ML report

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1   Simulation setup

Turbulent channel with constant pressure gradient (CPG). $Re_\tau = u_\tau(H - k_{md})/\nu$, where $u_tau = \sqrt{\tau_w/rho}$ and $\tau_w = -P_x(H - k_{md})$.
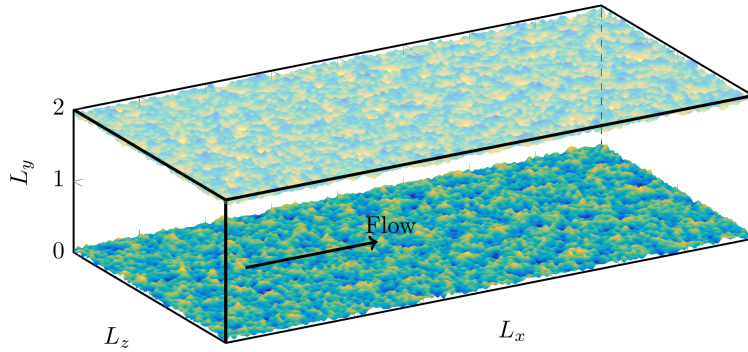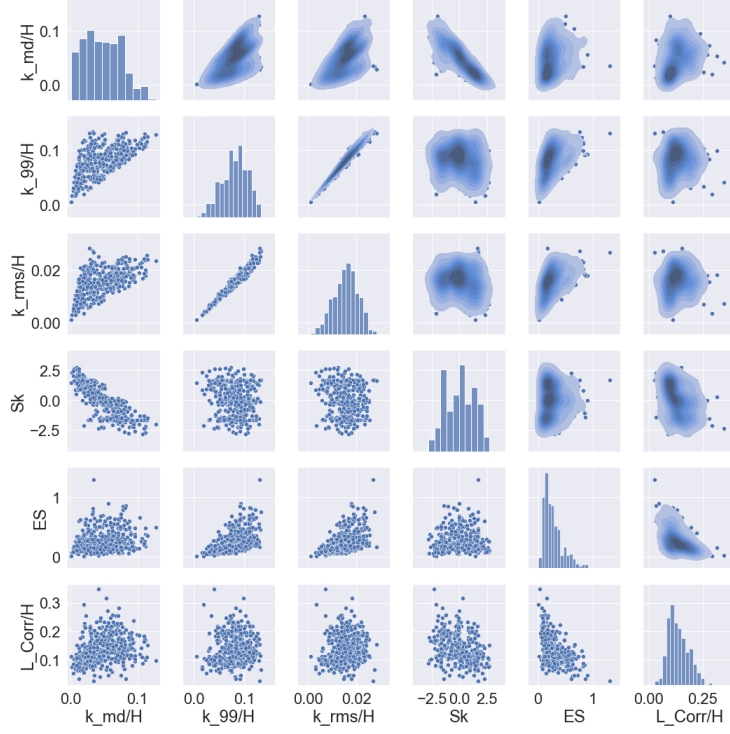

Figure 1: Schematic representation of simulation domain with an example pseudo-realistic surface mounted. Normalization of lengths with H is applied in the figure.

SurfaceID	Re_τ	L_x/H	L_z/H	N_x	N_z	Δ_x^+	Δ_z^+	$\Delta_{y,k}^+$
0-199	500	2.4	0.8	480	160	2.5	2.5	≈ 1.74
200-399	500	3	1	576	192	2.6	2.6	≈ 1.74

Table 1: Simulation domain setup

2   Roughness configuration

Identical Re_τ, variying $k_{99} = \Phi_{0.08,0.02}$

2.1 PDF

Weibull:
$$f(k) = \lambda\beta^{\lambda}k^{(\lambda-1)}e^{-(\beta k)^{\lambda}},$$

Bimodal:
$$k(i) = min\{\Phi_{0,1}(i), \Phi_{-\lambda,\lambda}(i)\},$$

Gaussian:
$$f(i) = \frac{1}{\sigma\sqrt{2\pi}}e^{-\frac{1}{2}(\frac{i-\mu}{\sigma})^2}$$

2.2 PS

- $\lambda_0 = 0.8H$ (Surface ID 0-199), $= 1H$ (Surface ID 200-399).

- $\lambda_1 = 0.04H$.

- PS normalized by $\lambda_{diff} = \lambda_0 - \lambda_1$.

