

# EMPIRIC APPROACH TO FORECAST HOT EXTREMES FOR ENERGY MODELING

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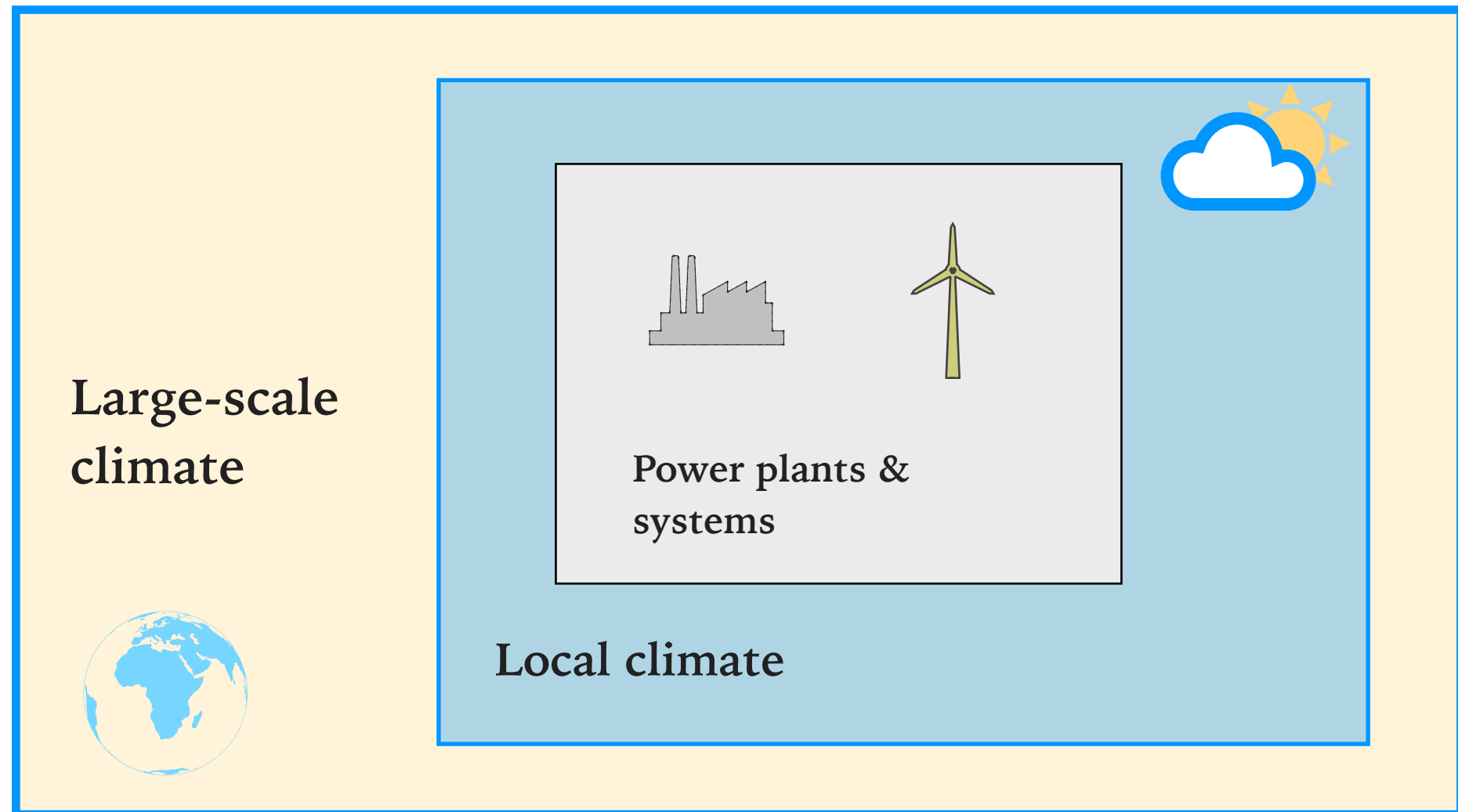
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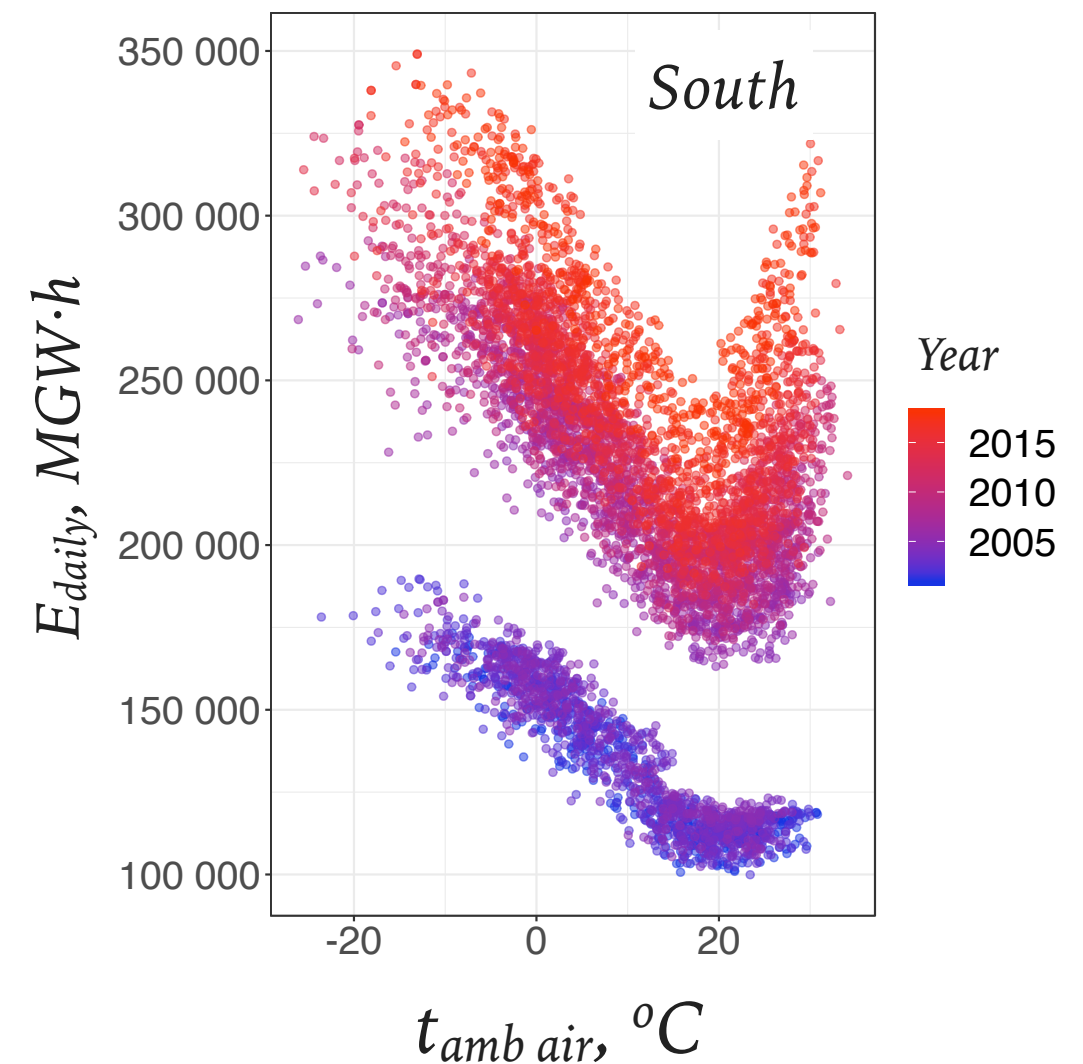
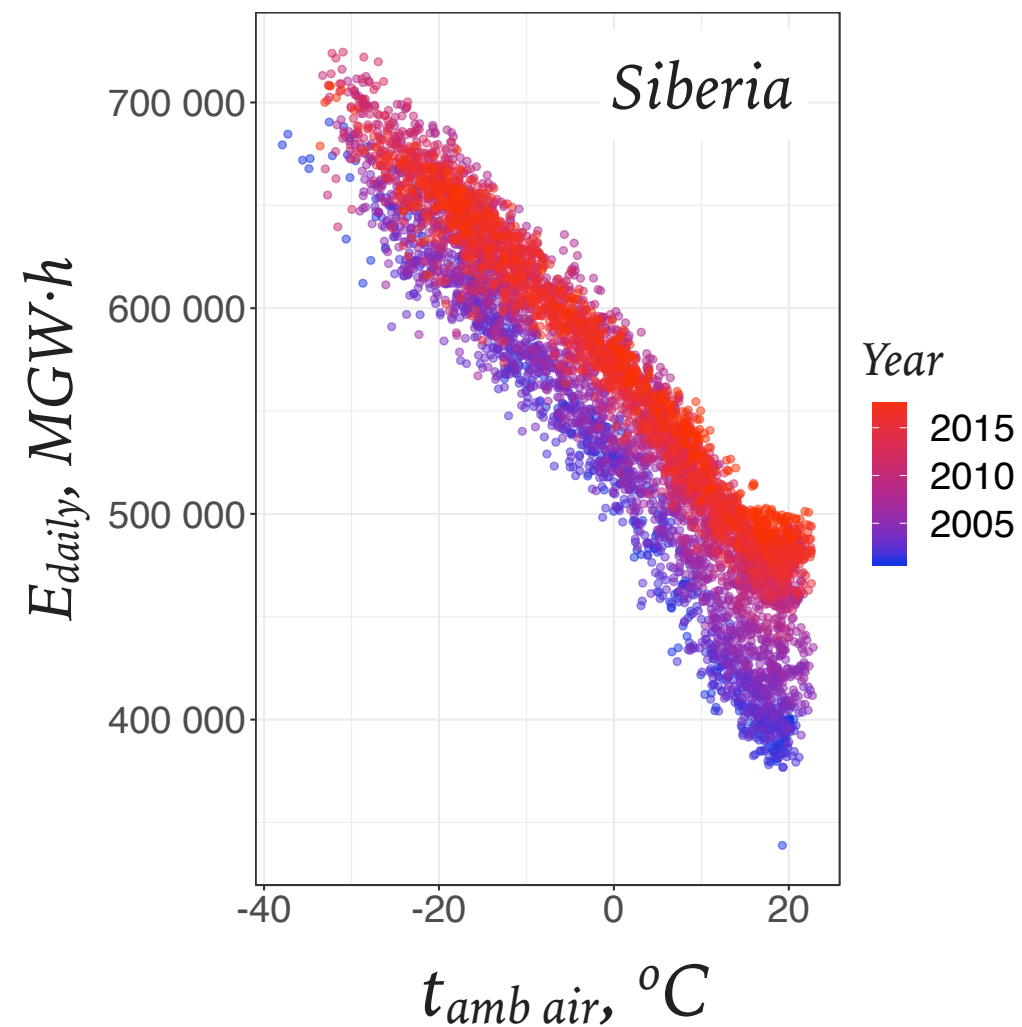
# MOTIVATION

