Homogenization of long-term snow observations

First results of impact and validation of quantile mapping-correction of Austrian daily snow height observations

Gernot Resch, Barbara Chimani,
Roland Koch, Wolfgang Schöner, Christoph Marty

Snow is important for the global climate system and a serious economic factor in alpine countries.

Covers > 50 % of Northern Hemisphere in winter.

Essential component of the cryosphere.

Large influence as insulation and reflective cover.

Influence on weather (and therefore climate).

Annual Austrian turnover with lift tickets: 1.4 bil. €

Cable cars, gastronomy, sports equipment, transport in Austria: 7.9 bil €

99.000 jobs = 2.7 % Austrian labourmarket

Out of these reasons (and many more), it's worthwhile having a detailed look on not only the future but the past of snowheight.

Luckily, there are lots of observations available obtained by national weather and hydrographic services.

Unluckily, almost no effort has been put in their homogenization.

So, it would be a good idea to do that!

First steps in the homogenization of Austrian and swiss daily snow heights have been performed by Austrian Weatherservice ZAMG and Swiss SLF

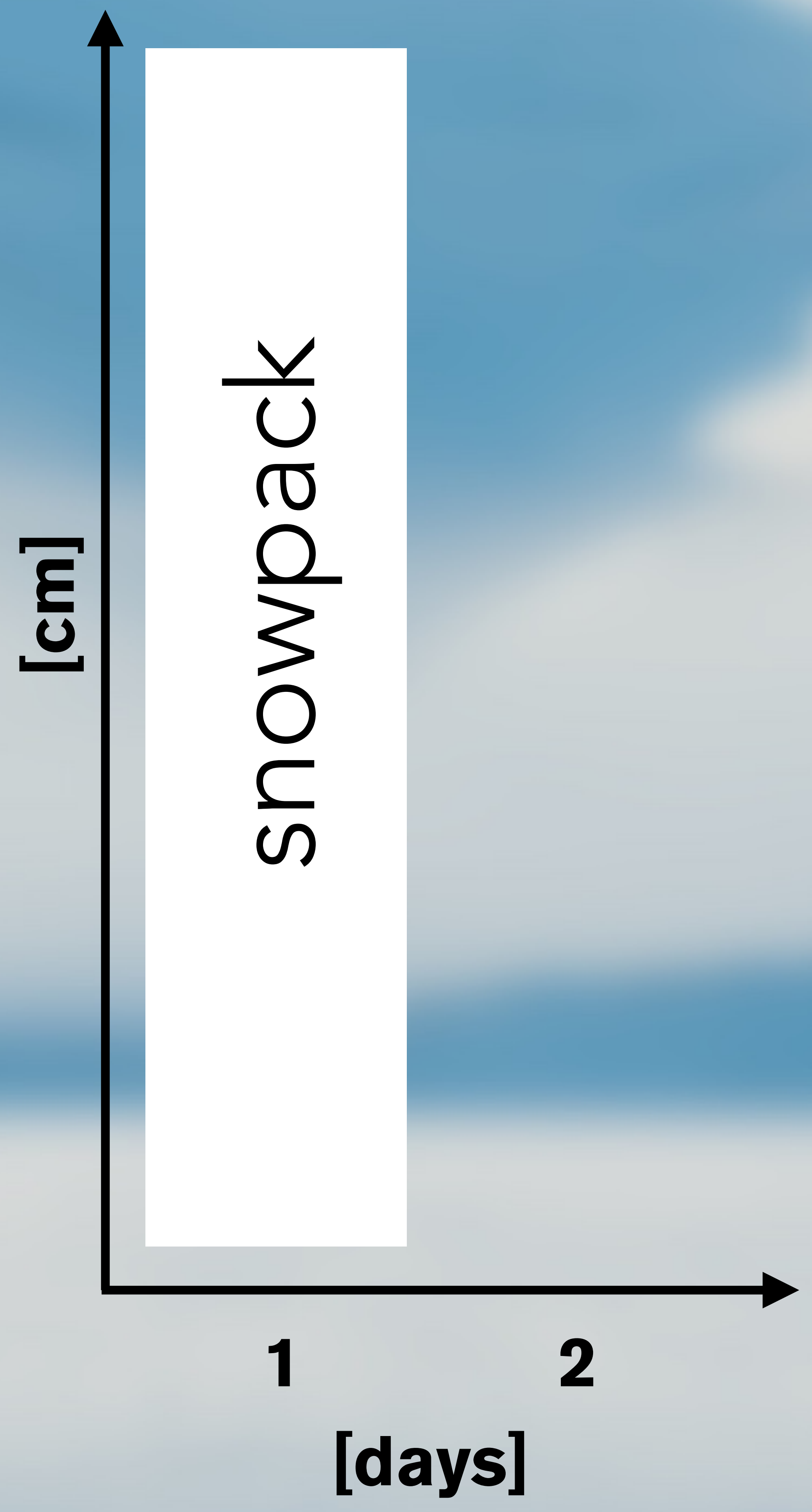
(Schöner et al. 2019)

The used method has been evaluated.

(Marcolini et al. 2019)

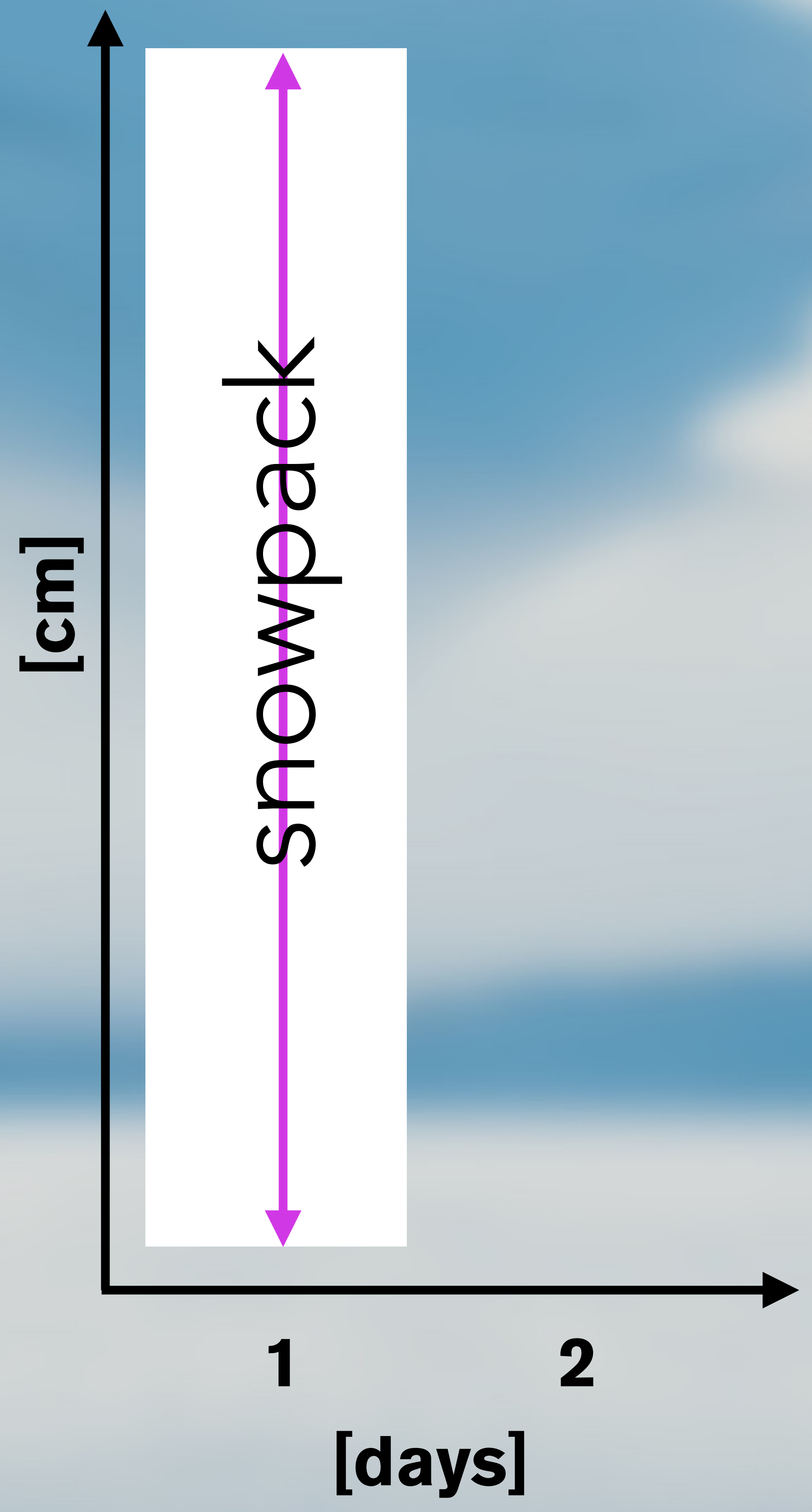
In the ongoing Hom4Snow-Project (SLF and University of Graz), the created snow datasets are being expanded and more advanced methods developed.

Refresher: Snow height measurements



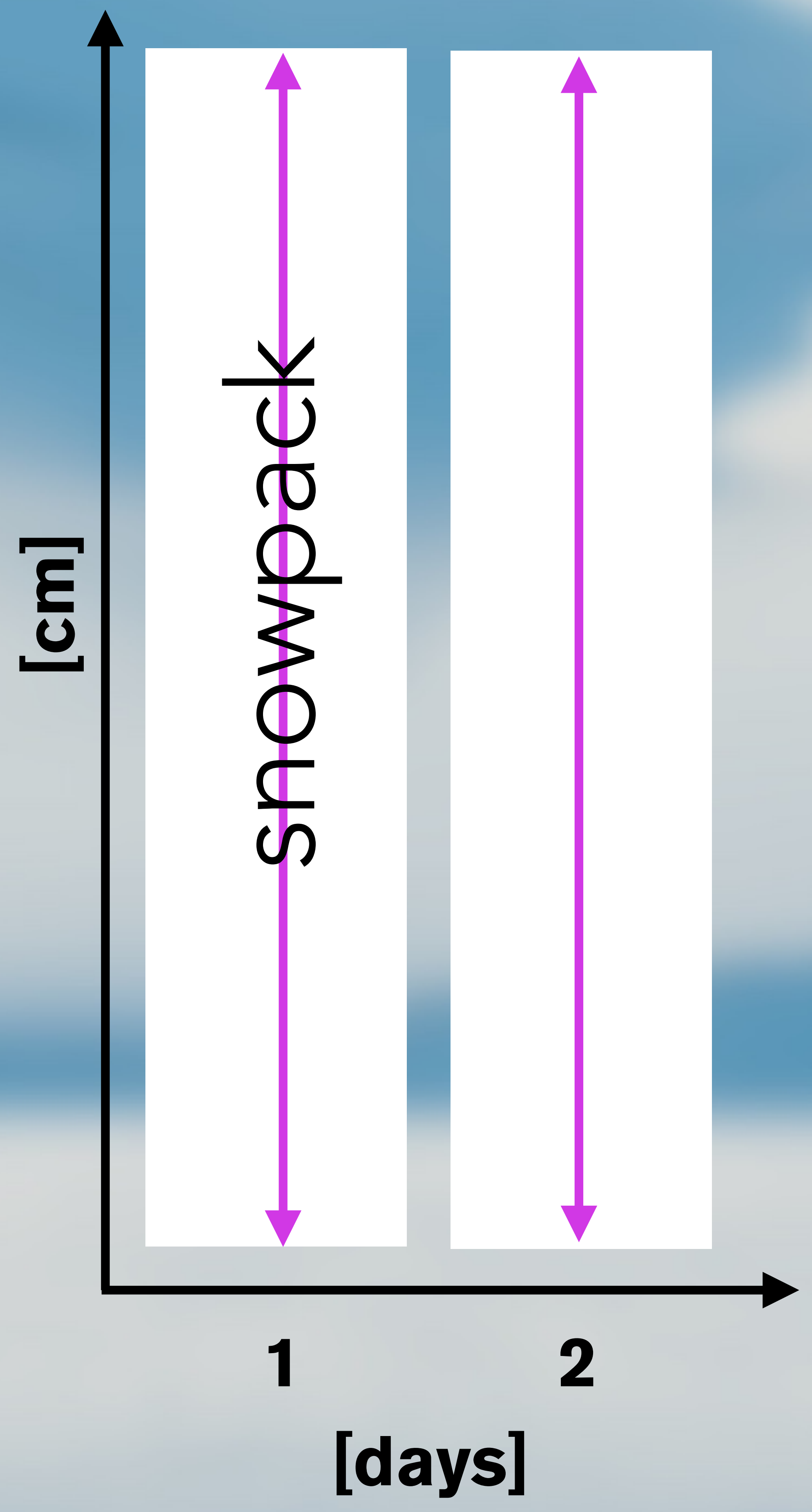
Refresher: Snow height measurements

snowheight [HS]



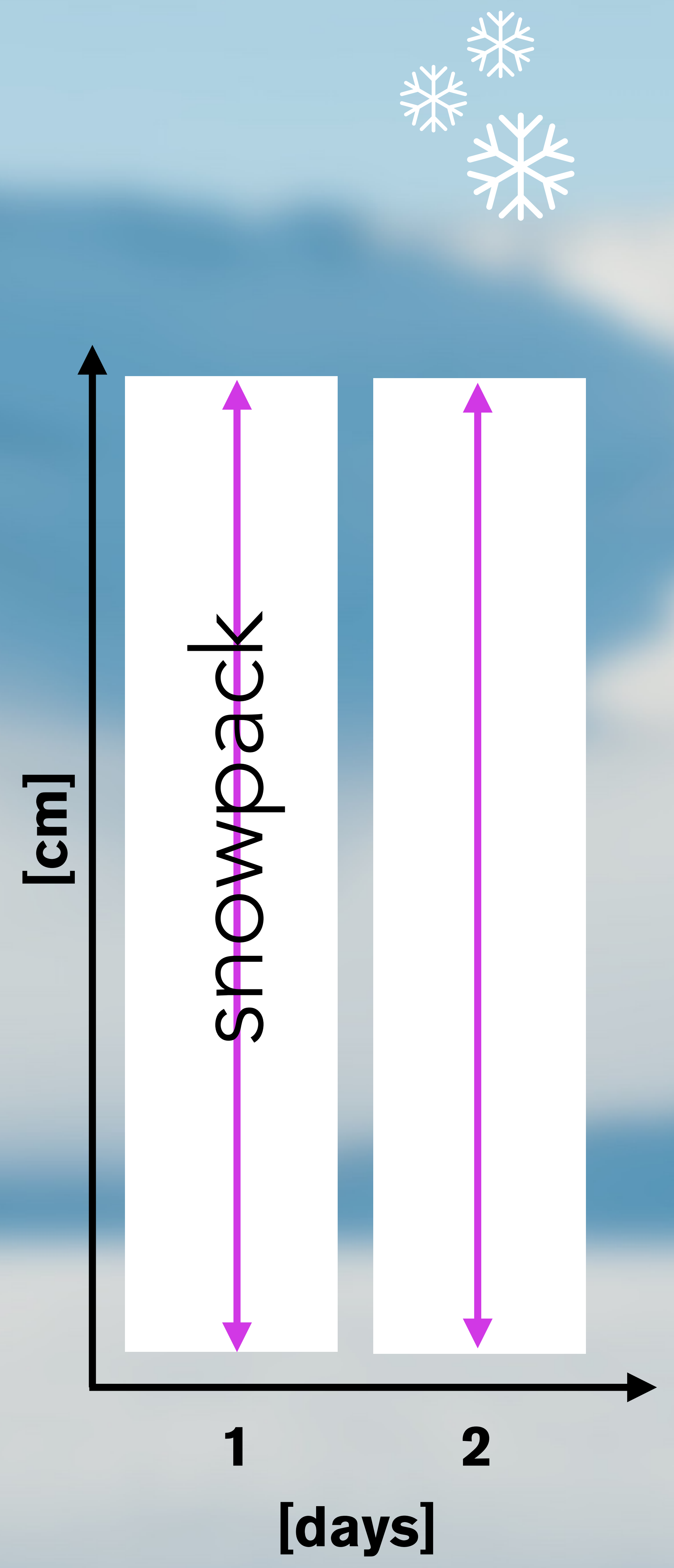
Refresher: Snow height measurements

snowheight [HS]

