Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Effects of shelter types on temperature measurements

Lisa Hannak (Lisa.Hannak@dwd.de)
Sven Brinckmann, Karsten Friedrich,
Florian Imbery, Frank Kaspar

Deutscher Wetterdienst

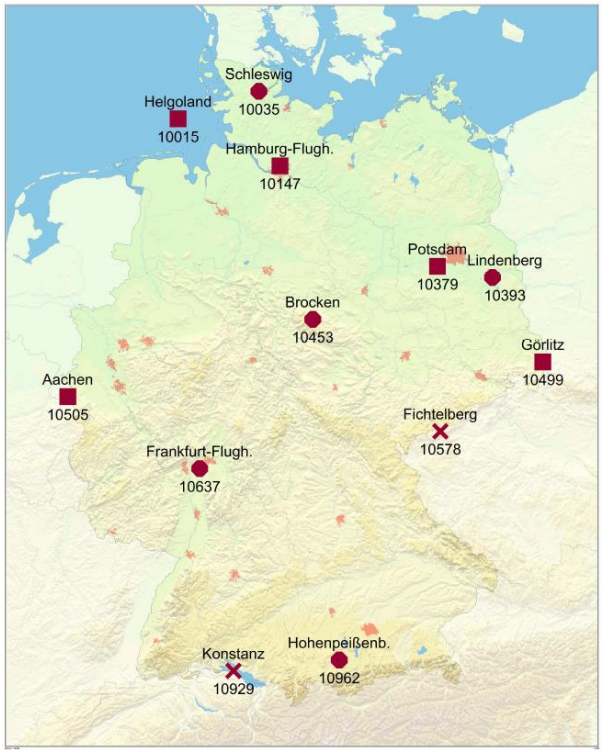
Comparison of different shelter types

- Why do we compare temperature measurements of different shelter types?
- Measurements: study configuration
- Results: analysis of differences
- Correlation analysis
- Summary and Outlook

Why do we compare temperature measurements of different shelter types?

Why do we compare temperature measurements of different shelter types?

➔ Study of parallel measurements between manual and automatic measurements



Why do we compare temperature measurements of different shelter types?

➔ Study of parallel measurements between manual and automatic **temperature** measurements:

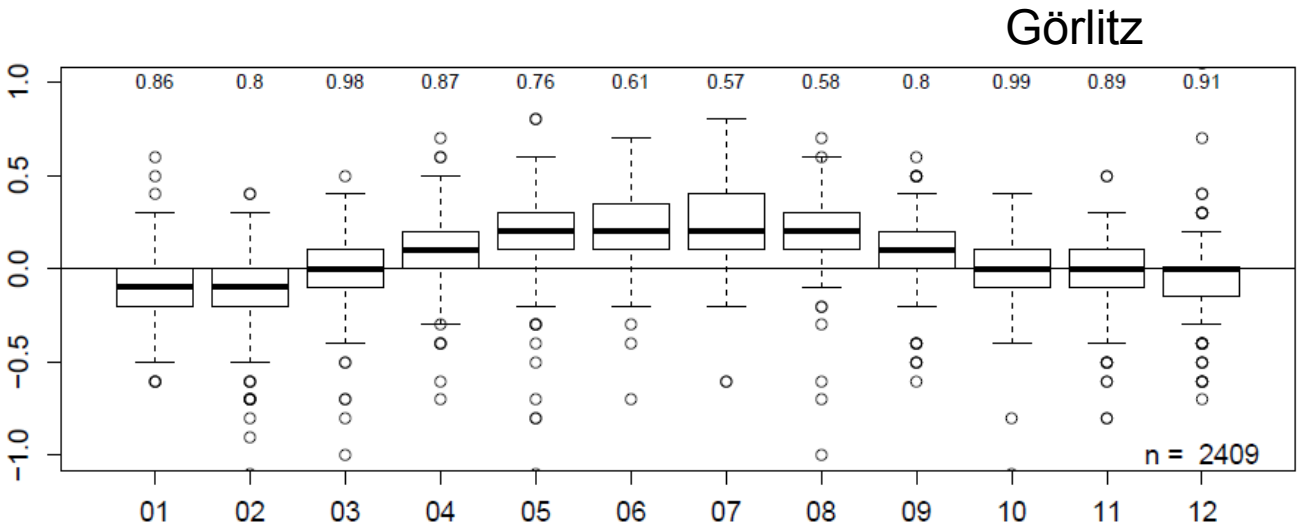
Manual configuration:
- Mercury-in-glass thermometer
- Stevenson screen

Automatic instrument:
- PT100 sensor
- (mostly) LAM 630 screen

Kaspar, F., Hannak, L., and Schreiber, K.-J.: Climate reference stations in Germany: Status, parallel measurements and homogeneity of temperature time series, Adv. Sci. Res., 13, 163-171, https://doi.org/10.5194/asr-13-163-2016, 2016.

Why do we compare temperature measurements of different shelter types?

manual automatic



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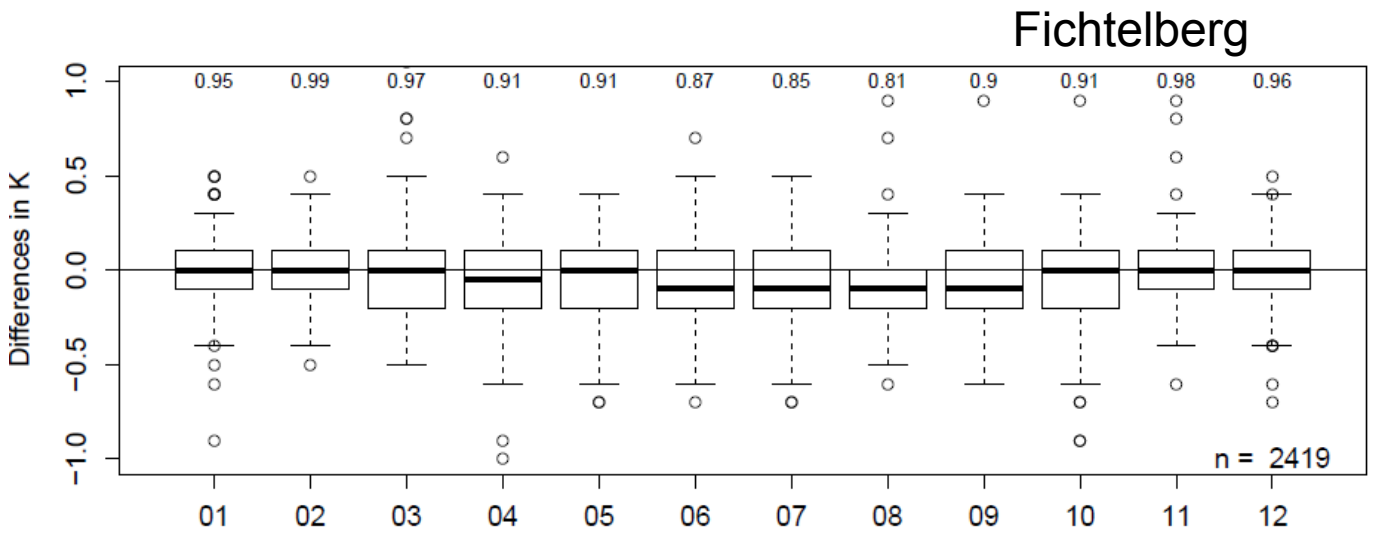
➔ When the instruments are in different shelter types the differences of daily maximum temperature have an annual cycle

