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How accurate were the measured trend of precipitation in Ny-Ålesund (Svalbard) in the last 40 years?

Olivier Champagne, Olga Zolina, Hans-Werner Jacobi

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Artificial Trends or Real Changes? Investigating Precipitation Records in Ny-Ålesund, Svalbard

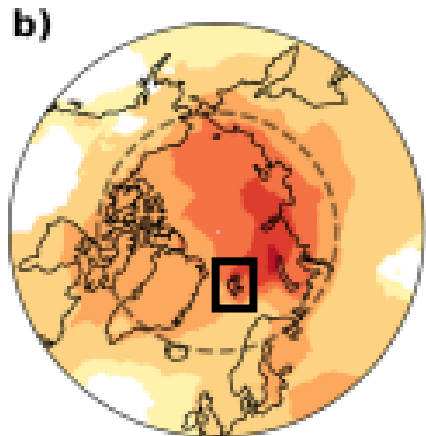
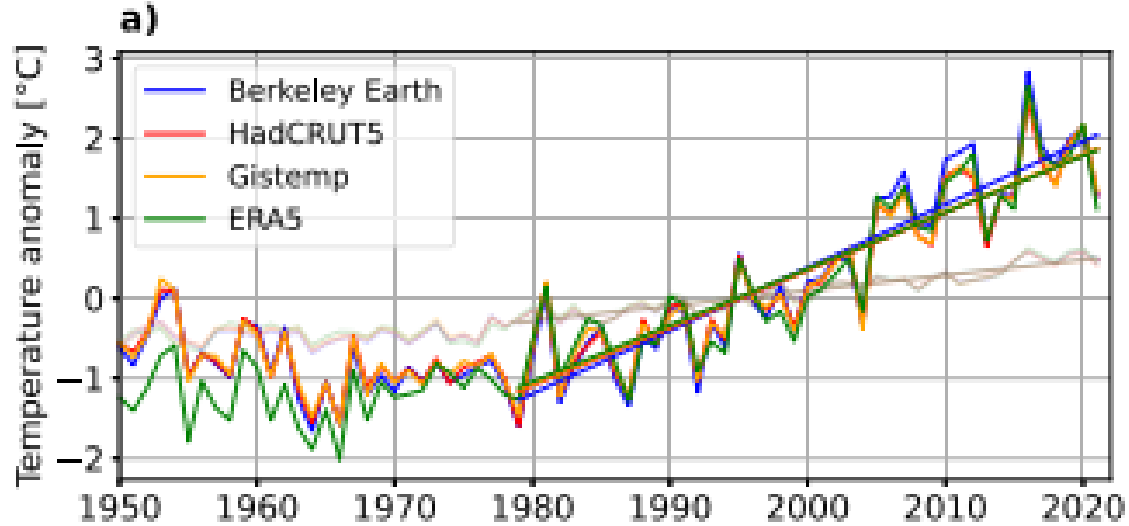
Olivier Champagne, Olga Zolina, Hans Werner Jacobi
Institut des Géosciences de l'Environnement, UGA, CNRS, Grenoble, France

IUGG general assembly 2023
July 14th

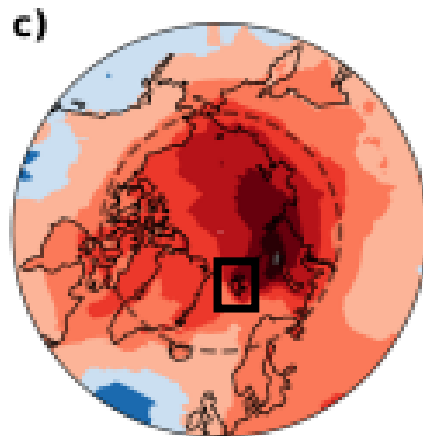
Rapid Arctic environmental Changes: implications for well-being, resilience and Evolution of Arctic communities – RACE



Introduction



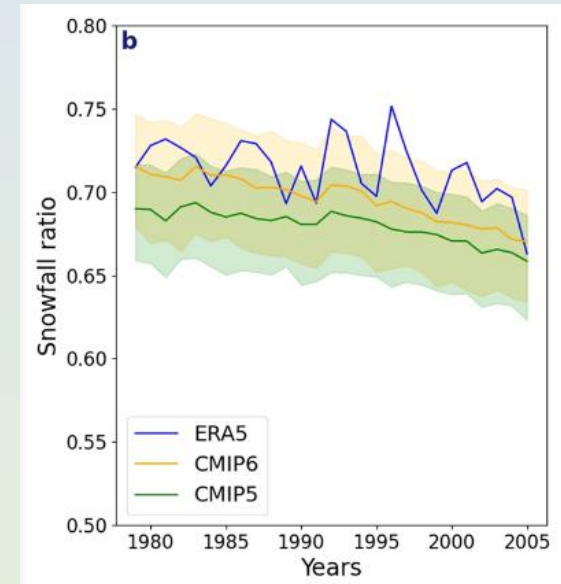
-1.50 -0.75 0.00 0.75 1.50
Temperature trend [°C decade⁻¹]



0 1 2 3 4 5 6 7
Local amplification

Rantanen et al. 2022

- **Warming in the Arctic** 2 to 4 times higher than the global average
- Amplification mostly in **winter** on the sea **between Svalbard and Russia** (mostly due to sea-ice reduction)
- **Svalbard** is one of the land region **the most affected by the warming** (~3°C in 20 years in Ny Alesund)

