SUPPLEMENTARY METHODS

Post-hoc analysis soil colour and spider colour variation

To explore whether background matching is a plausible hypothesis to explain the replacement of the black and orange morphs across a precipitation gradient, we performed an informal analysis. This is not presented as a formal analysis because the resolution and quality of soil data obtained is too coarse. The analysis explored the association between soil brightness and colour variation. We obtained an Australian soil colour raster layer from the CSIRO data access portal (available at: https://data.csiro.au/collection/csiro:55860?q=soil%20colour&_st=keyword&_str=14&_si=1). This layer consisted of RGB values for Australian soils at a 90m resolution. We used the geographical records of each colour morph to extract brightness values for each record using the function 'extract' from the R package terra v1.7 (Hijmans, 2023).

Because the distribution of the obtained brightness values was patchy and not continuously distributed (Supplementary figure 8), we transformed this variable into a categorical variable with two categories: low brightness (values <= 75) and high brightness (values > 75). Using a contingency table, we then explored the association between soil colour brightness and colour morph with a Chi-square test of independence. All the assumption of Chi-square test of independence were met.

SUPPLEMENTARY TABLES AND FIGURES

Supplementary table 1. Parameter estimation, their standard error (SE) and ANOVA significant test results (sum of squares, F statistic and P-value) from the linear models per side (dorsal or ventral). These models used as response variable the total temperature differences between the initial and final measurements after 5 minutes (ΔT). The colour morph variable used “black” as reference, and “black-and-white” as comparison.

	Ventral					Dorsal				
Parameter	**Coefficient**	**SE**	**Sum of squares**	**F-value**	**P-value**	**Coefficient**	**SE**	**Sum of squares**	**F-value**	**P-value**
Weight (gr)	-0.60	3.82	0.006	0.013	0.90	-7.02	3.07	1.53	5	**0.03**
Colour morph	-0.55	0.20	3.44	7.24	**0.01**	-0.42	0.16	1.97	6.44	**0.01**

Supplementary table 2. Parameter estimation, their standard error (SE) and ANOVA significant test results (sum of squares, F statistic and P-value) from the linear models per side (dorsal or ventral). These models used as response variable the maximum change in temperature in 20-second intervals (maxHR = ΔT/sec). The colour morph variable used “black” as reference, and “black-and-white” as comparison.

	Ventral					Dorsal				
Parameter	**Coefficient**	**SE**	**Sum of squares**	**F-value**	**P-value**	**Coefficient**	**SE**	**Sum of squares**	**F-value**	**P-value**
Weight (gr)	-0.10	0.03	4.2E-4	6.66	**0.01**	-0.13	0.03	6E-4	14.61	**0.0004**
Colour morph	-0.006	0.002	0.002	8.88	**0.004**	-0.007	0.001	5.6E-4	13.62	**0.0006**

Weight : Colour morph	0.15	0.07	1.9E-4	4.29	**0.004**	0.06	0.07	3.8E-5	0.93	0.34

Supplementary table 3. Parameter estimation, their standard error (SE) and ANOVA significant test results (sum of squares, F statistic and P-value) from the linear models per side (dorsal or ventral). These models used as response variable the average temperature in the field (°C). The colour morph variable used “black” as reference, and “black-and-white” as comparison.

	Ventral					Dorsal				
Parameter	**Coefficient**	**SE**	**Sum of squares**	**F-value**	**P-value**	**Coefficient**	**SE**	**Sum of squares**	**F-value**	**P-value**
Wind speed (m/s)	-0.46	0.23	5.36	3.40	0.07	-0.59	0.28	26.41	10.35	**0.003**
Luminosity	0.001	0.001	13.35	8.47	**0.007**	0.0002	0.006	0.68	0.26	0.60
Web Height (cm)	-0.006	0.01	1.78	1.13	0.29	0.008	0.013	0.08	0.03	0.85
Wind temperature (°C)	0.59	0.15	23.32	14.08	**7E-4**	0.59	0.20	21.78	8.54	**0.007**
Colour morph	0.07	0.49	0.038	0.02	0.87	-0.48	0.69	1.25	0.49	0.48

Supplementary table 4. Tukey HSD test comparing the mean values between colour morphs of the Christmas spider across six climatic variables. Values in bold are statistically significant.

Pairwise comparison	Climatic moisture index	Potential evapotranspiration	Precipitation	Solar radiation	Mean daily maximum air temperature	Mean daily minimum air temperature
Black-and-white vs. Black	-3.96 (-13.68,5.74)	**9.43(5.25,13.61)*** **	**0.04(-0.07,0.16)*** **	**0.64 (0.30,0.97)*** **	**25.26(17.26,33.26)*** **	**9.19(1.61,16.78)* **
Orange vs. Black	**-51.22 (-70.47, -31.99)*** **	**20.41(12.13,28.69)*** **	**-0.66 (-0.89,-0.42)*** **	**1.68 (1.02,2.35)*** **	**34.74(18.9,50.58)*** **	6.25(-8.76,21.26)
Orange vs. Black-and-white	**-47.25 (-64.43 -30.08)*** **	**10.97(3.58,18.37)*** **	**-0.70 (-0.91,-0.49)*** **	**1.04(0.45,1.63)*** **	9.48(-4.65,23.62)	-2.94(-16.34,10.45)

***P-value<0.001

**P-value<0.01

*P-value<0.05

Supplementary table 5. Results of the pairwise comparison of the climatic niche of the colour morphs of Austracantha minax using COUE (Centroid shift, Overlap, Unfilling and Expansion) scheme. The comparisons were made based on the second morph's niche using the first morph's niche as reference.

