

INFLUENCE OF IRREGULARITIES OF WATER VAPOR FIELD IN SURFACE LAYER OF THE ATMOSPHERE ON THE RESULTS OF SATELLITE MONITORING OF HYDROPOWER STRUCTURES IN REGION OF RESERVOIRS

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Results are presented for the modeling of coordinate errors in the projected GNSS system of monitoring the Zagorsk GAES-2 that are caused by local atmospheric irregularities in the surface layer. It has been established that for mean meteorological conditions, these errors can reach 0.8 mm for elevation and 0.1 mm for horizontal position. It is noted that actual instantaneous irregularities exceed mean values by an order of magnitude and can thus cause larger errors in coordinates.

Keywords: GNSS monitoring; hydropower structure; atmospheric nonuniformity; tropospheric delay.

The use of automated high-frequency observation systems for monitoring the technical state of hydropower structures, including by means of modern satellite radio navigation measurements (GNSS) [1, 2] makes it possible to monitor the stability of hydropower structures in real time in automatic mode. The basic principles of satellite technology of monitoring of hydropower structures, the general rules of construction, and the structure of satellite geodetic control systems are described in [3].

The accuracy of satellite coordinate definitions is affected by systematic errors of GNSS measurements, such as those of satellite orbits, multi-path propagation and action of the atmosphere, and so forth. Some errors are of defined diurnal and semidiurnal character that makes it possible to take account of them in an effective manner for satellite observations lasting days and longer [4]. The effect on GNSS radio signals of surrounding natural and climatic factors is merely reported. It is usually indicated that the latter may cause substantive errors. However, the authors do not know of even one study in which an attempt would have been made to estimate numerically the size of errors introduced by local climatic systems. This is explained in part by the extraordinarily difficult solution of the problem of the interaction of the atmosphere and the non-uniform terrain on the scale order of several kilometers or less.

The unsatisfactory study of the question of the effect of local climatic features on the results of satellite monitoring has caused a lack of any practical recommendations about decreasing the corresponding errors. Along with this, one should emphasize that in regions of hydropower structures where there is pronounced non-uniformity of the terrain (the boundary of dry land and the reservoir surface of the water), special attention must be paid to such questions. When passing over a water surface, an air mass receives an additional inflow of water vapor. Appearing thereafter over shoreline GNSS stations, this air mass causes an increase in the moisture component of the tropospheric refraction of GNSS radio signals.

This work is devoted to an estimation of the effect of atmospheric non-uniformities in the ground layer that are caused by the presence of reservoirs near the observation stations, on the results of coordinate determinations in satellite systems of monitoring hydropower structures. The specific example of the Zagorsk GAES-2 (ZaGEAS-2) is considered. The approximate coordinates of the station are 56.5° N and 38.1° E. The upper pool has a form of an irregular oval extended along an east-west line. The length of the upper pool is approximately 4 km, and the width is between 250 and 1000 m. A satellite monitoring grid has been designed to monitor the stability of hydropower structures on the territory of ZaGAES-2. Figure 2 shows a fragment of the network. Hereafter we will examine the effect of atmospheric non-uniformity on the processing of the VPPS — GPS3 vector. The VPPS monitoring station is installed at the water in-

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