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USING ARCGIS 9.X FOR 2D SHALLOW WATER FLOW MODELING

Summary. There are a lot of programs used for modeling of shallow water flow, e.g. MIKE 21(DHI), SMS (EMSi). These programs comprises of three parts: pre-processor (for preparation of input data), computational model, and post-processor (for evaluation of outputs). Outputs from the computational model are usually the velocity and water depth. For further processing (e.g. solving of various analyses) is more suitable conversion these inputs and outputs to the geographical information system (ArcGIS).

This paper is dealing with using computational model of the program SMS and ArcGIS.

UŻYCIE PROGRAMU ARCGIS 9.X DLA DWUWYMIAROWEGO MODELOWANIA PRZEPLYWU WODY

Streszczenie. Jest wiele programów używanych do modelowania przepływu wody, jak np. MIKE 21(DHI) czy SMS (EMSi). Programy te składają się z trzech części: pre-processora (dla przygotowania danych wejściowych), modelu obliczeniowego i post-processora (dla oszacowania produkcji). Produktem modelu obliczeniowego są zazwyczaj prędkość i głębokość wody. Dla dalszego przetwarzania (np. rozwiązywania różnych analiz) odpowiedniejsza jest zamiana tych danych wejściowych i produktów końcowych na geograficzny system informacyjny (ArcGIS).

W tym referacie przedstawiono użycie modelu obliczeniowego programów SMS i ArcGIS.

1. Introduction

A lot of software for shallow water flow modeling which works with different types of data is used presently. The programs are processing various input data and output data which are available in many formats. If we need to work with several software together, we must convert input data or output data to corresponding formats.

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The Surface Water Modeling System (SMS) serves for hydraulic calculations of shallow water flow [1]. This program consist of several computational modules which are able to solve free surface water flow, genesis and propagation waves, sediment transport, and quality of water. We can work with vector data and/or raster data in the SMS. The solution process can be divided into three following steps:

- pre-processing (preparation of input data),
- computation,
- post-processing (evaluation of output data).

ArcGIS (geographical information system – GIS) is made by the company ESRI. Advantage of GIS is its ability to work with many types of data formats. They include:

- text data (descriptions),
- vector data (lines, contour lines, edges),
- raster data (maps, pictures),
- digital terrain model DTM (type of data format – TIN),
- geodatabases.

Input and output data of hydraulic model FST2DH will be saved to the geodatabases into ArcGIS for further using.

We are able to make interface between GIS and other programs, for example SMS. The process is shown in Fig. 1.

