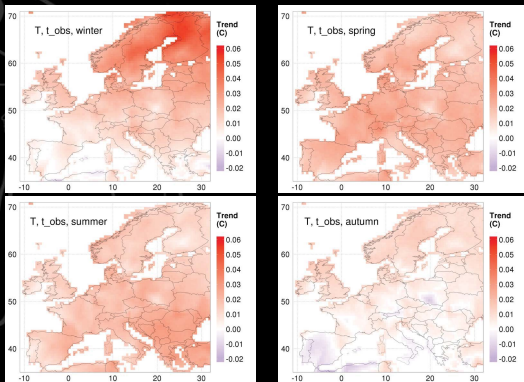
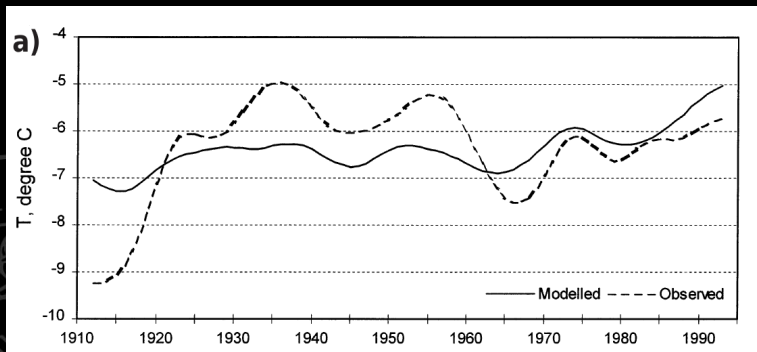


Probabilistic approach to attribute warming to changes in atmospheric circulation

Irene Nilsen , James Stagge, Lena Tallaksen



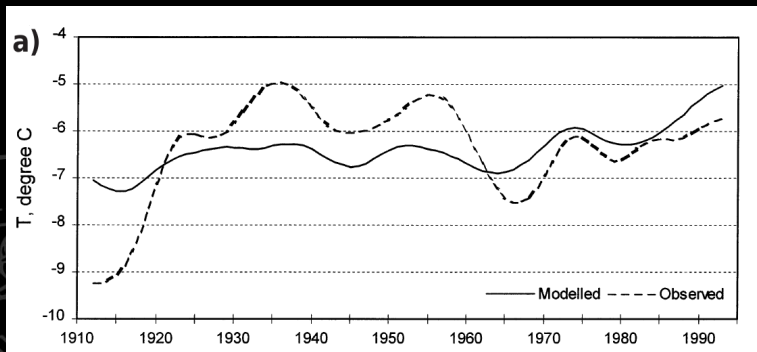
Causes of winter warming



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

1960s-1990s: Positive phase of NAO

Causes of winter warming

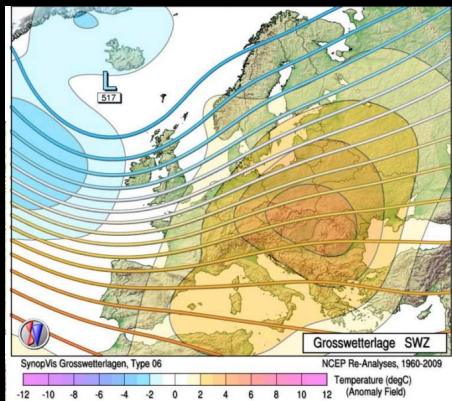


Source: Hanssen-Bauer and Førland 1998, Climate research 10, 143.

1960s–1990s: Positive phase of NAO

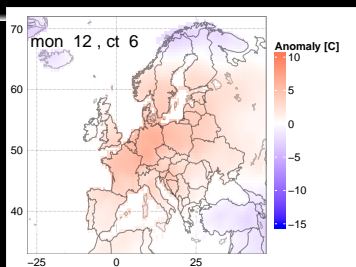
1930s–1950s: Low sea ice extent? + circulation? + other?

