Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

Large eddy simulation study of 3D wind field in a complex mountainous area under different boundary conditions

Yan LI, Lei YAN, Xuhui HE

Key words: Large eddy simulation; Spectral representation method; Recycling method; High mountainous canyon; Wind characteristics; Atmospheric boundary layer; Computational domain

Cite this as: Yan LI, Lei YAN, Xuhui HE, 2024. Large eddy simulation study of 3D wind field in a complex mountainous area under different boundary conditions. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 25(7):541-556. https://doi.org/10.1631/jzus.A2300613

Numerical model

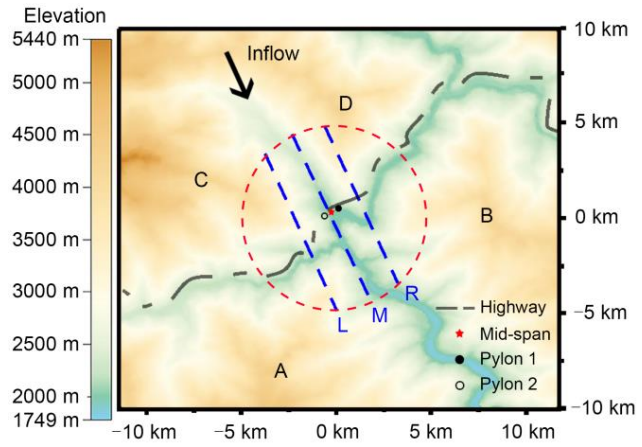

Fig. 1 Topographic map of a complex mountainous area and monitored points and lines

Table 1 Computational domain arrangements for eight calculation domain heights (H_m = 1 m, L_m=5.5 m)

Case number	H_D	L_D	Cell number (million)
1	$2H_m$	$0.77L_m$	5.00
2	$2.25H_m$	$0.77L_m$	5.40
3	$2.50H_m$	$0.77L_m$	5.74
4	$2.75H_m$	$0.77L_m$	6.02
5	$3H_m$	$0.77L_m$	6.18
6	$4H_m$	$0.77L_m$	6.74
7	$5H_m$	$0.77L_m$	7.24
8	$6H_m$	$0.77L_m$	7.80

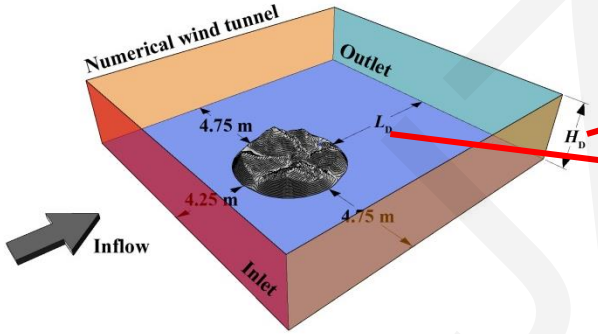

Fig. 2 Sketch map of the computational domain of the numerical wind tunnel

Table 2 Computational domain setups for four distances from the outlet to the terrain model (H_m = 1 m, L_m=5.5 m)

Case number	H_D	L_D	Cell number (million)
1	2Hm	0.77Lm	5.00
9	2Hm	2Lm	5.19
10	2Hm	3Lm	5.33
11	2Hm	5Lm	5.56

Inlet boundary of numerical model

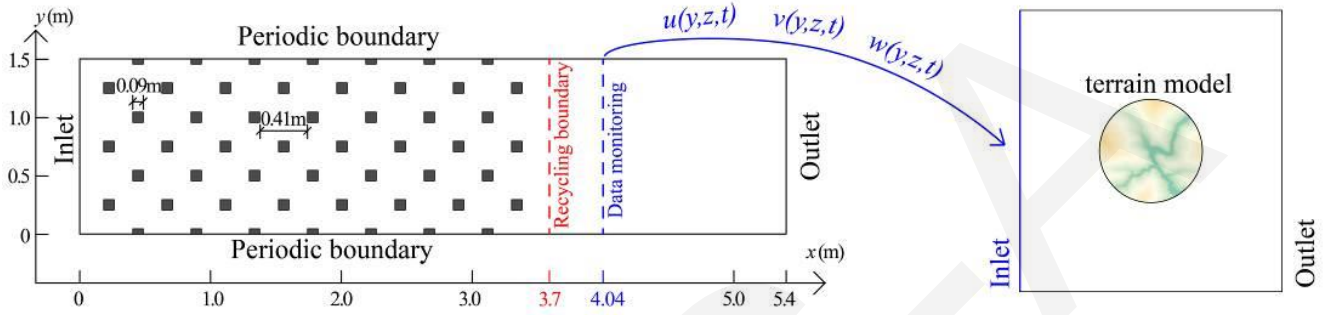

Fig. 3 Configuration of numerical wind tunnel simulating arrangement of floor roughness elements

