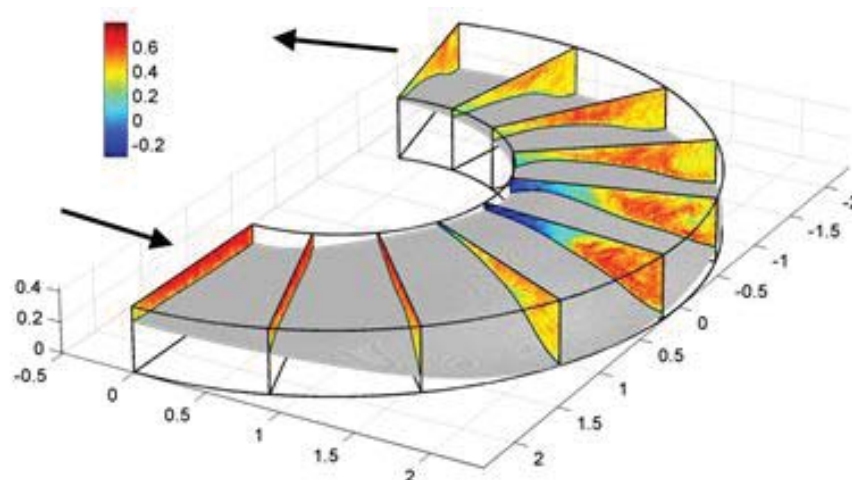


LARGE EDDY SIMULATION OF A CURVED OPEN-CHANNEL FLOW OVER TOPOGRAPHY

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Most rivers have the natural tendency to follow a winding course in their alluvial plane. This shape is the result of centrifugal forces in the turbulent flow in combination with erodible banks and bed. It is therefore important to understand how the shear stresses at the boundaries are distributed and to what extent they are related to the general features of the bend, like curvature, depth to width ratio and bed roughness. To that end Large-eddy flow simulations (LES) are performed of a curved open-channel flow over topography based on a laboratory experiment. In the experiment, the large-scale bed topography had developed to a more or less stationary shape which was prescribed in the LES model as boundary conditions neglecting the small-scale dune forms by means of a straightforward immersed boundary scheme in combination with a simple wall-modeling approach [1]. The small-scale dunes are accounted for in the numerical model by means of a parametrization of the roughness. The sensitivity of the flow to this roughness parametrization is examined by simulating the flow for three different roughness heights. It was found that, notwithstanding the coarse method of representing the dune forms, the qualitative agreement of the experimental results and the LES results is rather good. Comparison of the LES results with the Reynolds averaged numerical simulation results reveals surprisingly good agreement. This good agreement is explained by the minor importance of turbulence stress gradients in the contribution to the transverse and streamwise momentum balance. Moreover, it is found that in the bend the structure of the Reynolds stress tensor shows a tendency toward isotropy which enhances the performance of isotropic eddy viscosity closure models of turbulence.

This observation is remarkable since highly anisotropic turbulence might well be expected considering the complex nature of the geometry. Furthermore, the LES results reveal a pronounced recirculation zone near the convex inner bank of the flume due to the shallowness of the flow and strong curvature of the flume. At the interface between the recirculation zone and the main flow, a curved mixing layer is identified as well as strong upwelling flow motion that is accompanied with large production of turbulent kinetic energy.



Earlier work on more schematized geometries with a flat bed revealed that turbulence anisotropy contributes to the formation and strength of the secondary circulation cells, disqualifying e.g. $k-\epsilon$ as a turbulence model for those cases [2,3]. Apparently the highly schematized geometries put higher demands on the turbulence modeling whereas nature is merciful in this respect by providing a more complex geometry yet a simpler flow.

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