W3.3. Manifestations of the Ongoing Climate Change in Northern Eurasia

P. Ya. Groisman
University Corp. for Atmospheric Research
at NOAA National Climatic Data Center
Asheville, North Carolina, USA
Richard W. Knight
North Carolina State University
at NOAA National Climatic Data Center
Asheville, North Carolina, USA
Olga N. Bulygina
All-Russia Research Institute for Hydrometeorological Information
Obninsk, The Russian Federation
Nina A. Speranskaya
State Hydrological Institute
St. Petersburg, The Russian Federation

Typical daily temperature variance distribution in mid-latitudes

- **~80% - seasonal cycle**
- **~15-20% - weather variability**
- Residual – everything else (e.g., climate variability and change)

$$Y = \Sigma X_i$$

X_i [i=1,..k] >0; X_i [i=k+1,..n] <0

- $\Rightarrow$ E Y could be $\approx$ 0
- But, D Y >> 0.

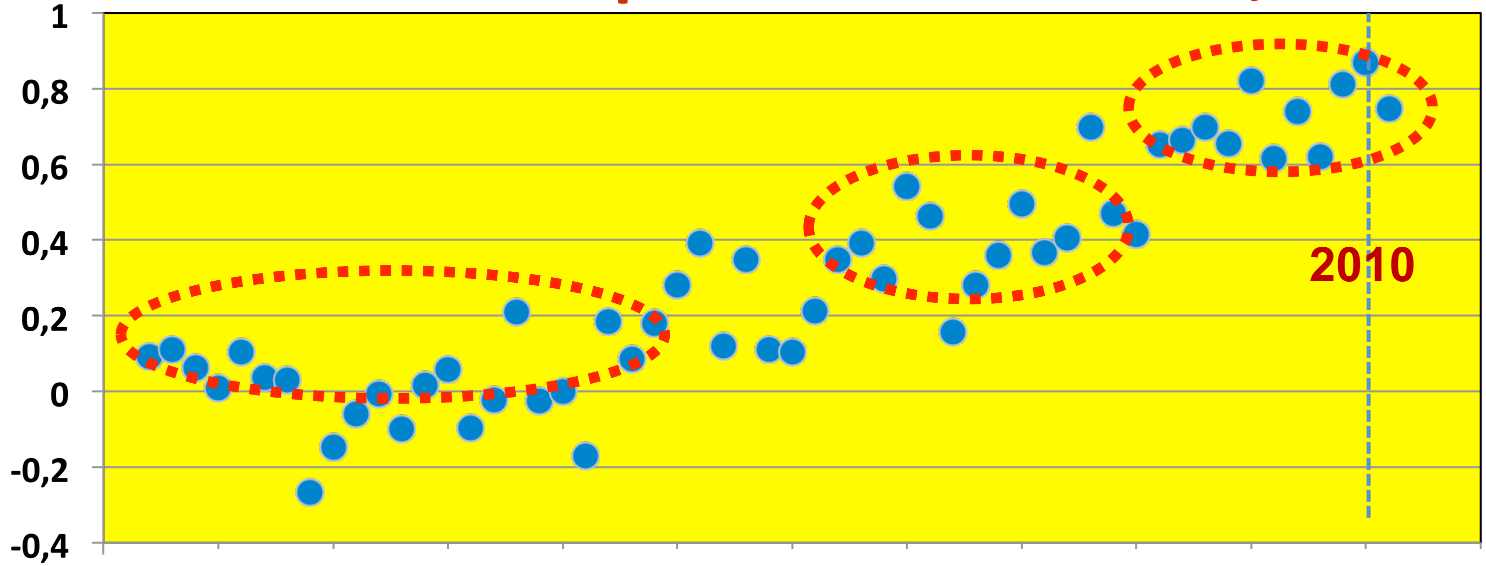
In real world: E Y $\neq$ 0;

X_i interact among themselves,

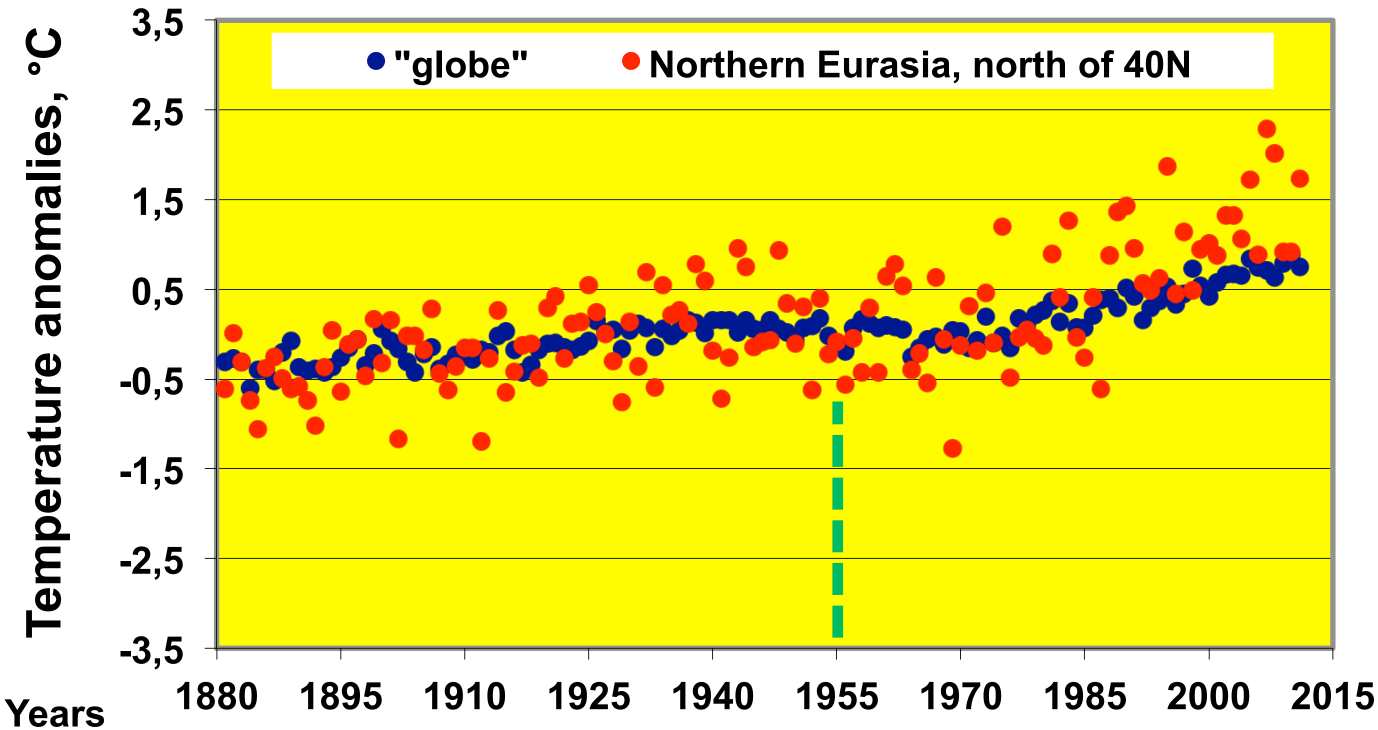
Y feedback to X_i variations

Global Surface Air Temperature Anomalies, °C

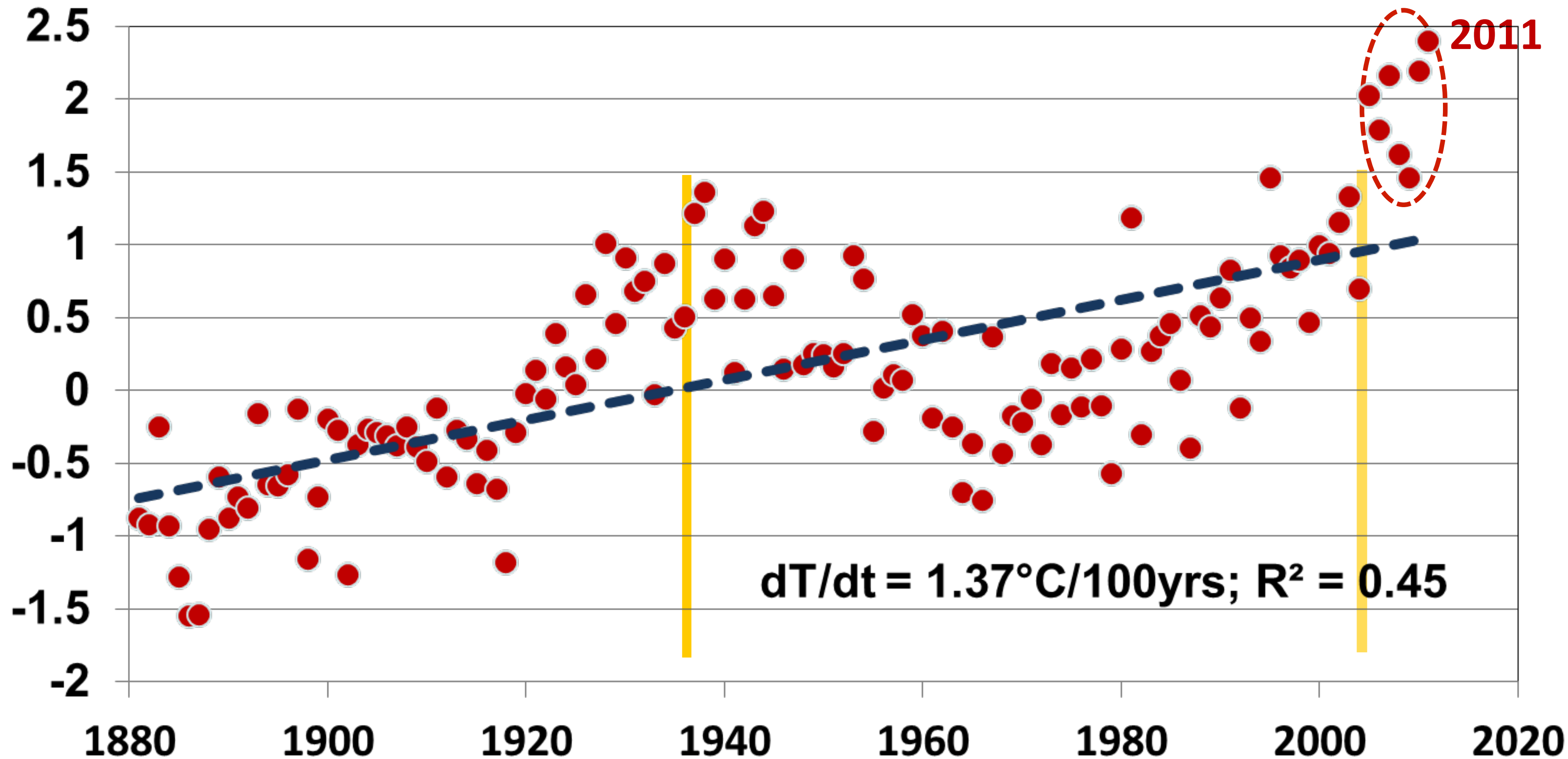
Annual temperature



Rates of increase of annual temperature for the "globe" (60°S to 90°N) and Northern Eurasia are **0.91 °C/130 yr and 1.5°C/130yr** respectively. (Lugina *et al* 2007, updated).



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

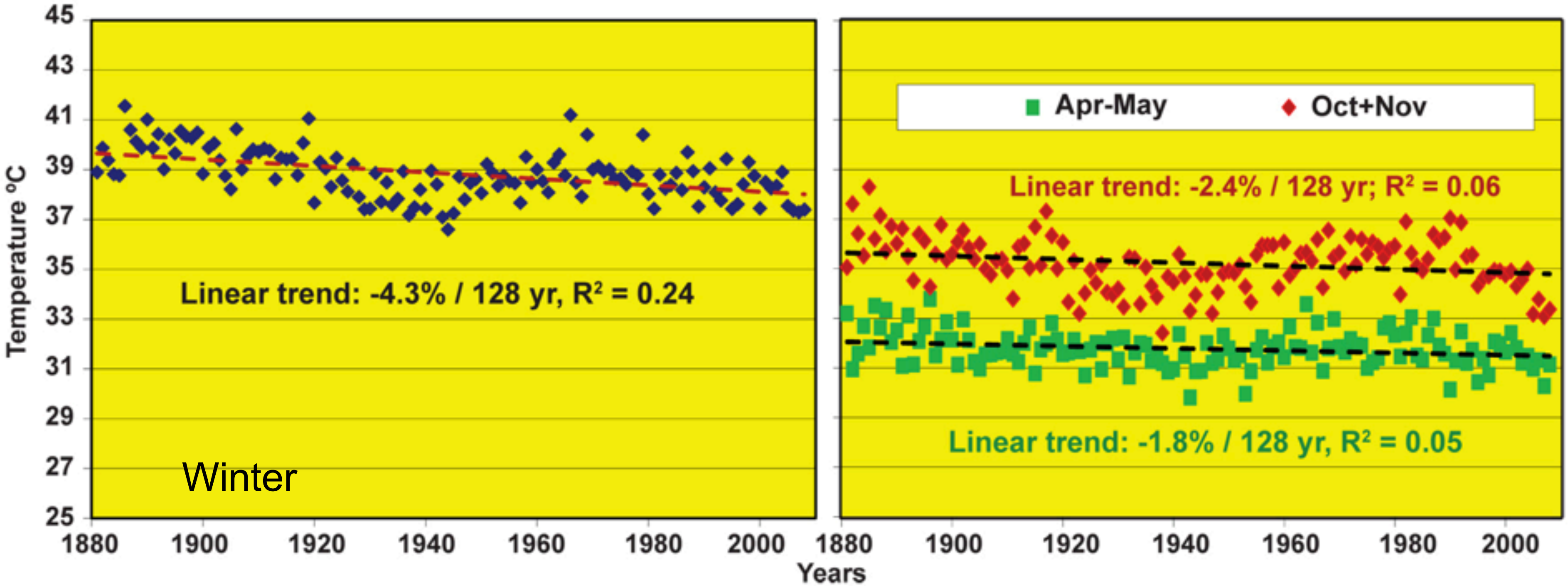


Linear trend for the entire period of instrumental observations is 1.79°C/131 years but there were periods (e.g., 1936-2004) when there was no statistically significant linear trend (Groisman *et al.* 2006, updated).

Anomalies were calculated from the mean values for the 1951-1975 reference period.

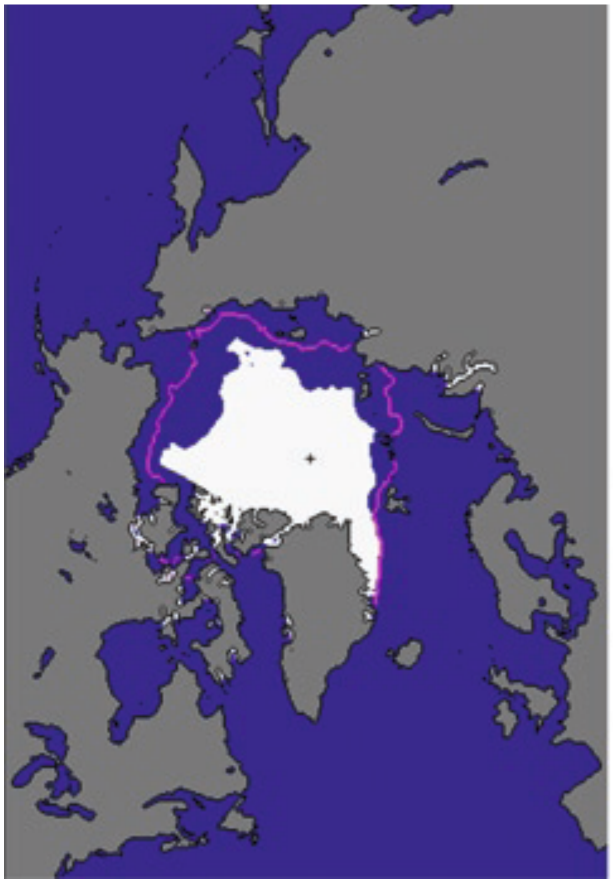
Decrease in surface air temperature meridional gradients over the Northern Hemisphere estimated as a difference of tropical mean zonal temperature (zone 0°- 30°N) and polar mean zonal temperature (zone 60°N - 90°N)

(Groisman and Soja 2009)

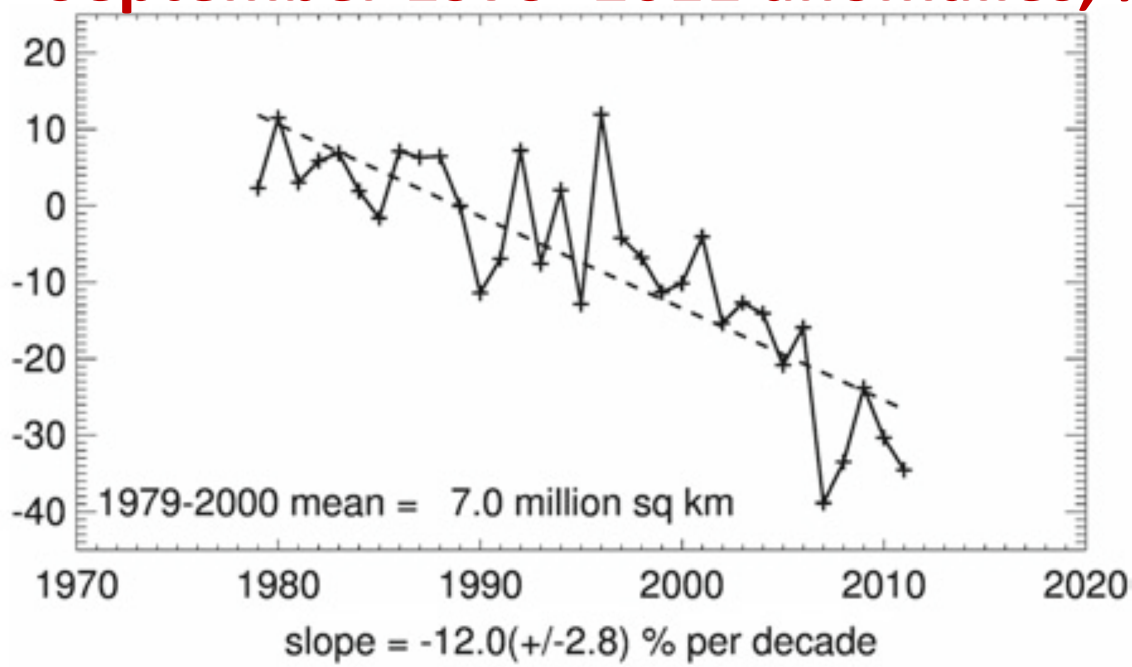


For Northern Eurasia climate, zonal heat and water vapor transport are of critical importance.

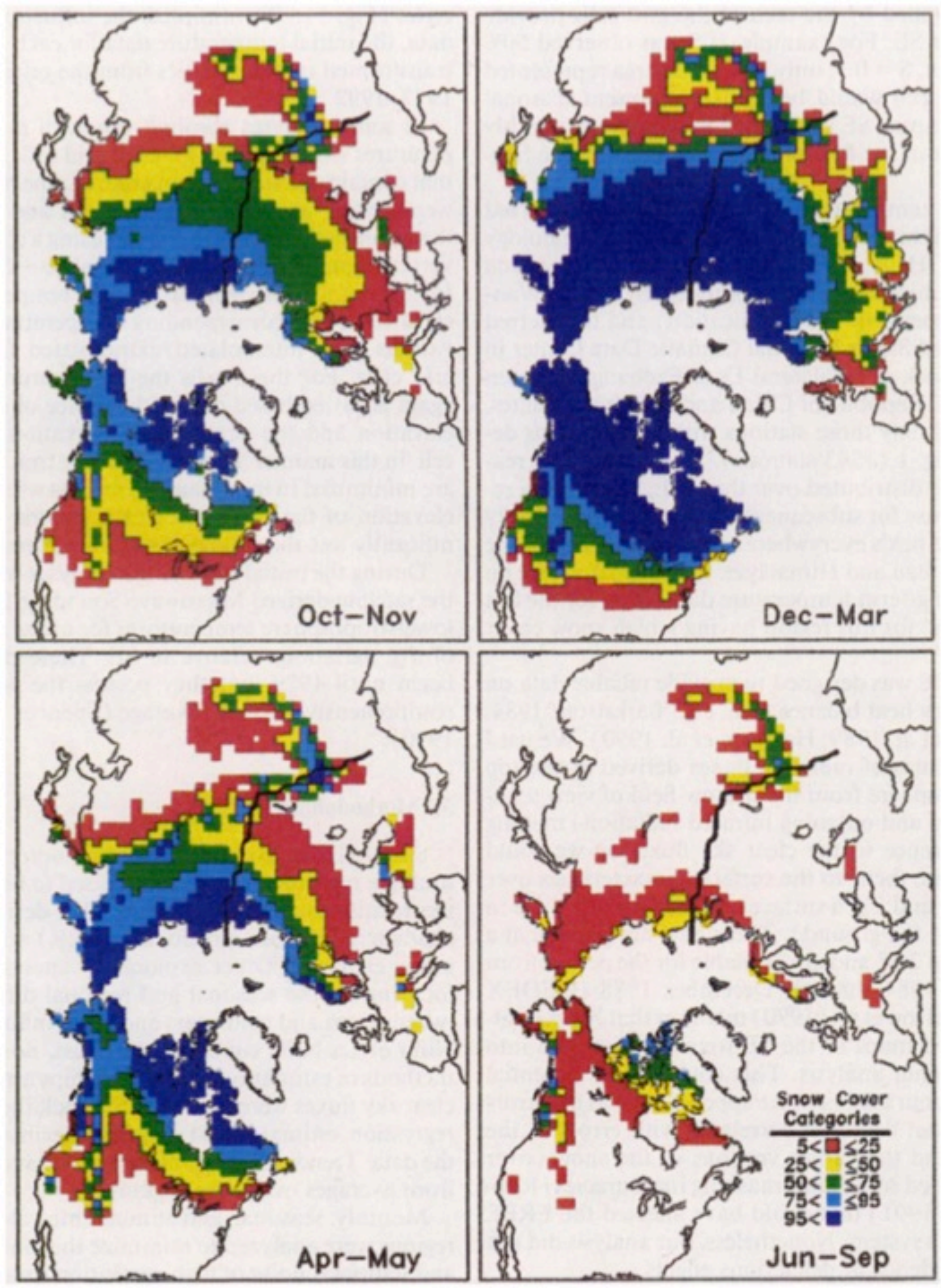
Northern Hemisphere sea ice extent as of mid-September 2011



