Global weirding or insignificant change?

Extremes in a changing climate

ETH zürich

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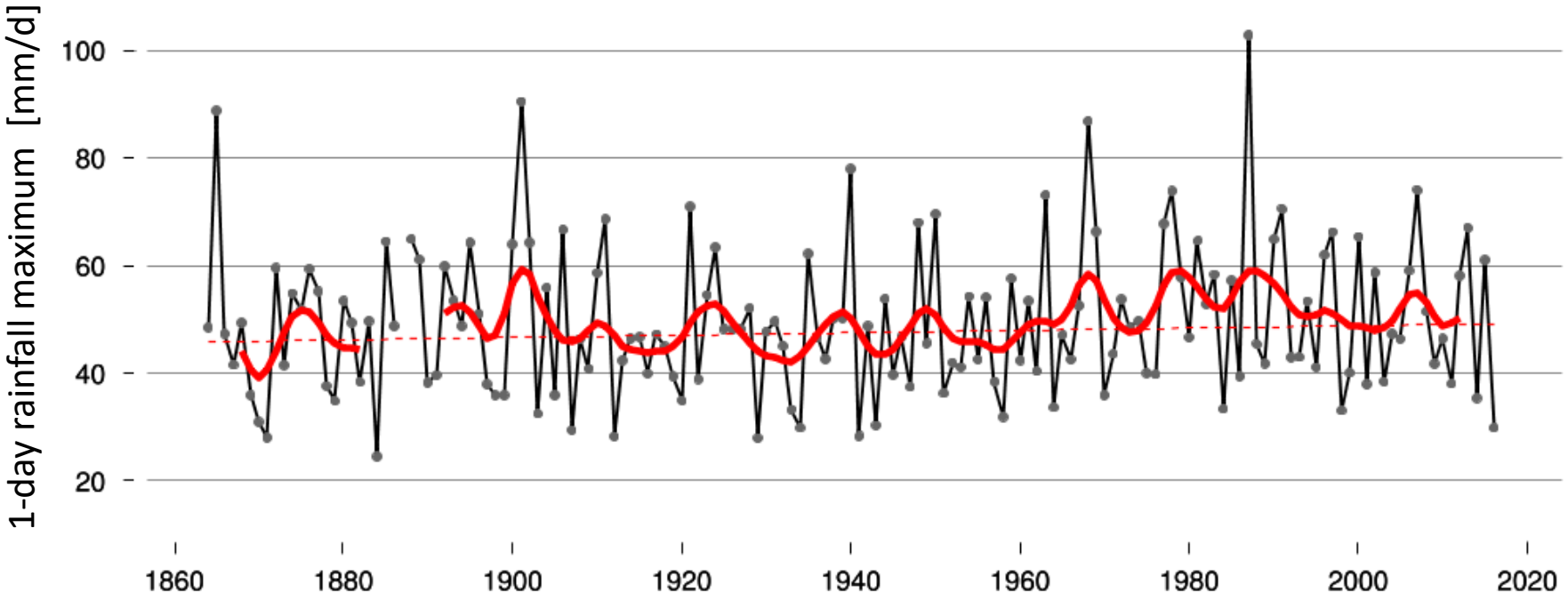
Global weirding?

Insignificant change?



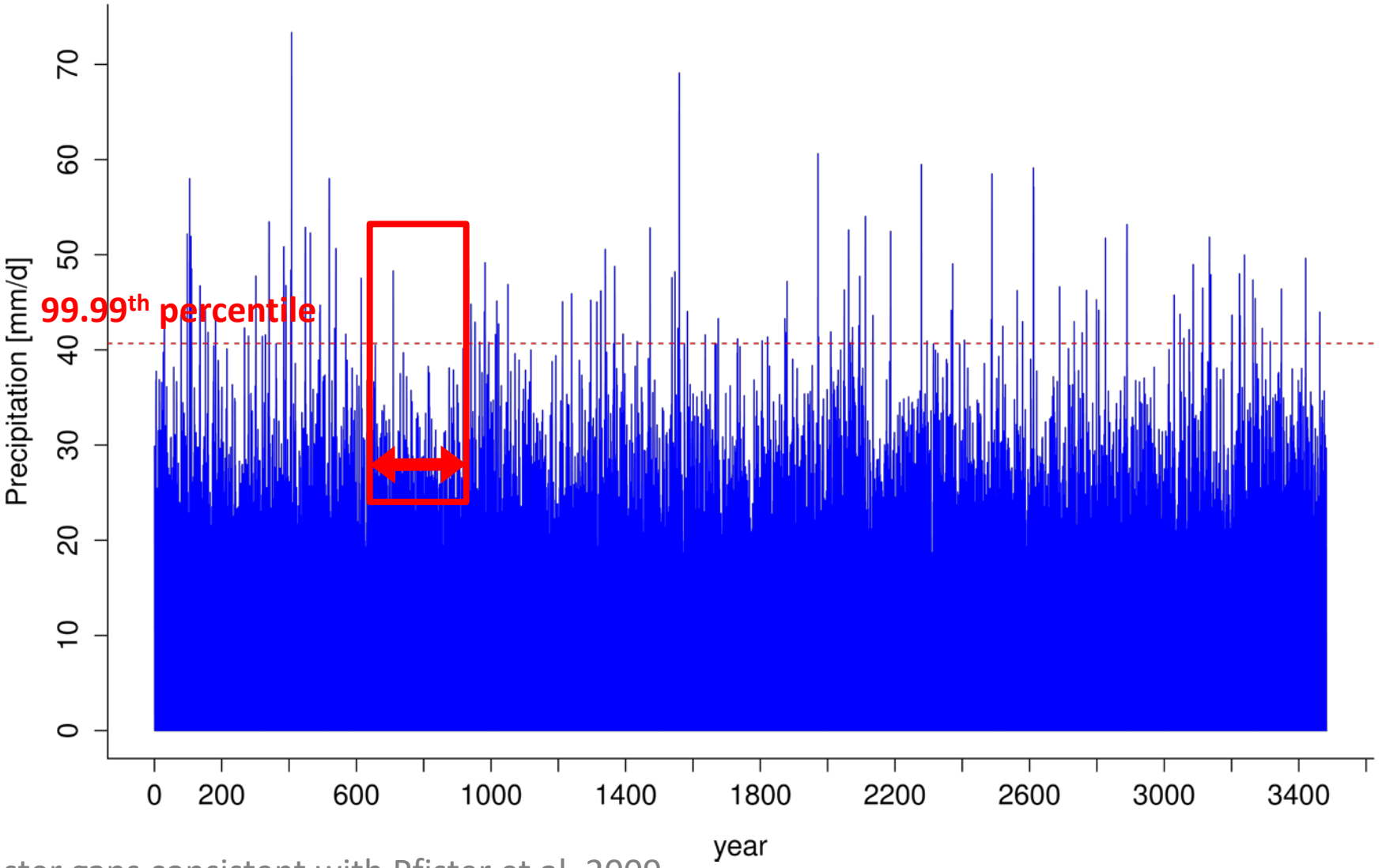
www.meteoschweiz.ch (2017)

Global weirding or insignificant change?

Neither… we need to differentiate

Locally natural variability is very large

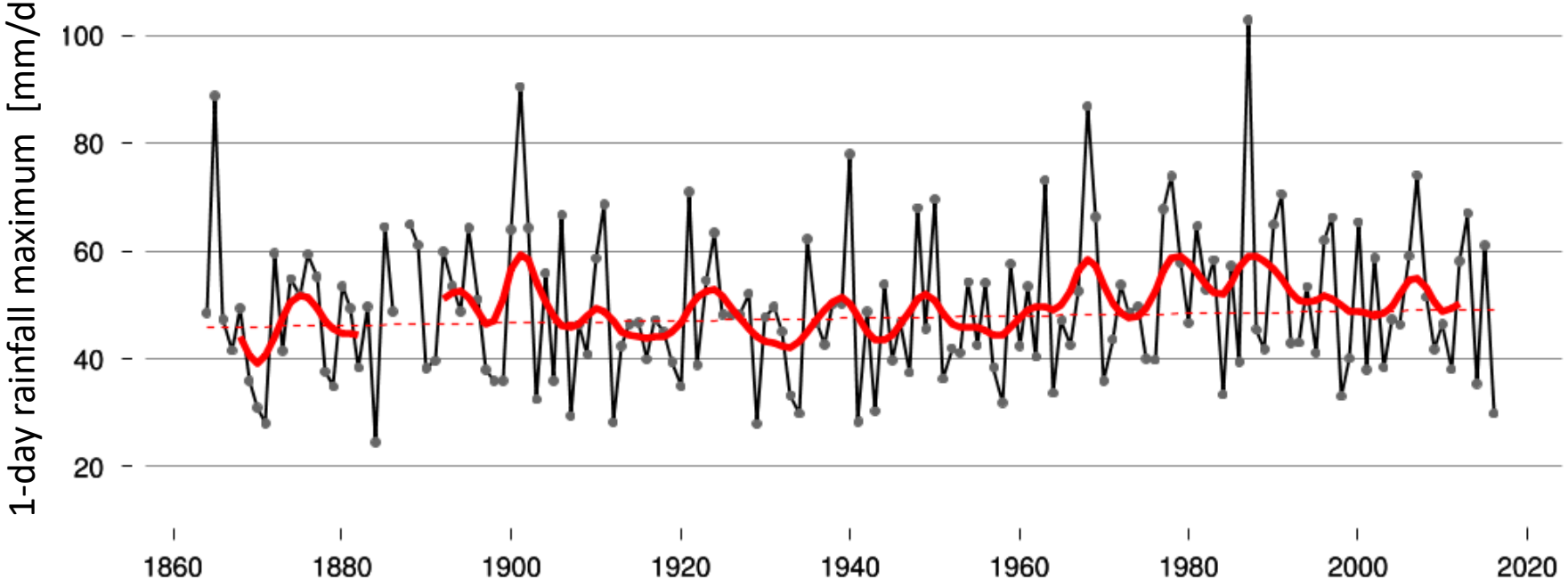
Daily precipitation in pre-industrial control run



Disaster gaps consistent with Pfister et al. 2009

Change or no change?

