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Hydro-morphodynamics of bed discordance confluences. Simulations based on laboratory data

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Mountain-river confluences are characterized by steep and narrow tributaries that supply abundant sediment load to the confluence, whereas the main channel provides the dominant flow discharge. The abundant tributary bed load with respect to that of the main channel, together with the low discharge ratio between the tributary and main channel ($Qr < 1$), result in a marked bed discordance between both channels. This bed discordance is a key feature that highly influences the hydrodynamics and morphodynamics of the confluence, when compared to those at concordant confluences. In discordant confluences, the interaction between hydrodynamic and morphodynamic processes is still unknown, which makes necessary further research that focuses on this interaction. This study presents the results of two fully 3-D eddy resolving simulations based on the bathymetry and water surface obtained from one laboratory experiment. The experiment was conducted in a 70º asymmetric laboratory confluence under mobile bed conditions and with continuous sediment supply to both channels. The simulations were performed for two extreme bathymetric conditions: i) those corresponding to the beginning of the experiment, so-called initial state, and ii) those corresponding to the equilibrium, i.e. when the bed morphology reached a steady state. The simulations provide a complete description of the mean flow, turbulence statistics and dynamics of the large-scale coherent flow structures. In addition, the simulations allow to relate the flow features to the patterns of bed shear stress, for the mean and instantaneous flow fields. The results corroborate the major role of the bed discordance on the hydrodynamics of the confluence. The bed discordance induced a two-layer flow structure, according to which the near-surface flow of the main channel was outward deflected by the tributary inflow, whereas the near-bed flow, sheltered by the bed discordance, progressed unimpeded downstream. Also, the bed discordance favored the formation of a strongly coherent vortex in the lee of the tributary-mouth bar. This vortex was responsible for the erosion at the tributary mouth, as observed during the experiment. At the initial state and at equilibrium, the simulations revealed the absence of streamwise oriented vortical cells, commonly observed in concordant confluences. The absence of these cells was consistent with the sediment segregation observed at the bed surface at equilibrium.