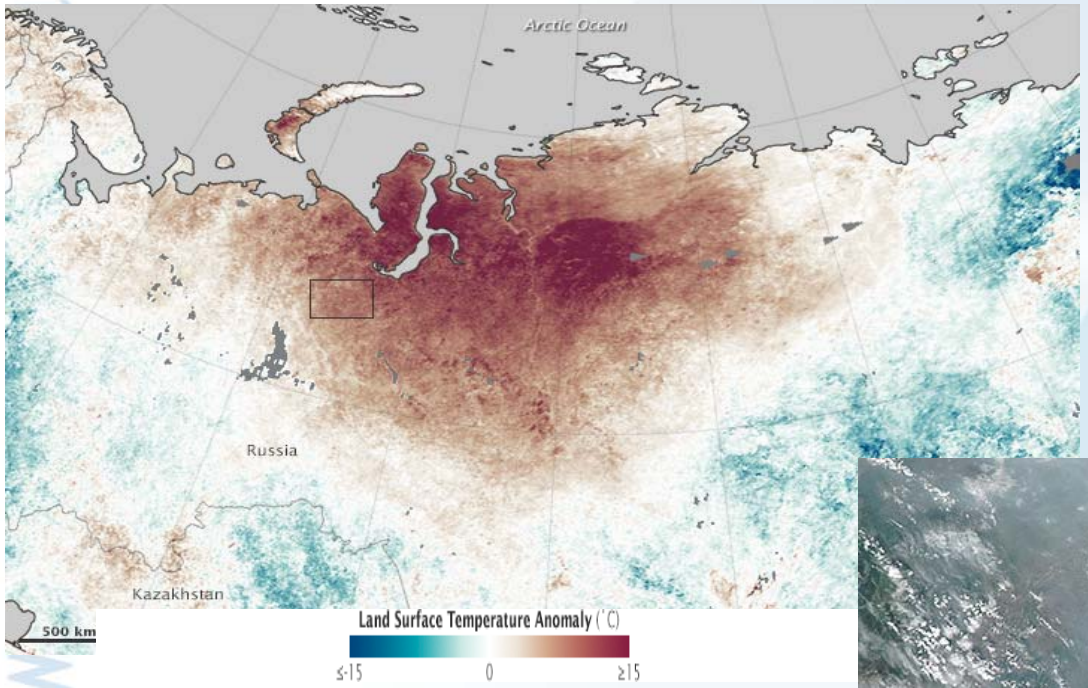
The most dramatic climate change over the globe is expected here

Boreal forests of Northern Eurasia is considered as a likely tipping element by end of this century

The region of unregulated and devastating anthropogenic impacts



North of Siberia, July 2013, Terra MODIS

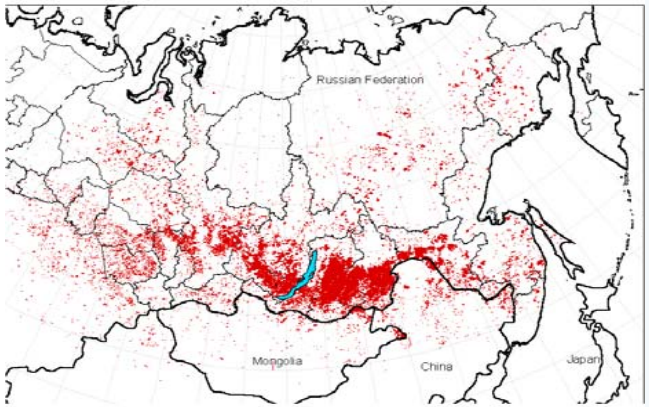


Land surface temperature anomalies for 20-27 July
measured 32ºC
daily July average 16ºC

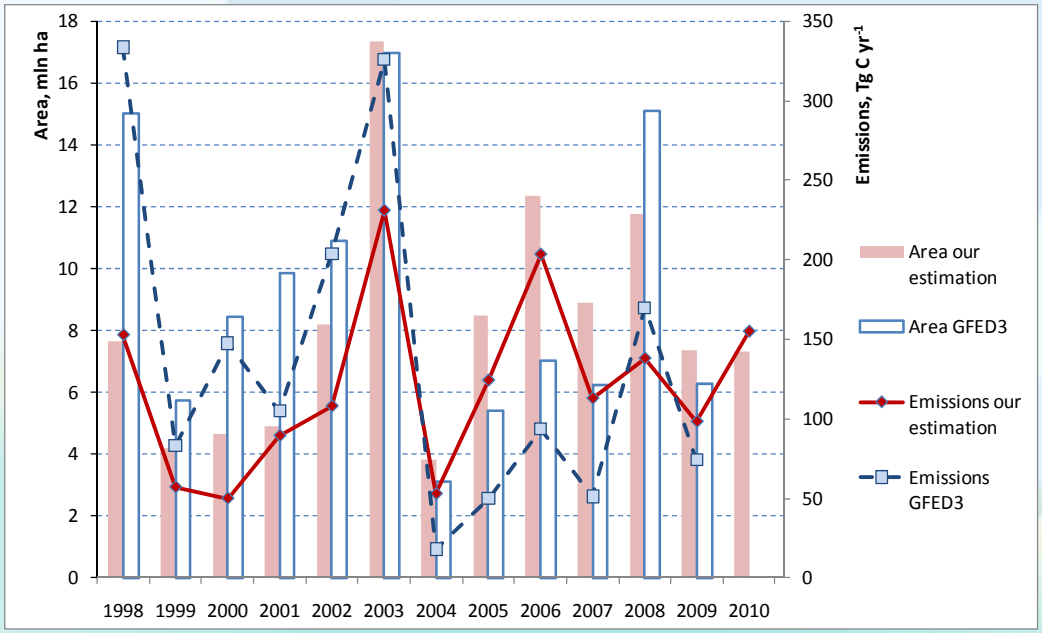
Source: http://earthobservatory.nasa.gov/IOTD/

Acceleration of natural and human-induced disturbances

April - November of 2003 year. The total hot spots distribution in Siberia and Far East . NOAA/AVHRR 12,15,16
Center of Remote Sensing. Institute of solar-terrestrial physics SB RAS.