Comparison	Niche stability	Niche expansion	Niche unfilling	D	I	Equivalency niche conservatism	Equivalency niche divergence	Similarity niche conservatism A -> B	Similarity niche divergence A -> B	Observations
black vs. black-and-white	0.99	3.00E-05	0.17	0.64	0.82	0.34	0.6	0.001	0.99	Similar values in both directions
black vs. orange	0.6	0.39	0.11	0.25	0.45	1	0.003	0.08	0.93	Similar values in both directions
black-and-white vs. orange	1	0	0.35	0.21	0.39	0.99	0.001	0.04	0.94	Similar values in both directions

Supplementary table 6. Results of the multiple matrix regression models (MMR) using change in colour morph frequency (including all the colour morphs) as response variable. For each variable we reported their partial correlation coefficient ($r_{partial}$) and P-value. Variables with a significant effect are in bold.

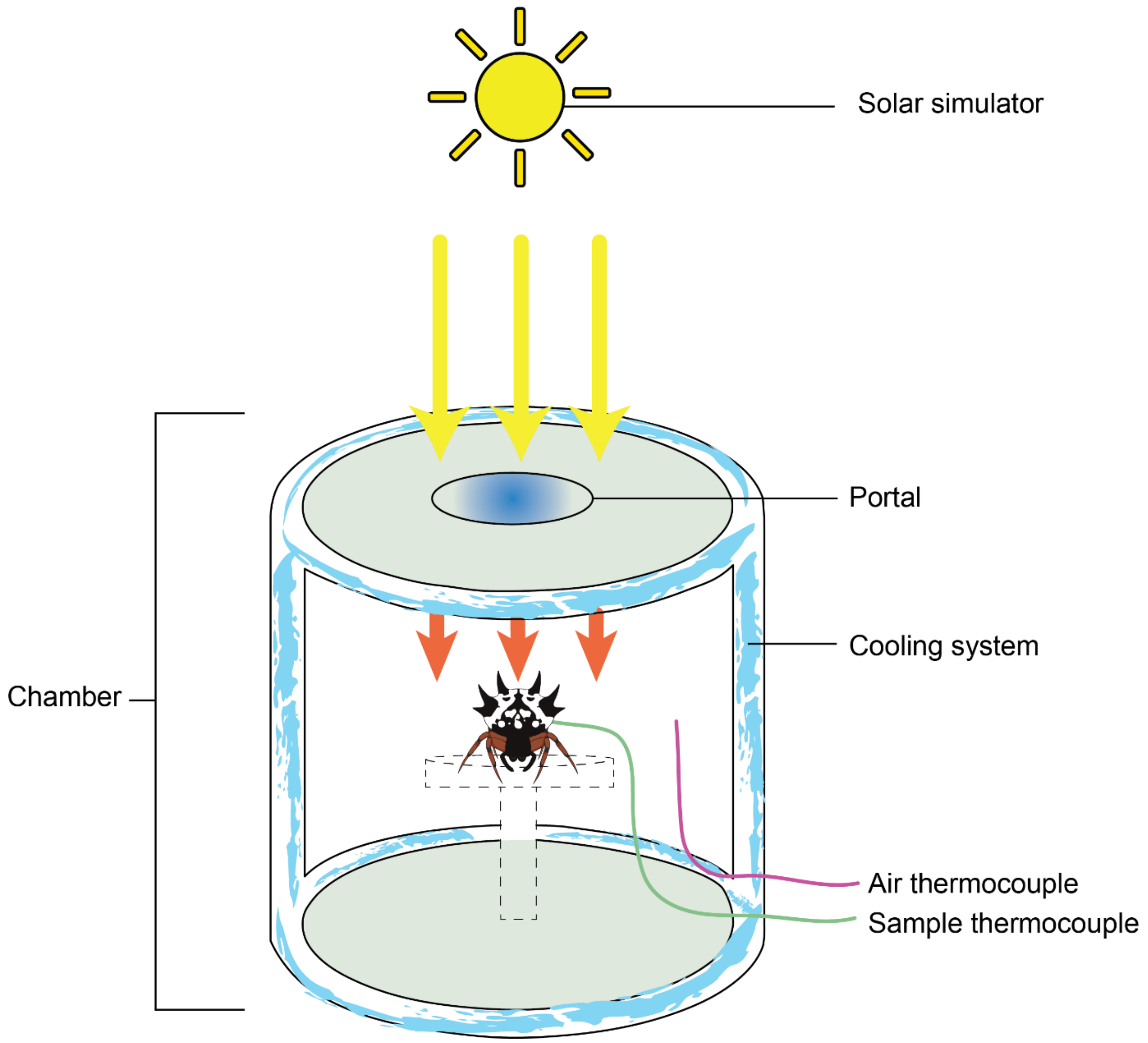
Variable	$r_{partial}$	P-value
AWAP precipitation	0.13	0.002
AWAP minimum temperature	0.008	0.85
AWAP maximum temperature	-0.05	0.14
AWAP solar radiation	-0.05	0.15
AWAP vapor pressure	0.025	0.51
AWAP geographical distance	0.004	0.82
CHELSA Precipitation amount	0.078	0.07
CHELSA Climatic moisture index	0.073	0.07
CHELSA mean daily maximum 2m air temperature	0.03	0.37
CHELSA mean daily minimum 2m air temperature	0.02	0.37
CHELSA Surface downwelling shortwave flux in air	-0.014	0.67
CHELSA potential evapotranspiration	0.02	0.47
CHELSA geographical distance	-0.015	0.48

