

# Multidecadal daily hail time series for Switzerland from radar proxies and ERA-5 reanalysis

## MOTIVATION

**Hailstorms** regularly cause substantial damage and costs in **Switzerland**. Addressing this hail risk is challenging, especially in a changing climate, when hail occurrence and frequency may change. Recent studies showed significant differences in interannual variability of hail occurrence north and south of the Alps in the last two decades (Barras et al. 2021, Nisi et al. 2018). However, this **variability** and its **changes** and **drivers** have not been analysed in a **long-term** approach. To do that a new **daily hail time series for Northern and Southern Switzerland** from 1959 to today is produced from radar proxies and ERA5 reanalysis data.

## DATA - RADAR

Empirical radar product from MeteoSwiss:

### Probability of Hail (POH)

Gridded daily dataset, 1x1 km res., values from 0 - 100 %. Hail time series is produced from years 2012 - 2021.

**Hailday if:**  
POH ≥ 80% for an area of at least 580/499 km<sup>2</sup> of region **north / south**.

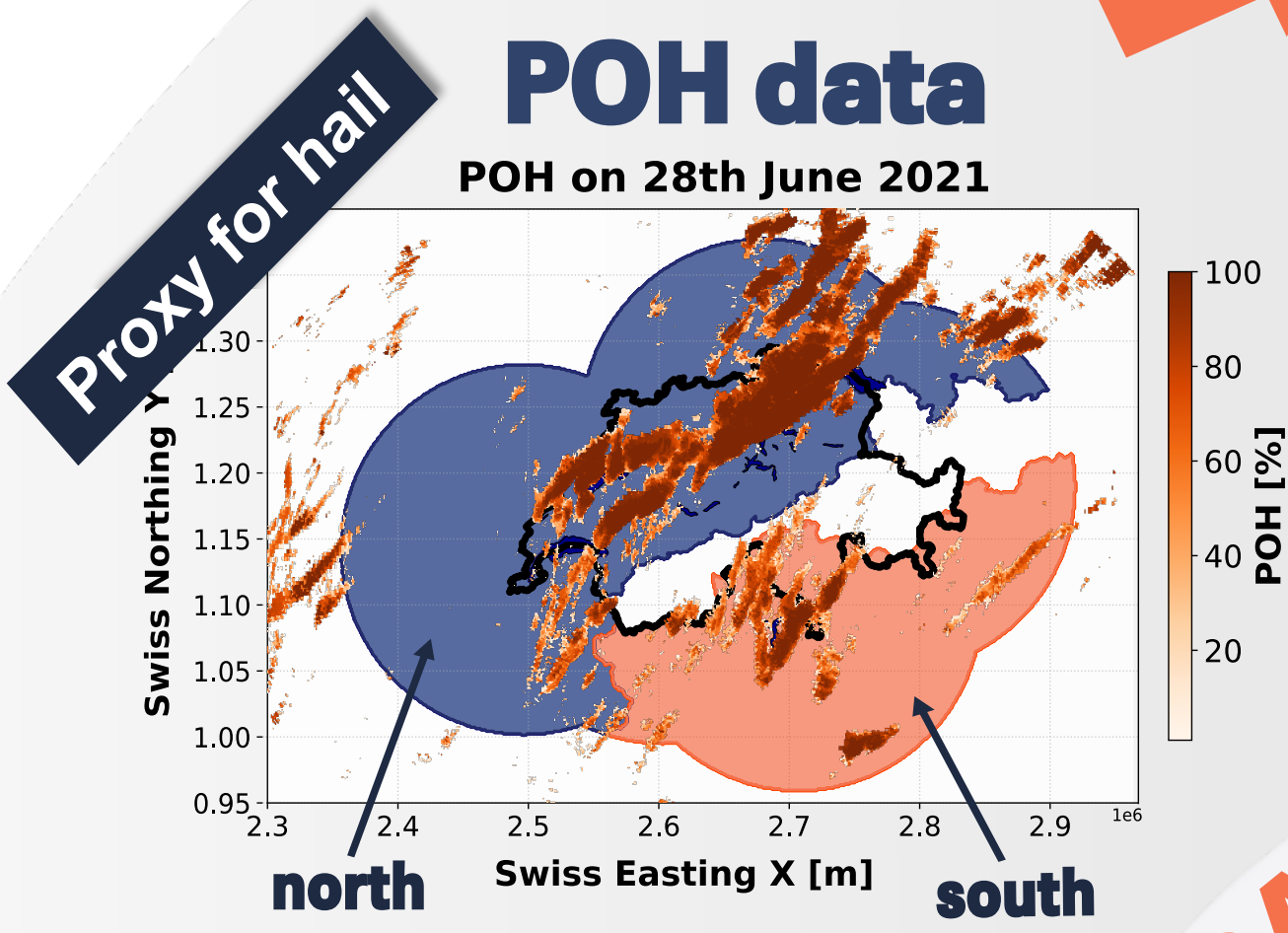


Fig. 1: Probability of hail (POH) gridded data product on 28th June 2021. Large sections of POH ≥ 80% (dark orange) cover parts of Switzerland. The blue and red shaded outlines show the two regions for which a separate time series was constructed: North and South of the Alps plus the respective 140 km radar buffer of the five Swiss radars.