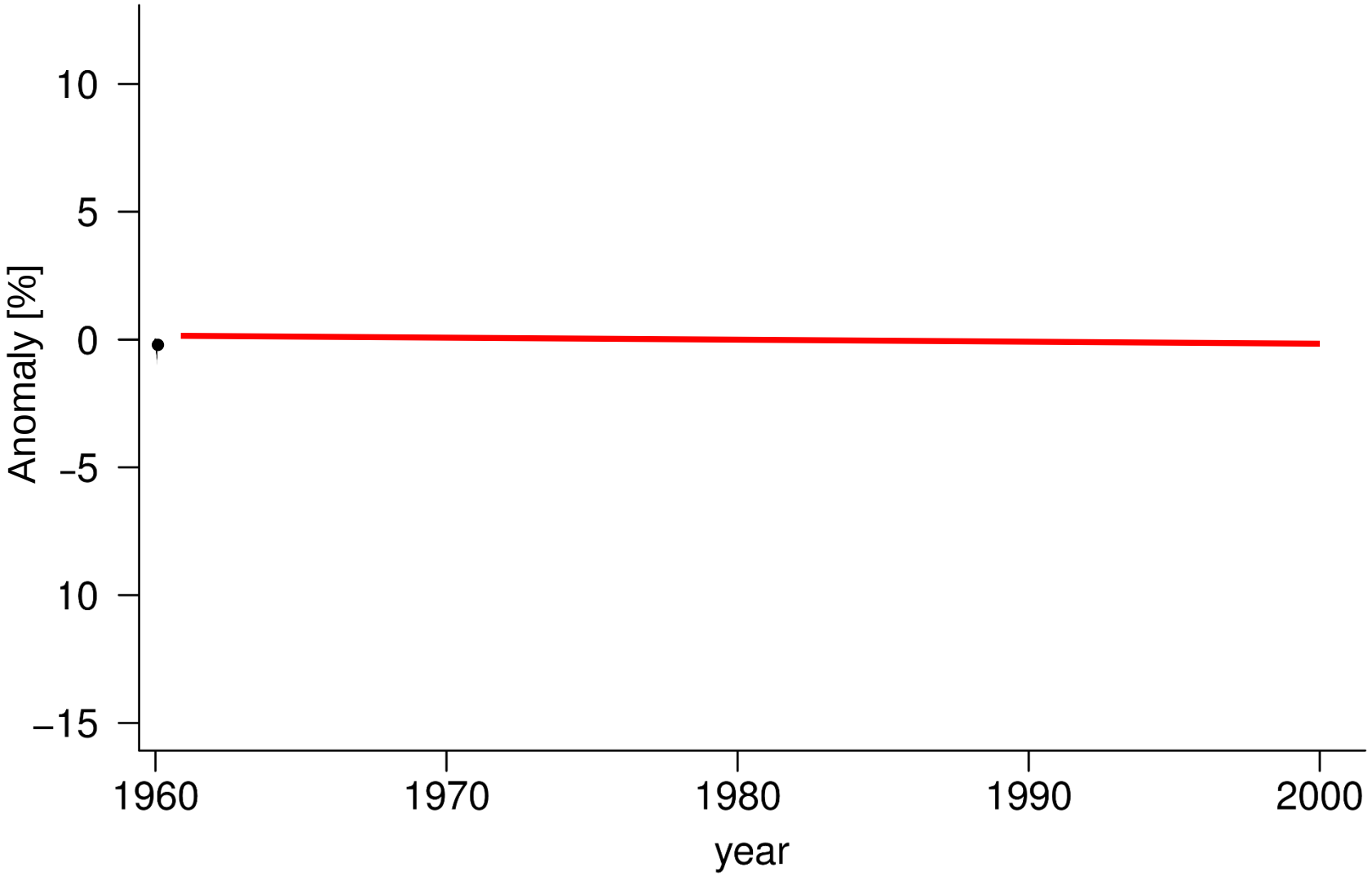
1-day precipitation maxima 1864-2016 (Chaumont)



www.meteoschweiz.ch (2017)