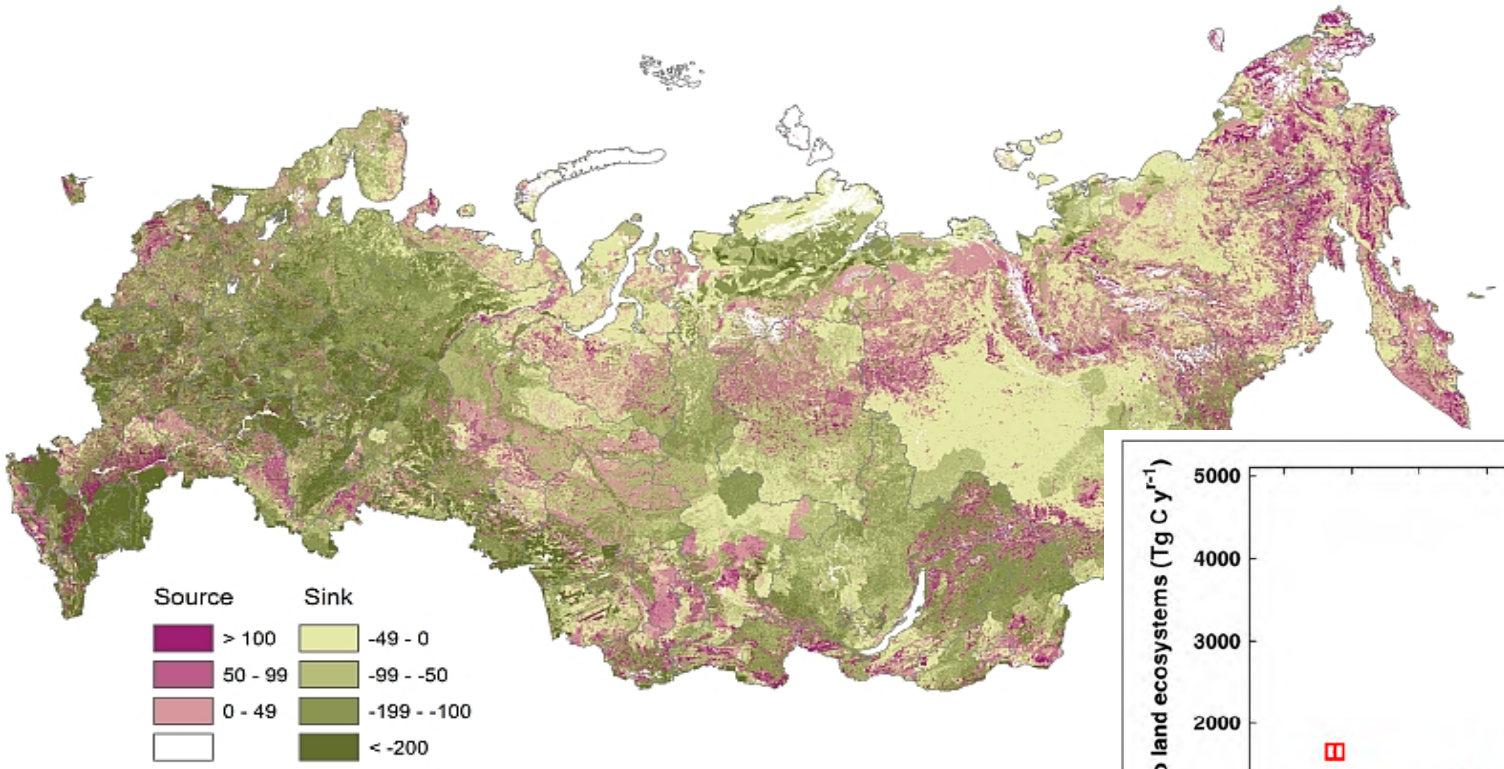
- ▲ the average area of wild fires in Russia in 1998 - 2010 exceeded 9 million ha including 5 million ha of forests
- ▲fires in 2011 – 20 million ha, 2012 – 25 million ha
- ▲these fires produced direct carbon emissions at ~130 million ton C per year
- ▲an outbreak of Siberian moth in Russia in 2001 covered ~10 million ha
- ▲the total direct C emissions due to disturbances are from 250-300 million t per year

