



University of Liege - Faculty of Applied Sciences
ArGenCo – Architecture, Geology, Environment and Constructions
GEO³ - Geotechnologies, Hydrogeology and Applied Geophysics



Regional scale flow and transport modelling for the management of groundwater and surface water bodies in the framework of the EU Water Directive

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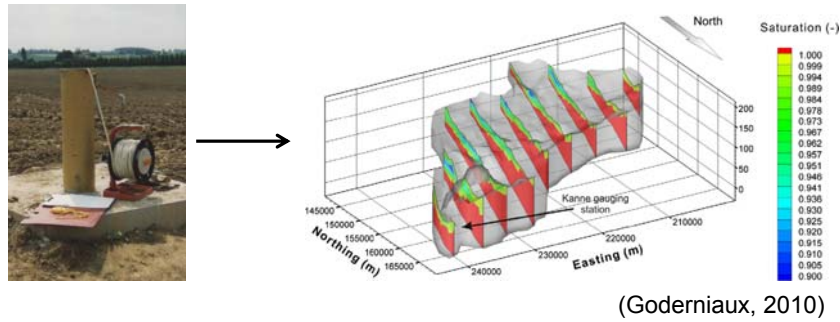
HydroEco'2011
2-5 May 2011, Vienna, Austria



(...) river basin district (...) is identified as the main unit for management of river basins

(DIRECTIVE 2000/60/EC « Water Framework Directive »)

An integrated management at regional scale requires characterization and modelling



As managing tools in the framework of the EU Water Directive, regional scale models should provide:

- **quantitatively**
 - an estimation of the evolution of water balance terms (reserves), groundwater-surface water interactions (baseflow), and hydraulic head trends for several scenarios with regional impacts
- **qualitatively**
 - an estimation of the evolution of nitrate trends for several input scenarios

However, flow and transport models at regional scale face specific problems:

- complexity of geology and hydrogeology
- heterogeneity of level of knowledge
- representativity of measured parameters
- time-consuming simulations



How can we deal with these problems while meeting the manager needs?

The approach we developed is characterised by regional scale transient flow and transport models including no more complexity than needed or supported by the data. These models provide:

- quantitatively
 - an estimation of water balance, groundwater-surface water interactions, and hydraulic head trends
- qualitatively
 - an evaluation of nitrate trends

Presentation of the approach

Applications of the approach

Synclitorium of Dinant: quantitative results

Geer basin: quantitative results

Presentation of the approach

Applications of the approach

Synclitorium of Dinant: quantitative results

Geer basin: quantitative results

The **approach**, implemented in **SUFT3D**, consists in **three** steps:

1. subdividing the zone of interest into **subdomains** corresponding to **independent hydrogeological units** or **variously characterised zones**

2. selecting the **equations** governing flow and transport into **each subdomain**



3. defining **internal boundary conditions** between subdomains: 1st type, 2nd type impervious or 3rd type

Groundwater-surface water interactions are taken into account through 3rd type boundary conditions

$$Q_{sw}^{gw} = \frac{K \times L \times l}{e} \times (H_{sw} - H) = \alpha \times (H_{sw} - H)$$

