

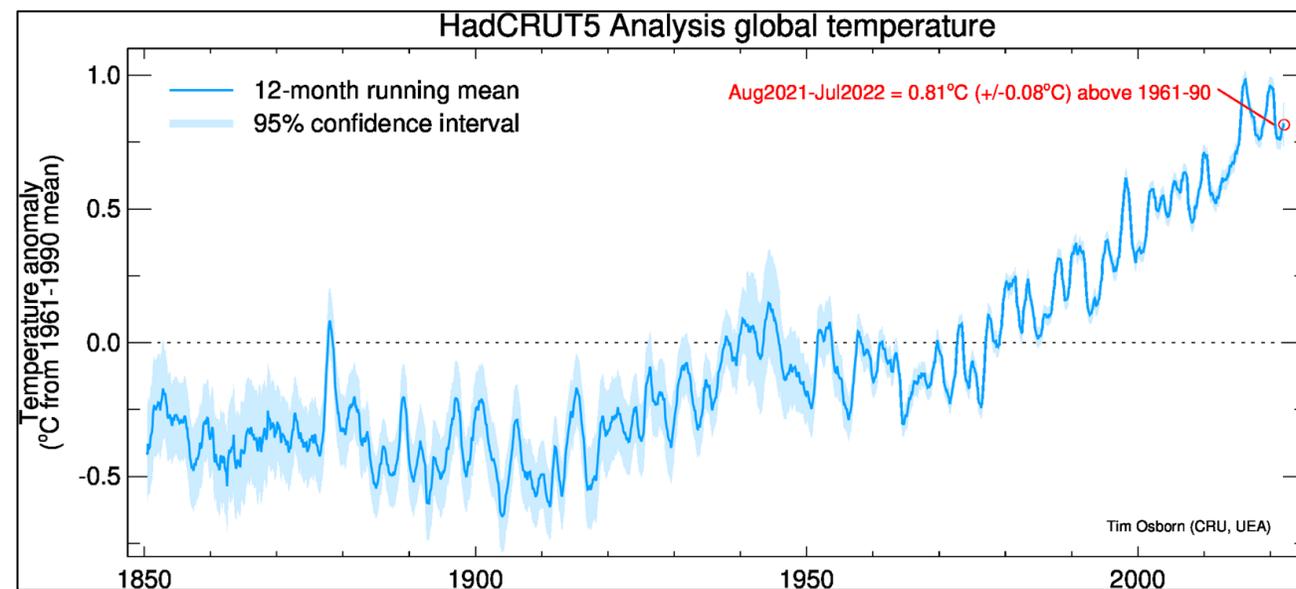
# Unsettling Climate and Energy

Steven E. Koonin, New York University  
Notre Dame Physics Colloquium

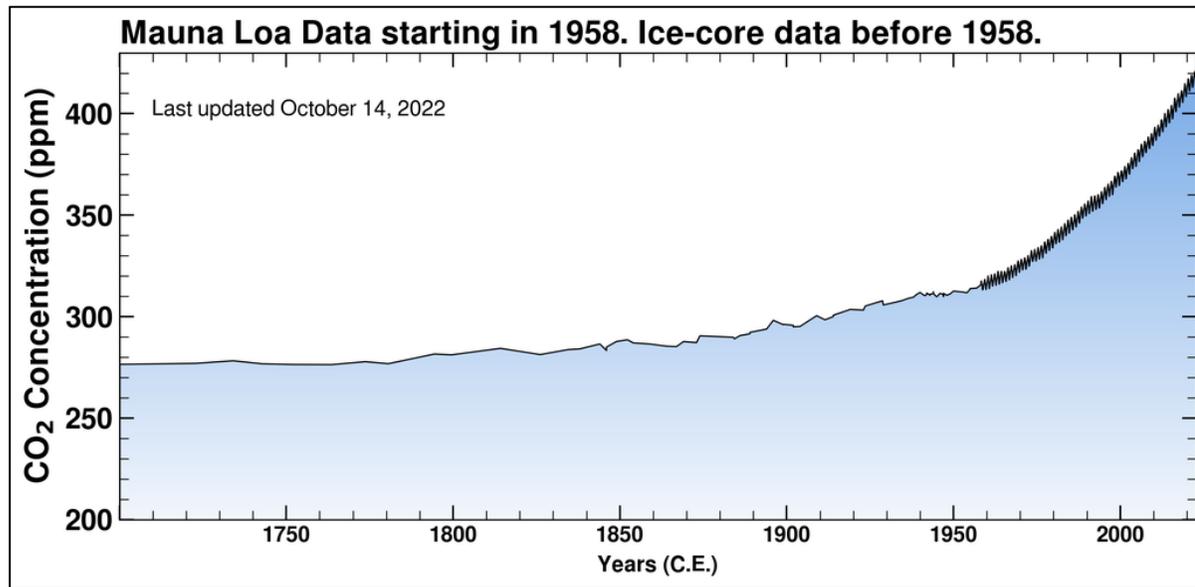
November 2, 2022

# Climate and energy are front and center today

<https://crudata.uea.ac.uk/~timo/diag/tempdiag.htm>



<https://keelingcurve.ucsd.edu/>



- How and why have the global and local climates changed in the recent and distant past?
- How will climates change in the future under natural and growing human influences?
- How will those changes impact ecosystems and societies?
- How should society respond?

# Responses must strike a balance



- Certainties and Uncertainties of climate science
- Hazards and Risks of a changing climate

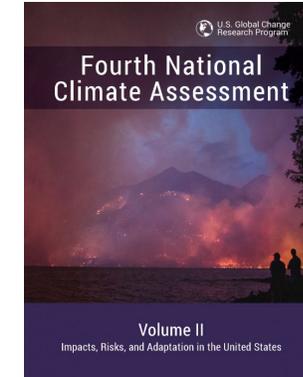
- Values and priorities
- Risk tolerance
- Intergenerational and geographical equities
- Efficacies/Costs of various responses

- Growing demand for reliable/affordable/"clean" energy

# Assessment reports define the science (vice “The Science”)

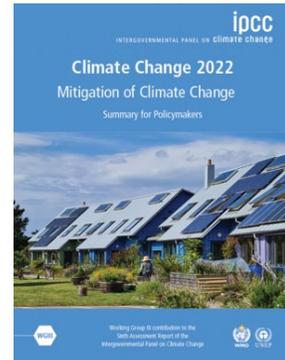
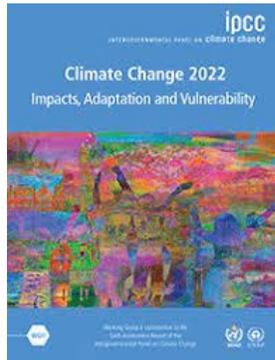
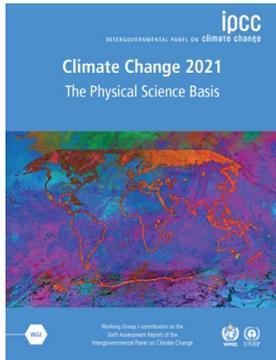


UN IPCC Fifth Assessment Report (AR5, 2014)



US Climate Science Special Report (CSSR, 2017)  
US Fourth National Climate Assessment Vol II (2018)

NCA5 in 2023

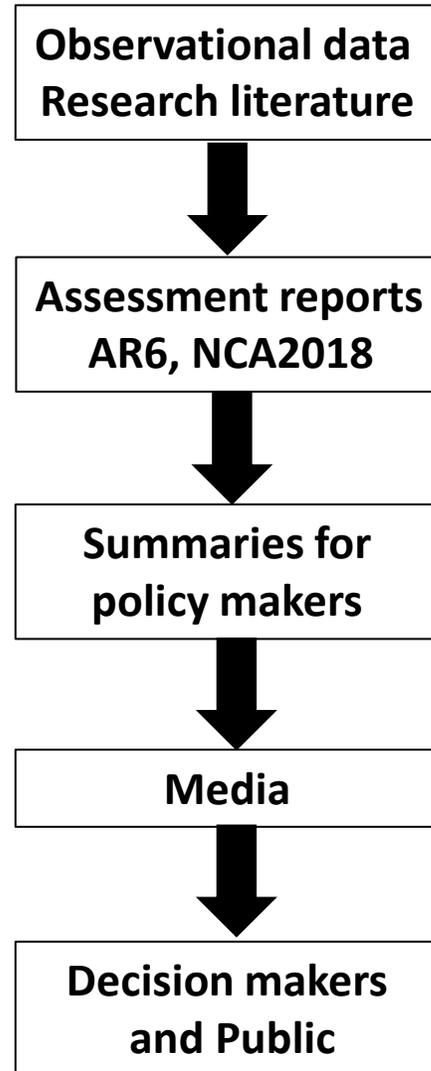
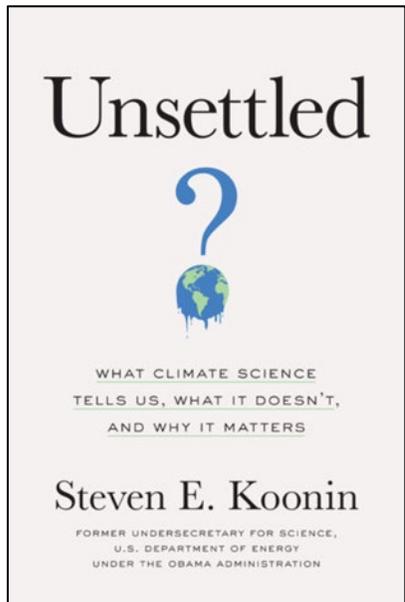


**The reports say important (and surprising) things**

**Most people have not read these reports**

UN IPCC Sixth Assessment Report (AR6, 2021-22)

# The telephone game turned science into “The Science”



## There's much bad behavior along the way

- Confusing weather with climate
- Confusing “climate change” with “a changing climate”
- Highlighting recent trends without historical context
- Implausibly extreme emissions scenarios termed “business as usual”
- Minimization of uncertainties
- Alarming predictions that never materialize and are soon forgotten
- Non-expert and activist reporters aiming to persuade rather than to inform
- Suppression of legitimate divergence from the consensus (“denier”, ...)

# Greenland has been losing ice faster (but it's just weather)

[SEK, WSJ 2/17/22](#)

[NASA press release, March 2020](#)

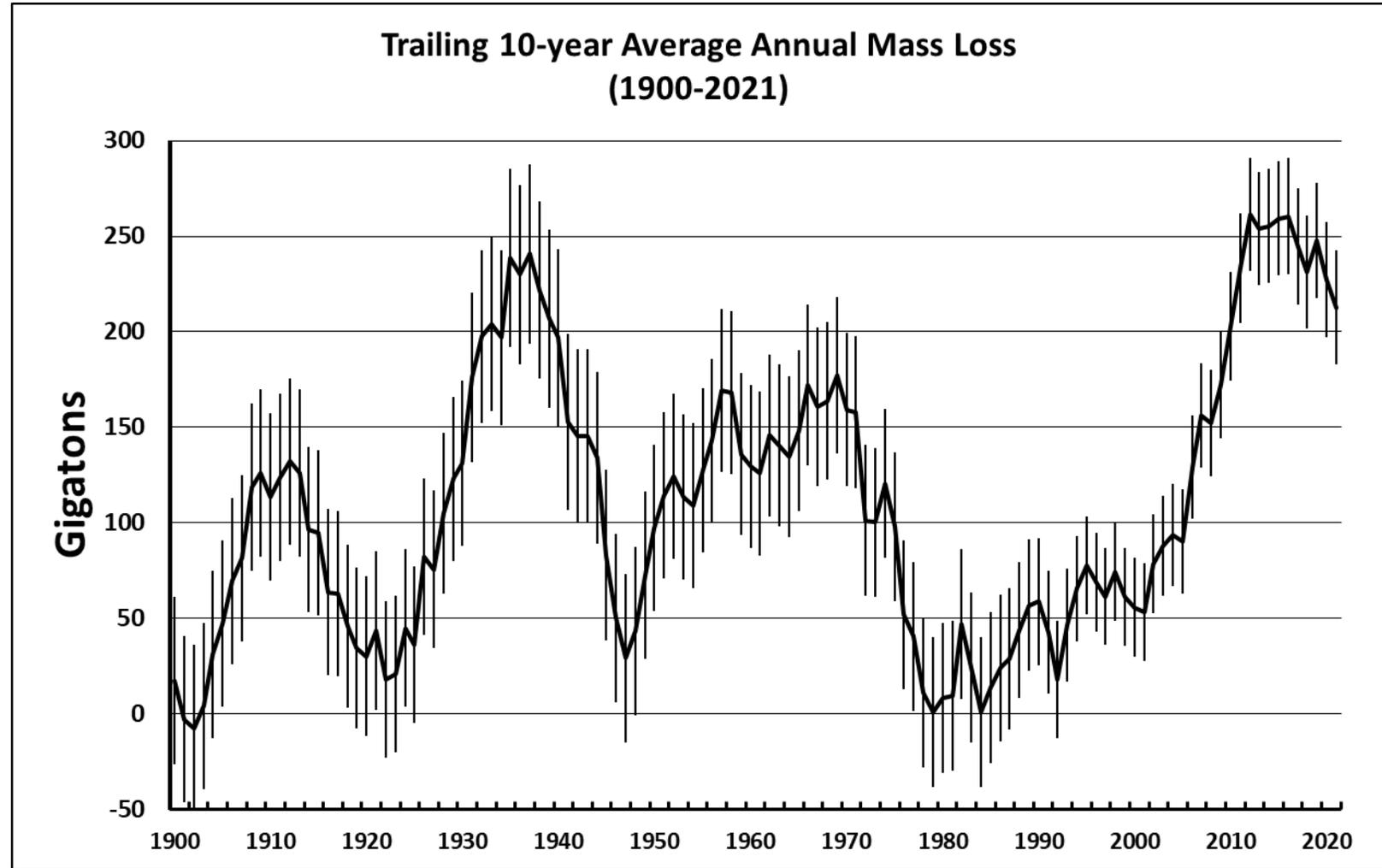
[The Guardian, December 2019](#)

## Greenland's ice sheet melting seven times faster than in 1990s

Scale and speed of loss much higher than predicted, threatening inundation for hundreds of millions of people



Glaciers calving icebergs in south-west Greenland, which has lost 3.8tn tonnes of ice since 1992, and **the rate of ice loss has risen from 33bn tonnes a year in the 1990s to 254bn tonnes a year in the past decade.**