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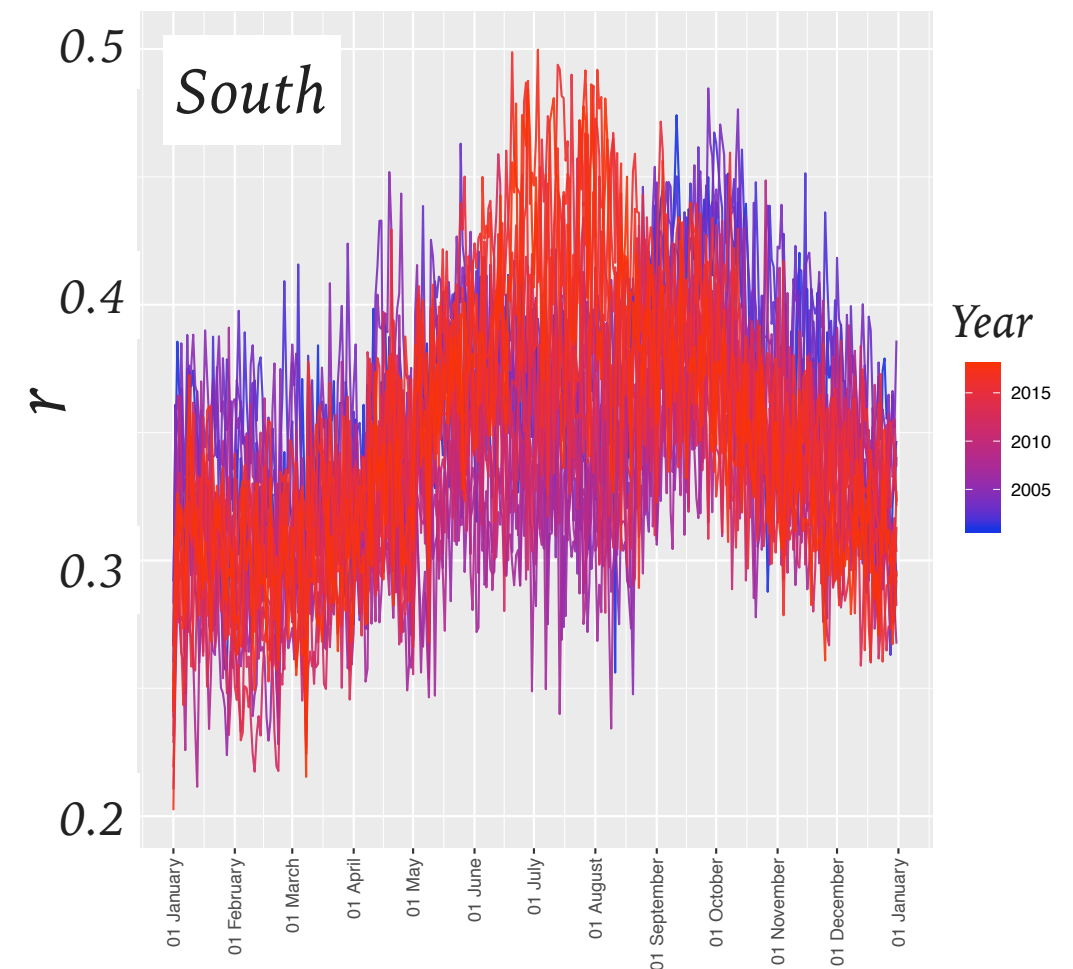
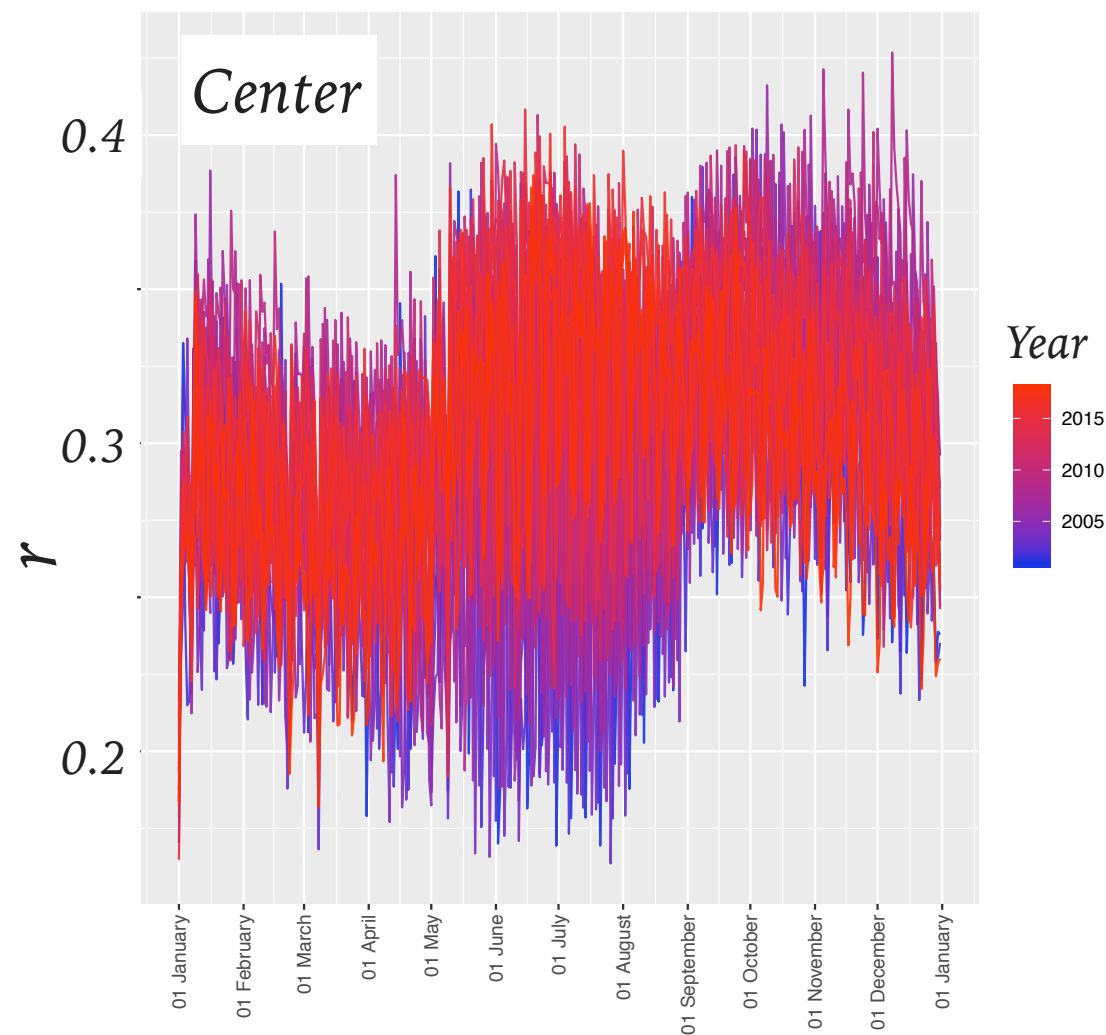
# MOTIVATION