## POH hail time series

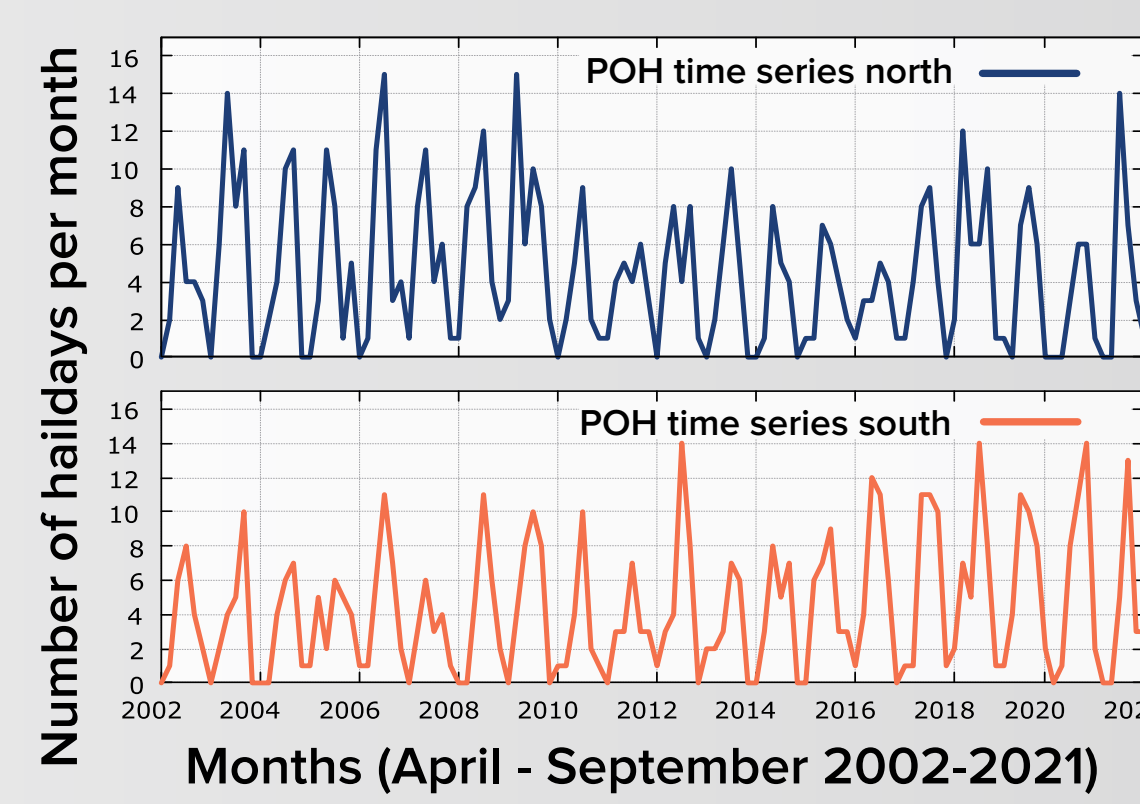


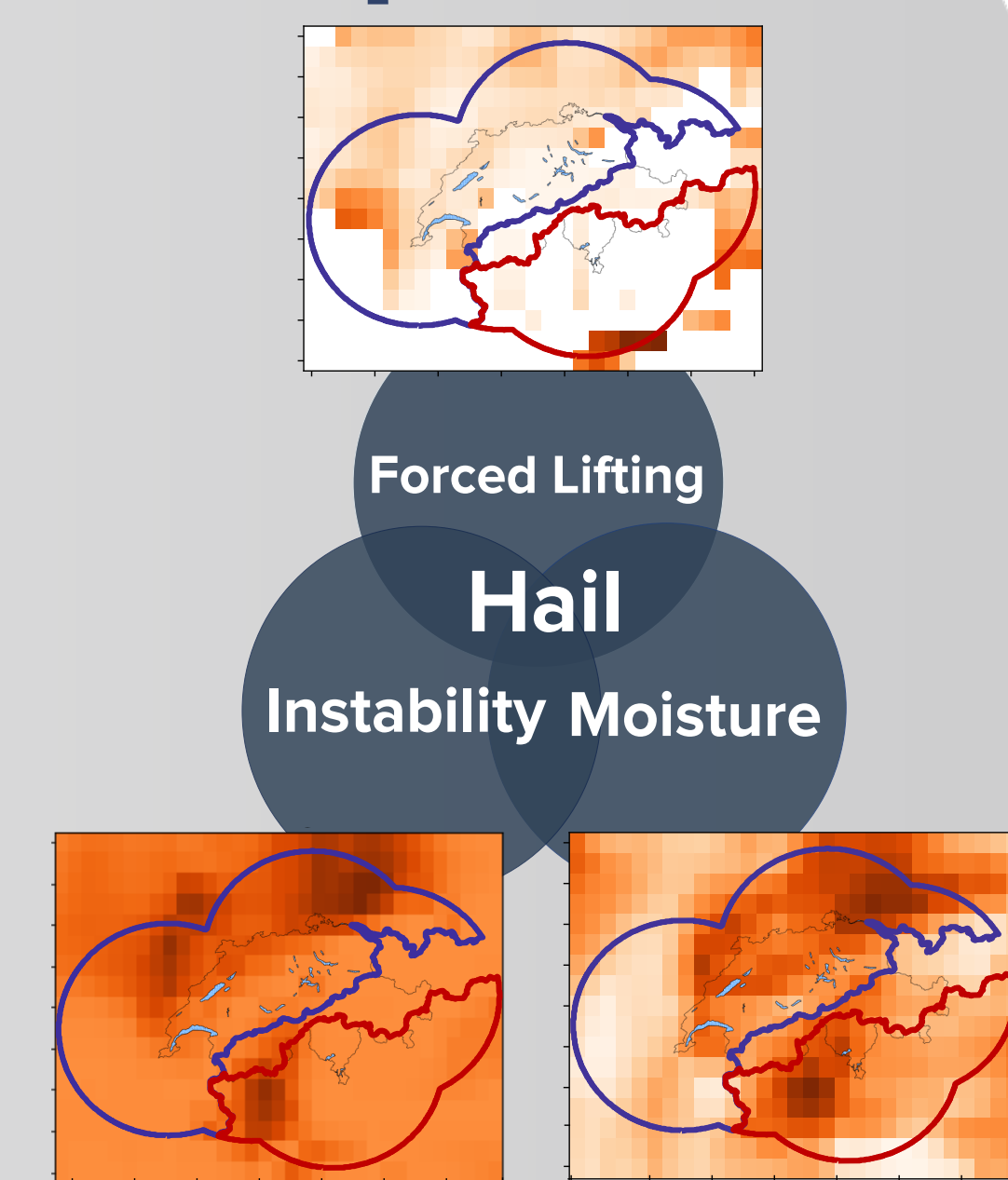
Fig. 2: POH time series for the region north and south extracted from POH data (Fig. 1). Daily values were aggregated by month. A hailday is defined as a day with POH ≥ 80% for at least 580 / 499 km<sup>2</sup>.