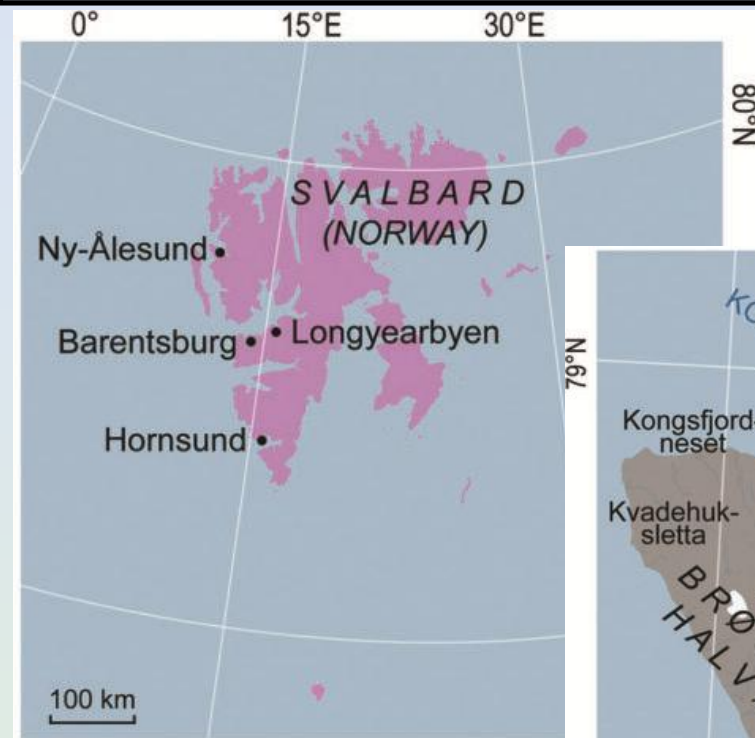


McCrystall et al. 2021

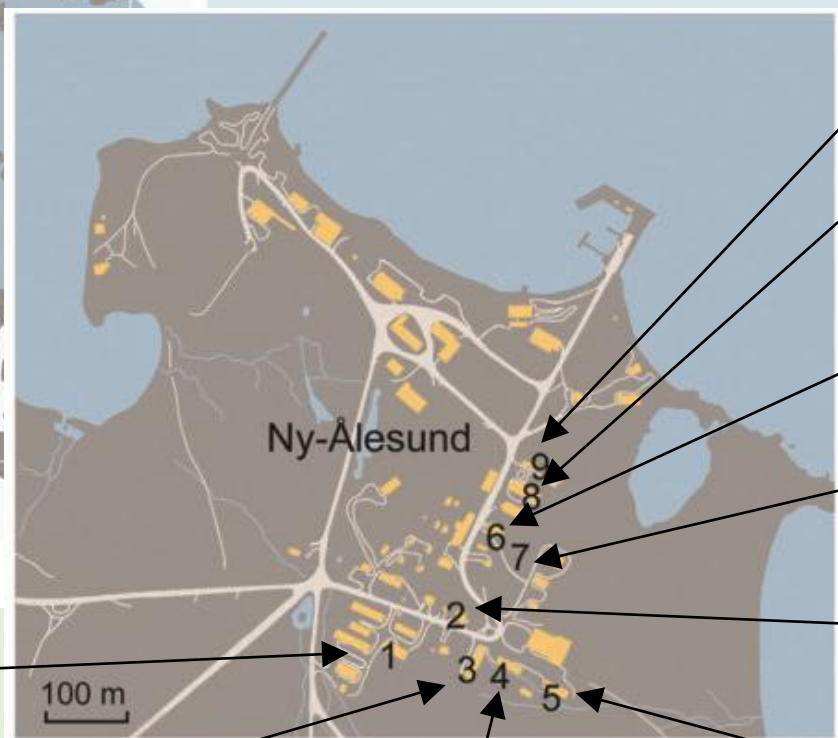
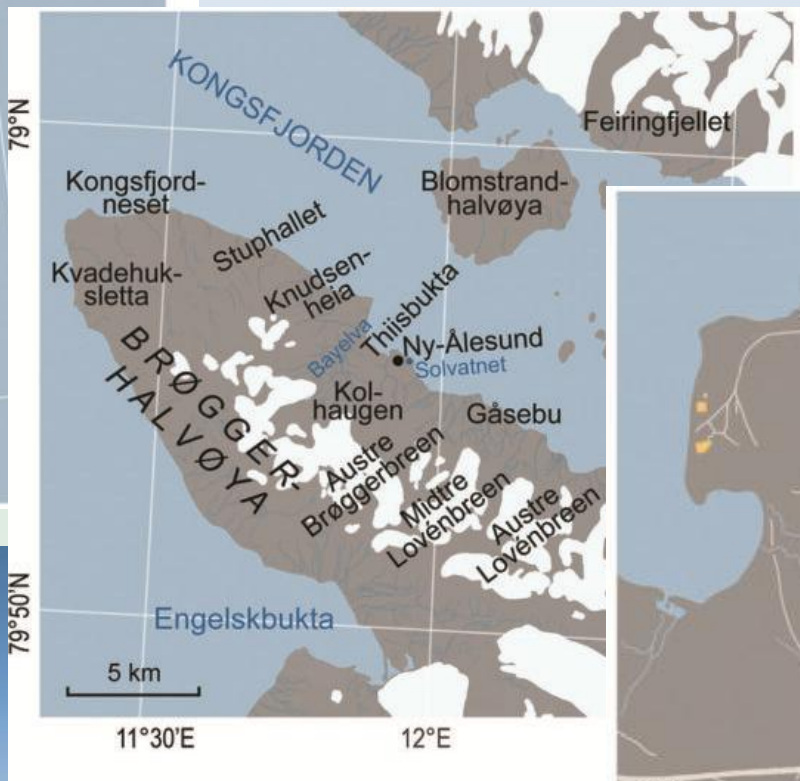
=> Implication for rainfall, hydrology and the ecosystem

Introduction

Ny Alesund: An important site for many research in the Arctic (weather, climate, hydrology, glaciers, soil, vegetation, herbivores, birds...)