Supplementary table 7. Results of the pairwise multiple matrix regression models (MMR) with the variables with a significant effect on the change in colour morph frequency. MMR models incorporated only two morphs at a time, to examine if certain variables strongly influenced frequency changes in specific morphs. For each variable we reported their partial correlation coefficient ($r_{partial}$). Variables with a significant effect are in bold.

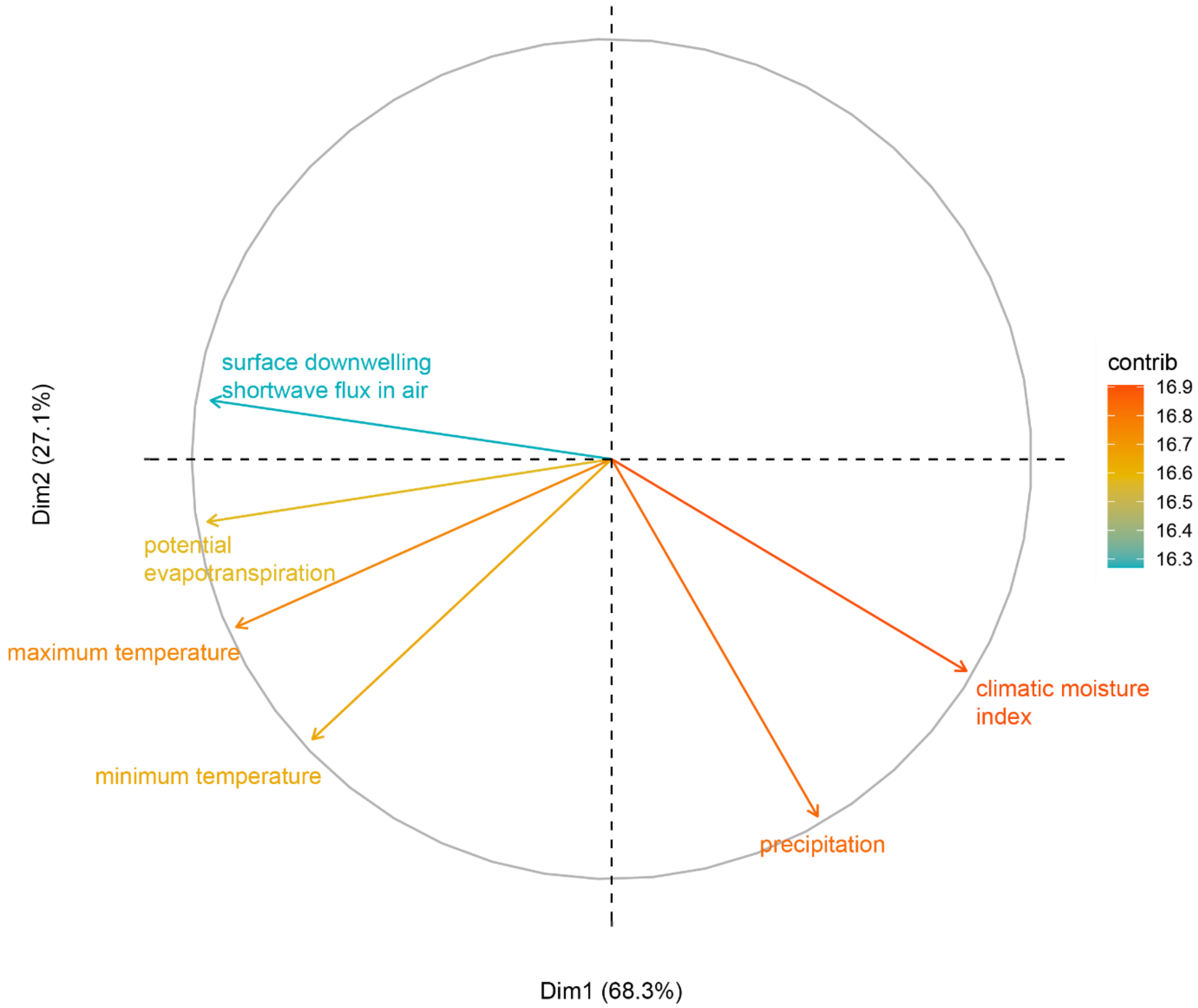
Pairwise comparison	CHELSA geographical distance	CHELSA precipitation	CHELSA mean daily minimum 2m air temperature	AWAP geographical distance	AWAP precipitation	AWAP minimum temperature	AWAP maximum temperature
Black-and-white vs. Black	0.003	0.04	0.06	0.01	0.08	0.03	-0.06
Black vs. Orange	-0.06	**0.29****	0.018	-0.01	**0.37****	-0.02	-0.04
Black-and-white vs. Orange	**-0.05***	**0.15***	-0.03Su	-0.01	**0.16****	-0.05	-0.01

