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The Cryosphere
Discussions

Interactive comment on "The role of a mid-air collision in drifting snow" *by* Shuming Jia et al.

Anonymous Referee #1

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General comments:

This manuscript aims to investigate the effect of midair particle-particle collision on drifting snow using a three-dimensional numerical model. The theoretical frame work of the model is standard in recent numerical studies of drifting snow, but authors consider the collision between airborne particles, which is excluded from previous drifting snow models. Numerical simulations of the model adopt the non-periodic boundary condition in the streamwise direction. In addition, the realistic particle size distribution measured in wind tunnel experiments and field observations is used for simulations. Then, numerical results are compared with previous experimental and observational data to check the validity of the model. However, there are many lack of descriptions, analyses, and discussions as listed in specific comments. Therefore, the current manuscript fails to meet the publication quality of The Cryosphere.

Specific comments:

1. Introduction

1) Please explain that why authors focus on a role of a mid-air collision in wind-blown sand transport and drifting snow.

2) Please refer to important previous studies for a mid-air collision in aeolian particle transport: for example, Carneiro, M. V. et al.: Midair Collisions Enhance Saltation, Physical Review Letters, 111, 058001:1-5, 2013. Li, D. et al.: Inter-particle collision effects on the entrained particle distribution in aeolian sand transport, International Journal of Heat and Mass Transfer, 58, 97-106, 2013.

2. Model and method

3) For the drag force acting on a particle F_D, the function of particle Reynolds number f(Re_p) and the particle relaxation time T_p are used. In general, the drag force is expressed using the drag coefficient C_D, the projected area of particle A, and the square of relative velocity between particle and wind as written in Yamamoto et al. (2001). What is different from the general formula? Please explain the physical meaning of f(Re_p) and T_p.

4) In mid-air collision model, I cannot understand "To avoid repetition, there is the limitation condition of x_Ai < x_Bi". Please justify this limitation.

5) The change in particle velocity due to the mid-air collision is similar to the calculation process of discrete element method (DEM) without the friction. Please justify the mid-air collision model. Also, for {\lambda} and e of the recovery coefficient of ice, the applicable range should be rewritten on the basis of Supulver et al. (1995).

6) Please describe boundary conditions at bottom and top. Is the boundary condition of snow particles same as wind?

7) The aerodynamic entrainment and the splash process are important sub-physical

processes in drifting snow. Especially, Sugiura and Maeno (2000) measured two- dimensional particle motion near the snow surface; and then, they categorize splash functions according to the type of snow. Please write the detail of these two processes.

3. Results

8) Before the comparison with previous experiments and simulations, please justify if the mid-air collision model correctly works. In general, a very small value of time step {\delta_t} is required in the calculation of the collision between particles: 10ˆ-6 s as the typical value.

9) In the simulation setup, the length of streamwise direction is 2 m. This length is quite- short to analyze the transport property and structure. Indeed, the streamwise length of wind tunnel experiments exceeds approximately 10 m. Nishimura et al. (2014) compared vertical profiles of wind and particle speeds at 6 m and 12 m leeward from the wind tunnel entrance; then, they reported that the drifting snow does not reach the steady state at 6 m length. In addition, most of the drifting snow simulation utilize the periodic boundary condition in the streamwise direction, in order to reproduce well-developed drifting snow. Therefore, I don't understand the state of drifting snow calculated using the model. This doubt about the accuracy of simulation are found in many points of Results and Discussions.

10) Please write the gamma function of particle diameter.

11) In Fig. 3, data of previous wind tunnel experiments and numerical simulations are shown. Here, Nemote and Nishimura (2004) considered the suspension layer up to 20 m height. Thus, the experiment and simulation situations of drifting snow are different. Why authors compare these previous studies? Although numerical data without and with the mid-air collision are drawn as solid and dashed lines, please draw data points. How the friction velocity of x-axis are estimated?

12) "the snow transport flux at various friction velocities are consistent with the simulation results of Nemoto and Nishimura (2004), mainly because the same splash function is adopted." Recent numerical study with this splash function (Niiya et al.: Spatiotemporal Structure of Aeolian Particle Transport on Flat Surface, J. Phys. Soc. Jpn., 86, 054402:1-11, 2017.) reported that the splash function of snow underestimates the snow transport flux at higher friction velocities. To avoid this, the current drifting snow model divides the splash process into two types: rebound and splash (Nemoto and Nishimura (2004), Zwaaftink et al., (2014)). Please discuss the reason that this simulation obtains the same level of snow transport flux as previous model.

13) In Fig. 4, the collision frequency is measured. Please define it. "one particle may experience over 10 collisions per second when the particle concentration is 10ˆ8 mˆ-3" This meaning changes depending on the definition of collision frequency.

14) Elghobashi, S.: On predicting particle-laden turbulent flows. Appl. Sci. Res., 52, 309- 326, 1994. presented a classification map for the types of interaction between particles and turbulence. In the paper, the particle-particle interaction (i.e., collision) is not negligible when the particle volume fraction exceeds 10ˆ-3. Also, the granular temperature, is fluctuation of particle velocity, plays an important role in the particle-particle collision of granular gas. Please check the collision frequency from the view point of particle volume fraction, and quantify the particle activity as the granular temperature.

15) In Fig. 5, the critical height is calculated from the vertical profile of the particle concentration. Please show it. Vertical profiles of wind speed, friction velocity, particle speed, particle concentration, and so on are key to understand the mechanism of drifting snow; however, they are not shown in current manuscript.

4. Discussions

16) Only the skin friction velocity in drifting snow is focused in Discussions. Since this manuscript aims to the role of a mid-air collision, authors should discuss deeply the mid- air collision from various viewpoints.

17) If authors study the skin-friction velocity in drifting snow as the additional discussion, please refer the recent experiment (Walter et al.,: Experimental assessment of Owen's second hypothesis on surface shear stress induced by a fluid during sediment saltation, Geophys. Res. Lett., 41, 6298-6305, 2014.).

18) P.13, L. 205: "because frequent inter-particle collisions can produce many high energy particles..." Particles lose the energy by the energy dissipation due to the collision. Please explain the meaning of sentence.

19) The particle transport flux increases as the square of friction velocity in recent studies, but also it is strongly depending on the particle diameter according to Sugiura et al. (1998). In this simulation, the polydisperse particles of 100-600 μm diameter is considered. Please discuss more carefully this point.

Technical corrections:

1) Is F_di of Eq. (6) same as F_D of Eq. (3)?

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