THE IMPACT OF MODERN CLIMATE CHANGES ON THE GROUNDWATER RECHARGE IN THE EUROPEAN PART OF RUSSIA

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Modern climatic changes in the European Part of Russia (EPR)

Meteorological data of more than 20 weather stations from south to north of EPR

- Widespread increase in air temperature (to 2 °C) and decrease in wind speed (to 1.5 m/s) from 1980
- Ambiguous changes in precipitation and air humidity
Latitudinal changes of precipitation $\Delta P$

A predominant increase in annual precipitation up to 50 mm/year

Different changes of seasonal precipitation in southern and northern regions

North:
- increased winter and summer precipitation
- decrease in autumn precipitation

South:
- decrease in winter and summer precipitation;
- increased autumn precipitation

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Comparison of mean annual and seasonal values for 1965-1988 и 1989-2018

Latitudinal changes of air temperature $\Delta T$

- **General increase in annual temperature to 0.5-1.4°C**
- **Increase in air temperature in all seasons**
- **Maximum increase in winter temperature - by 1.5 - 3.0°C**
The predominant decrease in wind speed by an average of 0.7 m/s.

Relatively uniform seasonal decrease in wind speed by an average of 0.5-1 m/s.

Minor annual and seasonal changes in air humidity by ±1-3%.
How observed climate change affects groundwater recharge?

Research method: - simulation of groundwater recharge processes

### Groundwater recharge model

#### Block 1: Model of surface water and energy balance – code SurfBal

Grinevskiy, Pozdniakov (2010) [https://doi.org/10.1134/S0097807810050040](https://doi.org/10.1134/S0097807810050040)

Grinevskiy et al., (2018) [https://doi.org/10.1007/s10040-018-1831-1](https://doi.org/10.1007/s10040-018-1831-1)


Calculation the upper boundary flow and energy condition for HYDRUS 1D taking into account the snow accumulation and melting and freezing-thawing of the soil.

Input Data:
- daily seepage to the soil;
- daily potential evapotranspiration (FAO Penman-Monteith equation)

#### Block 2: Unsaturated flow model with root water uptake – code HYDRUS-1D

(Šimůnek et al. 2009)

Input Data:
- daily seepage to the soil;
- typical vegetation and soil parameters

Summary results:
- surface runoff
- actual evaporation and transpiration
- groundwater recharge

Processing simulation results to find out change of annual water balance, based on comparing previous (1965-1988) and modern (1989-2018) periods

\[
\Delta P = \Delta ETR + \Delta S + \Delta W \\
\pm \Delta V
\]

\(\Delta\) – difference between 1965-1988 and 1989-2018

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**Input Data:**
- daily meteorological data for 1965-2018;
- typical vegetation and soil parameters
Simulation results: modern climatic changes of water balance

Surface runoff $\Delta S$

Latitudinal changes of annual surface runoff $\Delta S$ for different landscapes

- Different changes of annual runoff in southern and northern regions: increase in the north, decrease in the south
- The best correlation between changes of surface runoff $\Delta S$ and precipitation $\Delta P$

Comparison of mean intra-annual surface runoff

- General degradation of thawed flood runoff
- Increased winter runoff due to thaws
Simulation results: modern climatic changes of water balance

**Evapotranspiration** \( \Delta ET = \Delta E + \Delta TR \)

Latitudinal changes of annual evapotranspiration \( \Delta ET \) for different landscapes

- **Irregular changes** of annual evapotranspiration:
  - increase in the north and south and
decrease in the central part

**Complex and opposite impact:**

- an increase in precipitation and temperature leads to an *increase of transpiration*
- a decrease in wind speed leads to a *decrease in evaporation*

Correlation between changes of transpiration \( \Delta TR \) and precipitation \( \Delta P \)

Correlation between reduction in evaporation \( \Delta E \) and wind speed decreasing \( \Delta U \)
**Simulation results: modern climatic changes of water balance**

**Groundwater recharge $\Delta W$**

Latitudinal changes of annual groundwater recharge $\Delta W$ for different landscapes

- No changes of groundwater recharge in the south and increase by 20-60 mm/year (up to 50%) in the north

**Correlation between changes of recharge $\Delta W$ and winter-spring precipitation**

**Correlation between changes of recharge $\Delta W$ and aridity index $\Delta (P/ETP)$**

**Correlation between recharge change $\Delta W$ and soil freezing depth decreasing**
Conclusions

Despite a significant increase in air temperature, simulated *groundwater recharge* in the southern regions *did not change, but even increased* in the central and northern regions of European Part of Russia.

There are two main reasons of this phenomena:

1. Despite an increase in air temperature, there was no significant increase in evapotranspiration, since *the increase in air temperature is compensated by a decrease in wind speed*.

2. *Climatic changes in winter have a major impact on the increase in groundwater recharge* - an increase in winter temperature and precipitation leads to an increase in moisture absorption during periods of winter thaws when there is no evapotranspiration.

Analysis and *understanding of the modern climatic changes impact* on the processes of water balance transformation in the critical zone *make it possible to predict them more confidently in the future*. 
Thank you for attention

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