## DATA - ERA5

→ 70 variables / indices calculated that characterize a hail favouring atmosphere, which means **instability, moisture and a forced lifting**.

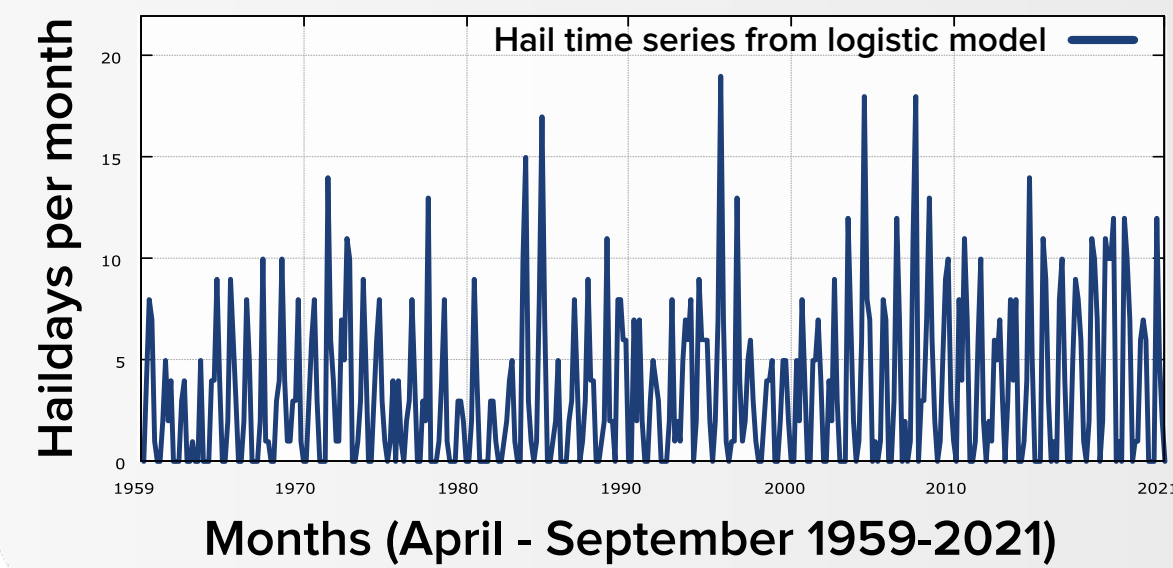
→ For each variable daily values were extracted for the region north and south for 1959 - 2021 (min/max/mean at specific time).

