Ecole Nationale de la Météorologie
Direction des Etudes
42, avenue Gaspard Coriolis
BP 45712
31057 TOULOUSE Cedex 1

PROJET DE FIN D'ETUDES

INGENIEURS DE L'ECOLE NATIONALE DE LA METEOROLOGIE

FICHE DE PROPOSITION DE SUJET

Titre du sujet proposé :
Evaluating the snow model Crocus against highly-resolved snow measurements from winter 2015-2016 at Weissfluhjoch, Switzerland.

Organisme ou service proposant le sujet :
CNRM / Centre d'Etudes de la Neige (Grenoble)

Responsable principal du stage :

Responsable principal (le responsable principal est l'interlocuteur direct de l'Ecole. C'est à lui, en particulier, que seront adressés les courriers ultérieurs) :

NOM : CALONNE Prénom : Neige

téléphone : 04 76 63 79 19 Mél : neige.calonne@meteo.fr

Autres responsables :
LAFAYSSE Matthieu matthieu.lafaysse@meteo.fr 04 76 63 79 28

Le stage présente-t-il un caractère de confidentialité ? : non

Le stage peut-il être effectué à distance ?: non

1) Description du sujet – livrables attendus

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

unprecedent 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.

2) lieu du stage, durée ou période

CNRM, Centre d'Etudes de la Neige, 1441 rue de la Piscine, 38400 Saint Martin d'Hères
Durée de 4 à 6 mois.

References

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) ANew Method for Comparing and Matching Snow Profiles, Application for Profiles Measured by Penetrometers. Front. Earth Sci. 4:52. doi: 10.3389/feart.2016.00052