KU LEUVEN

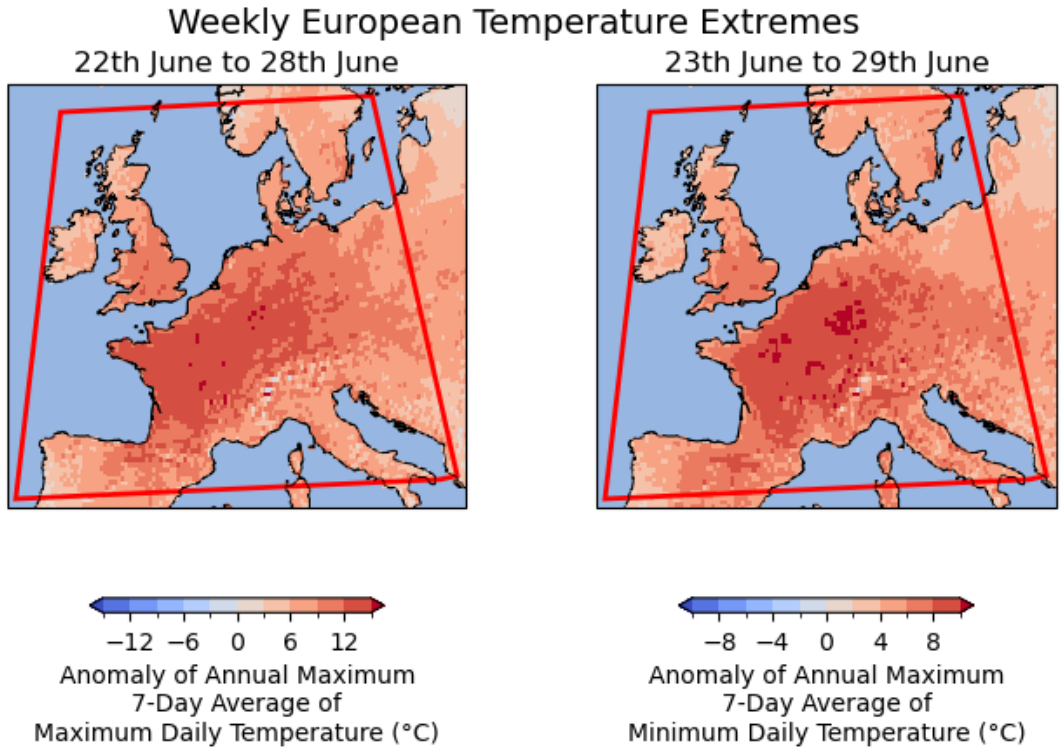
CORDEX.be II

What atmospheric dynamics can teach us about future heatwaves in Belgium

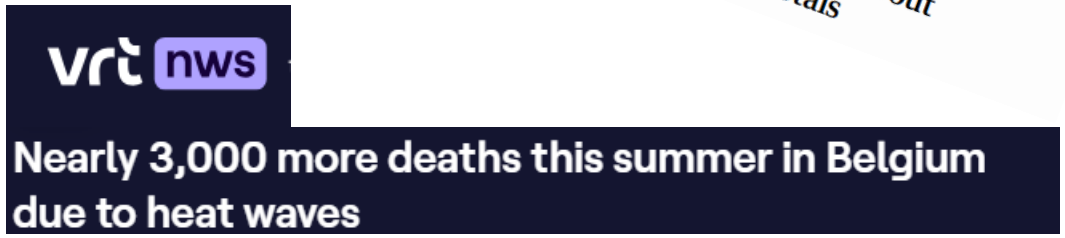
Fien Serras, Inne Vanderkelen, Wouter Lampaert, Nicole van Lipzig



Record breaking heatwave of 2026







Temperature anomalies wrt 1991-2020 June climatology

WWA

➔ What type of future heatwaves to expect?

➔ Will they be driven by same atmospheric conditions as today?

Building further on GCM selection

- Framework for GCM selection for Belgium based on Lamb Weather Type classification and the strength of climate change signal
- Focus on extreme heat

➔ Selected GCMs:

EC-Earth3-Veg SSP5-8.5
for GWL2 and GWL3

EC-Earth3-Veg SSP2-4.5
for GWL2 and GWL3

NorESM2 SSP3-7.0
for GWL2 and GWL3

Climate Dynamics (2024) 62:9927–9949
https://doi.org/10.1007/s00382-024-07432-7

ORIGINAL ARTICLE

Check for updates

Optimizing climate model selection in regional studies using an adaptive weather type based framework: a case study for extreme heat in Belgium

Fien Serras[1] · Kobe Vandelanotte[2,3] · Ruben Borgers[1] · Bert Van Schaeybroeck[2,4] · Piet Termonia[2,3] · Matthias Demuzere[5] · Nicole P. M. van Lipzig[1]

(Presented at the CLM Assembly in Leuven in 2023)

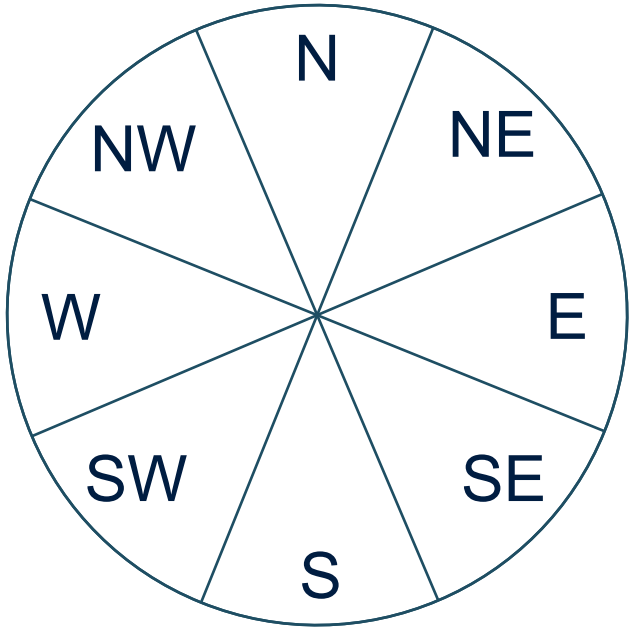
Simulation set-up & technical details

- COSMO-CLM6 TERRA_URB with ECOCLIMAP-SG
- Parameter settings based on NUKLEUS
- EUR12 → CPM 2.8 km centered over Belgium
- EC-Earth3-Veg SSP5-8.5
  - Historical: 1995-2014
  - GWL2: 2031-2050
  - GWL3: 2049-2068

  No bias correction (yet)

Lamb Weather Type Classification (“LWT”,13 types)

Directional types

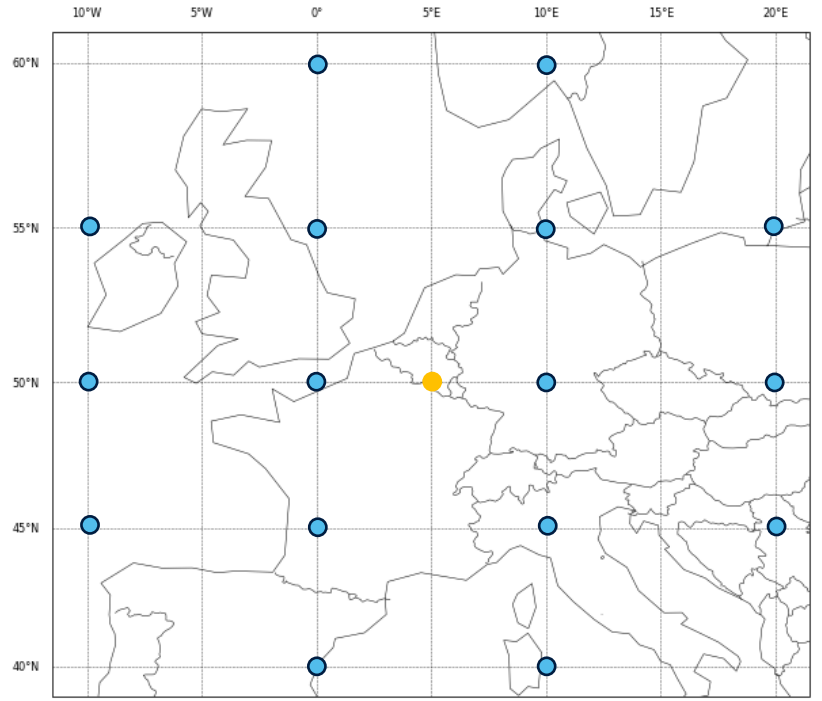


Rotational types

Strong (s) versus weak (w)

(Anti)Cyclones

sA, wA and sC, wC



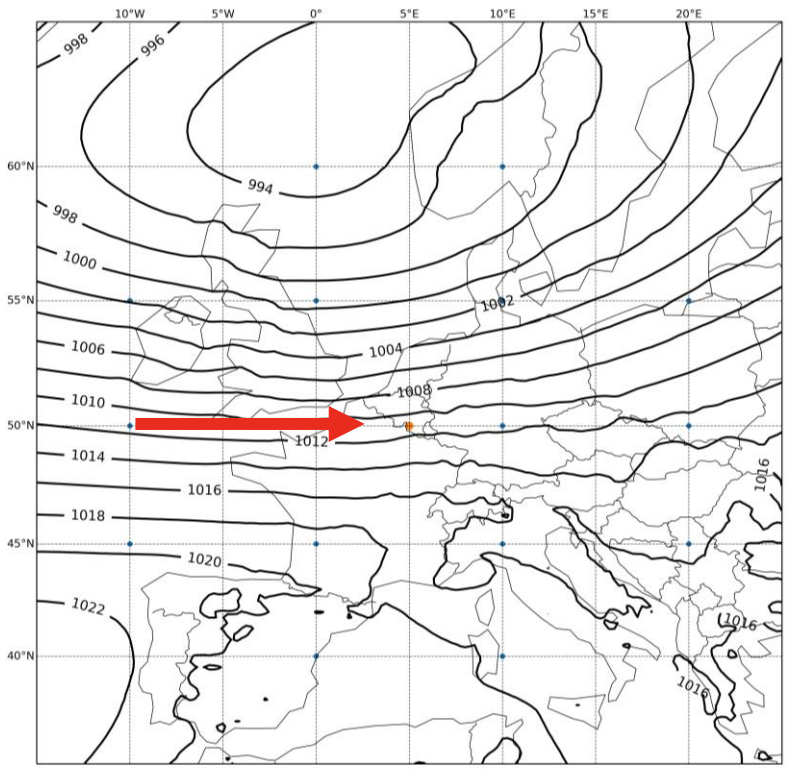
Unclassified

“Low Flow” → LF

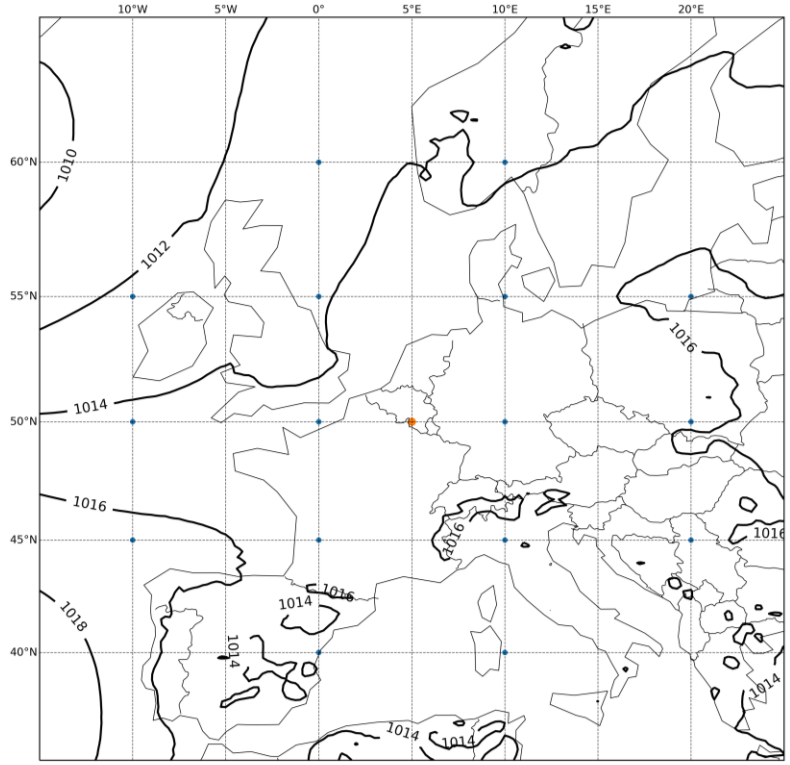
Lamb (1950) in *Q.J.R. Meteorol. Soc.* || Jenkinson & Collison (1977) in Synopt Climatol Branch Memorandum

Examples (from ERA5 data)

