Hydrological changes and possible causes

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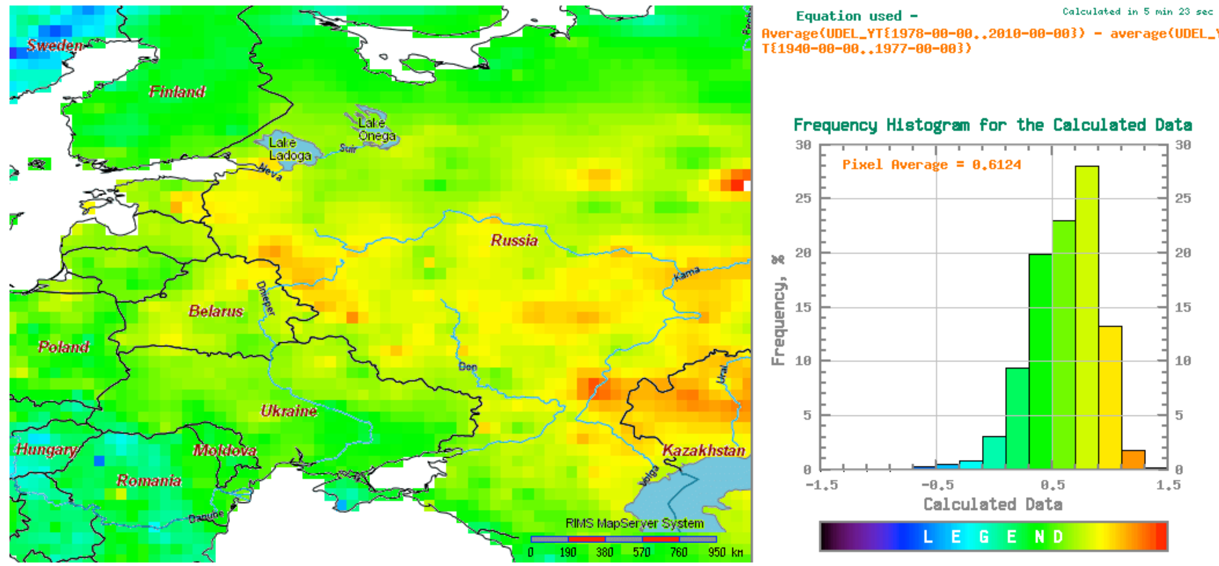
University of New Hampshire

State Hydrological Institute

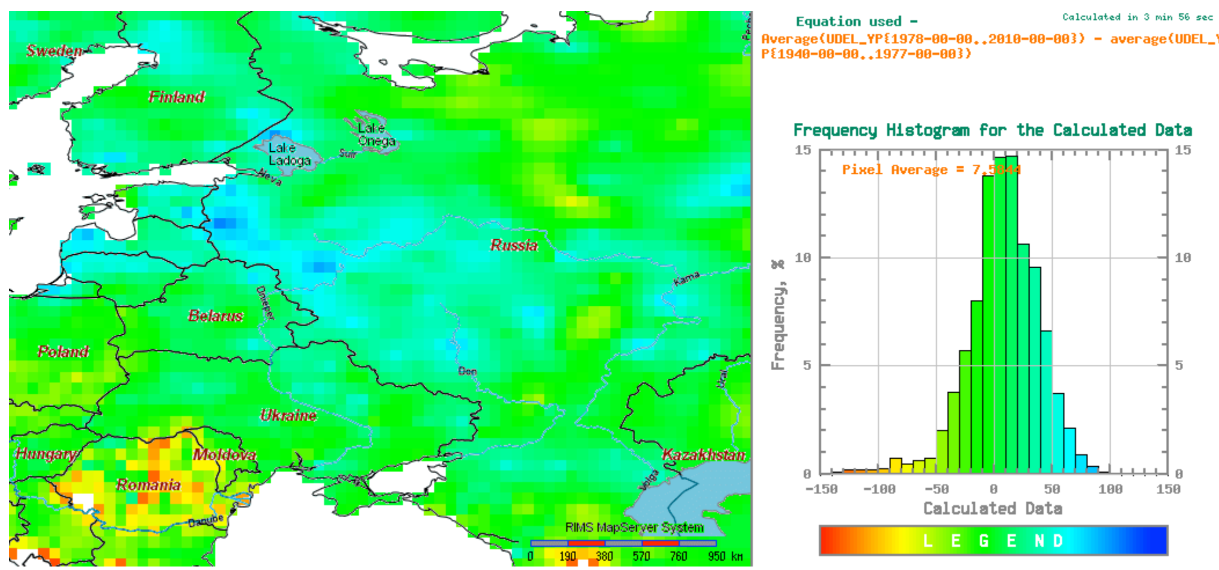
International NASA LCLUC Regional Science Meeting in Central Europe
Sopron, Hungary
10/16/2014 : 10/22/2014

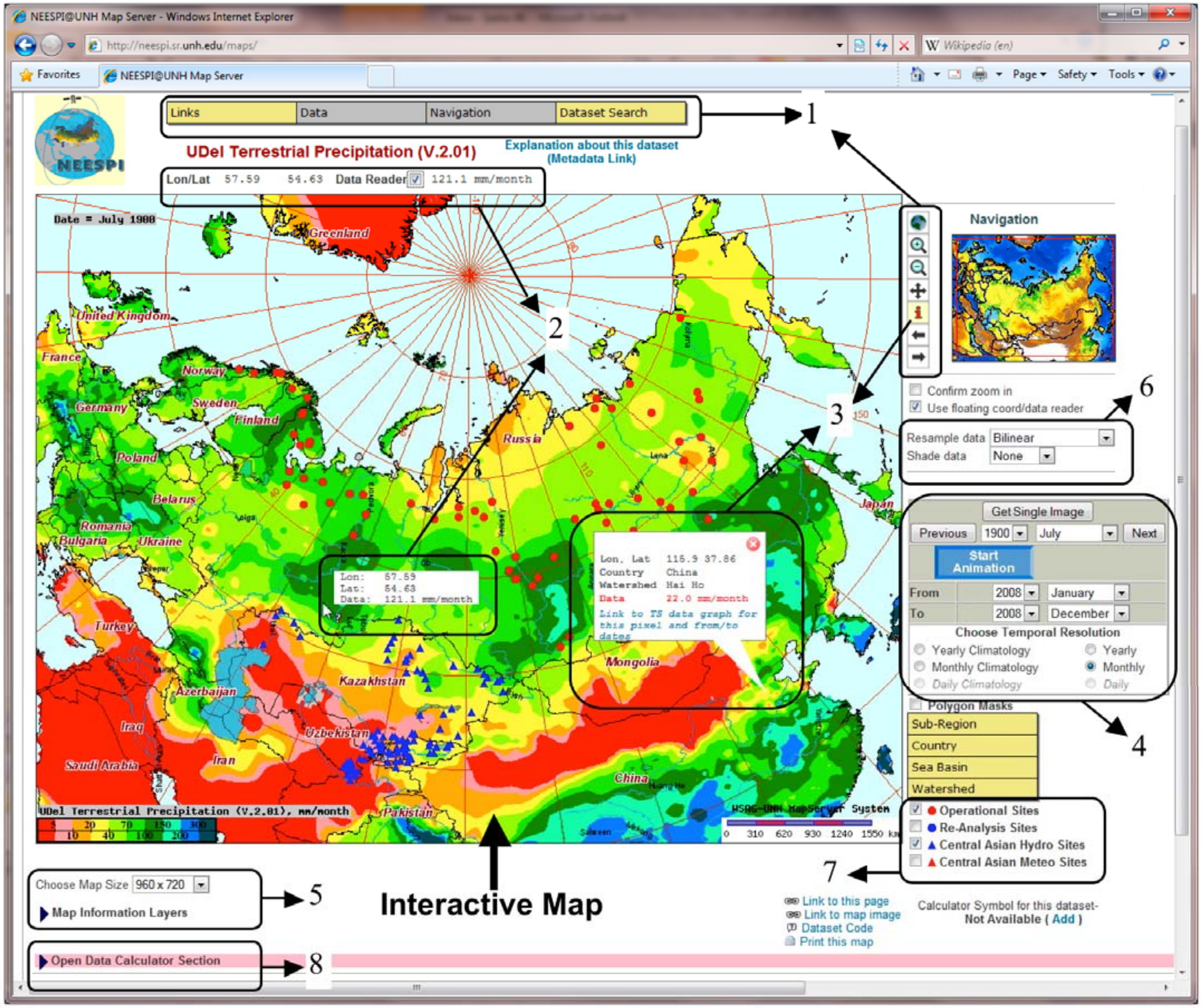
UDEL gridded global monthly data, 0.5 degree spatial resolution

Deviation of mean annual air temperature over 1978-2010 from 1940-1977



Deviation of mean annual precipitation over 1978-2010 from 1940-1977





NEESPI RIMS

Regional Integrated Mapping and Analysis System

http://neespi.sr.unh.edu/maps

Global:
http://earthatlas.sr.unh.edu/maps

1) data search/selection, spatial navigation, metadata link, etc.;

2) coordinate and map data value reader;

3) pixel query tool (i-tool) gets coordinates, country, watershed, and map data value;

4) time series navigation tool;

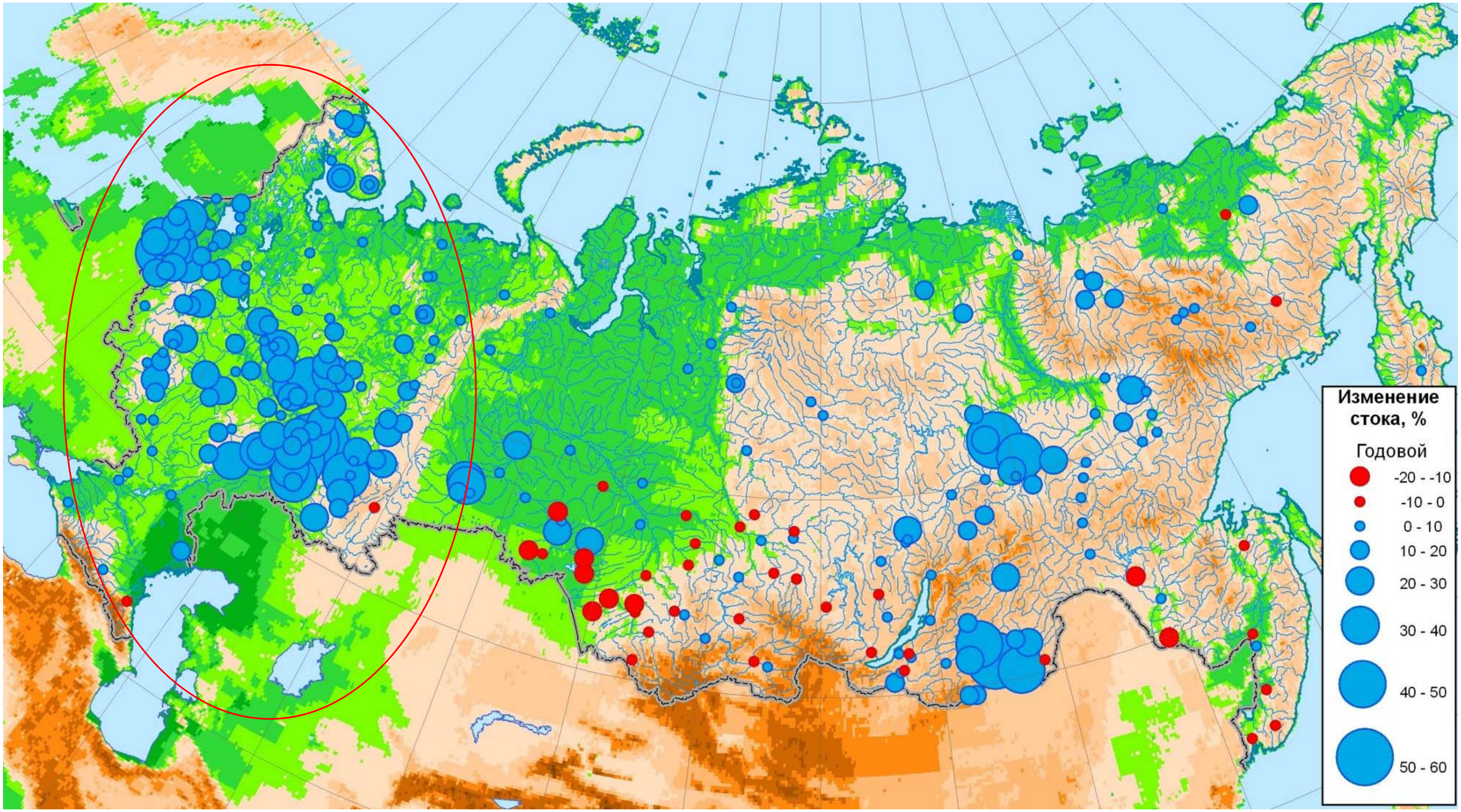
5) map size and base layer choices;

6) data interpolation and shading tools;

7) point/station data list with clickable symbols that open station pages in a separate browser window;

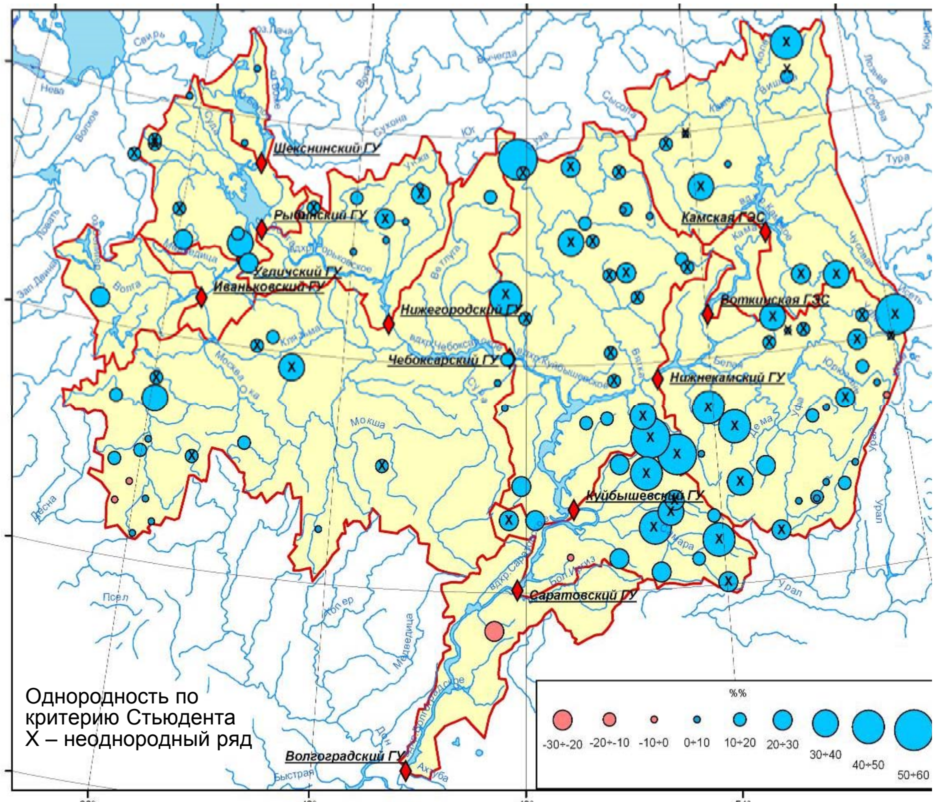
8) fold-out section to run the Data Calculator application to perform mathematical and logical functions over gridded or vector datasets;.