Pedersen et al. 2022



University of Groningen



Natural Environment Research Council



National Centre for Polar and Ocean Research



National Institute of Polar Research



Alfred Wegener Institute





Institute Paul Emile Victor



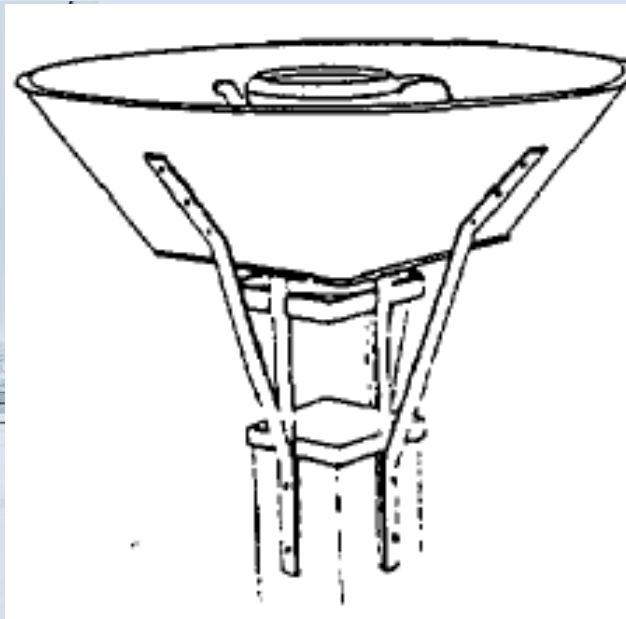
National Research Council 

Norwegian Polar Institute 

Korea Polar Research Institute 

Polar Research Institute of China 

Introduction



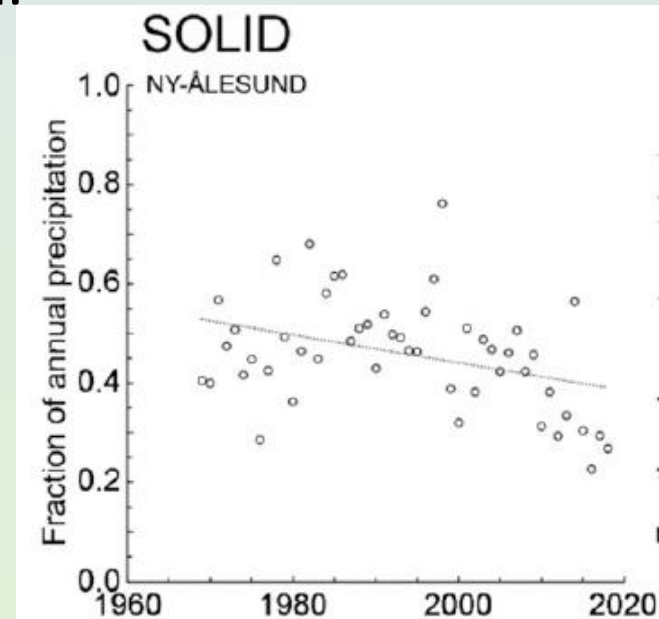
- **Manual precipitation measurements** at 6am and 6pm (1975-2022) with a Norwegian Gauge and Nipher windshield.

- **Automatic measurements** in 1994-2022 with Geonor T-200, alter windshield.

Rain gauges with a single windshield lead to a **large snow undercatch** mainly during **windy conditions** and for **dry snow** (colder temperature).

Strong warming leads to **less snowfall** and **more humid snow**
=> The accuracy of rain gauge measurements improved recently

How the trends of precipitation can be impacted by this change in rain gauge measurements?



Forland et al. 2020

Introduction

Forland and Hanssen Bauer (2000)

INCREASED PRECIPITATION IN THE NORWEGIAN ARCTIC: TRUE OR FALSE?

EIRIK J. FØRLAND and INGER HANSSSEN-BAUER

The Norwegian Meteorological Institute, P.O. Box 43, Blindern, 0313 Oslo, Norway

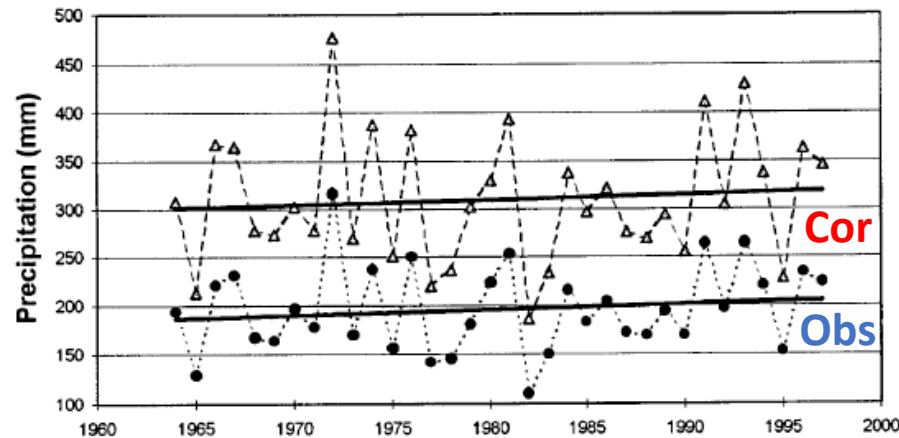


Figure 7. Annual values of measured (●) and 'true' (Δ) precipitation at Svalbard Airport 1964–1997 (solid lines indicate linear trends).