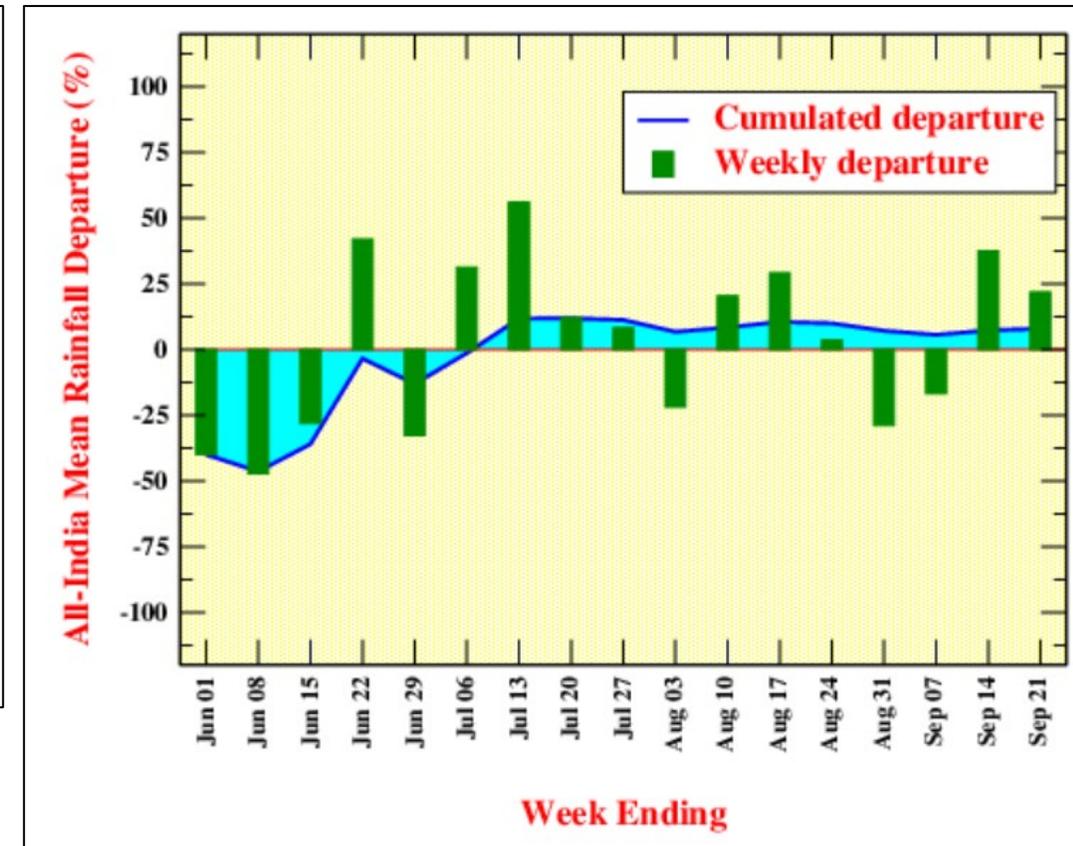
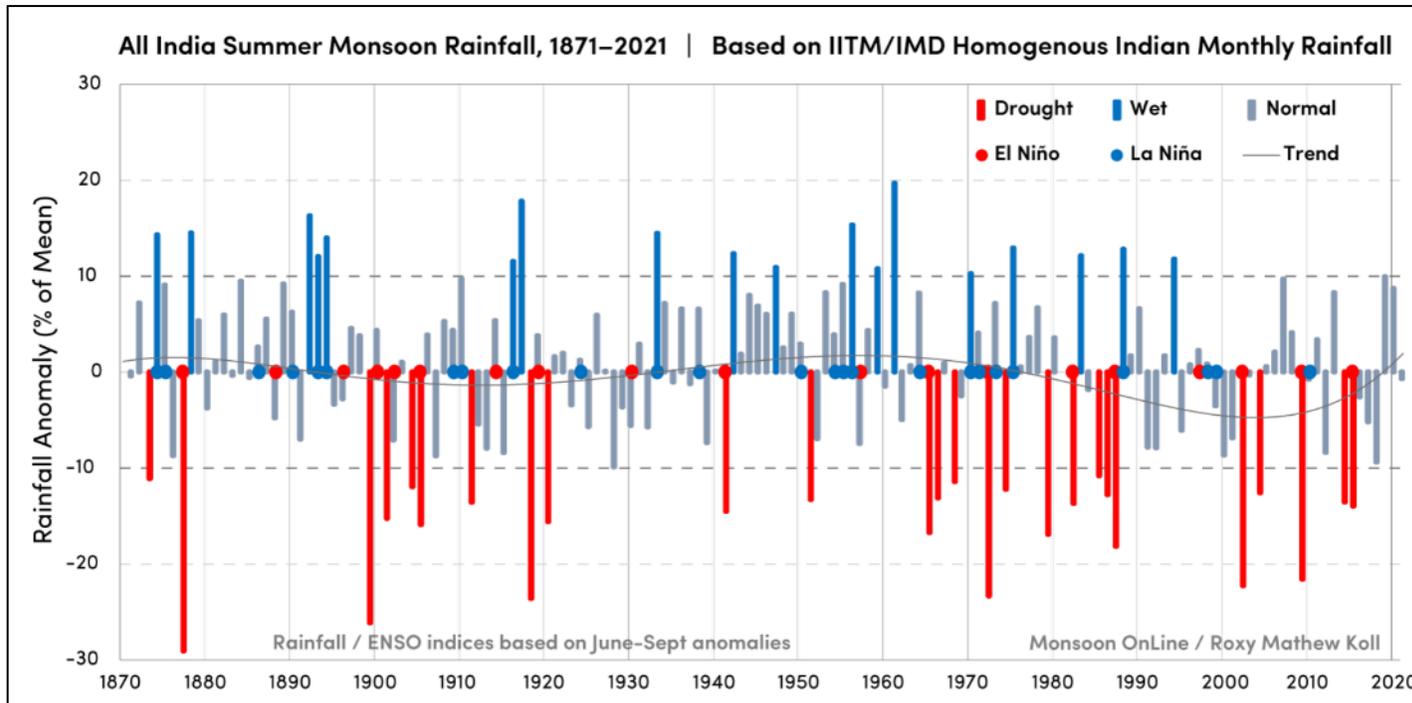
[Mankoff et al.](#)

# Monsoon historical context

<https://mol.tropmet.res.in/monsoon-interannual-timeseries/>

2022 Cumulative to date

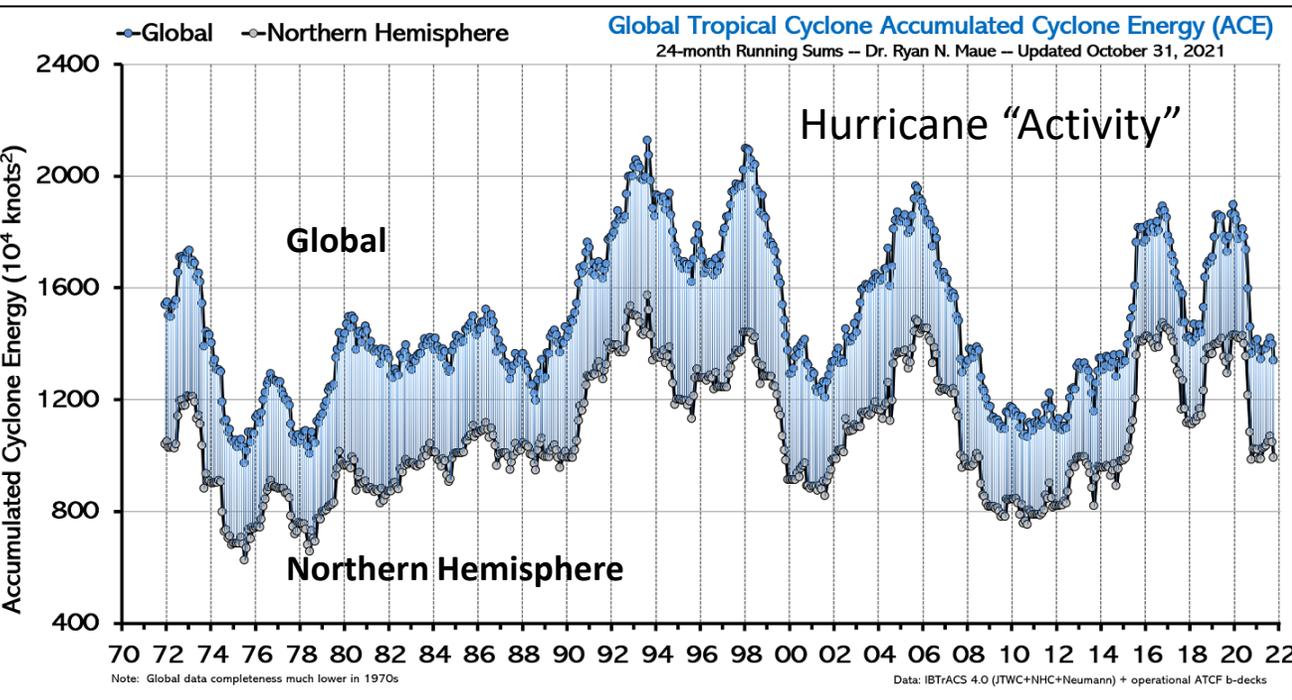
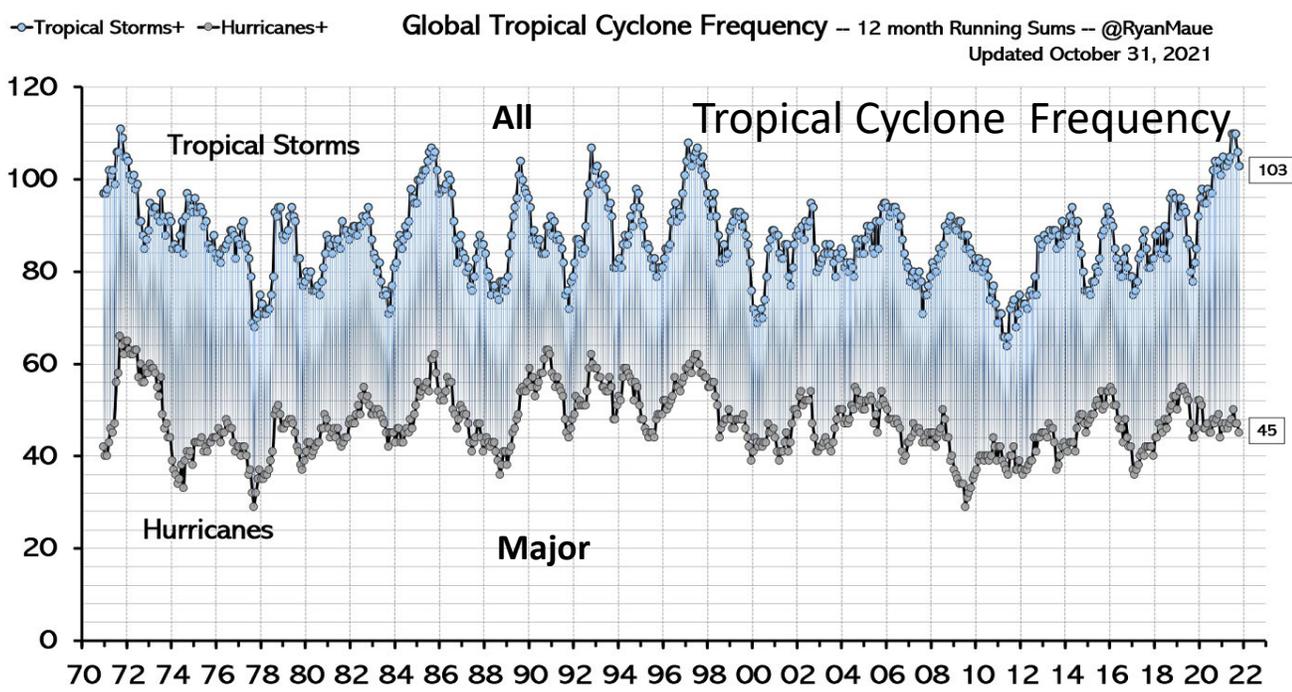
<https://mol.tropmet.res.in/all-india-weekly-rainfall/>



The All-India area-weighted mean summer monsoon rainfall (AISMR), based on a homogeneous rainfall data set of 306 rain gauges in India, developed by the Indian Institute of Tropical Meteorology, is widely considered as a reliable index of summer monsoon activity over the Indian region. The time series evolution of AISMR anomalies is expressed as percentage departures from its long-term mean over 1871-2020 [~900 mm]. Drought years (below -10% departure) are marked in red color and flood years (above 10% departure) are marked in dark blue color. El Niño and La Niña conditions for the summer season are marked using red and blue dots.

# AR6: Tough to detect or attribute trends in most weather extremes

- “There is **low confidence** in most reported long-term (multidecadal to centennial) **trends in TC** [tropical cyclone] frequency- or intensity-based metrics”
- “There is **low confidence** in observed recent changes in the total number of **extratropical cyclones** over both hemispheres. There is also **low confidence** in past-century trends in the number and intensity of the **strongest extratropical cyclones** over the Northern Hemisphere...”
- “observational trends in **tornadoes, hail, and lightning** associated with severe convective storms **are not robustly detected** due to insufficient coverage of the long-term observations”
- “the observed intensity of **extreme winds** is becoming less severe in the lower to mid-latitudes, while becoming more severe in higher latitudes poleward of 60 degrees (**low confidence**)”
- “the frequency and intensity of **heavy precipitation** have **likely increased at the global scale** over a majority of land regions with good observational coverage” [Precip != flood]
- “Confidence about **peak flow trends** over past decades on the global scale is **low**, but there are regions experiencing increases, including parts of Asia, southern South America, the northeast USA, northwestern Europe, and the Amazon, and regions experiencing decreases, including parts of the Mediterranean, Australia, Africa, and the southwestern USA.” ...“there is **low confidence** in the human influence on the changes in **high river flows** on the global scale”
- “There is still limited evidence and thus **low confidence** in assessing these trends [in **hydrological droughts**] at the scale of single regions, with few exceptions”
- “The regional evidence on attribution for single AR6 regions generally shows **low confidence for a human contribution** to observed trends in **meteorological droughts** at regional scale, with few exceptions”
- “There is **medium confidence** that human influence has contributed to changes in **agricultural and ecological droughts** and has led to an increase in the overall affected land area”
- “There is **medium confidence** that **weather conditions that promote wildfires** (fire weather) have become more probable in southern Europe, northern Eurasia, the US, and Australia over the last century”



# Very little is happening with Hurricanes

<http://climatlas.com/tropical/>

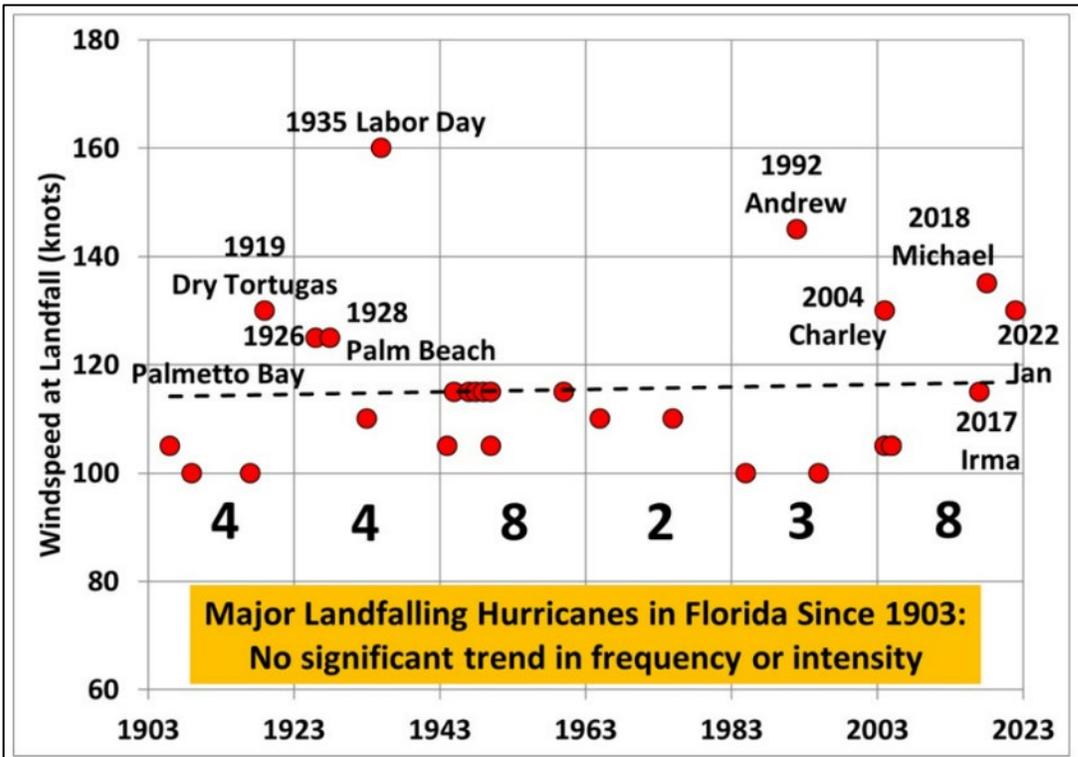
*... there is still low confidence that any reported long-term (multidecadal to centennial) increases in TC activity are robust ... – CSSR, p 258*

*... the strongest case for a detectable change in TC activity is the observed poleward migration of the latitude of maximum intensity in the northwest Pacific basin, with 8 of 11 authors rating the observed change as low to medium confidence ... The majority of the author team also had only low confidence that any other observed TC changes represented either detectable changes or attributable anthropogenic changes – Knutson et al., BAMS, October 2019*

*There is low confidence in most reported long-term (multidecadal to centennial) trends in TC frequency- or intensity-based metrics – IPCC AR6 11.7.1.2*

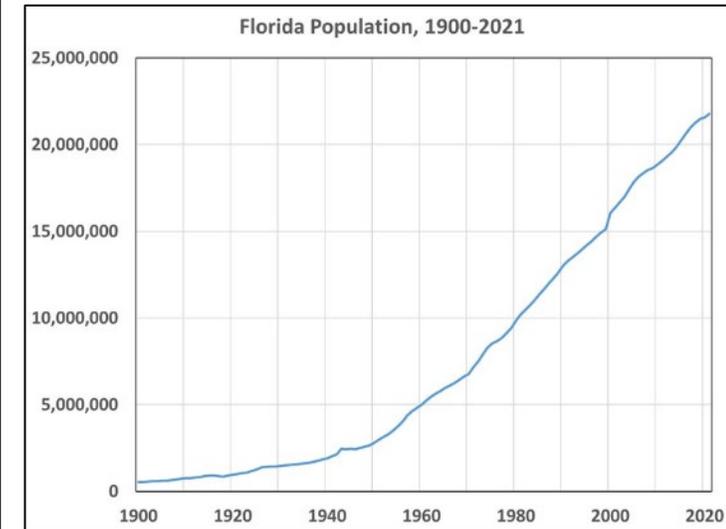
# Hurricane Ian historical context

[https://en.wikipedia.org/wiki/List\\_of\\_Florida\\_hurricanes](https://en.wikipedia.org/wiki/List_of_Florida_hurricanes)