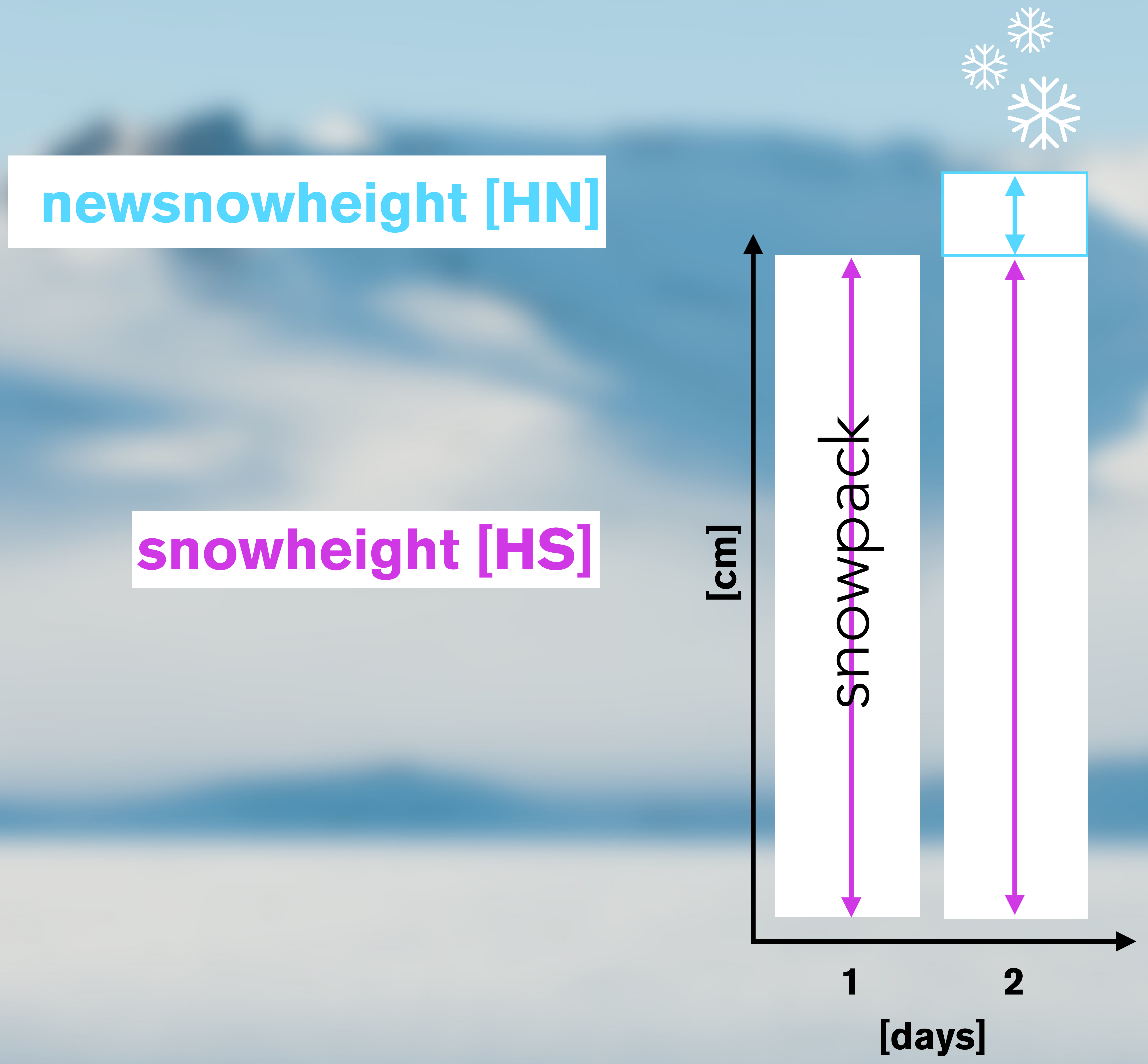


Refresher: Snow height measurements

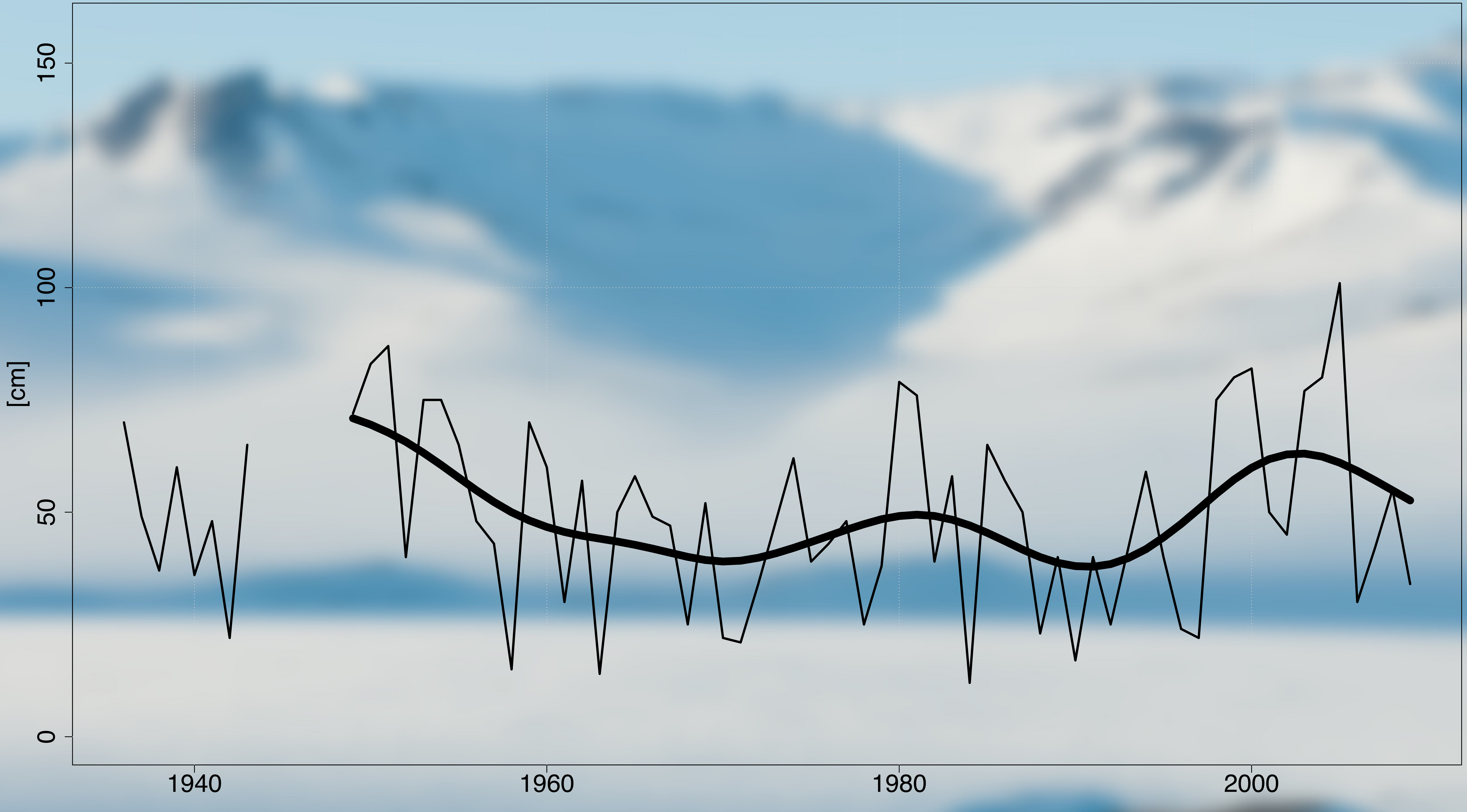
snowheight [HS]



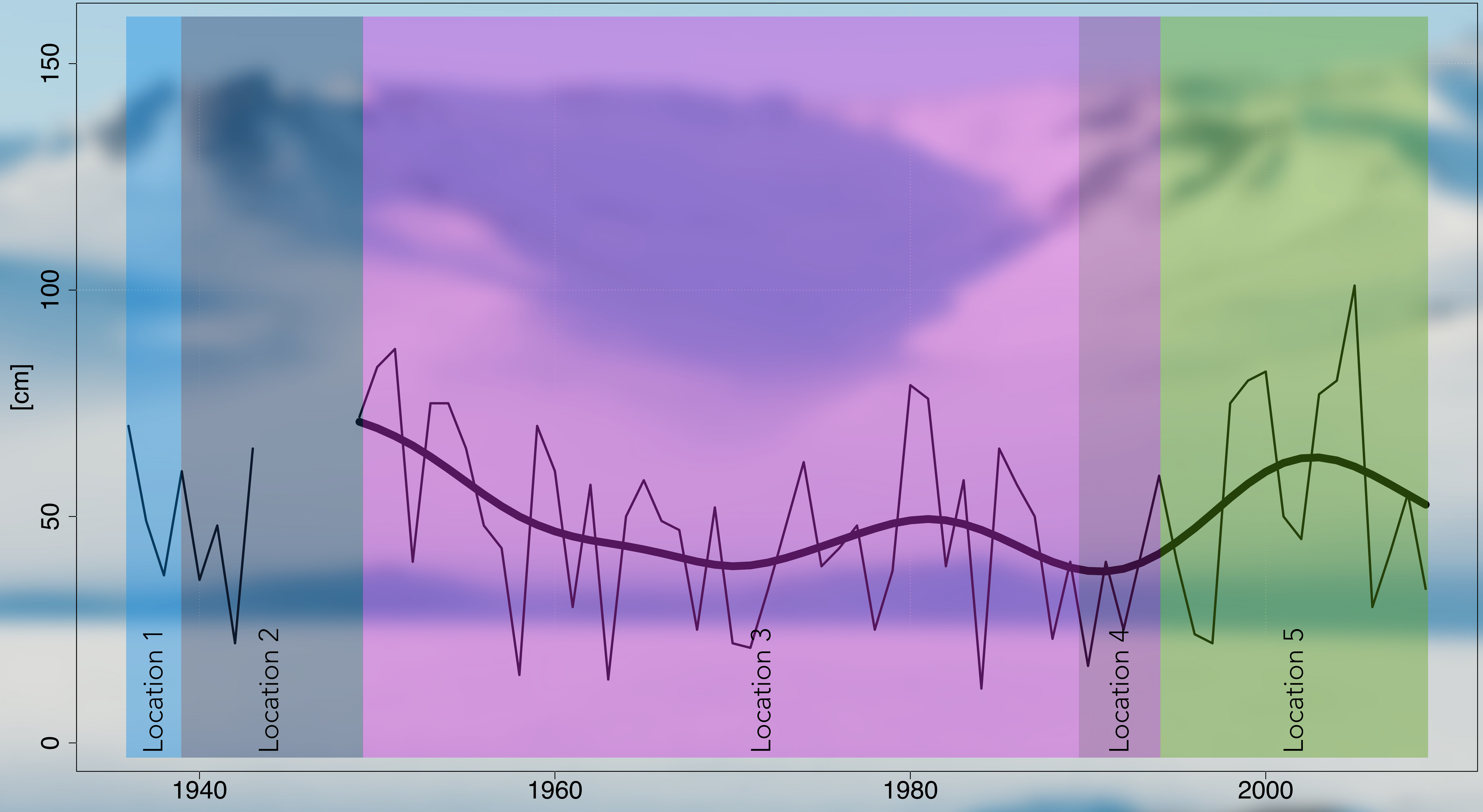
Refresher: Snow height measurements



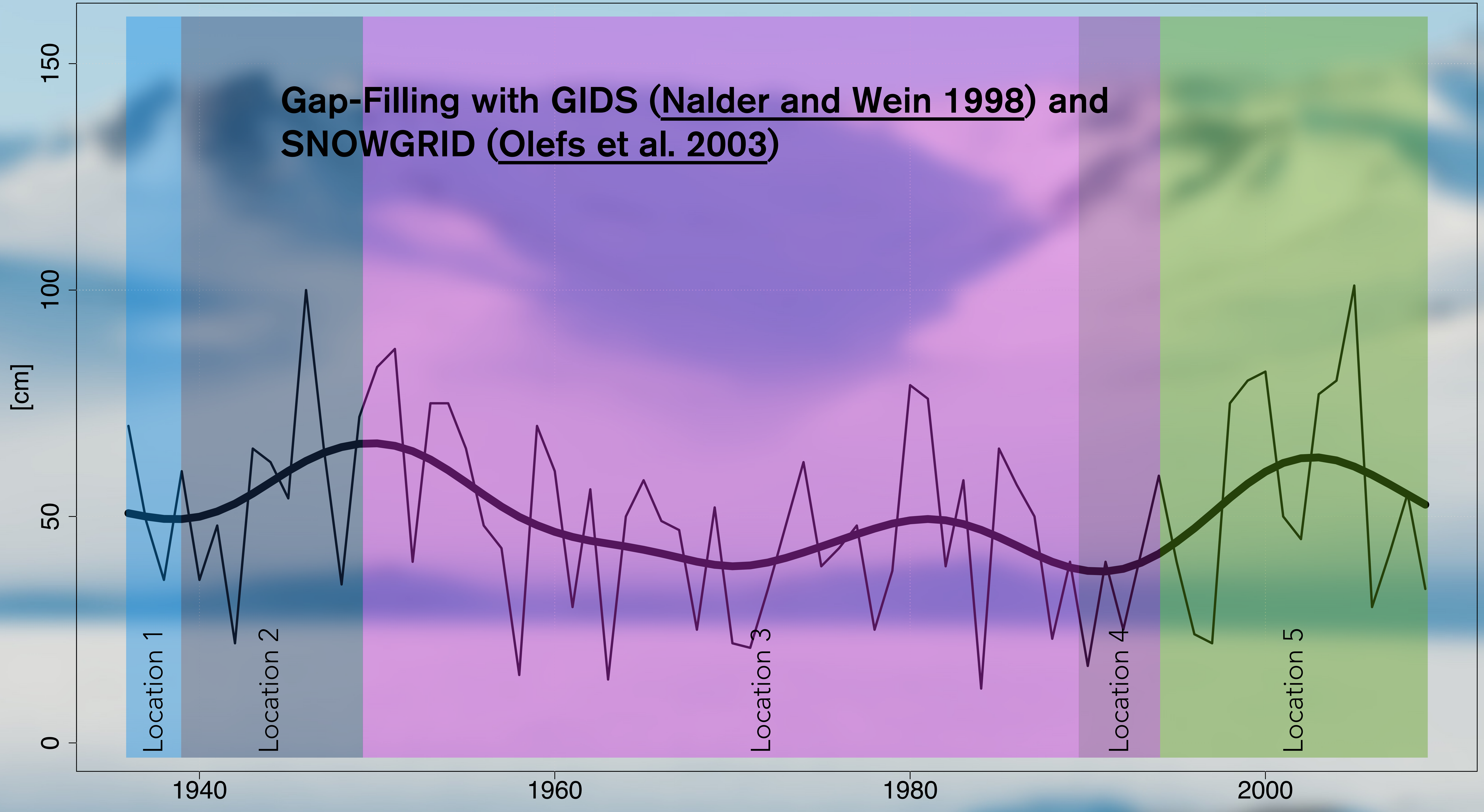
Performed correction steps in homogenization