A synoptic type classifies the state of the atmosphere



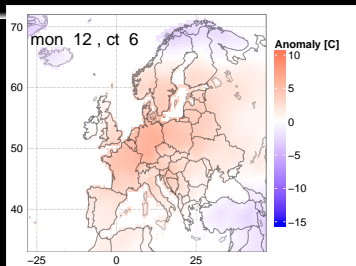
SVG = SynopVis Grosswetterlagen
Synoptic circulation classification (James, 2007)

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.

I've used WFDEI data for 1981-2010

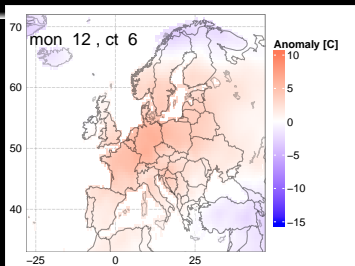


WFDEI = Watch Forcing Data Era-Interim (Weedon et al. 2014)
 bias-corrected Era-Interim, 0.5° spatial resolution.

Circulation-induced change

if warm STs become more frequent and cold STs less frequent.

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

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

ion? - Mentimeter - Mozilla Firefox

hess-19-3433-2015... x Hydrology: Climate ... x HESSD - Abstract - I... x HESS - Abstract - Bu... x

imeter.com/s/b2a6c63593d0bddc86163c10d29d1e2d/22d506b7794d

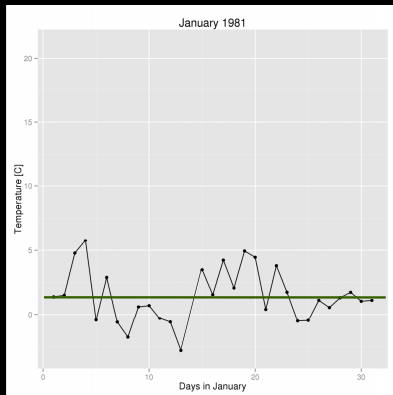
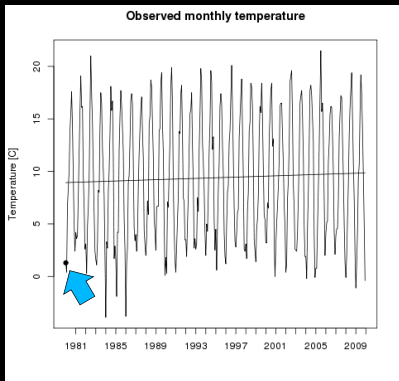
Go to **www.govote.at** and use the code **64 74 02**

What is the correct conclusion?

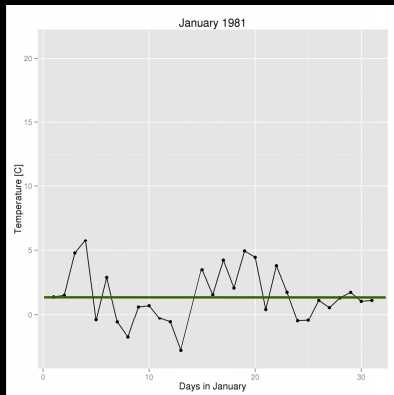
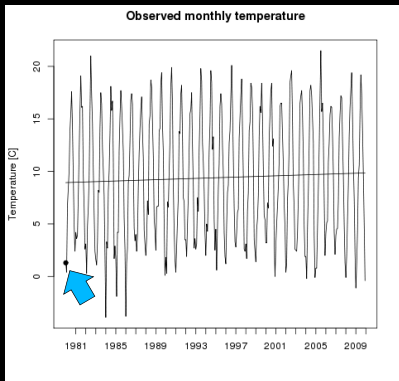
Changes in circulation can explain all the observed warming in Europe (1981-2010).	The hypothesis test revealed regions where warming is not explained by changes in circulation only..	In Scandinavia in winter, synoptic types did not warm over time.
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Prediction model: create a new hypothetical series