Why do we compare temperature measurements of different shelter types?

manual + automatic



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➔ When the instruments are in the same screen, there is no annual cycle

The shelter type has an effect on temperature measurements!

Measurement set-up

- PT100 sensor inside the LAM 630 shelter (with integrated fan)

- PT100 sensor inside the Stevenson screen

Measurement set-up

- PT100 sensor inside the LAM 630 shelter (with integrated fan)

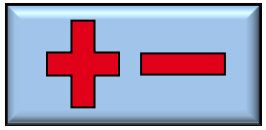
- PT100 sensor inside the Stevenson screen

Station sides: Lindenberg (since 2018) and Hohenpeißenberg (since 2015)

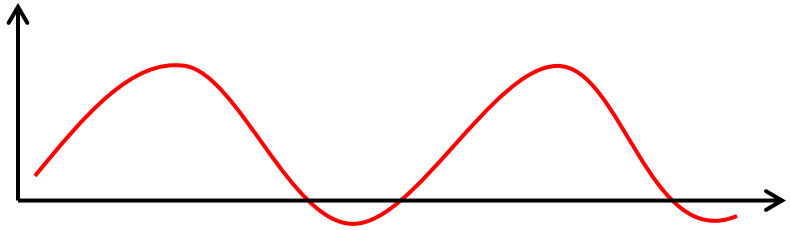
- Temporal resolution: 1 minute mean values
- other parameters: wind speed and direction (Lindenberg in 2m, Hohenpeißenberg in 10m), solar irradiance, relative humidity (inside the LAM 630), two temperature sensors inside the LAM 630

Aim of the parallel measurements

➔ Study/quantify the screen effect



➔ Regression model to model the screen bias



Results

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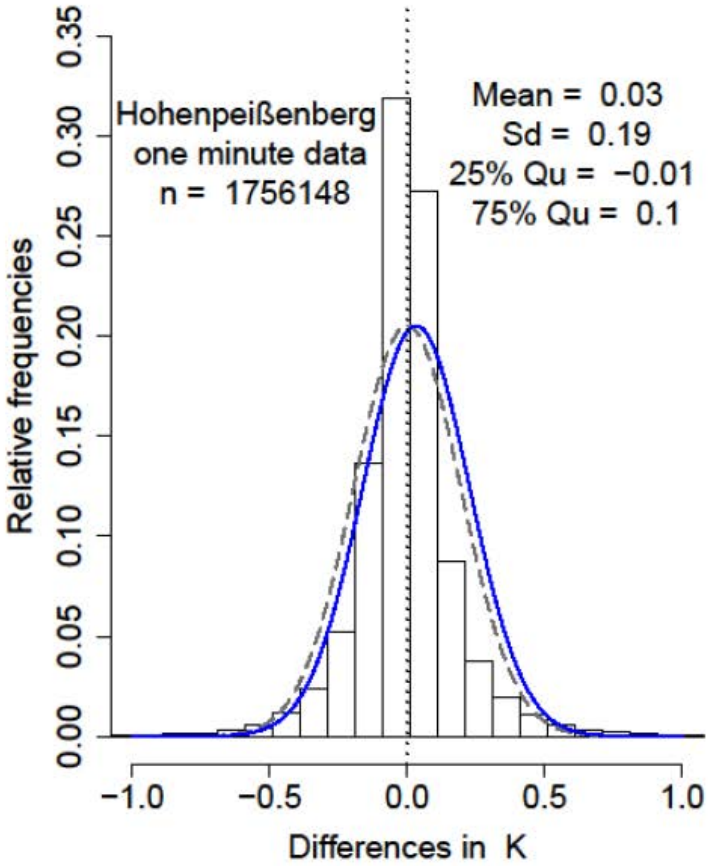
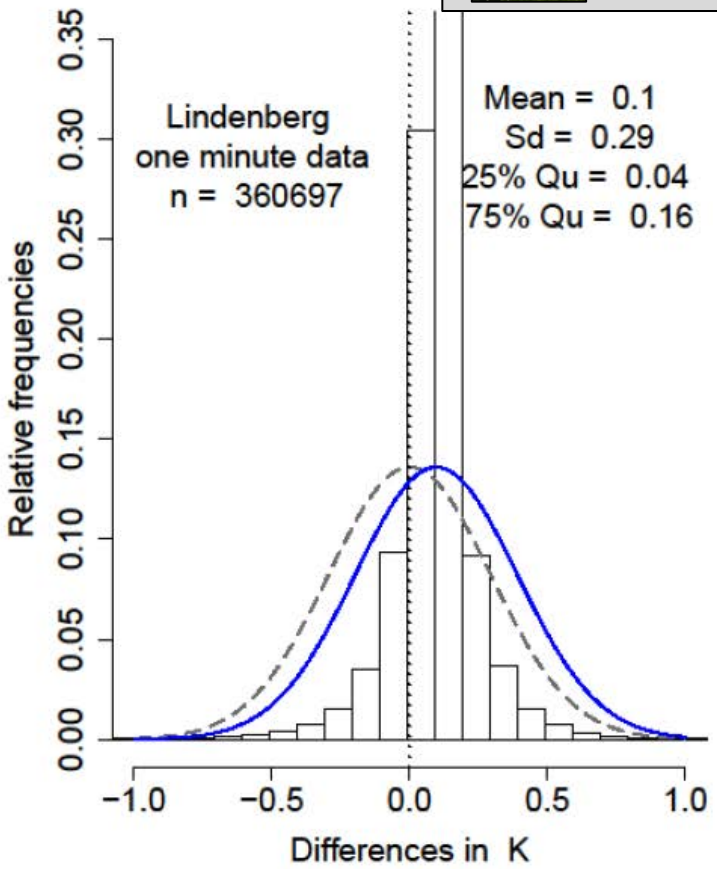
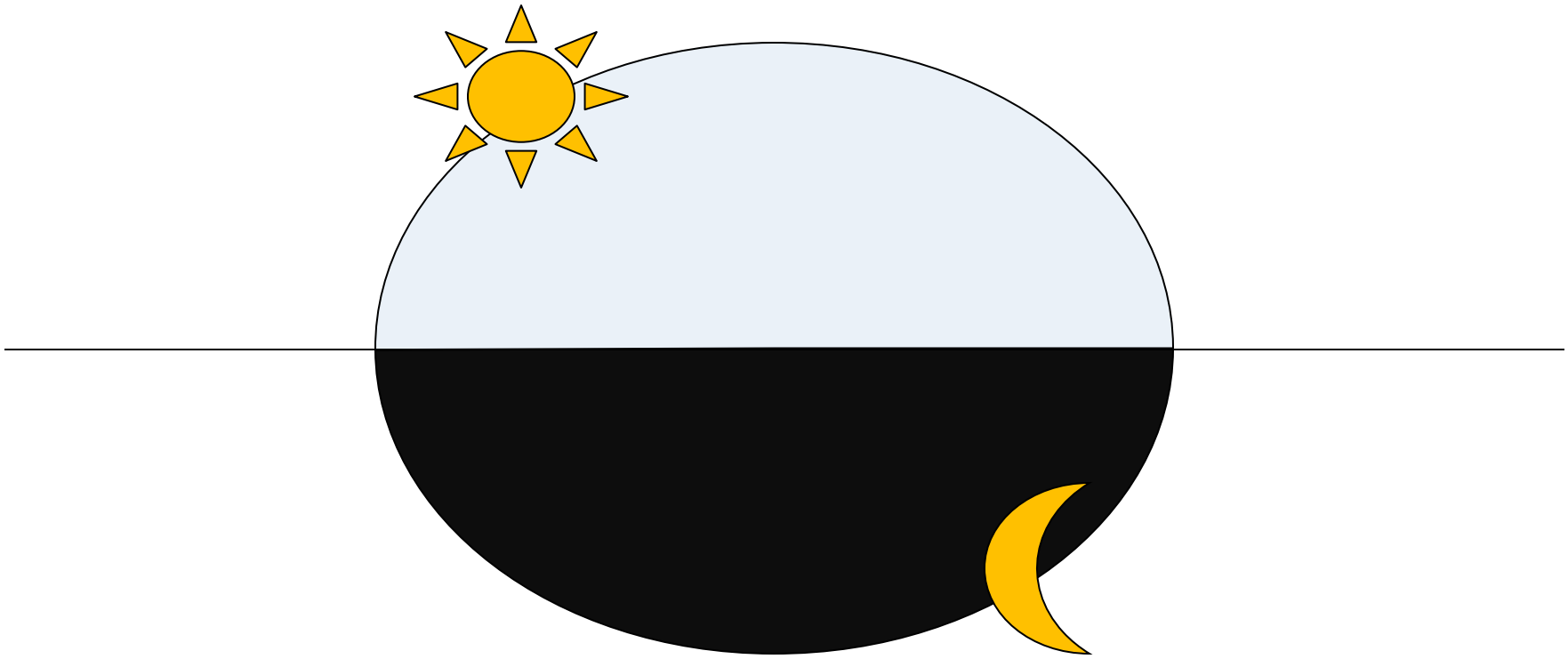
Differences between the different screens