W

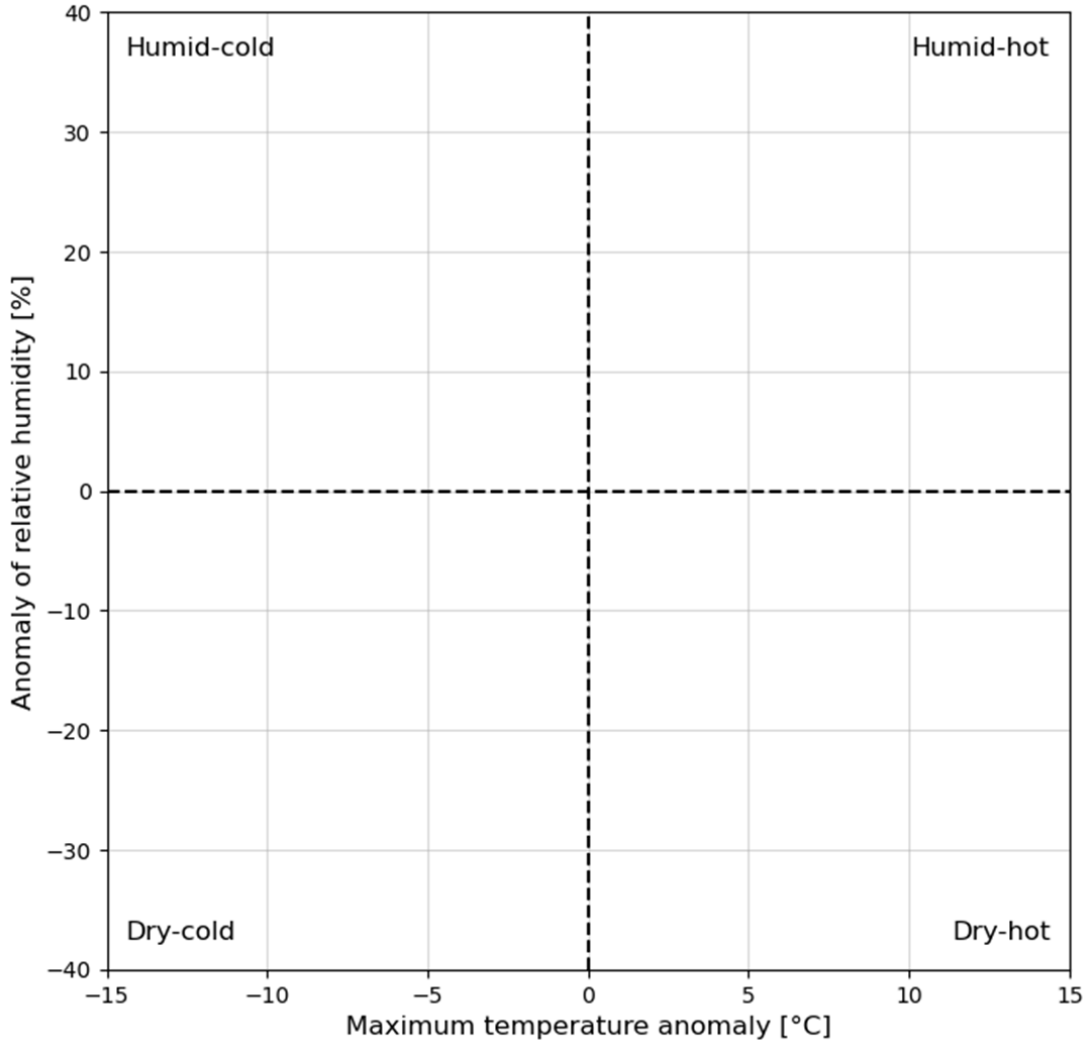


LF

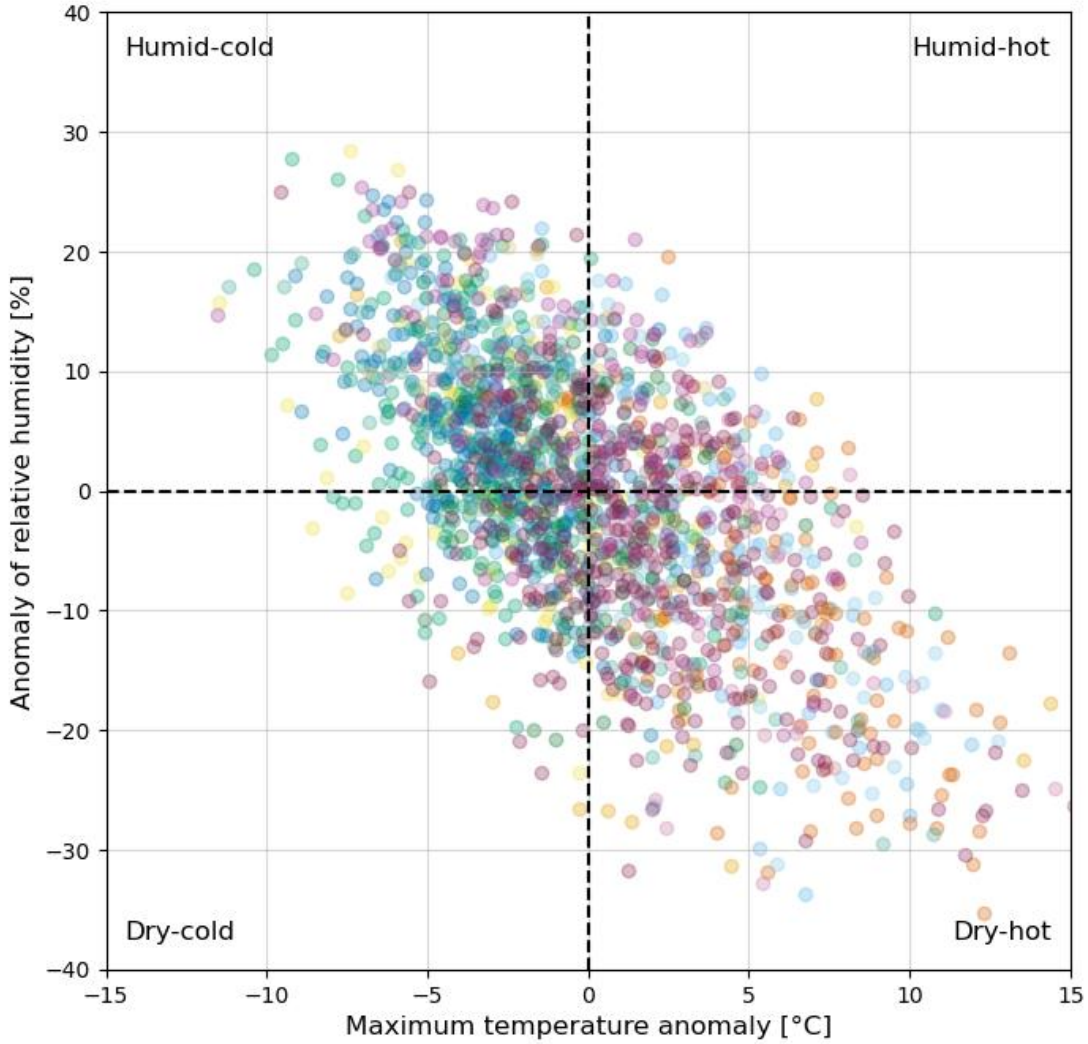


The contribution of weather types in the past

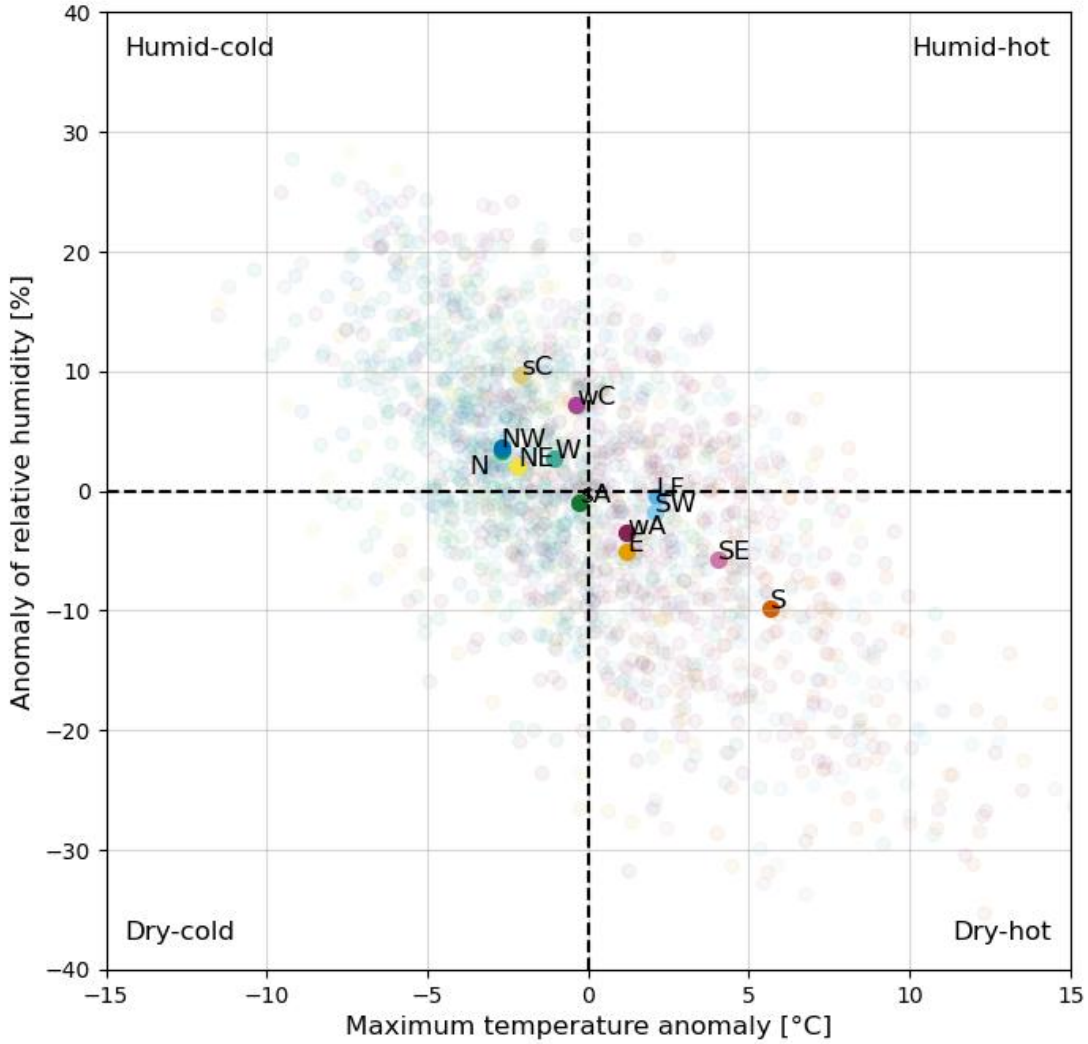
Categorization of weather types on summer days (JJA)



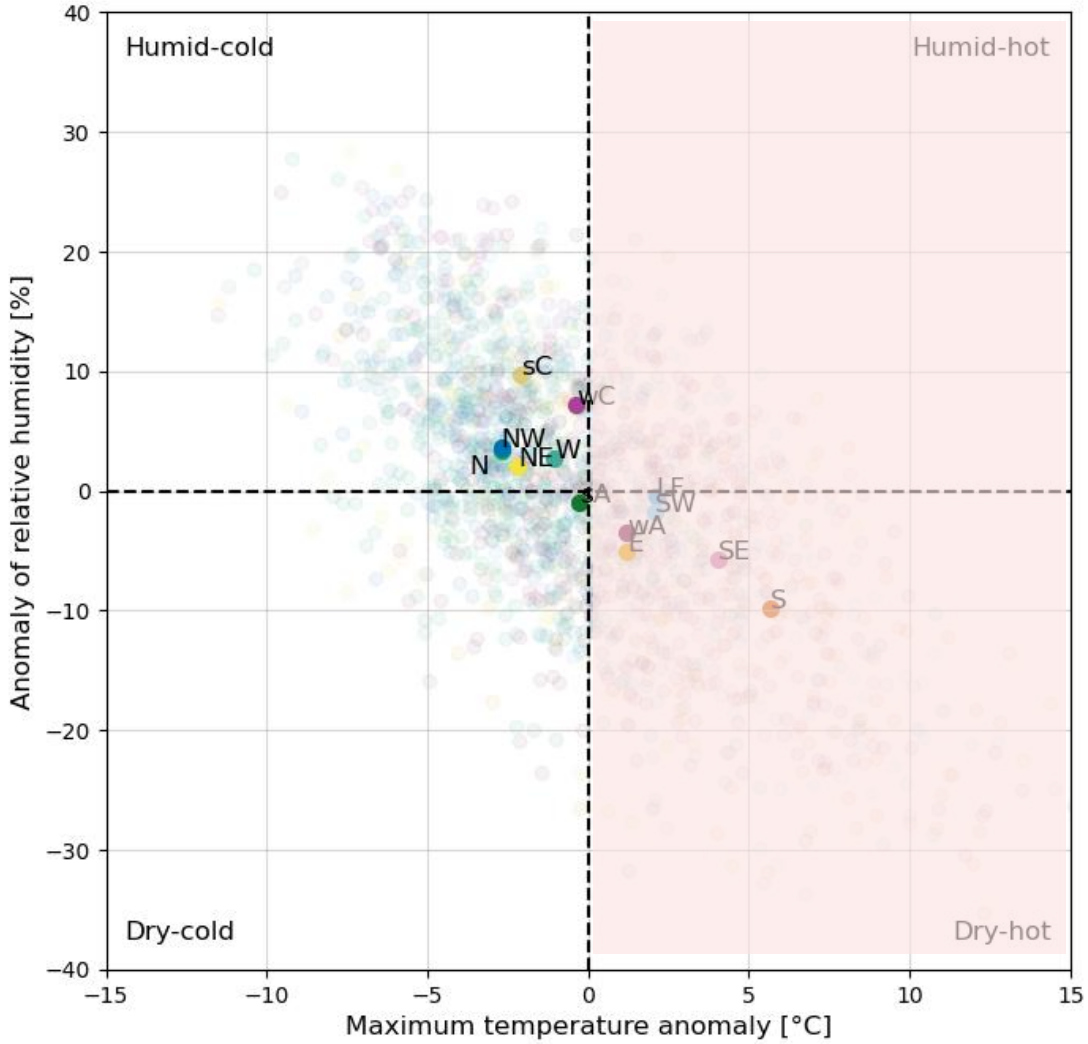
Categorization of weather types on summer days (JJA)



