ESF Project „*Establishment of interdisciplinary scientist group and modelling system for groundwater research*”

CLIMATE CHANGE IN A PART OF NORTHERN EUROPE IN THE CONTEXT OF THE SPATIAL DIFFERENCES OF THE CONTEMPORARY CLIMATE

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Project Nr. 2009/0212/1DP/1.1.1.2.0/09/APIA/VIAA/060

Motivation

- Regional Climate Models (RCMs) provide future climate projections – time series of meteorological variables
- How to express the results of RCM in a way that is meaningful for wider community (forestry, agriculture, etc.)?
- Where in contemporary Europe can we find the future climate of Riga (Vilnius, Tallin, Helsinki…)?
  - Where the climate in future will be similar to the contemporary climate in Riga (Vilnius, Tallin, Helsinki…)?
  - Expressing the climate change in time as a movement of points (cities) in geographical coordinates
- Quantifying similarity/dissimilarity of the climate in present and future
- Previous analysis (initiated by Latvian forestry sector) to find regions where the climatic conditions now is similar to those Latvia is going to have in the future
- Similar studies done by other groups for different climate indicators, regions, RCM

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Proposed method of calculating the difference between two climates

Difference in monthly average

Temperature:

$$\Delta T_i^{city} = \frac{1}{12}\sum_{m=1}^{12}\left|T_{i,m} - T_m^{city}\right|$$

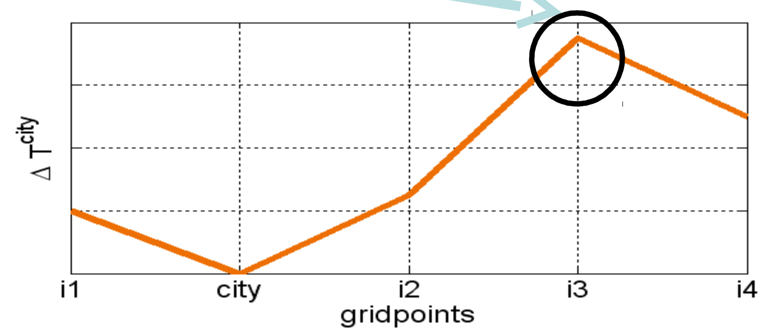
Precipitation:

$$\Delta p_i^{city} = \frac{1}{12}\sum_{m=1}^{12}\left|p_{i,m} - p_m^{city}\right|$$

The maximum of differences between city and grid-point

Penalty function

$$\Delta_i^{city} = 0.5\left(\frac{\Delta T_i^{city}}{\max\left(\Delta T^{city}\right)} + \frac{\Delta p_i^{city}}{\max\left(\Delta p^{city}\right)}\right).$$



For every city which climate is analyzed we construct the penalty function that measures the difference between the climate in the city and every grid point in the region where we expect the movement to take place.
The penalty function is the sum of difference in monthly temperature and precipitation values, weighted with the maximal difference in region.

Data sources and procedures

RCM

RCM Ensemble daily time series (1951-2100, 15 members ENSEMBLES)

Reference

E-OBS gridded observation dataset daily time series (0.5 · 0.5 °, 1981-2010) **OR** BaltAn65 reanalysis (HIRLAM NWP model) daily time series (11 · 11 km, 1981-2005)

Bias correction

Currently there is a necessity for bias correction of the results from Regional Climate Models. For bias – correction a high-resolution dataset containing observational information is needed – an observational dataset or Numerical Weather Prediction (NWP) dataset where data assimilation is used.

Monthly averages

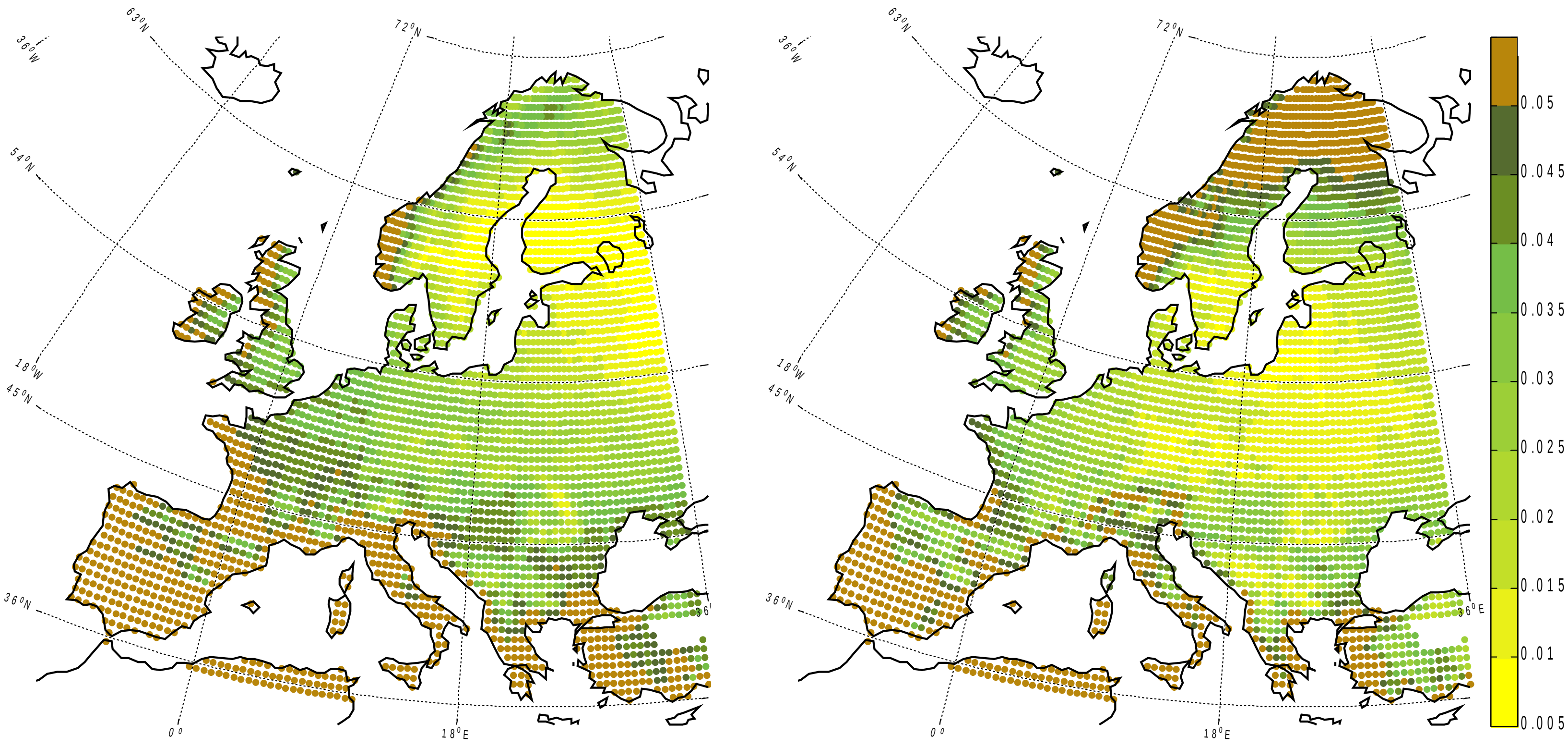
Ensemble median values of bias-corrected RCM for each point of interest,
30-year periods (1981 – 2010, 1982 – 2011, ...)