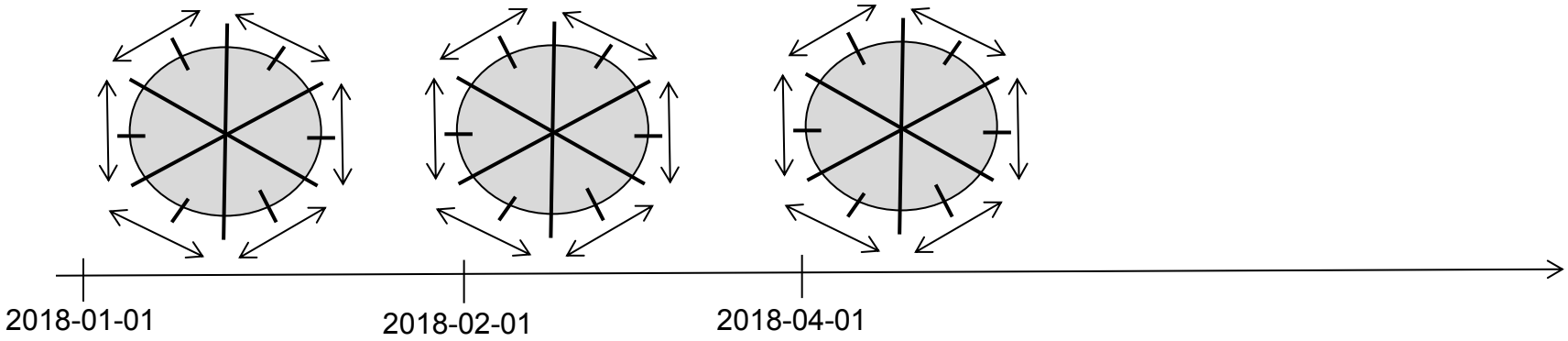


Results - Daily cycle



Results - Daily cycle

➔ Temporal resolution:
one minute mean values every ten minutes of Hohenpeißenberg

