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Interactive comment on "A 3-D simulation of drifting snow in the turbulent boundary layer" *by* N. Huang and Z. Wang

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General comments

The paper is of great interest. It introduces a 3D model coupling effects between wind and snow particles. The coupled model is evaluated on a flat erodible snow surface under various wind conditions and is compared to wind tunnel experiments, the results of which are published in the literature. The model takes into account all involved physical processes and allows to better understand behaviors of particles in a boundary layer. The main criticism that can be made is that this paper takes a great inspiration from a paper recently published for drifting sand by Dupont, Bergametti, Marticorena and Simoëns (Modeling saltation intermittency published in Journal of geophysical research : Atmosphere, vol 118, 7109–7128, doi:10.1002/jgrd.50528, 2013). This paper is mentioned in the article, but it is not clearly explained that the presented model is

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only an adaptation of an existing model. The use of an existing model in itself is not a problem, but it must be mentioned and for example the authors have to avoid to speak about “their model” (p 311 line 13).... The structure of the numerical model and the chosen hypothesis (for example, but it is not the only, the non inclusion of aerodynamic entrainment) are better explained in the original paper. I would therefore suggest that authors will rewrite the paper, refer to the original model and focus on their own contributions (which are very interesting) and present them in more details. The modifications of the existing model and the reasons of these modifications must be introduced and discussed. The choice of specific parameters for snow must be also better introduced and discussed. For example why choose the same parameters for the splash function initially developed for sand... Moreover the obtained results for sand and snow are very similar; this point must be further developed and also discussed in the light of the chosen hypothesis.

Simulations details :

- It is written that the initial wind database is obtained from the experimental results of wind tunnel : which experiments are these ? Did the authors perform their own experiments ? - It is not clearly written that the boundary conditions are periodic also for particle motion in order to simulate an infinite erodible soil and to obtain a well-developed saltation layer. It is probably true on the basis of the obtained results. But in this case, I did not understand why the cycle location is set up on meter upstream the particle layer. Thus we get successive bands with and without particles on the ground, which is not representative of a real case. - Figure 2 : I suppose that the size distribution of snow particles is the particle size distribution at the ground (It is a an initial condition, isn’t it ?). But the gamma distribution (Schmidt, 1980) is representative of particle size distribution in the boundary layer during drifting snow event. Similarly the particles trapped in the Faraday’s cage (Omiya et al., 2011) were particle in the saltation layer. Gunn and Marshall (1958) first reported that size distributions on the ground were approximately exponential in form, such that ND=N0exp(-λD) where D is the melted diameter of a snow particle, ND dD is the number of snow particles with a melted diameter between D and D + dD in a unit volume of air, N0 is the intercept, and λ is the slope (see for example Harimaya T., Kodama H., Muramoto K., 2004, Regional differences in snowflake size distribution, Journal of the Meteorological Society, 82(3), 895-903). What are the values of α and β ? What is the number 2617 : is it the number of numerically resolved particles ? What is the ratio between the real number of particles and the number of numerically resolved particles ? - What is the sensitivity of the numerical model to temperature and humidity ? Which model parameters are affected? Indeed, experiments carried out in cold wind tunnel were performed at different temperatures.

Results and discussion :

- The source of the experimental data must be clearly quoted in the references. I suppose that the data introduced in Figure 7 and 9 come from : T. Okaze, A. Mochida, Y. Tominaga, M. Nemoto, T. Sato, Y. Sasaki, K. Ichinohe, Wind tunnel investigation of drifting snow development in a boundary layer Journal of Wind Engineering and Industrial Aerodynamics, Volumes 104–106, May–July 2012, Pages 532–539. Sugiura, K., Nishimura, K., Maeno, N., Kimura, T., Measurements of snow mass flux and transport rate at different particle diameters in drifting snow, Cold Regions Science and Technology, Volume 27, Issue 2, April 1998, Pages 83-89 Y. Tominaga, T. Okaze, A. Mochida, Y. Sasaki, M. Nemoto, T. Sato, PIV measurements of saltating snow particle velocity in a boundary layer developed in a wind tunnel? Journal of Visualization, May 2013, Volume 16, Issue 2, pp 95-98. The date of publication of the previous article is 2013 instead of 2012 as written on the figure.

