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Transverse bed slope effects in an annular flume

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Large scale morphology, in particular bar dimensions and bifurcation dynamics, are greatly affected by the deflection of sediment transport on transverse bed slopes due to gravity and by helical flows. However, existing transverse bed slope predictors are based on a small set of experiments with a minor range of flow conditions and sediment sizes, and do not account for the presence of bedforms. In morphological modelling the deflection angle is therefore often calibrated on measured morphology. Our objective is to experimentally quantify the transverse slope effect for a large range of near-bed flow conditions and sediment sizes (0.17 – 4 mm) to test existing predictors, in order to improve morphological modelling of rivers and estuaries. We have conducted about 400 experiments in an annular flume, which functions as an infinitely long bended flume and therefore avoids boundary effects. Flow is generated by rotating the lid of the flume, while the intensity of the helical flow can be decreased by counterrotating the bottom of the flume. The equilibrium transverse slope that develops during the experiments is a balance between the transverse bed slope effect and the bed shear stress caused by the helical flow. We obtained sediment mobilities from no motion to sheet flow, ranging across bedload and suspended load. Resulting equilibrium transverse slopes show a clear trend with varying sediment mobilities and helical flow intensities that deviate from typical power relations with Shields number. As an end member we found transversely horizontal beds by counterrotation that partially cancelled the helical flow near the bed, which allows us to quantify helical flow. The large range in sediment mobilities caused different bed states from ripples and dunes to sheet flow that affect near-bed flow, which cause novel nonlinear relations between transverse slope and Shields number. In conclusion, our results show for a wide range of conditions and sediments that transverse bed slope effects are not simple functions of sediment mobility but depend strongly on bed state. We are now focusing on isolating effects of helical flow intensity and near-bed flow patterns, working towards a new transverse bed slope predictor for use in morphodynamic models.