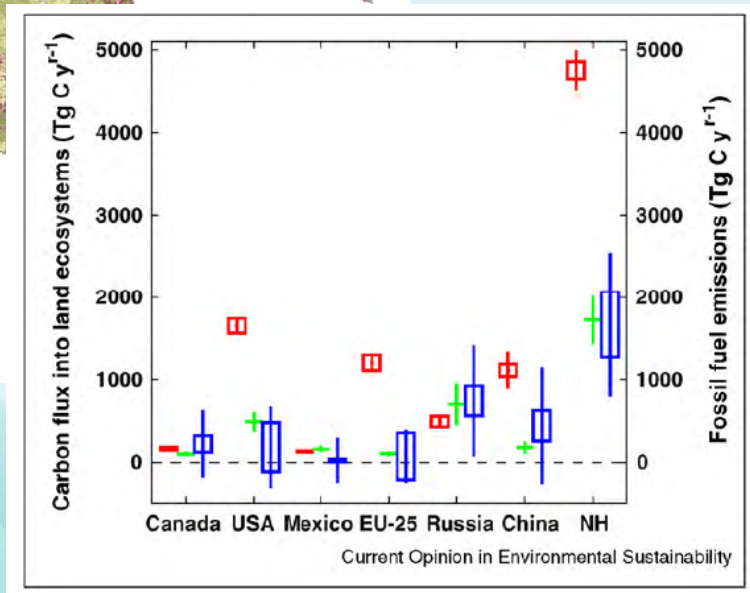


Risks for terrestrial ecosystems

- Negative consequences of permafrost destruction
- Loss of soil fertility, impoverishment of soil biota, decline of productivity of land
- Lack of water resources in arid regions
- Damage of land in river valleys due to increase of denudation
- Anomalous outbreaks and spatial distribution of traditional and new insects
- Alteration of forest fire regimes
- Loss of biodiversity
- “Green” desertification
- Air pollution, soil and water contamination

Full carbon account for Russia in 2009 – flux-based approach





All ecosystems of Russia in 2000-2010 served as a net carbon sink at 0.5-0.7 Pg per year

Of this sink ~95% was provided by forests

Source: Shvidenko et al. 2011

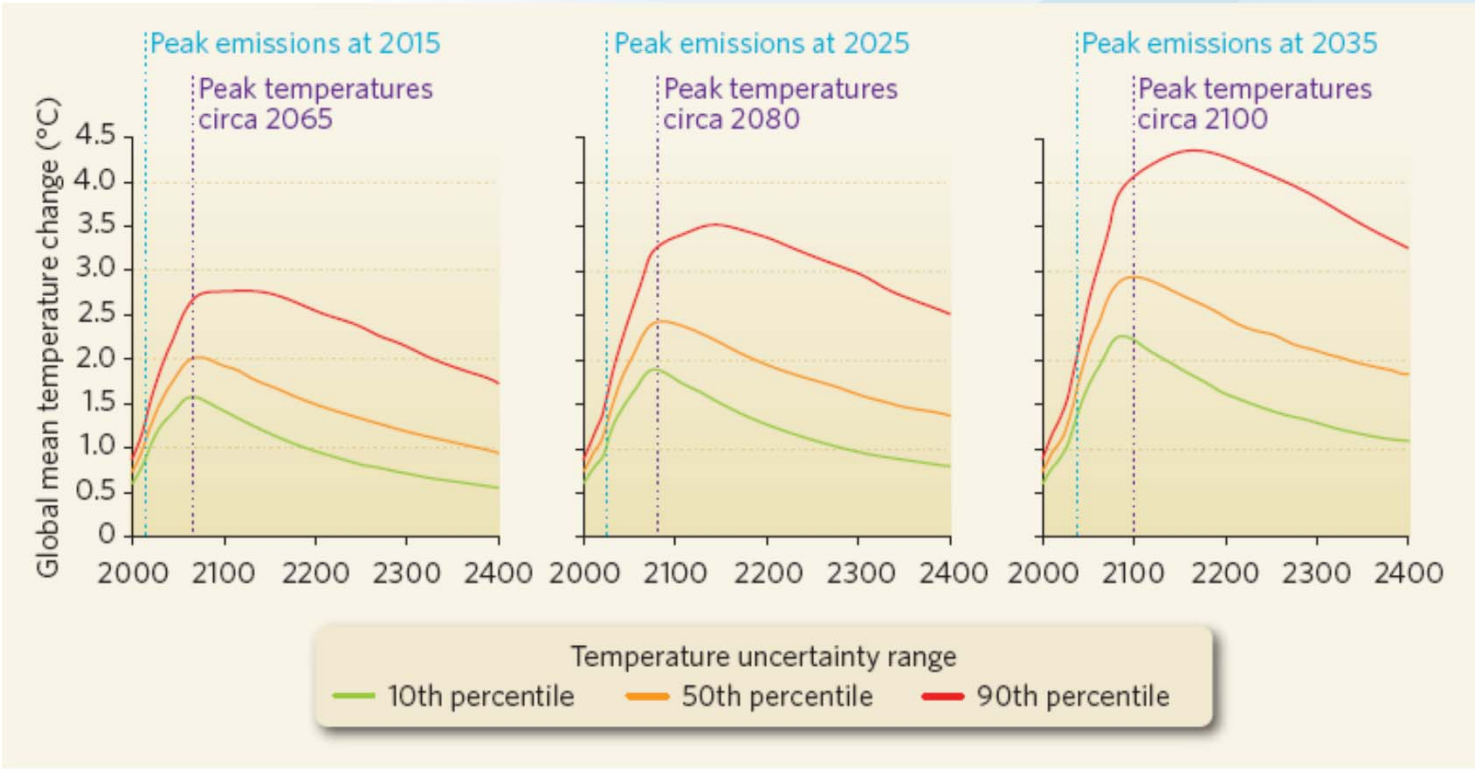
Source: Ciais et al. 2010

Practically all environmental/ climate change research deal with fuzzy systems (full complexity or wicked problems)

An Example - Terrestrial Biota Verified Full Carbon Account is a dynamic complicated open stochastic fuzzy system
The direct verification of results of FCA is not possible
Structural uncertainty cannot be reliably recognized within any individually used method

