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Effect of regional heterogeneities on inversion stability and estimated hydraulic properties field

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Hydraulic tomography showed great potential on estimating the spatial distribution of heterogeneous aquifer properties in the last decade. Though this method is highly performant on synthetic studies, the transition from an application to synthetic models to real field applications is often associated to numerical instabilities. Inversion techniques can also suffer from ill-posedness and non-uniqueness of the estimates since several solutions might correctly mimic the observed hydraulic data. In this work, we investigate the origin of the instabilities observed when trying to perform HT using real field drawdown data. We firstly identify the cause of these instabilities. We then use different approaches, where one is proposed, in order to regain inverse model stability, which also allows to estimate different hydraulic property fields at local and regional scales. Results show that ill-posed models can lead into inversion instability while different approaches that limit these instabilities may lead into different estimates. The study also shows that the late time hydraulic responses are strongly linked to the boundary conditions and thus to the regional heterogeneity. Accordingly, the use on these late-time data in inversion might require a larger dimension of the inverted domain, so that it is recommended to position the boundary conditions of the forward model far away from the wells. Also, the use of the proposed technique might provide a performant tool to obtain a satisfying fitting of observation, but also to assess both the site scale heterogeneity and the surrounding variabilities.