Anomalies of annual runoff (%) across Russia

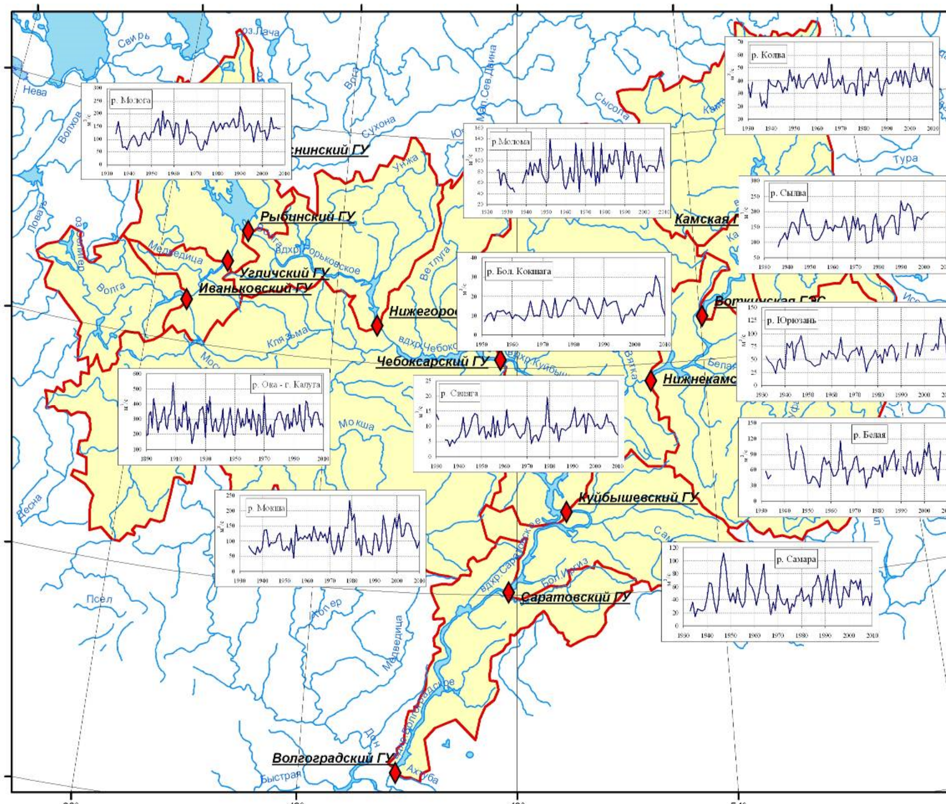


Deviation of annual runoff over 1978-2010 from 1940-1977

Change in annual runoff in Volga river basin



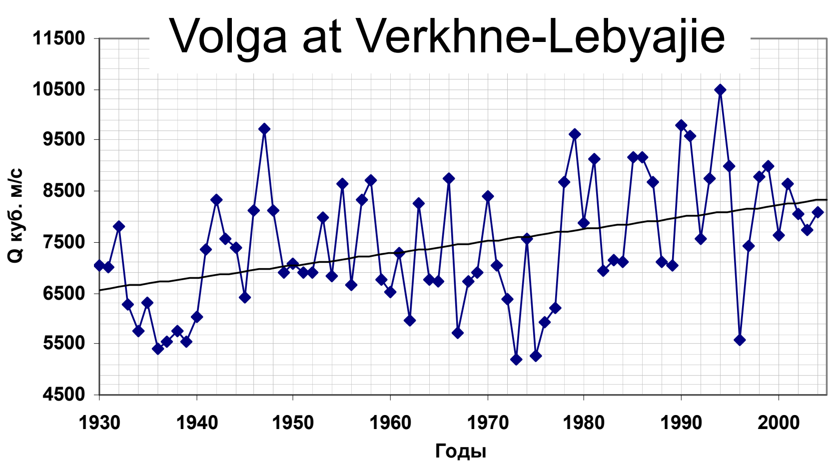
Deviation (%) of mean annual runoff (MAR) in Volga river basin over 1978-2010 from MAR over 1946-1977.

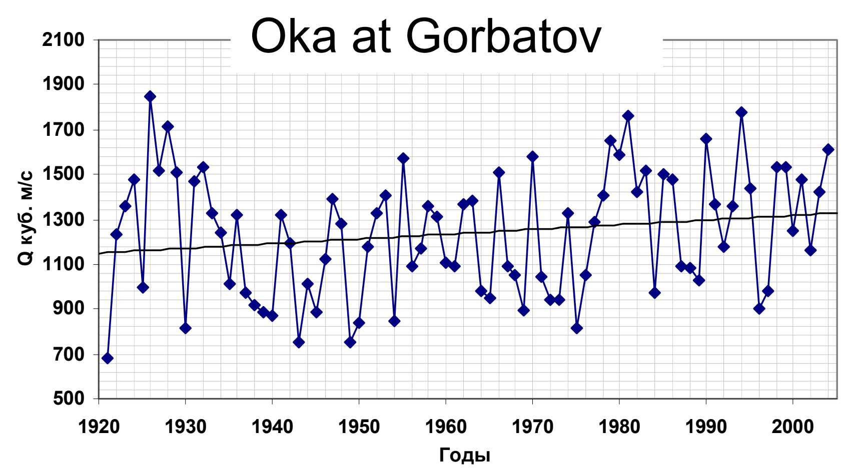


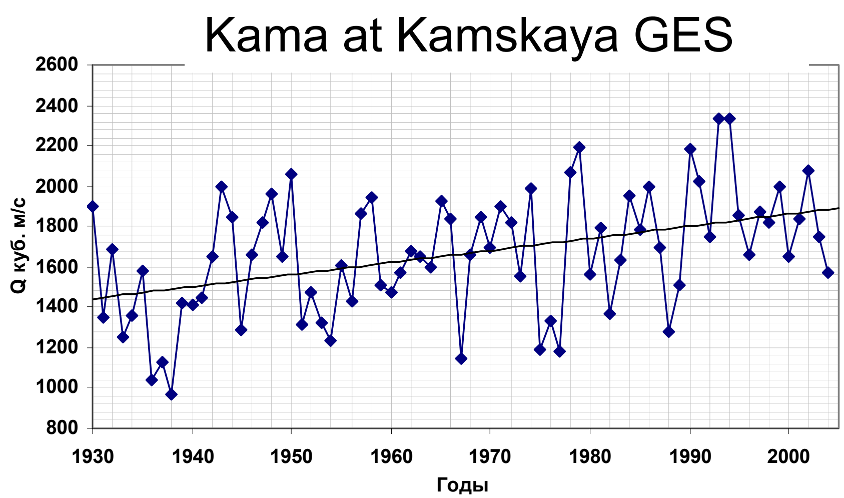
Annual discharge variation for some rivers in the Volga basin

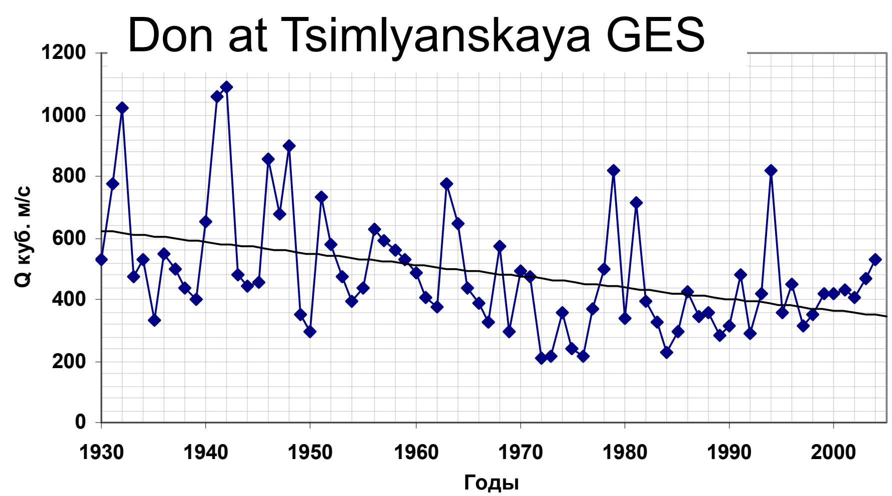
Data from SHI report, 2013

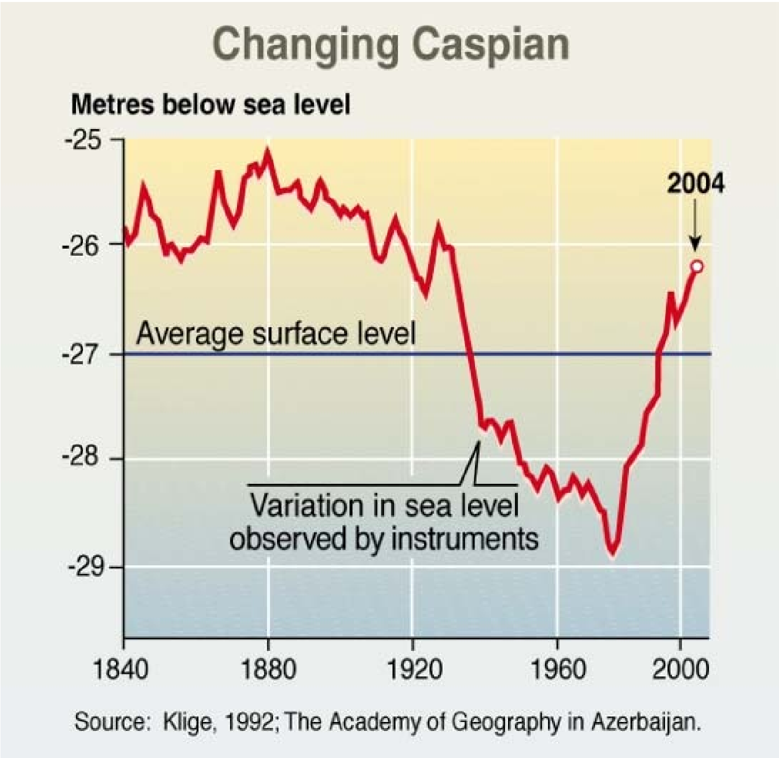
Dynamics of water resources for some European Russian rivers

