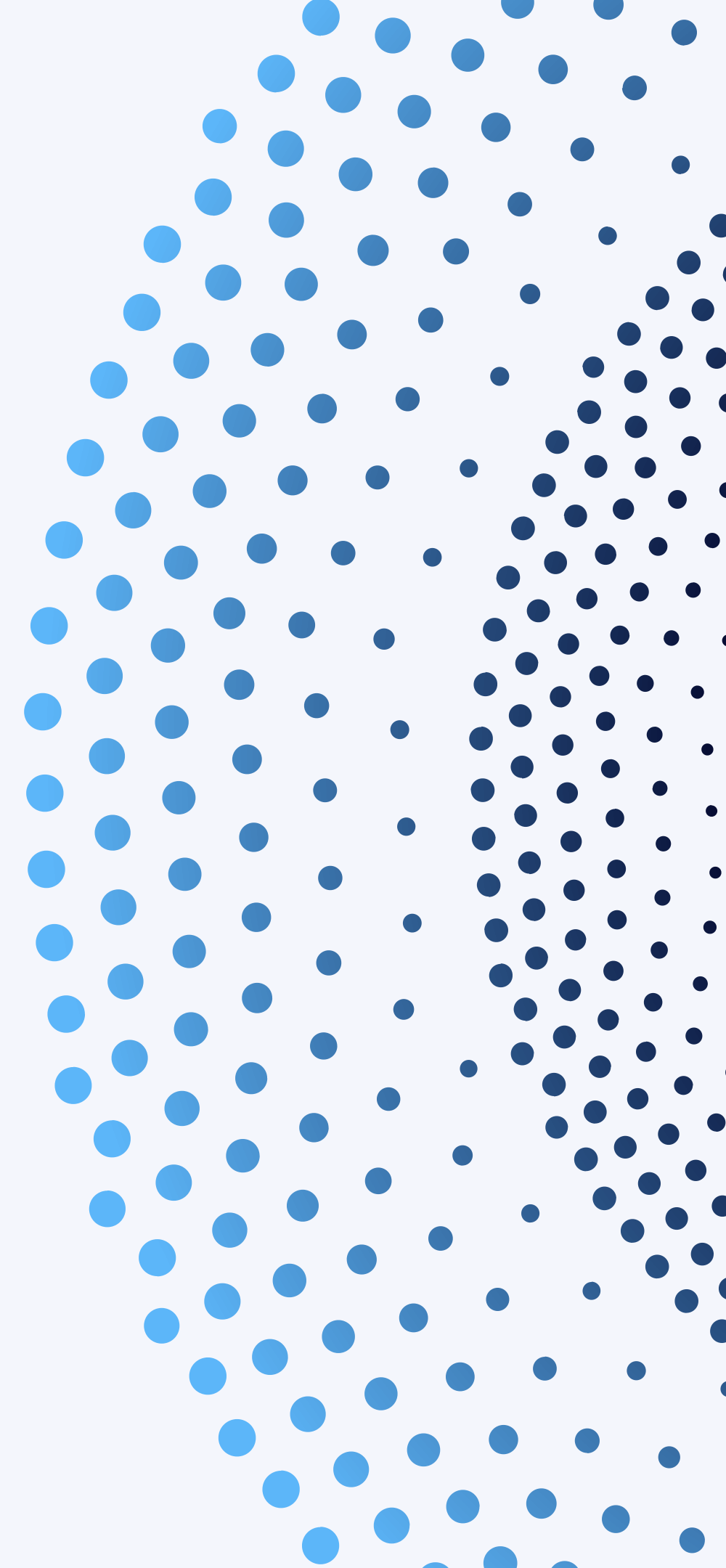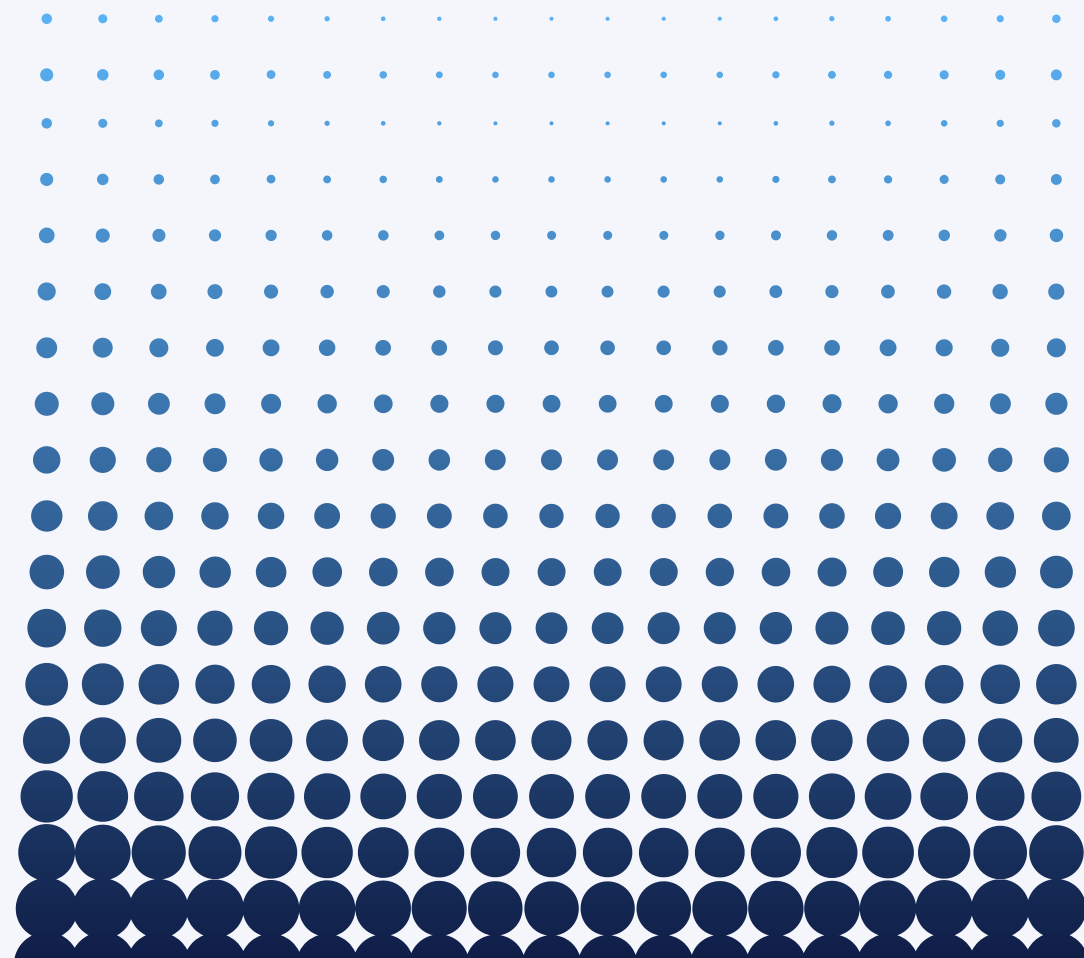# Università di Pisa