No significant trend difference between observations and corrections

Forland et al (2020)

| | 1979–2018 | | | | |
|------------------|-----------|-----|-----|-----|-----|
| | ANN | DJF | MAM | JJA | SON |
| Bjørnøya | 7 | 10 | 8 | 3 | 6 |
| Hopen | 5 | 5 | 11 | -1 | 5 |
| Hornsund | 9 | 10 | -2 | -2 | 23 |
| Barentsburg | 3 | 0 | -1 | 0 | 8 |
| Svalbard Airport | 12 | 22 | -5 | 3 | 24 |
| Ny-Ålesund | 13 | 24 | -2 | 1 | 22 |
| | | | | | |
| Bjørnøya | 5 | 8 | 5 | 2 | 4 |
| Hopen | 0 | 2 | 8 | -1 | -1 |
| Svalbard Airport | 8 | 14 | -7 | 1 | 18 |
| Ny-Ålesund | 9 | 18 | -4 | -1 | 18 |

Obs

Cor

The 'true' precipitation show a trend 10% lower than the actual measurement

Forland et al. (2000) is **outdated** and Forland et al. (2020) used a **unique correction factors** for the entire period (simplified corrected data serie).

What is the true precipitation data serie in 1975-2022 in Ny Alesund?

Objectives

What is the true precipitation data serie in 1975-2022 in Ny Alesund?

Main objectives:

- (i) Generate a corrected precipitation data set using different correction methods for Ny-Alesund
- (ii) Evaluate the change of trends between measured and corrected precipitation
- (iii) Explain the factors contributing to the misrepresentation of the trends from measured data

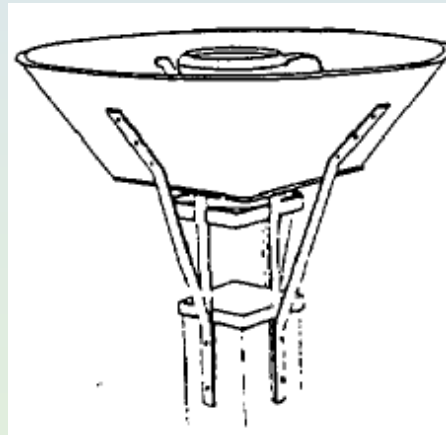
Methods: How to correct precipitation?

Reference pluviometer:

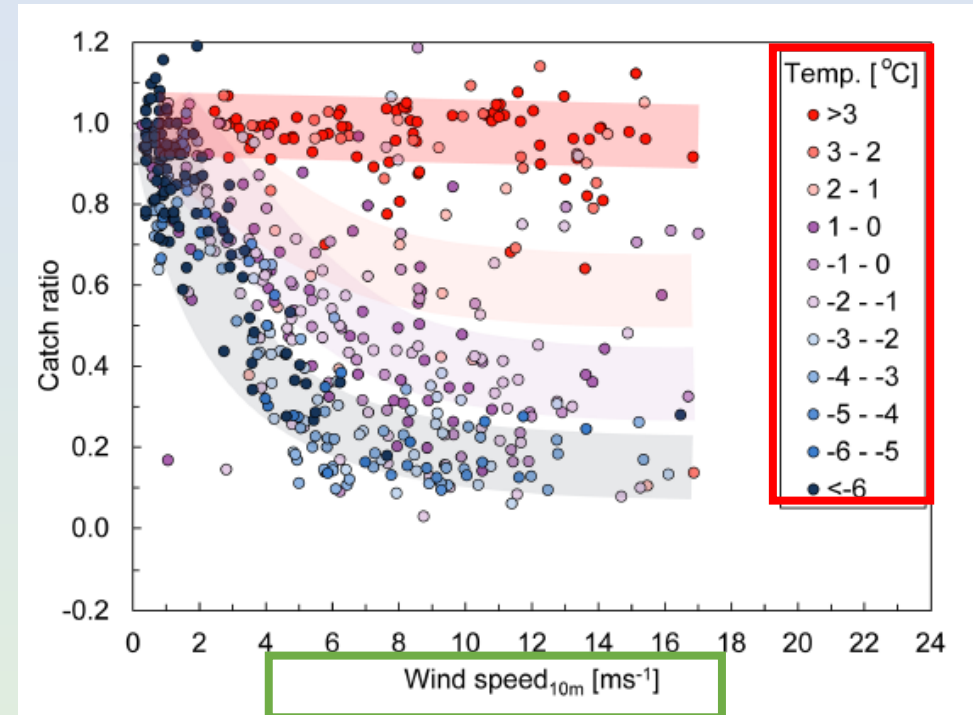


*Double Fence Intercomparison Reference
(Rasmussen et al. 2012)*

To compare
With the in-site
rain gauge



Ex of Haukeliseter (Norway)



*Relationship catch ratio/temperature/wind in
Haukeliseter (Norway) Wolff et al. 2015*