September 1979–2011 anomalies, %

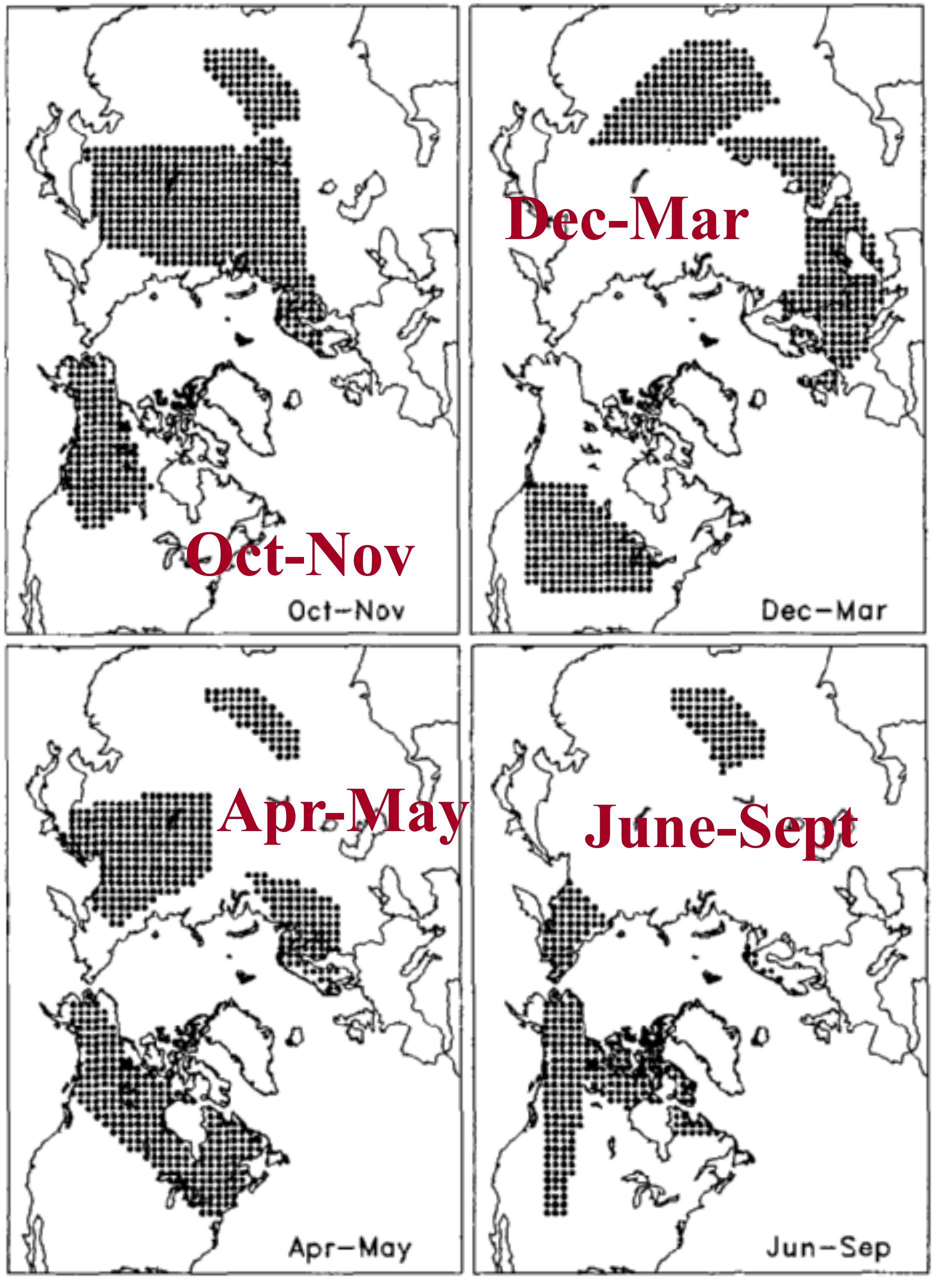


Archive of the US National Snow and Ice Data Center (http://www.nsidc.org/data/seaice_index/index.html)

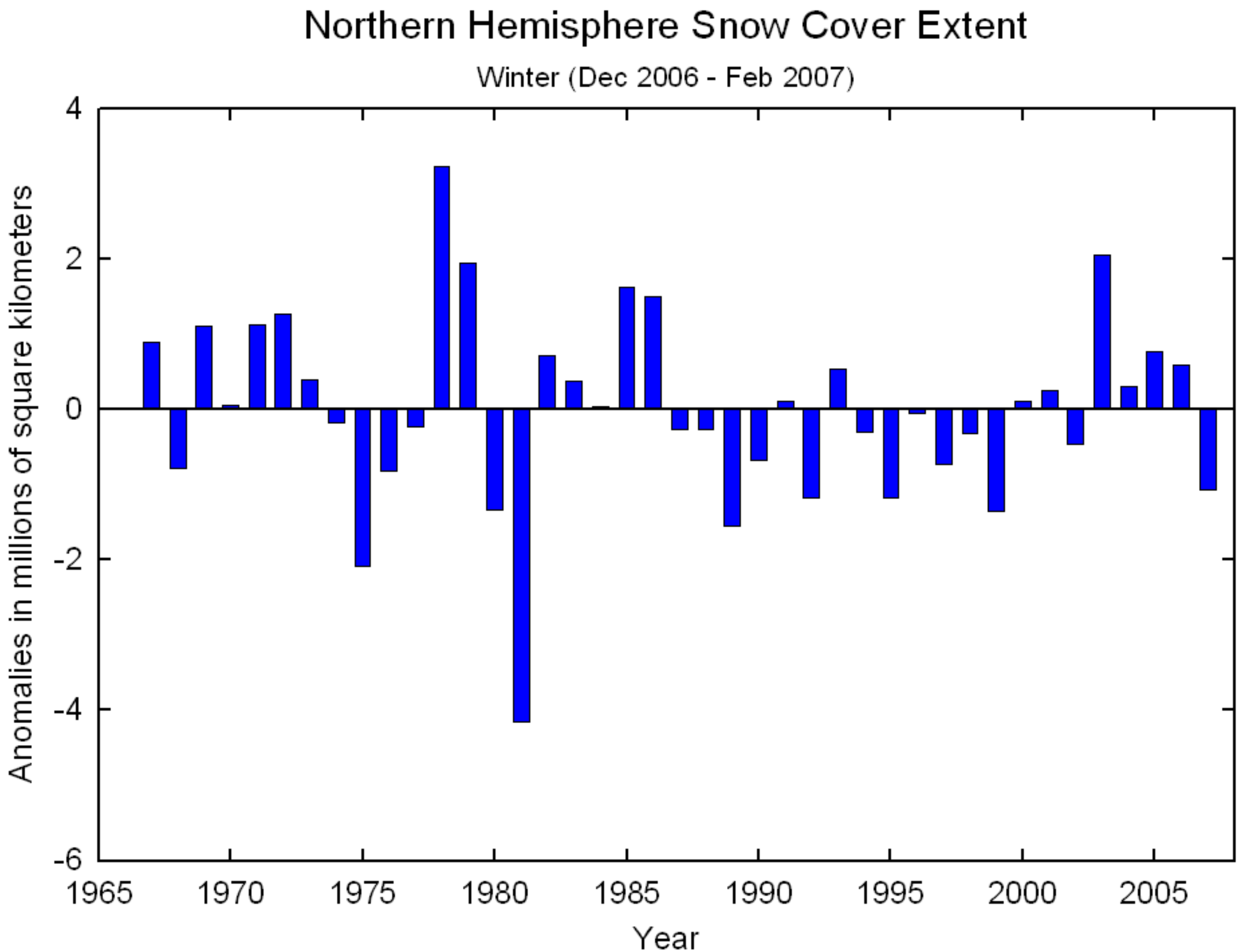


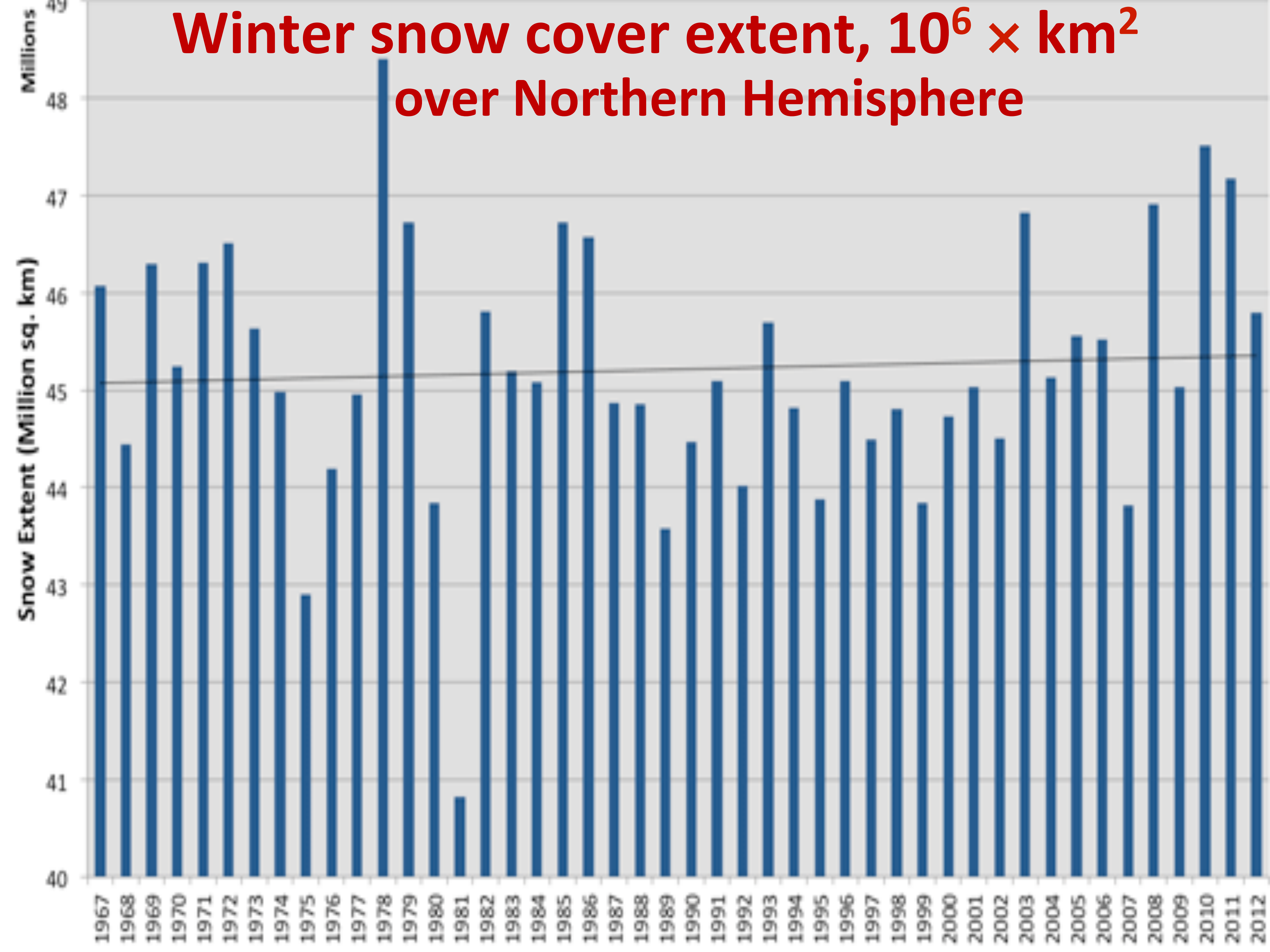
Northern Hemisphere snow cover (SC) climatology (most frequent snow cover – dark blue – to least frequent snow cover – colorless). (Groisman e al. 1994)

SC category	Fraction of time with SC
0	< 0.05
1	0.05 to 0.25
2	0.25 to 0.50
3	0.50 to 0.75
4	0.75 to 0.95
5	> 0.95



Temperature sensitive regions (Karl et al. 1993, Groisman et al. 1994). These are the regions where contemporary changes in snow cover have been mostly occurred with changes in hemispheric (or continental temperatures)


Northern Hemisphere Snow Cover Extent
Winter (Dec 2006 - Feb 2007)
Anomalies in millions of square kilometers
4
2
0
-2
-4
-6
1965
1970
1975
1980
1985
1990
1995
2000
2005
Year


Winter snow cover extent, $10^6 \times km^2$
over Northern Hemisphere
Millions
Snow Extent (Million sq. km)
49
48
47
46
45
44
43
42
41
40
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
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1985
1986
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1988
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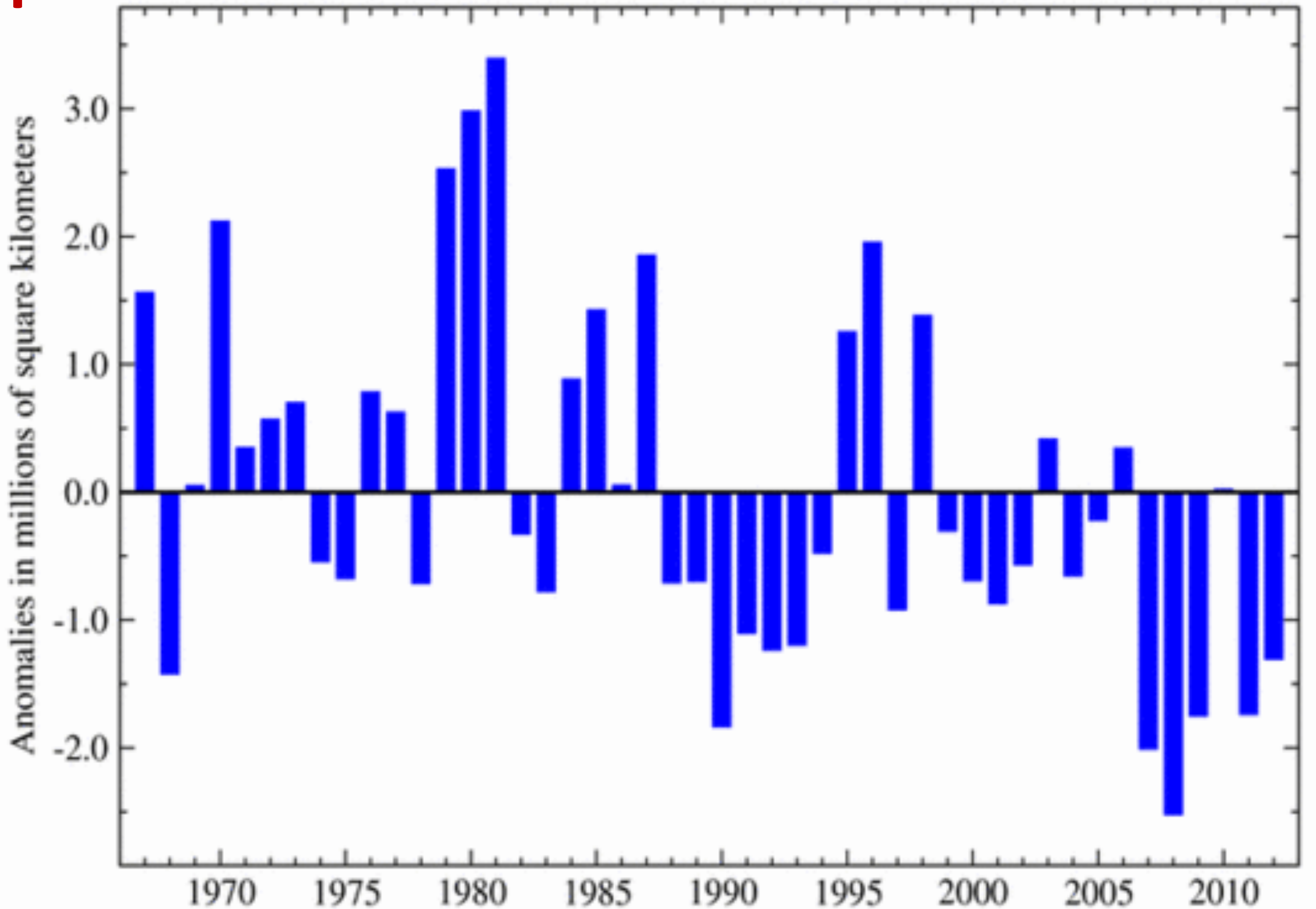
2007
2008
2009
2010
2011
2012

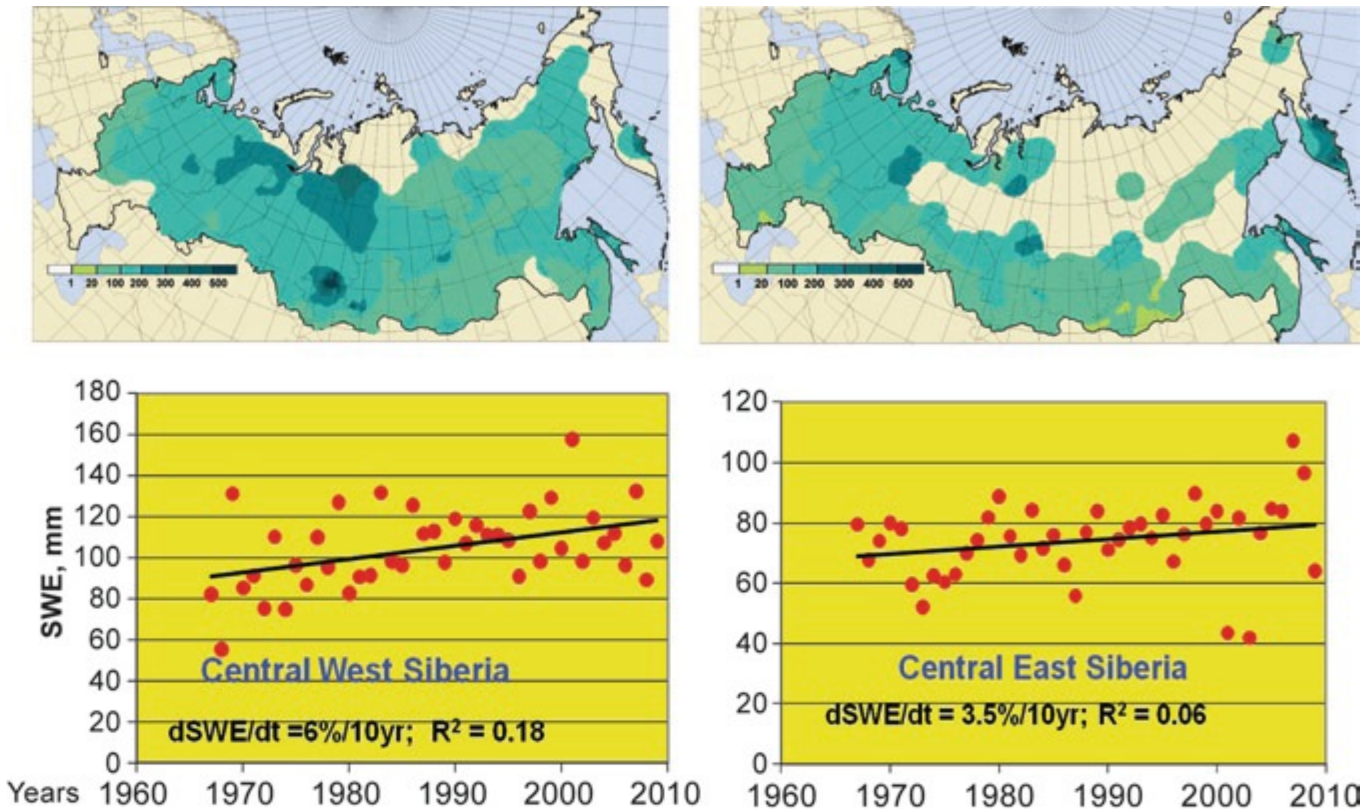
April snow cover extent anomalies over Eurasia



Snow cover extent from NOAA satellites for 1967-2012. NOAA NCDC 2011: State of the Climate Global Analysis April 2011. [Available at *http://www.ncdc.noaa.gov/sotc/service/global/snowcover-eurasia/201204.gif*]

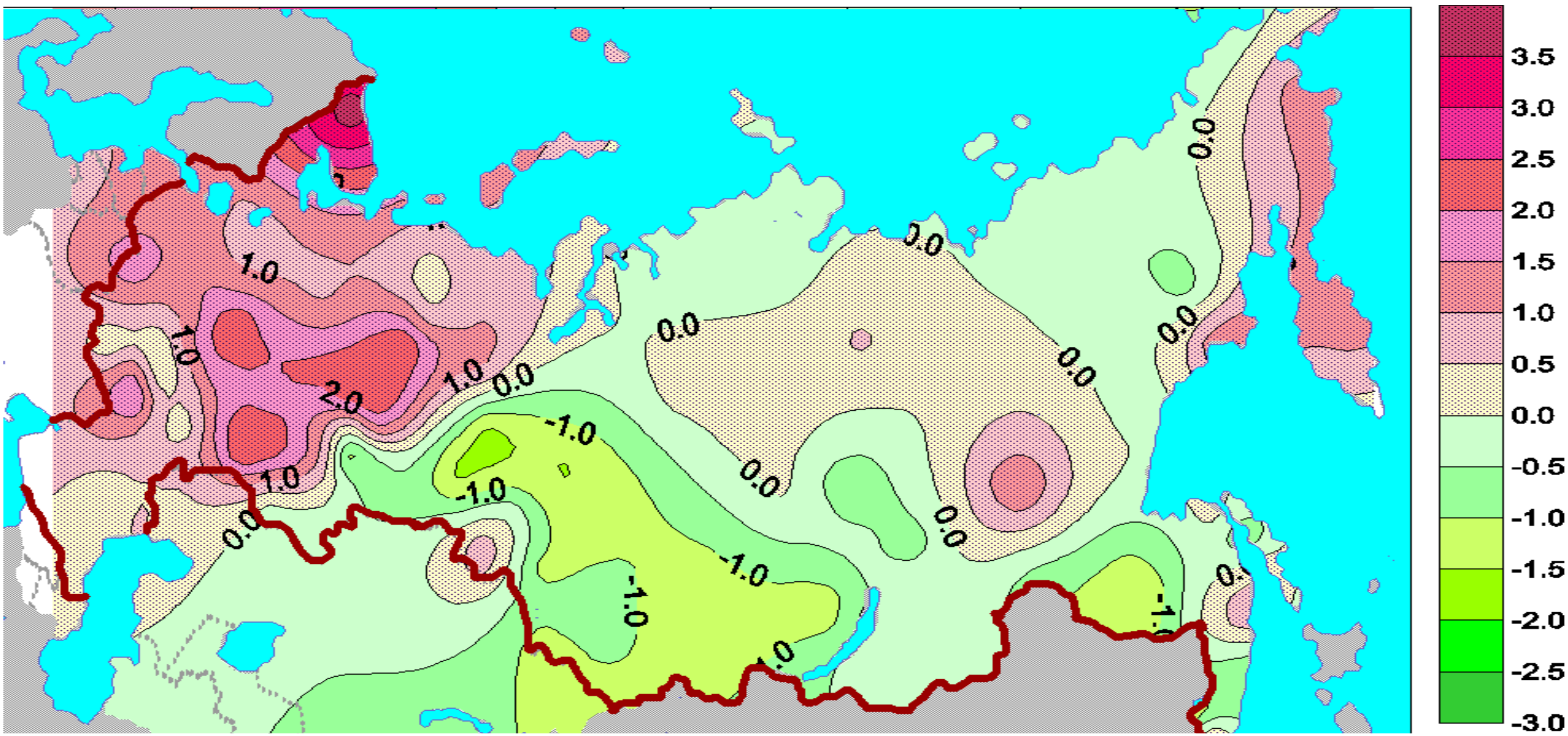
Mean maximum snow water equivalent, mm

Top. **Mean values for the 1966–2009 period along the snow surveys in the forested (*left*) and open ("field," *right*) areas.**



Bottom. **Changes in snow water equivalent over Northern Siberia along the "field" snow survey routes (approximately 55–65°N lat. belt).**
Increases within this belt are also observed eastward from Moscow (not shown) .

