An analysis of recent anomalously warm seasons in Europe

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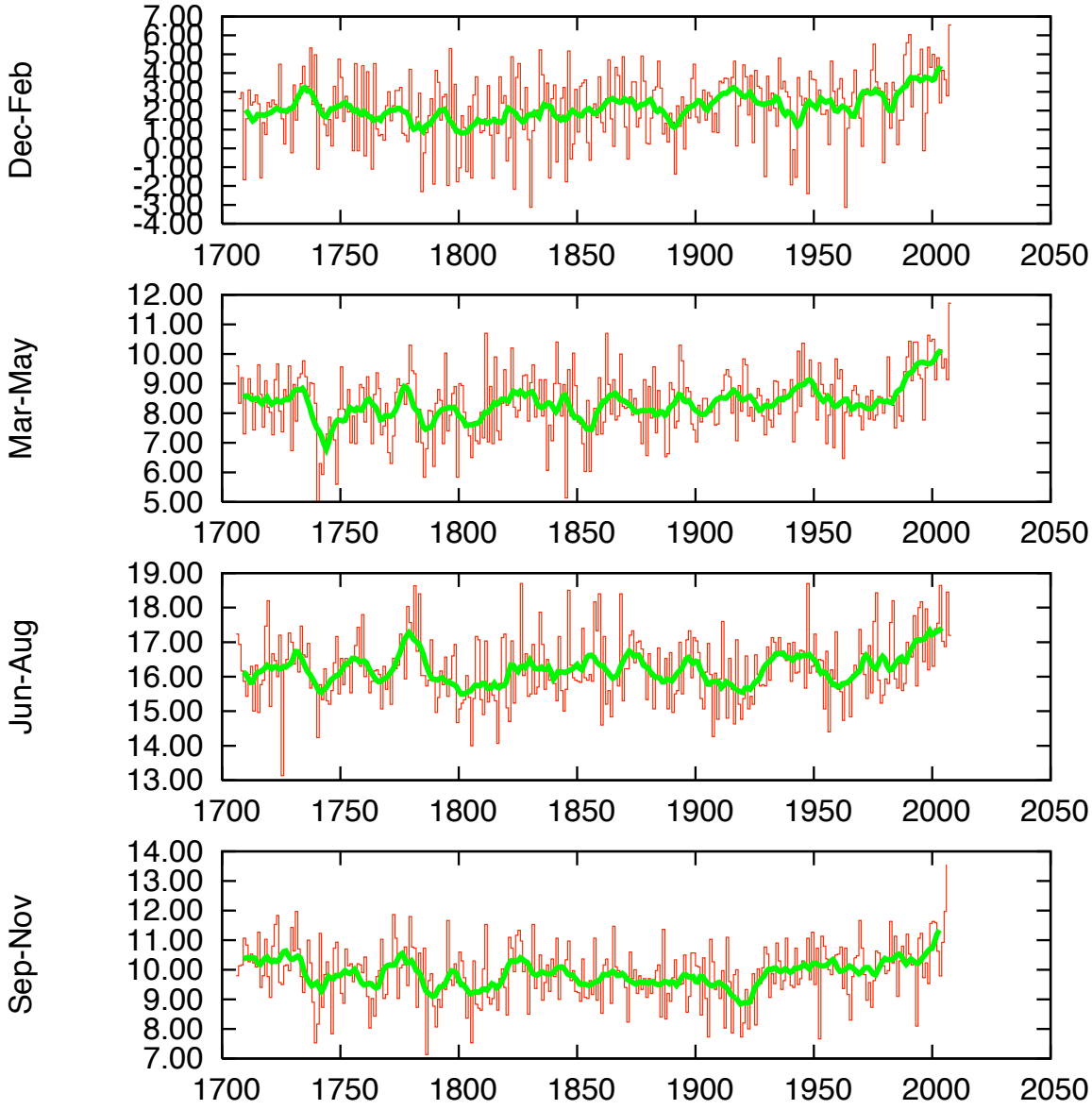
CDPW, 23 October 2007

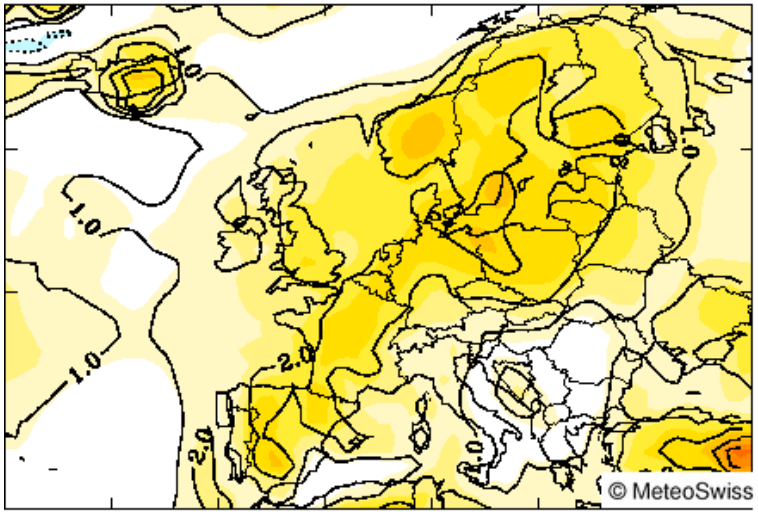
- Observations
- Trends
- Climate model trends
- 2006/2007 weather
- Climate model extremes
- What is going on?

Temperatures at De Bilt 1706-2007

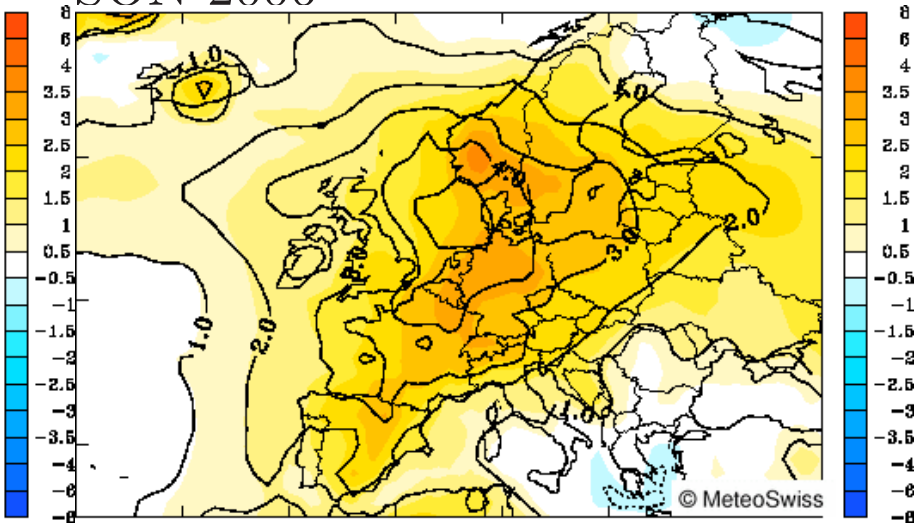


Temperatures in Europe relative to 1961-1990

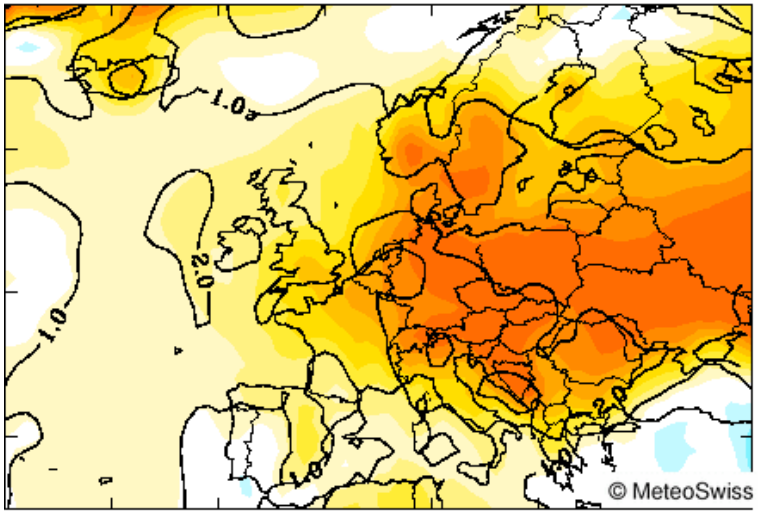
JJA 2006



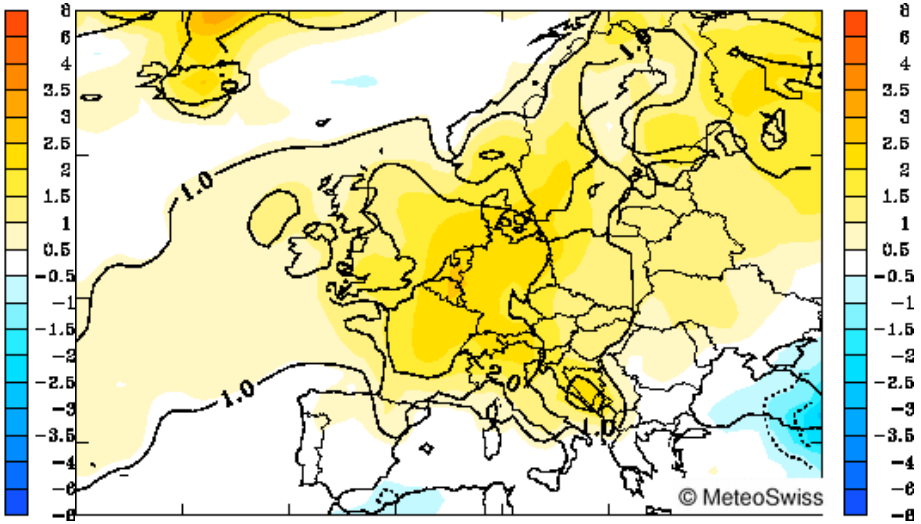
SON 2006



DJF 2006/2007



MAM 2007



Return times

- Fit tail of cumulative distribution to function $F(x)$, excluding year to be studied i
- Compute $T_i = 1/(1 - F(x_i))$

Consider two forms for $F(x)$:

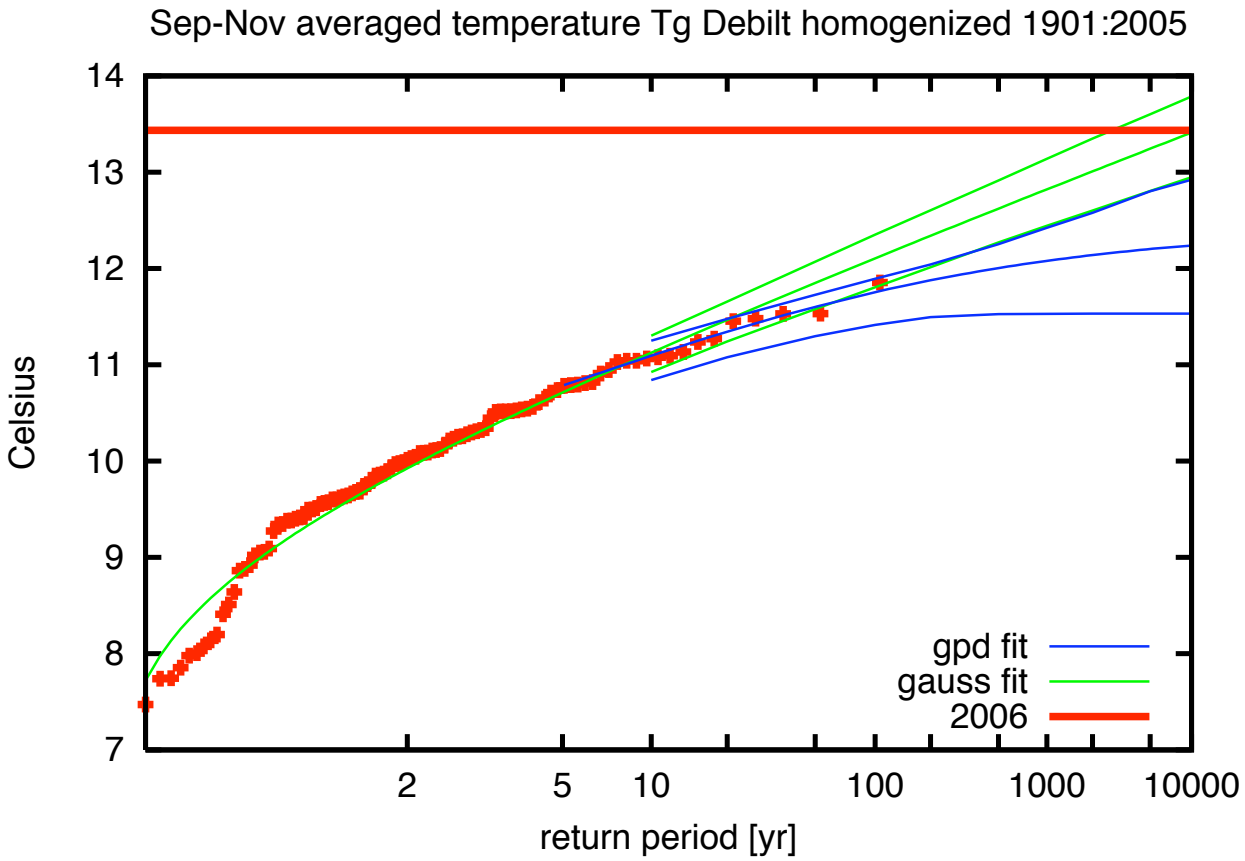
1. Normal distribution; in Europe works well in spring and autumn but not in summer (positively skewed) or winter (negatively skewed).
2. Peak-over-Threshold method: Generalised Pareto Distribution fitted to the tail above a threshold:

$$H(z) = 1 - \left(1 + \frac{z\xi}{\sigma}\right)^{-1/\xi} \tag{1}$$

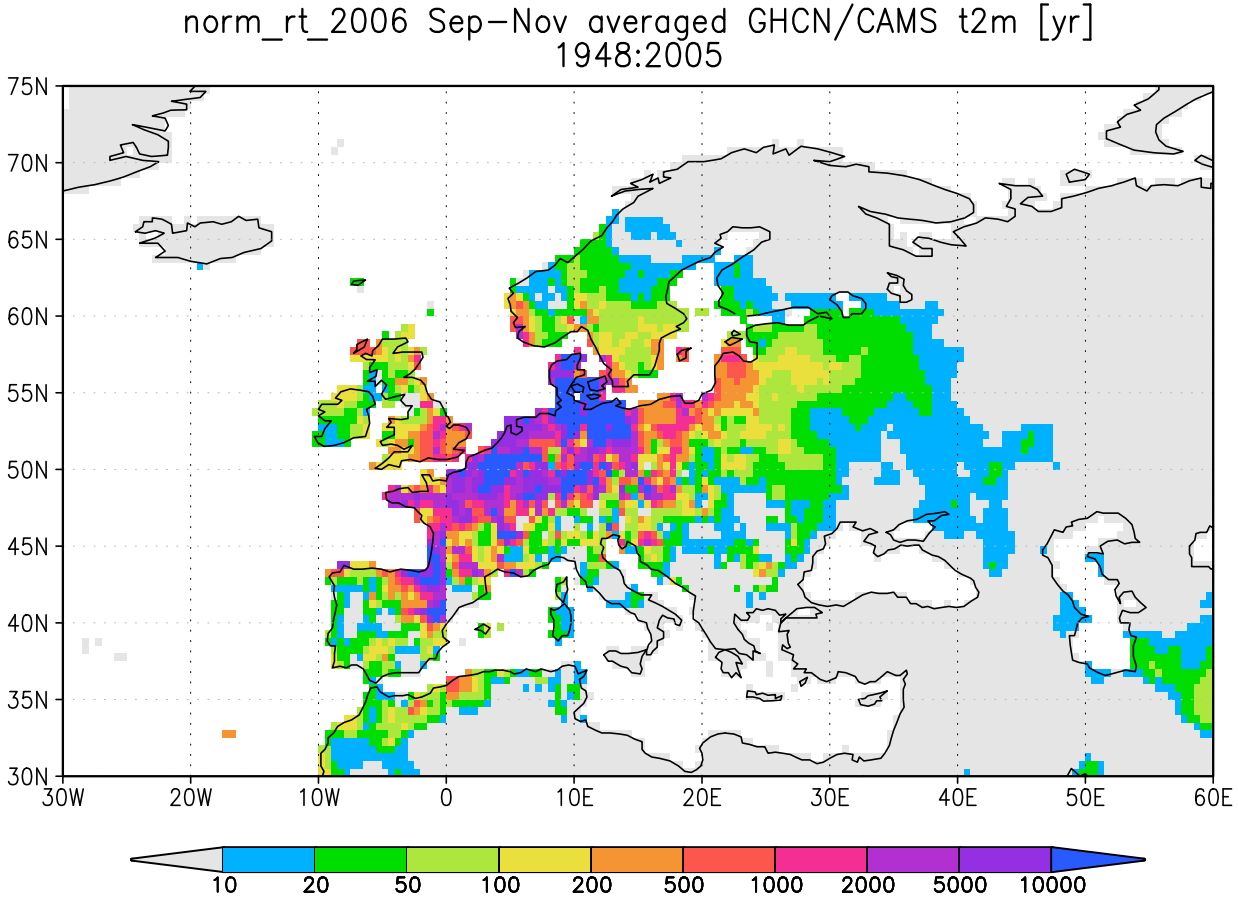
We take the threshold at 80% (fit to 10-20 points).

Hypothesis I: only interannual variability

Assume no other variability than interannual (autocorrelation zero from year to year).



Hypothesis I: only interannual variability



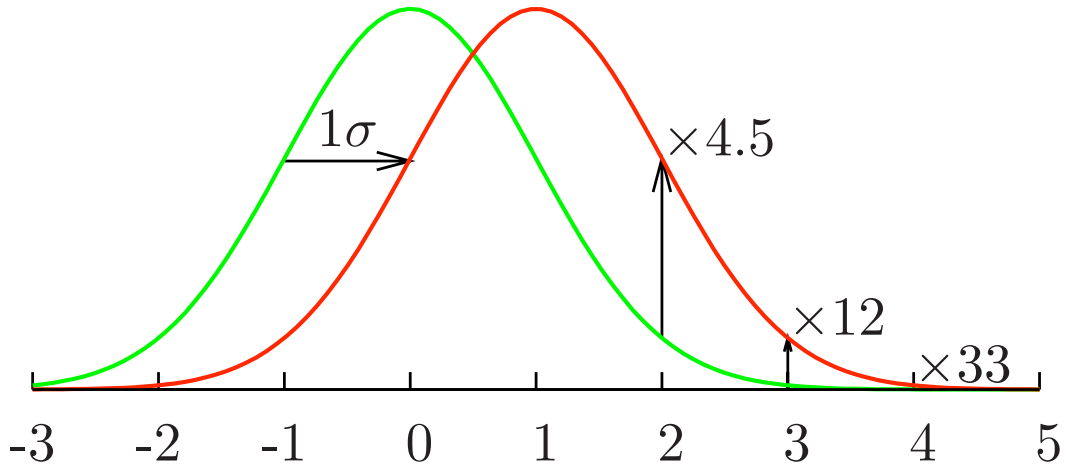
Without long-term variability the return times of autumn 2006 would be $\mathcal{O}(10^4)$ years in large parts of Europe.

Hypothesis II: PDF shifts only

Assume most long-term climate variability is global:

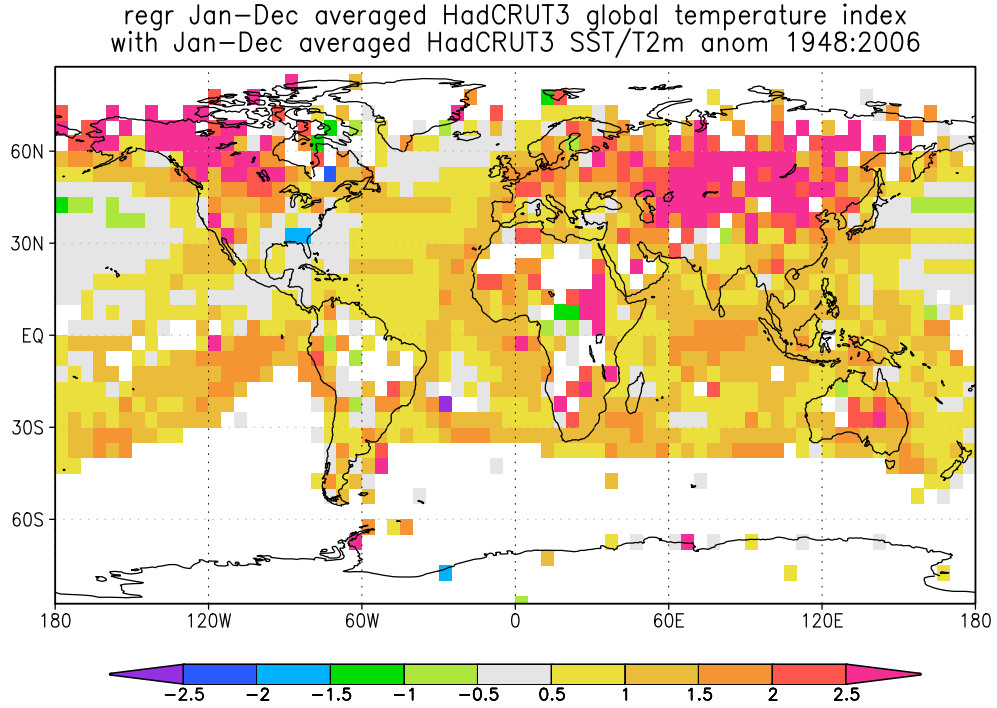
$$T'(x,y,t) = A(x,y)T'_{\text{global}}(t) + \epsilon(x,y,t) \tag{2}$$

The effects are largest in the tails of the distribution

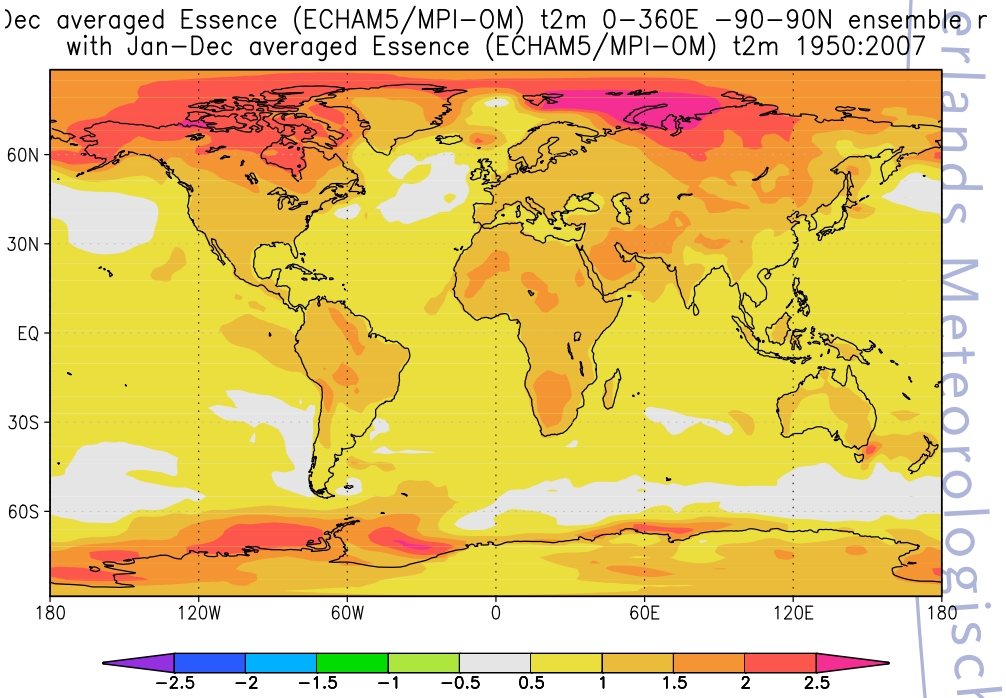


Local vs global warming: $A(x, y)$

HadCRUT3 observations



ESSENCE, 17 runs with ECHAM5/MPI-OM



Main features are very similar, how about the details?

