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The influence of transverse slope effects on large scale morphology in morphodynamic models

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All morphodynamic models are sensitive to a calibration of the transverse bed slope parameter, which determines the length of fluvial bars and active channel width, braiding index, stability of river bifurcations, and wave lengths of coastal sandbanks and sandwaves. Here we show by numerical modelling how different slope effect parameterisations affect morphology in rivers and estuaries. The transverse slope parameter determines the amount of downslope sediment transport due to gravity on slopes transverse to the main flow direction. When secondary currents are present, downslope sediment transport due to gravity is balanced by helical flows dragging the sediment upslope, and thereby also controls the adaptation of the bed to perturbations in the flow. An incorrect setting thus has major consequences for the predicted large-scale morphology, bank protection works and dredging volumes for fairway maintenance. Nevertheless, current morphodynamic models tend to underestimate slope effects, and thereby over-predict channel depth and braiding index, and therefore slope effects are often artificially increased when calibrating on existing morphology. However, current experimental results based on 224 experiments in a rotating annular flume, with a large range in near-bed flow conditions and sediment sizes, showed that the realistic calibration range of the slope parameters is much smaller than current model studies imply. These results suggest that such calibration is necessary to compensate for other, yet unidentified, model weaknesses such as issues with numerical schemes or missing processes. The objective of this study is to identify possible causes of the overdeepening of channels in the morphodynamic model Delft3D, and to quantify the sensitivity of predicted long-term morphology of different environments to the transverse bed slope effect, even when a measured bathymetry is used for calibration. To this end, three different model studies are conducted. Firstly, a simple straight river channel of five grid cells wide is used to test several parameter settings and their effect on the balance of downslope sediment transport and channel incision in comparison with an analytical model. Then, the effect of using slightly different slope options on changes in large-scale morphology is tested, based on the recent experimental findings. To this end, an existing large-scale river model and an existing large-scale estuary model are used. Preliminary results show that the simple model always prefers the configuration with one unrealistically deep channel, independent of parameter settings such as transverse slope effects, roughness and choice of sediment transport predictor. Predicted long-term morphology is more sensitive to small changes in slope effects when slope effects are increased when the model is calibrated to fit realistic channel dimensions.