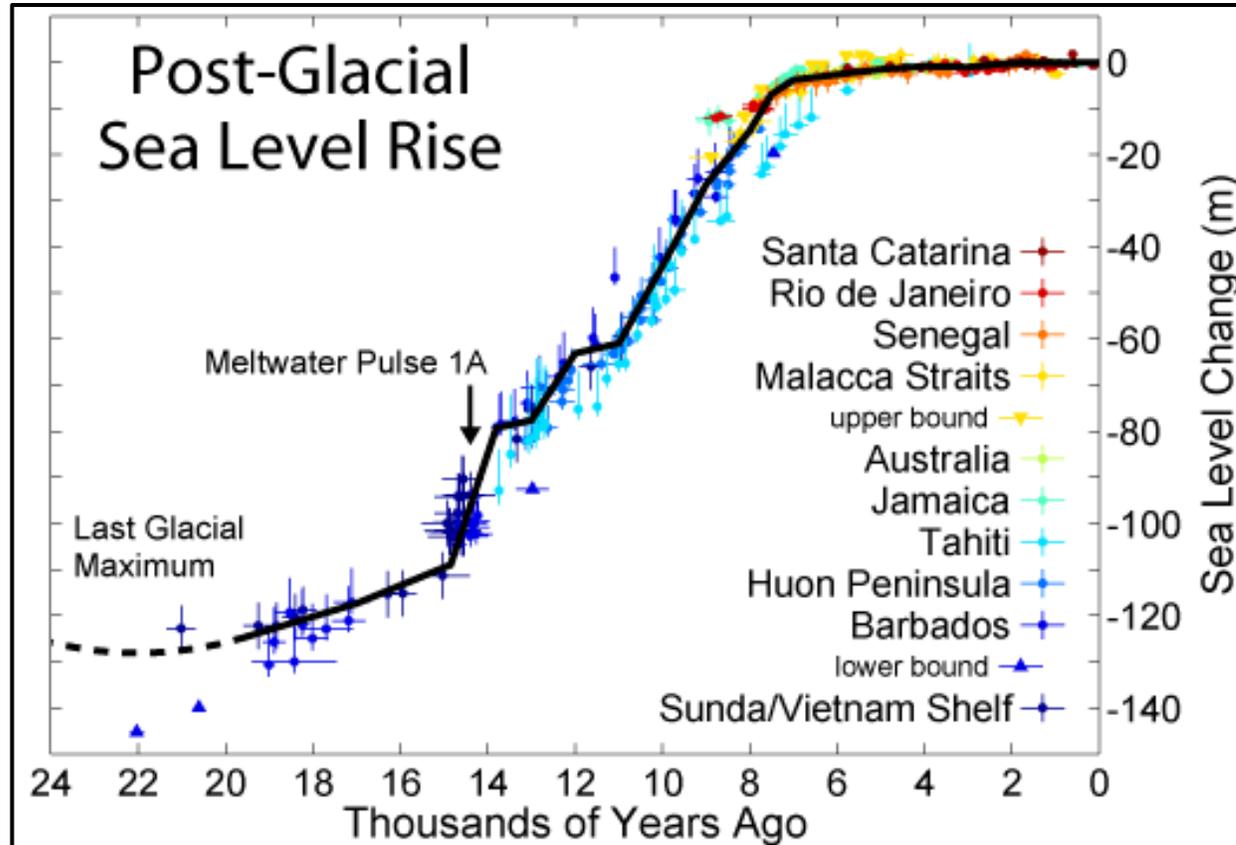


**Hurricanes causing 100 or more deaths in Florida<sup>[6][7][8]</sup>**

| Name           | Year    | Number of deaths |
|----------------|---------|------------------|
| "Okeechobee"   | 1928    | 2,500+           |
| Unnamed        | 1781    | 2,000            |
| Unnamed        | 1622    | 1,090            |
| Unnamed        | c. 1553 | 700              |
| Unnamed        | 1553    | <700             |
| Unnamed        | 1559    | 500              |
| Unnamed        | 1559    | ~500             |
| Unnamed        | 1683    | 496              |
| "Labor Day"    | 1935    | 409              |
| "Miami"        | 1926    | 372              |
| Unnamed        | 1563    | 284              |
| "Florida Keys" | 1906    | 240              |



# Sea level has been rising for 20,000 years

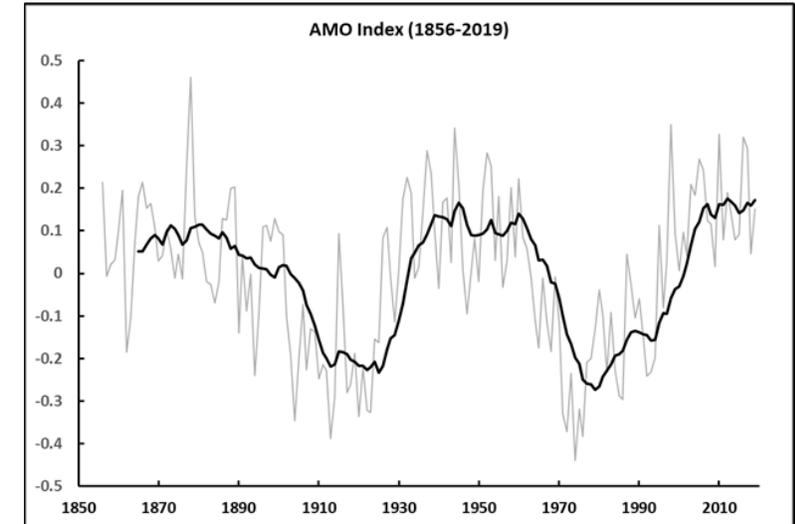
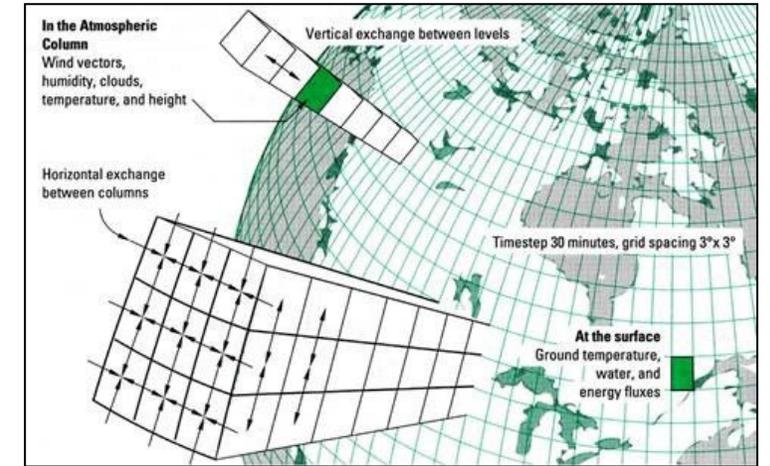
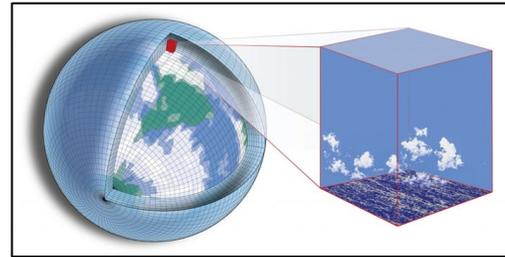


- **Has sea level rise (SLR) accelerated since ~1900?**
  - Discussion hinges on ~0.1 mm/yr differences
- **To what extent is acceleration anthropogenic?**
- **What will happen in the next few centuries?**

[https://commons.wikimedia.org/wiki/File:Post-Glacial\\_Sea\\_Level.png](https://commons.wikimedia.org/wiki/File:Post-Glacial_Sea_Level.png)

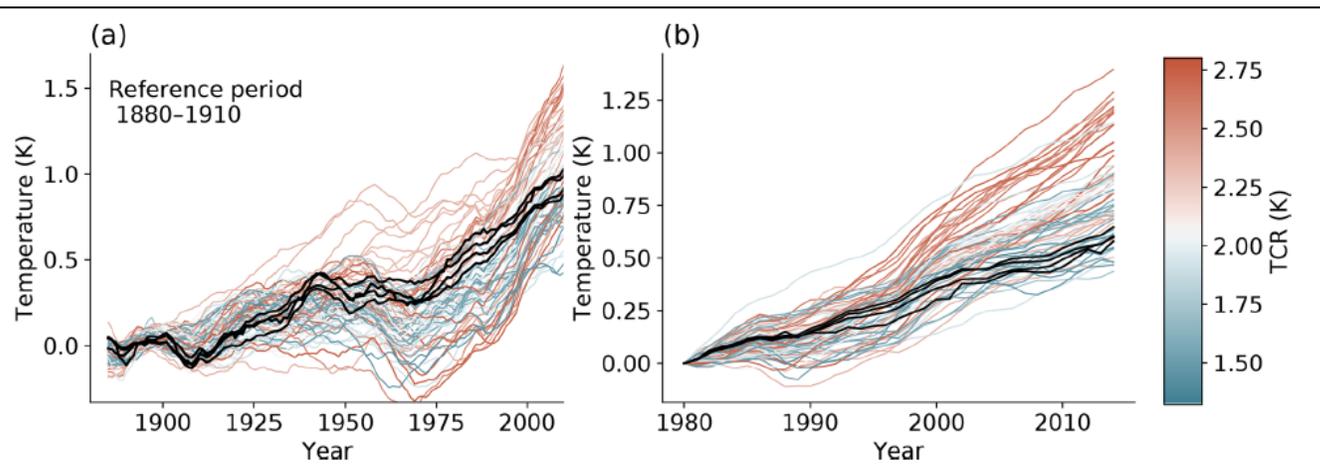
# Projections of future climates are not fit for purpose

- **A grand computational challenge**
  - $10^8$  voxels over  $10^8$  time steps
  - $10^{-3}$  precision
- **A multitude of discrepant models disagree among themselves and with the data**
  - Sub-grid parametrizations, tuning
  - Feedbacks (particularly clouds)
  - Poorly described multidecadal variability
- **The models haven't converged much over 15 years as they've become more sophisticated**
- **Regional projections are even more vague than global projections**

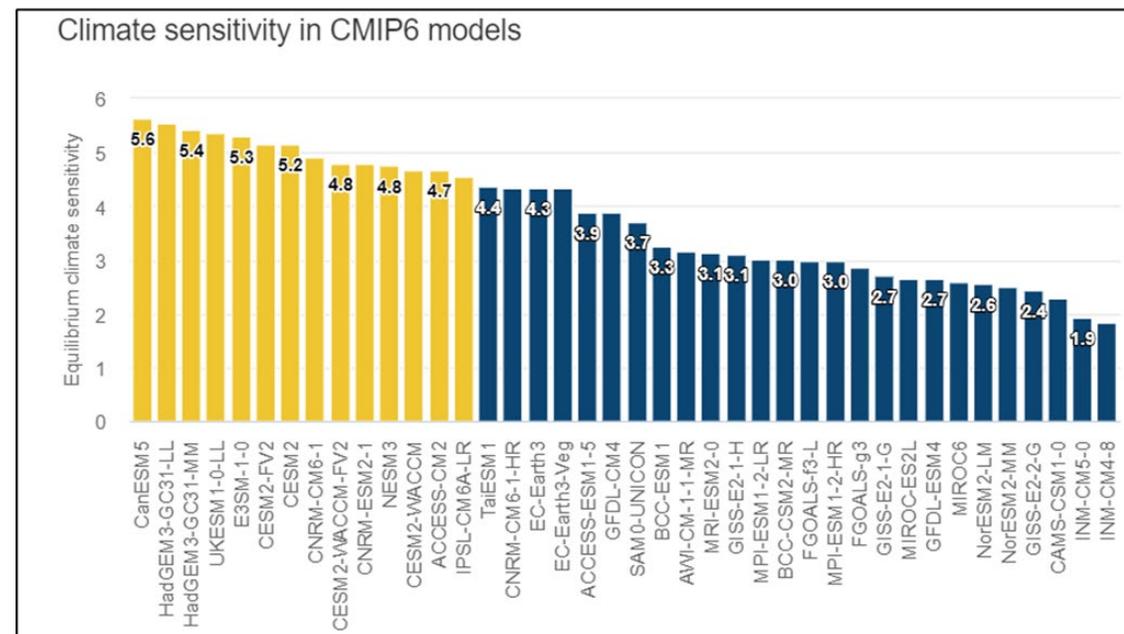


# Deficiencies of the latest generation of models

[Nijse et al. \(2020\)](#); 34 CMIP6 models



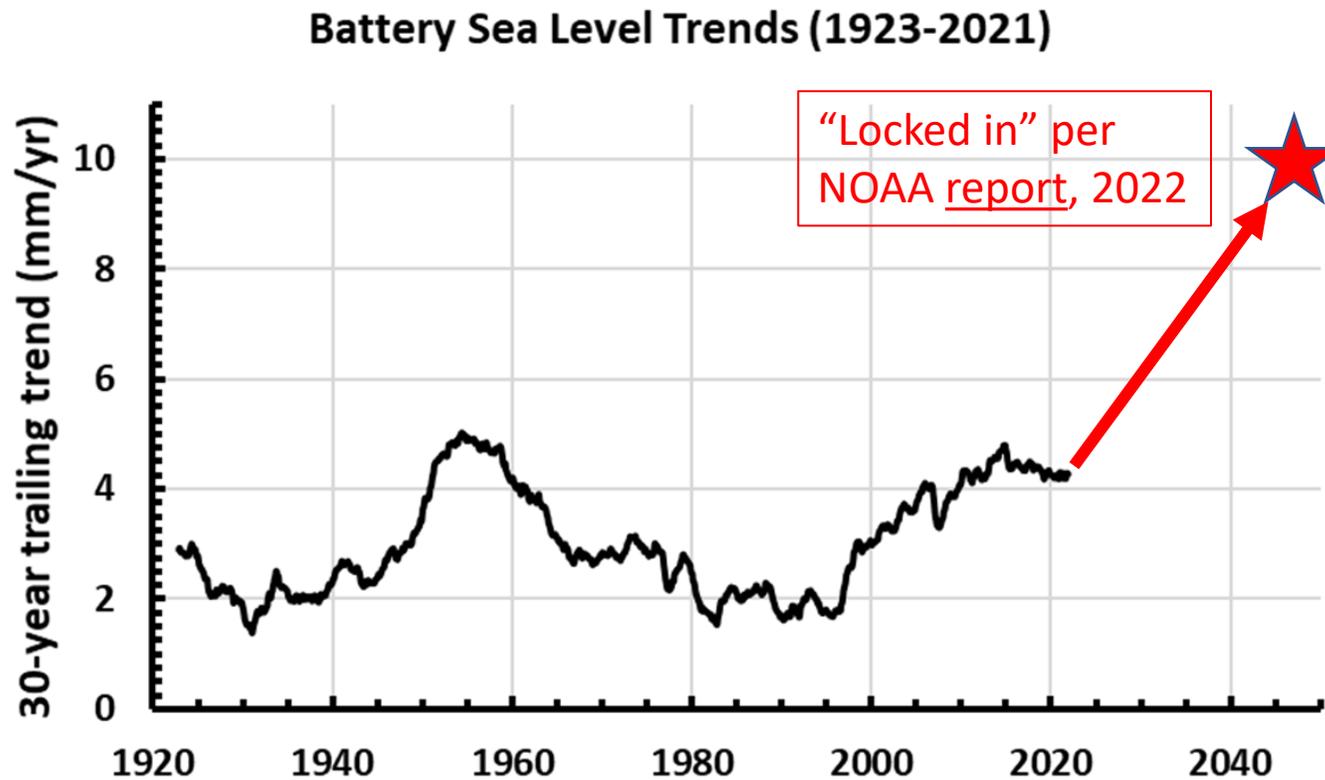
<https://www.carbonbrief.org/cmip6-the-next-generation-of-climate-models-explained>



... for many key applications that require regional climate model output or for assessing large-scale changes from smallscale processes, we believe that **the current generation of models is not fit for purpose.**

- [T. Palmer and B. Stevens, PNAS \(2019\)](#)

# Sea Level Projections are extraordinary



... the use of these [climate] models to guide local, practical adaptation actions is unwarranted. Climate models are unable to represent future conditions at the degree of spatial, temporal, and probabilistic precision with which projections are often provided, which gives a false impression of confidence to users of climate change information.

