A room temperature operating cryogenic cell for *in vivo* monitoring of dry snow metamorphism by X-ray microtomography

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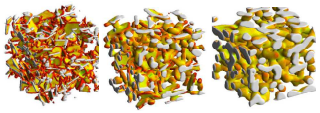
Context

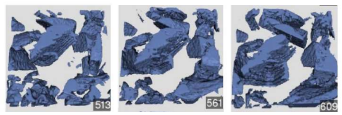
Three-dimensional (3D) images of snow offer the possibility of studying snow metamorphism at the grain scale by analysing the time evolution of its complex microstructure. Such images are also particularly useful for providing physical effective properties of snow arising in macroscopic models. Up to now, two different approaches have been used to obtain 3D images:

The static approach	The *in vivo* approach
Impregnated snow samples: microstructure is fixed	Non-impregnated snow samples: microstructure still evolves
At ambiant temperature	In a cold-room
Temperature conditions at the boundary conditions are fixed to avoid melting of the impregnation product (T~- 30°C)	Temperature conditions at the boundaries of the sample are controlled to drive the metamorphism
Time evolution: tomography of different snow samples collected at several time intervals	Time evolution: tomography of the same snow sample at several time intervals

Examples of 3D images obtained



Isothermal metamorphism (-2°C), Flin et al. 2004



Temperature gradient metamorphism (55°K m^{-1}, -7.6°C), Pinzer et al. 2012

OUR WORK: We developed a new in vivo cryogenic cell which:

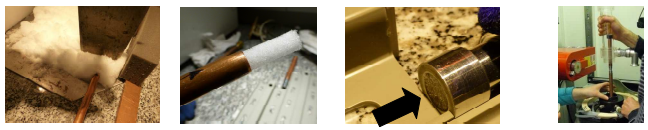
✓ allows to follow **the evolution of the same snow sample** with time

✓precisely **controls the temperature conditions** at the boundaries of the sample (choice of conditions for the snow metamorphism)

✓ can be used with **a large panel of tomographic scanners** provided with large cabin size: advantages in terms of speed, resolutions, imaging techniques…

Main requirements for the development of the cell:
- size of the cell linked to the desired resolution (source to sample distance)
- X-ray absorption properties of the materials used
- size of the snow sample large enough to be representative
- 360° rotation of the whole apparatus during the tomographic aquisitions

