Chalk Aquifer Management (CHARM): Groundwater modelling of a complex aquifer for the sustainable management of strategic drinking water reserves in Flanders (Belgium)

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1. Introduction & Study Area

Groundwater is an important source of drinking water in Belgium. In some regions, locally produced groundwater is the source of 100% of the drinking water supply.

The Chalk Aquifer is one of the most important aquifers in the Flanders Region. It is of strategic societal importance because it is well protected against negative influences from the surface (nitrates, pesticides) on the water quality.

2. Problem Statement & Objectives

Due to several reasons, the uncertainty regarding the Chalk Aquifer is large:

- Due to the relatively large depth of the aquifer in the northern part, borehole data is limited
- Strong spatial variability of hydraulic properties due to double porosity system: primary matrix vs. secondary fracture porosity
- Slow response of the aquifer on (historical) changes: information on past extractions needed to explain trends in hydraulic head
- Regional effect of extraction: need for larger-scale groundwater models

The main goals of the CHARM project are:

- To analyse the capacity of the Chalk Aquifer on a regional scale
- To deliver a management instrument that can be used for decision-making regarding the use of this aquifer for drinking water purposes
- Special attention will be given to the characterization of all sources of uncertainty and its incorporation in groundwater flow models

3. Link between well yield and geology

Two main groups of flow measurements are observed:

Left: only flow in 2-3m interval correlated with hardground (phosphatic gravel), rest of filter does not contribute

Right: flow more evenly distributed over filter due to presence of fractures

4. Spatial variability of hydraulic conductivity

A correlation between hydraulic conductivity and depth of the Cretaceous sediments is observed: high K when shallow, low K when buried deep

Primary permeability of Cretaceous deposits is low, but in the South increased secondary permeability is observed due to:

- Fracturing of deposits due to decompression following erosion of the overburden
- Increased fluid circulation and chemical weathering in river valleys

5. Uncertainty Analysis

Groundwater models of the Chalk Aquifer are set up on different scales

Application of the integrated Bayesian multi-model approach to quantify input, parameter and conceptual model uncertainty of Mustafa et al. (2018) in which MODFLOW is coupled with DREAM (Vrugt, 2016) and Bayesian Model Averaging is applied to assess total prediction uncertainty

6. Outlook

A full Bayesian approach is computationally expensive. Alternative methods will be explored and compared, e.g.:

- Approximate Bayesian Computation (ABC) (Vrugt et al., 2013)
- Bayesian Evidential Learning (BEL) (Scheidt et al., 2018; Hermans et al., 2018)

Different scenarios will be compared by using a decision model to convert the results of the uncertainty analysis to concrete strategies.

Based on this approach, well-founded decisions can be made regarding the quantitative use of the Chalk aquifer for drinking water purposes.

References:

- Hermans et al., 2018)