Electricity demand is strongly dependent on the ambient air temperature

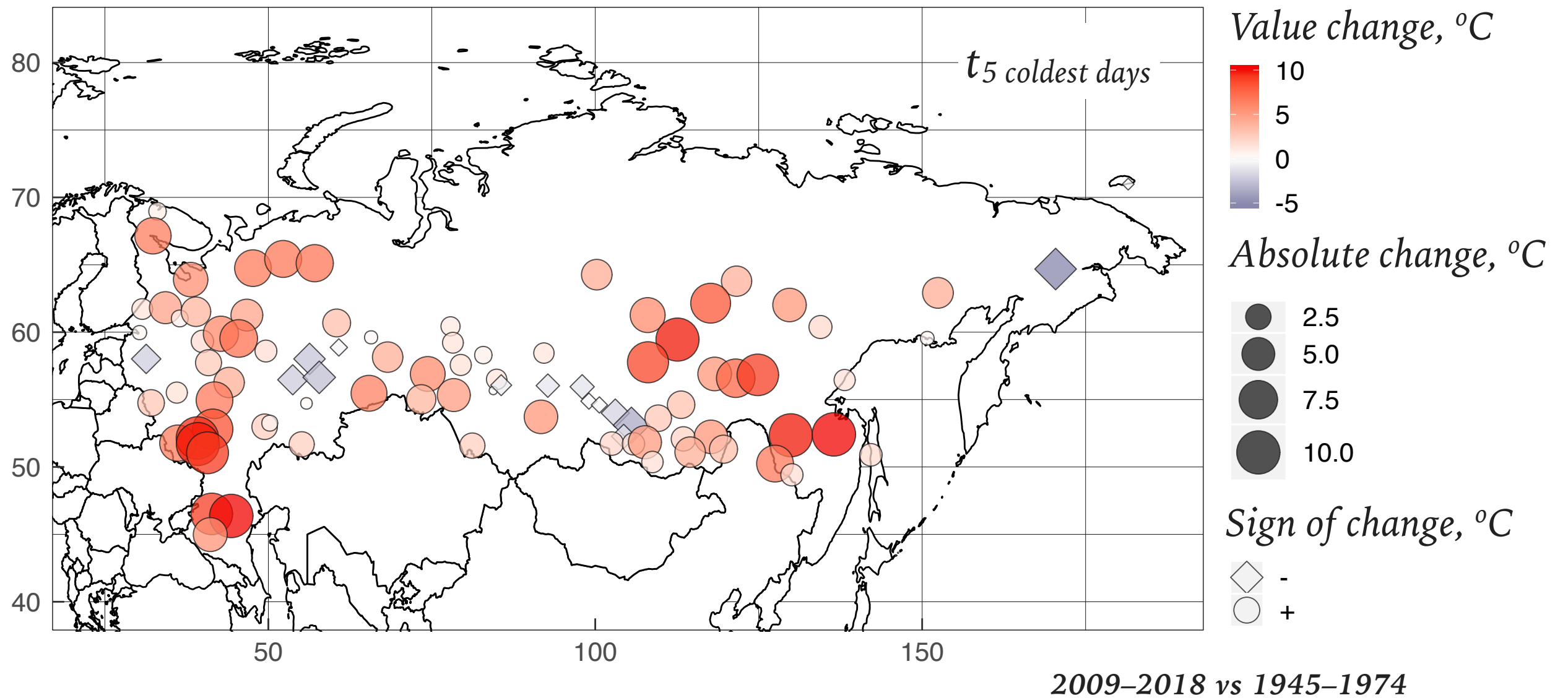


# MOTIVATION

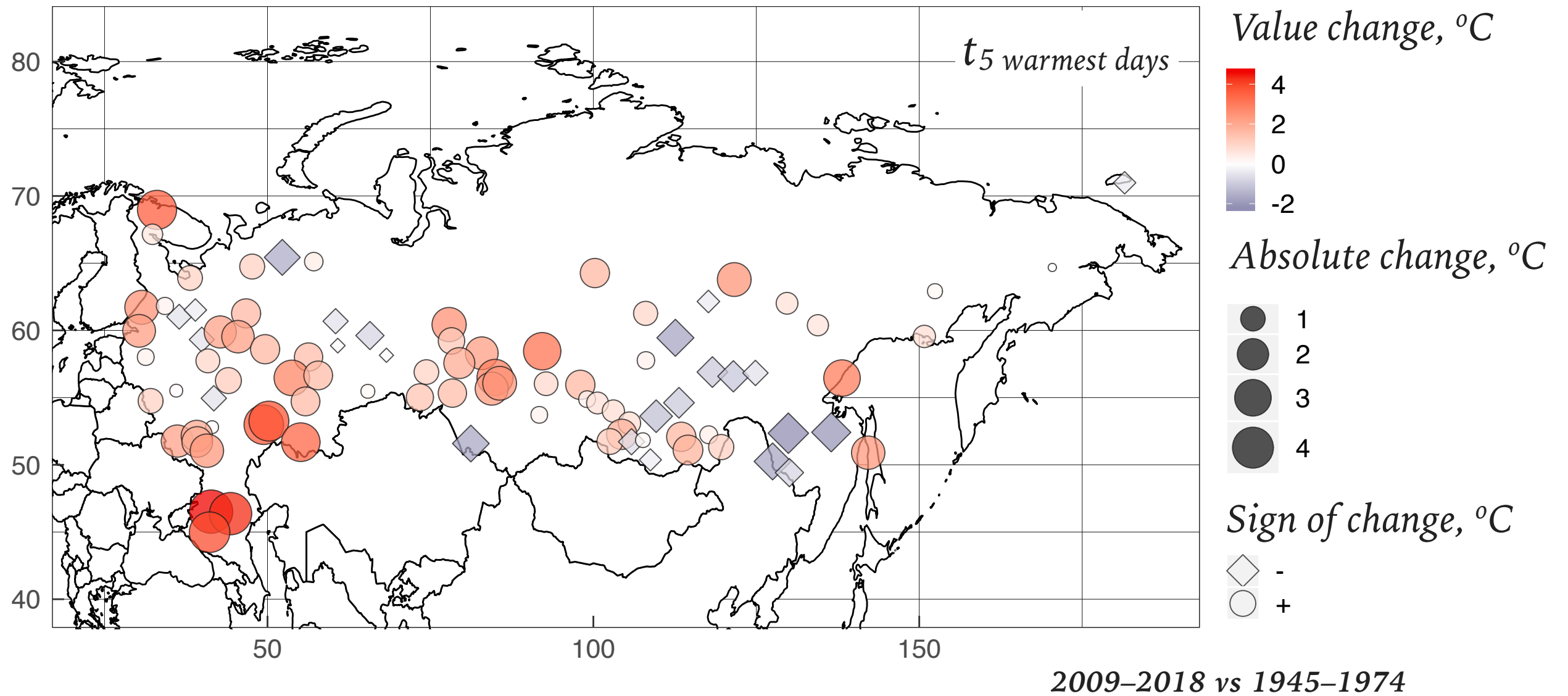
Relative amplitude of the daily electricity demand  $r = (E_{peak} - E_{night})/E_{daily}$



# EMPIRICAL EVIDENCE



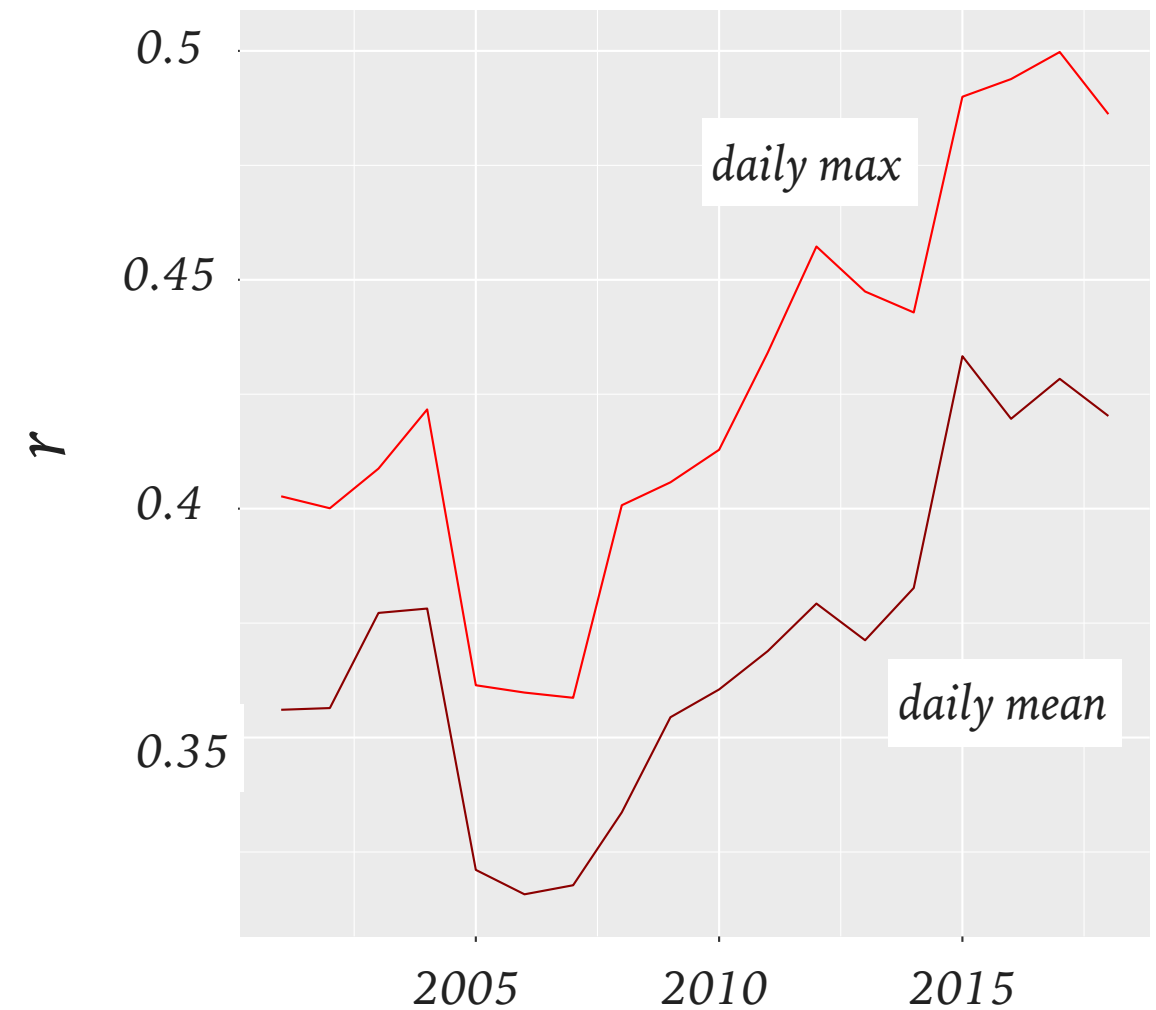
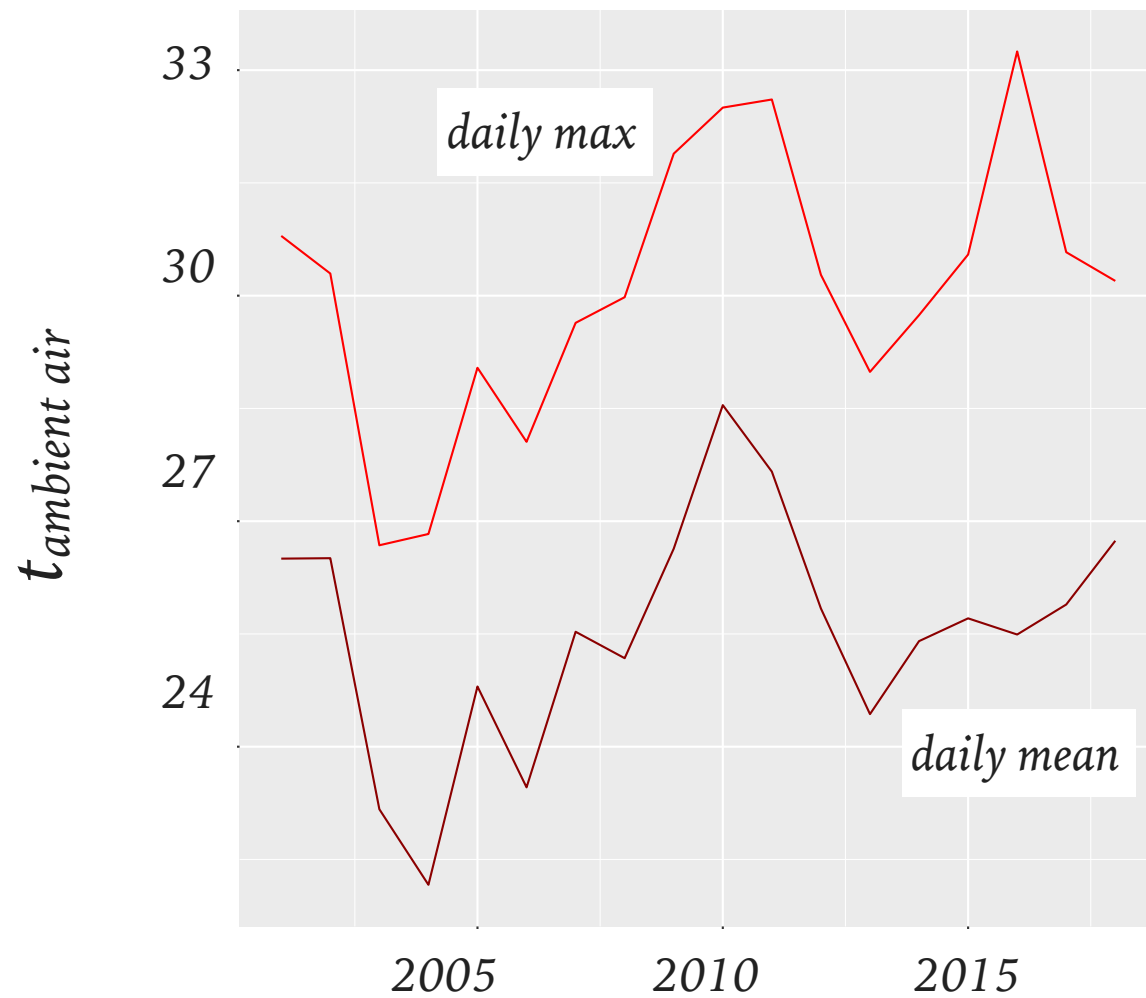
# EMPIRICAL EVIDENCE