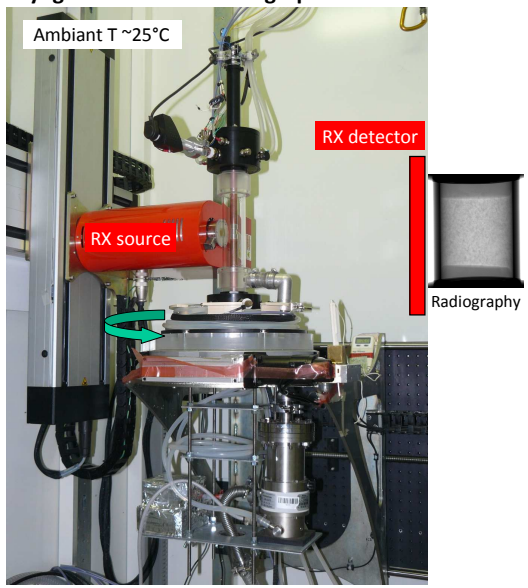
Snow sampling



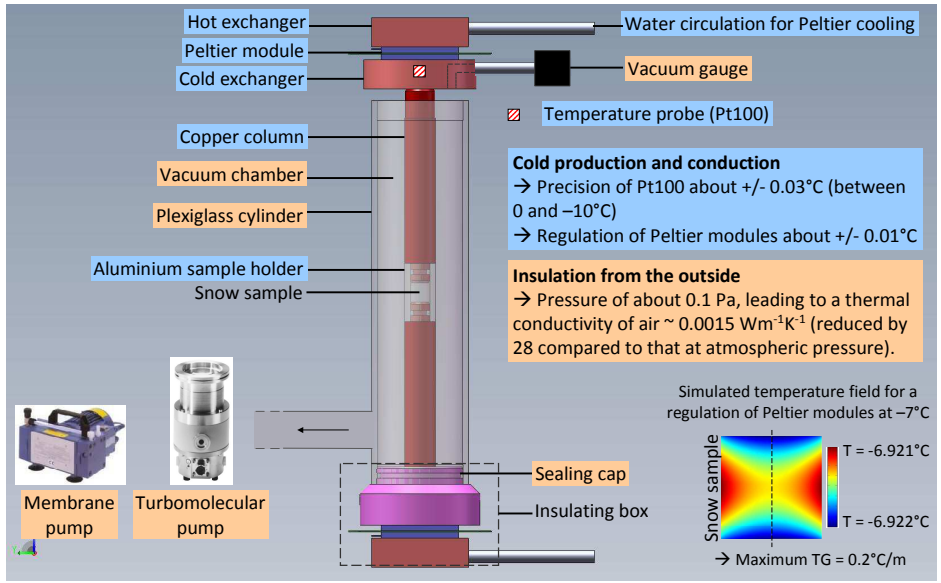
Sampling a cylindrical core into a snow slab | Diameter = 1 cm Length = 1 cm | Inserting into the aluminium sample holder | Placing the sample holder into the cell

Description of the cell

Cryogenic cell in the tomographic cabin

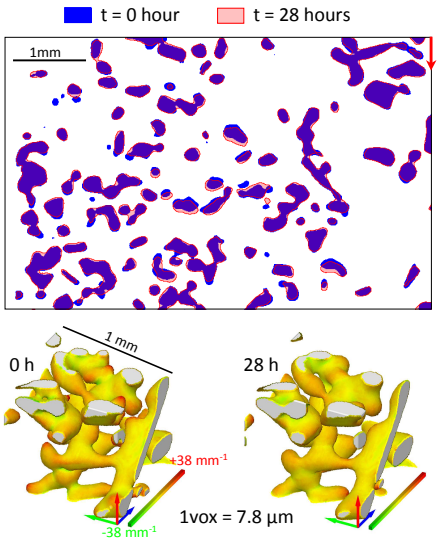


Components of the cell (symmetrical with respect to the sample)



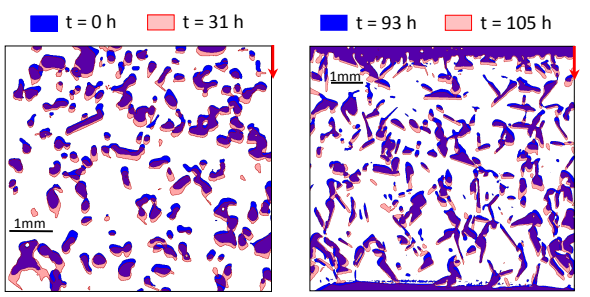
Preliminary results – Vertical cross sections and 3D images of snow

Equi-temperature metamorphism at –7°C

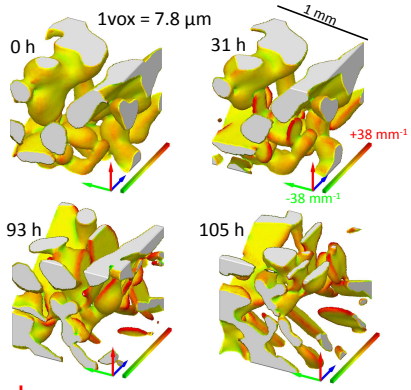


→ Slow evolution → Settlement
→ Grain rounding → Growth/decay of bonds

Temperature gradient (TG) metamorphism of 18°C/m at -2°C



→ Rounding at the top of grains → Fast evolution from RG to DH
→ Facetting at the base of grains → General growth of structures



red arrow oriented toward the base of the physical sample

Conclusion et perspectives

The cell can be very useful to improve our understanding of dry snow metamorphism:
- numerical computations of properties on the obtained 3D images
- study of the physical mechanisms involved at the grain scale
- development of metamorphism models at microscale by using the obtained 3D images as a guideline and validation tool.

Other experiments could be carried out under different conditions (temperature, TG, snow type…) and the cell could be adapted to the study wet snow metamorphism.

References:
- Flin, F., J. B. Brzoska, B. Lesaffre, C. Coléou, and R. A. Pieritz, 2004, *Annals of Glaciology*, 38(1), 39-44.
- Pinzer, B. R., M. Schneebeli and T. U. Kaempfer, 2012, *The Cryosphere*, 6, 1141-1155.

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