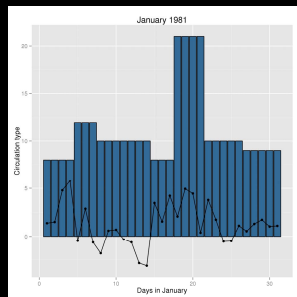
Prediction model: create a new hypothetical series



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

Link the estimated observed values with the synoptic type

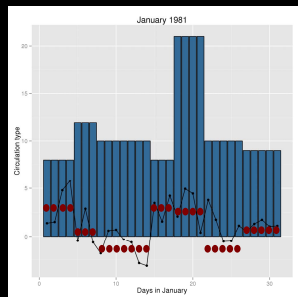
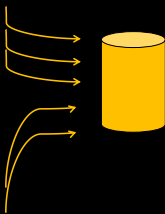
Mon	ST	Obs [°C]
1	8	2.0
1	8	2.1
1	8	4.9
1	8	5.6
1	12	-0.2
1	12	2.8
1	12	-0.3
1	10	-1.8
1	10	0.4
1	10	0.5
1	10	-0.1
...



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
1	10	-1.8
1	10	0.4
1	10	0.5
1	10	-0.1
...
1	12	2.0
1	12	5.9
...

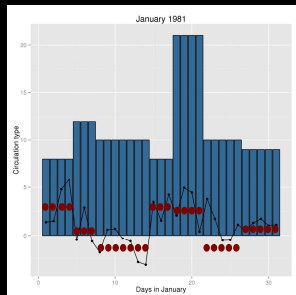


Replace estimated observed values with long-term mean

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
...
1	12	2.0
1	12	5.9
...

Calculate the mean
of the subset

Long-term
mean

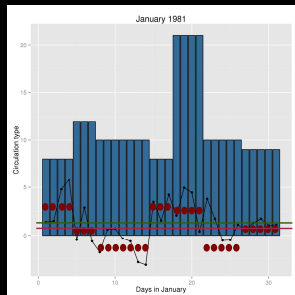


Replace estimated observed values with long-term mean

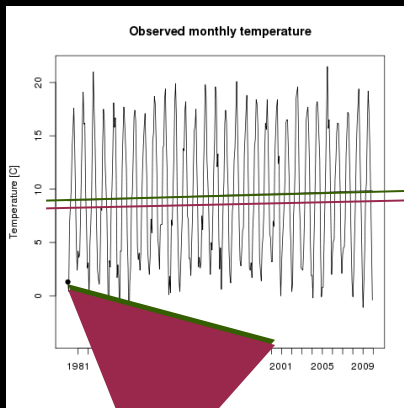
Replace the observed value with the long-term mean

Mon	ST	Obs [°C]	Mon	ST	Hyp [°C]
1	8	2.0	1	8	2.9
1	8	2.1	1	8	2.9
1	8	4.9	1	8	2.9
1	8	5.6	1	8	2.9
1	12	-0.2	1	12	0.2
1	12	2.8	1	12	0.2
1	12	-0.3	1	12	0.2
1	10	-1.8	1	10	-1.5
1	10	0.4	1	10	-1.5
1	10	0.5	1	10	-1.5
1	10	-0.1	1	10	-1.5
...
1	12	2.0	1	12	0.2
1	12	5.9	1	12	0.2
...

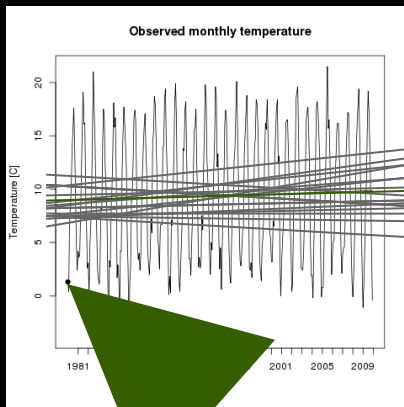
Diagram: A yellow cylinder labeled "Long-term mean" has yellow arrows pointing to the "Obs" column and red arrows pointing to the "Hyp" column.



