Technical note

The development of GIS-PMWIN and its application for mine-water modelling in the Far West Rand, South Africa

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ABSTRACT

A toolbar GIS-PMWIN was developed in ArcGIS 9.3 using the embedded Visual Basic for Application. The purpose was to create a linkage between ArcGIS and PMWIN for groundwater modelling with GIS data in PMWIN. Six function modules are developed, including: (i) set model dimension, (ii) modify the current model, (iii) export the grid specification file, (iv) prepare and export the boundary condition files, (v) set top and bottom elevation of layers, and (vi) prepare and export matrix data. Based on the conceptualisation of the study area, the model dimension, discretisation and many value setting processes can be easily carried out in ArcGIS rather than directly in PMWIN, through these function modules. The grid specification file and other input files can be exported as the PMWIN-compatible files which can be directly loaded to PMWIN for modelling. The linkage can be used with a higher version of PMWIN or ArcGIS. It has been applied to mine water modelling in the Far West Rand of the Witwatersrand basin to simulate dewatering and re-watering conditions and scenarios. The modelling practice is elaborated in detail as a case study, and it is demonstrated that the linkage is efficient and easy to use.

Keywords: ArcGIS, PMWIN, groundwater modelling, dewatering, re-watering

INTRODUCTION

Geographic information systems (GIS) are a powerful tool in the field of geosciences (Lukas et al., 1995). GIS has been extensively used to store, analyse and present both spatial and non-spatial data. Surface Water Resources of South Africa 1990 (WR90, Midgley et al., 1994), Water Resources of South Africa 2005 (WR2005, Middleton et al., 2009; Middleton et al., 2011), National Groundwater Database (NGDB), National Groundwater Archive (NGA) and National Groundwater Information System (NGIS)(coordinated and maintained by the Department of Water Affairs, DWA), Groundwater Resource Assessment Phase 1 and Phase 2 (GRA1 and GRA2 , coordinated by DWA) and the on-going GRA3. These datasets have been frequently used in hydrogeological projects. In addition to GIS, which serves as the main data platform, numerical modelling is a necessary approach for much groundwater research or practice, especially that related to water supply, aquifer evaluation and mass transportation. Various software programs are available for groundwater modelling, of which MODFLOW (McDonald and Harbaugh, 1983) is one of the most commonly used, partly because of its free and open-source code. However, data preparation for MODFLOW has long been a challenge that hydrogeologists face, especially for large-scale simulations with complicated hydrogeological conditions. A fixed data format is strictly required in MODFLOW for all of the input datasets, while most of the existing data are in GIS format. In South Africa, this scenario is typically the case.

There are some commercial software packages which both incorporate MODFLOW and support GIS data format, such as GMS (AQUAVEO, 2013), Visual MODFLOW (WHI, 2006) and Groundwater Vistas (Rumbaugh and Rumbaugh, 1998). However the high price and complicated method of pre-processing have made them less accessible to modellers, especially beginners and learners. PMWIN (Chiang, 2005) is an option that falls between MODFLOW and the aforementioned expensive modelling software in terms of data compatibility and price. The lower version, PMWIN 5.3, is free of charge and can be downloaded from the official website (http://www.simcore.com/pm53). Generally, PMWIN has the following advantages compared with the DOS version of MODFLOW:

- User-friendly interface
- Visualised pre-processor and post-processor
- A simple geo-referencing tool
- Several transport models (MT3D, MT3DMS, MOC3D, etc.) and inverse codes (UCODE and PEST) integrated

Because of its cheaper/zero price and the mentioned advantages, many modellers prefer PMWIN for conducting groundwater modelling. Unfortunately the most popular GIS data format, shapefile, is not supported in PMWIN. Modellers have to try to simplify their model to avoid the time-consuming pre-processing procedures, which can result in important information being left out or the required resolution for a specific study being lost. Moreover, the value-setting process for aquifer geometrics, boundary conditions, initial conditions, aquifer properties, and stresses like recharge and pumping, can only be done manually cell by cell or using some simple batch operations in the free version, PMWIN 5.3. Spatially-related operations are generally difficult to perform to speed up procedures. Even if this situation has been improved in the higher versions PMWIN Pro 7.x and 8.x, by importing a dxf or bln file, which can be converted to the zone file/polygon

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Received 10 July 2013; accepted in revised form 5 March 2014.

http://dx.doi.org/10.4314/wsa.v40i2.13
Available on website http://www.wrc.org.za
ISSN 0378-4738 (Print) = Water SA Vol. 40 No. 2 April 2014
ISSN 1816-7950 (On-line) = Water SA Vol. 40 No. 2 April 2014