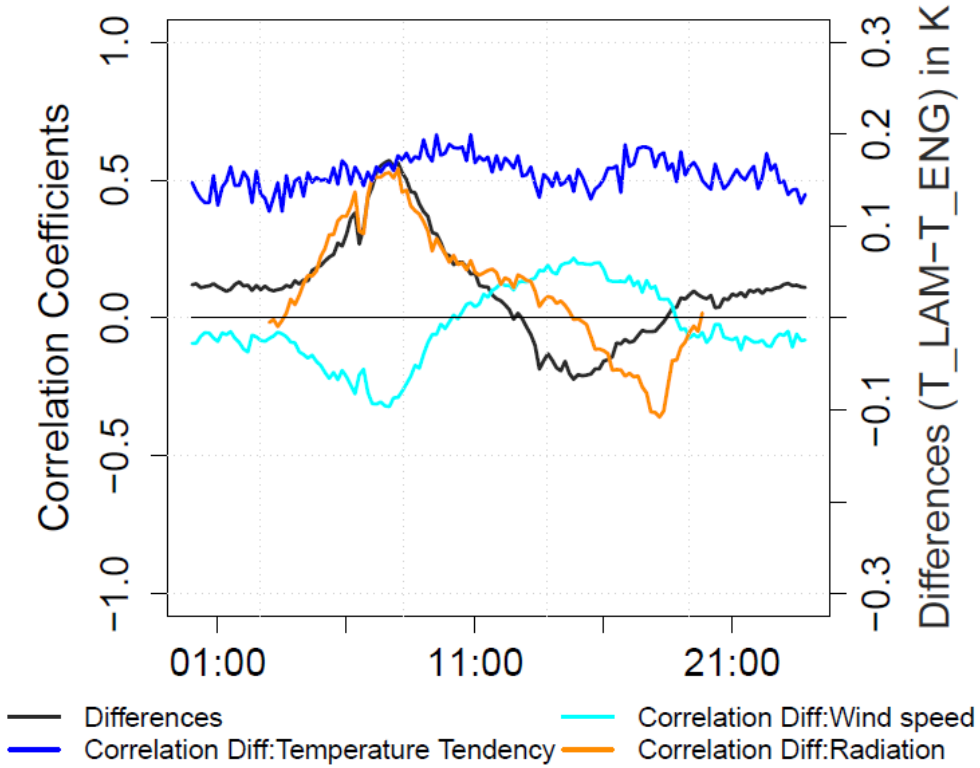


➔ Sorting values of one specific time (e.g. 1:50 UTC) → time series

➔ Averaging over all values for a specific time of the day or calculating correlation coefficients using the sorted time series

Results - Daily cycle

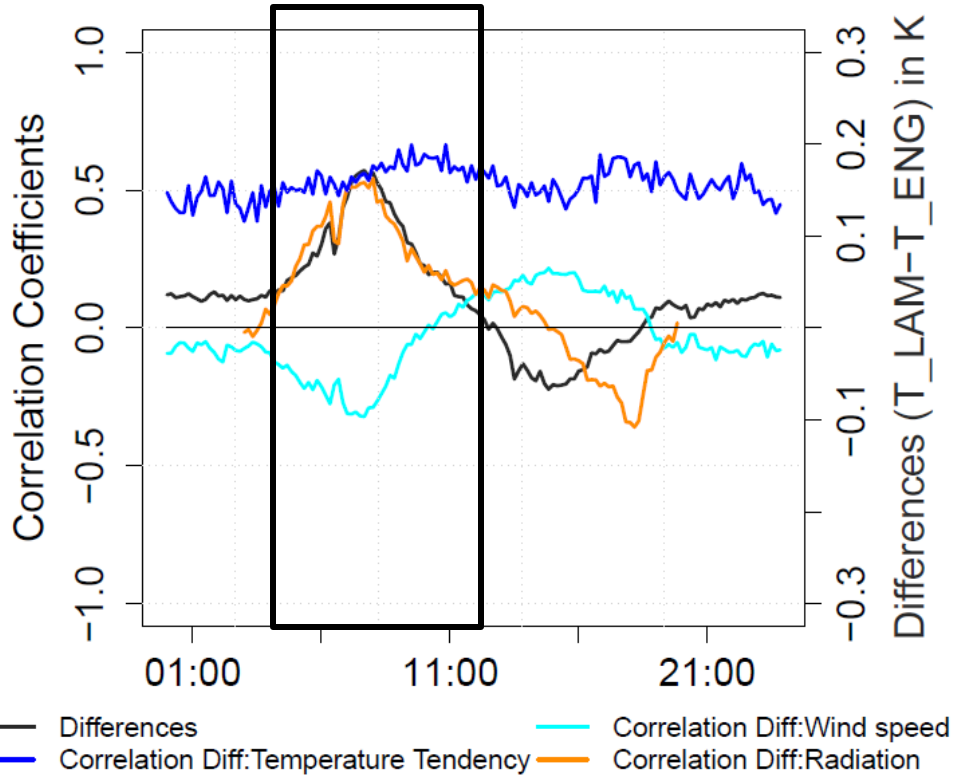
Daily cycle of differences between temperature measurements in different shelter types



Results - Daily cycle

Daily cycle of differences between temperature measurements in different shelter types

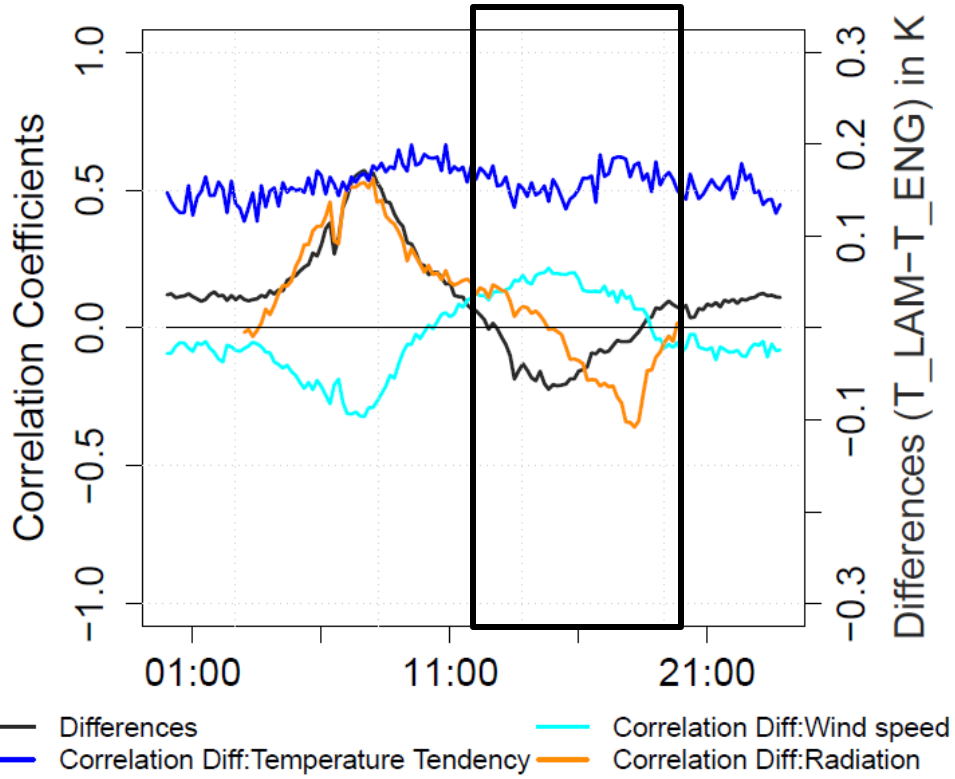
- Morning:
  - positive differences between shelter types
  - Positive correlation to radiation
  - Negative correlation to wind speed