- [Nissan et al. \(2019\)](#)

# Economic impact of future climate change

## All IPCC scenarios for the future involve substantial economic growth

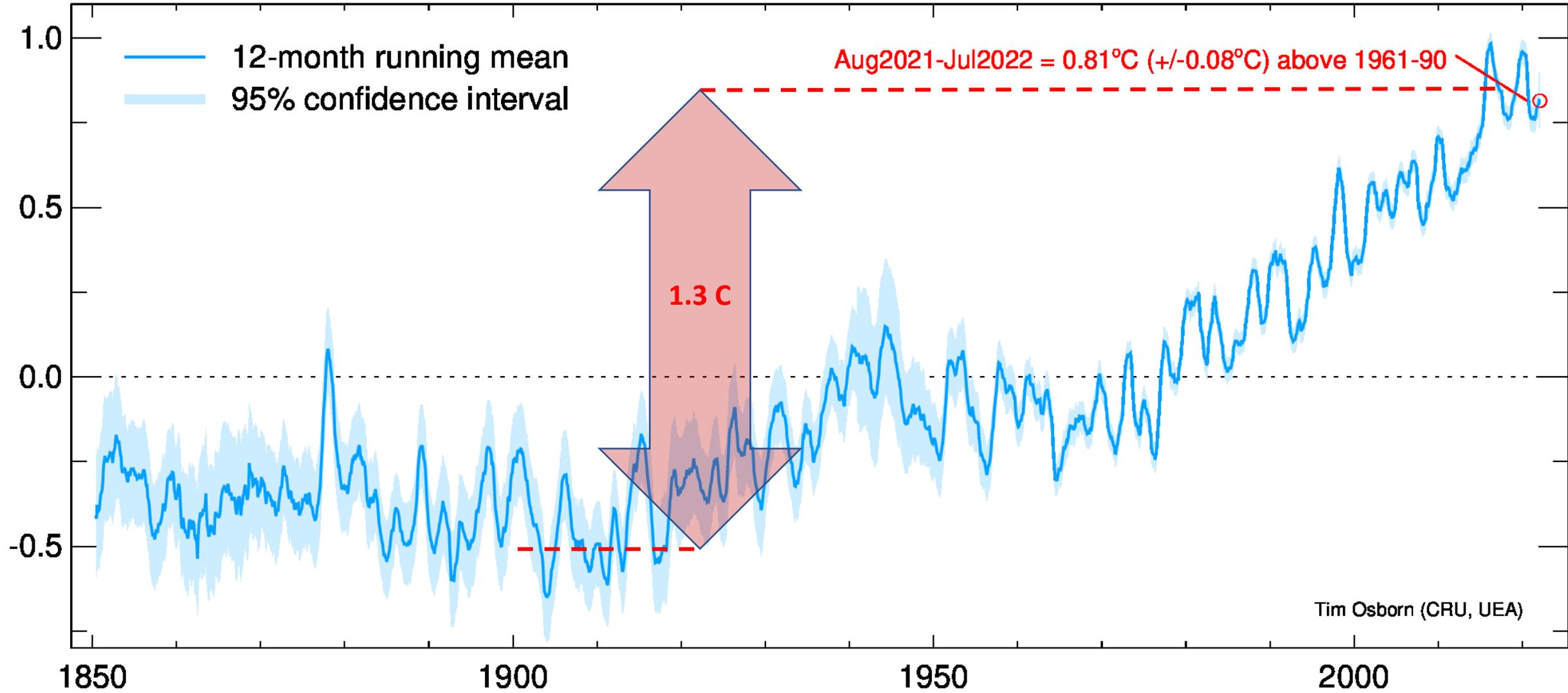
### IPCC AR5 WG2 Chapter 10:

*For most economic sectors, **the impact of climate change will be small relative to the impacts of other drivers** (medium evidence, high agreement). Changes in population, age, income, technology, relative prices, lifestyle, regulation, governance, and many other aspects of socioeconomic development will have an impact on the supply and demand of economic goods and services that is large relative to the impact of climate change.*

### AR6 WG2 Chapter 16 (pg. 2497):

*The wide range of estimates, and the lack of comparability between methodologies, does not allow for identification of a robust range of estimates with confidence (high confidence)...However, **the existence of higher estimates than AR5 indicate that global aggregate economic impacts could be higher than previously estimated** (low confidence due to the lack of comparability across methodologies and robustness of estimates).*

# HadCRUT5 Analysis global temperature



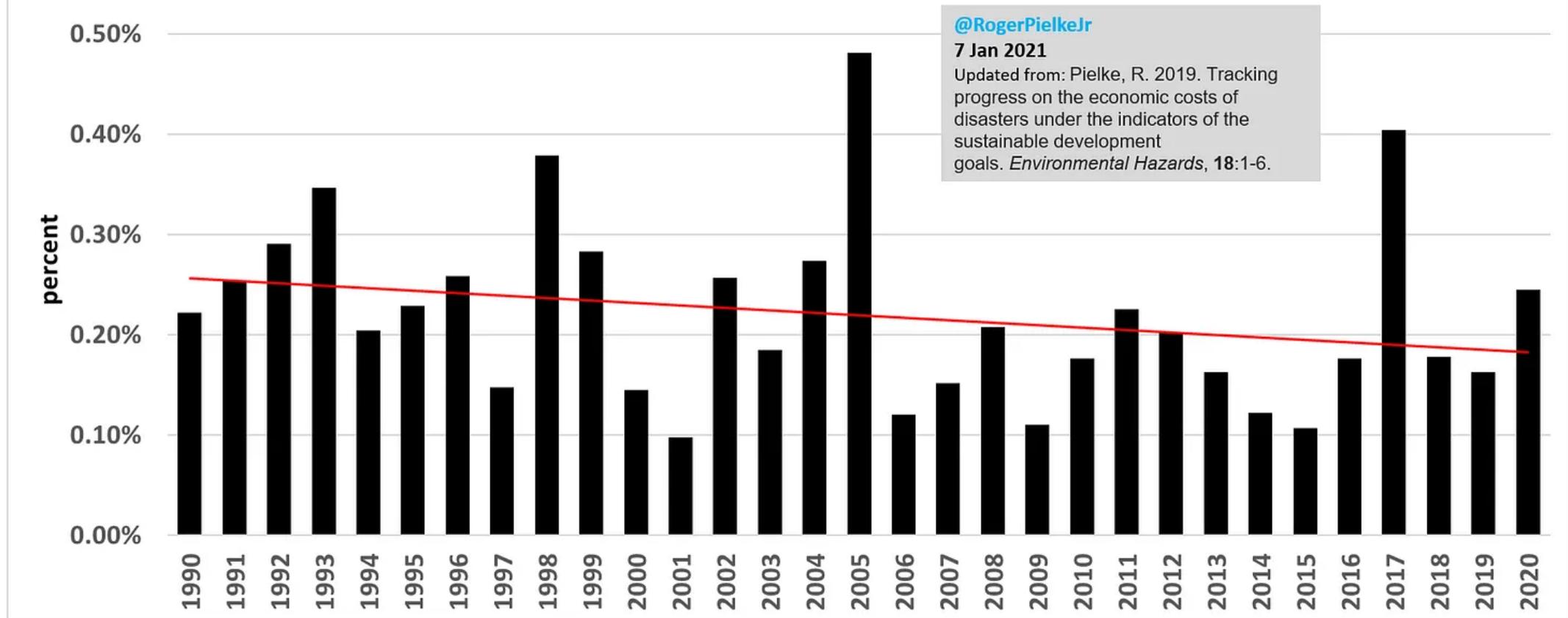
<https://crudata.uea.ac.uk/~timo/diag/tempdiag.htm>

# Humanity has prospered since 1900 despite 1.3C warming

| Indicator                          | Change                | Unit               | “1900”       | “Today”       |
|------------------------------------|-----------------------|--------------------|--------------|---------------|
| <a href="#">Global temperature</a> | <b>1.3 warmer</b>     | degrees C          | -0.5 (1905)  | +0.8 (2022)   |
| <a href="#">Population</a>         | <b>5X larger</b>      | Billions           | 1.65 (1900)  | 8.0 (2022)    |
| <a href="#">Life expectancy</a>    | <b>130% longer</b>    | Years              | 32 (1900)    | 72.6 (2019)   |
| <a href="#">Literacy fraction</a>  | <b>4X larger</b>      | percent            | 21.4 (1900)  | 86.25 (2016)  |
| <a href="#">GDP per capita</a>     | <b>6.8X larger</b>    | \$2011             | 2,241 (1920) | 15,212 (2018) |
| <a href="#">Food production</a>    | <b>34% greater</b>    | kcal/cap/day       | 2,192 (1900) | 2,928 (2018)  |
| <a href="#">Extreme poverty</a>    | <b>&gt;7X smaller</b> | Percent (<\$1/day) | 70 (1900)    | <10 (2015)    |
| <a href="#">Weather death rate</a> | <b>50X smaller</b>    | per million        | 241 (1920)   | 5 (2008)      |

## Global Weather Losses as Percent of Global GDP: 1990-2020

(Sources: Munich Re, World Bank)

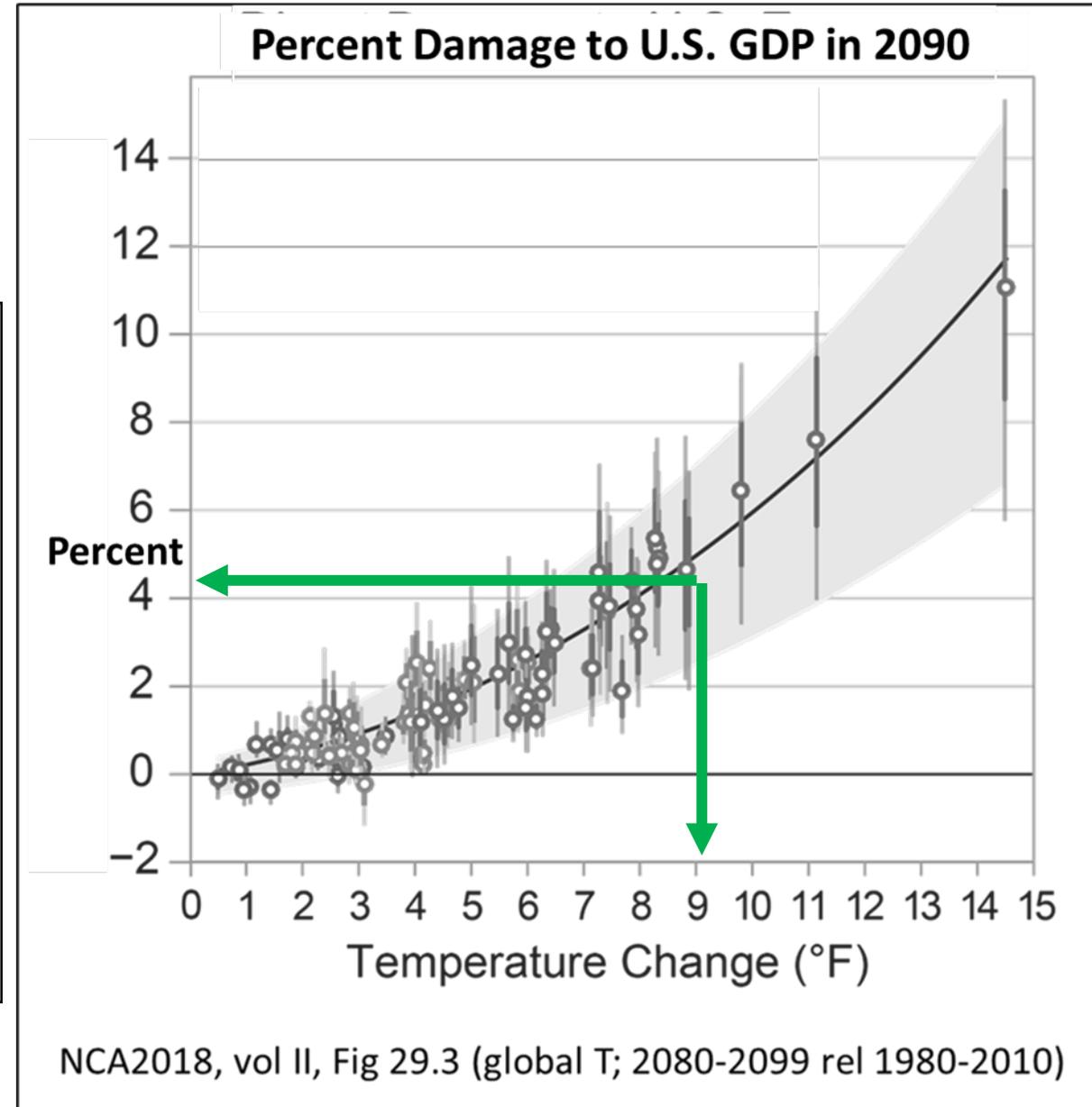
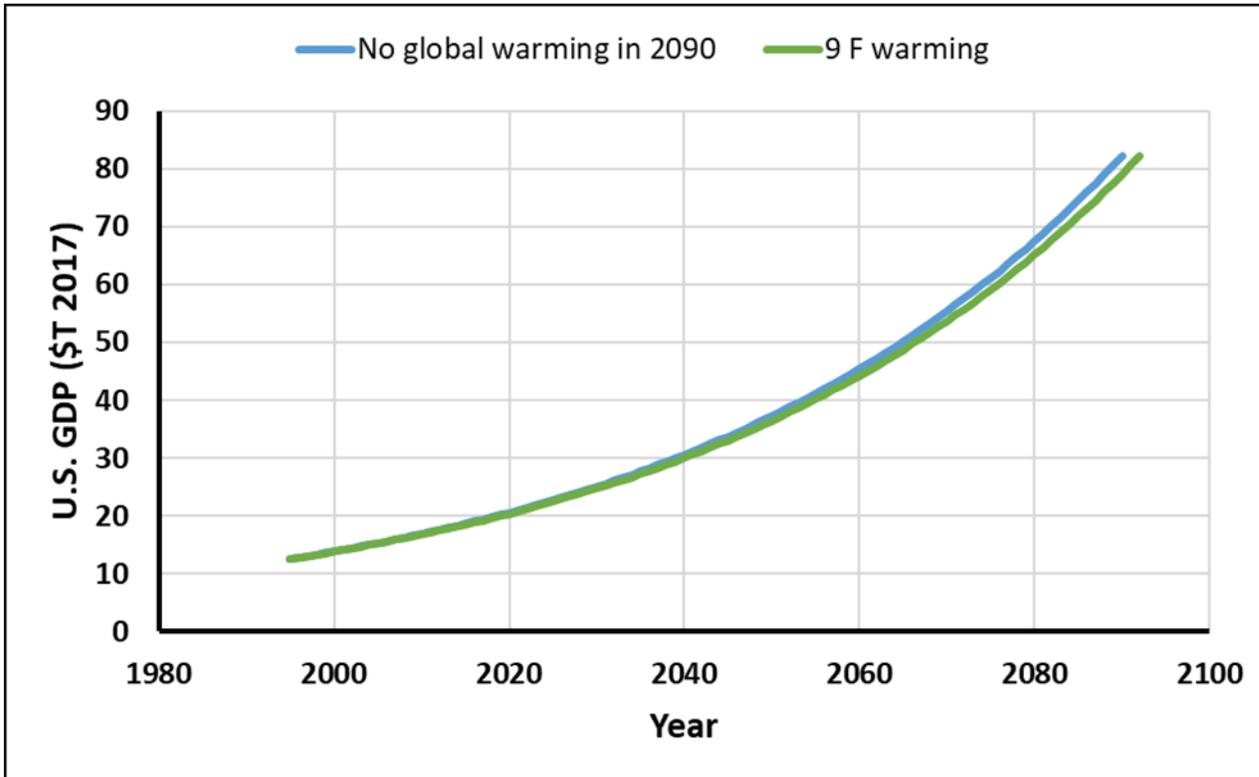


<https://rogerpielkejr.substack.com/p/global-disasters-a-remarkable-story>

... global average mortality and economic **loss rates that have dropped by 6.5 and nearly 5 times**, respectively, from 1980–1989 to 2007–2016.