## ERA5 variables that can predict hail



# HAIL TIMESERIES FOR SWITZERLAND

## Hail time series north



## Hail time series south

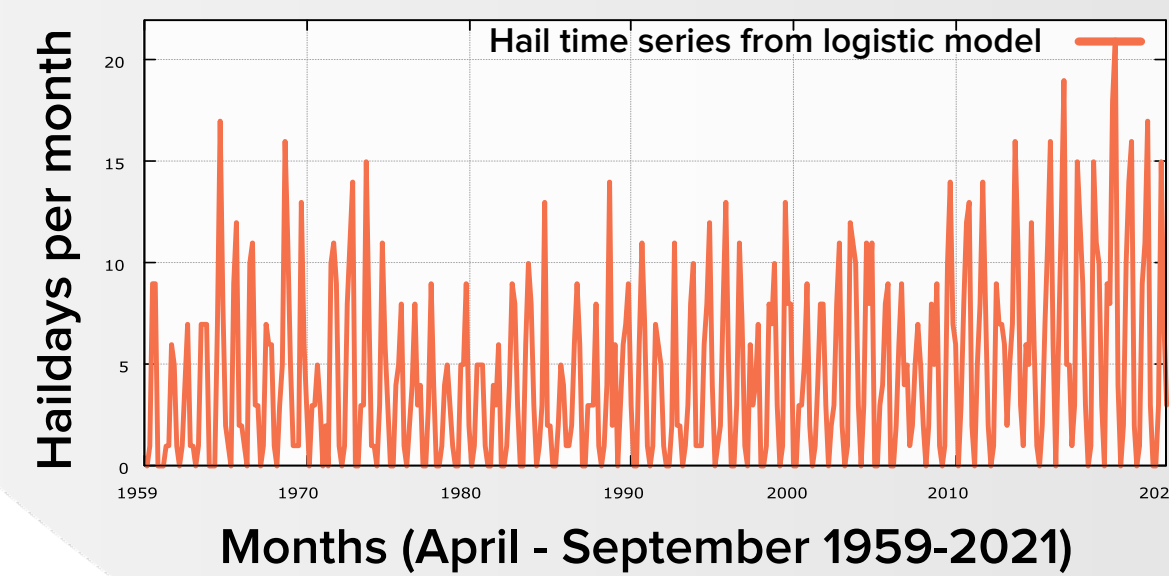


Fig. 3: Reconstructed daily hail time series from the two logistic regression models for north (upper) and south (lower). Both are aggregated by month and year. Both show a small significant positive trend, although stronger in south.

## RESULTS

- Good performance by both models with 90% / 92% test accuracy.
- Model predictors match those found in literature (Madonna et al. 2018, Mohr et al. 2015).
- Interannual variability and seasonality well reflected by models (not shown). Small positive trend in both regions.

## Logistic Hail Model

$$y = p_x = \frac{1}{1 + e^{-g(x)}} \quad \text{with } 0 \leq p_x \leq 1$$

**North:**  $g_{\text{hail north}} = \beta_0 + \beta_1 \times \text{factor}(\text{month}) + \beta_2 \times \text{SLI} + \beta_3 \times \text{TT} + \beta_4 \times Q_{\text{int}} + \beta_5 \times w_{\text{int}} + \beta_6 \times \text{BI}$

**South:**  $g_{\text{hail south}} = \beta_0 + \beta_1 \times \text{factor}(\text{month}) + \beta_2 \times \ln(\text{CAPE}) + \beta_3 \times \text{SLI} + \beta_4 \times \text{WS}_{0-6\text{km}} + \beta_5 \times K + \beta_6 \times \text{Icl}_{\text{height}}$

## Verification:

	North	South
AIC	611.1	867.7
BIC	688.3	933.9
CSI	0.7	0.62
POD	0.95	0.93
FAR	0.03	0.04
Acc.	0.93	0.9

## METHOD

### Multiple Logistic Regression:

= Prediction of haildays as a function of independent ERA5 variables (x) and dependent POH (y) as "truth"

→ Manual predictor selection with VIF pretreatment, AIC/BIC optimization, and expert judgement.

→ **Seasonality** addressed by a **factor (month)**. **Verification** with independent test dataset and selection of best model by CSI, accuracy, AUROC, precision, recall, etc.

## TAKE HOME MESSAGES

- This new time series is the first radar based multidecadal daily time series of hail in Switzerland. It enables us to study changes in the long-term variability of Swiss hail occurrence, as well as to identify local and remote drivers of this variability.
- With this we could improve our understanding of the meteorological-climatological variability, and, with the help of climate scenarios, infer about possible changes in the future.