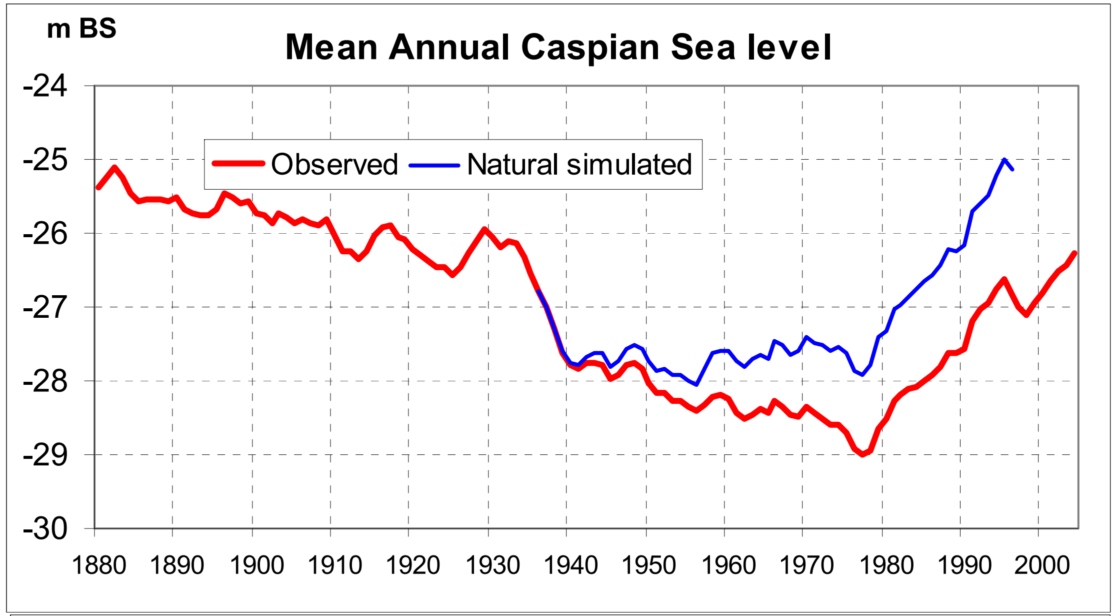


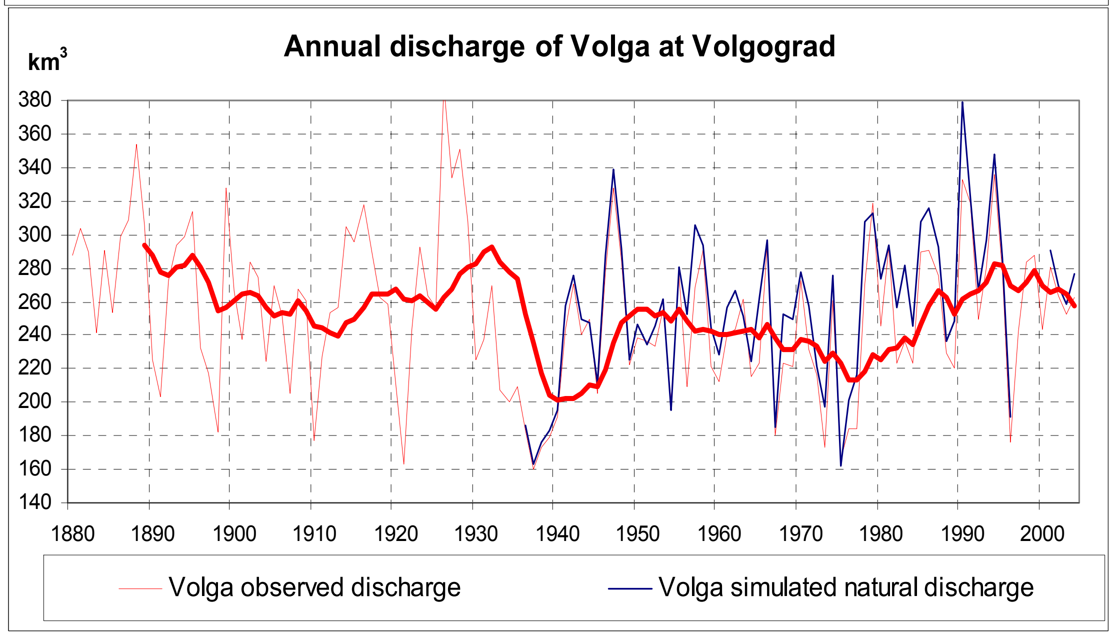




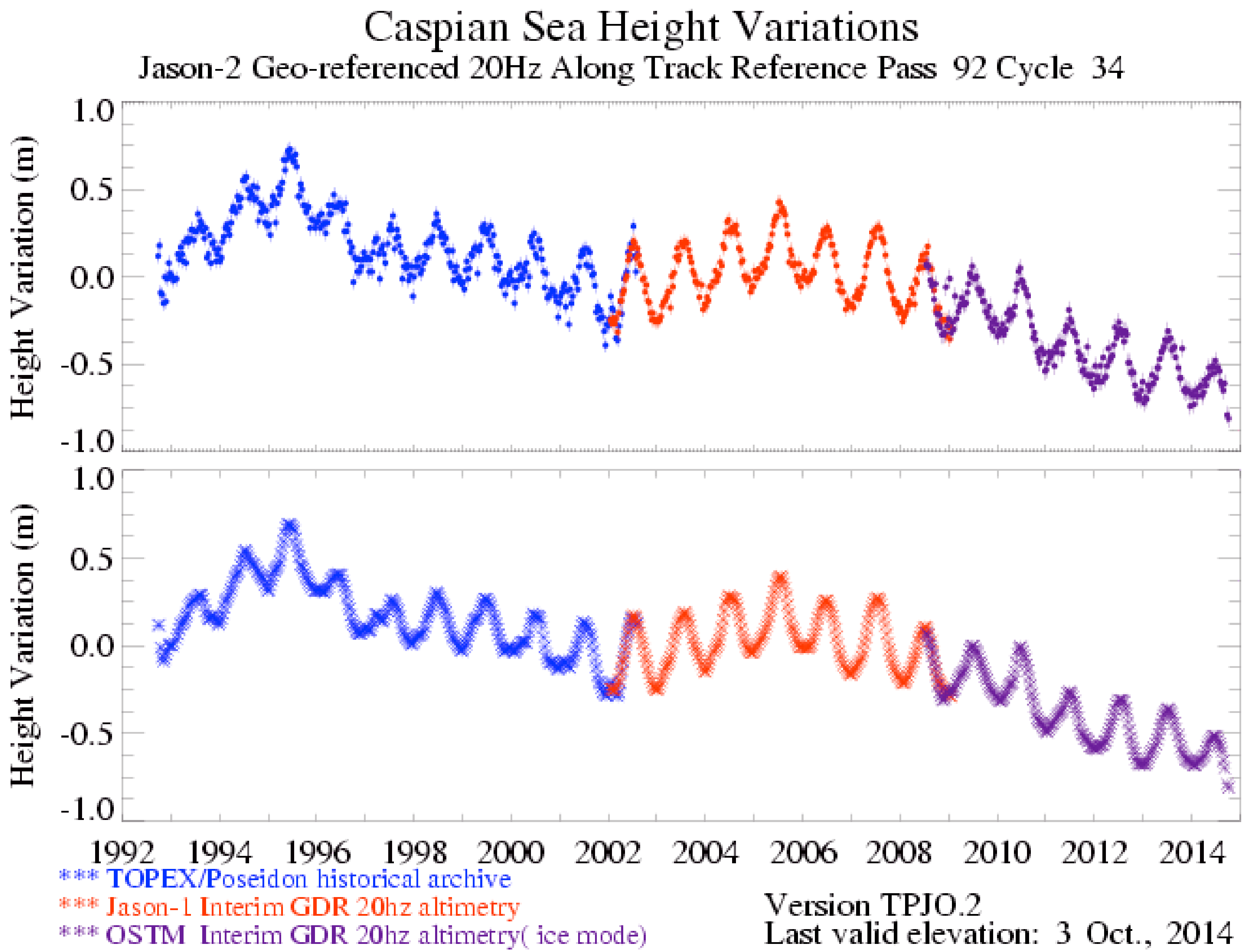






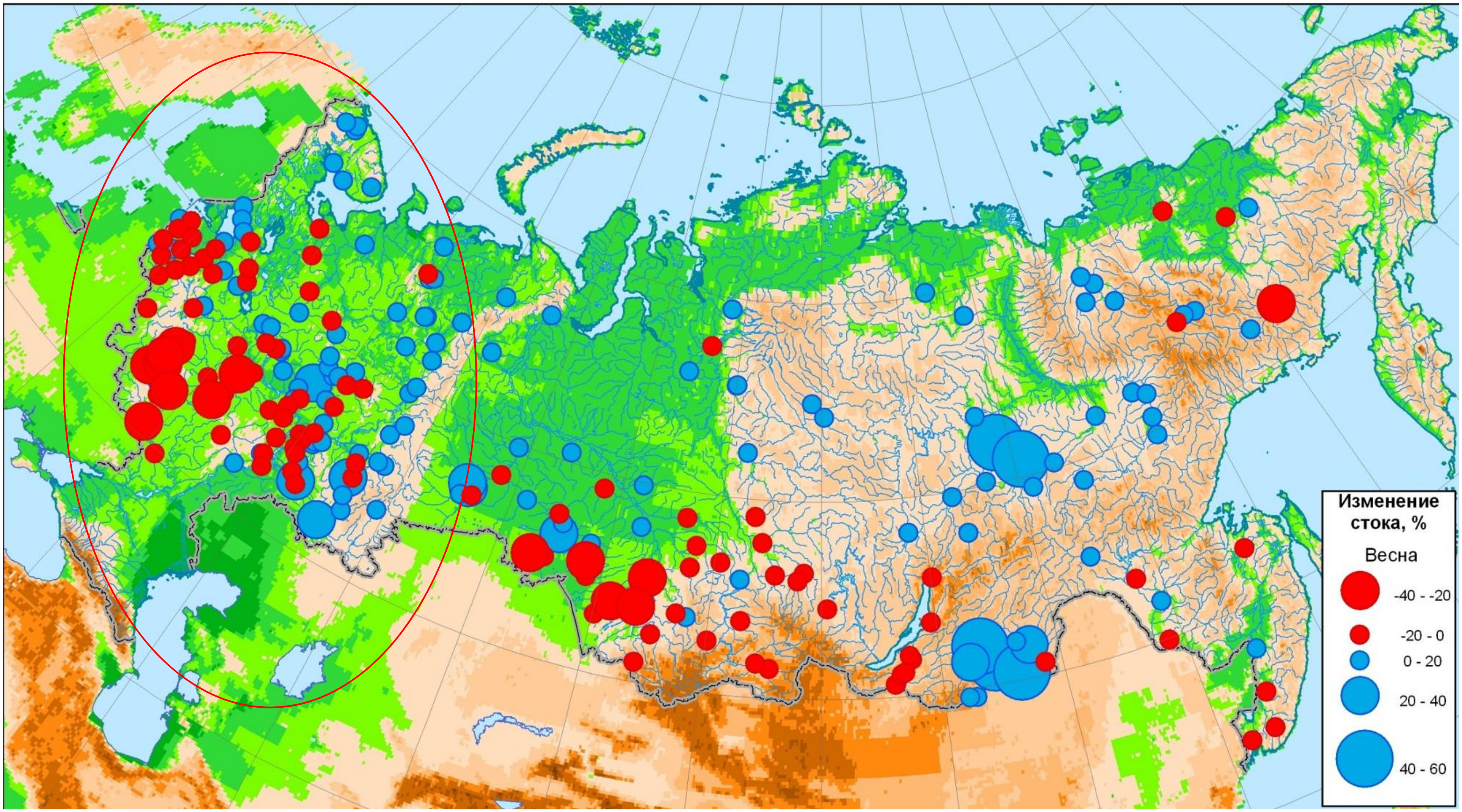


Caspian Sea level rise is mainly associated with increase in Volga river discharge



Caspian Sea Height Variations
Jason-2 Geo-referenced 20Hz Along Track Reference Pass 92 Cycle 34
Height Variation (m)
1.0
0.5
0.0
-0.5
-1.0
Height Variation (m)
1.0
0.5
0.0
-0.5
-1.0
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
*** TOPEX/Poseidon historical archive
*** Jason-1 Interim GDR 20hz altimetry
*** OSTM Interim GDR 20hz altimetry(ice mode)
Version TPJO.2
Last valid elevation: 3 Oct., 2014

Anomalies of spring runoff (%) across Russia

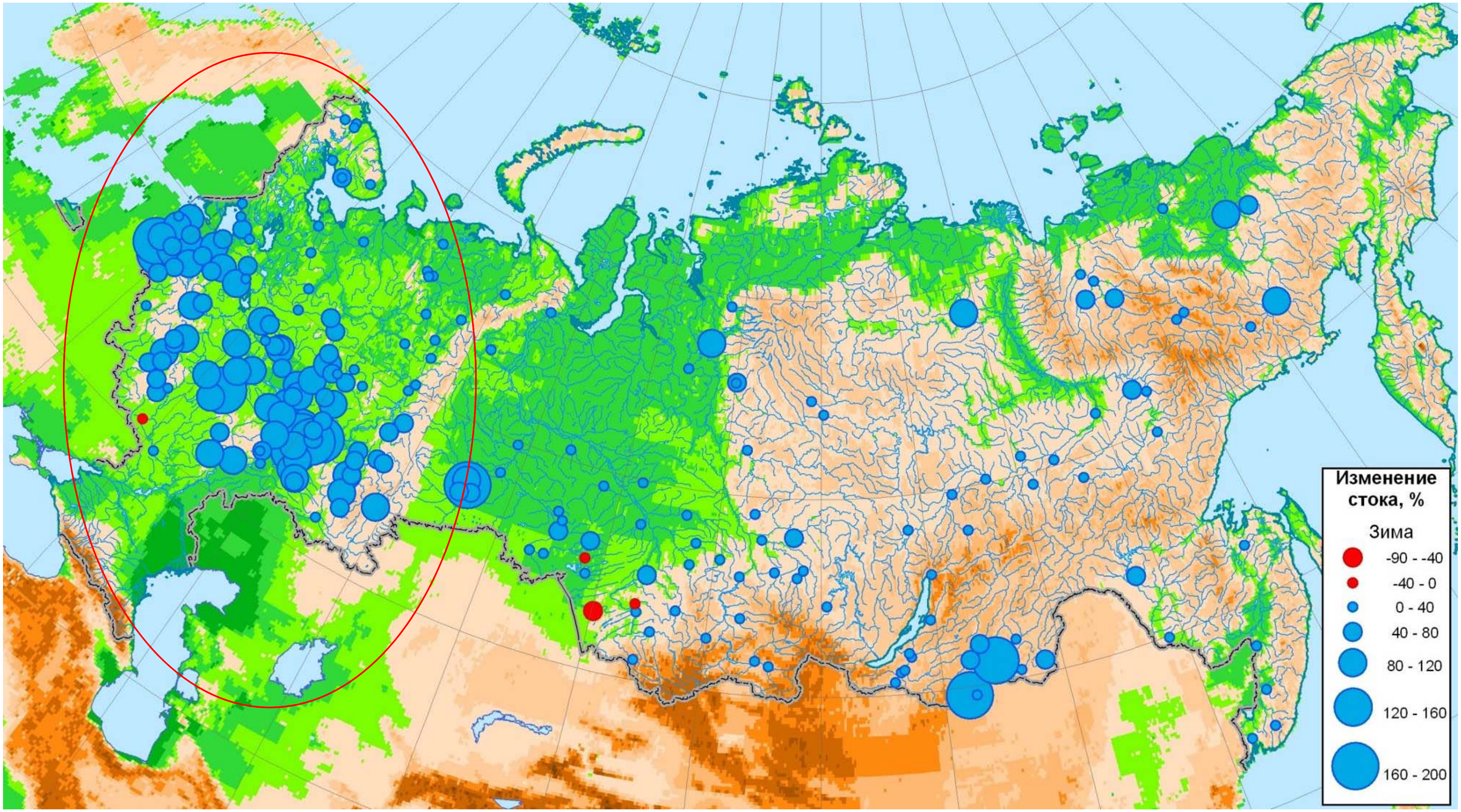


Deviation of spring runoff over 1978-2010 from 1940-1977

Anomalies of summer-fall runoff (%) across Russia

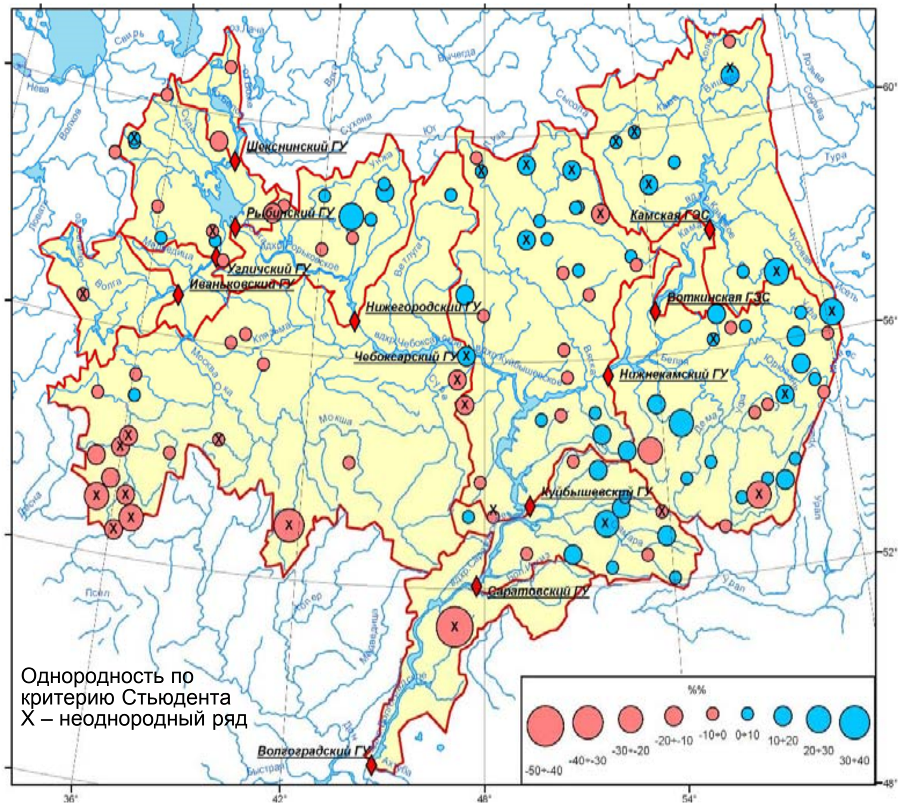
Deviation of summer-fall runoff over 1978-2010 from 1940-1977