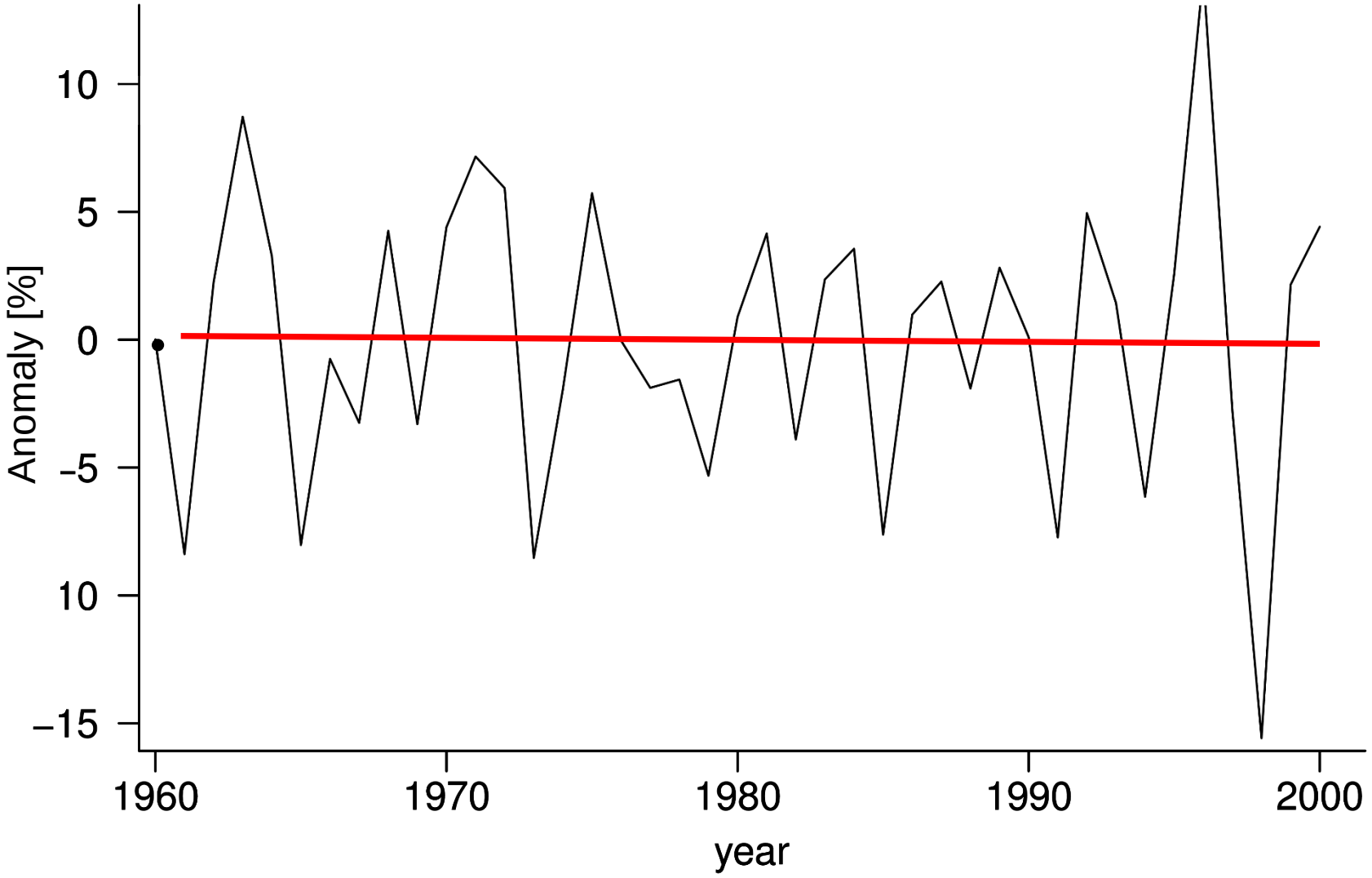
Climate models an ideal testbed

Annual 1-day rainfall maxima (rx1day) N Europe



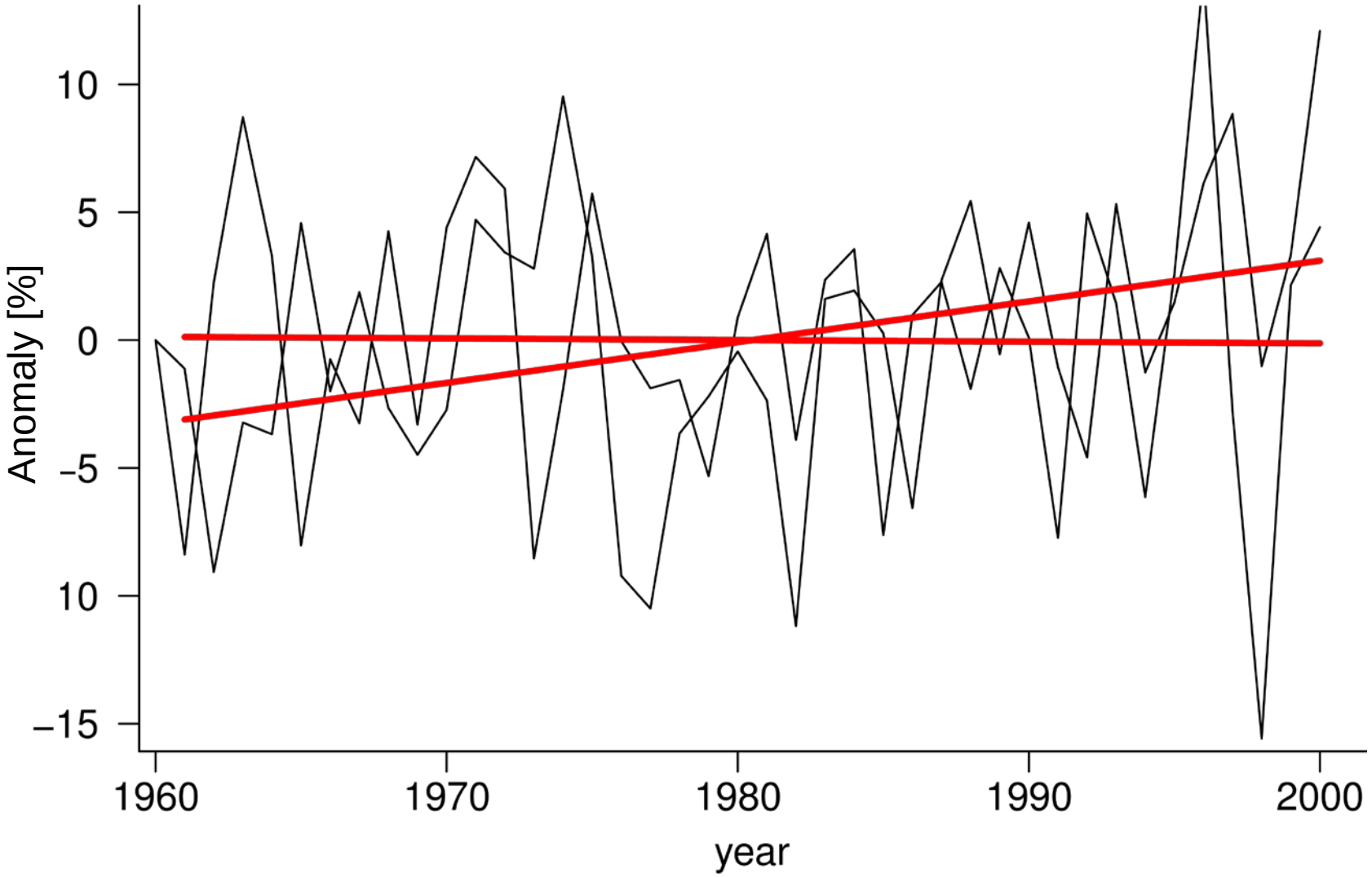
The butterfly effect

Annual 1-day rainfall maxima (rx1day) N Europe



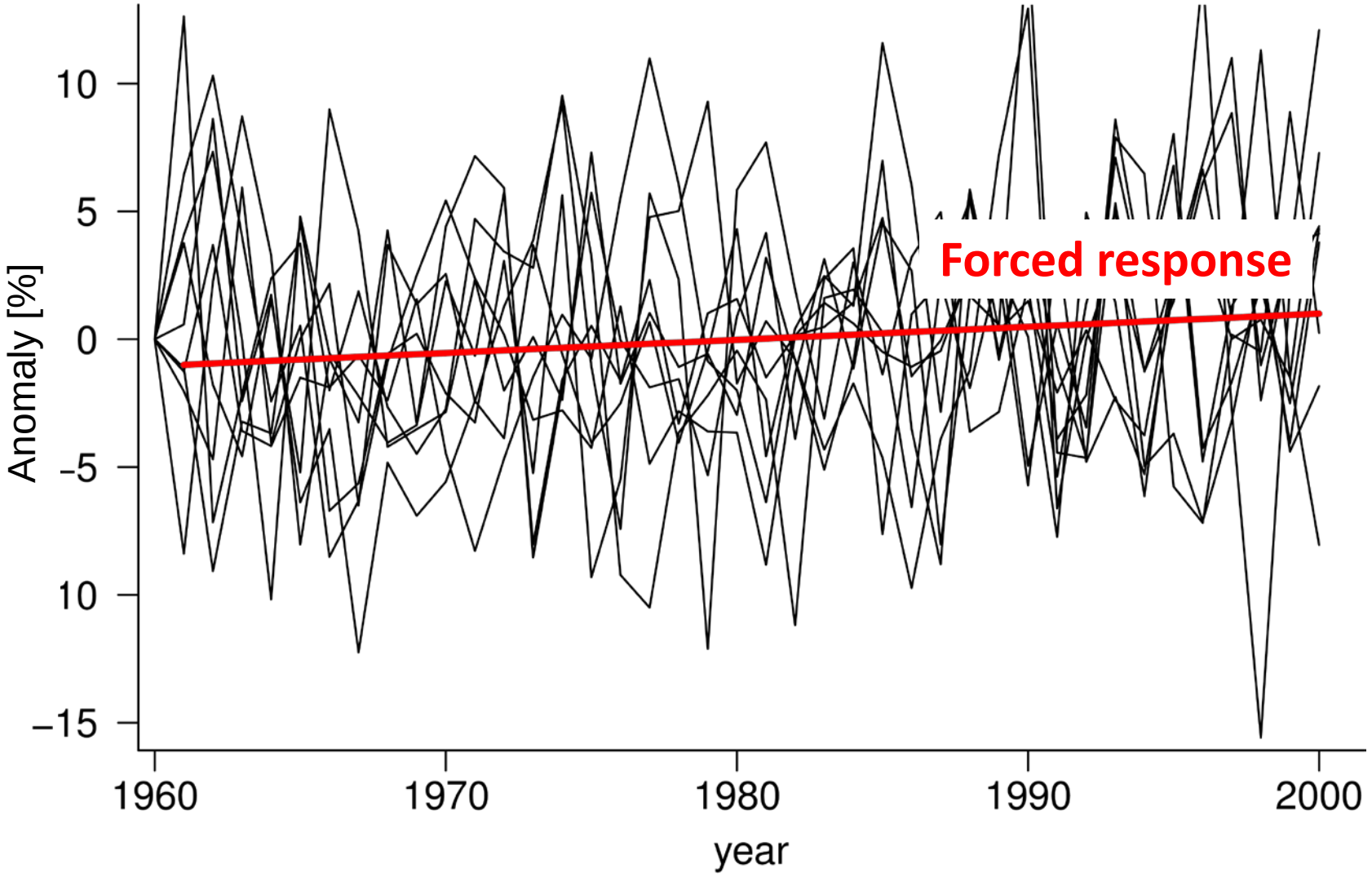
The butterfly effect

Two realizations of exact same model

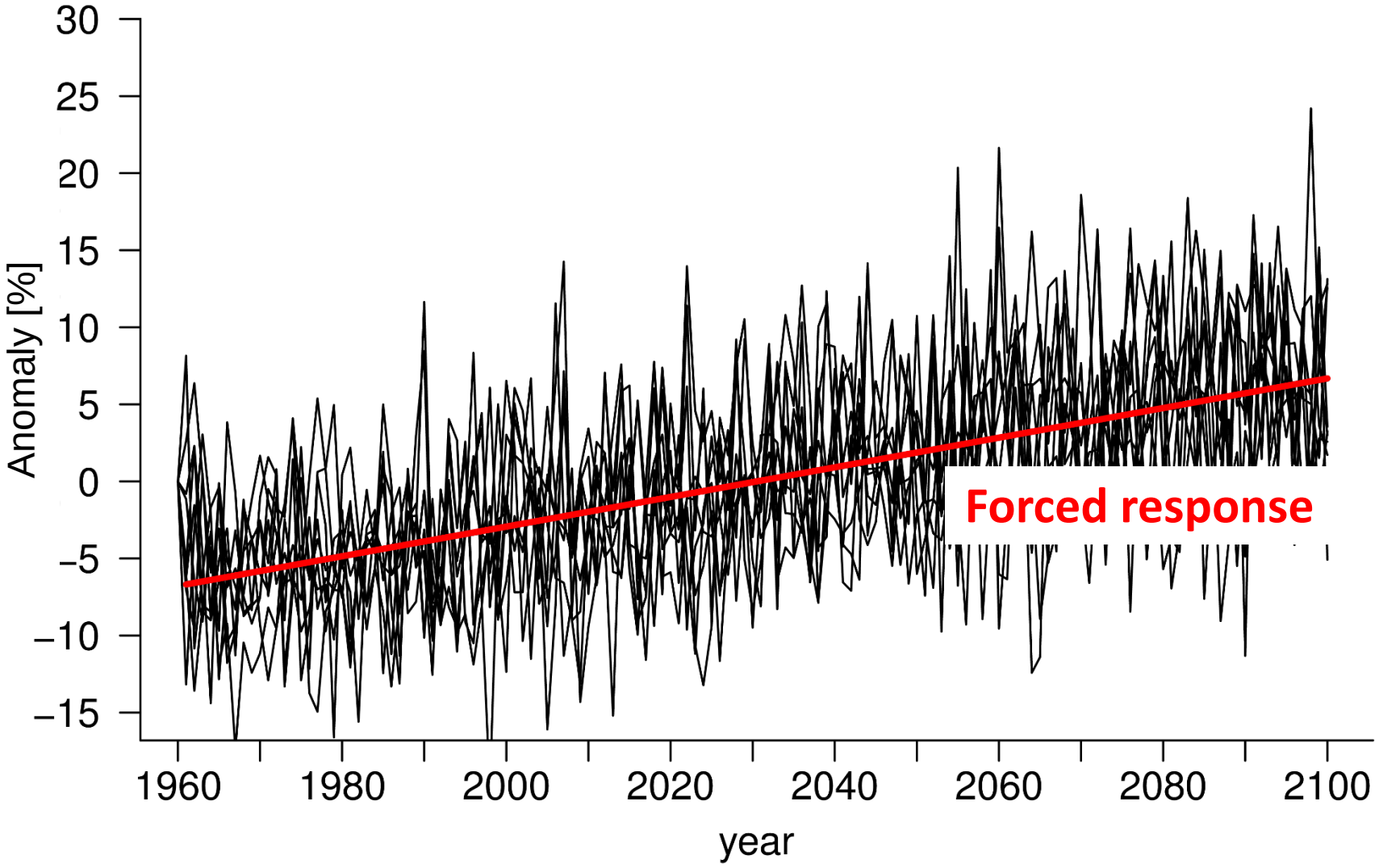


The forced response

The underlying signal that determines return period



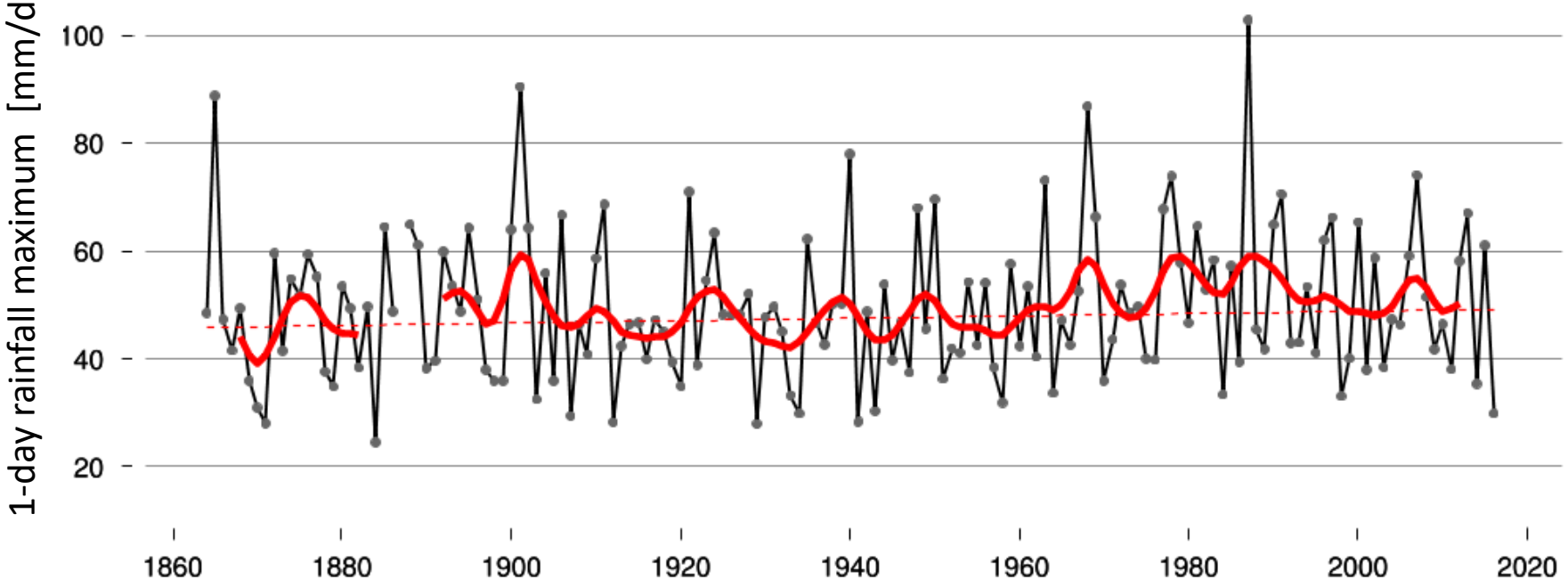
Forced response determines probability




The boy who
cried wolf –
reversed

Erring on the side of least drama?