- [Formetta and Feyen \(2019\)](#), *Empirical evidence of declining global vulnerability to climate-related hazards*

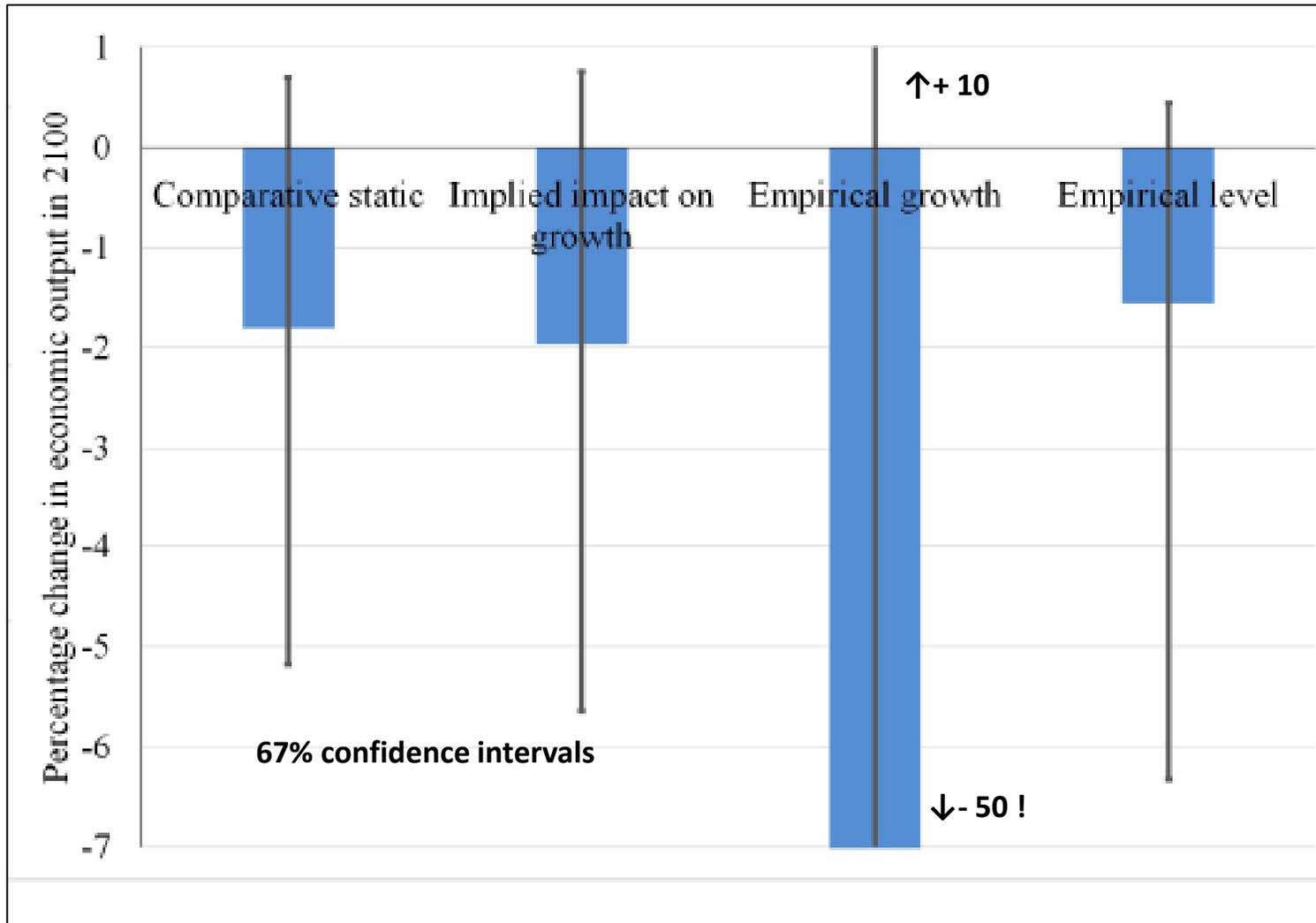
# Projected economic damage in 2100



NCA2018, vol II, Fig 29.3 (global T; 2080-2099 rel 1980-2010)

# Global economic impact of 4.3 C warming by 2100

[Tol \(2022\)](#)

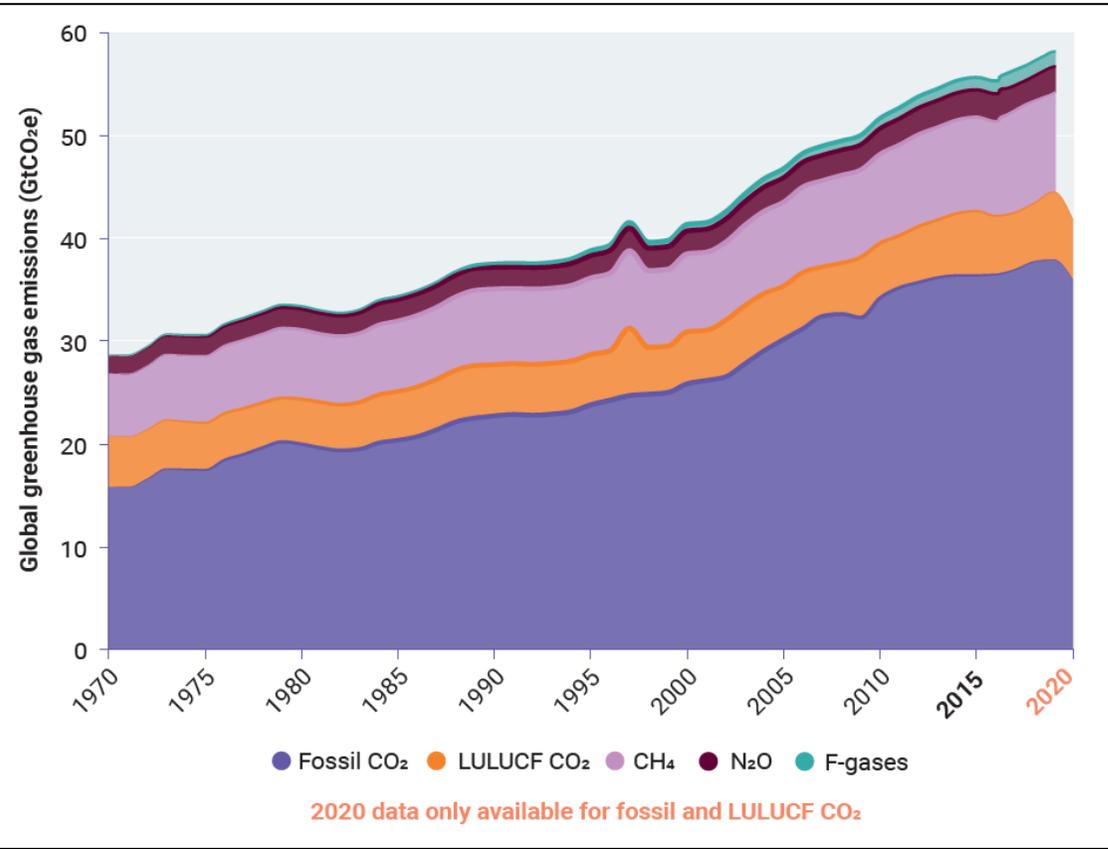


- [Lomborg 2020](#) notes the outliers are implausible
  - Iceland becomes 30 times richer than today
  - Mongolia 200 times richer than today, 4X richer per person than the US (!)
- There is good reason to discard the outliers [[Newell et al. \(2021\)](#)]
  - Extrapolates GDP growth rate rather than level
- Why doesn't AR6 WG2 discard outlier models as WG1 does for GCMs?

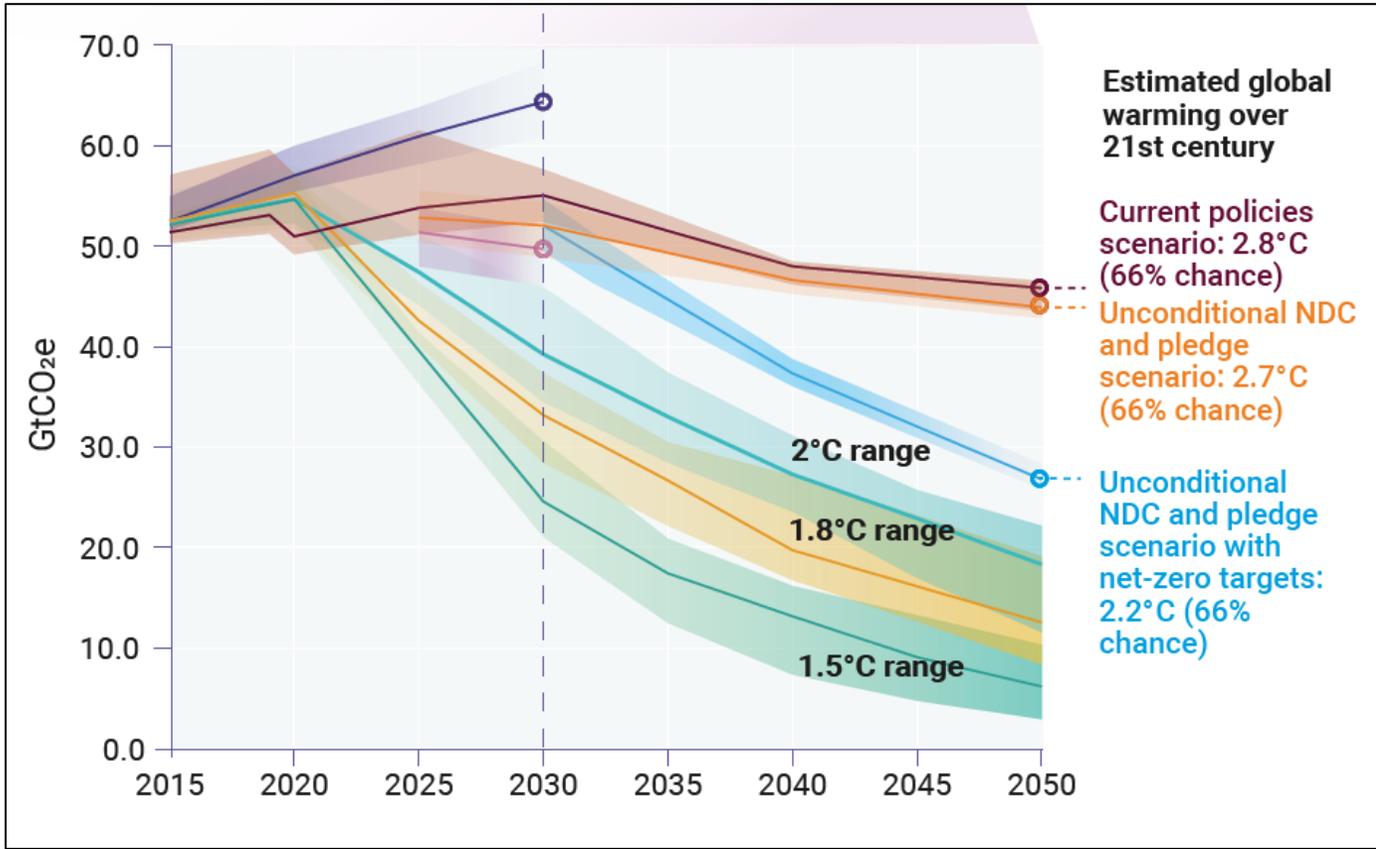
Response to a changing climate

# Net Zero by 2050

“to avoid the worst effects of climate change”



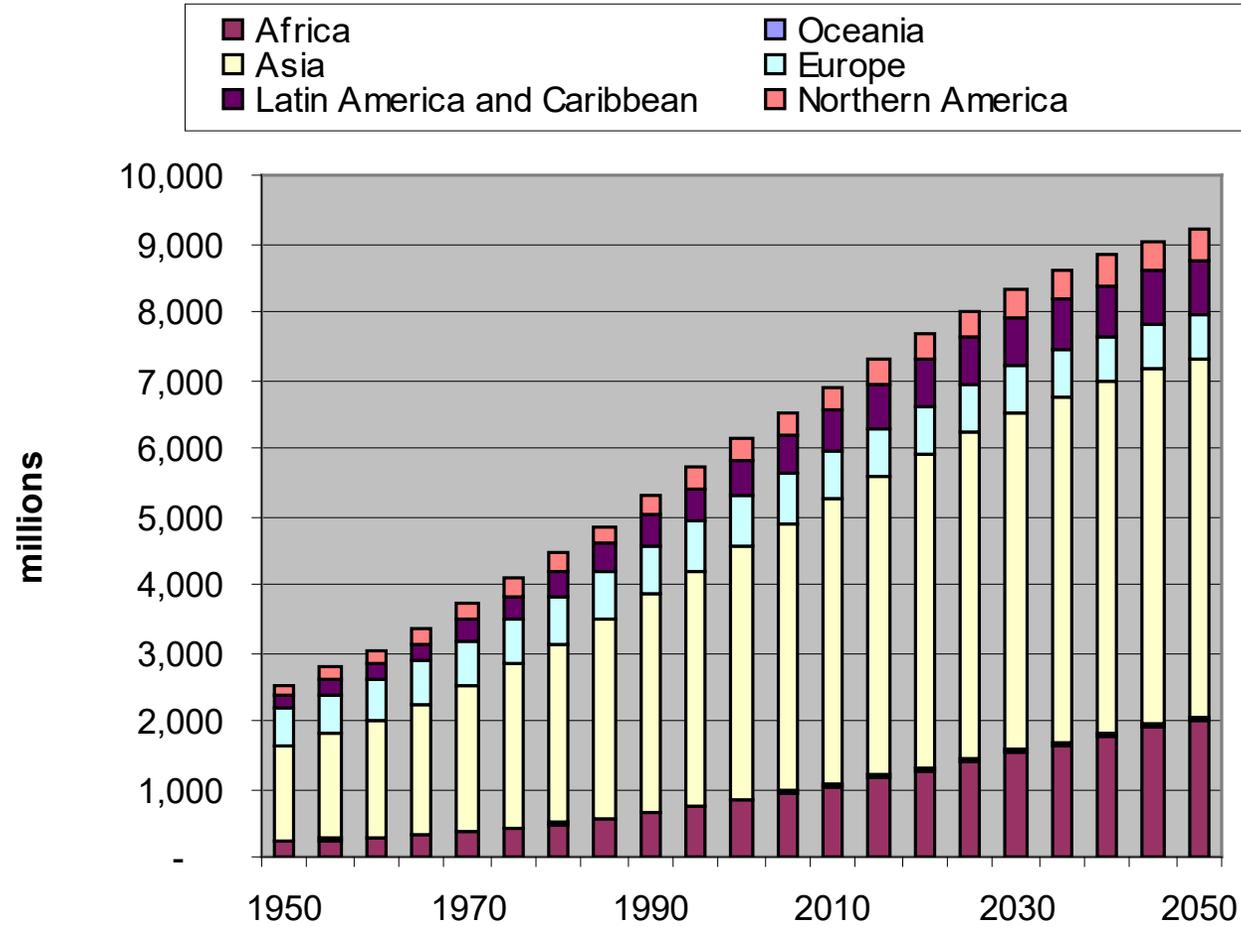
UN EGR21, Figure ES.1



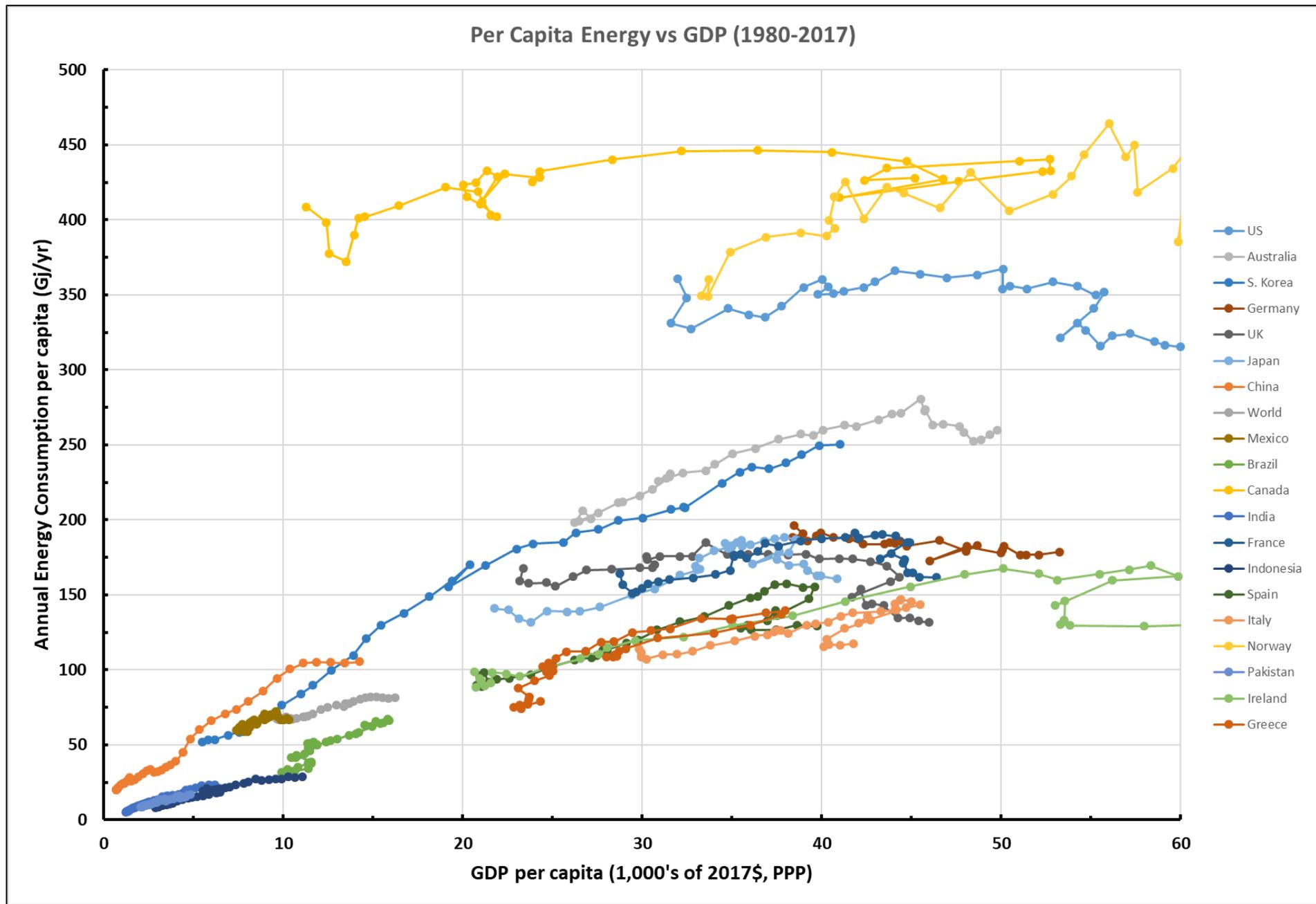
UN EGR21, Figure ES.6

Are large and rapid reductions desirable?