One time series, several locations in metadata

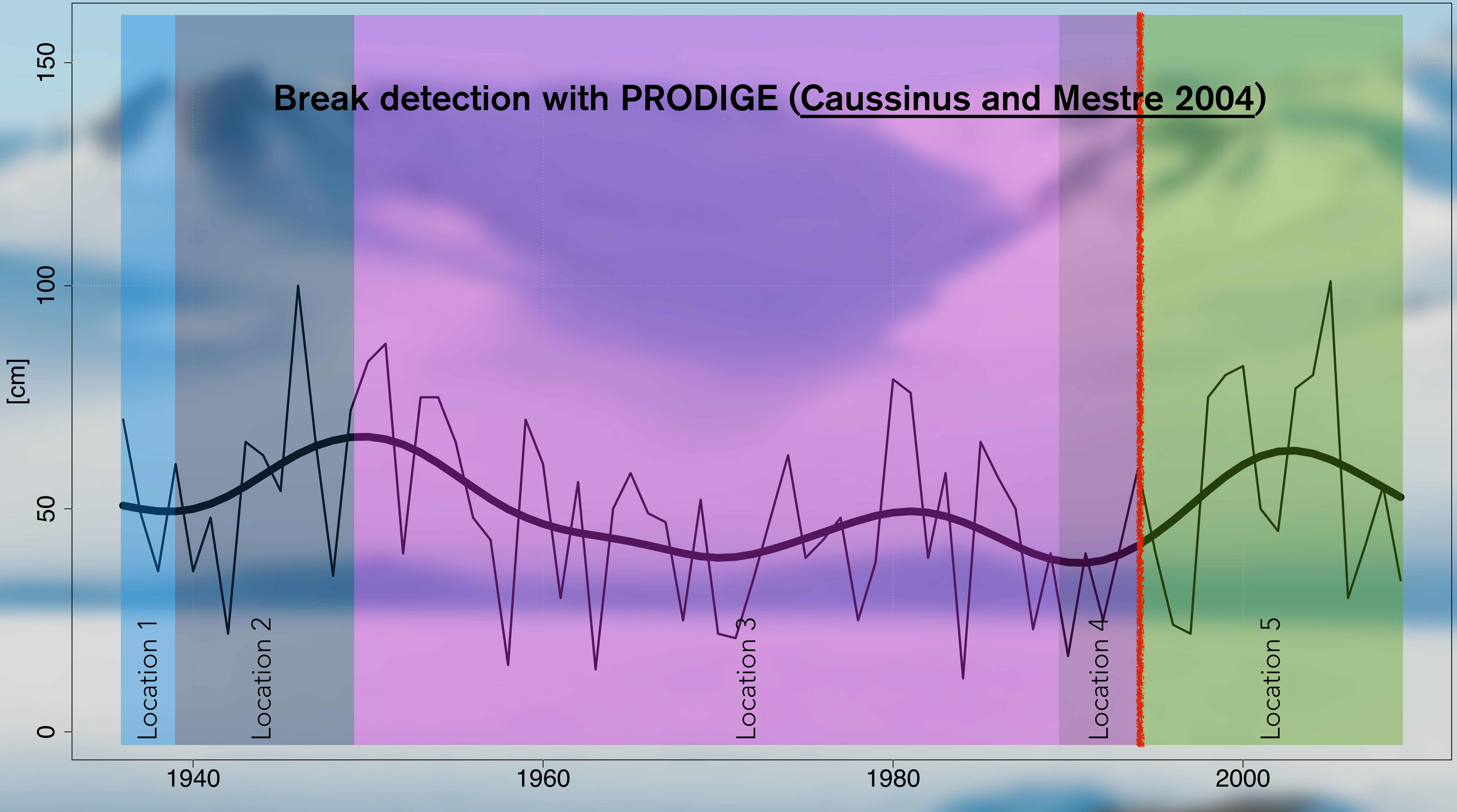


Gap-Filling

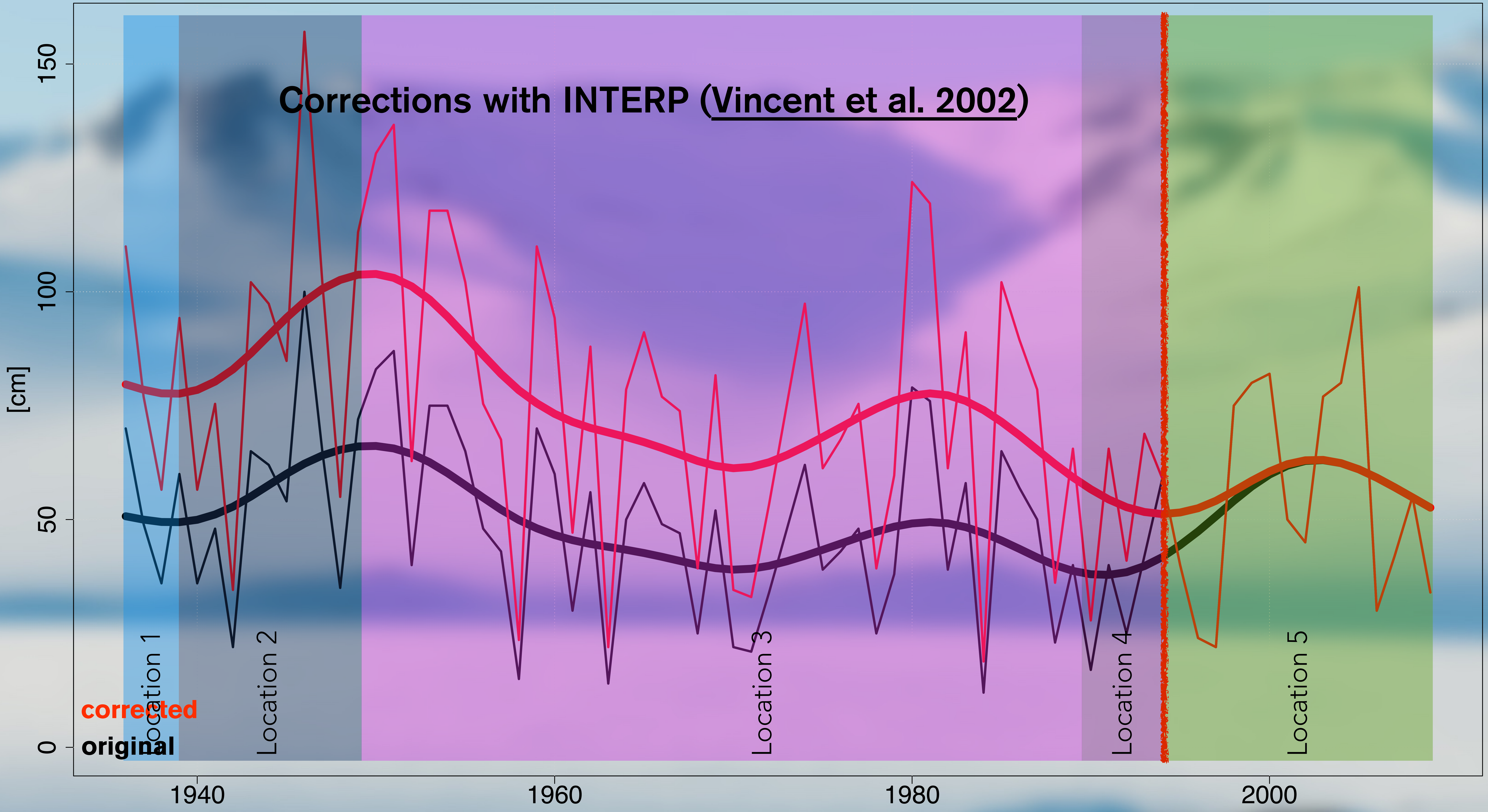


Gap-Filling with GIDS (Nalder and Wein 1998) and SNOWGRID (Olefs et al. 2003)
[cm]
0
50
100
150
1940
1960
1980
2000
Location 1
Location 2
Location 3
Location 4
Location 5

