Ferrara , 21, 22, 23 Settembre 2010 - Congresso:
Risorse geotermiche di media e bassa temperatura in Italia.
Potenziale, Prospettive di mercato, Azioni
Sessione POSTER

Organizzazione

con la collaborazione di

TOUGH2VIEWER: POST PROCESSING TOOL FOR VISUALIZATION OF GEOTHERMIC MODELS

P. Berry[a,b], S. Bonduá[a], V. Bortolotti[b], C. Cormio[a,b], A. Diolaiti[b], E. Lognoli[b]

[a] Department of Civil, Environmental, Materials Engineering - University of Bologna, Italy

[b]CINIGeo - National Interuniversity Consortium for Georesources Engineering – Rome, Italy

Abstract

TOUGH2 [1] is one of most used numerical simulator code for nonisothermal flows of multicomponent, multiphase fluids in one, two and three-dimensional porous and fractured media. Within the research project for the characterisation of geothermal reservoirs called MAC-GEO, the authors have developed an integrated system to facilitate the mesh creation and population of irregular grids by means of the open source GRASS GIS [2][3] and a specifically modified version of the code AMESH [4].
Now a days, available commercial software are able to manage and display regular TOUGH2 output data, but there are limitations on irregular grids. To overcome these limitations, an application able to read and manage TOUGH2 output files regarding irregular mesh has been developed. The software viewer is written in JAVA [5] and uses the JAV3D [6] libraries to be platform independent. It is possible to obtain an interactive 3D view of whole grid-blocks, blocks that are prism obtained from Voronoi polygons [7]. It also provide elementary statistics of all domain simulated or permits to get all information about a single block, plot vertical variable profiles and export extracted data in text format. Several functionality was implemented in the code for block search, contour mapping and surface 3D mapping of available TOUGH2 primary variables (P, T, Sg, etc). The viewer is able to display also 2D and 3D vectorial view of the flux between blocks, for each time step in which the simulation proceed. It's also possible to visualize each rock types with different colours. At this stage of the development work, it is possible to read and visualize TOUGH2-EWASG [8] processed data (regular and irregular mesh) and that referring to TOUGH2-EOS1 (Cylindrical mesh). The application is under developing but the beta version now in use is a valid help for the post processing phase to inspect the simulated data coming from TOUGH2.

Feature

In order to visualize an irregular TOUGH2 data grid, the developed viewer manages many files of the TOUGH2 input/output data-set files. In particular, the data needed for a correct geometric visualization are: the input file for AMESH containing the spatial coordinate of each block node of the grid, the thickness for each layer and rock types; the file *"segmt"* that contains all the coordinate of surrounding blocks for each grid-blocks node; the output data file from TOUGH2.
After that extracted data are read, it is possible to visualize the geothermal model in 3D view (figure 1) with usual 3D CAD mouse command: changing point of view, orientation and zooming functions.
The main window of the software has all commands needed to work with the model, change variable to plot or change time step to plot. It is possible to restrict the view, split the model along the tree principal direction, change the perspective view to parallel view and automatically expand all layers along z axis (figure 2).
To get the data associated to a single block it is sufficient to search and click on the block, then a window appears where the user can select, for a fixed time step, the variable to plot along Z direction, or for a single block the evolution of the selected variable with time (figure 3).

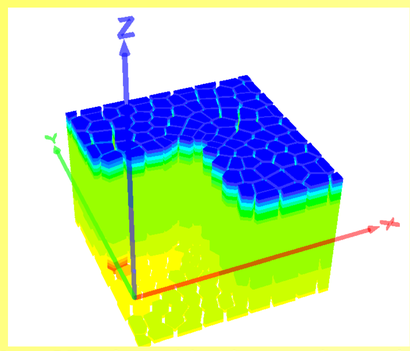


Fig.1 – 3D plot with chromatic scale for a primary variable with a split of a section of the domain.

Fig.2 – Layer separation of the grid to enable block parameters individuation.