### World population to 2050 - UN data



- “Older” Developed World, “Younger” Developing World
- Urbanization (50M per year; 50% to 70% urban)



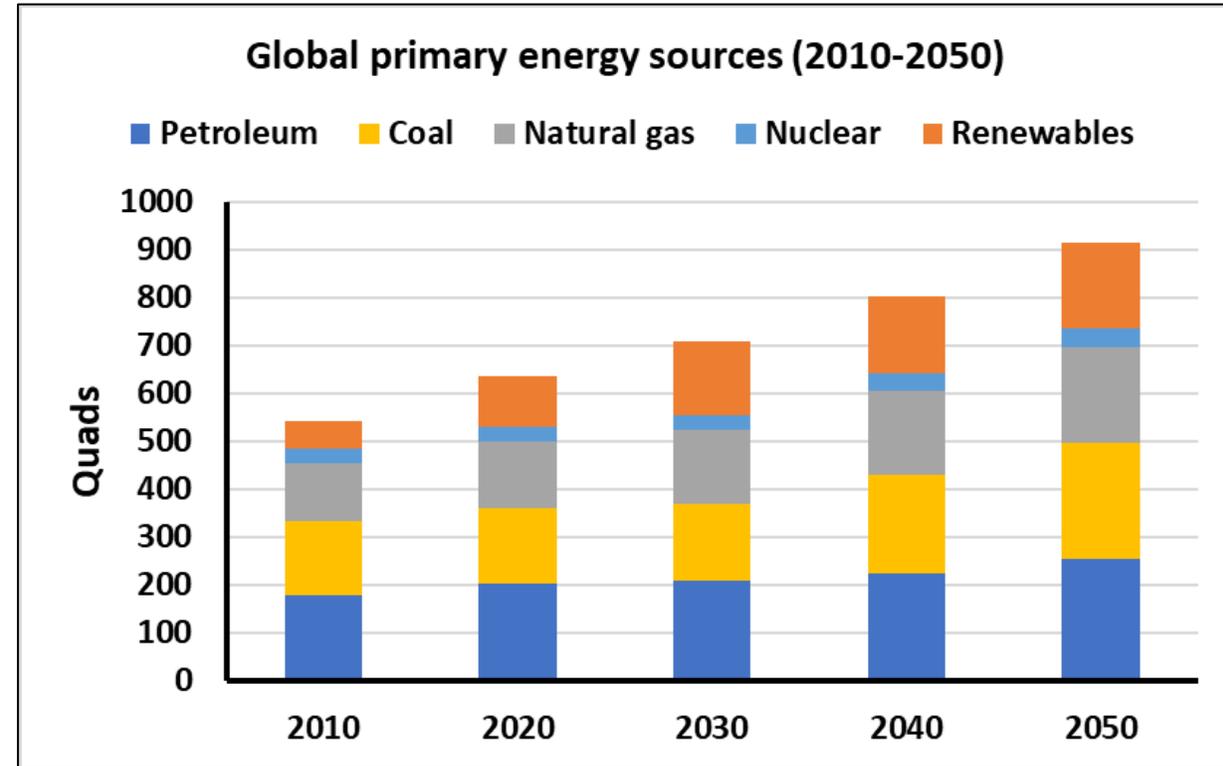
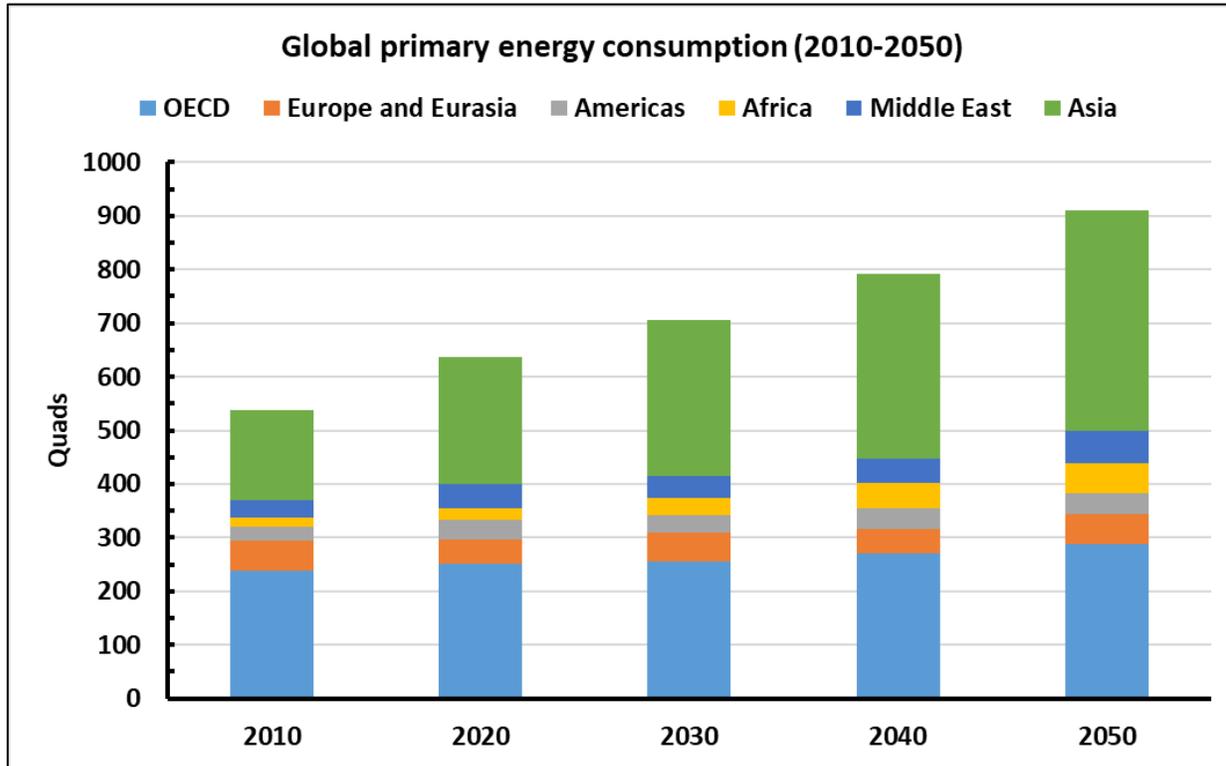
# Energy poverty



- **US per capita energy consumption is 30X that of Nigeria**
- **3B people use less electricity per year than the average US refrigerator**

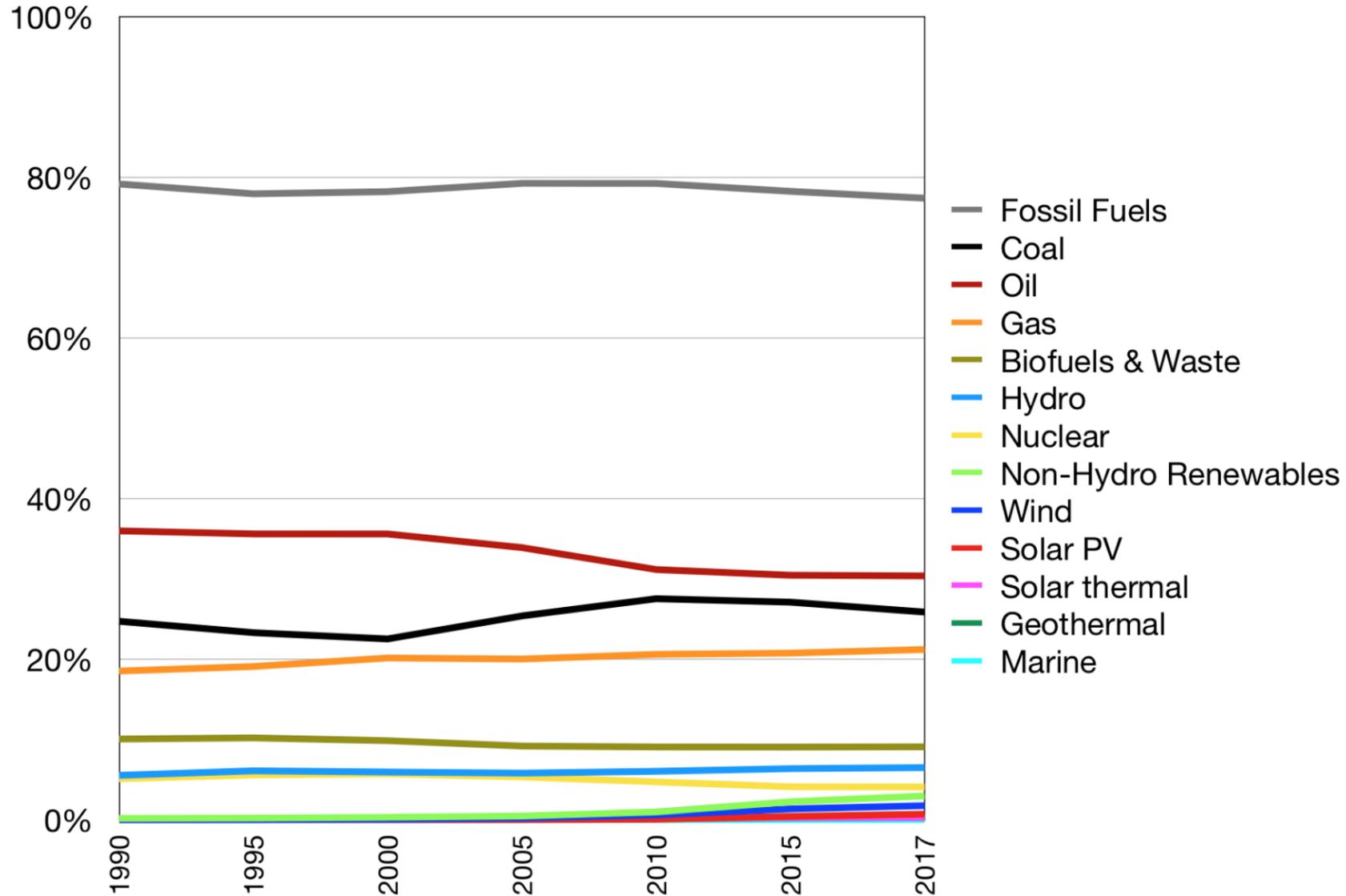
# Projected energy consumption and sources

Assumes current policies



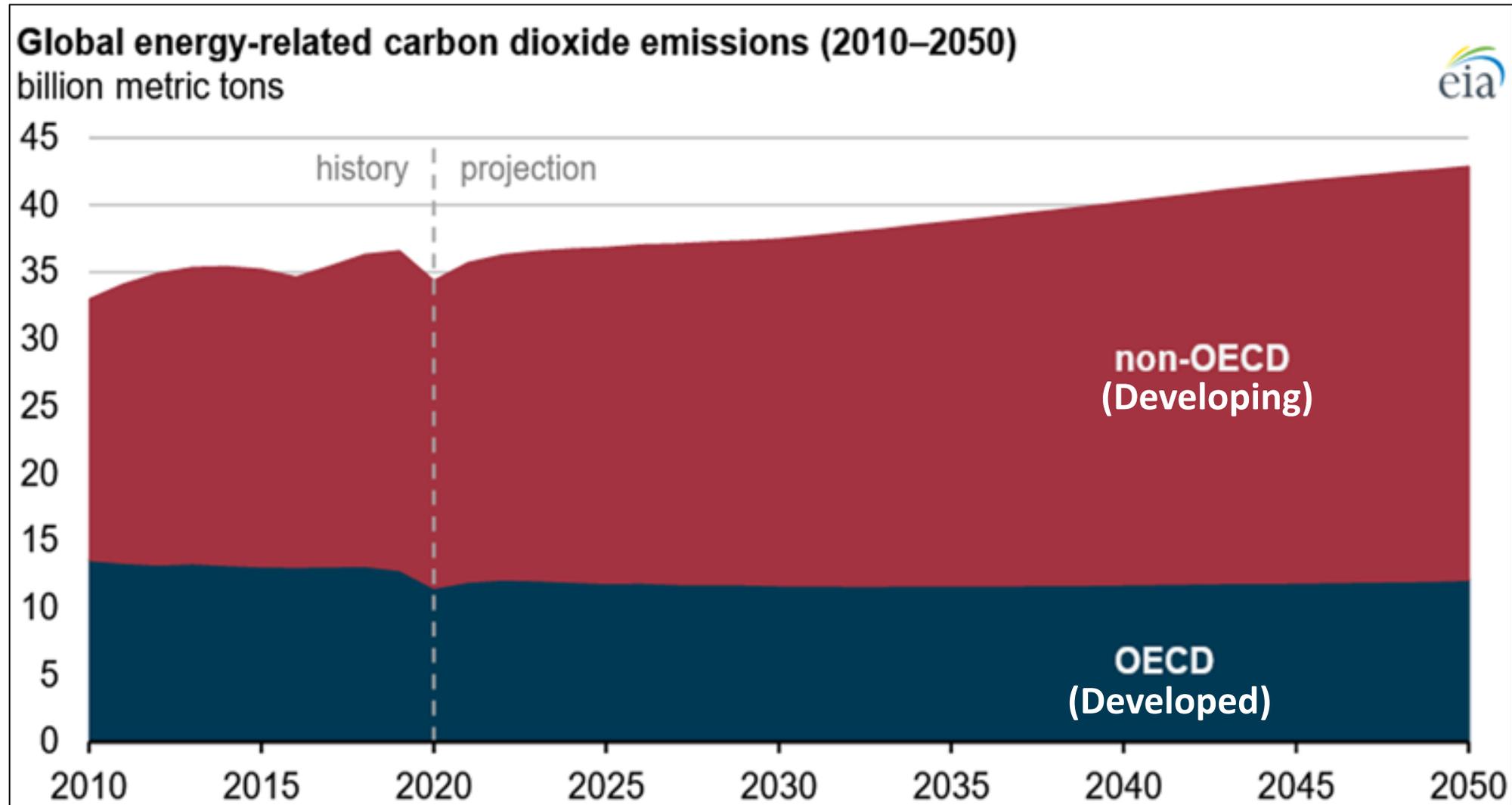
# Fossil fuels have remained predominant recently

Global energy by fuel type (1990-2017)



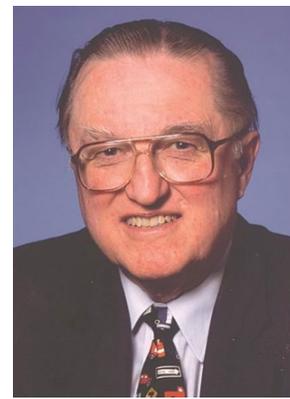
# Developing world drives increased emissions

<https://www.eia.gov/energyexplained/energy-and-the-environment/outlook-for-future-emissions.php>



*The elite's environmental deterioration is often the common man's improved standard of living*

- [Up and Down with Ecology \(1972\)](#)



Anthony Downs  
(1930-2021)

“science compels us ....” → “What do you mean ‘us’”?!

