EGU22-4296
https://doi.org/10.5194/egusphere-egu22-4296
EGU General Assembly 2022

Dual-frequency spectral radar retrieval of snowfall microphysics: a deep-learning based approach

Anne-Claire Billault–Roux, Gionata Ghiggi, and Alexis Berne
Environmental remote sensing laboratory, Ecole Polytechnique de Lausanne, Switzerland (anne-claire.billault-roux@epfl.ch)

Better understanding and modeling snowfall microphysical properties and processes is a key challenge in atmospheric science, crucial for snowfall quantification, remote sensing, and weather prediction in general.

The use of meteorological radars for this intent has become quite popular, in particular through two techniques: the use of multi-frequency radar variables on the one hand, and of radar Doppler spectra on the other. Combining both techniques is however a challenging task, complicated by the variability of ice crystals properties and atmospheric conditions, in addition to measurement errors and artifacts such as radars' imperfect calibration and beam matching. We propose a novel approach to retrieve snowfall microphysical properties, by making the most of dual-frequency Doppler spectrograms while relaxing some assumptions on beam-matching and non-turbulent atmosphere.

The technique is based on a two-step deep-learning framework inspired from auto-encoder models, which are generally used for dimension reduction purposes: an encoder maps high-dimensional data to a lower-dimensional “latent” space, while the decoder tries to recover the original signal from this latent space. In the proposed framework, dual-frequency Doppler spectrograms constitute the high-dimensional input, while the dimensions of the latent space are constrained to represent the snowfall properties which we seek to retrieve.

As a first step, a decoder neural network is trained to generate Doppler spectra from a given set of microphysical variables, using simulations from the radiative transfer model PAMTRA as training data. In a second step, the encoder network learns the inverse mapping, from dual-frequency spectrograms to the microphysical latent space. It is trained on real data, and outputs values in the latent space which, when passed as input to the decoder – whose parameters are now frozen – yield reconstructed spectrograms that should match the original data.

In comparison with classical methods, which provide a direct gate-to-gate inversion of the problem, the proposed framework allows to take into account the spatial continuity of the microphysical variables by using convolutions in the architecture of the models, thereby reducing the ill-posedness of the problem.

The method was implemented on X- and W-band data from the ICE GENESIS campaign that took

place in January 2021 in the Swiss Jura, and showed promising results. Comparisons with in-situ airborne data also collected during the campaign allow for in-depth assessments of the performance of the algorithm.