



HyVis and InVis: Two tools for the visualization of structures and 3d interpolation in ArcView

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Abstract

The 3d interpolation, structural modeling and visualization of hydro geological and environmental data in a GIS are always difficult. Two small tools were developed to support these tasks in ArcView 9.x. InVis uses 3d data from boreholes or wells to interpolate vertically in 1d and then in horizontal layers in 2.5d. HyVis takes borehole data from a standard database to generate the base information for cross sections. The structural information is then used to interpolate the bottom slices for each layer. Both tools are programmed in VBA and use the extensions Spatial Analyst, Geostatistical Analyst and 3D Analyst.

1 Introduction

The handling of 3d data in GIS is always a problem: GIS are oriented in 2d and 2.5d interpolation and visualization but they have no capabilities for real 3d data. ArcView is one of the most widespread GIS tools and therefore the extensions Spatial Analyst, 3D Analyst and Geostatistical Analyst were used to support two 3d modeling concepts. Both tools presented here work with dialogs to support the user. The results can be visualized seamlessly in the 3D Analyst.

1.1 InVis

In environmental geology soil, soil water, soil air and groundwater data are given in 3d: Additionally to the Northing and Easting the depth of sample is used to characterize the location of a sample. For most of the contaminated sites a statistical criterion – mean, median, highest or lowest value – is used. In a big contaminated site as the Bitterfeld area (Germany) the contamination spreads over various aquifers and a total depth of some 50-100 m. For groundwater modeling approaches it may be also reasonable in some areas to interpolate hydraulic parameters e.g. hydraulic conductivities and storage coefficients although a structural modeling approach as described and implemented in HyVis is in most cases more suitable.

For these purposes an interpolation in 3d may be used and a GIS would be the first tool to work with: It provides a georeferenced data visualization and sophisticated data management tools for intersections, spatial calculations, database handling, interpolations etc.. Nevertheless a 3d interpolation technique is missing because GIS are horizontally oriented and only a few features support a 3d data handling. ArcView 9.x (ESRI 200x) is a common GIS and the development of new tools is possible via the VBA programming interface. This API was used to develop a standard 3d interpolation technique based on the predefined modules/classes for 2.5d interpolation in Spatial Analyst and Geostatistical Analyst.

1.2 HyVis

Hydrogeological modeling is widely dependent on 3d structures of aquifers and aquitards. Although the interpolation in 2.5d for the layer bottoms is supported in GIS the problems arise in the sparse dataset derived from boreholes. Any interpolation neglects the knowledge of the scientists and thus an enhancement by cross sections is advantageous. GIS as ArcView 9.x don't support the generation, visualization and work with cross section and the transfer of the results back to the horizontal 2.5d. Therefore cross sections with information of the surface geology and the boreholes derived from databases are created in an extra view. The data needed for HyVis are therefore as follows:

- A GRID or TIN of the surface elevation
- A geological map (vector data)
- The borehole information derived from a database.

The results of the cross section modeling are then transferred back to horizontal information and serve as a database for the 2.5d interpolation.

2 Methods

The methods for both tools, InVis and HyVis, are explained separately in the following chapters.

2.1 InVis

The interpolation in 3d is solved in a standard way with support of VBA scripts. Assumed that in boreholes the vertical information is given in a suitable resolution, the tool will interpolate in 1d with an inverse distance weighted approach. The user is asked for the setup of horizontal layers. For the middle of all these predefined layers a value is estimated and serves as an input for the subsequent 2.5d interpolation of values. Then the interpolation capabilities of the Spatial Analyst are used, by default the inverse distance weighted method is used because in the Spatial Analyst no variogram analysis (kriging) is supported.

2.2 HyVis

For HyVis no new methods were developed. The advantage of this tool is the combination of existing methods. The basic information is used to create cross sections based on the digitization of the cross section lines, the surface information and the boreholes. A workflow of the modelling process is shown in fig. 1.

