

Climate change: a summary for policy-makers

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Climate change: a summary for policymakers

- How rising atmospheric CO₂ causes global warming
- How global temperatures and sea level respond
- **Quantifying human influence on climate and weather**
- The fate of CO₂ and other anthropogenic emissions
- Global impact functions and the social cost of carbon
- Mitigation costs and pathways
- Policy options from carbon pricing to geo-engineering
- Capstone activity: design a robust climate policy

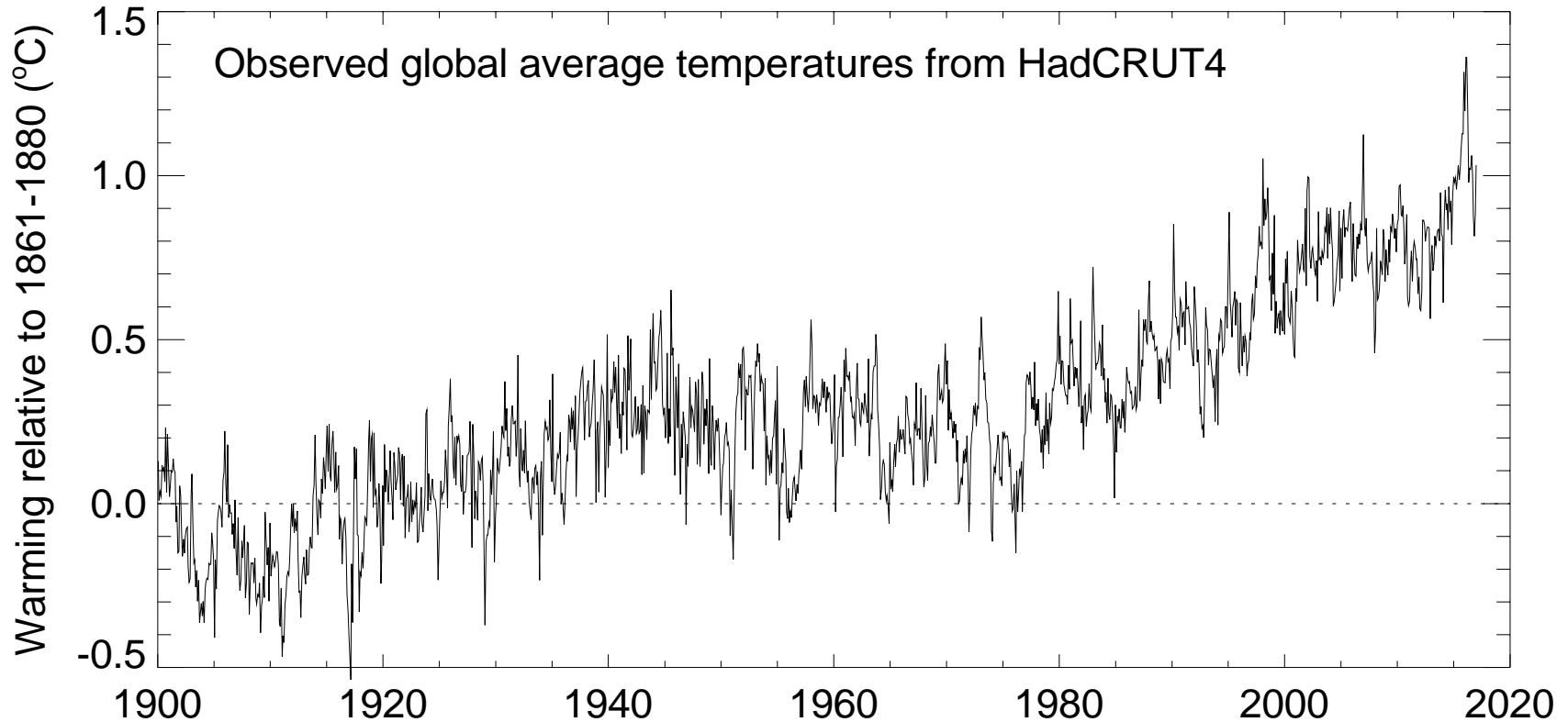
Conclusions from simple global climate models

- A very simple (“two coupled bathtubs”) model does a good job of capturing the short (few years) and long (few centuries) global surface temperature response to a global energy imbalance (radiative forcing).
- But observations (e.g. of the recent energy budget) only constrain key parameters like ECS and TCR to within a factor of three.
- So how do we work out how much of the observed warming is attributable to human influence?

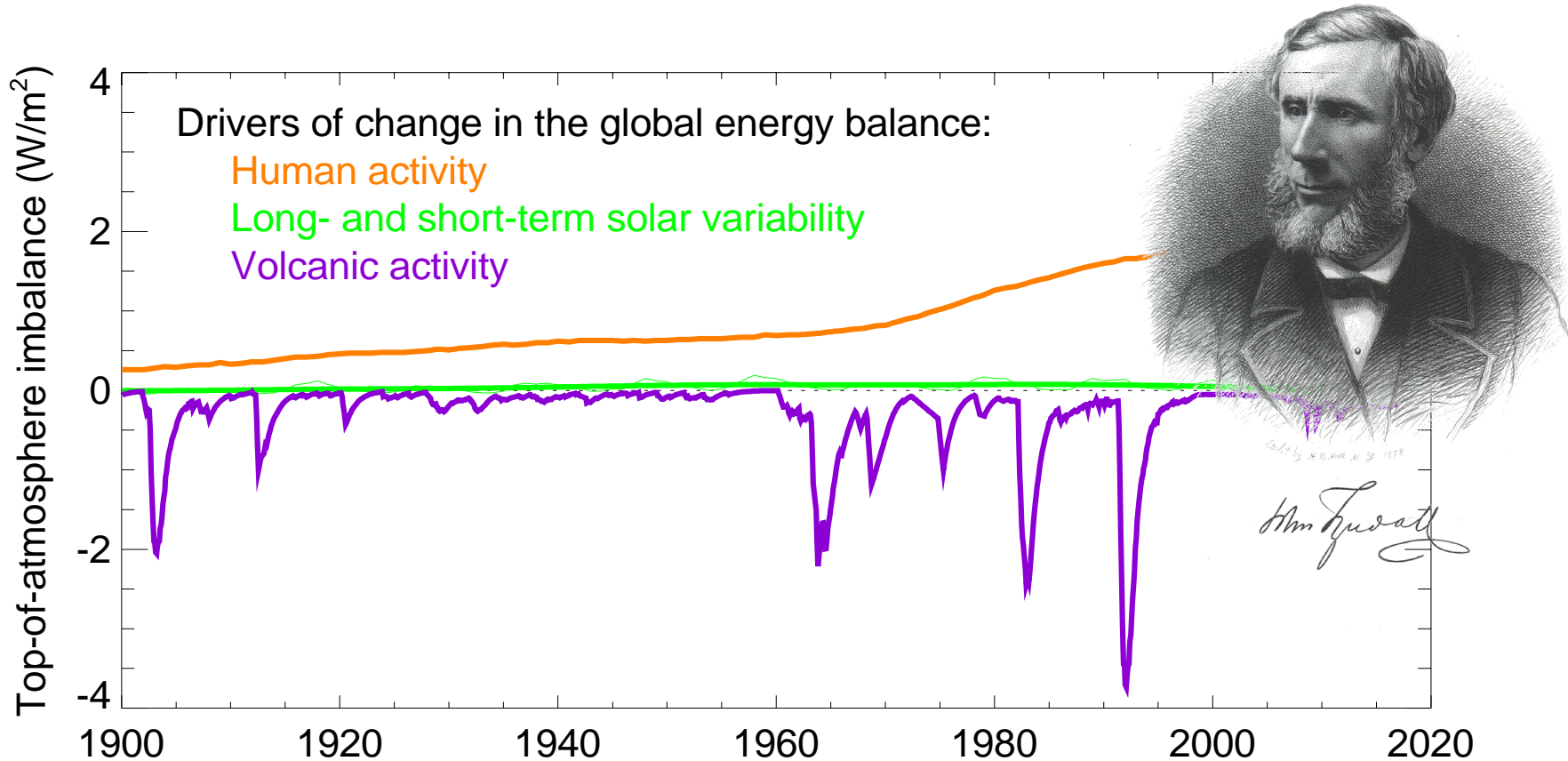
Why we still need to explain the evidence for human influence on climate

- “I would not agree that it [CO₂ emissions from human activity] is a primary contributor to the global warming that we see.”
 - Scott Pruitt, EPA Administrator, on CNBC, responding to the question “Do you believe it has been proven that CO₂ is the primary control knob for climate?”

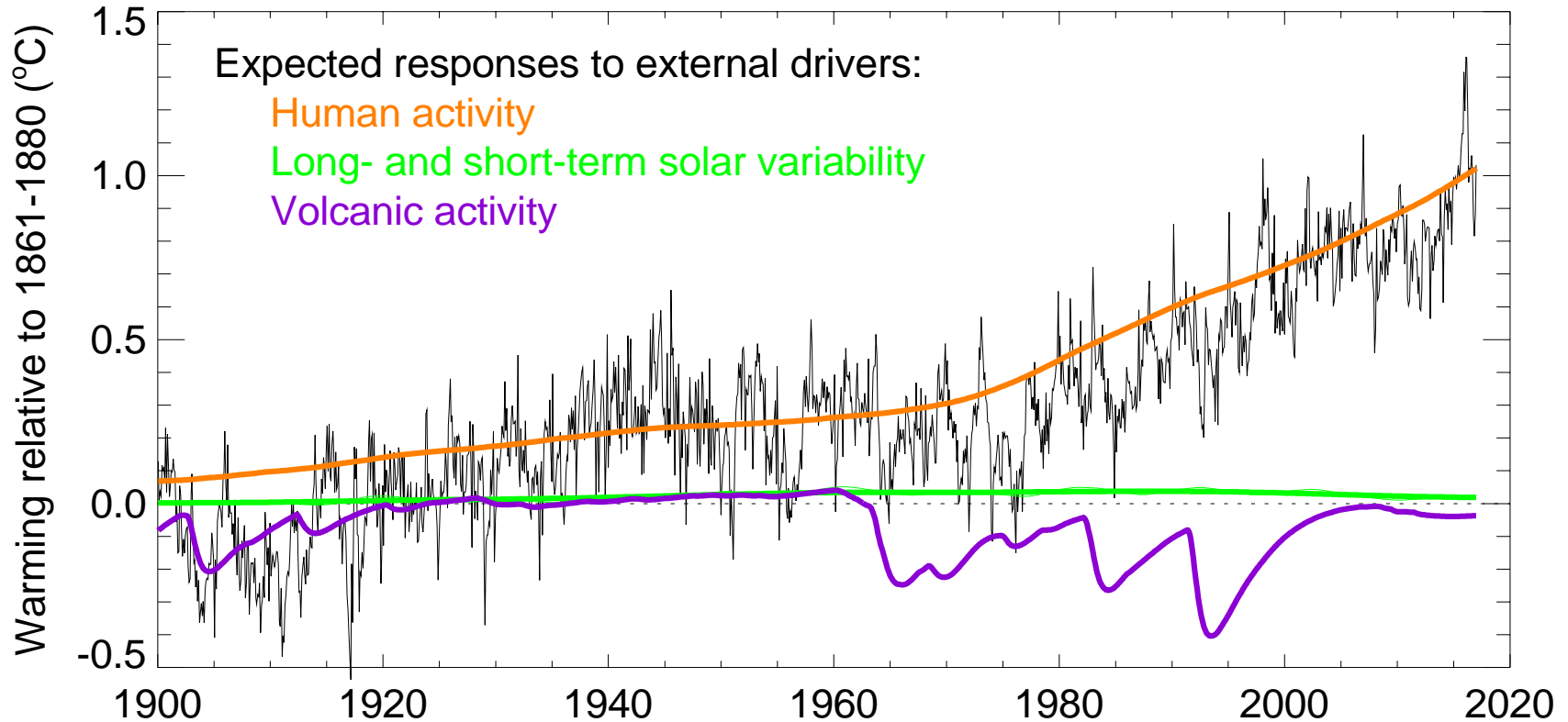
Even Pruitt sees warming:



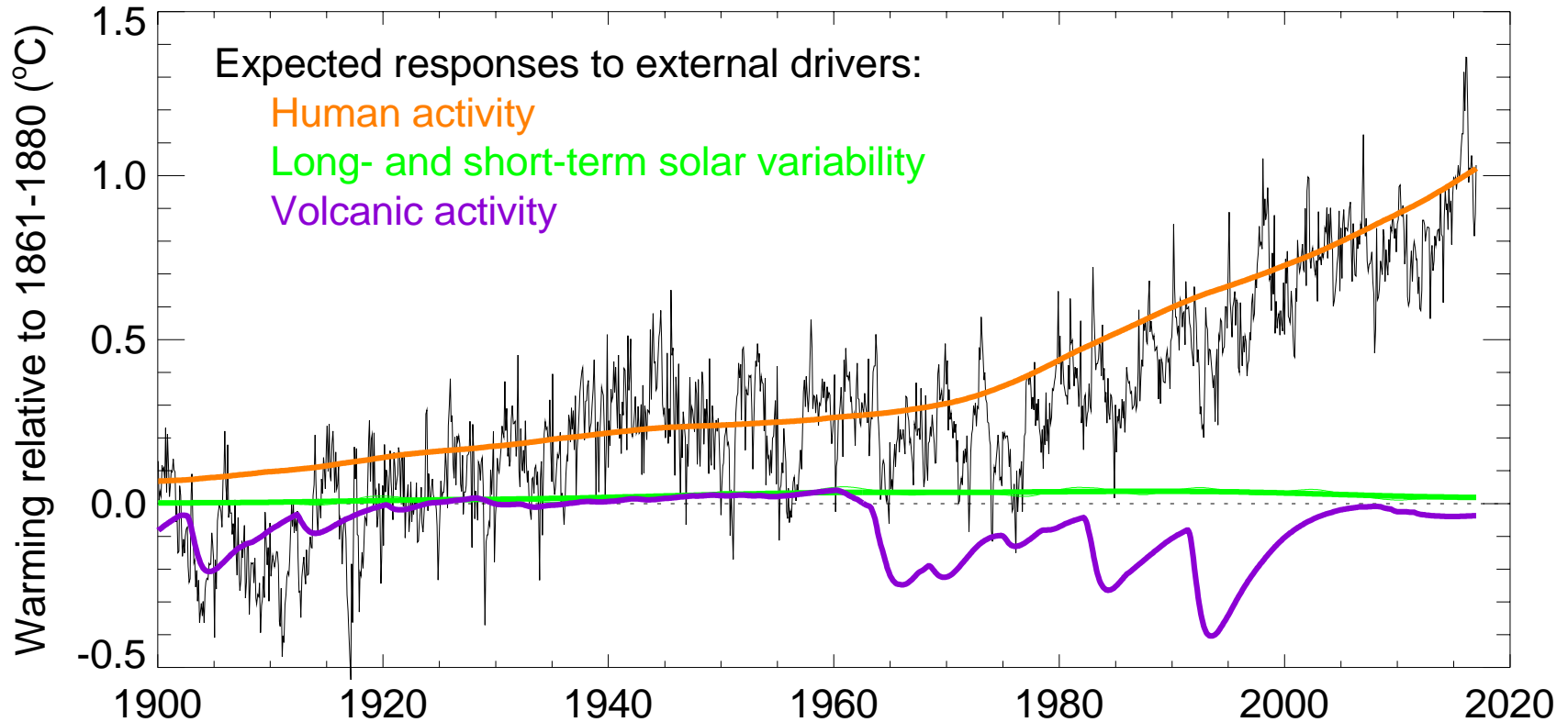
Both human activities and natural factors have been disturbing the global energy balance.



