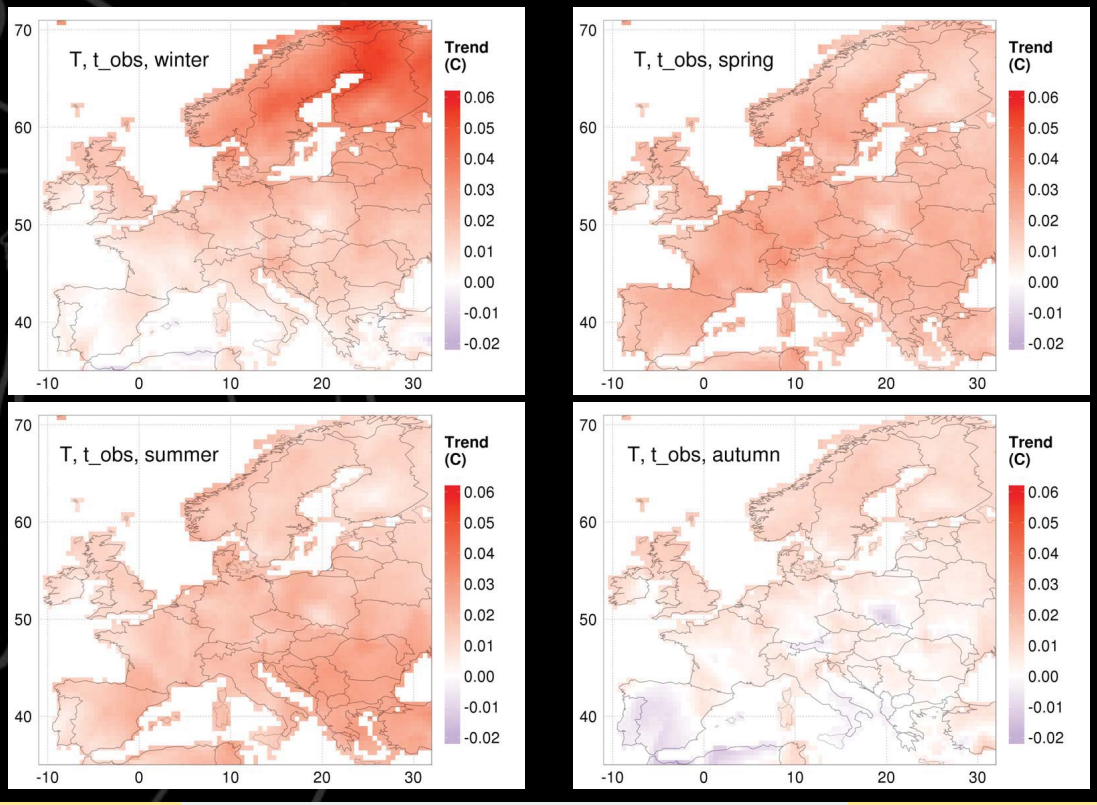
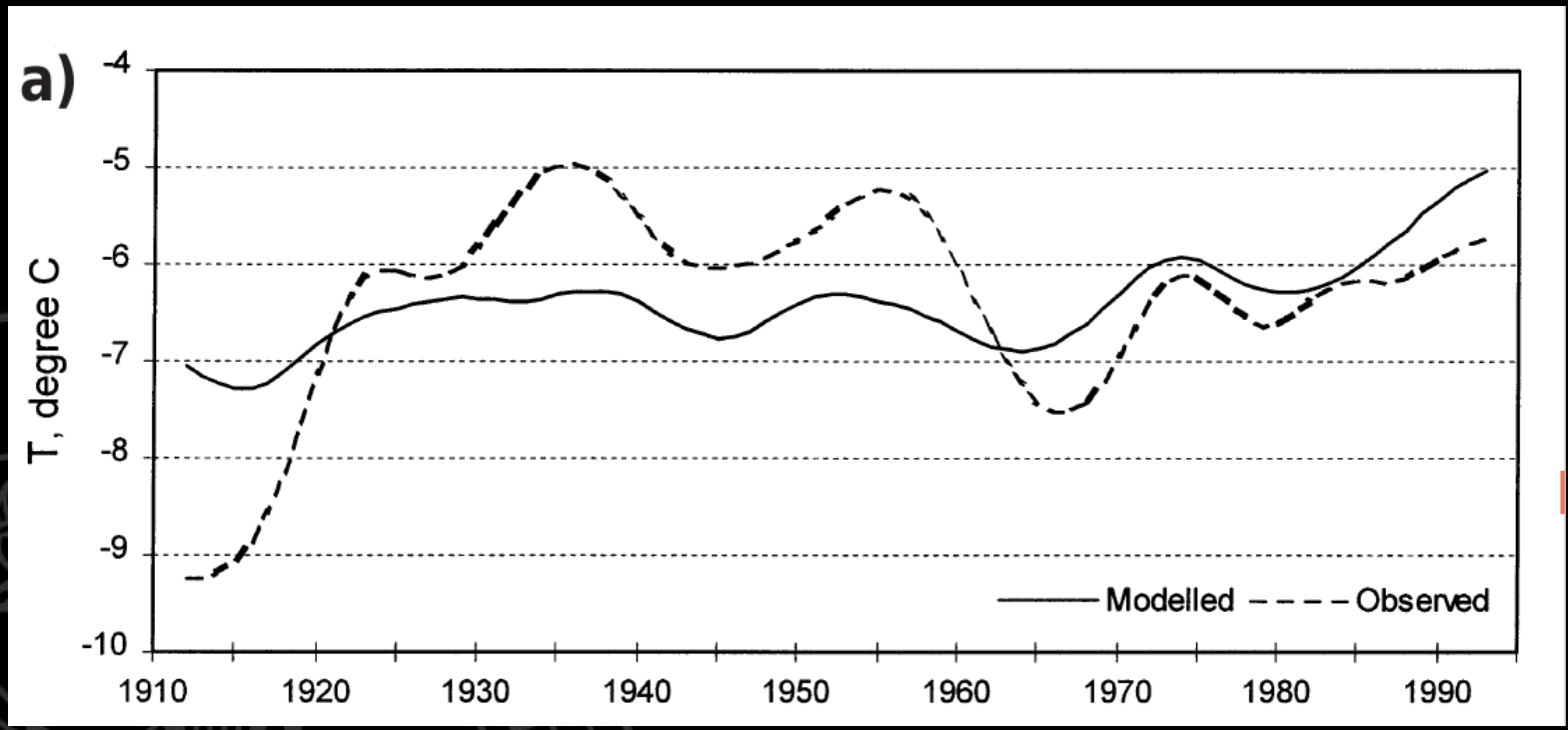
Probabilistic approach to attribute warming to changes in atmospheric circulation

Irene Nilsen , James Stagge, Lena Tallaksen



Causes of winter warming



Source: Hanssen-Bauer and Førland 1998, Climate research 10, 143.

1960s-1990s: Positive phase of NAO

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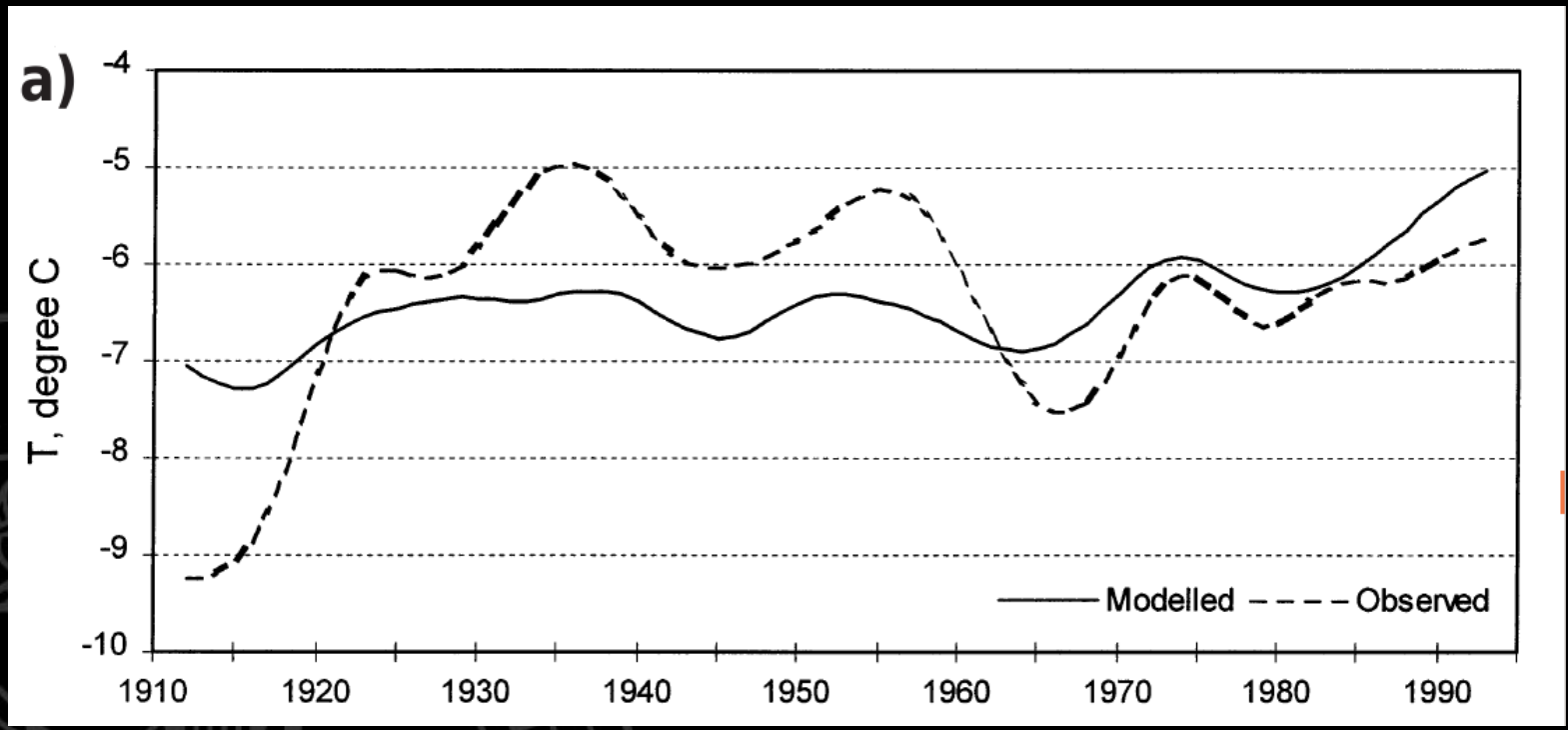
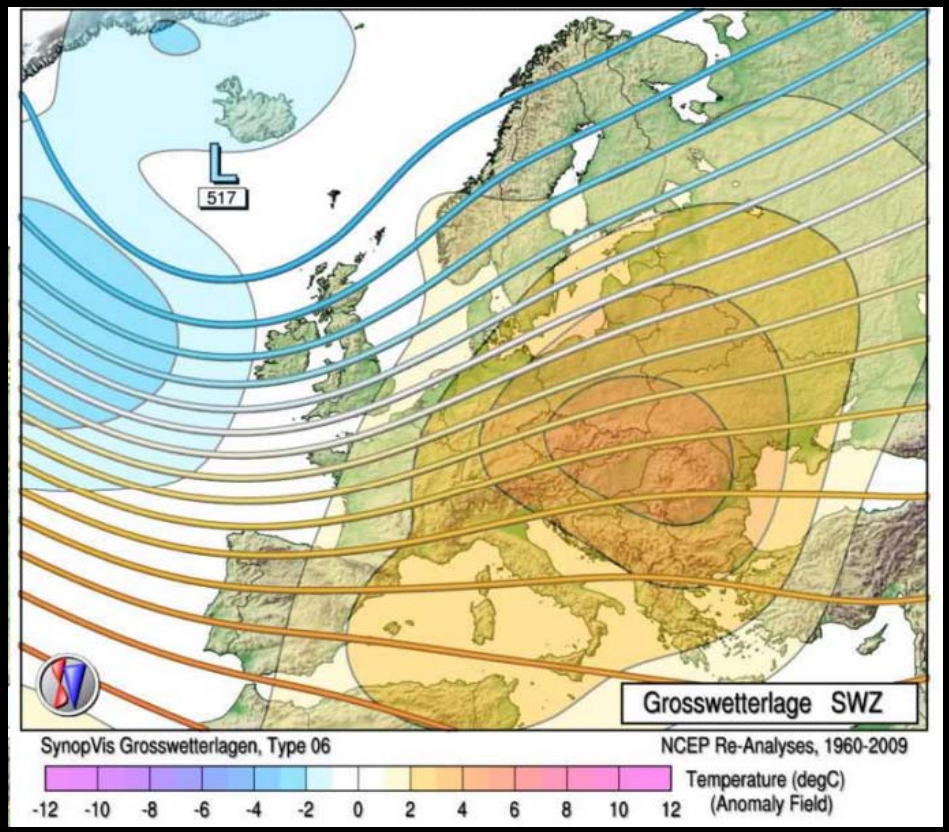