Monthly averages of E-OBS (1981-2010) **OR** BaltAn65 (1981-2005)

Penalty function

Spatial distribution of climate difference penalty function for each city of interest

Results. Tampere. Climate difference penalty function.



Less similar climate

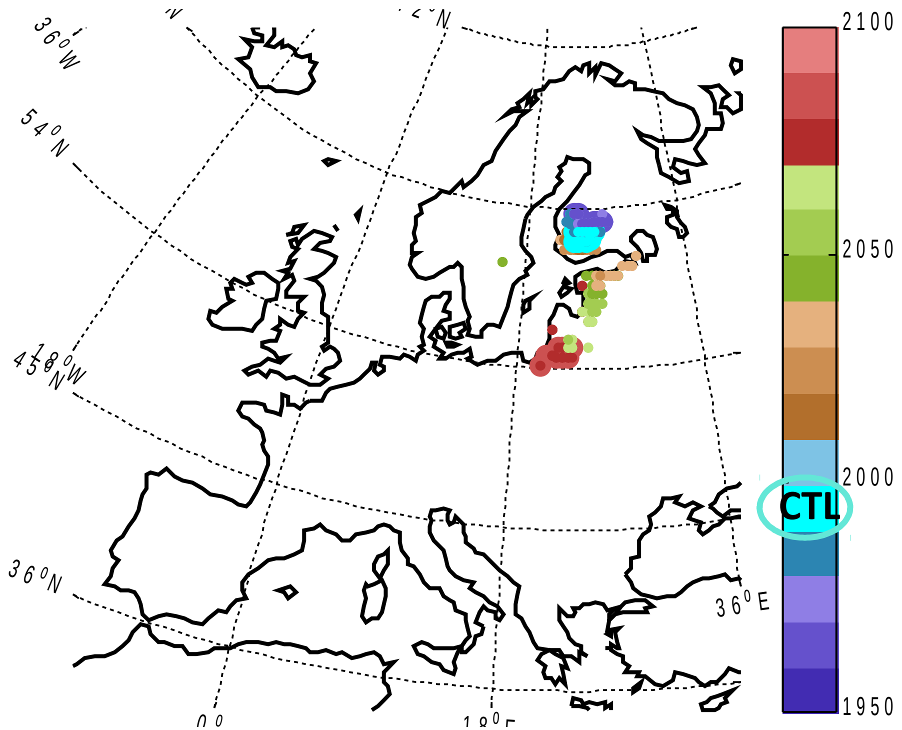
More similar climate

(a) 1981 - 2010 (b) 2071-2100

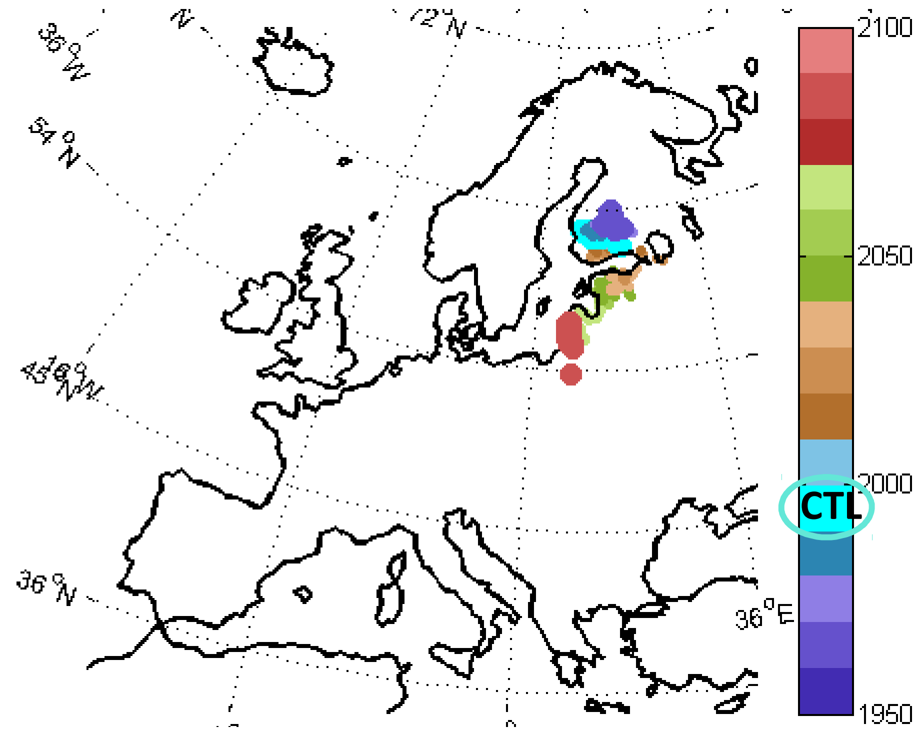
Climate distance between present climate in Europe (1981-2010 E-OBS data) and
(a) present climate in Tampere (b) future climate in Tampere

According to RCM the future climate of Tampere will be more similar to the present day climate of Lithuania than the present climate of Finland.