*P-value < 0.05

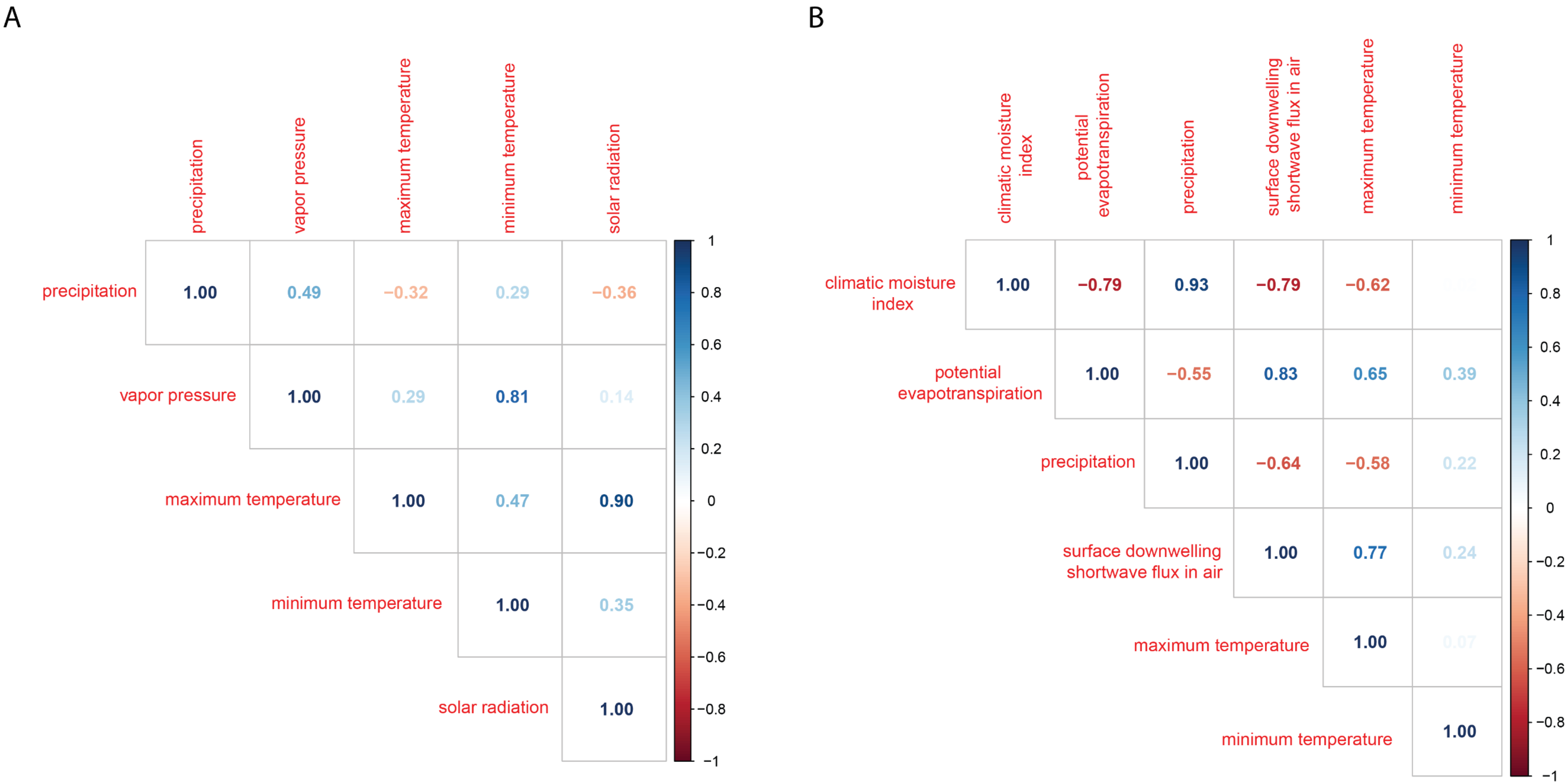
**P-value < 0.001



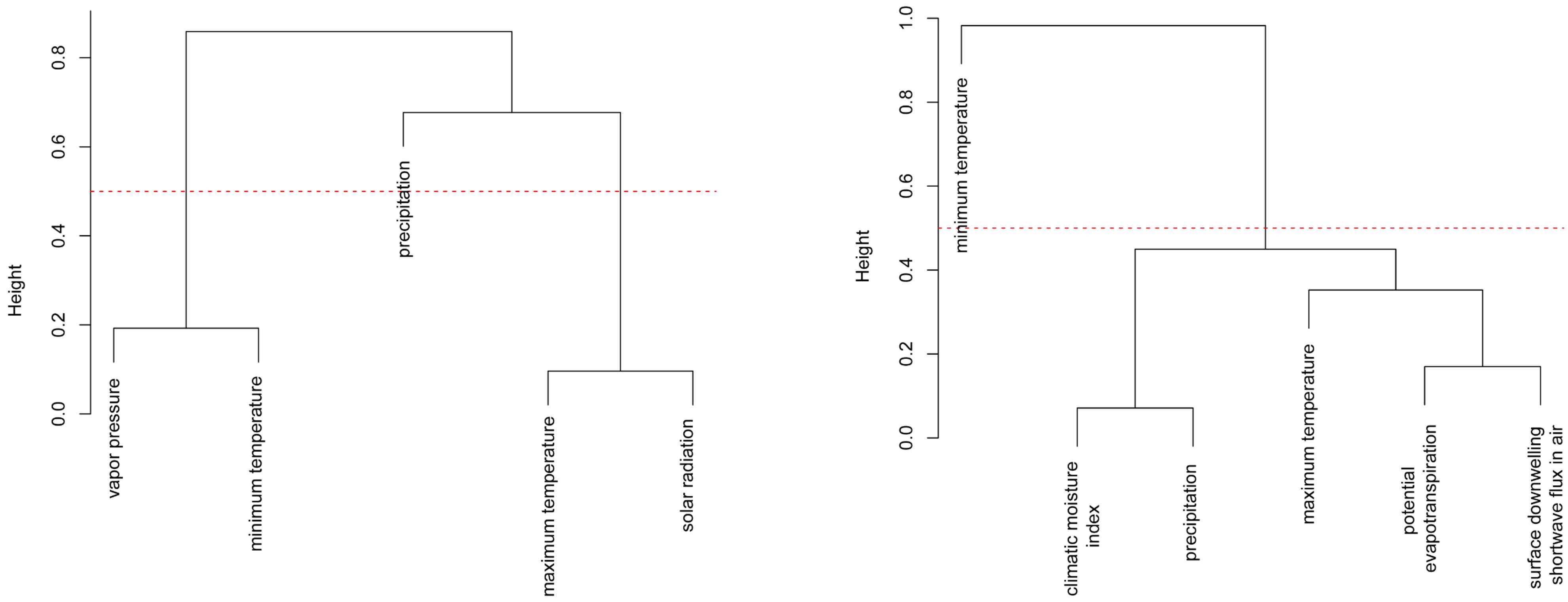
Supplementary figure 1. Heating rates experimental set up. We used a solar simulator as the light source coupled to if the black-and-white and black differ in their heating rates. The samples were inside a thermal chamber that minimizes the effect convection or conduction due to its cooling system that kept a stable air temperature.



