Analysis of the impact of climate change on the formation of groundwater recharge

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This research is dedicated to the evaluation of the impact of climate changes on the formation of groundwater recharge.

Field experiments were conducted in the south-western part of the Moscow artesian basin (MAB), which is situated in the Kaluga Region in Russia.

The climate of the Kaluga Region is temperate continental. The average annual temperature in the region fluctuates between 3.5–4.0°C to the north and between 4.0–4.6°C to the south. Warm period (with positive mean daily temperature) lasts for 205 days on the northern and 220 days on the southern part of the region.

In terms of precipitation, the Kaluga Region can be classified as the zone of sufficient moistening. Precipitation is unevenly distributed in this region: it varies from 390 to 867 mm on the northern part and from 422 to 858 mm on the southern part.

Input information is the climatic data (precipitation, temperature and air humidity) for the period from 1961 to 2012, collected by six meteorological stations in the Kaluga Region (Fig. 1). Increase in minimum, maximum and average air temperatures is observed since 1989 (Fig. 2). Analysis of the data indicates that from the 1961–1988 time period to the 1989–2012 time period, the average air temperature has increased by 1.13°C, the minimum air temperature has increased by 1.15°C while the maximum air temperature has increased by 1.05°C. The precipitation has increased from 4.4 mm/year to 68.3 mm/year.

Two-block model was used in the modelling of water balance processes of the formation of infiltration recharge.

In the first block, processes of precipitation, formation and melting of snow cover, canopy interception, canopy transpiration, snow evaporation, slope wash generation and moisture absorption of soil with account of seasonal soil freezing are modelled (Grinevskii & Pozdnyakov, 2010).

The second block is implemented in program HYDRUS 1D (Šimunek *et al.*, 2005) and represents a model of nonstationary moisture transfer in the unsaturated zone with account of processes of soil evaporation, water uptake by plants and water supply to groundwater level, infiltration recharge (Grinevskii & Novoselova, 2010).

Modelling was conducted for common landscapes (open, i.e. agricultural and closed, i.e. wooded), for common types of soils and unsaturated zones (clayey loam and sands) and for different depths of groundwater level (10 m, 5 m, 3 m, 1 m) (Grinevskii & Pozdnyakov, 2010).

The data of the landscape model are calibrated based on the comparison of the modelled data with the snow cover thickness.

As a result, variations in groundwater recharge in different landscapes are quantitatively described. It was mentioned that the average annual sum of the infiltration recharge, which can reach more, than 20 mm/year, significantly depends on the type of the landscape. For instance, the largest change in recharge was noticed for the closed landscape with sandy soil, while the least change in recharge was noticed for the open landscape with the same soil type.

Patterns of seasonal climate-change-induced variations (which in turn significantly depend on landscape) in infiltration recharge and patterns of other elements of water balance were also analysed.

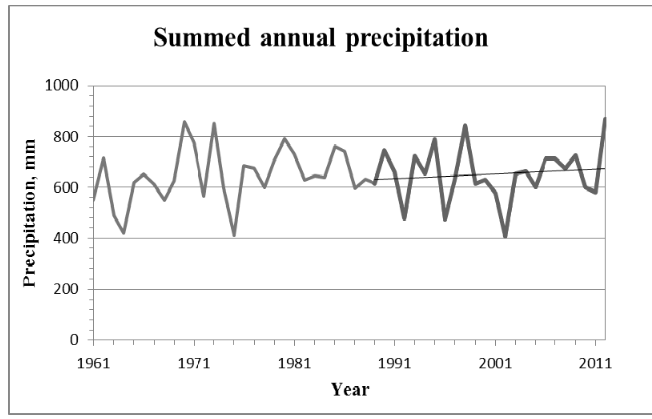

Fig. 1.: Graph showing annual precipitation sums for the period from 1961 to 2012 (trend line is drawn for the period from 1989 to 2012).

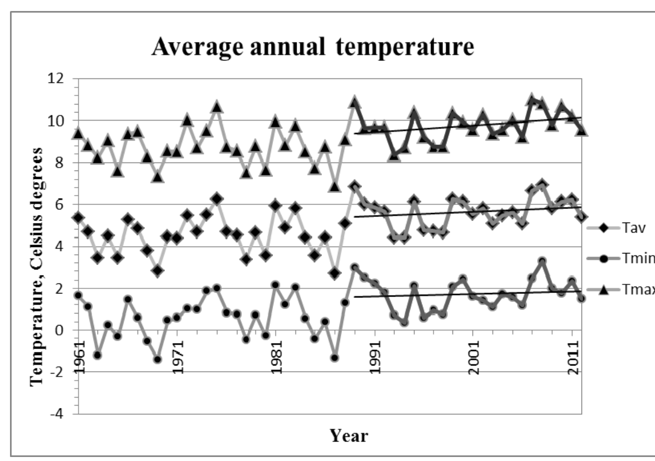

Fig. 2.: Graph showing average annual minimum (Tmin), maximum (Tmax) and average (Tav) temperatures for the period from 1961 to 2012 (trend lines are drawn for the period from 1989 to 2012).

Grinevskii, S. O., Novoselova, M. V. (2010): Water Resour, 37/6: 1-12.

Grinevskii, S. O., Pozdnyakov, S. P. (2010): Water Resour,. 37/5: 1-15.

Šimunek, J., van Genuchten, M. Th., Šejna, M. (2005) The HYDRUS_1D Software Package for Simulating the One-Dimensional Movement of Water, Heat, and Multiple Solutes in Variably-Saturated Media. Version 3.0., Dept Environ Sci, Univ California Riverside: pp. 270.