Changes of bias-corrected annual precipitation over Russia
Linear trends (mm yr $^{-1}$), the 1936-2000 period

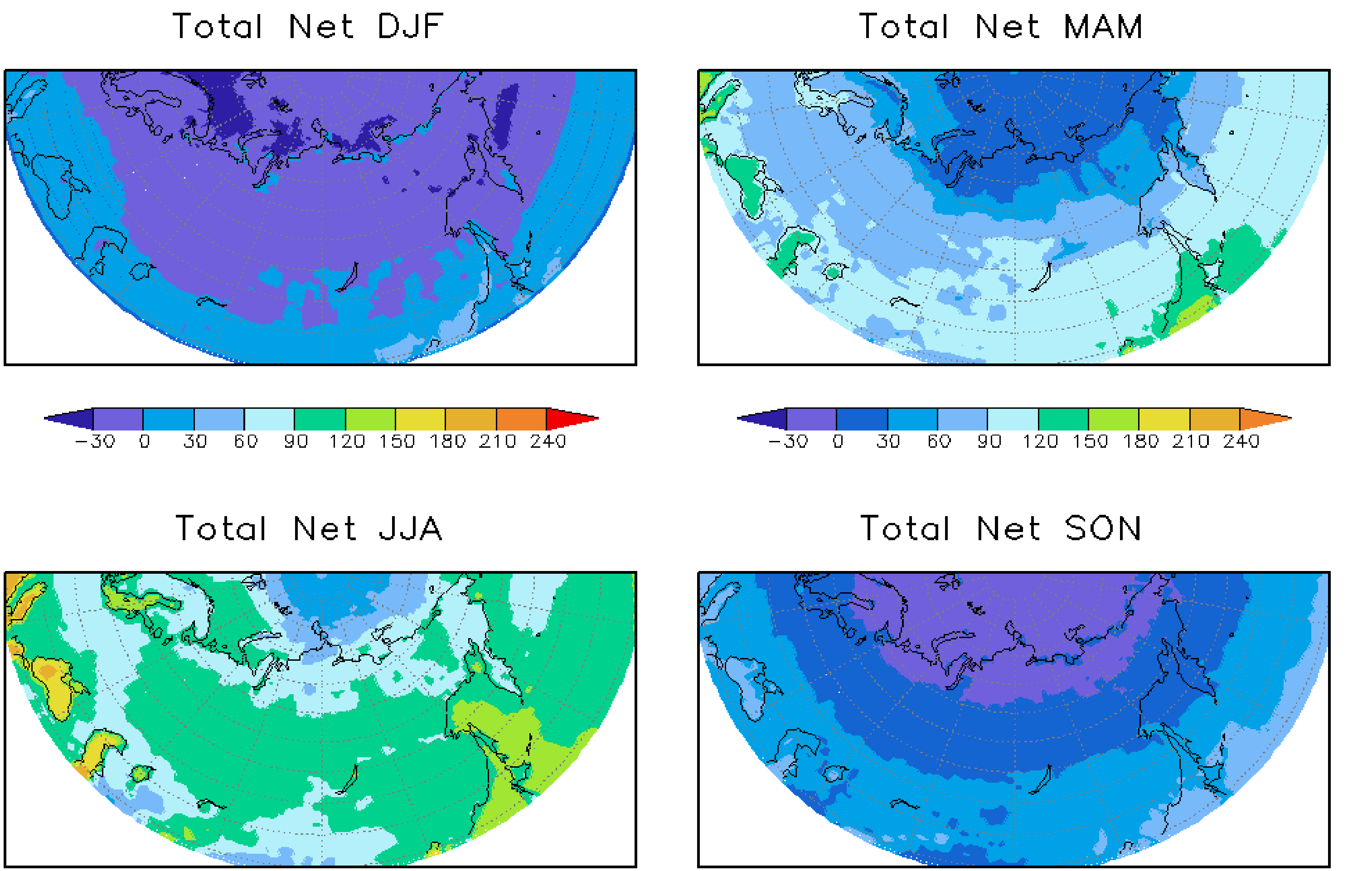


The increase in annual precipitation over European Russia was accompanied with

- **the highest (during the past 120 years) level of the Caspian Sea**
- **increase in the Volga River runoff**
- **water table rise, and**
- **increase in the spring/summer moisture content in the upper meter of soil**

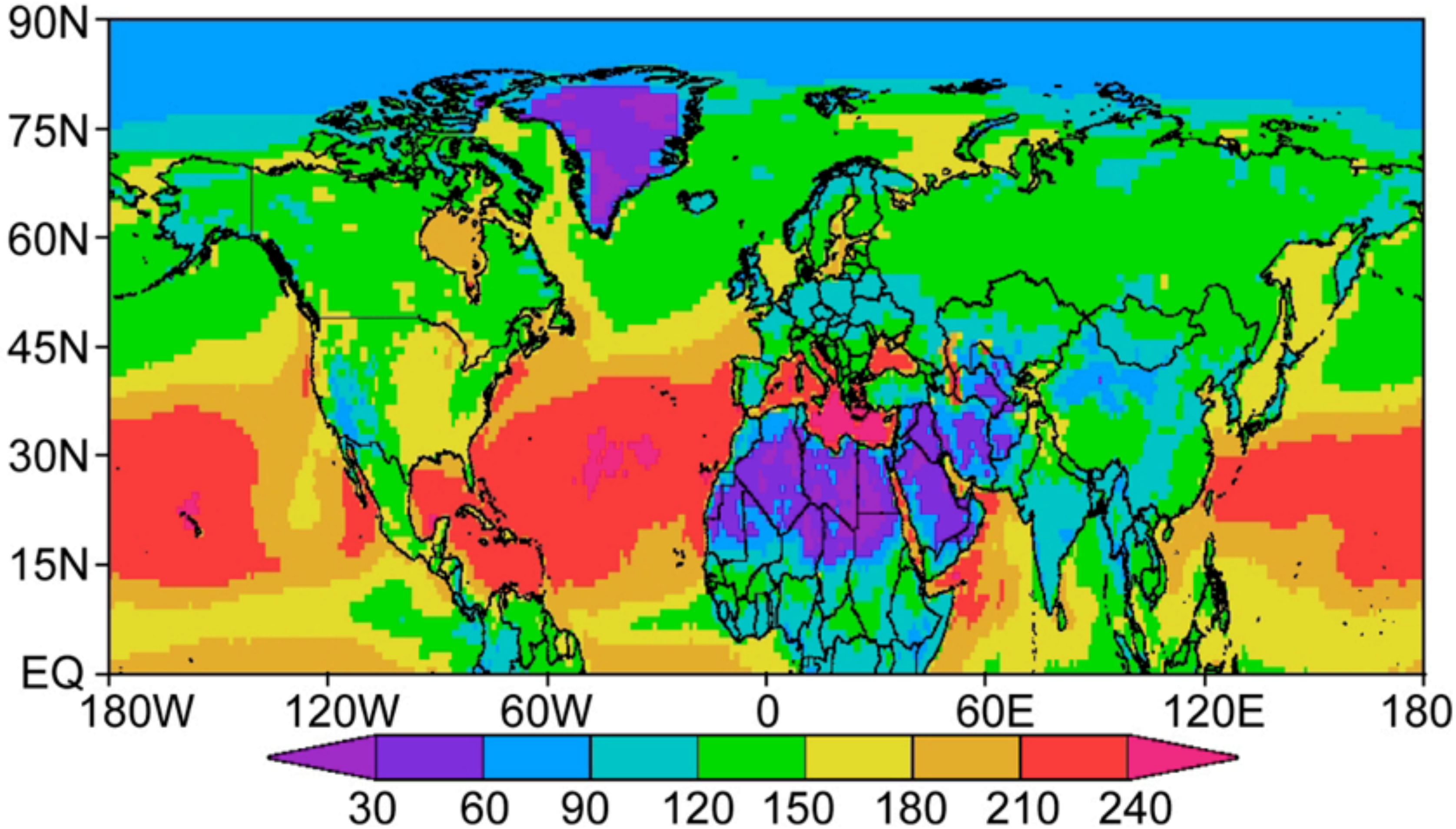
E.G. Bogdanova, N.A. Speranskaya, V. Yu. Georgievsky (2009, Personal communications)

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



(Stackhouse 2004)

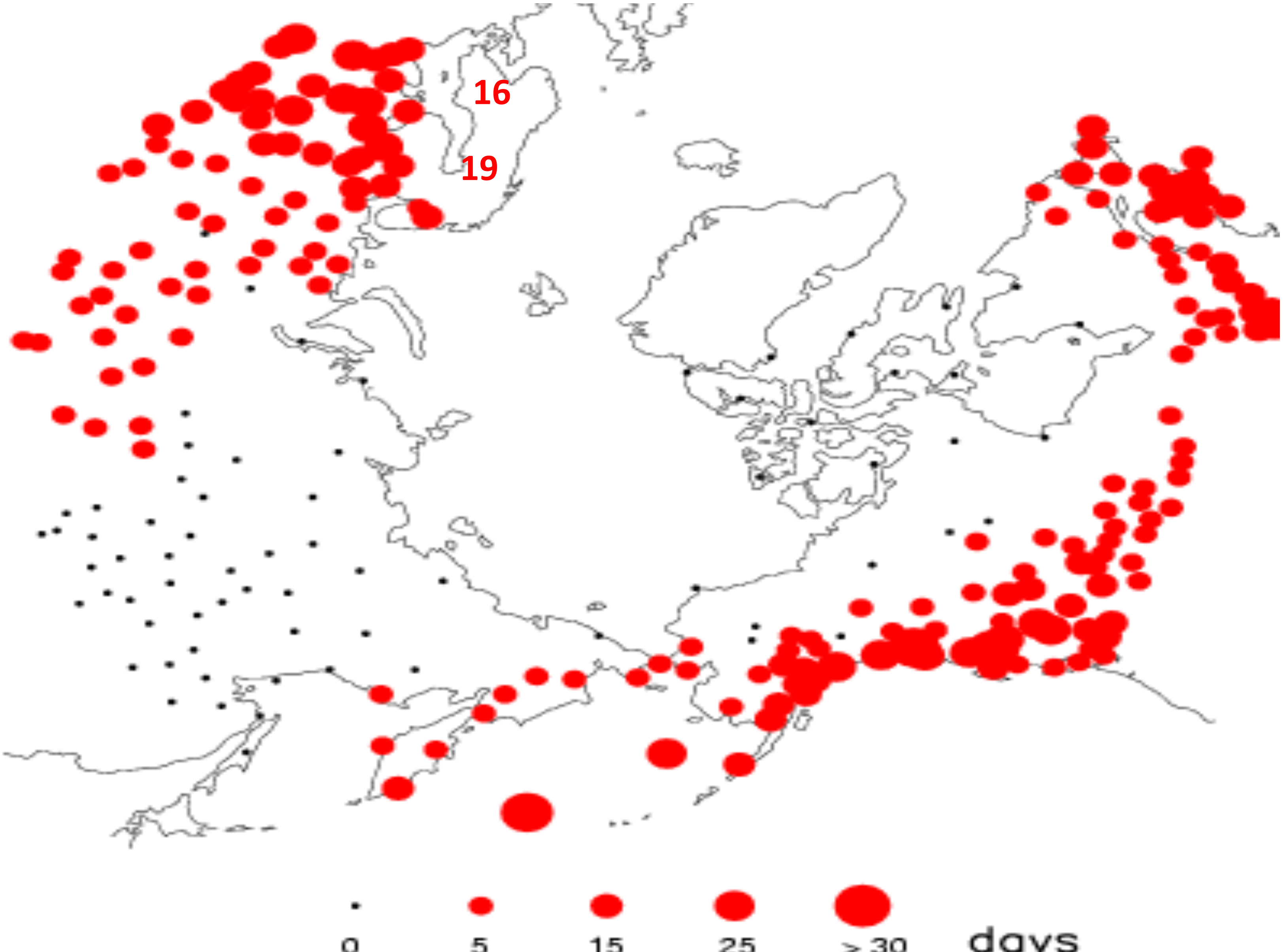
July total net irradiance (solar net + thermal infrared net)



The 22 year average from the NASA/GEWEX Surface Radiation Budget project.

Courtesy of Paul Stackhouse Jr. and Colleen Mikovitz, NASA Langley Research Center

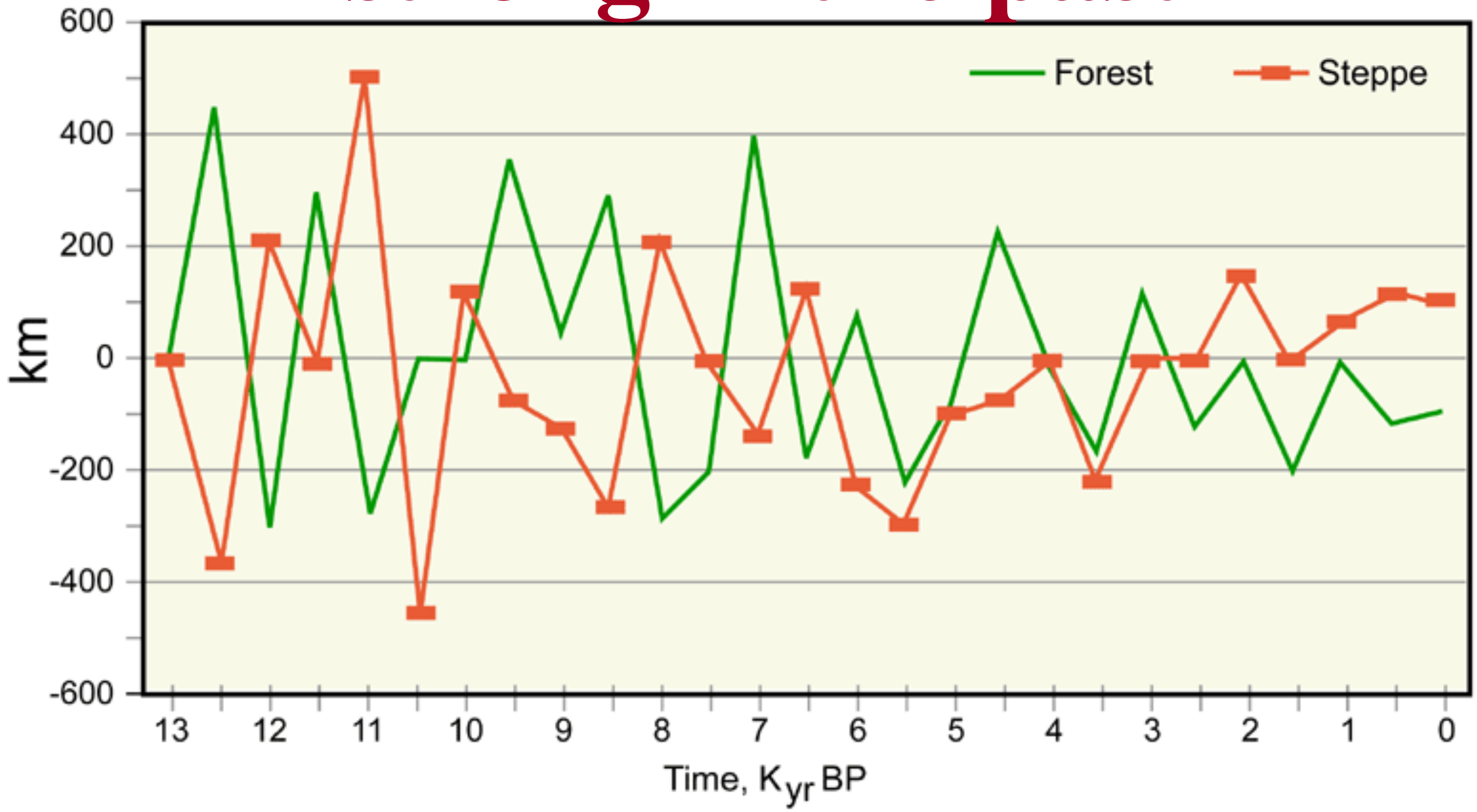
Thaw days. Winter Climatology



West of Northern Eurasia

(Europe)

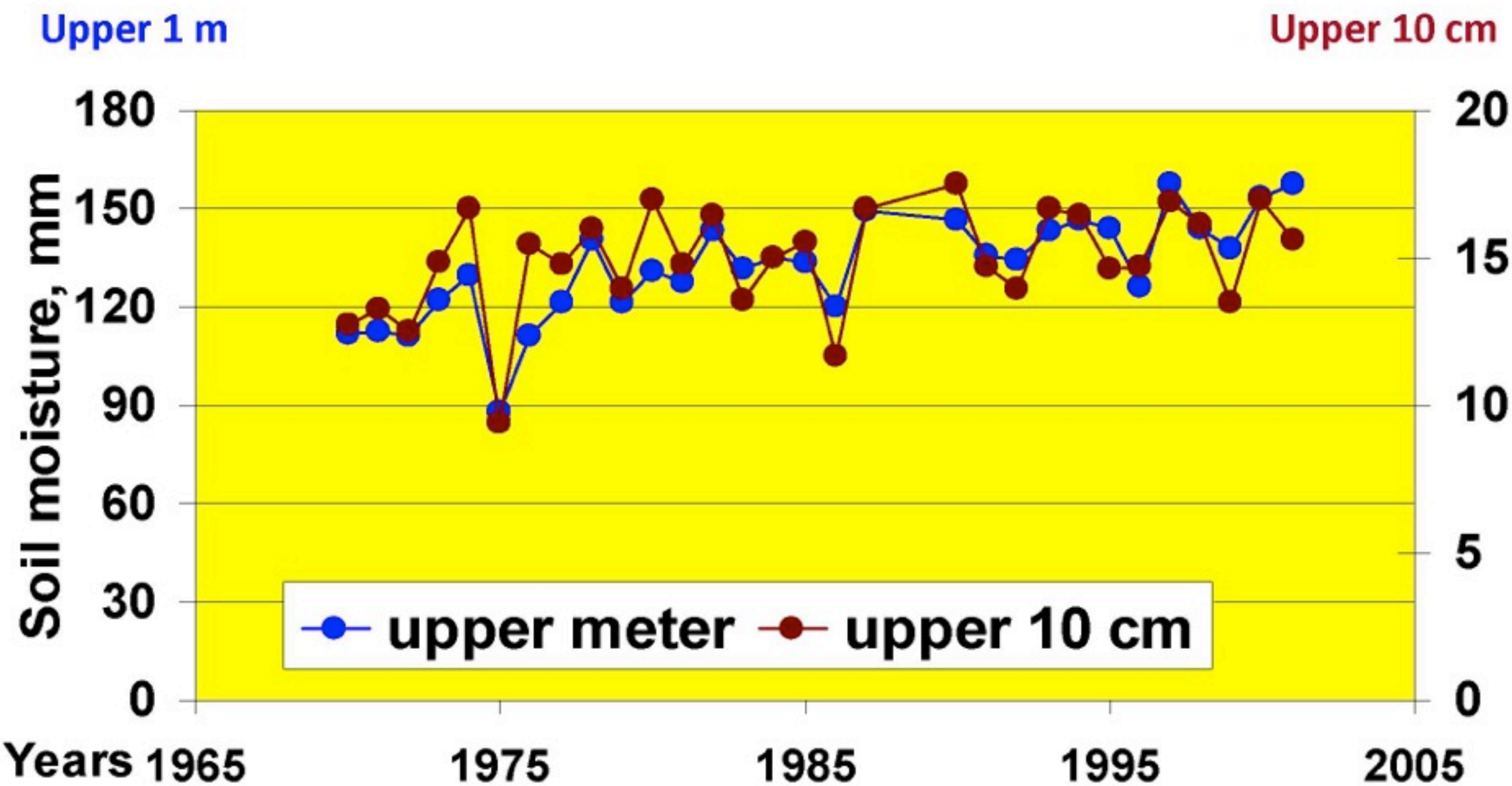
In Eastern Europe changes were strong in the past



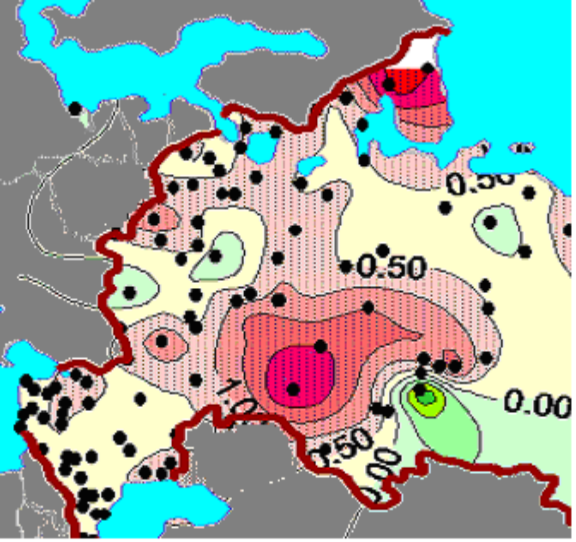
Changes of the northern boundaries of forest and steppe zones along the 39°E (past 13K years)

(Kozharinov and Puzachenko 2004)

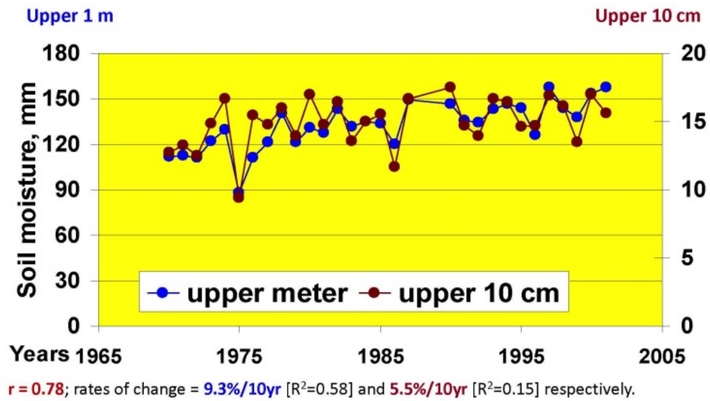
Soil moisture changes over European Russia south of 60°N during the warm season in the first upper 100 and 10 cm respectively (Speranskaya 2009)



r = 0.78; rates of change = 9.3%/10yr [R^2=0.58] and 5.5%/10yr [R^2=0.15] respectively.