Local vs global warming: $A(x, y)$

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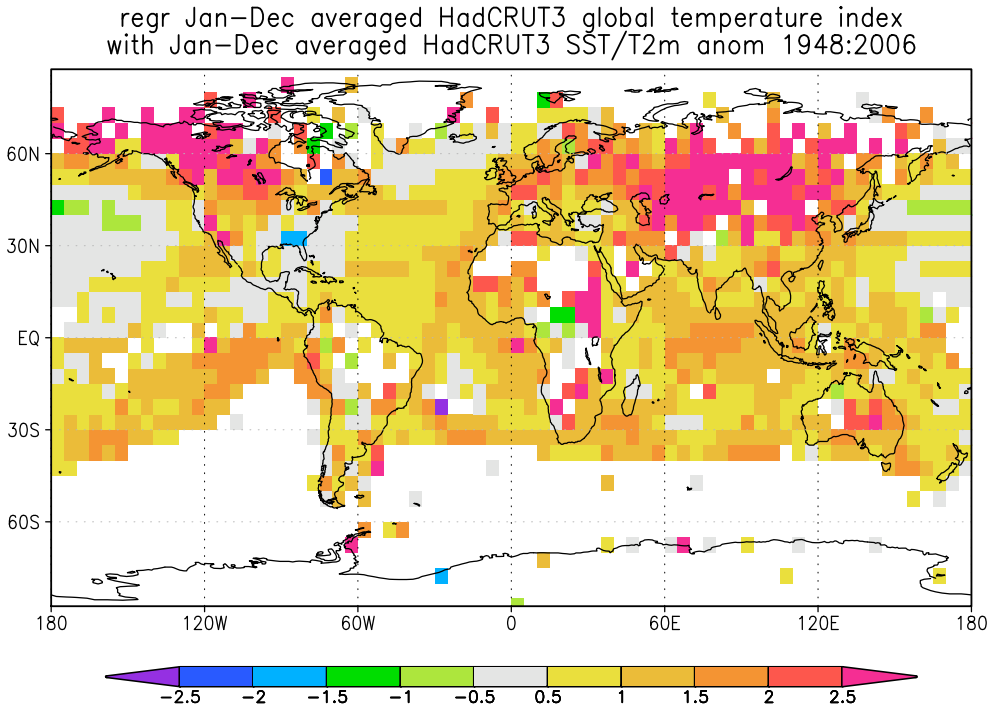
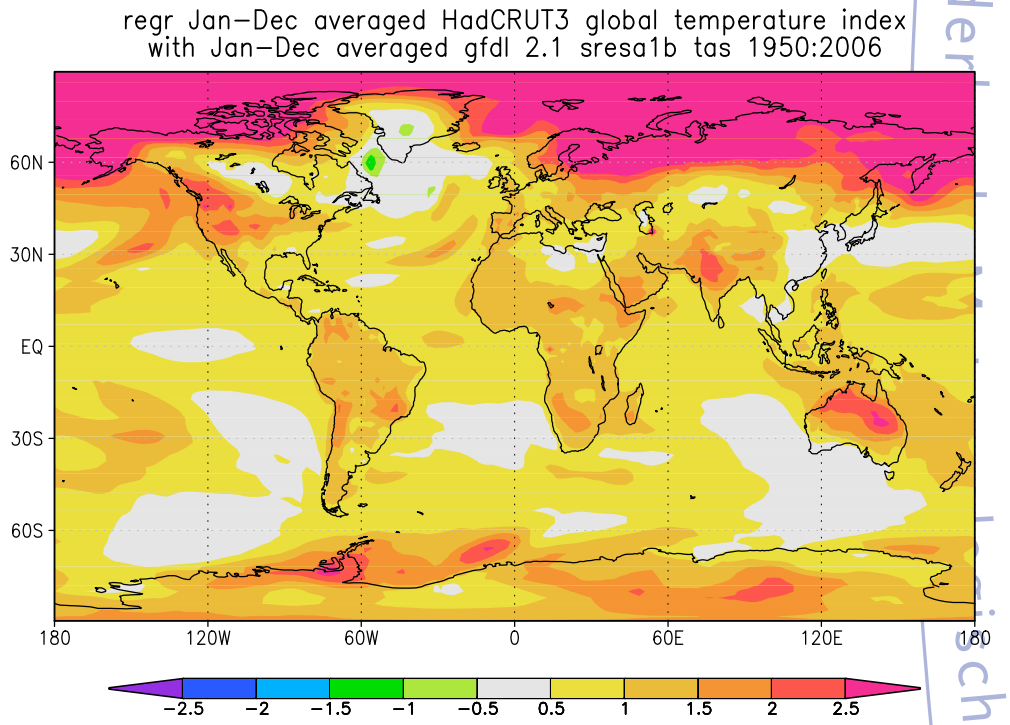
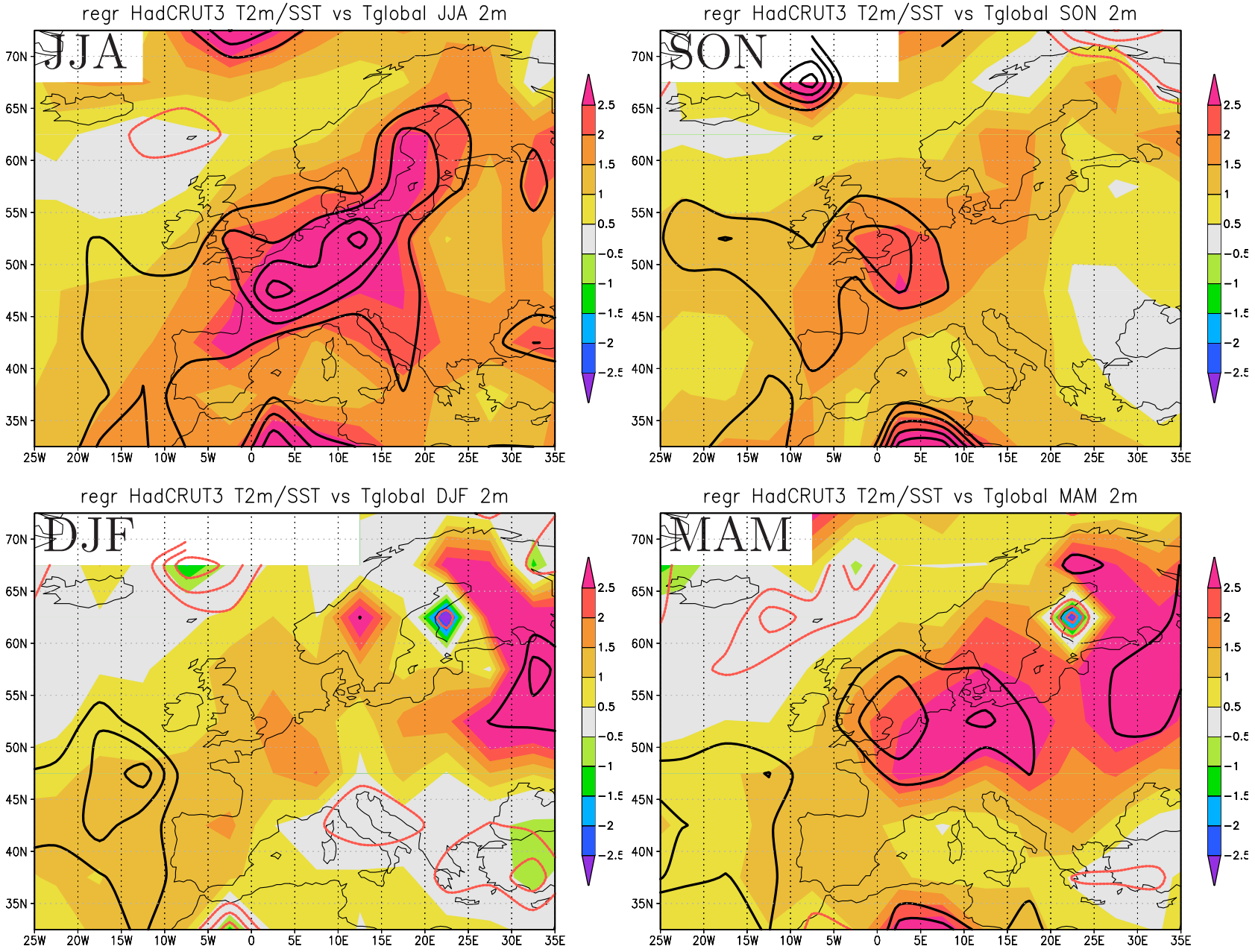


GFDL CM 2.1



Main features are very similar, how about the details?

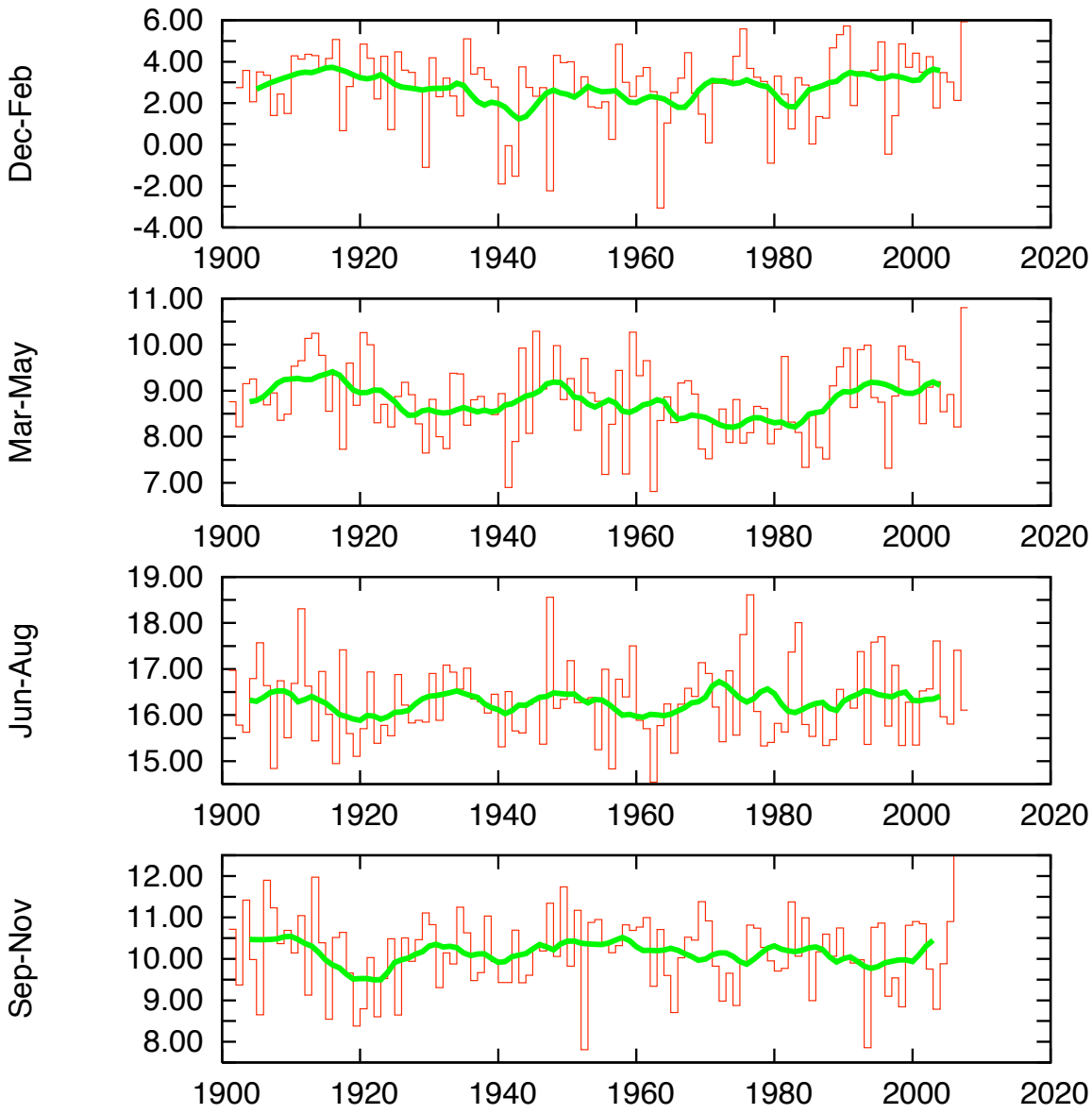
Observed trends, 2,3,4,5σ contours ECHAM5 1950-2006



Trends: $A(x, y)$

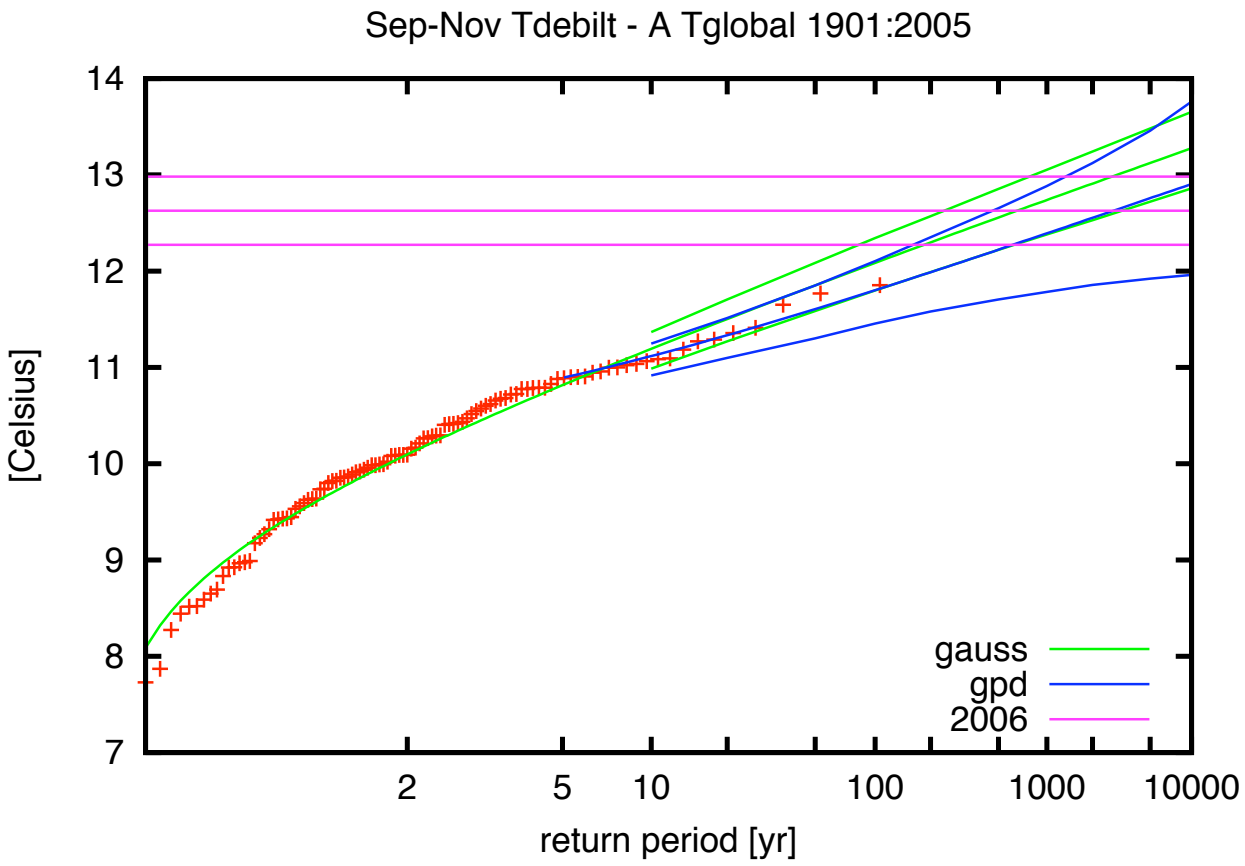
- West-central Europe has warmed almost a factor 2 faster than the global mean
- Climate models simulate a factor 1
- The difference is very unlikely due to natural variability
- We are investigating whch biases in the models contribute

