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Is it important to characterize complex patterns of riverbed hydraulic conductivities for assessing river-aquifer exchange fluxes? An evaluation with an integrated fully coupled hydrological model.

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Riverbed hydraulic conductivity is a critical parameter for the prediction of exchange fluxes between groundwater and surface water bodies. It was found in previous studies that it is important to characterize heterogeneity of riverbed hydraulic conductivity. In this context, we also investigated in the past whether the heterogeneity pattern of riverbed hydraulic conductivities (i.e. multiGaussian, different types of non-multiGaussian patterns) plays an important role. It was found that the heterogeneity pattern does not matter so much. However, these past studies were conducted with the subsurface hydrological model SPRING which only considers one way coupling and only vertical fluxes through the river-aquifer interface. In this study, the role of patterns was further explored using the fully coupled hydrological model HydroGeoSphere. A synthetic 3-D river-aquifer model was set up with a heterogeneous riverbed showing non-multiGaussian patterns in the form of meandering channels as the reference field. Data assimilation experiments were carried out with help of the Ensemble Kalman Filter to characterize the heterogeneous riverbed. The data assimilation experiments were conducted for four types of riverbed hydraulic conductivity (K) fields: (i) spatially homogeneous, (ii) heterogeneous with multiGaussian distribution, (iii) heterogeneous with non-multiGaussian distribution (channelized structures) and (iv) heterogeneous with non-multiGaussian distribution (elliptic structures). For all the data assimilation scenarios, state variables and riverbed K were updated by assimilating piezometric heads. The experiments were repeated for ten reference fields.
Results show that for all prior geostatistical models data assimilation was able to reduce the difference between simulated and measured hydraulic heads, and to improve the characterization of riverbed hydraulic conductivities and river-aquifer exchange fluxes. Results were slightly better for non-multiGaussian fields with channelized structures. Results were clearly worse if a homogeneous riverbed was assumed. In summary, among the three types of riverbed patterns, for most (9 out of 10) reference cases non-multiGaussian distributions with channelized structures reproduce the best riverbed K and river-aquifer exchange fluxes. However, the performance is not significantly better than for the other geostatistical models with heterogeneous fields. Therefore, conclusions for the fully and one way coupled models are similar.