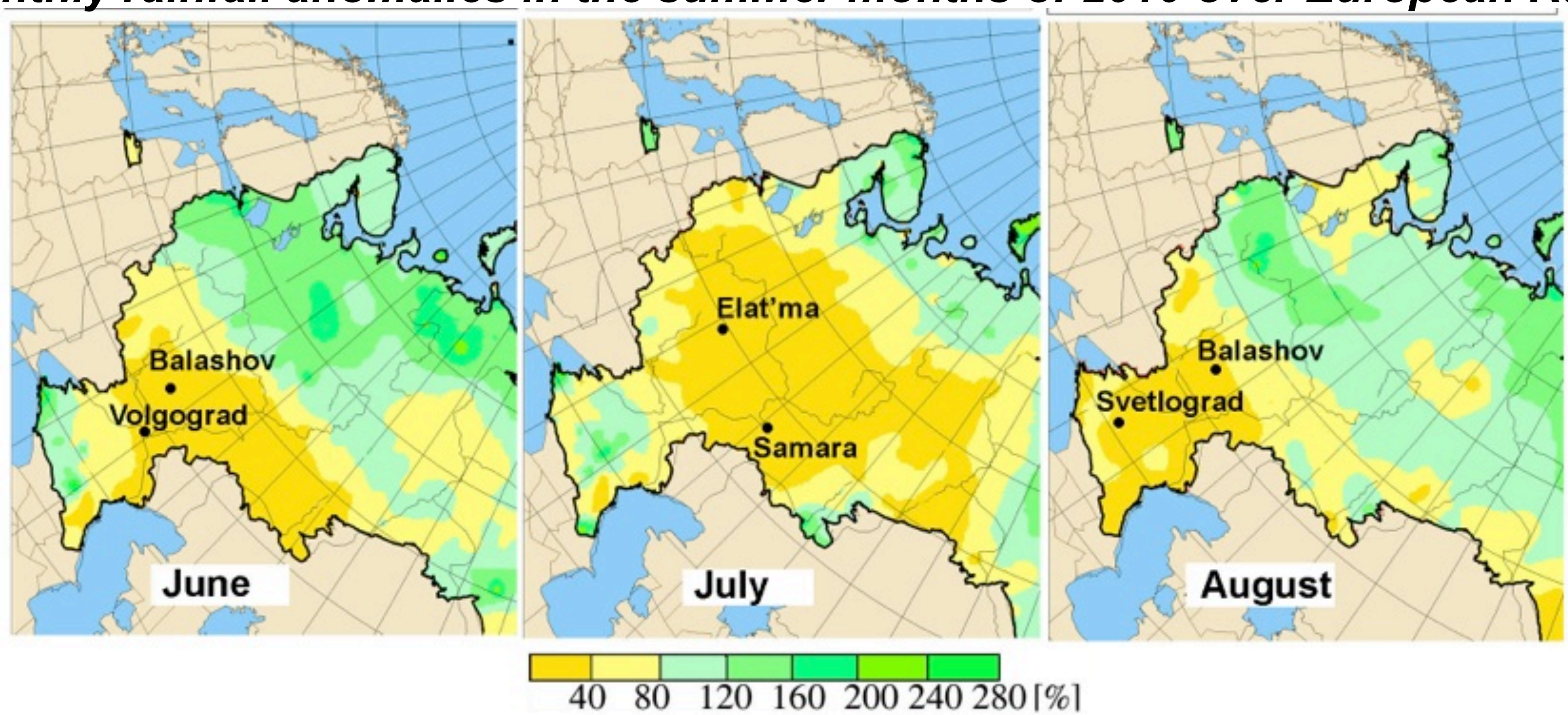
Annual precipitation. Linear trends for the 1936-2000 period (mm yr[-1]).



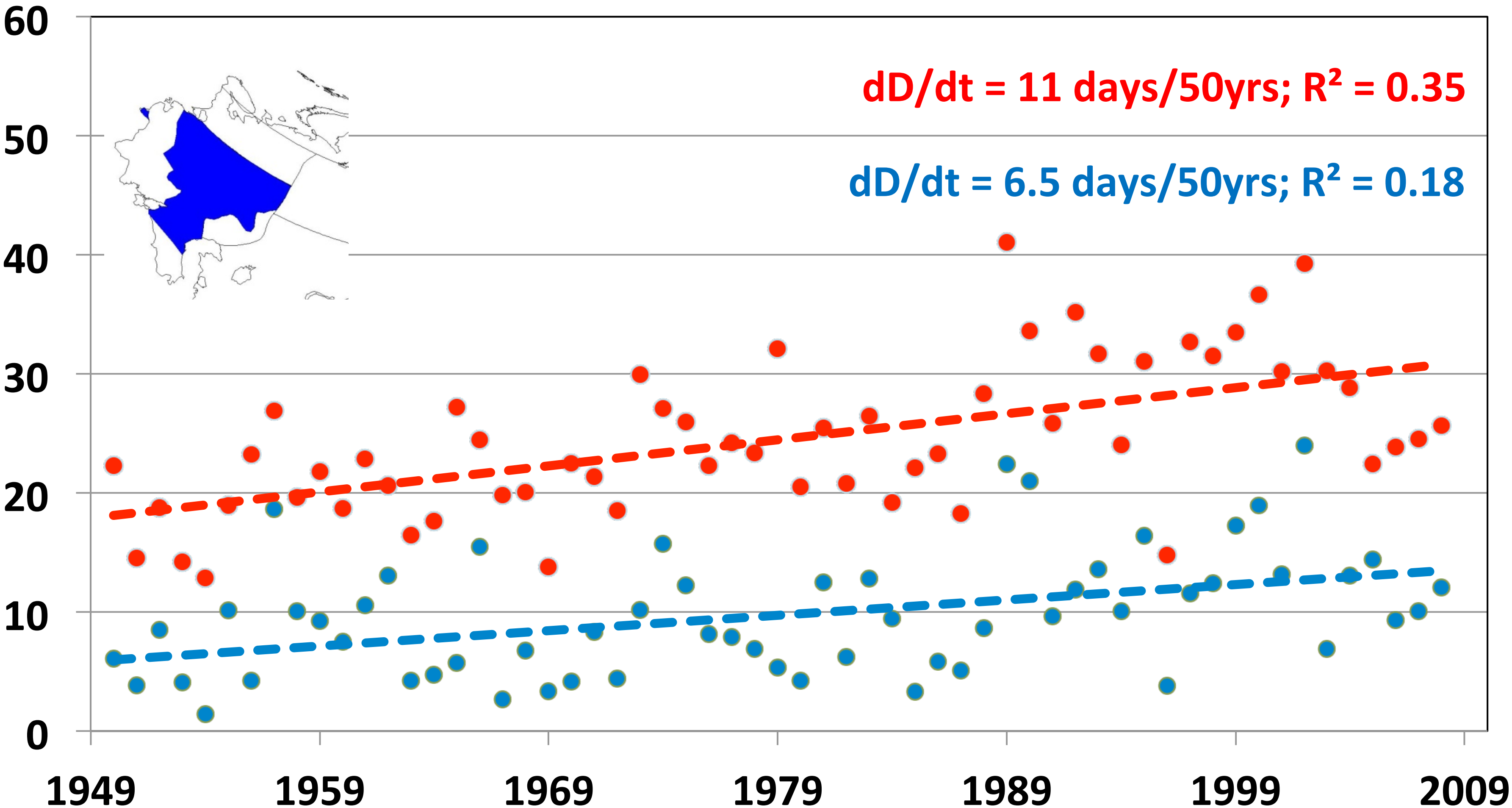
Upper layer soil moisture changes over European Russia south of 60°N during the warm season.

and again:

Monthly rainfall anomalies in the summer months of 2010 over European Russia

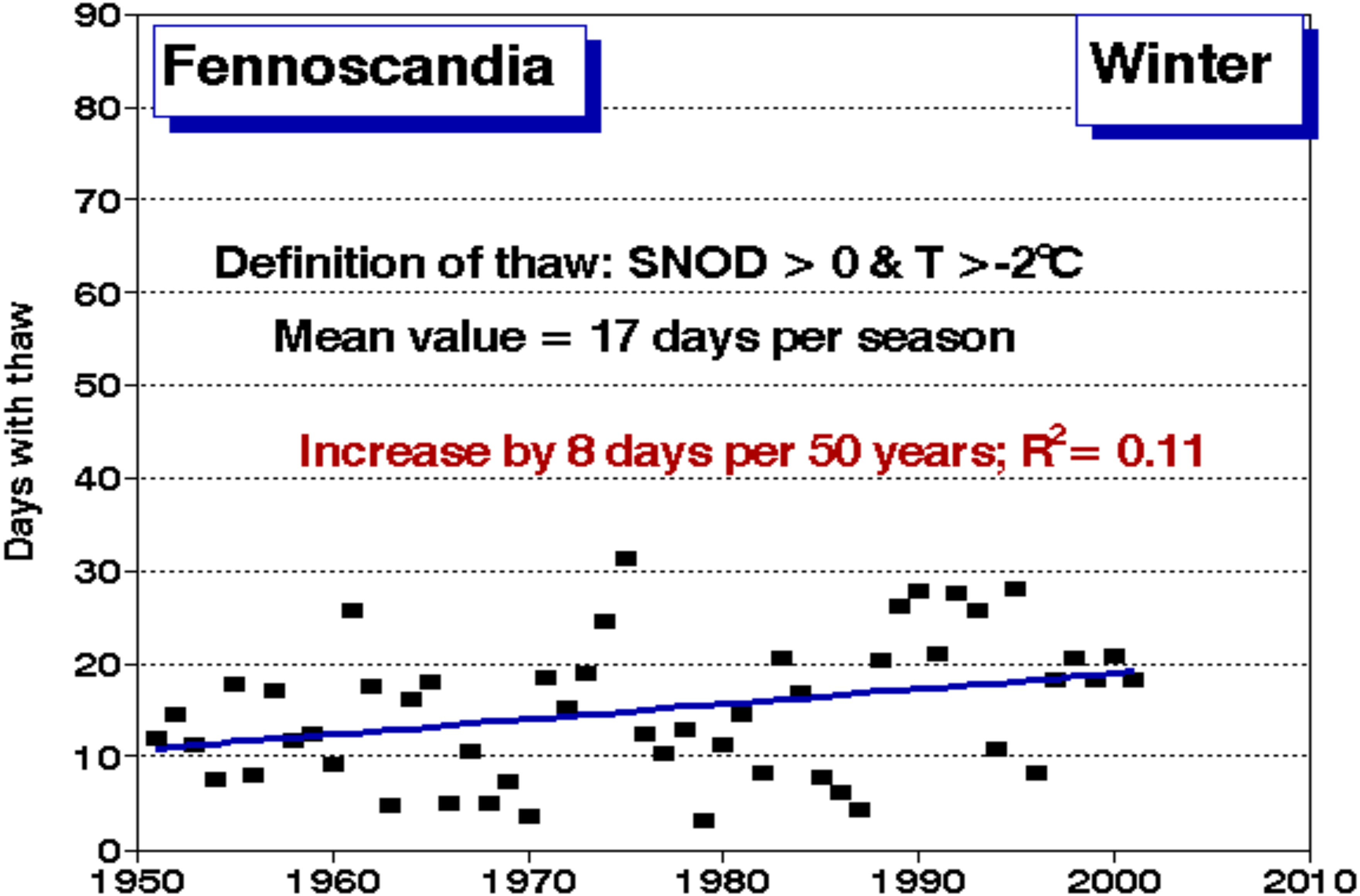


Annual and winter number of days with thaw over European Russia south of 60°N

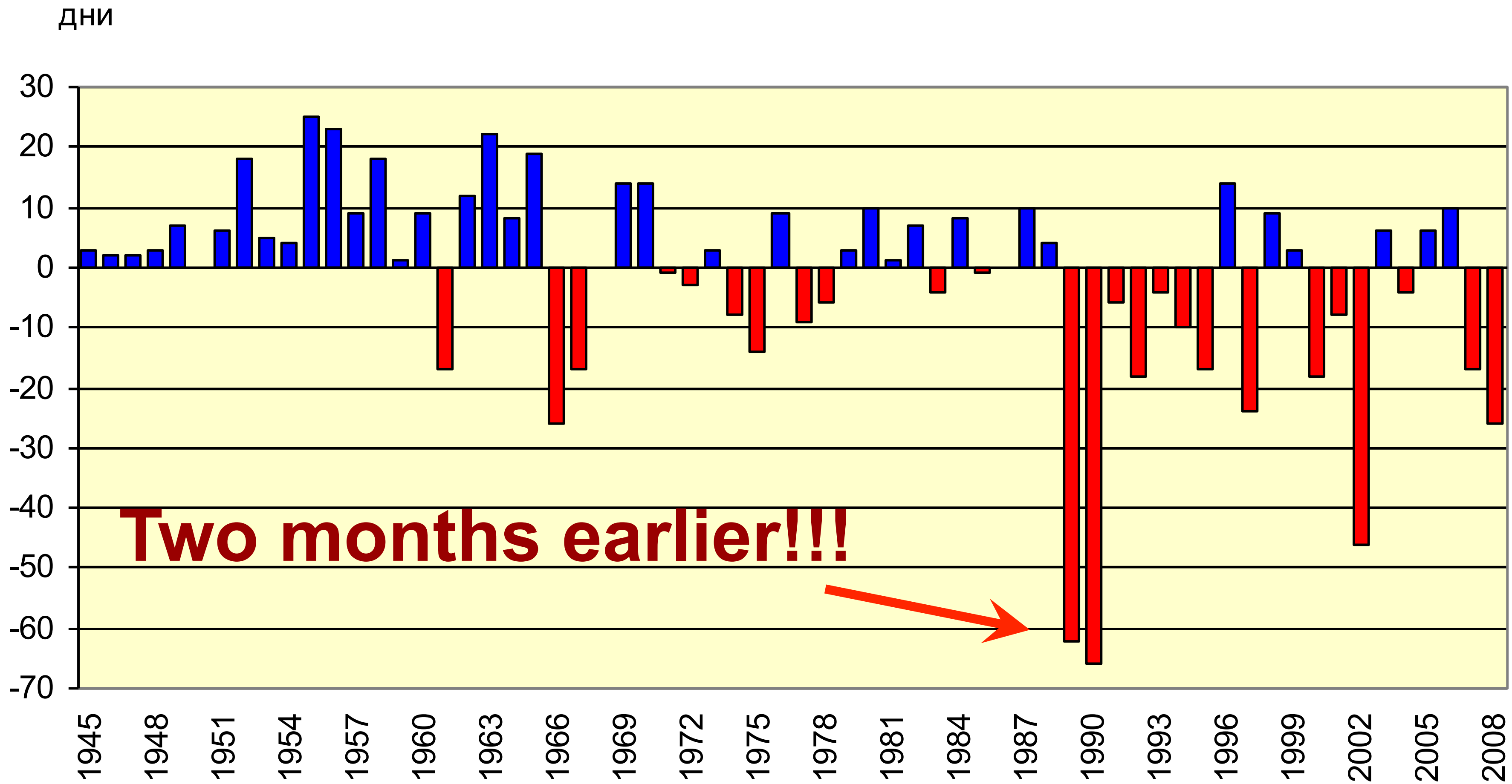


Days with thaw are defined as the days when the mean daily temperature is above -2°C while snow on the ground is above 5 cm.

Frequency of days with thaw

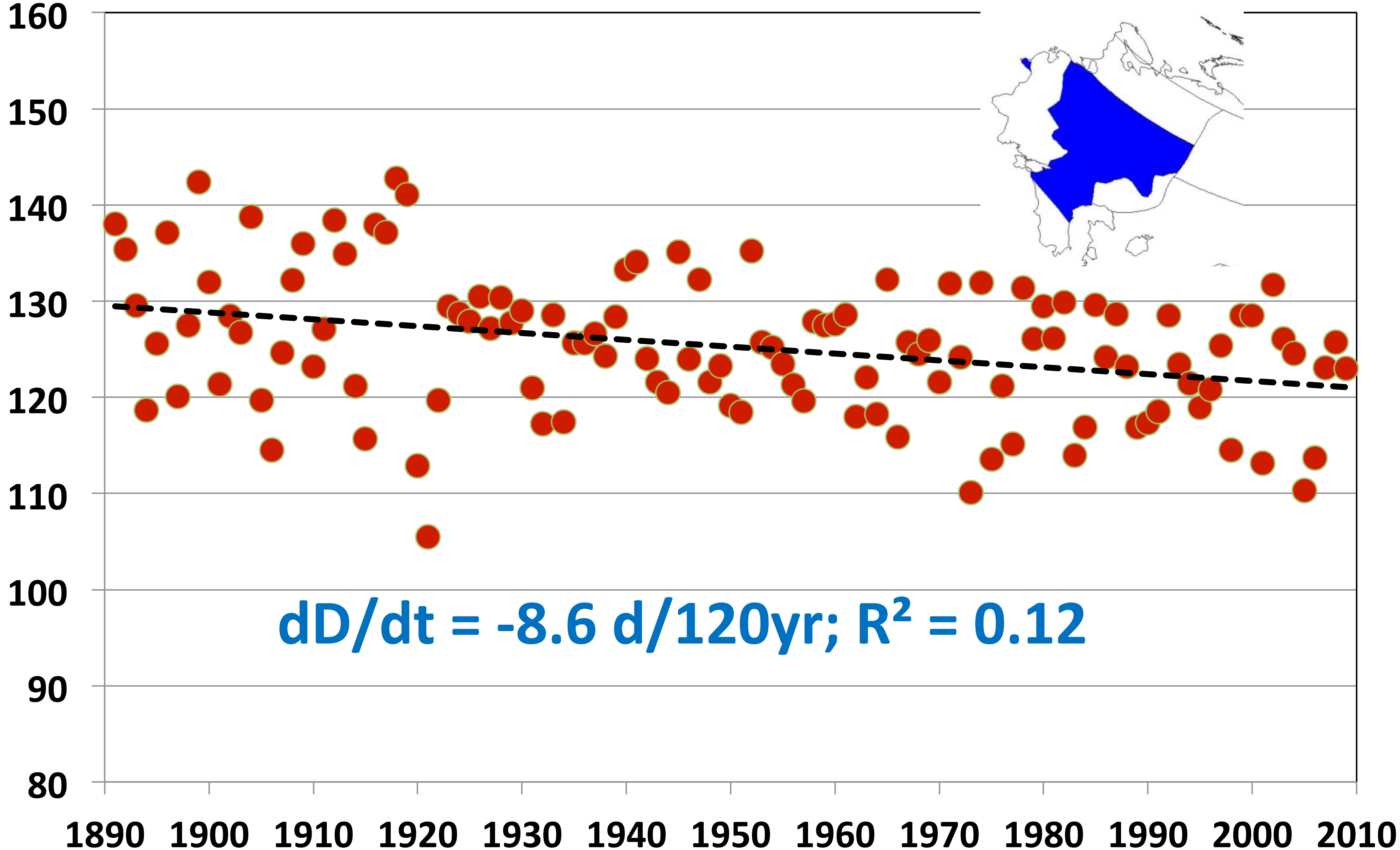


Anomalies (days) of the spring dates of daily surface air temperature transition through 0°C from the mean long-term values in central Belarus



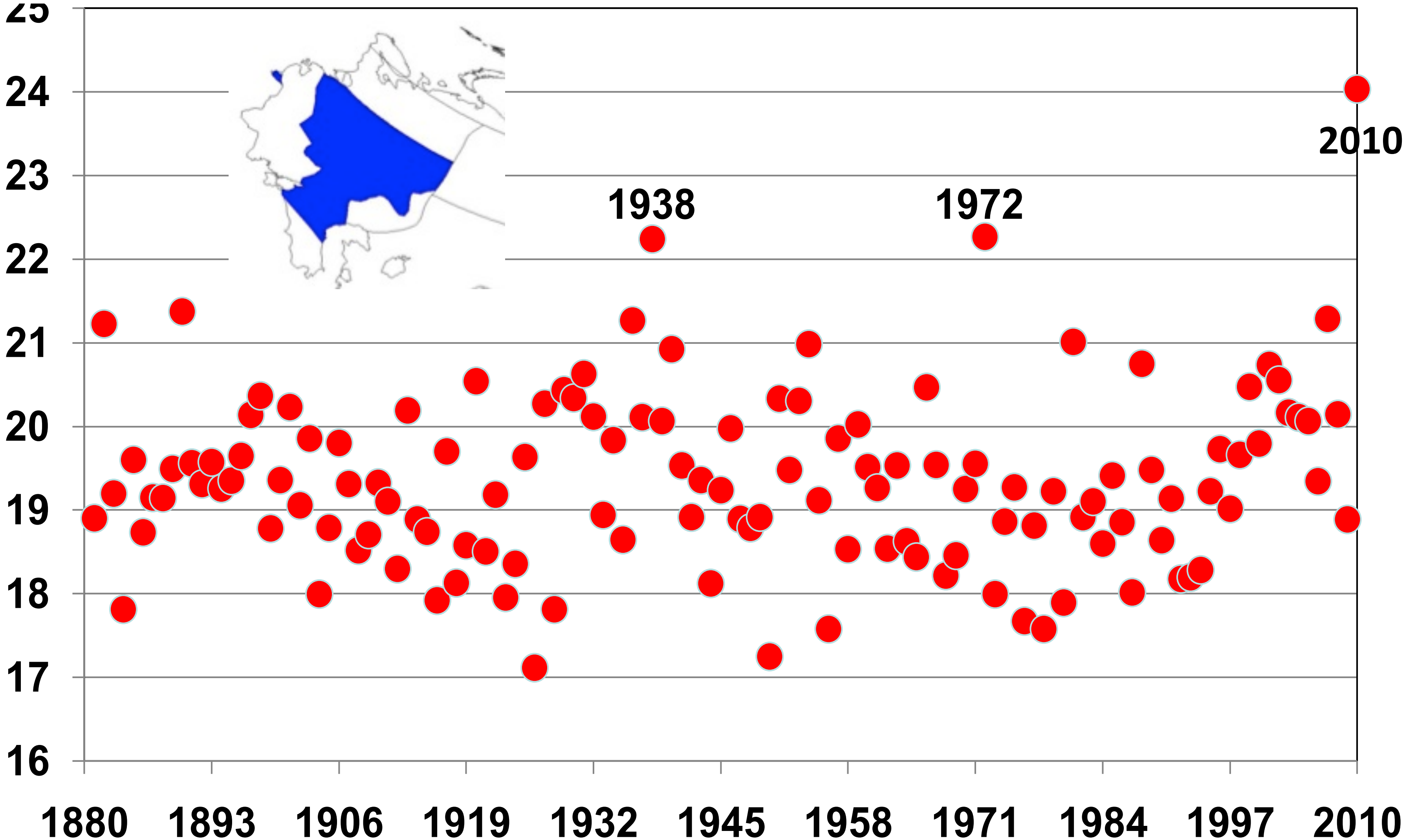
Elena V. Komarovskaya, 2009; Personal communication

