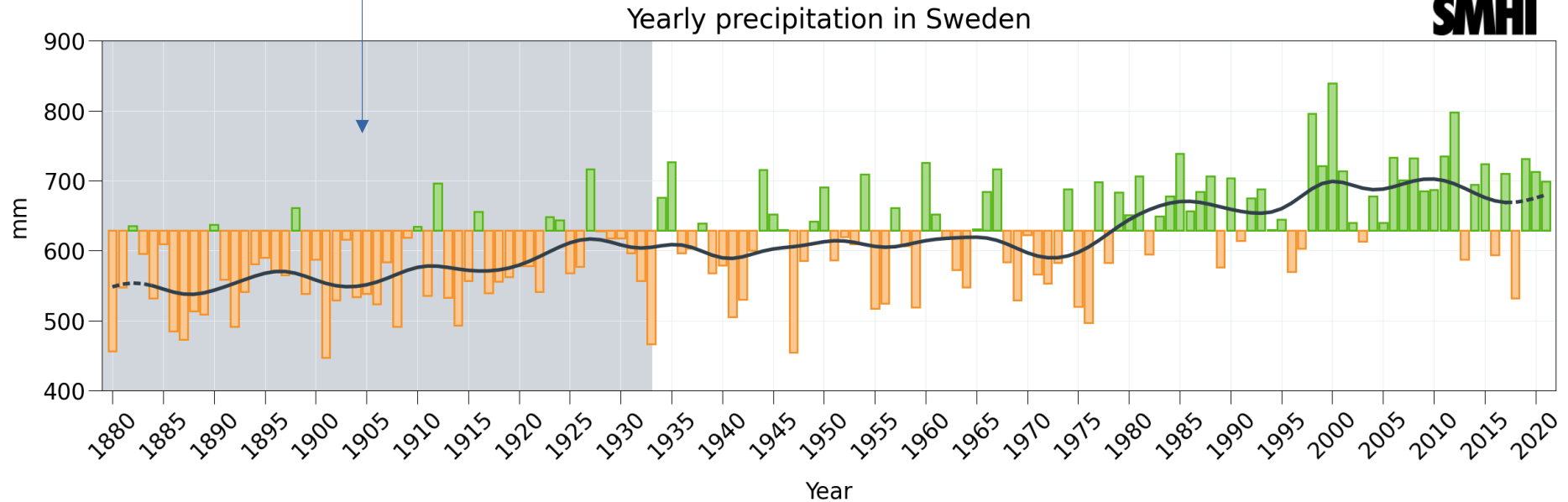


JOELSSON, L.M.T, SÖDLING, J., & ENGSTRÖM E.

**19TH CENTURY PRECIPITATION
MEASUREMENT METHOD
— A FIELD STUDY**

Long precipitation time series

Missing precipitation?
↓



The bars in the graph show the total rainfall for year. Green bars show higher and orange show lower precipitation than the average for the normal period 1961-1990. The gray line shows a running mean calculated over about ten years. Observations before 1933 are considered to have lower reliability than later observations. This is marked with a gray shadow in the diagram. Caution should be exercised in any climatological conclusions based on this time period.

History of precipitation observations in Sweden



Mid 18th century: Regular observations in Uppsala, Lund, and Stockholm

Early 19th century: Regular observations at five additional sites

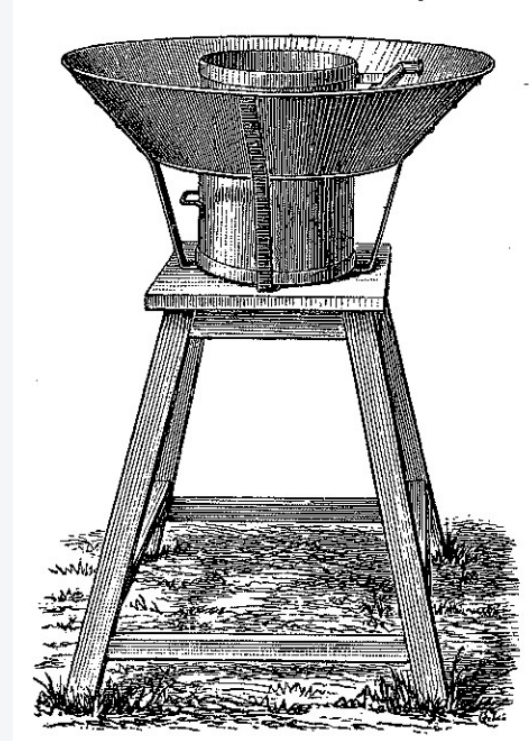
1858–1860: A network of 35 meteorological observation stations was set up by the Royal Swedish Academy of Sciences

End of 1870's: A network of more than 300 precipitation observation stations was set up with the aid of the agricultural organization “Kungliga Hushållningssällskapen”

1880: precipitation was observed at lighthouses.

Gauges and wind shields

- 1873**: Zinc can, 1 206.5 cm² mouth (1 Swedish square foot)
- 1873–mid 20th century**: 1 000 cm² mouth
- 1893–1935**: Wind shield



Gauges and wind shields

SMHI

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- 1893–1935:** Wind shield
- mid 20th century:** “SMHI can”, 200 cm² mouth, with Nipher wind shield
- 1960’s:** Light metal can



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- mid 20th century:** “SMHI can”, 200 cm² mouth, with Nipher wind shield
- 1960’s:** Light metal can
- 1995:** Automation of SMHI’s SYNOP stations, GEONOR, with Alter wind shield.