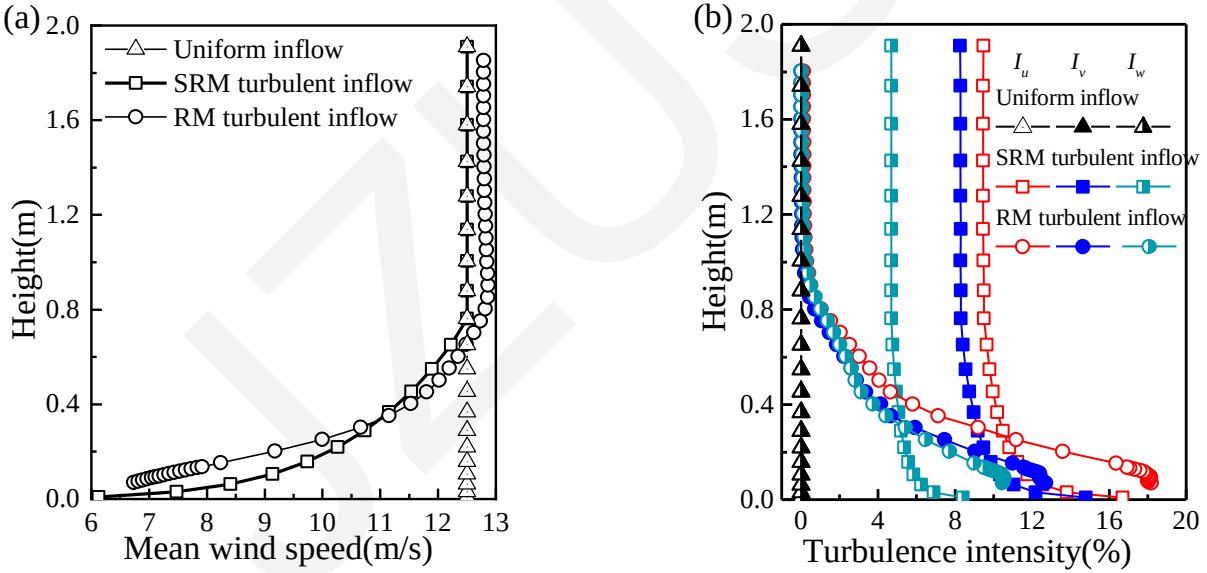

Fig. 4 Wind velocity profiles at the inlet boundary: (a) mean wind velocity profile and (b) turbulence in-tensity profile

Influence of computational field height on wind characteristics

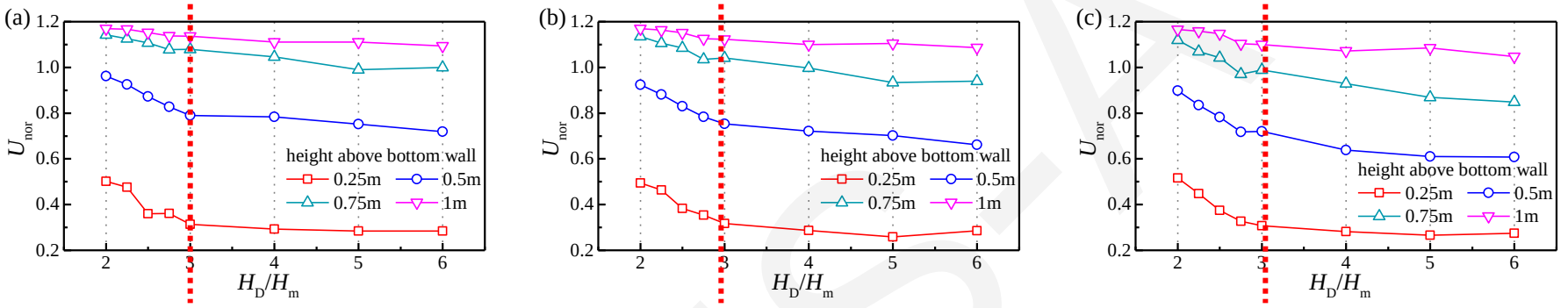

Fig. 5 Wind velocity profiles at the inlet boundary: (a) mean wind velocity profile and (b) turbulence in-tensity profile