Dates when vegetation season starts, Julian day in European Russia south of 60°N

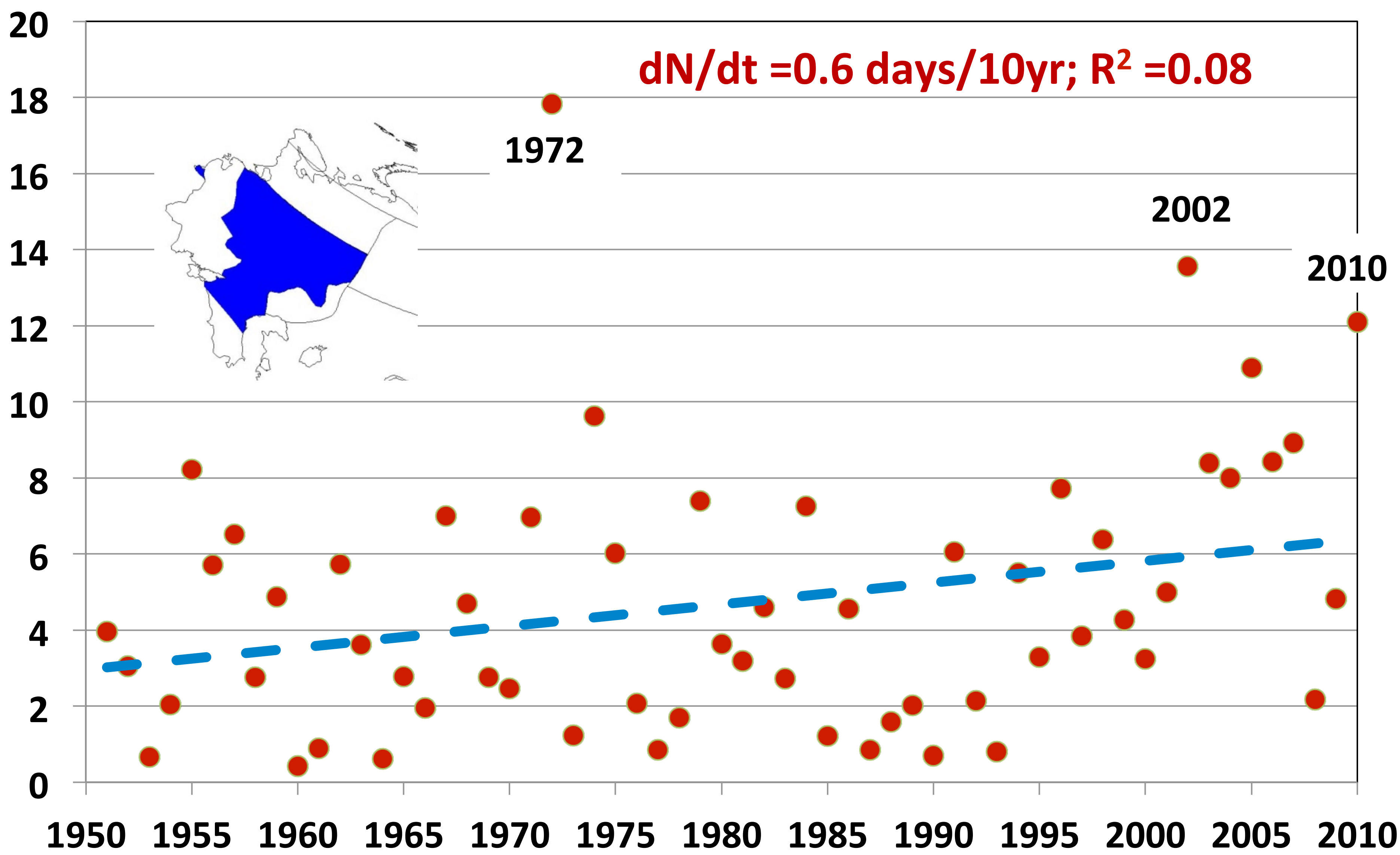


July-August surface air temperature (°C) area-averaged over European Russia south of 60°N

(Lugina et al 2006, updated)

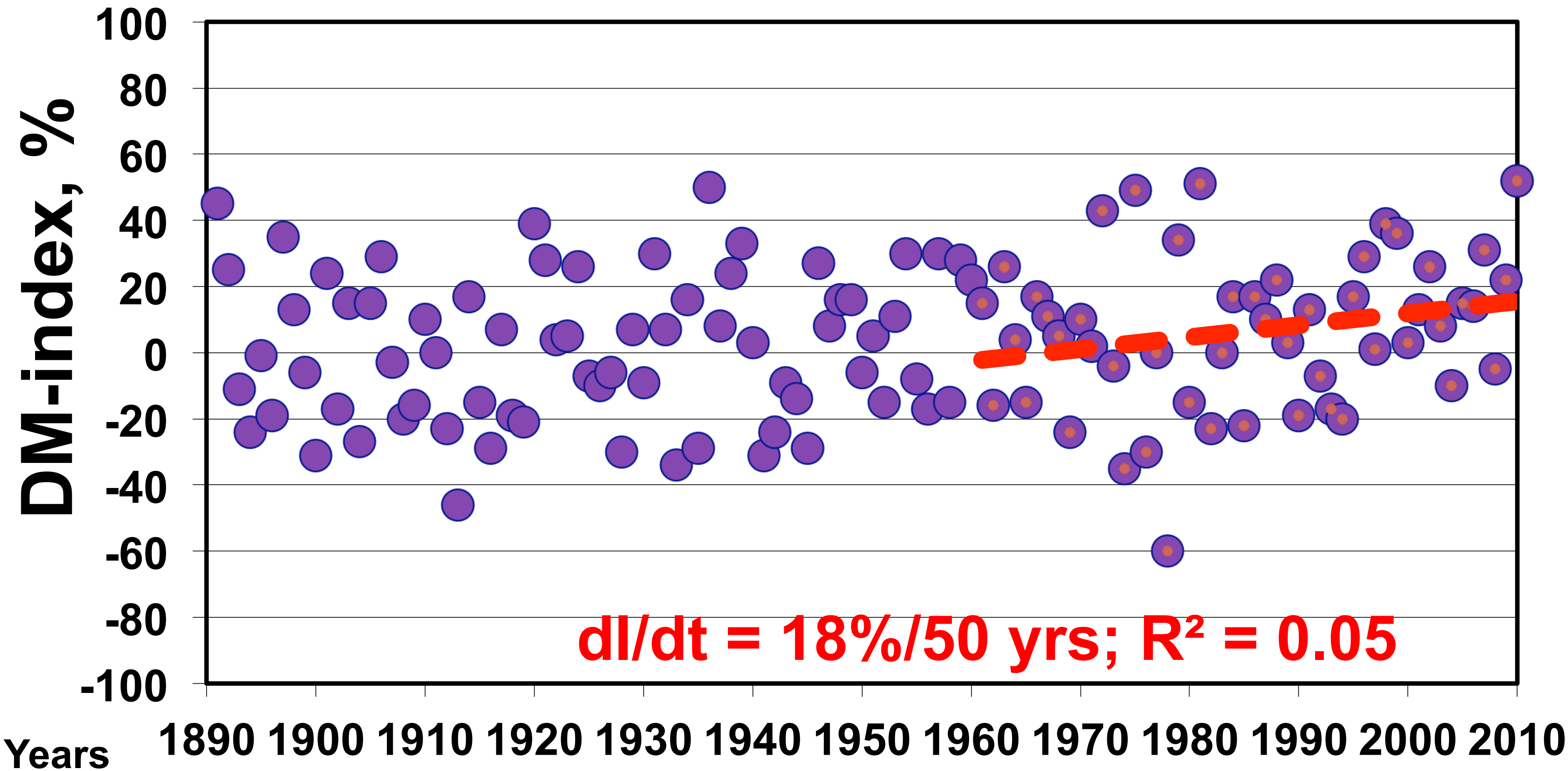


Dry episodes above 30 days during the warm season over European Russia, south of 60ºN, 1951-2010



Agricultural regions of European Russia, Belarus, and Ukraine. May – July Drought Index.

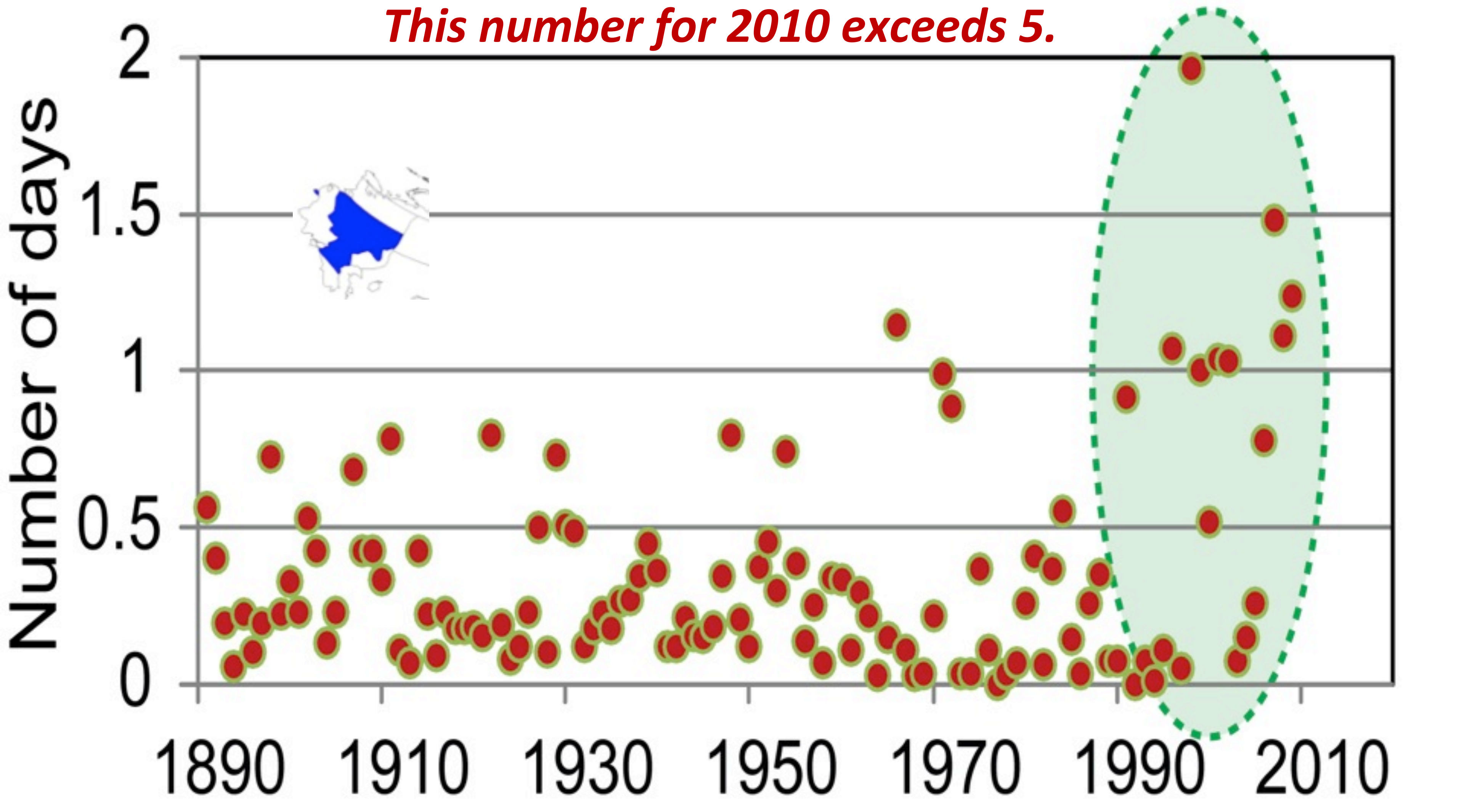
Meshcherskaya and Blazhevich, 1997, updated to 2010



Areas with excessively dry conditions minus areas with excessively wet conditions, (% of total area)

Number of days with “hot” nights (when minimum daily surface air temperatures remain above 23.9°C) area-averaged over European Russia south of 60°N during the 1891-2009 period.

This number for 2010 exceeds 5.

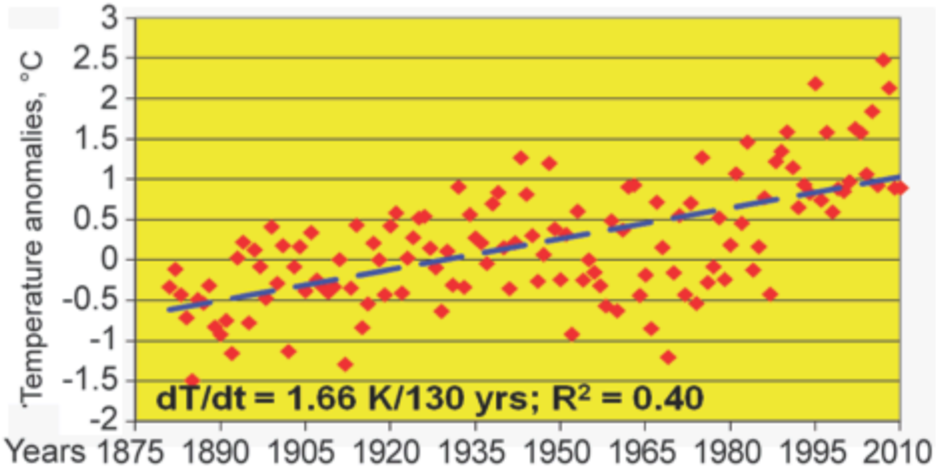


East of Northern Eurasia

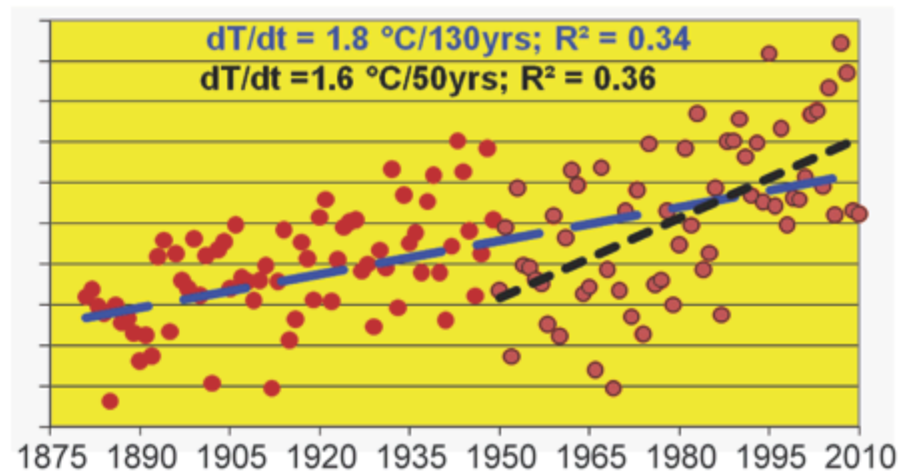
Asia

Annual surface air temperature anomalies

Asia north of 40°N

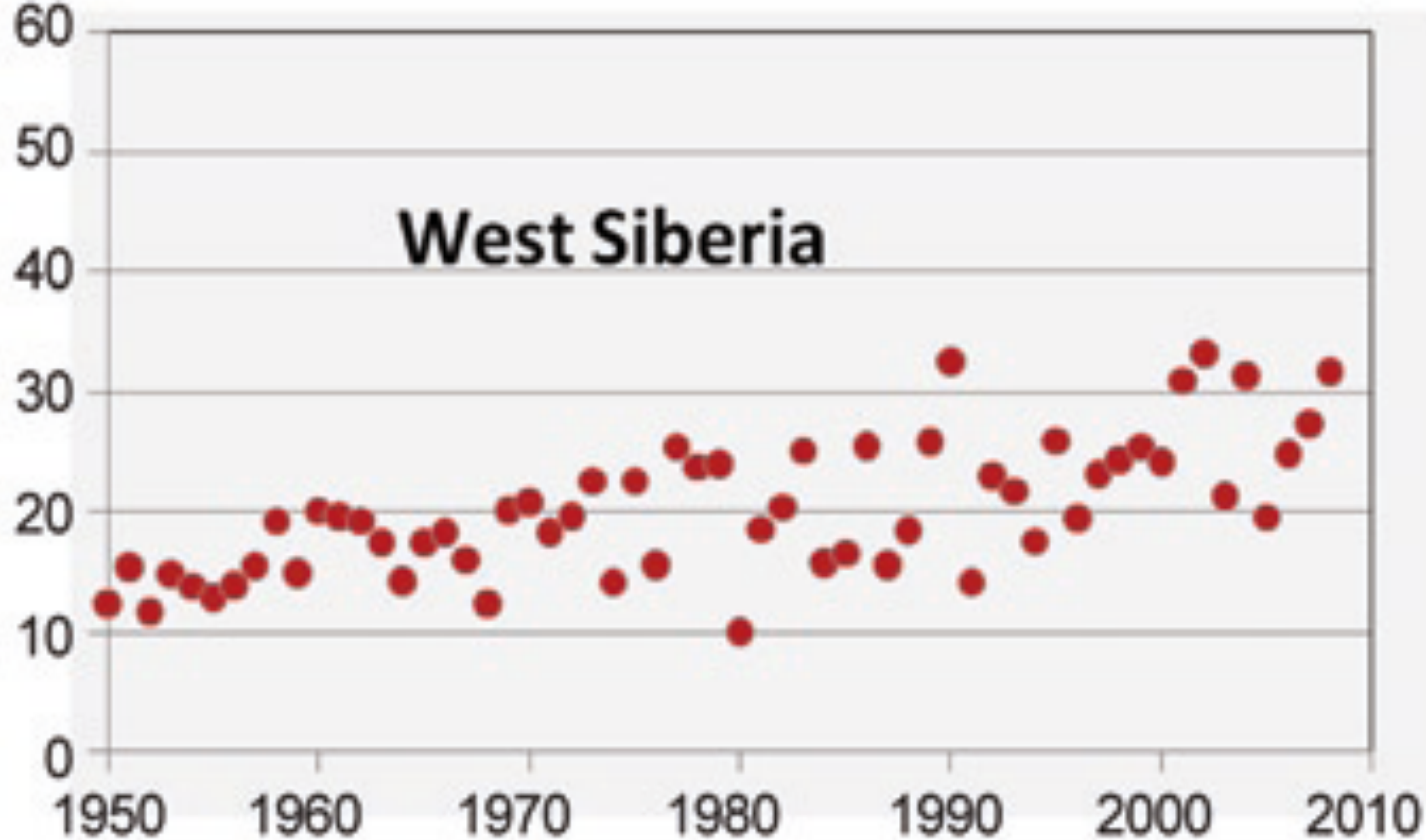


Siberia



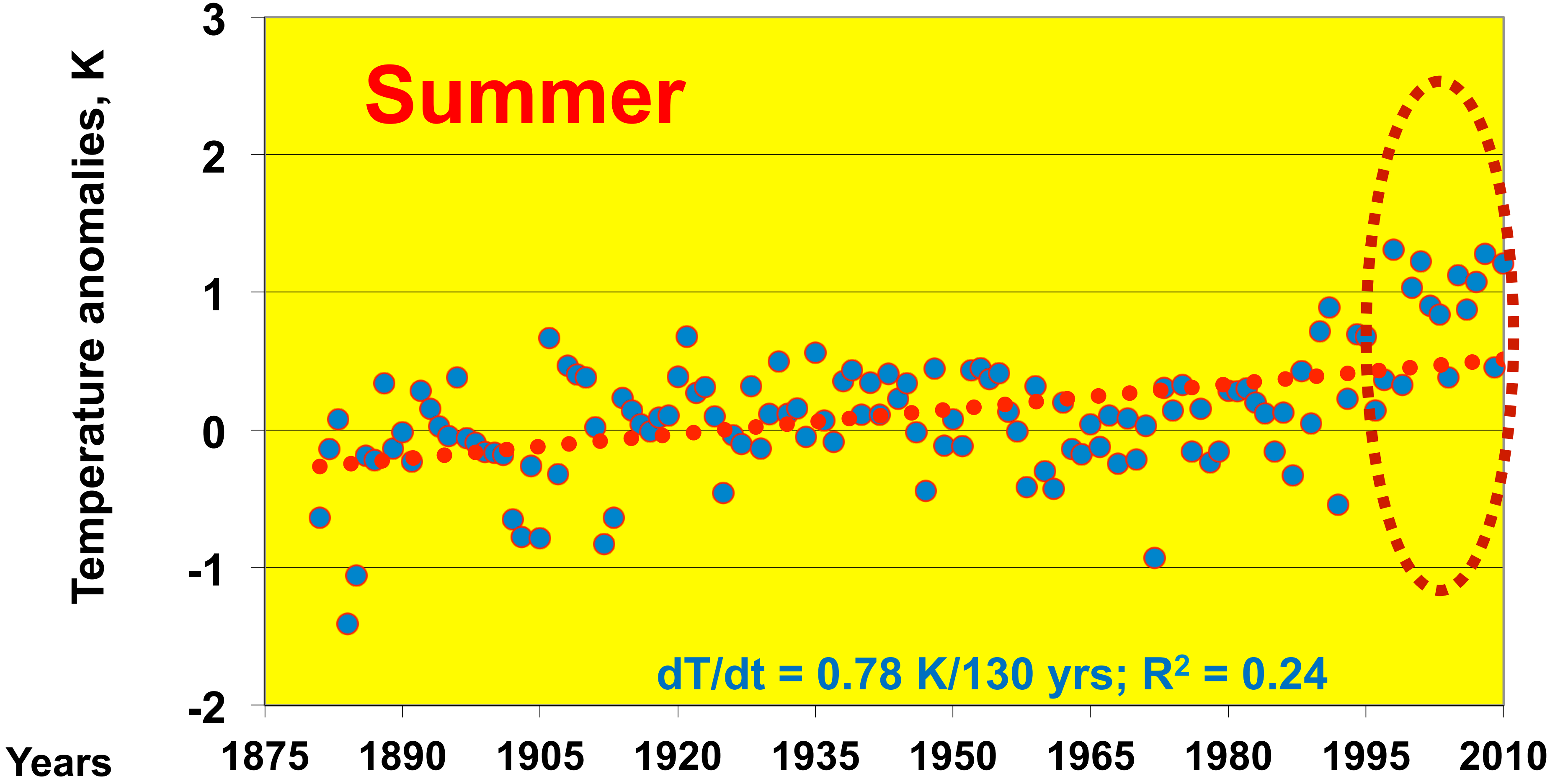
All anomalies are calculated as deviations from the long-term mean values for the 1951–1975 period