Weather at De Bilt $\epsilon(5°\mathrm{E}, 52°\mathrm{N}, t)$



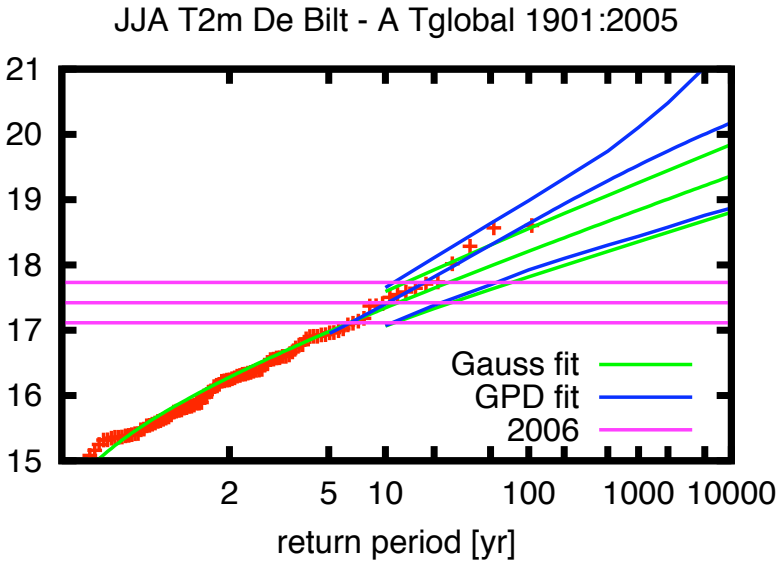
Autocorrelation is zero now

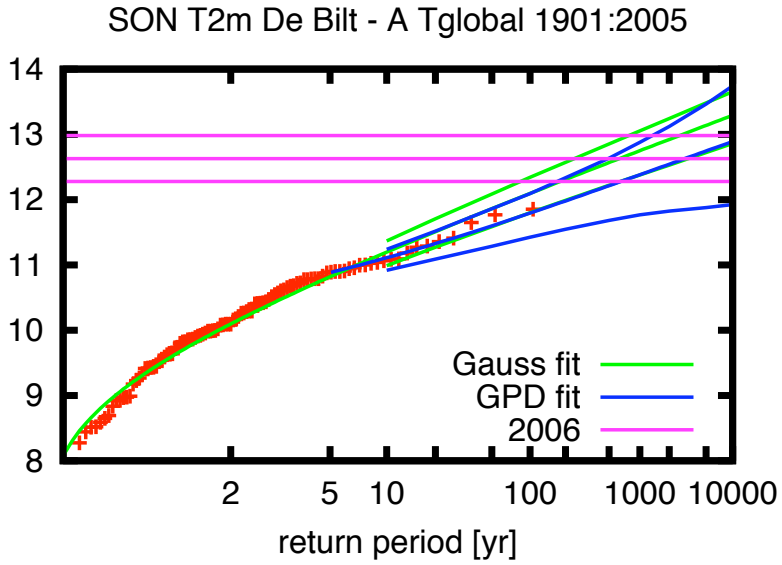
Weather at De Bilt $\epsilon(5°\mathrm{E}, 52°\mathrm{N}, t)$

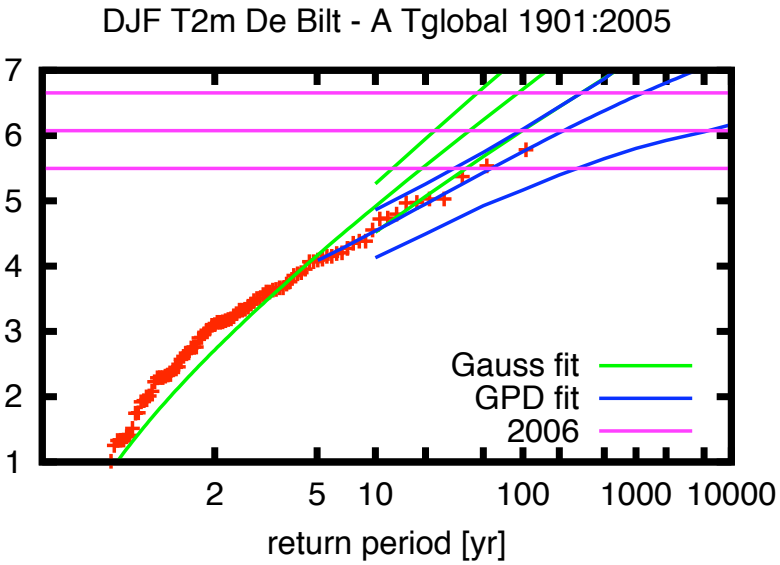


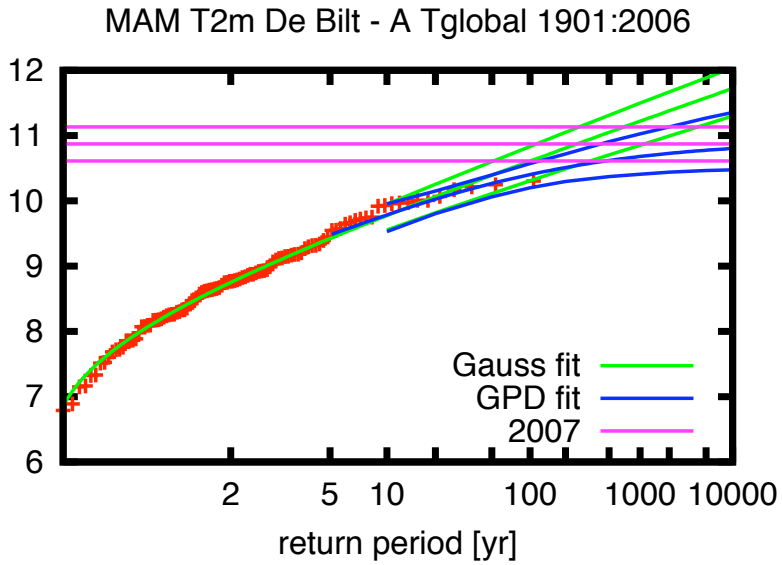
SON: $T_{2006} = 650$ yr, 95% CI: 125-10000 yr (normal distr.)

Weather at De Bilt $\epsilon(5°\mathrm{E}, 52°\mathrm{N}, t)$









De Bilt: return times of $\epsilon(5°\text{E}, 52°\text{N}, 2006/2007)$

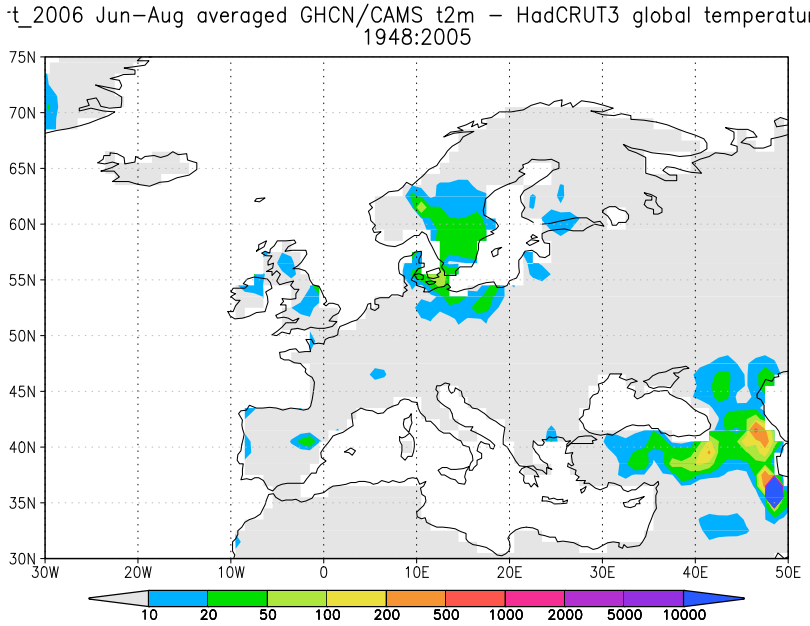
Given the distribution of the previous seasons

season	fit	central	2.5%
summer 2006	GPD	10	5
autumn 2006	Normal	650	125
winter 2007	GPD	220	55
spring 2007	Normal	250	75
product		$4\,10^8$	$2\,10^6$

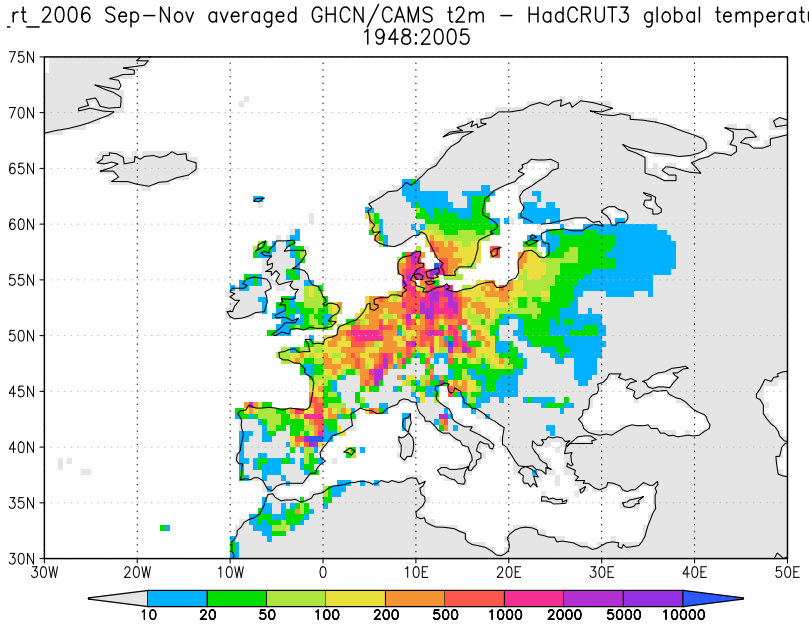
After subtracting the linear effect of global warming

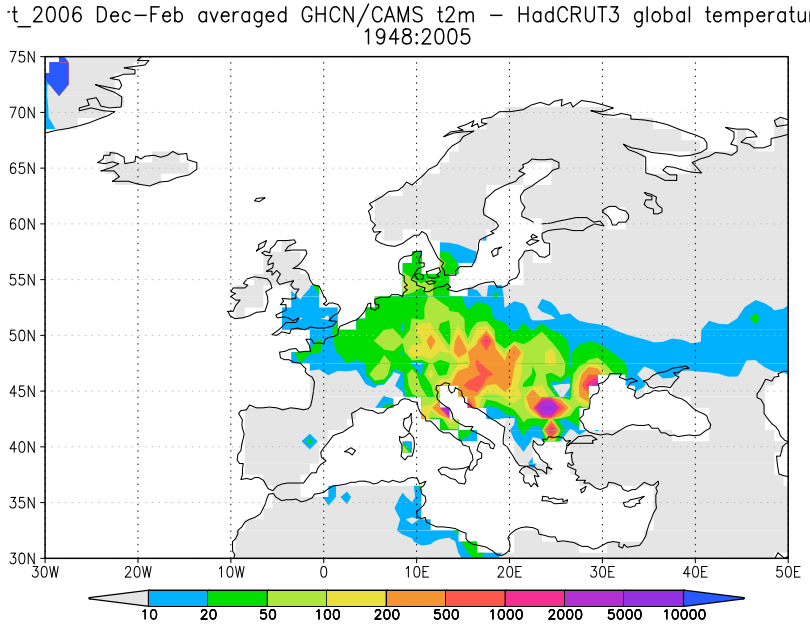
Europe: return times of $\epsilon(x, y, 2006/2007)$

