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Characterisation of the imprint of roughness topography on the near wall flow using the blanketing layer concept

Angela Busse[1,2,*] and Oleksandr Zhdanov[2]

[1] Department of Numerical Fluid Dynamics, Technische Universität Berlin
Müller-Breslau-Straße 15, 10623 Berlin, Germany.

[2] James Watt School of Engineering, University of Glasgow
James Watt South Building, University Avenue, Glasgow G12 8QQ, UK.

[*] angela.busse@tu-berlin.de.

ABSTRACT

In turbulent flows over rough surfaces, the near-wall flow is altered by the presence of the roughness features. Typically, in areas of moderate streamwise gradients of a rough surface the flow can follow the roughness contours whereas separation is induced by more extreme features, e.g., over deep pits or behind tall peaks in the roughness topography. The blanketing layer concept was introduced to quantify how the closely the mean flow follows the roughness topography (Busse, Thakkar & Sandham, 2017). For barnacle-type roughness, an approximately linear relationship was found between the roughness function ΔU^+ and the effective slope ES^B (or frontal solidity λ_f^B) of the blanketing layer, i.e., the blanketing layer topography can be used to quantify the sheltering effect that decreases the fluid dynamic roughness effect at high frontal solidity (Sarakinos & Busse, 2022).

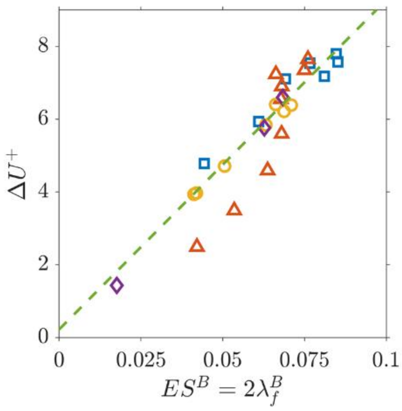

Figure 1: Dependency of the roughness function the effective slope of the blanketing layer; squares, circles and diamonds: isotropic cases: triangles: anisotropic cases

In this contribution, we will discuss the relationship between mean flow statistics, the topographical parameters of a rough surface, and the blanketing layer that forms over it. To this end, blanketing layers have been computed for a wide range of roughness conditions based on results from direct numerical simulations of turbulent channel flow and have been analysed using standard topographical approaches. The results demonstrate, e.g., that the abovementioned linear relationship between ΔU^+ and the effective slope of the blanketing layer is also observed for other statistically isotropic rough surfaces, but that deviations occur for strongly anisotropic surfaces. The Reynolds number dependency of the blanketing layer topography will also be investigated for several representative surface conditions.

References

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