The hypothetical series gives only *one* possible realization



The hypothetical series gives only *one* possible realization

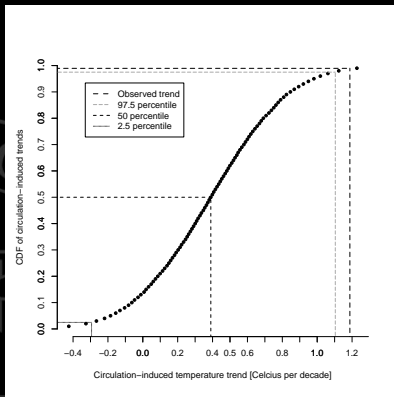


Part I: use resampling to assess the possible spread

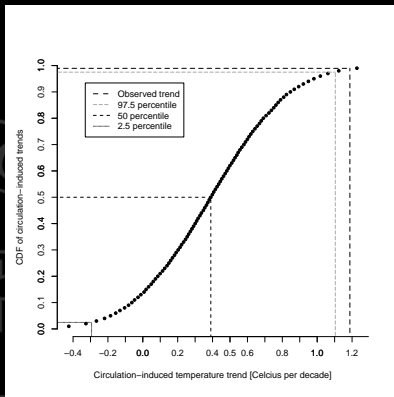
Resample the temperature on days in month i and synoptic type j 10 000 times

Mon	ST	Obs [°C]		Mon	ST	Re1	...	Re10000	
1	8	2.0		1	8	2.1	...	5.6	
1	8	2.1		1	8	2.1	...	5.6	
1	8	4.9		1	8	2.1	...	5.6	
1	8	5.6		1	8	2.1	...	5.6	
1	12	-0.2		1	12	2.8	...	-0.2	
1	12	2.8		1	12	2.8	...	-0.2	
1	12	-0.3		1	12	2.8	...	-0.2	
1	10	-1.8		1	10	0.4	...	0.5	
1	10	0.4		1	10	0.4	...	0.5	
1	10	0.5		1	10	0.4	...	0.5	
1	10	-0.1		1	10	0.4	...	0.5	
...
1	12	2.0		1	12	2.8	...	-0.2	
1	12	5.9		1	12	2.8	...	-0.2	
...	

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



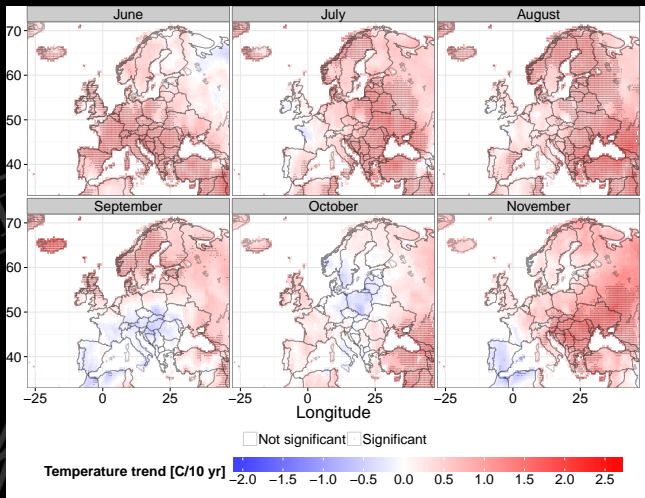
Part II: define a statistical test to compare the observed trend to the distribution of circulation-induced trends