Difference between can with and without wind shields: Previous studies



Cited by Hamberg (1910): Parallel observations, several stations, 1890–1895
May–October ~6 %, strong winds up to 20 %
November–April 10–35 %, strong winds up to 70 %

Hamberg (1910): Parallel observations, Särna, 1907–1910
11 %, wintertime (DJF) 35 %, summertime (JJA) 3 %

Bergsten (1954): Two sets of operational stations 1901–1930 and 1921–1950
10–15 %

Eriksson et al. (1989): Estimation, 2–15 % (rain), 5–50 % (snow)

Alexandersson (2002): Estimation from homogeneity breaks, 5–10 %

Difference between automatic and manual observations: Previous studies



Fredriksson & Ståhl (1994): Parallel observations with three automatic gauges, Norrköping, October 1993–May 1994

5 % (GEONOR)

Largest monthly departure 15 %

Alexandersson (2000): Comparison of simultaneously active stations

16 %

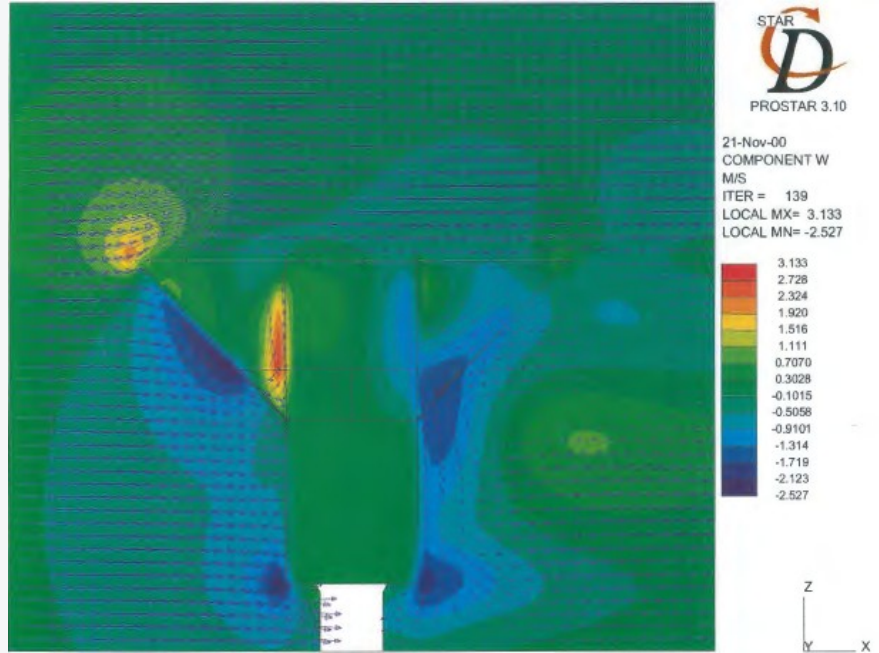
Wintertime (DJF) 22 %

Summertime (JJA) 12 %

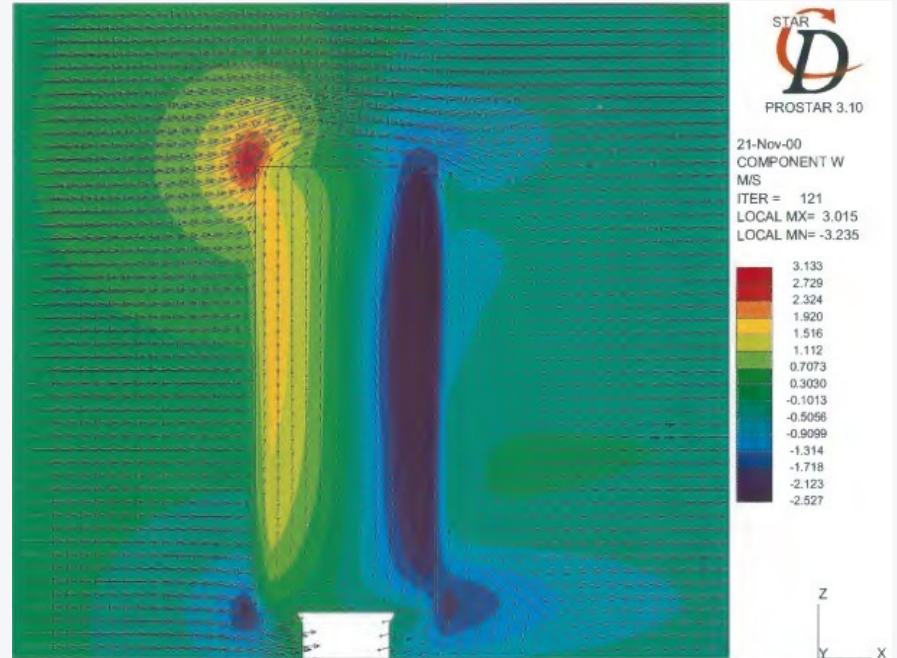
Large differences

No previous studies on the effect on the introduction of the SMHI can.

Problem with wind



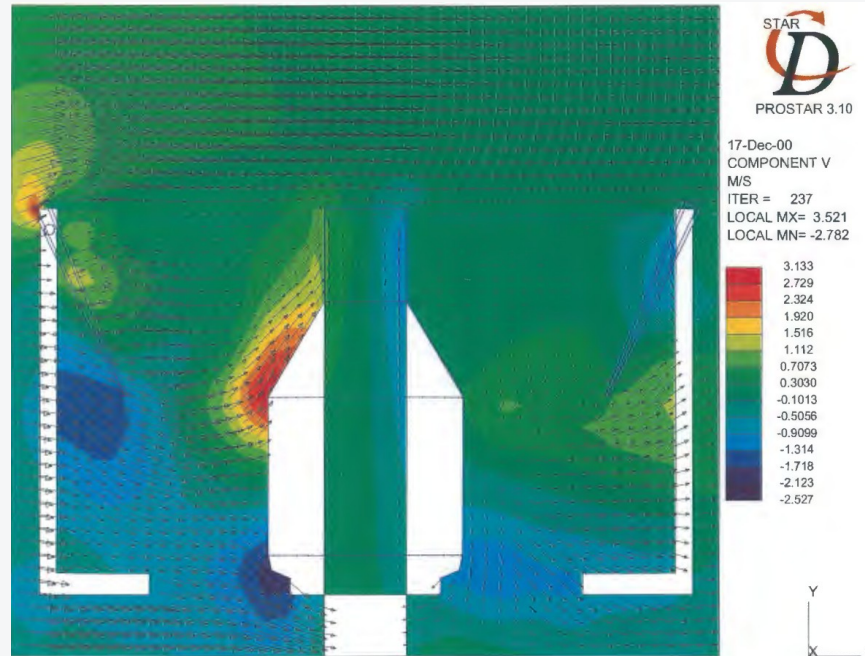
With wind shield



Without wind shield

CFD calculation of the airflow around a SMHI can

Problem with wind



CFD calculation of the airflow around a GEONOR can

Question



- 1) What is the effect of the introduction of wind shield over the Swedish precipitation measurement network 1893–1935?
- 2) How much does precipitation sums differ between historical and modern type cans (SMHI can and GEONOR)?
- 3) What is the difference for 1) and 2) for snow and rain?
- 4) What is the difference for 1) and 2) for windy and calm conditions?
- 5) How much of precipitation sums are lost by evaporation in the historical cans?
- 6) Can correction factors for precipitation observations prior to the mid 20th century be obtained?