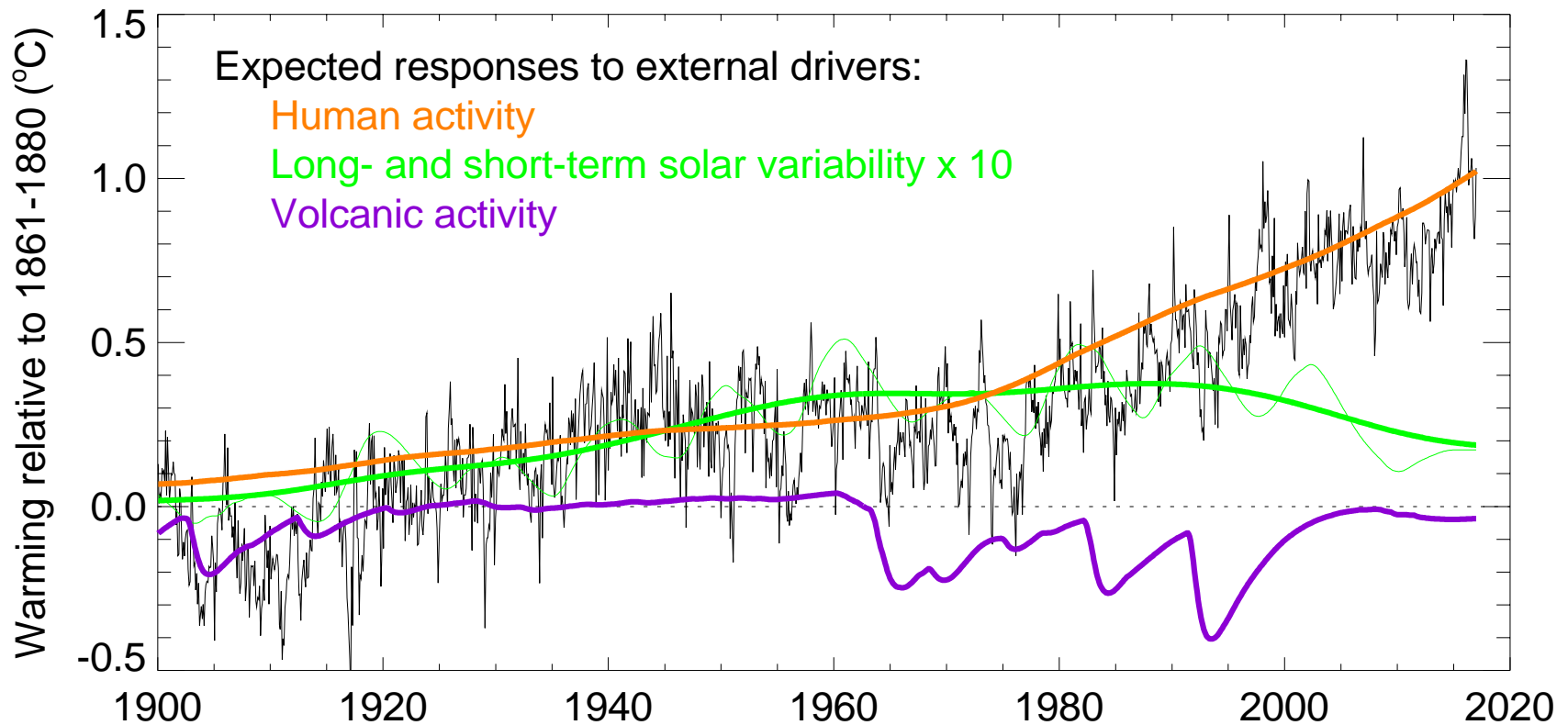
We know the climate system conserves energy...



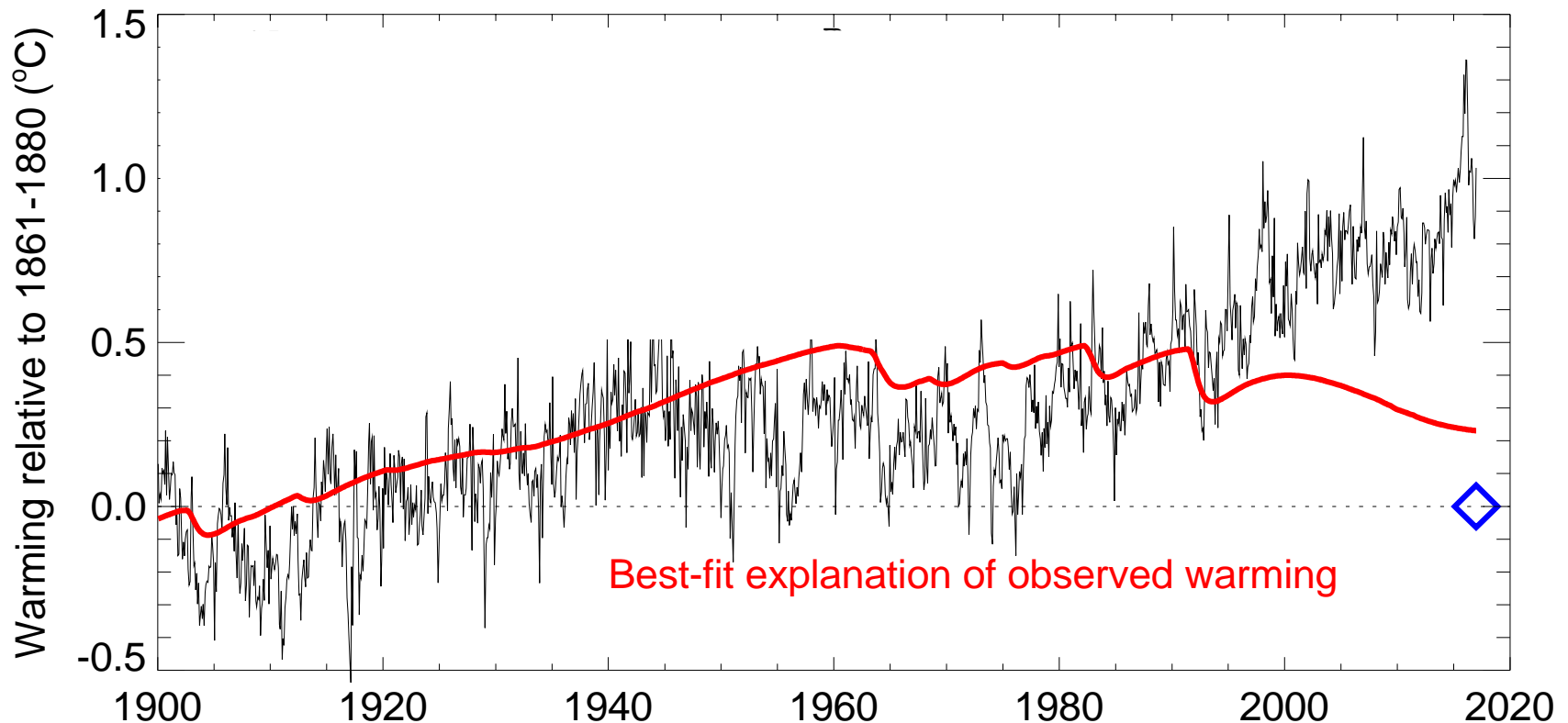
...but we don't know how large the responses to human and natural drivers are.



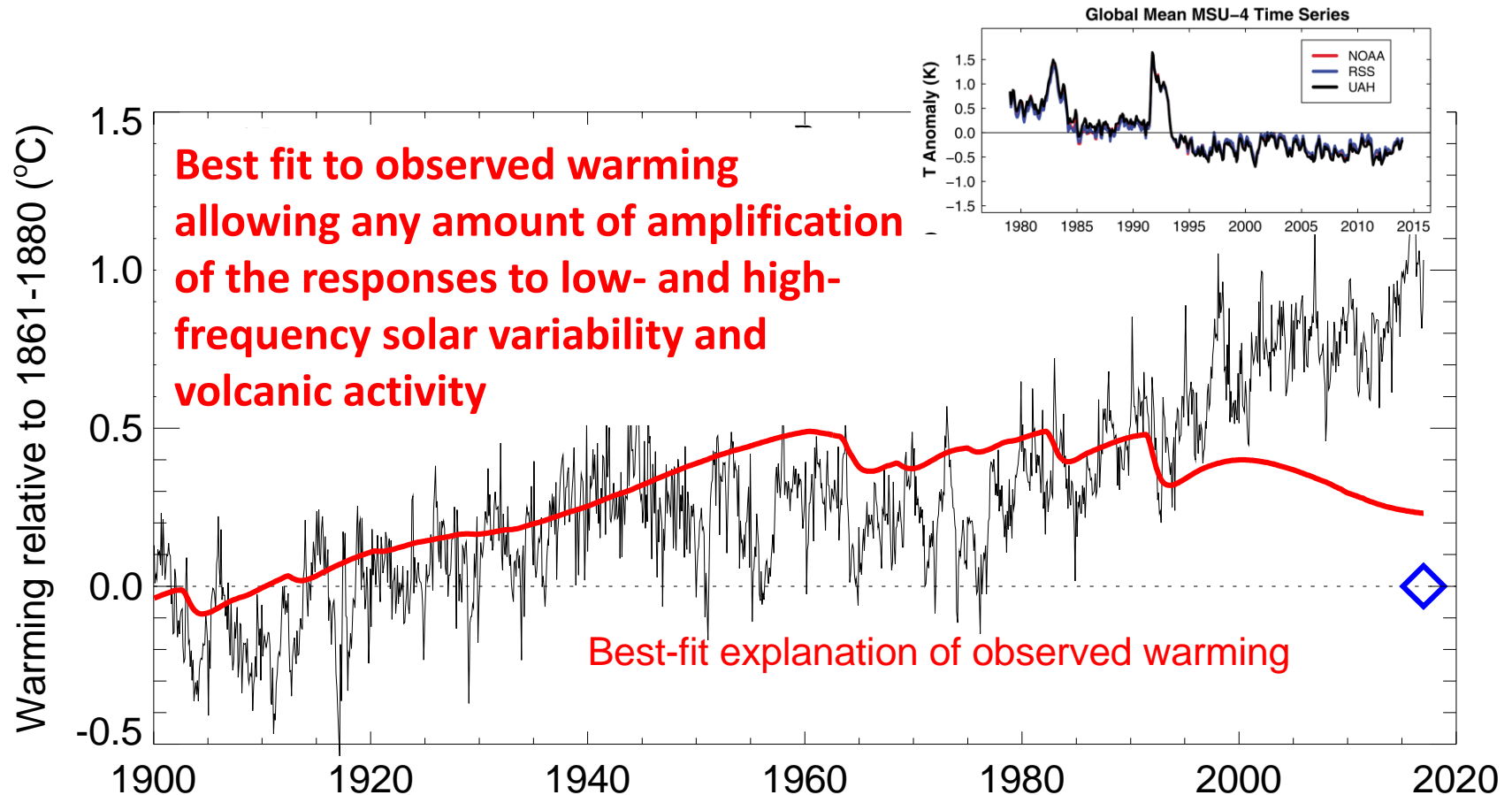
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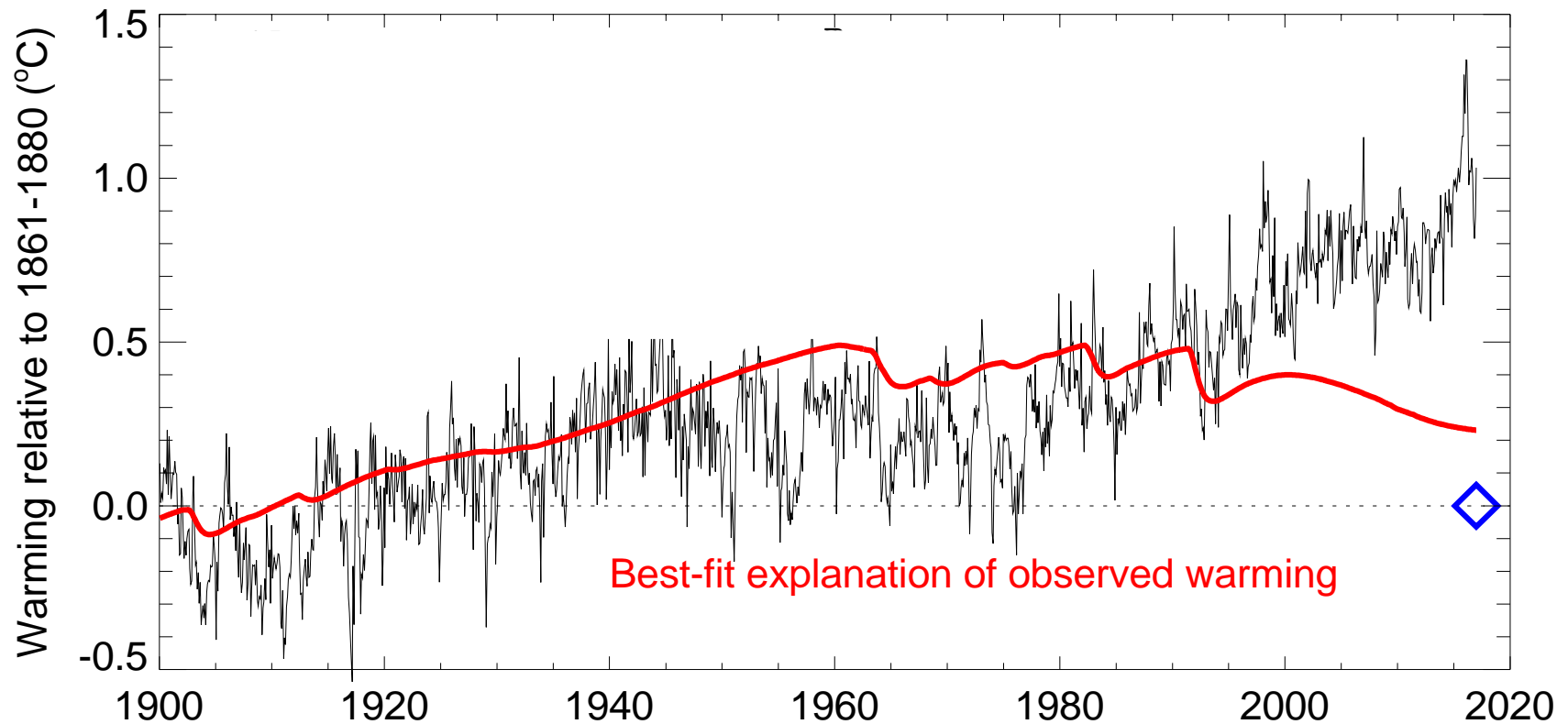
So we estimate them from the data, assuming first that CO₂-induced warming to date is zero