JJA 2006

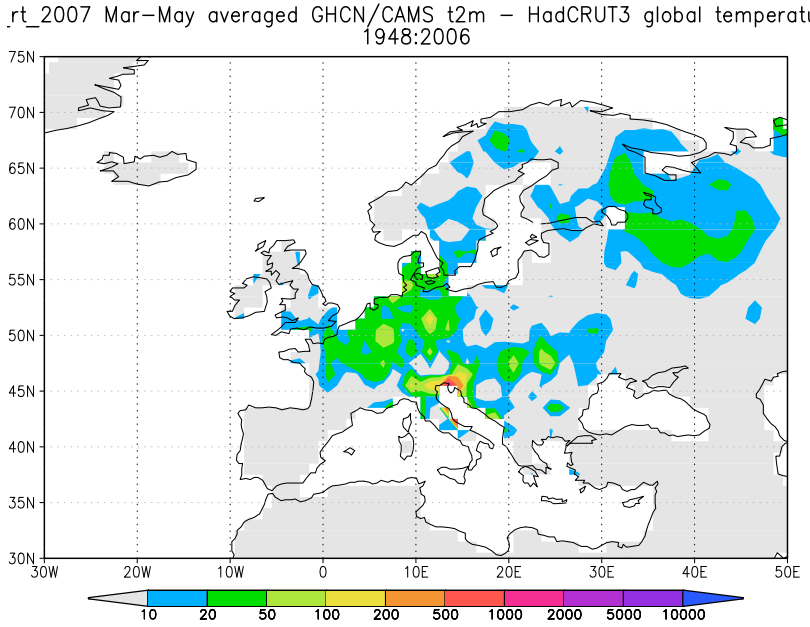


SON 2006





DJF 2006/2007



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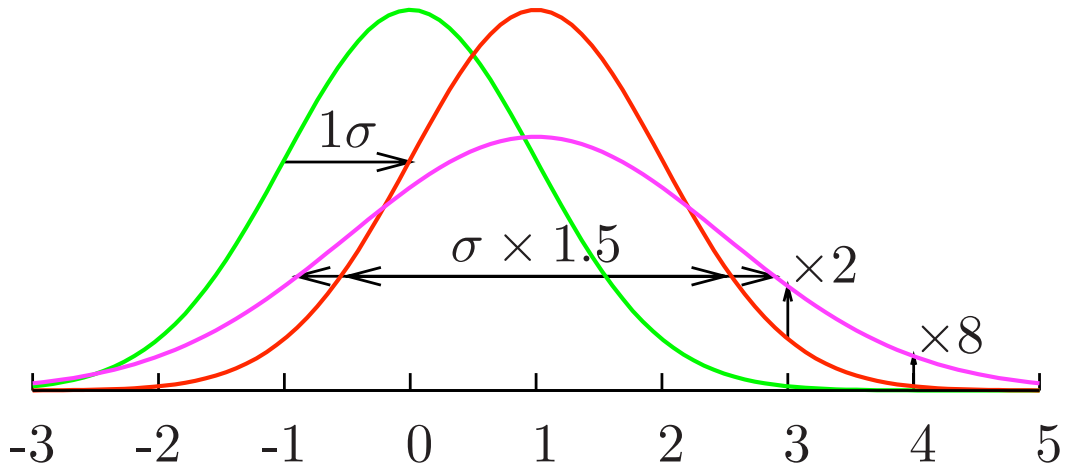
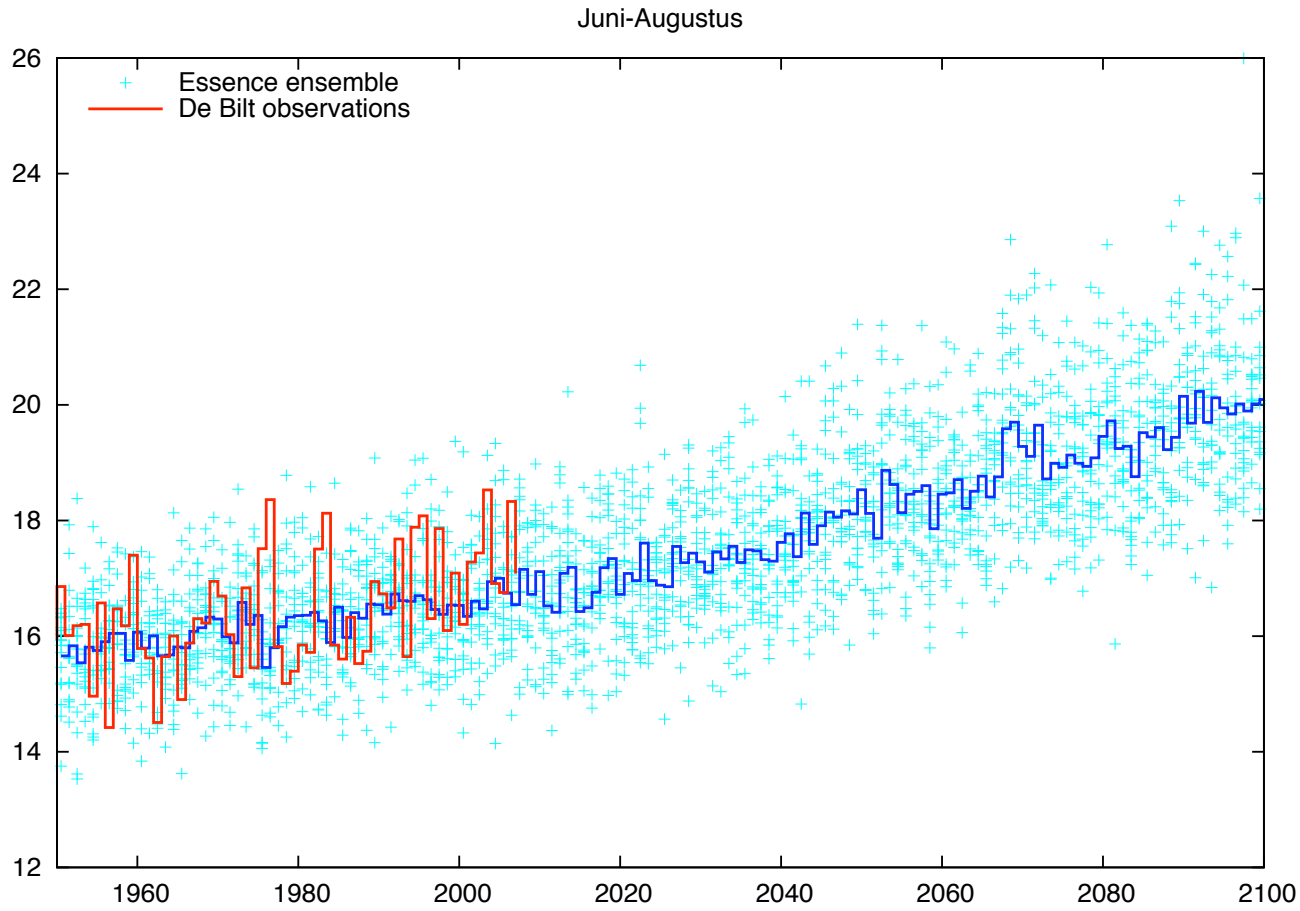
Hypothesis III: change in PDF as well as shift



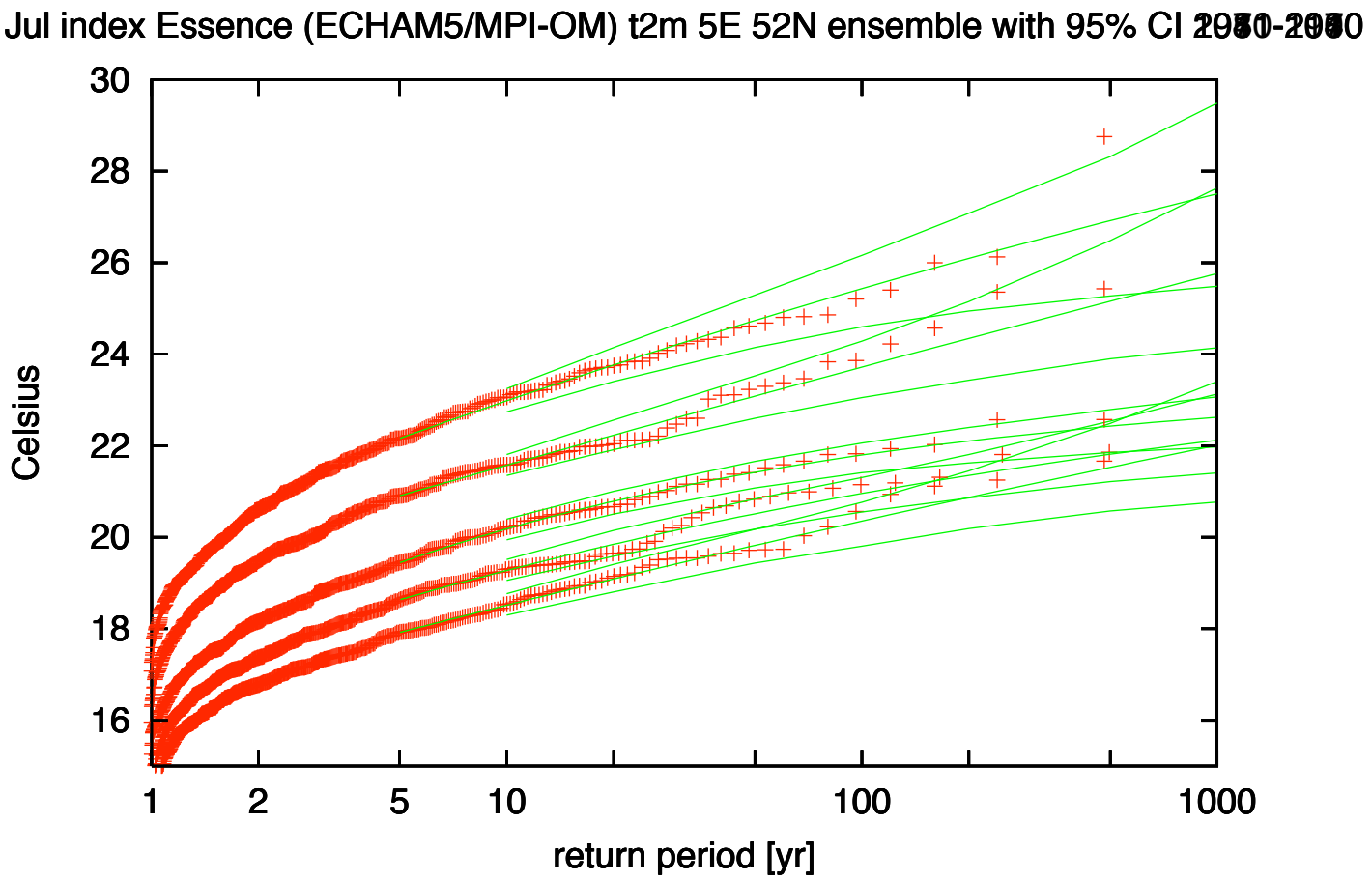
Not enough data in observations to determine changes in the width, look at climate models.

Change in PDF?



