Hydrological changes and possible causes

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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

Volga at Verkhne-Lebyajie

Oka at Gorbatov

Kama at Kamskaya GES

Don at Tsimlyanskaya GES
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

*** 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
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/
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 (m³/s)

Nyamunas-Smolinsky

Luga-Tolmachevo

Oka-Gorbatov

Velikaya-Pyatonovo
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
Dependence of the winter runoff from the depth of frozen soil

Moscow region WBS

Runoff, litres / sec vs. depth of soil freezing, cm
Understanding of changes in winter runoff
r. Medvenka F=21.5 km²

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

Barsukovskaya: June 22, 2002
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

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