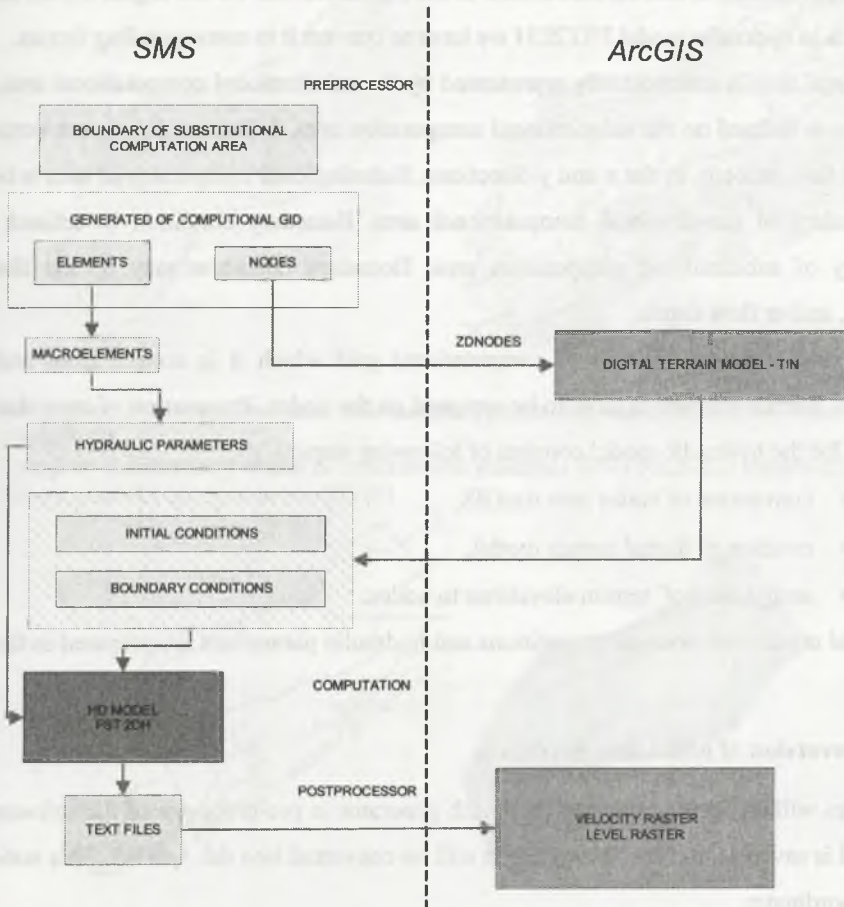


Fig. 1. The solution process between software SMS and ArcGIS
 Rys. 1. Rozwiązanie procesu pomiędzy oprogramowaniem SMS a ArcGIS

This paper shows the using of interface between to programs, ArcGIS 9.x and SMS (computational module FST2DH). The ArcGIS is used as pre-processor and post-processor.

2. Pre-processor

Pre-processor of the SMS is able to work with GIS data but SMS cannot work with TIN (SMS can work with ArcObject). TIN is type of format DTM. In the ArcGIS we work mostly with raster data, vector data, and TIN (i.e., digital terrain model). Digital terrain model is

spatial reproduction of real surface terrain in the digital format. To use digital terrain model as input data in hydraulic model FST2DH we have to convert it to corresponding format.

The real area is schematically represented by the substitutional computational area. Initial condition is defined on the substitutional computation area. Initial conditions are water depth and unit flow velocity in the x and y directions. Substitutional computational area is bounded by boundary of substitutional computational area. Boundary condition is defined on the boundary of substitutional computation area. Boundary condition may be the flow rate, velocity, and/or flow depth.

The first step is generated of computational grid which it is consist from nodes and elements. Terrain elevations have to be assigned on the nodes. Preparation of input data in the ArcGIS for the hydraulic model consists of following steps:

- conversion of nodes into ArcGIS,
- creation of digital terrain model,
- assignment of terrain elevations to nodes.

Initial conditions, boundary conditions and hydraulic parameters are prepared in the SMS.

2.1. Conversion of nodes into ArcGIS

Nodes will be firstly created by the mesh generator in pre-processor of the software SMS. The grid is saved as text file. The text file will be converted into the ArcGIS. This nodes has x and y coordinates

2.2. Creation of digital terrain model

Digital terrain model is made up of vector data which comprise points (fig. 2 left), contour lines (fig. 2 right), and edges (fig. 3 left). These data were created upon terrain measurements (i.e., geodetic measurement, aerial photogrammetry, laser scanning). DTM in the format TIN occurs by combination of these data. TIN is created by extension 3D analyst in the ArcGIS. Digital terrain model is shown in fig. 4. Boundary of substitutional computational area is red line.