Source: Hanssen-Bauer and Førland 1998, Climate research 10, 143.

1960s-1990s: Positive phase of NAO

1930s-1950s: Low sea ice extent? + circulation? + other?

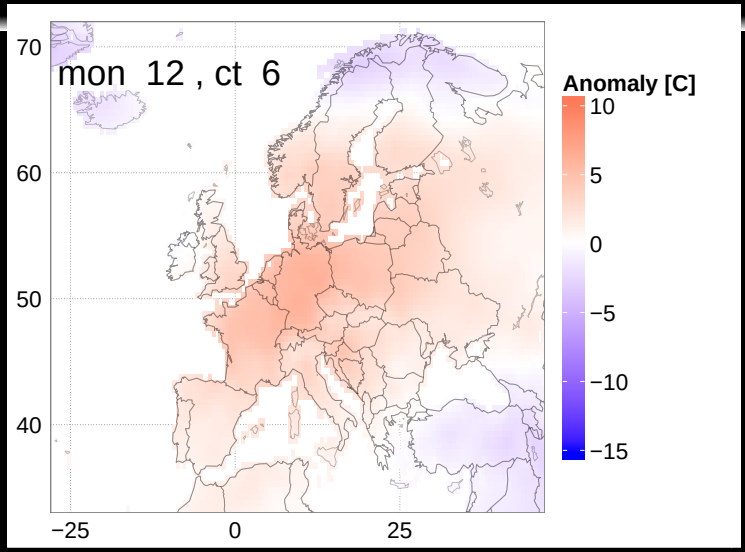
A synoptic type classifies the state of the atmosphere



SVG = SynopVis Grosswetterlagen

Synoptic circulation classification (James, 2007)

I've used WFDEI data for 1981-2010



WFDEI = Watch Forcing Data Era-Interim (Weedon et al. 2014) bias-corrected Era-Interim, 0.5 ° spatial resolution.

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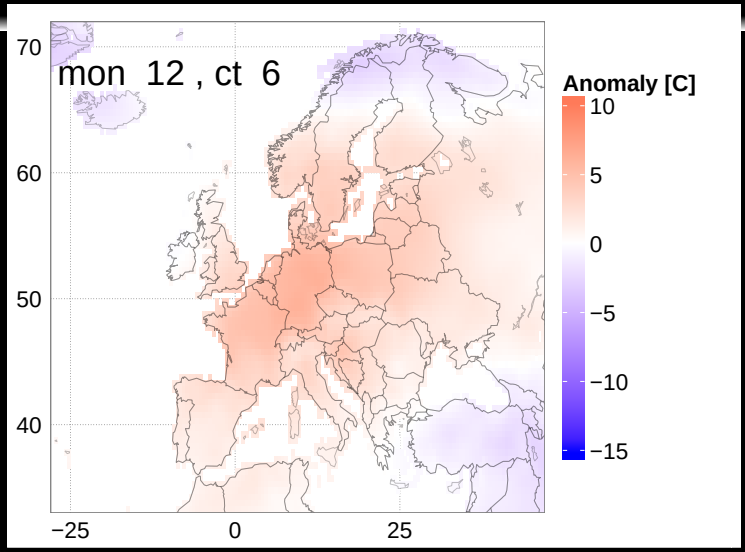

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Circulation-induced change
if warm STs become more frequent and cold STs less frequent.

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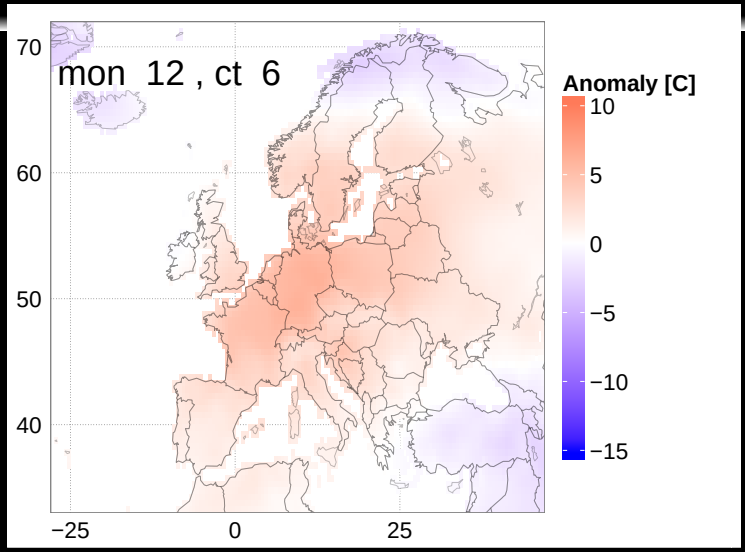

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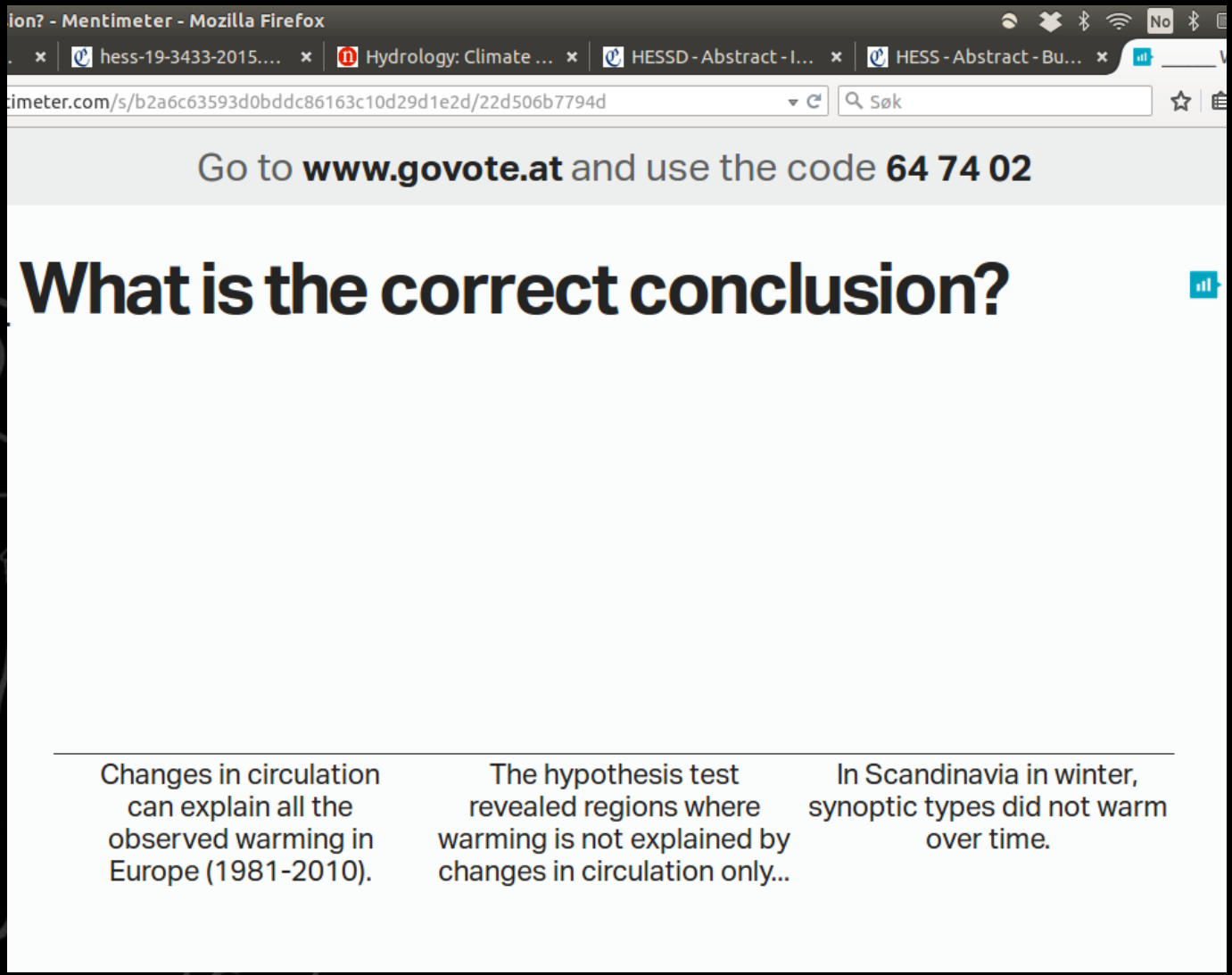
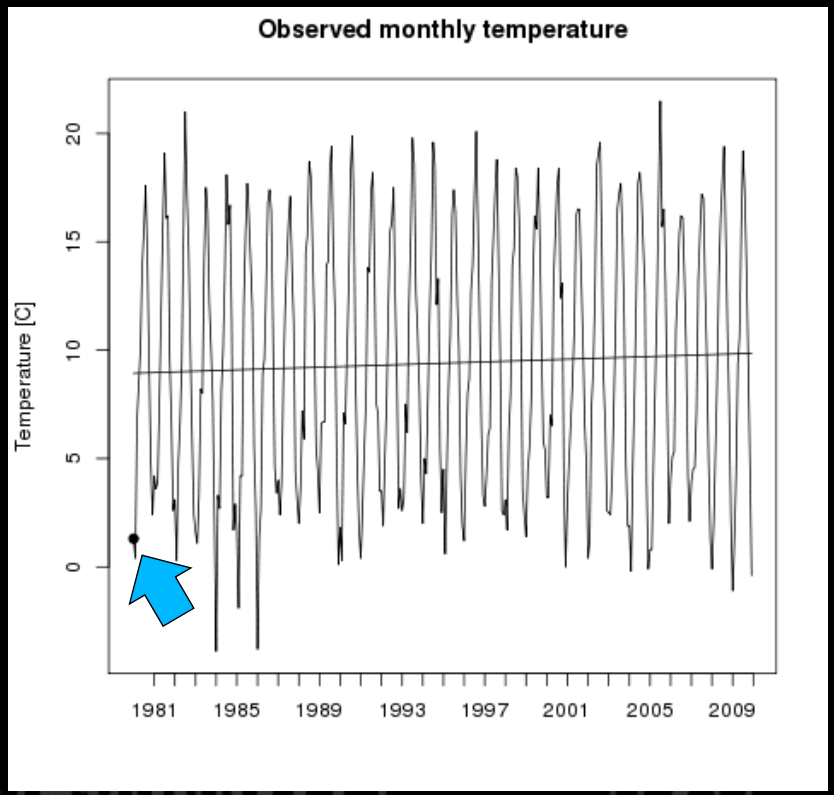
Circulation-induced change
if warm STs become more frequent and cold STs less frequent.