Approach

Two sets of replicas of historical precipitation cans was manufactured

Katterjåkk and Norrköping

With and without wind shield

Daily observations (work days)
November 2016–May 2021



Historical cans, Katterjåkk

Method



Ratios of historical cans measurements with and without calculated: *wind shield effect*

Ratios of historical cans and official (automatic) measurements calculated

Precipitation sums from the automatic stations was added to match the time of the test observation

Mean temperature, average wind speed, and wind gust speed was calculated for the accumulation time

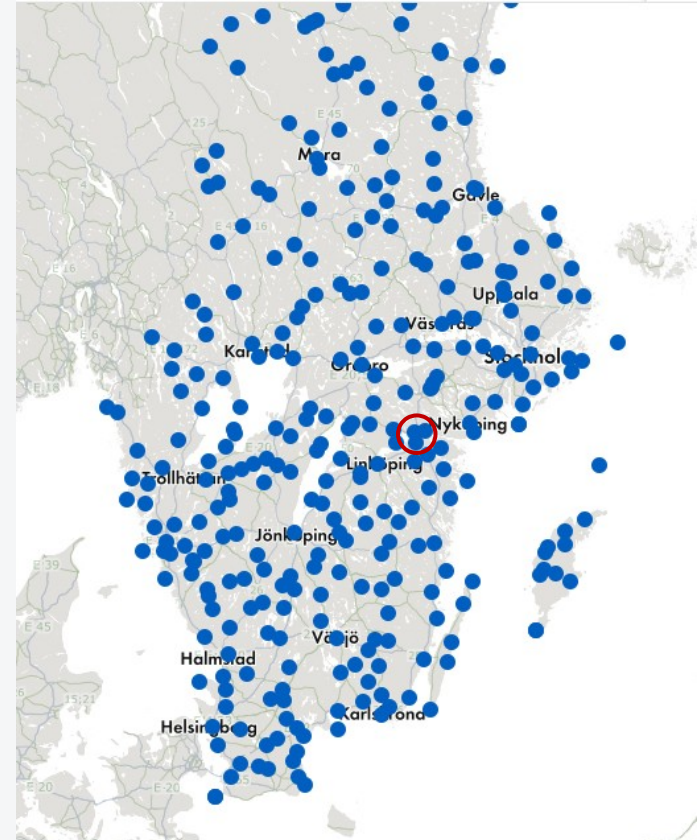
Norrköping

Observation site at SMHI's headquarters in Norrköping

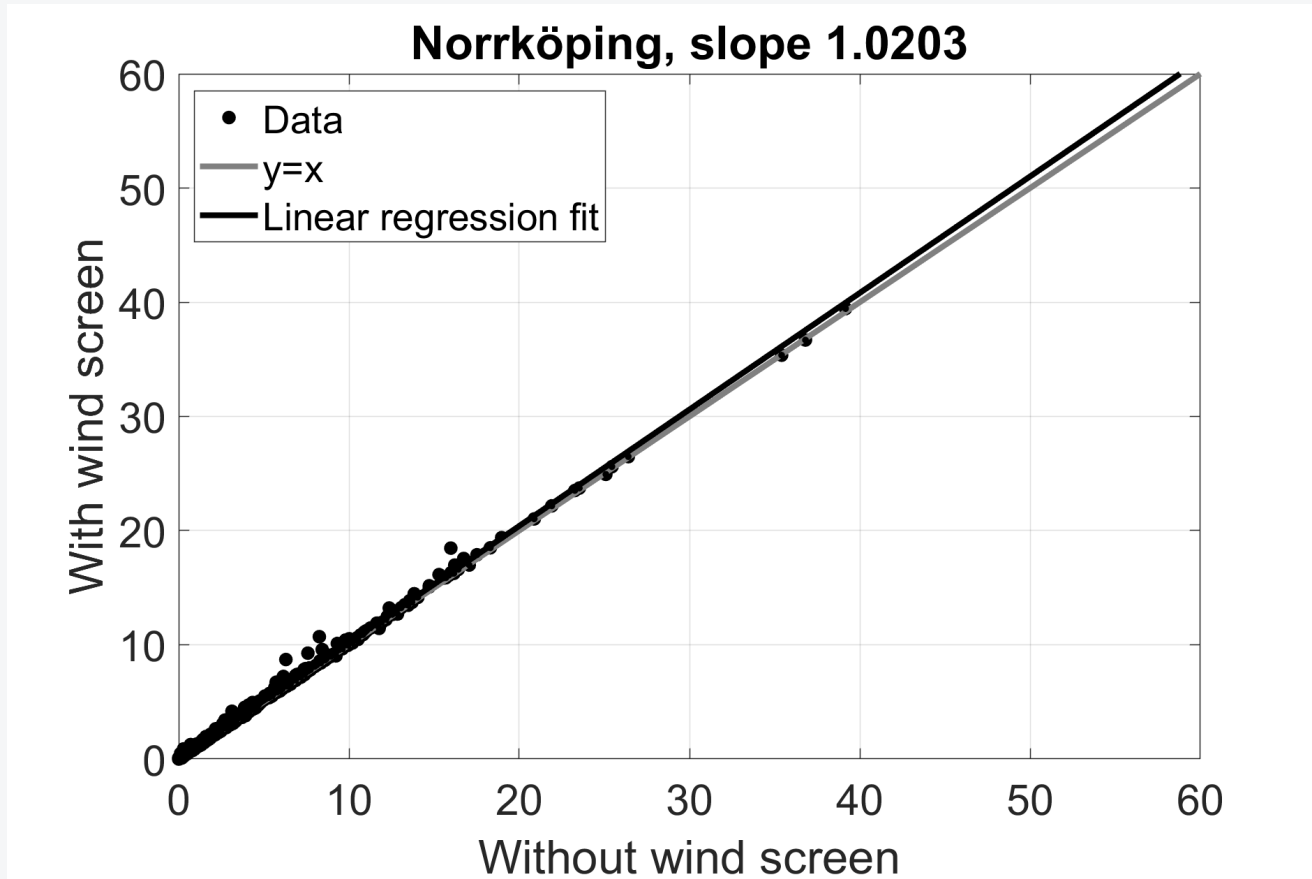
Wind class 3 of 7: "Quite well shielded site, where there can be a minor opening towards a larger field or lake. Well shielded site if it is situated in a generally windswept region" (Alexandersson, 2003)

