Moscow State University
Hydrogeology division

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

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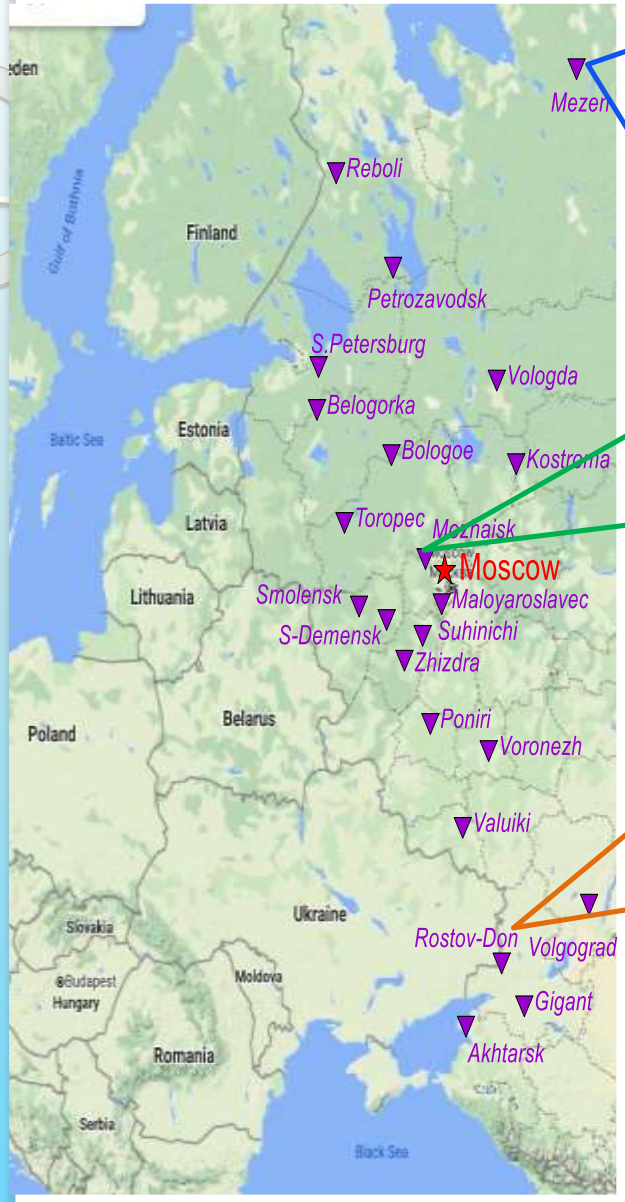
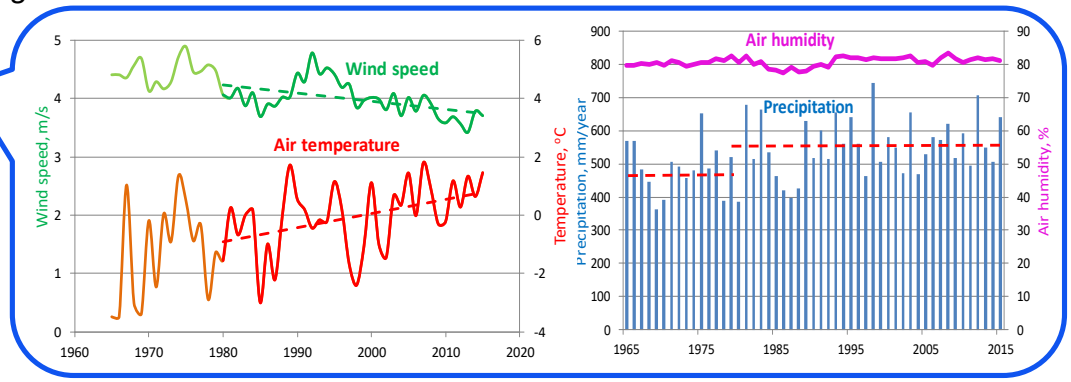
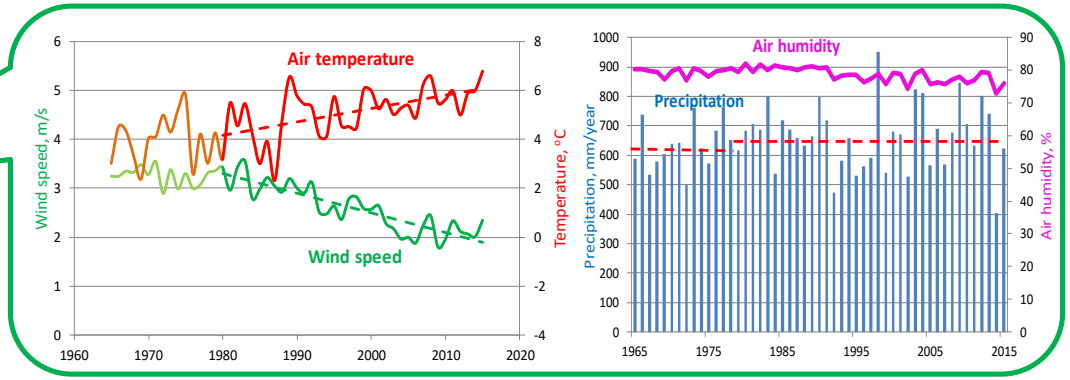
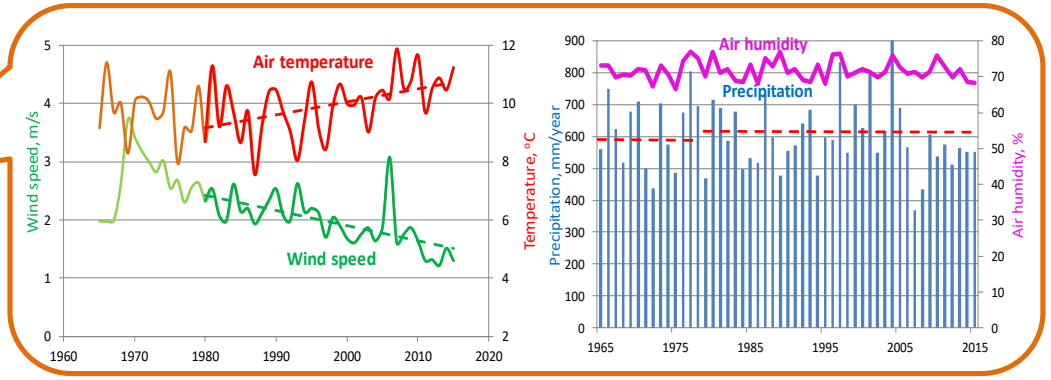
Modern climatic changes in the European Part of Russia (EPR)