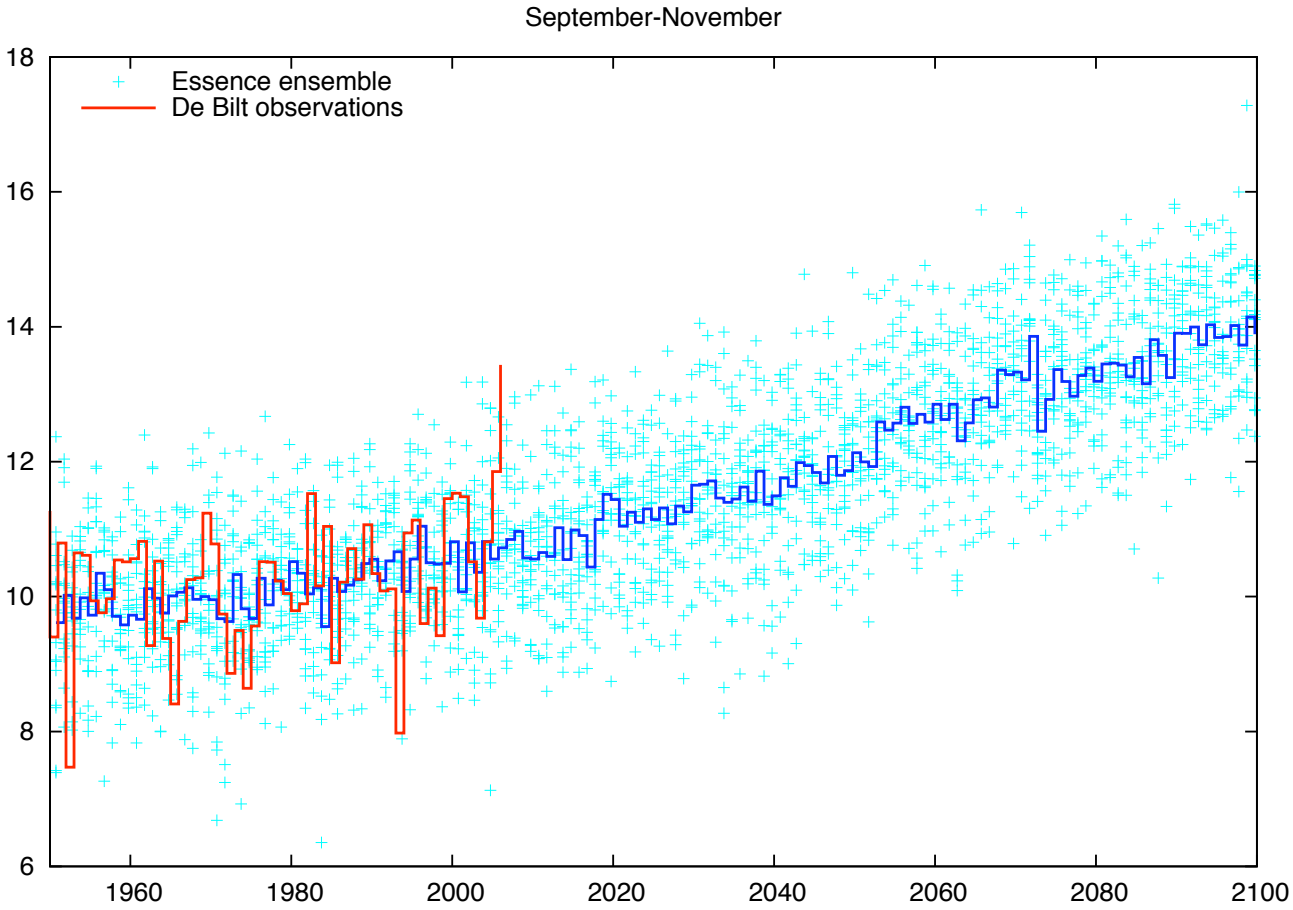
ESSENCE, summer temperatures

Change in PDF in summer



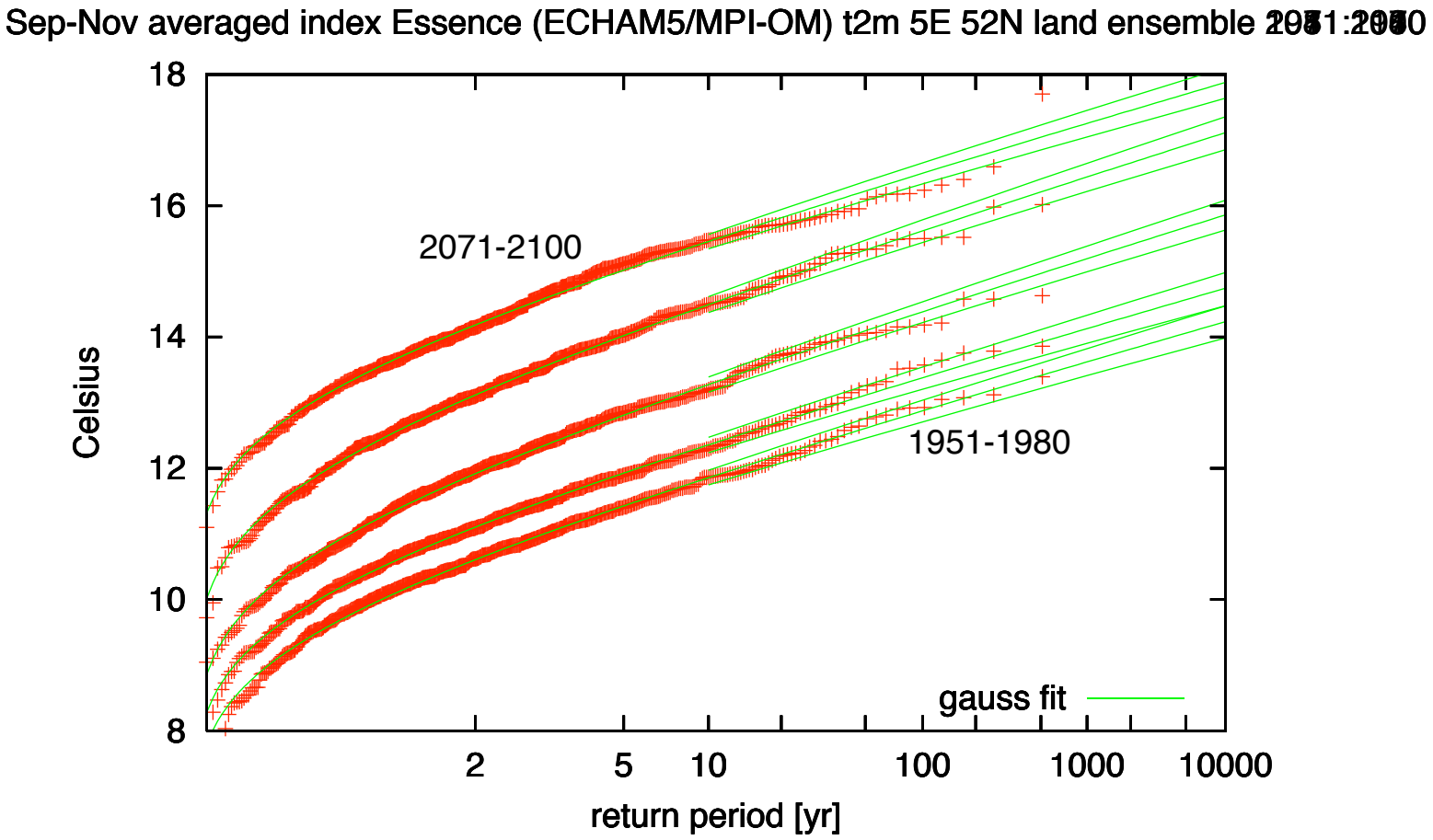
ESSENCE, GPD for every 30 years: 1951-1980, 1981-2010, 2011-2040, 2041-2070, 2071-2100.

Change in PDF?



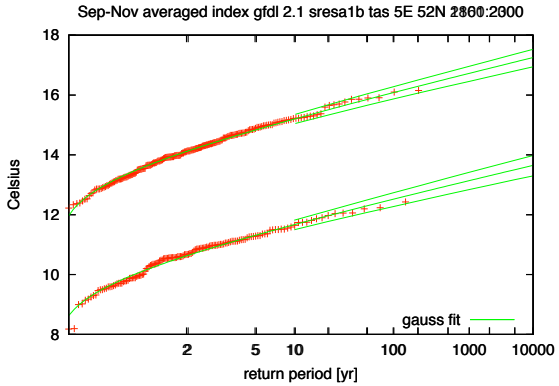
ESSENCE, autumn temperatures

No change in PDF in autumn

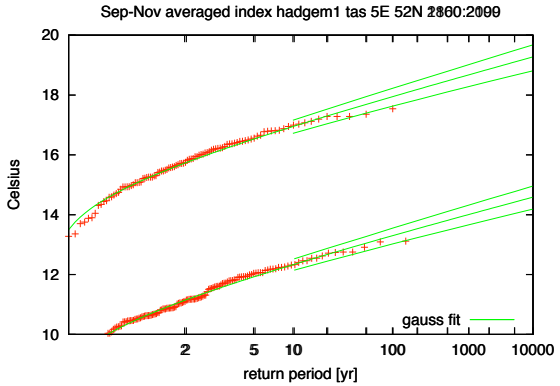


ESSENCE, GPD for every 30 years: 1951-1980, 1981-2010, 2011-2040, 2041-2070, 2071-2100.