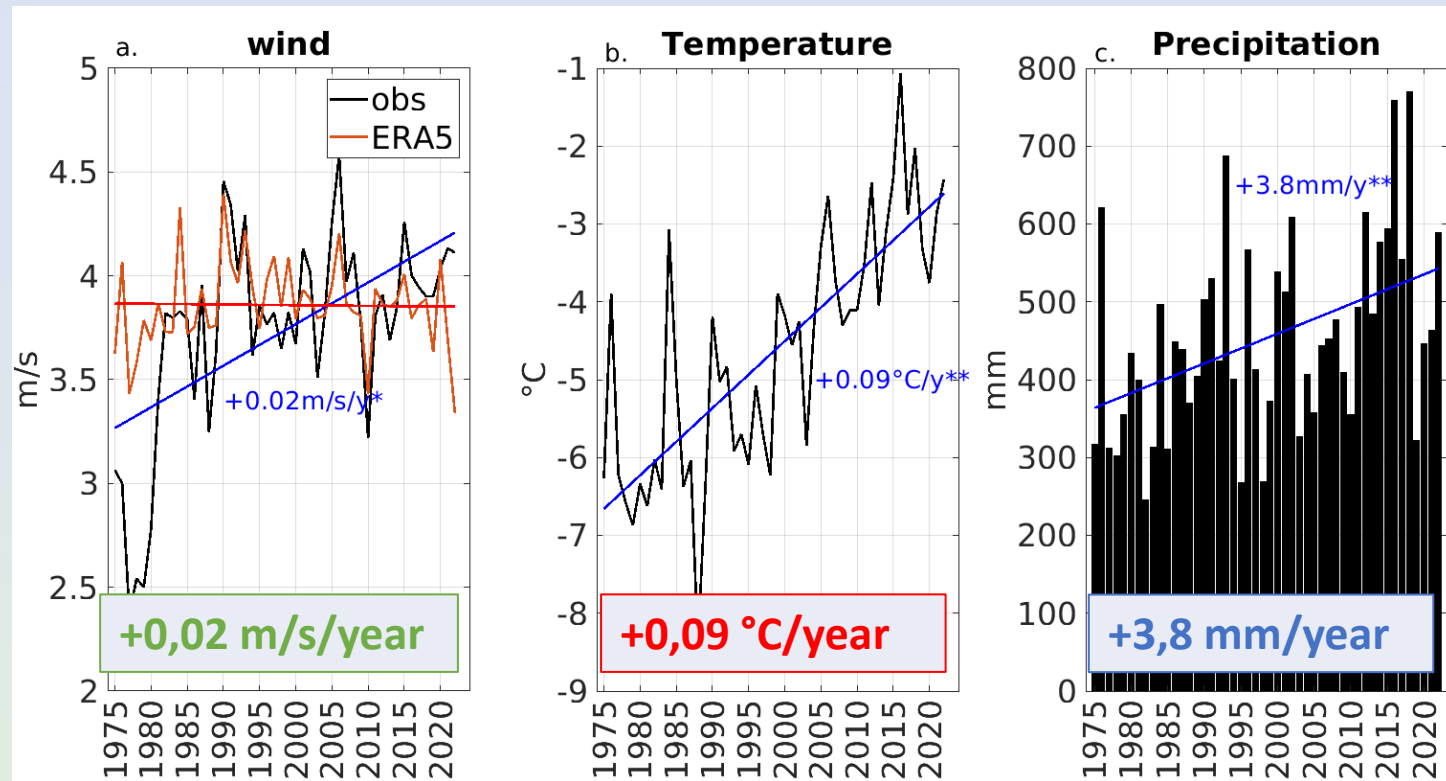
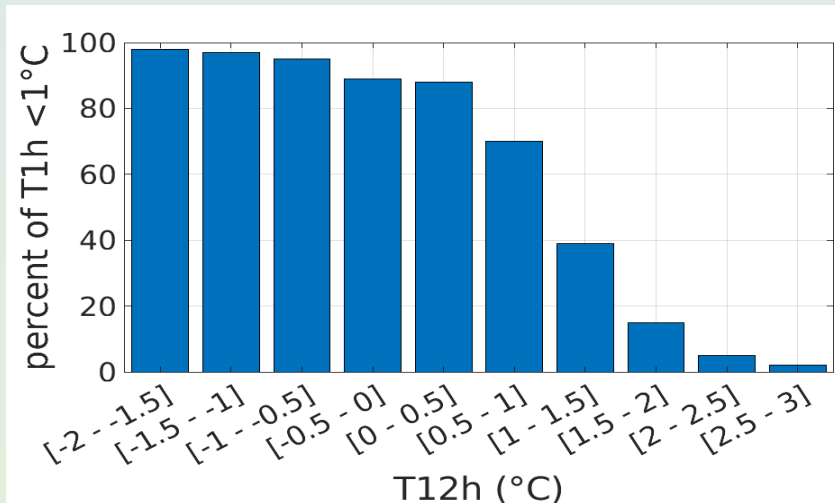
⇒ Correction factors based on a Exponential relationships
Functions of **Temperature** and **Wind**

Methods: Different correction factors

| | Location of comparison with reference | Nature of precip | Used variables |
|----------------------------------|---|---|--|
| Forland Norwegian (1996) | Joikionen (Finland) | Solid and Liquid separate | Temperature and Wind 2m |
| Forland Ny Alesund (2000) | Joikionen (Finland) and Ny Alesund | Solid and Liquid separate | Temperature and Wind 2m Reference |
| Adam (2003) | Joikionen (Finland) | Solid only | Wind 10m |
| Wolff (2015) | Haukelister (Norway) | All precipitation together | Temperature and Wind 2m Temperature and Wind 10m |
| Kochendorfer (2017) | Multiple locations | All precipitation together | Temperature and Wind 2m Temperature and Wind 10m |
| Kochendorfer bis (2017) | Multiple locations | Solid only | Wind 2m Wind 10m |