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





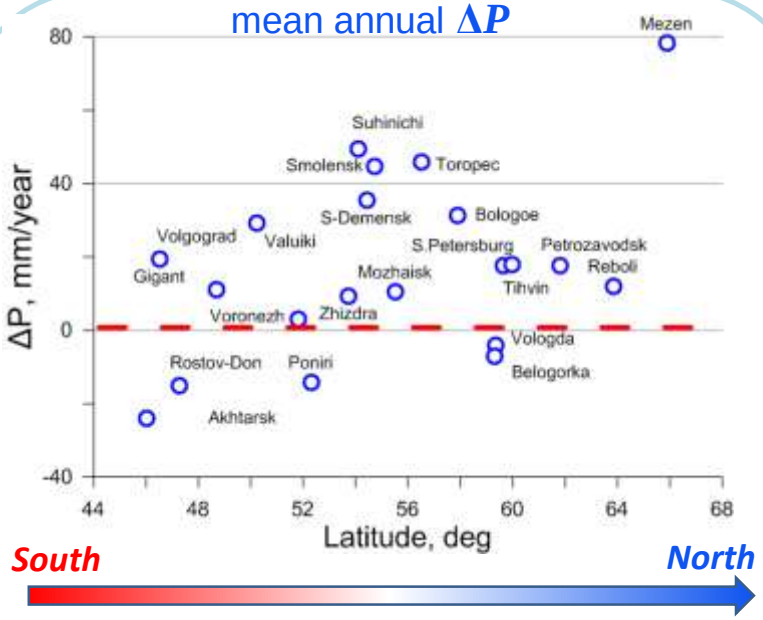




- Widespread increase in air temperature (to 2 °C) and decrease in wind speed (to 1.5 m/s) from 1980
- Ambiguous changes in precipitation and air humidity