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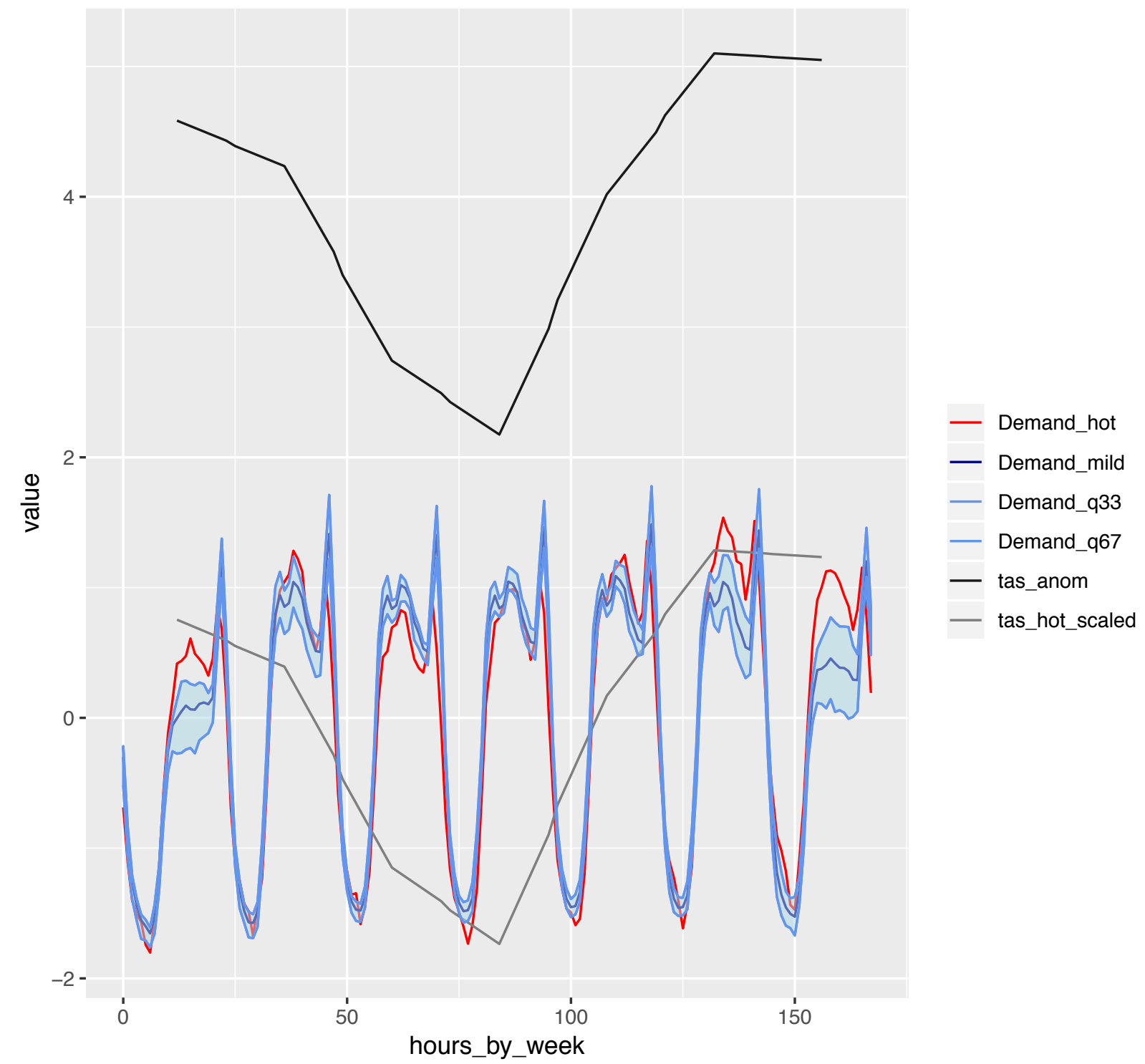
South

$$r = (E_{peak} - E_{night})/E_{daily}$$



# EMPIRICAL EVIDENCE

Hot year 2015 in south (month 8)  
Mean weekly tas is 30.4C (with usual tas being 25.4C)





# DATA

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*Roshydromet quality-checked archive of stations observations*

*Daily resolution*

*Dates considered: the time span between 1945 and 2018*

*Preprocessing of the raw meteorological records: dates completeness check, management of the missed observations etc.*

# DATA

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*Roshydromet quality-checked archive of stations observations*

*Daily resolution*

*Dates considered: the time span between 1945 and 2018*

*Preprocessing of the raw meteorological records: dates completeness check, management of the missed observations etc.*

*to be wrapped as R-package*

# METHODS

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*Kolmogorov-Smirnov (KS) criterion: testing central part of the temperature probability distribution*

*Maximum distance between cumulative distribution function corresponding to the tested samples*

*Anderson-Darling (AD) criterion: modification of the K-S test with more weight to the tails*

*20-years testing time spans: 1945-1964, ..., 1999-2018*

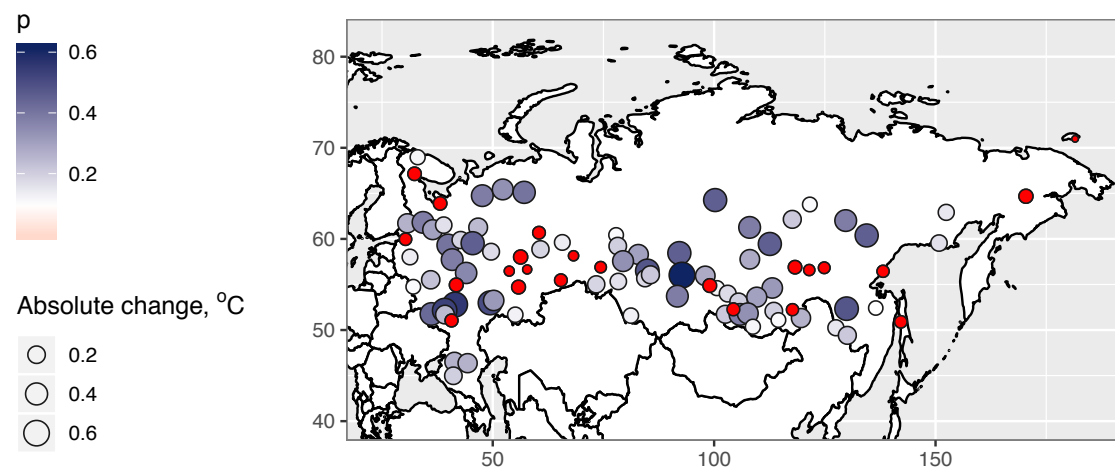
*Aggregation by seasons*

# METHODS

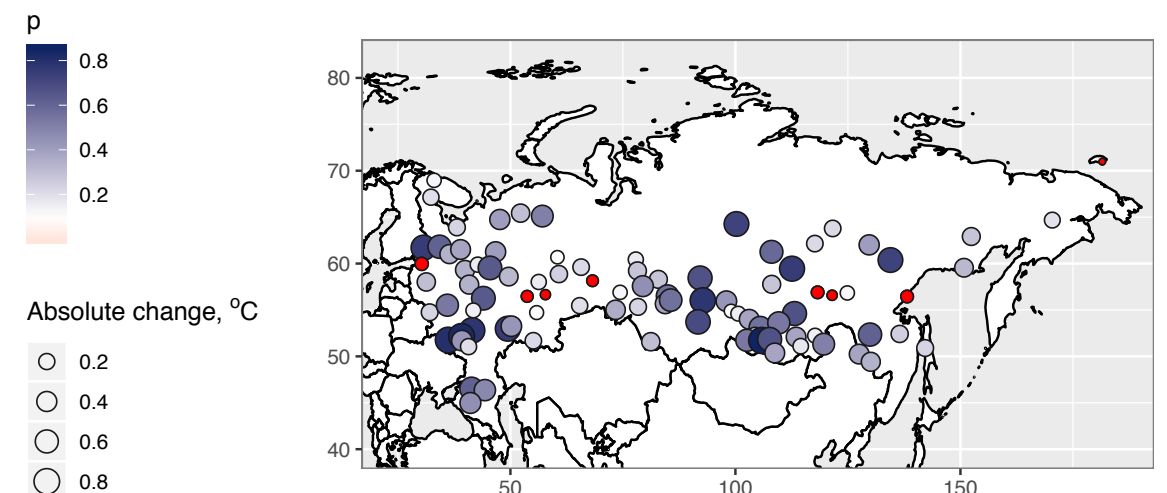
*Normalised temperature values were considered*

*Detrending of the original dataset was found to be quite essential*

*Raw data*



*Detrended data*

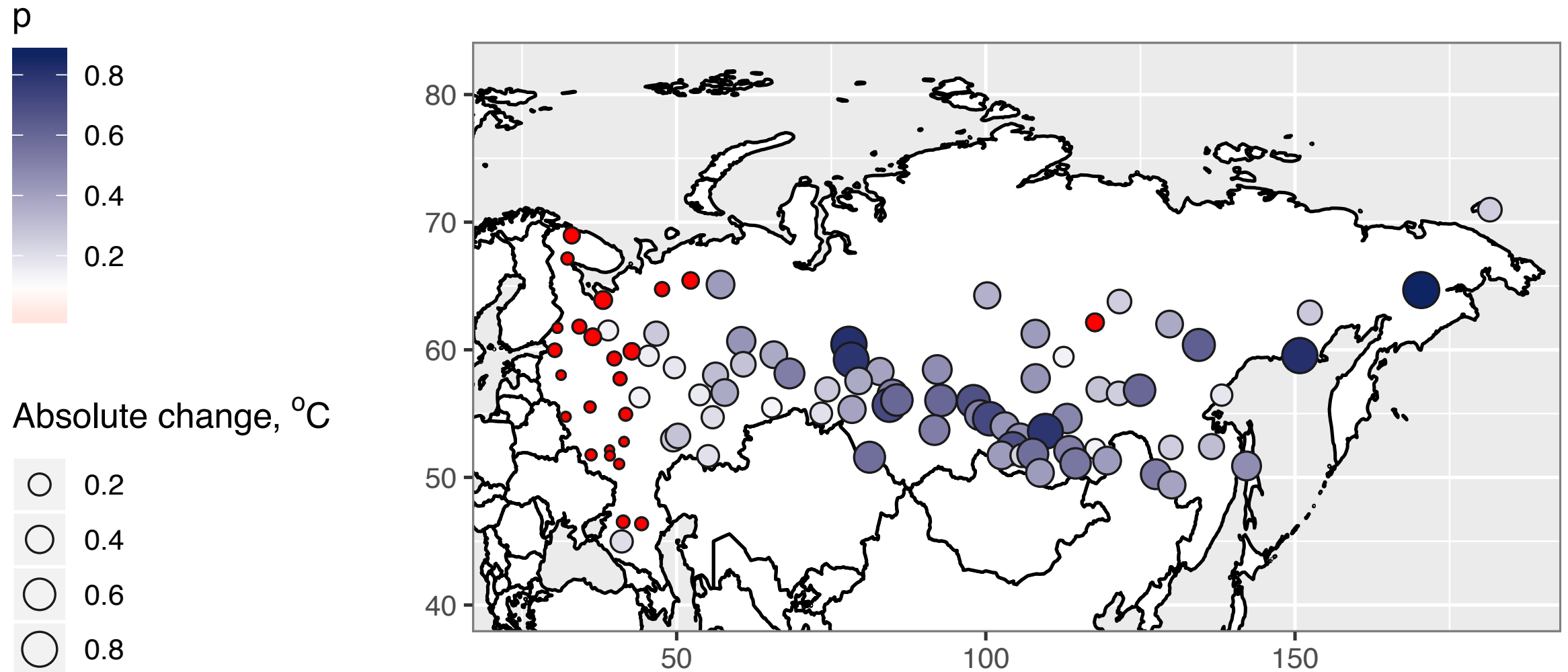


*K-S testing results for the summer season*

Low p values mean considerable evidence against stability of the probability distribution function

