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Validation of simulated flow direction and hydraulic gradients with hydraulic head observations using open source GIS

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It is recommended to check hydraulic gradients and flow directions predicted by a groundwater flow model that is calibrated solely with hydraulic head observations. It has been demonstrated in literature that substantial errors can be made when the model is not calibrated on these state variables.

Therefore, in this work, we perform a validation of a steady-state groundwater flow model, representing part of the Neogene aquifer (60 km^2) in Belgium. This model was developed and calibrated solely on groundwater head measurements, in the framework of the environmental impact assessment of the near surface repository for low- and intermediate-level short-lived waste, realized by ONDRAF/NIRAS at Dessel, Belgium. Horizontal flow directions, horizontal and vertical gradients for the entire area of the groundwater model were estimated from measurements at shallow monitoring wells within the groundwater flow model domain, and compared to the flow directions and vertical gradients predicted by the model. For obtaining horizontal flow directions and gradients, triangulation of groundwater levels was performed for combinations of three neighboring hydraulic head observations in the same hydrogeological layer within the model. The simulated equivalents at the same monitoring wells were used to repeat the same methodology, and calculate flow direction components. This analysis was performed in SAGA GIS and was visualized through QGIS. Comparison of the flow directions and flow gradients obtained from measurements and simulations gives an indication on the model performance. The calculations were performed for three sandy hydrogeological units used in the model.

A similar procedure was performed for the vertical hydraulic head gradients, where any combination of two hydraulic head observations at the same location but at different levels within the aquifer were used to validate the vertical gradients predicted by the model.

Besides model validation on average hydraulic heads, the variability of flow direction and hydraulic gradients in time was checked, by using the actually measured monthly time series, to verify the applicability of the steady-state modelling approach.

This basic assessment of flow directions and gradients using open source GIS can be used to identify potential areas of interest, were more detailed investigations would be recommended.