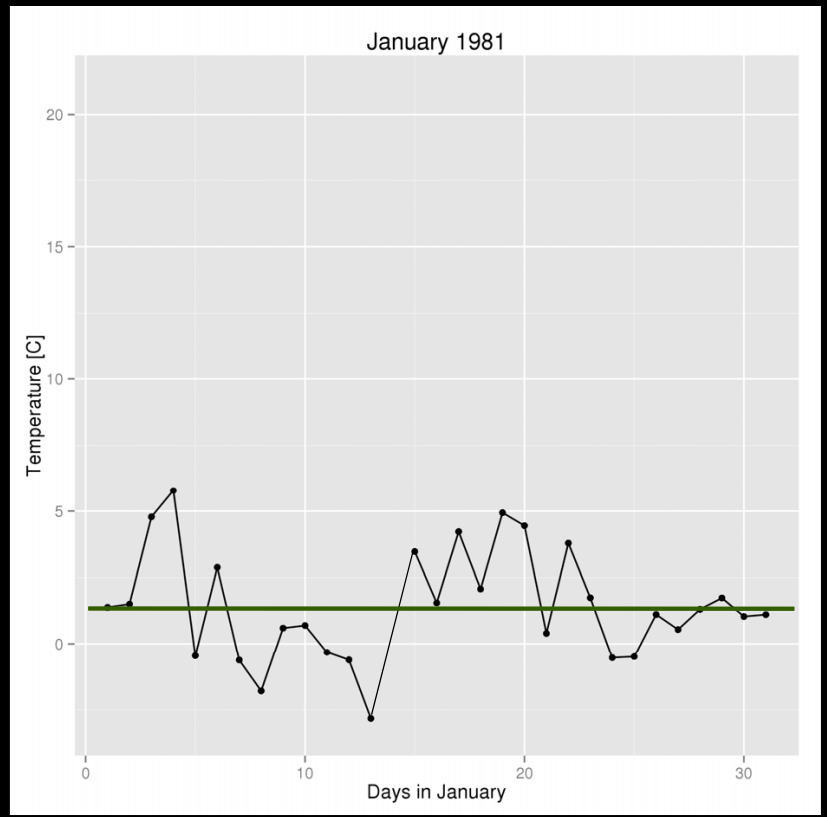
Within-type change
if synoptic types warm over time.

Please vote before the end of the result section



Prediction model: create a new hypothetical series





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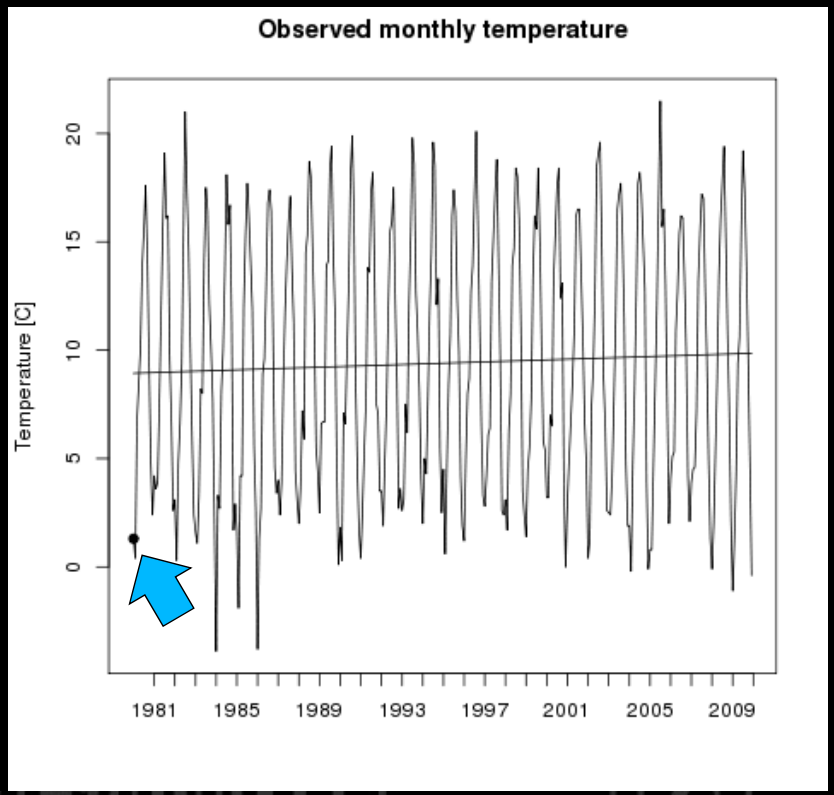
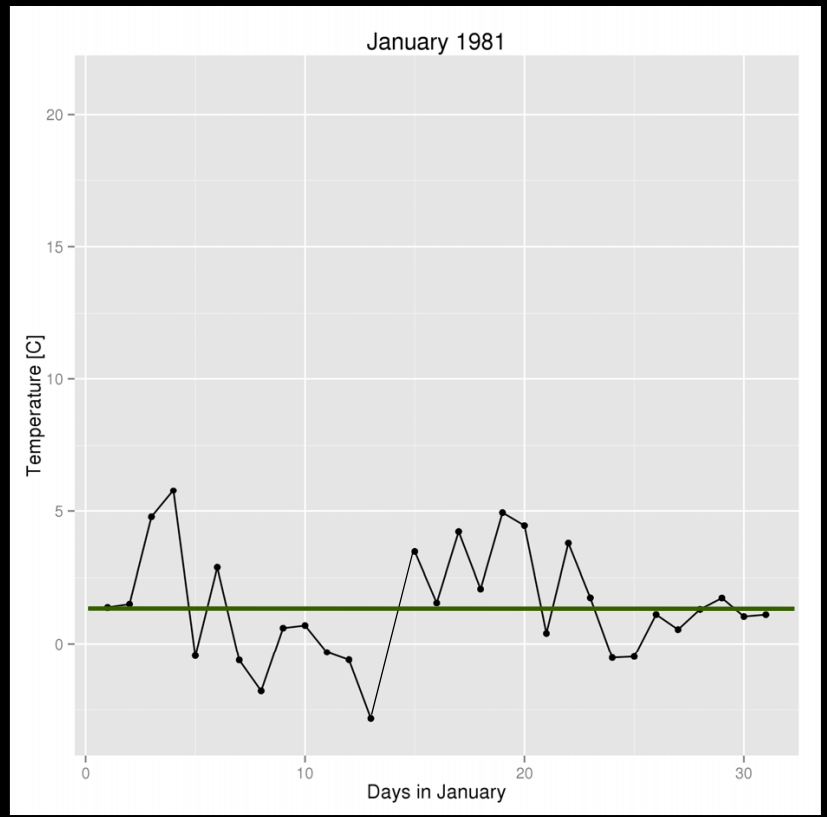
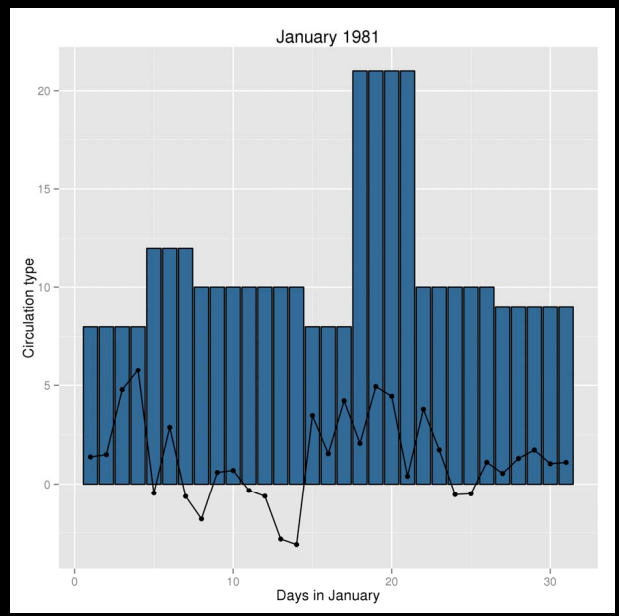




Method of hypothetical trends: Leathers and Ellis, 1996; Huth, 1999.