Fig.3 – Plotting of the primary variable in a column of blocks respect to the time step simulated.

Flux vector

The data set of the mass fluxes among adjoining blocks is printed, for each time step, in the TOUGH2 output data file. The viewer, for each block, draws one arrow that represent the incoming flux coming from a not constant number of neighborhood blocks (irregular mesh) and computes and plots in 3D view the direction and intensity of the flux vector (figure 6). It is possible to plot each vector in a normalized mode to avoid an unreadable overlap of segments. Each vector have color scale intensity. As for visualization of the blocks, it is possible to obtain the trend along Z direction or the evolution in time for each block.

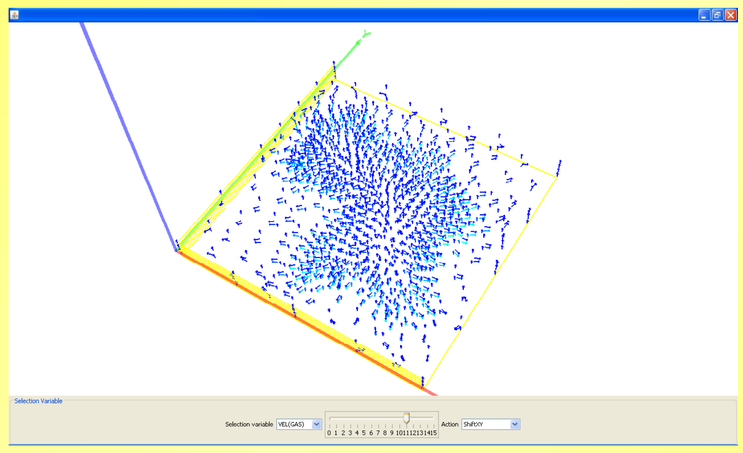


Fig.6 – 3D plots of a specific vector variable in a layer of the domain for a certain time step.

Mapping

Some kind of data coming from an irregular grid can't be plotted "as they are" but they need to be processed on a regular grid. The estimated data are obtained by means of the inverse distance weighting method. An interesting future work is to implement geostatistical approach to obtain more proper estimated data values.
It is possible to obtain a 2D mapping in XY, YZ, XZ planes (figure 4) and also to view a 3D surface of values of a specific layer (figure 5).

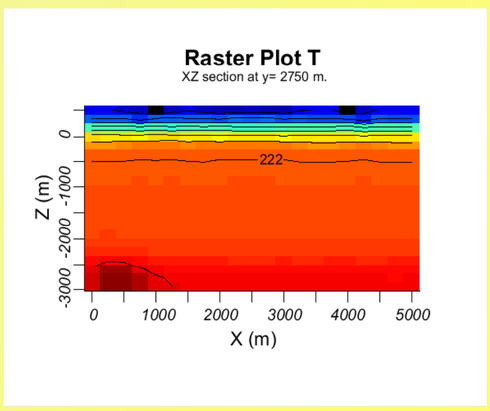


Fig.4 – Vertical map with chromatic scale of temperature values and isolines.