Categorization of weather types on summer days (JJA)



Categorization of weather types on summer days (JJA)

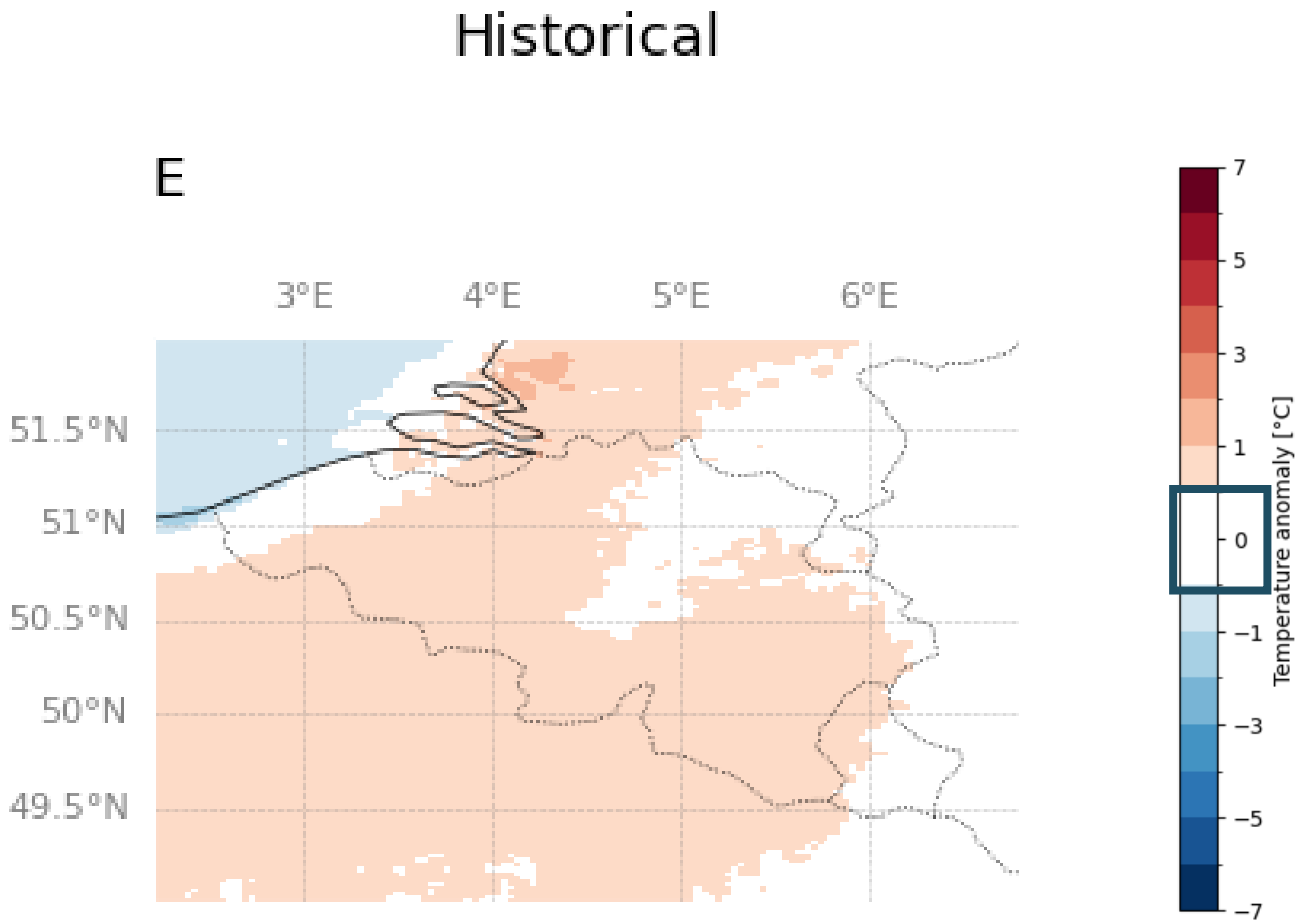


‘Typical WTs for warmer days’

Weather type contribution to anomalies

Intra-period comparison:

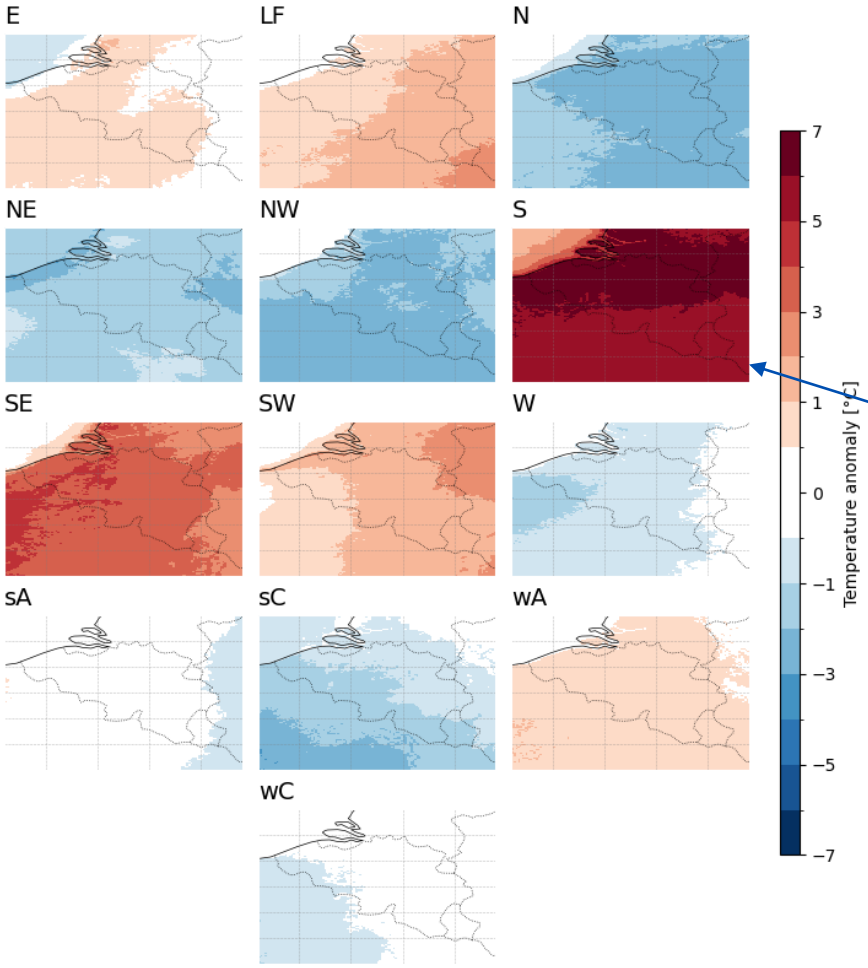
$$Anomaly = \overline{var_{LWT}} - \overline{var}$$

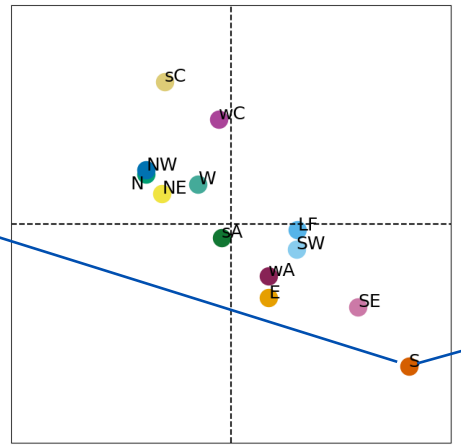


Values between **-0.1°C** and **0.1°C**

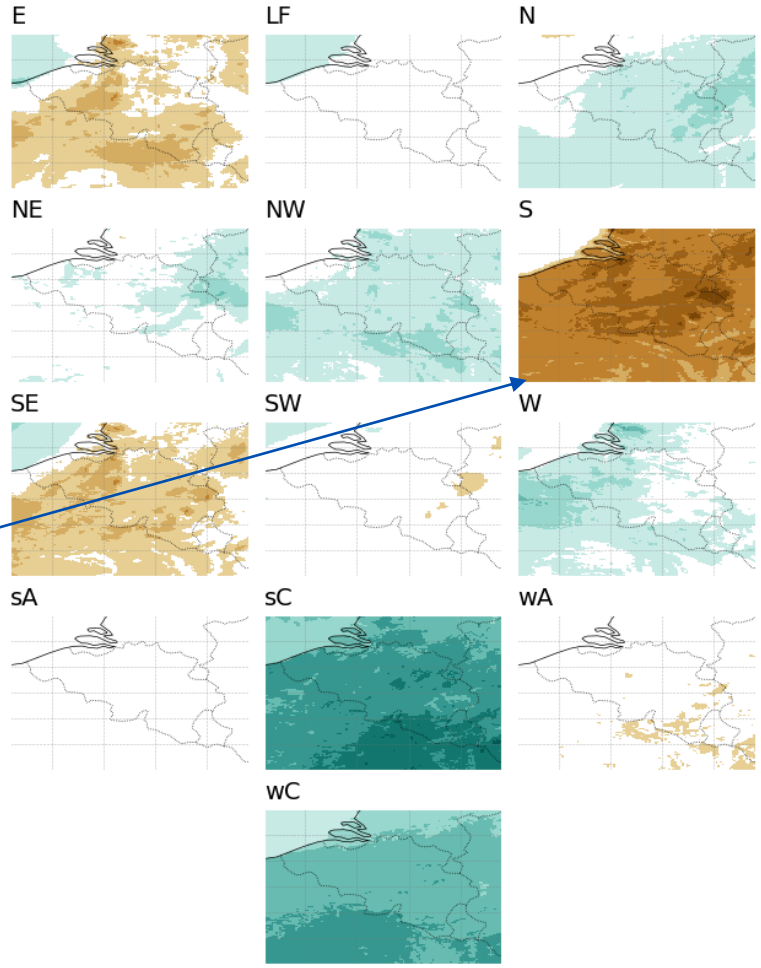
Variable-wise contribution

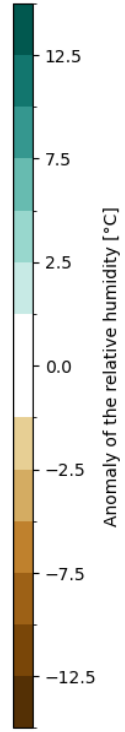
Temperature anomalies





Relative humidity anomalies





Variable-wise contribution



Does this change for different GWLs?