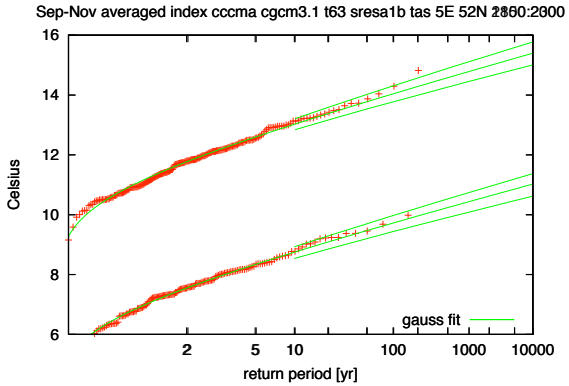
No change in PDF in autumn



GFDL CM2.1

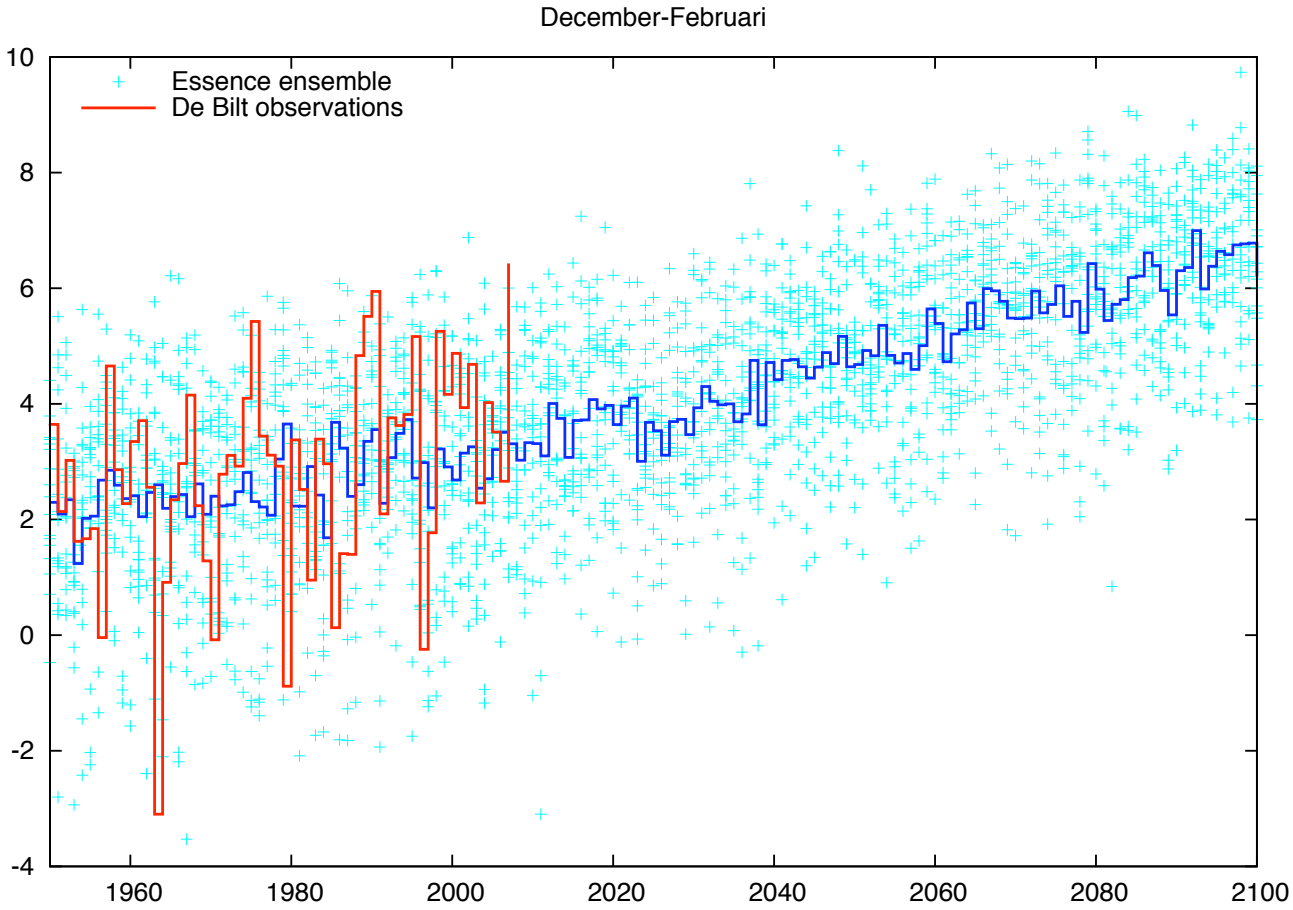


UKMO HadGEM1



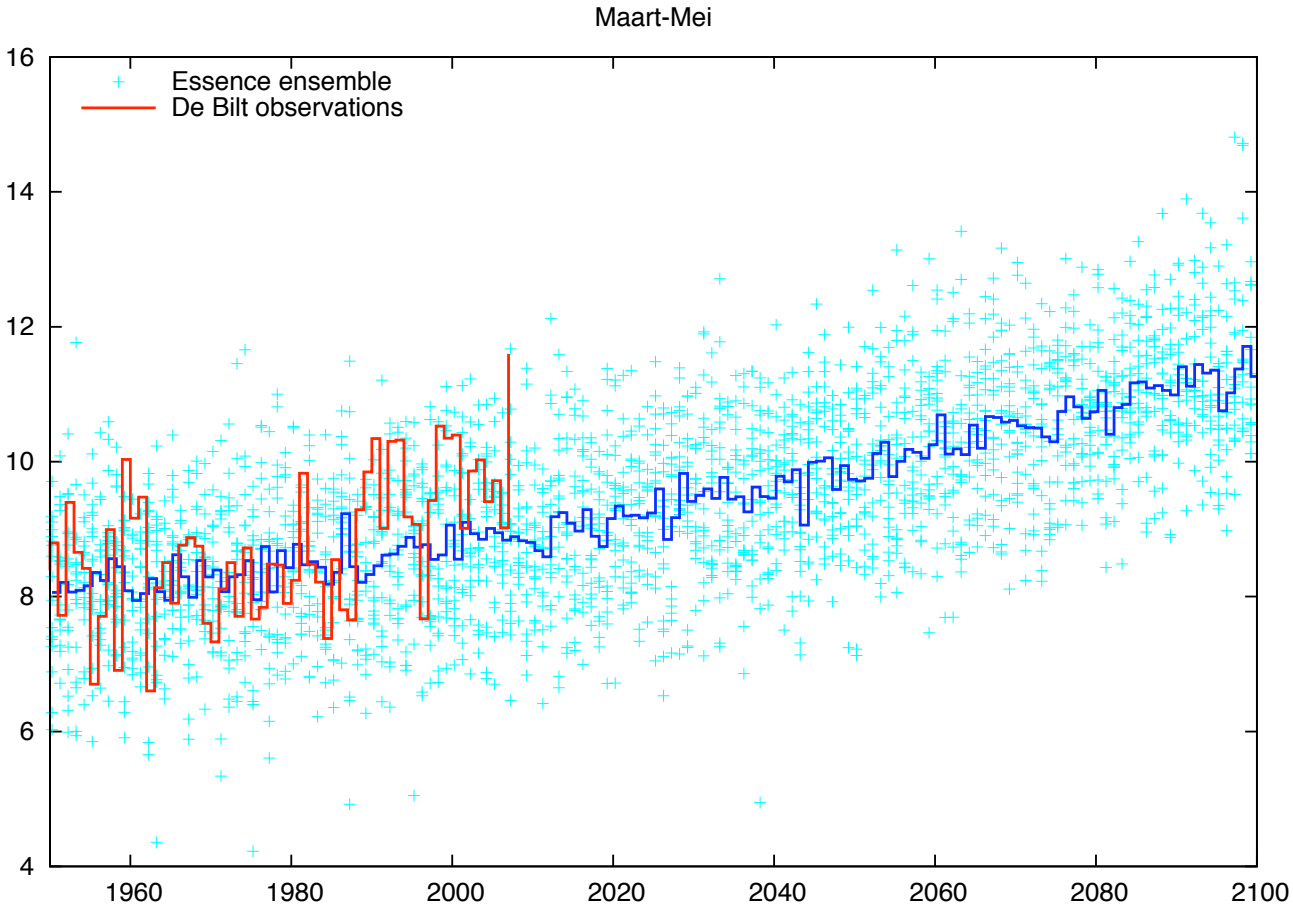
CCCMA CGCM3.1

Change in PDF?



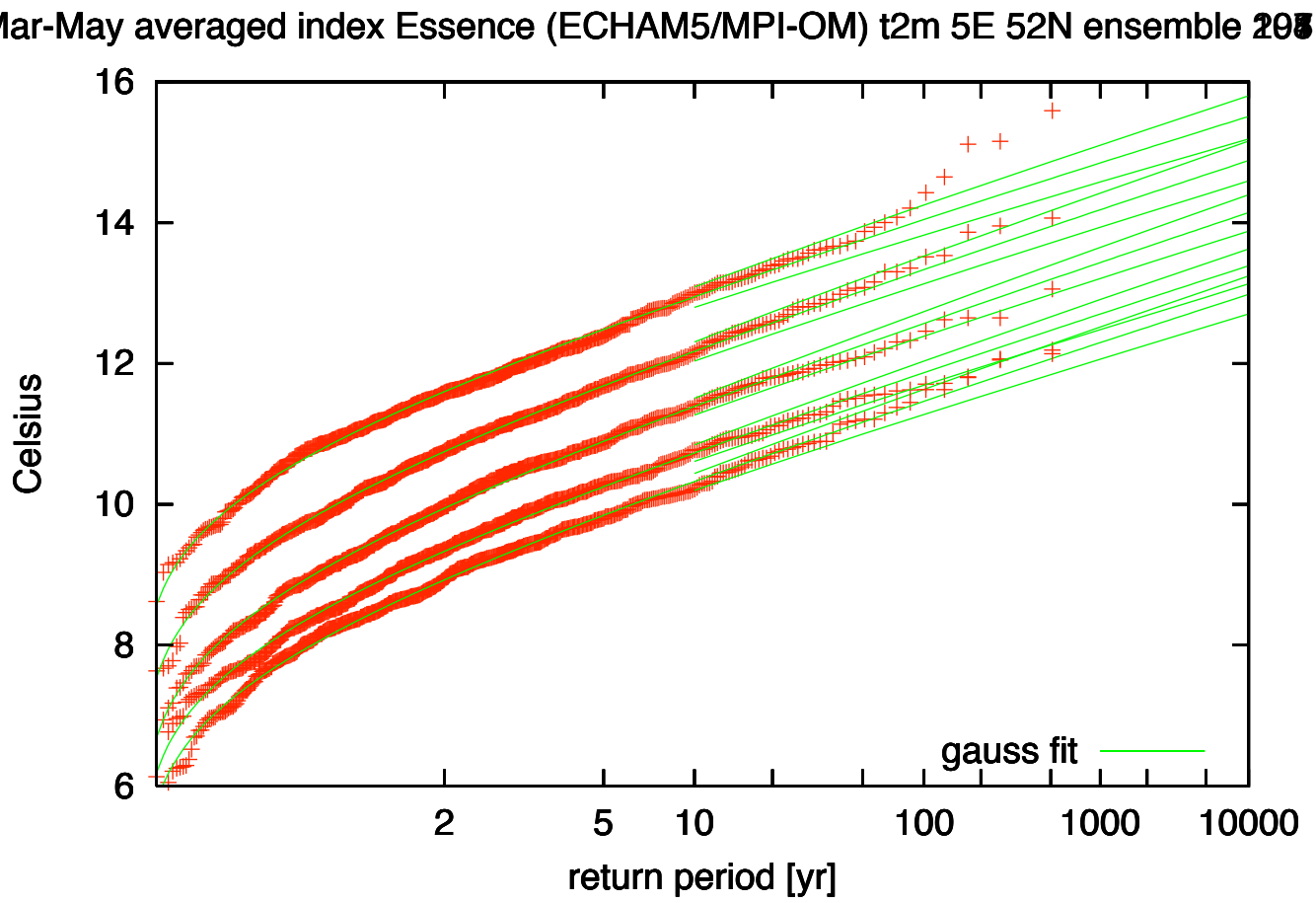
ESSENCE, winter temperatures

Change in PDF?



ESSENCE, spring temperatures

No change in high tail PDF in spring until 2095



ESSENCE, GPD for every 30 years: 1951-1980, 1981-2010, 2011-2040, 2041-2070, 2071-2100.

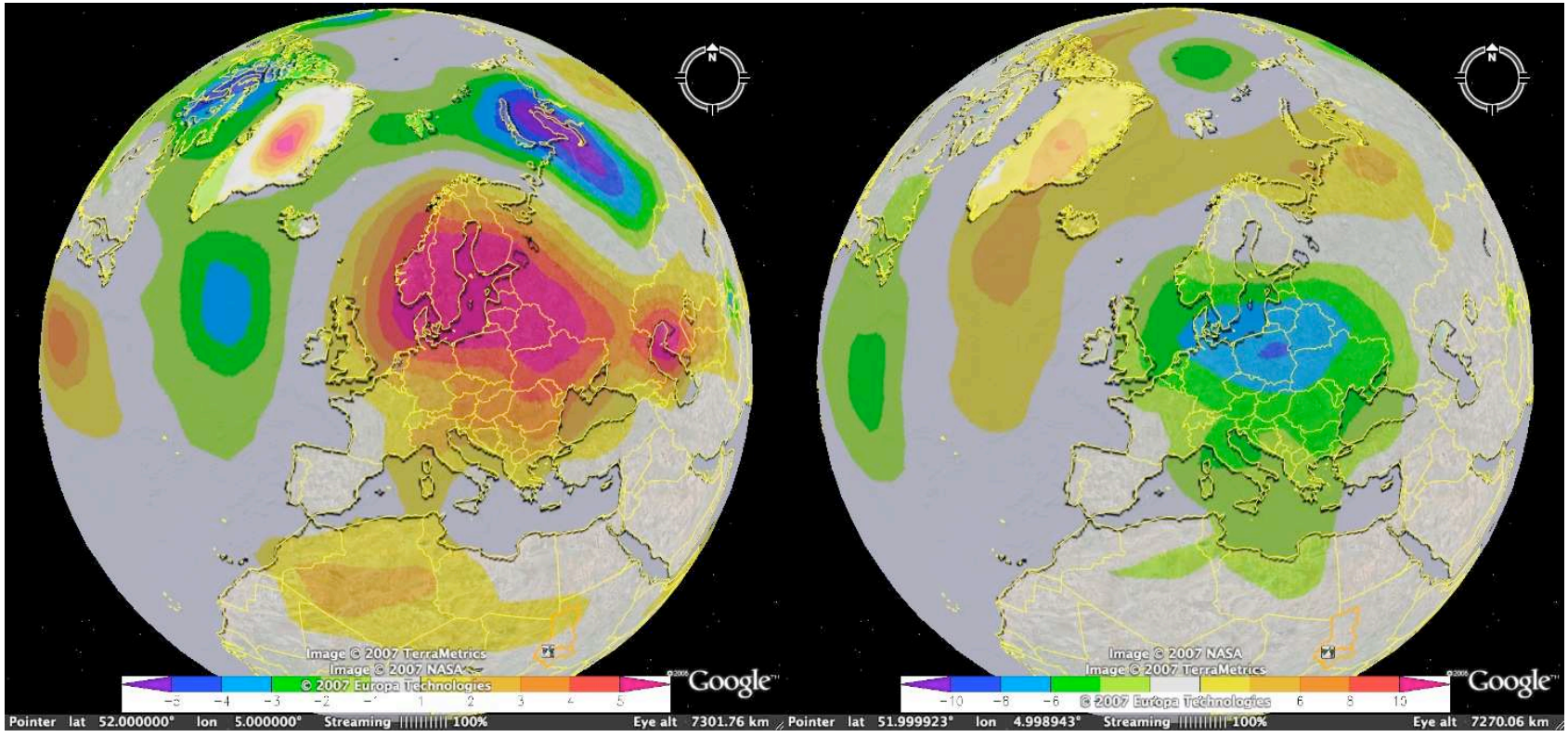
Weather $\epsilon(x, y, 2006/2007)$

- Highly improbable sequence of temperature anomalies after subtracting trend (and persistence)
- Climate models do not simulate a change in PDF, only a shift, except in summer

Conclusions and questions

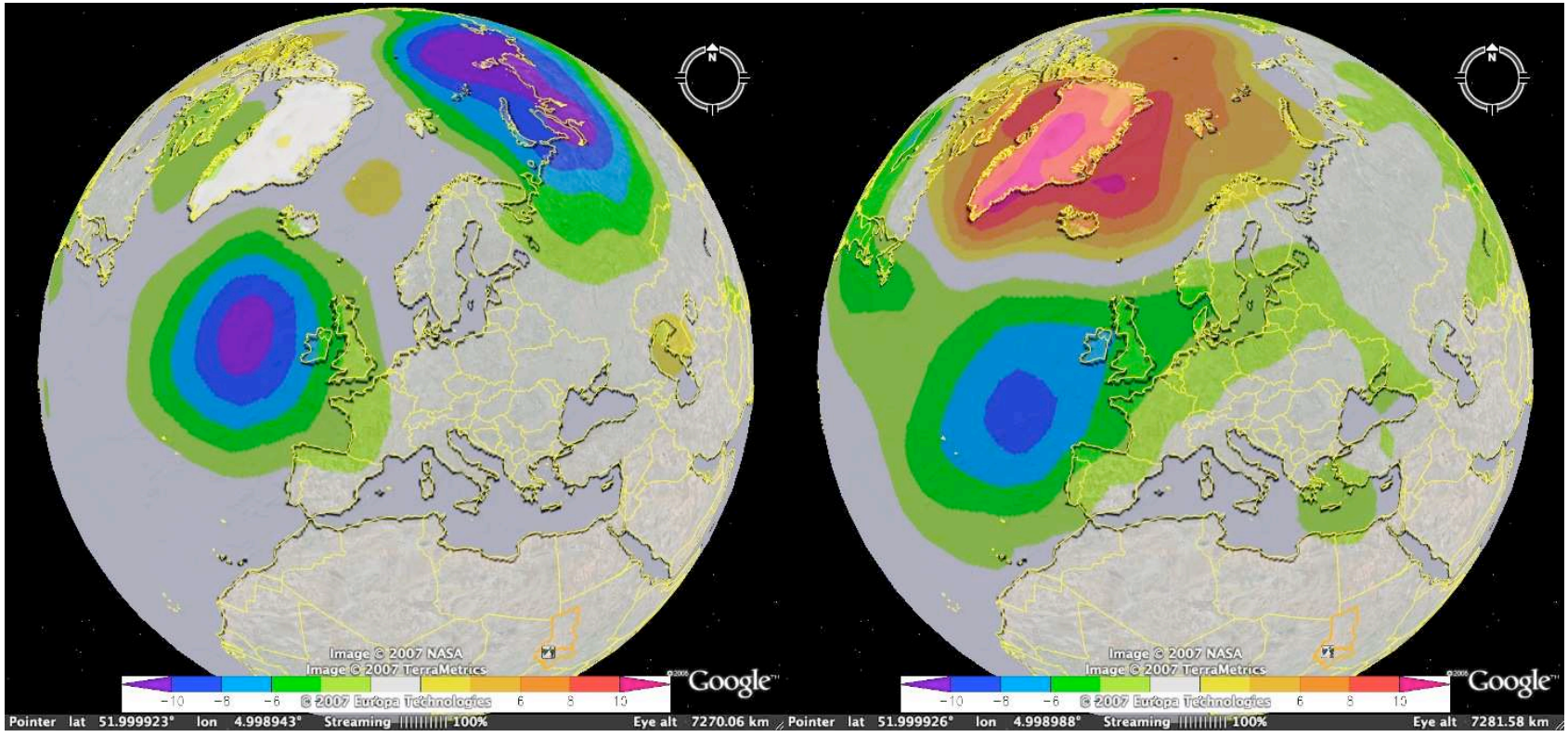
- The warming trend in west-central Europe is two times faster than the climate models simulate
- This is very unlikely due to natural variability
- On top of this trend, a series of unlikely temperature extremes occurred over the last year
- Climate models only simulate a change in PDF other than a shift in summer
- Missing non-linear physics in the climate models?

