Design Project – SIE 2023

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Improving precipitation estimates in an Alpine catchment

BACKGROUND AND OBJECTIVES

Precipitation measurements underly a *bias* resulting from *wind perturbing the airflow* around the gauge (**pluviometer**). Knowing this wind-induced precipitation under-catch would allow more precise **flood forecasting**, thus this project aims to explore different correction approaches. The data to be corrected consists of *29 SwissMetNet* stations in a study area that comprises the Upper Rhone basin and adjacent areas. To empirically correct the stations' measurements, three reference data sets are used. Additionally, correction functions that depend on meteorological variables like *air temperature* and *wind speed* are used to estimate the bias. The objectives are to *estimate* the precipitation under-catch using the different approaches, to identify the most promising method, and to examine the variance of undercatch in space.

[Pluviometers: 1518 H3 e 15188 Lambrecht and Pluvio2[1]]

REFERENCE DATA SETS

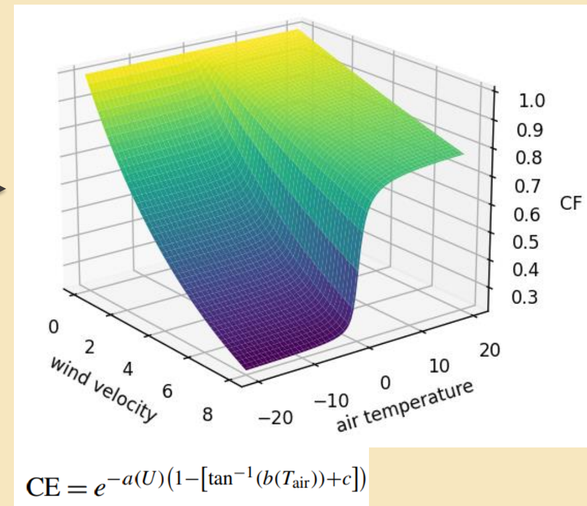
CombiPrecip & CombiValais (Radar Product)
Direct precipitation comparison

SLF observers (Solid Precipitation)
Comparison with calculated SWE

IMIS Automatic (Solid Precipitation)
Comparison with modelled SWE

METEOROLOGICAL ESTIMATION

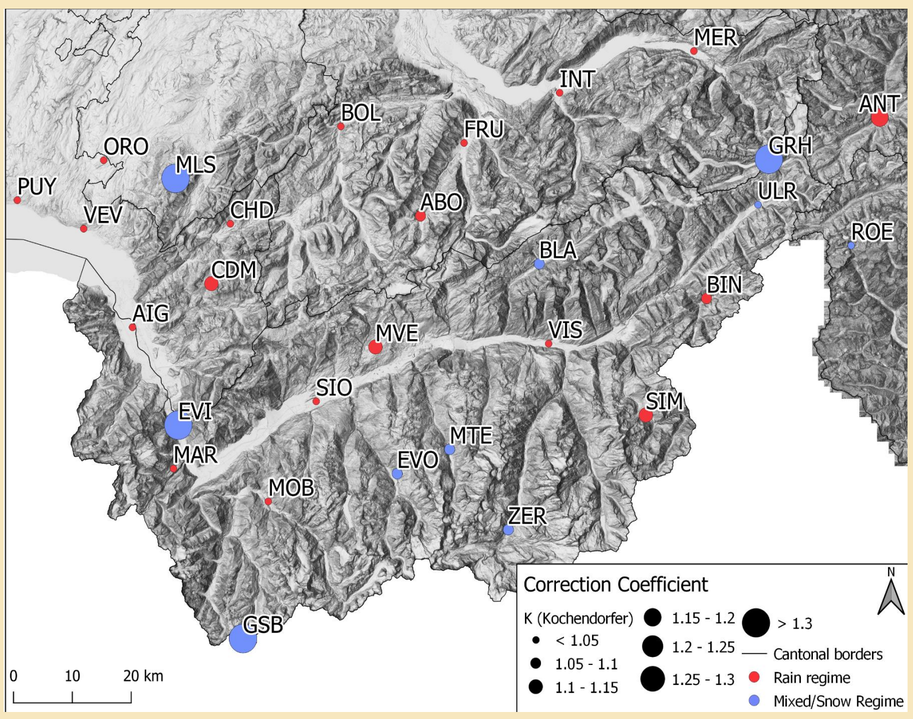
Under-catch correction functions



$$CE = e^{-a(U)\left(1-\left[\tan^{-1}(b(T_{air}))+c\right]\right)}$$

[Kochendorfer function for all precipitation [2]]