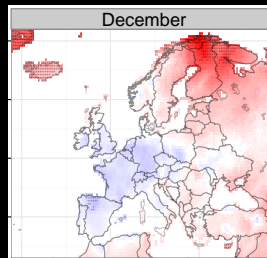
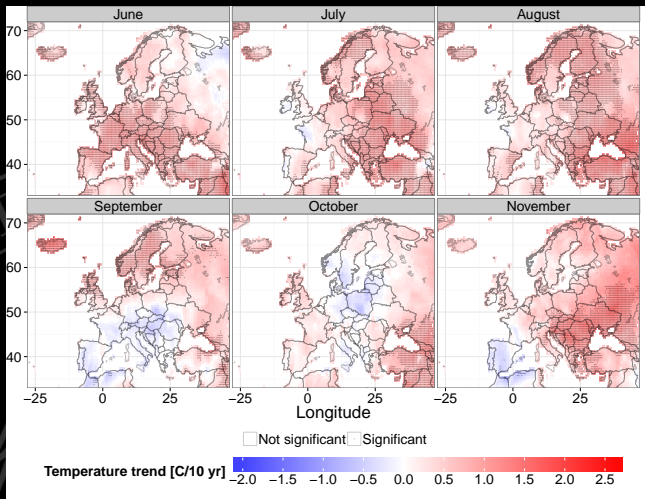
H_0 : Temp trend can be explained by changes in circulation only

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

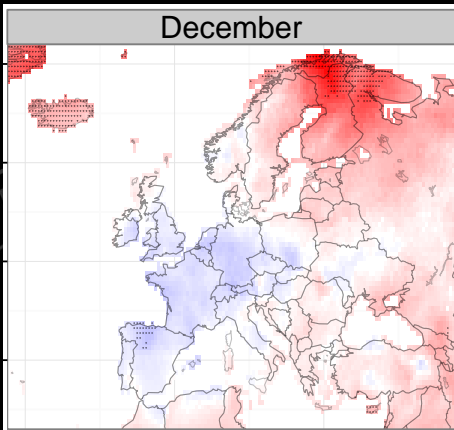
Significant observed temperature trends (dots)



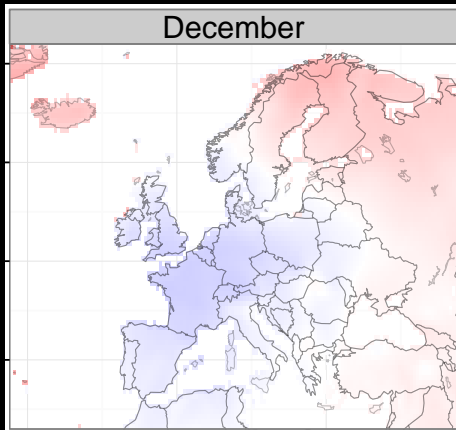
Significant observed temperature trends (dots)