Break detection



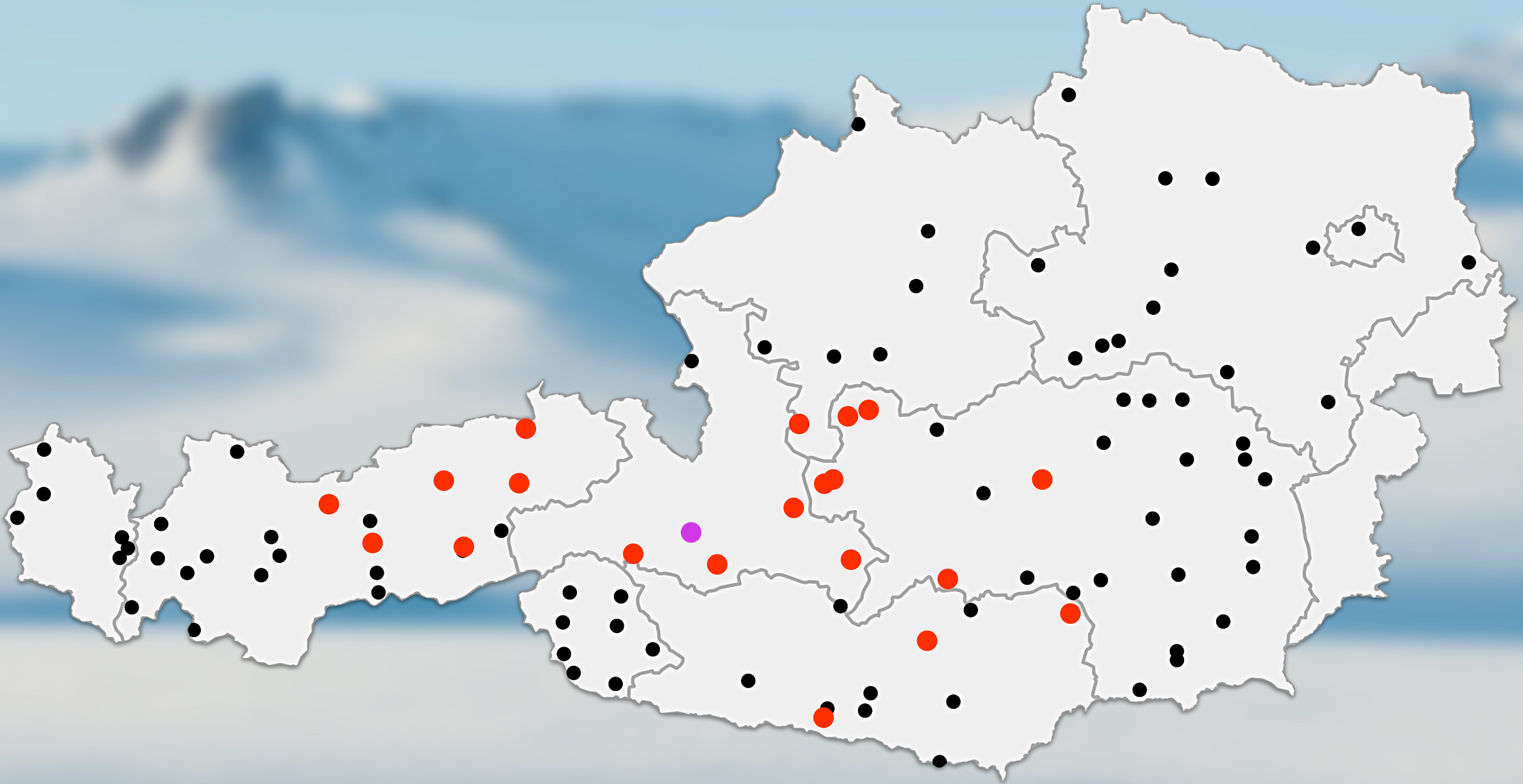
Corrections



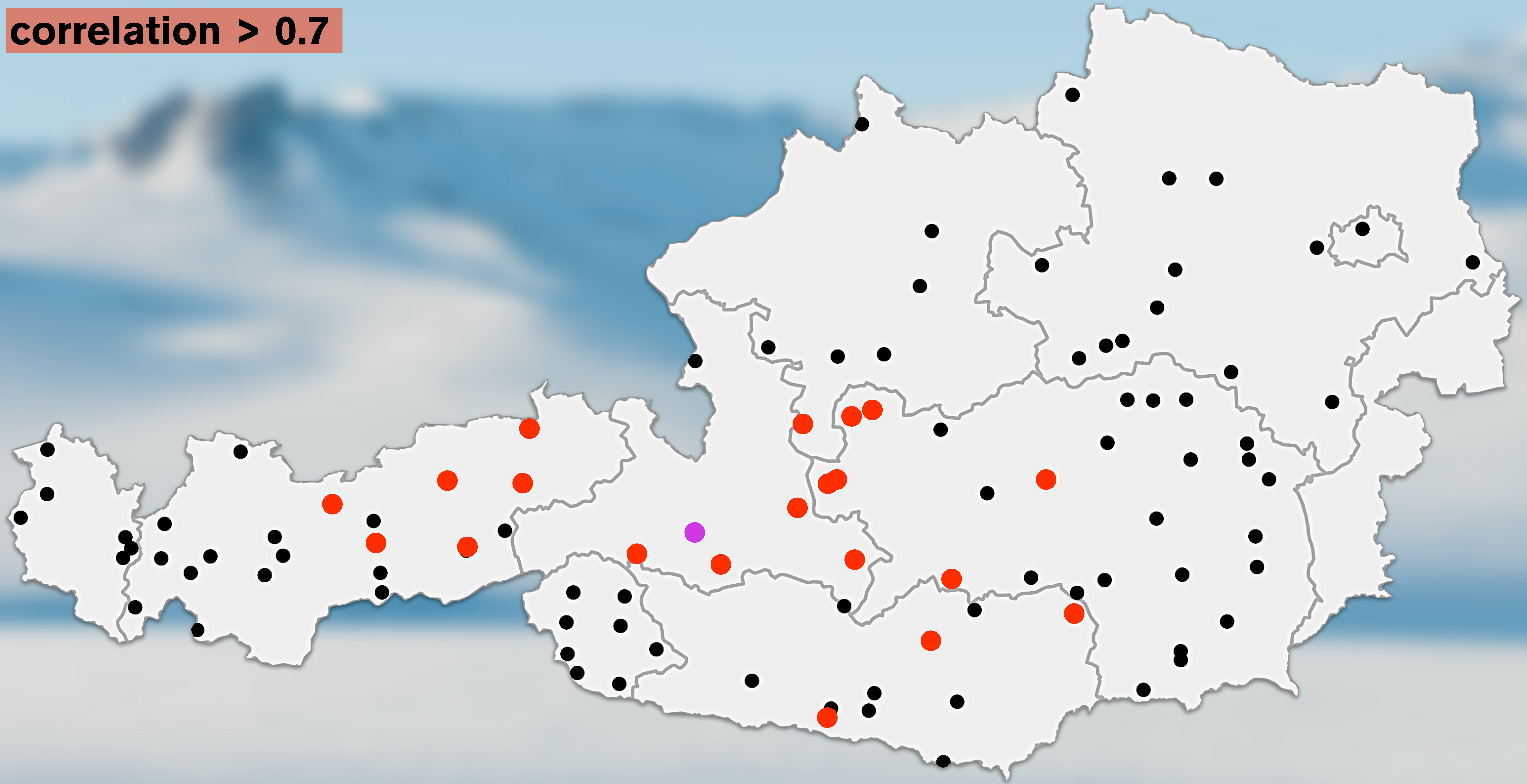
Calculation of correction values

1. Calculate reference series
2. Calculate correction factor

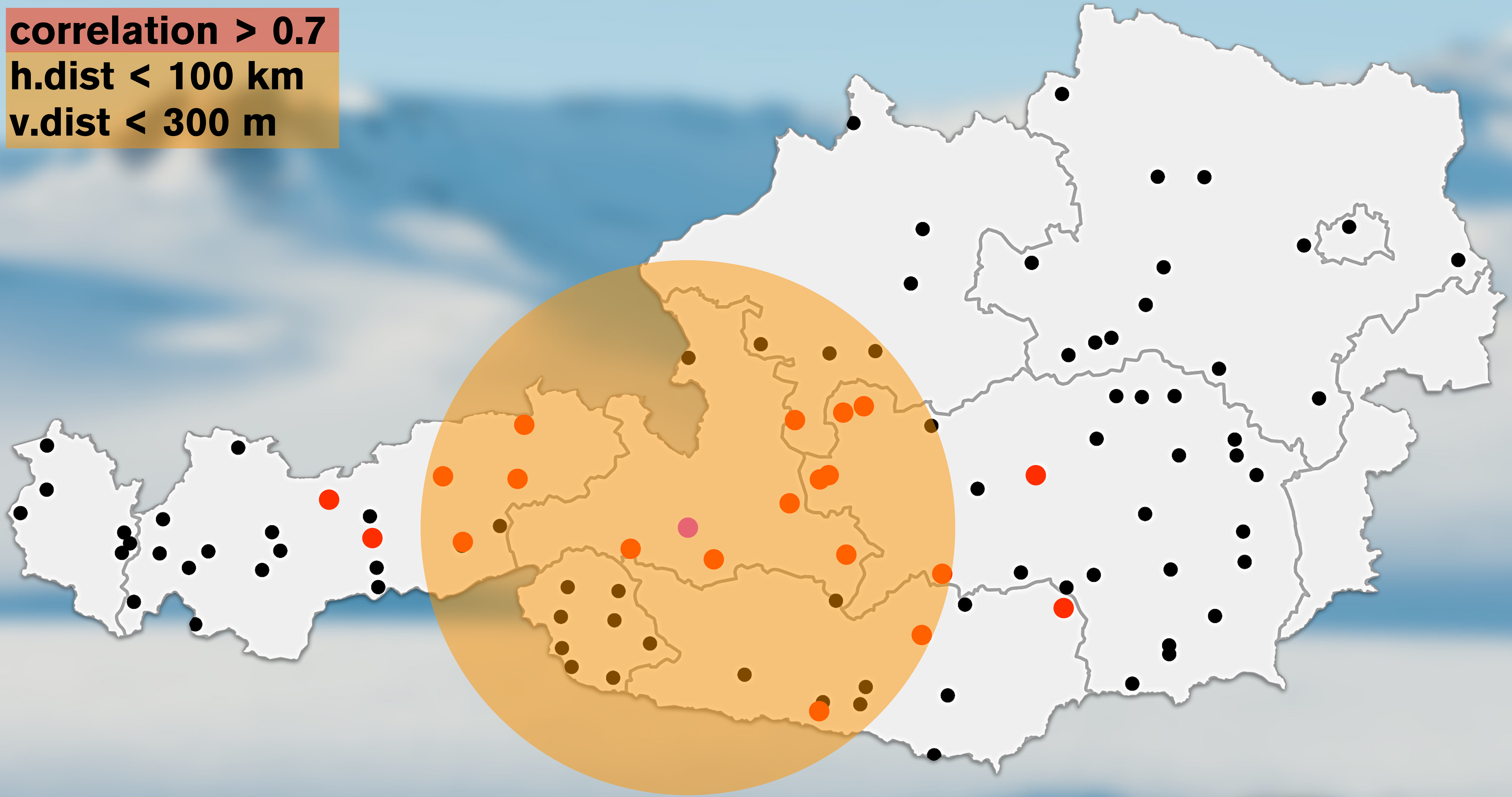
Calculation of reference series



Calculation of reference series



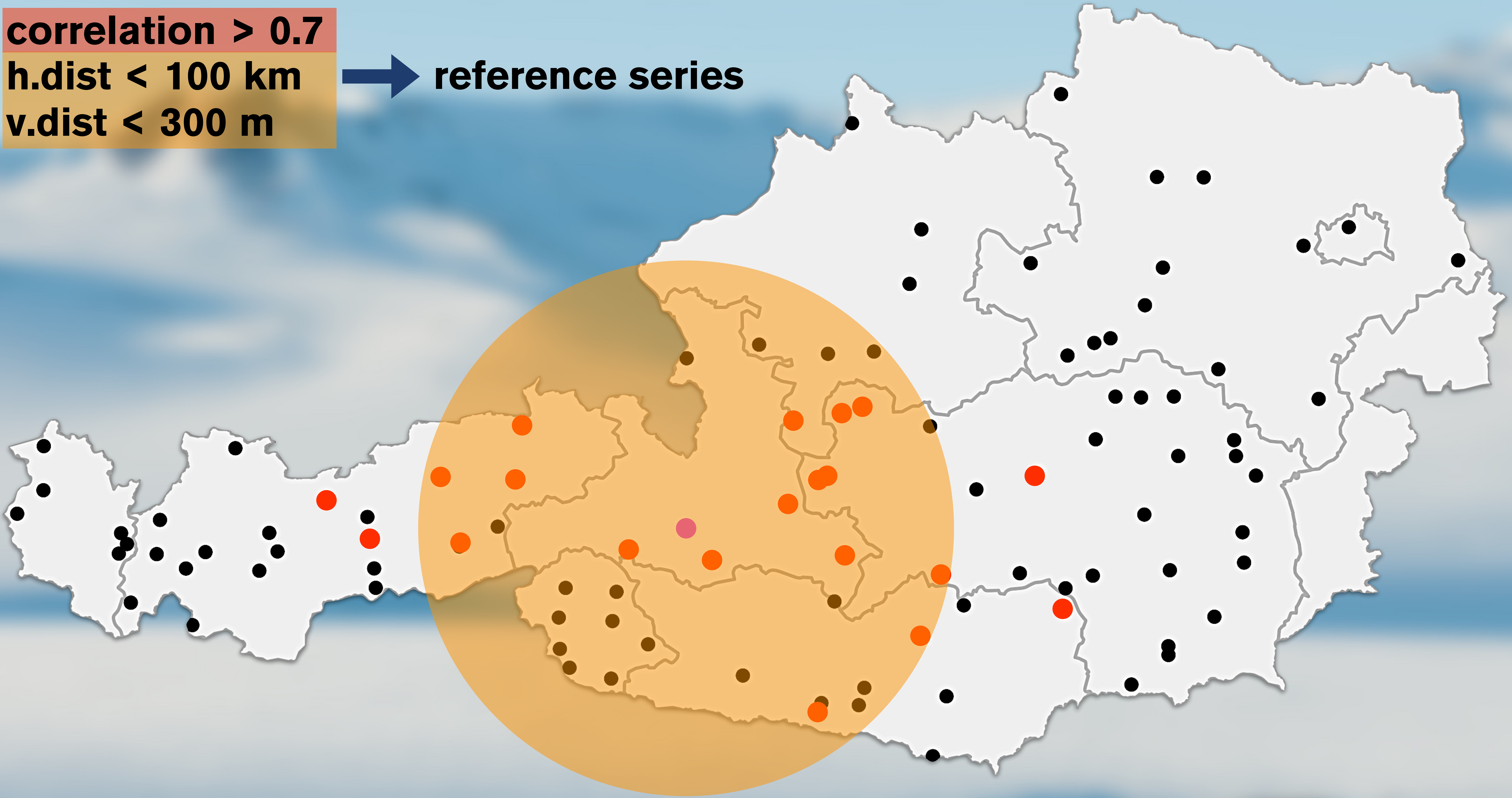
Calculation of reference series



Calculation of reference series

correlation > 0.7
h.dist < 100 km
v.dist < 300 m

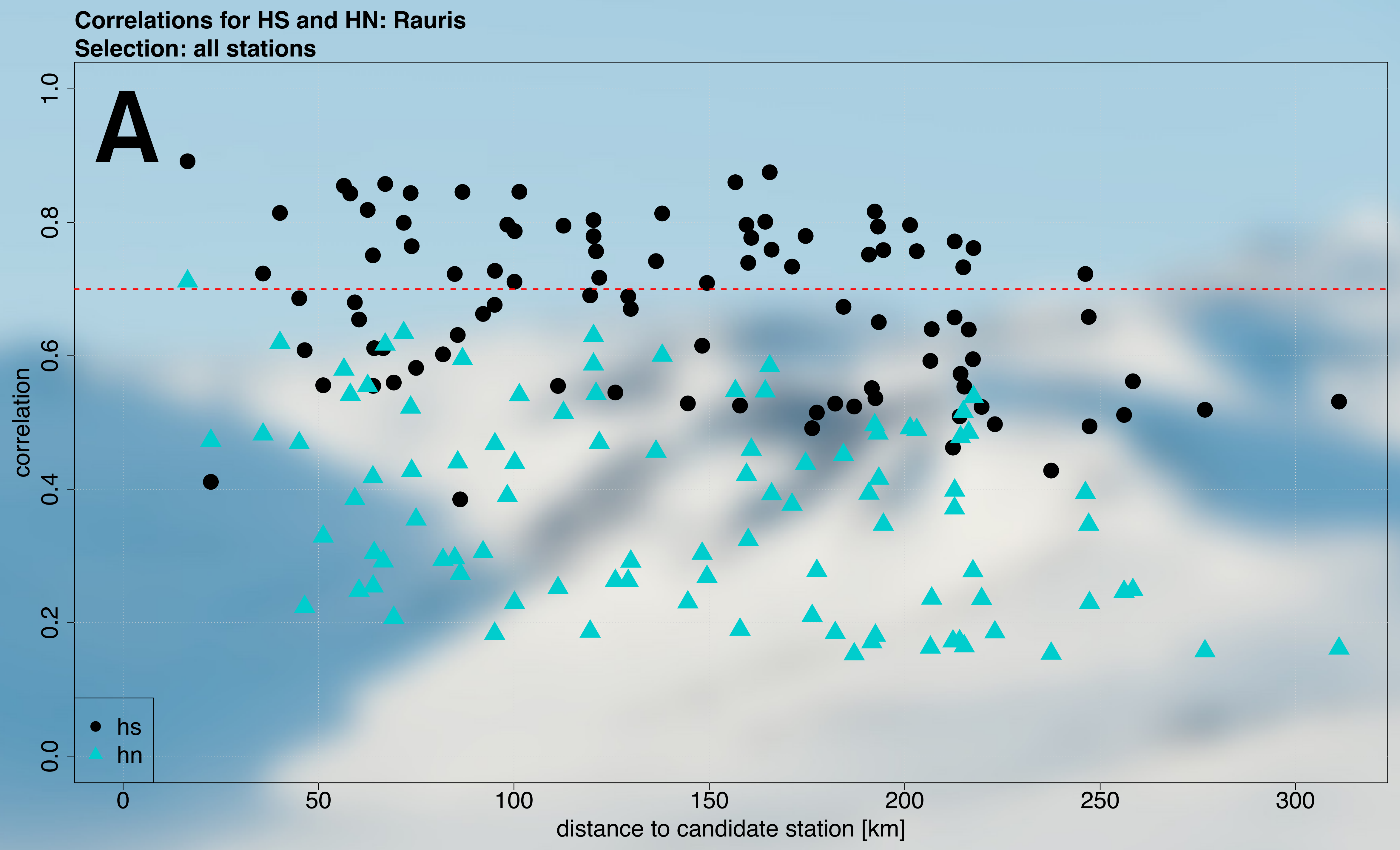
→ reference series



Delimiting candidates for reference series

Delimiting candidates for reference series

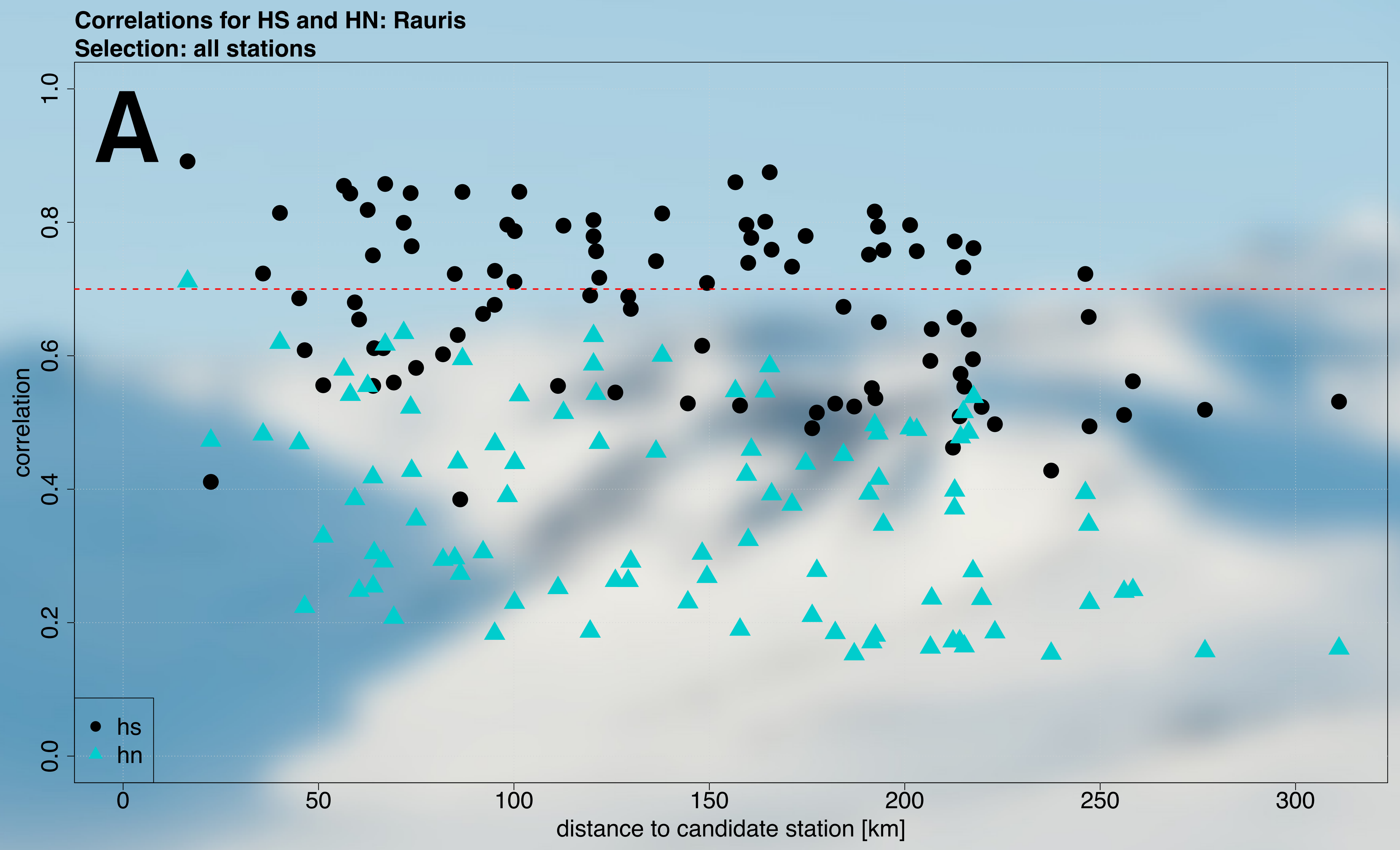
A: All stations in the database

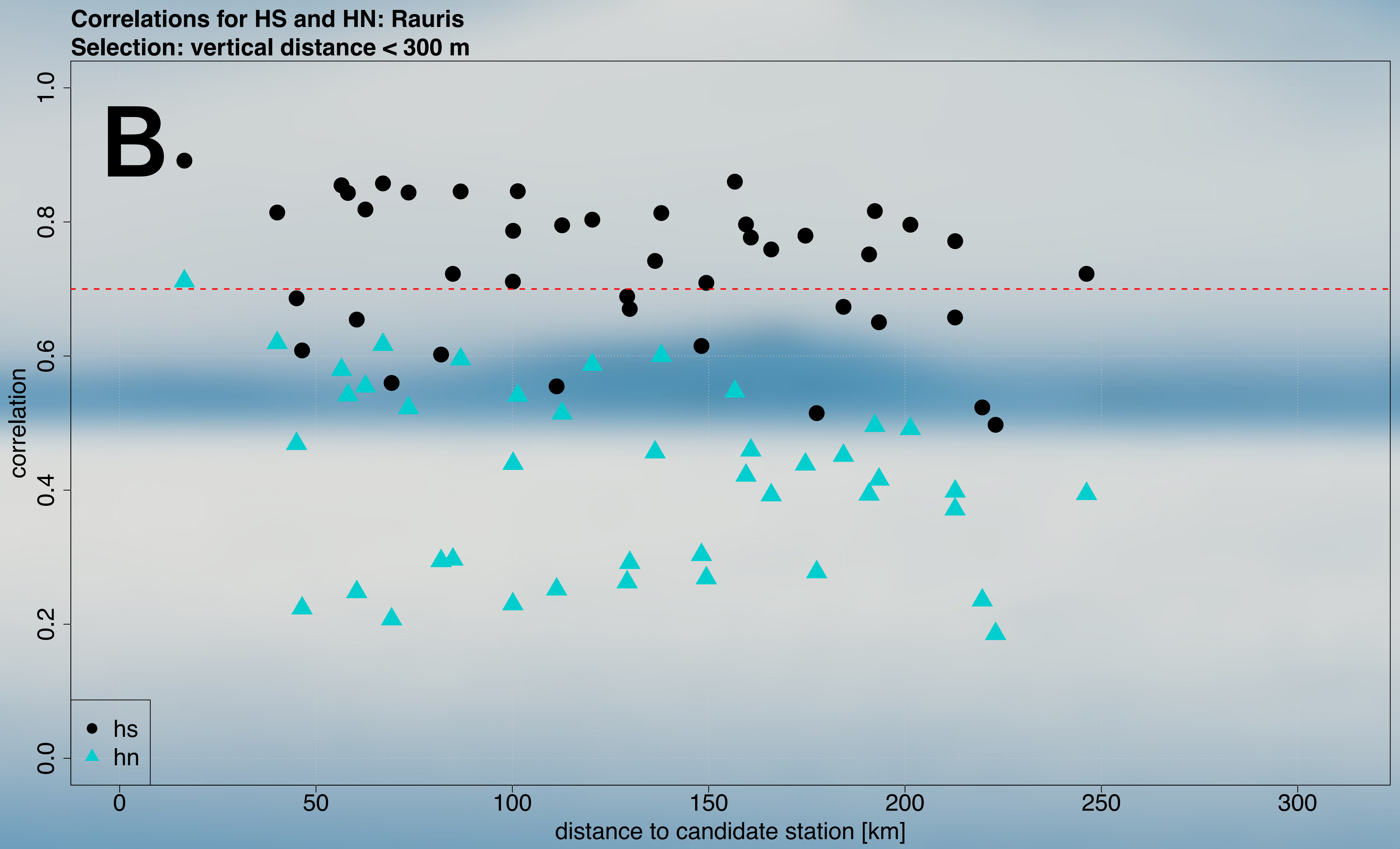


Delimiting candidates for reference series

A: All stations in the database

B: Vertical distance < 300 m





Delimiting candidates for reference series

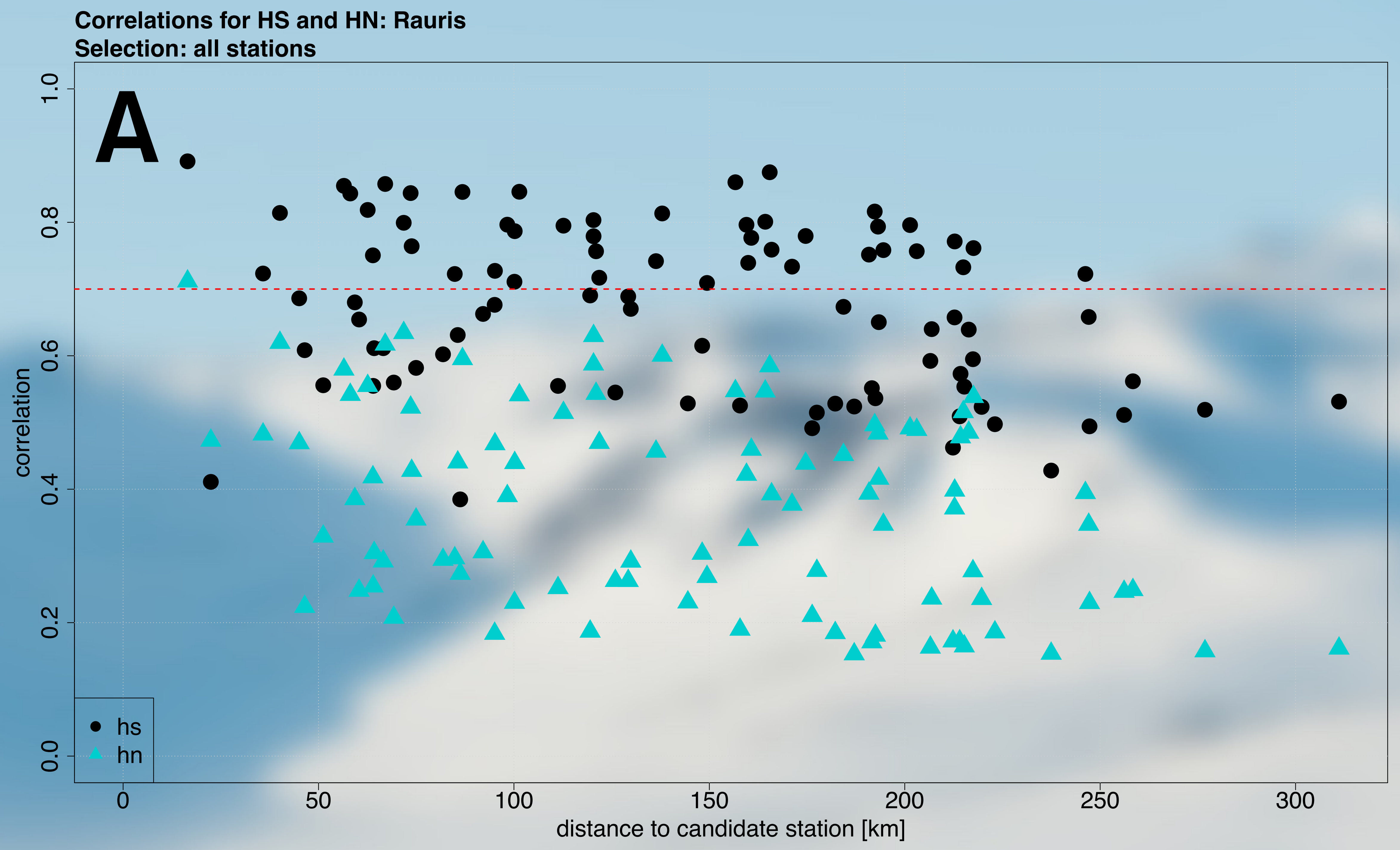