RESULTS AND DISCUSSION

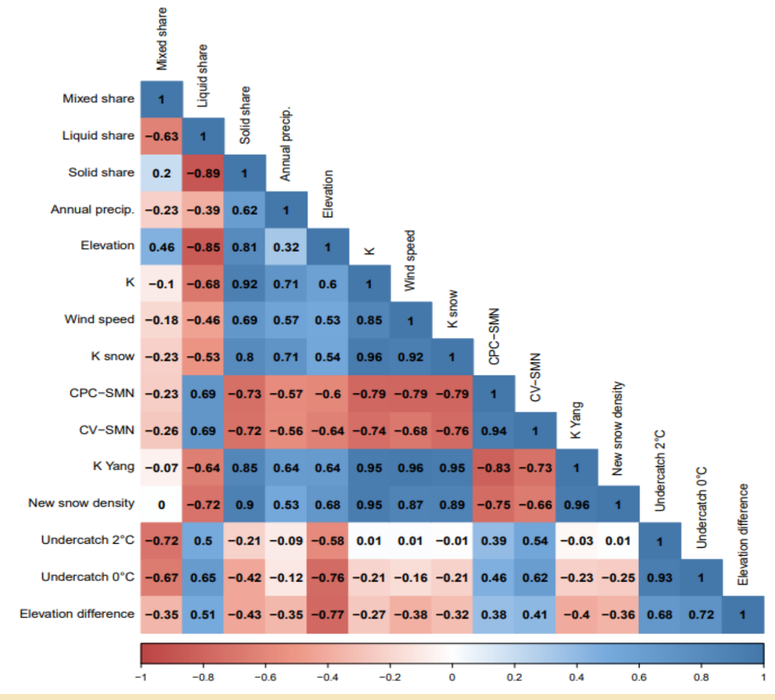


Main results of mean under-catch estimations:

- Kochendorfer function[2]: 2%-76% (**μ=12%**)
- Kochendorfer Snow function[3]: 9%-172% (**μ=42%**)
- Yang function[4]: 6%-33% (**μ=13%**)
- SLF observer (0°C threshold): 29-111% (**μ=76%**)
- SLF observer (2°C threshold): -16%-46% (**μ=31%**)
- CombiPrecip & CombiValais: ± 20%

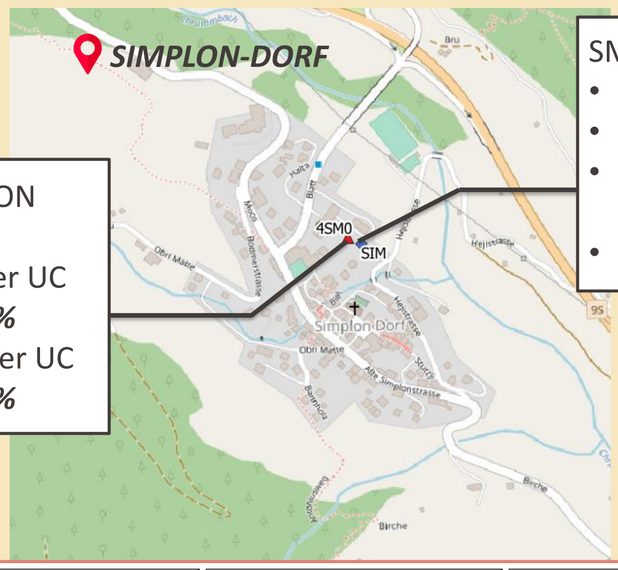
Main discussion points:

- Meteorological functions align with the expectations both on the magnitude and correlations with elevation and windspeed
- Measured UC does not positively correlate with wind speed
- CombiPrecip & CombiValais affected by biases



[Pearson's correlation coefficients, K=Kochendorfer, CPC=CompiPrecip, CV=CombiValais]

ZOOM ON A SINGLE STATION EXAMPLE

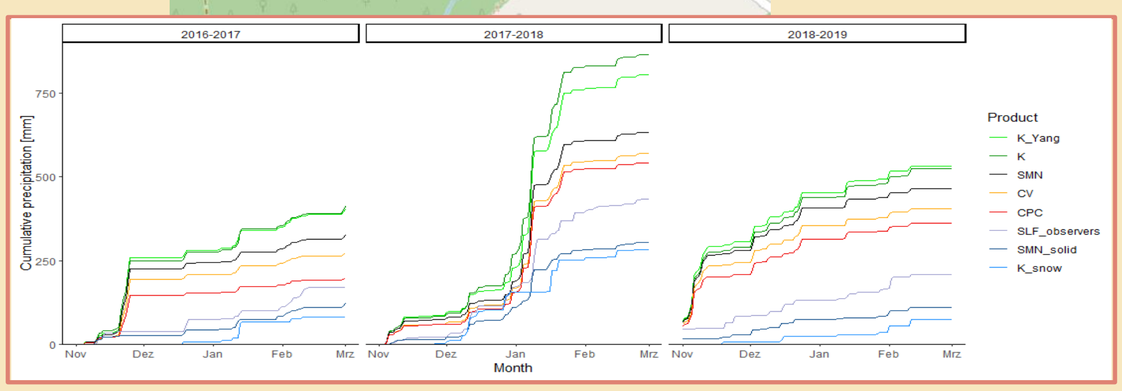


SMN STATION (1465 m):

- Kochendoffer UC: ***22%***
- Yang UC: ***17%***
- Kochendoffer UC snow: ***71%***
- CombiPrec UC: ***-8%***

IMIS STATION (1469 m):

- Observer UC 0°C: ***60%***
- Observer UC 2°C: ***16%***



CONCLUSIONS & RECOMANDATIONS

The initial hypothesis of under-catch for Canton Valais was between **20%** and **30%**. Given the results of the proposed function, it is still reasonable to consider this amount but these considerations should be always taken into account:

1. Using the actual data and models it is still not possible to obtain an accurate **ground truth**, hence an accurate estimation
2. The magnitude of wind-induced precipitation under-catch of **liquid** and **solid** precipitation is **significantly different**
3. It is possible to estimate that in **extreme** meteorological conditions, the under-catch could reach up to **200%** for solid precipitation

Moreover, to further analyze and improve the estimations

1. Further studies could use hydrological models for validation
2. More data should be acquired at the same locations of the SMN stations to limit the assumptions

Problems and Warnings

The models used to validate and confront the meteorological functions such as CombiPrecip and CombiValais base their calculations on the same data that we are trying to correct. SNOWPACK also uses uncorrected data as input.

REFERENCES: [1] https://www.meteosvizzera.admin.ch/tempo/i-sistemi-di-rilevamento/stazioni-al-suolo/rete-di-rilevamento-automatica/stumenti-di-misura.html
[2] Kochendorfer, J., and Coauthors, 2017a: The quantification and correction of wind-induced precipitation measurement errors. *Hydrol. Earth Syst. Sci.*, **21**, 1973–1989, https://doi.org/10.5194/hess-21-1973-2017
. [3] Kochendorfer, J., and Coauthors, 2017b: Analysis of single-alter-shielded and unshielded measurements of mixed and solid precipitation from WMO-SPICE. *Hydrol. Earth Syst. Sci.*, **21**, 3525–3542, https://doi.org/10.5194/hess-21-3525-2017.
[4] D. Yang, S. Ishida, B. E. Goodison, and T. Gunther. Bias correction of daily precipitation measurements for greenland. Journal of Geophysical Research: Atmospheres, 104(D6):6171–6181, 1999.