Link the estimated observed values with the synoptic type

Mon	ST	Obs[°C]
1	8	2.0
1	8	2.1
1	8	4.9
1	8	5.6
1	12	-0.2
1	12	2.8
1	12	-0.3
1	10	-1.8
1	10	0.4
1	10	0.5
1	10	-0.1
…	…	…



Replace estimated observed values with long-term mean

Pick all temperatures for month i and synoptic type j

Mon	ST	Obs [°C]
1	8	2.0
1	8	2.1
1	8	4.9
1	8	5.6
1	12	-0.2
1	12	2.8
1	12	-0.3
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1	10	0.4
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1	12	2.0
1	12	5.9
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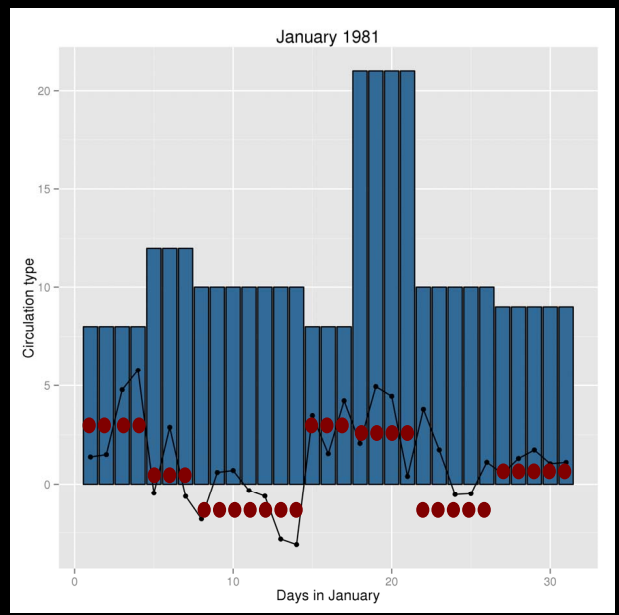

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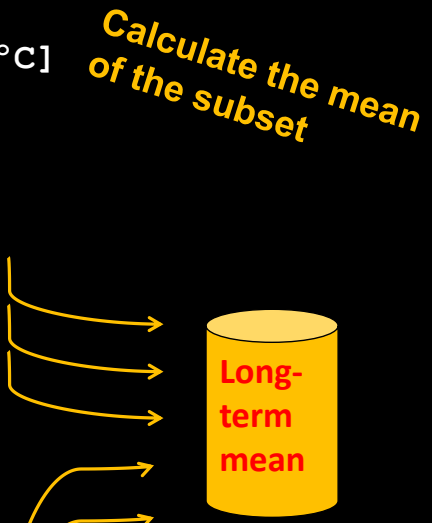

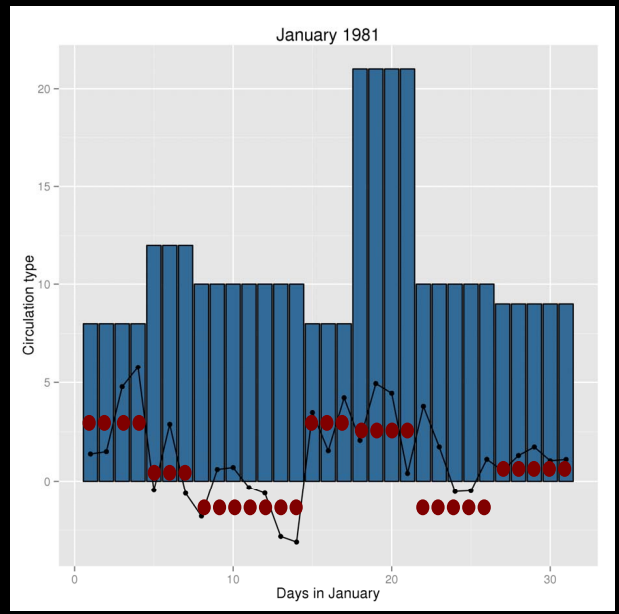

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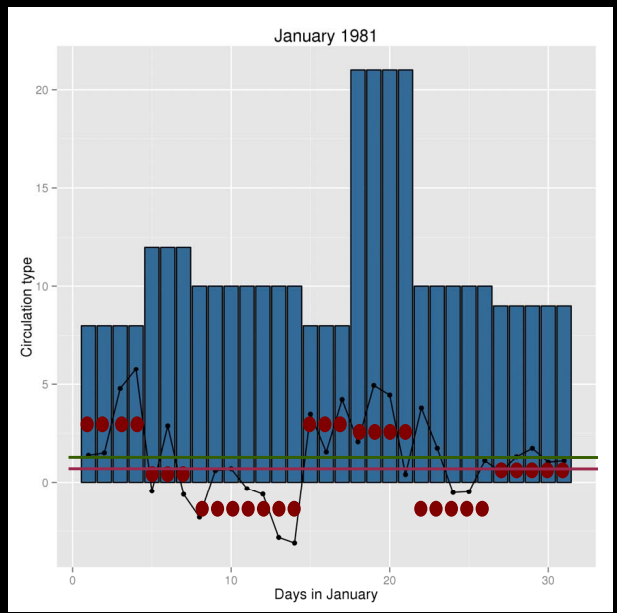
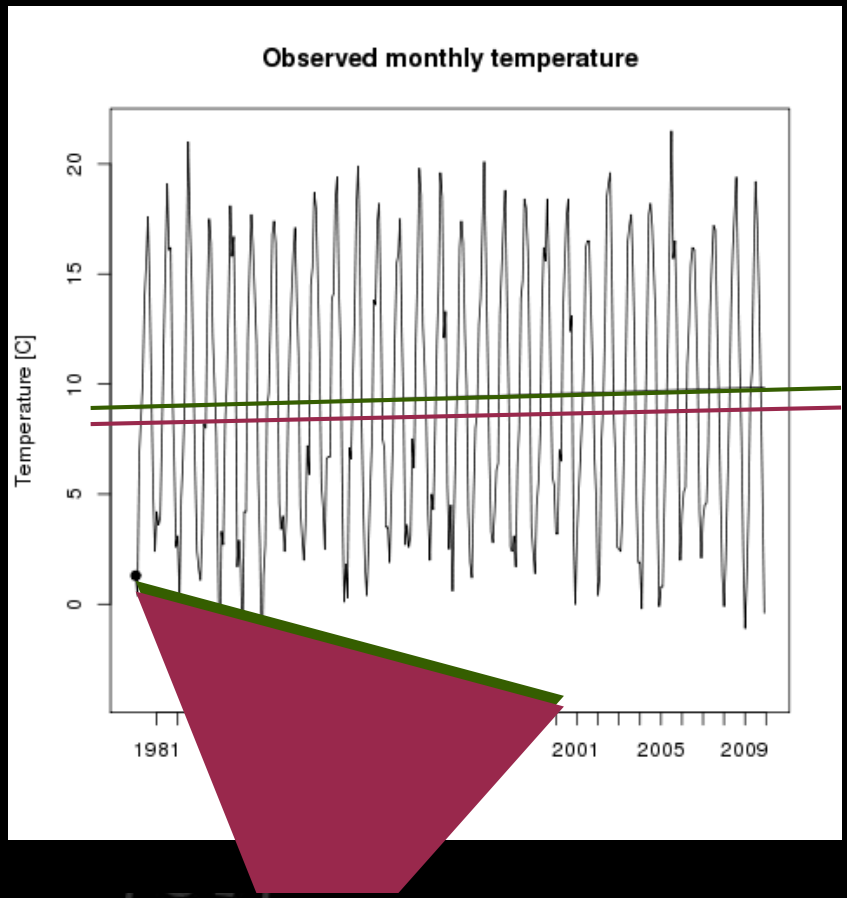
1	10	0.4
1	10	0.5
1	10	-0.1
…	…	…
1	12	2.0
1	12	5.9
…	…	…

Long-term mean

Mon	ST	Hyp [°C]
1	8	2.9
1	8	2.9
1	8	2.9
1	8	2.9
1	12	0.2
1	12	0.2
1	12	0.2
1	10	-1.5
1	10	-1.5
1	10	-1.5
1	10	-1.5
…	…	…
1	12	0.2
1	12	0.2
…	…	…



The hypothetical series gives only *one* possible realization



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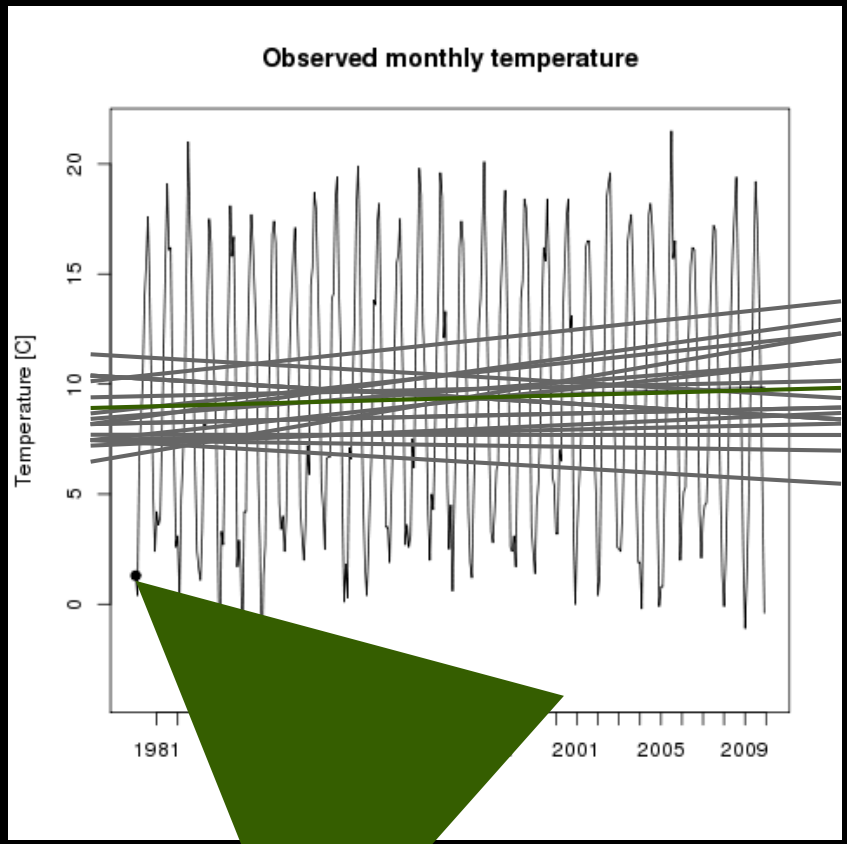

