Supplementary information

Article title: Influence of ridge spacing, ridge width, and Reynolds number on secondary currents in turbulent channel flow over triangular ridges

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Supplementary figures

Details of the simulations for the largest studied ridge spacing ($s/\delta = \pi$) using a twice bigger domain size in spanwise direction ($L_y = 2\pi$) at $Re_\tau = 550$ are presented in Table. SI 1. The results of this simulation in terms of mean velocity profiles and turbulent statistics are compared to those obtained using a spanwise domain size of $L_y = \pi$ in Fig. SI 1.

Spanwise averaged premultiplied streamwise energy spectra $k_x\phi_{uu}/u_\tau^2$ for $Re_\tau = 550$ are shown in Fig. SI 2 for surfaces with varied ridge spacing.

Premultiplied streamwise energy spectra $k_x\phi_{uu}/u_\tau^2$ for $Re_\tau = 1000$ are presented in Fig. SI3 for three selected spanwise locations, which correspond to the ridge centreline (left column in Fig. SI 3), the location of secondary current centres (middle column in Fig. SI 3), and the centre of the valley between ridges (right column in Fig. SI 3). For simulations performed at $Re_\tau = 1000$, the spectra were computed using at least 1728 instantaneous snapshots separated by approximately 31 viscous time units ($\Delta t^+ = \Delta t u_\tau^2/\nu$). In addition, spanwise averaged premultiplied streamwise energy spectra for the same surfaces at $Re_\tau = 1000$ are presented in Fig. SI 4. Reference smooth wall data are shown in Figs. SI 2e and 4e for the present smooth wall case; the spectrum from the DNS by Lee and Moser (2015) at $Re_\tau = 1000$ for a larger domain size is also included (see Figs. SI 3f and 4f).

Table SI 1: Parameters of the direct numerical simulation for $s/\delta = \pi$ in a twice wider domain. L_x, L_y, and L_z are the domain sizes in streamwise, spanwise, and wall-normal direction; N_x, N_y, N_z are the number of grid points in the streamwise, spanwise, and wall-normal direction; Δx^+ and Δy^+ are the grid spacing in plus units in the streamwise and spanwise direction, Δz^+_{min} and Δz^+_{max} are the minimum and maximum grid spacing in plus units in the wall-normal direction

Re_τ	L_x/δ	L_y/δ	L_z/δ	N_x	N_y	N_z	Δx^+	Δy^+	Δz^+_{min}	Δz^+_{max}
550	3π	2π	2.00	1152	1152	512	4.50	3.00	0.67	4.69

