Utilization of GIS Technology to Support Development of Flow and Contaminant Fate and Transport Models at US DOE Sites

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BACKGROUND

The Applied Research Center (ARC), at Florida International University (FIU), has supported the remediation efforts of the US Department of Energy’s Oak Ridge Operations (DOE/ORO) in Tennessee through the development of tools and techniques to support the modeling of transport and fate of contaminants in the subsurface. The focus of the project is to develop and implement GIS-based workflows and scripts to provide a systematic and efficient approach to performing various computational tasks. This involves transforming raw data into spatially and temporally enabled data that can support the modeling tasks.

METHOD

Development of an ArcSDE Geodatabase

The ORE Geodatabase (Fig. 2): A replicated relational database containing geospatial data layers that are stored on an Advanced Windows Server using ArcSDE for Server.

- Based on ArcSDE and ArcGIS Base (data models) which have served as data sources in the geographic information system (GIS) development with the ORE Geodatabase.
- Based on the ArcSDE information models that support the ORE Geodatabase.
- Comprised of data that can be used for water resource applications within the ORE Geodatabase.
- Modifications were then made for project specific input parameters.

Pre- and Post-Processing of Model Data using ArcGIS

- GIS/RPG software used to analyze pre and post processing of hydrological modeling data.
- The MIKE SHE model uses an extensive amount of GIS data inputs (Fig. 3).

Fig. 3. MIKE SHE Model Spatiotemporal (GIS) Data Inputs

ArcGIS ModelBuilder & Python

ArcGIS ModelBuilder in a python script was used to create repetitive model-specific geoprocessing tasks using ArcGIS ModelBuilder.

- ArcGIS was developed for use with the EPIC model, but it is scalable and reusable with geoscientists containing data relevant to other DOE sites.
- Contour tools and scripts automate the query and retrieval of thousands of data and flow transport parameters from the hydrological model.
- The ArcGIS model iterates through selected features and exports the results in tabular format.

Fig. 4. MIKE Model Run In MIKE SHE

ArcGIS Geodatabase Diagrammer

- Details of the ORE geodatabase data and schemes were generated using the ArcGIS Geodatabase Diagrammer utility for ArcGIS 10.2.
- ArcGIS Diagrammer is a productivity tool that allows creating, editing and managing geodatabase schemes.
- It generates reports (Fig. 6) and diagrams (Fig. 7) in the form of scalable graphics and serves as a visual editor which accepts XML workforce documents that are created by ESRI’s ArcGisDiagrammer.
- Reports generated depict the ORE geodatabase data structure and details of the features, tables and spatial and tabular data used during hydrogeological model development as well as any existing hydrogeological and spatial data.

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Fig. 6. ArcGIS Diagrammer/ Map Reader Diagram

Statistical Analysis

- Customized Python scripts were developed to perform statistical analysis on modeled data.
- A library of scripts was implemented and coupled with existing statistical tools, namely R, Python, and MATLAB.

BenEFITS & CONTRIBUTIONS

- GIS-based hydrological models can provide a spatial element that other hydrologic models lack.
- GIS enables hydrologists to preprocess and integrate data derived from multiple sources into a single management system.
- GIS-based approaches in hydrological modeling can be used to combine different layers of geographic information to create new integrated information which can be quite useful for creating dependent or independent hydrological variables.
- GIS was always a useful tool in visually displaying research results via maps, graphs and reports which helps to enhance the understanding and interpretation of model derived results and to obtain a perception closer to reality.

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