A: All stations in the database

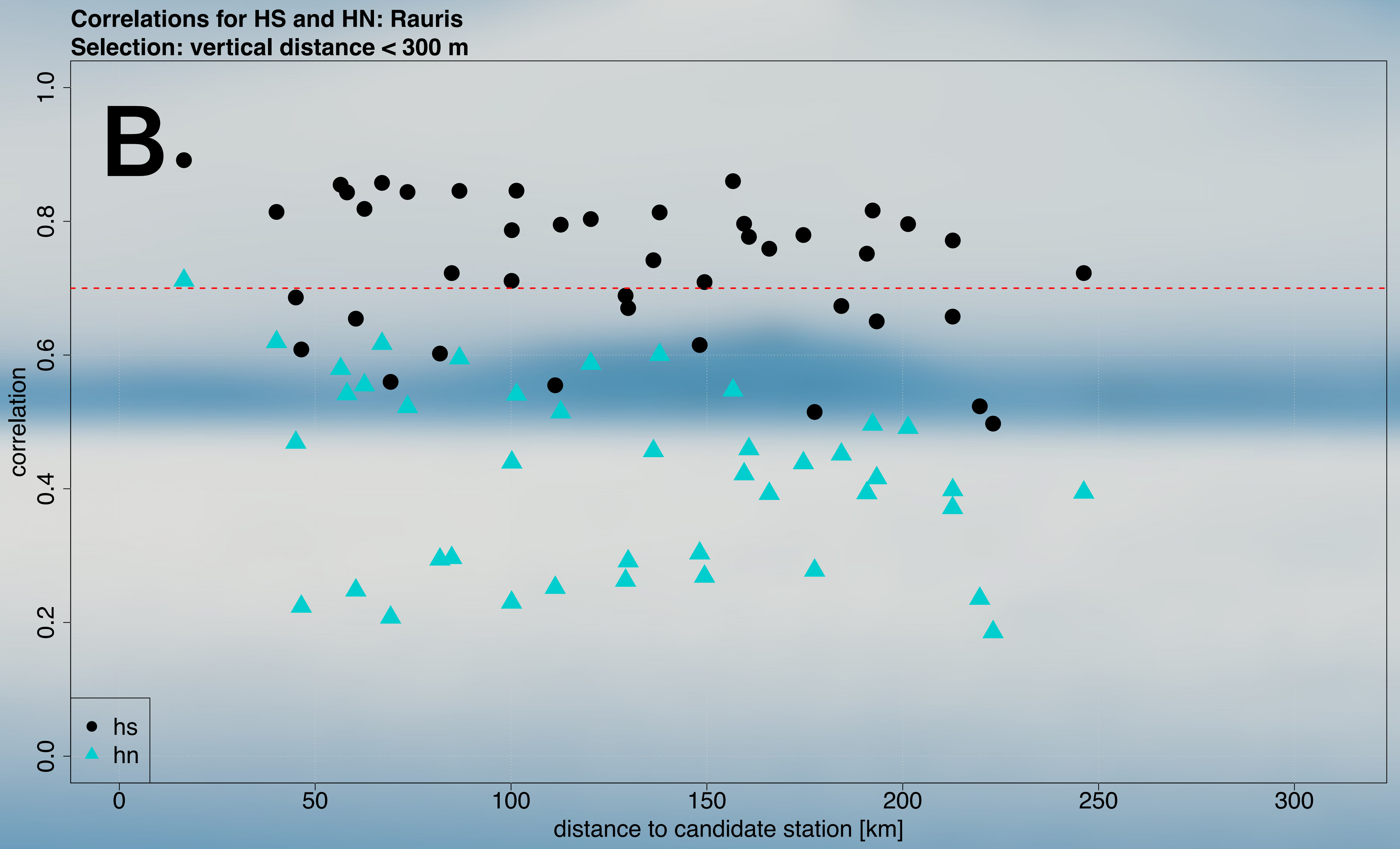
B: Vertical distance < 300 m

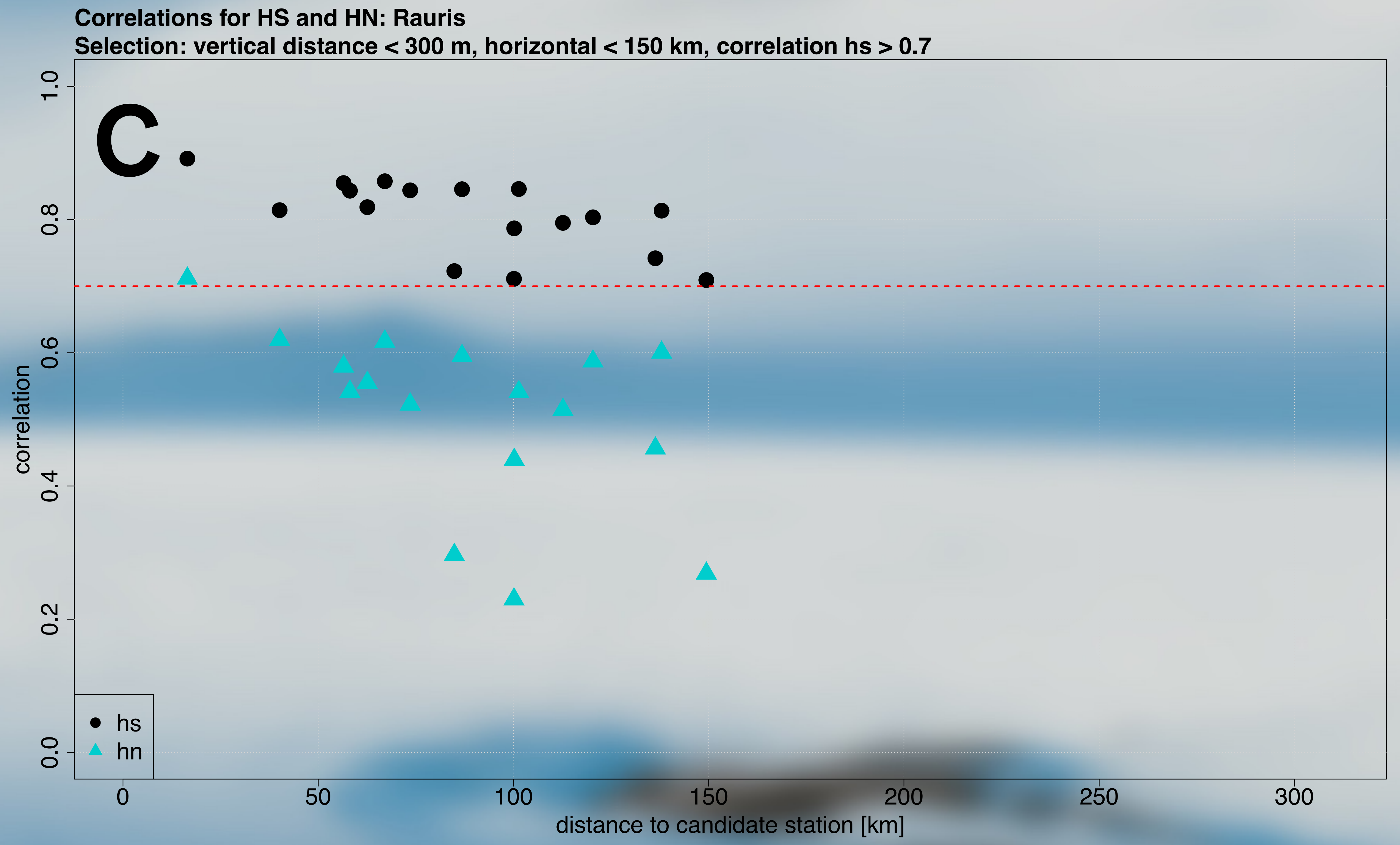
C: Vertical distance < 300 m +

Horizontal distance > 150 km +

Correlation HS > 0.7







Calculation of correction factor

Calculation of correction factor

correction factor

Calculation of correction factor

$$\text{correction factor} \rightarrow \frac{\text{median}\left\{\frac{C_a}{R_a}\right\}}{\text{median}\left\{\frac{C_b}{R_b}\right\}}$$

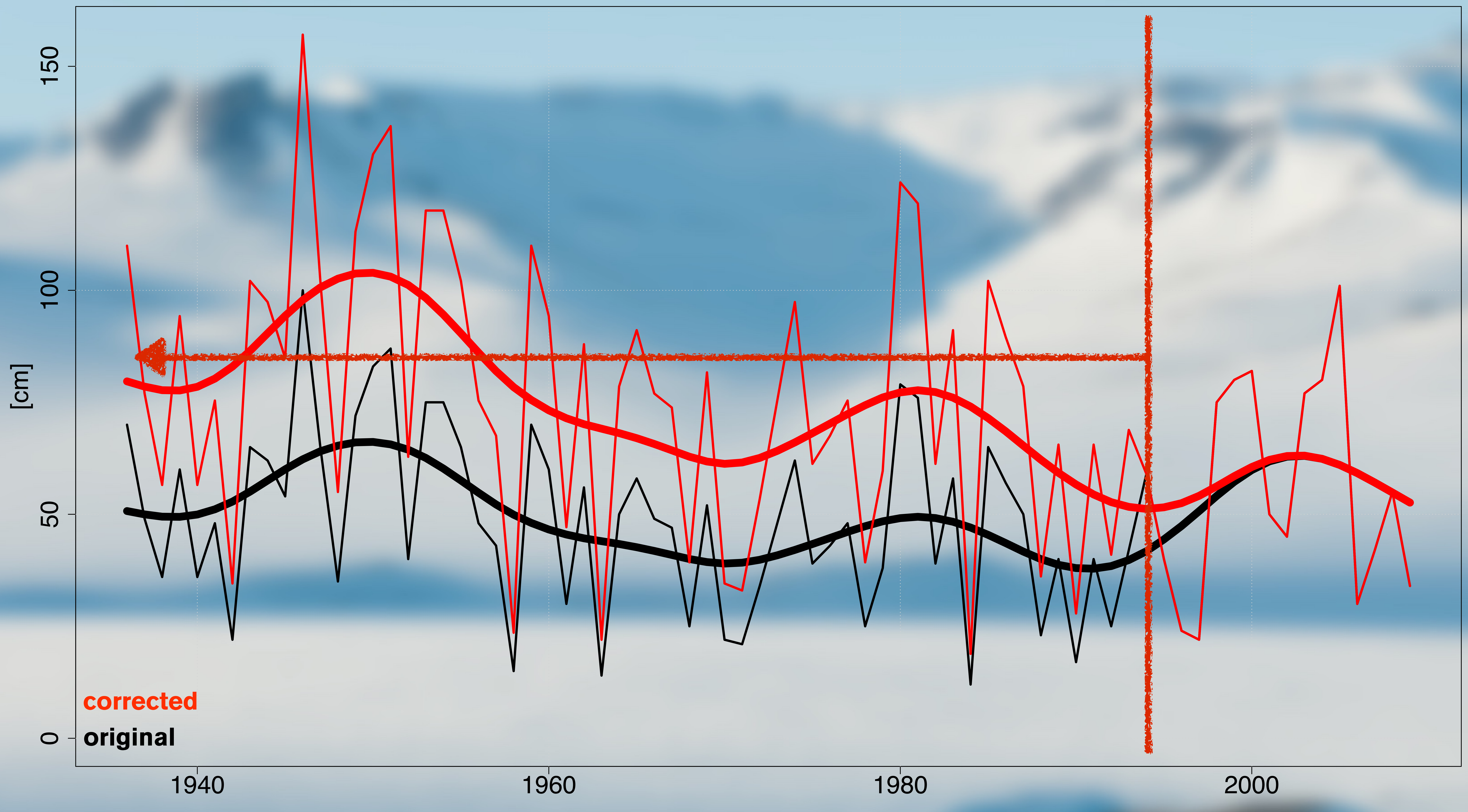
C_a = Candidate series after break
C_b = Candidate series before break
R_a = Reference series after break
R_b = Reference series before break

Calculation of correction factor

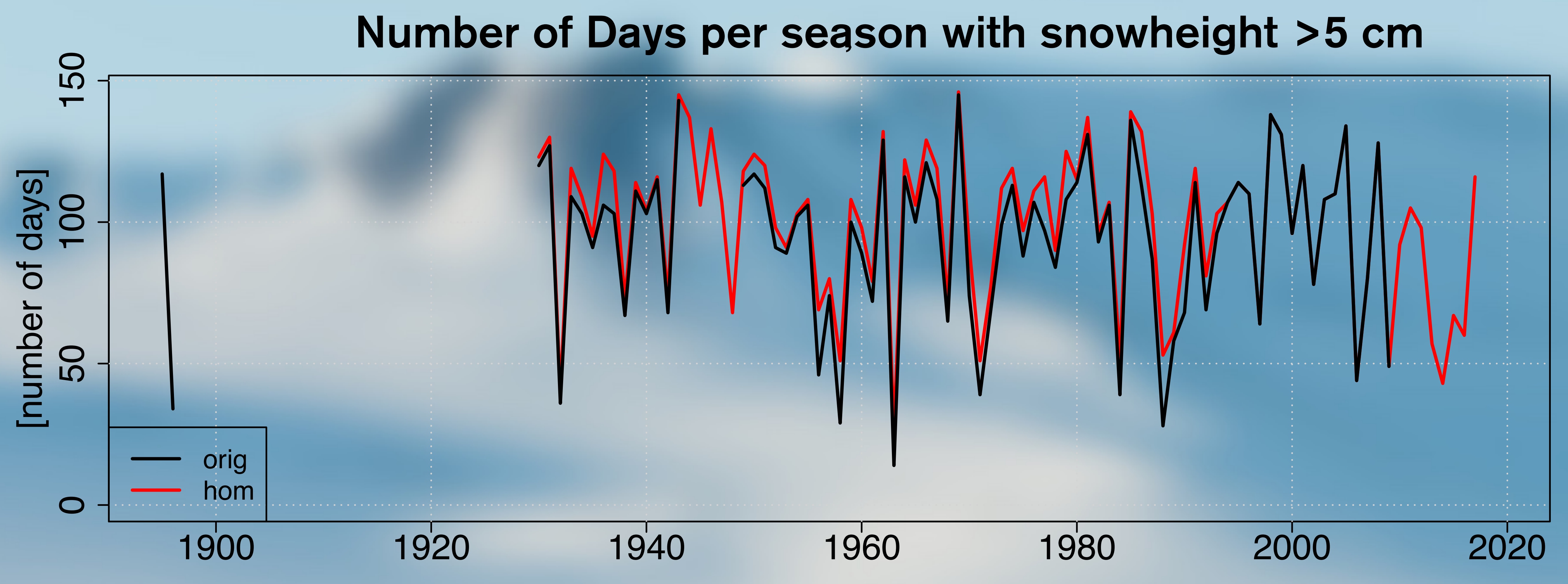
$$\text{correction factor} \rightarrow \frac{\text{median}\left\{\frac{C_a}{R_a}\right\}}{\text{median}\left\{\frac{C_b}{R_b}\right\}} \rightarrow \text{f.e. } 1.38$$