Automatic station close by with precipitation, wind, and temperature observations

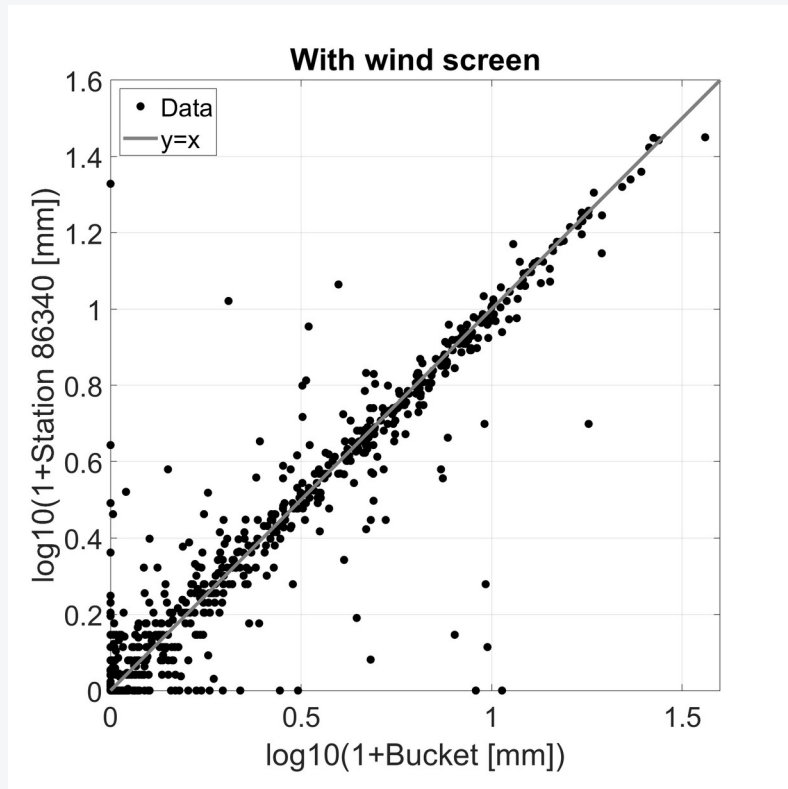
Unofficial manual precipitation observations just outside observational site (digitization ongoing)