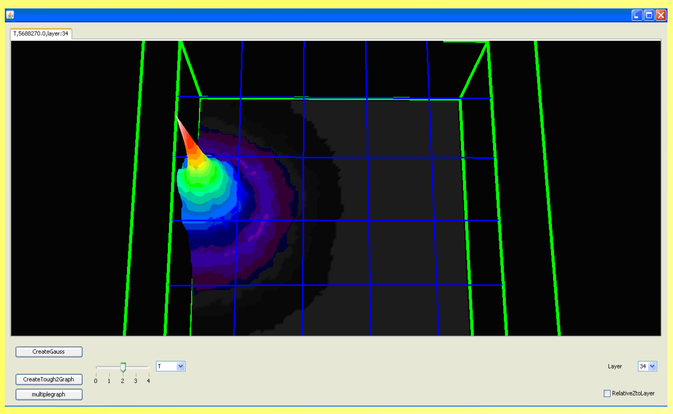
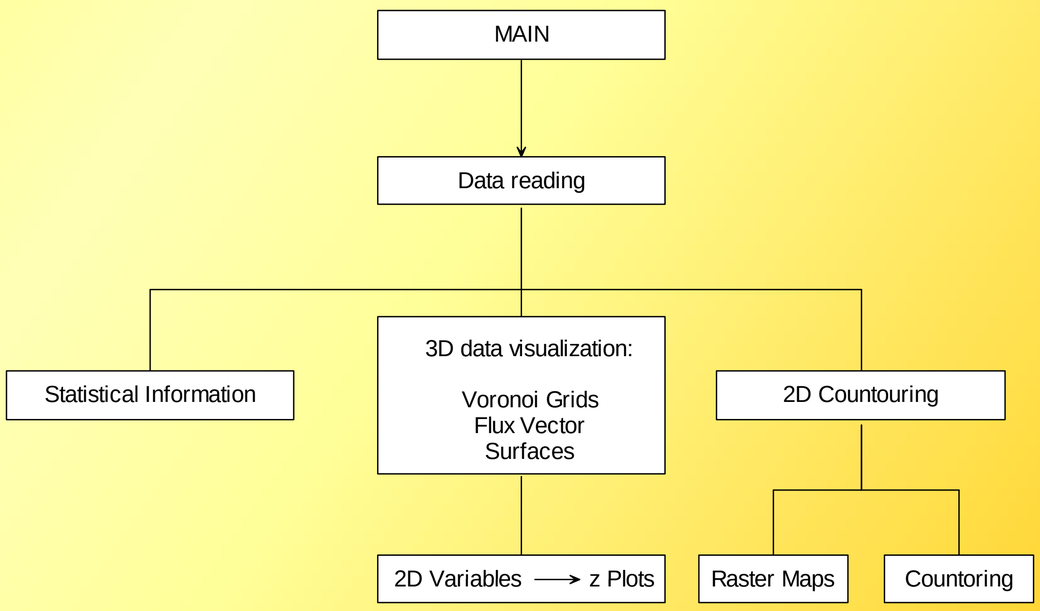


Fig.5 – 3D surface of a primary variable for a specific layer.

Software Diagram

The software is written in JAVA language [5] and uses the JAV3D [6] libraries to be platform independent. JAV3D is a scene graph-based 3D application programming interface for the Java platform.



Conclusion

In general, a simulation produces a very large amount of data. The capability to investigate easily each block of a mesh is a powerful and desirable feature that enables us to better understand the computed results. The use of irregular mesh is needed to investigate the behavior of geothermic reservoir near some point of interest such as for example the area around a well. For this purpose a visualization tool has been developed to simplify the step of data analysis and interpretation thanks to graphical 3D visualization and navigation.

References

[1] Pruess K., C. Oldenburg, G. Moridis : "TOUGH2 User's Guide, Version 2.0". Lawrence Berkeley Laboratory (1999). http://esd.lbl.gov/TOUGH2

[2] http://grass.itc.it/

[3] Neteler M., Mitasova H.. "Open Source GIS: A GRASS GIS Approach. Third edition". Springer, New York (2007)

[4] Haukwa C.: "AMESH. A mesh creating program for the Integral Finite Difference Method: User's Manual". Lawrence Berkeley Laboratory (1998). http://esd.lbl.gov/TOUGHPLUS/software-free.html

[5] www.java.com

[6] www.java3d.org

[7] www.voronoi.com

[8] Battistelli A., Calore C., Pruess K. "The simulator TOUGH2/EWASG for modelling geothermal reservoirs with brines and non-condensable gas", Geothermics, Volume 24, Issue 4 (1997)

Acknowledgements: This work is supported by MAC-GEO Project (Fondo per le Aree Sottoutilizzate, Ministero dello Sviluppo Economico, Ministero dell'Istruzione, dell'Universitá e della Ricerca, Regione Toscana).