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Temporal and spatial stationnarity of the snow regime assessed through deep-learning auto-encodding of SAR-image stacks

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Snow cover can be measured from multi-spectral optical images through the Normalized Difference Snow Index (NDSI). However, cloud cover affects the acquisition frequency. Radar snow detection offers independence from weather conditions. Despite existing method to detect snow melt [1] or measure snow depth [2], no existing method offers the possibility to detect any type of snow using only SAR images. To assess the different evolutions of the SAR signal during a winter season, we use a deep learning auto-encoding approach for the 2018-2019 winter over the Guil Basin in the French Hautes-Alpes using SLC Sentinel-1 images for three relative orbits: D66 (Descending), A88 (Ascending) and D139 (Descending). The images were geocoded using the French IGN DEM (BDALTI). On top of displaying the most representative temporal SAR signal profils on this area, this study help us to assess the spatial stationnarity of the SAR signal.

All the temporal profils were auto-encoded in three embedding following the framework detailed in [3]. The network was trained five times for each orbit. The chosen embeddings were the ones exhibiting the smaller correlation, leading to absolute value correlation between 0.10 and 0.20. The correlation between these embedding and the geographical features (latitude, longitude, altitude and incidence angle) is also below 0.30.

Then these embbedings were used to group the pixels in six clusters using a kmeans framework. The mean temporal profile was estimated for each cluster, as well as the histogram of the elevation distribution. Behaviours appear consistently for the three orbits. One cluster correspond to shadow or dark areas pixels, with a constitent low backscattering over the year and a spread elevation histogram. Another cluster correspond to pixels in high altitude areas which exhibit an increase in backscattering between October and March that we attribute to snow fall. The third cluster includes also high altitude pixels with a short drop of backscattering in October and May, certainly related to snow melt. The spatial pattern of the clusters for the A88 orbit shows a east-west shift in the class repartition while for the D66 and D139 the class repartition is more impacted by the altitude and follow the southward mountain arc. In further work, a train/validation/test dataset with no dataset shift will be design using the stationnarity of this cluster, as well as a second test set introducing a geographical dataset shift that can take in account both the ascending/descending differences and the topographic and climatic variation of snow cover.

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