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Coherent Structures in the Flow over Two-Dimensional Dunes
MOHAMMAD OMIDYEGANEH, UGO PIOMELLI, Queens University — Dunes are common large-scale bed irregularities found in rivers at high Reynolds numbers. One characteristic feature of the flow over dunes is the presence of boils, upwelling motions observed at the water surface. Understanding the dynamics of the eddies that cause boils is critical, since these eddies lift up sediment from the river bed and carry it to the surface. To analyse the dynamics of these large structures, we performed large eddy simulation of the flow over two-dimensional dunes at laboratory scale (the Reynolds number based on the average channel height and mean velocity is 18,900). Results show that the rollers generated in the separated shear layer interact with wall turbulence to form an inclined horseshoe vortex that reaches the surface; the upwelling is due to the ejection that occurs between the legs of the horseshoe. These vortices are initially vertical, but become inclined when they are advected to the surface; near-wall horseshoe vortices, on the other hand, start from a horizontal orientation. This indicates that these structures are unique to the flow over dunes, in which separation occurs at the crest. While the boil frequency is fairly low (they were found every $40h/U_b$ time, approximately) they are known to affect sediment transport significantly. A more quantitative analysis of the contribution of large vortices to mass and momentum transport is presently being carried out.

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