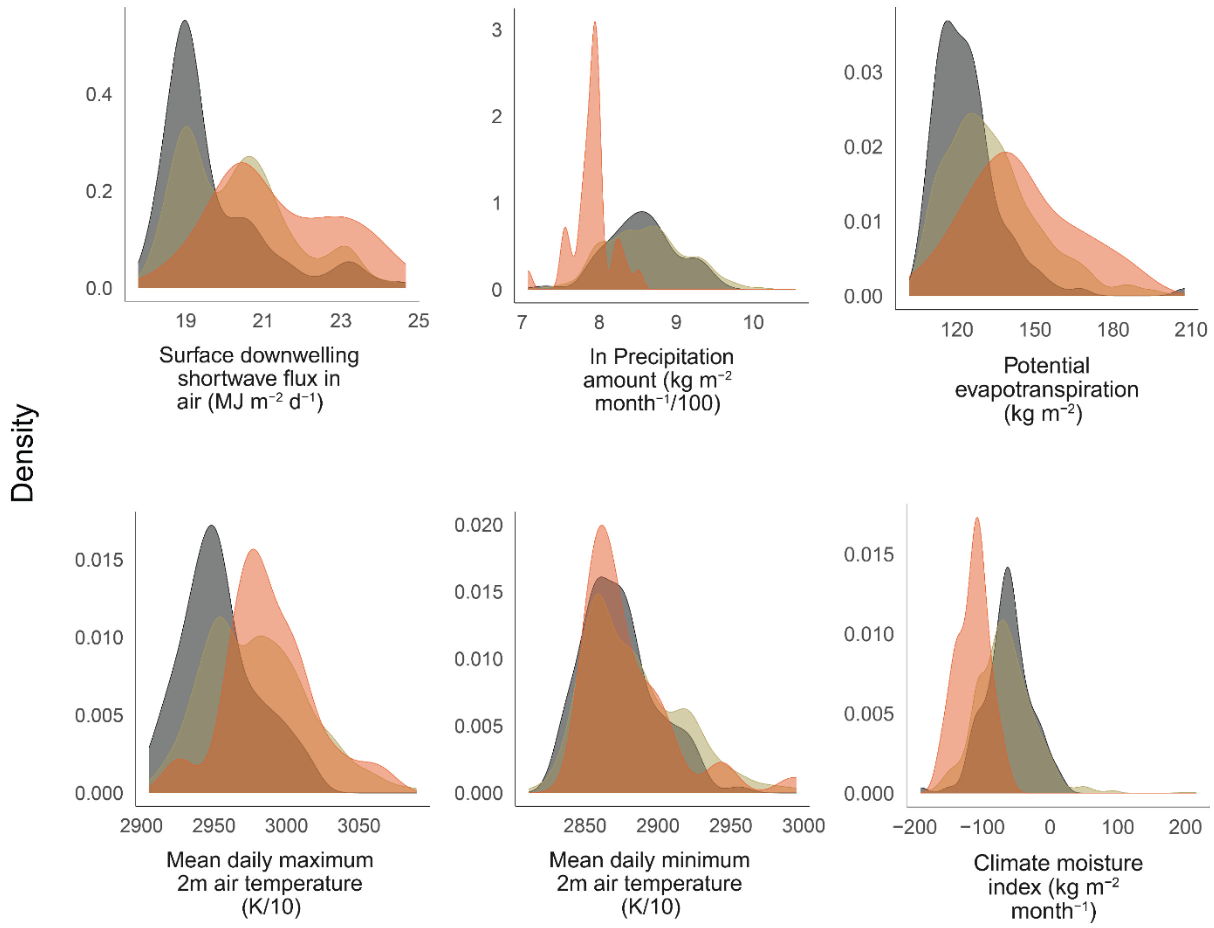
Supplementary figure 2. Principal component dimensionality and contribution per variable. We summarized the climatic variation in two principal components (PC) which explained 95.4% of the climatic variation.



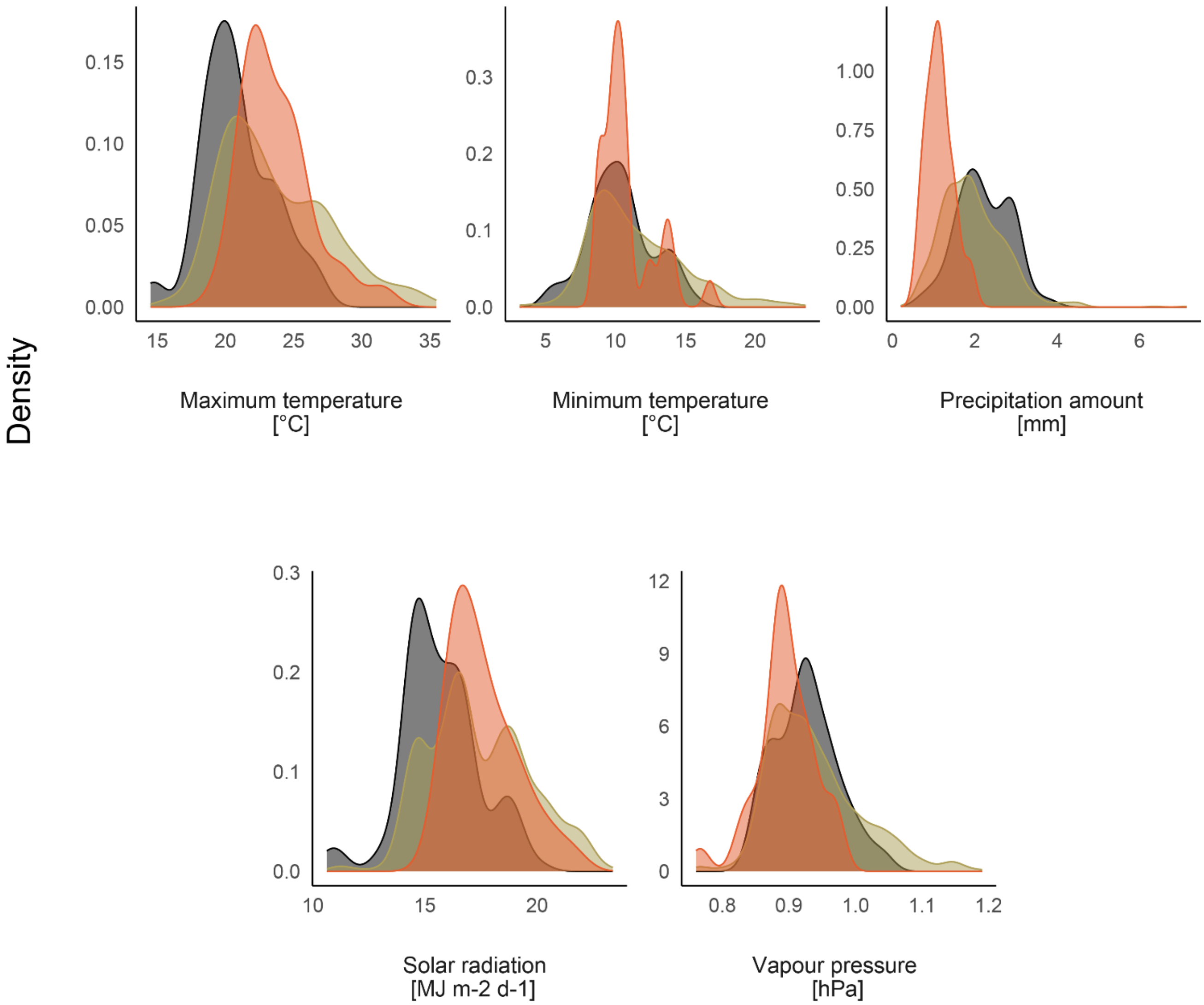
Supplementary Figure 3. Pearson's correlation heatmap of the values of climatic variables at the field locations. The left panel displays the pairwise correlation values from the AGCD/AWAP dataset, while the right panel exhibits the pairwise correlation values from the CHELSA v2.1 dataset.