Results. Tampere. Spatial trajectory of temporal climate change



(a) E-OBS

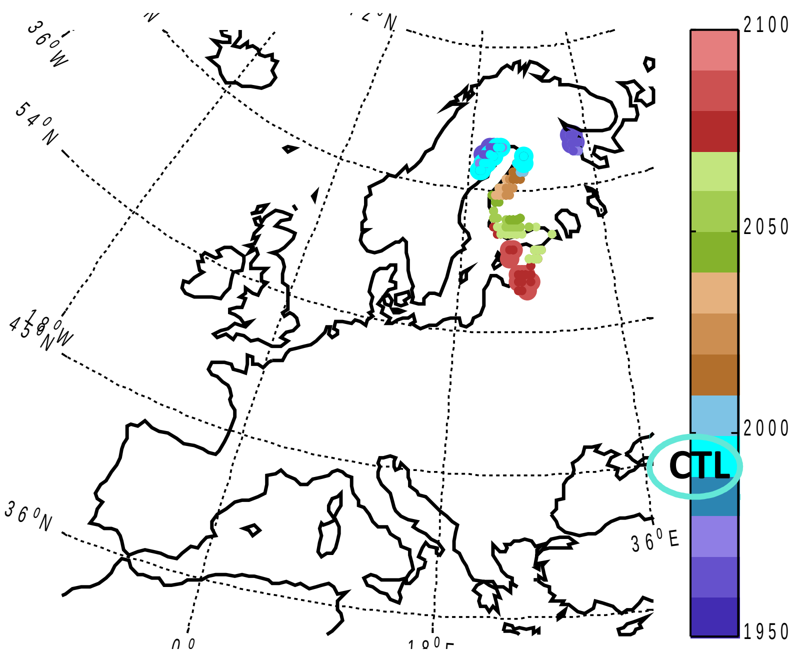


(b) BaltAn65

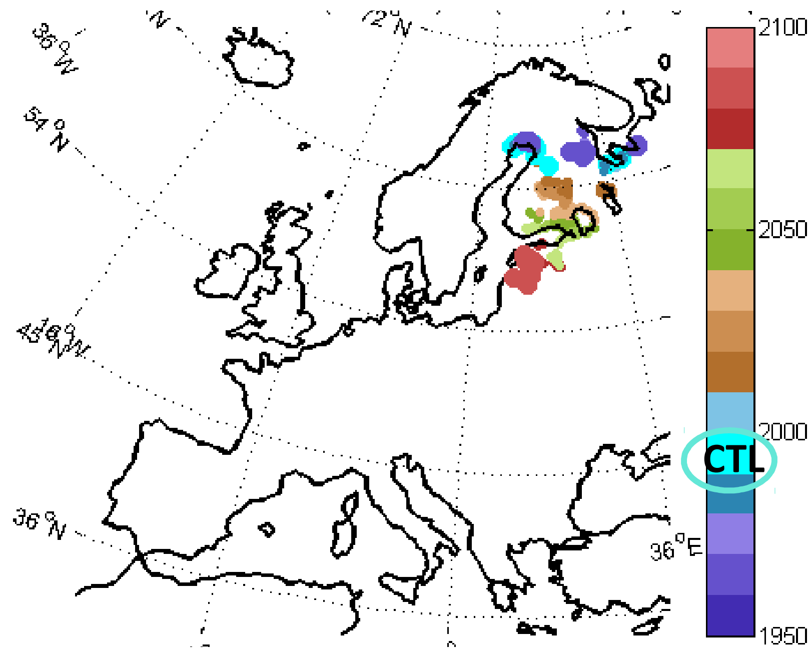
Patterns of the movement of Tampere representing the temporal change of the climate between 1951-1980 and 2071-2100 according to (a) observations (b) NWP model reanalysis

For each time period 10 points with the smallest value of penalty function are plotted
For Tampere there are no significant differences between results from observations and re-analysis