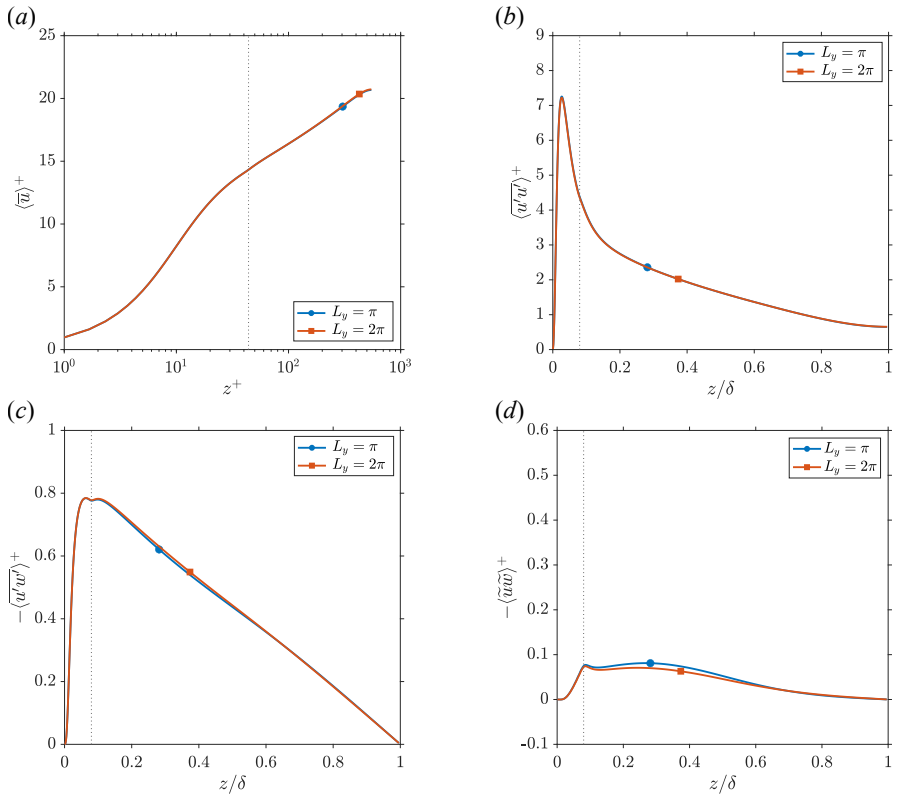

Fig. SI 1: Profiles of streamwise velocity (a), streamwise Reynolds normal stress (b), and Reynolds (c) and dispersive (d) shear stress profiles for surface with $s/\delta = \pi$ at $Re_\tau = 550$ in simulations with different spanwise domain size. Location of the ridge crest is marked by thin dashed vertical line