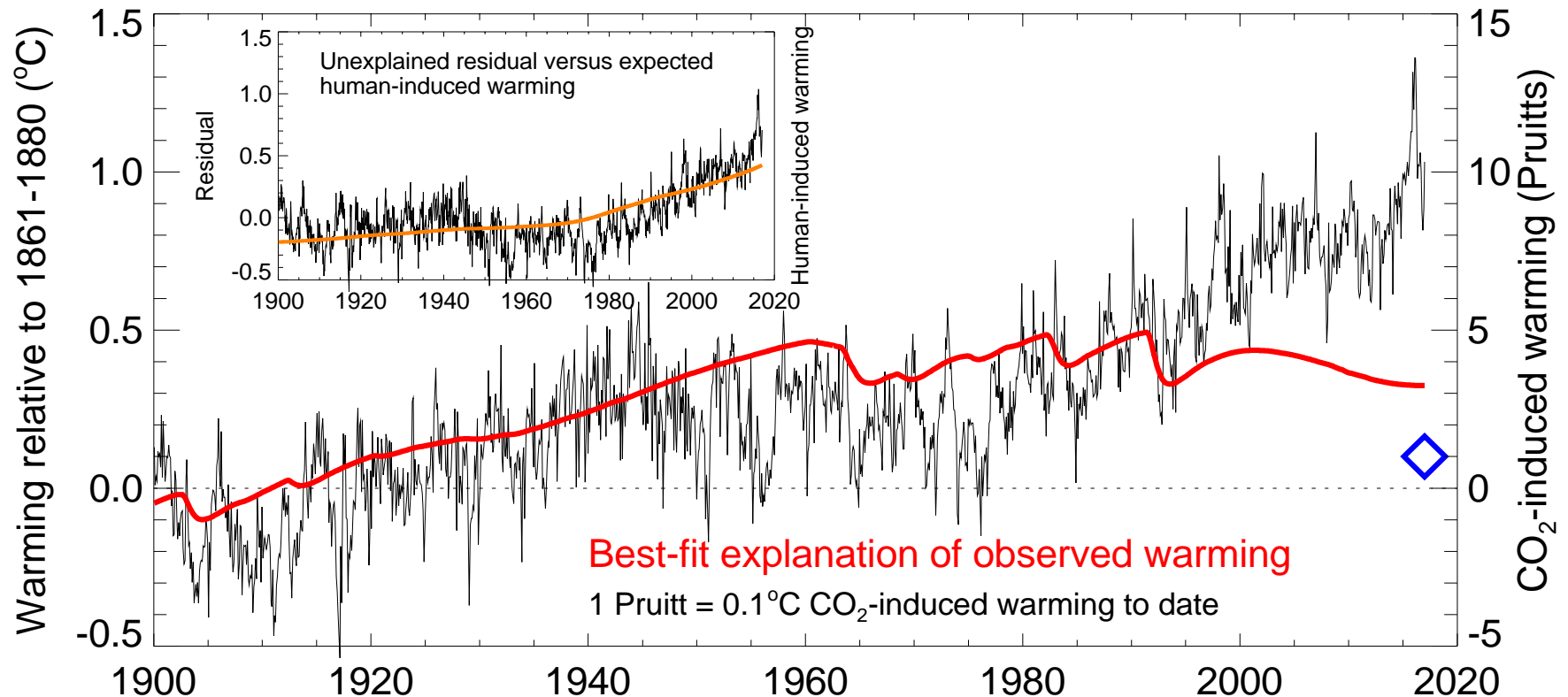
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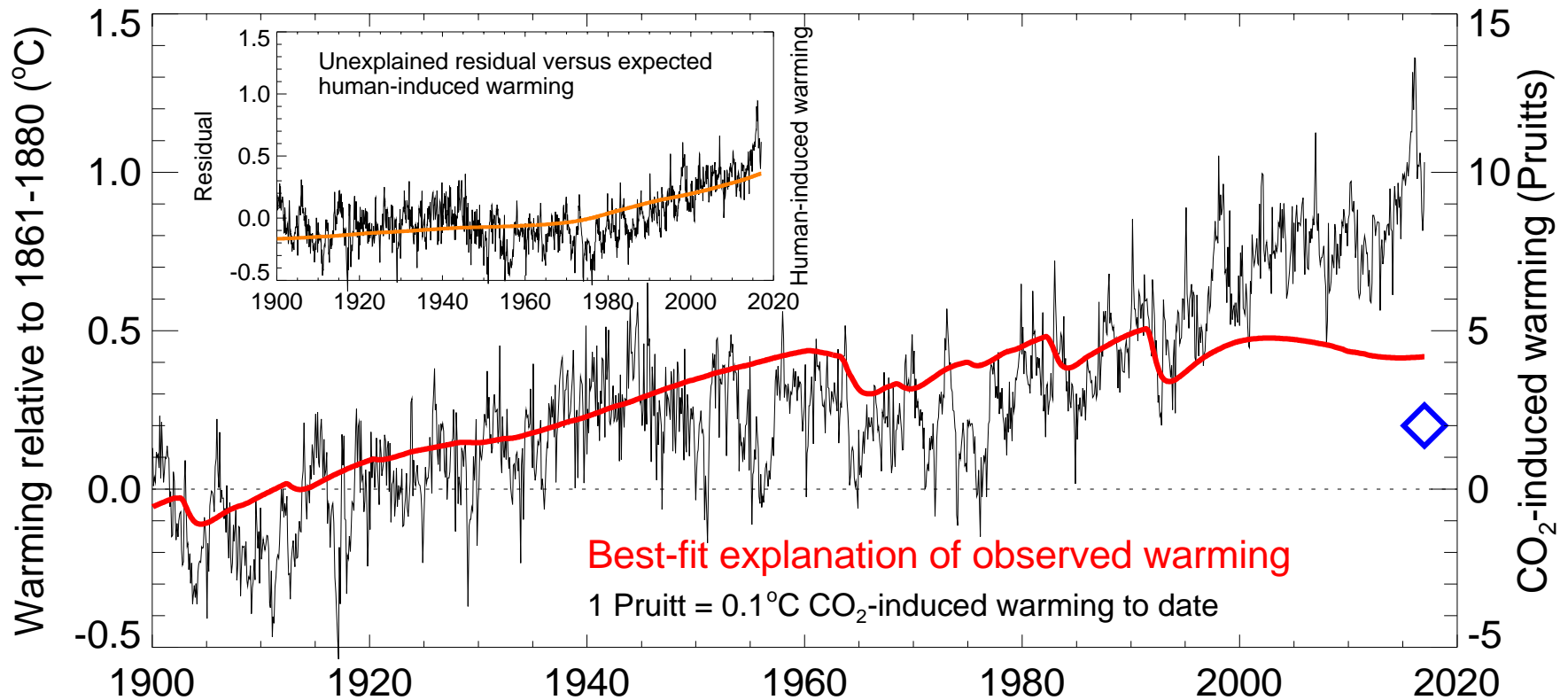
Residuals are improbably well correlated with the expected response to human activity



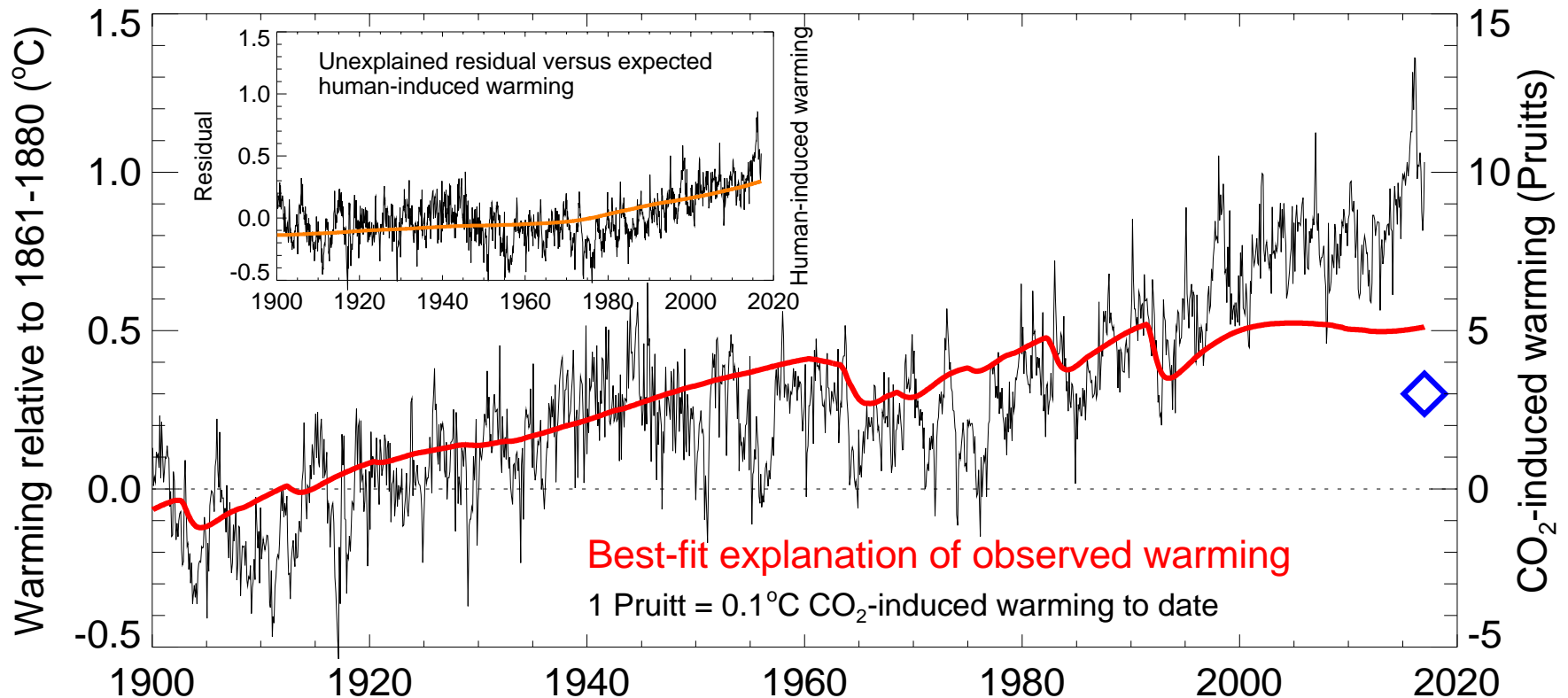
So we increase the amount of warming due to CO₂ emissions to date