Results. Oulu. Spatial trajectory of temporal climate change



(a) E-OBS

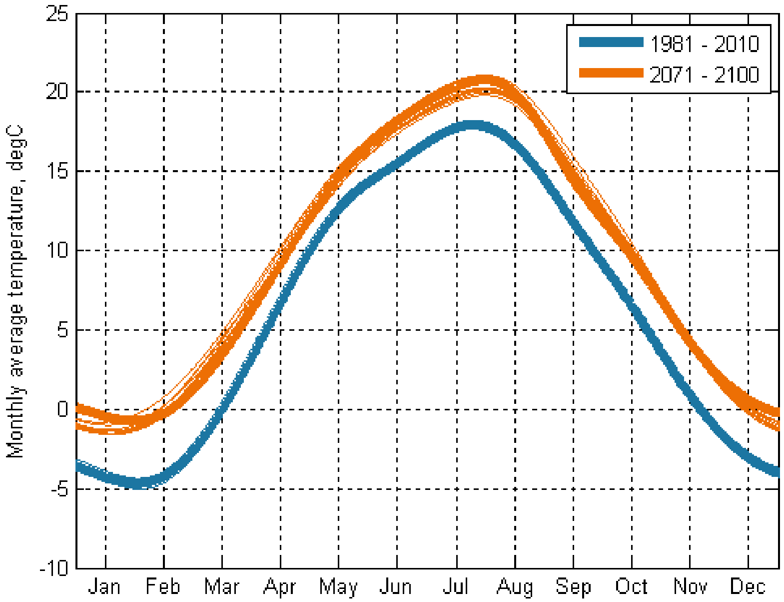


(b) BaltAn65

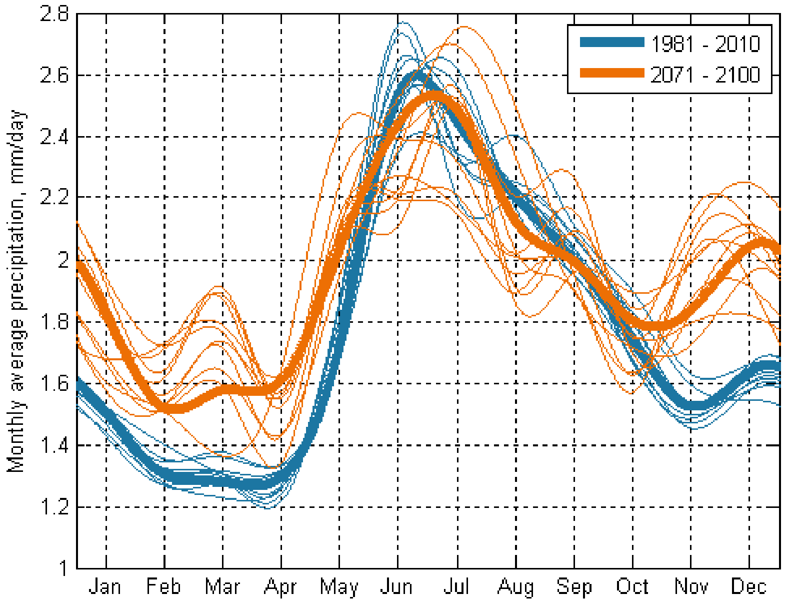
Patterns of the movement of Oulu representing the temporal change of the climate between 1951-1980 and 2071-2100 according to (a) observations (b) NWP model reanalysis

For Oulu there are some differences between observational and NWP datasets that could be explained by the higher resolution of NWP dataset.

Results. Vilnius. Monthly averages of points with similar climate.