Avalanche danger level classification

FOR DRY-SNOW CONDITIONS

The problem

In many countries with snow-covered mountain regions, avalanche warning services regularly issue forecasts to inform the public and local authorities about the avalanche hazard. Even today, these forecasts are prepared by human experts.

A key component is the **avalanche danger level**, usually communicated according to a five-level, ordinal danger scale, which summarizes avalanche conditions with regard to different factors and conditions.

ML models to predict avalanche danger level may well have potential to become a **valuable supplementary decision support tool** for avalanche forecasters when assessing avalanche hazard.

Envidat Dataset

High quality-controlled danger ratings for dry-snow avalanche conditions forecasted from different meteorological stations in Switzerland, during winter periods between 2001 and 2020.

+ Meteorological variables resampled 24-hour averages

+ Profile variables extracted from the SNOWPACK simulated profiles

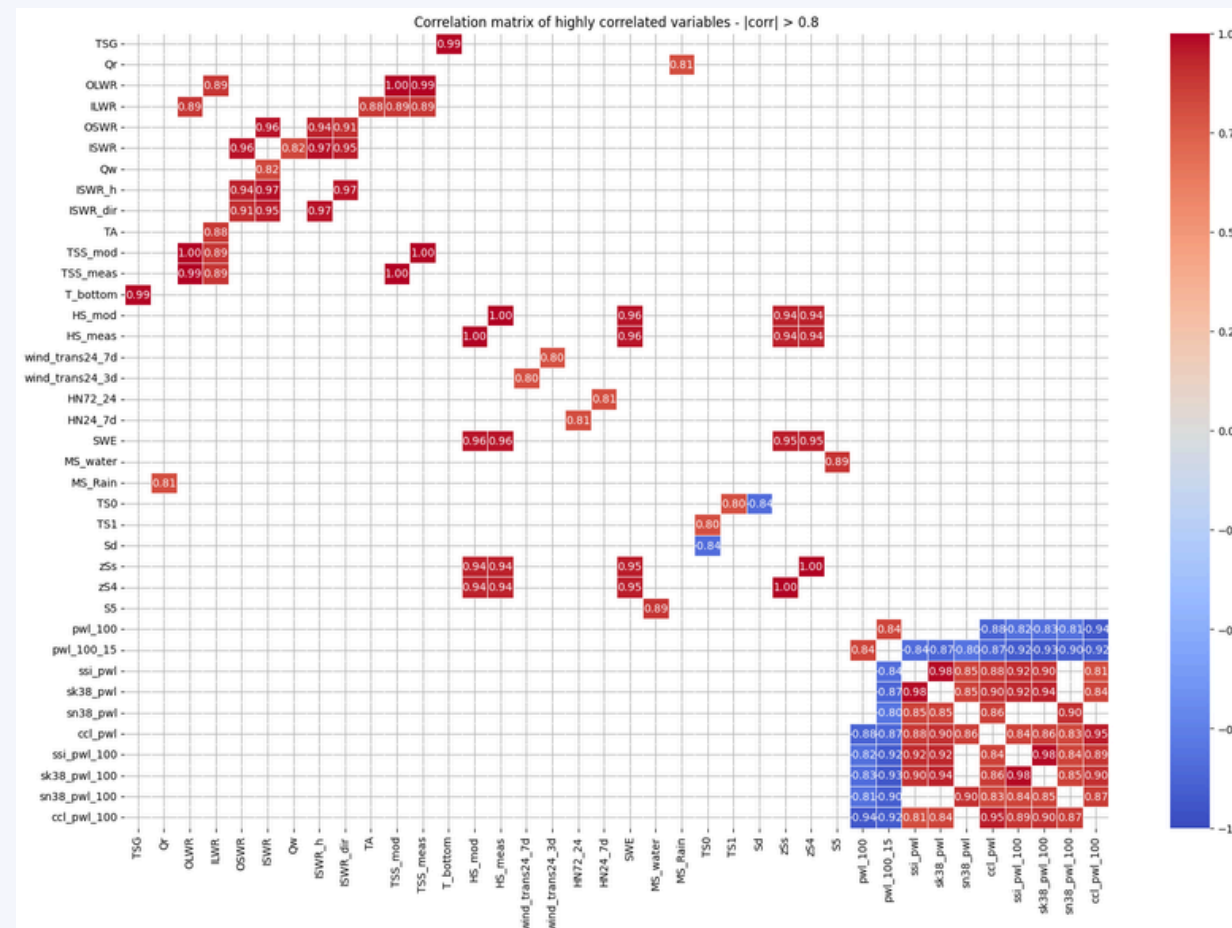**+** Danger ratings assigned in the Swiss avalanche bulletin
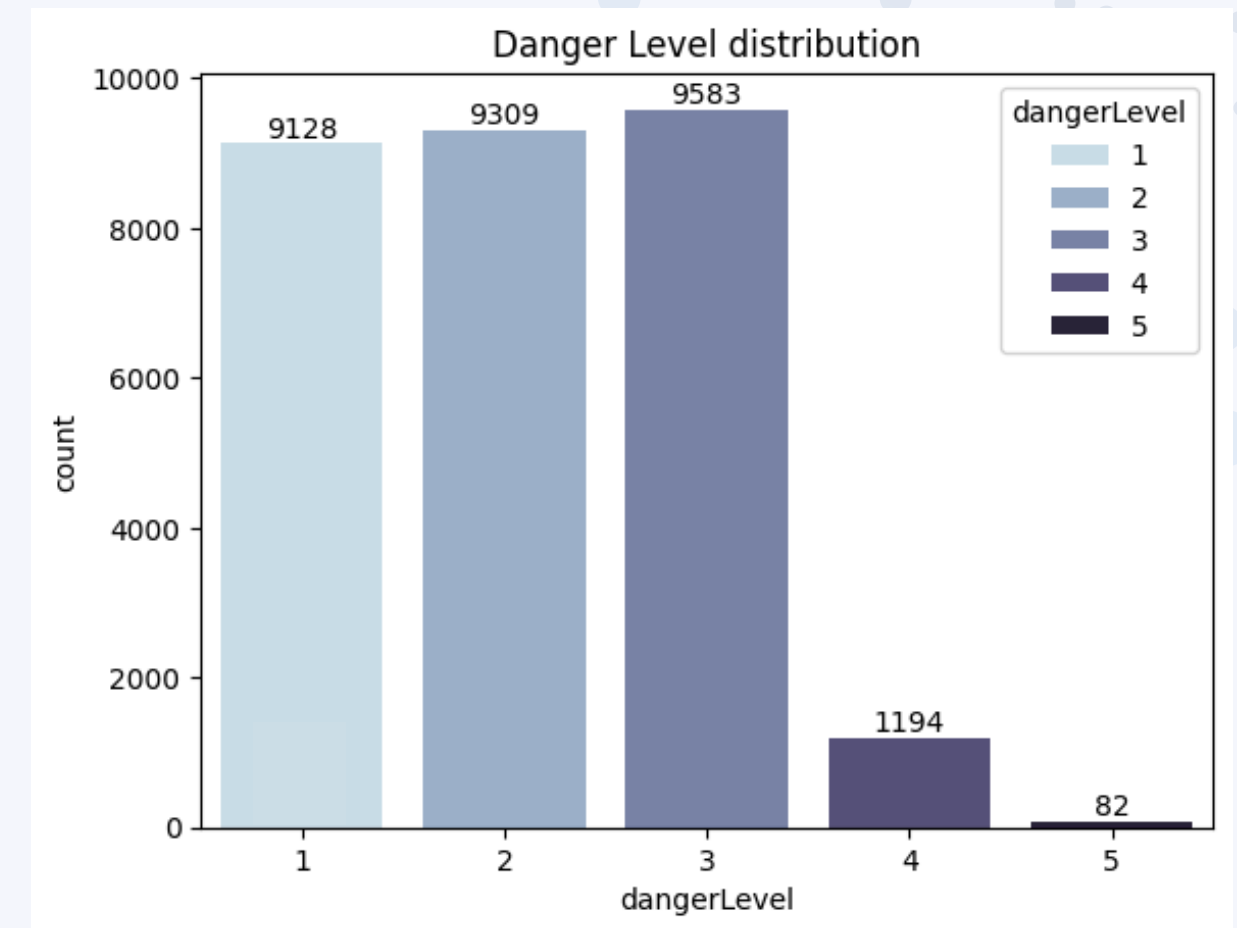
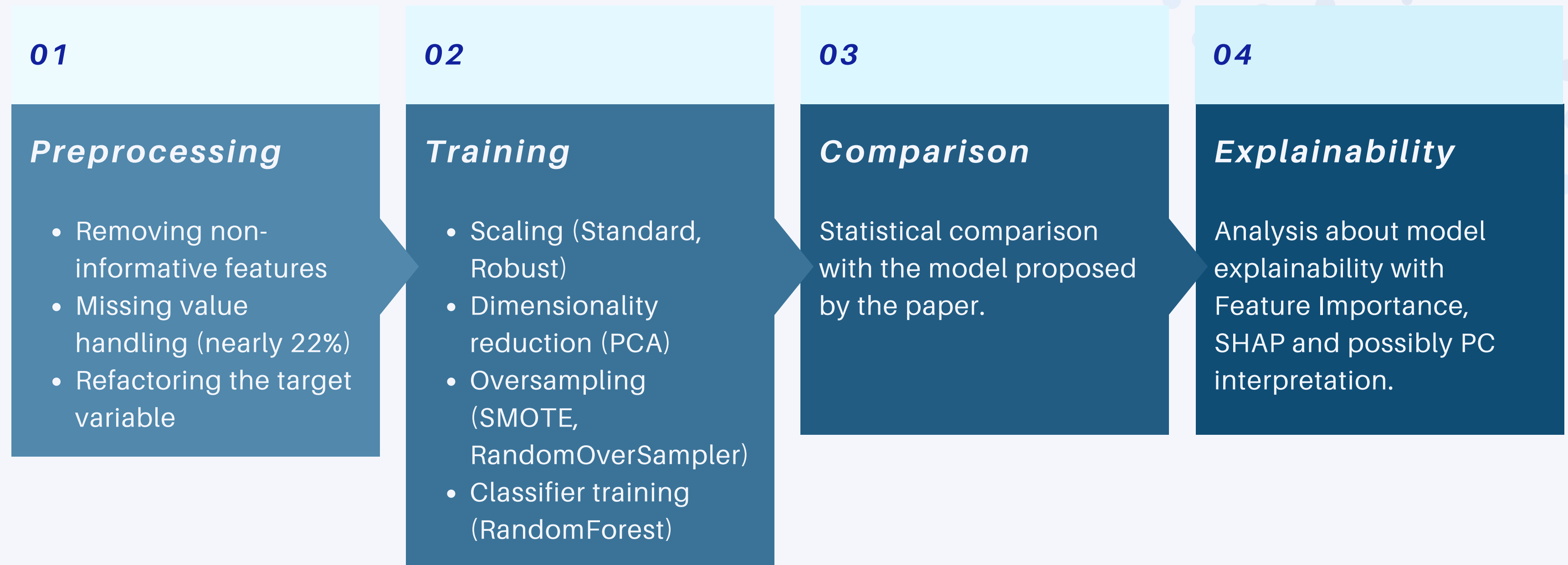# Envidat Dataset

