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3D numerical studies on stratification and mixing processes affecting fine sediment transport in the pre-dam of the Dhünn reservoir in Germany

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Fine sediment transport processes and the thermodynamics in reservoirs are key processes governing the water quality of reservoirs. With regard to a sustainable sediment management of reservoirs, the prediction of sediment transport and deposition is becoming increasingly important.

The subject of the present work was the 3D numerical simulation of fine sediment transport in a reservoir taking into account stratification and mixing effects which in turn are caused by temperature gradients and wind effects. In order to understand and investigate the driving factors for stratification processes and their impact on fine sediment distribution, the great pre-dam of the Dhünn reservoir in Germany served as case study. The investigations were conducted in sensitivity analyses adopting a 3D sediment transport model with Delft 3D. The impact of various physical and numerical parameters on temperature and fine sediment transport modeling was examined: the number of vertical layers, the input data for the heat model (e.g. relative humidity, air temperature, cloud coverage, solar radiation), the vertical diffusivity and wind effects. The sensitivity studies showed that the input data for the heat model have a minor impact on the temperature and sediment transport modeling within the tested range of parameters. However, the vertical diffusivity and especially the inclusion of wind showed a greater influence on the simulated temperature and suspended sediment concentration gradients. The temperature modeling results by inclusion/exclusion of wind were qualitatively compared with temperature data from literature and with measurement data over a period of one month. Hereby, the simulations showed a good agreement with measurement data by exclusion of wind effects.

The results of the studies provide a solid basis for the development of further models in fields where fine sediment transport is affected by stratification processes and can also be very useful in terms of a better understanding of the interactions between temperature, wind and fine sediment transport.