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Experience of determining S-wave velocities beneath the Caucasus from surface waves dispersion curves with the use of high-performance computing

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The Greater Caucasus, along with the Lesser Caucasus and the eastern part of the Anatolian Plateau, forms a tectonically active boundary between the Eurasian and Arabian plates. Since 2017, as part of the implementation of Project [1], a whole network of broadband seismic stations has been deployed here, allowing research in this area to be intensified.

One of the widely used methods for determining the velocity structure of the Earth's upper layers is ambient noise tomography. It is based on the fact that cross-correlation function of noise between two stations, averaged over a sufficiently long - on the order of a year or more - time interval allows to estimate the group and phase velocities of surface waves on paths between stations [2]. Further, using surface wave tomography [3], it is possible to estimate the two-dimensional velocity distribution depending on the period, and then, by solving the one-dimensional inverse problem, to determine the vertical velocity profiles of S-waves.

In this work, cross-correlation functions for all possible interstation paths were computed for records from 69 stations for the year 2018. Dispersion curves of group and phase velocities of Rayleigh waves for periods of 5-30 s were obtained using spectral-temporal analysis. Two-dimensional surface wave tomography was performed, resulting in lateral velocity distributions for periods of 7-22 s, reflecting the velocity structure at depths from 5 to 30-40 km [4]. To solve the inverse problem, it was planned to use T.B. Yanovskaya's program [5], based on the conjugate gradient method. The velocity profile in it is parameterized as follows - up to three layers with constant velocity in the crust and layers with linearly varying velocity in the mantle, varying the thickness of the layers and the velocity within them. The initial model was chosen based on works [6] and [7]. It turned out that the specificity of the data does not allow varying the thickness of the layers, and when only the velocities are varied, it is not possible to obtain an adequate solution. Varying the thickness of the layers is possible by changing the input data, but then it is necessary to run the processing program hundreds of times. The program itself is not resource-intensive when it is possible to use a minimal distributed computing system, but there arises the task of designing a scheme for setting up a group of independent tasks, solved distributedly with subsequent selection of the optimal solution. The paper presents an example of solving this problem and the velocity profiles obtained in this way.

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