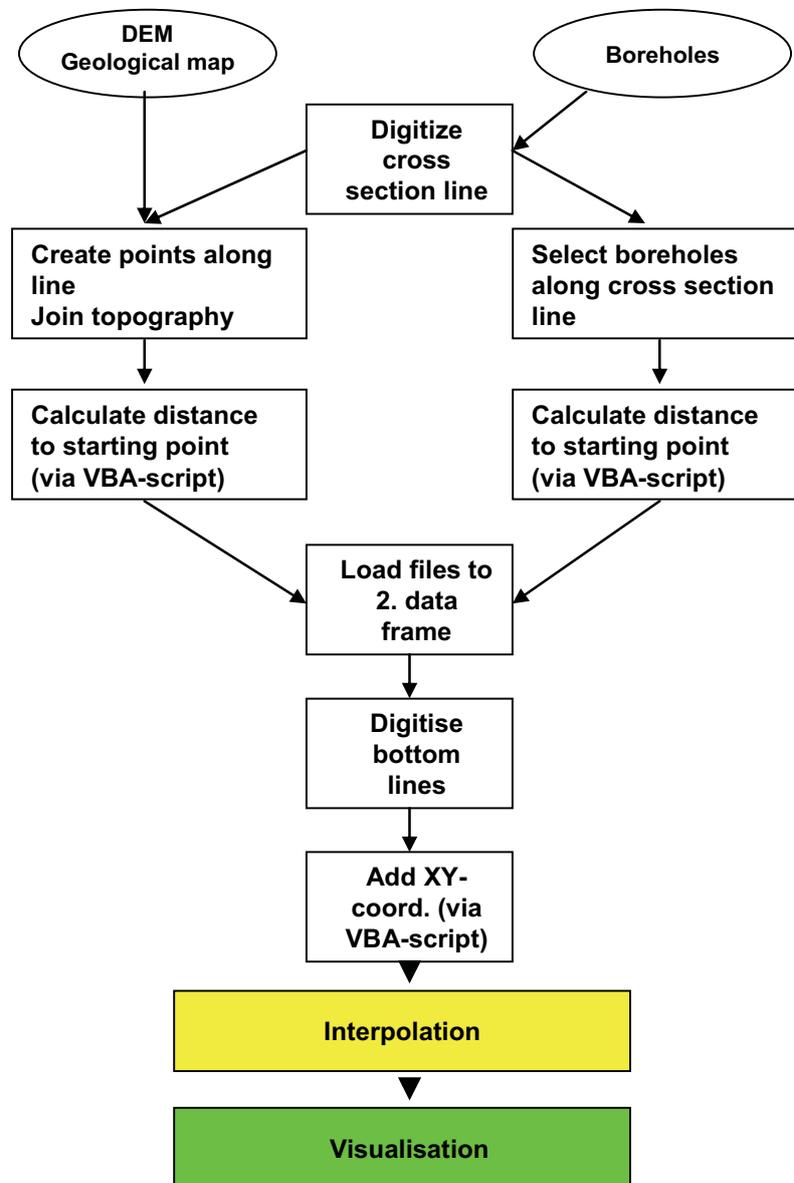


Figure 1: Workflow of the modelling process with HyVis

It should be mentioned that it is advantageous to connect boreholes; a projection of boreholes to a distant cross section line is not supported in a correct way. The cross sections should also cross each other at borehole locations otherwise virtual boreholes should be constructed manually. Fig. 2 shows a digitized cross section line and the selected boreholes along this line.

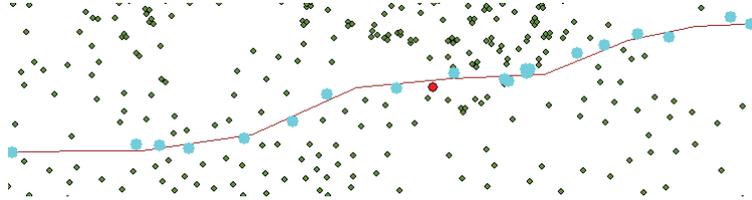


Figure 2: Cross section line with the selected boreholes in a certain distance to the line.