Annual number of days with thaw in West Siberia



Northern Asia, north of 40°N

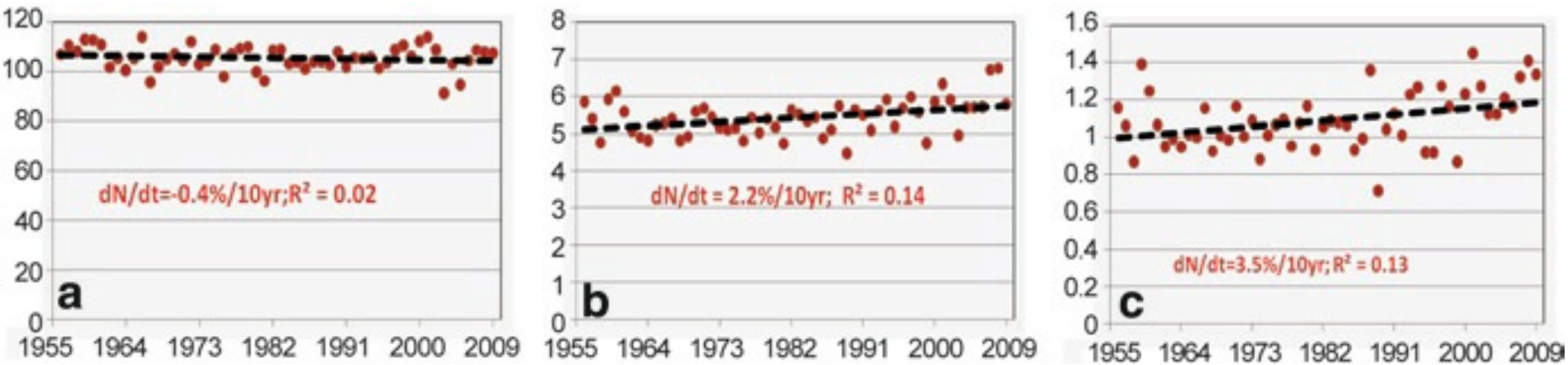
Summer temperature anomalies for the past 130 years; 1951-1975 reference period



Archive of Lugina et al. 2007, updated

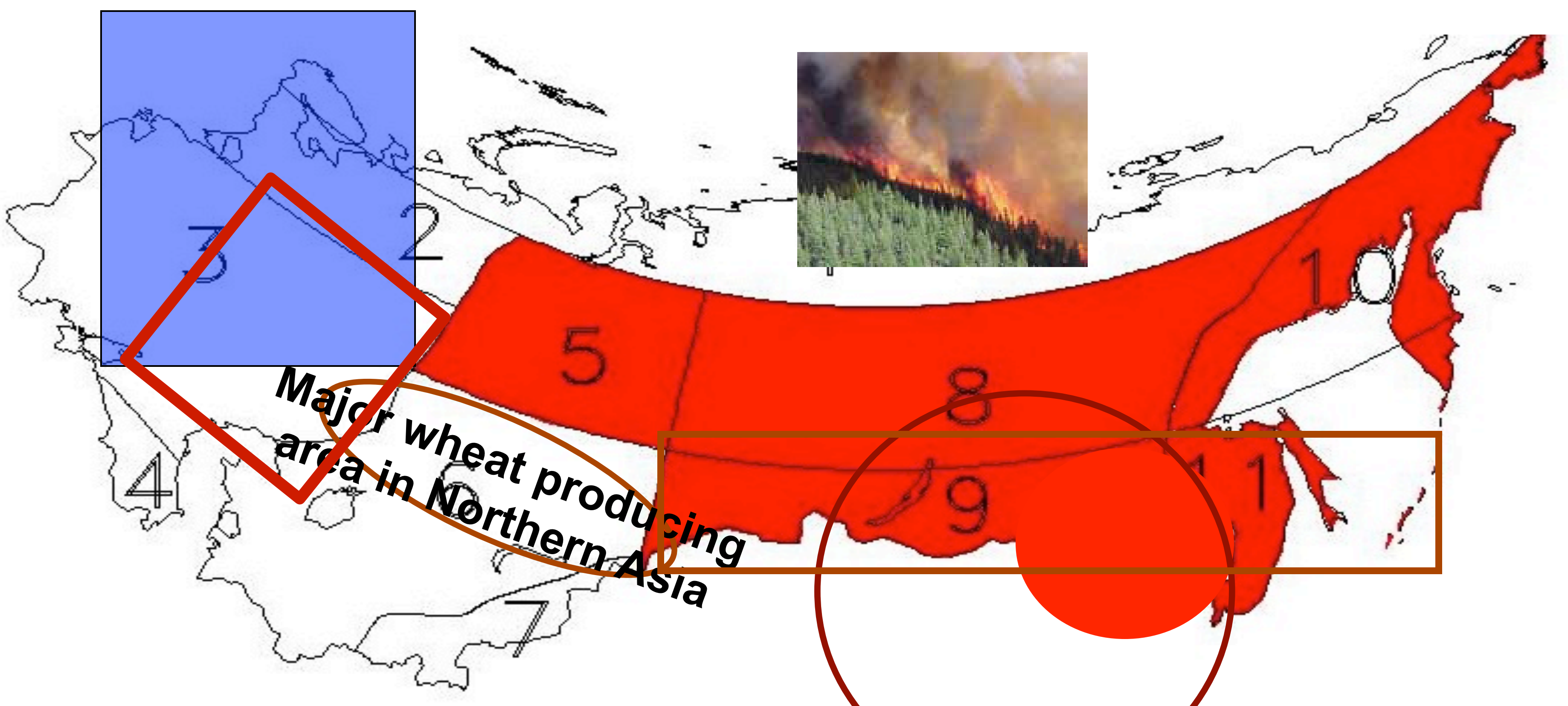
Annual number of days with precipitation over Siberia south of the Arctic Circle

(a) above 0.5 mm **(b) in the upper 5 %** **& (c) 1 % of daily rain events**



Changes in the surface water cycle over Northern Eurasia that have been statistically significant in the 20th century

More humid conditions (blue),
more dry conditions (red),
more agricultural droughts (circled),
more prolonged dry episodes (rectangled).



Groisman et al 2009 (Bull. Amer. Meteorol. Soc.)

Intense fire in a *Pinus sylvestris* forest, resulting in a likely conversion to steppe

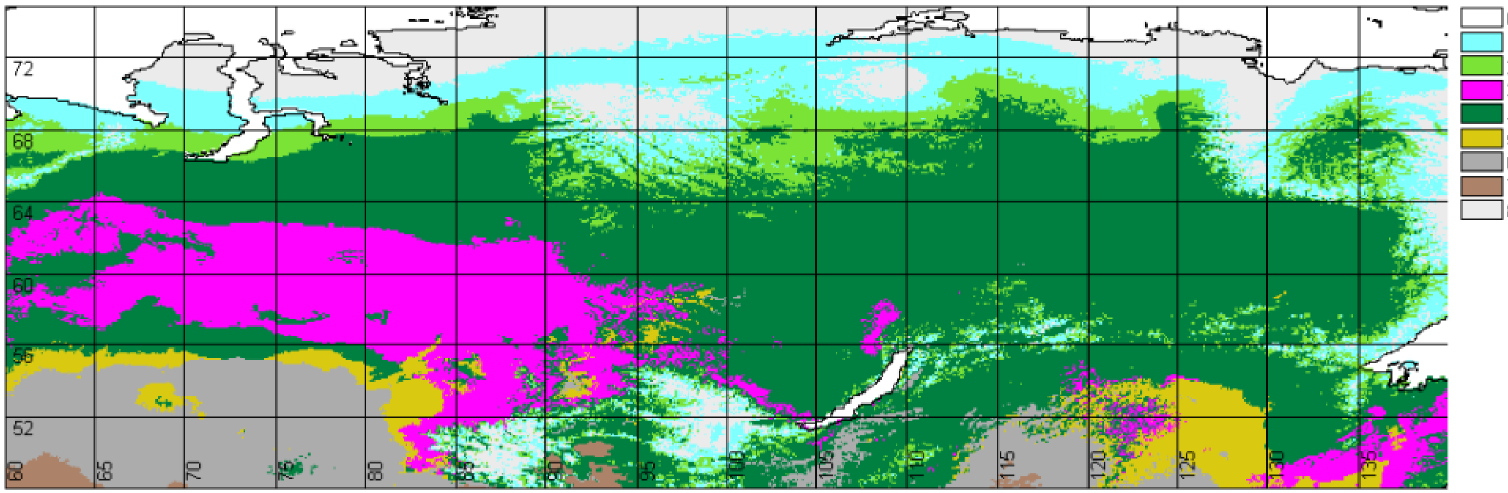
- **Left**, no regeneration after several years; **right**, no regeneration after 20 years (Siberia)

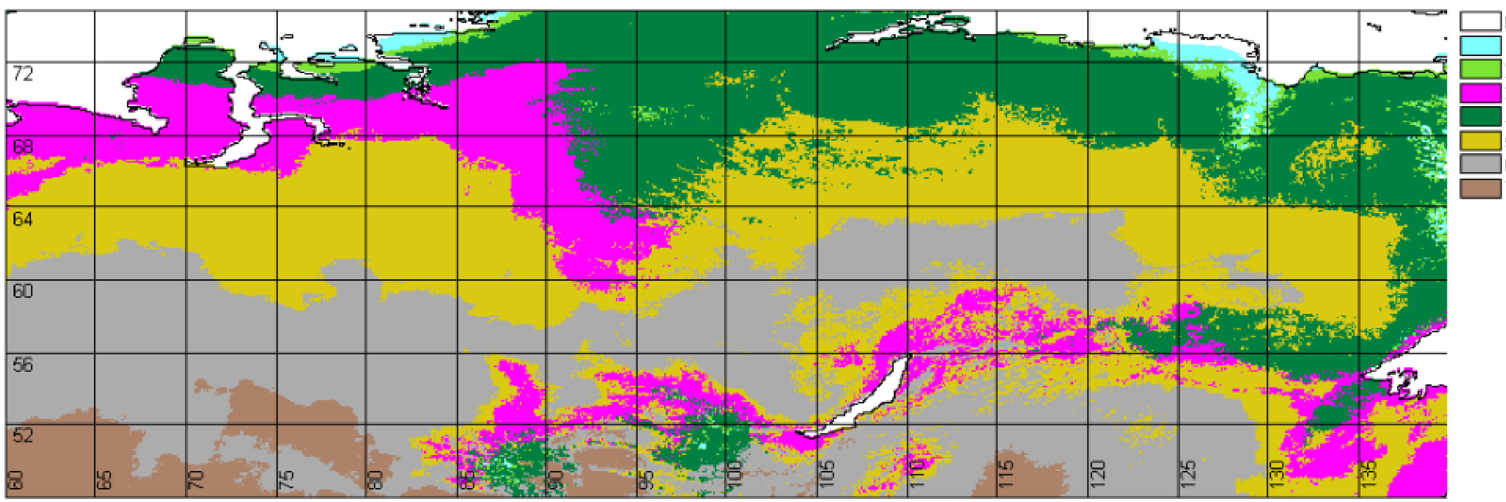
Tchebakova et al. (2009)

Landscape after forest fires

- **Thawing of ice-rich permafrost, triggered by forest fire in Central Yakutia, transforms boreal forest into steppe-like habitats (photo by Vladimir Romanovsky)**

Biome distribution over Siberia in current (a) and 2090 (b) climates (Vygodskaya et al. 2007)





Water (0),Tundra (1), forest-tundra (2), darkleaf taiga (3) and lightleaf taiga (4), forest-steppe (5), steppe (6), semidesert (7), and polar desert (8).

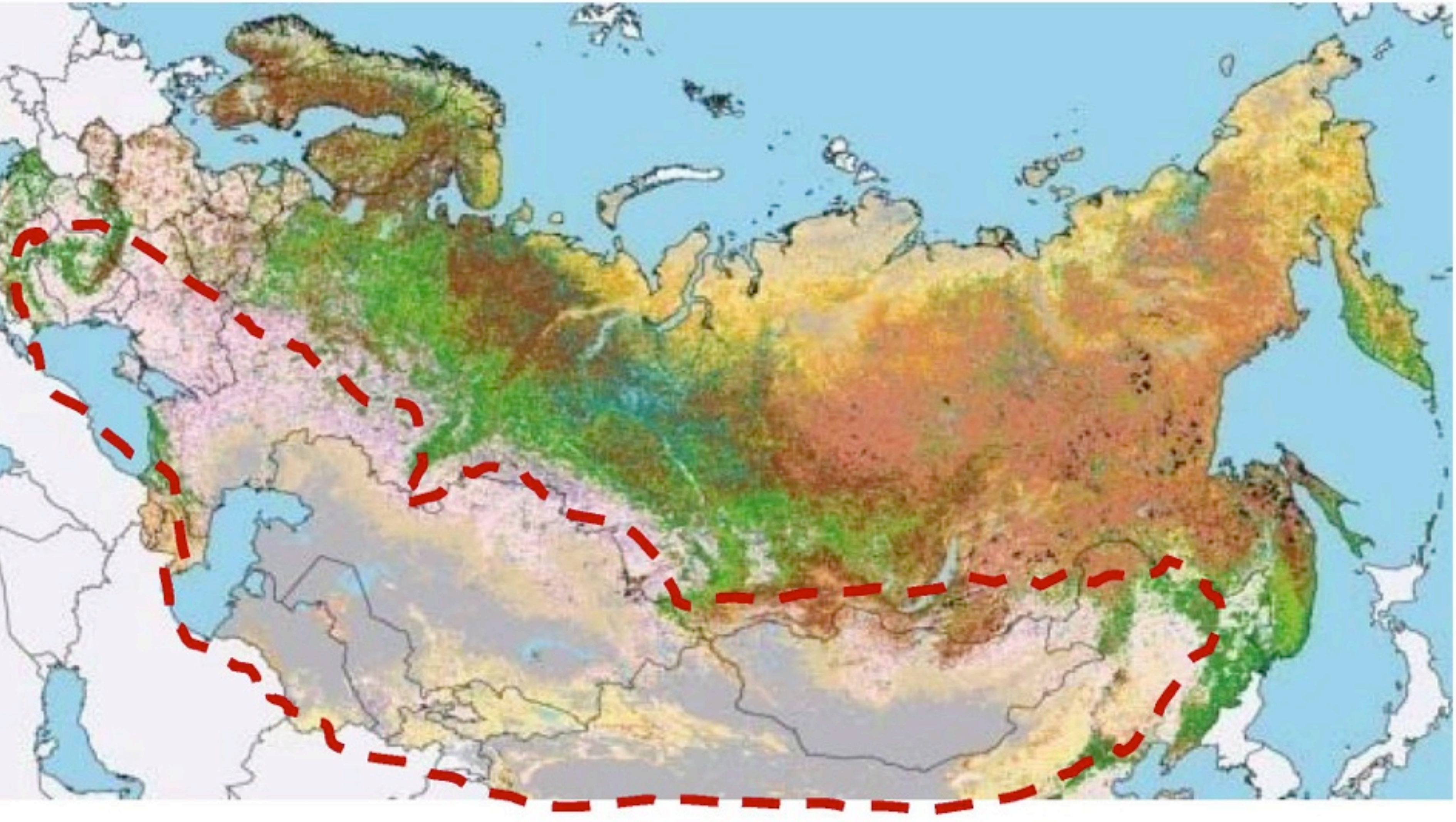
Estimates and projections of the mean surface air temperature changes over Siberia, °C

Period	Annual	Winter	Summer	Comments
5,500-6,000 BP	1–4	1–4	0–5	Compared to the mid of the 20th century
Past 130 years	1.8	2.4	1	Regional linear trends, °C per 130 years
2,081-2,100	3–5	3–8	1–2	Compared with the 1980–2000 period

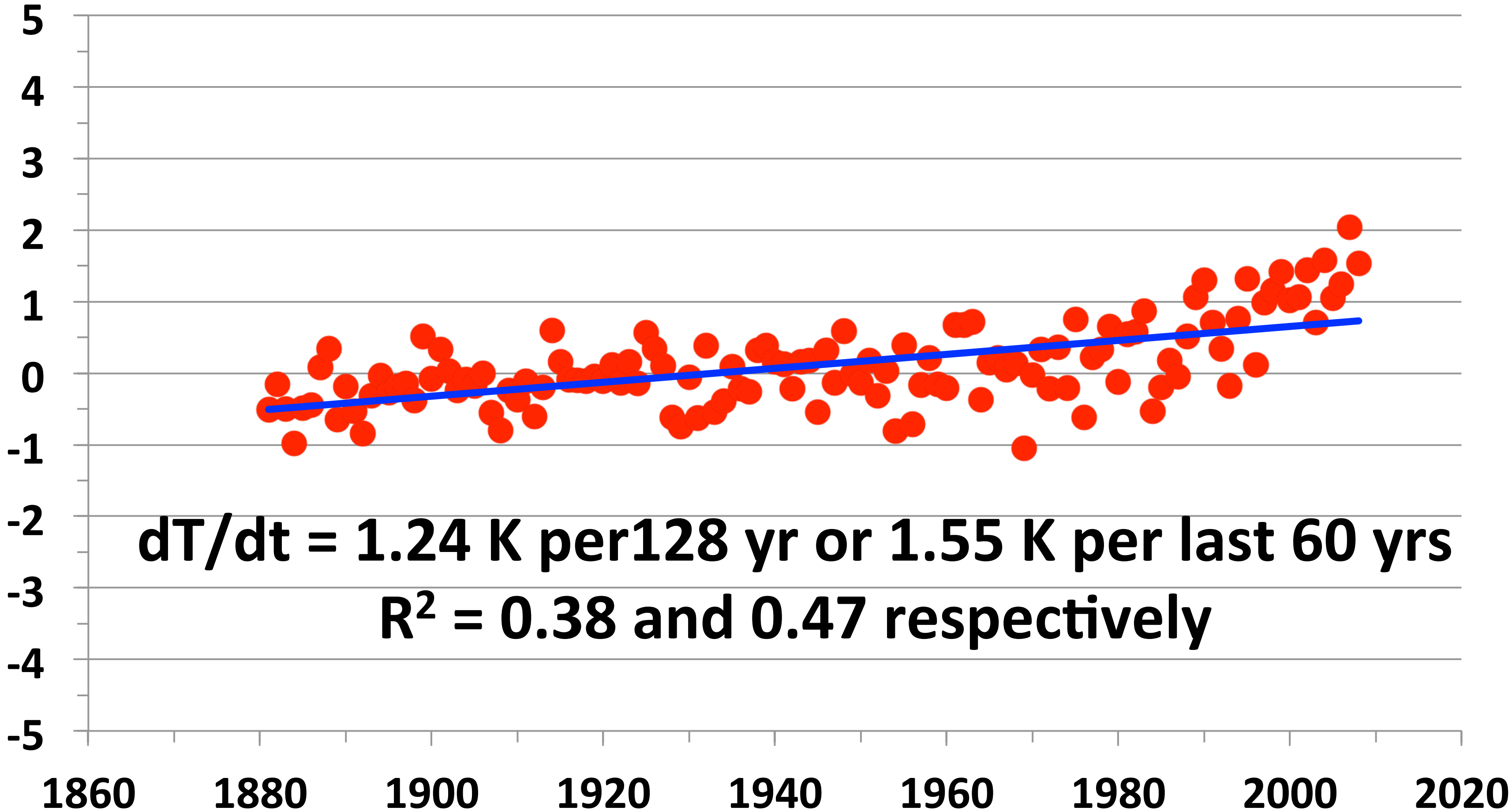
(a) "climatic optimum" of the Holocene (paleoclimatic reconstructions; Klimanov and Novenko 2010; Velichko et al. 1992),
(b) during the period of instrumental observations (past 130 years); and
(c) as projected by the contemporary GCMs.