# RESULTS

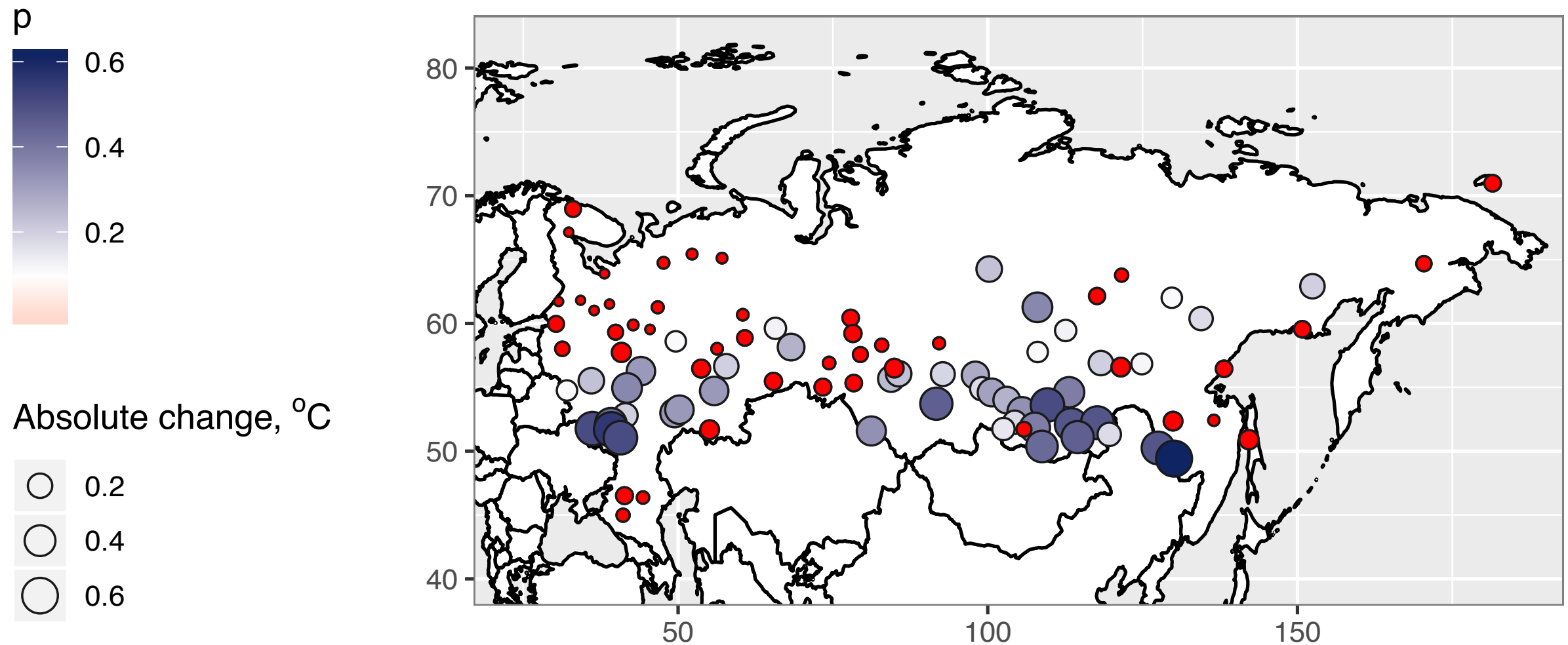
## *K-S testing results for the winter season*



**Red circles** are the stations with changes in probability distribution functions on 10% confidence level

# RESULTS

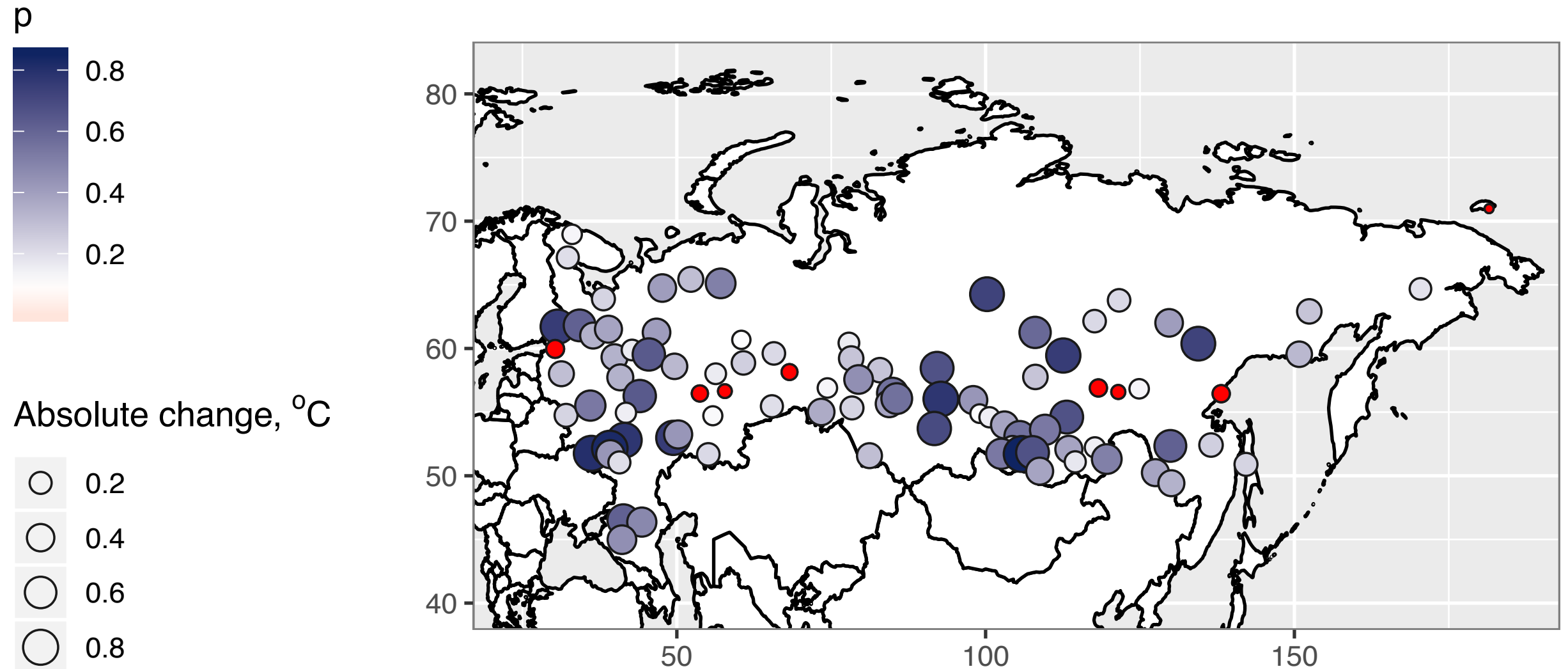
## *K-S testing results for the spring season*



**Red circles** are the stations with changes in probability distribution functions on 10% confidence level

# RESULTS

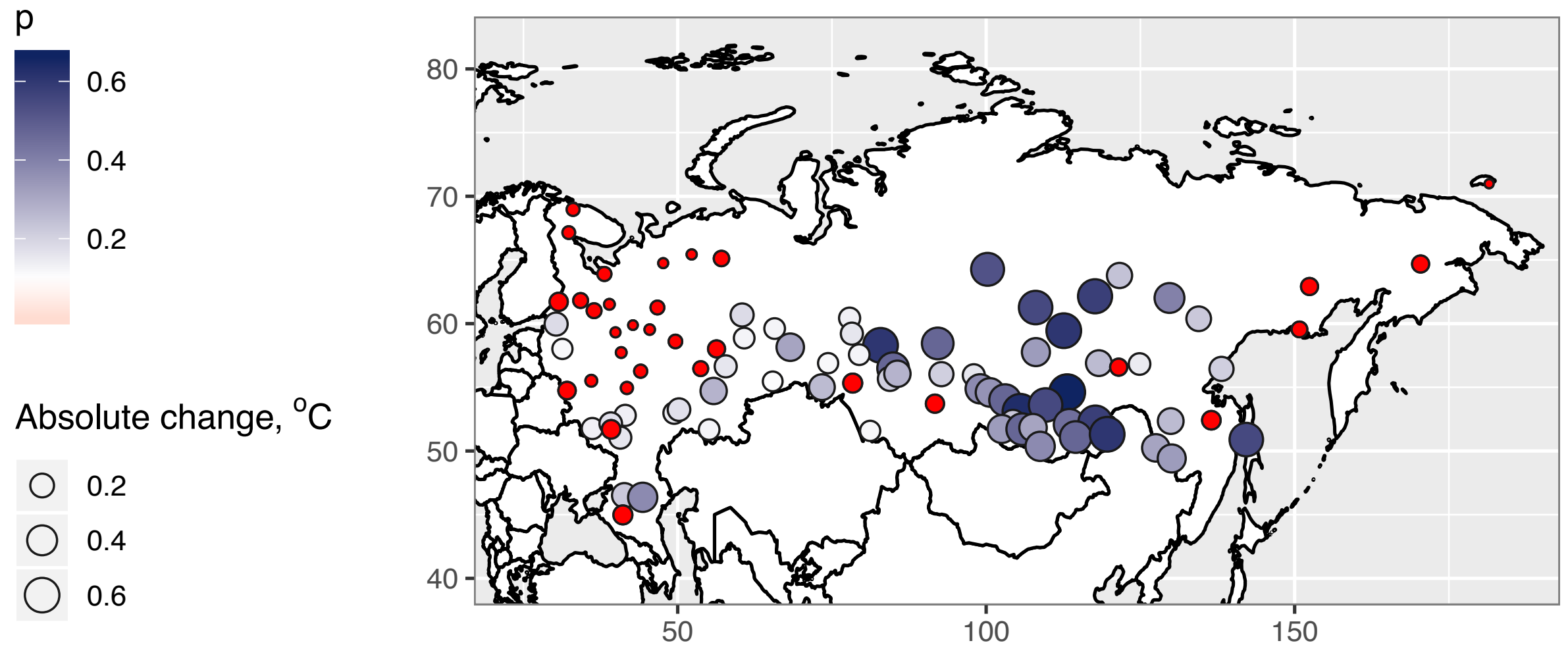
## *K-S testing results for the summer season*