The cross sections will be visualized in a separate view because the coordinates don't match the Easting and Northing values of the map. This procedure is supported by VBA scripts (see fig. 3).

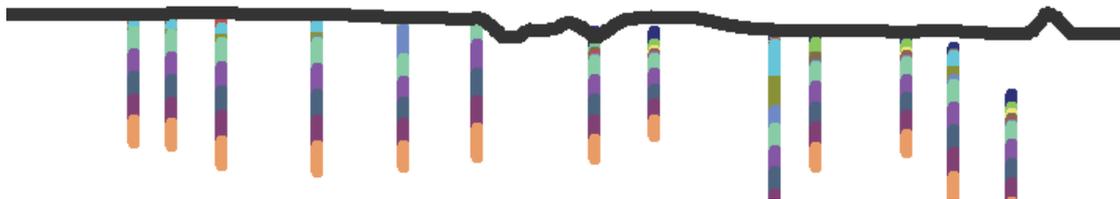


Figure 3: Cross section view with surface and boreholes.

The user then digitizes the bounding lines for each layer in the cross sections and this allows also for an implementation of additional geological knowledge e.g. of the outlines of erosive channels, terrace sediments or suitable slopes and gradients of layers (see fig. 4).

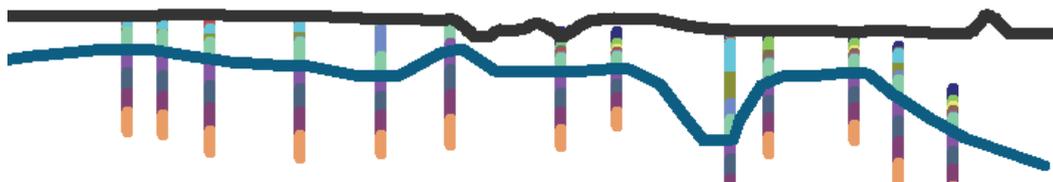


Figure 4: Digitisation of bottom lines in the cross section based on borehole information.

The digitized lines are then converted to points via VBA scripts and attributed with values for Easting and Northing. The points for each surface or bottom of a layer are then used as an enhanced database for the interpolation. The results of the interpolation are not controlled automatically, so the user has to control for intersections of surfaces/bottoms and how to handle this. Especially erosive structures, perhaps – depending on the model area – with anthropogeneous impacts like mining must be handled thoroughly.

3 Results and discussion

Both methods were used in the frame of several projects and proved to be helpful. Especially the dialogs are necessary for a seamless and fluent workflow. Nevertheless the manual is needed to support the modeling process. ArcView itself is not the best tool to model in 3d but a real geological modeling system has at least two disadvantages compared to the proposed methods: First

it is expensive and not affordable in most cases and second the software ArcView is a common tool that is well known by geoscientists. On the other hand the disadvantages of these methods are also clear. First of all special geological features like faults are not supported and it is difficult to implement them because of the general capabilities of ArcView. Fading out of layers and lenses can be modeled but only with some tricks, which are not supported by the VBA scripts. The visualization in 3d via the 3D Analyst and Arc Scene is not high resolution and the handling of extrusions is not self explaining so that the result is good for working but not for a high resolution presentation. The standard formats (shape files and ASCII-GRIDs) are mostly supported by subsequently used numerical groundwater modeling tools, e.g. Feflow™ or MODFLOW with preprocessors, or mining tools, e.g. EVS/MVS, so that parameter distributions or structural models can be imported in a comfortable way. A visualisation result from InVis is given in fig. 5.