Indian PM Narendra Modi ([11/21](#)):

*The **colonial mindset** hasn't gone. We are seeing from developed nations that **the path that made them developed is being closed for developing nations***



Nigerien President Mohamed Bazoum ([6/22](#)):

*Africa is being **punished by the decisions of Western countries to end public financing for foreign fossil-fuel projects by the end of 2022...We are going to continue to fight, we have fossil fuels that should be exploited.***



# Climate alarm robs youth of their optimism



<https://www.telegraph.co.uk/global-health/climate-and-people/eco-anxiety-fear-environmental-doom-overcome/>

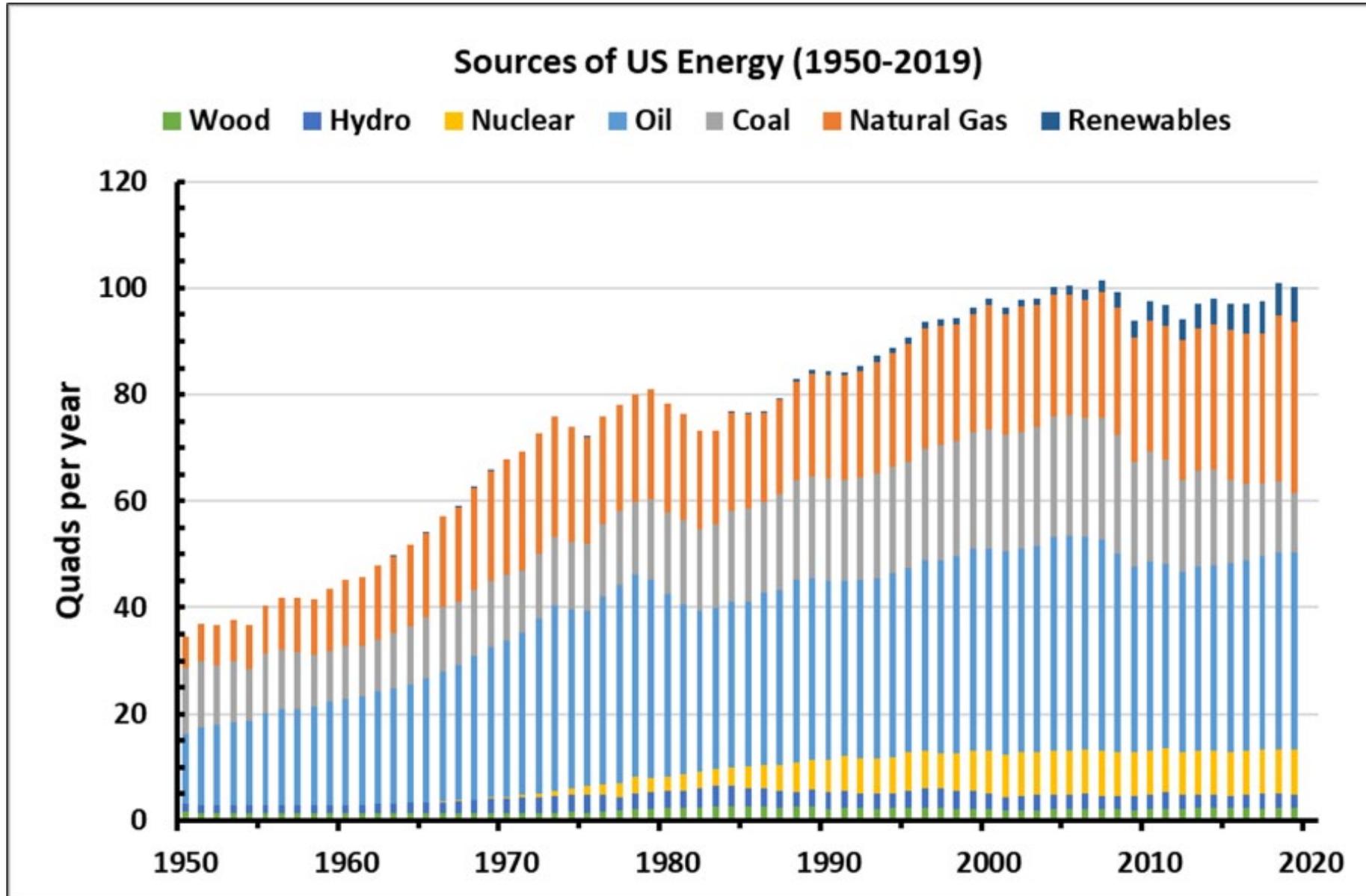


*We're getting handed a piece-of-shit planet, and I refuse to hand that down to my child. Until I feel like my kid would live on an earth with fish in the water, I'm not bringing in another person to deal with that.*

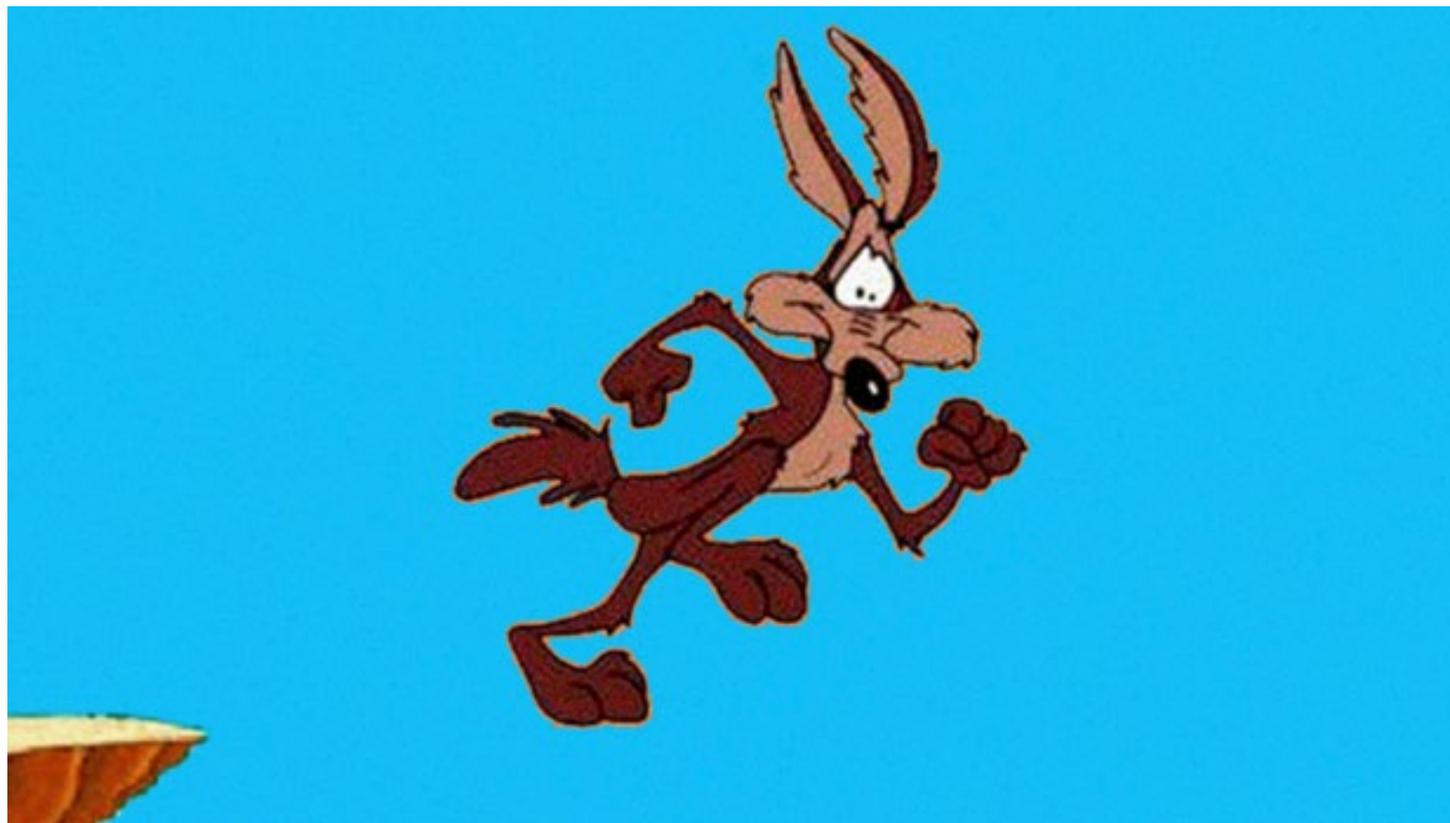
- [Miley Cyrus \(2019\)](#)

Are large and rapid reductions possible?

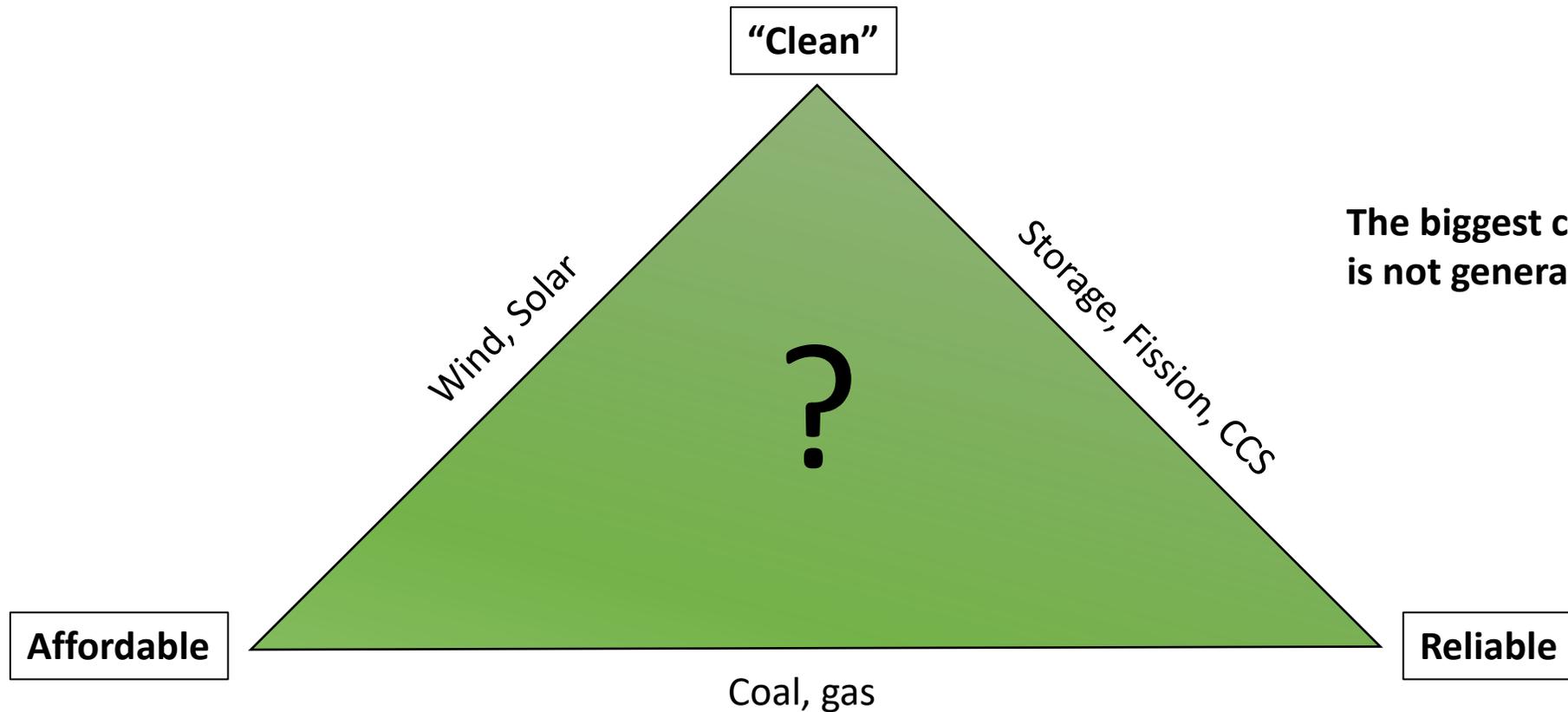
# Energy systems evolve over decades



Toward an all-renewable, all-electric world



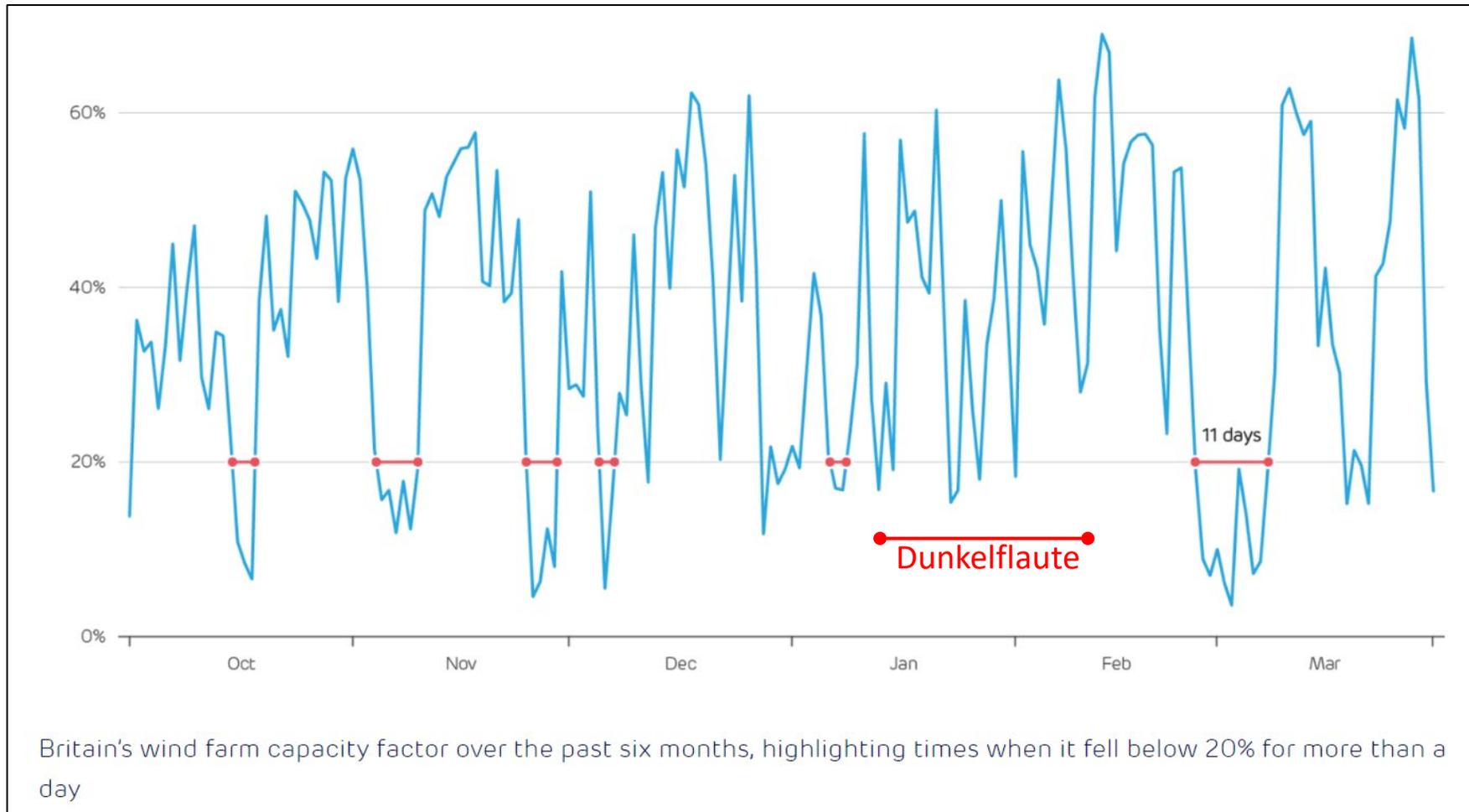
# The Electrical Grid's Troubled Triangle



**The biggest cost of a green grid is not generation, but reliability.**

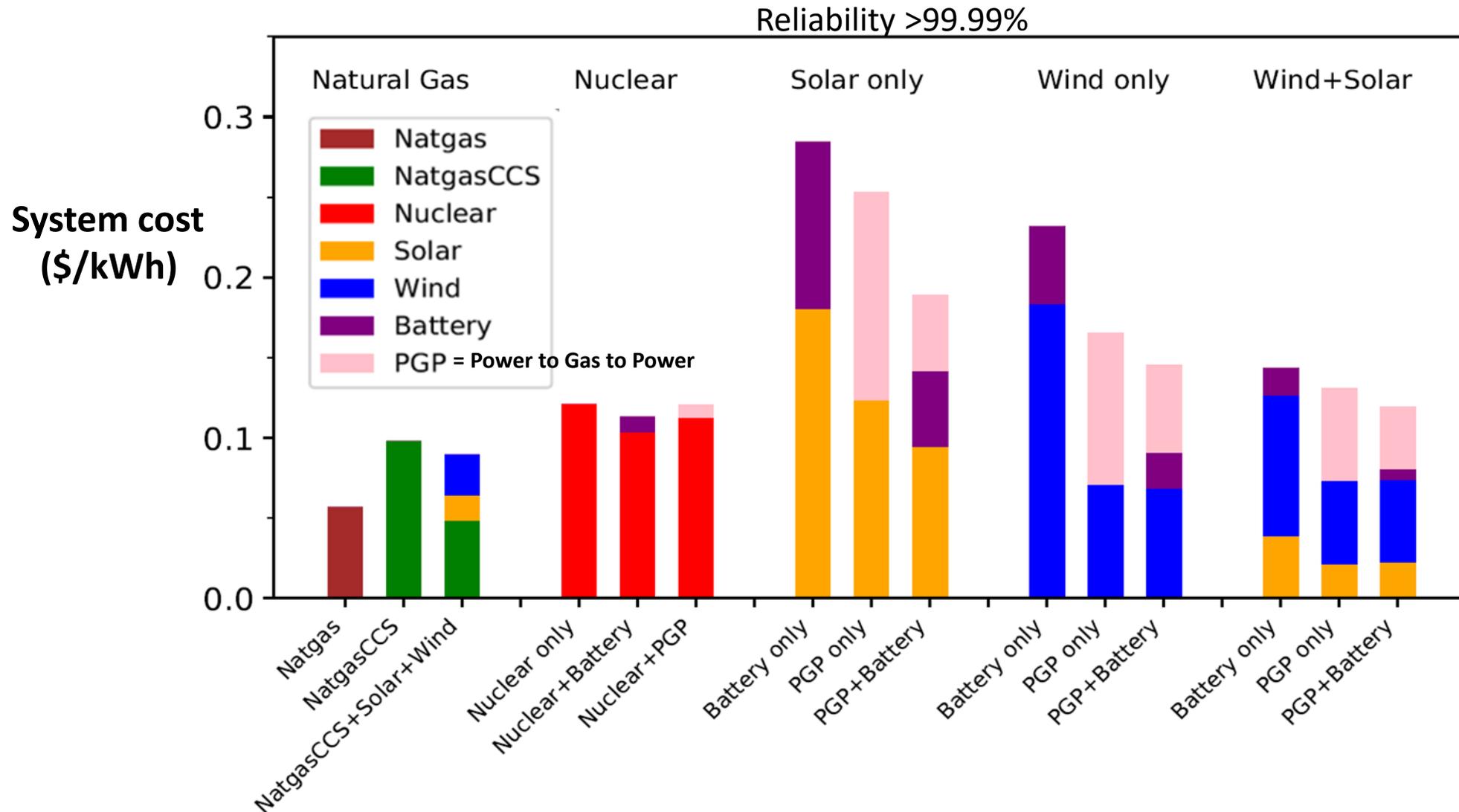
# Daily wind generation in the UK (2020-21)