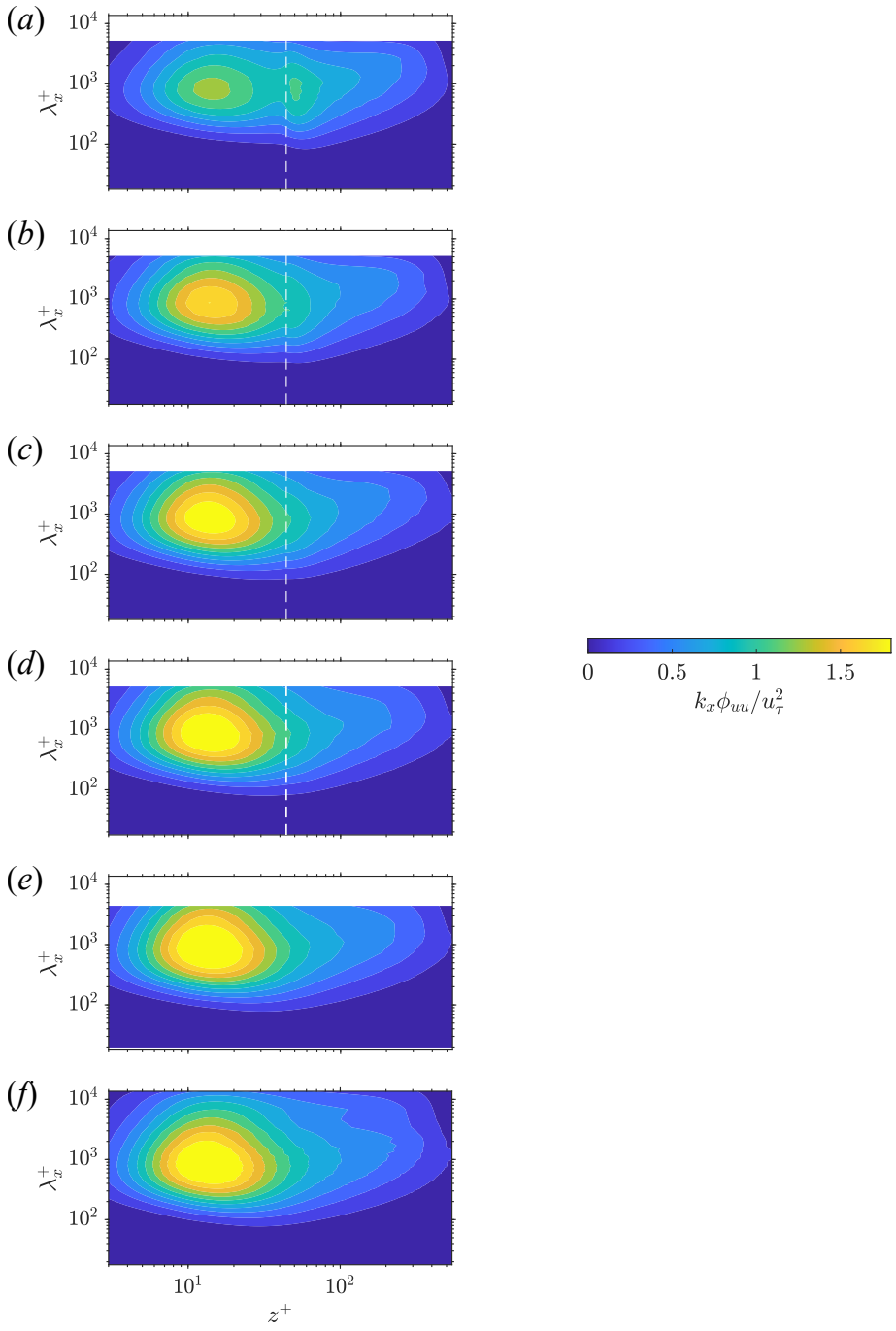

Fig. SI 2: Spanwise averaged premultiplied streamwise energy spectra $k_x\phi_{uu}/u_\tau^2$ at $Re_\tau = 550$ as a function of streamwise wavelength (λ_x) and wall-normal location (z) for surfaces with varied ridge spacing (a) $s/\delta = \pi/8$, (b) $s/\delta = \pi/4$, (c) $s/\delta = \pi/2$, (d) $s/\delta = \pi$. The thin white dashed line marks the wall-normal location of the ridge crest. Reference smooth wall data is shown in (e). In addition, data from the channel flow DNS of Lee and Moser (2015) at $Re_\tau = 550$ for a larger domain size is included in (f)