Results - Daily cycle

Daily cycle of differences between temperature measurements in different shelter types

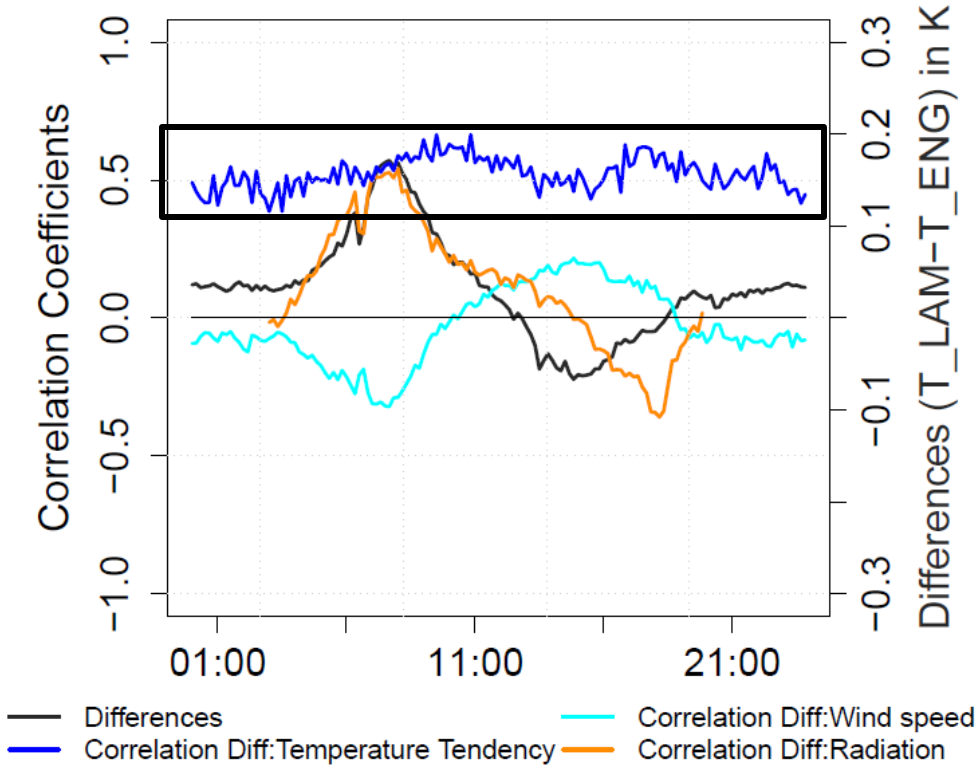
- Afternoon:
  - negative differences between shelter types
  - Positive correlation to wind speed
  - Negative correlation to radiation (with delay!)



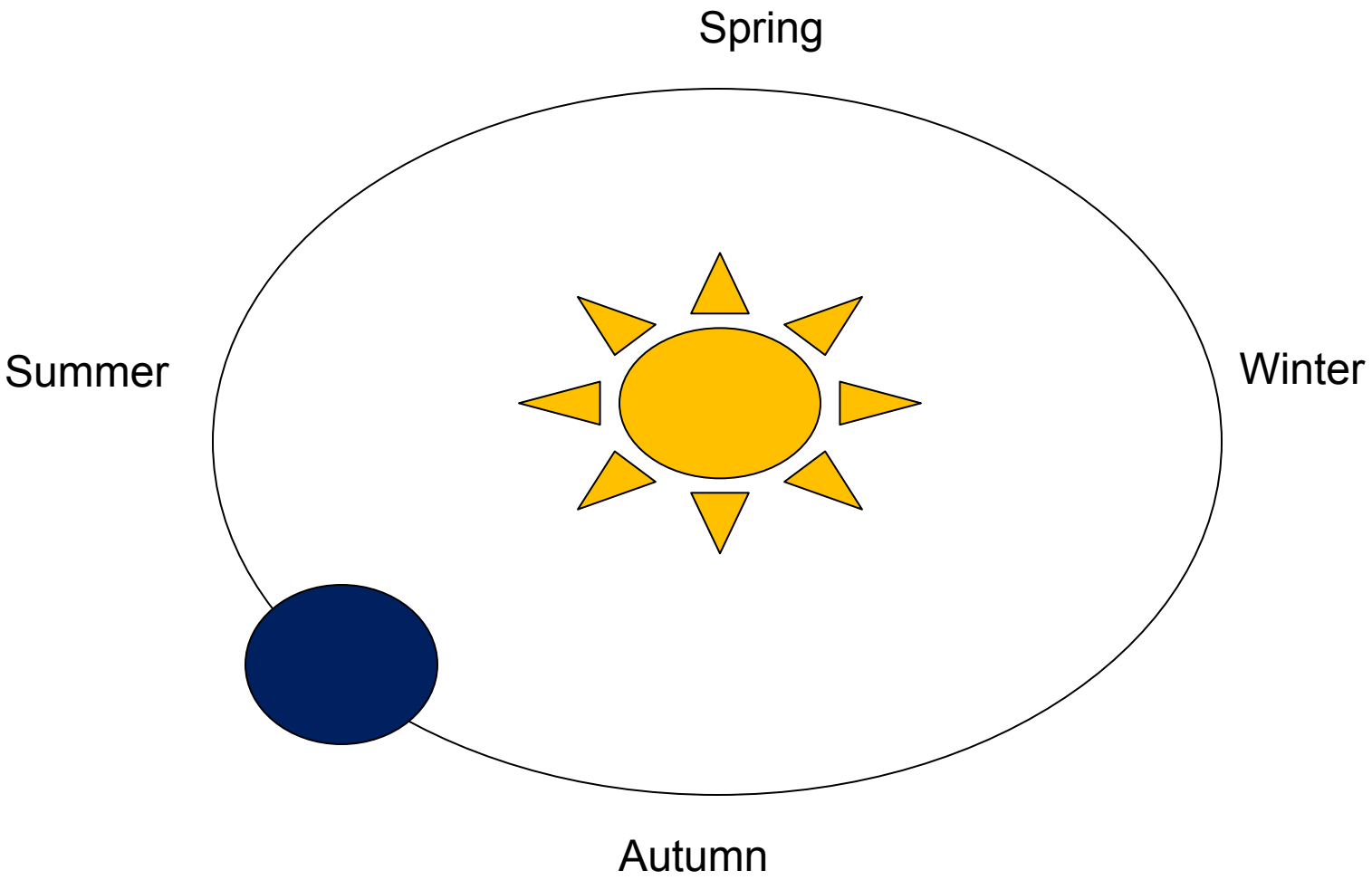
Results - Daily cycle

Daily cycle of differences between temperature measurements in different shelter types

