

A reference database with transient river and drain boundary conditions for Modflow

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A modelling instrument was built that is able to semi-automatically set up a (steady-state or transient) groundwater model. With a given model area and modelling period, the instrument is able to select the appropriate hydrogeology data and boundary conditions, and to build a Modflow groundwater model. The river and drainage boundary conditions are selected from a PostgreSQL/PostGis database, which has been built with surface water data from various data sources using open source tools like the PostGis geoprocessing functions and the Python programming language.

The basic surface water data cover the area of the Flemish Groundwater Model, which covers Flanders and includes parts of France, the Netherlands and Wallonia. The data come from a large variety of data sources like the digital elevation model, GIS layers with hydrographic data, the navigable waterways map, hydrologic and hydraulic models. It includes geospatial data (both vector and raster) and alphanumeric data like discharge and stage hydrographs. A basic assumption was to use only existing and readily available data.

The challenge was to bring these data together and transform them into a useful set of river and drainage data, which can serve as boundary conditions for both steady-state and transient Modflow models.

All data are managed and processed in the open-source relational DBMS PostgreSQL. The database is spatially extended with PostGis, which adds support for geographic objects allowing location queries and geoprocessing tasks to be run in SQL. All geoprocessing tasks are performed with PostgreSQL and PostGis functions, with Python as the enveloping programming language.

The water surfaces (streams, rivers, canals, watercourses) are first represented as polygons with an appropriate width and area. As Modflow is a 3D finite-difference groundwater flow model, these water surfaces must be converted into surface water elements that can be assigned to individual Modflow grid cells. A resolution of 25 m for the grid cells was chosen, resulting in a grid that acts as a cutting tool to cut the water surfaces into about 2.4 million surface water elements.

Every surface water element is given appropriate properties. Modflow requires the location (xy coordinates) and the properties stage, riverbed elevation and conductance for river and drain elements. The surface water elements have many additional useful properties, e.g. area, riverbed thickness, river category, name and references to the base data sources. These properties are all derived from the various data sources and attributed to the surface water elements. Priority rules are defined for locations where different data sources are available. An important step in processing the water stages involves removing artifacts from the water surface profile along flow paths.

Deriving transient stages involves the following concept: an appropriate (stage or discharge) hydrograph is used as a template for the stage dynamics. Transient stages are computed using a simple rescaling function. This requires the database to store extra stage and date properties for the surface water elements. The hydrograph dynamics and the absolute stages in a surface water element are matched dynamically when the database is queried at runtime. This concept avoids an explosion of the database size compared to other options: if every surface water element had its own series of transient stages, the database would count about 17 billion records.

The resulting database contains 2.4 million records with elementary surface water elements, and 11.5 million records with flow and stage dynamics for calculating transient stages. A map

representation of the surface water elements contained in the resulting reference database is shown in the figure below.

Finally a Matlab application was built to perform a query in the database, given the user defined model area and modelling period. The elementary river and drain boundary conditions may be spatially merged, depending on the user defined cell size, or merged in time according to the user defined stress periods.

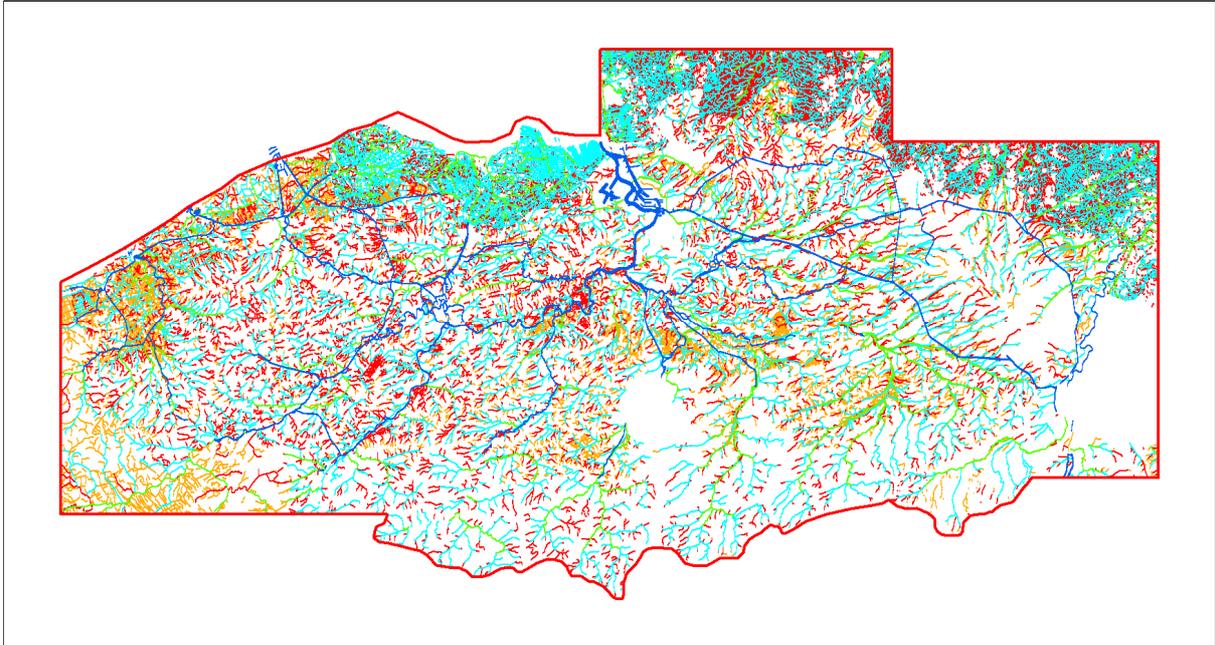


Figure: Map representation of the surface water elements contained in the resulting reference database.