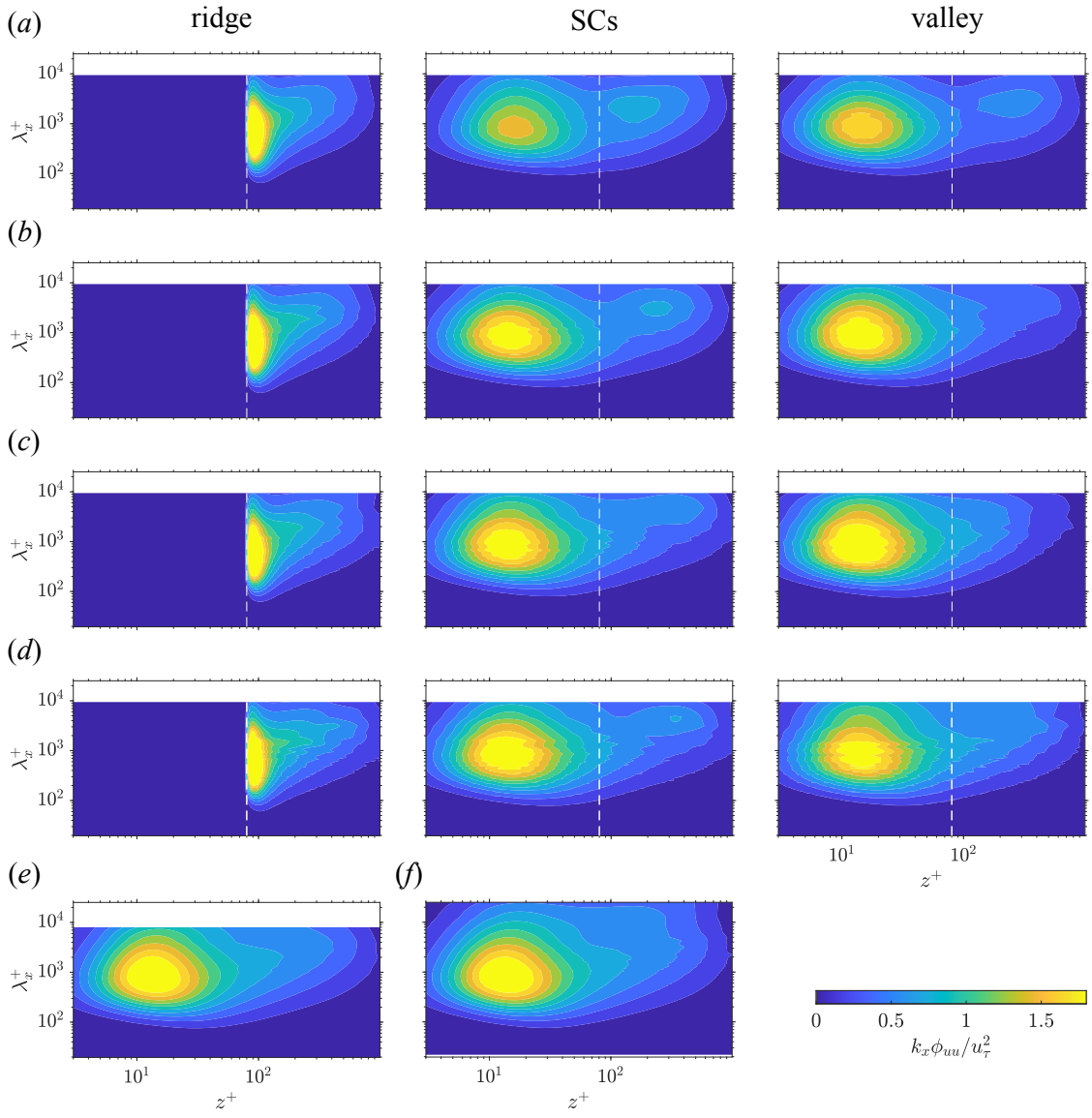

Fig. SI 3: Premultiplied streamwise energy spectra $k_x\phi_{uu}/u_\tau^2$ at $Re_\tau = 1000$ as a function of streamwise wavelength (λ_x) and wall-normal location (z) for surfaces with varied ridge spacing (a) $s/\delta = \pi/8$, (b) $s/\delta = \pi/4$, (c) $s/\delta = \pi/2$, (d) $s/\delta = \pi$ at three different spanwise locations: ridge centreline (left column), location of secondary current centres (middle column), and centre of the valley between ridges (right column). The thin white dashed line marks the wall-normal location of the ridge crest. Reference smooth wall data is shown in (e). In addition, data from the channel flow DNS of Lee and Moser (2015) at $Re_\tau = 1000$ for a larger domain size is included in (f)