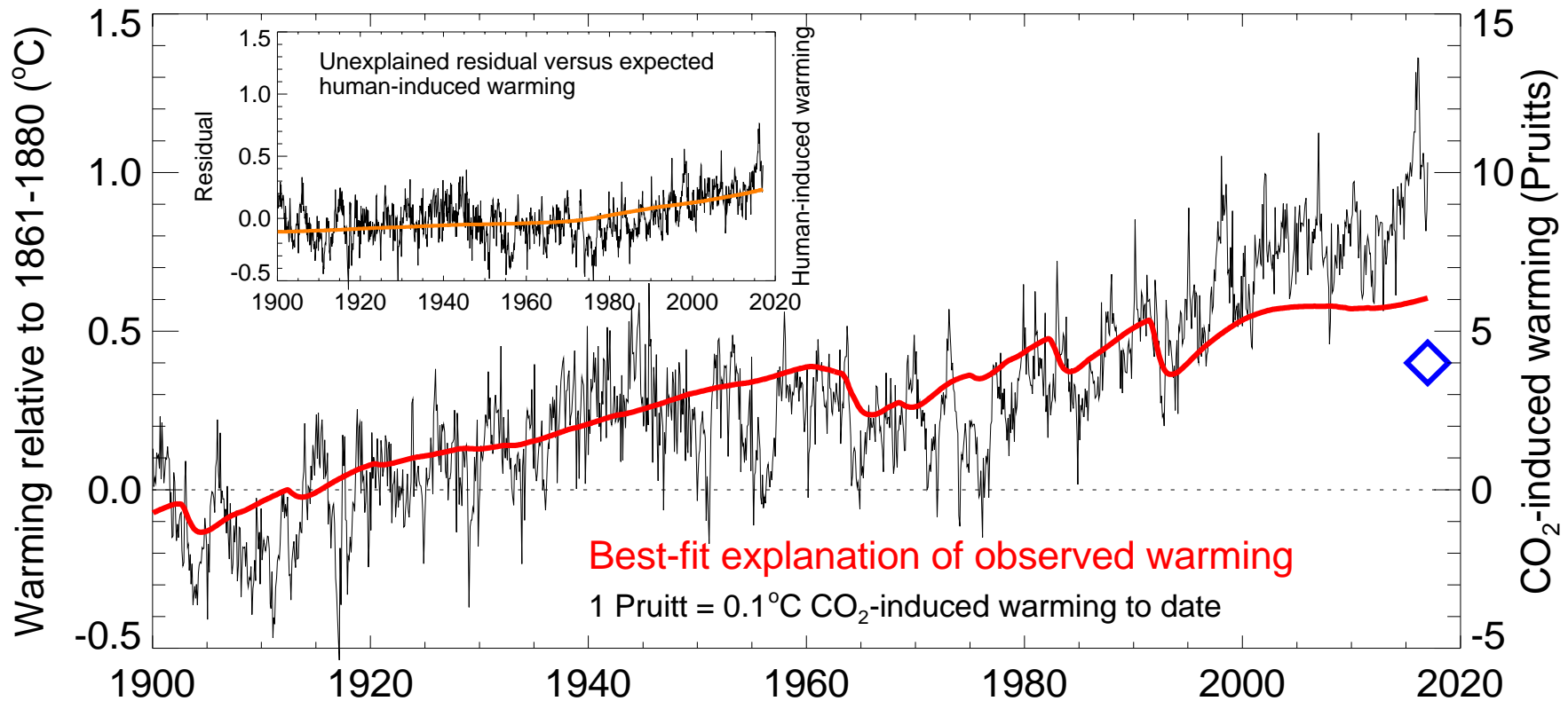
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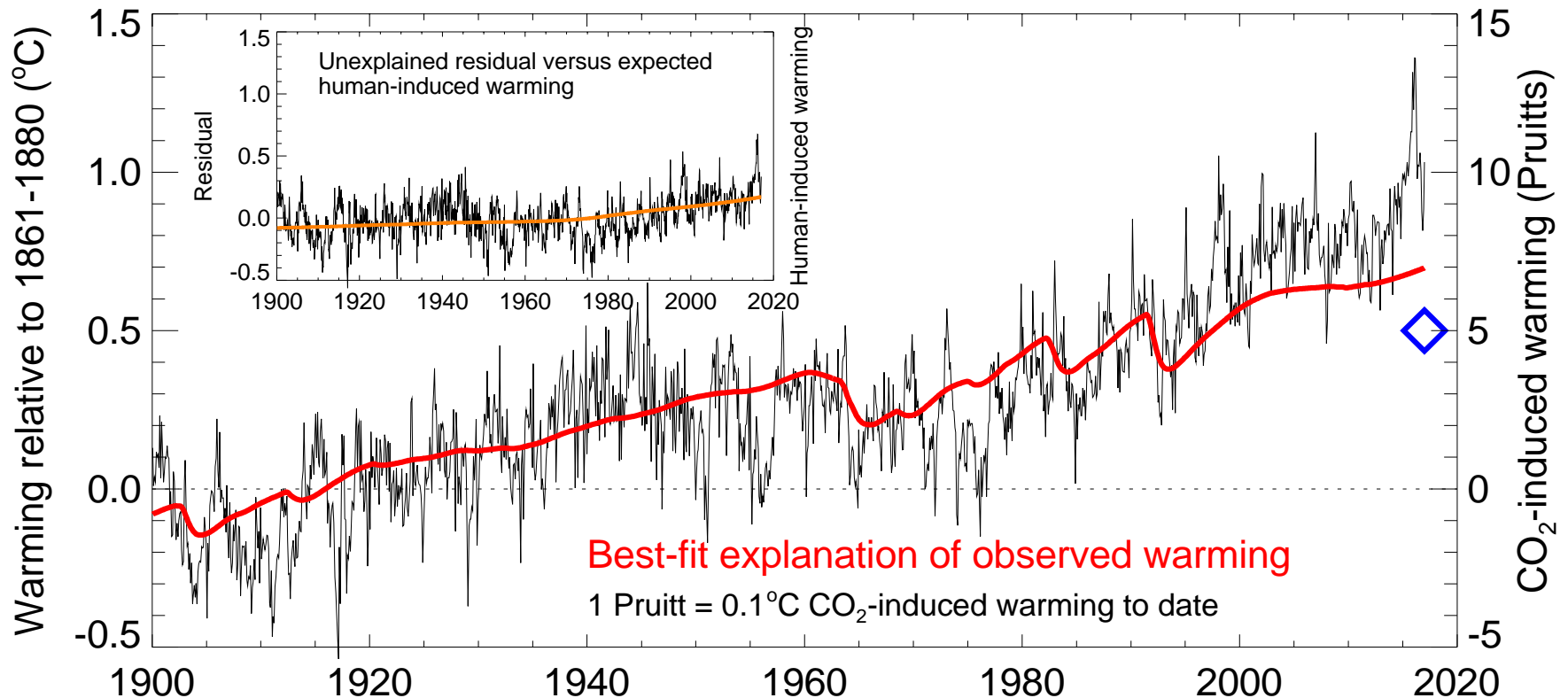
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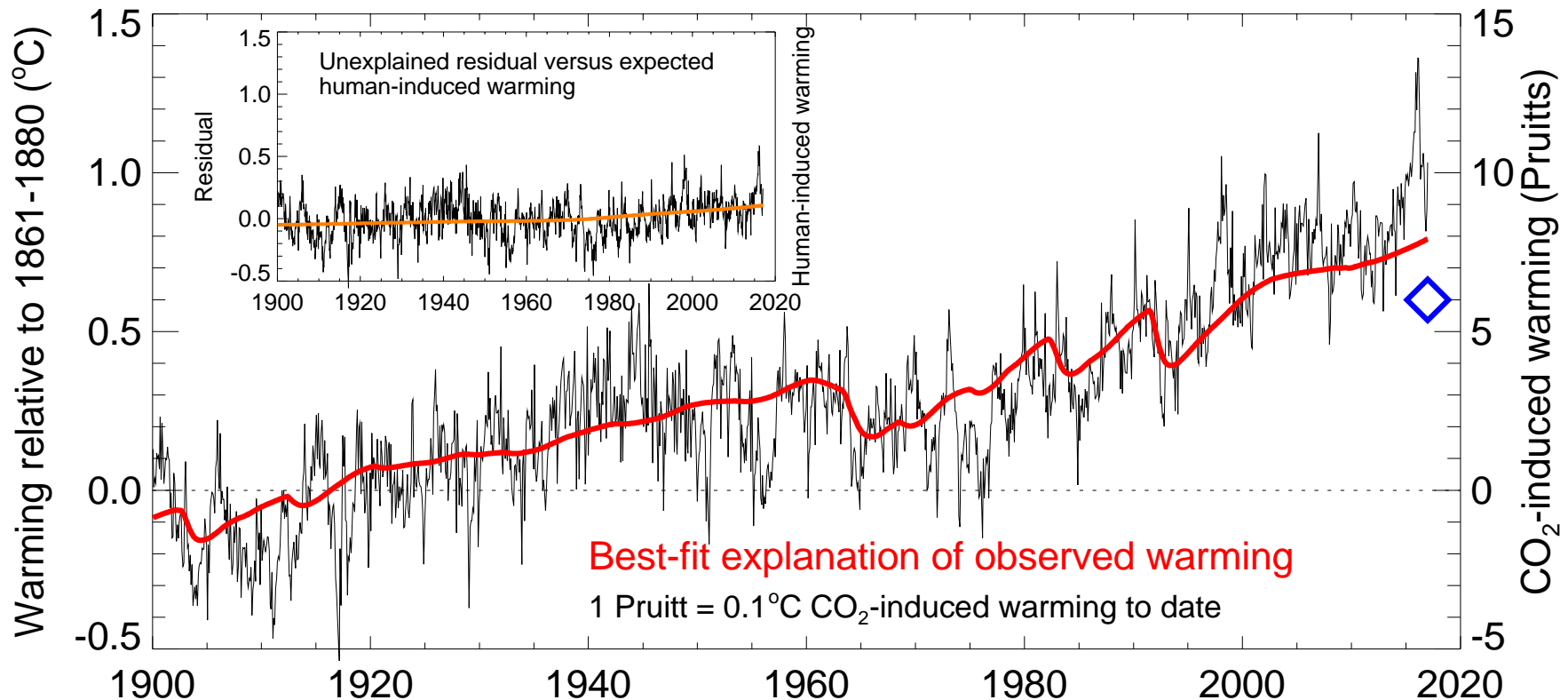
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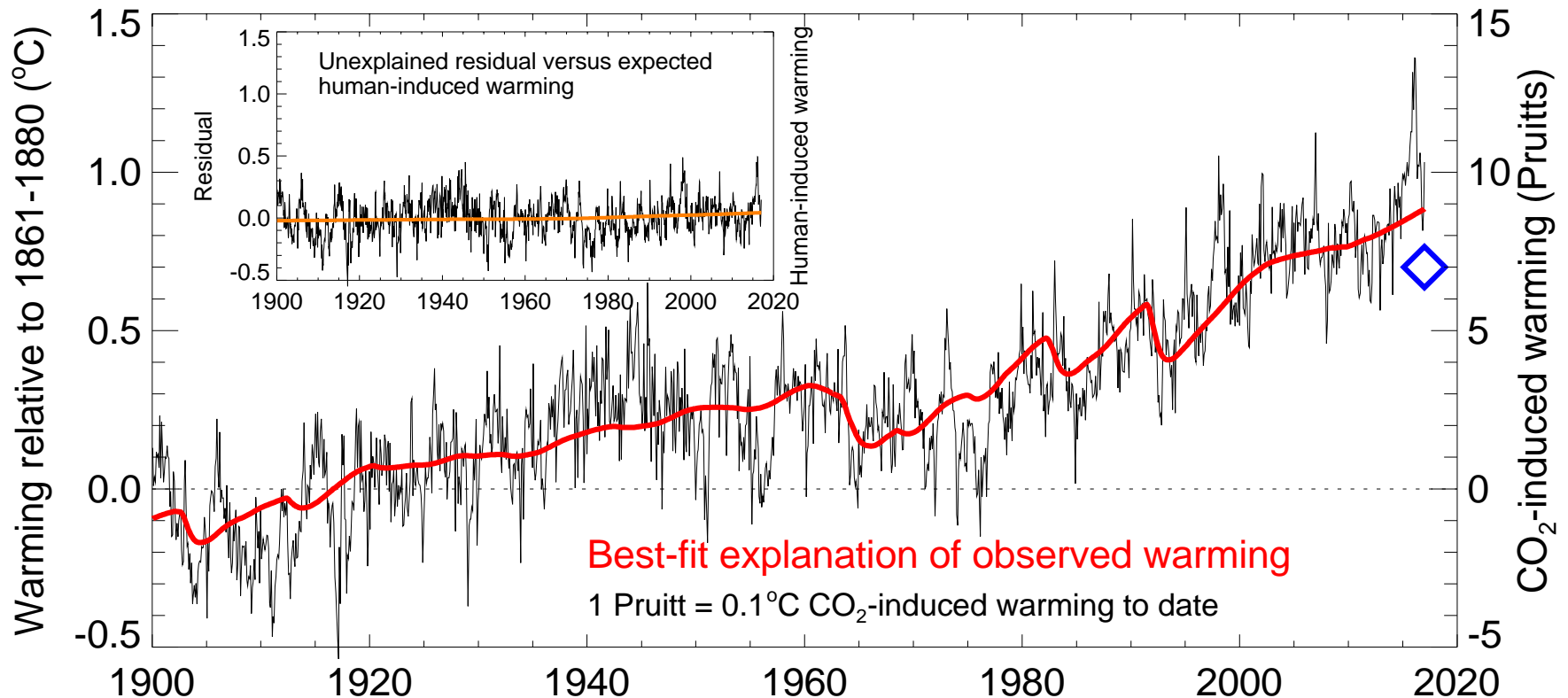
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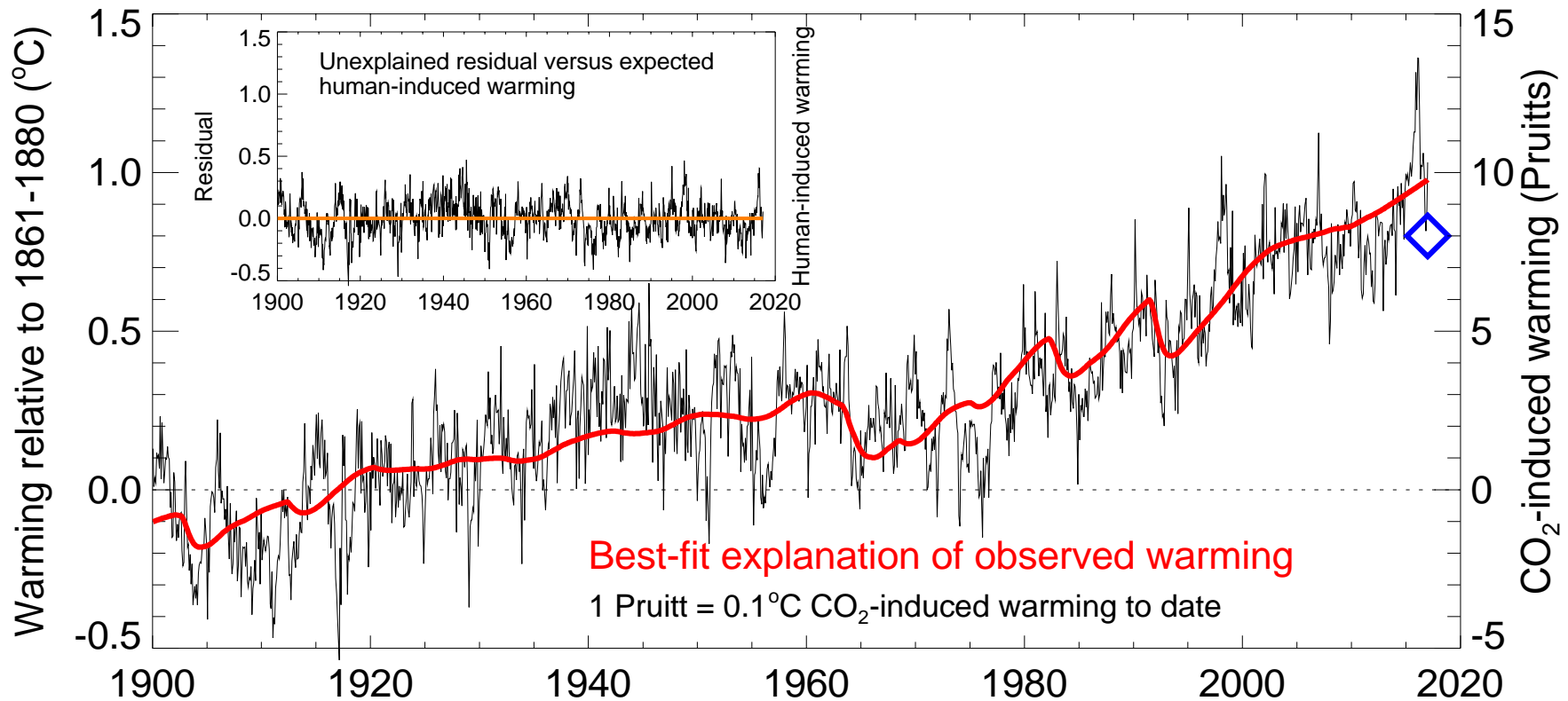
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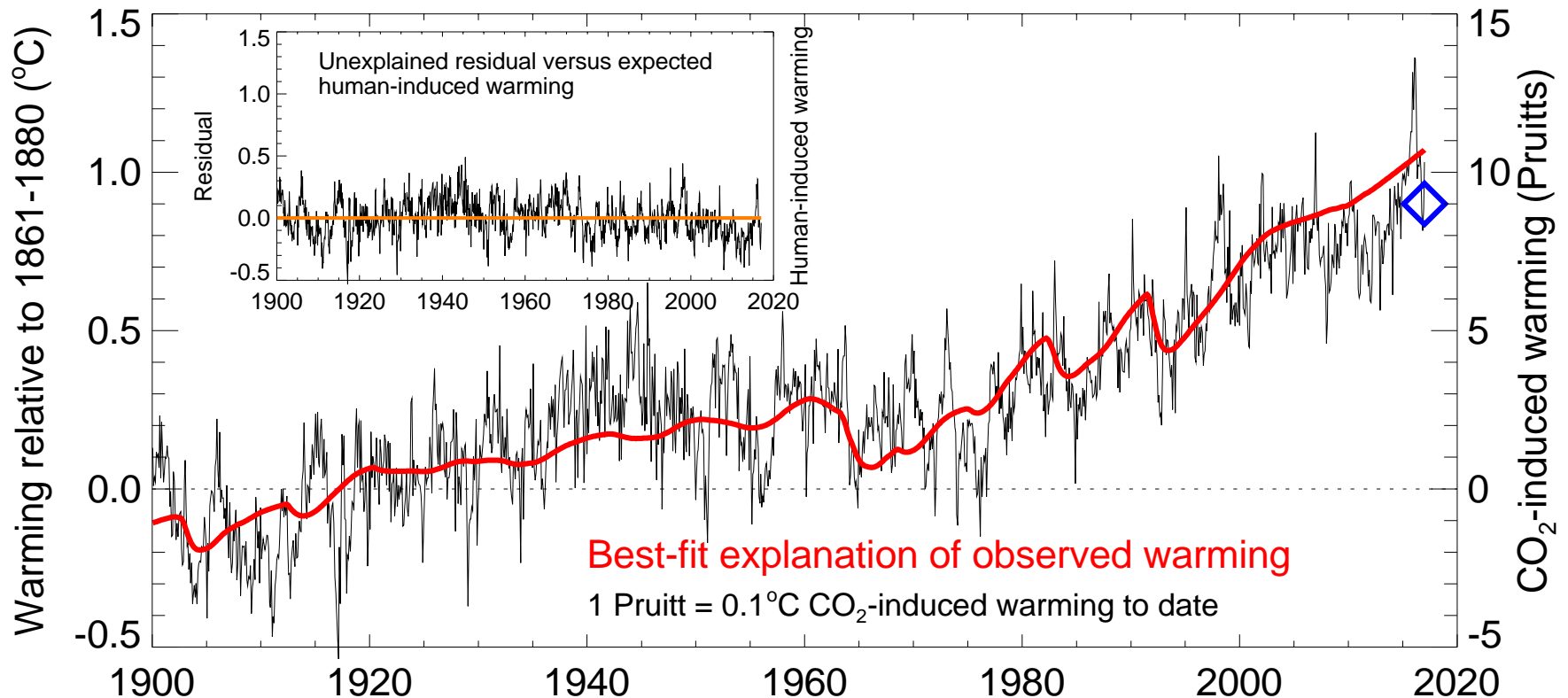
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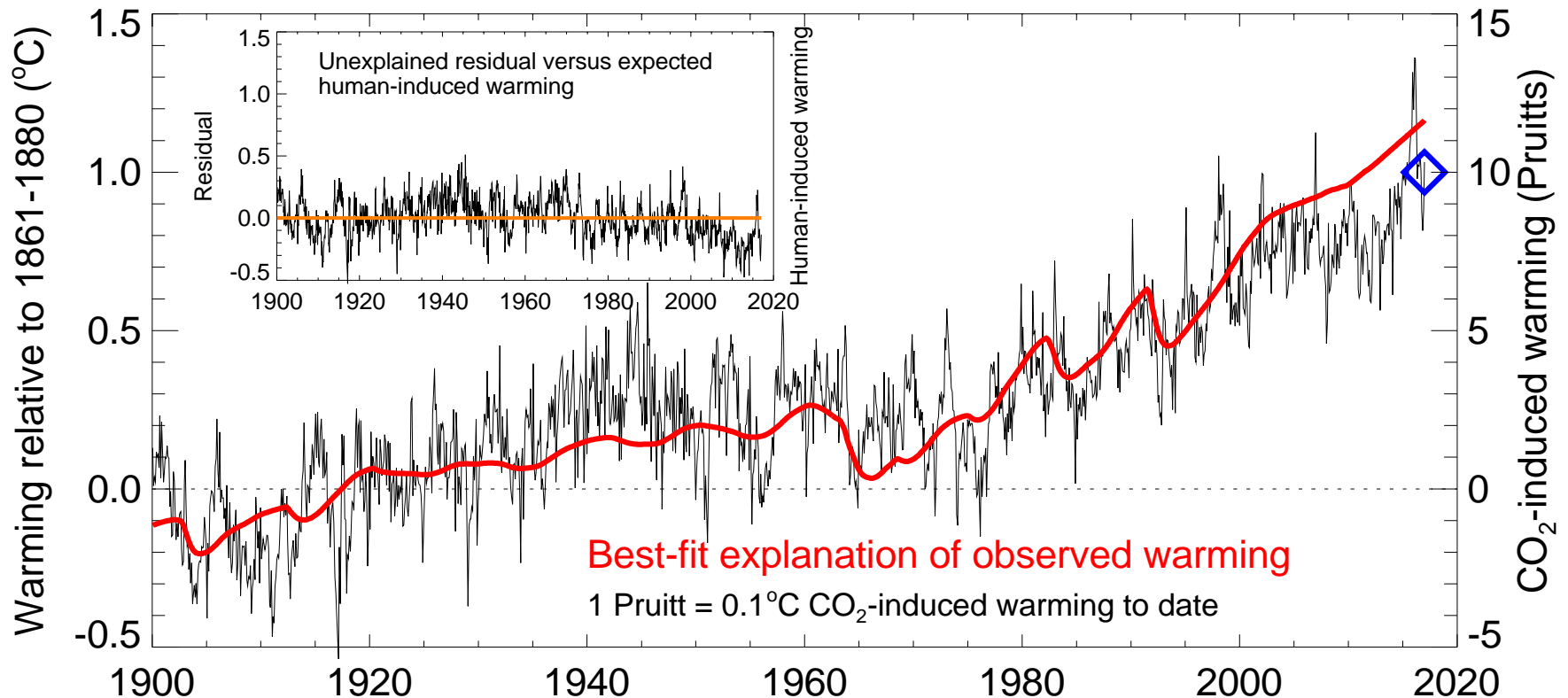
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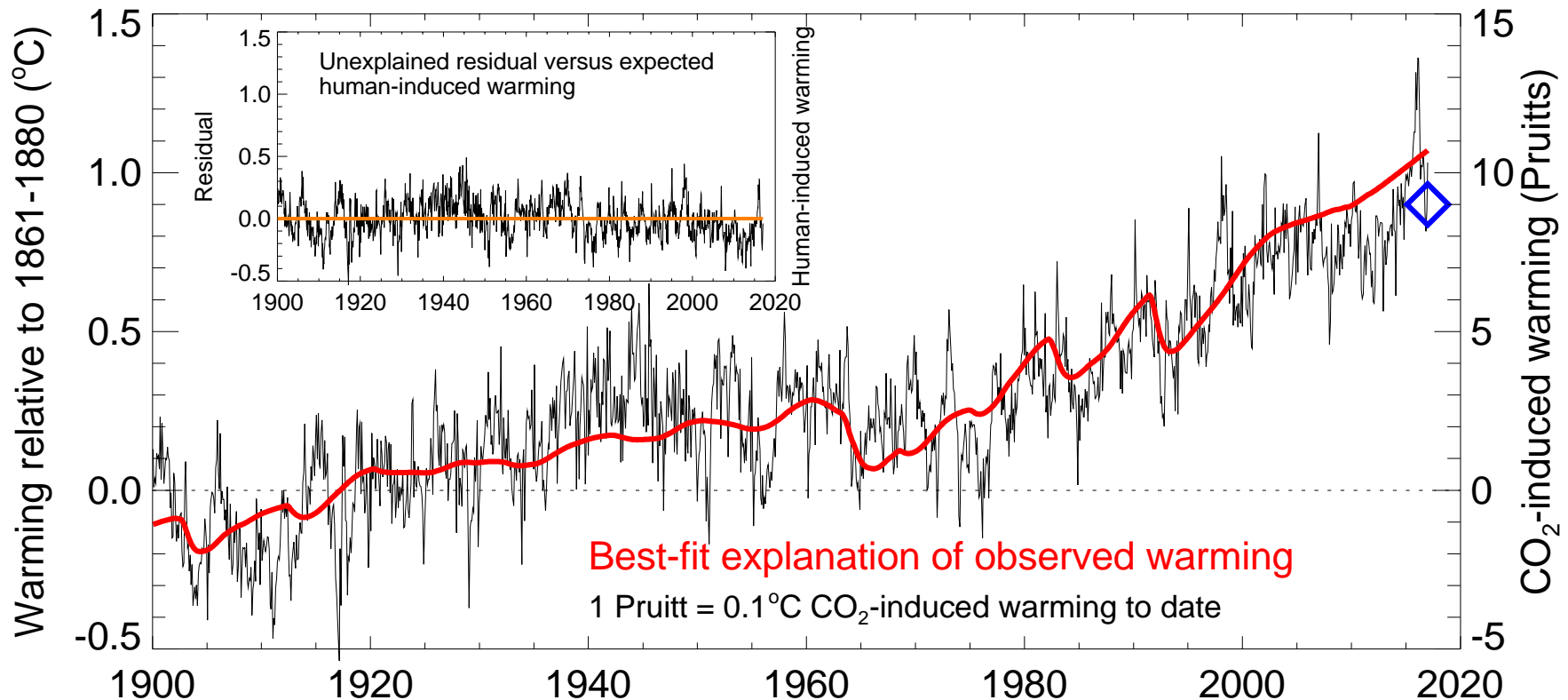