Observed trends and median of resampled trends



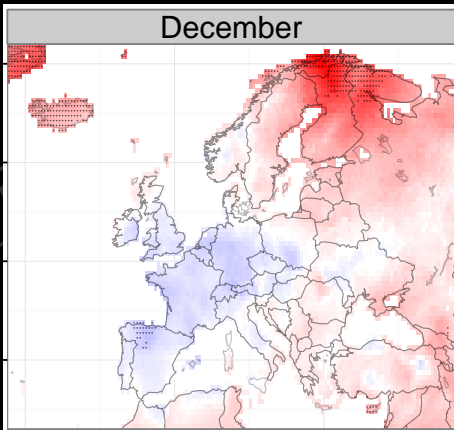
Observed trend



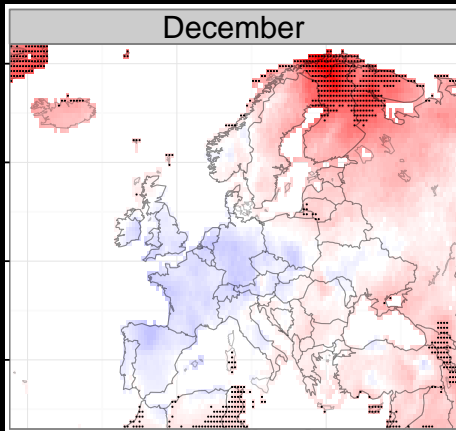
Circulation-induced trend



Comparing observed trend and "within-type" regions



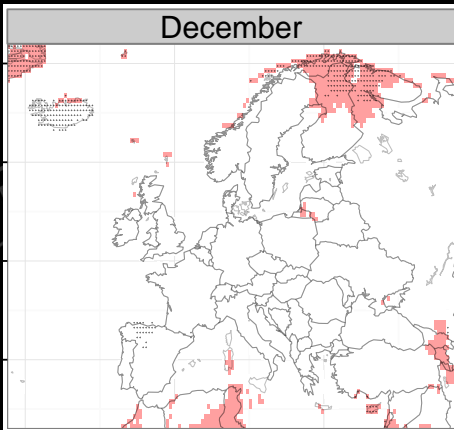
Observed trend



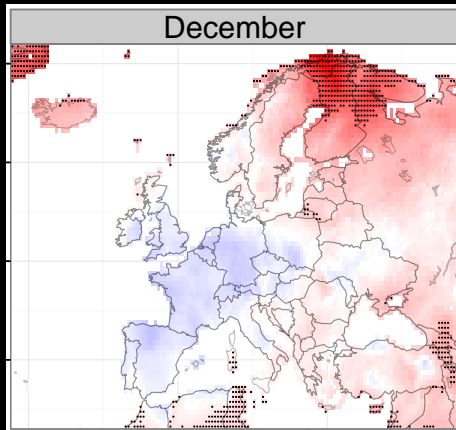
Rejected H_0

SIS

Comparing observed trend and "within-type" regions

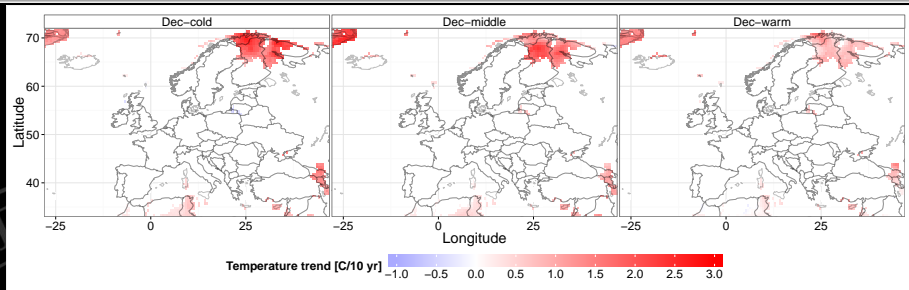


Combination

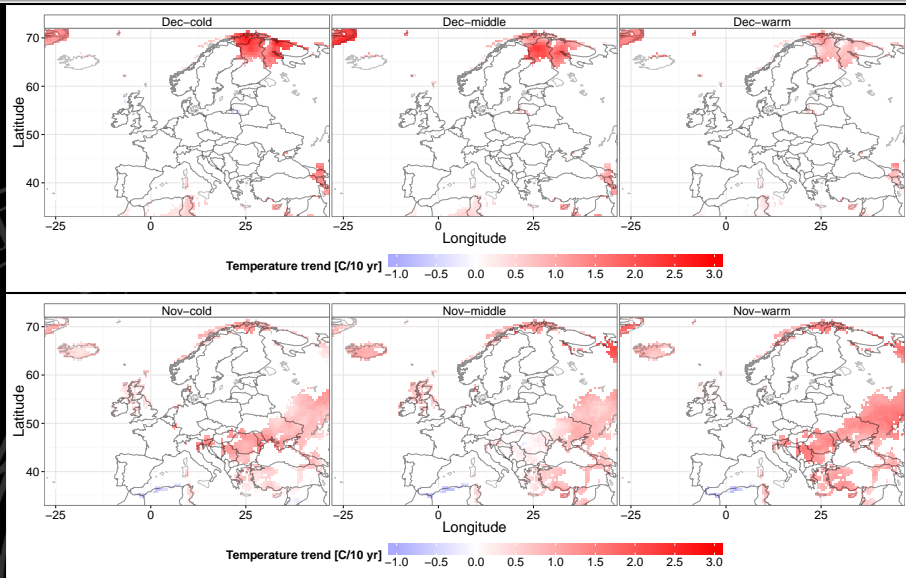


Rejected H_0

Circulation changes cannot explain recent warming



Circulation changes cannot explain recent warming



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

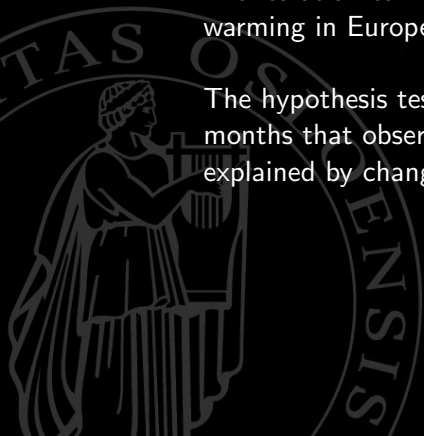