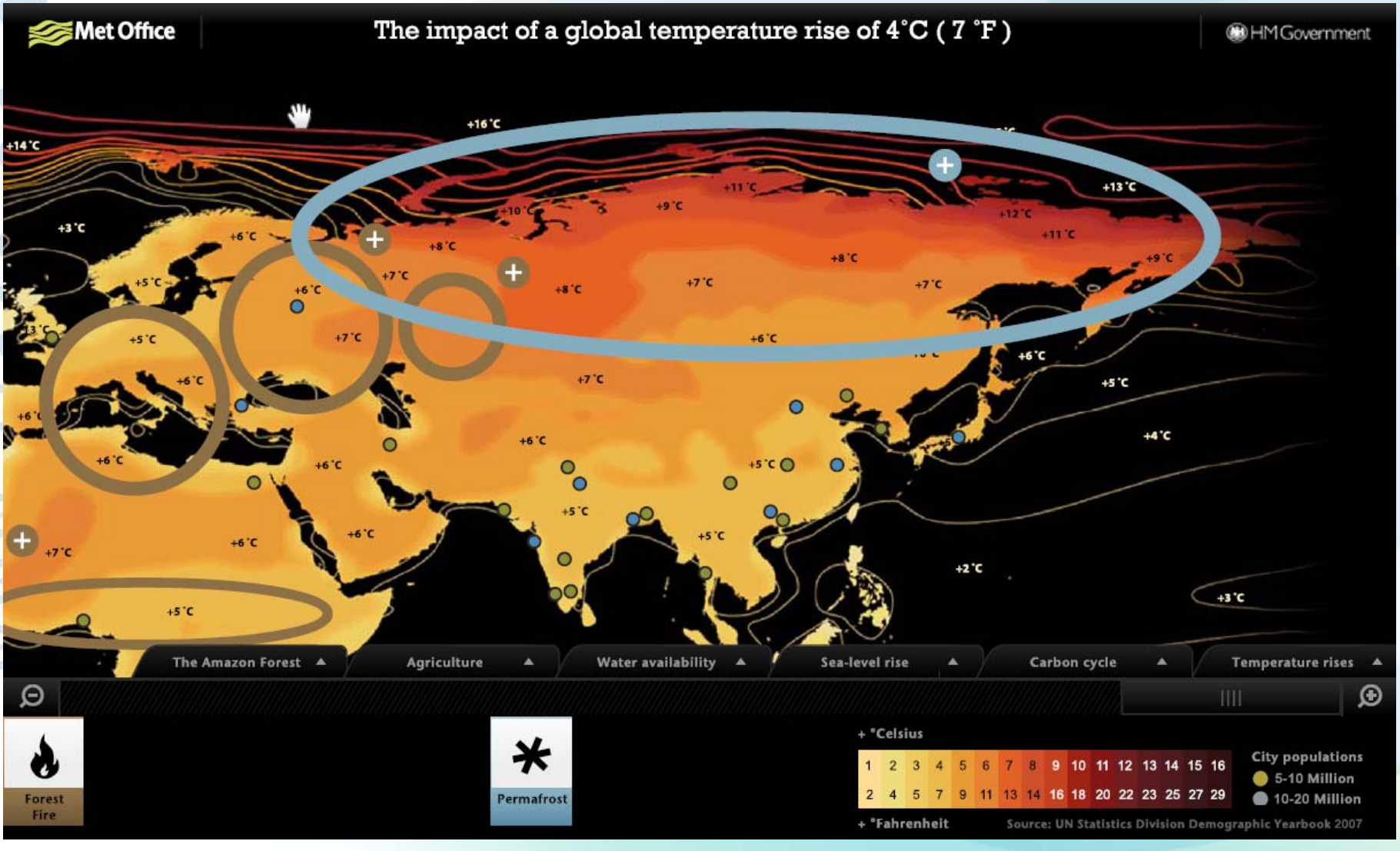
Landscape-ecosystem approach
Process-based models
Flux measurements
Multi-sensor remote sensing concept
Inverse modelling

The world should be planning to adapt to 4°C of warming



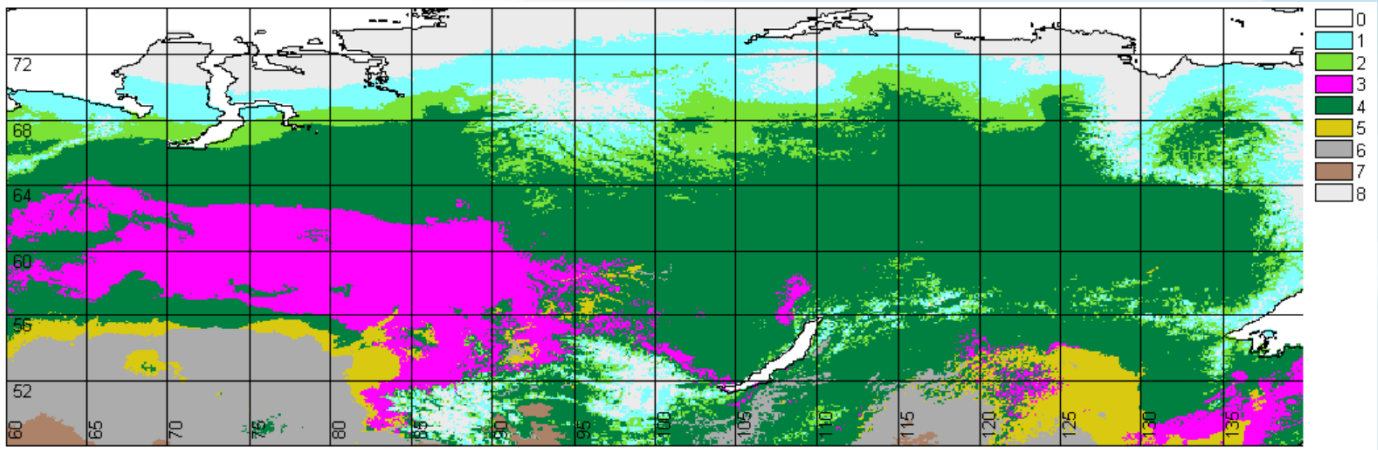
Global average surface temperature scenarios for peak emissions at three different dates with 3%-per-year reductions in greenhouse gas emissions.
Source: Parry et al. Nature 458, 30 April 2009