Methods: Data used

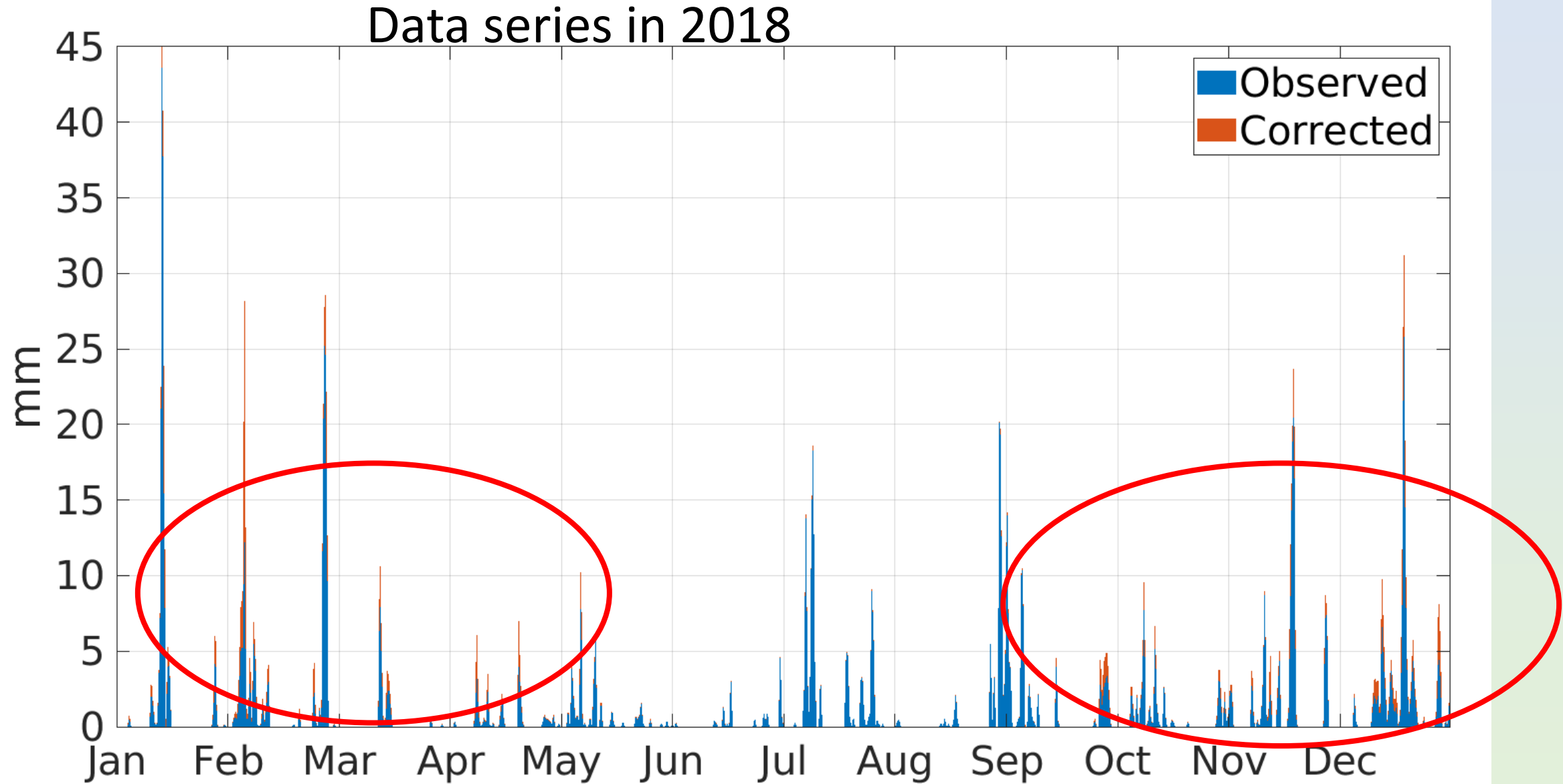
- Air **Temperature 2m** and **Wind 10m** (1975-2022)
- **Wind 2m** calculated from **Wind 10m** with a logarithm relationship ($Z_0=0,02m$ and $\alpha =12$)
- **Rain and Snow** separated based on hourly data:



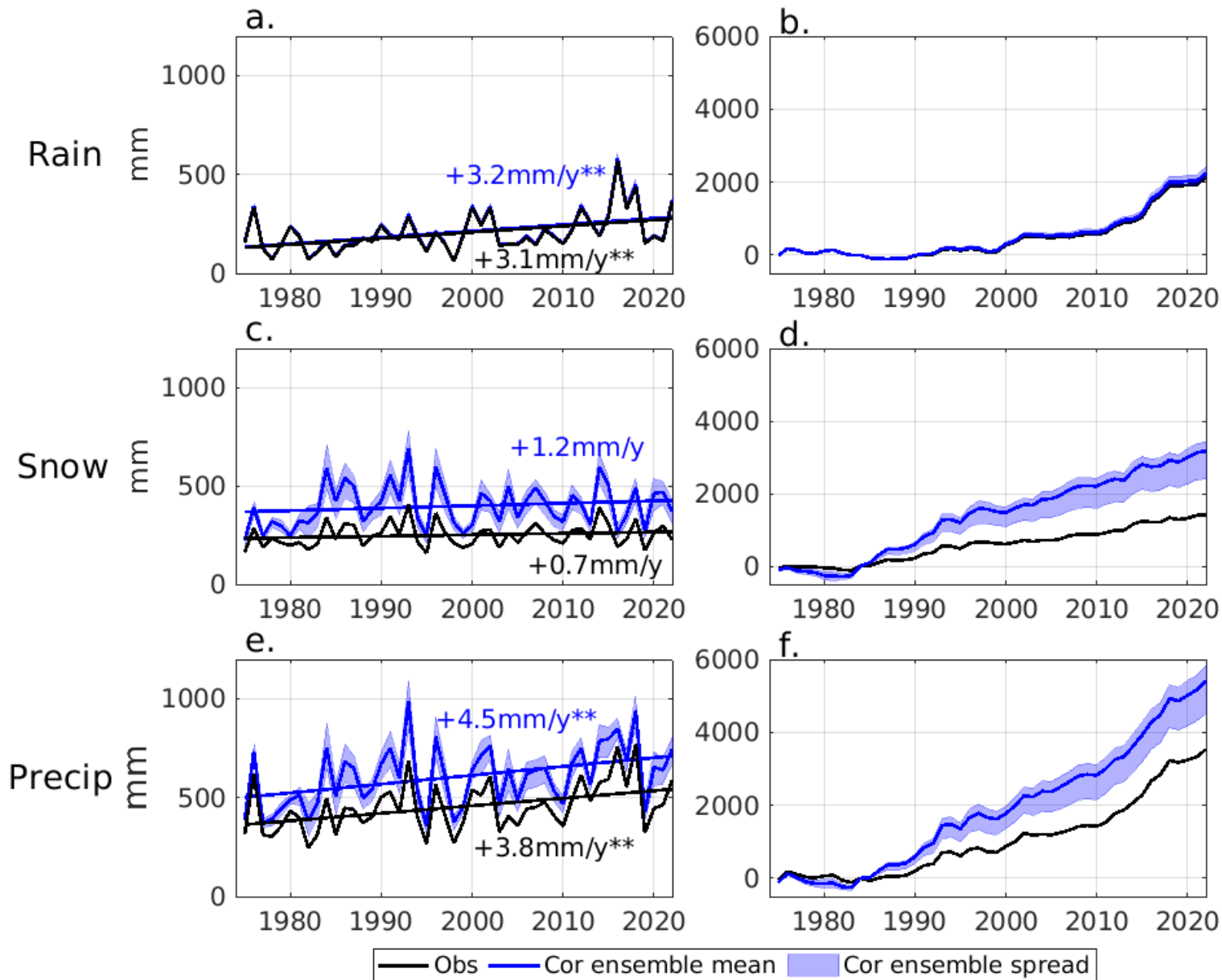
- **Corrections** applied to 12-hourly **precipitation** (1975-2022) and based on observed winds and ERA5 reanalyses winds