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

Latitudinal changes of precipitation ΔP

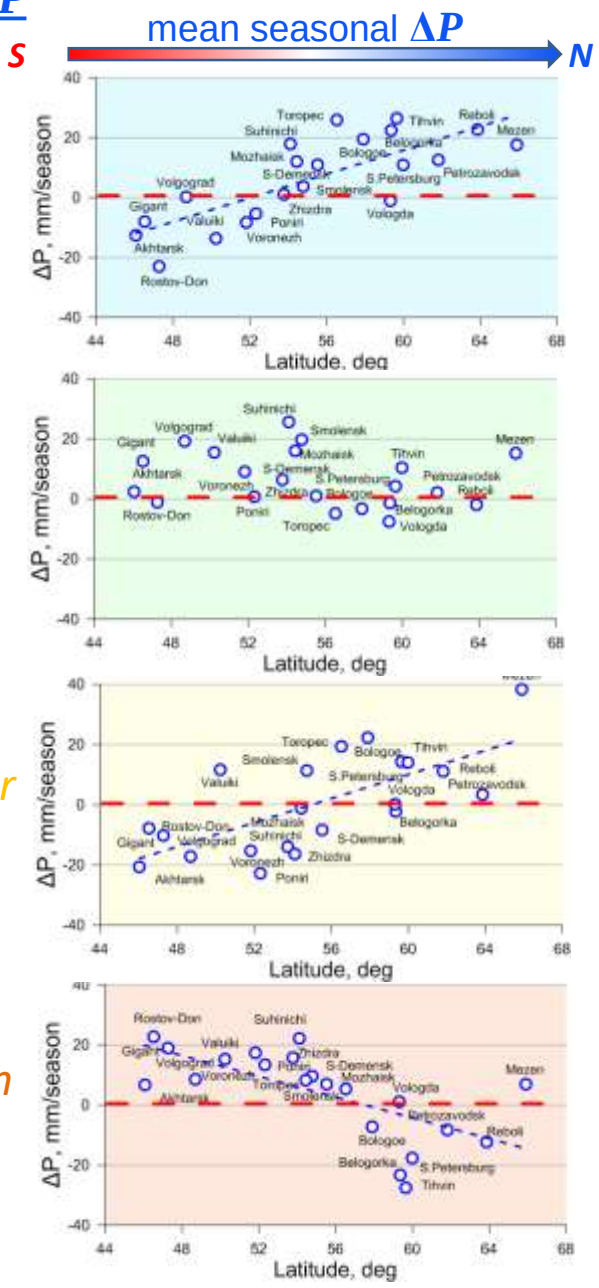


- A predominant increase in annual precipitation up to 50 mm/year

- Different changes of seasonal precipitation in southern and northern regions

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

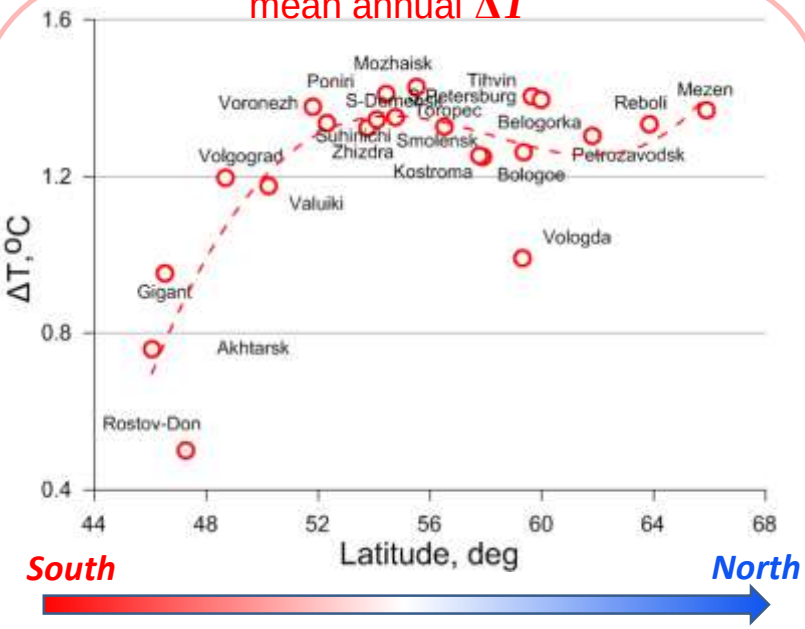
South : ✓ decrease in winter and summer precipitation;
✓ increased autumn precipitation



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

Latitudinal changes of air temperature ΔT

mean annual ΔT



- General increase in annual temperature to 0,5-1,4°C

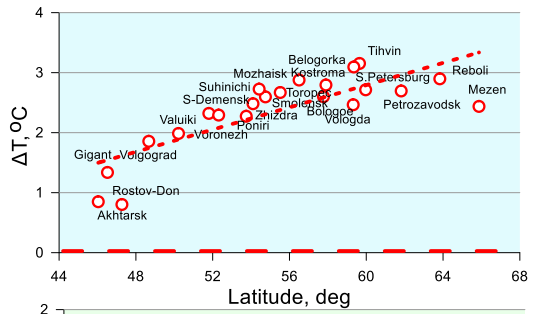
- Increase in air temperature in all seasons