Part I: use resampling to assess the possible spread

Resample the temperature on days in month i and synoptic type j 10 000 times

Mon	ST	Obs[°C]
1	8	2.0
1	8	2.1
1	8	4.9
1	8	5.6
1	12	-0.2
1	12	2.8
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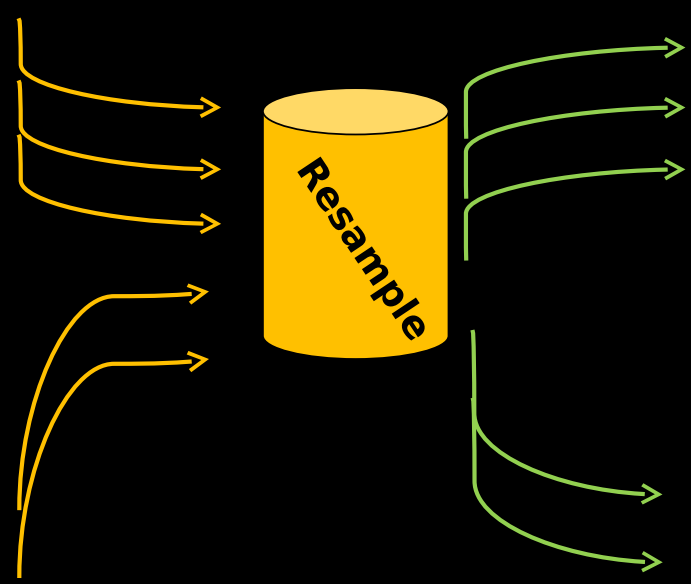
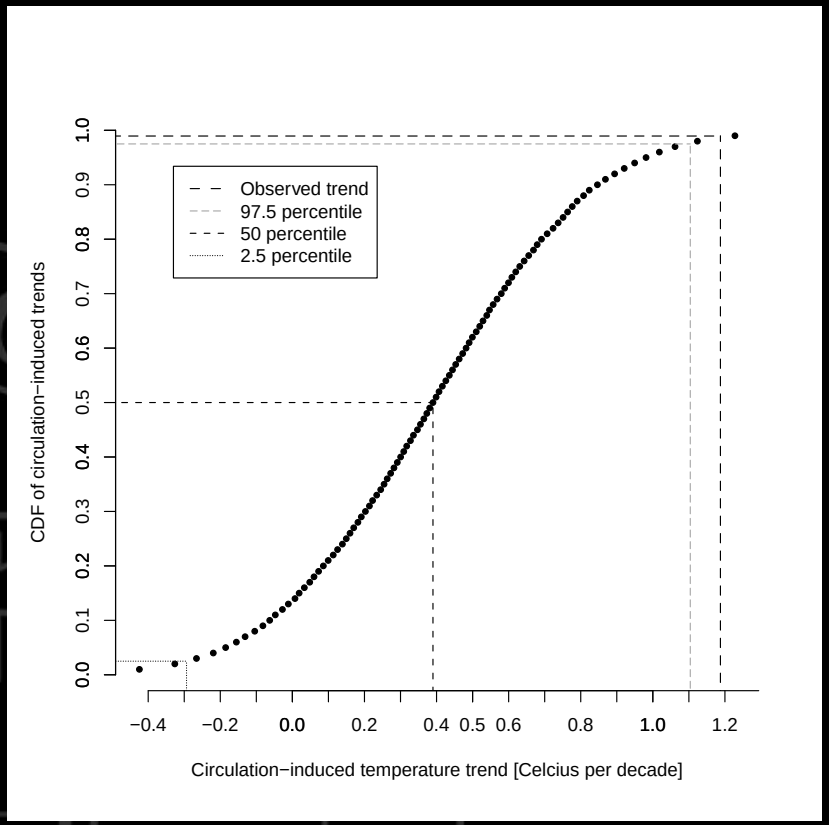


Mon	ST	Re1	…	Re10000
1	8	2.1	…	5.6
1	8	2.1	…	5.6
1	8	2.1	…	5.6
1	8	2.1	…	5.6
1	12	2.8	…	-0.2
1	12	2.8	…	-0.2
1	12	2.8	…	-0.2
1	10	0.4	…	0.5
1	10	0.4	…	0.5
1	10	0.4	…	0.5
1	10	0.4	…	0.5
…	…	…		
1	12	2.8	…	-0.2
1	12	2.8	…	-0.2
…	…	…	…	…

Part II: define a statistical test to compare the observed trend to the distribution of circulation-induced trends



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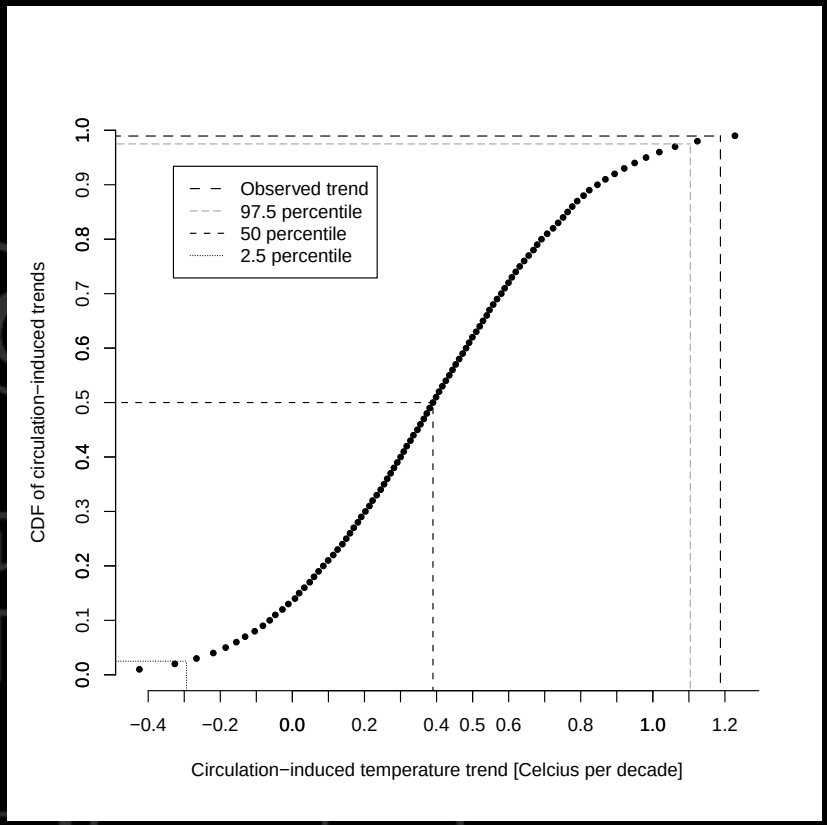
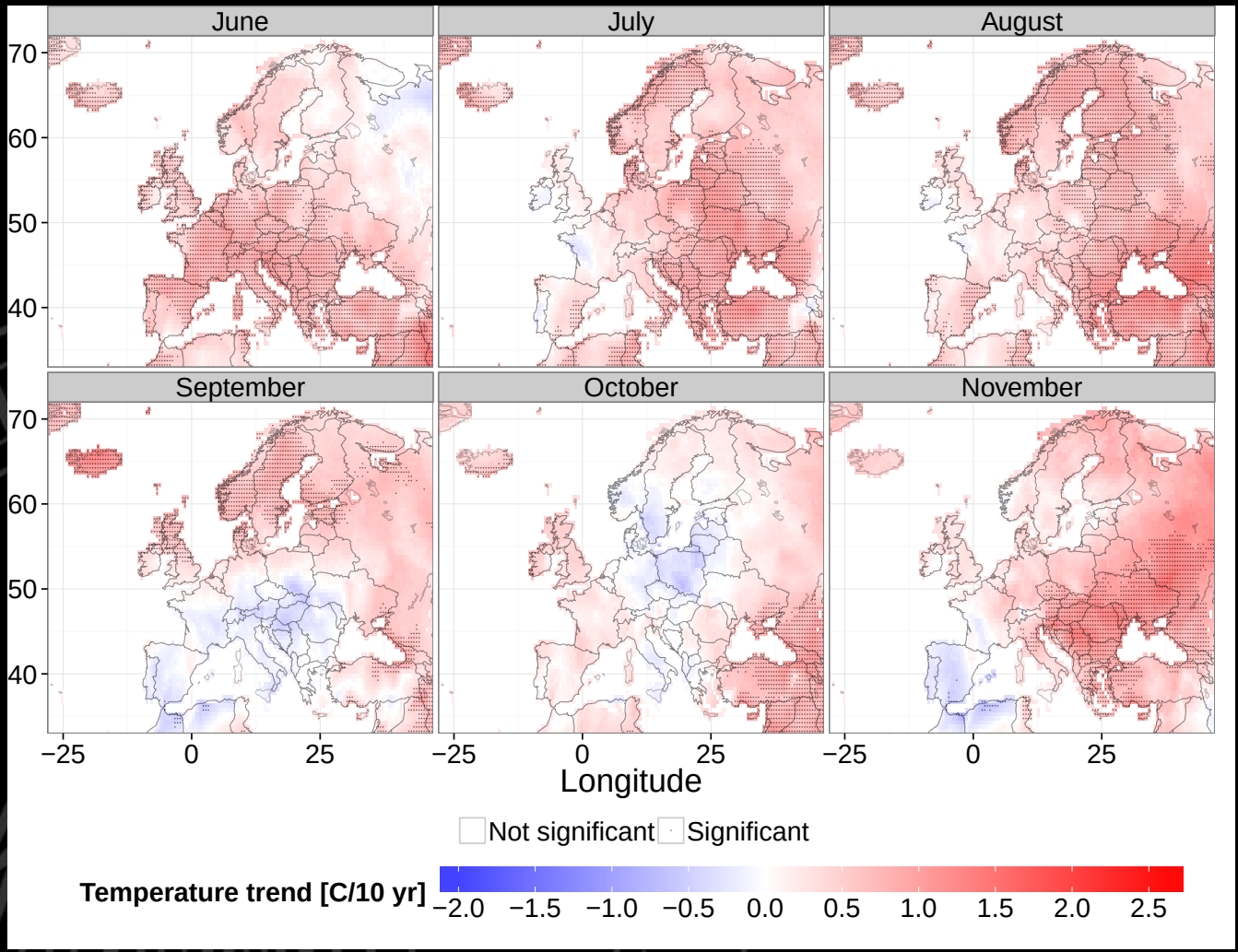


H_0: Temp trend can be explained by changes in circulation only

H_a: Temp trend cannot be explained by changes in circulation only

Significant observed temperature trends (dots)