- What are the references of the papers of Lv (2012) and Sedmit (1984) cited in Figure 4. It is impossible to have a general picture of the relevance and quality of conclusions without having access to data and experimental conditions.

- As previously said there is a lot of similarity between results presented in Dupont et al. and in this paper. For example, we can compare Figures 3 and 6 in this paper and Figure 9 in Dupont et al. Some conclusions are also very close. “for μ1< 100 μ m, the gravity force becomes much lower than the drag force, and so, particles start to be transported higher by turbulence structures of the flow, reaching the limit between saltation and suspension motions (Dupont et al. 2013)” should be compared with “It can be seen that turbulence can significantly affect the trajectory of snow particles with diameter smaller than 100 μm (this paper)”...”The high sand concentration patterns correlate mostly with the high wind speed patterns . . .the correlation between sand concentration and the wind velocity field is hardly visible motions (Dupont et al. 2013)” should be compared with “ By comparing the concentration and corresponding cloud map, it can be found that the particle concentration shows a direct proportional relationship with the local wind velocity (this paper))”. . .. Throughout the analysis, similarities and differences must be set out and analysed.

- Figure 7 / In the experiments of Okaze, three different velocities have been tested : 5 m/s, 7 m/s and 9 m/s. It corresponds roughly to u*=0,22 m/s, 0,37 m/s and 0,55 m/s (see figure 9 in the paper). I cannot recognize these measurement points in figure 7 b. The transport rate of drifting snow in the saltation layer is calculated by integrating over the vertical mass flux profile of the drifting snow within saltation layer.The integration range was from 0 to 0.03 or 0.05 m in the case of Okaze et al.. But which height did you chose? And what about Sugiura ? To compare between themselves the results, heights of integration must be the same.

- Figure 9 / Others recent data are available in the literature (u*=0,37 m/s in Nishimura et al., 2014, Snow particle speeds in drifting snow, J. Geophys. Res. Atmos.,119, doi:10.1002/2014JD021686.

- Figure 12 / Experiment by Gromke : In this paper it is also written that Nishimura and others (1998) and Sugiura and others (1998), both using a SPC (Sato and others, 1993), report an increase in the share of small particles over height within the saltation layer. The data of Sugiura and others (1998) show a less pronounced increase in the share of small particles at lower heights for larger free stream and friction velocities. . . their results imply a decrease of the mean snow particle diameter with height, whereas our results indicate a fairly constant mean particle diameter with only a slight tendency to decrease with height. This may be due to the resolution of the CMOS chip (0.05 mm) in combination with the image processing and evaluation which does not allow resolution of the smallest particle sizes in such detail as the SPC, and to the different snow particle characteristics in the experiments" Do you have any comments on it ?

- p312 line 4 : How is estimated the length λx and λy (from time average spatial autocorrelation of Cp ?)

- p 312 line 27 : "It can be seen that the STR increases rapidly and reaches a dynamic equilibrium state in a short time". It is probably due to the choice of the splash function parameters (equations 8 and 11) which were not determined for snow particles (Kok and Renno, 2009), (Anderson and Haff (1991]. In the study of OKaze et al., 2012, the saltation layer nearly attained equilibrium in the downstream region from x=9 m to x=11,5 m. Okaze also remind that Takeuchi (1980) and Tabler (2003) indicated that the total transport rate of drifting snow, suspension, reached equilibrium around several hundred meters.

References :

- Some references must be added in order to illustrate the influence of drifting snow on mass balance of the Antarctic ice sheets. One proposal : Gallee et al., 2012 DOI 10.1007/s10546-012-9764-z) but other references can be proposed by the authors. - The reference (Michaux et al., 2012) is written in French. It is not easily accessible and this reference can be replaced by another one written in english Michaux et al., 2001, Drifting-snow studies over an instrumented mountainous site: II. Measurements and numerical model at small scale, Annals of Glaciology. - All papers introducing experimental data, which are used to evaluate the numerical model, must be cited.

Interactive comment on The Cryosphere Discuss., 9, 301, 2015.