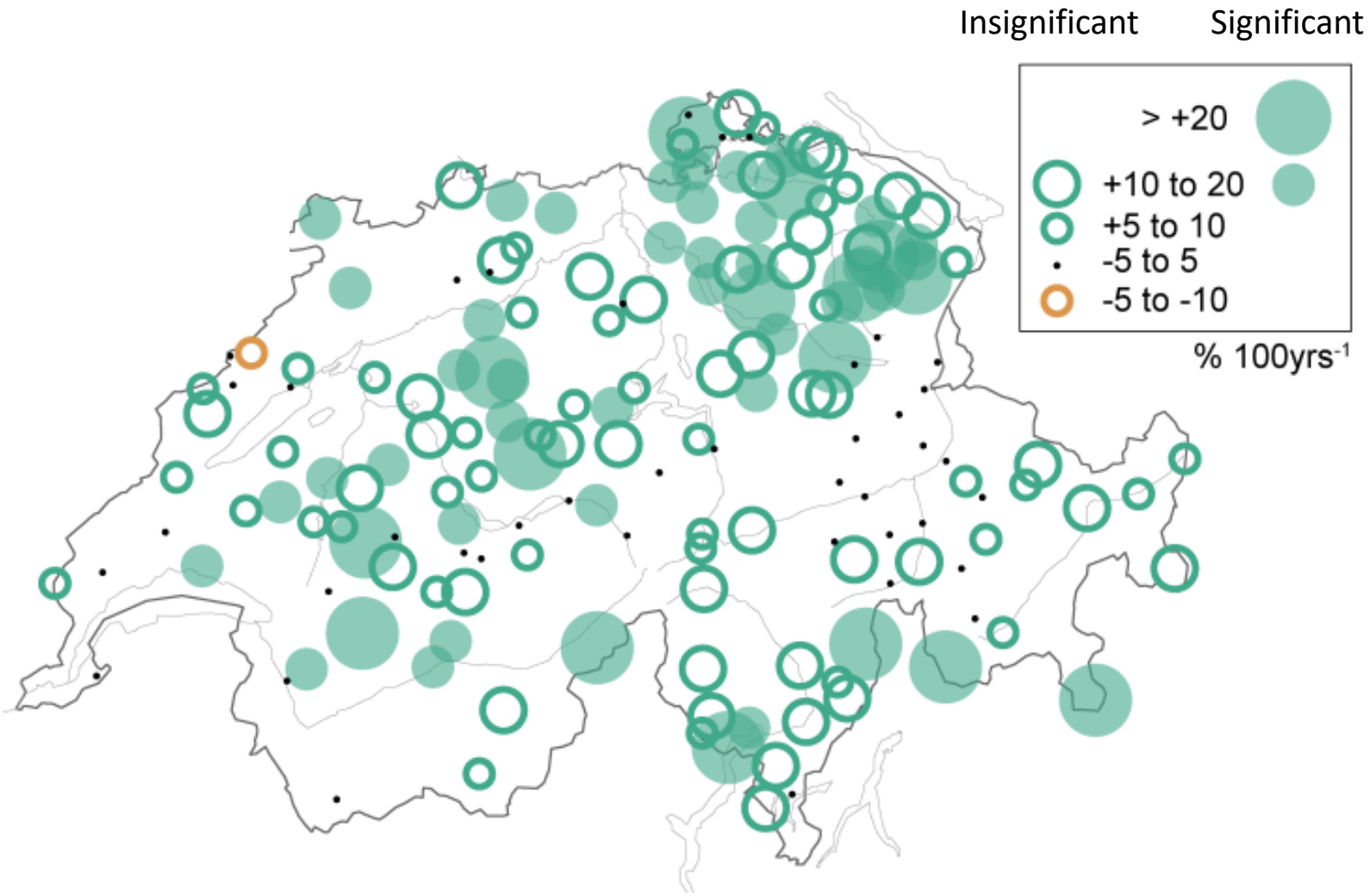
1-day precipitation maxima 1864-2016 (Chaumont)



www.meteoschweiz.ch (2017)

The score is 91:9 and 31:0

Trends in 1-day precipitation maxima 1901-2014



Scherrer et al. (2016), *J Geophys Res.*

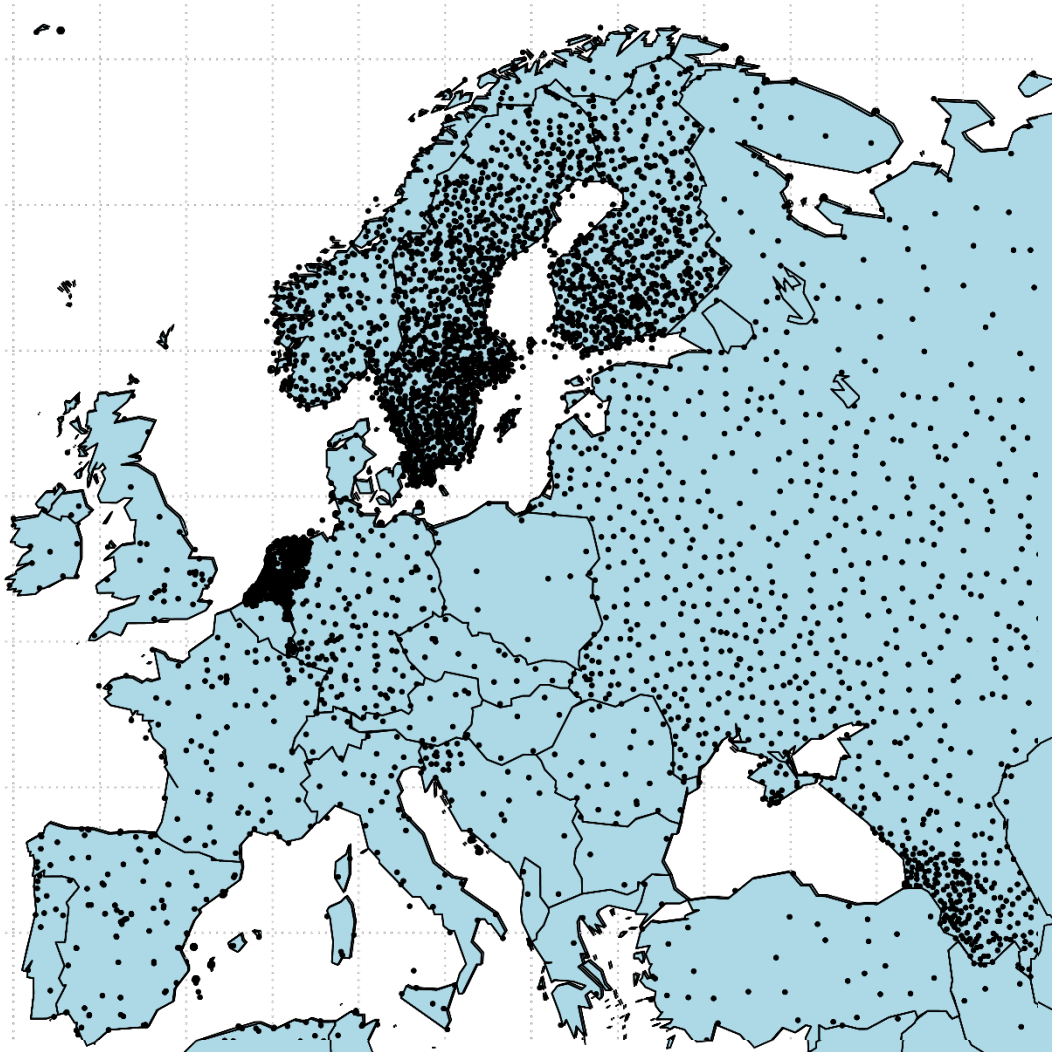
The map of shame

Stations with complete daily rainfall data 1951-2010

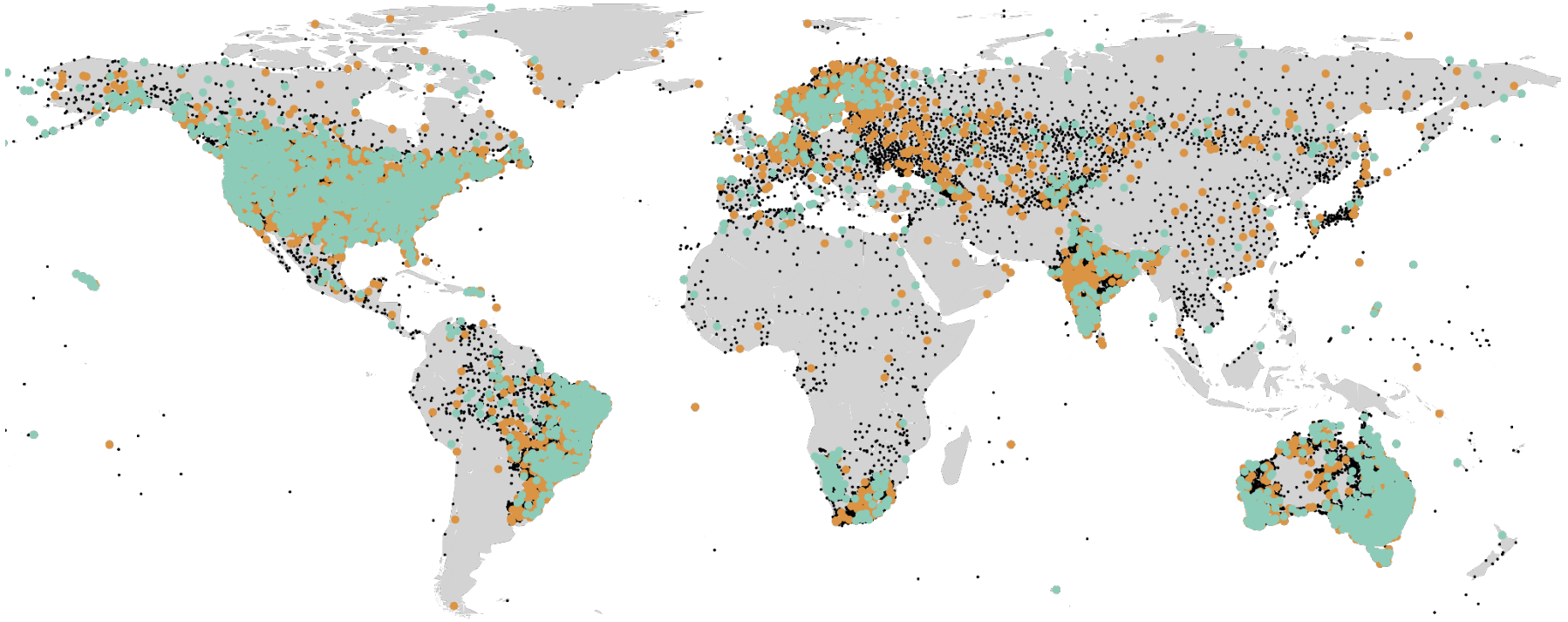
Restricted data access prevents vital research

Less stringent – more data

Stations with reasonable daily rainfall availability



More increase than decrease in heavy precip

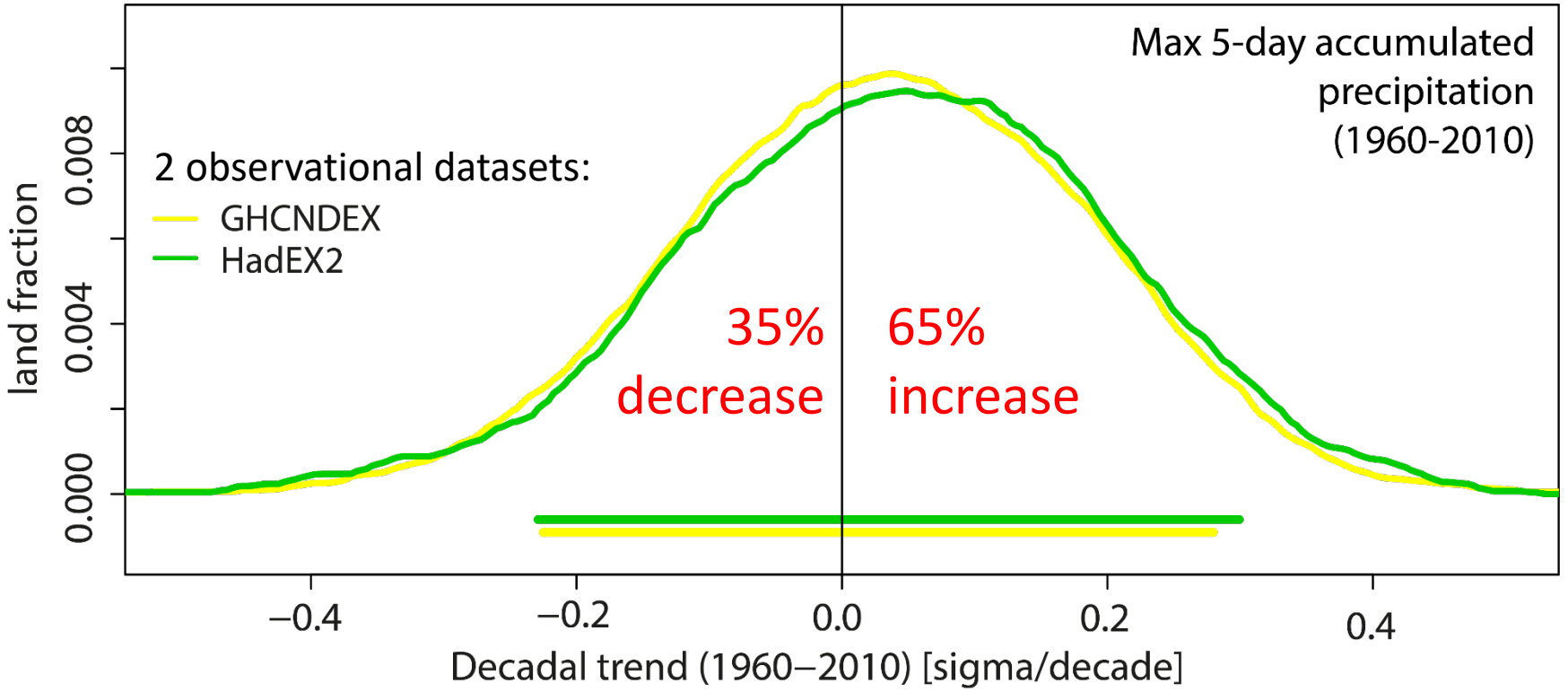


- significantly negative relationship with global mean temperature
- significantly positive relationship with global mean temperature
- non-significant relationship with global mean temperature