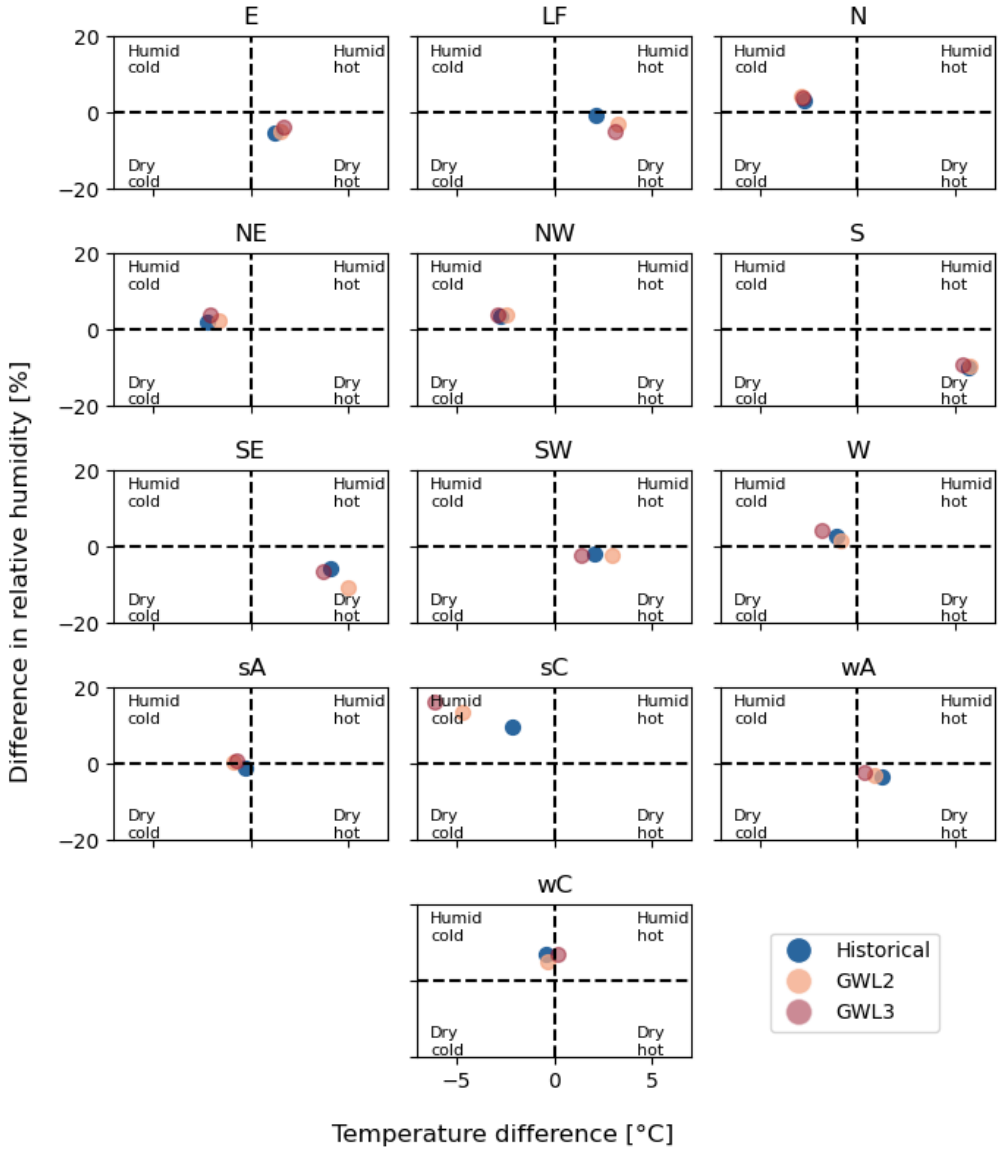
General frequency of occurence in JJA



Less than 2% change in the occurence frequency between the different periods

Changes in the contribution

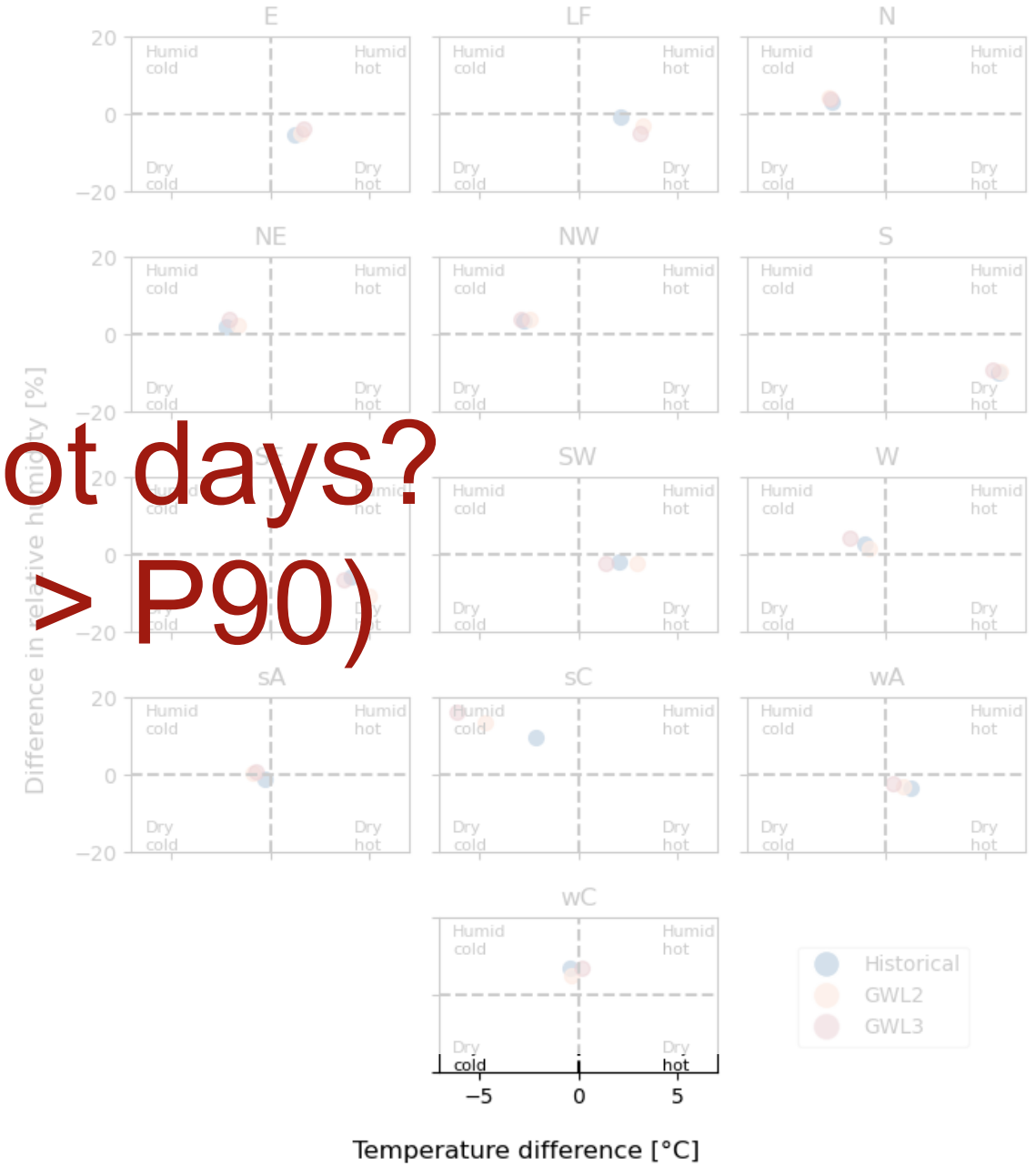
Most weather types: similar categorization



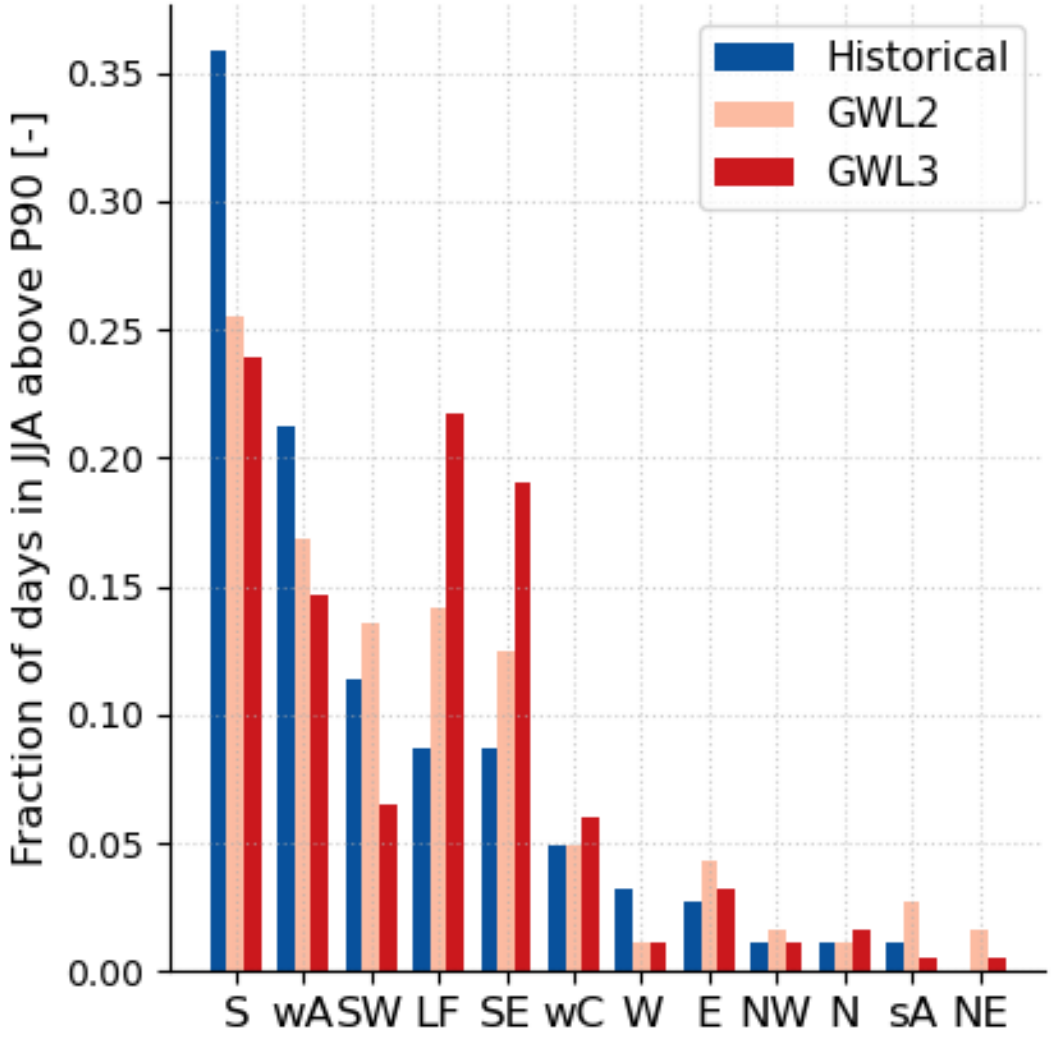
Changes in the contribution

- Less than 2% change in the occurence frequency over the different periods

What about hot days? (days with T > P90)



Relative importance of WTs for hot days



Historically: 60 % of hot days occur under S, wA or SW (dry-warm types)

Under GWL2 and GWL3:
Other weather types emerge on hot days:
S and wA decrease, while LF and SE increase

Selection of future heatwaves ‘storylines’

Selection of two heat waves:

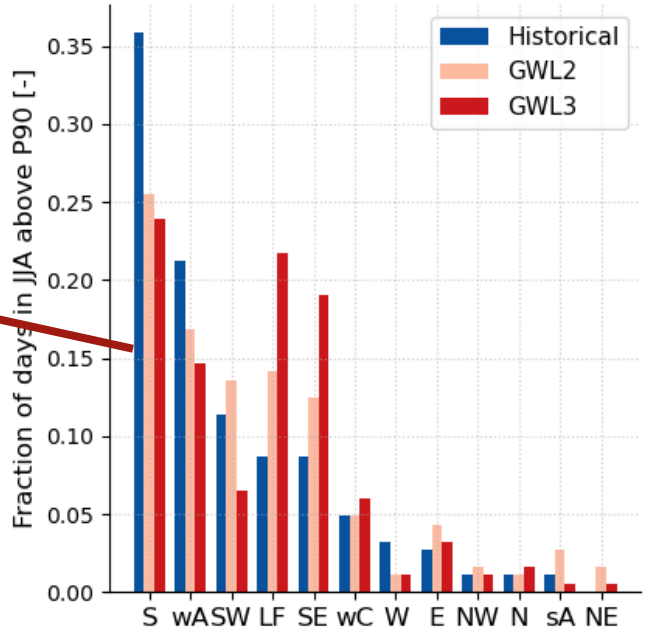
1. Based on the July 2019 heatwave
   = 5-day heatwave with **highest average daily maximum temperature**

2. Heatwaves with weather types irrelevant in the past

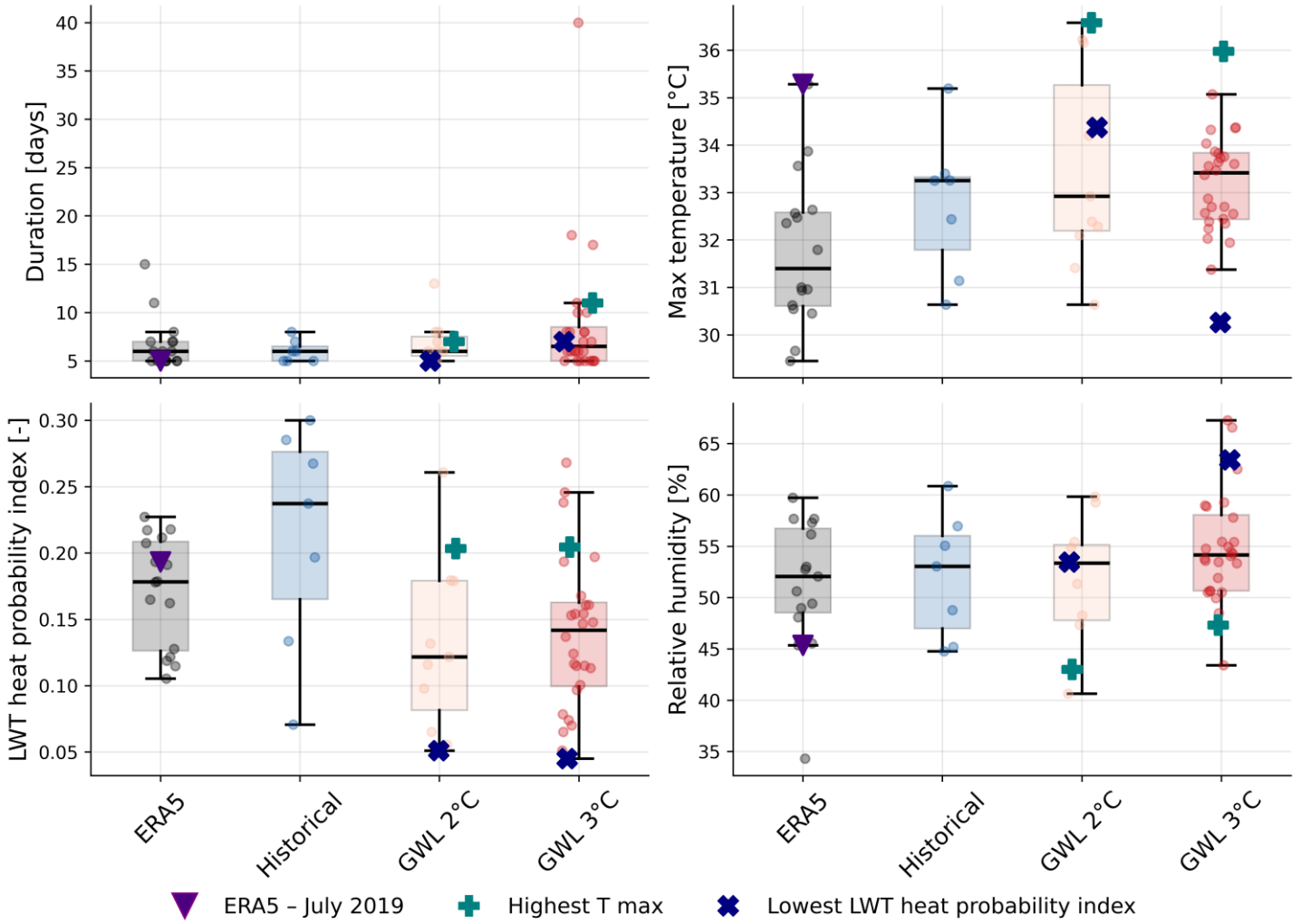
$$LWT\ heat\ probability\ index = \frac{\sum_{i=1}^{N} \lambda_i}{N}$$