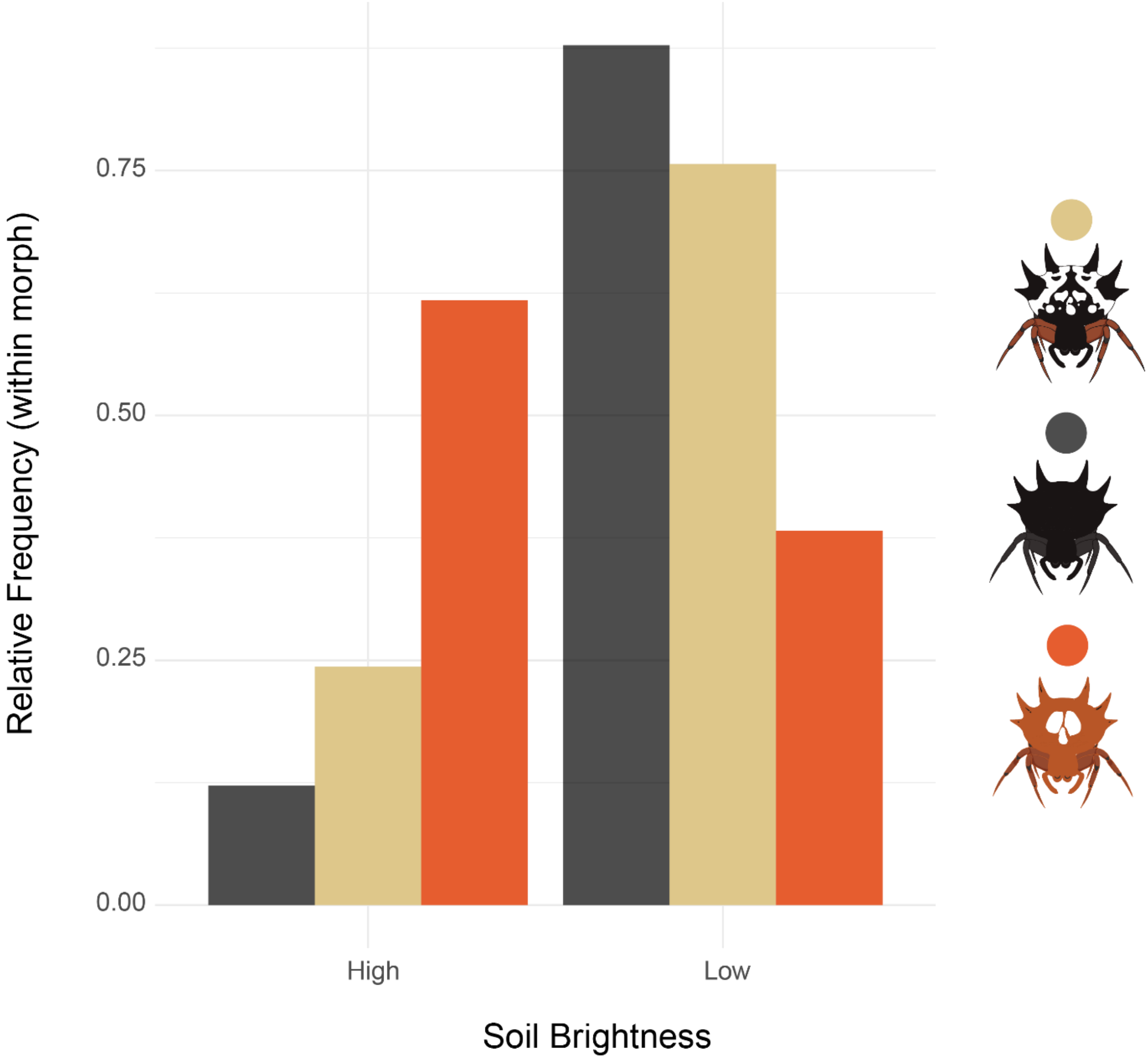
Supplementary figure 4. Hierarchical clustering analysis using Pearson correlation values resulting from all possible pairwise comparisons between the climatic variables per dataset. We considered a pair of variables as independent if they had a pairwise distance > 0.5. Left panel corresponds to the AGCD/AWAP dataset and right panel corresponds to the CHELSA v2.1.