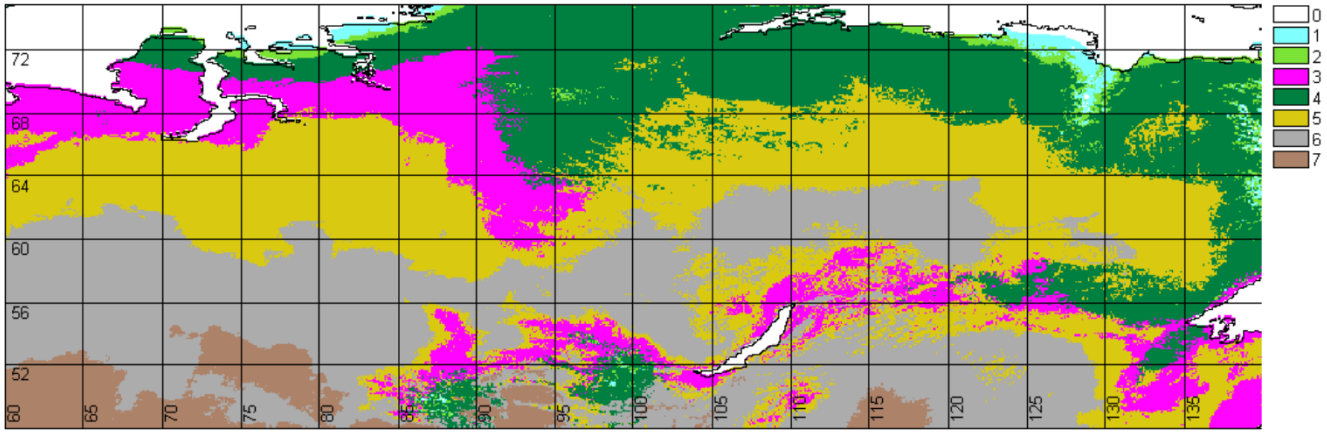
Northern Eurasia under +4° C globally



http://www.actoncopenhagen.decc.gov.uk

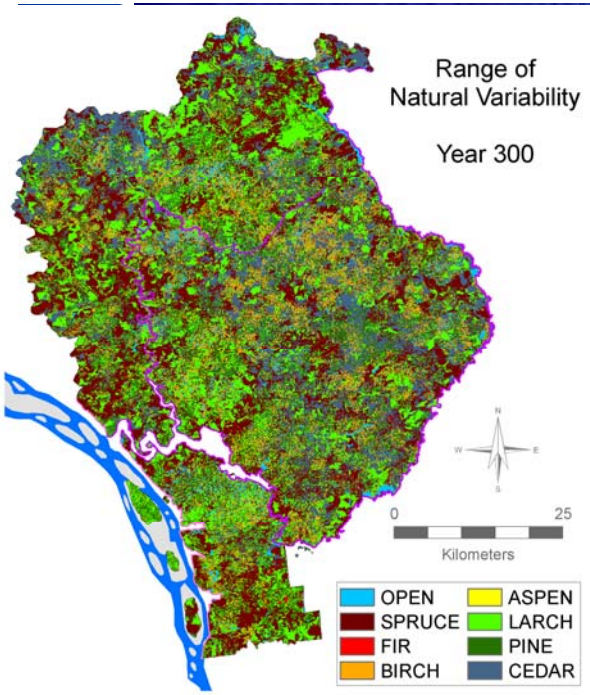
Distribution of bioclimatic zone in Northern Asia under current (a) and 2090 climate (Tchebakova et al. 2009)