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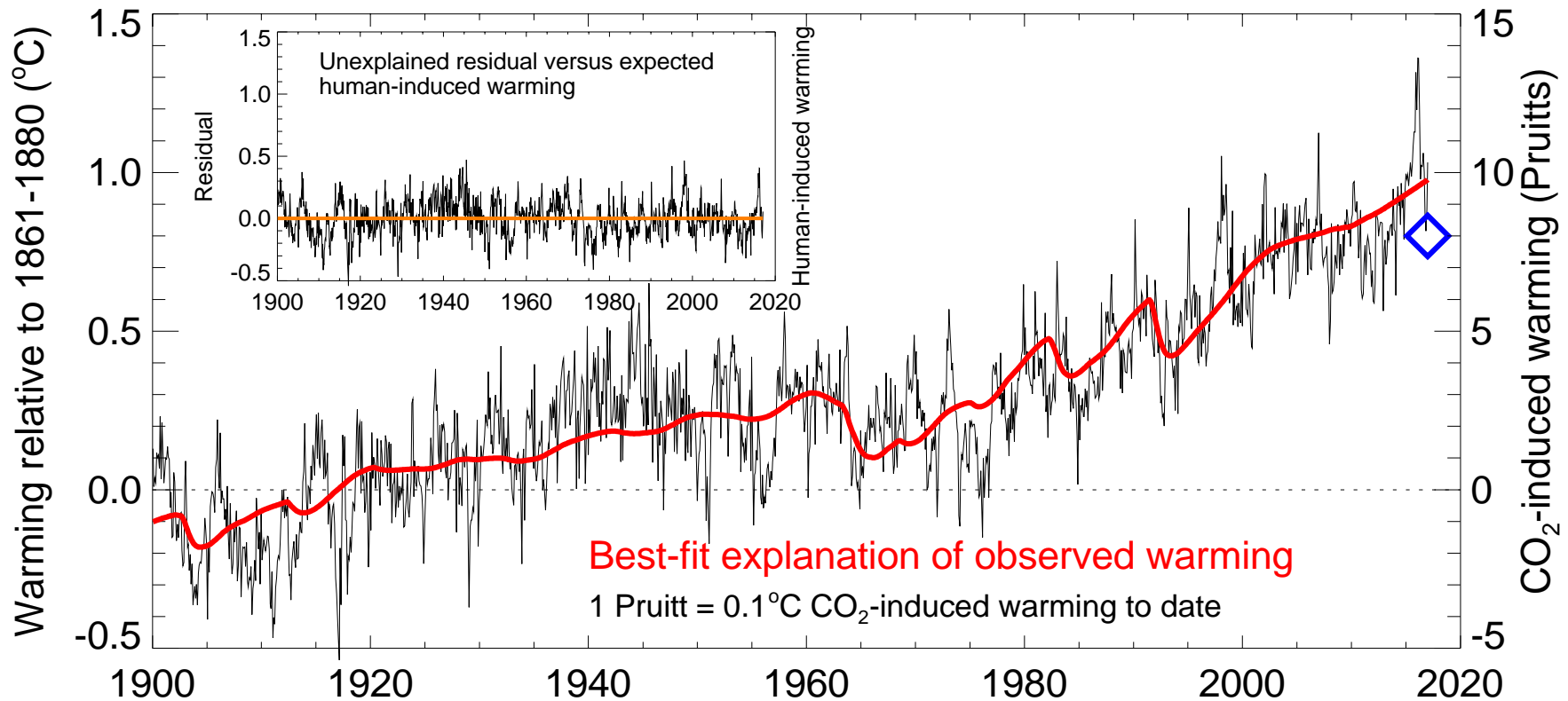
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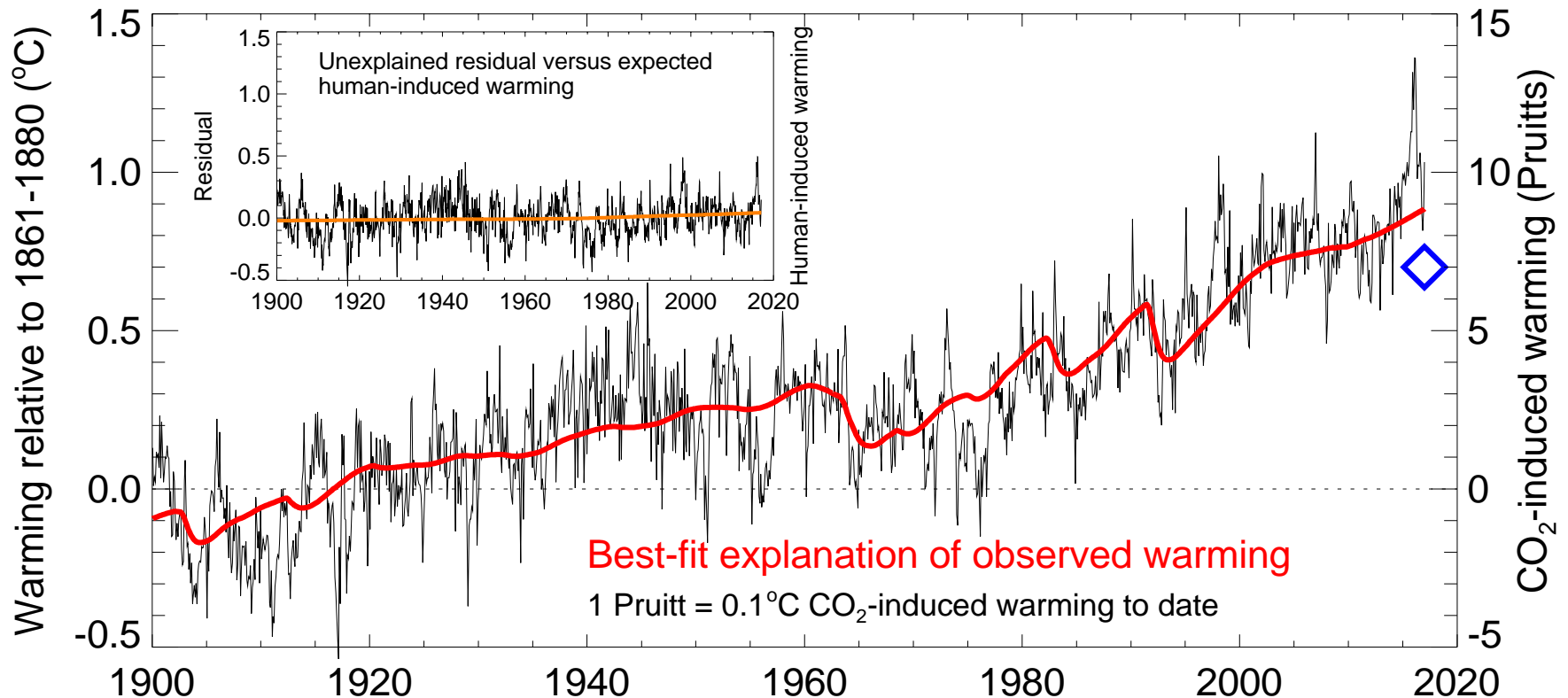
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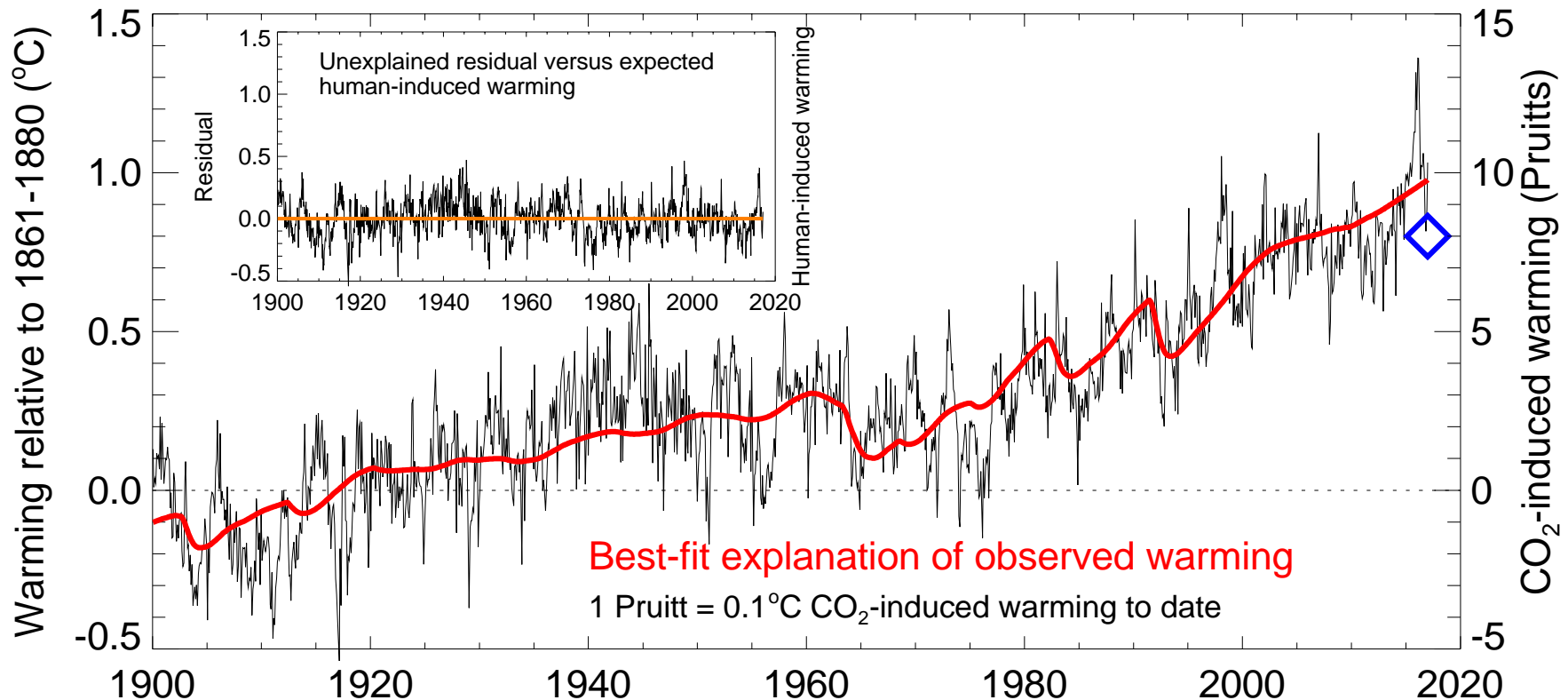
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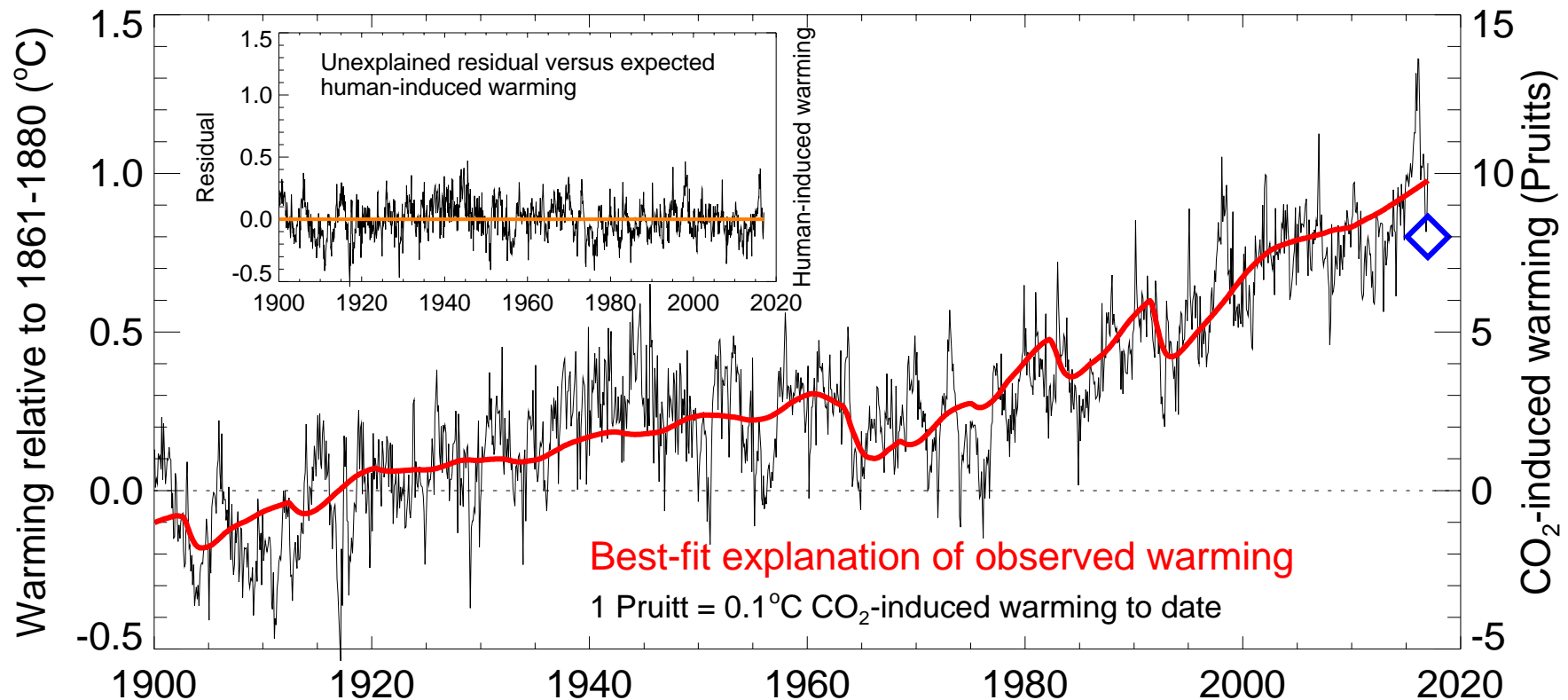
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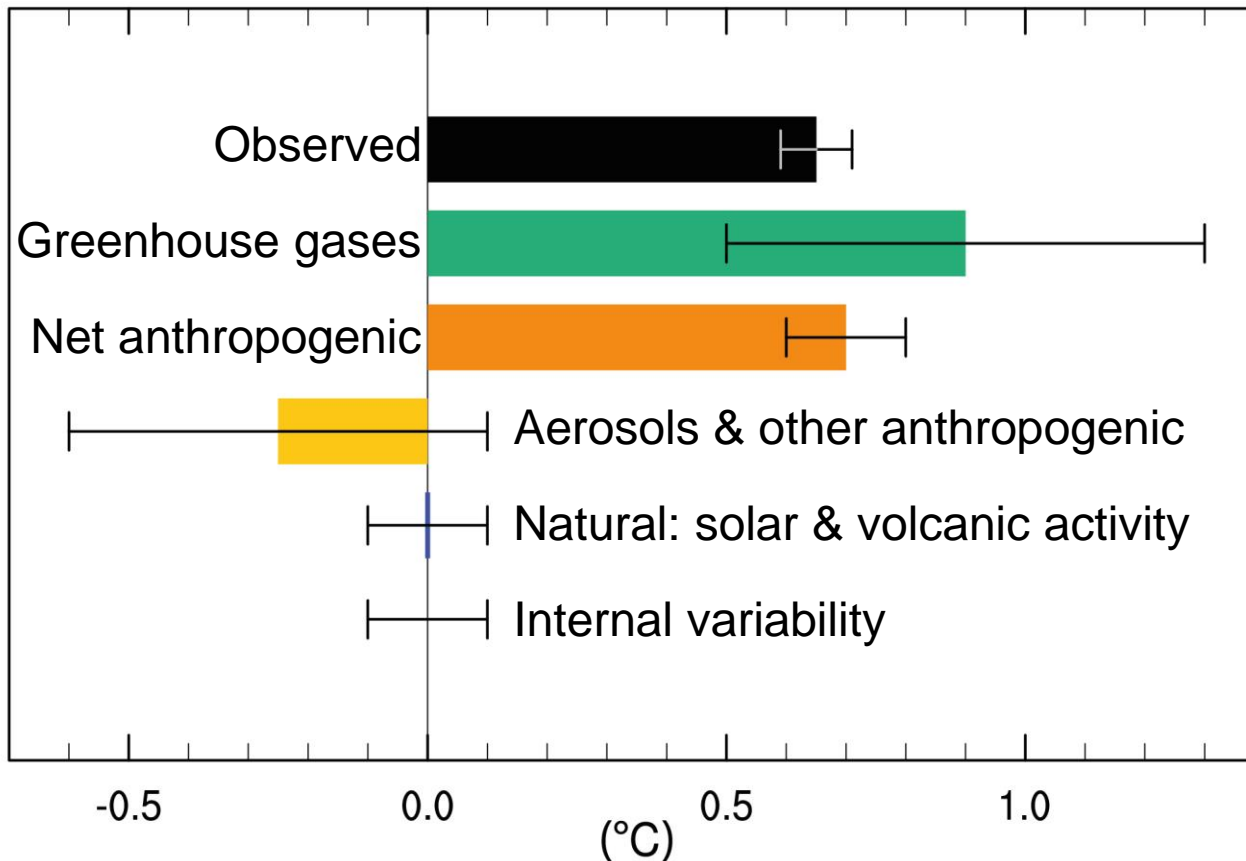
And obtain the best fit, with no unexplained residual suspiciously resembling human-induced warming, at 0.8°C CO₂-induced warming to date



