

A deep learning approach to downscale and correct wind fields in complex terrain

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Wind-driven transport of snow particles (referred to as drifting snow) impacts the spatial variability of mountain snowpacks, with direct consequences for hydrology and avalanche hazard. Estimating such consequences requires modeling wind fields at a higher resolution than the current kilometeric horizontal resolution used in the numerical weather prediction (NWP) systems.

In this context, we introduce a new strategy to both downscale and post-process wind fields from NWP systems to decametric scales. We use an explainable artificial neural network (ANN) to correct the largest errors of NWP data. The ANN first processes multiple variables that have been identified as good proxy to explain the variability of air flow in complex terrain, and then send the corrected result to a downscaling scheme called DEVINE. The latest leverage on a convolutional neural network (CNN) trained to replicate the behaviour of the complex atmospheric model ARPS, previously run on a large number of synthetic Gaussian topographies. This CNN architecture appears as an efficient downscaling tool whose minimalist architecture, low input data requirements (NWP wind field and high-resolution topography) and competitive computing times may be attractive for operational applications.

The full model both corrects biases and downscales large scale NWP wind fields, thus producing a signal well suited for drifting snow applications. We assessed the performance of the model using a large number of wind observations from in-situ automatic weather stations in Switzerland, French Alps, Corsica and French Pyrenees and show that our model significantly reduces NWP errors, notably for the highest and most exposed observation stations.