- Maximum increase in winter temperature - by 1.5 - 3.0°C

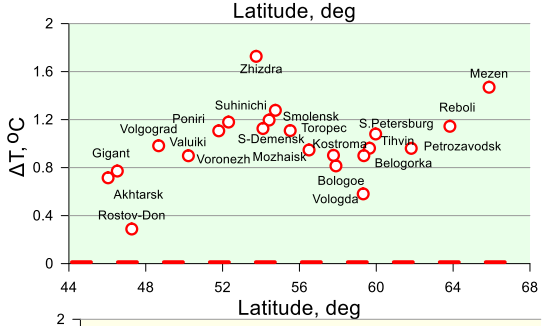
mean seasonal ΔT

S — N

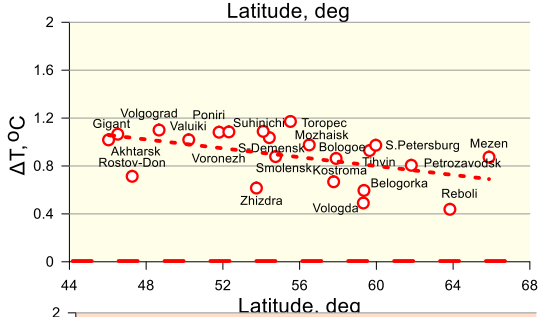
Winter



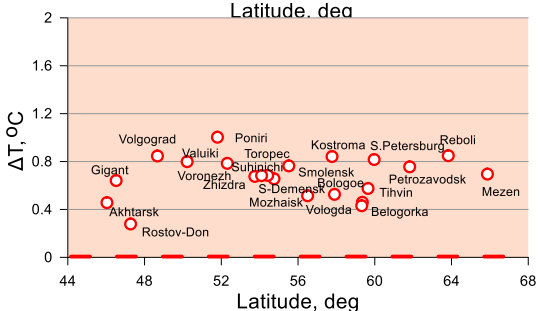
Spring



Summer

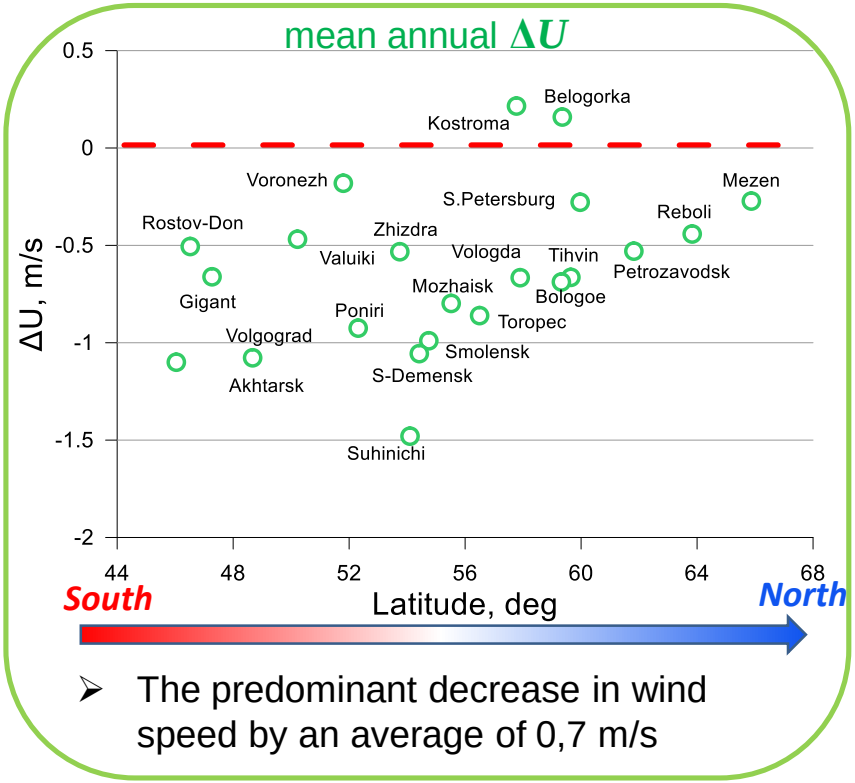


Autumn



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

Latitudinal changes of wind speed ΔU