(a) temperature

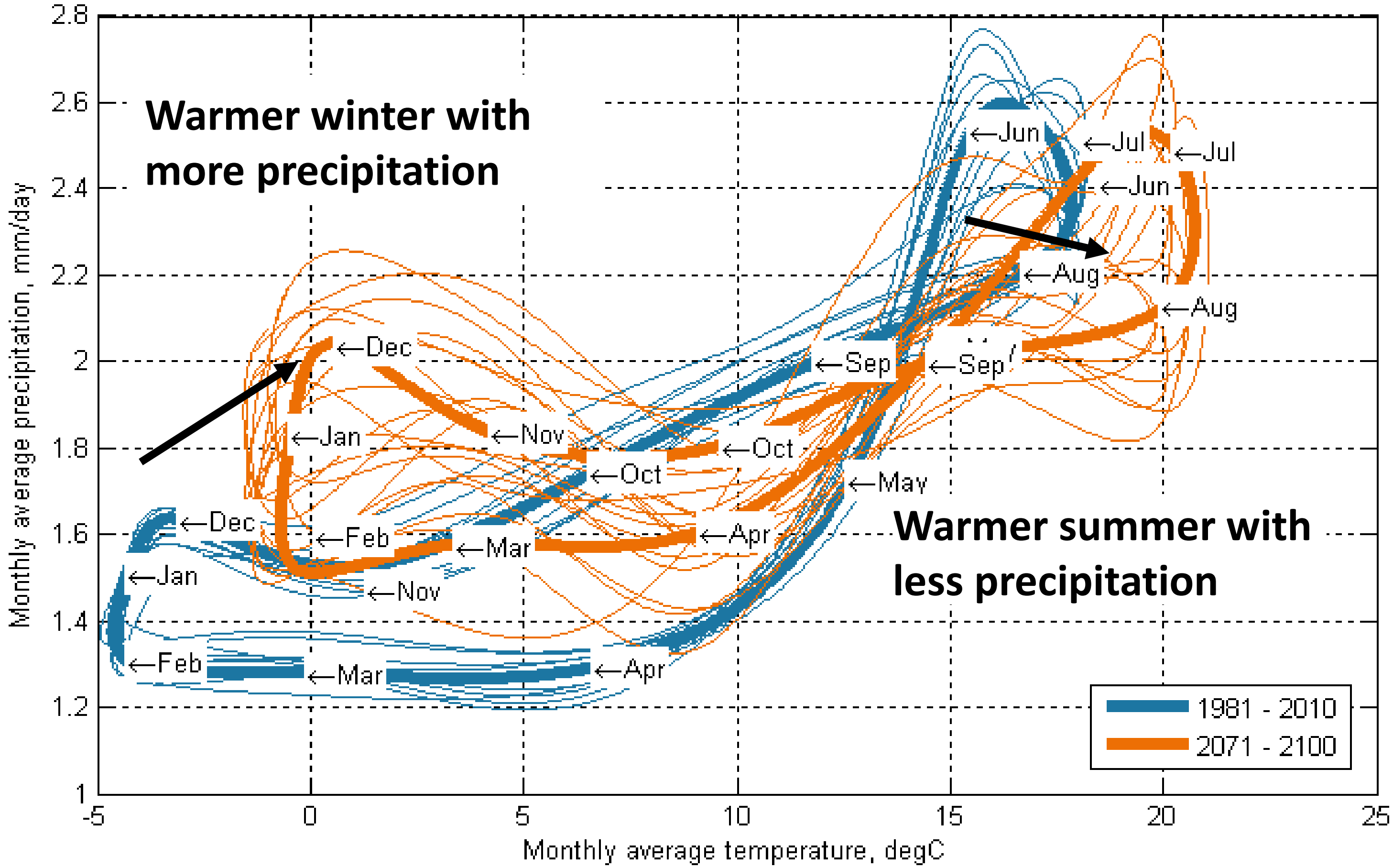


(b) precipitation

Monthly average values of 10 climatically closest points to Vilnius , 1951-1980 (blue) and 2071-2100 (red). Observational data from the climatically closest points are plotted with thin lines, median of the bias-corrected RCM ensemble – with thick line.

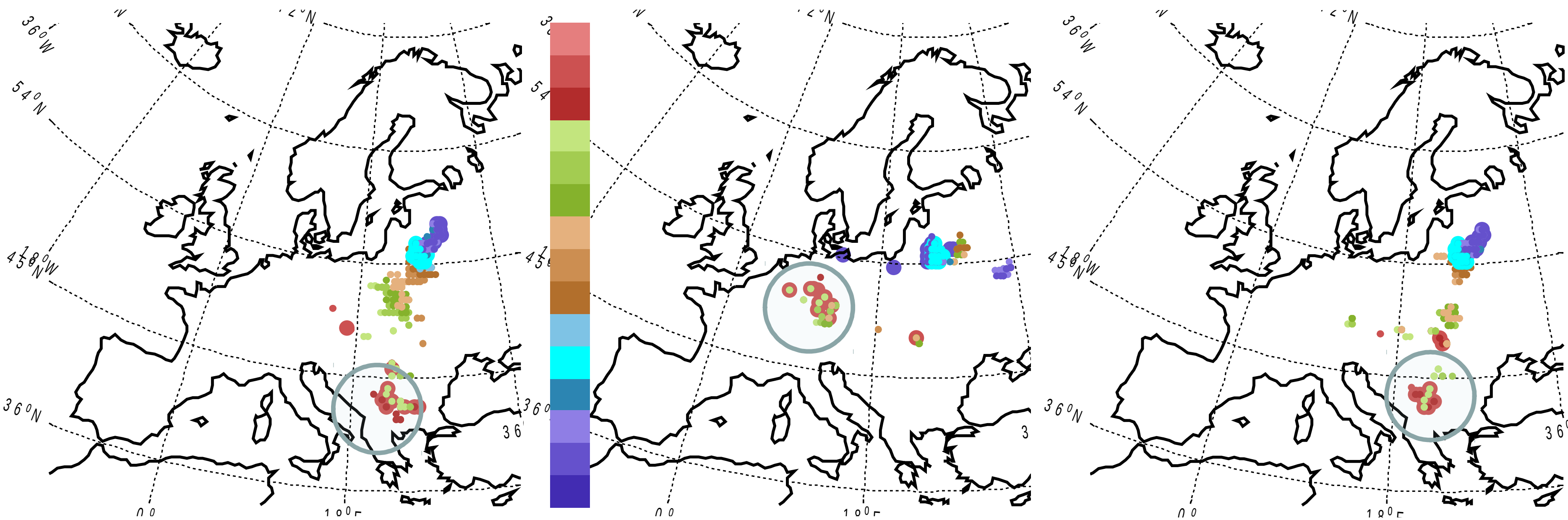
Analysis of the climatically closest points to Vilnius reveals a better match between current Europe and future Vilnius temperatures than current Europe and future Vilnius precipitation values.

Results. Vilnius. Comparison of RCM data and observational data of the nearest points



Temperature and precipitation of the 10 nearest locations to Vilnius in the periods 1981-2010 (blue) and 2071-2100 (orange). Observational data from the climatically closest points are plotted with thin lines, median of the bias-corrected RCM ensemble – with thick line.