hydraulic head
=
unknown of the problem

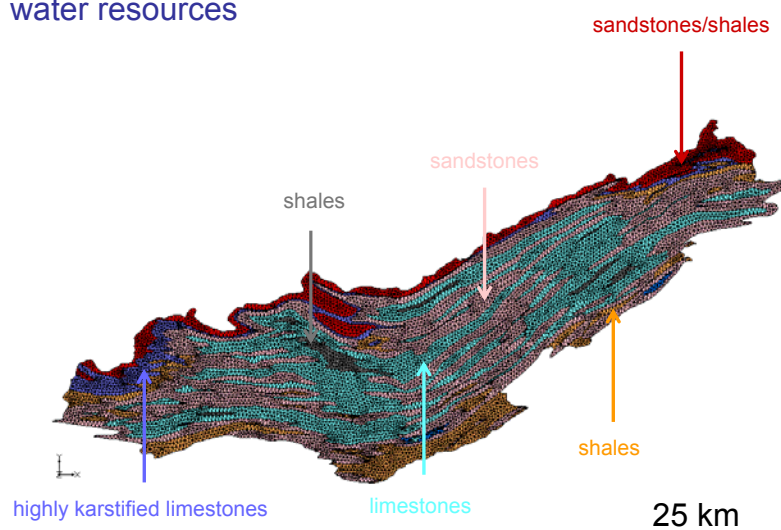
Presentation of the approach

Applications of the approach

Synclinorium of Dinant: **quantitative** results

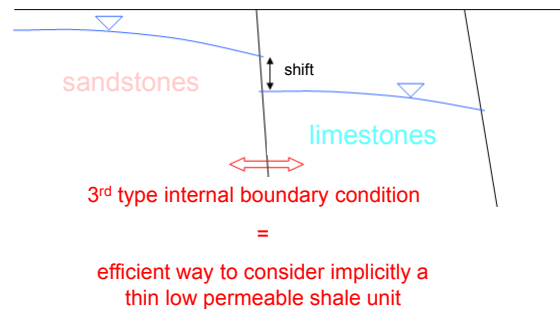
Geer basin: quantitative results

Three water bodies located in the Synclinorium of Dinant have been modelled for helping the management of their water resources



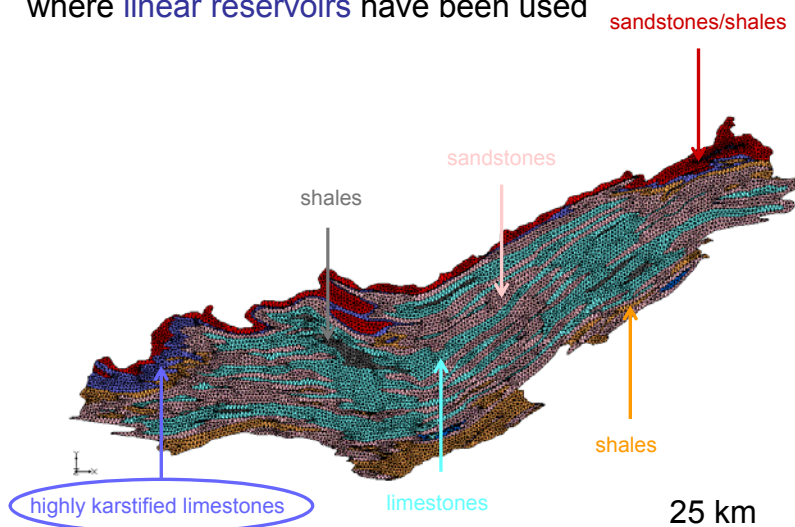
The subdomains and the internal boundary conditions have been defined based on the hydrogeological units and the hydrologic sub-basins for:

- considering the hydraulic head shift between sandstones and limestones units

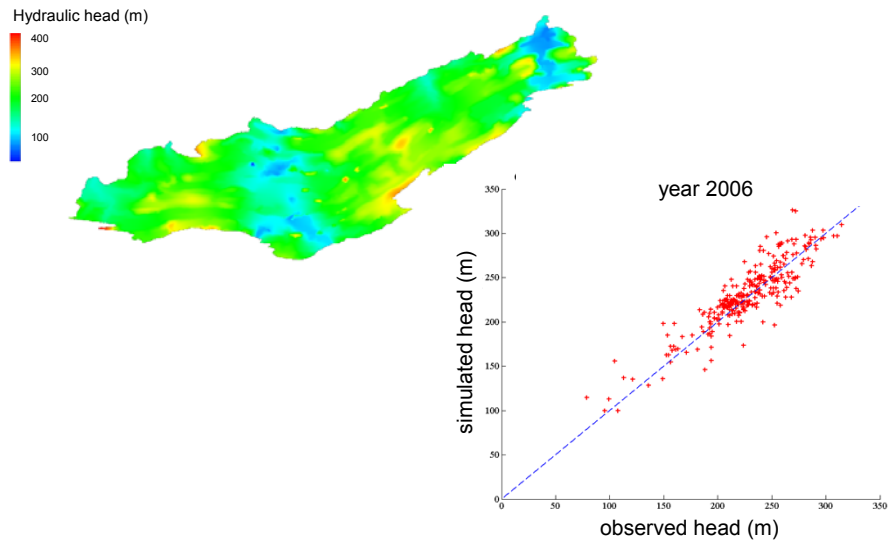


- evaluating groundwater flux exchanges between the main hydrologic sub-basins

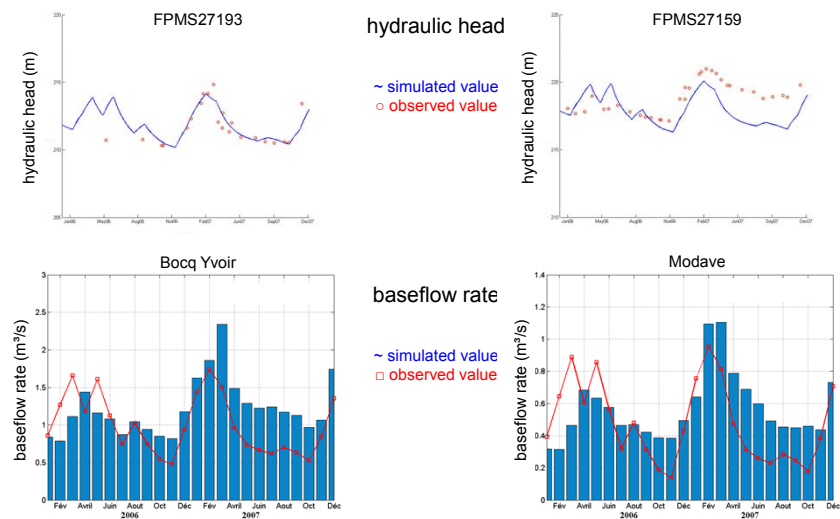
Flow in porous media equations have been used in each subdomain except in the highly karstified limestones where linear reservoirs have been used



The calibration has been performed in steady-state (UCODE_2005) using both hydraulic head and baseflow rate observations



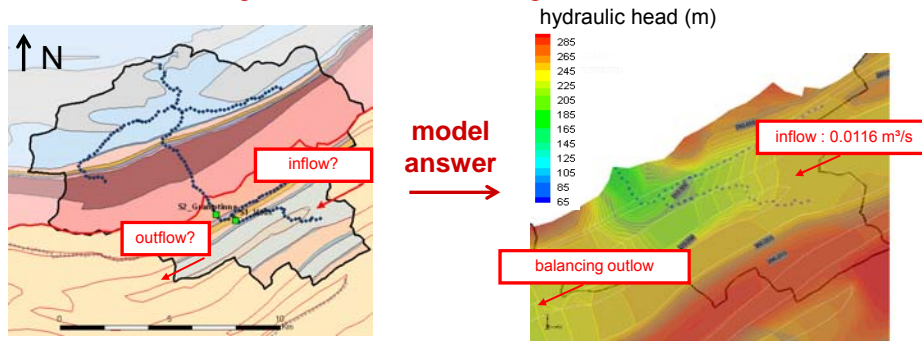
The groundwater flow calibration has then been performed in transient regime using both hydraulic head and baseflow rate observations



The calibrated model has been used for:

- obtaining additional information about the water balance of key sub-basins

What are the groundwater flux exchanges between sub-basins?



- obtaining boundary conditions for a local impact model linked to an open pit extension project

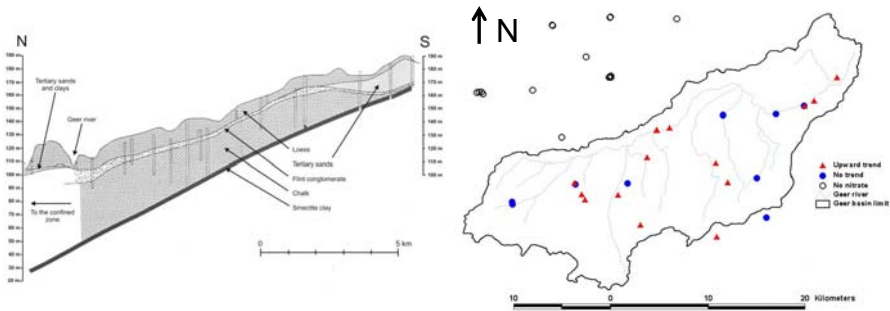
Presentation of the approach

Applications of the approach

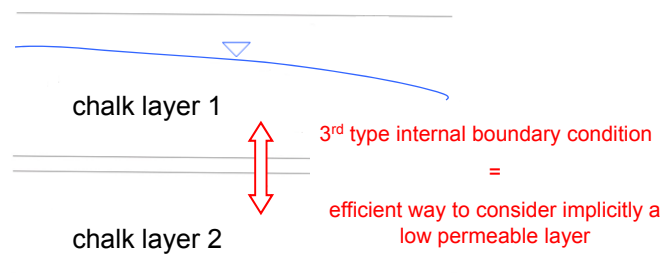
Synclitorium of Dinant: quantitative results

Geer basin: quantitative results

The chalk aquifer of the Geer basin constitutes important groundwater resources for the city of Liege but nitrate concentration in groundwater is increasing for 50 years