→low LWT heat probability index:

Detecting ‘emerging heatwaves’



Positioning of heat waves



Focus on the heatwaves under GWL2

Event characterisation

Hottest heatwave

Average Tmax: 36.0°C

7 days

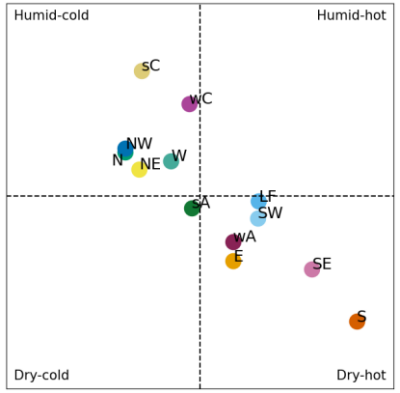
S-S-SE-SE-SE-SE-S

***Unlikely weather type* future heatwave**

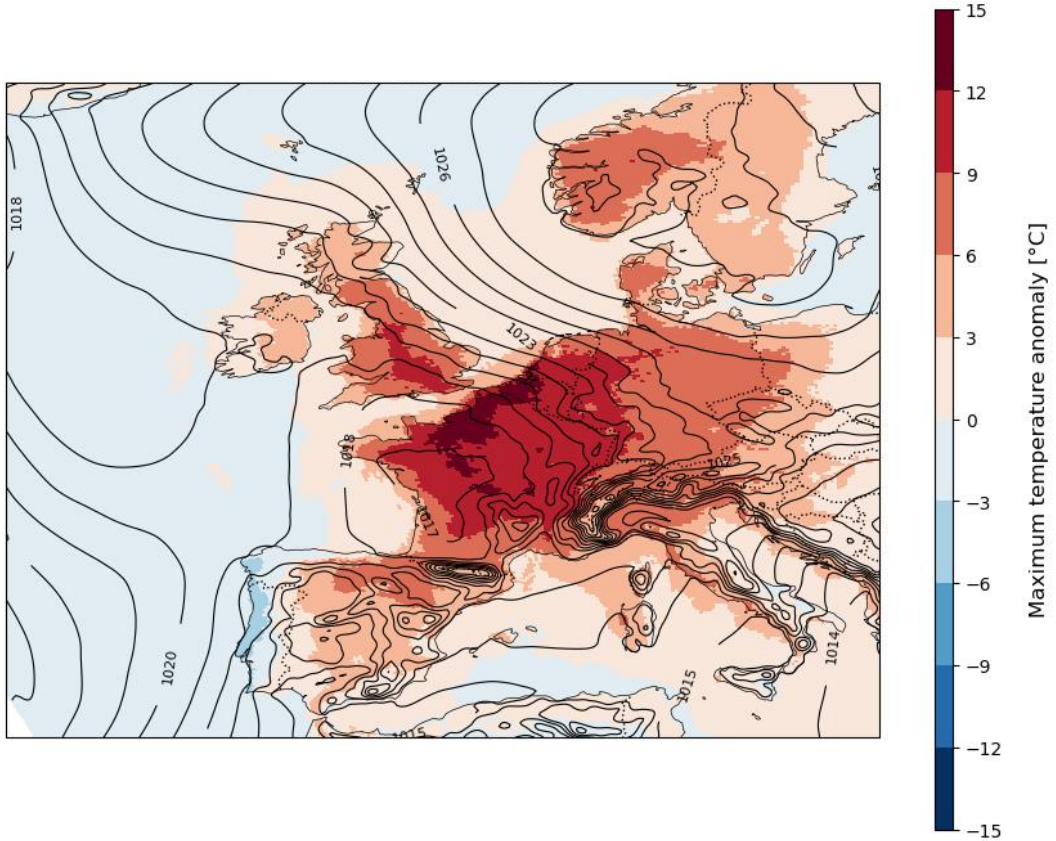
Average Tmax: 34.4°C

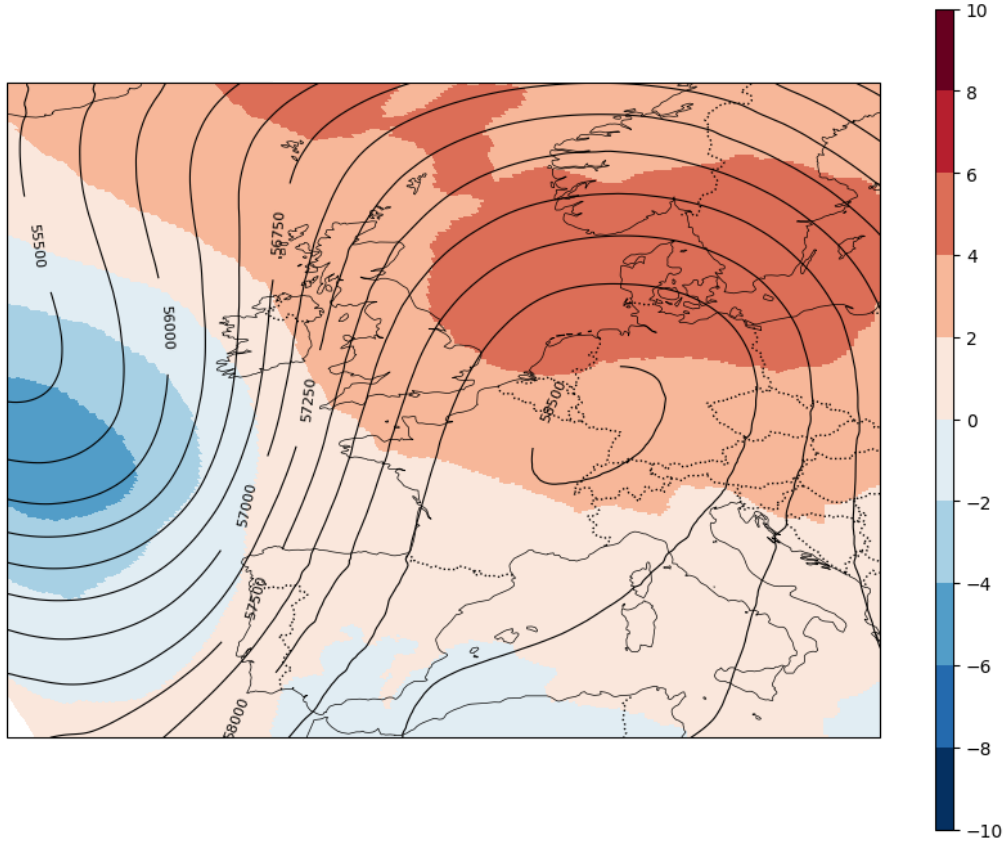
5 days

sA-sA-sA-NW-NW



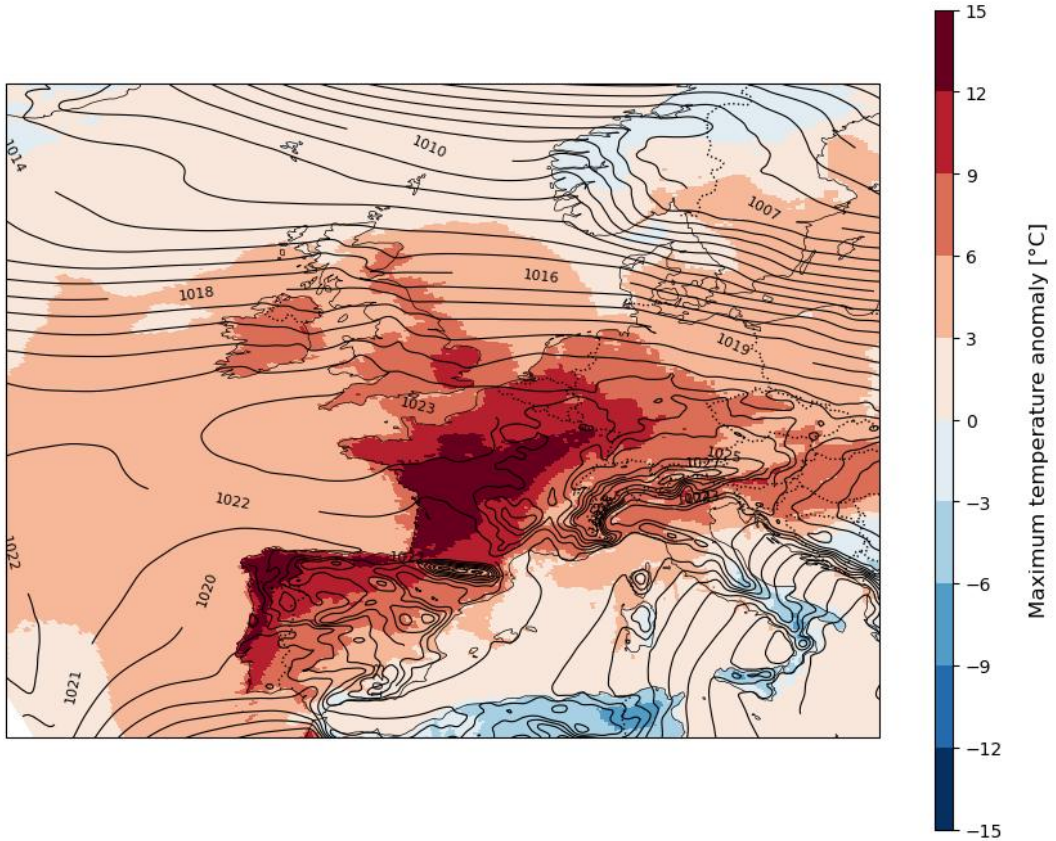
Event with highest average maximum temperature

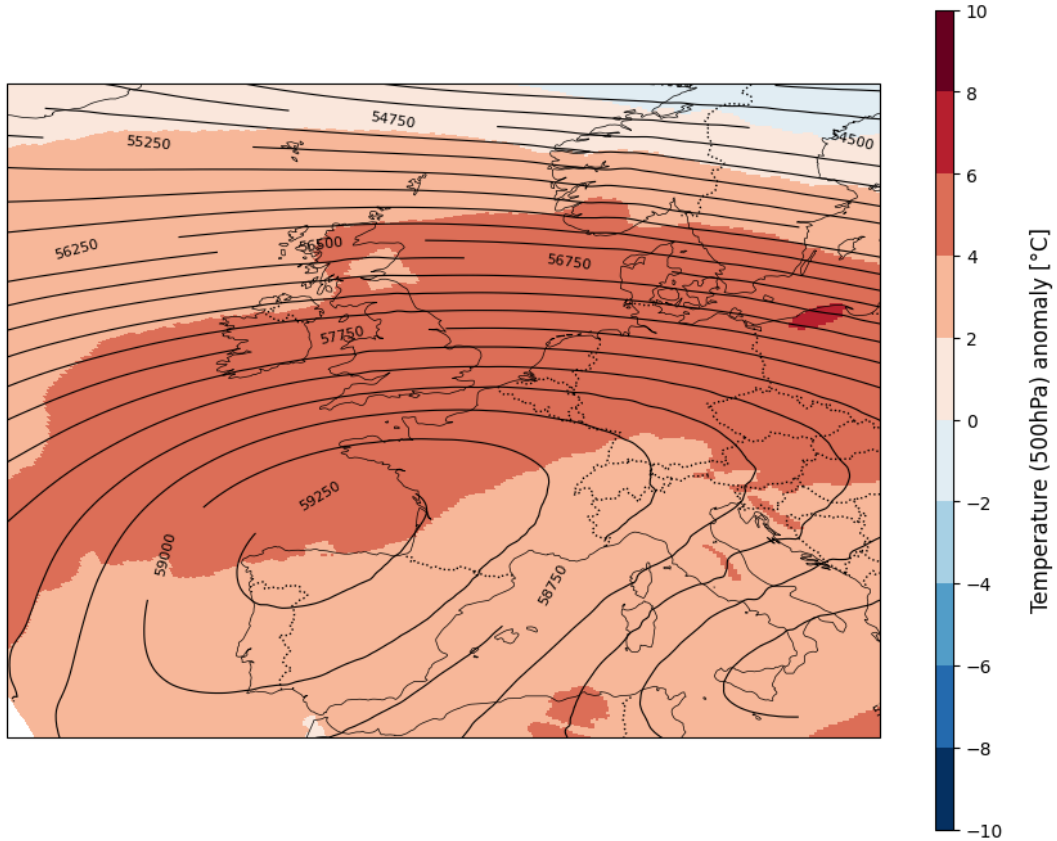




S-S-SE-SE-SE-SE-S

Event with lowest LWT heat probability





sA-sA-sA-NW-NW

Conclusions

- Changing role of atmospheric dynamics for extreme heat in Belgium
- Clear warm/cold weather types (e.g. S, SE, LF vs N, NE, sC)
- Small shifts in weather types towards the future
- Heatwaves in Belgium may emerge under circulation patterns that rarely produced heat in the past

➔Potentially more humid and more stressful heat events

Next steps

- Bias correction for impact analysis
- Include additional simulations (EC-Earth3-Veg SSP2-4.5 downscaling)
- Work out storylines for heat stress and health applications

Any questions/comments/ feedback?