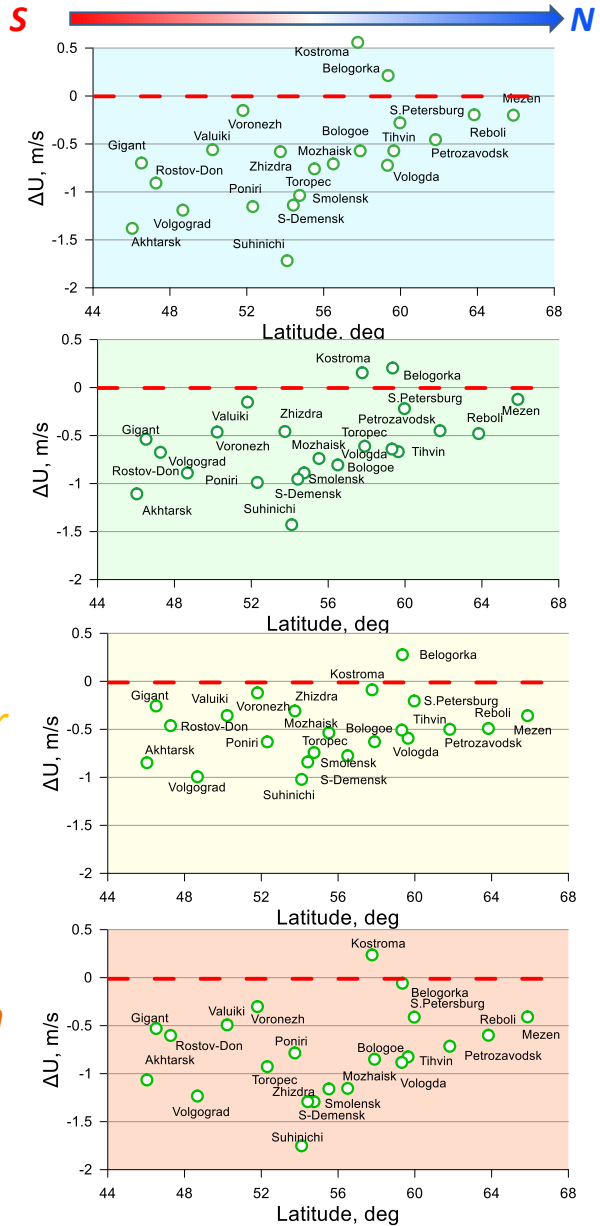
- The predominant decrease in wind speed by an average of 0,7 m/s

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

Air humidity ΔH

- Minor annual and seasonal changes in air humidity by ±1-3%

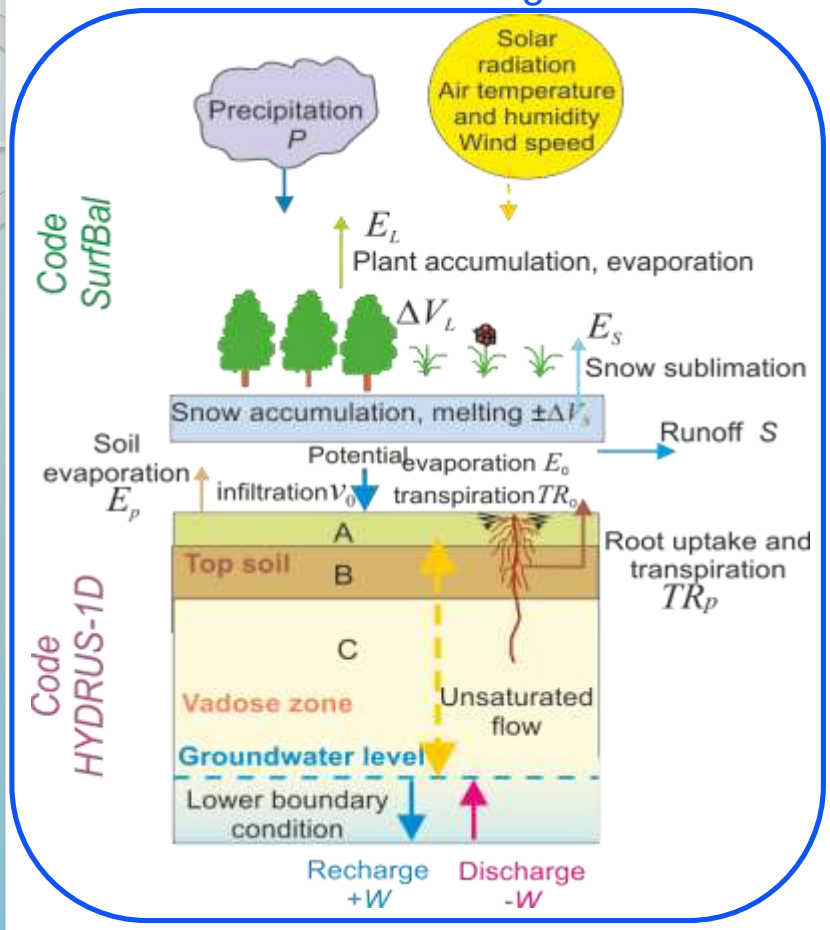
mean seasonal ΔU



How observed climate change affects groundwater recharge ?

