Estimating the effect of pre-existing snowdrift on turbulent airflow and subsequent snowdrift in the numerical simulation

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Background

Matured snowdrifts generated by previous periods of drifting snow events behave as walls for airflows. Boundary conditions in the numerical simulation should be updated following the snowdrift shapes.

Purpose:
Investigate the effect of boundary changes due to snowdrift formation during a drifting snow event using a numerical simulation model
Overestimate? or Underestimate? without boundary updates

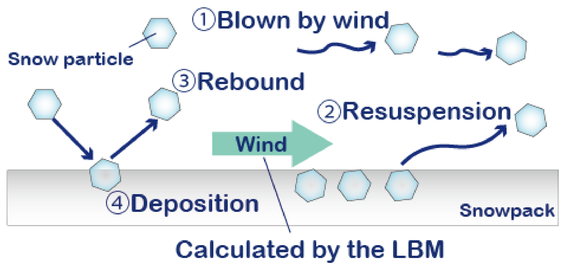
Target:
Snowdrift distribution around three types of ideal fences

Model

SMOWL (Tanji et al. 2021; Tanji et al. 2023)

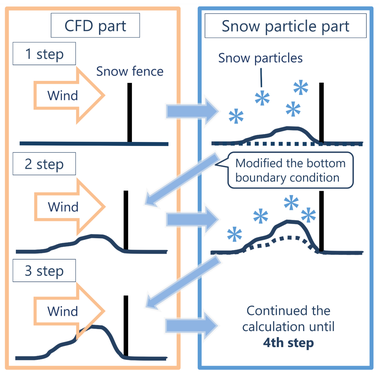
◆ CFD part
Calculates background wind using the Lattice Boltzmann method (LBM)
- Greater parallel computation efficiency
- Suitability for applying complicated boundaries

◆ Snow particle part
Predicts trajectories of representative snow particles using the results of the CFD part

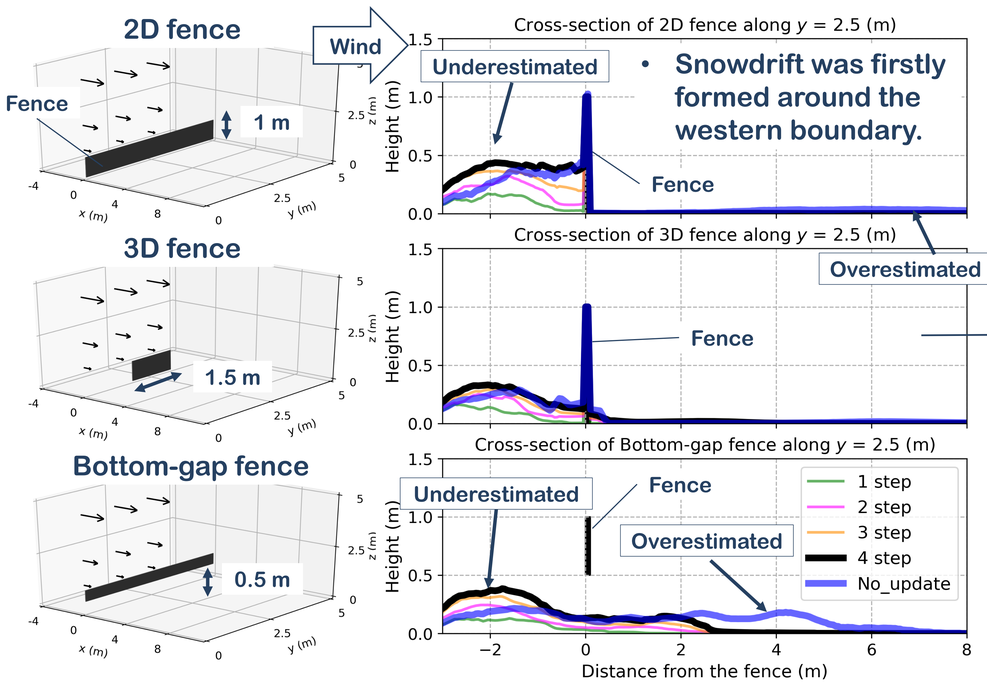


① Snow particles are blown by wind (Nishimura and Hunt 2000).
② Accumulated snow particles are resuspended if the friction velocity exceeds the threshold value (Bagnold 1941; Clifton et al. 2006).
③ Snow particles colliding with snow or ground surfaces rebounds if they have a large energy (Okaze et al. 2018).
④ If not, snow particles accumulate.

