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MODELING SECONDARY FLOWS AND SUSPENDED SEDIMENT IN MEANDERING RIVERS: A COMPARATIVE STUDY OF 2D AND 3D APPROACHES WITH FIELD DATA INTEGRATION

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Abstract. This study investigates a strongly three-dimensional phenomenon: the flow structure and its effect on sediment transport along the curves of a large meandering river. The research presents a detailed description of this phenomenon using high-resolution spatial and temporal field data collected via acoustic technology. These observations are compared with the results of various numerical models (2D and 3D), incorporating different correction criteria for the 2D model to account for the helical flow structure in curves and the non-homogeneous vertical distribution of suspended sediments. To address the research objectives, the openTELEMAC-MASCARET numerical model is implemented, utilizing its Telemac2D and Telemac3D modules coupled with SISYPHE. Field data reveal a significant impact of helical motion on suspended sediment redistribution, resulting in a net solid flux towards the point bar of the curves. In a reach with successive curves, this effect causes the transported suspended sediment core to exhibit gradual behavior, while velocities in the channel center shift abruptly between curves. This phenomenon occurs because the transfer of liquid discharge from the inner to the outer bank is more pronounced in the upper flow layer (where velocities are highest), while the lower layer is affected by the helical movement. As maximum sediment concentrations are present in this lower layer, sediment is transferred in the opposite direction. Regarding 2D modeling, the method proposed by Petkovsek (2015) adequately reproduces the position and magnitude of the maximum concentration core, but overestimates values at the point bar and shows erroneous behavior in some cases (e.g., in cross sections over apexes). Notably, this method considers a flow balance for each vertical (as established by Rozovskii) without accounting for the transverse flow towards the outer bank in curves resulting from discharge transfer. Nevertheless, results align better either without any correction or with the correction presented by Finnie et al. (1999), at a much lower computational cost than required for a 3D model. This demonstrates behavior and trends similar to those measured in the transverse distribution of vertical mean values, indicating an accurate representation of hydraulic and sedimentological phenomena. However, further verification is necessary to calibrate the suspended sediment concentration values obtained in TELEMAC 3D, which showed an underestimation of up to 70% compared to measured data.

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