**Red circles** are the stations with changes in probability distribution functions on 10% confidence level

# RESULTS

## *K-S testing results for the autumn season*



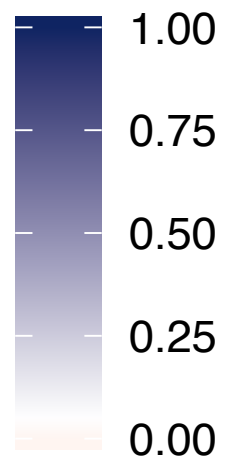
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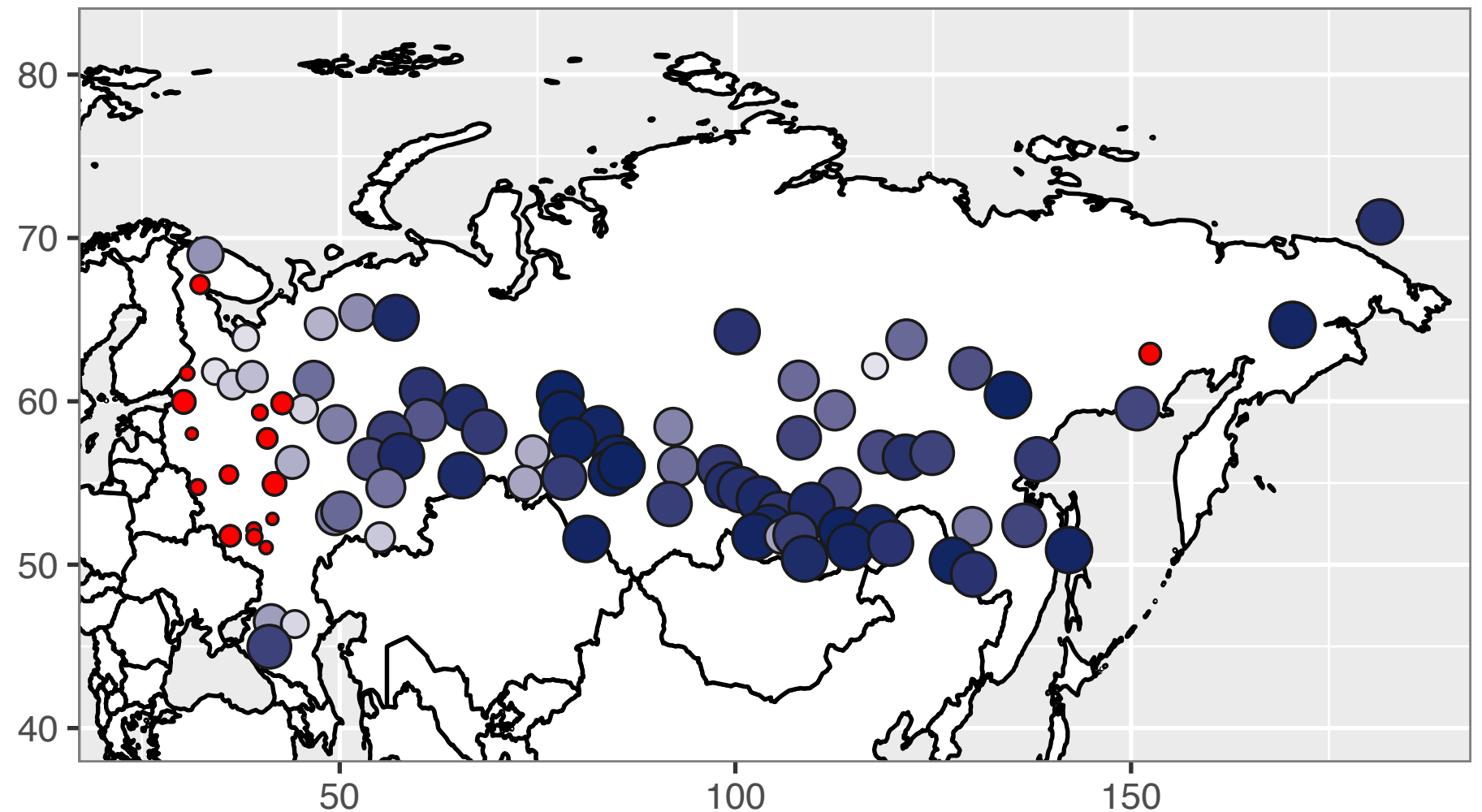
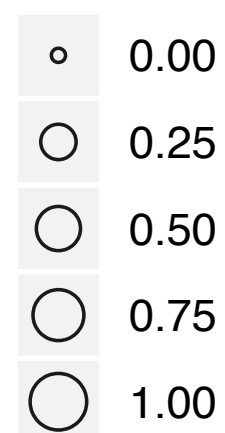
# RESULTS

## *A-D testing results for the winter season*

p of the A-D test



Absolute change, °C

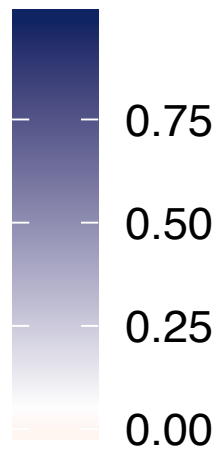


**Red circles** are the stations with changes in probability distribution functions on 10% confidence level

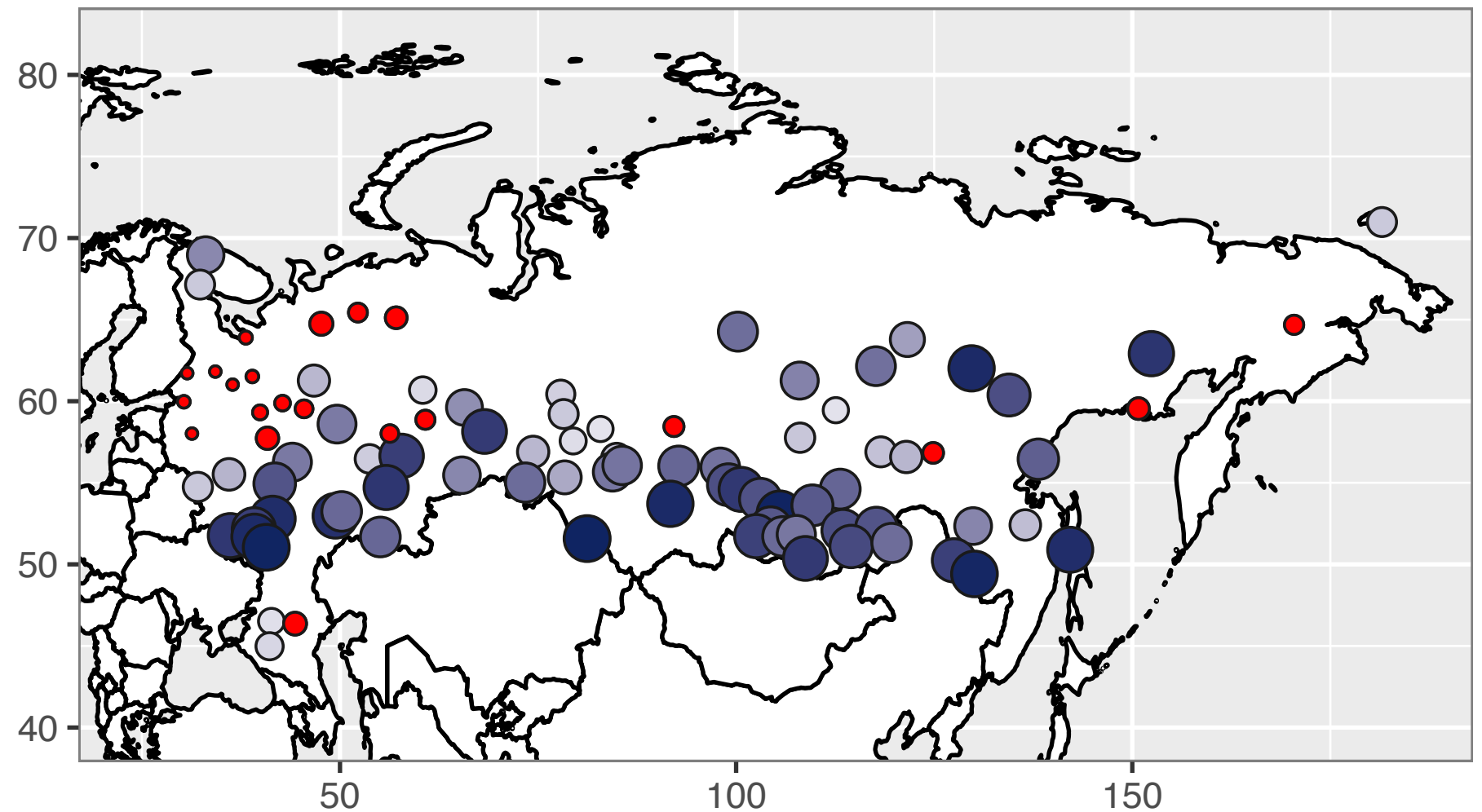
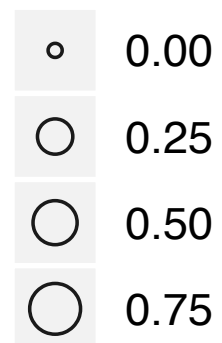
# RESULTS

## *A-D testing results for the spring season*

p of the A-D test



Absolute change, °C

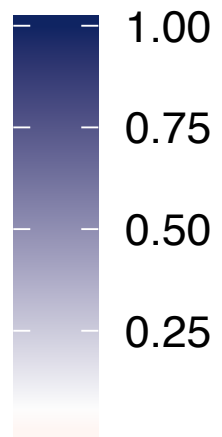


**Red circles** are the stations with changes in probability distribution functions on 10% confidence level

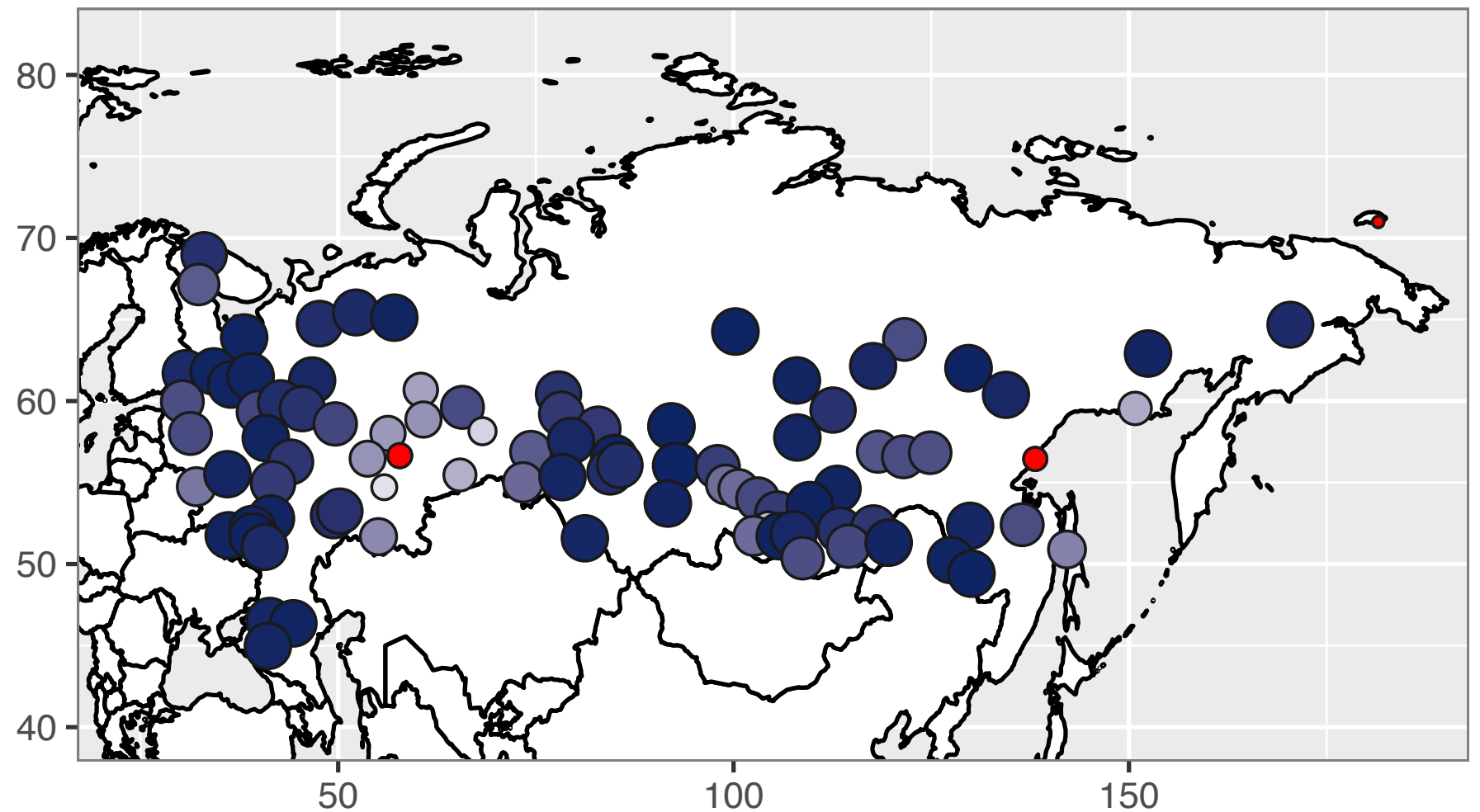
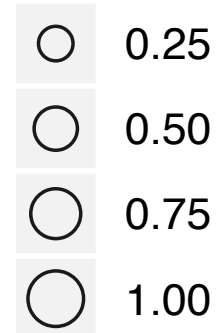
# RESULTS