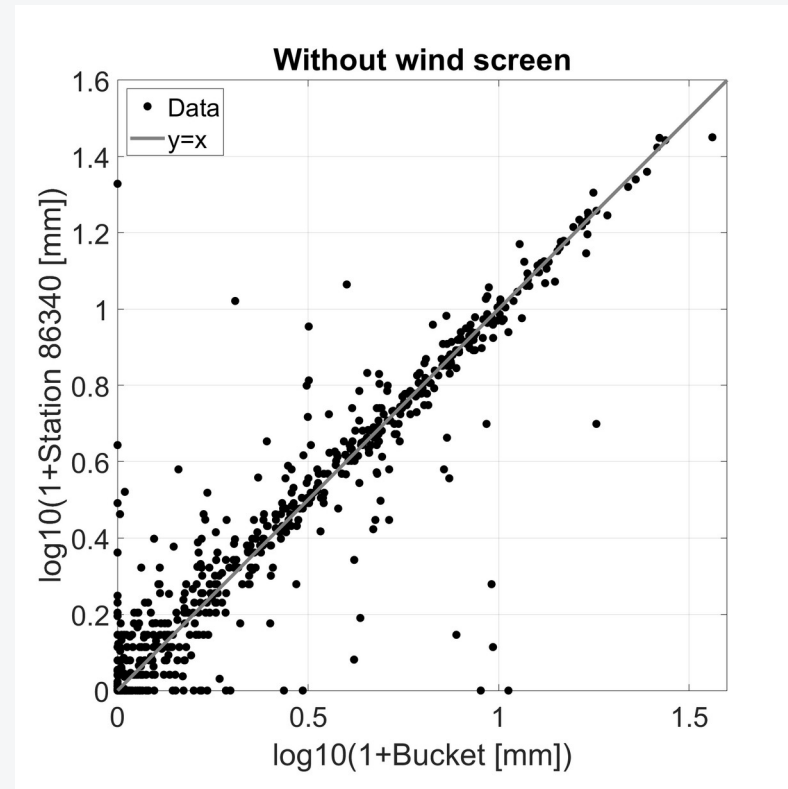
Results — with vs. without windscreen



Results — automatic vs. historical cans

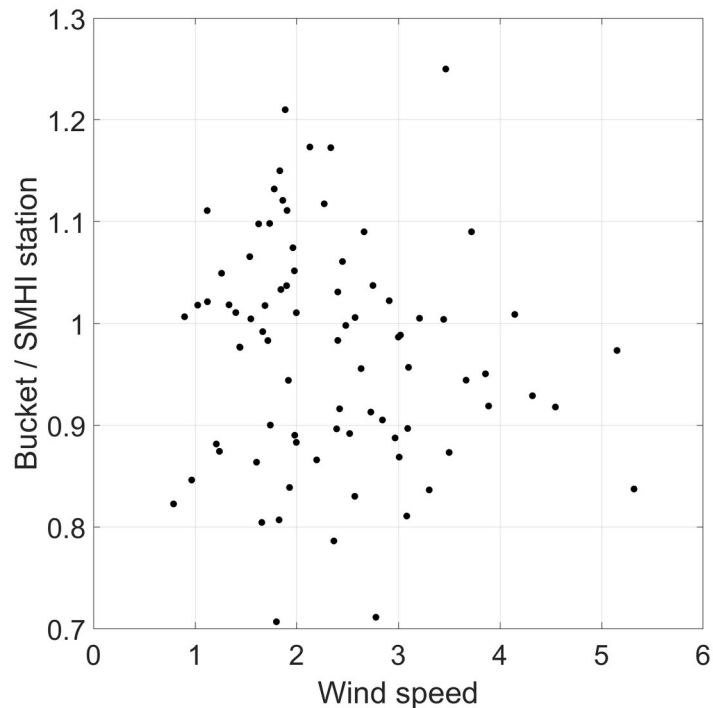


$k = 1.09$

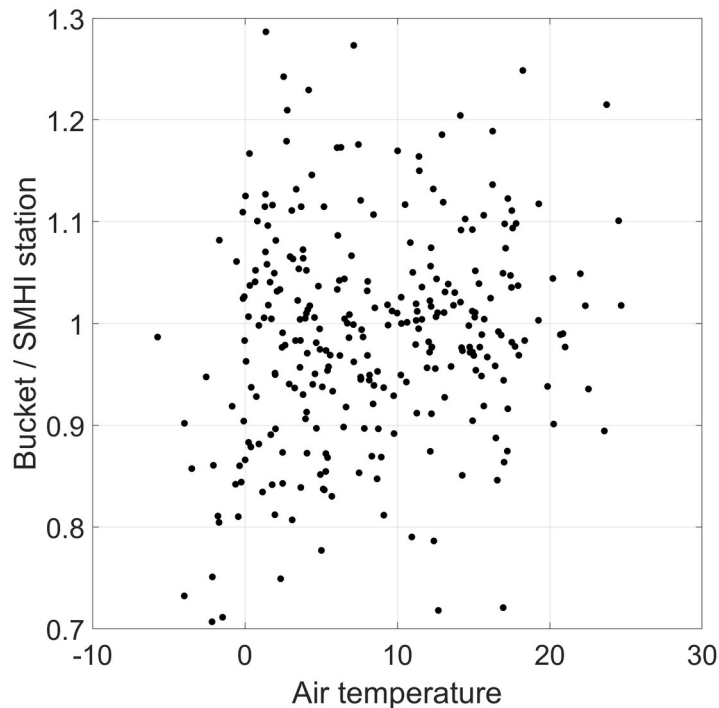


$k = 1.07$

Results — precipitation vs. other variables **SMHI**

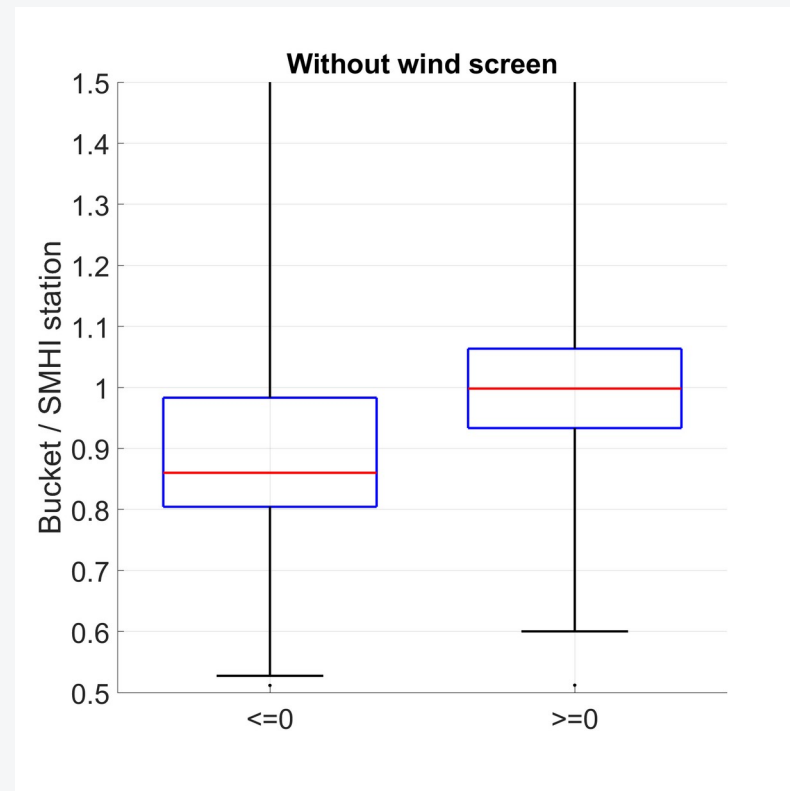
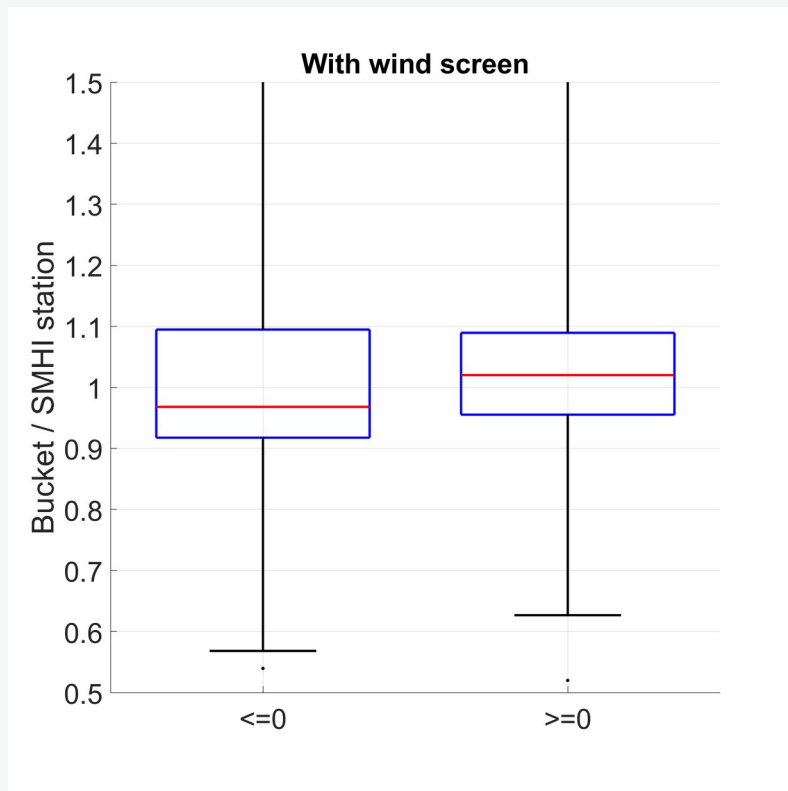