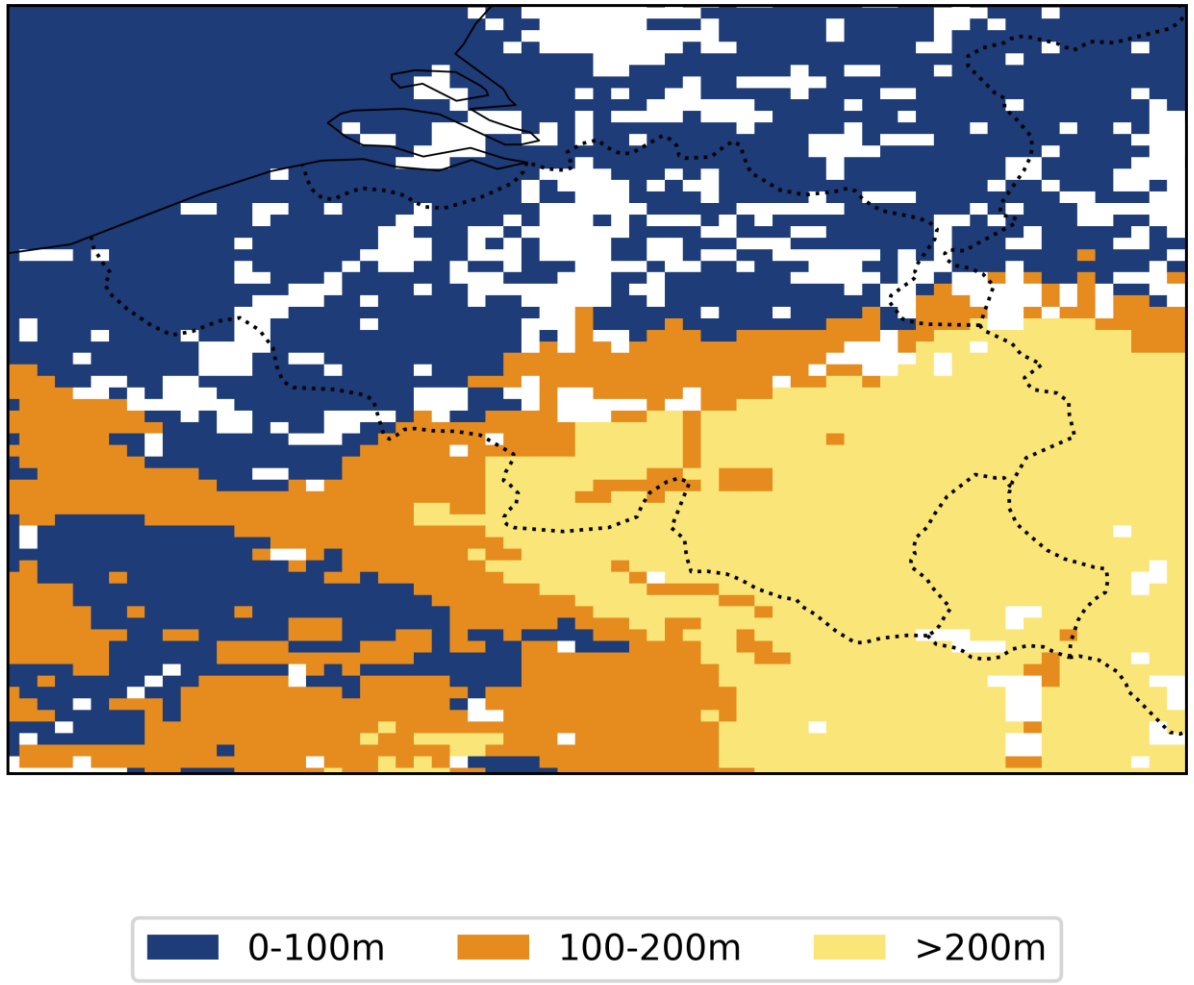
➔ Feel free to send an email

Fien.serras@kuleuven.be

Model evaluation

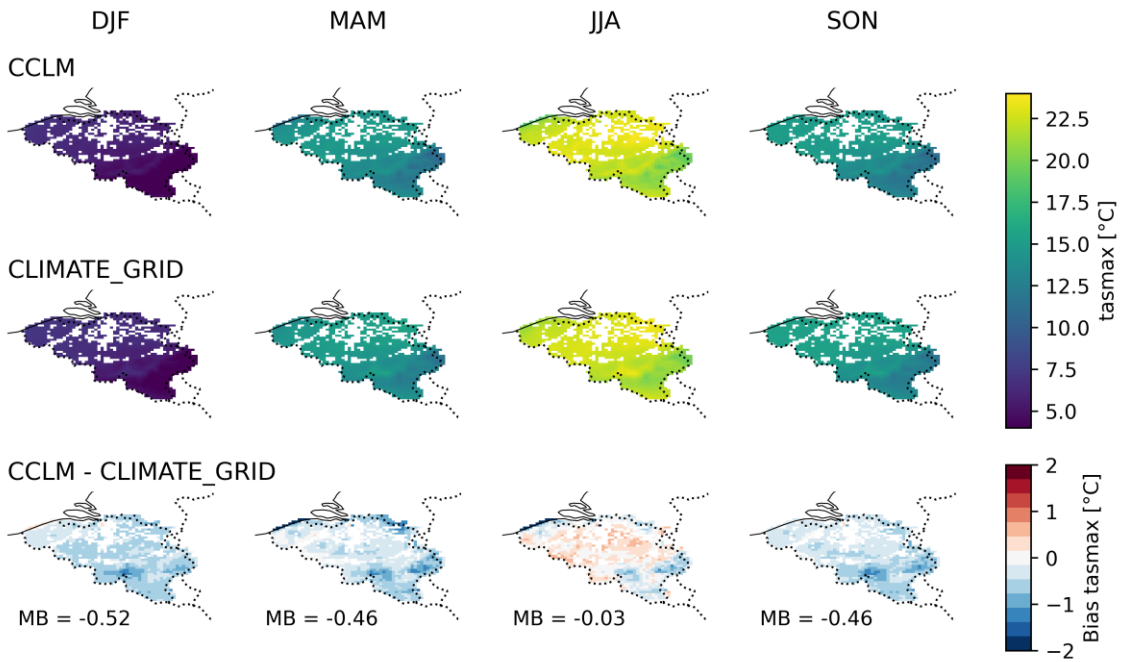
CLIMATE_GRID: a Belgian gridded observational dataset