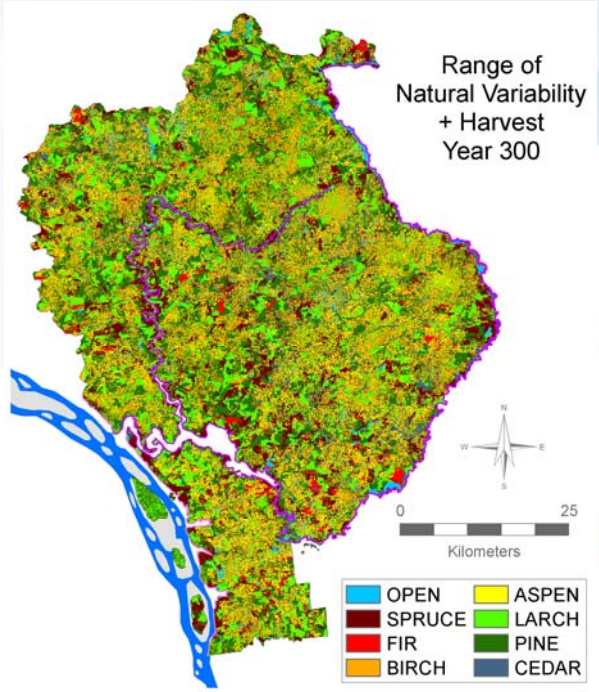


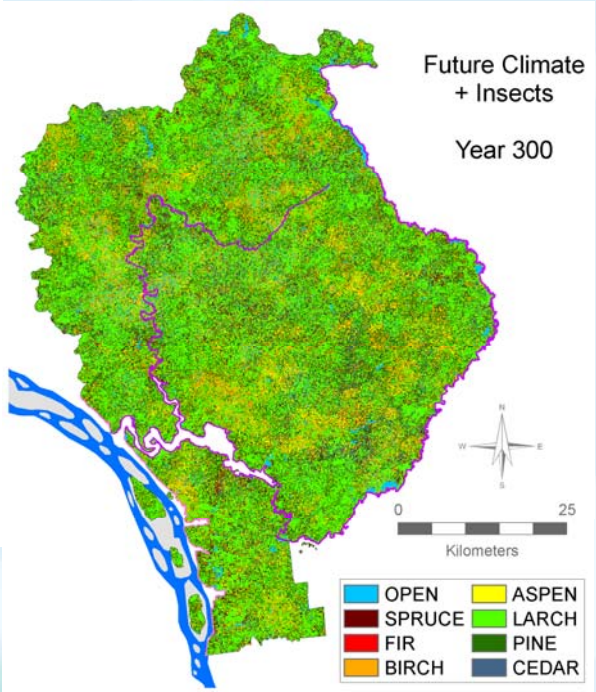


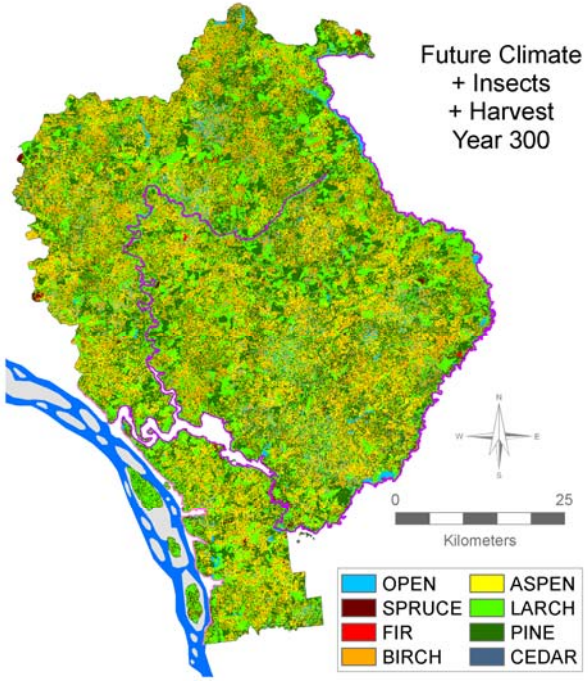
Water (0), tundra (1), forest tundra (2), dark coniferous (3), light coniferous (4), forest steppe (5), steppe (6), desert (7), polar desert (8).

Adaptive forest management: climate change *vs* management (LDSM Landis – II)





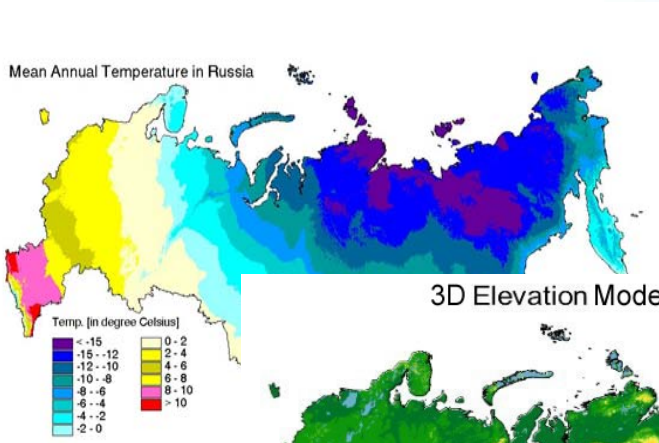


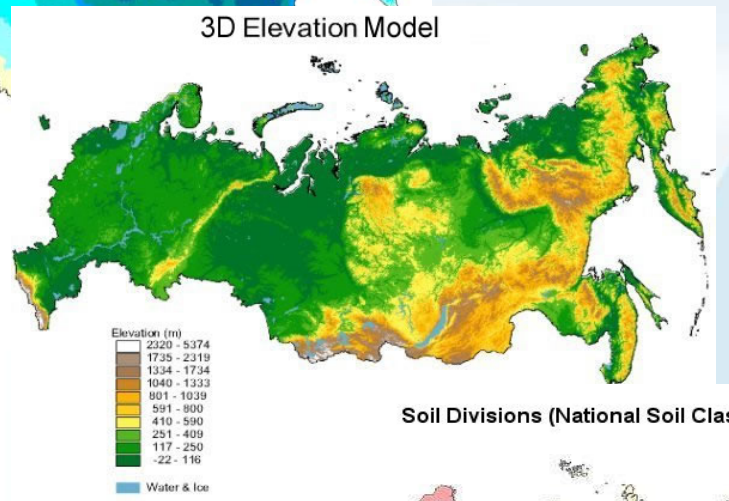


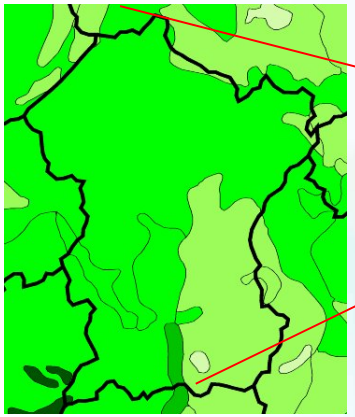
Northern Forest Enterprise of Irkutsk oblast
Source Gustafson, Shvidenko et al. 2008