Results. Vilnius



(a) Temperature (b) precipitation (c) Temperature and precipitation

$$\Delta_i^{city} = 0.5\left(\frac{\Delta T_i^{city}}{\max\left(\Delta T^{city}\right)} + \frac{\Delta p_i^{city}}{\max\left(\Delta p^{city}\right)}\right)$$

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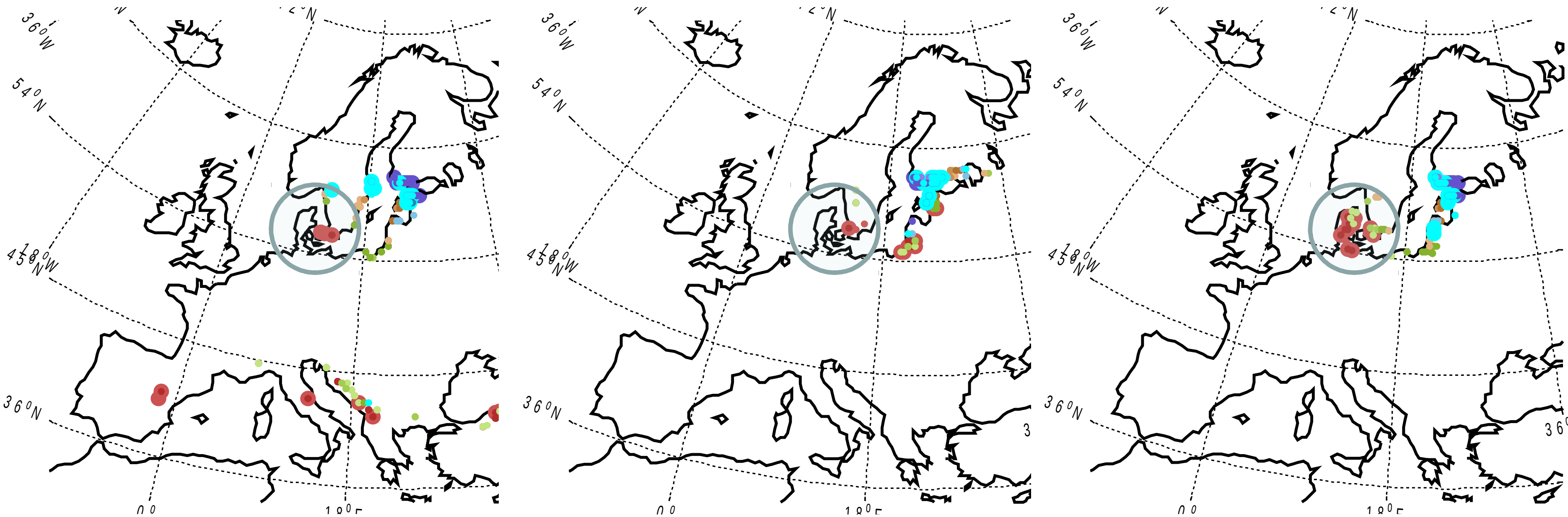
Spatial distribution of the 10 climatically closest points to Vilnius (1951-1980) until (2071-2100)

For Vilnius the points that are closest in temperature do not coincide with points that are closest in precipitation.

Results. Tallin



(a) Temperature

(b) precipitation

(c) Temperature and precipitation

$$\Delta_i^{city} = 0.5\left(\frac{\Delta T_i^{city}}{\max\left(\Delta T^{city}\right)} + \frac{\Delta p_i^{city}}{\max\left(\Delta p^{city}\right)}\right)$$

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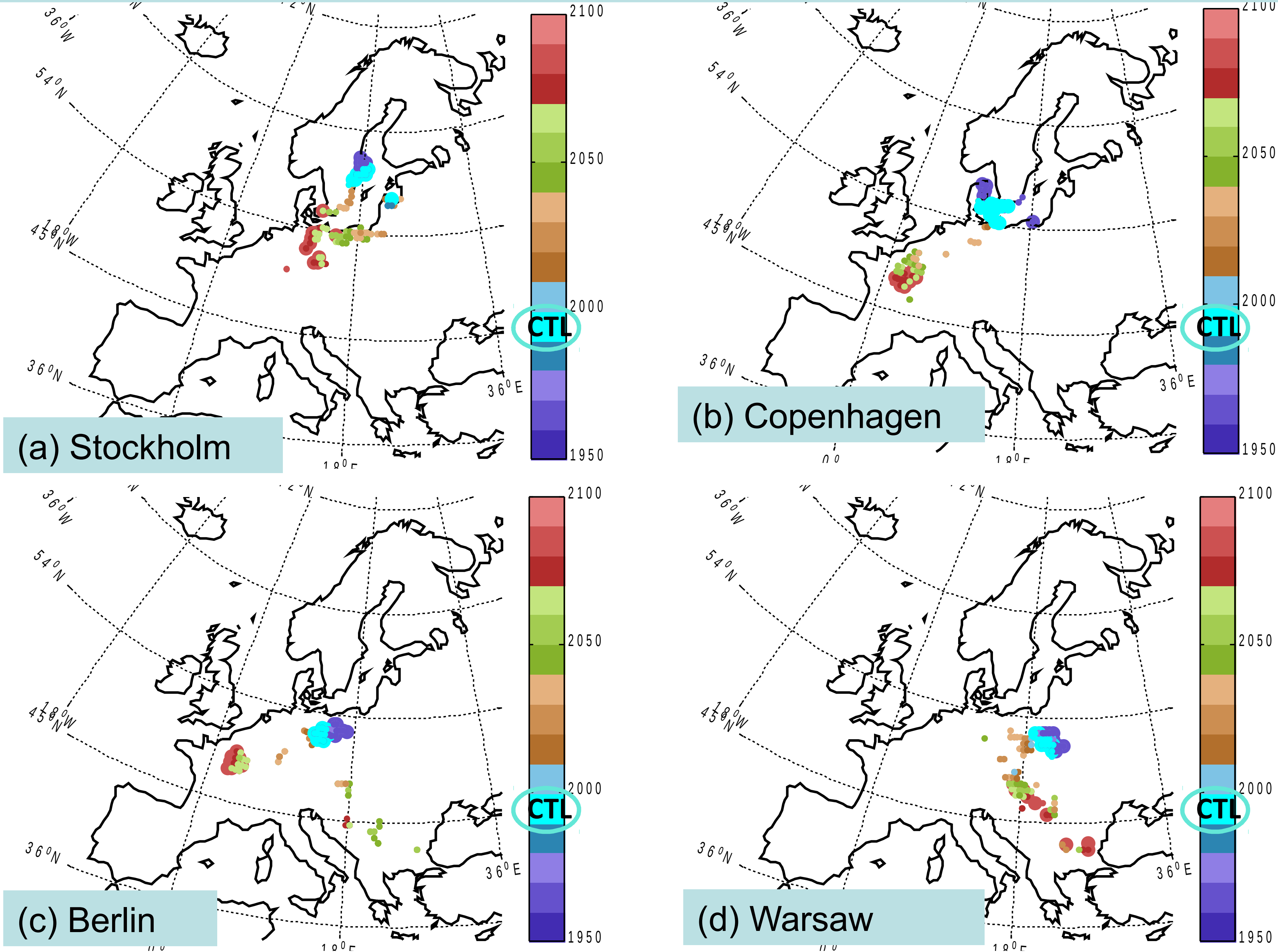
Spatial distribution of the 10 climatically closest points to Tallin (1951-1980) until (2071-2100)