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Absolute change, °C

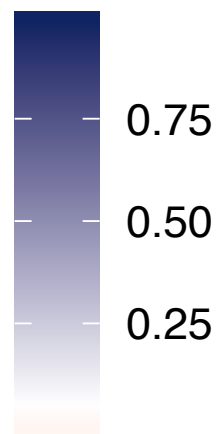


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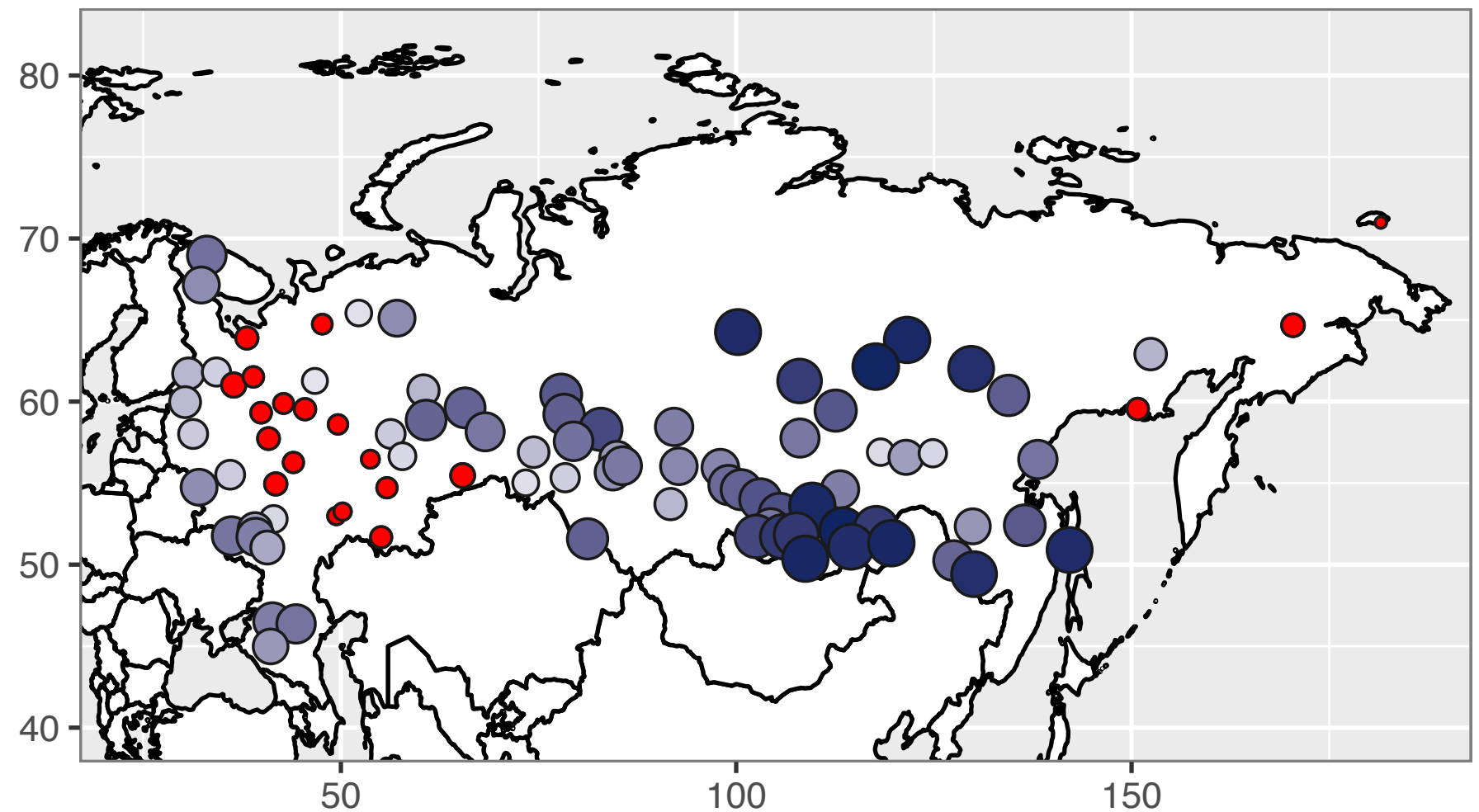
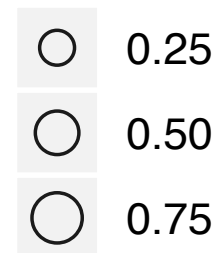
# RESULTS

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p of the A-D test



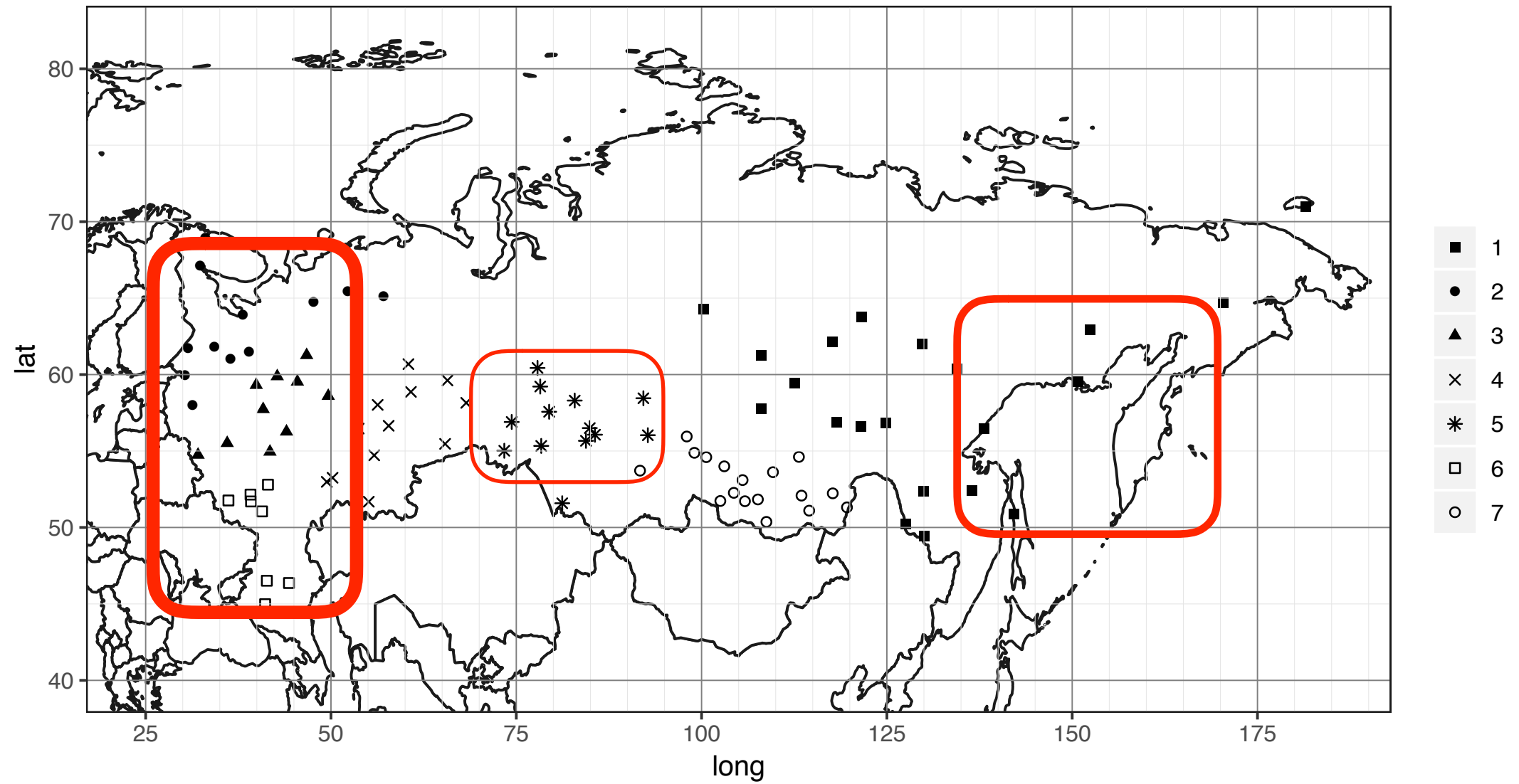
Absolute change, °C



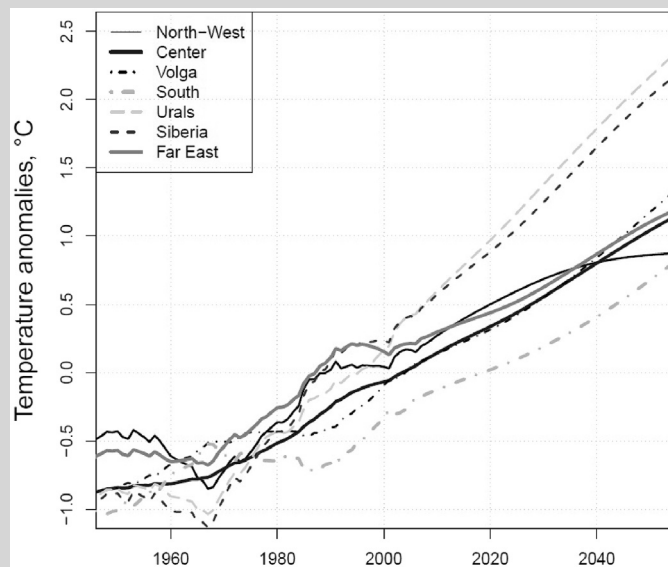
**Red circles** are the stations with changes in probability distribution functions on 10% confidence level