Update of Westra et al. 2013
Fischer and Westra 2017, *in prep*

More increase than decrease

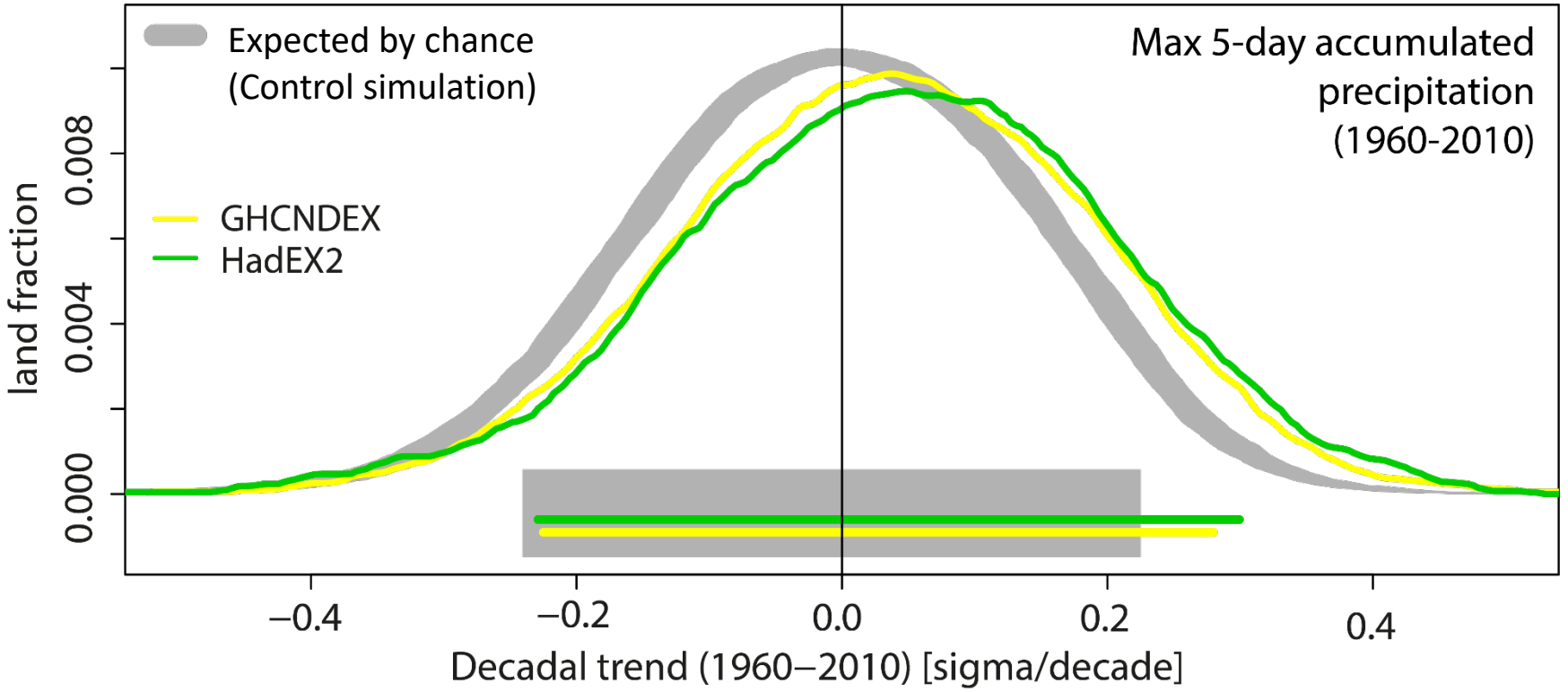
Histogram of «global» heavy rainfall trends



Fischer and Knutti 2014b, *GRL*

Not to be expected by chance

Internal variability cannot explain the observed trends



Fischer and Knutti 2014b, *GRL*

Consistent with Min et al. 2011, *Nature*, Zhang et al. (2013) *GRL,* and Westra et al. (2013) *J Climate*

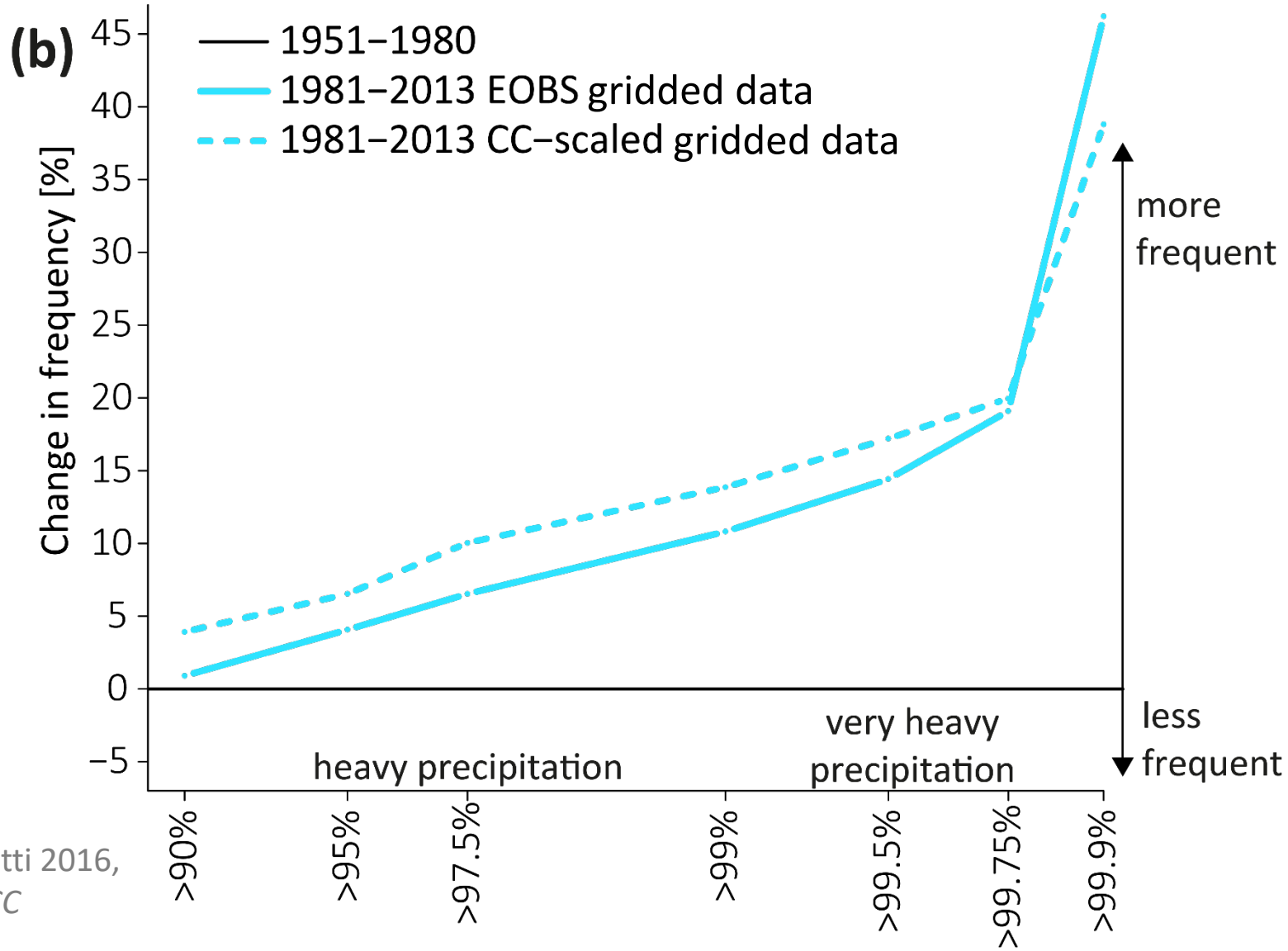
Insignificant change?

No! Changes in heavy rainfall and temperature extremes are detected at global scale

Why? - Same weather in a warmer climate?