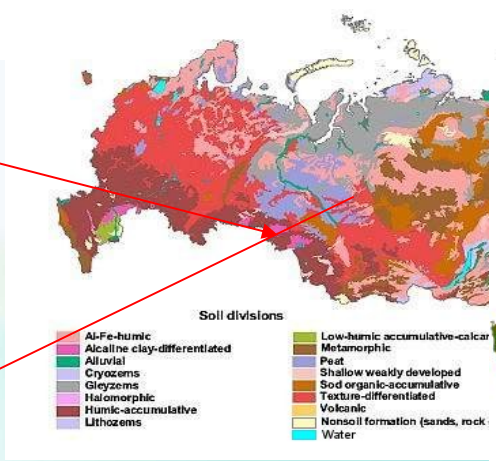
Need of an integrated approach: the first step - unified information background

Hybrid Land Cover – an information basis of Integrated Land Information System



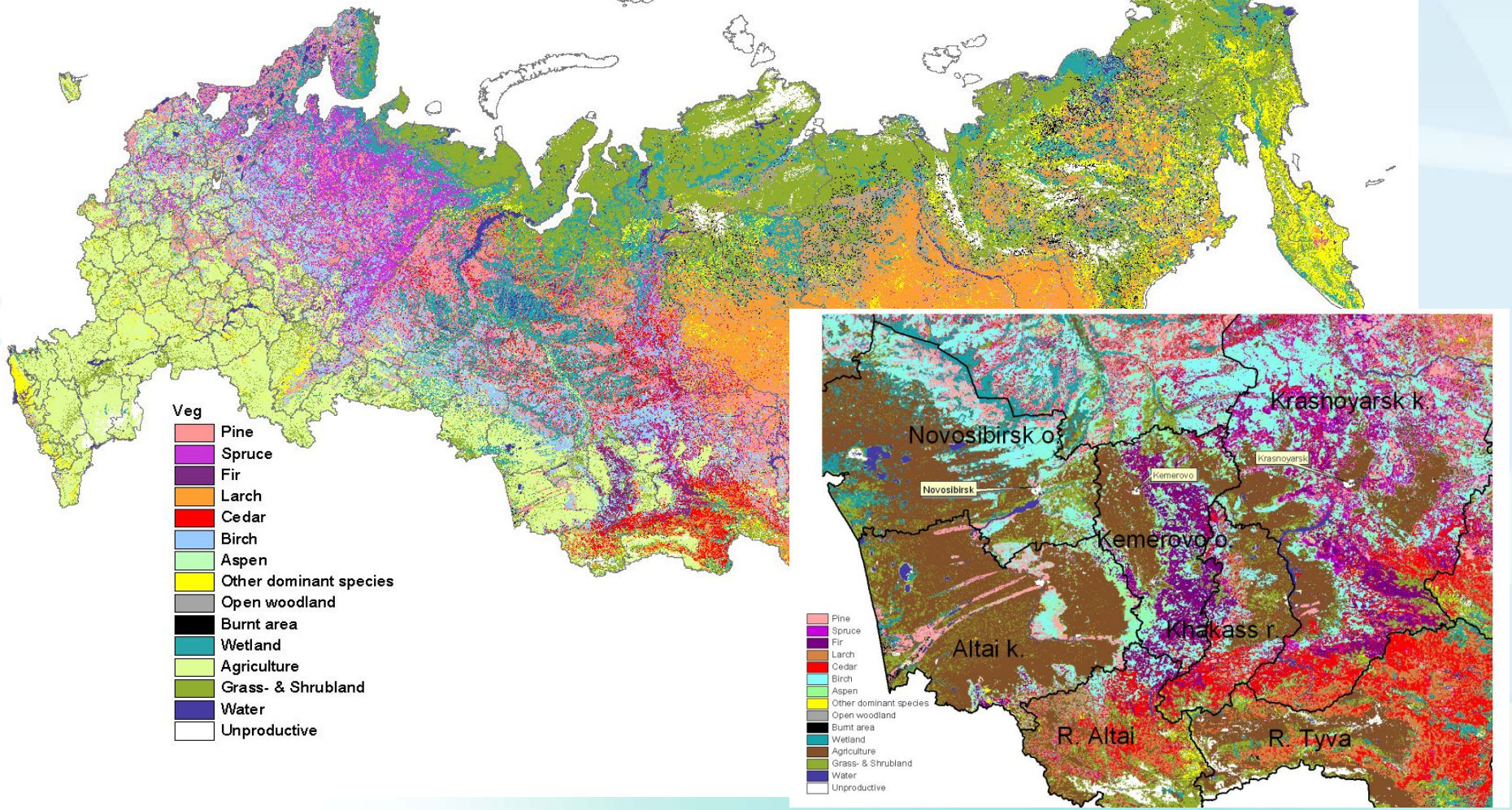




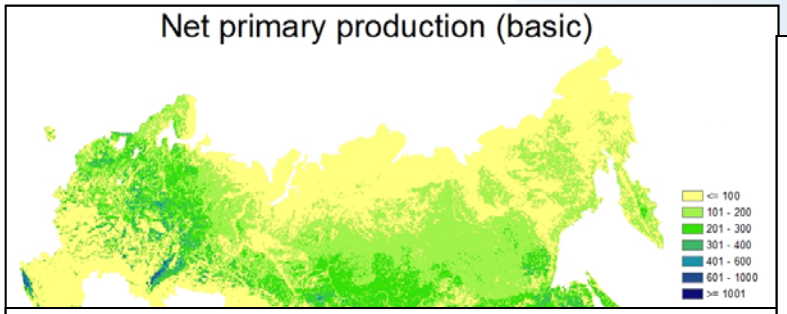


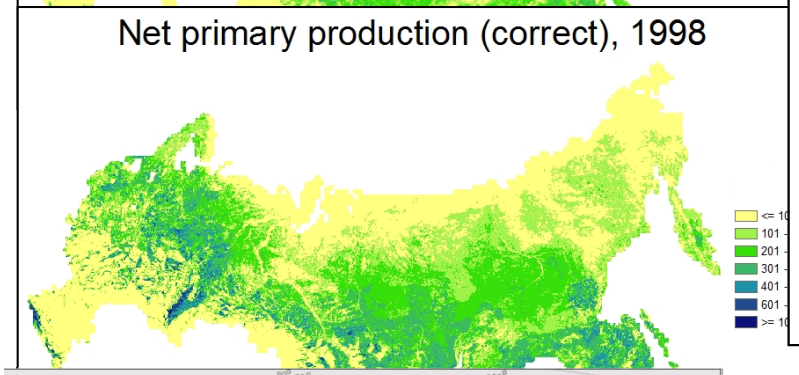
Hybrid land cover 2009 – a background of the Integrated Land Information System

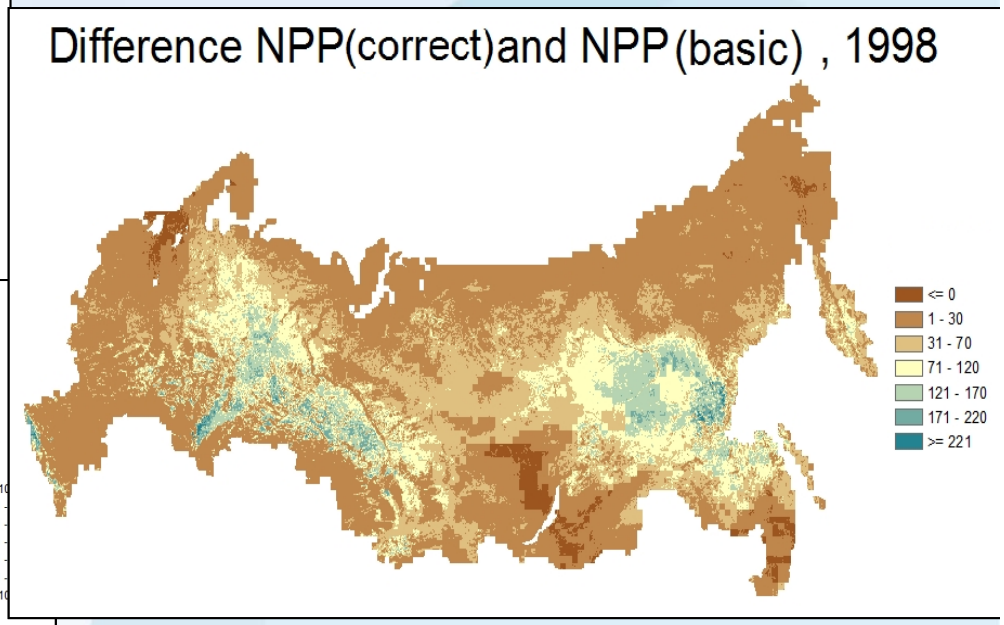
(1 km resolution)