- All day:
  - Constant correlation to temperature tendency (changes between two successive one minute mean values every ten minutes of the sensor in the LAM 630)



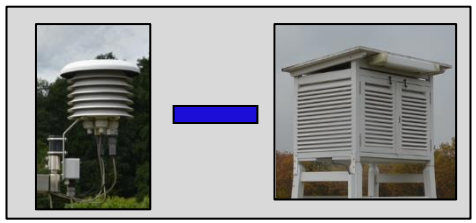
Results - Annual cycle

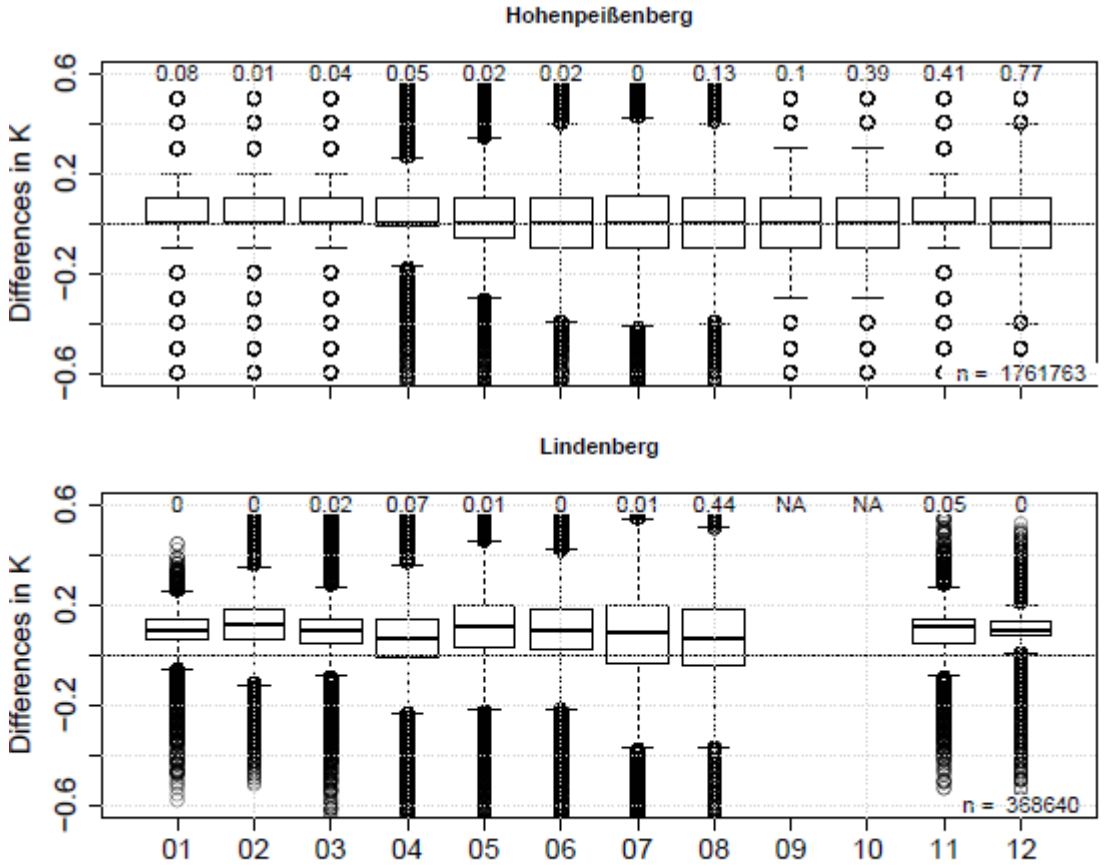


Results - Annual cycle

Differences between screen types (1-min Data)

- LAM 630 minus Stevenson screen
- No annual cycle in the median of the differences
- In summer the standard deviation is larger





Results- Annual cycle

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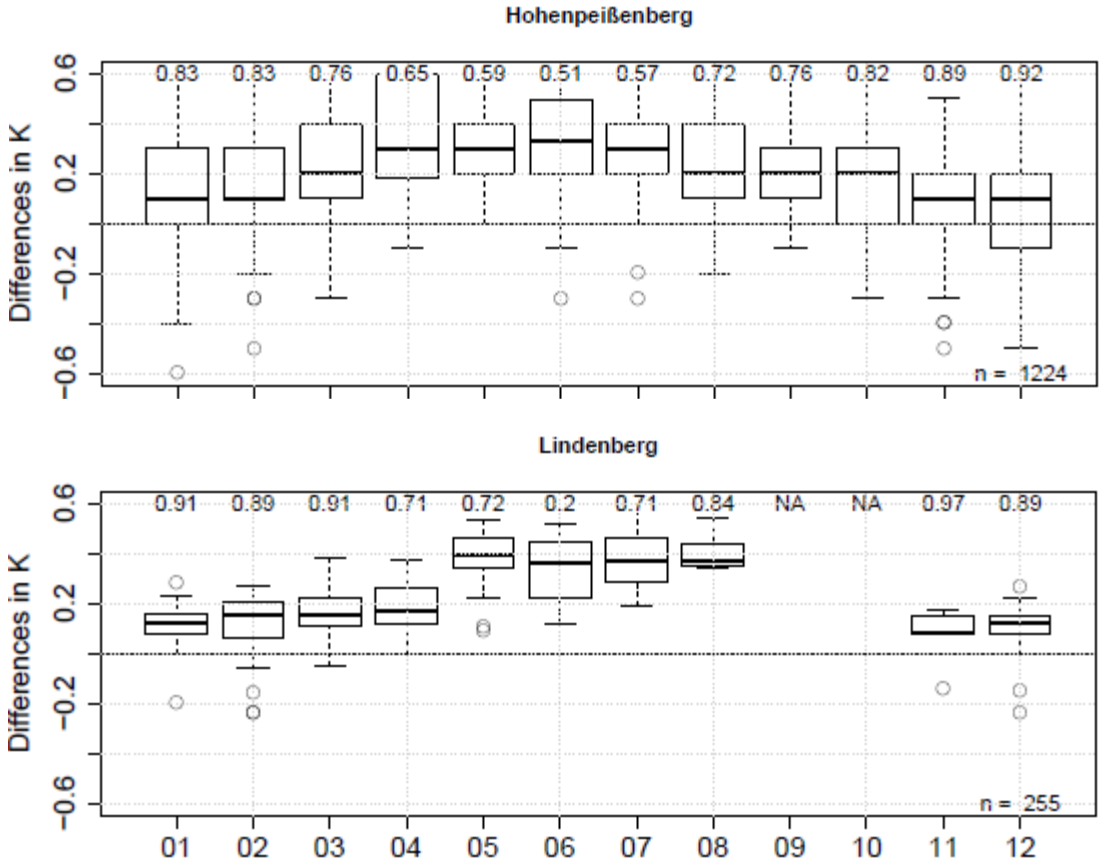
Differences of daily maximum temperature