Fig. 2. Substitutional computational area with measured points (left) and contour lines (right) from ArcGIS [3]

Rys. 2. Zastępczy obliczeniowy obszar ze zmierzonymi punktami (lewy rysunek) i warstwicami (prawy rysunek) z programu ArcGIS [3]

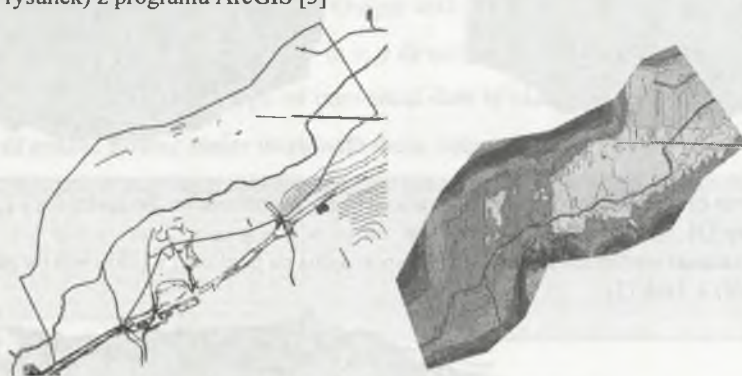


Fig. 3. Substitutional computational area with measured edges (left) and digital terrain model (right) from ArcGIS [3]

Rys. 3. Zastępczy obliczeniowy obszar ze zmierzonymi krawędziami (lewy rysunek) i cyfrowy model terenu (prawy rysunek) z programu ArcGIS [3]



Fig. 4. Spatial model of digital terrain model from ArcGIS [3]

Rys. 4. Przestrzenny model cyfrowego modelu terenu z programu ArcGIS [3]

2.3. Assignment of terrain elevations to nodes

We have to assign terrain elevation to each node. Nodes from the SMS are converted through the text file into the ArcGIS. Those converted computational nodes have x, y coordinates. Z-coordinate is assigned from the digital terrain model. Nodes are depicted in fig. 5 with red colour.

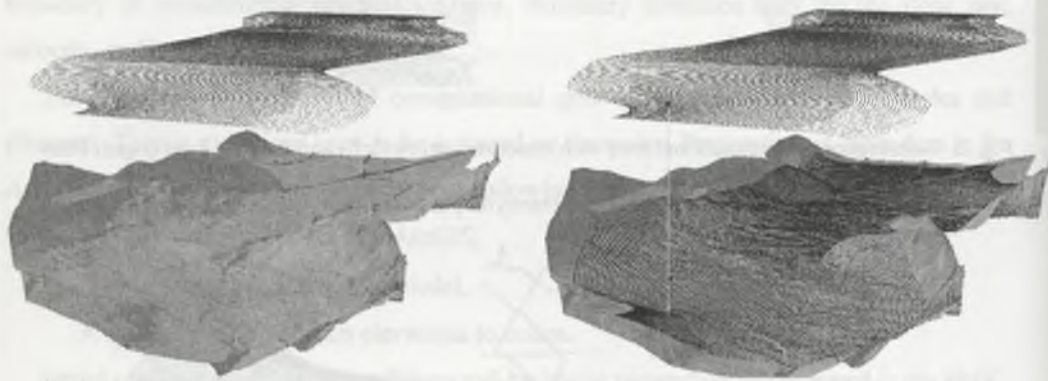


Fig. 5. Scheme of assignment of terrain elevations to z – coordinate on the nodes (up) 1. step, (down) 2. step [3]

Rys. 5. Plan zadania wyniesień terenu do z – współrzędna na punktach węzłowych (w górze) 1. krok, (na dół) 2. krok [3]

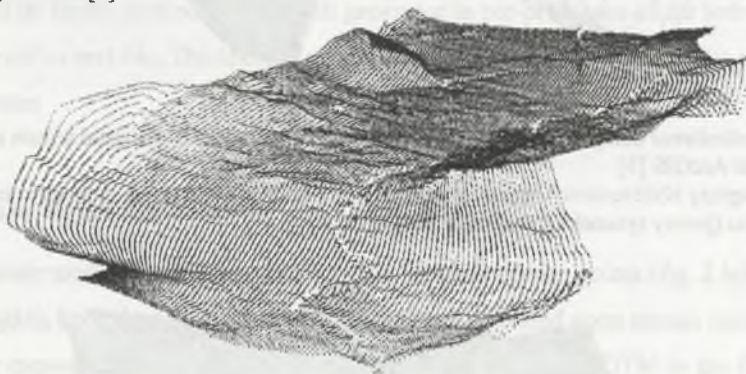


Fig. 6. The nodes with z – coordinate [3]

Rys. 6. Punkty węzłowe z z – współrzędne

The modified nodes are converted back into the SMS.