1) Exclusion of the urban areas (fr_paved > 0.2)
2) Elevation-based separation

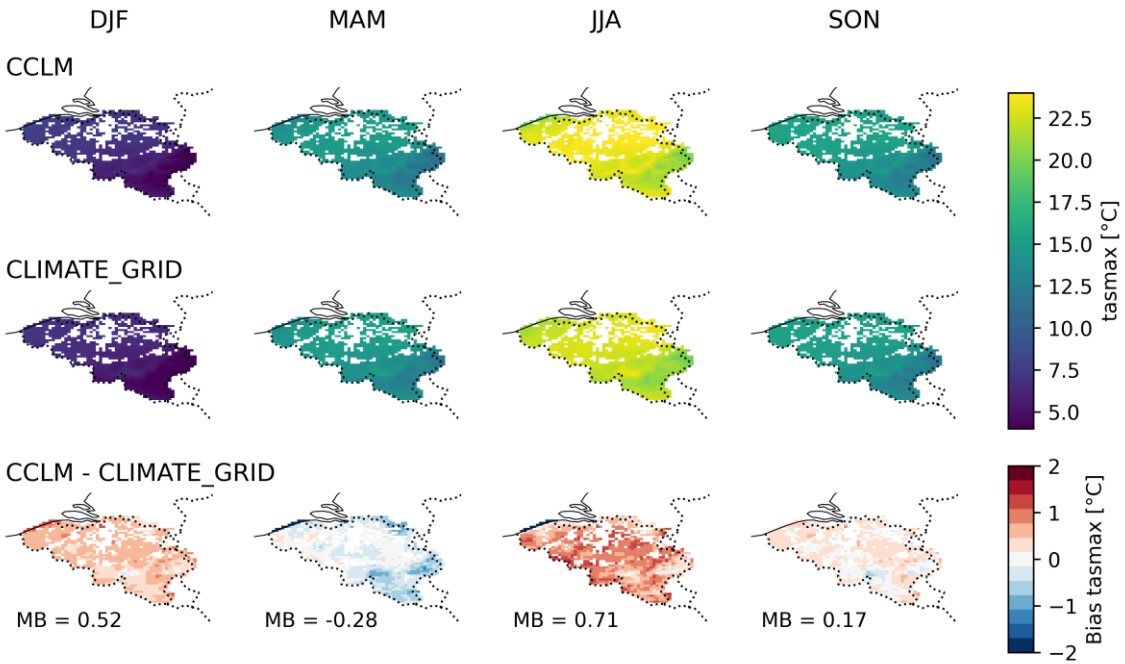


ERA5 versus EC-Earth3-Veg downscaling for maximum temperature

ERA5



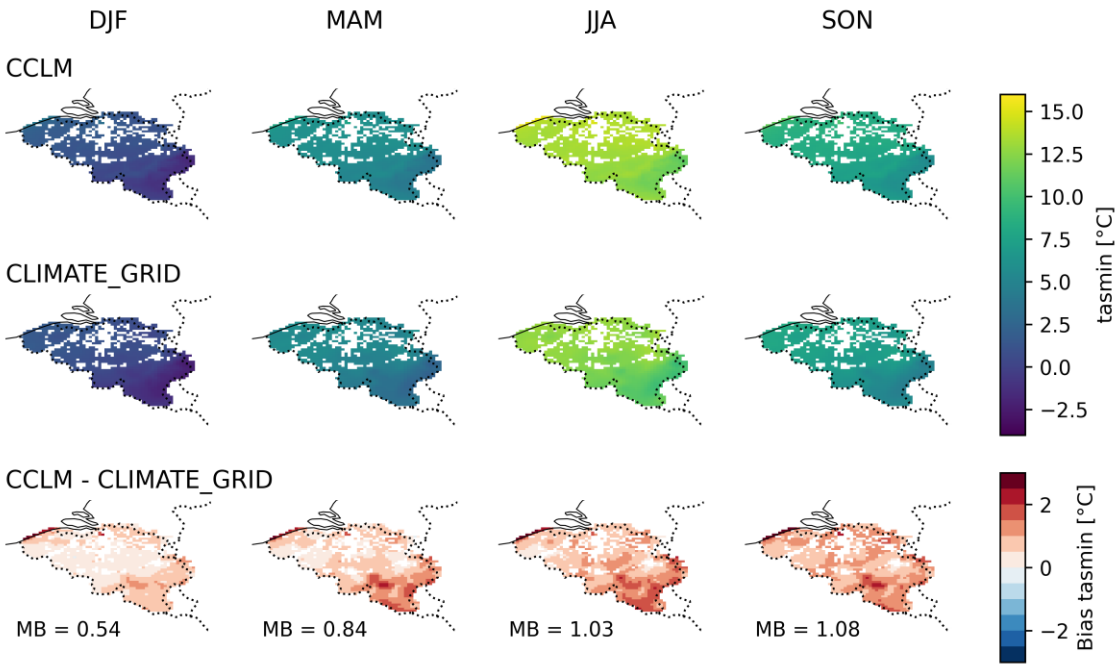
EC-Earth3-Veg



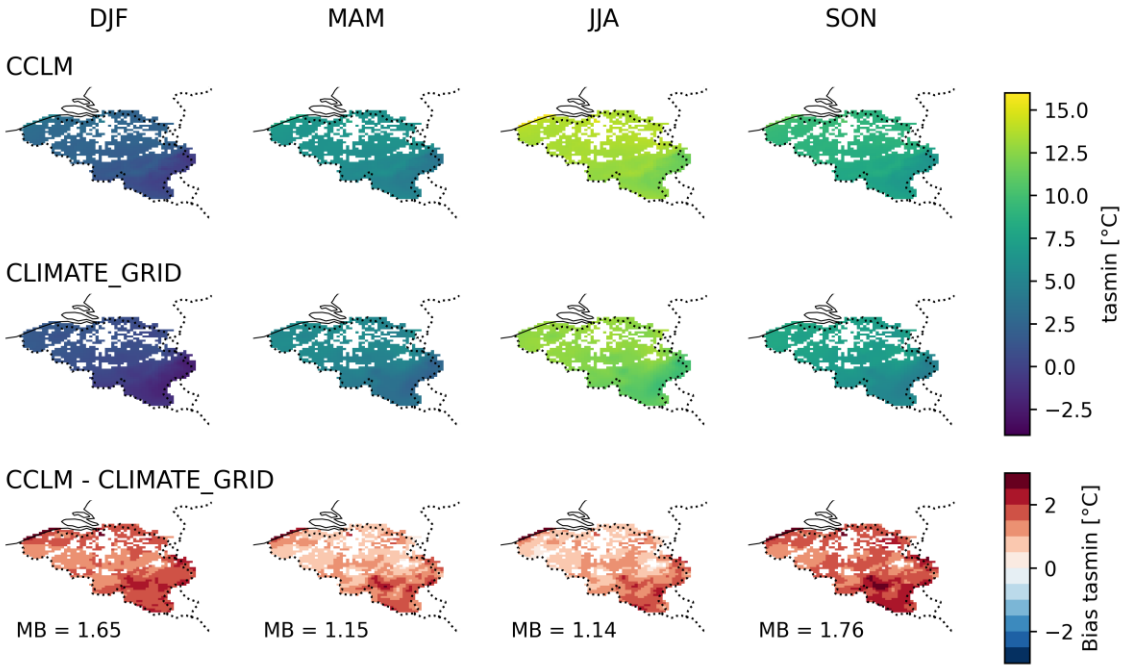
KU LEUVEN

ERA5 versus EC-Earth3-Veg downscaling for minimum temperature

ERA5



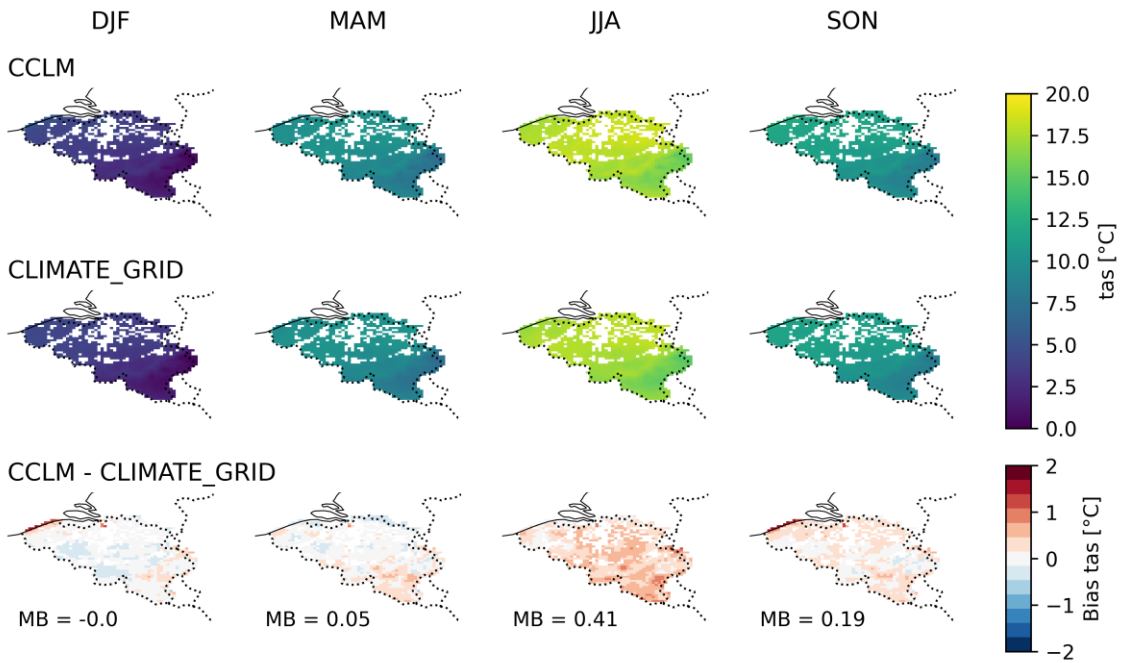
EC-Earth3-Veg



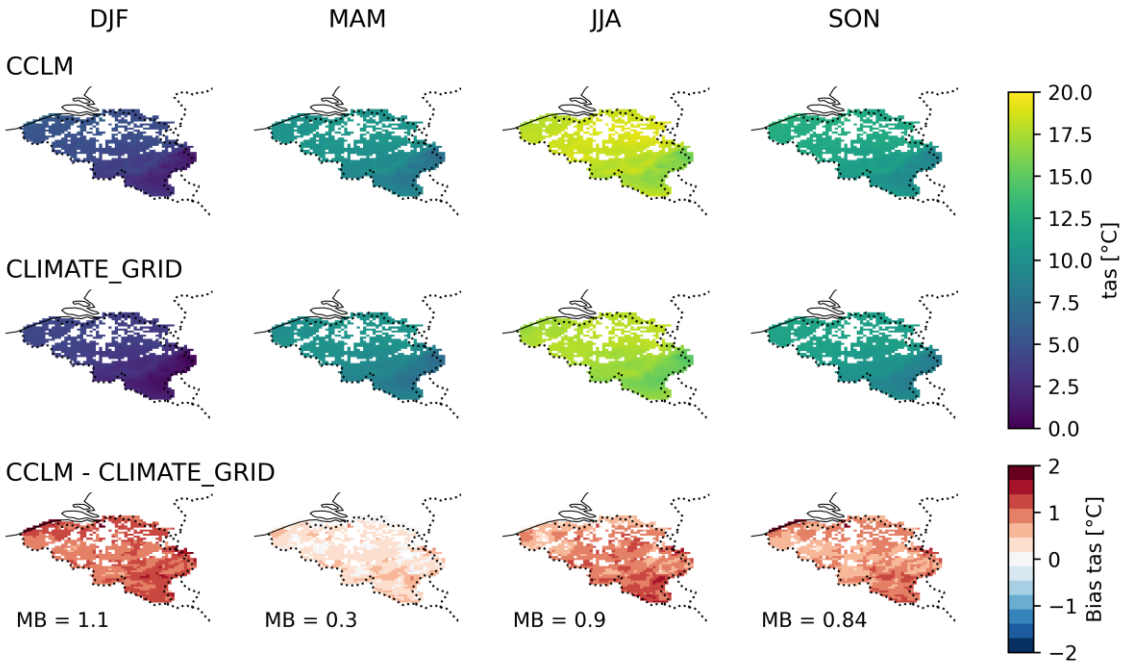
KU LEUVEN

ERA5 versus EC-Earth3-Veg downscaling for temperature

ERA5



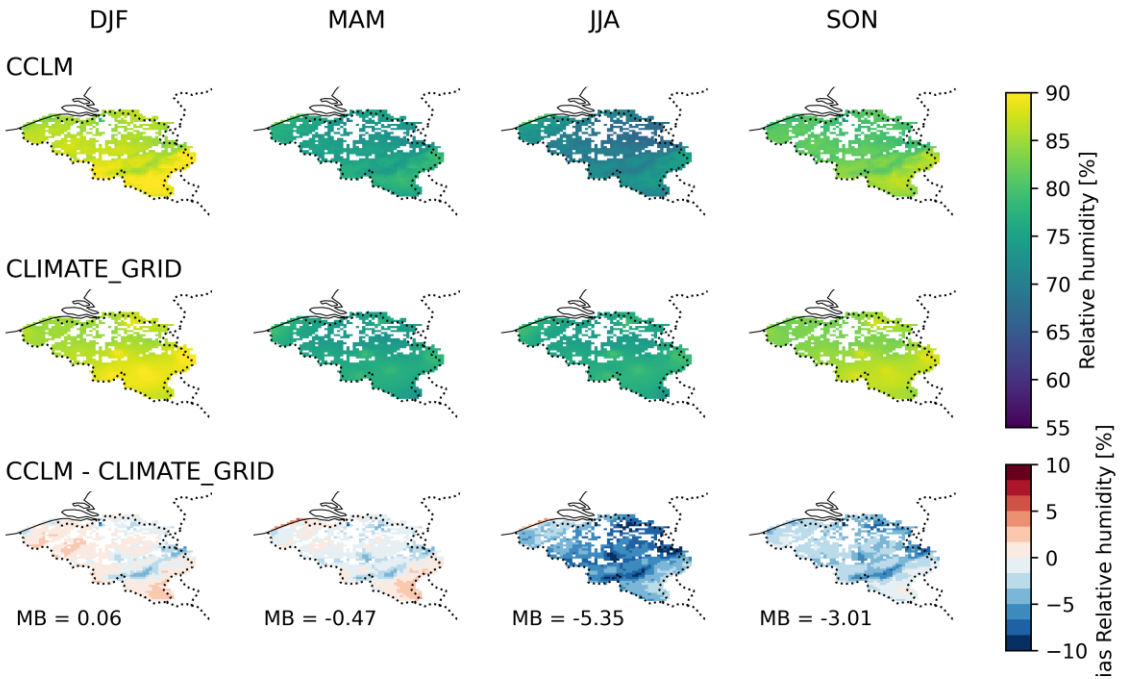
EC-Earth3-Veg



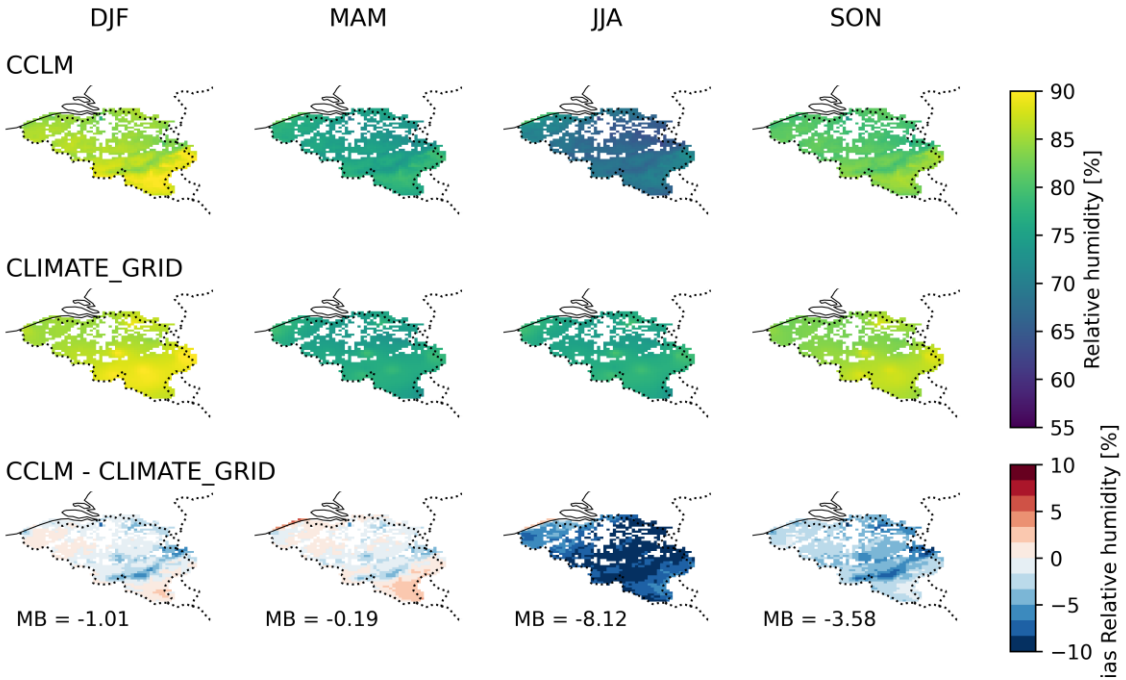
KU LEUVEN

ERA5 versus EC-Earth3-Veg downscaling for relative humidity