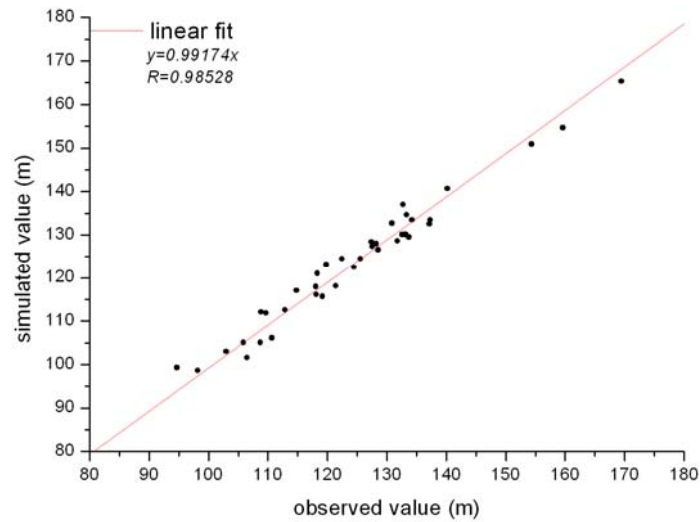


The zone of interest has been subdivided vertically into two subdomains interacting through a 3rd type internal boundary condition for taking implicitly into account a low permeable layer separating two permeable chalk layers

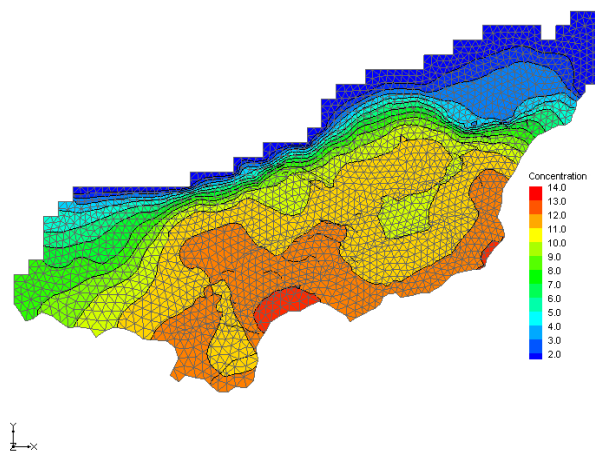


Flow in porous media equation and mixing cell for transport has been used in each subdomain

The groundwater flow calibration has been performed in steady-state (high and low groundwater level periods) using hydraulic head observations

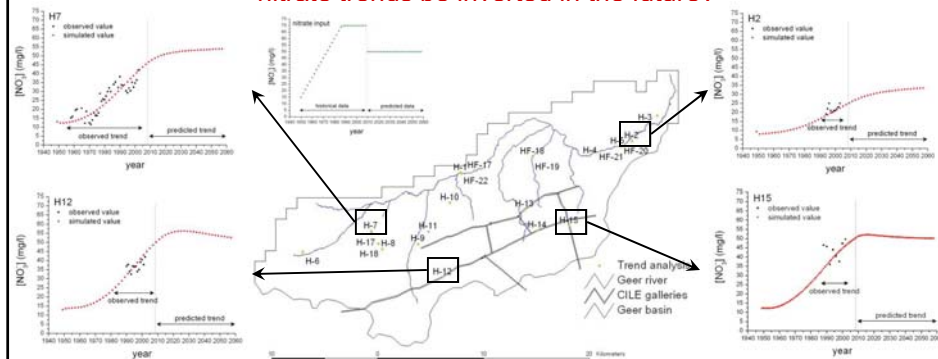


The calibration of transport has been performed on the calibrated steady-state flow field using tritium data and nitrate trends



The calibrated model has been used for evaluating the evolution of nitrate trends until 2060 using a simplified input scenario

Assuming a future nitrate input signal of 50 mg/L, will the increasing nitrate trends be inverted in the future?



The **model answer** is **yes** in the **southern** but no in the **northern** and **eastern** parts of the basin with thicker unsaturated zones

The approach proposed for regional scale groundwater flow and transport modelling has proved to meet the manager needs of Wallonia in the framework of the EU Water Directive. The models allow:

- **quantitatively**
 - obtaining additional information on water balance and particularly on inter-basin groundwater flux exchanges
 - simulating future hydraulic head trends and groundwater-surface water interactions based on transient calibration
- **qualitatively**
 - evaluating the evolution of nitrate trends in the future

Although flow and transport model at regional scale face a lot of problems, this **approach is promising for helping the integrated management of water resources as required by the **EU WFD****

Thank you for your attention!