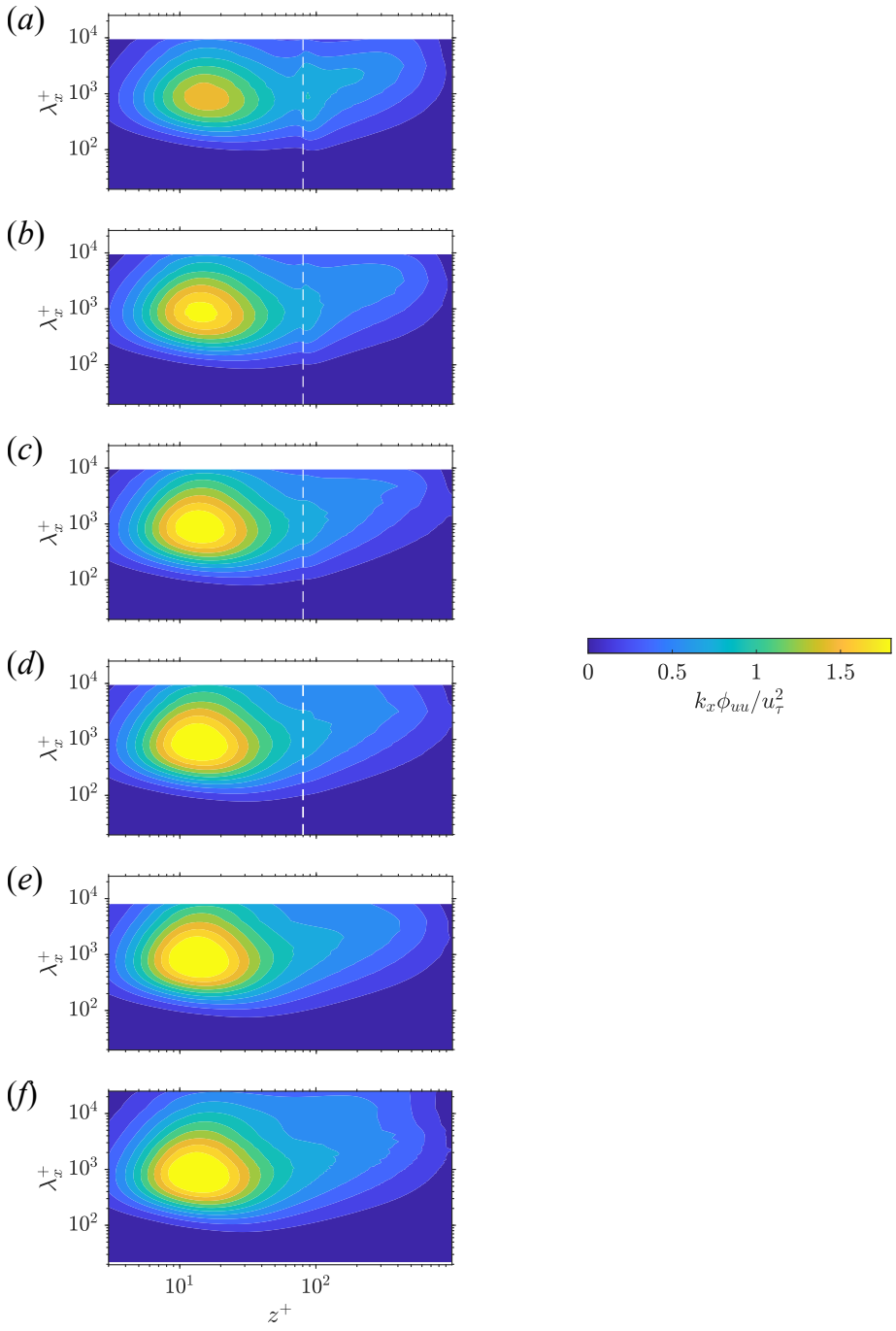

Fig. SI 4: Spanwise averaged premultiplied streamwise energy spectra $k_x\phi_{uu}/u_\tau^2$ at $Re_\tau = 1000$ as a function of streamwise wavelength (λ_x) and wall-normal location (z) for surfaces with varied ridge spacing (a) $s/\delta = \pi/8$, (b) $s/\delta = \pi/4$, (c) $s/\delta = \pi/2$, (d) $s/\delta = \pi$. The thin white dashed line marks the wall-normal location of the ridge crest. Reference smooth wall data is shown in (e). In addition, data from the channel flow DNS of Lee and Moser (2015) at $Re_\tau = 1000$ for a larger domain size is included in (f)

References

Lee, M. and Moser, R. D. Direct numerical simulation of turbulent channel flow up to $Re_\tau \approx 5200$. *Journal of Fluid Mechanics*, 774:395–415, 2015. doi: 10.1017/jfm.2015.268.