EGU23-7240, updated on 20 Apr 2024
https://doi.org/10.5194/egusphere-egu23-7240
EGU General Assembly 2023

Snow cover estimation by deep-learning segmentic segmentation of radar images based on optical image references

Mathias Montginoux[1], Flora Weissgerber[1], Céline Monteil[2], and Alexandre Girard[3]
[1]ONERA/DTIS, Université Paris-Saclay, F-91120 Palaiseau, France (flora.weissgerber@onera.fr)
[2]EDF R&D LNHE - Laboratoire National d'Hydraulique et Environnement, Chatou, France (celine-c.monteil@edf.fr)
[3]EDF R&D PRISME - Performance, Risque Industriel, Surveillance et Maintenance pour l'Exploitation, Chatou, France (alexandre.girard@edf.fr)

In order to improve the forecasting of hydraulic production, EDF uses optical satellite images to evaluate the snow cover [1]. These images are acquired daily by the MODIS instrument of the Terra satellite and provide a snow product through the Normalized Difference Snow Index (NDSI). However, part of the information on the snow cover is lost due to clouds. To complete those gaps, radar satellite images can be interesting because it does not depend on weather conditions.

Dry snow and wet snow have different SAR signature. Wet snow can be detected since its backscatter decreases [2]. Dry snow detection is more challenging. It may be performed with a polarimetric approach [3], and the snow depth (SD) can be estimated using optical images as auxiliary inputs [4]. In this work, wet snow was detected and SD was estimated over the Guil basin in the Alps (420 km²) for the years 2018 and 2019 on three relative orbits of Sentinel-1: the D66 (descending, 87 images), A88 (ascending, 119 images), and D139 (descending, 90 images). The results show an accumulation of snow in autumn on the SD and a peak of snowmelt in spring on the detection of wet snow.

Then we propose to detect the snow from SAR images using a convolutional neural network trained with optical images from MODIS as labels. For the dataset, a smaller area is chosen around Abriès (of approximately 59km²) and we select 36 images for each of the three orbits to study the winter 2018-2019. A binary semantic segmentation is computed from two SAR inputs: R_{wet} from [2], and R_{dry} a polarimetric ratio inspired from [3]. The trained model, called SESAR U-net, gives a snow detection with an overall accuracy of 80% for our test set. This low accuracy result can be explained by the fact that MODIS images have a resolution 25 to 100 times coarser than the SAR images, which hinder both the training and the evaluation of the model. Further works will consider the uncertainty of the MODIS label in the loss computation to improve the training.

[1] M. Le Lay et al., “Use of snow data in a hydrological distributed model: different approaches for improving model realism,” in EGU General Assembly Conference Abstracts, EGU General Assembly Conference Abstracts, p. 14545, Apr. 2018.
[2] T. Nagler et al., “Advancements for snowmelt monitoring by means of sentinel-1 sar,” Remote Sensing, vol. 8, 04 2016.

[3] A. Reppucci et al., “Estimation of snow-pack characteristics by means of polarimetric SAR data,” in Remote Sensing for Agriculture, Ecosystems, and Hydrology XIV (C. M. U. Neale and A. Maltese, eds.), vol. 8531, p. 85310Z, International Society for Optics and Photonics, SPIE, 2012.
[4] H. Lievens et al., “Snow depth variability in the Northern Hemisphere mountains observed from space,” Nature Communications, vol. 10, p. 4629, Dec. 2019.