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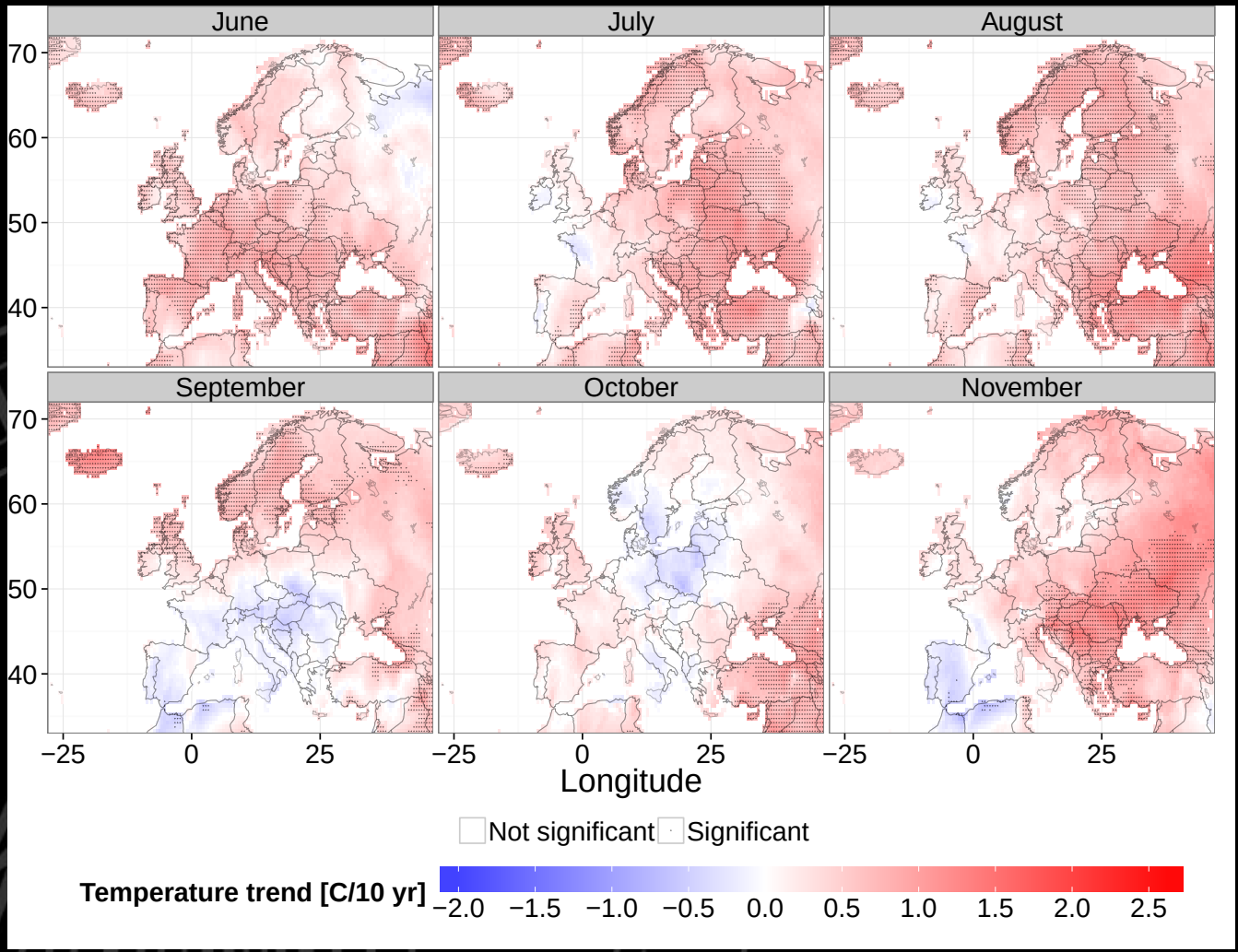
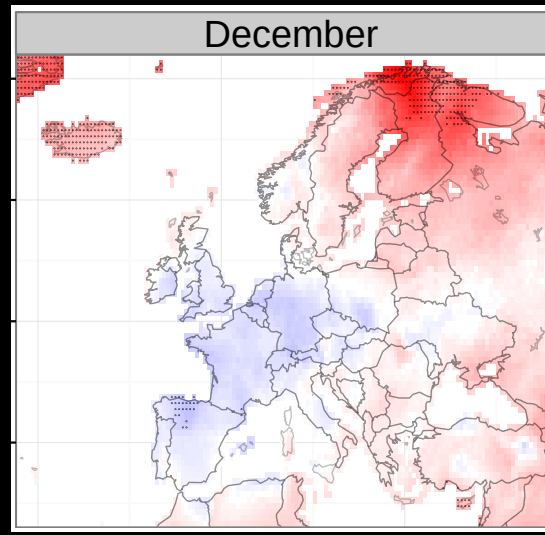
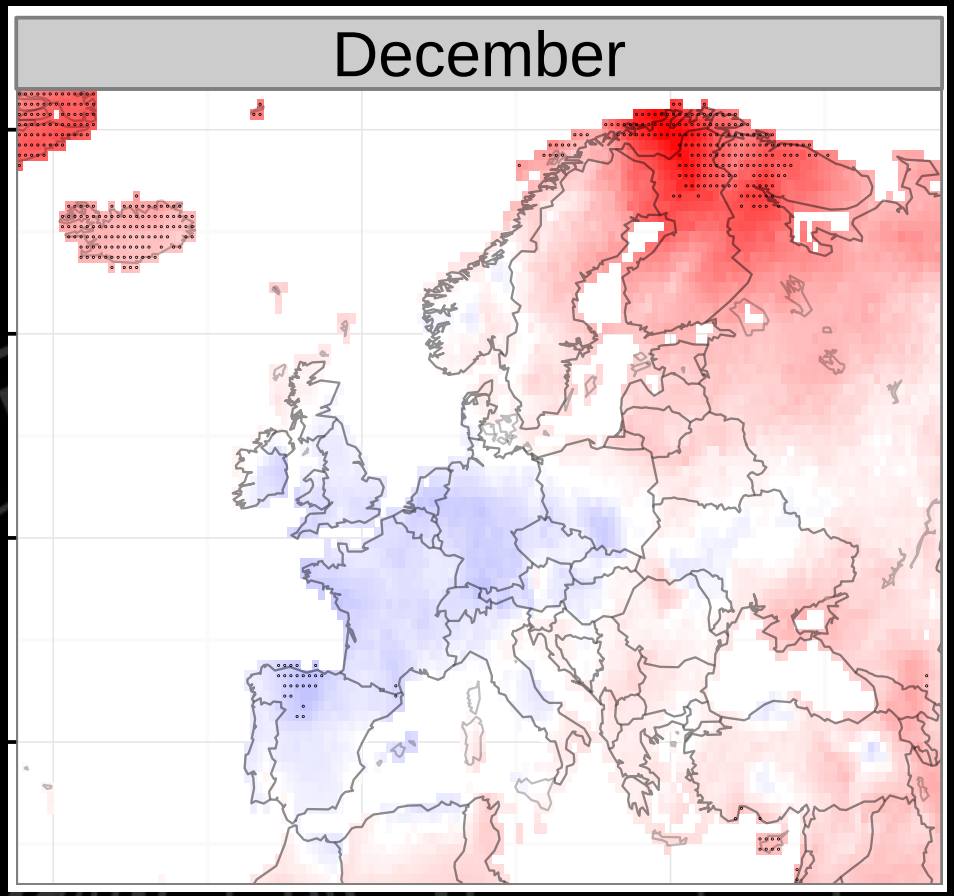
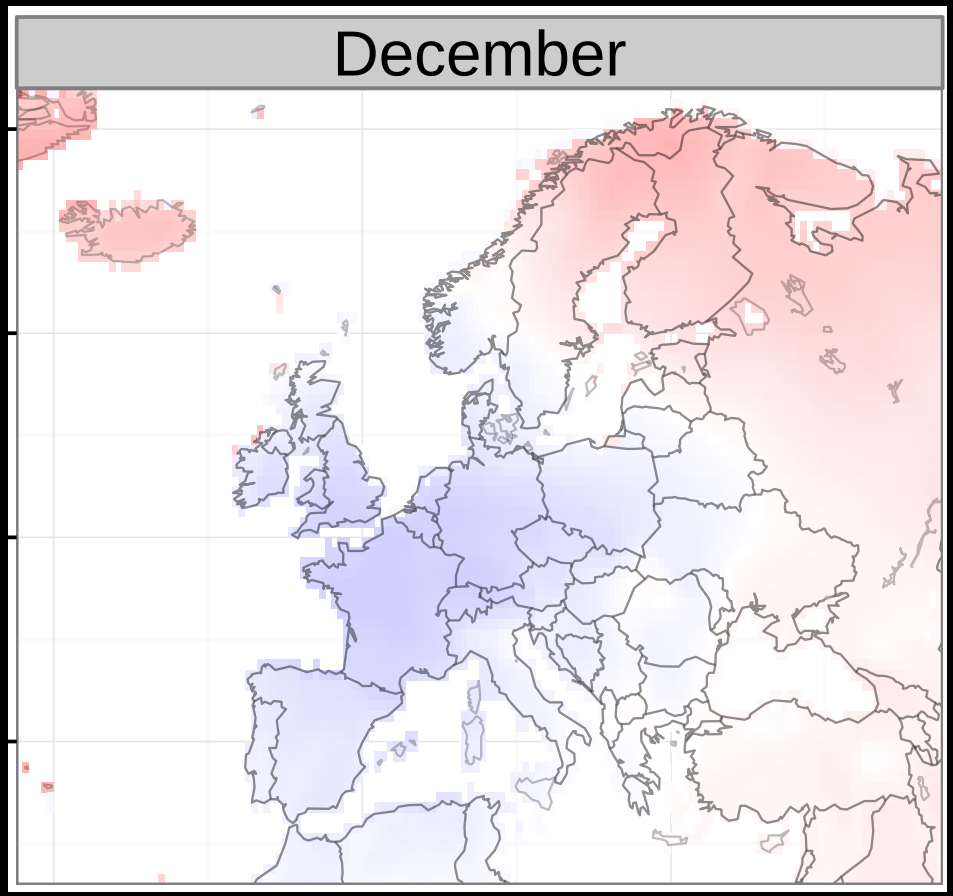