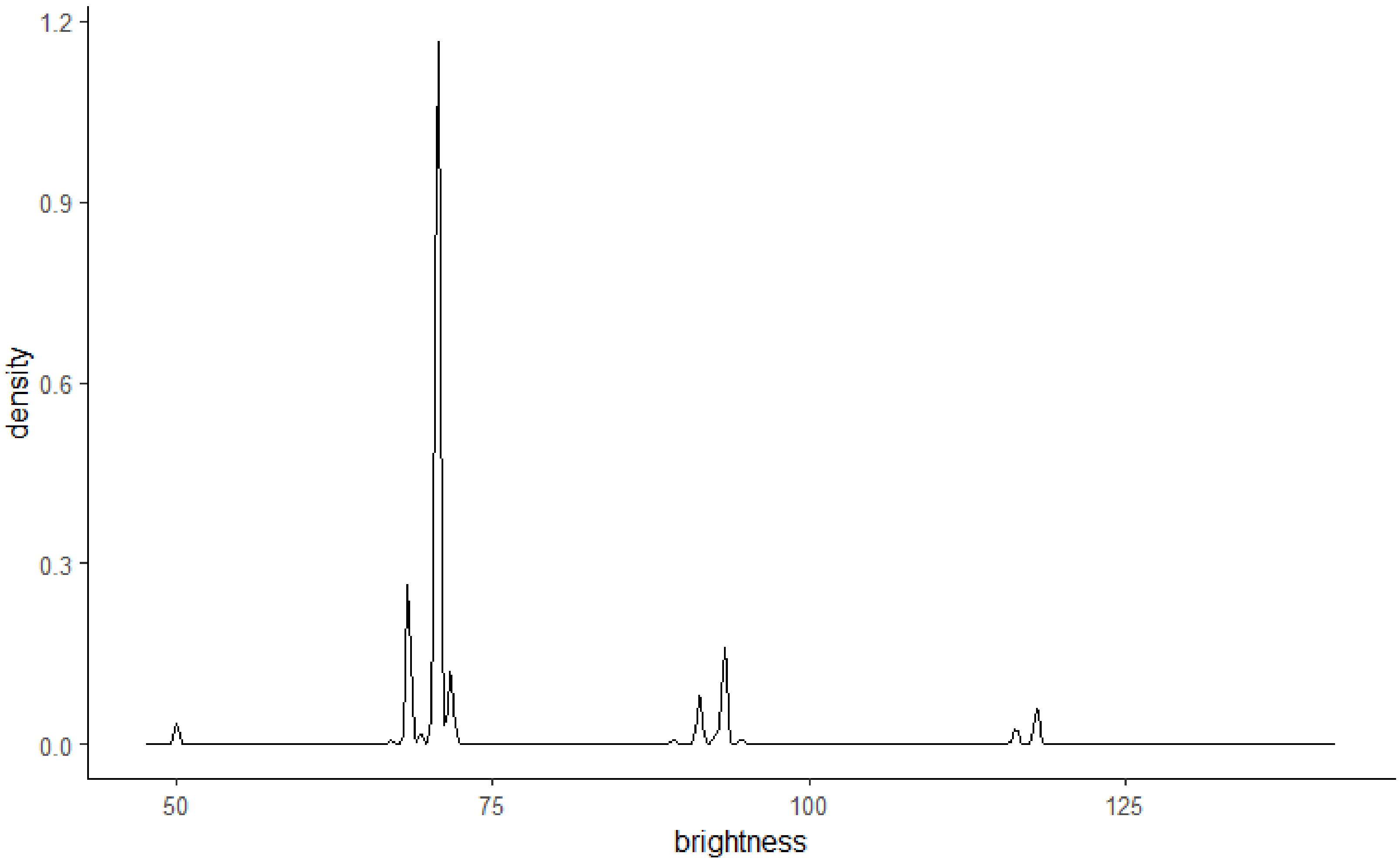
Supplementary figure 5. Realized climatic niche density plots per variable of the CHELSA v2.1 dataset. Colour morphs are coded as in Figure 3.



Supplementary figure 6. Realized climatic niche density plots per variable of the AGCD/AWAP v2.1 dataset. Colour morphs are coded as in Figure 3



Supplementary figure 7. Relative frequency with each morph per soil brightness category. Chi-square test of independence result is $X^2 = 35.86$, DF = 2, P = 1.62E-8



Supplementary figure 8. Probability density function of the brightness values of the geographical records in our dataset. This graph clearly shows that the variable is not continue and evenly distributed.