



CNRM, UMR 3589



Proposition de Stage M2 ou de fin d'Etude pour 2021

Nom du laboratoire (et n° de l'unité) dans lequel se déroulera le stage :

Météo-France, CNRM, UMR 3589, Centre d'Etudes de la Neige CEN, (Grenoble)

Titre du sujet proposé :

Evaluating the snow model Crocus against highly-resolved snow measurements from winter 2015-2016 at Weissfluhjoch, Switzerland.

Nom et statut du (des) responsable(s) de Stage (**préciser si HDR**) :

Matthieu Lafaysse (CEN, chercheur et chef d'équipe « Modélisation du manteau neigeux »)
Neige Calonne (CEN, chercheur dans l'équipe « Matériau neige »)

Coordonnées (téléphone et e-mail) du (des) responsable(s) de thèse :

Matthieu Lafaysse : matthieu.lafaysse@meteo.fr
Neige Calonne : neige.calonne@meteo.fr

Résumé du sujet (le descriptif ne doit pas dépasser une page recto/verso)

Snow models allow simulating the physical and mechanical processes of snow to predict the state of the snowpack in 1D at a given location and under given boundary conditions. These models are crucial for various applications such as avalanche danger forecasting, climate studies, or water resource management. Among the different physical prognostic variables of the model, the two main structural properties are density, which describe the proportion of ice and air in a given snow volume, and specific surface area (SSA) of snow, which is related to the size and shape of the microstructure and is defined as the ice-air interface surface area over the snow mass. Accurate simulations of these two parameters are essential as they intervene in most physical and mechanical snow processes. However, only coarse evaluations of density and SSA simulations by snow models were performed up to now because of insufficient data and the challenge to define an appropriate methodology (Viallon-Galinier et al., 2020).

The goal of this internship is to perform a detailed evaluation of the density and SSA simulations from the French model Crocus, developed at CNRM. To do so, we will use the RHOSSA dataset that provides a unique time-series of density and SSA from different instruments over winter season 2015-2016 at the Weissfluhjoch research site, Swiss Alps



(full description in Calonne et al. 2020). Especially, it offers unprecedented high spatial and temporal resolutions: daily and sub-mm vertical resolution data against the weekly and sub-cm resolution data as presented in previous studies. A methodology has already been proposed to evaluate the Swiss SNOWPACK model on this dataset (Calonne et al. 2020). We will extend this preliminary study by exploring the potential of this dataset for snow model evaluations based on the Crocus model for which several configurations applied at Weissfluhjoch will be assessed (simulations are available with different physical options and sets of parameters, Lafaysse et al., 2017). Simulations of density and SSA are known to have a satisfactory skill in terms of bulk and surface snow properties (Menard et al., 2021) but were never evaluated at finer vertical scale and considering time. Here, vertical profiles of the properties at sub-mm scale and their evolution at a daily frequency will be analysed and compared, based on an existing matching data algorithm notably (Hagenmuller et al. 2016). Overall, the work of the internship will include (1) processing and analyses of the RHOSSA data and the Crocus simulation output, (2) a comprehensive comparison study between measurements and simulations, and (3) investigation of the model potential source of errors and sensitivity study, when needed.

Potential candidates have a strong interest in cryospheric sciences and numerical modelling, are proficient with the Python language and Linux environment.

Période de stage : 4 à 5 mois, début de stage souhaité en Mai 2021 ou à l'automne 2021.

Lieu du stage : CEN, 1441 rue de la piscine, 38400 St Martin d'Hères

Calonne, N., Richter, B., Löwe, H., Cetti, C., ter Schure, J., Van Herwijnen, A., Fierz, C., Jaggi, M., and Schneebeli, M.: *The RHOSSA campaign: multi-resolution monitoring of the seasonal evolution of the structure and mechanical stability of an alpine snowpack*, *The Cryosphere*, 14, 1829–1848, <https://doi.org/10.5194/tc-14-1829-2020>, 2020.

Lafaysse, M., Cluzet, B., Dumont, M., Lejeune, Y., Vionnet, V., and Morin, S.: *A multiphysical ensemble system of numerical snow modelling*, *The Cryosphere*, 11, 1173-1198, doi:10.5194/tc-11-1173-2017, 2017.

Menard, C. B., Essery, R., Krinner, G., Arduini, G., Bartlett, P., Boone, A., Brutel-Vuilmet, C., Burke, E., Cuntz, M., Dai, Y., Decharme, B., Dutra, E., Fang, X., Fierz, C., Gusev, Y., Hagemann, S., Haverd, V., Kim, H., Lafaysse, M., Marke, T., Nasonova, O., Nitta, T., Niwano, M., Pomeroy, J., Schädler, G., Semenov, V. A., Smirnova, T., Strasser, U., Swenson, S., Turkov, D., Wever, N., & Yuan, H. *Scientific and Human Errors in a Snow Model Intercomparison*, *Bulletin of the American Meteorological Society*, 102(1), E61-E79, <https://doi.org/10.1175/BAMS-D-19-0329.1>, 2021.

Viallon-Galinier, L., Hagenmuller, P., Lafaysse, M. *Forcing and evaluating detailed snow cover models with stratigraphy observations*, *Cold Regions Science and Technology*, 180, 103163, <https://doi.org/10.1016/j.coldregions.2020.103163>, 2020.

Hagenmuller P and Pilloix T (2016) *A New Method for Comparing and Matching Snow Profiles, Application for Profiles Measured by Penetrometers*. *Front. Earth Sci.* 4:52. doi: 10.3389/feart.2016.00052