Anomalies of winter runoff (%) across Russia

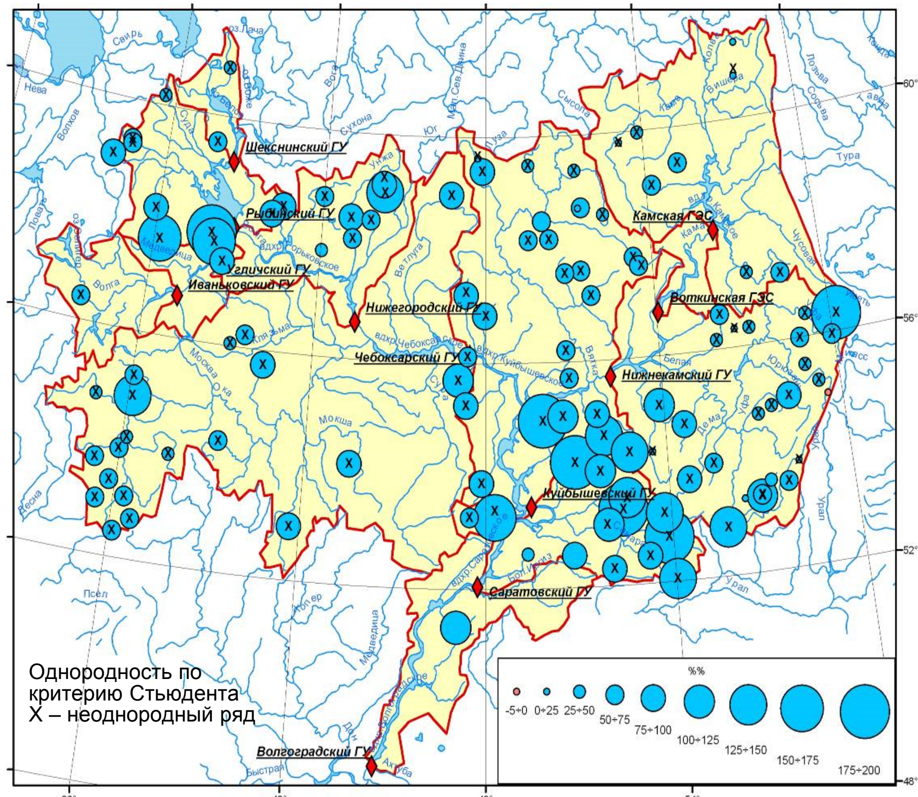


Deviation of winter runoff over 1978-2010 from 1940-1977

Change in spring and winter runoff in Volga river basin



Deviation (%) of mean spring runoff (MSR) in Volga river basin over 1978-2010 from MSR over 1946-1977.

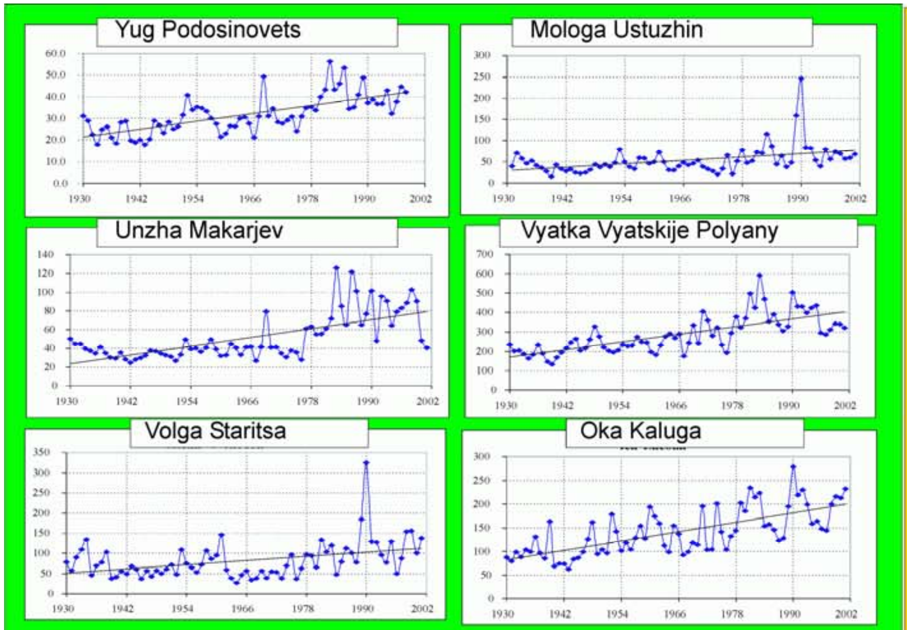


Deviation (%) of mean winter runoff (MWR) in Volga river basin over 1978-2010 from MWR over 1946-1977.

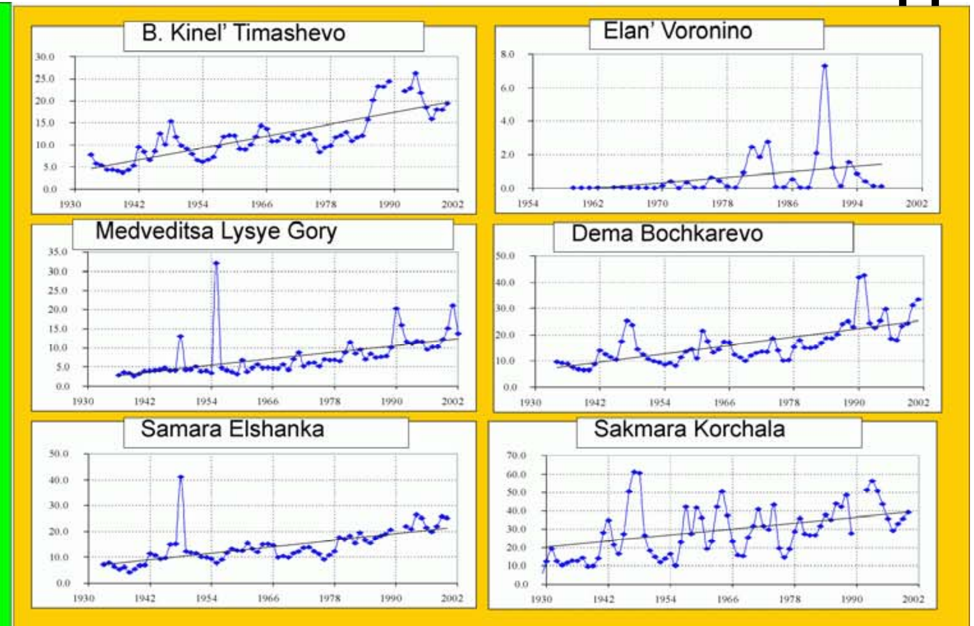
SHI report , 2013

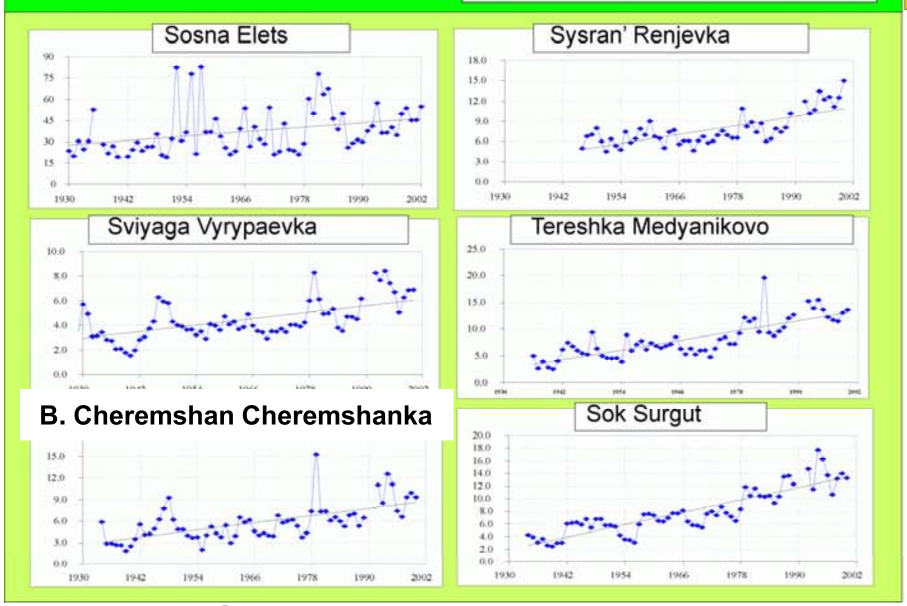
Annual mean winter river discharge (Dec. to March)

Forest



Steppe



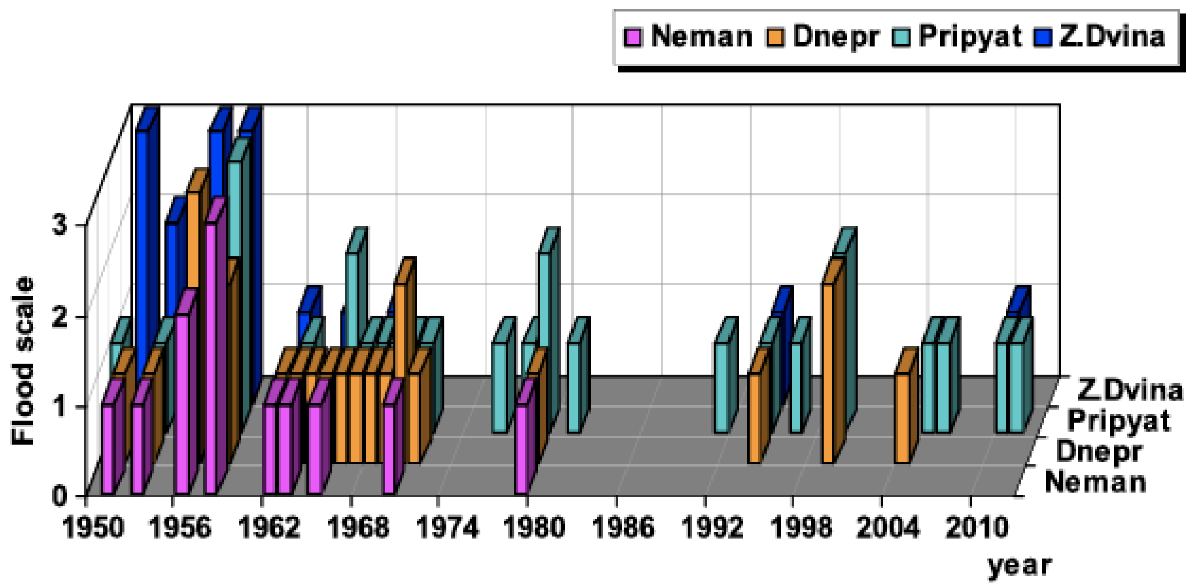


Forest-Steppe

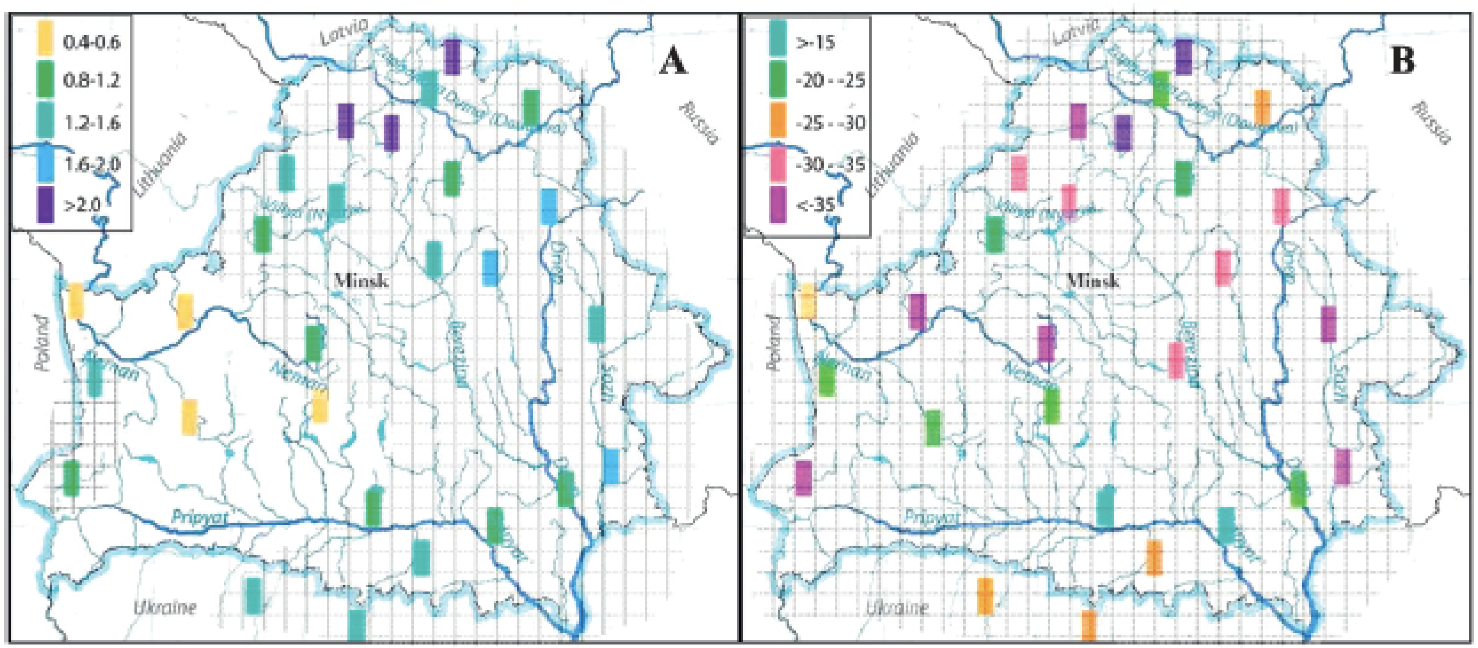
Medium-size drainage basins in European Russia without large reservoirs

Source: State Hydrological Institute, St. Petersburg, Russia

Changes in winter (min) and spring (max) streamflow in Belorussia



Frequency of inundations with different grades (according to Nezhihovskiy 1956) (3–outstanding with repeatability 1 per 55–100 year, 2—large with repeatability 1 per 10–50 year and 1—small with repeatability 1 per 5–8 year).

