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Flexible Environmental Modeling with Python and Open - GIS

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Numerical modeling now represents a prominent task of environmental studies. During the last decades, numerous commercial programs have been made available to environmental modelers. These software applications offer user-friendly graphical user interfaces that allow an efficient management of many case studies. However, they suffer from a lack of flexibility and closed-source policies impede source code reviewing and enhancement for original studies. Advanced modeling studies require flexible tools capable of managing thousands of model runs for parameter optimization, uncertainty and sensitivity analysis. In addition, there is a growing need for the coupling of various numerical models associating, for instance, groundwater flow modeling to multi-species geochemical reactions. Researchers have produced hundreds of open-source powerful command line programs. However, there is a need for a flexible graphical user interface allowing an efficient processing of geospatial data that comes along any environmental study.

Here, we present the advantages of using the free and open-source Qgis platform and the Python scripting language for conducting environmental modeling studies. The interactive graphical user interface is first used for the visualization and pre-processing of input geospatial datasets. Python scripting language is then employed for further input data processing, call to one or several models, and post-processing of model outputs. Model results are eventually sent back to the GIS program, processed and visualized. This approach combines the advantages of interactive graphical interfaces and the flexibility of Python scripting language for data processing and model calls. The numerous python modules available facilitate geospatial data processing and numerical analysis of model outputs. Once input data has been prepared with the graphical user interface, models may be run thousands of times from the command line with sequential or parallel calls. We illustrate this approach with several case studies in groundwater hydrology and geochemistry and provide links to several python libraries that facilitate pre- and post-processing operations.