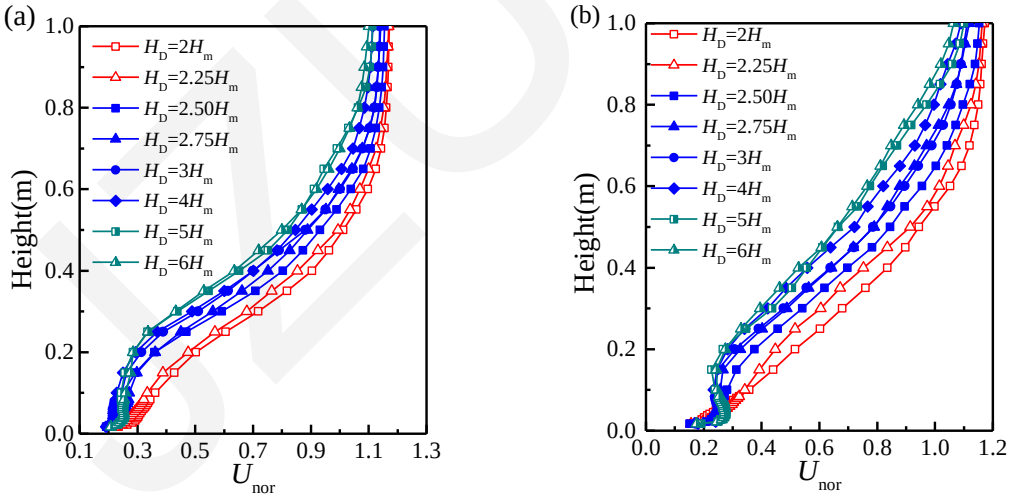

Fig. 6 Profiles of normalized mean wind velocity at (a) Pylon 1 and (b) Pylon 2 simulated through different computational domain heights

Influence of wake region length on wind characteristics

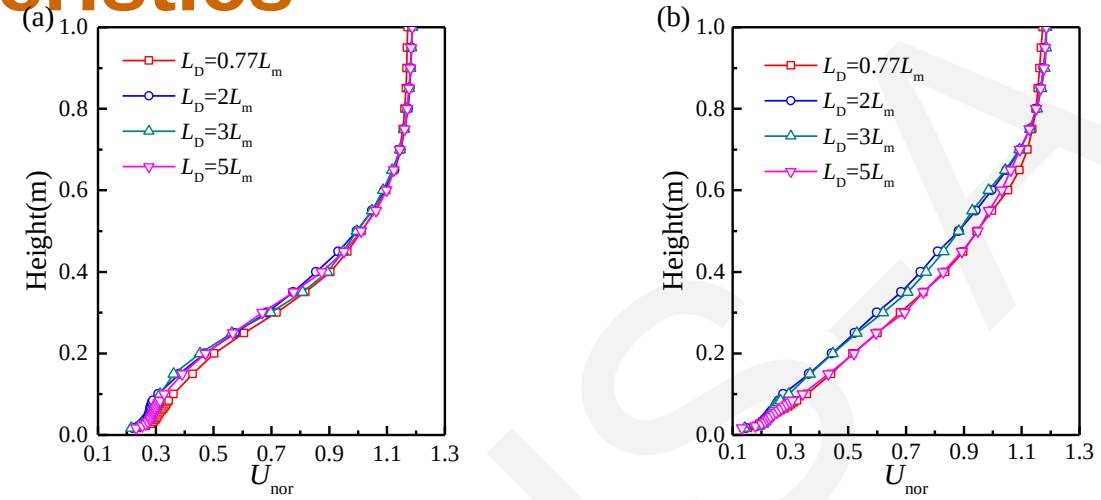

Fig. 7 Profiles of normalized mean wind velocity at (a) Pylon 1 and (b) Pylon 2 simulated with different distances from outlet to terrain model

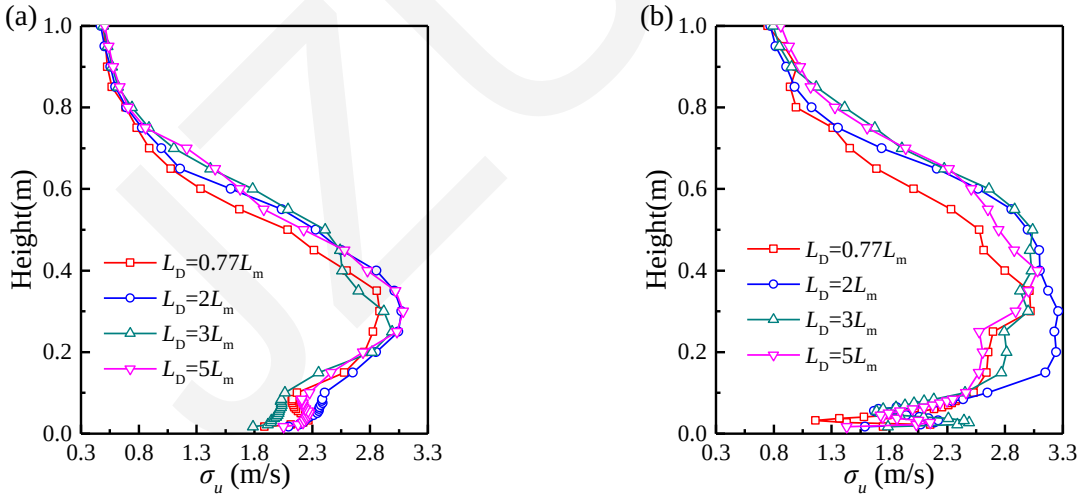

Fig. 8 Profiles of standard deviation of longitudinal component of turbulence at (a) Pylon 1 and (b) Pylon 2 simulated with different distances from outlet to terrain model