$r = -0.10$ (without wind shield)

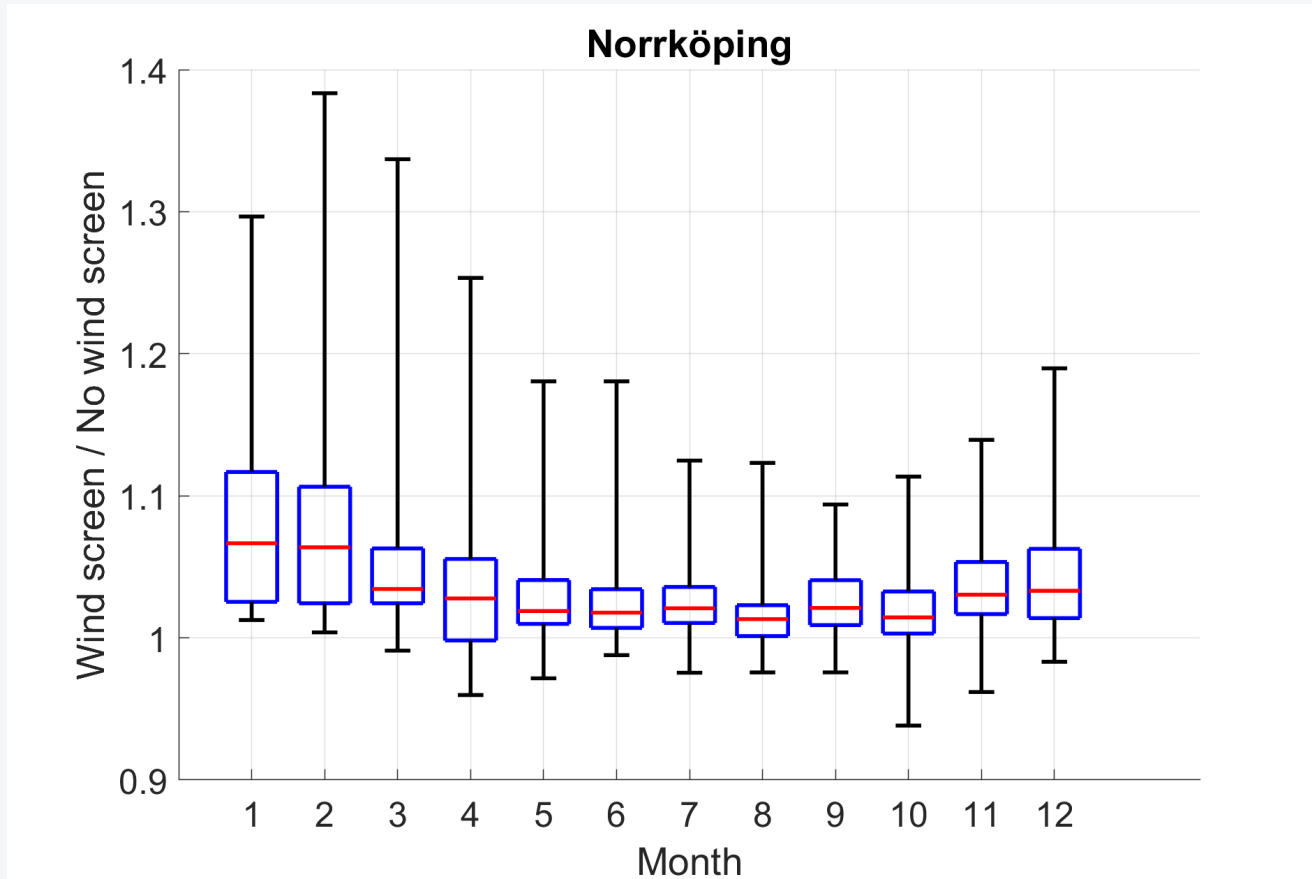


$r = 0.19$ (without wind shield)

Results — sub- and superzero temp.