Responding to speculation with facts

- The best explanation of the observed global mean surface temperature record, in a simple least-squares sense, is that CO₂ emissions from human activity have contributed about 80% of the observed warming since 1870.
- Attempting to explain the observed temperature record with natural factors alone, even allowing any amount of amplification of the response to low- and high-frequency solar variability and volcanic activity, leaves an unexplained residual that is suspiciously well correlated with the expected response to human activity.

“It is *extremely likely* that human influence has been the dominant cause of the observed warming since the mid-20th century” – IPCC (2013)



**Contributions to
global warming
since 1950
Fig. 10.5**

Evolution of the IPCC's “attribution” statement

- “The balance of evidence suggests that there is a discernible human influence on global climate.” (1995)
- “Most of the observed warming over the last 50 years is *likely* to have been due to the increase in greenhouse gas concentrations.” (2001)
- “Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations.” (2007)
- “It is *extremely likely* that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together.” (2013)
 - “The best estimate of the human-induced contribution to warming is similar to the observed warming over this period.” (2013b)
- “Human activities are estimated to have caused approximately 1.0° C of global warming above pre-industrial levels, with a *likely* range of 0.8° C to 1.2° C.” (2018)
 - *Likely*= $P > 0.66$; *Very likely*= $P > 0.9$; *Extremely likely*= $P > 0.95$

For more information, data and an up-to-the-minute estimate of human-induced warming, see globalwarmingindex.org

Most climate-related harm is associated with extreme weather, not global averages



Thanks to Fredi Otto for event attribution slides

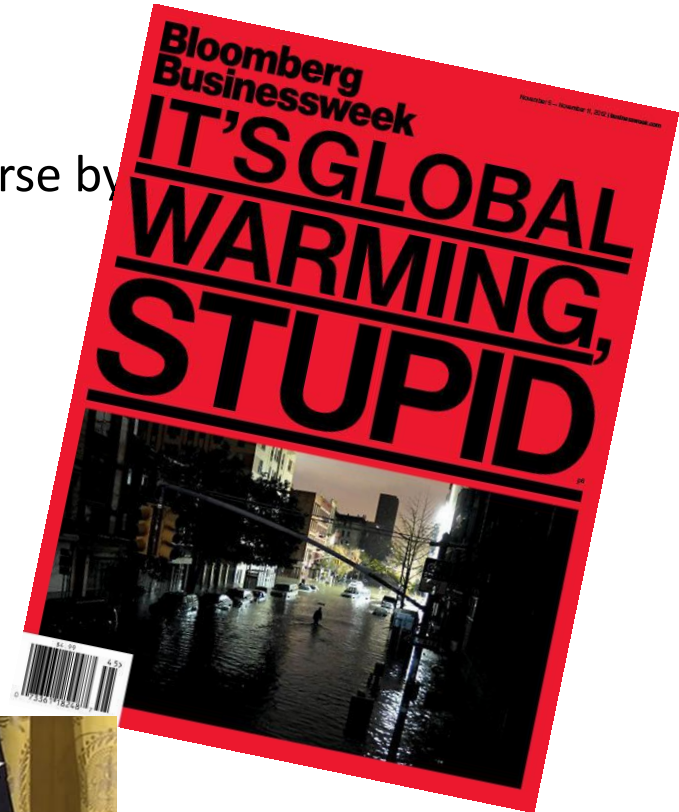
Common assumptions:

a) All e:



#everydayclimatechange+

e worse by

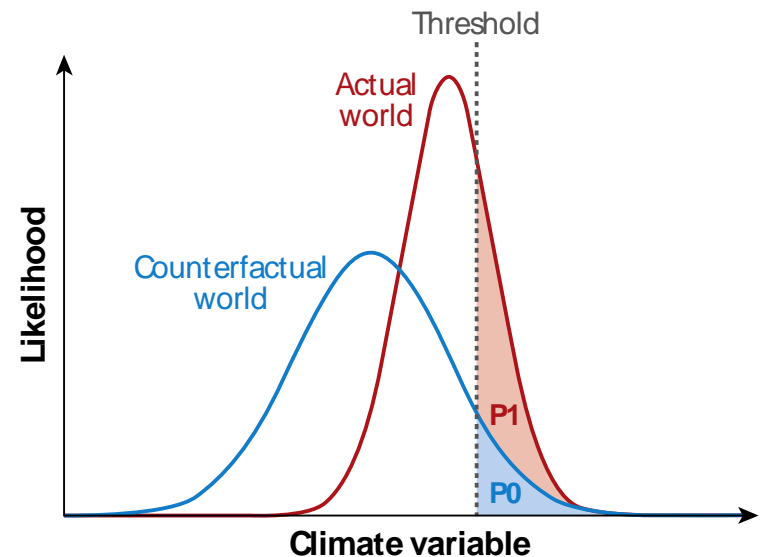
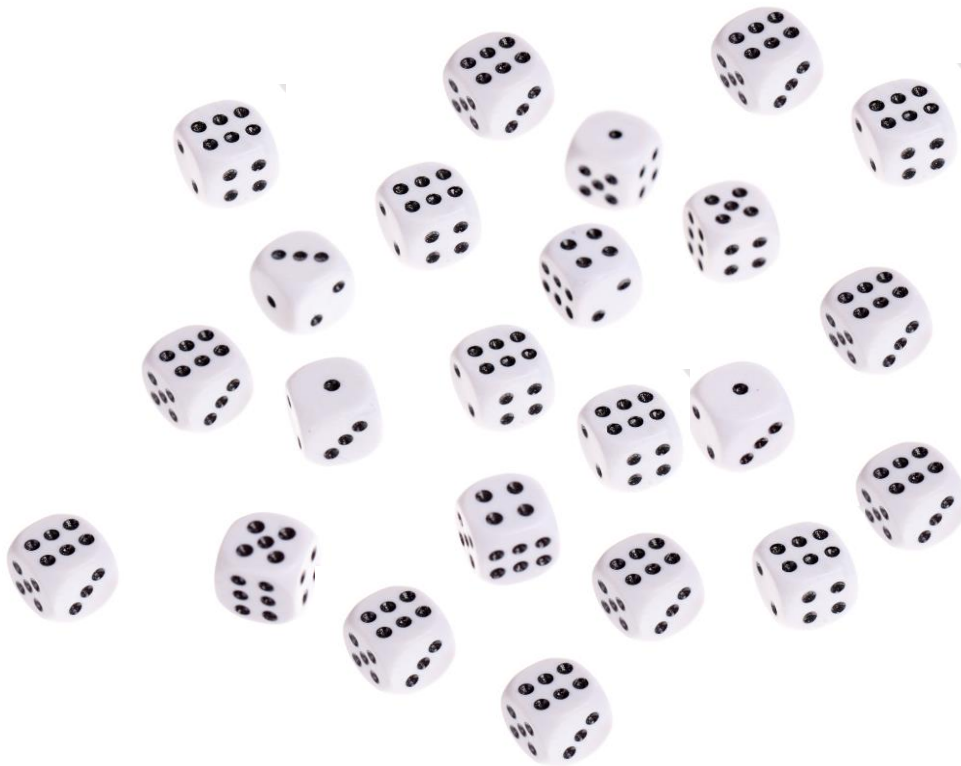


b) We cannot attribute

ogenic climate change

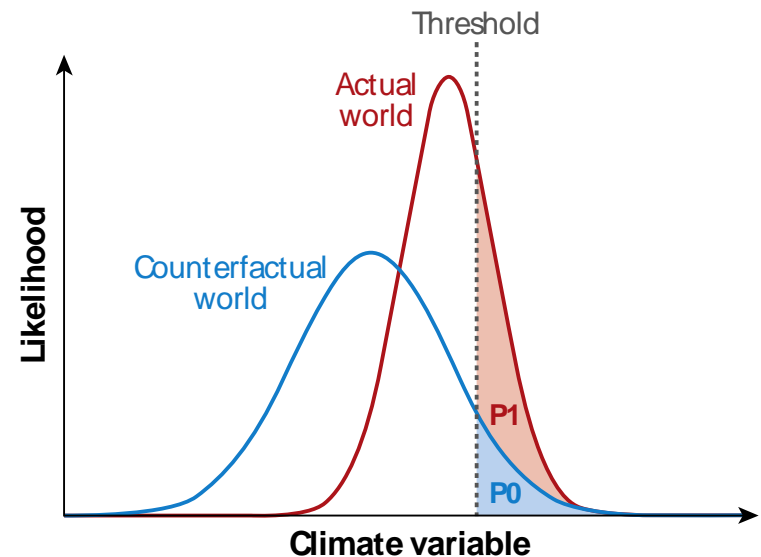
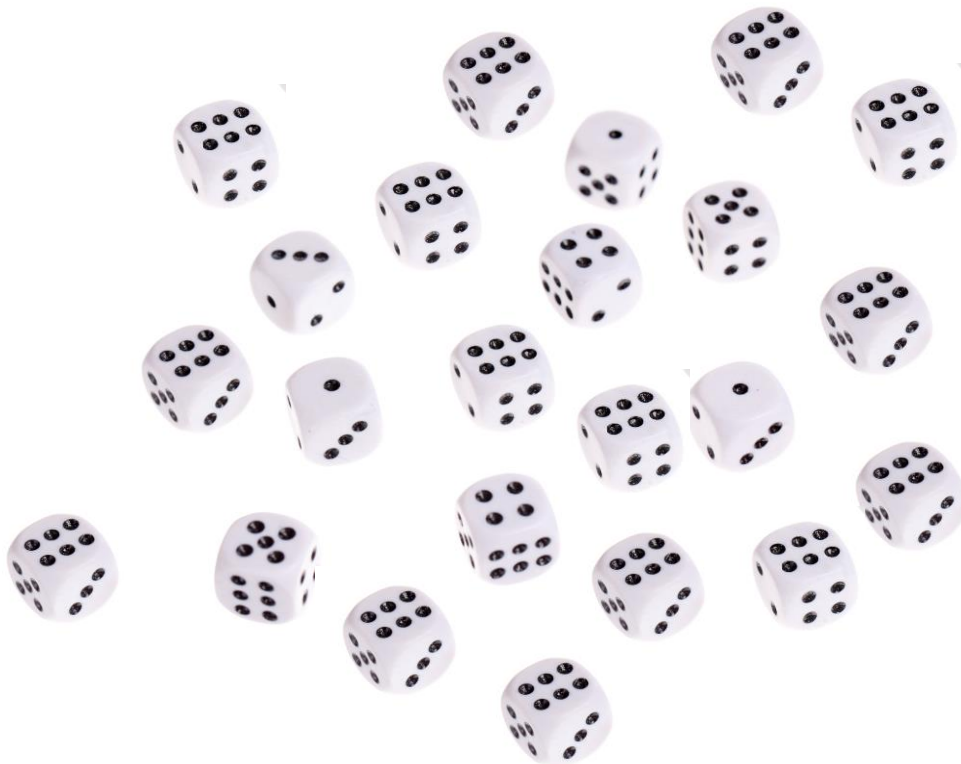


Few harmful events would never have occurred “but for” climate change



See Allen, 2003; Otto 2017

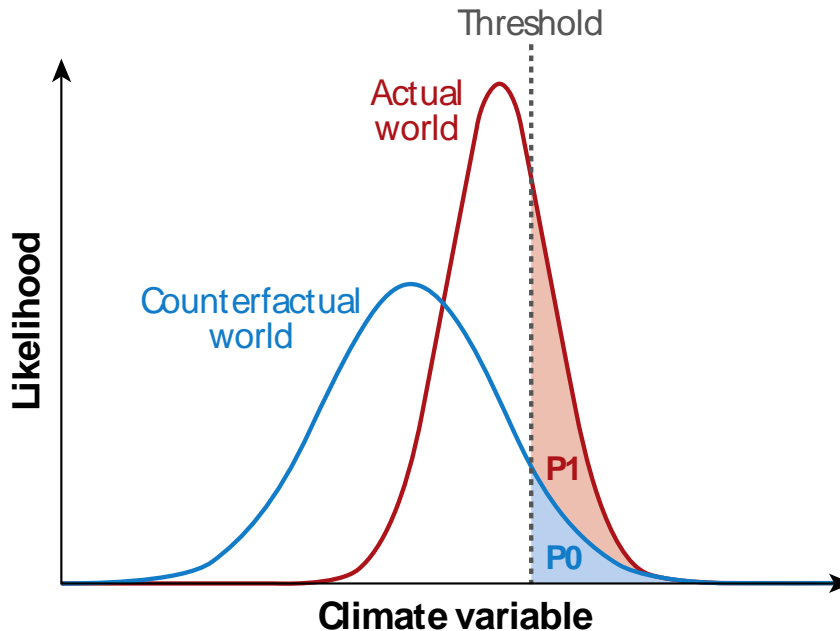
But we can ask how has climate change affected the risk of such a harmful event?



See Allen, 2003; Otto 2017

Fraction attributable risk

(probably should have been called Fraction Attributable Hazard)



P_0 : Probability of exceeding a threshold in “world that might have been” (no anthropogenic forcings).

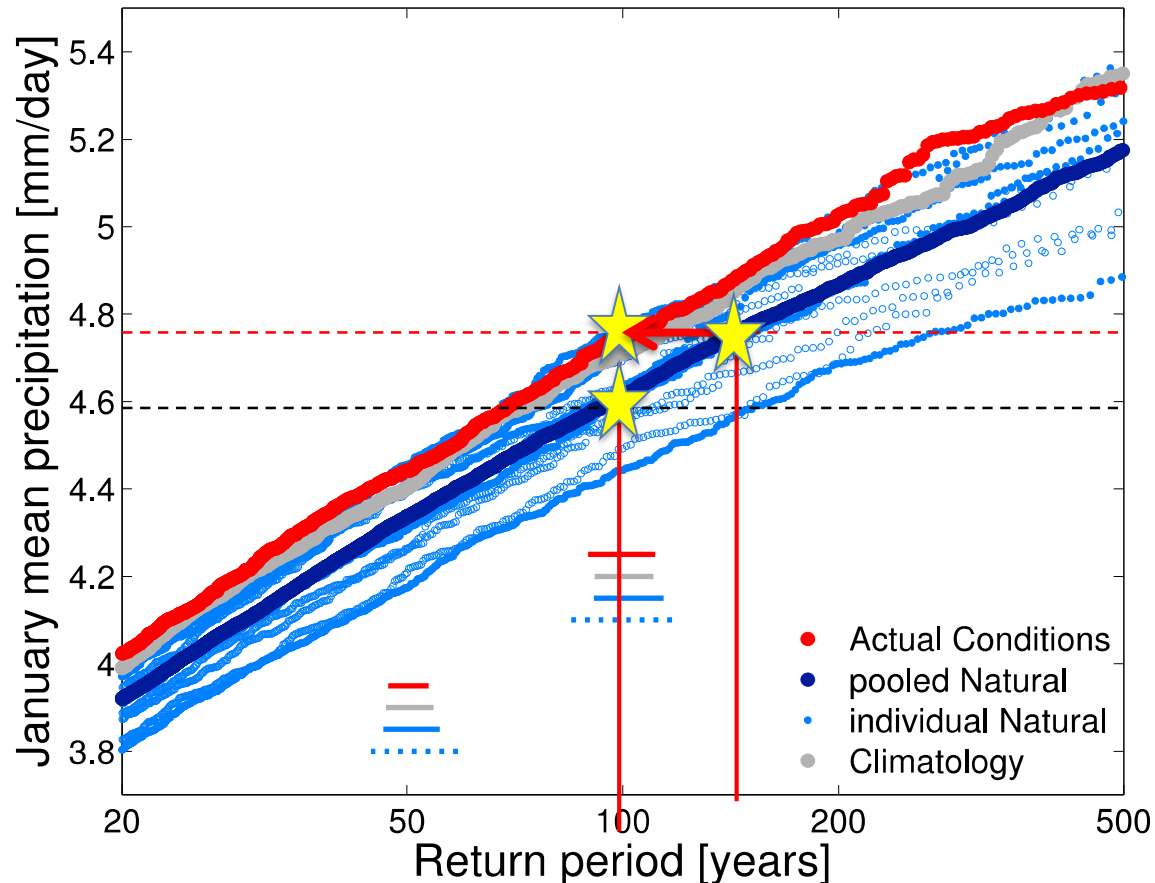
P_1 : Probability of exceeding a threshold in “world that is”.

$$FAR = 1 - (P_0/P_1)$$

FAR ~1 threshold exceeded only in the actual world with human influence

FAR < 0 threshold more likely to be exceeded in the natural world

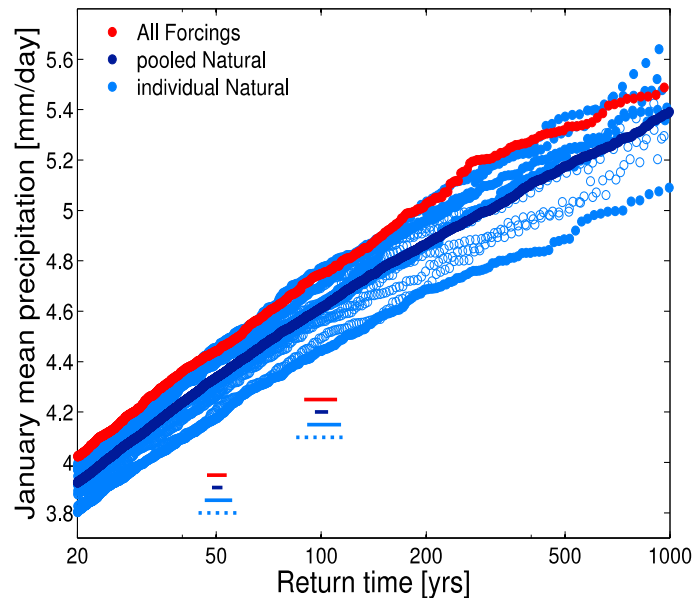
How we attribute changes in risk: the example of the UK floods of 2014



