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Conceptualization and calibration of anisotropic, dynamic alluvial systems: Pitfalls and biases in current modelling practices

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Physical properties of alluvial environments are typically featuring a high degree of anisotropy and are characterized by dynamic interactions between the surface and the subsurface. A literature review on current modelling practice shows that hydrogeological models are often calibrated using isotropic hydraulic conductivity fields and steady state conditions. We aim at understanding how these simplifications affect the predictions of hydraulic heads and exchange fluxes using fully coupled, physically based synthetic models and advanced calibration approaches. Specifically, we present an analysis of the information content provided by averaged, steady state hydraulic data compared to transient data with respect to the determination of aquifer hydraulic properties. We show that the information content in average hydraulic heads is insufficient to inform anisotropic properties of alluvial aquifers and can lead to important biases on the calibrated parameters. We further explore the consequences of these biases on predictions of fluxes and water table dynamics.
The results of this synthetic analysis are considered in the calibration of a highly dynamic and anisotropic alluvial aquifer system in Switzerland (the Rhône River). The results of the synthetic and real-world modelling and calibration exercises provide insight on future data acquisition, modelling and calibration strategies for these environments.