Circulation



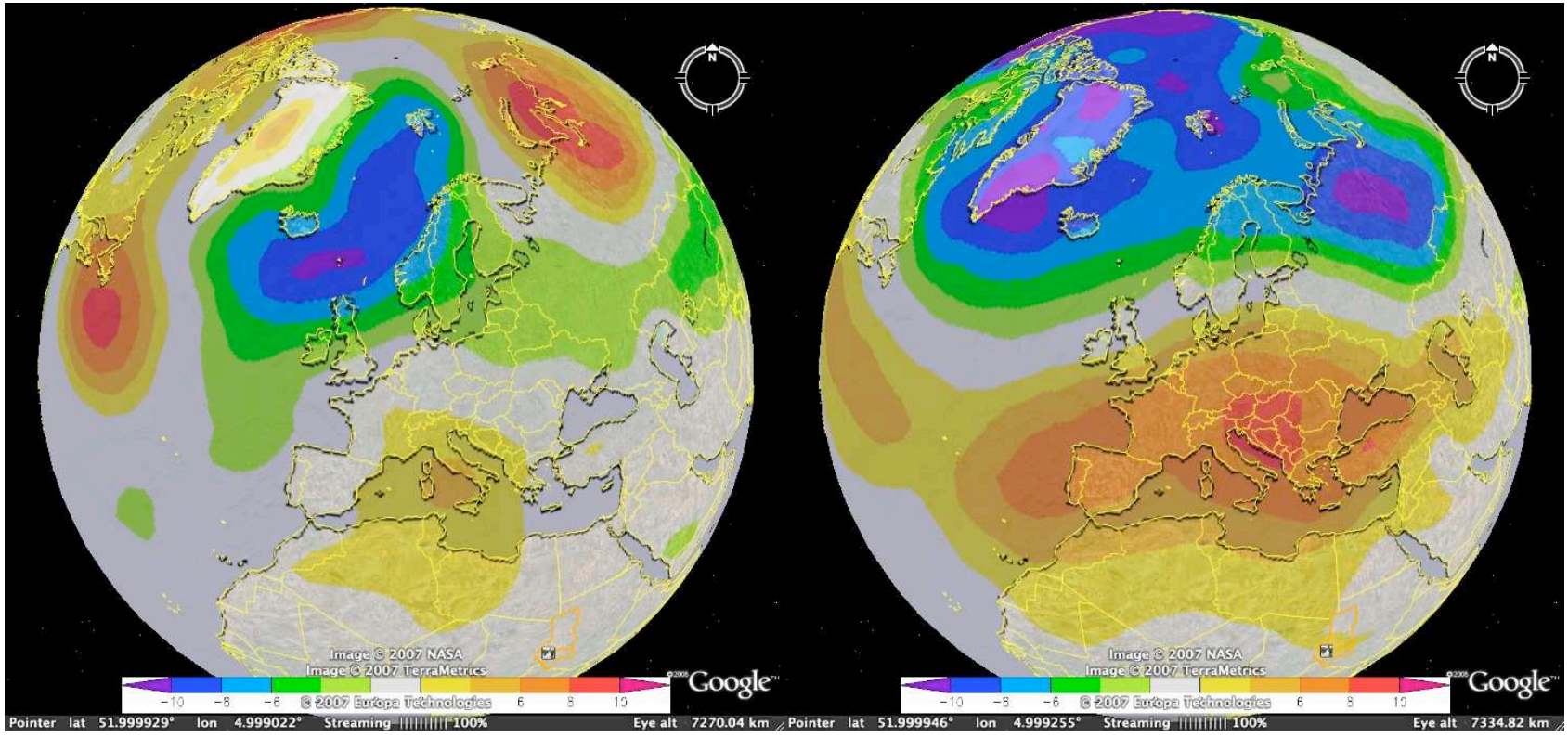
July 2006 August 2006

Circulation



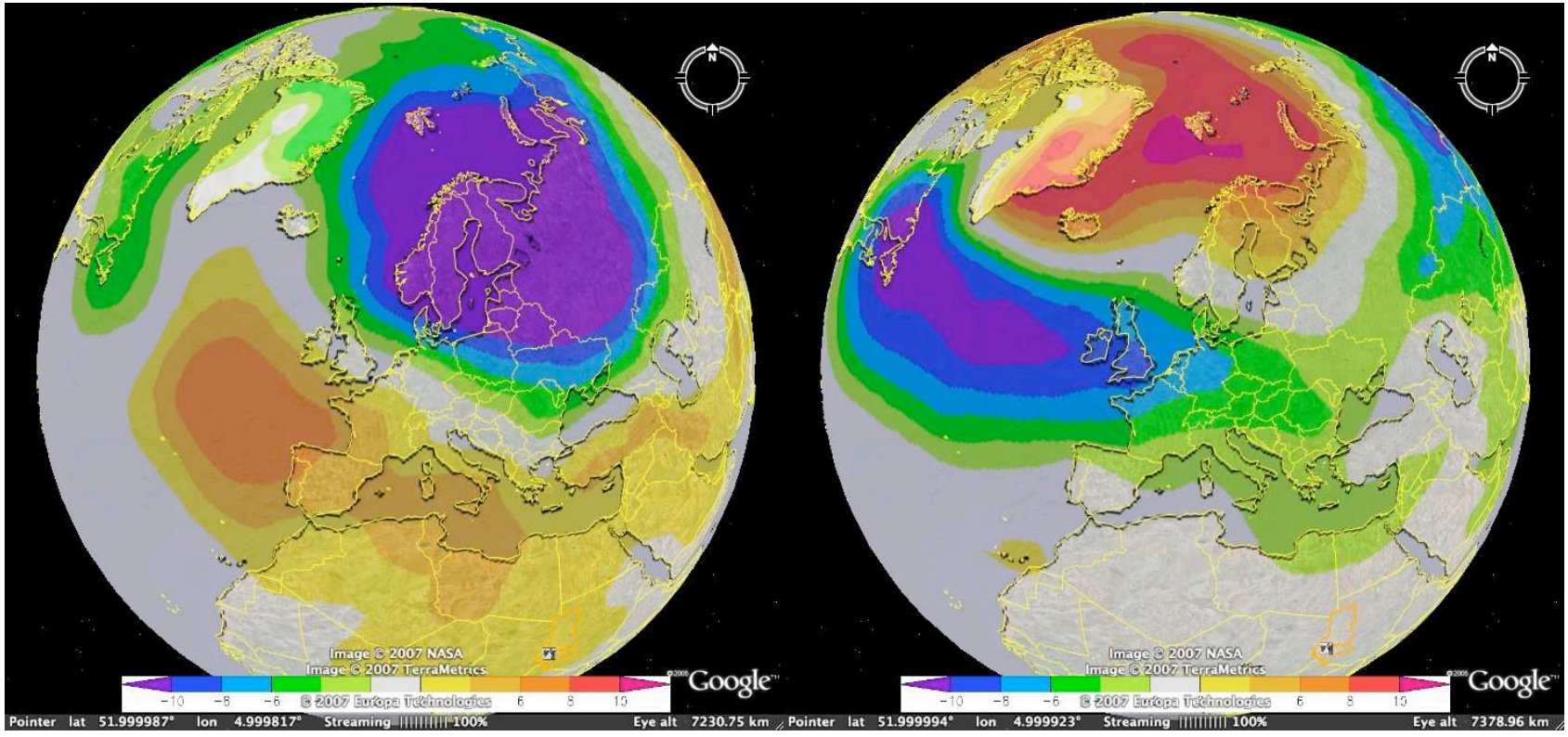
September 2006 October 2006

Circulation



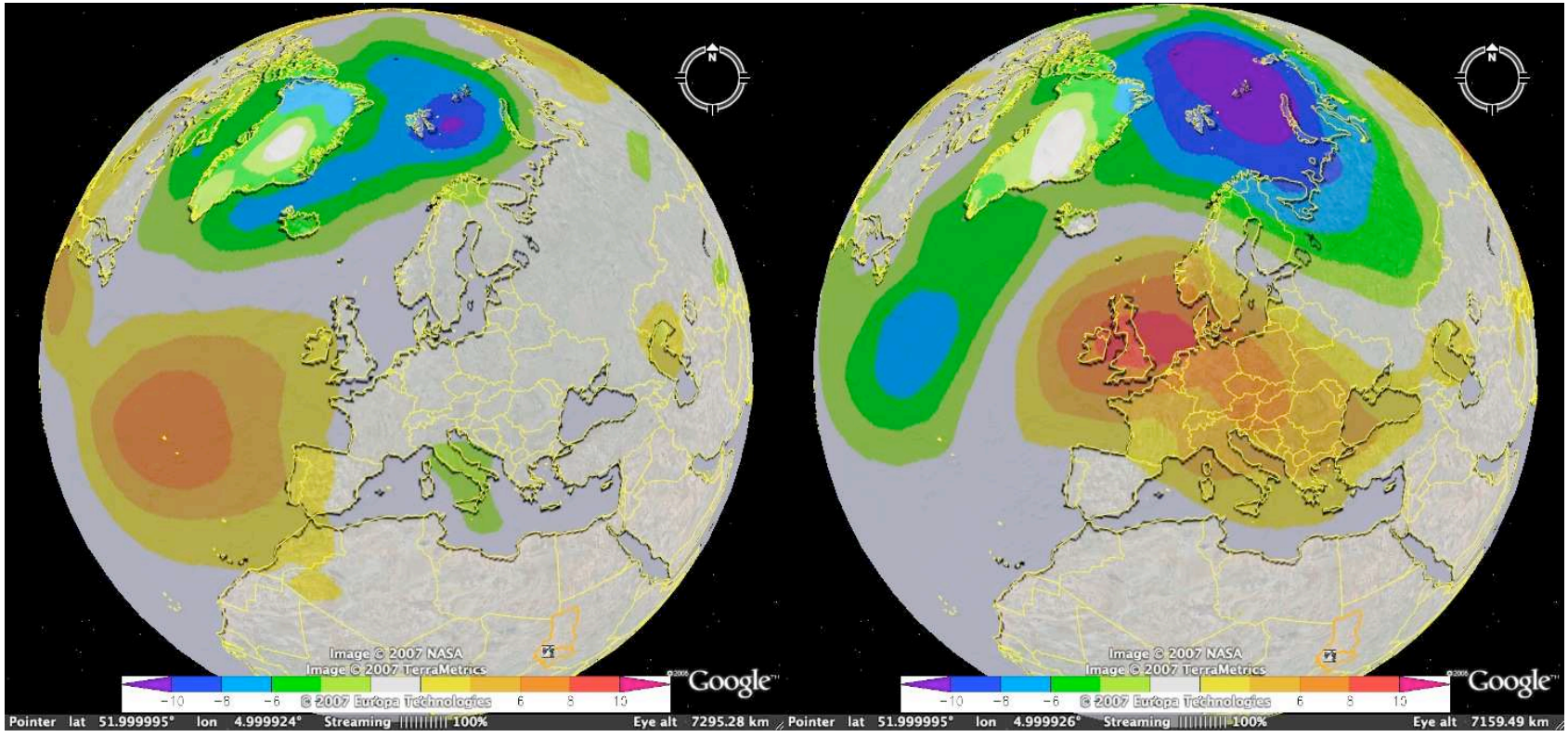
November 2006 December 2006

Circulation



January 2007 February 2007

Circulation



March 2007 April 2007