(extracted from Chapter 3 of Groisman and Gutman 2012)

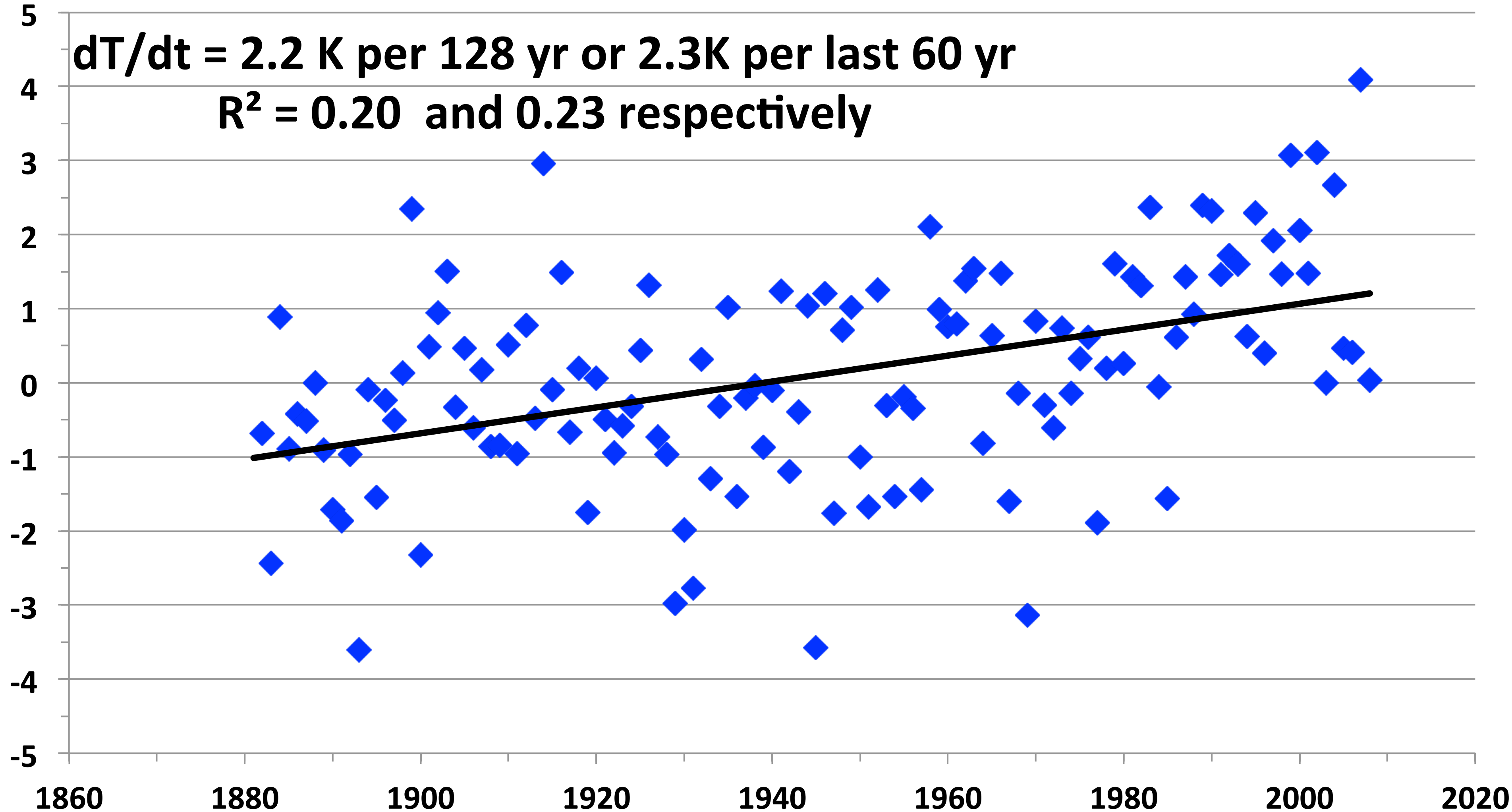
Dry Latitudinal Belt of Northern Eurasia, DLB



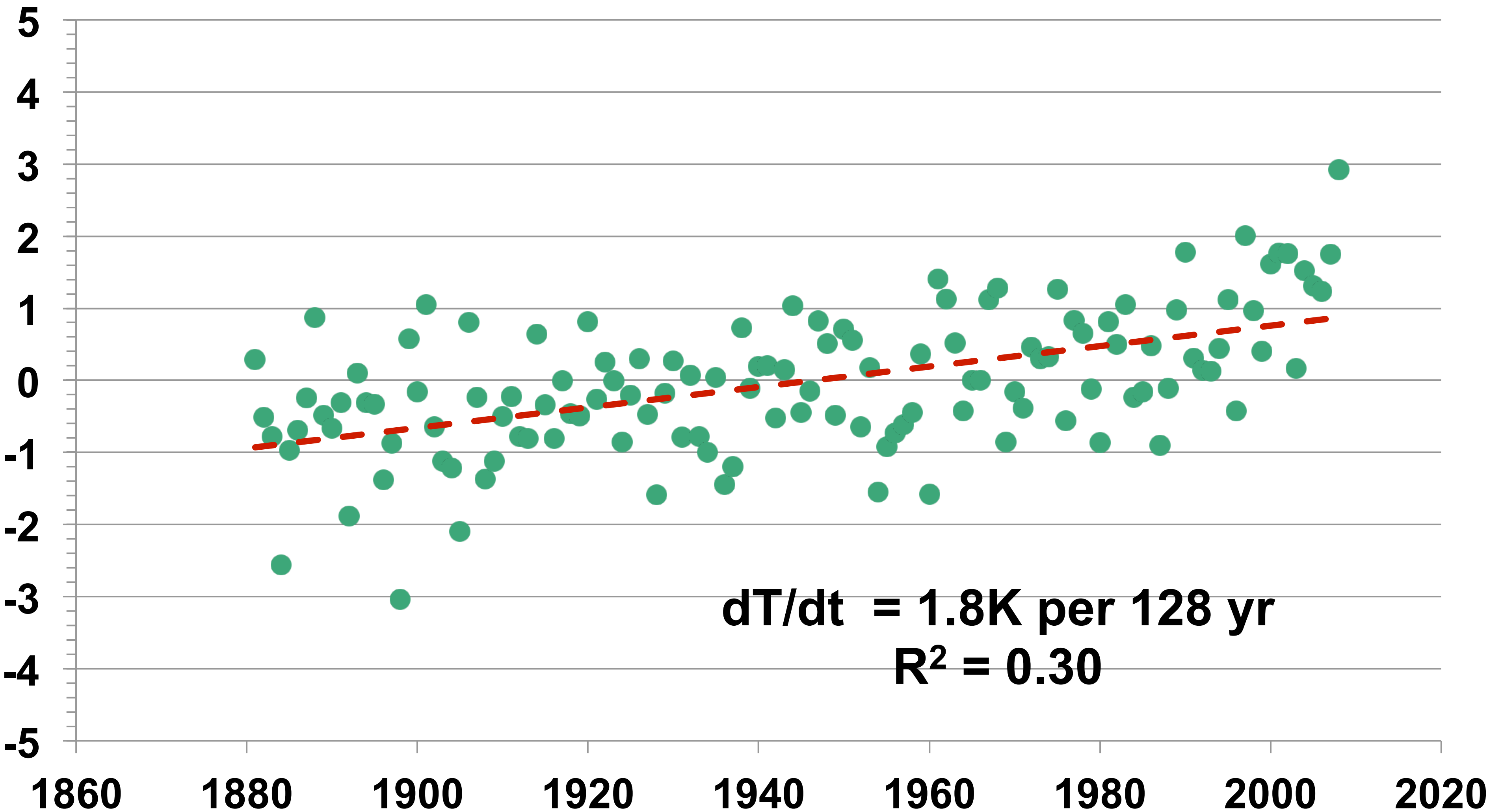
Annual surface air temperature anomalies over the DLB



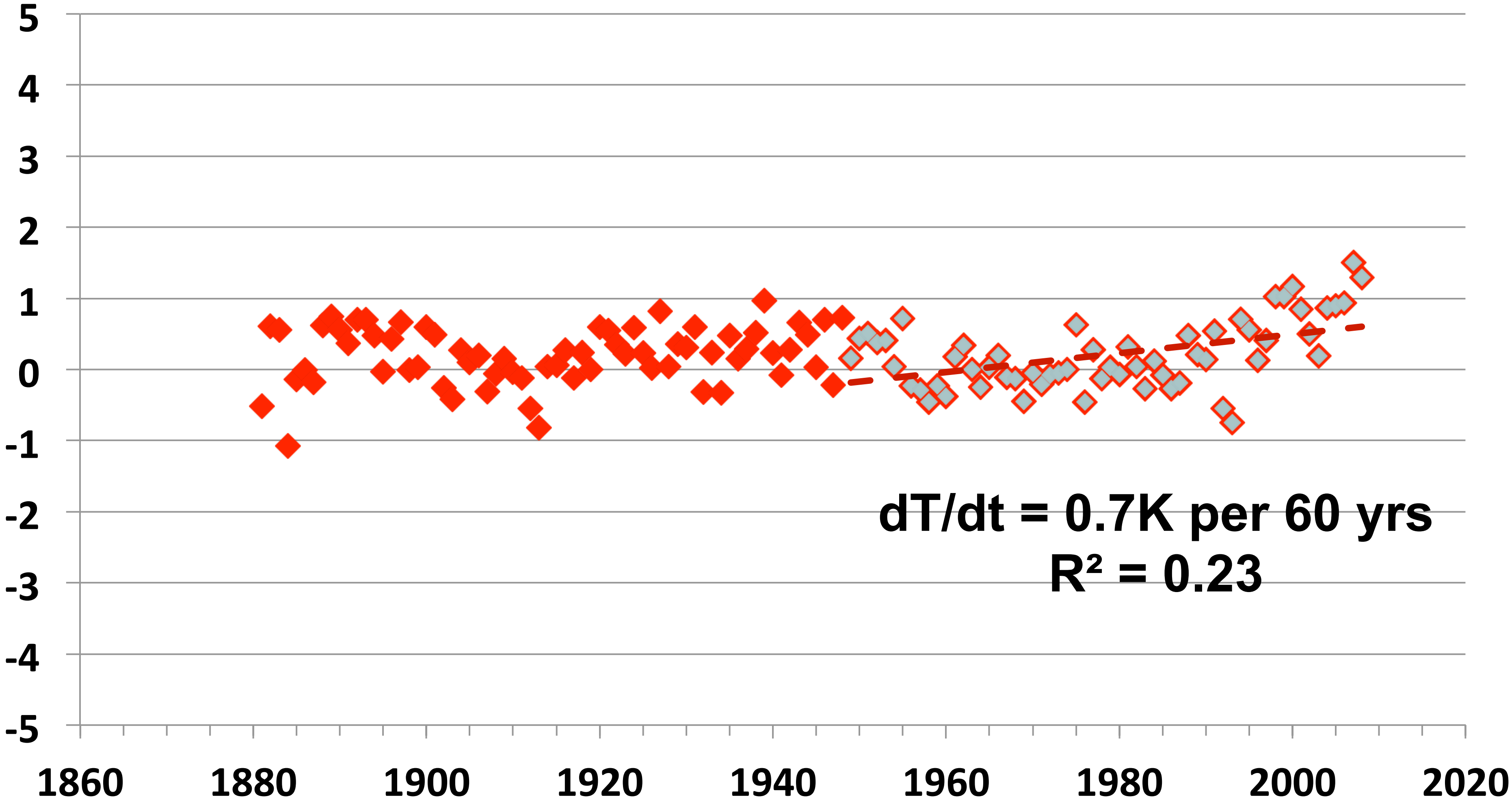
Winter surface air temperature anomalies over the DLB



Spring surface air temperature anomalies over the DLB



Summer surface air temperature anomalies over the DLB

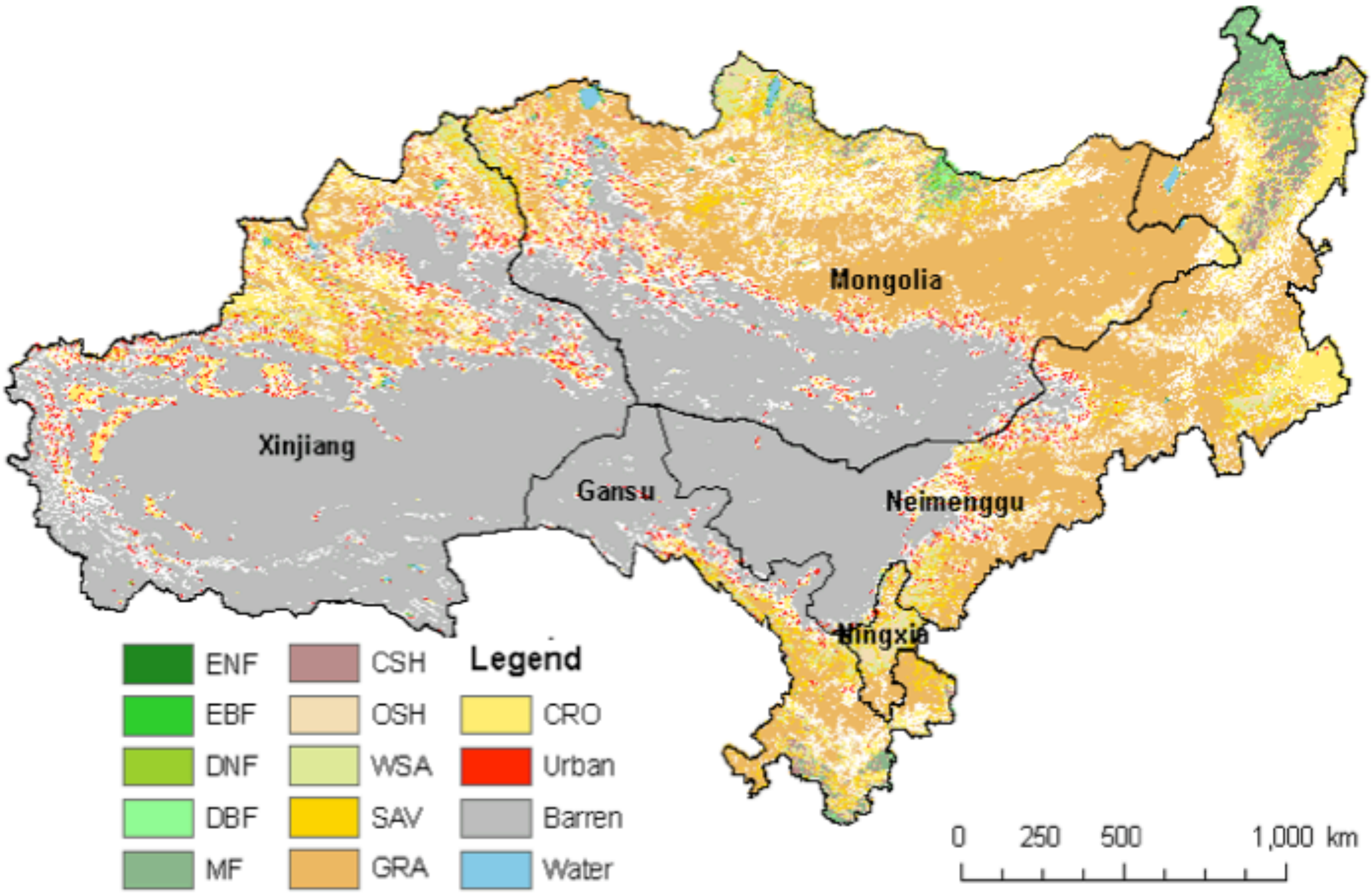


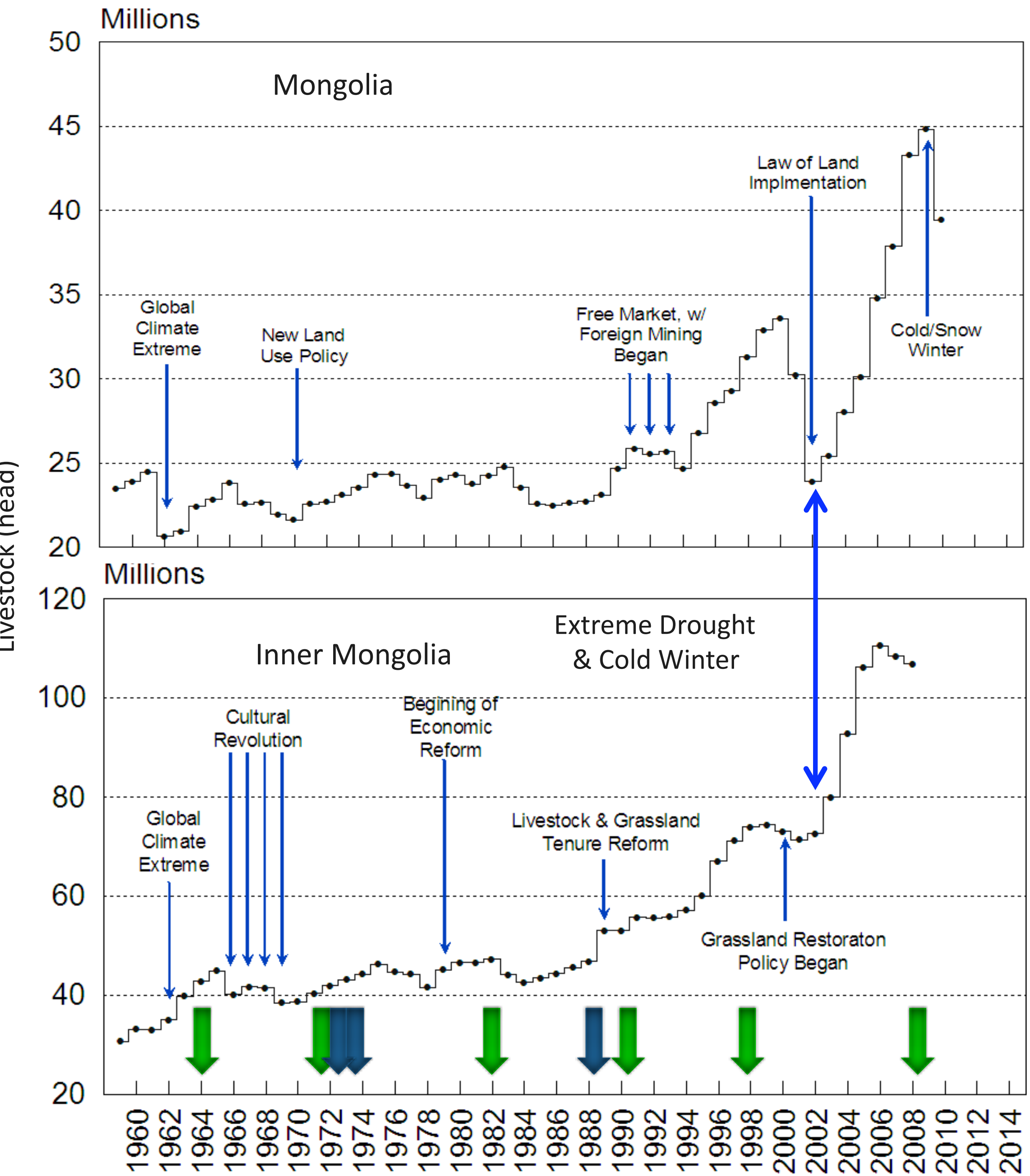
Major concerns in DLB

- Water supply and storage (including the cryosphere)
- Soil erosion (including dust storms)
- Infrastructure fabric (societal sustainability)

Dryland ecosystems in East Asia

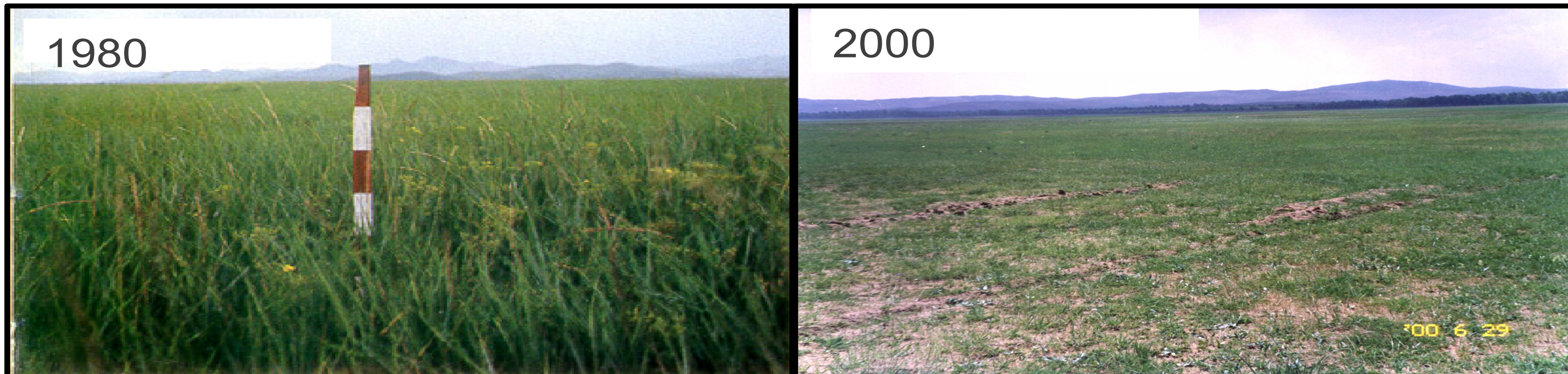
Land use and land cover of the Drylands of East Asia derived from 2004 MODIS (Qi et al. 2012)

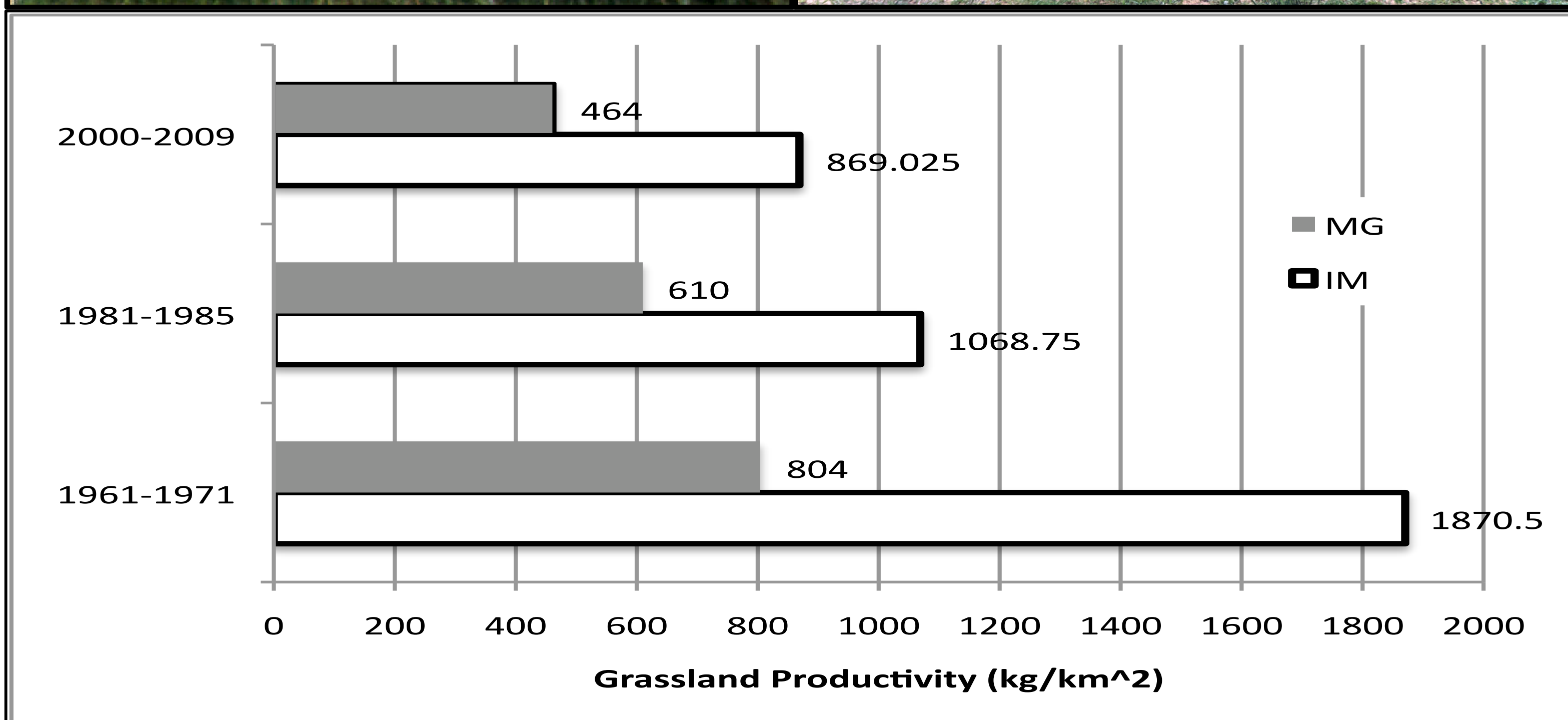




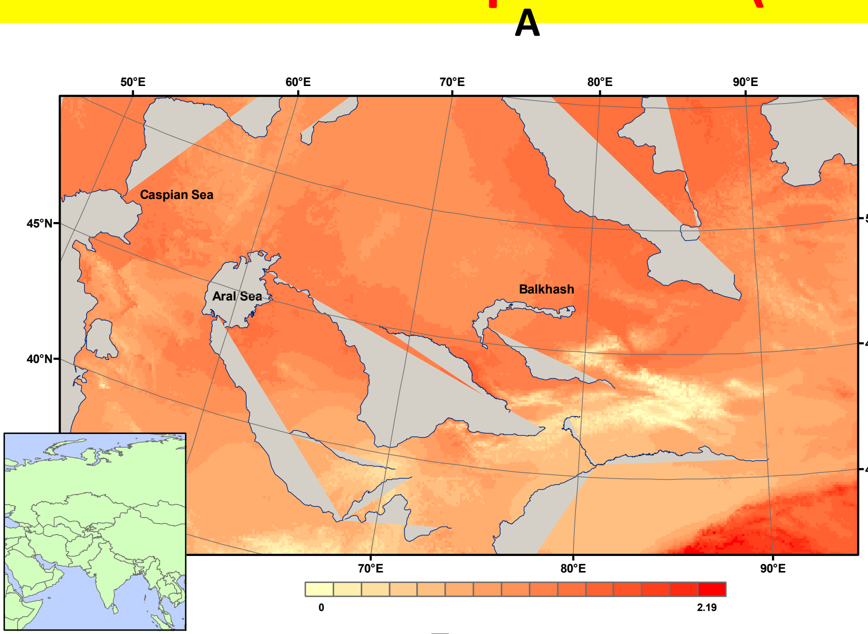
Droughts and/or severe winter storms closely coincided with reduction of livestock animals in Mongolia and Inner Mongolia. Qi et al. 2012.

