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Tomography-based investigation of concurrent snow creep and isothermal metamorphism

Antoine Bernard^{1,3}, Pascal Hagemmuller¹, Guillaume Chambon², and Maurine Montagnat³

¹Univ. Grenoble Alpes, Université de Toulouse, Météo-France, CNRS, CNRM, Centre d'Etudes de la Neige, Grenoble, France (antoine.bernard@univ-grenoble-alpes.fr)

²UR-ETNA, INRAE, Grenoble, France

³Univ. Grenoble Alpes, Grenoble-INP, CNRS, IRD, Institut des Géosciences de l'Environnement, Grenoble, France

Once on the ground, the microstructure of snow, i.e. the three-dimensional arrangement of ice and pores, quickly evolves with metamorphism and deforms under the overburden of the overlying snow. Understanding these concurrent processes is important to predict the evolution of the physical and mechanical properties of snow which are crucial for many applications, such as avalanche forecasting. To this end, we monitored oedometric creep tests of snow under isothermal conditions at -8.6°C for about one week with X-ray tomography. We investigated the evolution of recent snow under a constant load of around 4 kPa, where both ice matrix creep and metamorphism are active. Our time-series comprises one of the most highly-resolved images of snow microstructure evolution, with a temporal resolution of 3 h and spatial resolution of 8.5 microns and thousands of images. Interestingly, we observed distinct effects of the overburden and of the vapor transport on the microstructure evolution. In particular, the quantification of the ice bond network through the Euler characteristic and the min-cut surface shows that metamorphism progressively increases the bond size almost independently of the applied overburden, while the application of an overburden yields a rapid increase of the bond coordination number. These distinct impacts exhibit the difficulty to accurately reproduce the time evolution of recent snow by snow cover models, whose snow microstructure representation with density and snow type remains too coarse.