Influence of inlet boundary condition on wind characteristics

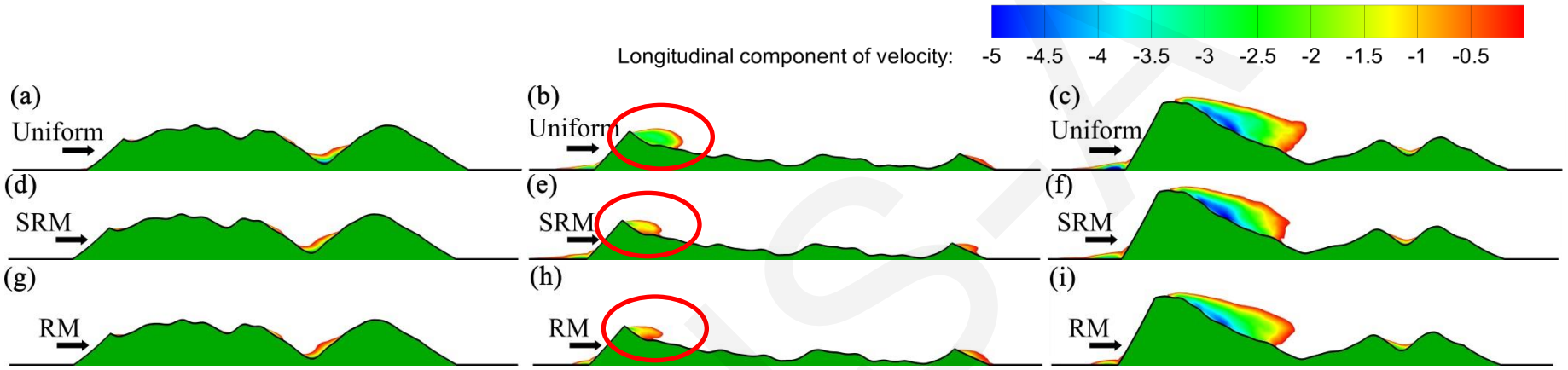

Fig. 9 Contours of regions with a negative longitudinal component of velocity on the plane along lines L, M and R with uniform inflow (a, b, c), SRM inflow (d, e, f) and RM inflow (g, h, i).

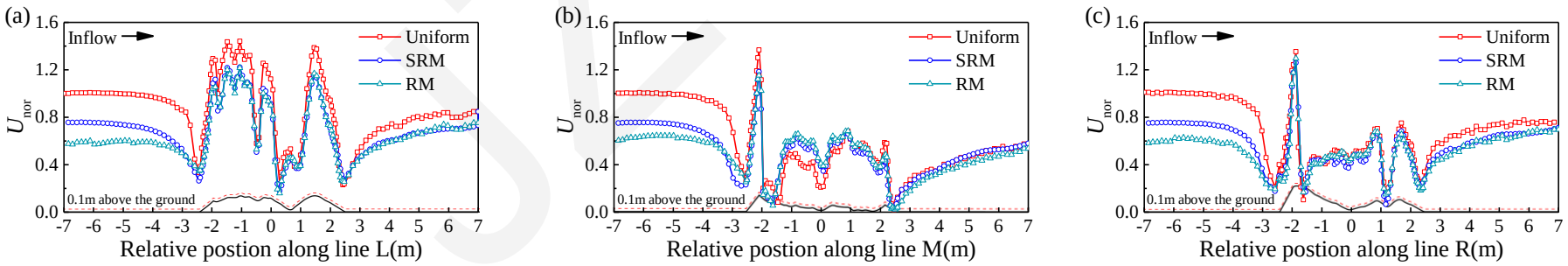

Fig. 10 Normalized mean wind velocity at 0.1 m above ground level (red dotted line) along (a) line L, (b) line M and (c) line R.

Conclusions

- The change of the wind field characteristics with the change of H_D slows down when H_D is greater than triple the model height. H_D slightly influences the wind field if it is greater than five times the model height.
- The inlet turbulence has little effect on the shape of the mean wind velocity profile, but significantly influences the profile of the standard deviation of the longitudinal component of turbulence.
- There is a significant impact on the airflow separation of the turbulence in the inlet when the terrain slope is gentle. However, when the slope is steep, changes in the wind field due to inlet turbulence are limited.