Our probabilistic approach showed that changes in circulation cannot explain all the observed warming in Europe 1981-2010.



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

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The hypothesis test revealed which regions and months that observed warming is very likely not explained by changes in circulation only.

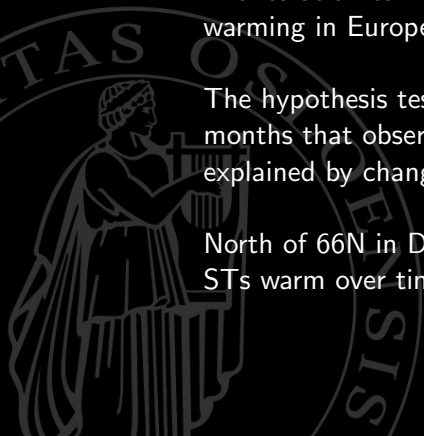


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North of 66N in December, we documented that STs warm over time – within-type change.

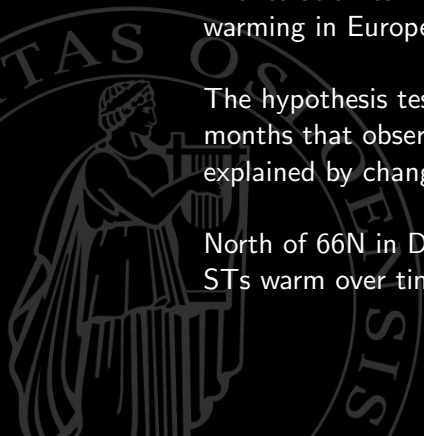


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Validity range of SVG for temperature

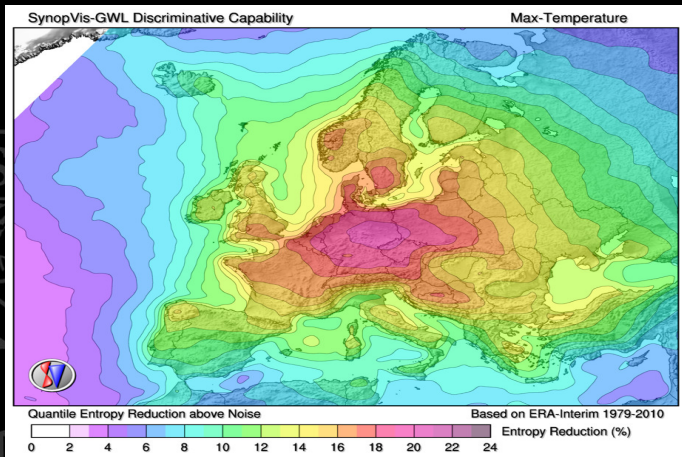


Table: James, pers. comm.