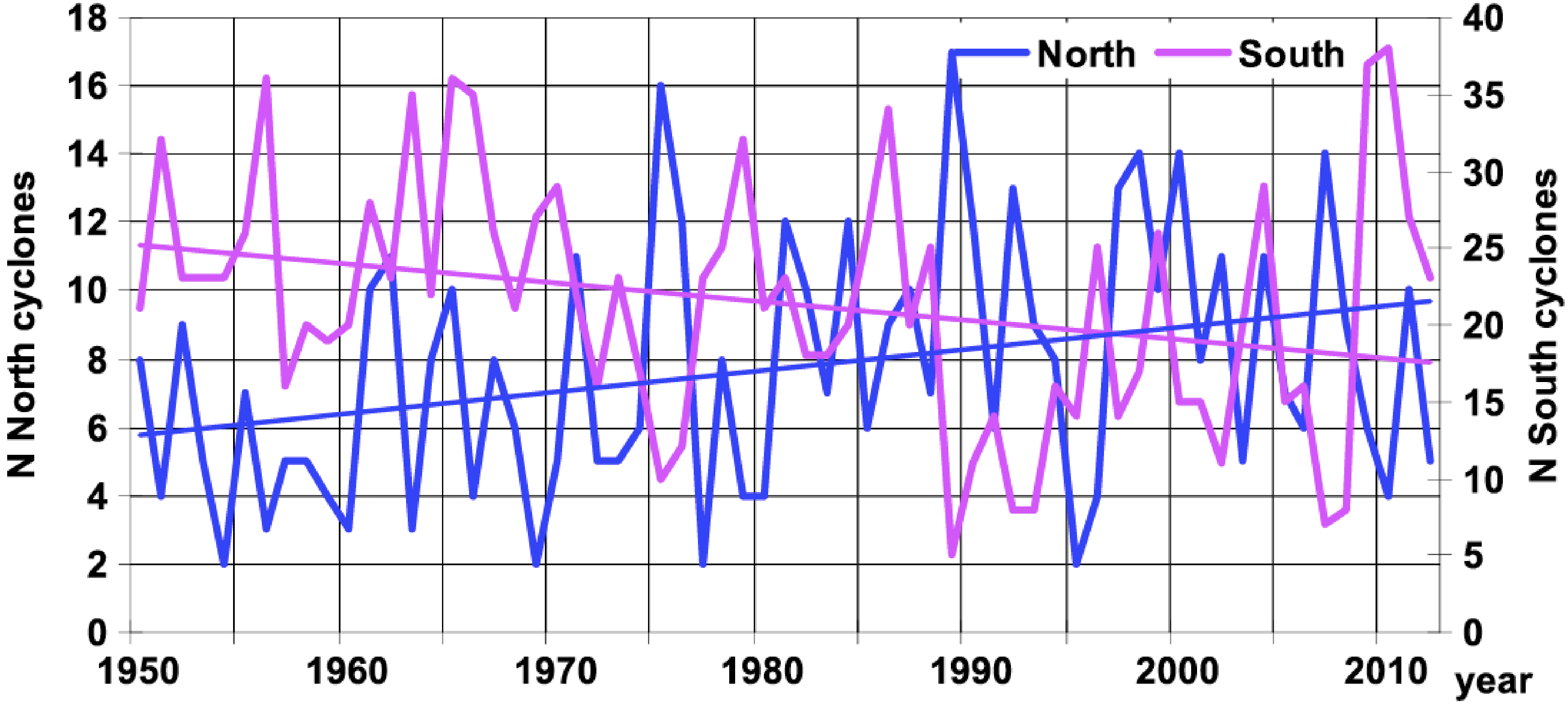


Spatial distribution of the net streamflow change during the winter season (A) and spring freshet (B), litre s^{-1} km^{-2}. The hatched areas in the maps outline statistically significant values of change at the 0.05 level. /I. Partasenok et al, ERL 2014/

Map of Europe with examples of trajectories of four types of cyclones that have different origins. Dates of cyclone beginning are: North 13.01.2003, West 12.01.2004, Scandinavian 23.12.1996, and South 16.01.1984.

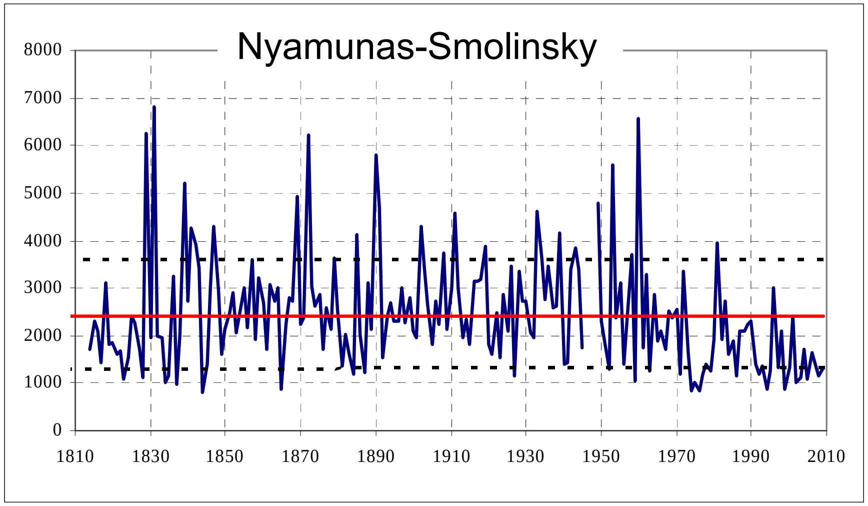
/I. Partasenok et al, ERL 2014/

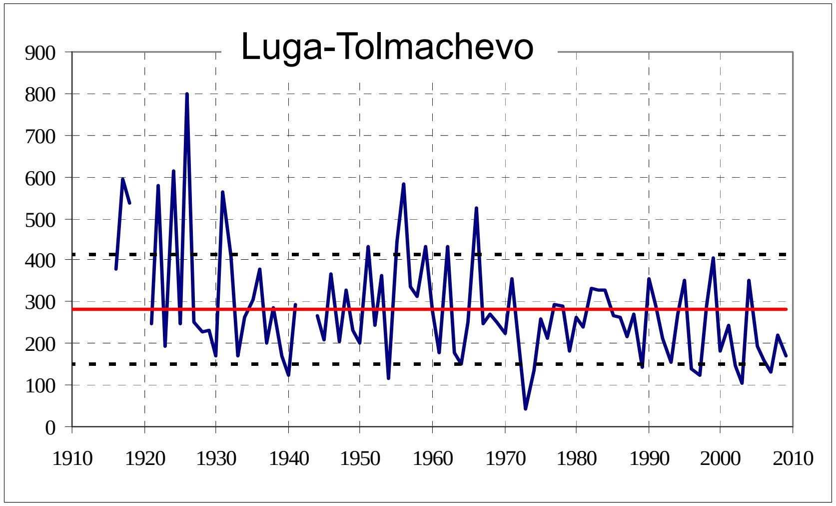
Time series and linear trends (statistically significant at the 0.05 level) of the North and South cyclones in the first domain (by NCEP reanalysis).

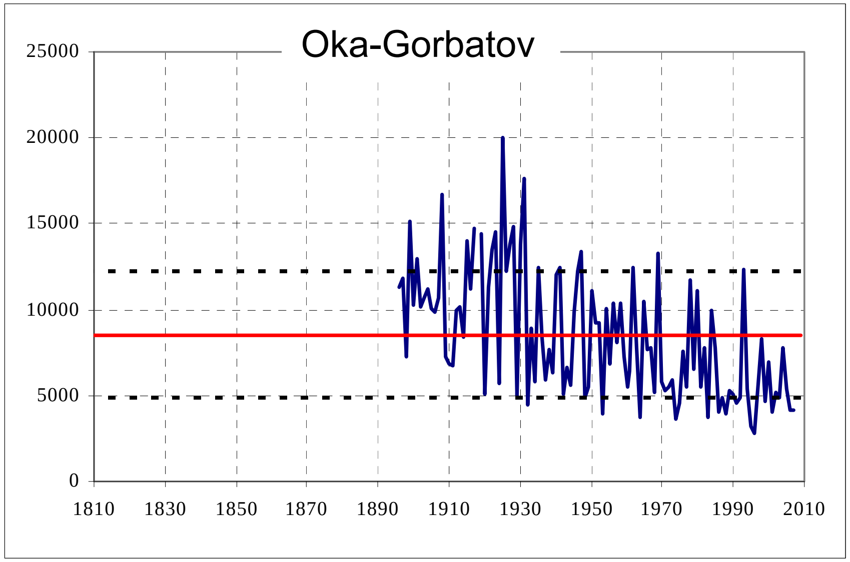


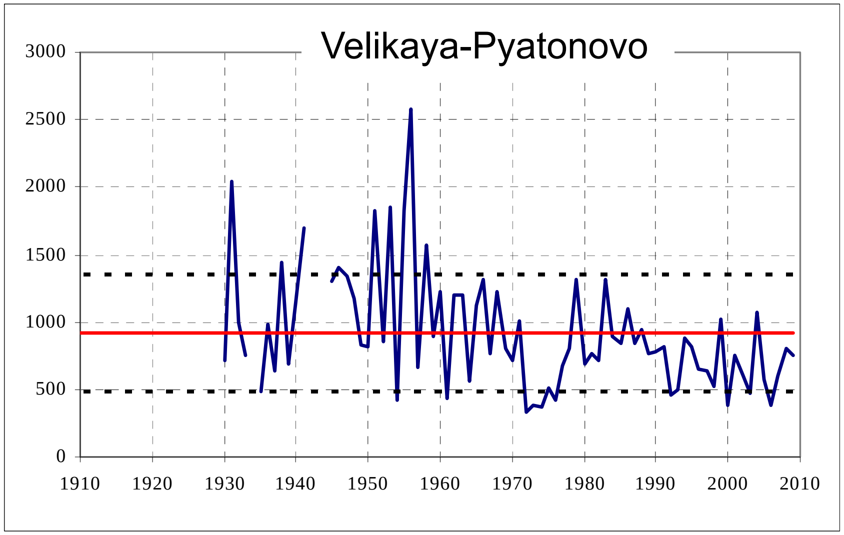
The pattern of change in streamflow corresponds to the geography of cyclone frequencies trends. North cyclones mostly influence the precipitation and winter and spring streamflow in the Belorussia /I. Partasenok et al, ERL 2014/

Maximum annual discharge (m^3/s)









What are major causes of changes in discharge?

Climate changes:

Increase in annual precipitation
+
Increase in air temperature, particularly in winter and spring seasons

↓

During cold period: more snowmelt less soil freezing

↓

The significant volume of water formed during thaws and spring snowmelt contribute to increase of soil moistening

↓ + Good conditions for infiltration

Ground water level increasing

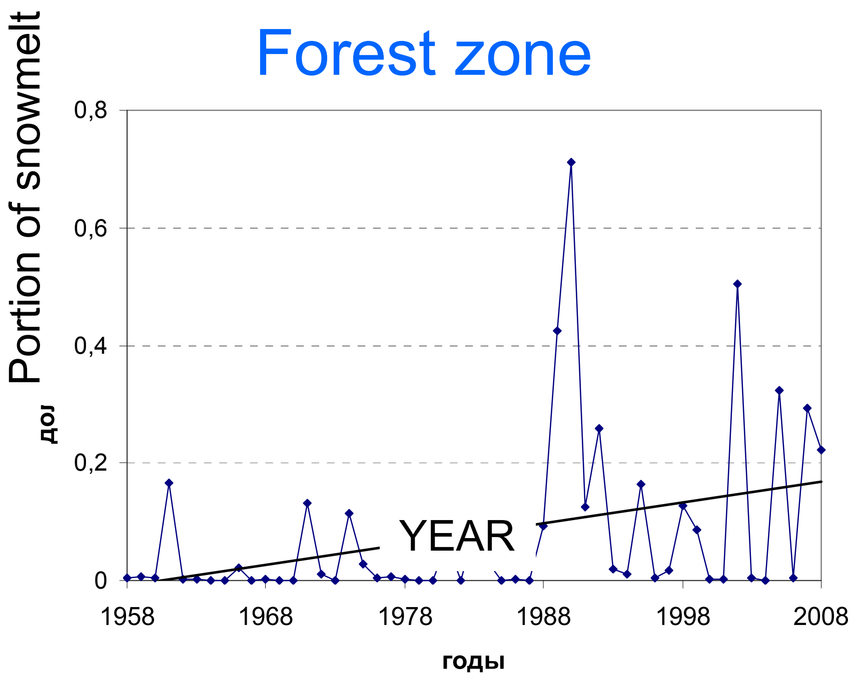
↓

Increase in the streamflow during low-flow periods

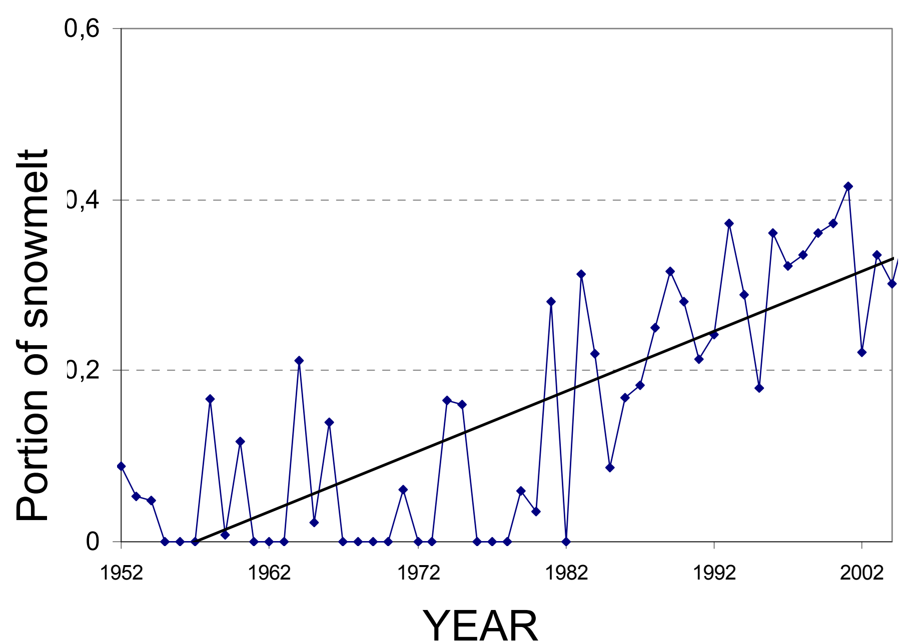
Contribution of winter snowmelt to winter runoff

