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Analiza parametryczna i weryfikacja eksperymentalna numerycznego modelu przepływu wiatru WAsP

Parametric analysis and experimental verification of the numerical wind flow model WAsP

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Abstract

The PhD thesis on parametric analysis and experimental verification of the WAsP wind flow (Wind Atlas Analysis and Application Program) applies to modeling and prediction of wind flow in non-urbanized terrain. The aim of the doctoral thesis is to assess the numerical operation of the WAsP wind flow model based on the wind data, measured using four measuring masts. The use of several measuring masts allowed to check whether the WAsP calculation model is suitable for a given location or to demonstrate limitations in its application for various terrain conditions. Wind data, i.e. wind speed and direction from measurement masts, were used to implement this objective. In the WAsP model and during its evaluation, data regarding terrain formation and coverage - orography and roughness of the area were taken into account. Wind tests for each of the measuring masts lasted over 3 years. Verification of the numerical operation of the WAsP wind flow model consisted in extrapolating the results of wind measurements from three measurement masts to the location of one measuring mast. During extrapolation, Weibull distribution parameters were determined (shape parameter *k*, scale parameter *A*) and average wind speed *v*. The determined distribution parameters based on the WAsP model for data from three measurement masts were compared with the actual values measured at a given location. The calculations were carried out in four variants, corresponding to the locations of each measuring mast.

In the PhD thesis, the issues related to the definition of terrain conditions, including the compliance of the theoretical description of the area with real conditions, were thoroughly analyzed. A digital altitude terrain model and a digital terrain roughness model were developed. The digital elevation model presented in the dissertation was developed on the basis of SRTM-3 data (Shuttle Radar Topography Mission), while the development of the digital roughness model was based on the data of the European Environmental Protection Agency (EEA), Corine Land Cover 2012 data (CLC2012). The use of CLC2012 data to define a digital terrain roughness model is the new approach presented in the dissertation. Terrain models were developed using the GIS (Geographic Information System) computer program - Global Mapper.

Wind calculations made using the WAsP numerical wind flow model were made in a professional computer program for WindPRO wind energy. In order to perform additional experimental verification of the numerical WAsP wind flow model, topographical coefficients of the area were proposed and determined. The topographic coefficient of the terrain allows you to quickly check the correctness of the WAsP model for the given terrain conditions.

Analysis of the calculated parameters of the Weibull distribution and average wind velocity for areas with high roughness values in the area, combined with significant diversity of the relief, showed the greatest limitations in the use of the WAsP model. In order to assess the correctness of the WAsP model operation, the Weibull distribution was compared and the R^2 determination coefficients were determined. In addition, the mean calculated wind velocities were compared with the average measured wind speeds for a given location of the measuring mast. For this purpose, a *PE* percentage error was calculated for all measuring heights in relation to the measured values. For the roughness of the terrain above 1 m and changes in the elevation profile above 50 m in the close vicinity of the measuring mast, the value of the determination coefficient R^2 was in the worst case 0.783. The value of the topographic coefficient of the area reached the highest value of 16,69. The highest value of the percentage error of *PE* for areas with high diversity of land was 13.74%.

For areas with less diversified terrain, the WAsP model was characterized by high accuracy. The calculated R2 determination coefficients reached a value in the range of 0.966 ÷ 9.998. The *PE* percentage error oscillated between 0.71% ÷ 14.46%. The lowest value of the calculated topographic coefficient of the area was 3.98 (simple terrain), and the highest 12,59 (slightly complex terrain).

Based on the obtained results, it was noticed that high values of roughness of the terrain together with large changes in the terrain height, in close proximity to the measuring mast have the greatest impact on extrapolation of wind parameters using the WAsP numerical wind flow model. In this case, the final result of the calculation is affected by an error. Therefore, it was found that the WAsP wind flow model has significant limitations in obtaining results of calculations convergent with real conditions and should not be used in such cases.