Observed trends and median of resampled trends

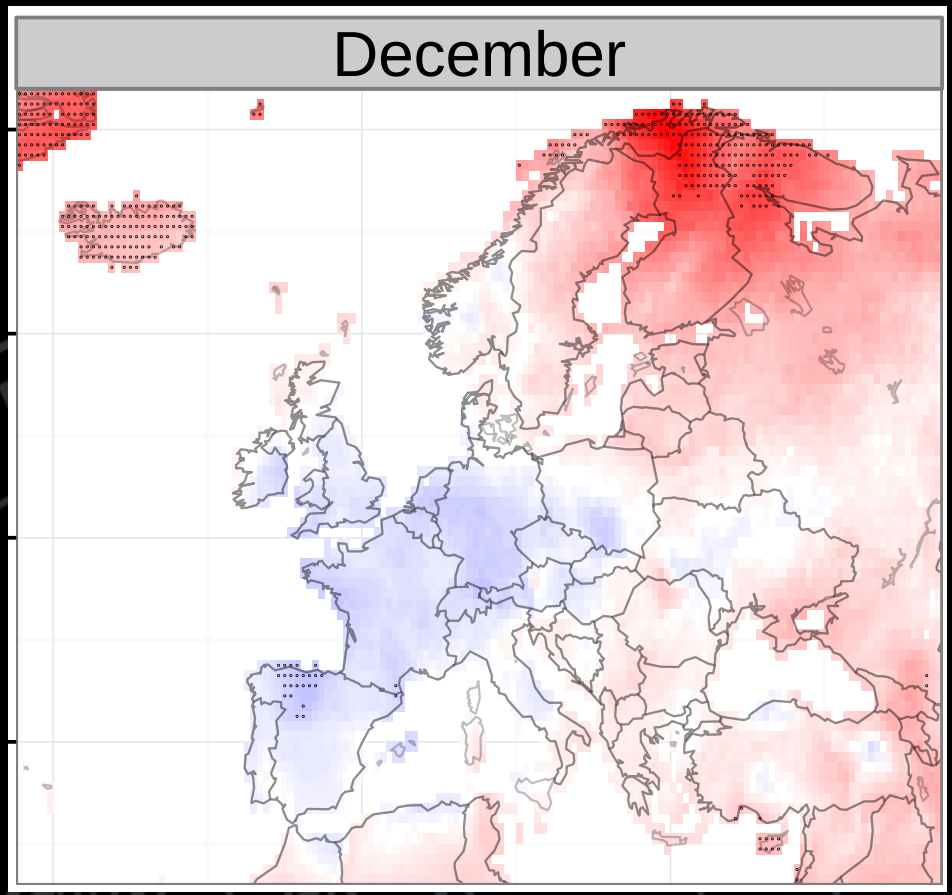


Observed trend

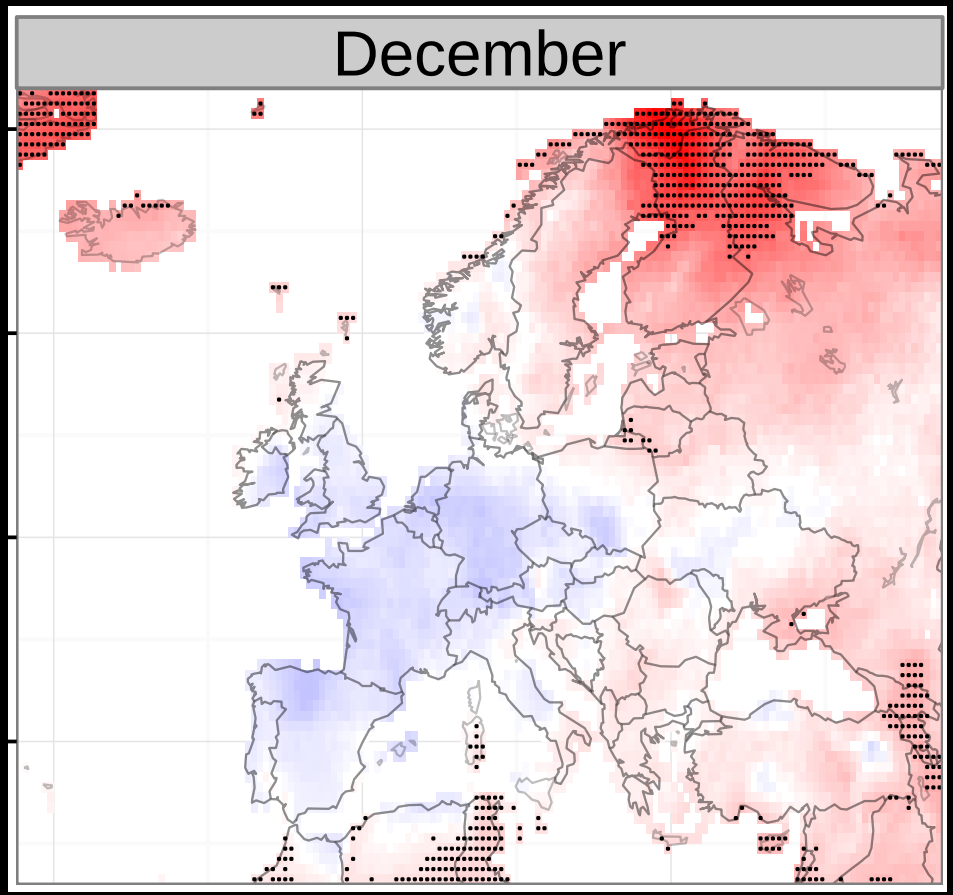


Circulation-induced trend

Comparing observed trend and "within-type" regions

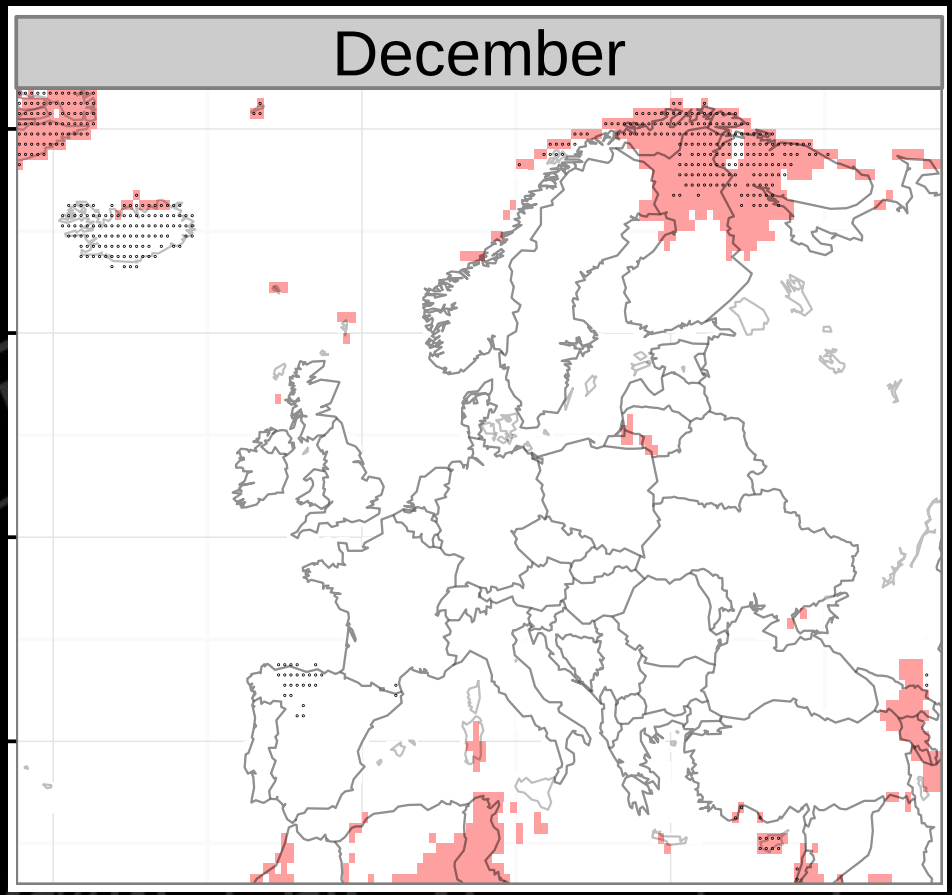


Observed trend

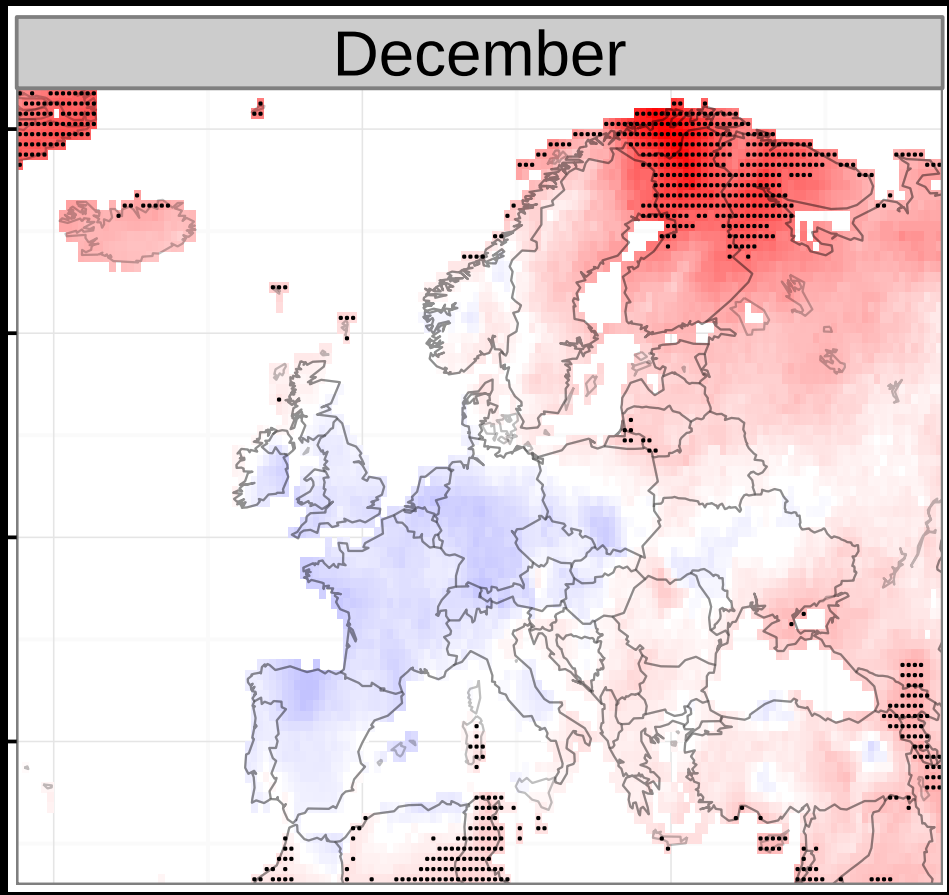


Rejected H_0

Comparing observed trend and "within-type" regions

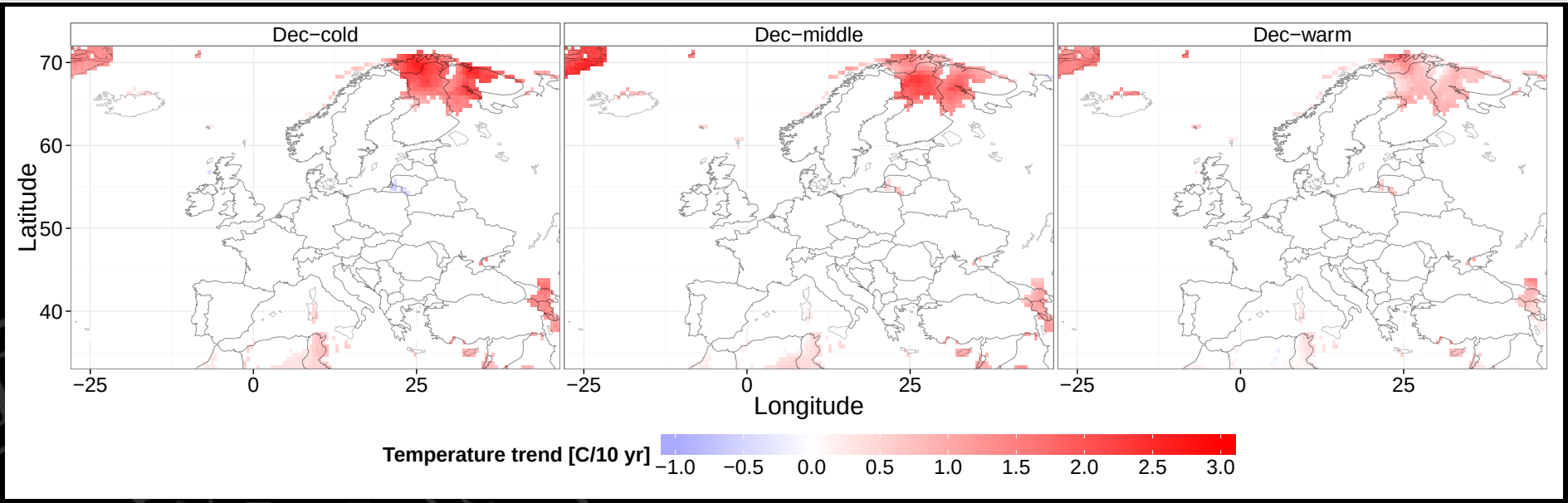


Combination



Rejected H_0

Circulation changes cannot explain recent warming