Research method: - simulation of groundwater recharge processes

Groundwater recharge model



Input Data: ✓**daily meteorological data for 1965-2018 ;**
✓**typical vegetation and soil parameters**

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

Grinevskii, Pozdnyakov (2010) https://doi.org/10.1134/S0097807810050040
Grinevskiy et al, (2018) https://doi.org/10.1007/s10040-018-1831-1
Pozdniakov et al (2019) https://doi.org/10.1016/j.jhydrol.2020.125247

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: (results of block 1)
✓**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)

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**

$\Delta P = \Delta ETR + \Delta S + \Delta W \pm \Delta V$

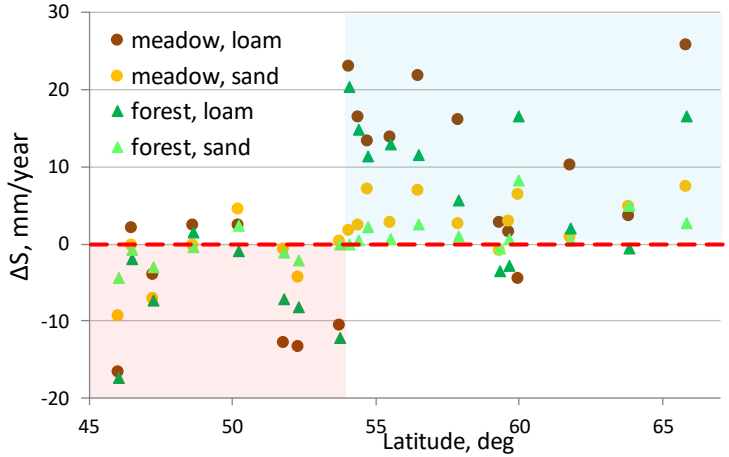
Precipitation = **Evapotraspiration** + **Surface runoff** + **Groundwater recharge** ± **change in Water storage**

Δ – difference between 1965-1988 and 1989-2018

Simulation results: modern climatic changes of water balance

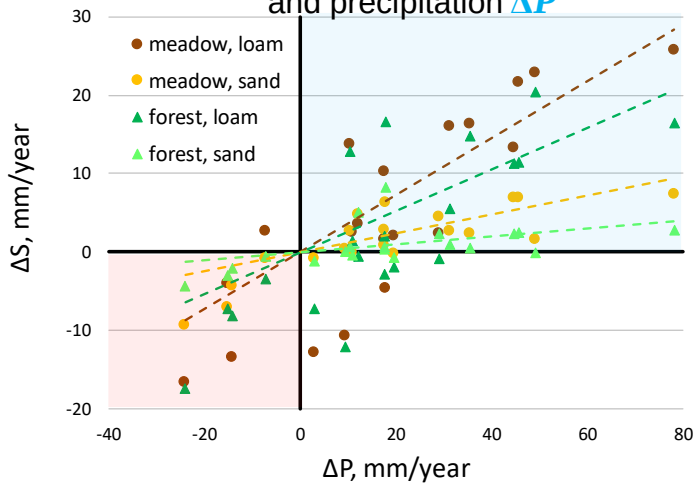
Surface runoff ΔS

Latitudinal changes of annual surface runoff ΔS for different landscapes

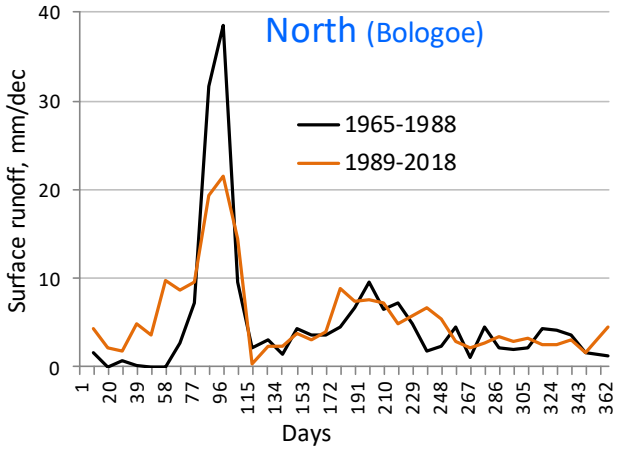


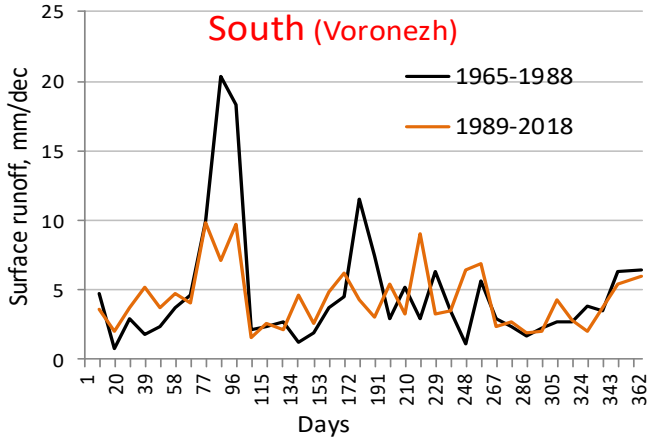
- ***Different changes*** of annual runoff in southern and northern regions: increase in the north, decrease in the south