- Roll-off length: $L_r/\lambda_{diff} = \Phi_{0.4,0.04}$.

- PS slope:$\theta_p = -|\Phi_{0.75,0.3}|$.
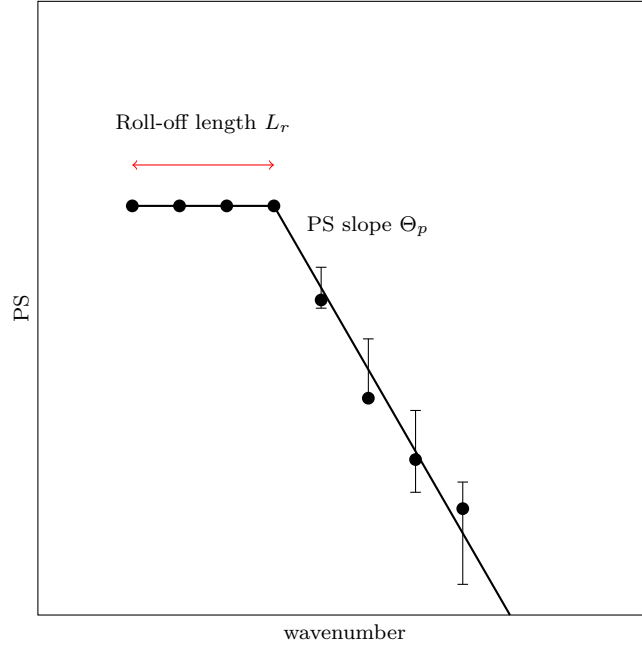
- Randomize along PS(20): $PS(i) - \Phi_{0,0.5*i}$.

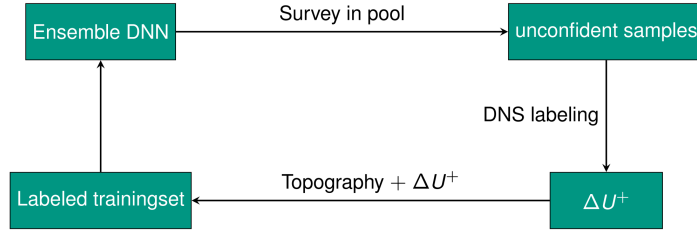Figure 2: PS Sketch

3 Active learning

Figure 3: Flow chart of the present active learning framework

3.1 Ensemble deep neural network

Input: Discretized $\log(\text{PS})$ and PDF/k_t, k_{99}, k_t, λ_0/k_t, λ_1/k_t.
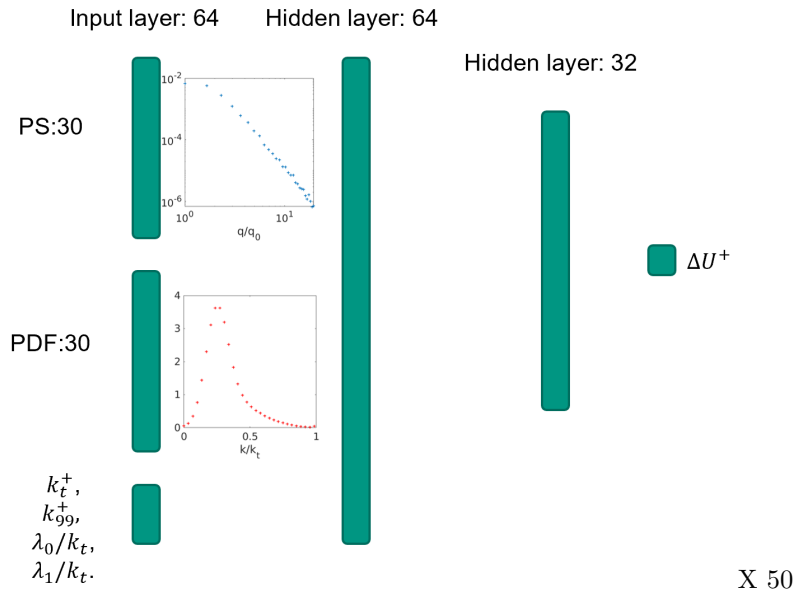Output: averaged prediction ($\mu_{\Delta U^+}$) & uncertainty prediction ($\sigma_{\Delta U^+}$)

Figure 4: Sketch of ensemble DNN, output: averaged prediction $(\mu_{\Delta U^+})$ & uncertainty prediction $(\sigma_{\Delta U^+})$