ERA5



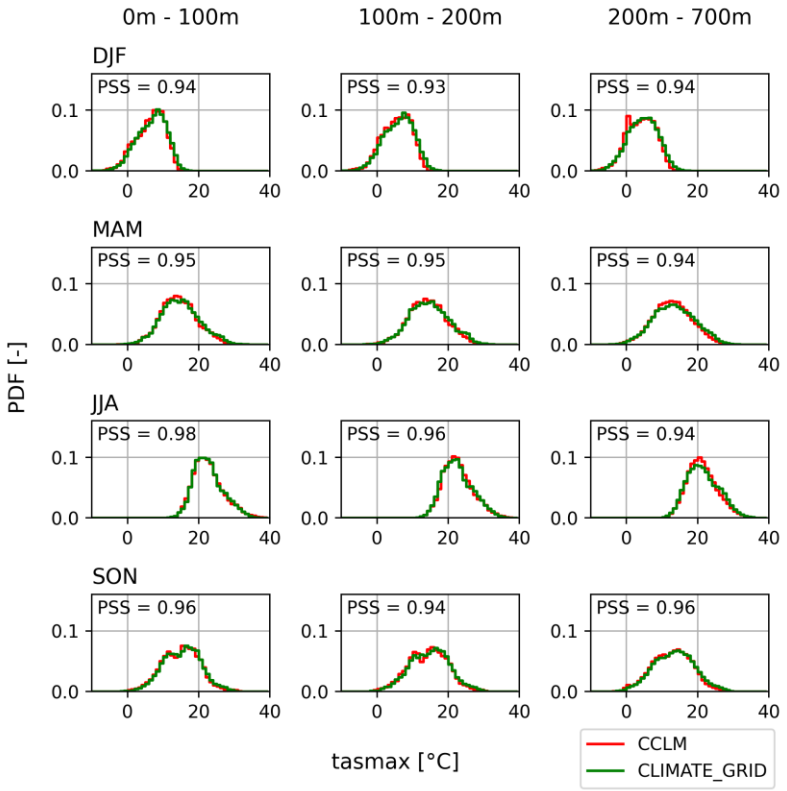
EC-Earth3-Veg



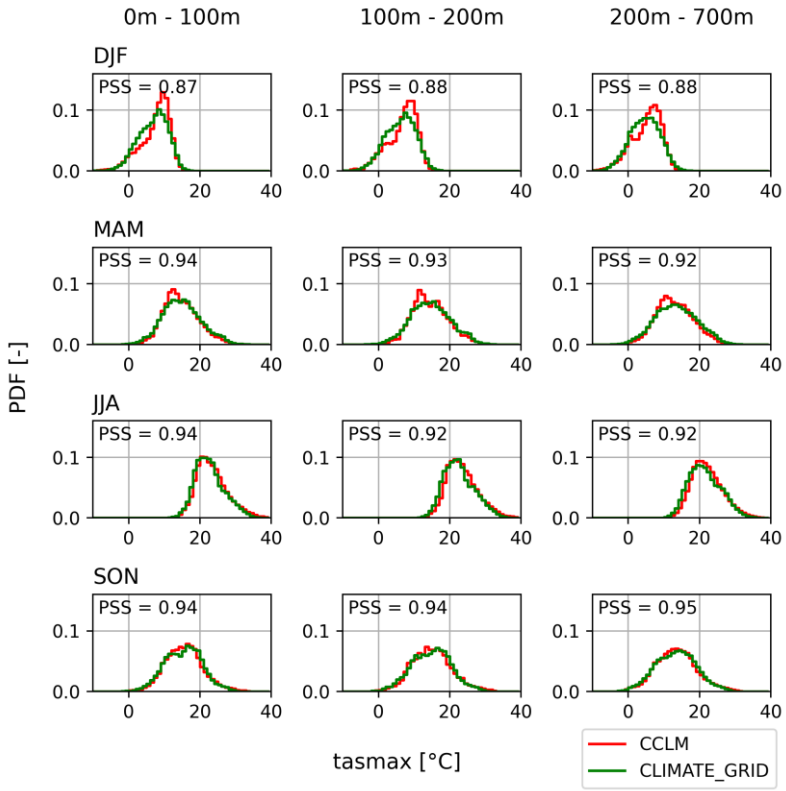
KU LEUVEN

Evaluation: ERA5 versus EC-Earth3-Veg downscaling for maximum temperature

ERA5

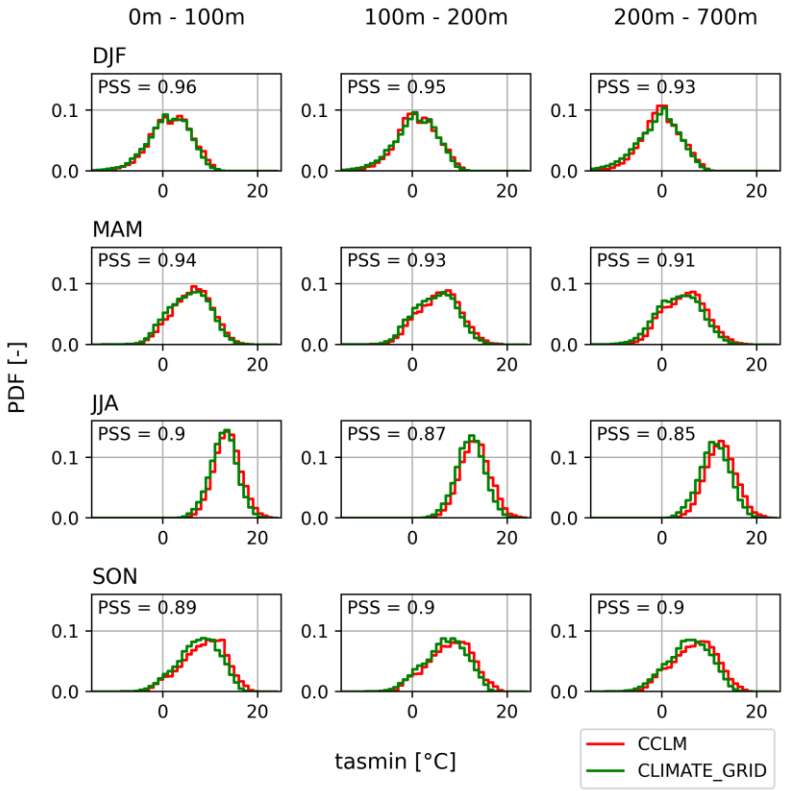


EC-Earth-Veg

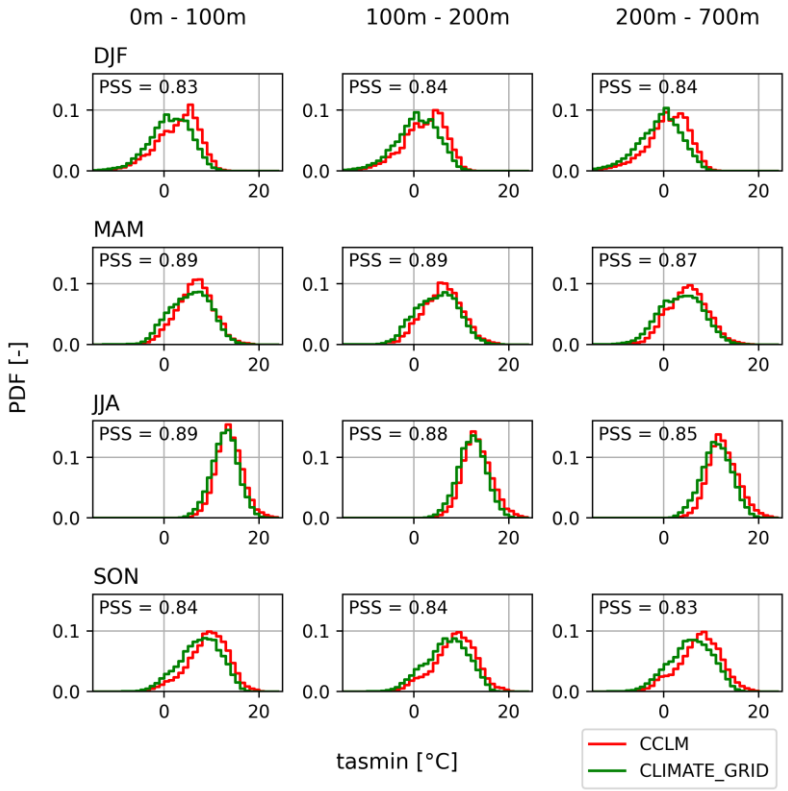


Evaluation: ERA5 versus EC-Earth3-Veg downscaling for minimum temperature

ERA5

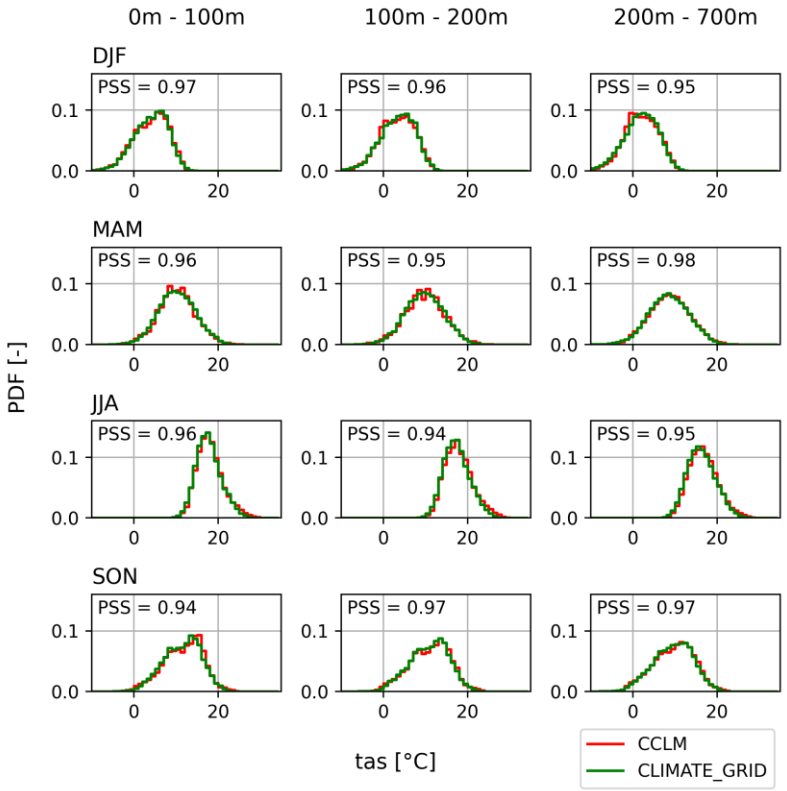


EC-Earth-Veg

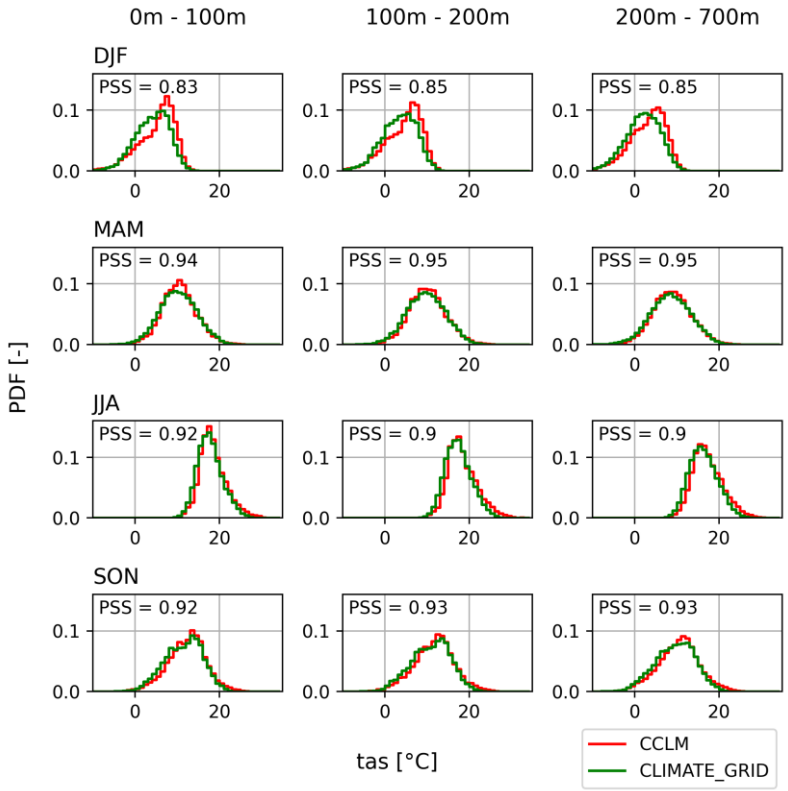


Evaluation: ERA5 versus EC-Earth3-Veg downscaling for temperature

ERA5

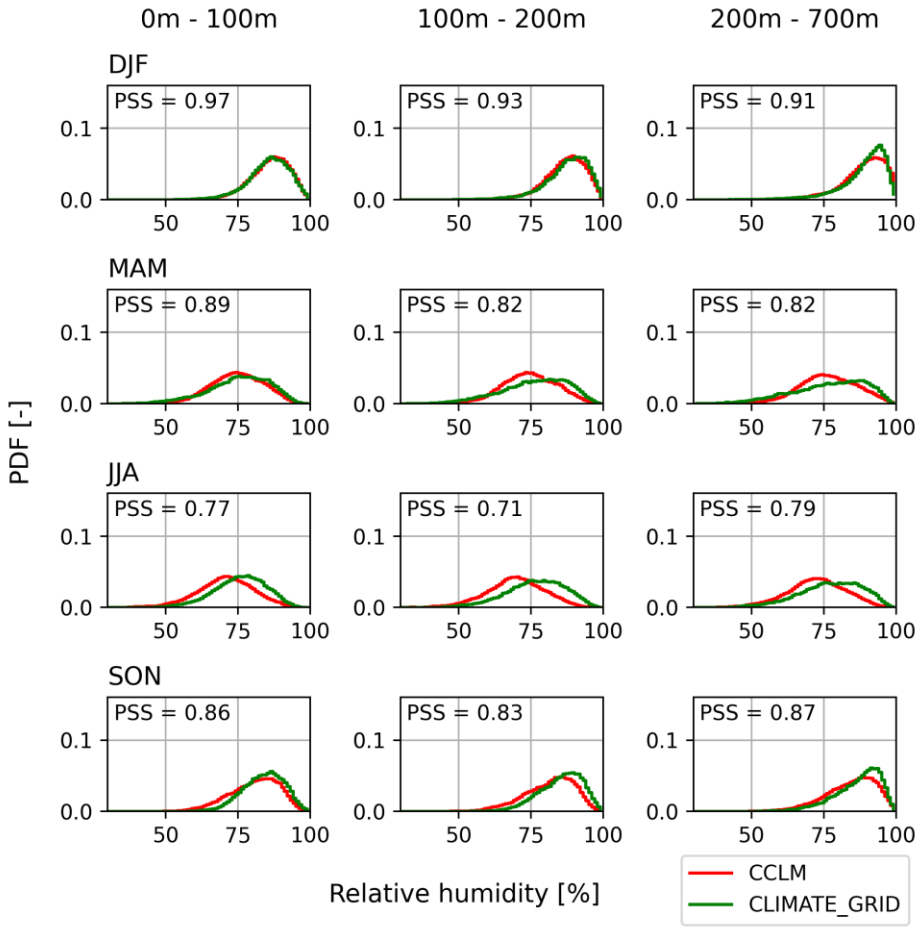


EC-Earth-Veg



Evaluation: ERA5 versus EC-Earth3-Veg downscaling for relative humidity

ERA5



EC-Earth-Veg