Contribution of winter snowmelt to winter streamflow

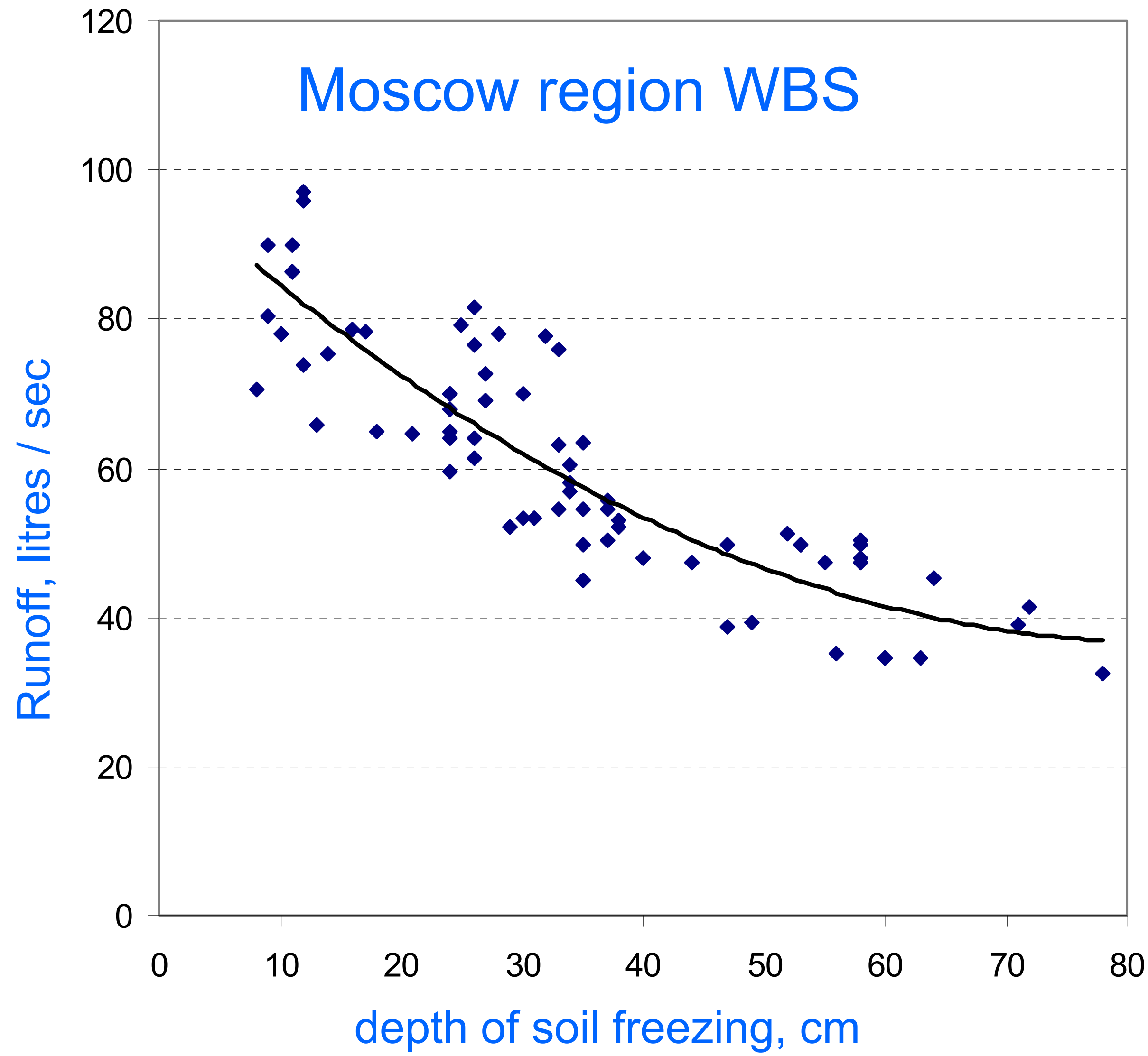
Forest zone



Forest-steppe zone

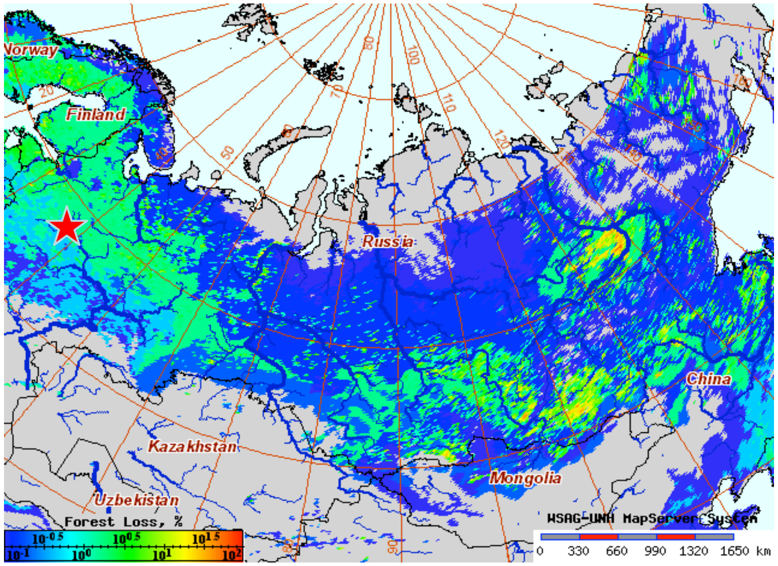


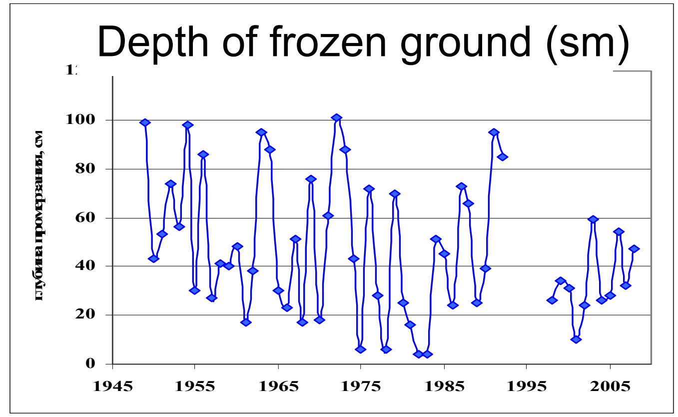
Dependence of the winter runoff from the depth of frozen soil



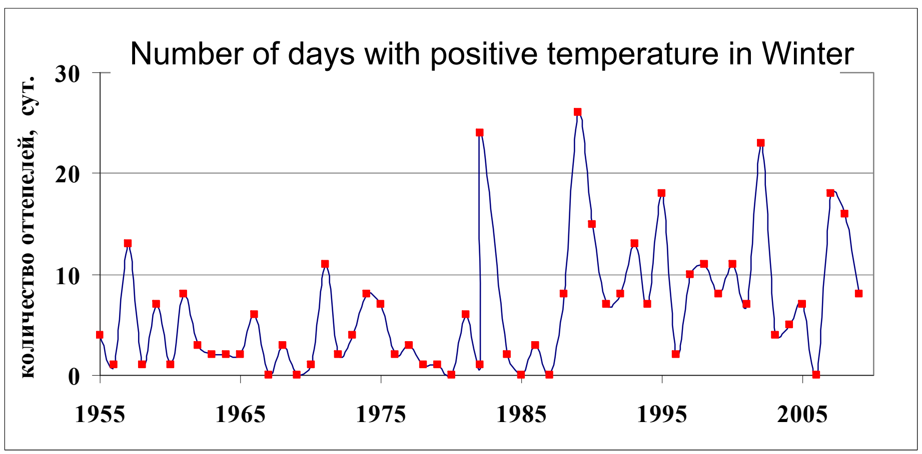
Understanding of changes in winter runoff

r. Medvenka F=21.5 km^2





Winter Runoff (l/s)

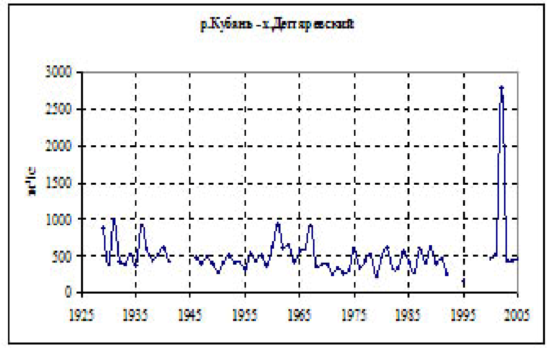


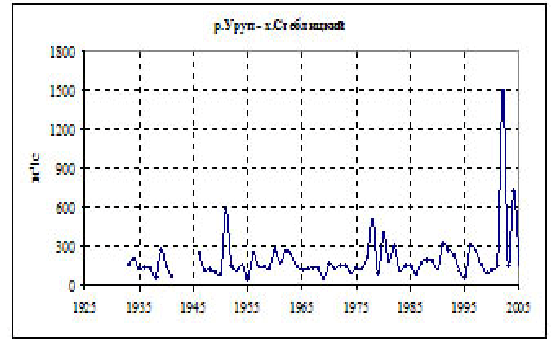
LTM winter runoff (l/s) 1958 -1980	Contribution of different elements into the winter runoff for Medvedka watershed			LTM winter runoff (l/s) 1981-2008
	Fall soil water content	Winter snowmelt	Depth of frozen ground	
49,6	**6**	**38**	**56**	**93,2**

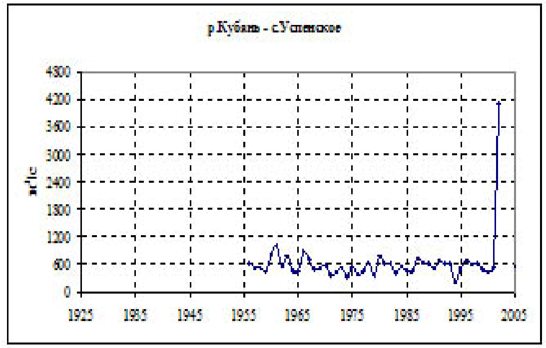
Contribution to increase in winter river discharge: Depth of frozen ground – 56%
Winter snowmelt – 38% , Fall soil water content – 6%

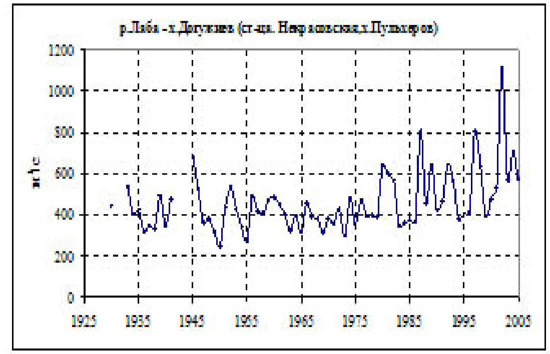
Courtesy to Igor Kaluzhny, SHI, Russia

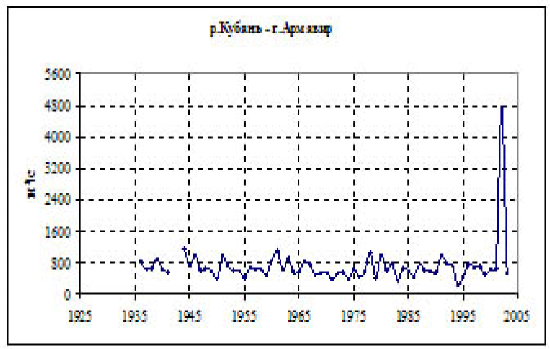
Maximal water discharges in the Kuban river basin

