Direct two – phase numerical simulation of snowdrift remediation using three – dimensional deflection fins

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ABSTRACT

We present a versatile three – dimensional two – phase model for simulating snow drift relocation around buildings utilizing deflection fins of various shapes and sizes. The first phase involves numerically obtaining the air velocity profile around the building and fin using a velocity – pressure Navier – Stokes algorithm, while the second phase involves direct classical simulation of snowfall with particle – particle, particle – surface and one – way particle – gusting wind interactions introduced to control accumulation, erosion, clumping and drifting. Because the simulation technique is direct, it is potentially useful for storms and surfaces with widely varying conditions. We are also able to consider the effect of crosswinds.

KEYWORDS: Deflection fin simulations, direct snowfall simulations, drifting simulations

NOMENCLATURE

A, B, C	computational cell dimensions
a	drag force coefficient
b	snowflake repulsion coefficient
c	snowflake sticking coefficient
g	acceleration of gravity
i,j,k	indices in x, y and z directions
Δt	time step
m	mass of snowflake
μ	kinematic viscosity of air
n_x, n_y, n_z	number of x, y and z grid points
v_{ij}	relative velocity of two snowflakes
P	pressure
ρ	density of air
R	radius of snowflake
r_{ij}	separation between two snowflakes
θ	Heaviside step function
u	x – component of velocity
v	y – component of velocity
$\vec{v}$	air velocity
W	z– component of velocity
x	horizontal coordinate
y	lateral coordinate
z	vertical coordinate

1. INTRODUCTION

Snow exhibits a wide range of characteristic dynamics, ranging from slow, almost vertical snowfall to the chaotic whirling and drifting seen in blizzards. Especially at extreme latitudes the drifting of snow can present significant challenges to people along many different fronts. Because computer simulations and mathematical modeling are very useful in understanding and even predicting the behavior of physical systems, especially ones that are associated with negative impact on people, researchers have mathematically investigated snowfall and its effects in one, two and three dimensions. The drifting and accumulation of snow in natural environments is directly related to avalanche danger; computer simulations have been used to estimate snow loading,[1] transport[2] and drifting[3,4] in natural settings with the purpose of avalanche warning.[1-4]. In addition to snow behavior in natural settings, snow drifting in three dimensions around buildings of different shapes and aspect ratios[5-7] and even cubes[8] has been modeled.

Although it is very useful to understand the dynamics of snow drifting and transport, results of the processes themselves can present significant