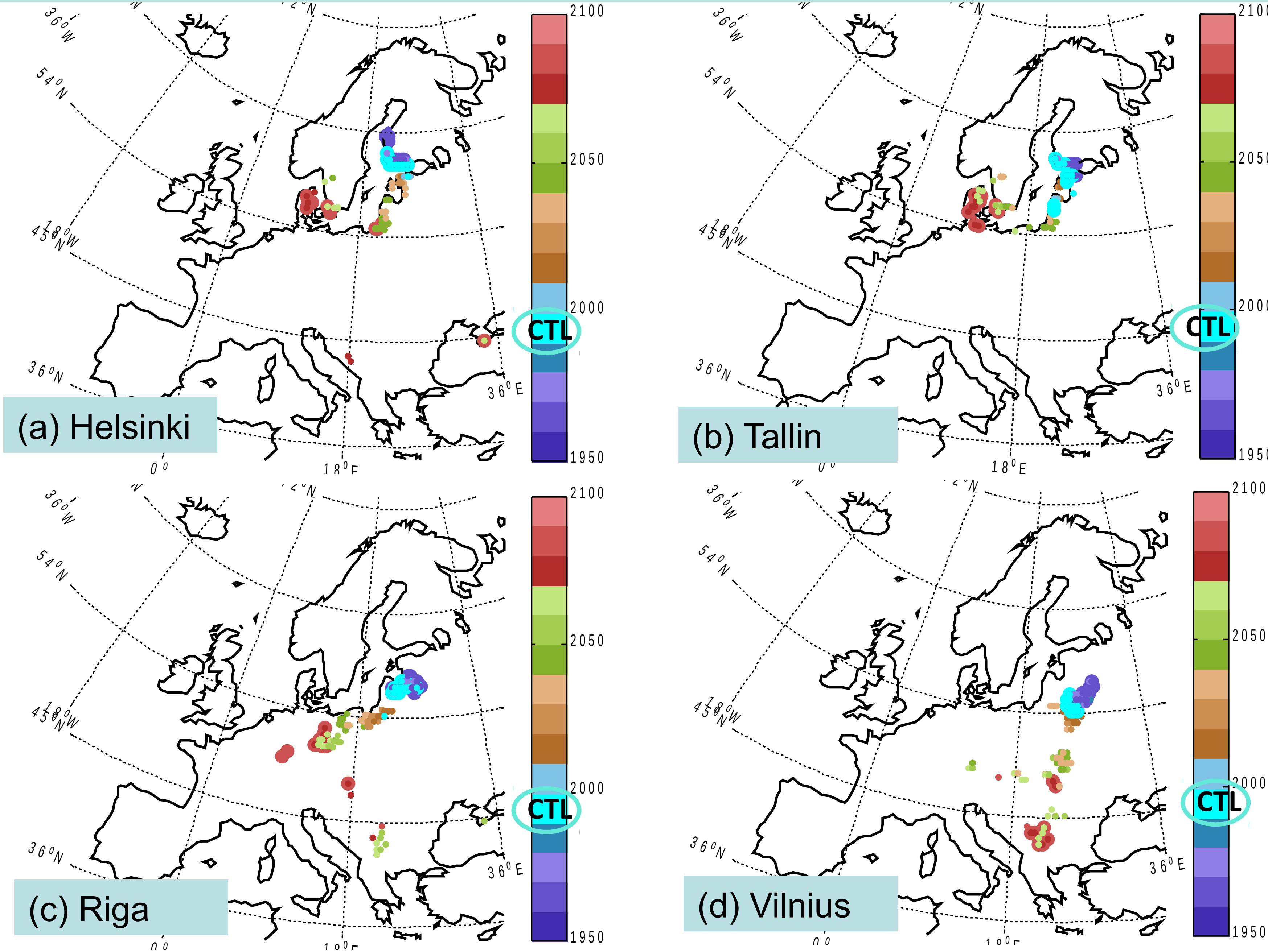
For Tallin there is some overlap between the points that are closest in temperature and the points that are closest in precipitation.

