Permafrost in the Caspian Sea basin in the Late Glacier Era as a possible trigger of the sea transgression: checking the hypothesis using a hydrological model

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Paleogeographic data give grounds to assert that at the end of the Valdai Ice Age, transgressions of the Caspian Sea took place, and the sea level during these periods exceeded the current one by tens of meters. The physical mechanisms, climatic or others, that could have caused such an extreme sea level rise have not yet been established. At the same time, in the modern Volga basin, traces of very large ancient river channels are widespread, which could have been formed by ancient rivers with the water flow 2-3 times larger than the modern rivers. Thus, the hypotheses of the extreme rise in the Caspian Sea level can be reduced to considering possible sources of the increase in the flow of the ancient rivers. However, the question of possible sources of such a significant river flow remains open. At the end of the Paleocene - beginning of the Holocene, precipitation over the Caspian Sea catchment was not higher than now, the contribution of melted glacial waters in the Late Glacial Era was also insignificant. Hypotheses about significant changes in the catchment area of the Caspian Sea during those times are not confirmed by paleogeographic data either. In our work, we test the hypothesis that the river inflow into the ancient Caspian Sea could significantly exceed the current inflow due to the spread of post-glacial permafrost over the sea catchment area, which contributed to a decrease in runoff losses due to infiltration into frozen soils.

The physical validity of the above hypothesis was tested using numerical experiments with a hydrological model of the Volga River basin, developed on the basis of the ECOMAG modeling platform. Assuming that the climatic conditions in the modern Volga basin area during the Late Glacial Era were close to the current conditions, numerical experiments were carried out to simulate deep freezing of soil throughout the entire territory of the modern Volga basin area. It is shown that under permafrost conditions, the Volga River runoff increases by 15-20% and does not provide a twofold rise in water inflow into the sea, estimated from paleogeographic data. At the same time, the experiments have shown that such extreme inflow of water into the Caspian Sea could be formed under the conditions of deep freezing of soils and in the absence of seasonal thawing of the frozen catchment area, i.e. at a colder climate than the modern one.