Heavy rainfall change consistent with theory

Precipitation in Europe scaled by Clausius-Clapeyron

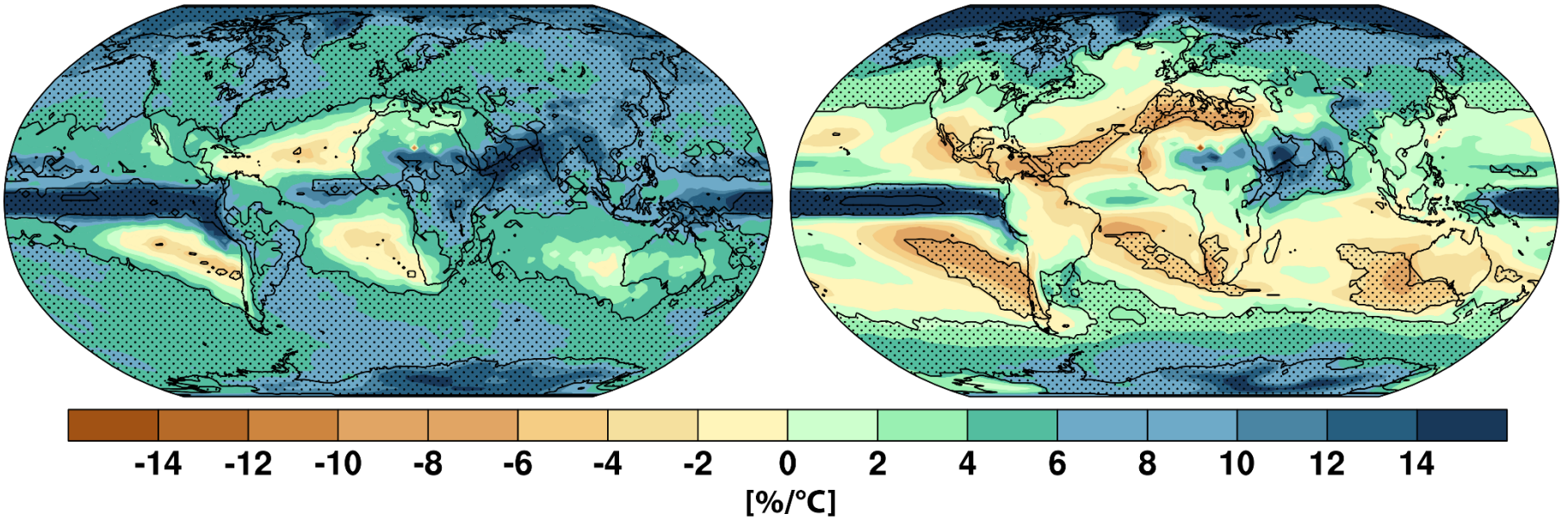


Fischer and Knutti 2016, *Nature CC*

Extremes more robust than mean

Change in heavy precipitation

Change in annual mean precipitation



Stippled area fraction: 73%

Stippled area fraction: 27%

Stippled if 80% of CMIP5 models agree on sign of forced response

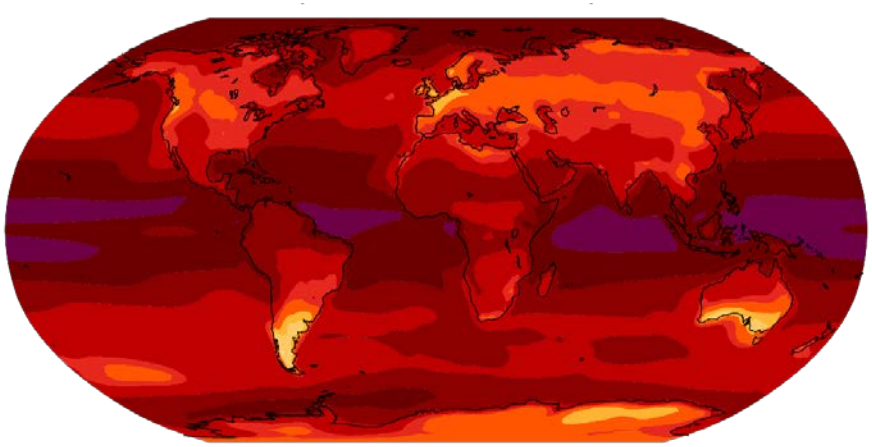
Fischer et al., 2014, *GRL,*
see also Kröner et al. 2016*, Clim. Dyn* for mean precip

Warming explains most changes in hot days

Change in number of hot days at 2°C global warming

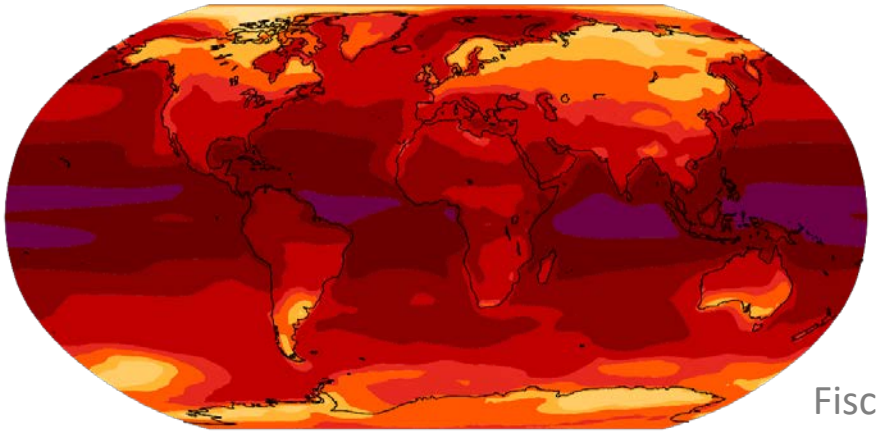
Simulated 2°C warming

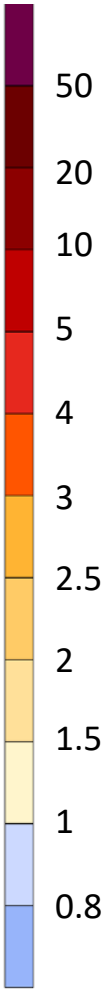
Global mean ratio 7.1



Estimated 2°C shift

Global mean ratio 7.5





Probability ratio

Fischer and Knutti, 2015, *Nature CC*

Consistent with Cattiaux et al. (2016), Fischer and Schär (2010), Sillmann, Schaller et al. (2017), *in prep*

GEOPHYSICAL RESEARCH LETTERS, VOL. 39, L06801, doi:10.1029/2012GL051000, 2012

Evidence linking Arctic amplification to extreme weather in mid-latitudes

Jennifer A. Francis[1] and Stephen J. Vavrus[2]

Received 17 January 2012; revised 20 February 2012; accepted 21 February 2012; published 17 March 2012.

[1] Arctic amplification (AA) – the observed enhanced warming in high northern latitudes relative to the northern hemisphere – is evident in lower-tropospheric temperatures and in 1000-to-500 hPa thicknesses. Daily fields of 500 hPa heights from the National Centers for Environmental Prediction Reanalysis are analyzed over N. America and the N. Atlantic to assess changes in north-south (Rossby) wave characteristics associated with AA and the relaxation of poleward thickness gradients. Two effects are identified that

[3] Exploration of the atmospheric response to Arctic change has been an active area of research during the past decade. Both observational and modeling studies have identified a variety of large-scale changes in the atmospheric circulation associated with sea-ice loss and earlier snow melt, which in turn affect precipitation, seasonal temperatures, storm tracks, and surface winds in mid-latitudes [e.g., *Budikova*, 2009; *Honda et al.*, 2009; *Francis et al.*, 2009; *Overland and Wang*, 2010; *Petoukhov and Semenov*, 2010;

GEOPHYSICAL RESEARCH LETTERS, VOL. 40, 4734–4739, doi:10.1002/grl.50880, 2013

Revisiting the evidence linking Arctic amplification to extreme weather in midlatitudes

Elizabeth A. Barnes[1]

Received 17 July 2013; revised 8 August 2013; accepted 14 August 2013; published 4 September 2013.

[1] Previous studies have suggested that Arctic amplification has caused planetary-scale waves to elongate meridionally and slow down, resulting in more frequent blocking patterns and extreme weather. Here trends in the meridional extent of atmospheric waves over North America and the North Atlantic are investigated in three reanalyses, and it is demonstrated that previously reported posi-

hereafter) suggest that atmospheric Rossby waves have elongated meridionally in recent decades due to Arctic amplification. They hypothesize that these elongated waves propagate more slowly and favor more extreme weather conditions. They speculate that as the earth continues to warm, Arctic amplification will increasingly influence the North Atlantic atmospheric circulation, potentially causing more extreme

?

PNAS

Quasiresonant amplification of planetary w… and recent Northern Hemisphere weather

Vladimir Petoukhov[a,1], Stefan Rahmstorf[a], Stefan Petri[a], and Hans Joachim Schellnhuber[a,b,1]

[a]Potsdam Institute for Climate Impact Research, D-14412 Potsdam, Germany; and [b]Santa Fe Institute, Santa Fe, NM 87501

Contributed by Hans Joachim Schellnhuber, January 16, 2013 (sent for review June 15, 2012)

In recent years, the Northern Hemisphere has suffered several devastating regional summer weather extremes, such as the European heat wav… in Pakista… Here, we… sistent lo… atmosphe… Those pat…

I. Quasiresonance Hypothesis

Generally the large-scale midlatitude atmospheric circulation is

LET…

edited by Jennifer Sill…

Global W…ng and Winter Weather

IN MID-JANUA… LOBE OF THE POLAR VORTEX SAGGED SOUTHWARD OVER THE CENTRAL and eastern U… States. All-time low temperature records for the calendar date were set at O'Hare Airport in Chicago [–16°F (–27°C), 6 January], at Central Park in New York [4°F (–15.6°C), 7 J…], and at many other stations (*1*). Since that event, several substantial snow storms have b… the East Coast. Some have been touting such stretches of extreme cold as evidence that global warming is a hoax, while others have been citing them as evidence that global warming is causing a "global weirding" of the weather. In our view, it is neither.

temperate latitudes. It's an interesting idea, but alternative observational analyses and simulations with climate models have not confirmed the hypothesis, and we do not view the theoretical arguments underlying it as compelling [see (*3*–*6*)].

Other studies have suggested that the loss of Arctic sea ice may influence the atmospheric circulation in mid-latitudes during summer [e.g., (*7*)]. Sea-ice losses dur-

