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Gustiness in thermally-stratified urban turbulent boundary-layer flows and the influence of surface roughness

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Wind gusts are examined for the mean wind speed, fluctuations, turbulence intensities and fluxes for a real urban topography. Using large-eddy simulation (LES), a wide range of boundary-layer stability is considered: the bulk Richardson number, Rb ∈ [-0.41, 0.82]. Ratios of the proposed gustiness statistics, G, over the conventional time-averaged turbulence statistics are maximised for $z/H_{ave} \sim 1$ (where H_{ave} is the mean building height). There is a strong linear scaling of G with the plan-area building packing density, λ_p ($R^2 \sim 0.8$), and the trend persists to stably- and unstably-stratified flows. By contrast, the normalised building-height variability (σ_H), σ_H/H_{ave}, and the scaled frontal-area density (λ_f), $\lambda_f H_{ave}/\sigma_H$, are found to be of more appropriateness as scaling parameters for G compared to their original forms, σ_H and λ_f. While the dependence of G on λ_p, λ_f and σ_H are inconclusive at greater heights, effects of the surface inhomogeneity do not vanish and those of thermal stratification amplify. Noticeable differences cannot be unambiguously distinguished between the sensitivities of the zeroth- to the second-order gustiness statistics to the boundary-layer stability. It is argued that urban wind hazards may be weakened through urban planning with optimised combinations of the morphometric parameters.