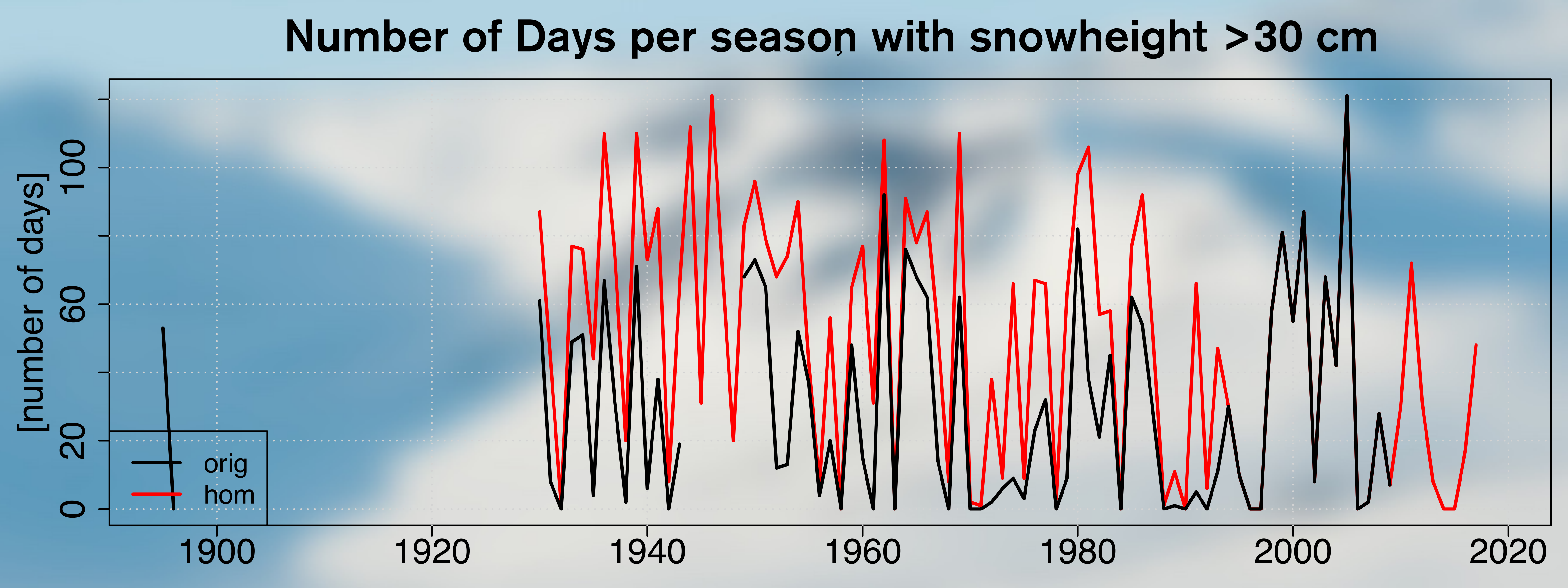
C_a = Candidate series after break
C_b = Candidate series before break
R_a = Reference series after break
R_b = Reference series before break

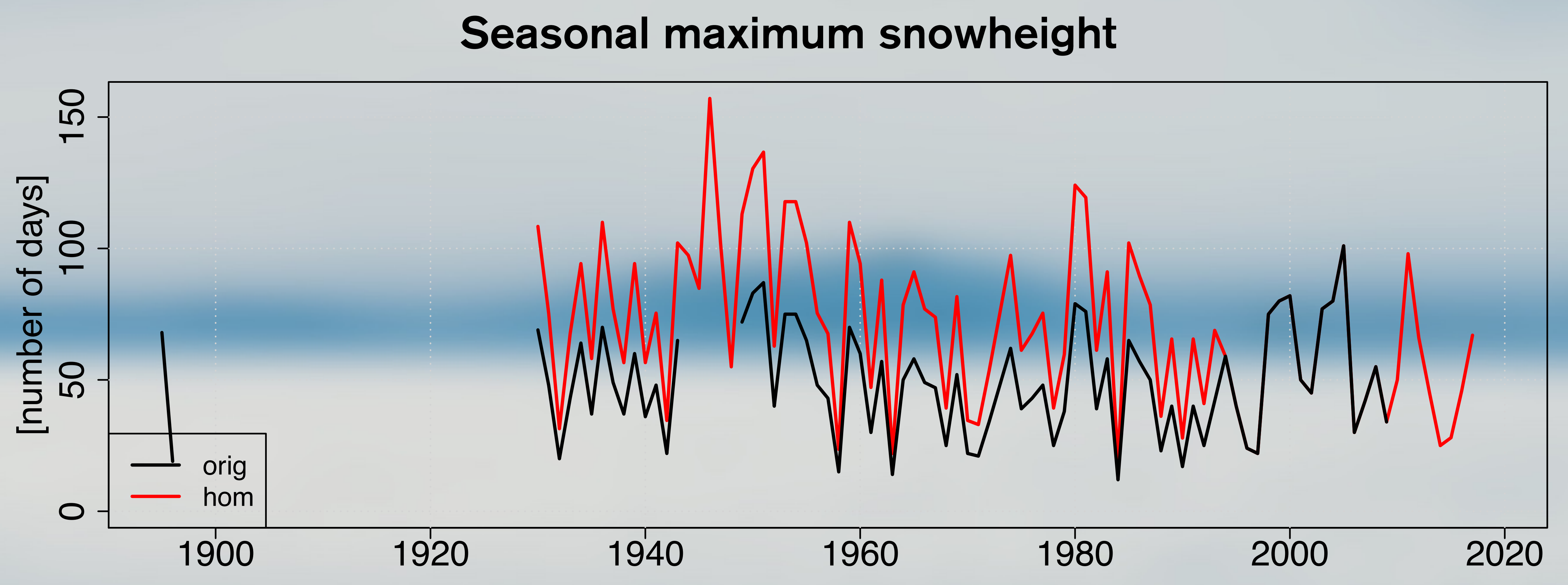
Apply correction factor to every value before break



Different impact on calculated parameters: Overestimation of extreme parameters in Rauris (Salzburg)

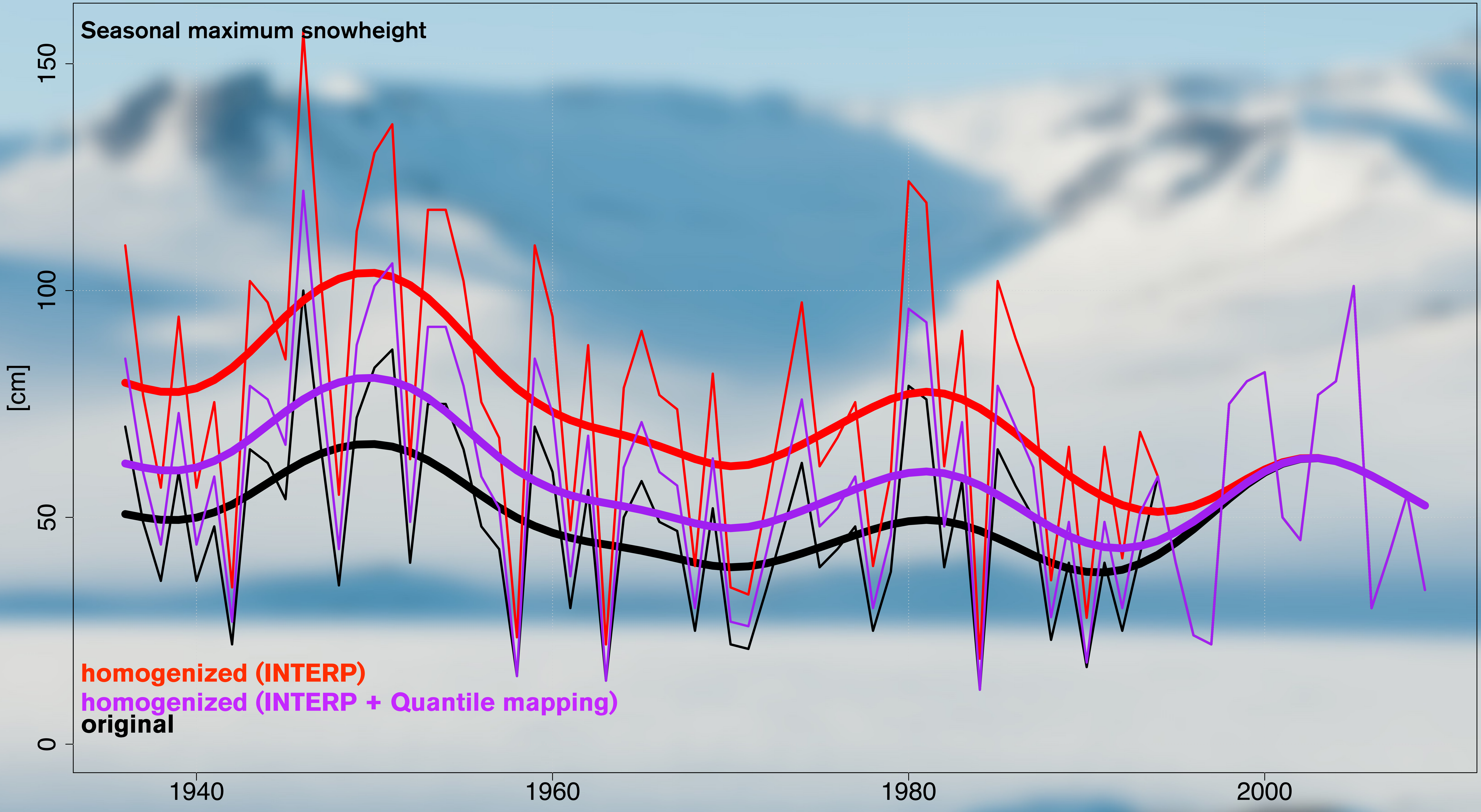




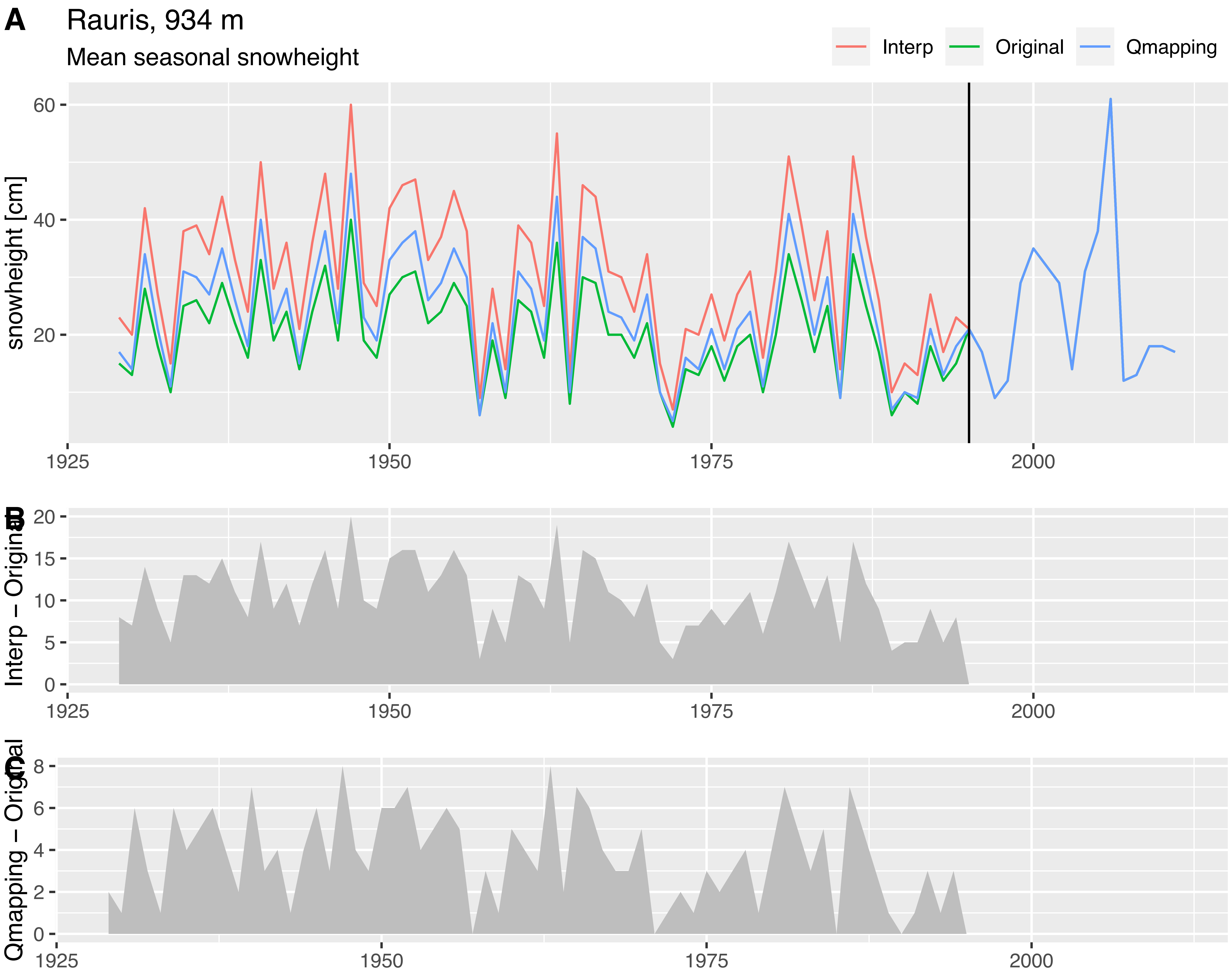


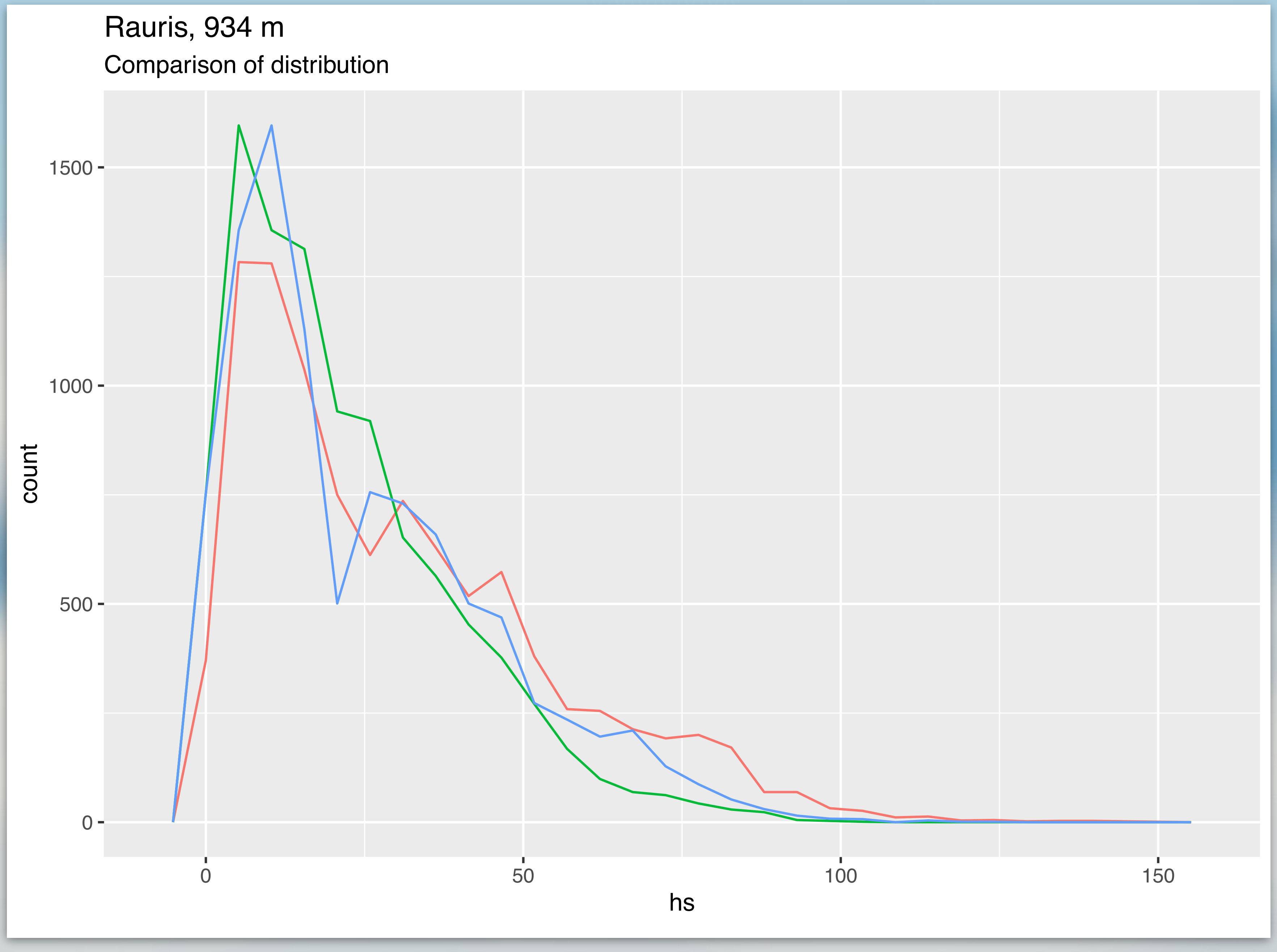
Attempt to apply method on different quantiles, f.e. quartiles, to avoid overestimation of extremes