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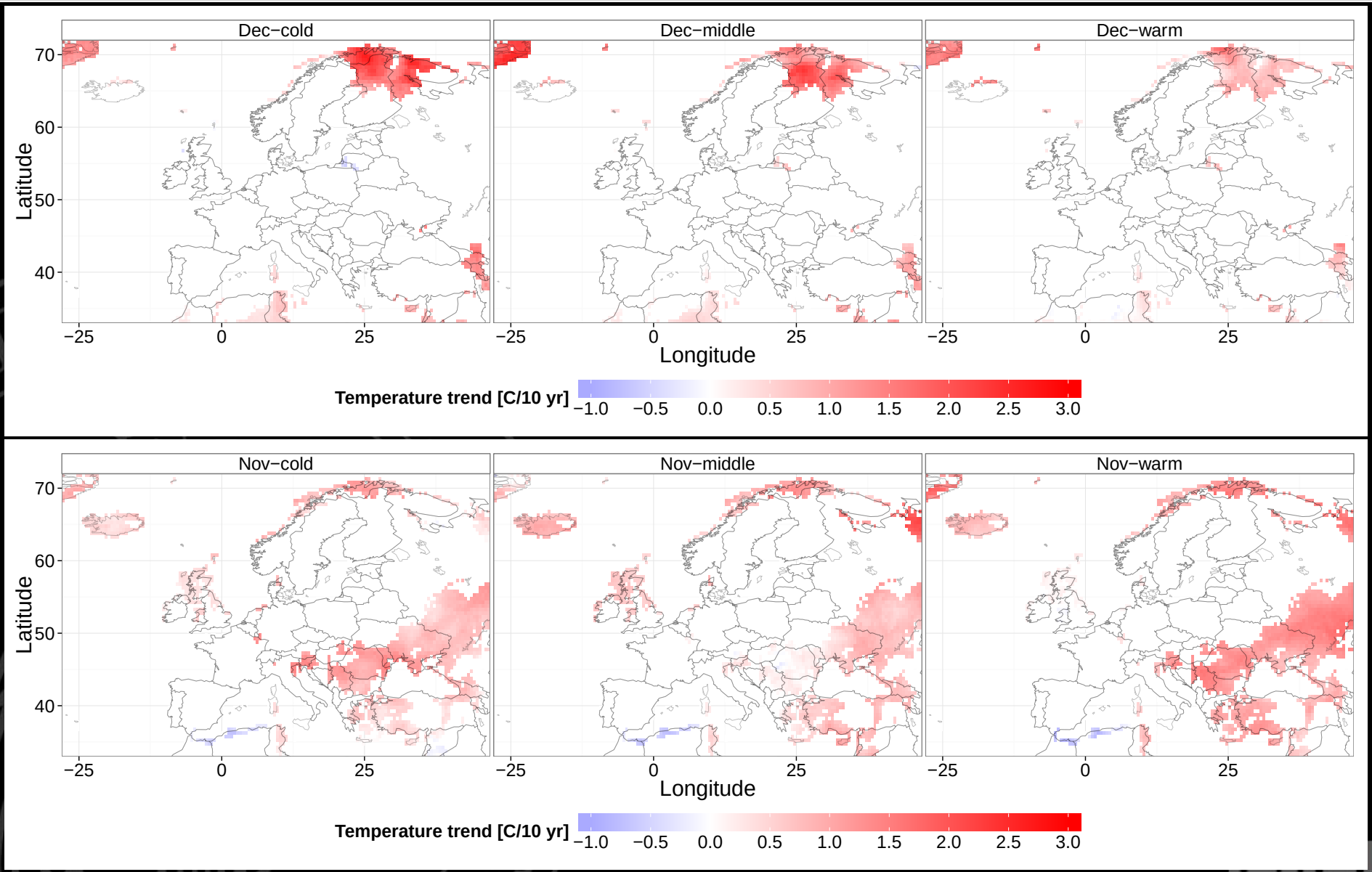

Our method allows us to compare estimated observed trends to a distribution of circulation-induced trends

Our probabilistic approach showed that changes in circulation cannot explain all the observed warming in Europe 1981-2010.

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Validity range of SVG for temperature

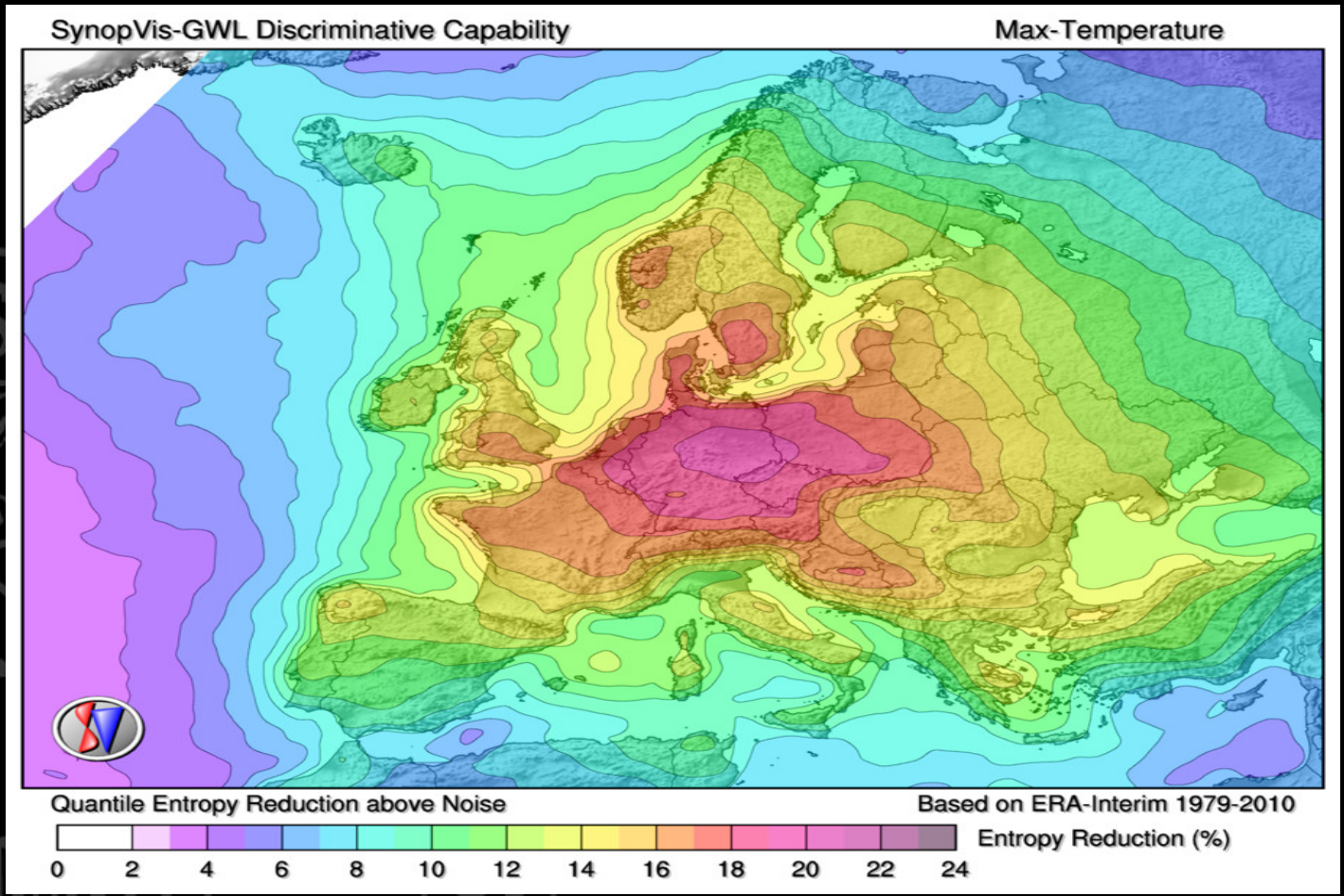

Table: James, pers. comm.