29.296
Rows

80
Columns

Presence of correlated features

Highly imbalanced class distribution

Workflow

Goal: Multiclass Classifier for explainable prediction of Avalanche Danger Level.

01

Preprocessing

- Removing non-informative features
- Missing value handling (nearly 22%)
- Refactoring the target variable

02

Training

- Scaling (Standard, Robust)
- Dimensionality reduction (PCA)
- Oversampling (SMOTE, RandomOverSampler)
- Classifier training (RandomForest)

03

Comparison

Statistical comparison with the model proposed by the paper.

04

Explainability

Analysis about model explainability with Feature Importance, SHAP and possibly PC interpretation.

References

Pérez-Guillén, C., Techel, F., Hendrick, M., Volpi, M., van Herwijnen, A., Olevski, T., Obozinski, G., Pérez-Cruz, F., and Schweizer, J.: **Data-driven automated predictions of the avalanche danger level for dry-snow conditions in Switzerland**, Nat. Hazards Earth Syst. Sci., 22, 2031–2056, 2022.
https://doi.org/10.5194/nhess-22-2031-2022

Pérez-Guillén, C., Techel, F., Hendrick, M., Volpi, M., van Herwijnen, A., Olevski, T., Obozinski, G., Pérez-Cruz, F., Schweizer, J. (2022). **Weather, snowpack and danger ratings data for automated avalanche danger level predictions**. EnviDat.
https://www.doi.org/10.16904/envidat.330

Pérez-Guillén, C., Techel, F., Volpi, M., and van Herwijnen, A.: **Assessing the performance and explainability of an avalanche danger forecast model**, Nat. Hazards Earth Syst. Sci., 25, 1331–1351, 2025.
https://doi.org/10.5194/nhess-25-1331-2025