- **Ensemble mean** calculated from 7 correction methods (Adam and Wolff 10m excluded)
- **Trends** calculated for 10 different periods: **Entire period** (1975-2022) and **40y periods** from 1975-2014 to 1983-2022.

Results: Observed vs corrected data series



Results: Interannual evolution



1975-2022 Trends:

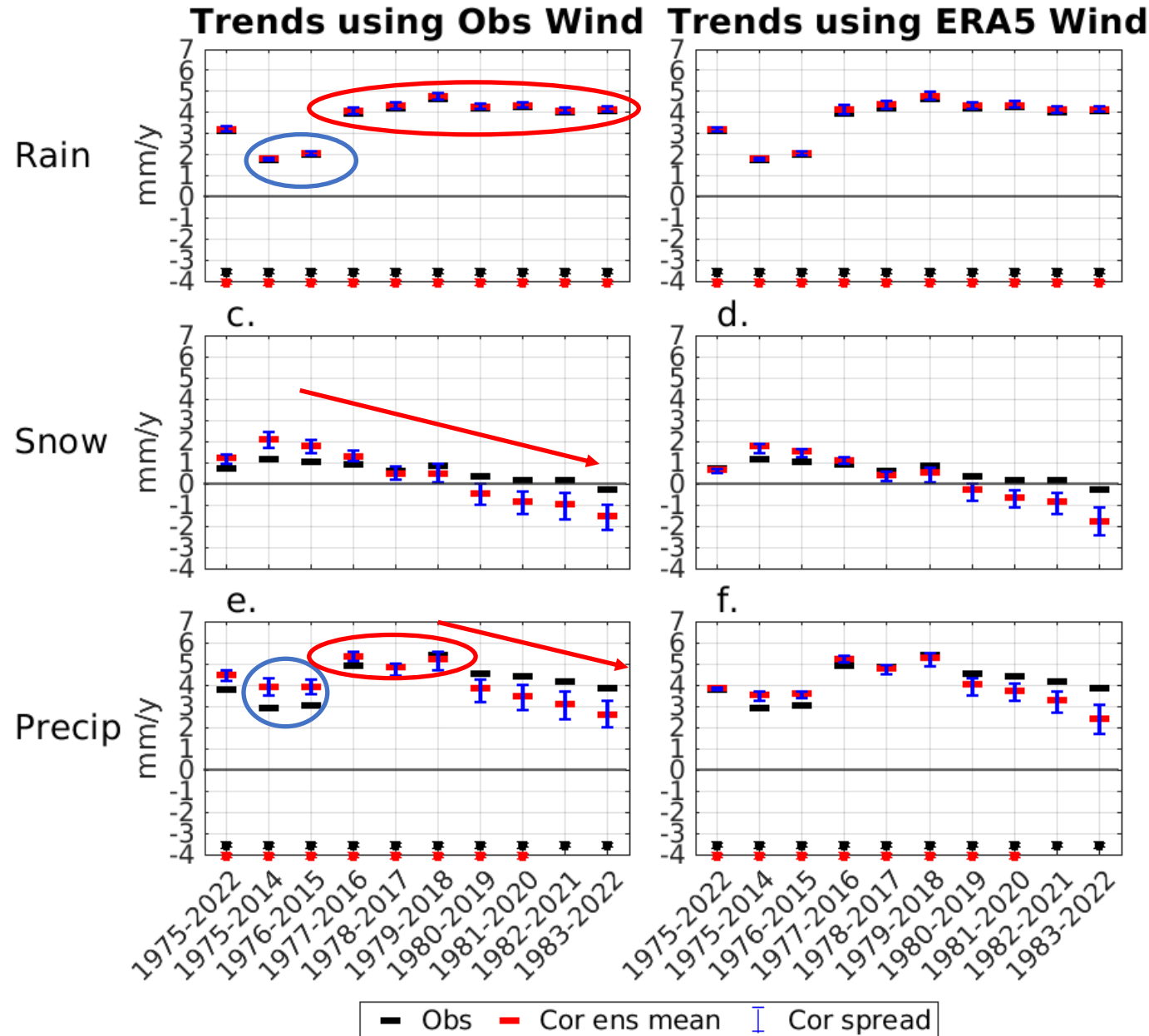
Significant increase of Rainfall (+113%) with a recent period (2011-2018) very wet.

Low and non significant increase of snowfall in observed (+14%) and corrected data (+15.7% ± 0.6).

