Better characterizing the microphysical properties and processes of snowfall is key to improving numerical weather and climate models, both in terms of quantitative precipitation forecast, and to quantify the radiative contribution of ice and mixed-phase clouds.

Meteorological radars are highly valuable to study precipitation microphysics: for instance, vertically-pointing radar profilers provide measurements throughout the entire atmospheric column. Among the more widely used radar variables, the radar reflectivity ($Z_e$) depends on the number concentration and on the size of hydrometeors within a radar resolution volume; the mean Doppler velocity informs on the fall speed of the particles. These variables may be used to retrieve information on the underlying microphysical properties of the hydrometeors (here, snow particles): e.g., size, bulk density, ice water content, etc. In the past decades, using data from radars at two or three different frequencies has shown promise for more accurate retrievals of snowfall properties.

In this project, the student will use dual-frequency radar measurements of reflectivity and mean Doppler velocity to retrieve estimates of certain snowfall properties. The data come from the WProf and ROXI radars (resp. W- and X-band) deployed during the ICE GENESIS campaign, which was conducted in La Chaux-de-Fonds (NE) in January 2021.

Main ground-based site during the ICE GENESIS campaign.

Additionally, the project will make use of a precomputed synthetic dataset containing snowfall microphysical properties and corresponding simulated radar variables.

The proposed outline of the project is as follows, and may be adapted depending on the time constraints and interest of the student:

- A first step of the project will consist in **identifying which microphysical properties** may reasonably be retrieved from the radar variables.

- Depending on the available time, we propose to implement two distinct **deep-learning approaches**, inspired from Chase et al. 2021 and from Billault-Roux et al. 2023. This will allow to identify advantages and disadvantages of each approach.
Another objective of the project will be to quantify the **importance of each input feature** (reflectivity and mean Doppler velocity at each frequency) in the final result (e.g., with SHAP method). Additional input features may be included, such as higher-order radar moments (spectral width, skewness), to investigate their role.

**Validation of the retrieval** (evaluation of accuracy) would be performed through comparison with in-situ measurements available during the campaign.

**References:**