- LAM 630 minus Stevenson screen
- Annual cycle in the differences of daily maximum temperature



Results- Annual cycle

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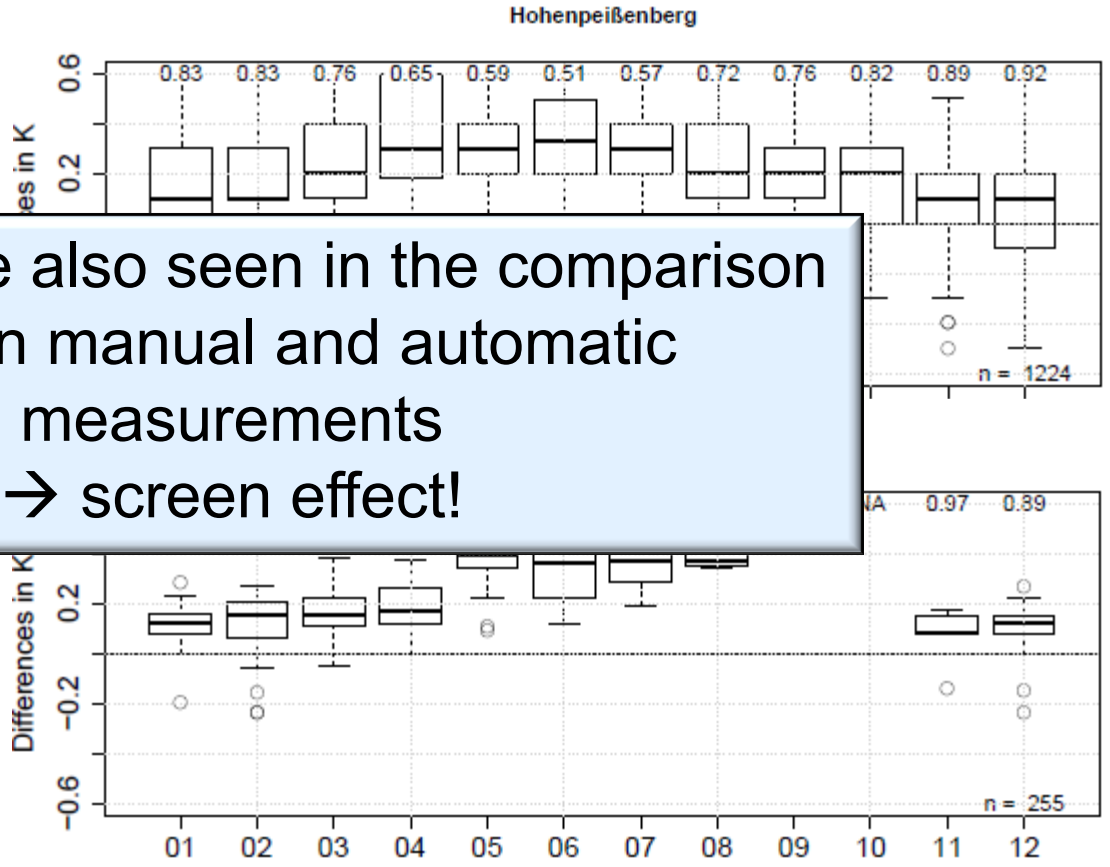
Differences of daily maximum temperature

- LAM 630 minus Stevenson screen
- Annual cycle in the differenc maximur

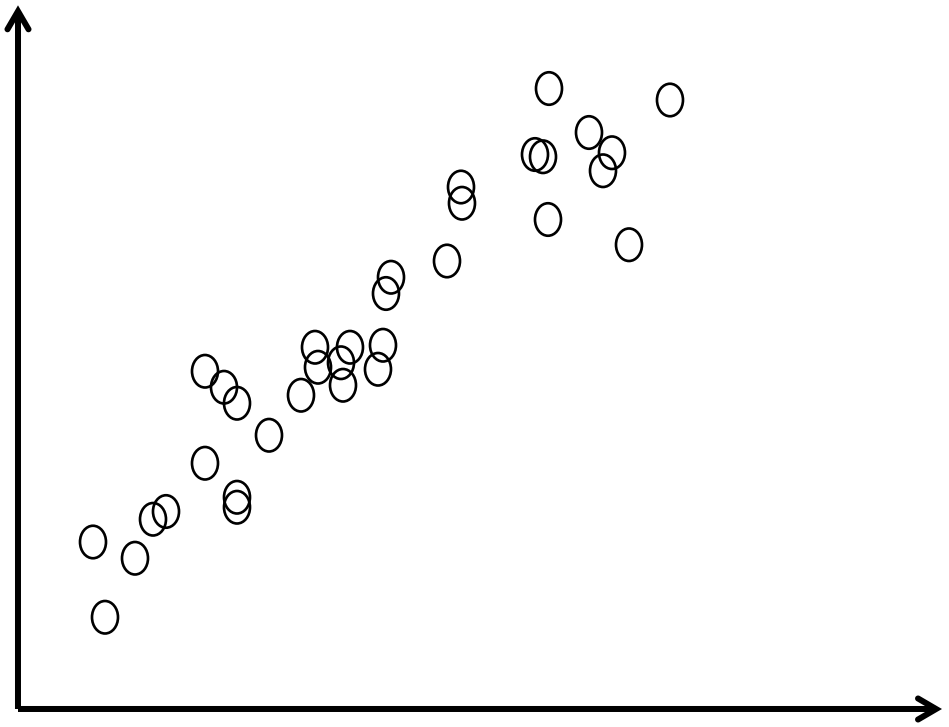
This we have also seen in the comparison between manual and automatic measurements
→ screen effect!