Results

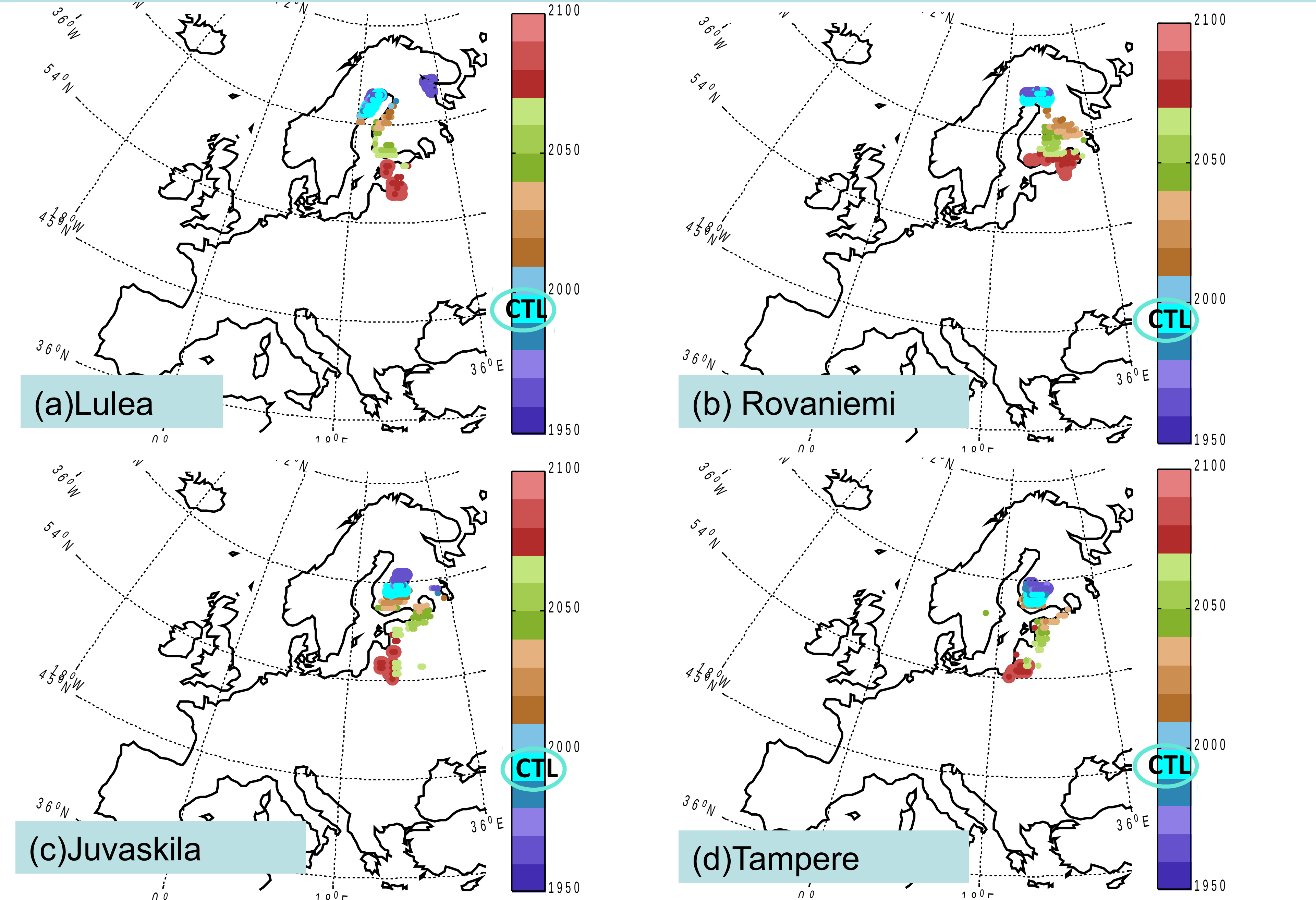


(a) Stockholm
(b) Copenhagen
(c) Berlin
(d) Warsaw
2100
2050
2000
1950
CTL
36°W
54°N
45°N
18°W
36°N
36°E
18°E

Results


(a) Helsinki
(b) Tallin
(c) Riga
(d) Vilnius
2100
2050
2000
1950
CTL
36°W
54°N
45°N
18°W
36°N
36°E
0°
18°E

Results



(a)Lulea
(b) Rovaniemi
(c)Juvaskila
(d)Tampere
2100
2050
2000
1950
CTL
36°W
54°N
36°N
36°E

Conclusions

- The method for calculating the distance between the climates is presented.
- Climatically close locations in contemporary Europe (1981-2010) of Northern European cities have been found (according to a median of ensemble of the model runs).
- Imaginary patterns of the movement of the cities representing the temporal change in time 1951-1980 until 2071-2100 have been analysed.
- The closest points of T, p combination automatically do not equally overlap with the closest according to each of components of penalty function - ΔT and Δp.
- Lulea, Juvaskila and Tampere (among the analysed set of locations) are those with the future 2071-2100 climate the closest to the contemporary climate of Latvia.
- Imaginary trajectory of the climate change is oriented in South/SouthWest direction except Warzsaw. Its trajectory moves towards South East direction.

Acknowlegments

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- BaltAn65 reanalysis (HIRLAM NWP model) daily data series for Northern Europe has been available thanks to colleagues in Tartu University

Thank you for your attention!

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