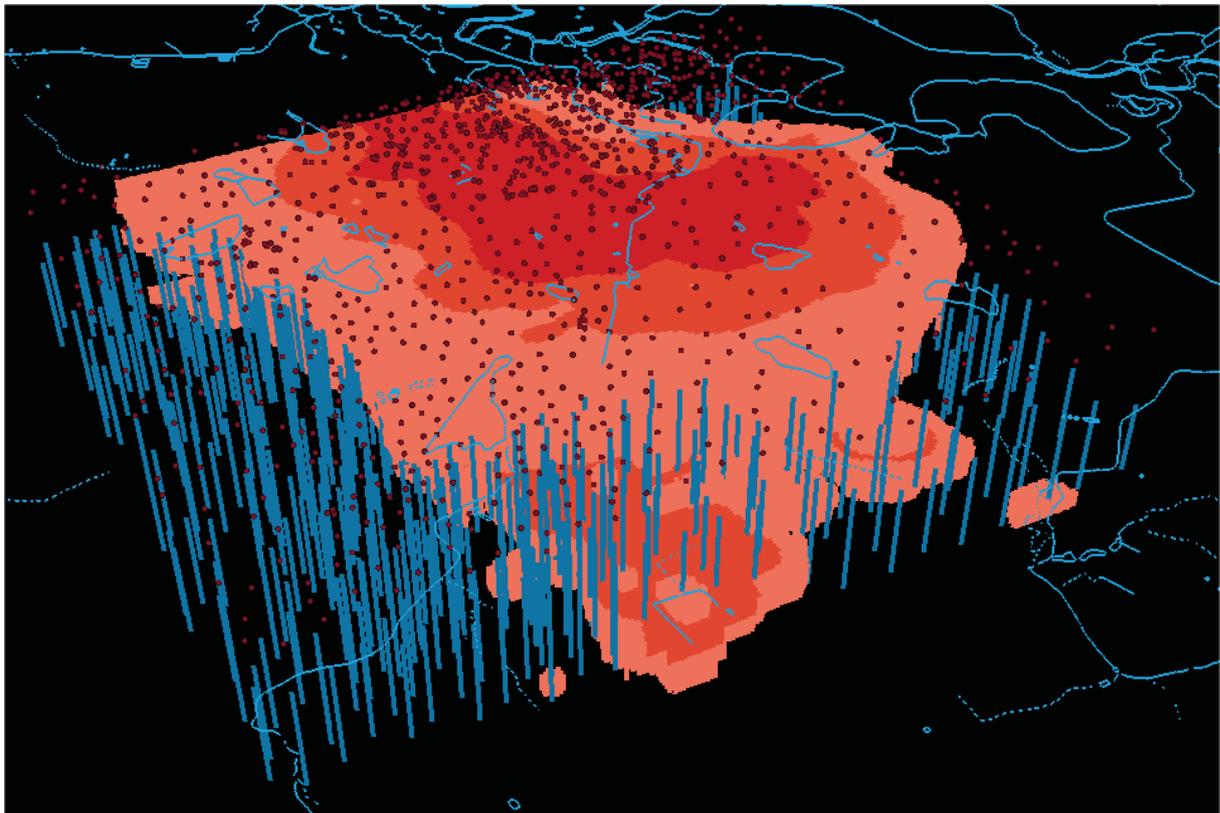


Figure 5: Visualisation result with InVis in 3D Analyst. Isosurfaces can be visualised as well as the boreholes and on top a map of the surface water system.

4 Conclusion

The tools are available as “OpenSource” so that the scripts may serve additionally for two purposes.

First the VBA scripts are helpful to improve them for the own needs. They are well documented and easy to understand. An improvement should be possible for advanced users who are capable and already used to VBA programming.

Second the VBA scripts may also serve to learn high sophisticated strategies and their implementation in a programming language.

Compared to commercial closed source the user knows what is going on and can adapt own improvements as necessary. The VBA programming with ArcObjects allows for very high sophisticated extension of the standard tools and the programming language itself is easy to learn - ArcObjects is not easy but there is support via sample scripts on ESRI's homepage and good books e.g. Burke (2003).