- The best correlation between changes of surface runoff ΔS and precipitation ΔP



Comparison of mean intra-annual surface runoff





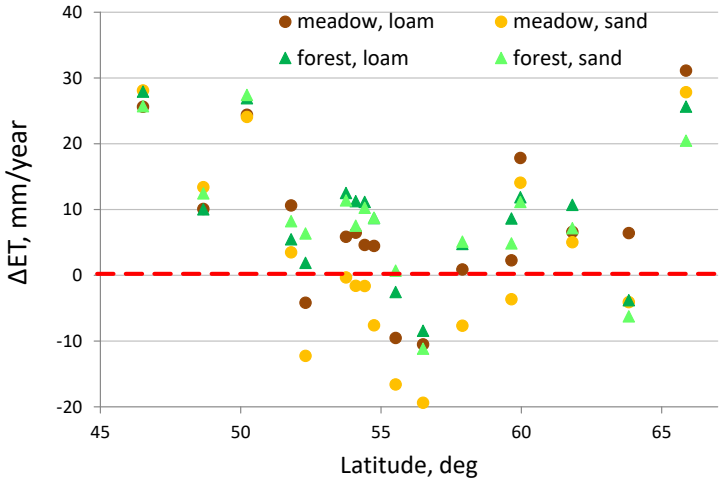
- General ***degradation of thawed flood runoff***

- ***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 ΔET for different landscapes



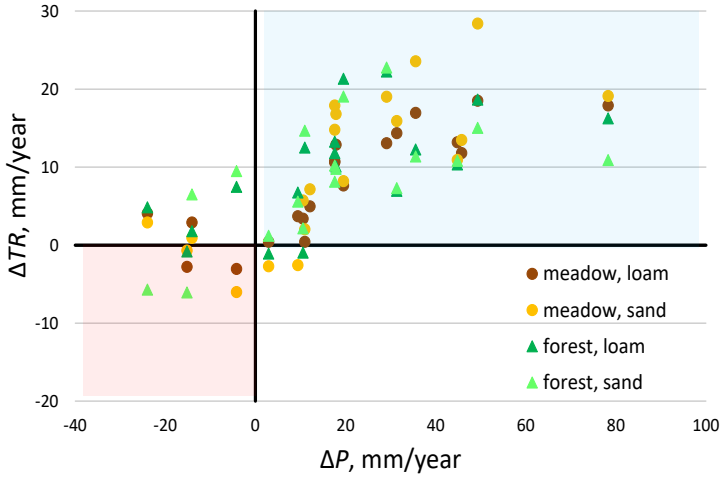
- ***Irregular changes*** of annual evapotranspiration:
  increase in the north and south and decrease in the central part

Complex and opposite impact:

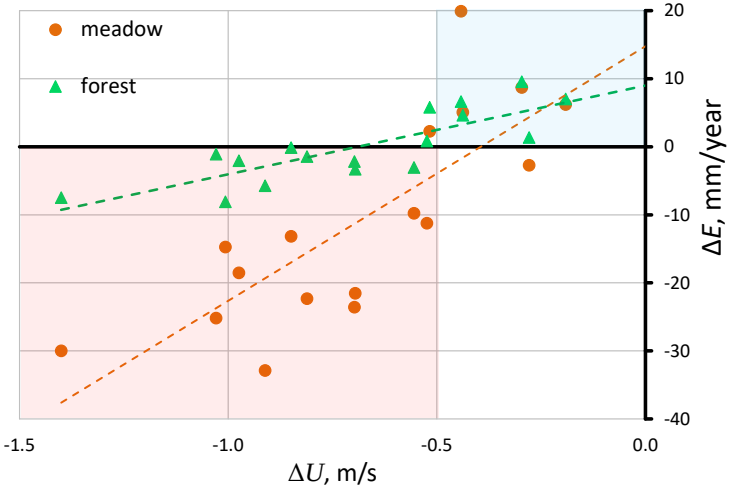
an increase in precipitation and temperature leads to an ***increase of transpiration***