# SUMMARY

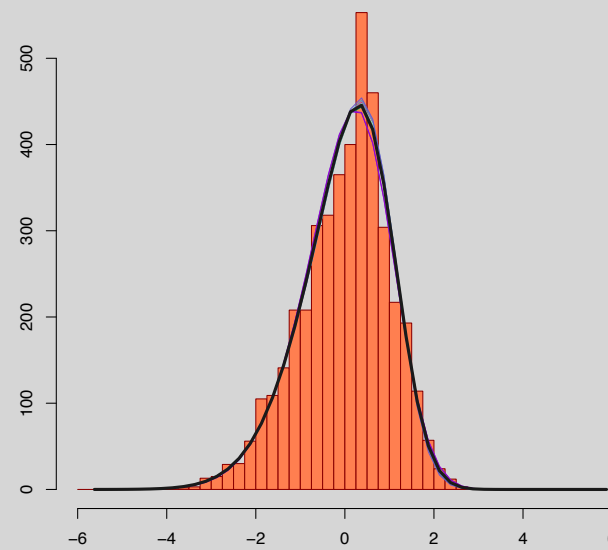
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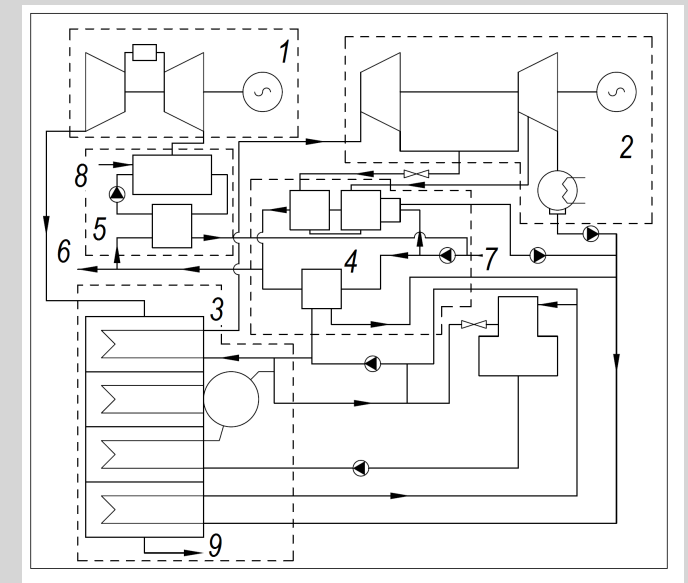
# APPLICATION



Projection of the large-scale climate trends



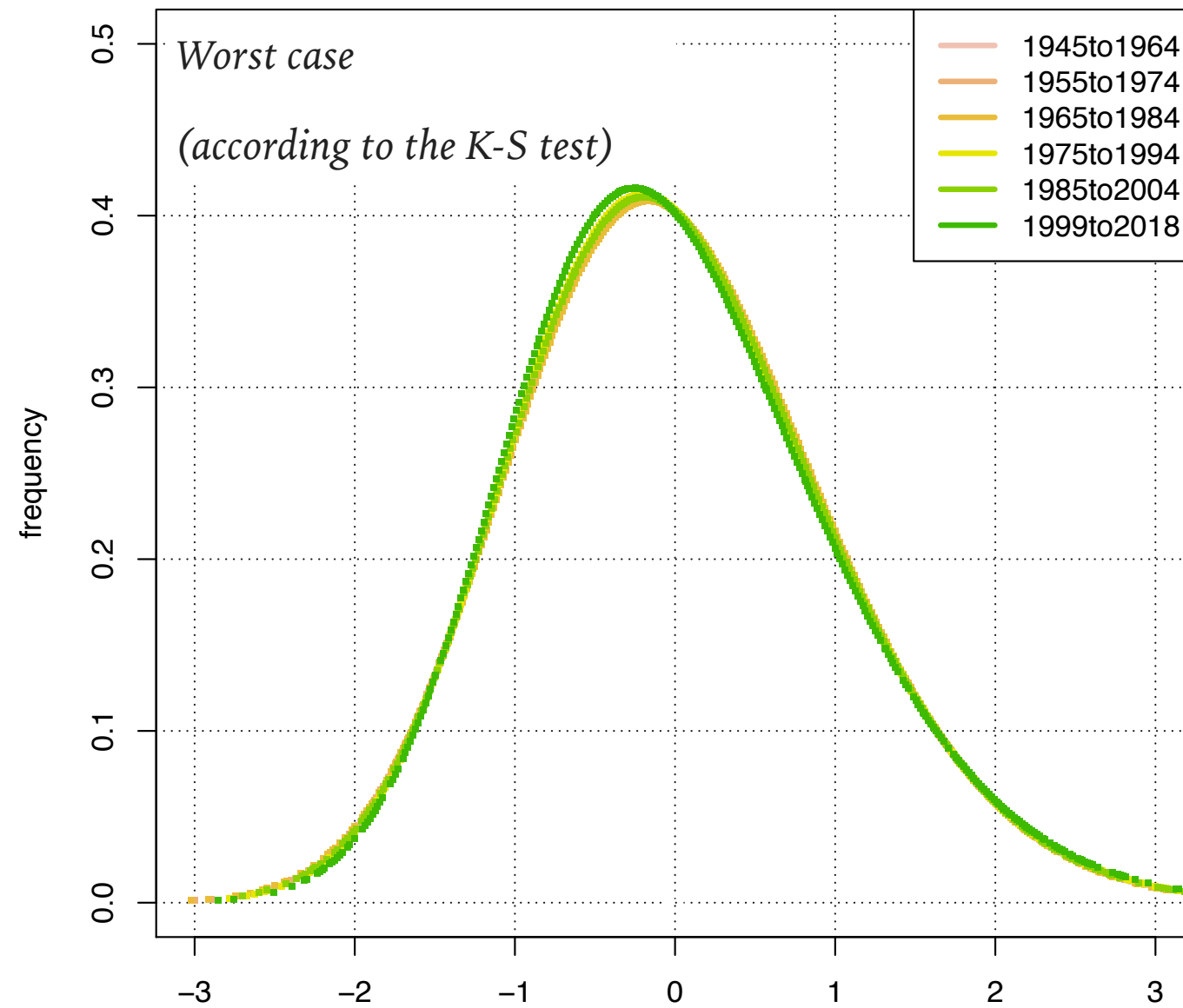
Modelling of the local climate features



Thermal circuit modeling

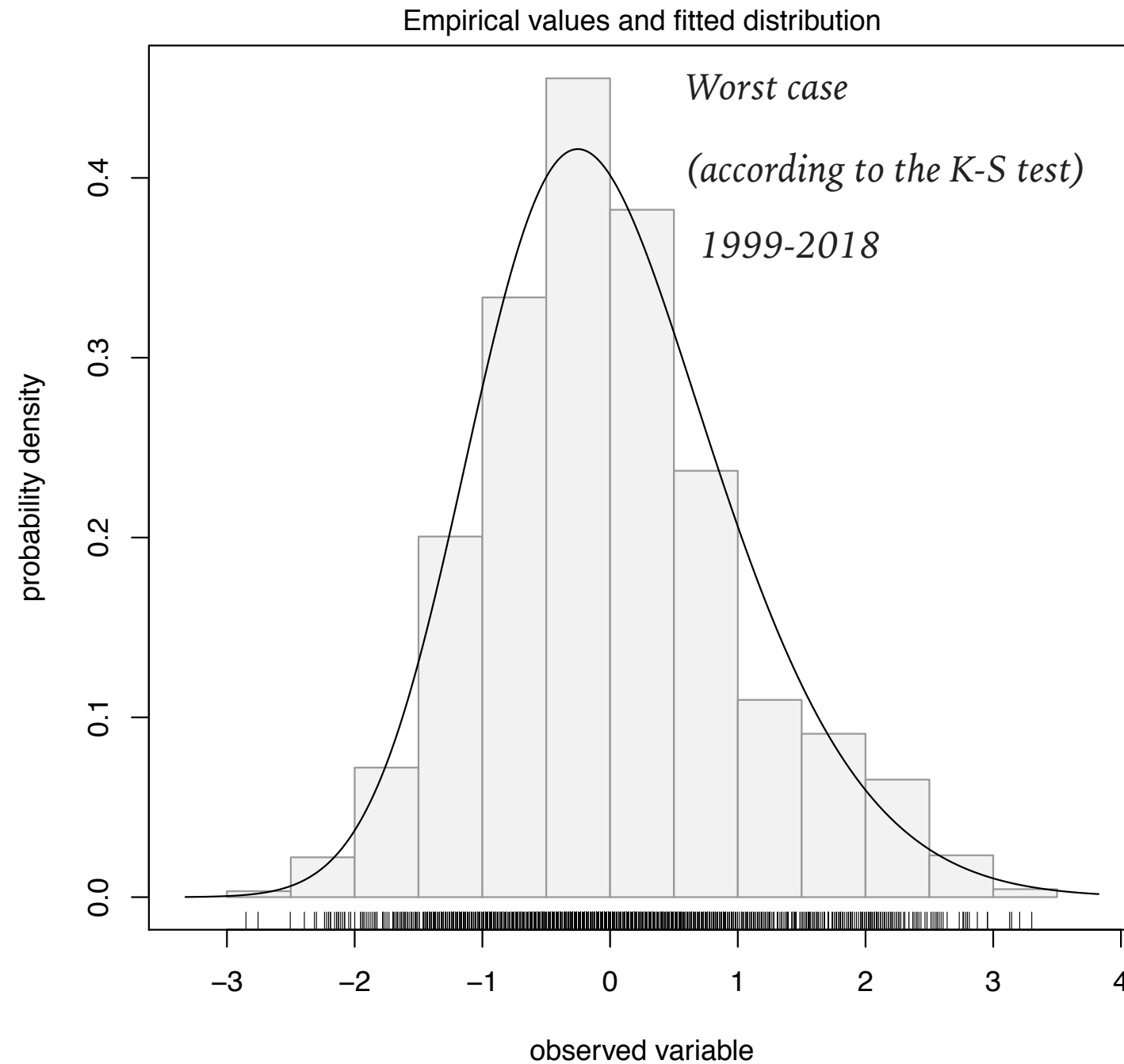
# APPLICATION

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# APPLICATION

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# SUMMARY

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1. There is an evidence of **change in the daily temperature pdfs** across Russian territory during different seasons on 10 to 40% of the meteorological stations
2. Evolution of the **pdfs' central part is more pronounced** as compared with pdfs' tails
3. Mainly **spring** and **winter** seasons are impacted
4. Approximation of the daily distribution with the skewed normal function seem to be quite an appropriate way to account for local meteorological condition



# Thank you for your attention!

The project was supported by RFBR (project 20-08-00320 A) in part of extremal values assessment and by RSF (project 18-79-10255) in part of energy modelling applications