Drifting snow dynamics with wind-tunnel experiment and numerical modeling

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It is known that there are four fundamental sub-processes in the drifting snow: aerodynamic entrainment, grain trajectories, grain-bed collisions, and wind modification (Bagnold, 1941). Although many investigations were carried out to reveal each sub-process, 'aerodynamic entrainment' and 'grain-bed collisions' are still poorly understood and more detailed studies are essential.
In this study, we carried out wind tunnel experiments and numerical simulation, particularly setting the focus on the development process of drifting snow.

The wind tunnel experiment was performed at a cold-laboratory of the Cryospheric Environmental Simulator of the NIED, Japan. The muss flux and diameter of drifting snow particles were measured with the Snow-Particle-Counter. Wind velocities were also measured with an ultra sonic anemometer.
For a numerical simulation, the random flight model of the snow drift developed by Nemoto and Nishimura (2004) was used.

Firstly, we focused on the initial stage of development of the snow drift. Drifting snow starts by the process of entrainment of snow surface particles by the wind. It is assumed that the entrainment process of the particles by wind is predominant over the splash process (grain-bed collision) at the initial stage of development of the drifting snow. Although, in the numerical model the number of particles entrained by wind is considered as proportional to the shear stress of the wind and its difference with a threshold value (Anderson and Haff, 1988 1991; Shao and Li, 1999), the quantitative actual value based on an observational data for the proportional coefficient does not known yet. That is why, we determined and selected its value by comparing wind tunnel experiment results for snow transport rate calculated by the model. Obtained value was found to be larger than a coefficient used in the previous study (Nemoto and Nishimura, 2004), that suggested possible overestimation of entrained particles' number.

By using obtained coefficient (mentioned above), results of numerical modeling were compared with real wind tunnel measurements for a cross section of the wind tunnel where both splash and entrainment process are assumed to be developed. It was found that modeled and measured results for friction velocity u_*= 0.27 m/s agreed well, but for higher u_*value snow transport rate was larger in the numerical model. It suggested that splash function (Sugiura and Maeno, 2000), overestimates the number of ejected particles for wind velocities higher than u_*= 0.27 m/s. But still in result of numerical computation performed with a disregarded ejection of the new particles from bed, the model calculation has shown larger values than ones measured by the wind tunnel experiment.
After comparison made for particle size distribution of the drifting snow particles it was found that wind tunnel experiment results agreed well with the output of the model for u_*= 0.27m/s; but for higher u_*values numerical prediction for number of large particles transported at high heights was overestimated. According to the splash function, supported and proven by observational results, the vertical restitution coefficient tends to be greater than horizontal one, therefore ejected particles have larger probability to get higher speeds. On the other hand, although it is expected that large particle is harder to eject comparing to a small particle due to the conservation of momentum, the particle size dependency is not considered in the presently accepted splash function. Therefore, in modeling results then wind velocity increases and speed of the impacting particle increases as well, large particles would get higher vertical speeds than real, and as result, disagreement between modeled and measured particle size distribution at the high heights arises. On the basis previously described, an elucidation of the particle size dependency can be named to be important for splash process.