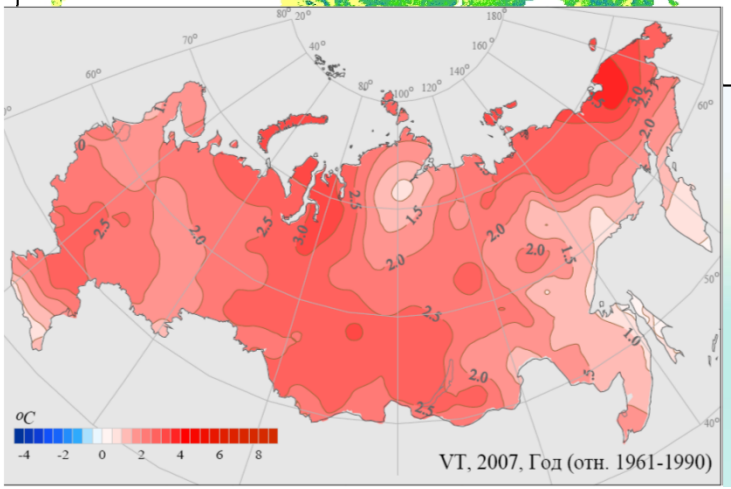


Correction of many year empirical averages for actual climate of individual seasons: An example of temperature impact on forest NPP









Examination of different regression models

$\Delta NPP = F(\Delta DD>5^oC, \Delta P>5^oC, \Delta[CO_2])$

$\Delta HR = \Phi(N>0^oC, P>0^oC, \Delta T>0oC, W)$

$\Delta HR = \varphi$ (11 seasonal climatic indicators)

Inter-seasonal variability of NPP and HR can reach 15-30%, dependently of size of area