Geophysical Research Abstracts
Vol. 14, EGU2012-6550-1, 2012
EGU General Assembly 2012

Scalable Generalization of Hydraulic Conductivity in Quaternary Strata for Use in a Regional Groundwater Model

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The cover of Quaternary sediments especially in formerly glaciated territories usually is the most complex part of the sedimentary sequences. In regional hydro-geological models it is often assumed as a single layer with uniform or calibrated properties (Valner 2003). However, the properties and structure of Quaternary sediments control the groundwater recharge: it can either direct the groundwater flow horizontally towards discharge in topographic lows or vertically, recharging groundwater in the bedrock.
This work aims to present calibration results and detail our experience while integrating a scalable generalization of hydraulic conductivity for Quaternary strata in the regional groundwater modelling system for the Baltic artesian basin - MOSYS V1. We also present a method for solving boundary transitions between spatial clusters of lithologically similar structure.
In this study the main unit of generalization is the spatial cluster. Clusters are obtained from distance calculations combining the Normalized Compression Distance (NCD) metric, calculated by the CompLearn parameter-free machine learning toolkit, with normalized Euclidean distance measures for coordinates of the borehole log data. A hierarchical clustering solution is used for obtaining cluster membership identifier for each borehole. Using boreholes as generator points for Voronoi tessellation and dissolving resulting polygons according to their cluster membership attribute, allows us to obtain spatial regions representing a certain degree of similarity in lithological structure. This degree of similarity and the spatial heterogeneity of the cluster polygons can be varied by different flattening of the hierarchical cluster model into variable number of clusters. This provides a scalable generalization solution which can be adapted according to model calibration performance. Using the dissimilarity matrix of the NCD metric, a borehole most similar to all the others from the lithological structure point of view, can be identified, from the subset of each cluster members. The log structure of this borehole then is applied throughout the territory of the corresponding spatial cluster.
Before results of this generalization can be incorporated into the geometric structure used in the MOSYS V1 modelling system, a method for solving transitions between different lithological structures of adjacent clusters is required. We assume a common sedimentation sequence for Quaternary sediments in the territory of Latvia. This allows us to use a customized 3D linear interpolation method for connecting model strata between adjacent spatial clusters. First, we connect layers with common lithology types directly, interpolating their thickness. Then, linear interpolation completes the gradient transitions between all the remaining material layers.
The strength of this method is that it can be performed algorithmically and coupled with different scales of generalization, provided by the hierarchical clustering solution, allows us to search for the most appropriate representation of the Quaternary strata in the regional groundwater model for the Baltic artesian basin.

This study is supported by the European Social Fund project No. 2009/0212/1DP/1.1.1.2.0/09/APIA/VIAA/060

References:
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