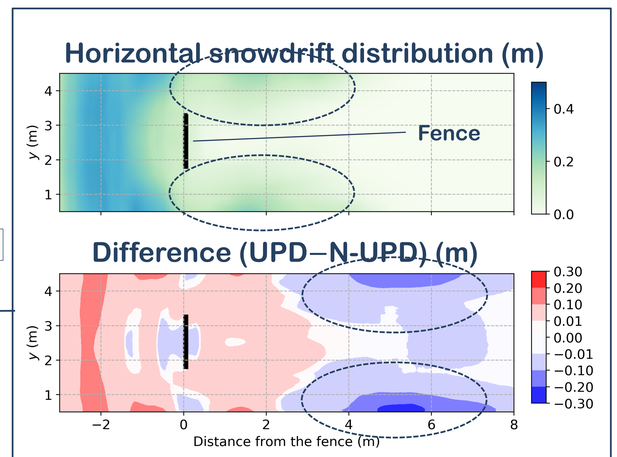
◆ Update process
UPD (Update experiment)
Boundaries of snowdrifts
⇒No-slip boundary (4 times)
One step calculation: a 2-h drifting snow event.
⇒2 h × 4 times = **8 h**
N-UPD (No-update experiment)
⇒ 8 h × 1 times = **8 h**



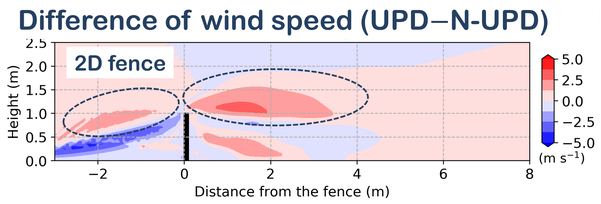
Results

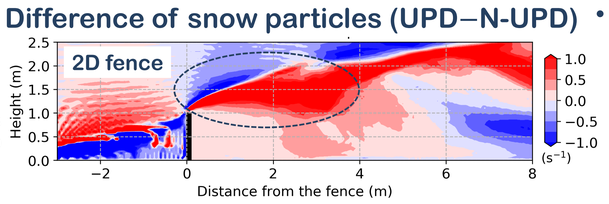


- Snowdrift was firstly formed around the western boundary.



- Arc-shape snowdrift was generated from both sides of the fence
- Snowdrift height on the end of the arc-shape snowdrift was overestimated.

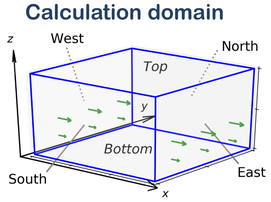




- The previous snowdrift was formed along the streamline of the wind in UPD.
⇒Wind speed was strengthened.
⇒Particles were blown far.

Boundary conditions & setting

Calculation domain



West:
Laminar inflow (logarithmic profile)
6 m/s wind speed at 10 m height
East: Free flow
North & south: Cyclic
Top: Free slip
Bottom & fence & snowdrift: No-slip

Calculation domain (x, y, z)	15.75 m, 5 m, 5 m
Grid spacing	0.05 m
Output	Every 1 s
Integration time of CFD part	1 hr 30 s (30 s is spin-up time)
Number of member in snow particle part	3600
Shape of snow particles	Sphere
Diameter & density of snow particles	135 μm, 910 kg/m^3

Conclusions

- N-UPD underestimated snowdrifts in front of fences and overestimated snowdrifts on leeward side of fences.
2D: 2 m distance from the fence
3D: End of the arc-shape snowdrift
Bottom-gap: Most of leeward areas
- Previous snowdrifts on windward side accelerated wind speed and blew snow particles to out of the domain.
- Considering previous snowdrift structures is important for estimating snowdrift distribution more accurately.

Reference: Tanji, Seika, Estimating the effect of snowdrift formation on turbulent airflow and subsequent snowdrift around three types of fences, J. Wind Eng. Ind. Aerod., 261, 106089, 2025.

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