Reasons for differences

- Different radiation effect on screens
- Different inertia time
- Different ventilation
- Different heat accumulation inside the screen (especially when the wind is weak)
- Temperature differences at two positions inside the shelter

Correlation analysis



Correlation analysis

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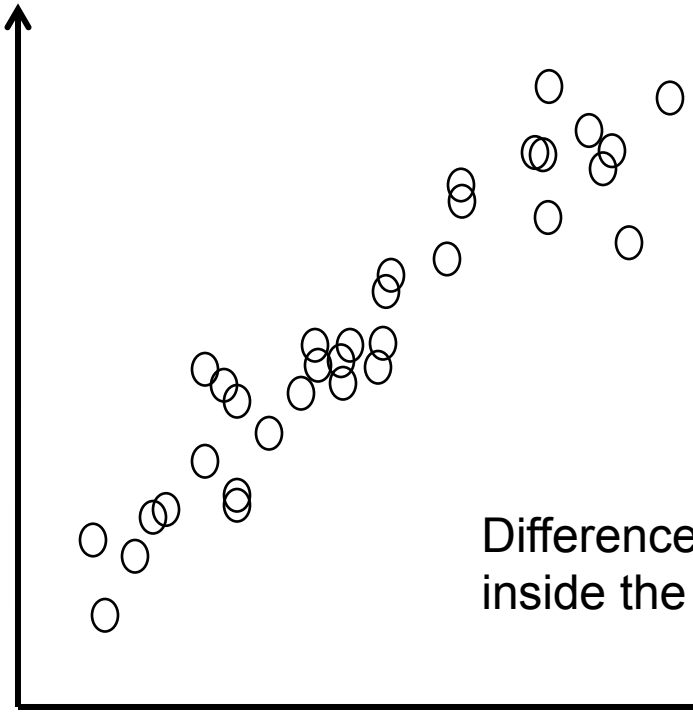
Solar irradiance: RAD
Solar irradiance tendency: RADdt

Wind speed: V

Temperature
tendency: Tdt



Differences of two temperature sensors
inside the lamellar shelter: T_S2-T_S1

Relative humidity: RH
Relative humidity tendency: RHdt

Correlation analysis

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Linden-berg	Diff - V	Diff - RAD	Diff - RADdt	Diff – T_S2-T_S1	Diff - Tdt	Diff - RH	Diff - RHdt
1 min mean	0.198	0.143	0.114	-0.154	0.305	-0.072	-0.126
10 min mean	0.233	0.195	0.269	-0.245	0.581	-0.097	-0.455
10 min actual	0.195	0.137	0.224	-0.163	0.564	-0.064	-0.381

Correlation analysis

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Lindenberg:

- Temperature changes of two successive values (temperature tendency)
- Relative humidity changes of two successive values (relative humidity tendency)
- Global radiation and tendency
- Wind speed (2 meter height)
- Temperature differences inside lamellar shelter

Correlation analysis

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Hohen-peißen-berg	Diff - V	Diff - RAD	Diff - RADdt	Diff – T_S2-T_S1	Diff - Tdt	Diff - RH	Diff - RHdt
1 min mean	-0.049	0.026	0.084	-0.243	0.275	0.069	-0.092
10 min mean	-0.061	0.044	0.263	-0.175	0.511	0.082	-0.335
10 min actual	-0.051	0.025	0.207	-0.243	0.272	0.068	-0.250

Correlation analysis

Hohen-peißen-berg	Diff - V	Diff - RAD	Diff - RADdt	Diff – T_S2-T_S1	Diff - Tdt	Diff - RH	Diff - RHdt
1 min mean	-0.049	0.026	0.084	-0.243	0.275	0.069	-0.092
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10 min actual	-0.051	0.025	0.207	-0.243	0.272	0.068	-0.250

Hohenpeißenberg:

- Temperature changes of two successive values (temperature tendency)
- Relative humidity changes of two successive values (relative humidity tendency)
- Global radiation changes of two successive values (Global radiation tendency)
- Temperature differences inside lamellar shelter

Summary

- ➔ Mean differences between screen types are small
- ➔ Differences between screen types are larger for daily maximum temperature values
  - ➔ Annual cycle with larger differences between screen types in summer

- ➔ Differences between screen types are correlated to
  - ➔ Temperature tendency
  - ➔ Temperature differences inside lamellar shelter
  - ➔ Radiation tendency
  - ➔ Relative humidity tendency
  - ➔ Wind speed in 2m height (Lindenberg)

Outlook

- ➔ Fit linear model to model screen bias
- ➔ Use variables with large correlation coefficients as predictors
- ➔ Test model

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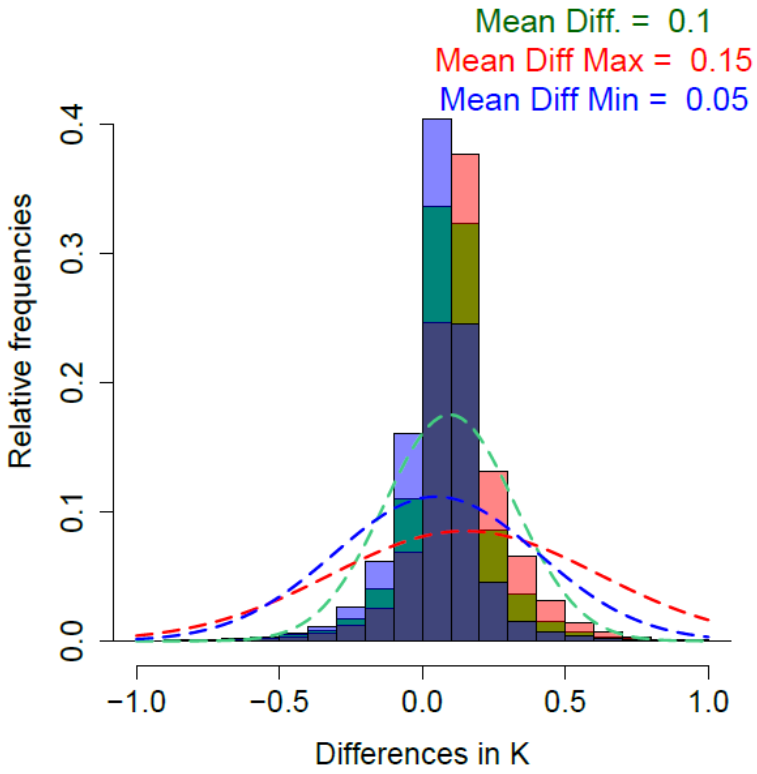
- ➔ Test model

Thank you!

Lindenberg (data resolution: 10 minute)

- Green:
  Differences of 1-min-values every 10 minute
- Red:
  Differences of maximum 1-min-values within 10 minutes
- Blue:
  Differences of minimum 1-min-values within 10 minutes



Lindenberg

➔ Correlation in the case of sunny moments (RAD > 120 W/m^2)

(T_LAM 630 – T_Stevenson screen)
and V : -0.16