a decrease in wind speed leads to a ***decrease in evaporation***

Correlation between changes of transpiration ΔTR and precipitation ΔP



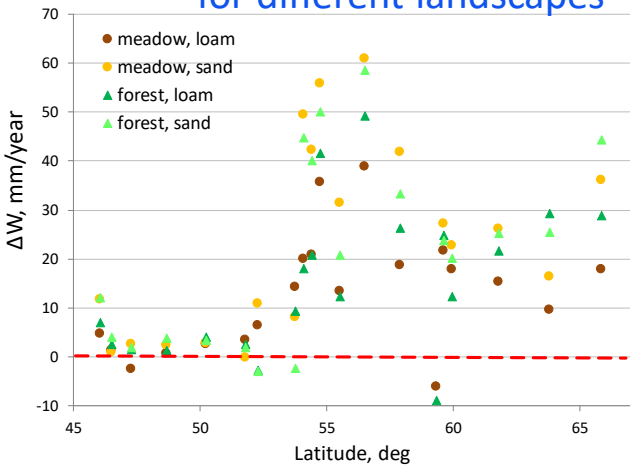
Correlation between reduction in evaporation ΔE and wind speed decreasing ΔU



Simulation results: modern climatic changes of water balance

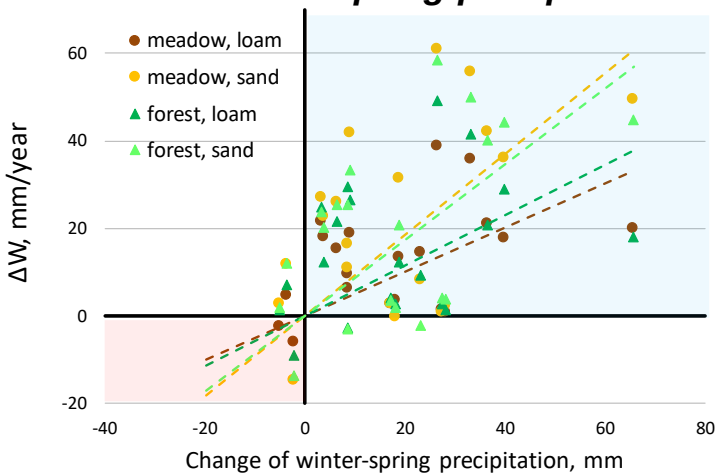
Groundwater recharge ΔW

Latitudinal changes of annual groundwater recharge ΔW for different landscapes

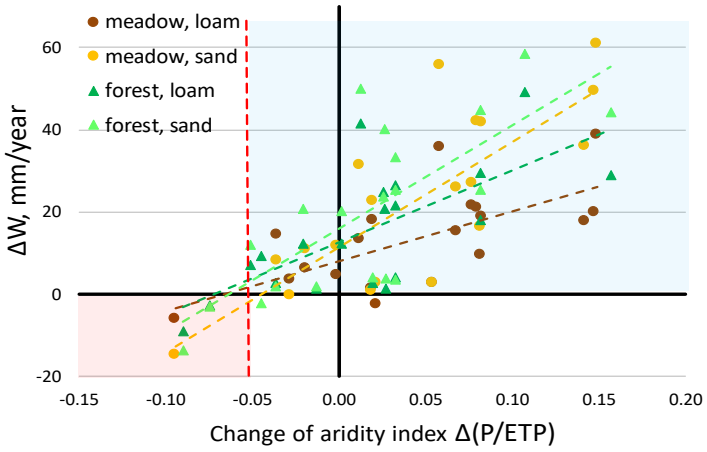


- No changes of groundwater recharge in the south and increase by 20-60 mm/year (up to 50%) in the north

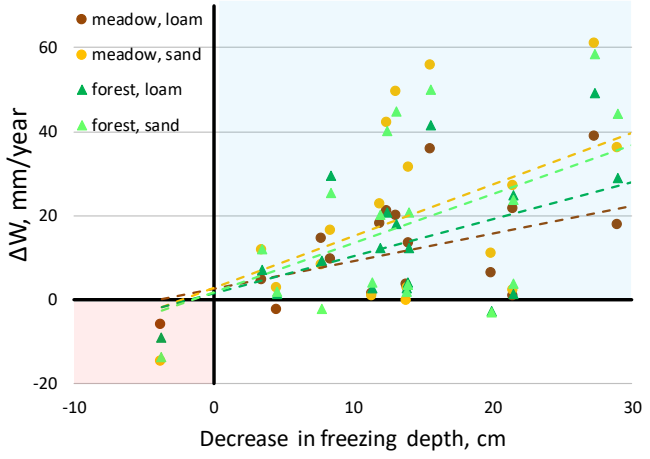
Correlation between changes of recharge ΔW and ***winter-spring precipitation***



Correlation between changes of recharge ΔW and ***aridity index* Δ(P / ETP)**



Correlation between recharge change ΔW 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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