Impact of INTERP + quantile mapping

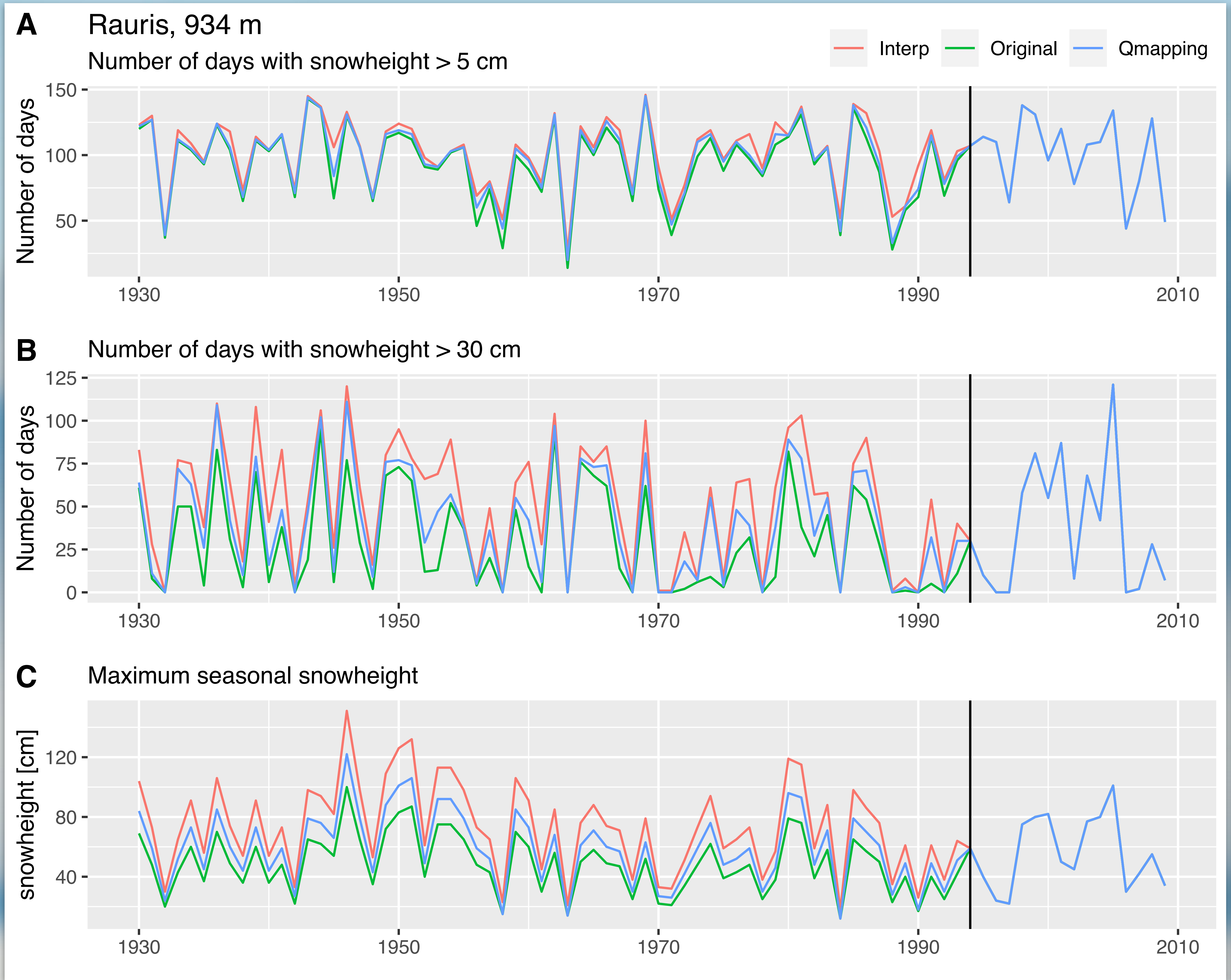


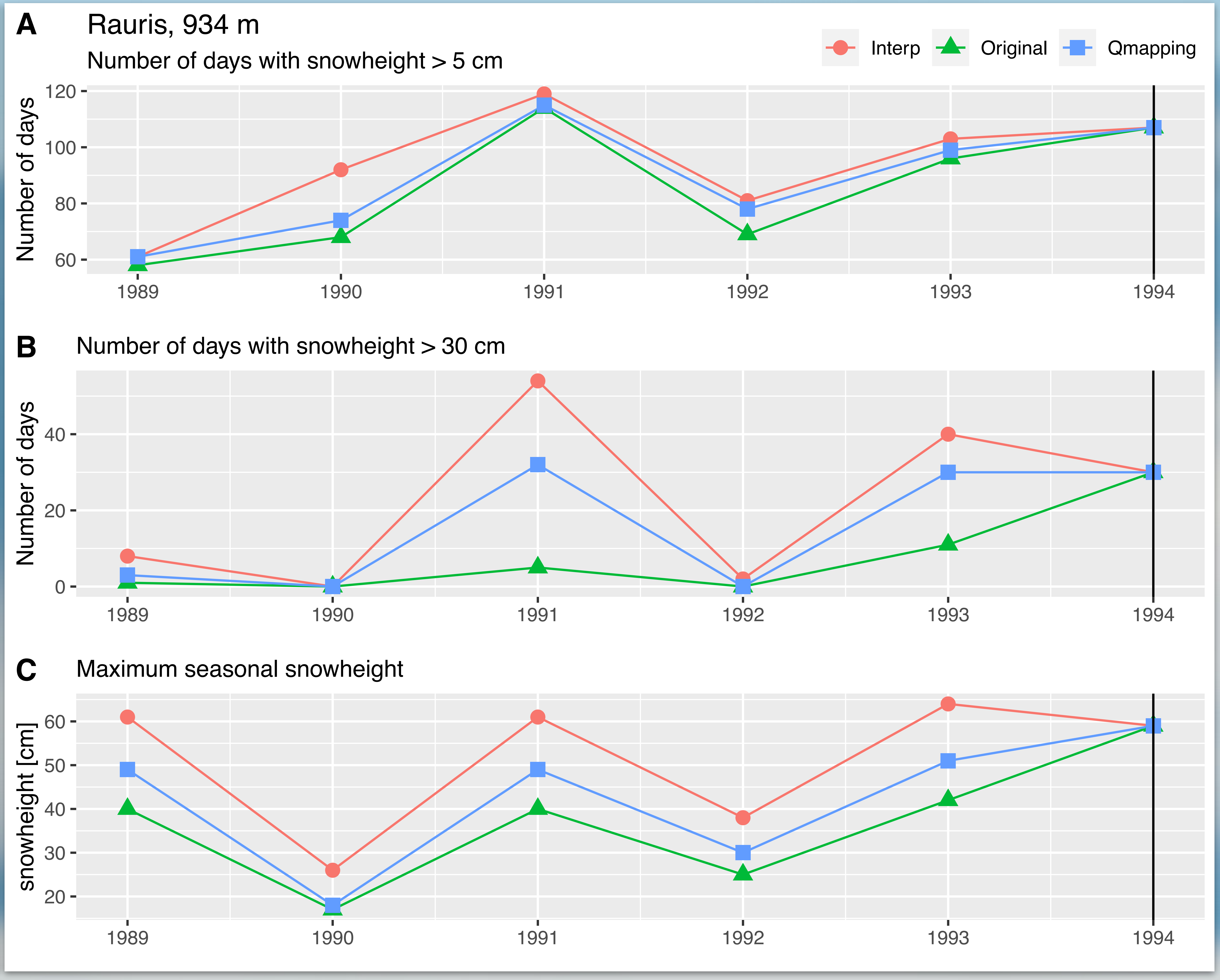
Analysis of Qmapping-Approach





Analysis of Qmapping-Approach





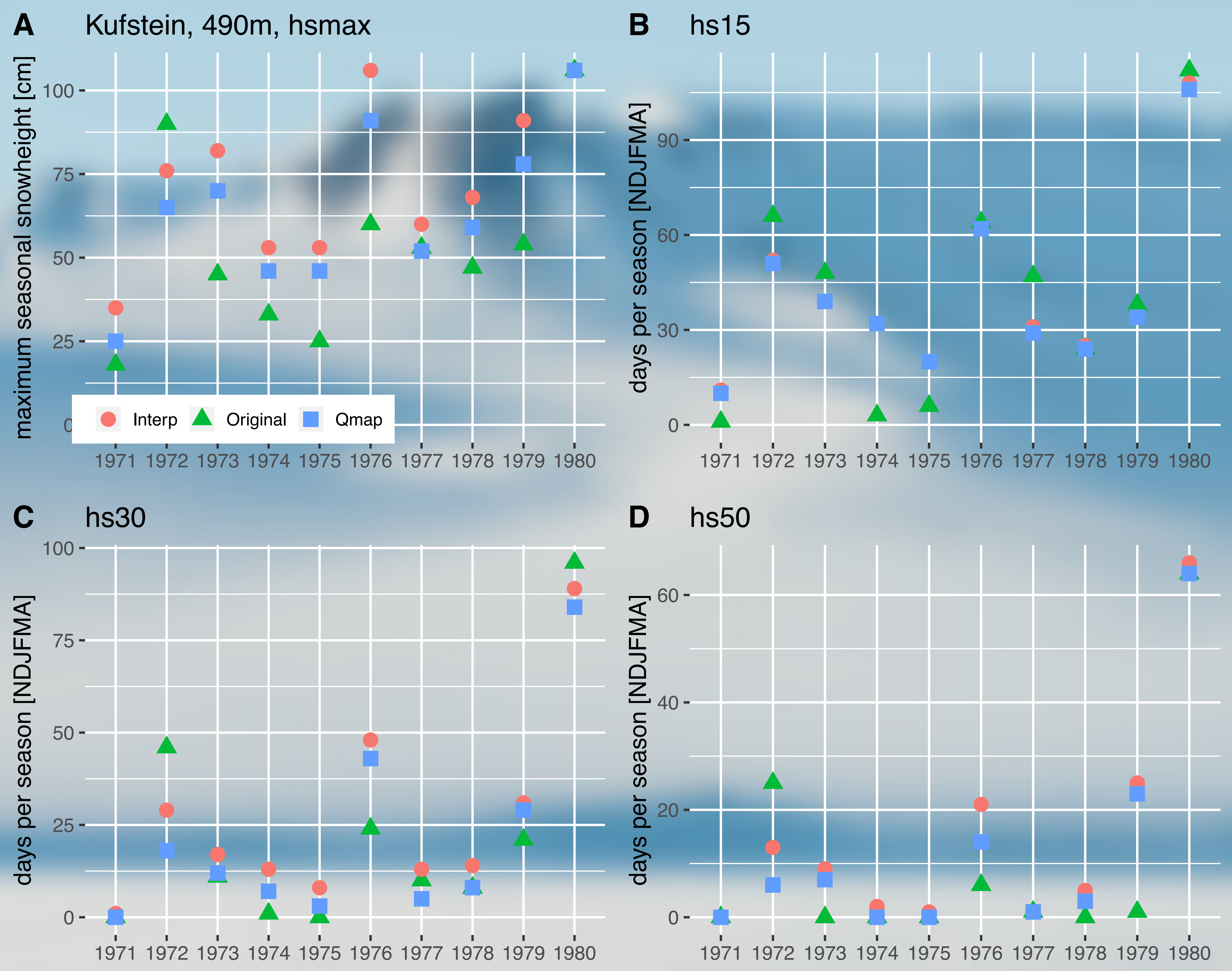
Validation of Qmapping-Approach

Approach A:
Introduce break by replacing a decade with values from highest correlation station from reference-network

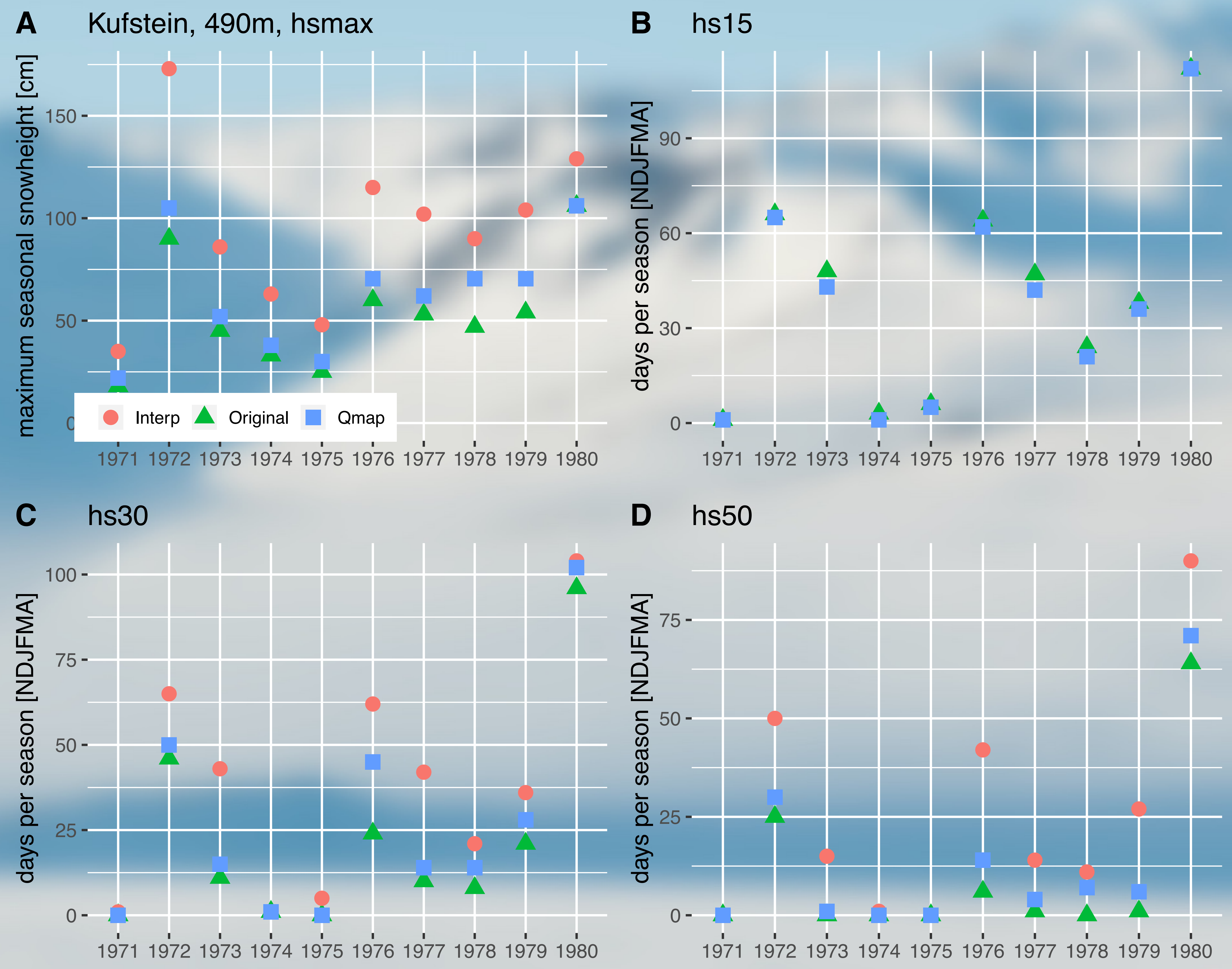
Approach B:
Introduce break by applying random adaption-factors to several quantiles of original series