news & views

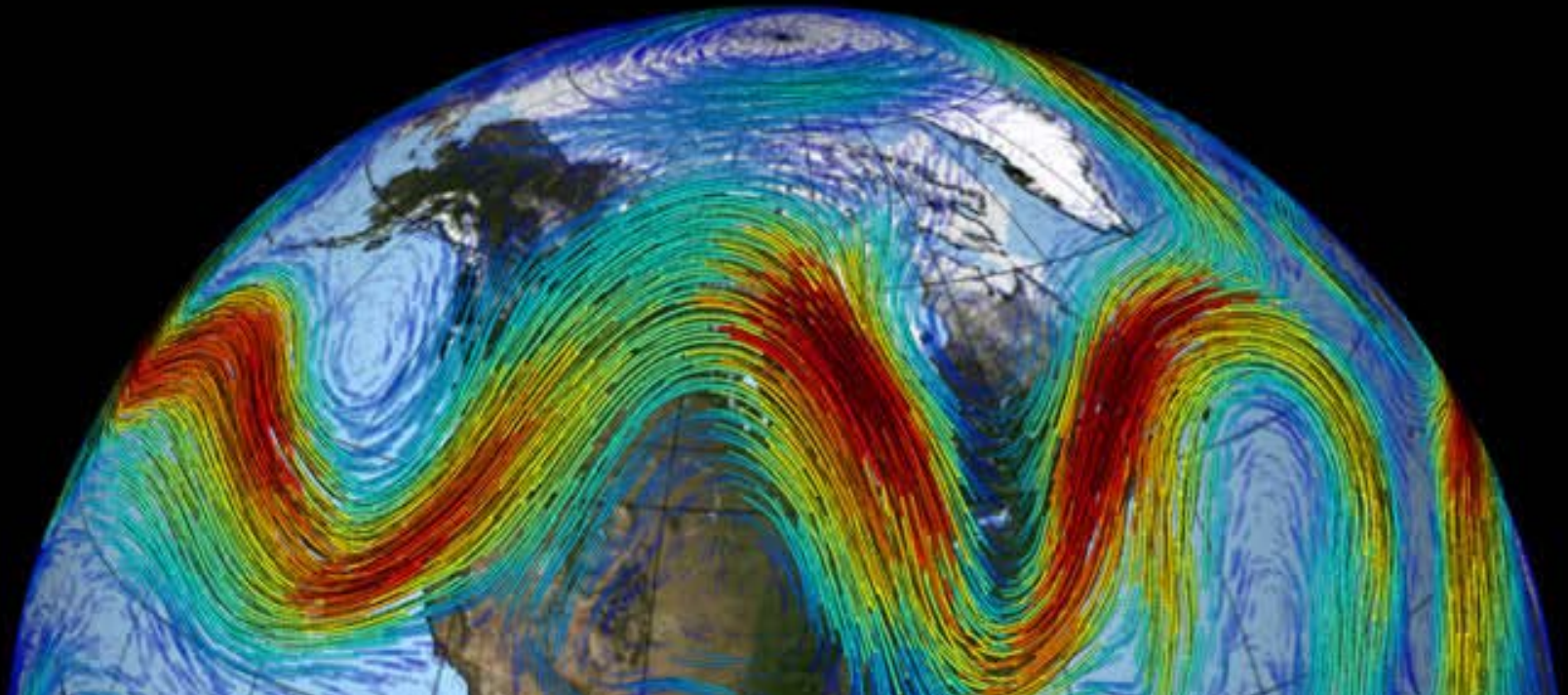
IMPACTS

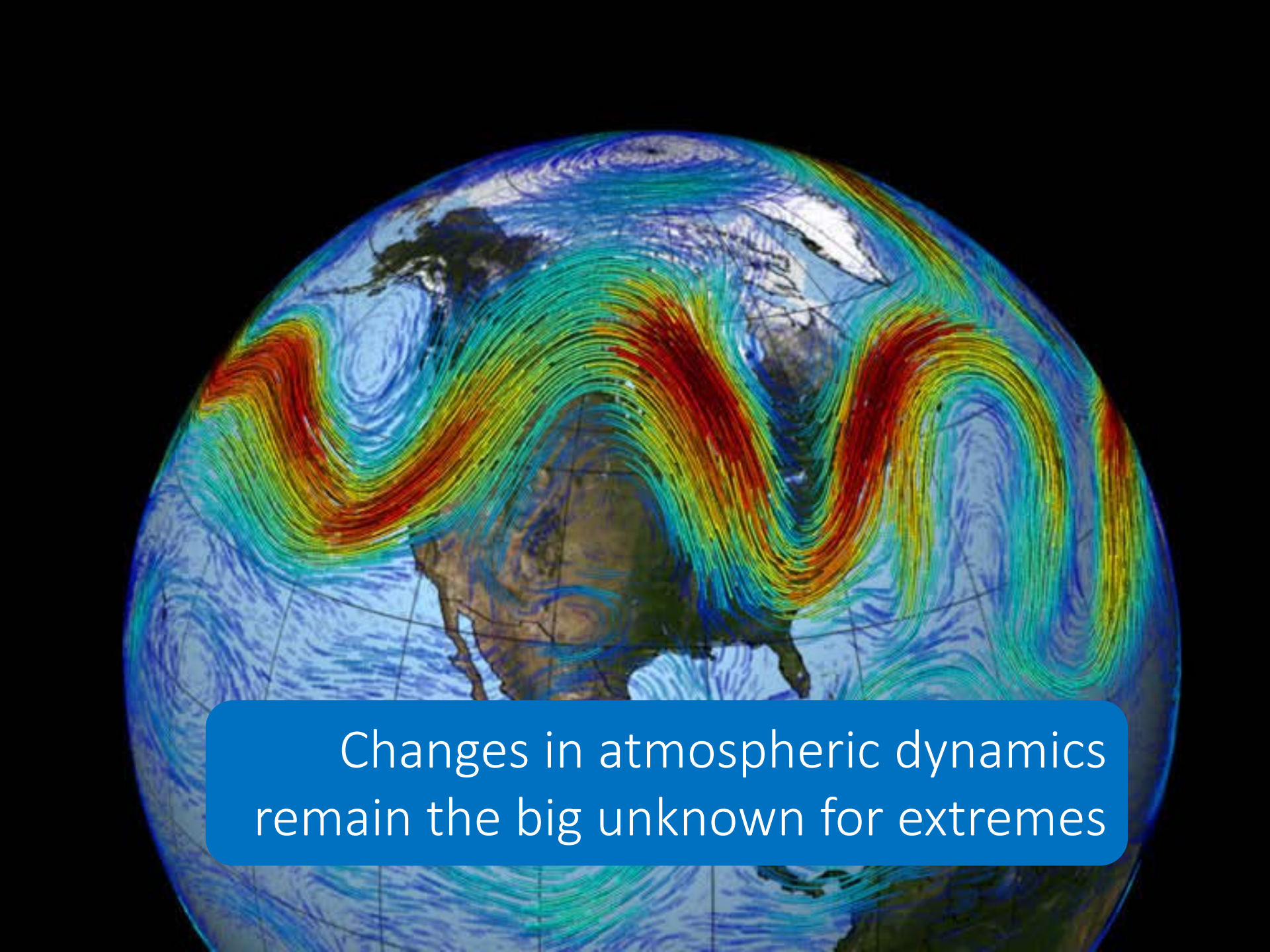
Heated debate on cold weather

Erich M. Fischer and Reto Knutti

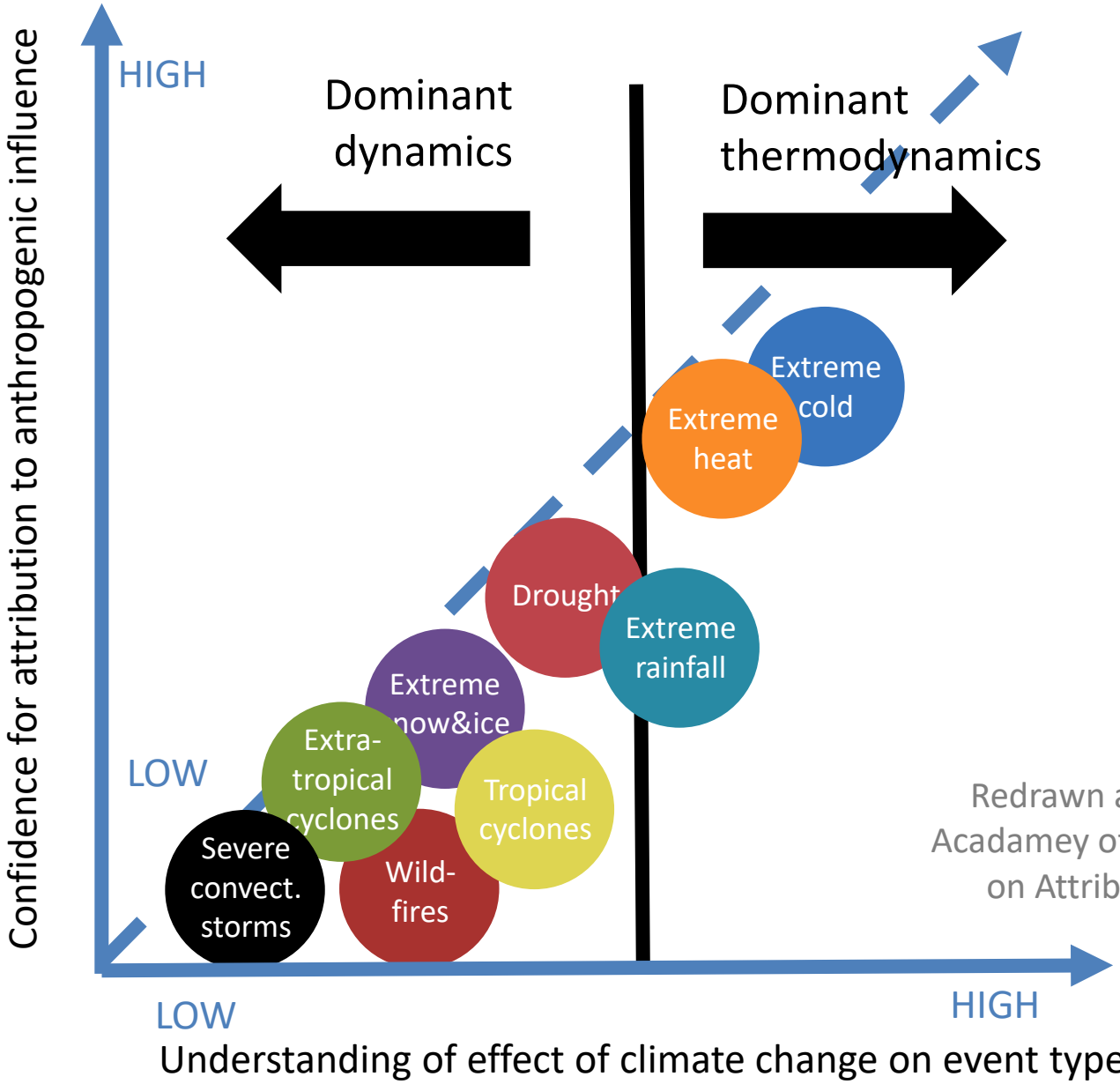
Arctic warming has reduced cold-season temperature variability in the northern mid- to high-latitudes. Thus, the coldest autumn and winter days have warmed more than the warmest days, contrary to recent speculations.

- Changes are complex but likely not inexistent
- Observational evidence is affected by high variability
- Many model runs are required to isolate a signal
- Link between «meandering» and extremes is not straight-forward




Changes in atmospheric dynamics
remain the big unknown for extremes

Dominant thermodynamics – higher confidence



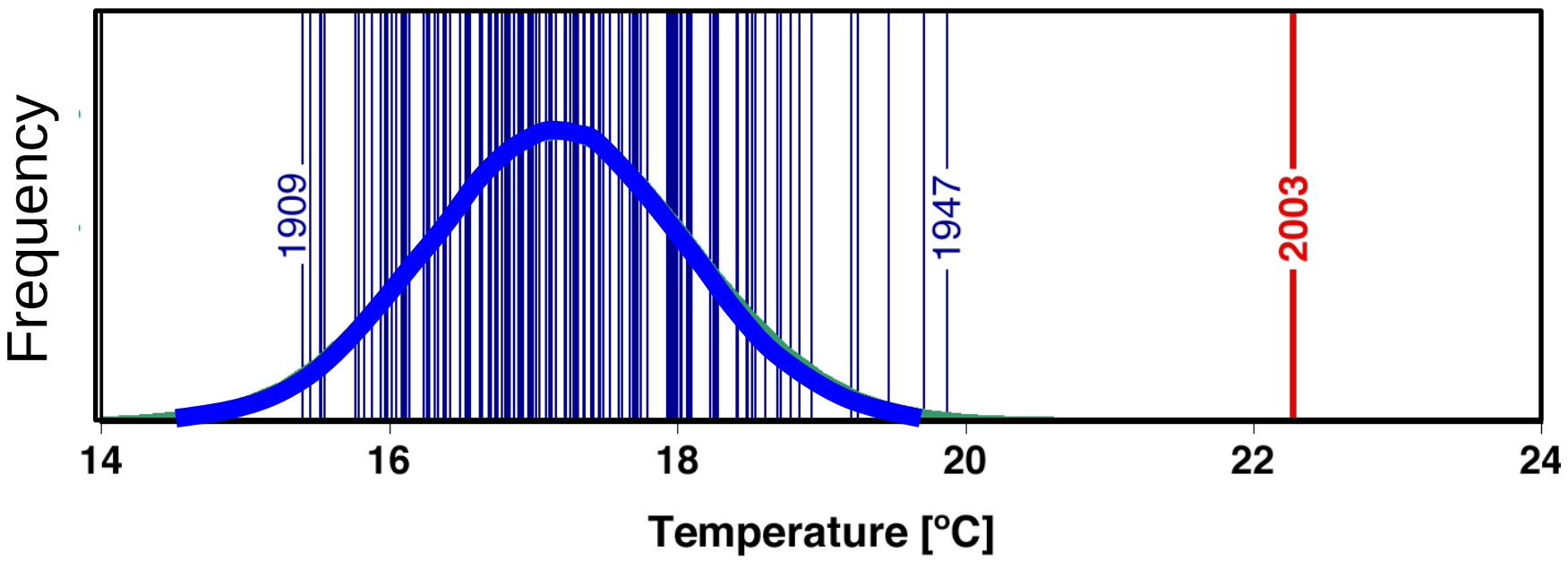
Confidence

The more dominant the thermodynamic contribution – the higher our confidence

Today’s changes in extremes – nothing but simple warming?

