ESRF	**Experiment title: Study of the faceting transition of snow under temperature gradient**	**Experiment number**: ME-797
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Shifts: 12	**Local contact(s)**: Elodie Boller (email: boller@esrf.fr) Xavier Thibault (email: xavier.thibault@esrf.fr)	*Received at ESRF:*

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Report:

The experiment ME-797 resulted in the publication of two peer-reviewed papers:

1. **The temperature gradient metamorphism of snow: Model and first validations using X-ray microtomographic images**

Abstract:

During a snowfall, the snow crystals accumulate on the ground and gradually form a complex porous medium constituted of air, water vapour, ice and sometimes liquid water. This ground-lying snow transforms with time, depending on the physical parameters of the environment. This process, called *metamorphism*, can be divided into three main types: the *wet snow* metamorphism, the *isothermal* metamorphism, and the *temperature gradient* (TG) metamorphism.

Among these different kinds of metamorphisms, the last one is probably the most interesting. Typically occurring by cold and clear nights, when the TG between the top and the bottom of the snow layer is high, this metamorphism is characterized by the formation of facets at the bottom of the grains, while upper parts remain rounded.[1, 2]

Since the TG metamorphism may be the source of weak layer formation in the snow cover, its study has major issues in avalanche sciences,[3] and is an active research field in snow and ice

community (see the introduction of Sommerfeld,[4] for a detailed review until 1983). Despite of this interest, the TG metamorphism remains quite poorly understood. In particular, two fundamental questions have not really been solved. First, what is the driving force of the matter exchange in the ice matrix and what are the associated mechanisms? Second, what determines practically whether well-rounded or faceted shapes can appear?

These two questions have been addressed and partly solved by Colbeck[2] twenty years ago, but the results where based on 2D observations and very simple approximations on the snow geometry. In our approach, we would like to take advantage of X-ray microtomographic techniques and revisit these questions by using high-resolution 3D images.

We first present a simple model that estimates the matter fluxes in a snow sample submitted to temperature gradients, and address the faceting issue by using standard concepts of crystal growth. We then describe a TG experiment, followed by X-ray microtomographic measurements that give 3D images of the metamorphosed snow structures. Then, we apply our model to one of the obtained snow samples, in order to check its validity.

2. The temperature gradient metamorphism of snow: vapour diffusion model and application to tomographic images

Abstract:

A simple physical model describing the temperature gradient metamorphism of snow is presented in this work. This model, based on Kelvin's equation and Fick's law, takes into account the local variation of the saturating vapour pressure with temperature. It can determine locally, depending on both the pressure and temperature fields in the snow structure, whether the ice is condensing or subliming. This model can also explain the formation of facets that occurs during the metamorphism. Thanks to X-ray microtomographic images of snow samples obtained under low to moderate temperature gradient conditions, this model has been tested and compared to the reaction-limited model proposed in a preceding work (Flin and others, 2007).

References

[1] Flin, F., J.-B. Brzoska, R.A. Pieritz, B. Lesaffre, C. Coléou and Y. Furukawa, 2007. The temperature gradient metamorphism of snow: Model and first validations using X-ray microtomographic images, Kuhs, W., ed., *Physics and Chemistry of Ice*, RSC Publishing, Cambridge, UK, 181-189.

[2] Flin, F. and J.-B. Brzoska, 2008. The temperature gradient metamorphism of snow: vapour diffusion model and application to tomographic images, *Ann. Glaciol.*, **49**, 17-21.