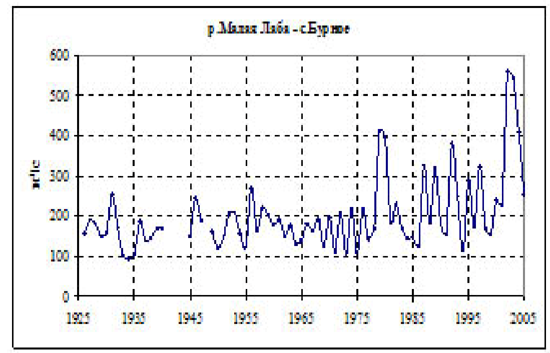


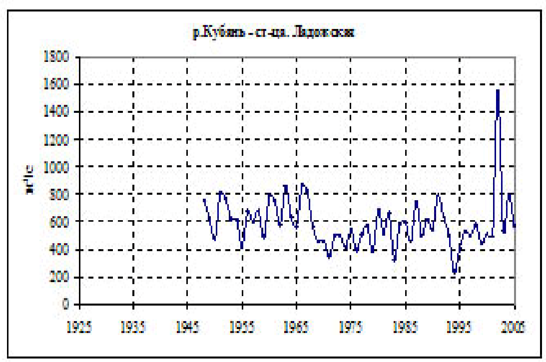


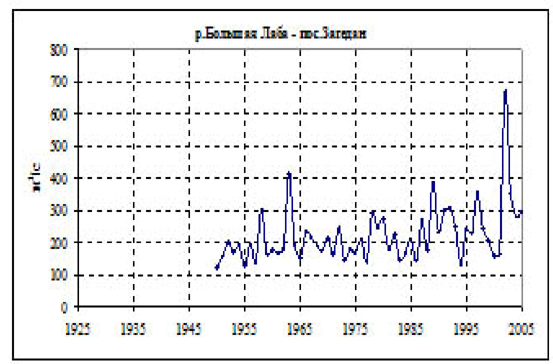




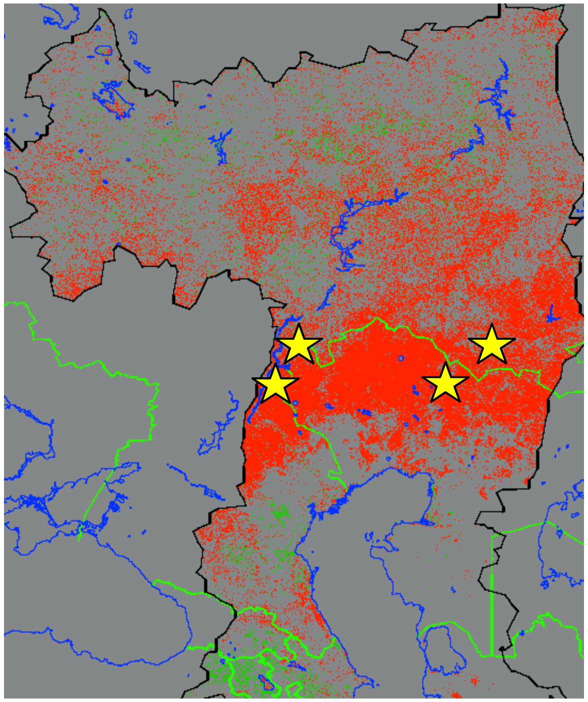


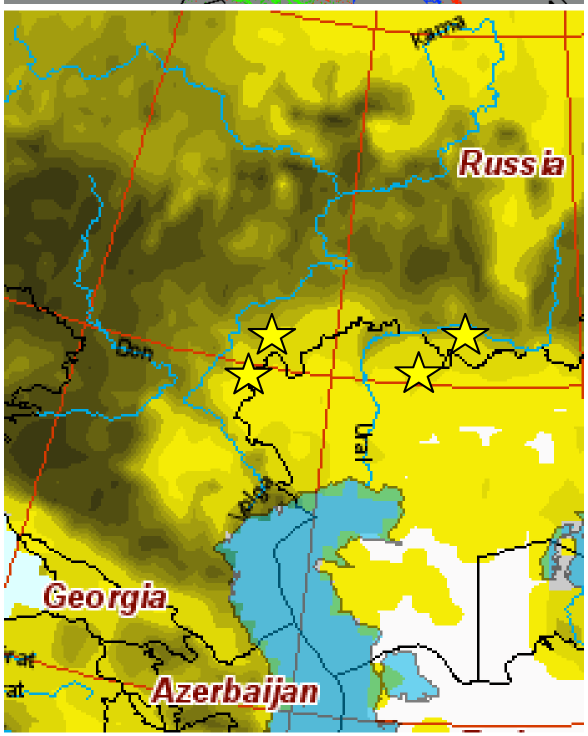


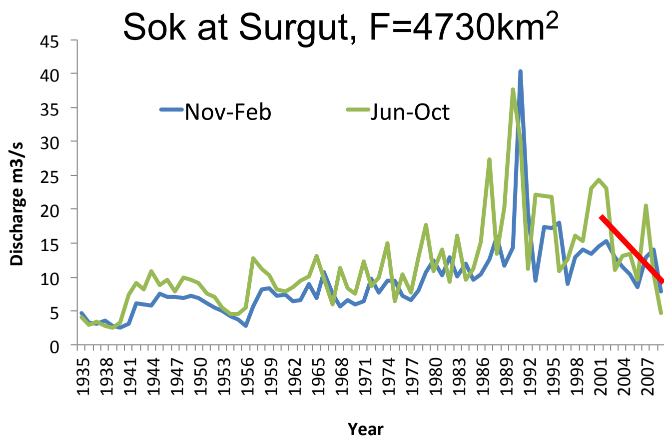


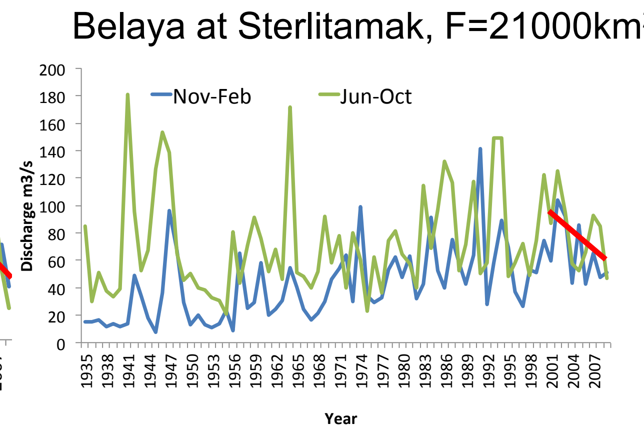


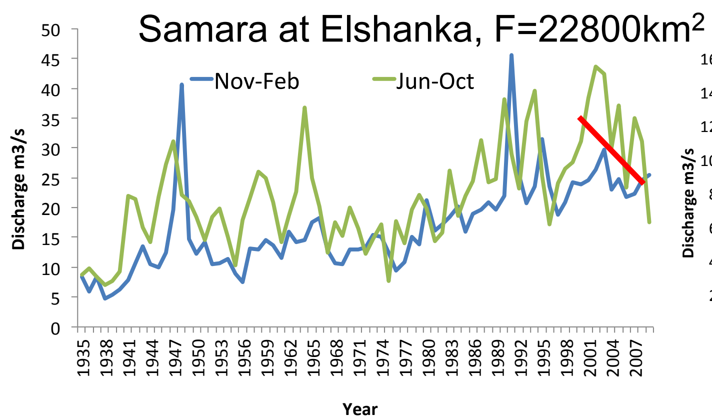
Vegetation change

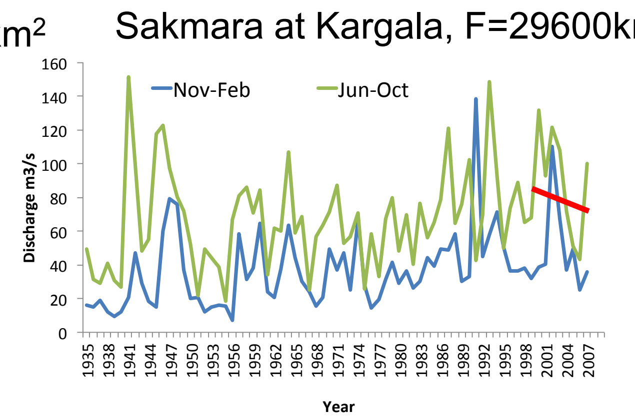




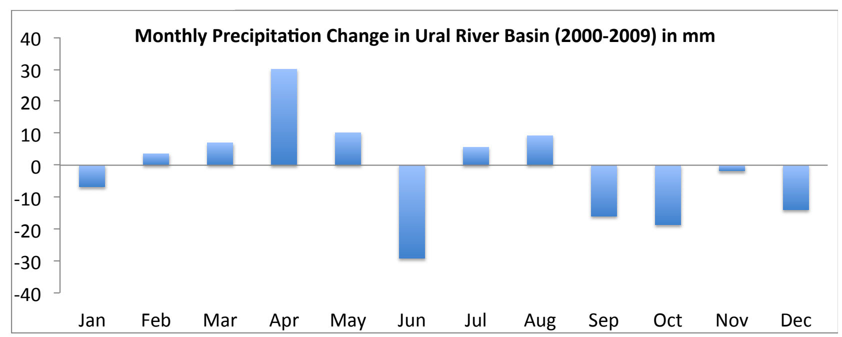




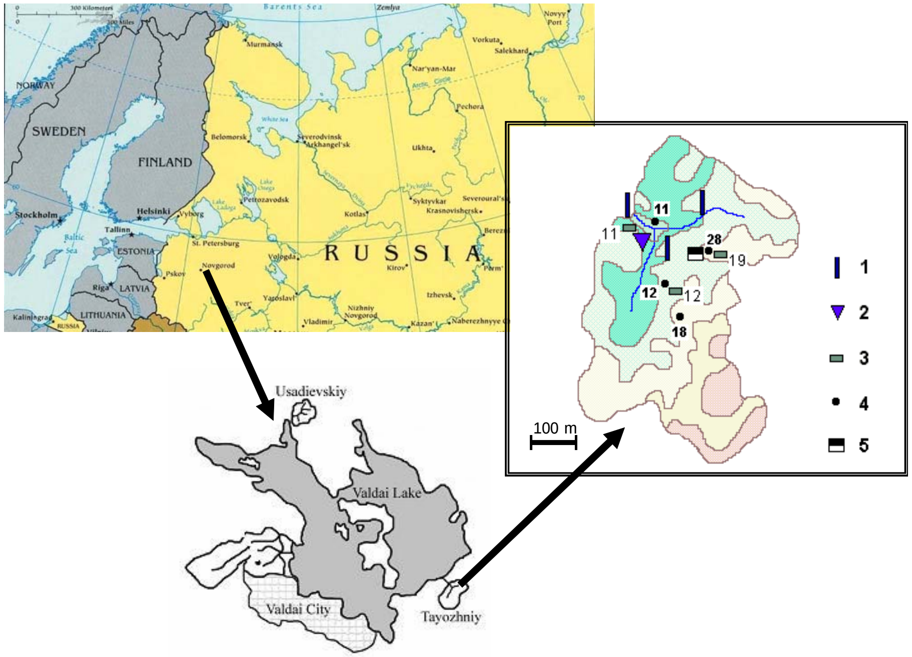




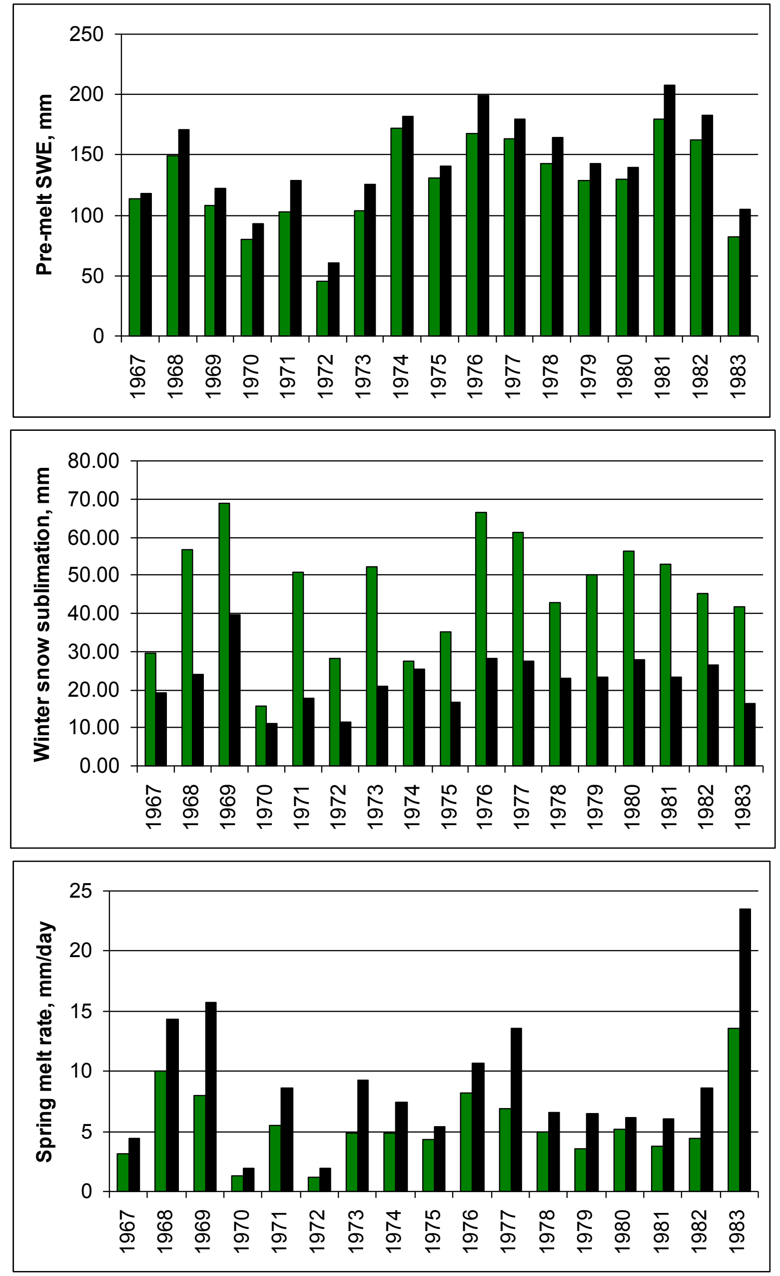
MODIS NDVI trends for Caspian Sea Basin 2000-10 (courtesy to Saachi Sassan)
Cropland distribution (lower map)



There is a significant positive trend in summer-fall runoff over long-term period. However, since 2000 this trend has shown negative tendency.