Results — monthly values



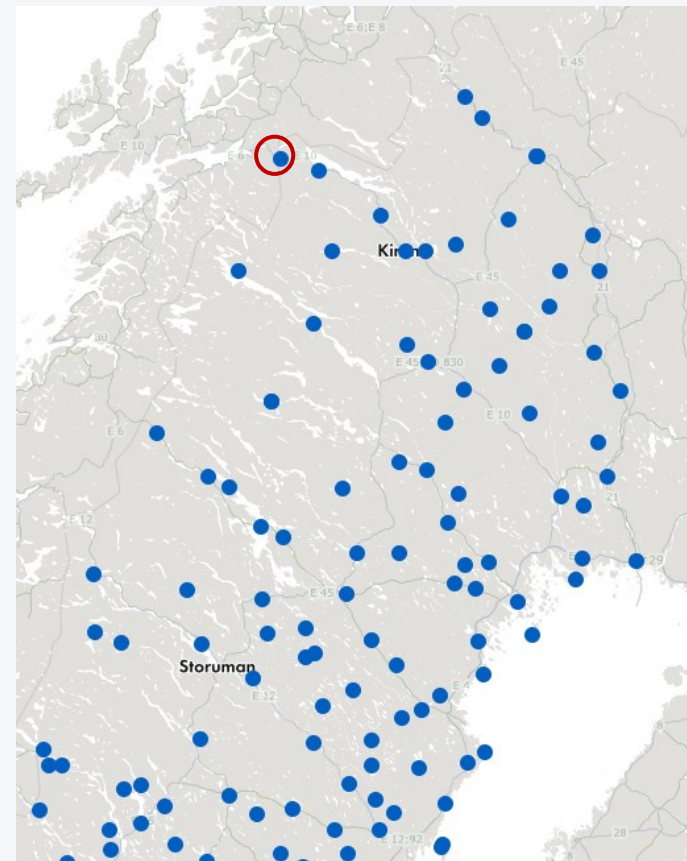
Katterjåkk

Mountain station

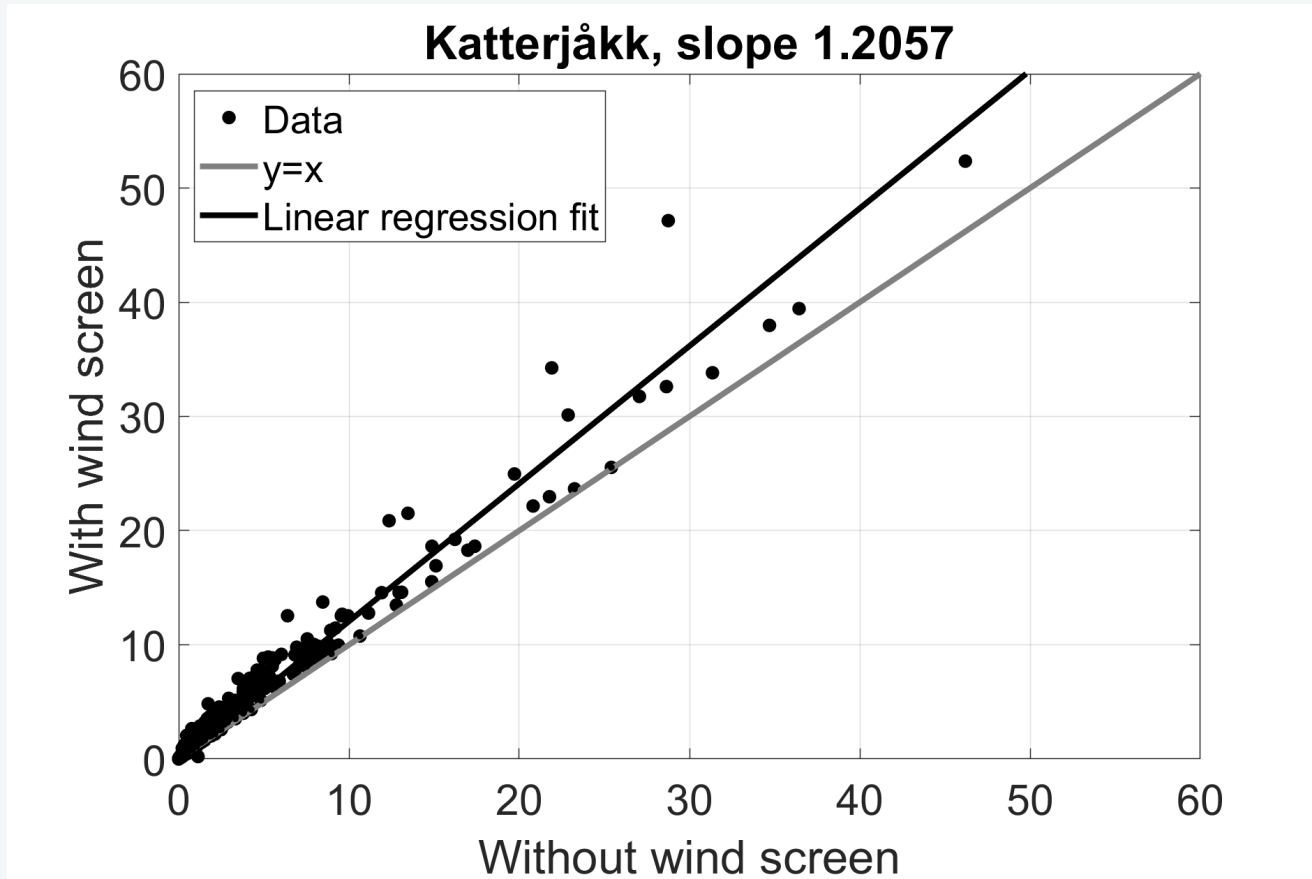
Wind class 5 of 7: “Open site with only partial protection from buildings or trees, sites on a hill or hillside in the inland” (Alexandersson, 2003)

Official manual precipitation observations parallel to test observations

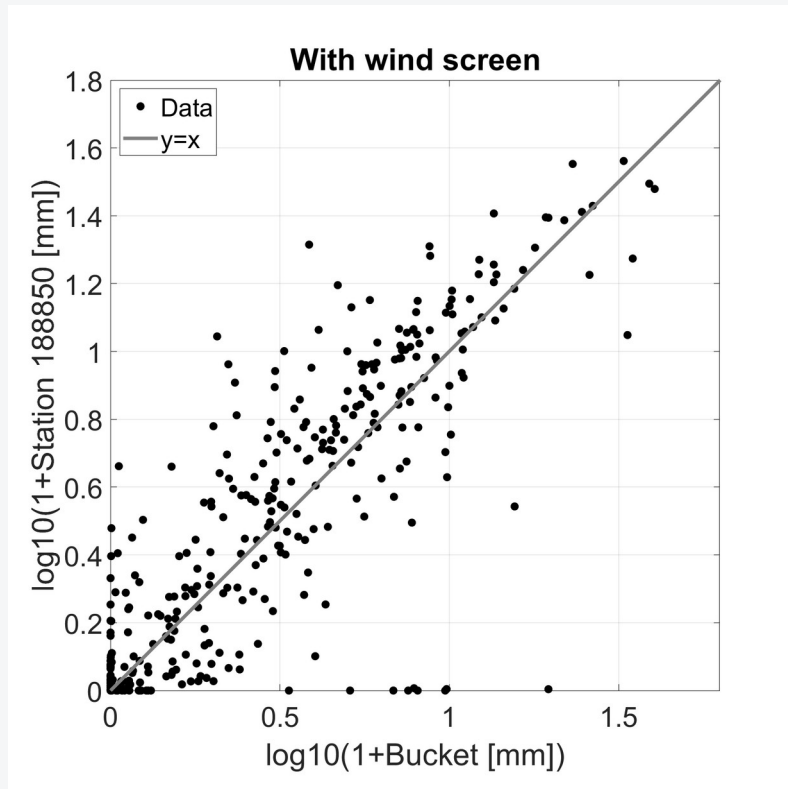
Automatic station in a small depression about 50 m south of test site with precipitation and temperature observations, wind mast on a small hill 40 m further south



