Digital mapping of topsoil water stagnation in forest-steppe

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Spatial heterogeneity of topsoil water stagnation reflects the landscape water-cycle dynamic and its mapping is of particular importance for regions with intensive agricultural land use. In our research, we hypothesize that the surface and subsurface water redistribution process determines the spatial heterogeneity of topsoil water stagnation. To test our hypothesis, we conducted studies in two key areas in the forest-steppe zone, the center of the East European plain with contrasting soil moisture-regime. Kurskiy key site (35 ha) located in the Central Russian Upland, characterized by free-drainage condition due to deep groundwater, the loesslike loams parent material, and the dense network of shallow hollows on flat interfluves. Kirsanovskiy (390 ha) key site located on a slightly undulating poorly dissected interfluve with low hydraulic conductivity parent material in Volga Upland. The input data for analysis are high-resolution digital elevation models and the values of water-stagnation coefficient of 76 points in the Kurskiy site and 91 in the Kirsanovskiy site. The water-stagnation coefficient is the ratio of the optical density of alkaline soil extract (closely dependent on the soil-water regime) to pyrophosphate extract (quite stable and similar in different forest-steppe soil). The larger the coefficient, the prolonged the soil saturation with water. The landscape process (surface and subsurface water redistribution) was simulated using SIMulated Water Erosion (SIMWE), implemented in open-access software GRASS GIS. The spatial variation of the topsoil water stagnation was determined through a linear regression analysis in which the dependent variable was the water-stagnation coefficient at the description points, and the independent variables were the simulated parameters of redistributed runoff. The runoff redistribution values alone determine the water-stagnation coefficient with the accuracy of more than 80% for both key sites. Thus, we have confirmed the leading role of the landscape process (the moisture redistribution) in the formation of spatial heterogeneity of topsoil water stagnation in two different key sites with contrasting drainage conditions. In the Kurskiy site, the topsoil water stagnation is predicted for about 5% of the total area, in the Kisranovsky site – for about a third.

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