The Cryosphere Discuss., 9, C1294–C1298, 2015
www.the-cryosphere-discuss.net/9/C1294/2015/

Interactive comment on "Microstructure-based modeling of snow mechanics: a discrete element approach" *by* P. Hagenmuller et al.

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Received and published: 26 July 2015

We thank referee #1 for his interesting and constructive feedback that helped us to improve the paper.

The authors addressing certainly a very important issue in snow modelling, name the influence of micro-structure on snow mechanics. They approach the structure with the Discrete Element Method (DEM). However, following points should be addressed in the article:

0.0.1 Comment 1

There is no reference as to which temperature the mechanical behaviour is connected to or how the temperature dependence is taken into account.

As investigated in section 3.2.2, the simulated macroscopic behavior of dry snow strongly depends on the microscopic cohesion σ_{ice} and friction coefficient $\tan\varphi$ at the contacts. The effects of temperature on the mechanical behavior of snow could be taken into account by changing the microscopic contact law from a fixed law to a temperature-dependent law, to the extent that sintering effects remain limited. However, the aim of the article is to propose a mechanical model accounting explicitly for snow microstructure. The final goal of the model is to investigate the link between the geometry of the microstructure and the mechanical behavior of snow for a fixed microscopic contact law. That is why this temperature dependence was not implemented.

To clarify this point, the following text was added to the paper l.23 p.1438: "Here, we fixed the microscopic cohesion to 1 MPa. However, the effects of temperature on the macroscopic behavior of snow, to the extent that sintering effects remain limited, could be considered by accounting for the influence of temperature on the microscopic cohesion."

0.0.2 Comment 2

The DEM model taking into account the interaction between snow grains is not presented in a clear way: The cohesion model needs a better explanation and presentation in formulas for the reader to understand e.g. what is tan(phi) referring to?

The friction coefficient $\tan\varphi$ corresponds to the ratio between the normal force and the shear force between two spheres sliding against each other. This notation is commonly used to describe a Mohr-Coulomb model.

To clarify the definition of the microscopic contact law, the following figure (Fig. 1) and a general description of the contact law (p.1432, l.5 “The contact law is here elastic, cohesive and frictional. It is described by a Mohr-Coulomb model. The elastic part is controlled by the stiffness of the contact E, the cohesive part is controlled by the shear and tensile strengths σ_{ice} of the contact and the frictional part is controlled by the friction coefficient $\tan\varphi$ which links the shear force resisting to sliding to the normal force.") were added.

0.0.3 Comment 3

Is bonding or re-bonding taken into account?

As explained in the text (l.28 p.1431 to l.2 p.1432), the bonds that exist in the initial microstructure are elastic, cohesive and frictional. The new bonds created during deformation are only elastic and frictional. Sintering during deformation is therefore not taken into account.

The following text was added l..2 p.1432: “Sintering during deformation is therefore not taken into account."

0.0.4 Comment 4

No validation e.g. comparison with experiments has been presented for the DEM model developed. Therefore, are the material properties chosen meaningful?

The microscopic contact law was set according to typical values of cohesion and friction coefficient found in the literature for ice. We agree that an important scatter on these parameters remains, and, as shown by the sensitivity analysis, that this scatter directly affects the macroscopic compressive behavior of snow. As pointed by reviewer, the model was not evaluated by experiments. This evaluation would also help to ad-

just precisely the microscopic contact law parameters (e.g. temperature dependence). However, this is beyond the scope of the paper, which focuses on the presentation of a new mechanical model accounting directly for the geometry of the snow microstructure.

Interactive comment on The Cryosphere Discuss., 9, 1425, 2015.

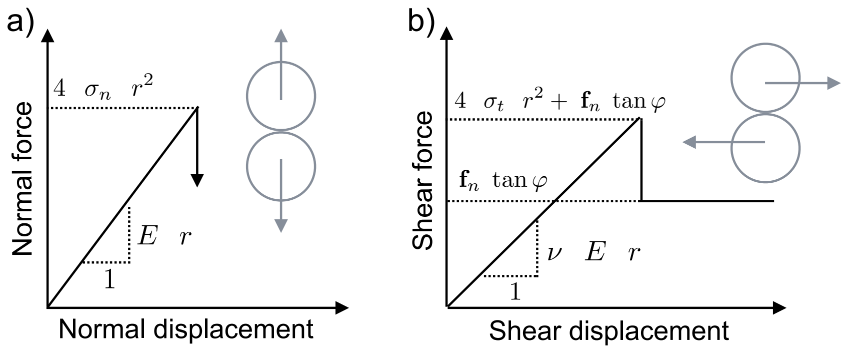

Fig. 1. Behavior of a sphere-sphere contact in two simple cases: normal loading (a) and simple shearing under constant normal force $\mathbf{f}_n$ (b).