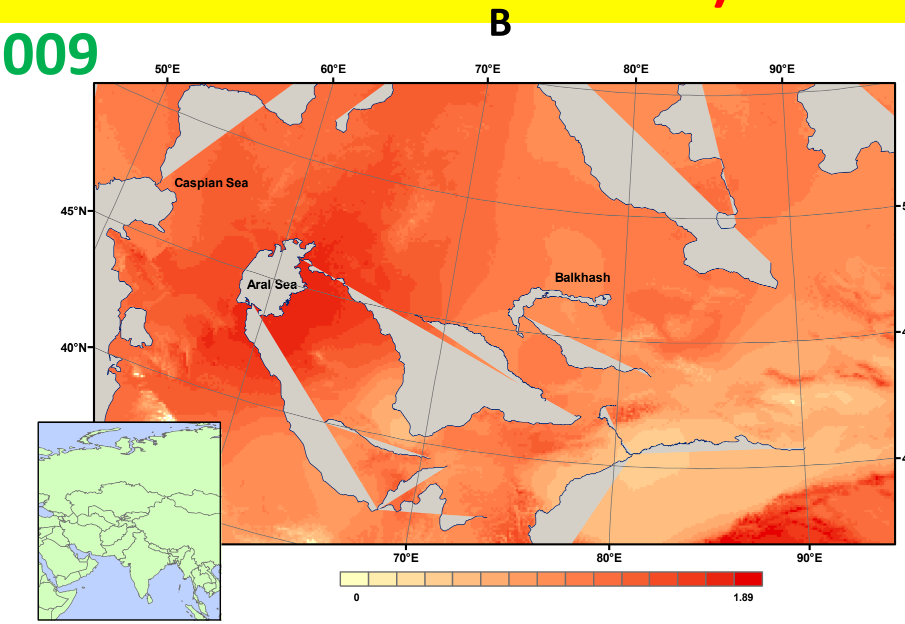
Degradation of grassland productivity (kg km^{-2}) during the three time periods from 1961-2009 (Qi et al. 2012)

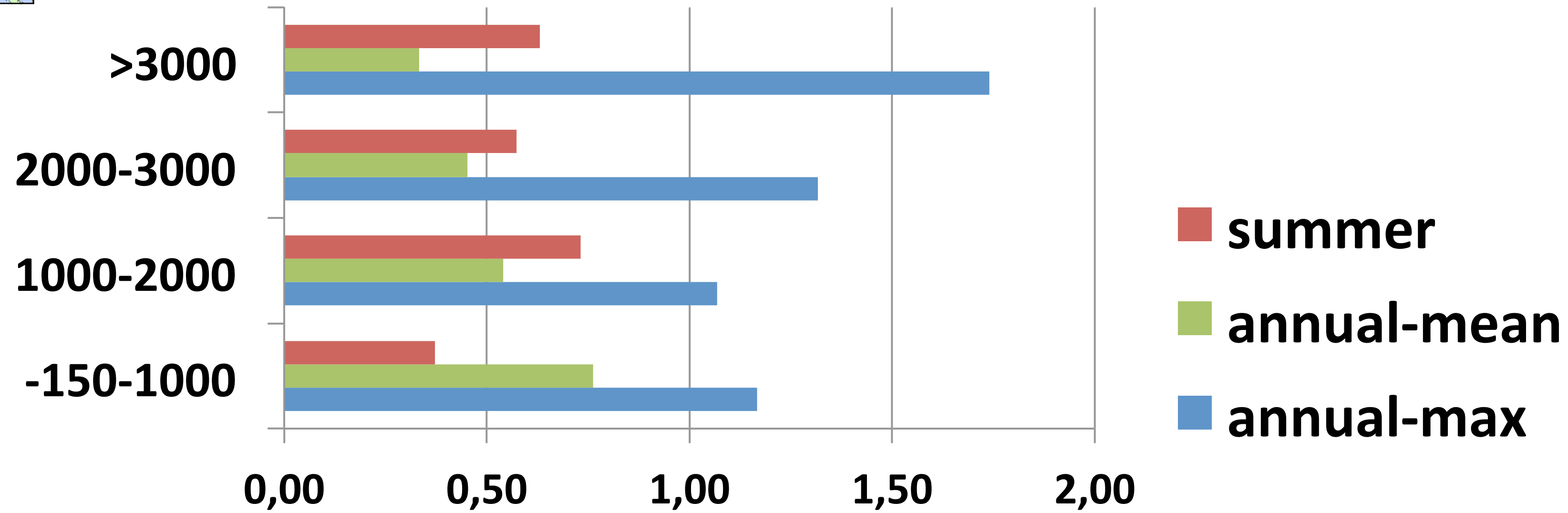




Differences in 30-year averages of annual (left) and summer (right) surface air temperature (Δ = AV.973-2003 – AV.1942-1972). Aizen 2009

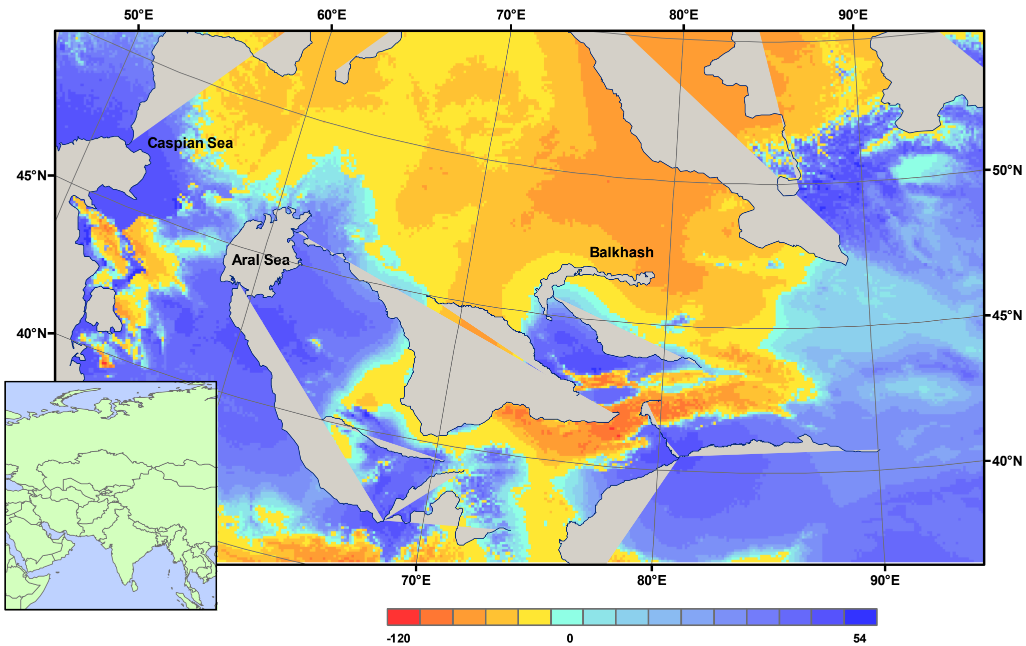






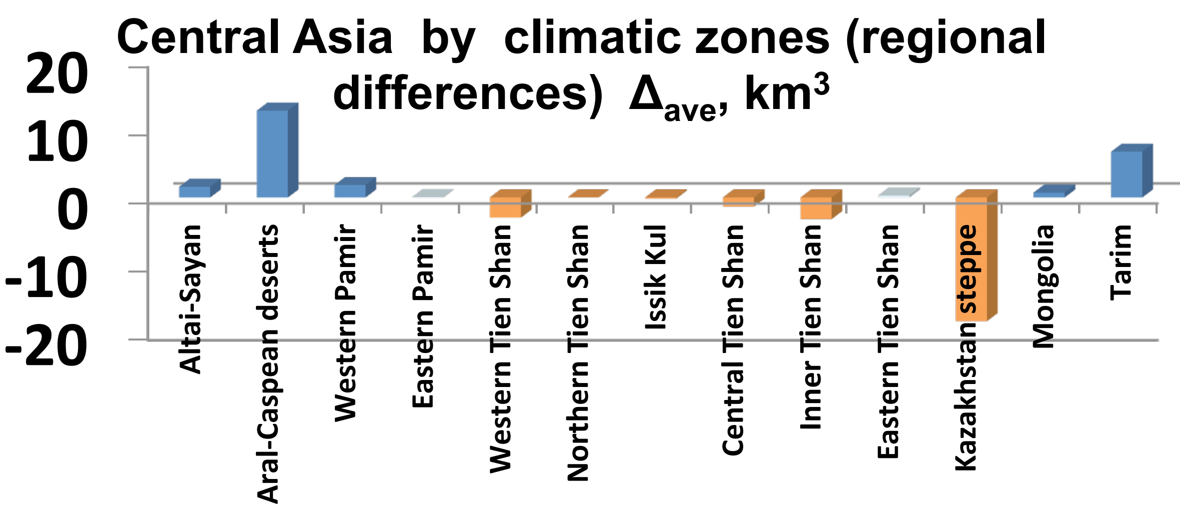
Average weighted differences annual, annual-maximum and summer means of air temperatures (1973-2003 and 1942-1972) for altitudinal belts

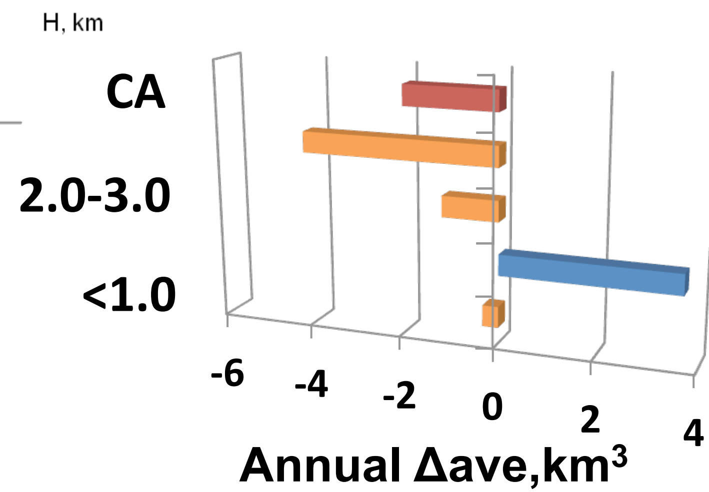
Differences in 30-year averages of annual precipitation (Δ = AVE1973-2003 – AVE1942-1972)



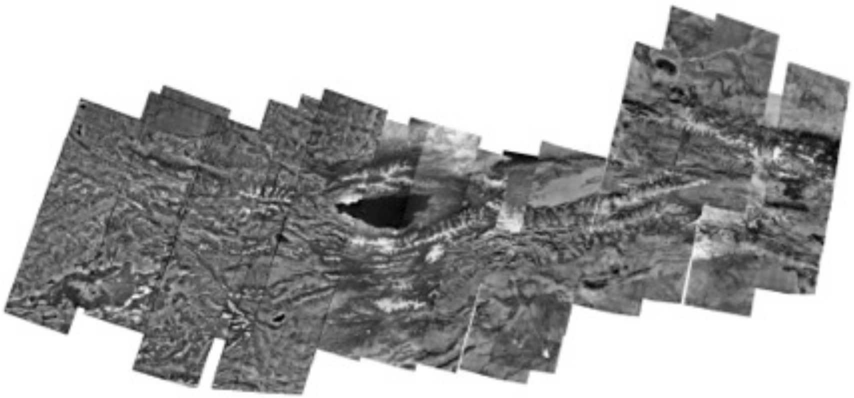
Average weighted differences in annual precipitation for the periods from 1973- 2003 and 1942-72 (Δ, km^3)

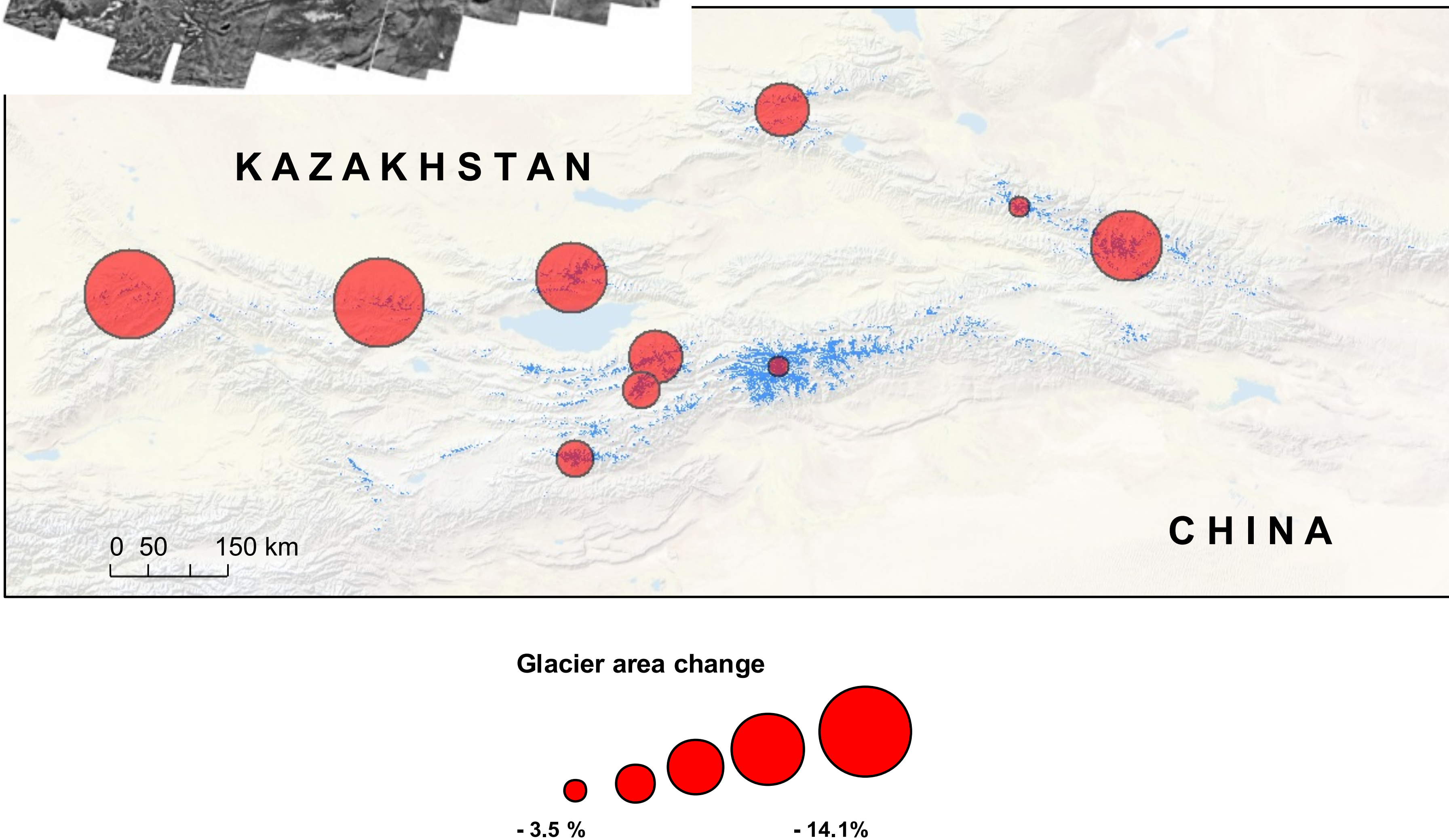
Aizen 2009





1,617 km^2 (-10.1%) glacier area reduction during the last thirty years in Tien Shan

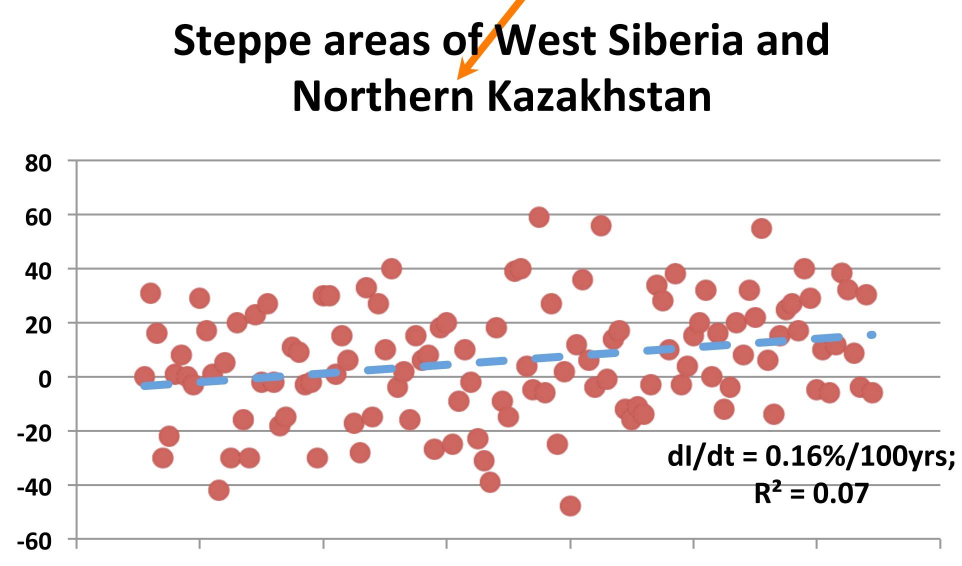


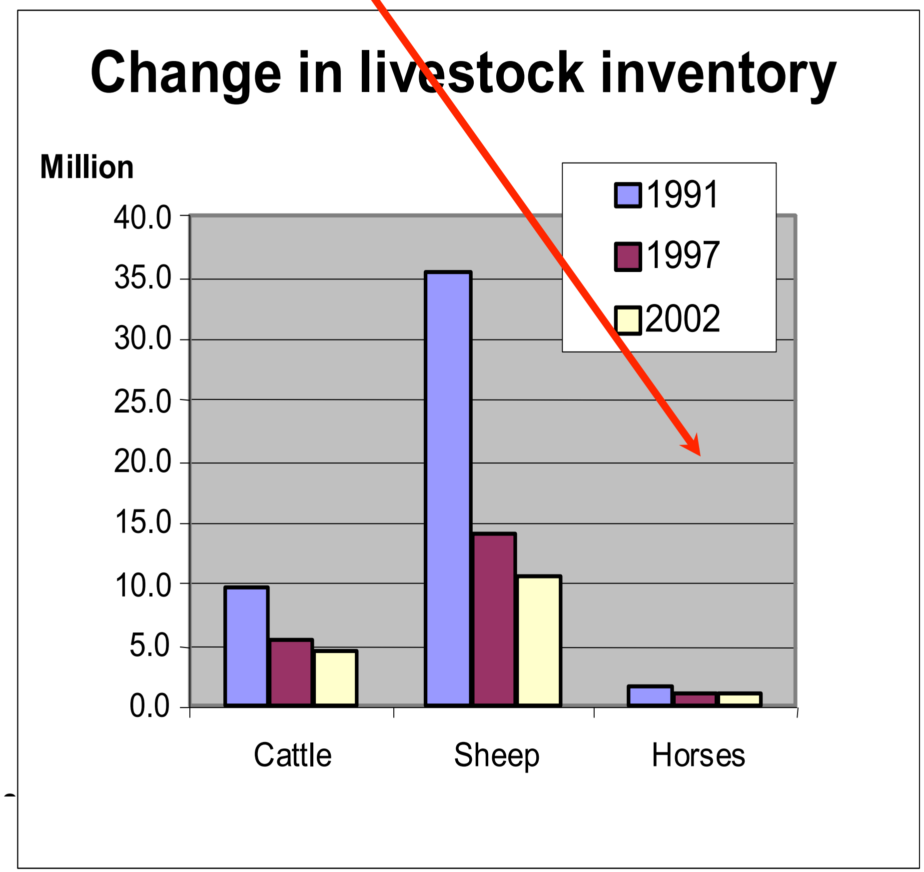


“Social Shocks” superimposed with environmental changes (example: Kazakhstan).

Satellite data show greening, meteodata show drying, and socio-economic data show decline.

Regional drought index (Mescherskaya & Brazhevich, 1997, updated to 2009)





Monitoring and projection of dust storms and air pollution

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.

General Statement. We observe:

- global and continental-scale warming and in the past few decades
- retreat of seasonal snow cover, reduction of the Arctic ice cover are accompanied with increase in maximum snow cover over most of Northern Eurasia;
- reduction of the meridional temperature gradient, changes in atmospheric circulation that
- Numerous observational studies show that in the past several decades precipitation has become more intense over most of the extra-tropics. At the same time, (and often in the same regions) precipitation events may occur less frequently or come in sequences of prolonged no-rain and wet periods. European Russia is one of these regions.