Global weirding or insignificant change?

Extremes in a changing climate

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Global weirding?
Insignificant change?
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)
Climate models an ideal testbed

Annual 1-day rainfall maxima (rx1day) N Europe

![Graph showing annual 1-day rainfall maxima anomaly in N Europe from 1960 to 2000. The graph indicates no significant change over the years.]
The butterfly effect

Annual 1-day rainfall maxima (rx1day) N Europe

![Graph showing annual 1-day rainfall maxima anomalies in N Europe](image-url)
The butterfly effect

Two realizations of exact same model
The forced response

The underlying signal that determines return period

![Graph showing anomaly percentage over years from 1960 to 2000. The graph includes a red line indicating forced response.](image-url)
Forced response determines probability.
The boy who cried wolf – reversed
Erring on the side of least drama?

1-day precipitation maxima 1864-2016 (Chaumont)
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

2 observational datasets:
- GHCNDEX
- HadEX2

35% decrease
65% increase

Max 5-day accumulated precipitation (1960-2010)
Not to be expected by chance

Internal variability cannot explain the observed trends

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

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

Warming explains most changes in hot days

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

Global mean ratio 7.1

Simulated 2°C warming

Global mean ratio 7.5

Estimated 2°C shift

Fischer and Knutti, 2015, *Nature CC*

Consistent with Cattiaux et al. (2016), Fischer and Schär (2010), Sillmann, Schaller et al. (2017), *in prep*
Evidence linking Arctic amplification to extreme weather in mid-latitudes

Jennifer A. Francis¹ and Stephen J. Vavrus²

Received 17 January 2012; revised 20 February 2012; accepted 21 February 2012; published 1 March 2012.

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 polarward thickness gradients. Two effects are identified that...

Revisiting the evidence linking Arctic amplification to extreme weather in midlatitudes

Elizabeth A. Barnes¹

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

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...

Quasiresonant amplification of planetary waves and recent Northern Hemisphere weather

Vladimir Petoukhov¹,², Stefan Rahmstorf², Stefan Patrì³, and Hans Joachim Schellnhuber⁴,⁵,¹

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 wave in Pakistan. Here, we present long-term atmospheric circulation data that show quasiresonant amplification of planetary waves and recent Northern Hemisphere weather.

1. Quasiresonance Hypothesis

Generally the large-scale midlatitude atmospheric circulation is 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...
- 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

Understanding of effect of climate change on event type

Confidence for attribution to anthropogenic influence

Redrawn after National Academy of Science Report on Attribution (2016)
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
Today’s return period

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