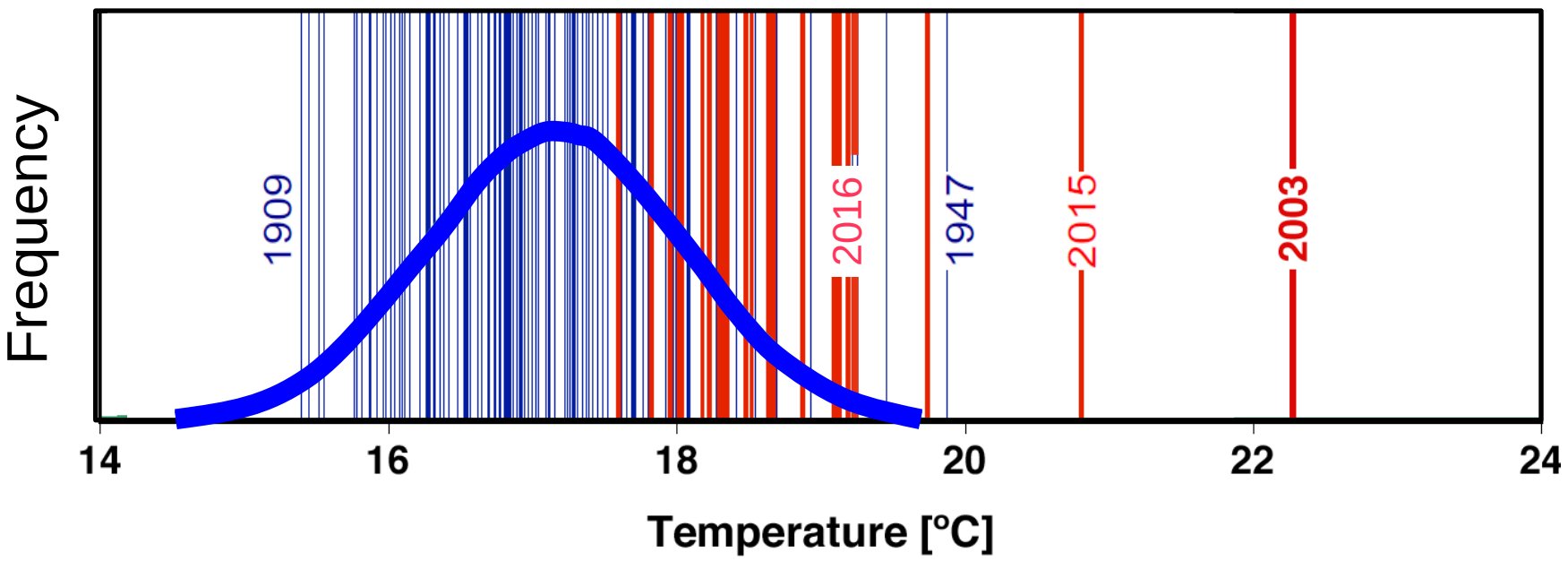
The prime example of an extreme

Average summer temperature at 4 Swiss stations



Schär et al. 2004

Projection becomes reality 1990-2016



Update von Schär et al. 2004

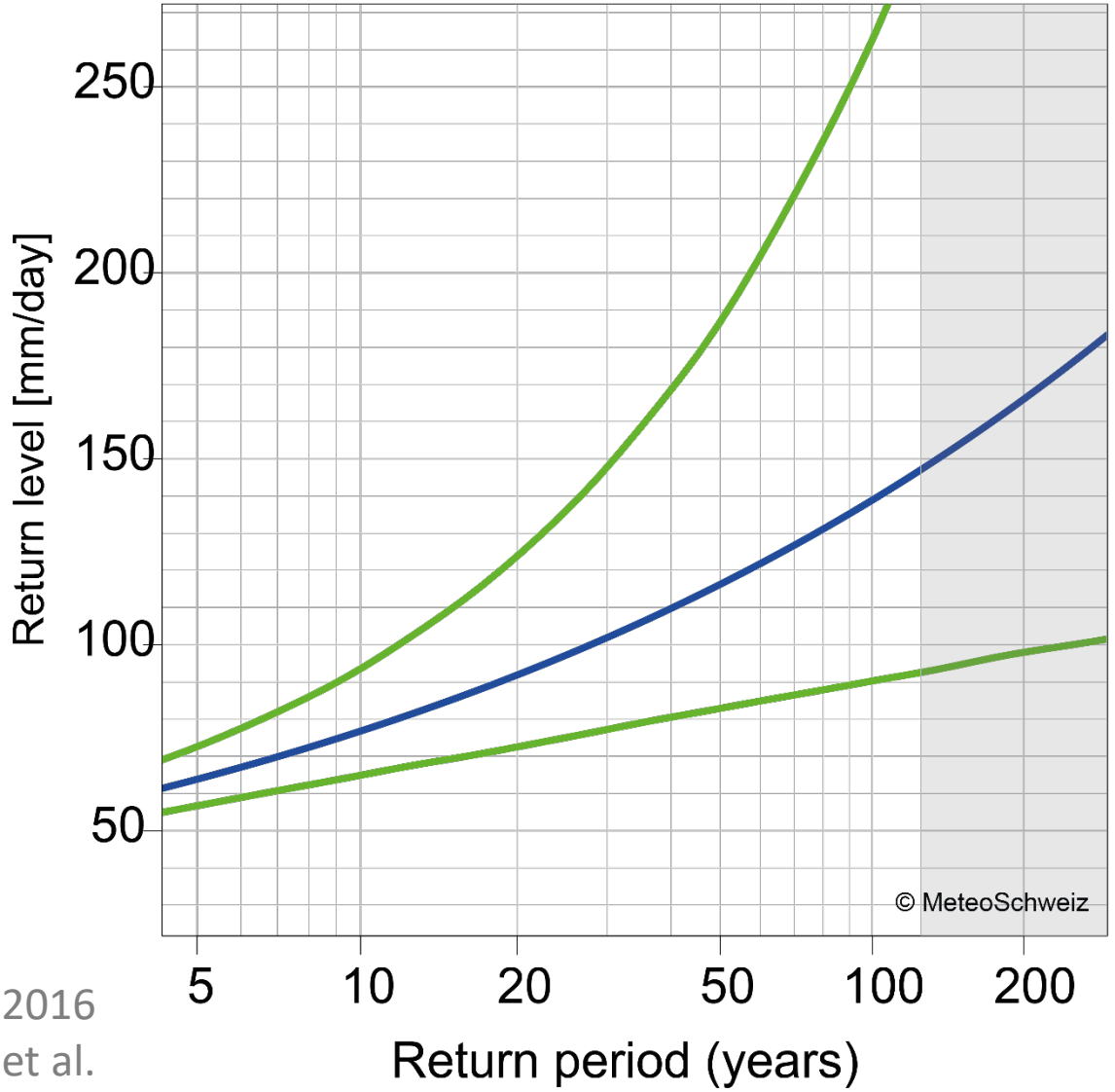
Today's return period

What used to be a
1-in-50 year in the early 1990s
has become a in 1-in-5 year summer

Christidis et al. 2014, Nature CC

Return periods are sensitive

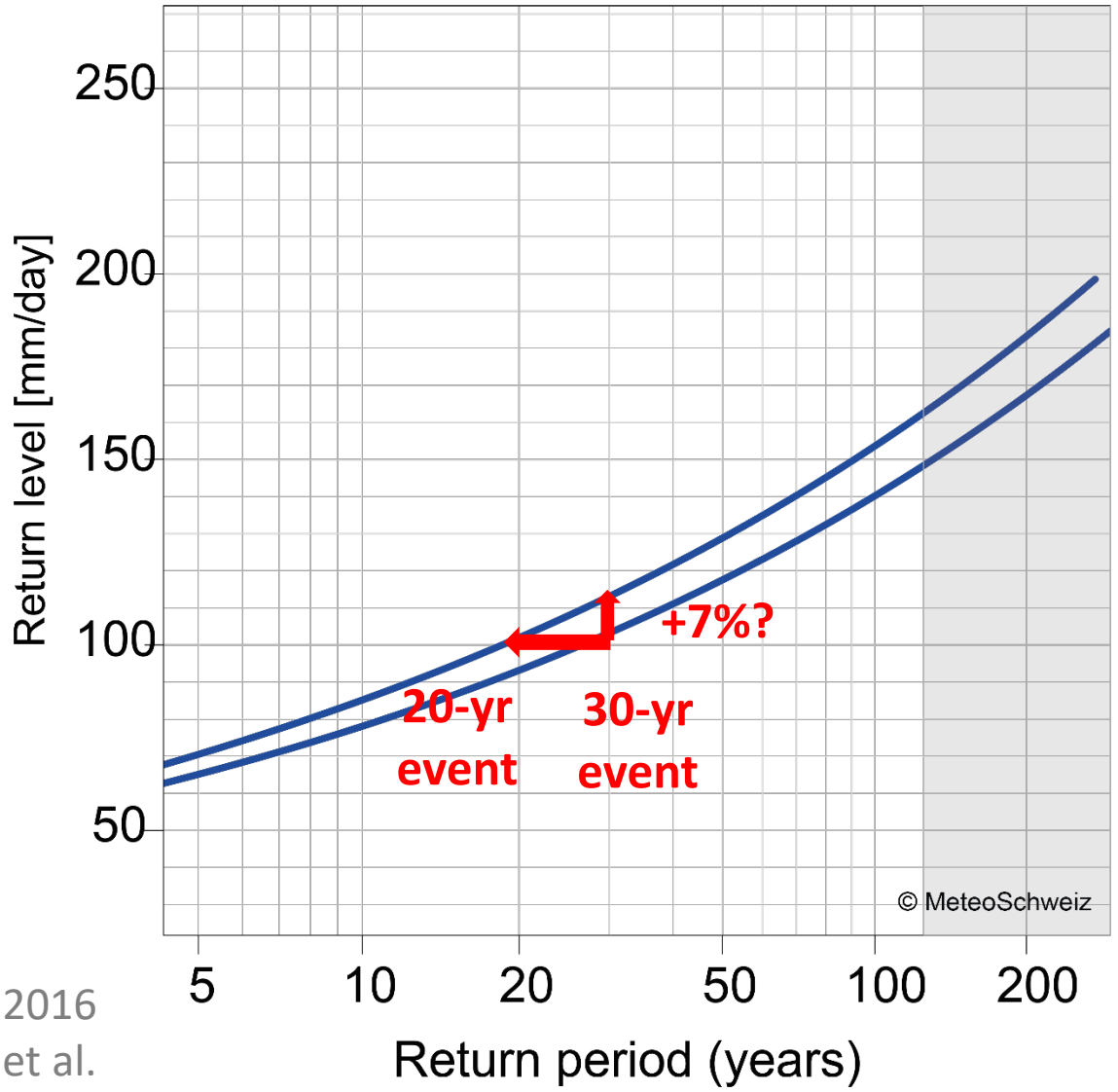
Return period of 1-day heavy rainfall in Zürich



Source Meteoschweiz 2016
Frei, Fukutome et al.

Has the 30-yr event become a 20-yr event?

1-day return period for Zürich Fluntern



Modified from Meteoschweiz 2016
Frei, Fukutome et al.

Conclusions

- Neither «global weirding» nor «insignificant change»
- Large-scale changes in temperature and heavy rainfall extremes are clear
- Changes in atmospheric dynamics remain a major uncertainty
- Thermodynamic effects alone, have already substantially increased probabilities of temperature and heavy rainfall events