Location of the Tayozhny Creek basin.
1 – streamflow gauge at the basin outlet,
2 – rain gauge, 3 –soil moisture and temperature measurement points, groundwater measurement points , 5 – evapotranspiration gauge



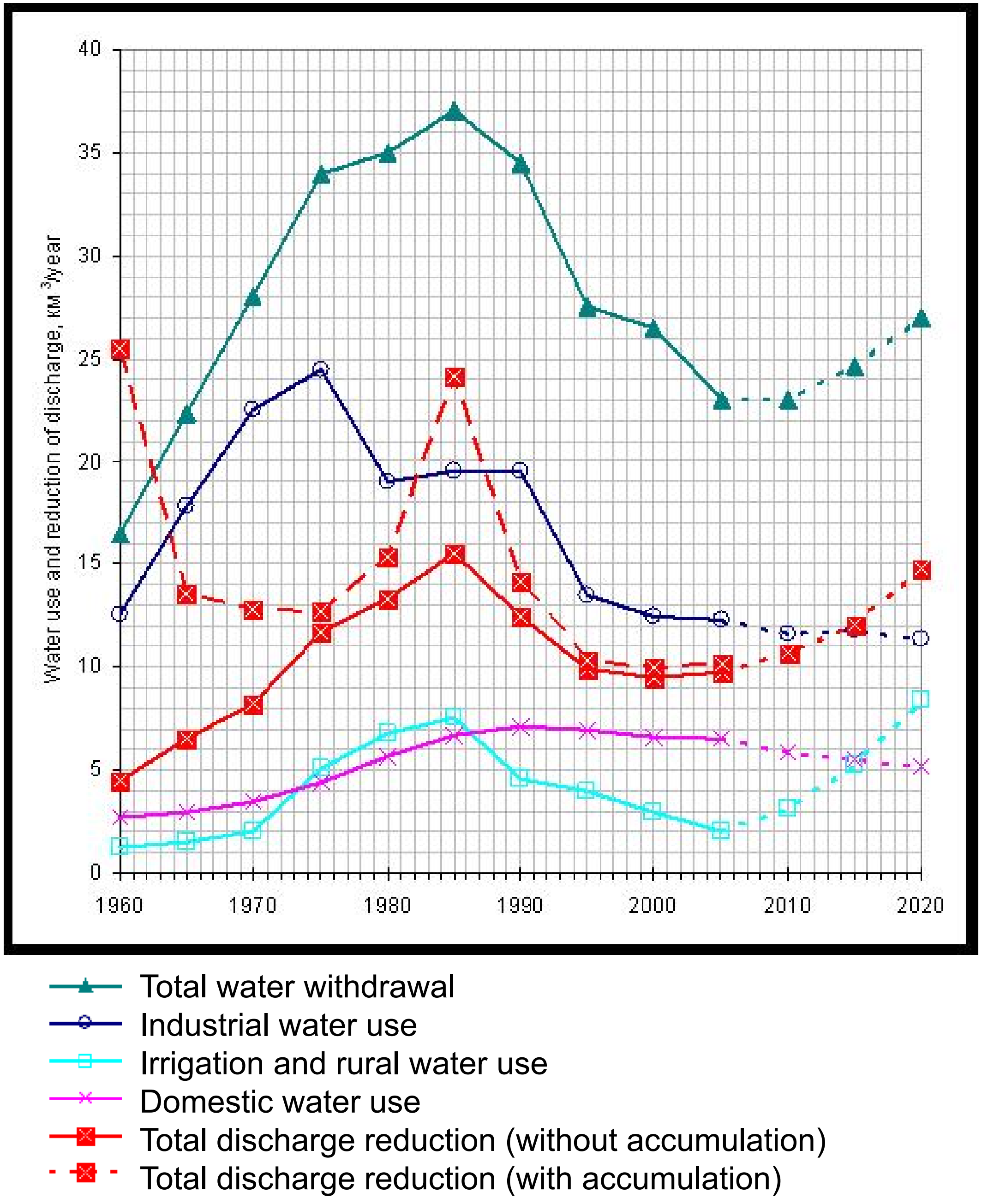
Influence of forest cutting on pre-melt snow water equivalent (upper), snow sublimation, and snowmelt rate (lower): green bars - forest; black bars –deforested area

Kuchment, L.S., Gelfan, A.N., Demidov, V.N. (2011) Modeling of the hydrological Cccle of a forest river basin and hydrological consequences of forest cutting *The Open Hydrology Journal*, **5**, 9-18

Human impact on river discharge

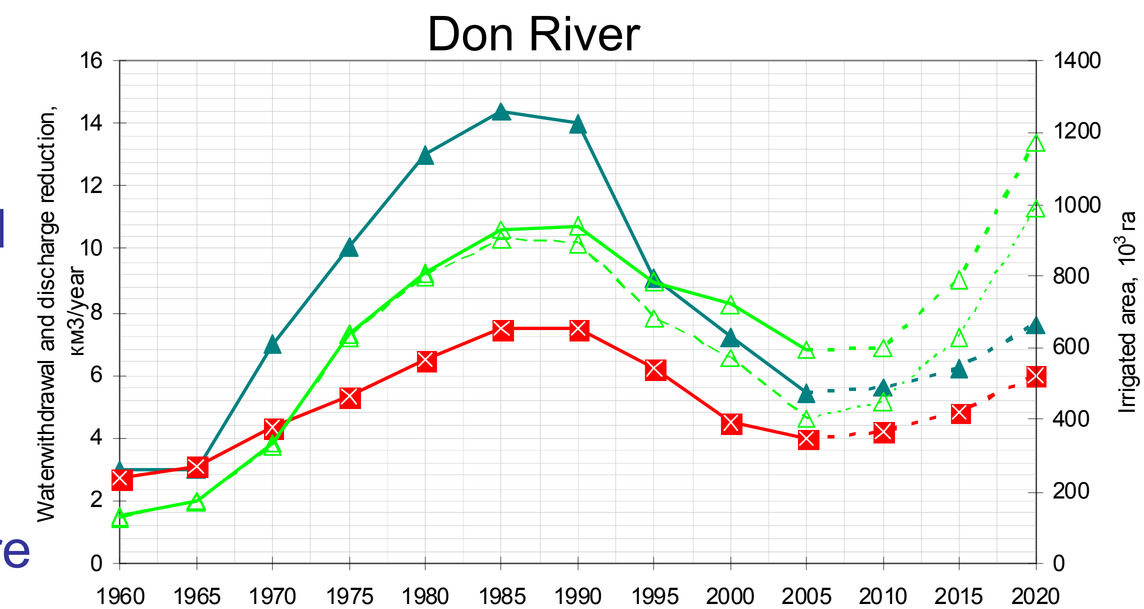
Dynamics of water withdrawal for different human needs and the reduction of annual discharge under human impact in the Volga river basin.

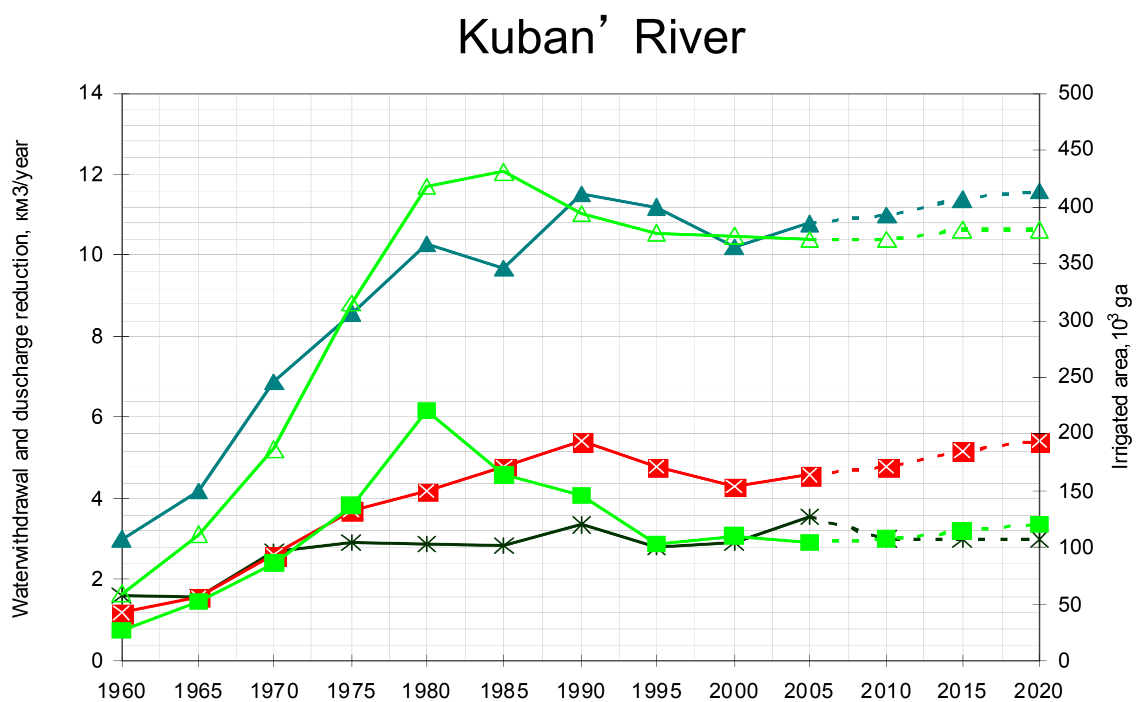
Estimates of State Hydrological Institute (2008)



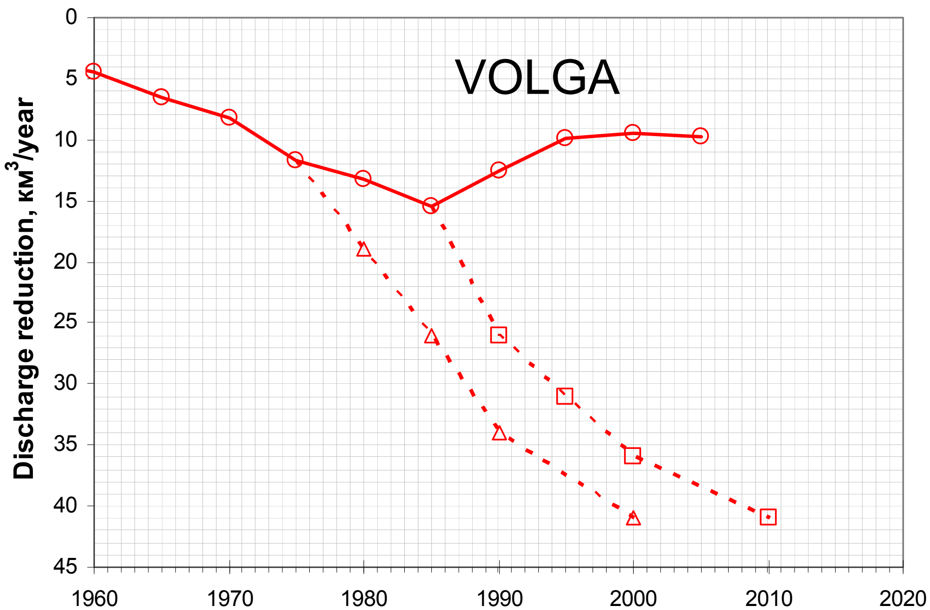
Dynamics of water withdrawal for different anthropogenic needs, change of irrigated areas and the reduction of annual discharge under human impact (including future projections).

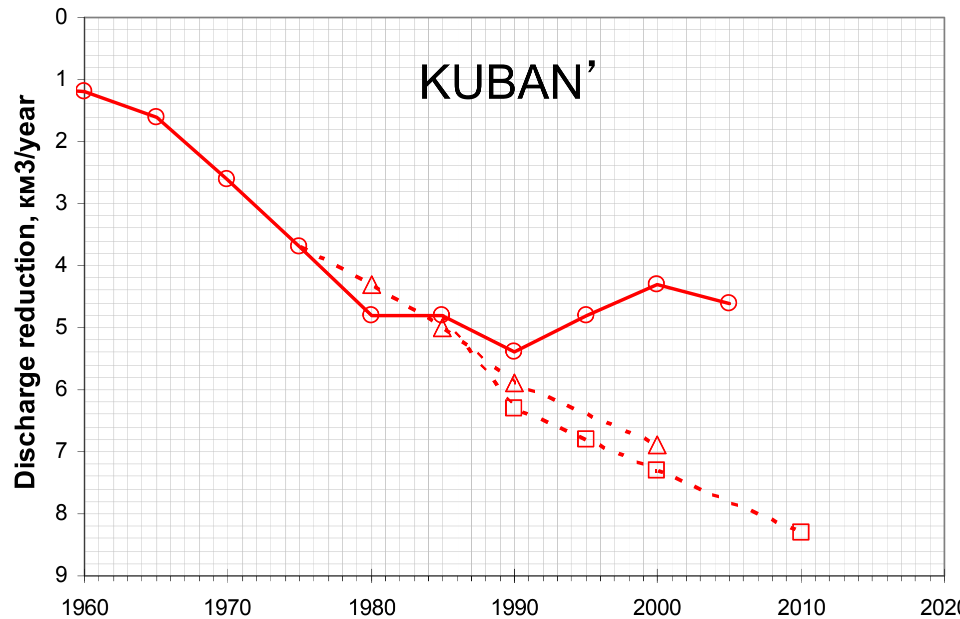
Estimates of State Hydrological Institute (2010)

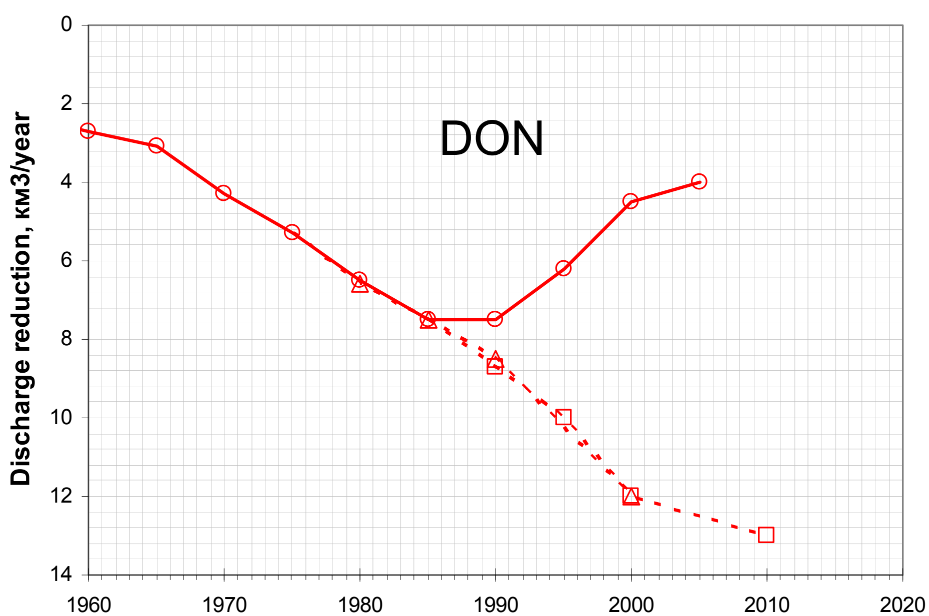




Water withdrawal
Total discharge reduction
Irrigated areas
Sprinkling areas
Rice areas
Water transfers







Anthropogenic changes in annual discharge based on old and contemporary estimates of SHI

2008 - -1975 estimate - -1985 estimate

Summarizing conclusions

• Water is the key to understand effects of global change, natural variability and human vulnerability

• There are a lot evidences of significant changes in hydrological regime across Eastern European

• Causes of these changes need to be better quantified

• More detailed investigations of climate change influence on various hydrological characteristics with consideration of changes in land cover/use and water management are necessary