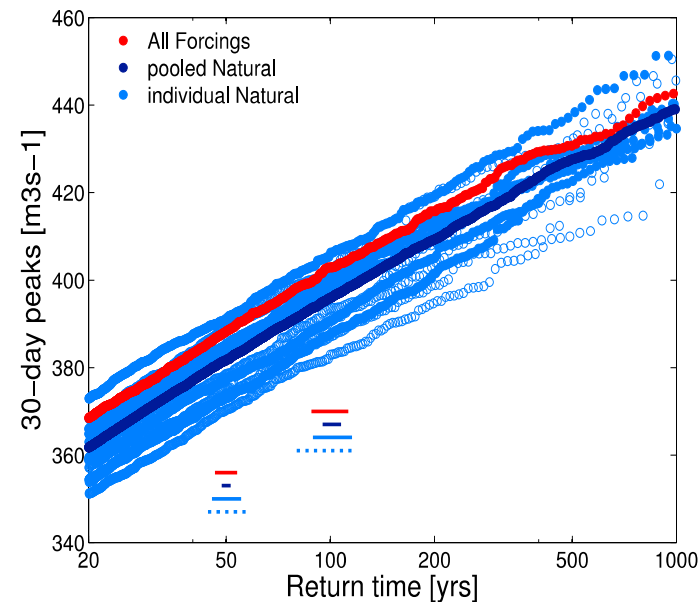
Schaller et al., 2016

Need to be very clear what you're interested in

Simulated UK rainfall January 2014



Simulated Thames river flow January 2014

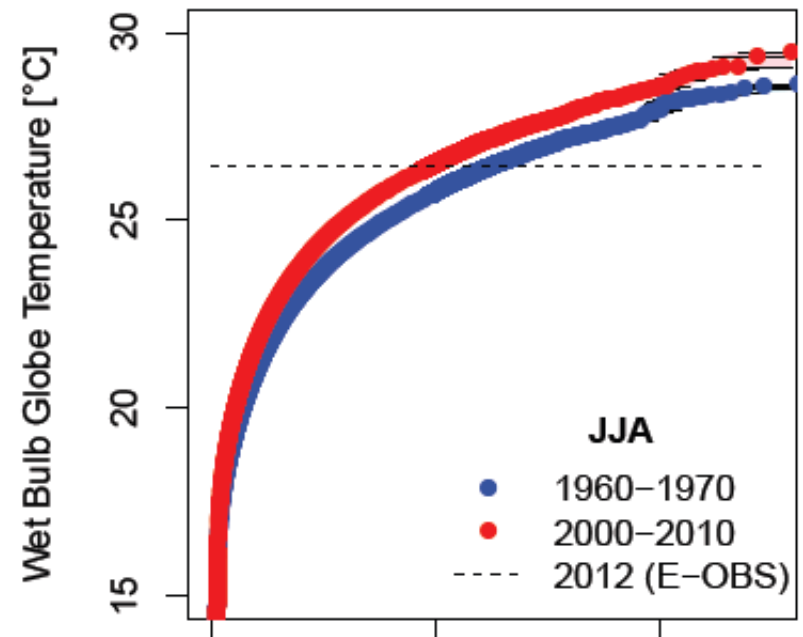
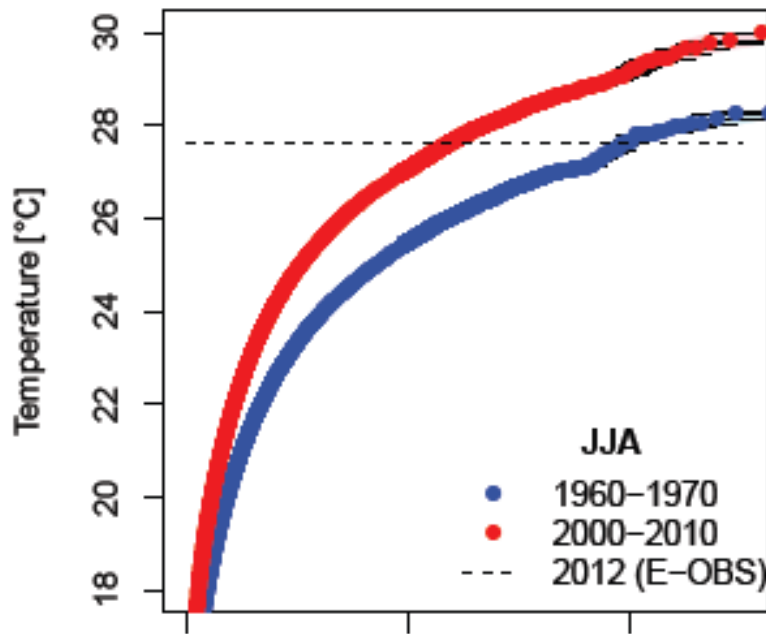


And you need a lot of computing power ~134,000 simulations!

Schaller et al., 2015

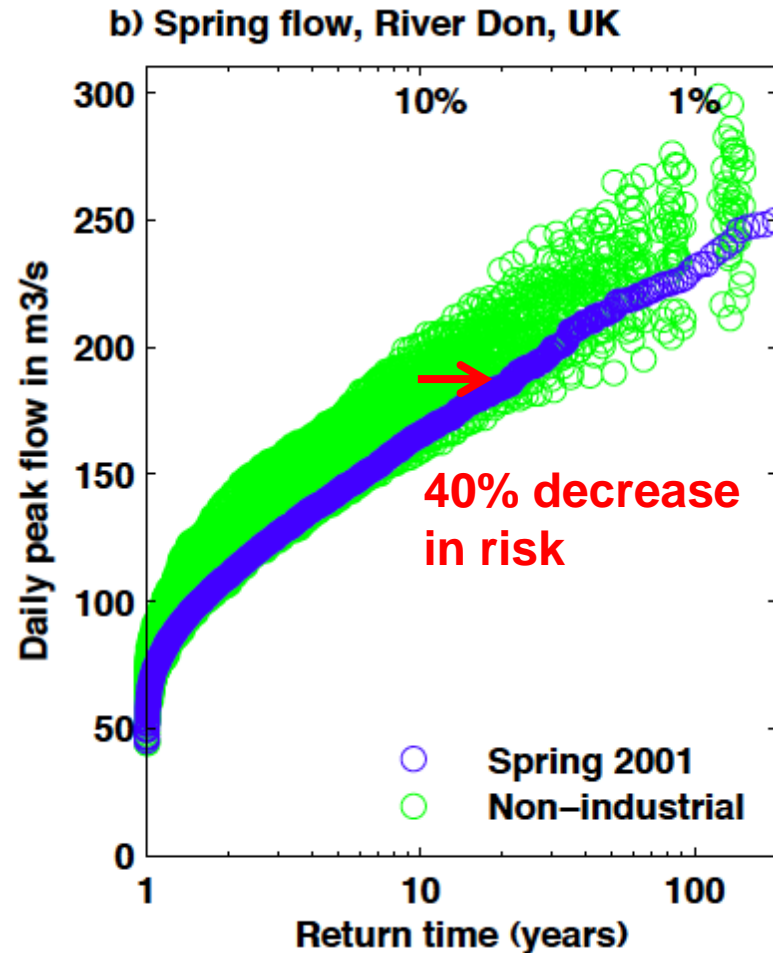
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Heatwave in Serbia: much smaller increase in risk of high heat stress index than risk of high temperature



Sippel and Otto 2014

Not all events are being made more likely: a flood that didn't happen in Spring 2001



Kay et al., 2011

This may be starting to matter...

51. *Further requests* the Executive Committee of the Warsaw International Mechanism to initiate its work, at its next meeting, to operationalize the provisions referred to in paragraphs 49 and 50 above, and to report on progress thereon in its annual report;
52. *Agrees* that Article 8 of the Agreement does not involve or provide a basis for any liability or compensation;
53. *Decides* that, in the implementation of the Agreement, financial resources provided to developing countries should enhance the implementation of their policies, strategies, regulations and action plans and their climate change actions with respect to both mitigation and adaptation to contribute to the achievement of the purpose of the Agreement as defined in Article 2;

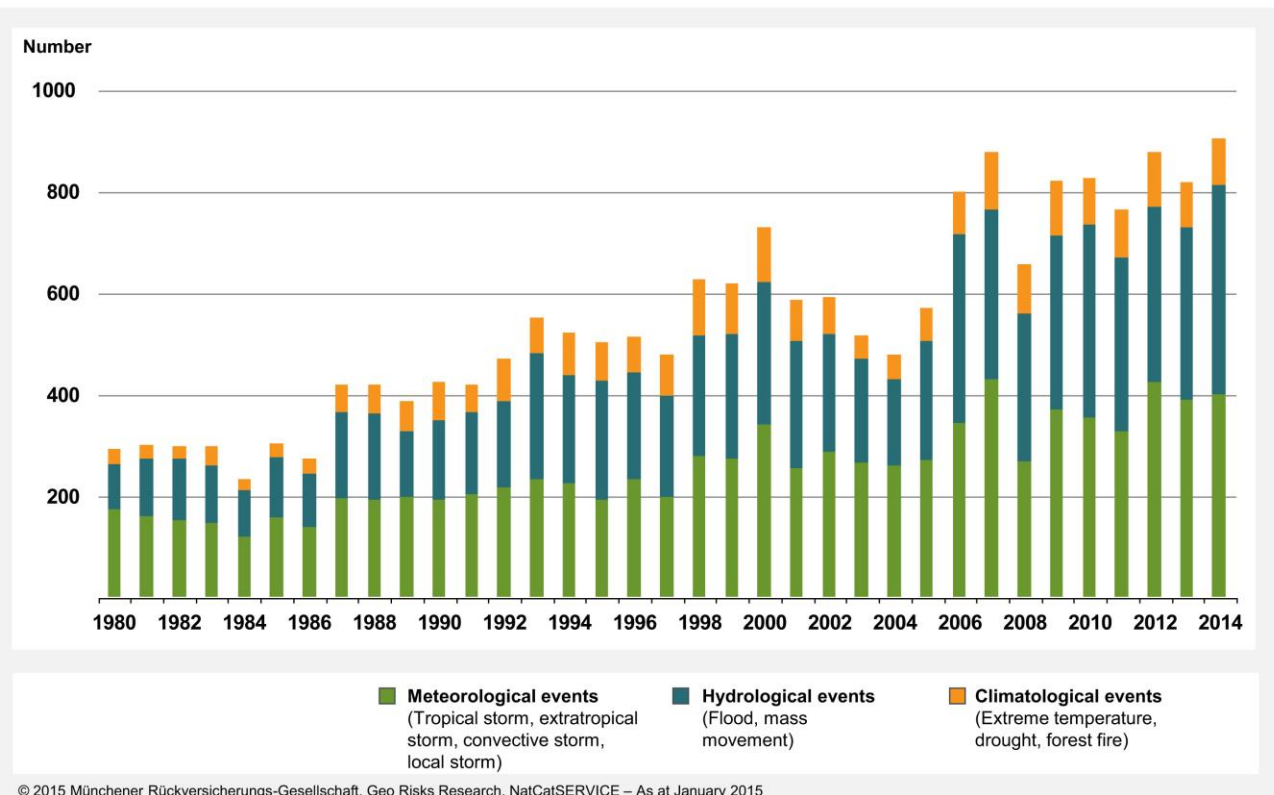
The numbers are potentially large

NatCatSERVICE

Weather related loss events worldwide 1980 – 2014

Number of events

Munich RE 



© 2015 Münchener Rückversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE – As at January 2015

Hoeppe, 2016

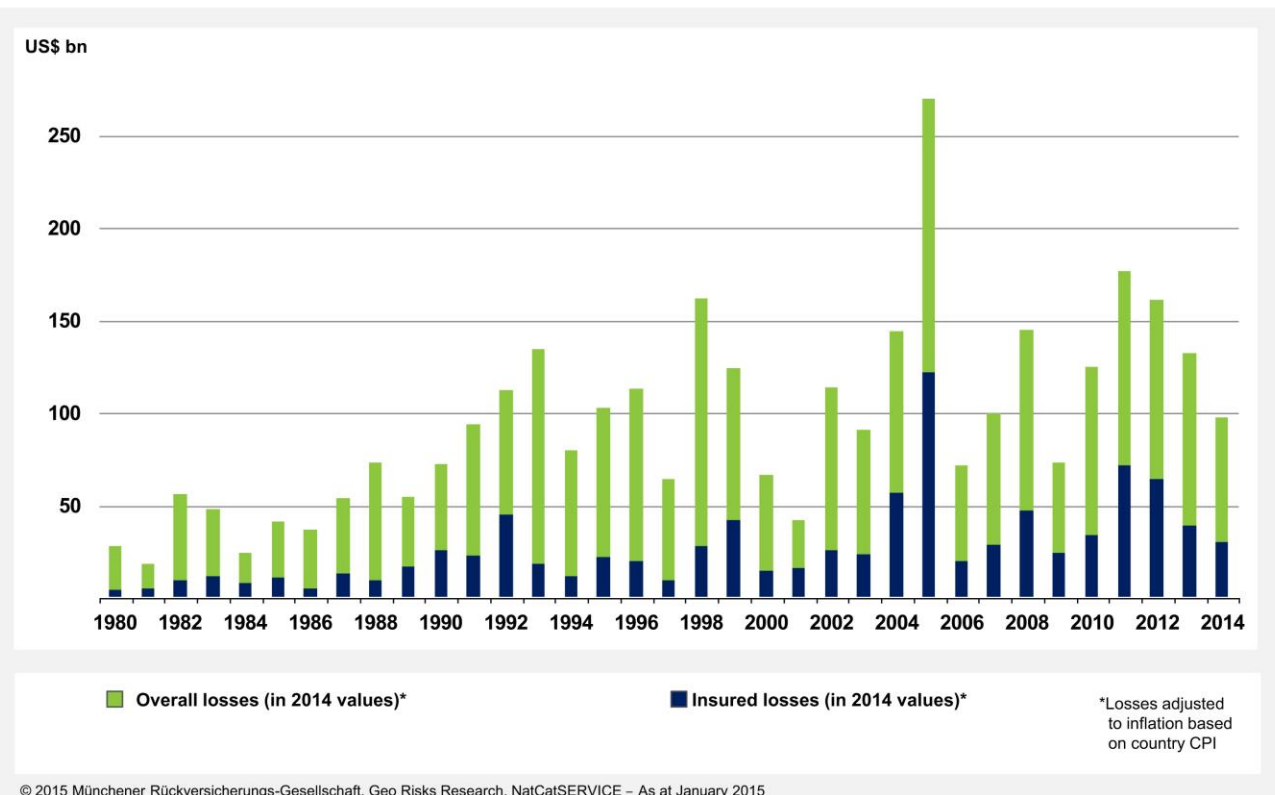
The numbers are potentially large

NatCatSERVICE

Weather-related loss events worldwide 1980 – 2014

Overall and insured losses

Munich RE 



Hoeppe, 2016

Systematic assessment of climate change damages is possible: New Zealand example

Year	Date	Event	FAR	Cost (\$M)	Attributable Cost (\$M)
2007	10 -12-Jul	North North Island	0.30	68.65	20.595
2017	3-7 April	North Island	0.35	66.4	23.24
2013	19-22 April	Nelson, BoP	0.30	46.2	13.86
2017	7-12 March	Upper North Island	0.40	41.7	16.68
2015	18-21 June	Lower North Island	0.10	41.5	4.15
2016	23-24 March	West Coast-Nelson	0.40	30.2	12.08
2015	2-4 June	Otago	0.05	21.5	1.075
2015	13-15 May	Lower North Island	0.30	21.9	6.57

<https://treasury.govt.nz/sites/default/files/2018-08/LSF-estimating-financial-cost-of-climate-change-in-nz.pdf>