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Influence of cohesion on drifting snow investigated in cold wind-tunnel

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Aeolian transport of particles occurs in many geophysical contexts such as wind-blown sand or snow drift and is governed by a myriad of physical mechanisms. Most of drifting particles are transported within a saltation layer and has been largely studied for cohesionless particles whether for snow or for sand. Thus, the theoretical description of aeolian transport has been greatly improved for the last decades. In contrast cohesive particles-air system have received much less attention and there remain many important physical issues to be addressed.

In the present study, the characteristics of drifting cohesive snow phenomena is investigated experimentally. Several wind tunnel experiments were carried out in the Cryopsheric Environment simulator at Shinjo (Sato et al., 2001). Spatial distribution of wind velocity and the mass flux of drifting snow were measured simultaneously by an ultrasonic anemometer and a snow particle counter. Compacted snow was sifted on the floor and left for a determined duration time to become cohesive by sintering. Two kinds of snow beds with different compression hardness were used (“hard snow” with a compression hardness of about 60 kPa and “semi hard snow” with a compression hardness of about 30 kPa). Wind tunnel velocity varied from 7 m/s to 15 m/s. Moreover steady snow drifting can be produced by seeding snow particles at a constant rate at the upwind of the test section.

It was shown that :

- on hard snow cover, aerodynamic entrainment does not occur and saltating particles from the seeder just rebounded without splashing particles composing the snow surface (Kosugi et al.,2004). At a given transport rate, the characteristic decay length lv,which can be seen as an estimation of the height of the saltating layer, exhibits a quadratic dependence with the air friction speed, u*. It is in agreement with results obtained by Ho (2011) with saltating sand on non-erodible bed. More surprisingly, lv increases with snow particles diameter, which means that restitution coefficient over hard snow cover also increases with snow particles diameters.

- On loose snow cover, without seeder, data analysis from Sugiura et al. (1998), shows that lv is proportional to u* to the power 1.4. This results therefore supports the idea that cohesionless snow doesn't exist: on erodible sand bed configuration, the decay length is invariant (Ho, 2012).

-on semi hard snow cover, without seeder, the inter-particle cohesion makes the transport unsteady and spatially inhomogeneous. lv is proportional to u* to the power 1.6. It is therefore an intermediate case between "loose" and "hard "snow. Restitution coefficient on semi-hard snow is higher than on loose snow cover but smaller than on hard snow cover. Particles are mainly lifted through aerodynamic entrainment so that saturation length is not obtained in the wind-tunnel : the transport rate is two orders of magnitude lower than the maximum transport rate observed for loose snow.

-on semi hard snow cover, with seeder, the drifting snow flux dramatically increases, even for low wind speed, leading sometimes to snow cover vanish. Experimental results provide evidence that impacting particles are efficient to lift cohesive snow particles : the transport rate increases to nearly 10.