3. Computation

FST2DH solves the 2-D horizontal flow, depth-integrated continuity, and momentum equations by applying a flux-based finite element method (FEM). Velocity components in two horizontal dimensions are calculated as well as water levels [2].

4. Post-processor

Output data of FST2DH model are global velocity and water levels. They are time variables. These outputs are written in the text files. Output text file of levels includes columns with x , y coordinates, and levels. Output text file of velocity includes columns with x , y coordinates, and velocity components in x , y direction. Text file with outputs is converted into ArcGIS through converter. Type of converted data is raster. The database created from raster data will enable further easier work with these data.

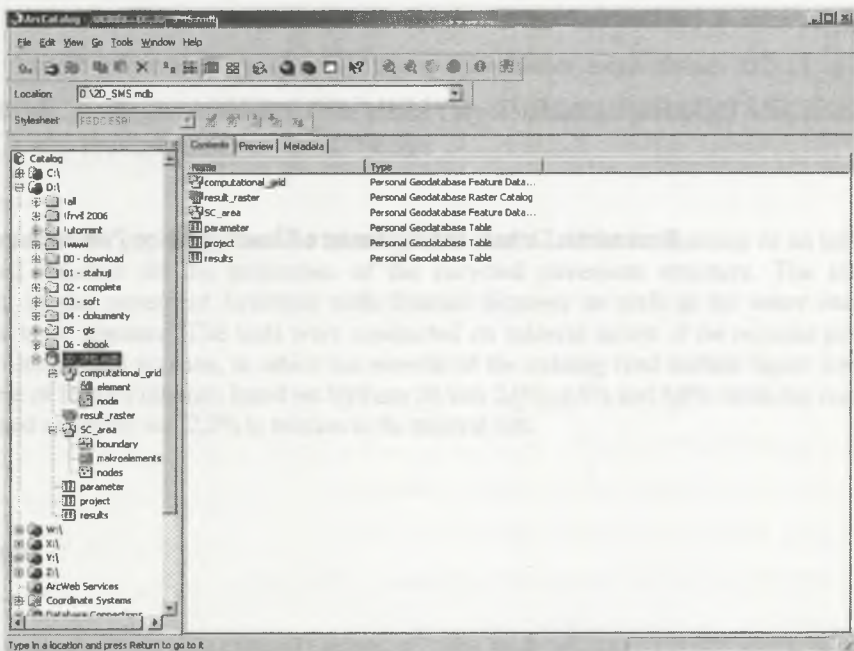


Fig. 7. Example of database for surface water flow modeling in ArcGIS

Rys. 7. Przykład bazy danych dla strumienia wody powierzchniowej zamodelowanego w ArcGIS

5. Conclusions

Created interface between software SMS and ArcGIS will serve as part of pre-processor and post-processor. Modification of outputs in ArcGIS will enable easier manipulation with these data for future processing, for example risk analyses.

This work has been carried out with the financial support of the Agency for the Development of Universities in the Czech Republic, project no. FRVŠ 2005/2007/G1 „The use of geographical information system for modelling of 2D horizontal water flow“.

LITERATURE

1. <http://www.ems-i.com>.
2. User's Manual for FESWMS FST2DH Two-dimensional Depth-averaged Flow and Sediment Transport Model. U.S. Department of Transportation Federal Highway Administration, publication No. FHWA-RD-03-053, September 2002.
3. Čejp J.: 2D matematické modelování proudění vody v záplavovém území. Diploma theses, Brno University of Technology, Faculty of Civil Engineering, Brno, 10/2004.

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