Reply to comments RC2 on “egusphere-2022-81”

3D hydrogeological parametrization using sparse piezometric data

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Dear Referee, please find below the point by point answers (in blue) to your comments (in black).

The manuscript is well structured and well written.

In my opinion, the main novelty of the manuscript is the following: estimation of hydrodynamic characteristics (k and n) of a 3D flow model comparing the calibrated 2D transmissivities rather than the hydraulic head measurements. At the beginning, the transmissivities of a 2D flow model are estimated comparing sparse measurements of hydraulic heads obtained by means of piezometers (actually the aquifer in this study is synthetic) with the heads calculated by the 2D flow model. According to vertical logs data collected in the piezometers a 3D reconstruction of litho-facies is obtained and e 3D flow model realized. In order to estimate the hydraulic conductivity values for each element of the 3D model an inverse procedure involving the transmissivities is implemented: the hydraulic conductivity in each facies is calculated optimizing the distance between the 2D inversion transmissivities and the 3D transmissivities.

> We thank the reviewer for his appreciation of the work, and we are glad that it can be understood in the way that this summary demonstrates.

In literature already exist studies in which the aquifer is conceptualized as a multiple-continuum, where the volumetric fraction of a geo-material within a cell of the numerical flow model is calculated by Multiple Indicator Kriging and the hydraulic head data are embedded jointly within a three-dimensional inverse model of groundwater flow: model parameters (k and n) are estimate by a Maximum Likelihood fit between measured and modeled - vertically average - hydraulic heads, resulting in a spatially heterogeneous distribution of hydraulic conductivity (Guadagnini et al., 2004; Straface et al., 2011).

The authors should support their approach, i.e., the transmissivities versus the hydraulic heads conditioning, comparing the two inversion strategies and showing the advantage to compare the 2D transmissivities rather than the vertically averaged hydraulic heads.

> We also thank the reviewer for his comments that give us the opportunity to better highlight the innovative aspects or our work.
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> First of all, our idea is motivated by the usual way of groundwater calibration which is mostly performed in 2 dimensions. We question the use of the transmissivity field obtained through 2D calibration to build a 3D representation of the aquifer i.e. to estimate the structure of the heterogeneities and their related hydraulic conductivity. Our approach consists in estimating the transmissivity first with a 2D model calibration and then to build the 3D representation of the aquifer using the calibrated transmissivities only. It is quite different from the approaches dealing with 3D representation of an aquifer by joint inversion of 3D hydraulic data conditioned by the piezometric heads or conditioned by piezometric heads and geophysical

data (Straface et al., 2011) or measured parameter values through direct measurements or indicators (Guadagnini et al., 2004.).

The choice of using a 2D model inversion, leading to transmissivity conditioning, instead of a 3D inversion, is also guided by 2 criteria.

First, the hydraulic heads are little sensitive to the vertical heterogeneity. Therefore, their use to calibrate hydraulic conductivities without additional constraints is more pertinent in 2D.

Second, 2D calibrations are way more parsimonious than the 3D ones in terms of data management and computational effort.

We will add some sentences in the introduction to better highlight these innovative aspects compared to other ones.