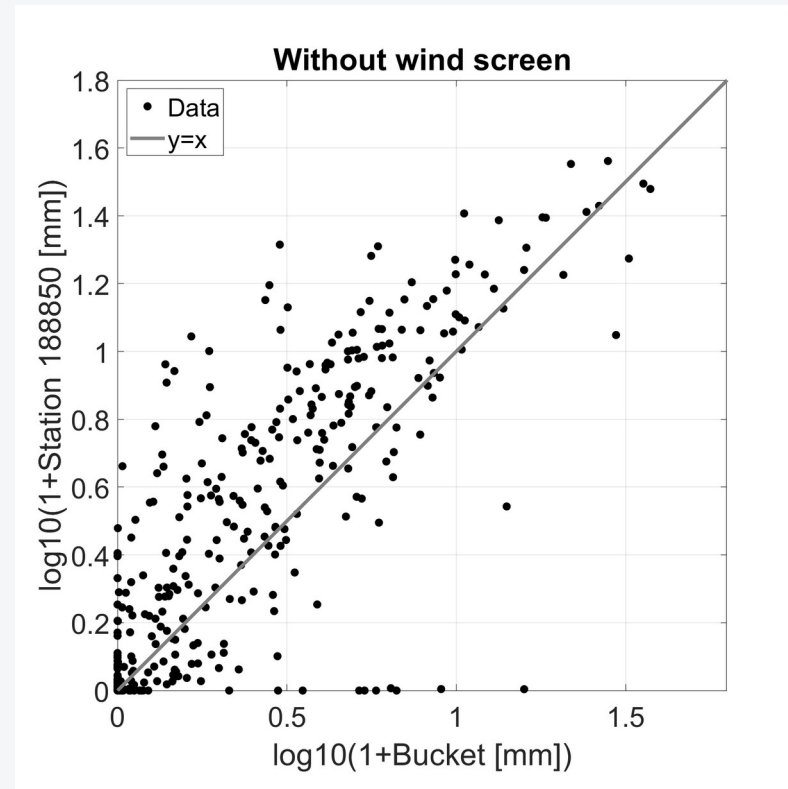
Results — with vs. without windscreen



Results — automatic vs. historical cans

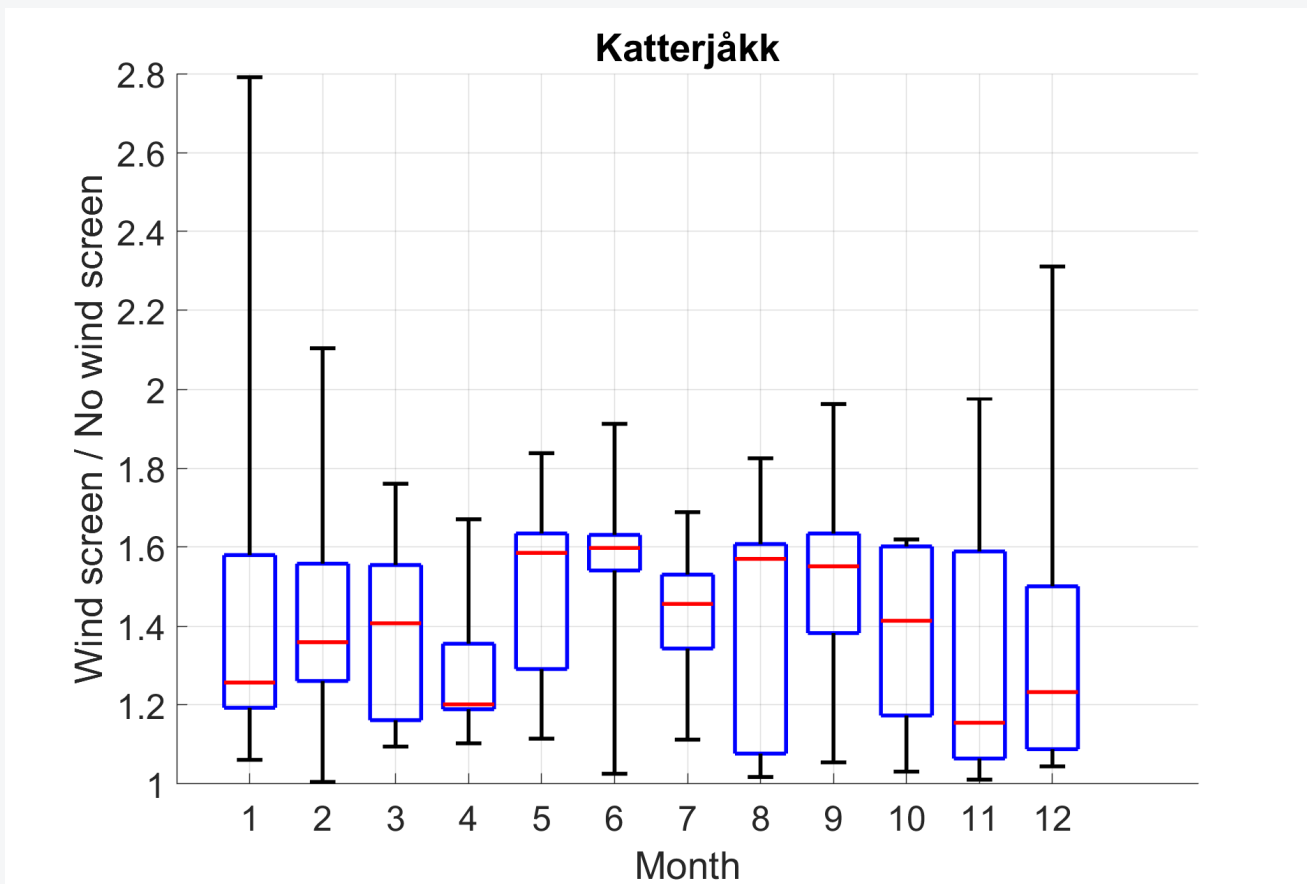


$k = 1.16$



$k = 1.05$

Results — monthly values



Summary

The wind shield effect:

2 % (Norrköping)

20 % (Katterjåkk)

The historical cans collect
5–16 % more precipitation than
the automatic gauge

No clear relationship between
wind shield effect and other
meteorological parameters

Significant shift in wind shield
effect for subzero temperatures



Historical cans, Katterjåkk

Remaining work

The manual measurements from Katterjåkk and Norrköping are to be analysed

Precipitation type notes are to be more closely studied



Historical cans, Katterjåkk



THANK YOU FOR YOUR ATTENTION