Significant increase of precipitation in observed (+49%) and corrected data (+42% ± 1.6)

How uncertain are these trends?

Results: Trends uncertainties



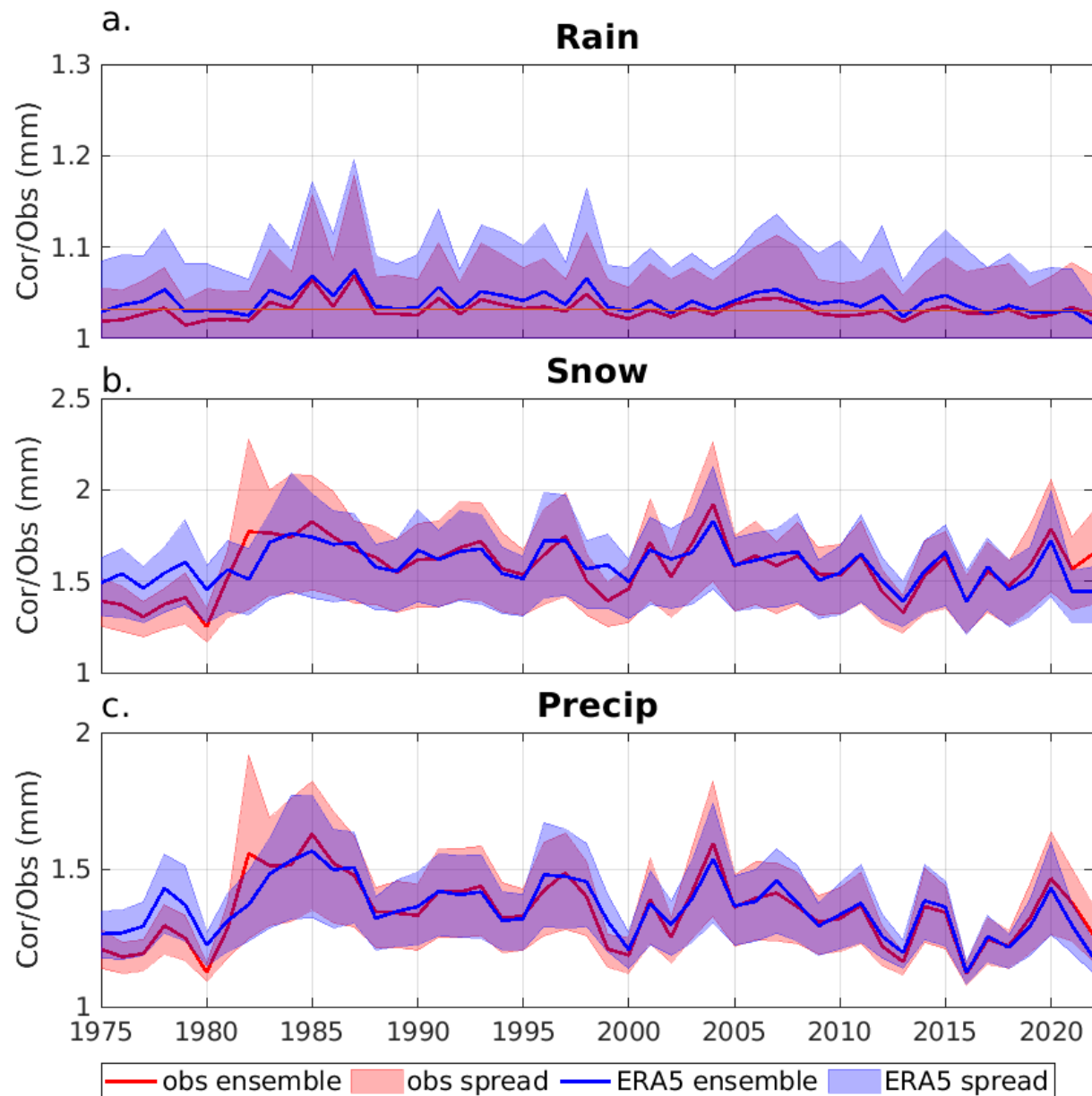
Increase of rainfall higher when excluding years 1975 and 1976 in trend calculation

Trends of snowfall becoming very low in observed and even **decreasing** in corrected data in recent period (1980-2019 onward)

Trend of precipitation peaking in **1979-2018** in observed and corrected data, then **decreasing** mostly in corrected data

Why these rapid changes of trends?

Results: Correction factors



Correction factor for Rain: 1.03 (± 0.01)
decreasing significantly (-0.02)

Correction factor for snow of 1.58 (± 0.15),
decreasing significantly (-0.20)

Correction factor for precipitation of 1,35
(± 0.12), decreasing significantly (-0.25)

=> **80% (-0,20/-0,25)** of the change in
correction factor due to more humid snow.
20% to change from snow to rain.

Conclusion

| | observed | corrected |
|----------------------------|---------------------|--|
| Total annual precipitation | 453mm | 607mm (± 41) |
| Trend (1975-2022) | +3,8mm/year +49% | +4,5mm/year ($\pm 0,13$) +42% (± 1.6) |
| Trend (1979-2018) | +5,4mm/year | +5,2mm/year ($\pm 0,3$) |
| Trend (1983-2022) | +3,8mm/year | +2,6mm/year ($\pm 0,5$) |

- **37% (± 13)** of the 1983-2022 observed precipitation trend is **artificial**, mainly due to **more wet snow**
- The **corrected mean ensemble** precipitation serie **will be submitted for publication!**
- In future we suggest to use **Kochendorfer 10m method** (adapted to all rain gauges, to 10m wind, calculated for rain and snow together and less sensitive to high winds).

Thank you!



| | observed | corrected |
|----------------------------|-----------------------------|--|
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olivier.champagne@univ-grenoble-alpes.fr