Approach C:
Use Swiss (and Austrian)parallel measurements and test Approach A and B

A (reference-network)



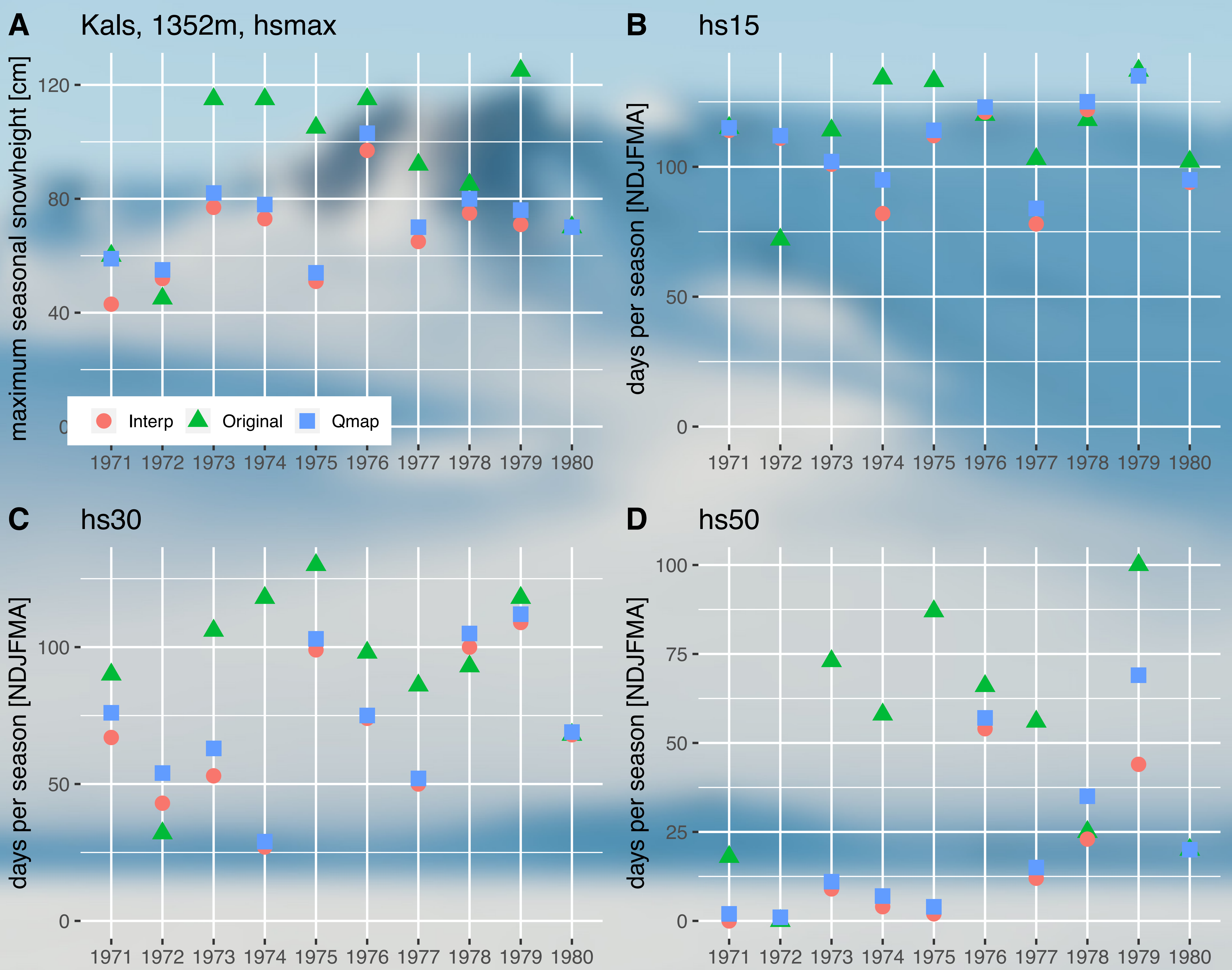
B (random-adjustments)

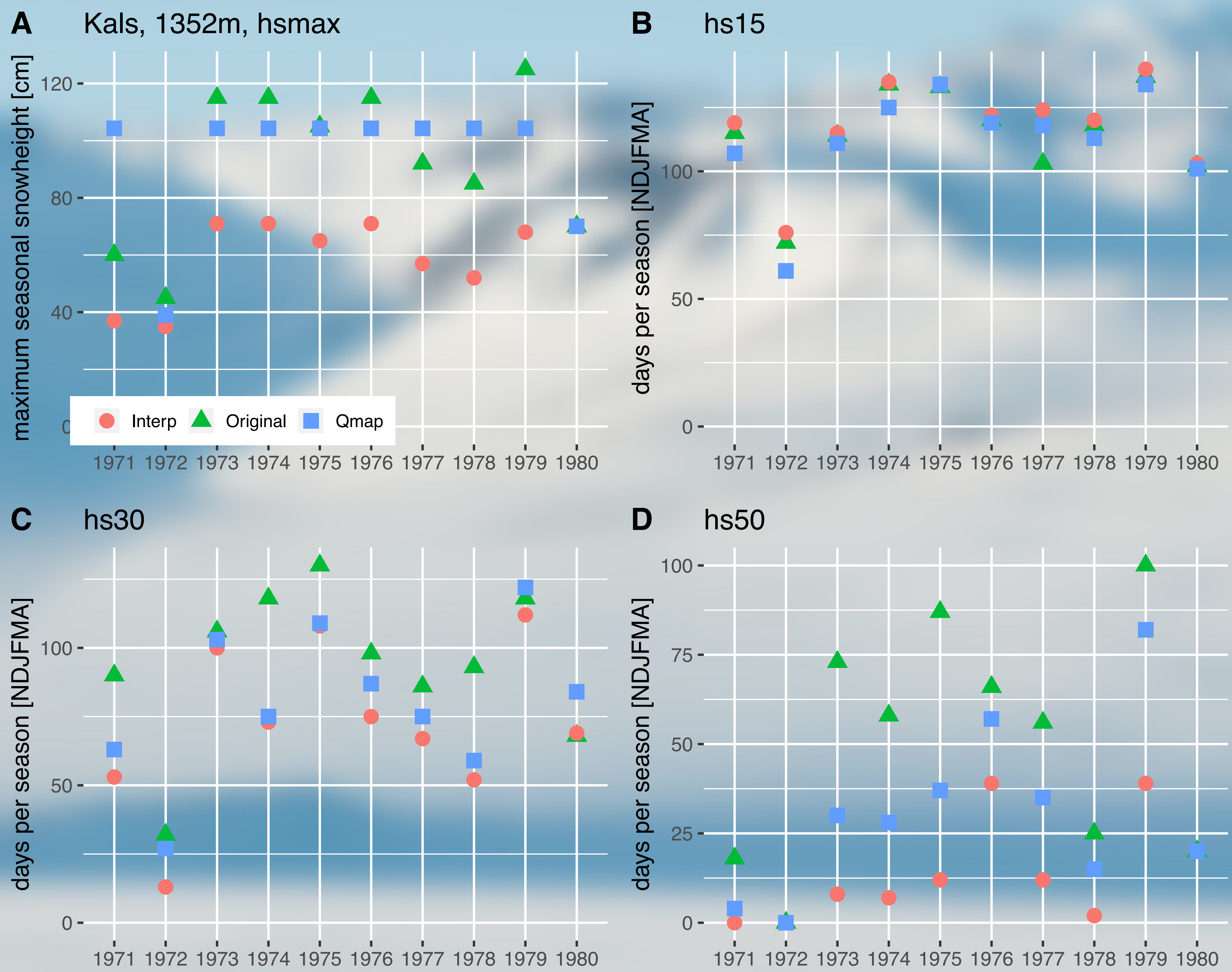


Example for low-elevation-station

A (reference-network)

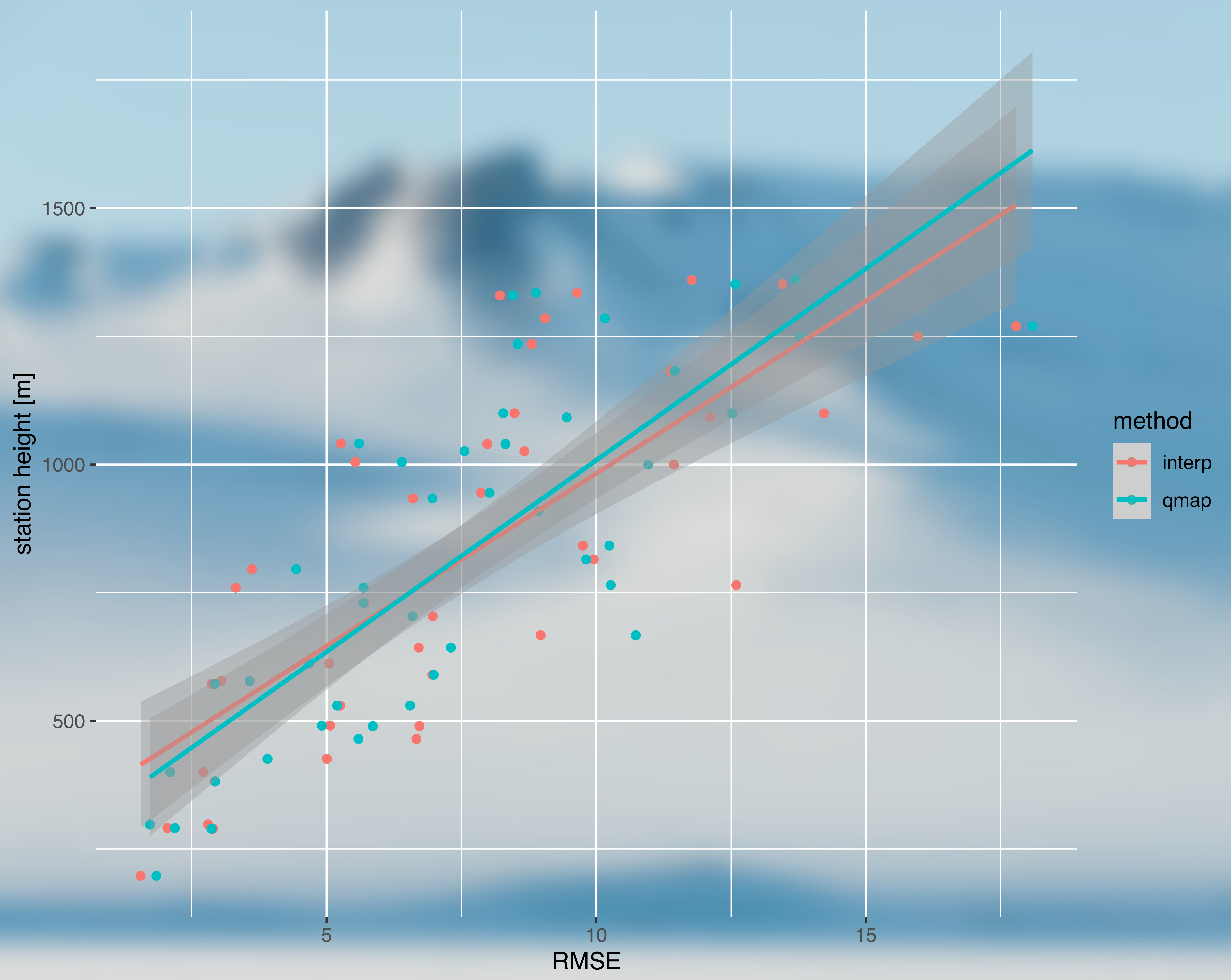
B (random-adjustments)





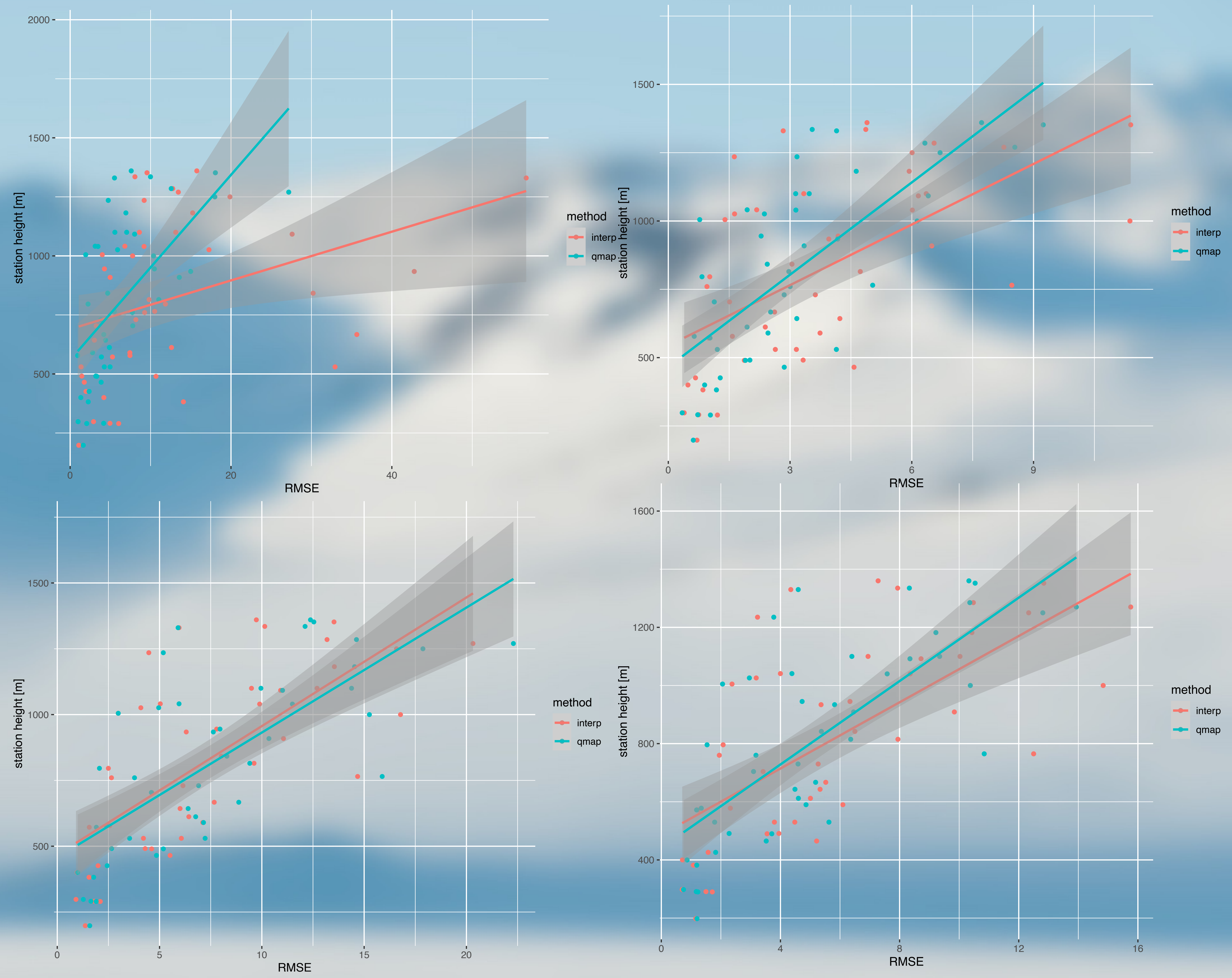
Example for higher-elevation-station

A (reference-network)



Qmapping shows slightly better results, but dependent on station

B (random-adjustments)



Qmapping in most of the experiments better, but sometimes worse. Ongoing analysis of reasons.

Outlook

1. Currently, data is separated into quartiles to avoid errors. Next steps: Analyze different impacts of dynamic-quantile-ranges (depending on station data range).

2. Analyze reasons behind bad performance of Qmapping in some of the random-data-adjustment-experiments.

3. Start Approach C: Use Swiss (and Austrian) parallel measurements and test Approach A and B

4. Add more stations to the network (currently 69, increase to 85) to get denser network and publish dataset.

Take Home Messages

1. Homogenization of snow height measurements is possible and should be performed.

2. The method INTERP (Vincent et al. 2002) is working well for corrections, but overestimates large snow heights.

3. Applying INTERP for different quantiles improves the results, but the validation and details about the quantile mapping are not finished yet.

Your ideas and input are highly welcome!

Correspondence to: gernot.resch@uni-graz.at