<https://reports.electricinsights.co.uk/q1-2021/when-the-wind-goes-gas-fills-in-the-gap/>

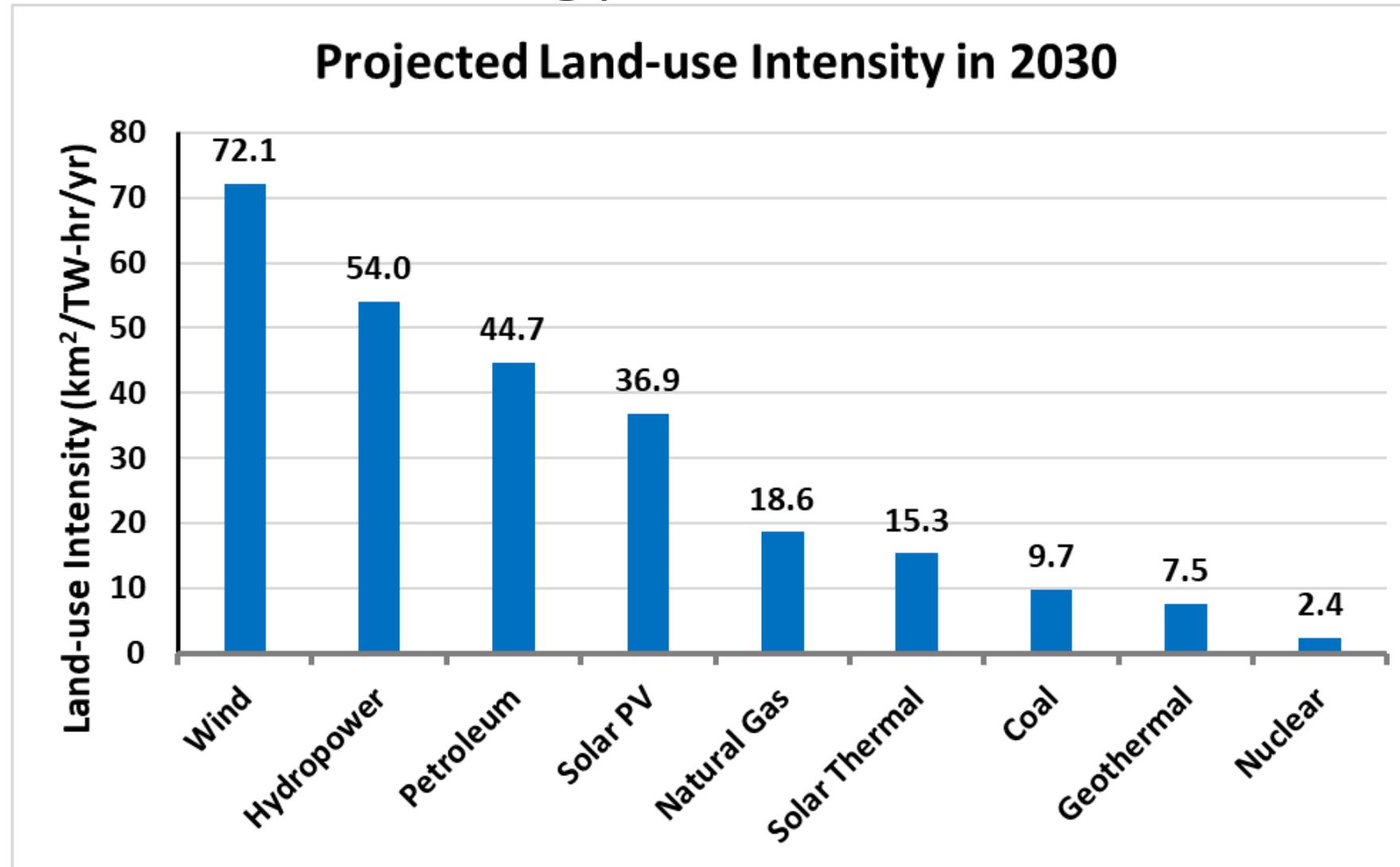


# Reliable renewable grids are very expensive

[Dowling, Caldeira, and Lewis \(2020\)](#) and related papers



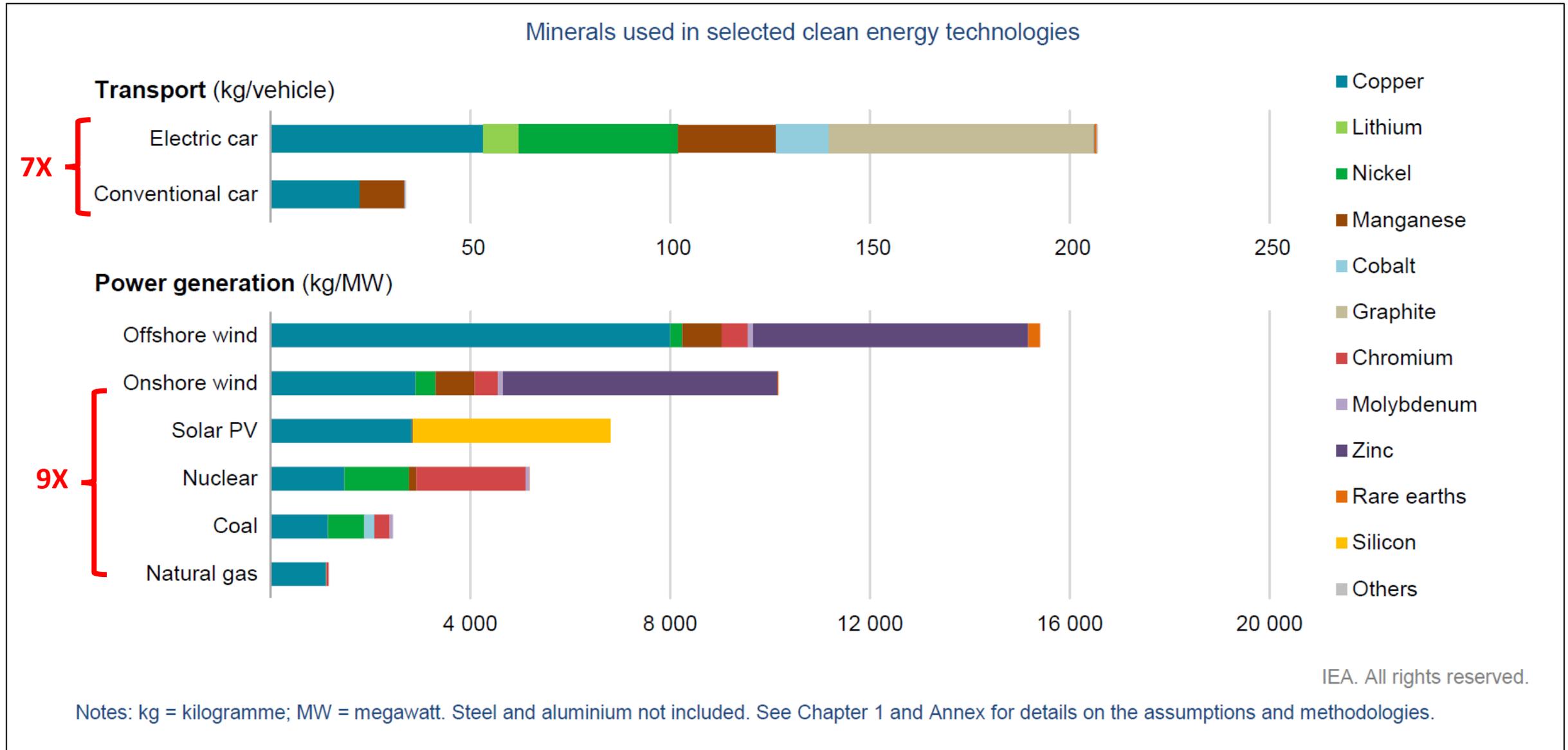
# Renewable energy is land-intensive



<https://www.globalchange.gov/browse/multimedia/projected-land-use-intensity-2030>

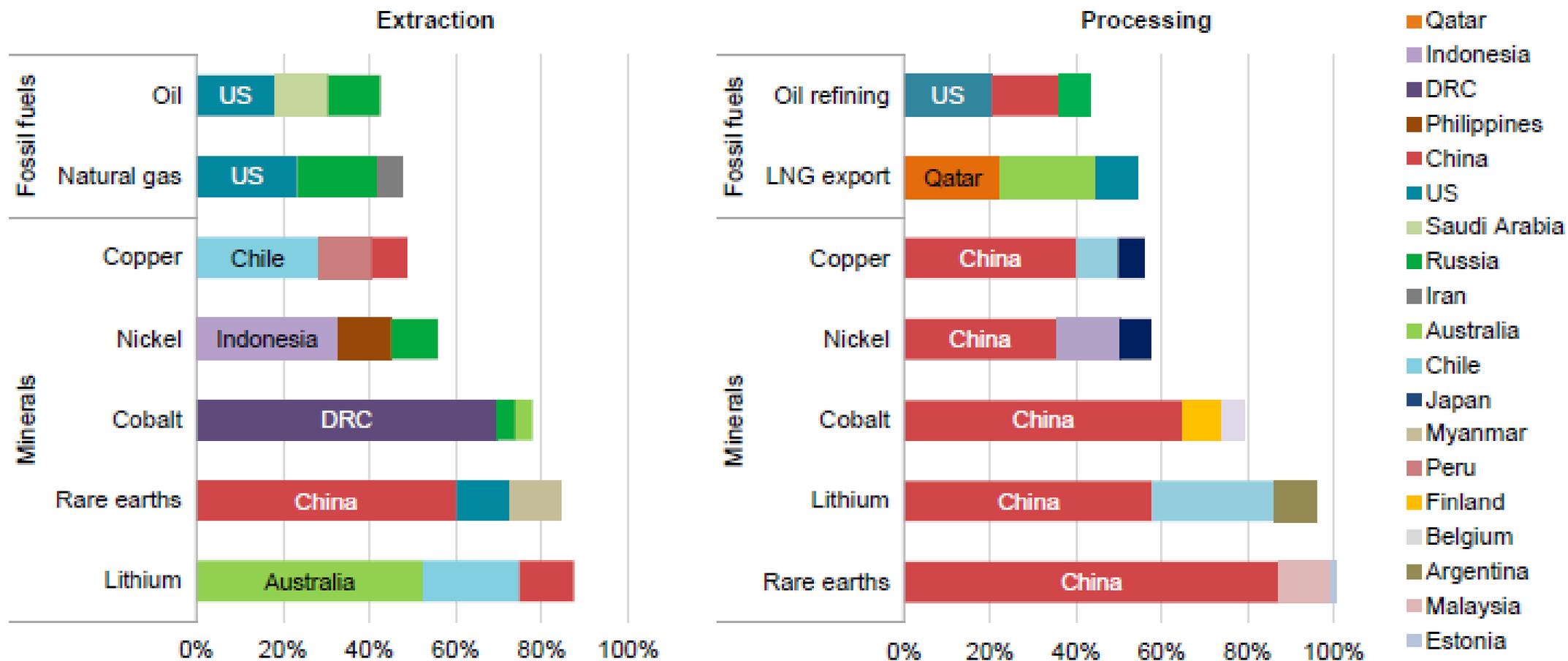
# Modern energy technologies use more high-value materials

<https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions>



## Production of many energy transition minerals today is more geographically concentrated than that of oil or natural gas

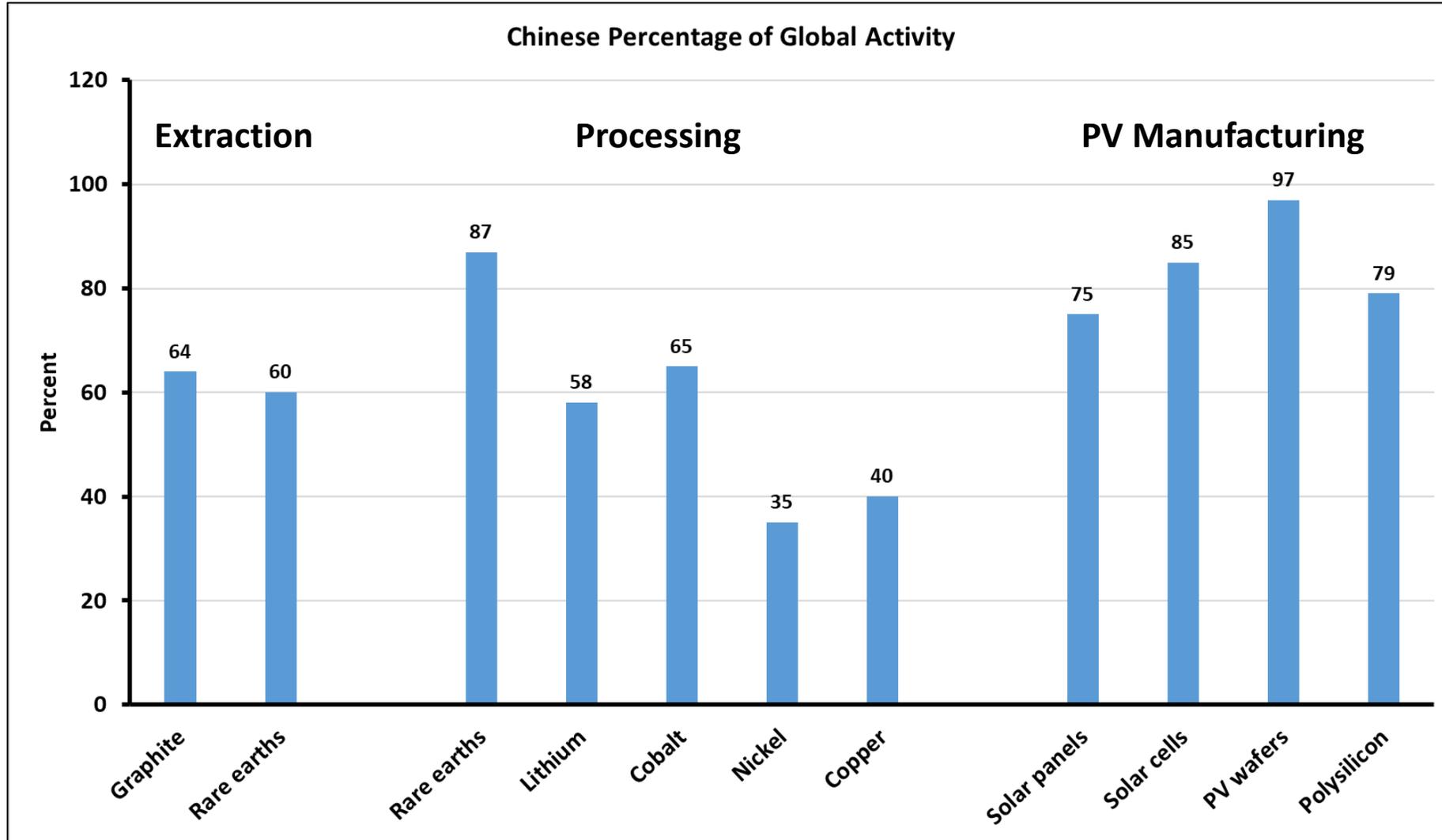
Share of top three producing countries in production of selected minerals and fossil fuels, 2019



IEA. All rights reserved.

# China is a major player in critical materials and PV manufacturing

<https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions>



# Adaptation will be the dominant response

- It is **agnostic**
  - indifferent to natural vs human-caused changes
- It is **proportional**
  - adapt more if the change is greater
- It is **local**
  - politically palatable as spending is “here and now”
  - does not require global consensus
- It is **autonomous**
  - It will happen on its own
- It is **effective**

# Lessons from the crisis in Sri Lanka



**The farrago of magical thinking, technocratic hubris, ideological delusion, self-dealing, and sheer shortsightedness that produced the crisis in Sri Lanka implicates both the country's political leadership and advocates of so-called sustainable agriculture**

– T Nordhaus and S Shah, [Foreign Policy 03/22](#)

*Precipitous emissions reductions are far more dangerous than climate change itself*

# We must not “Gruberize” climate science

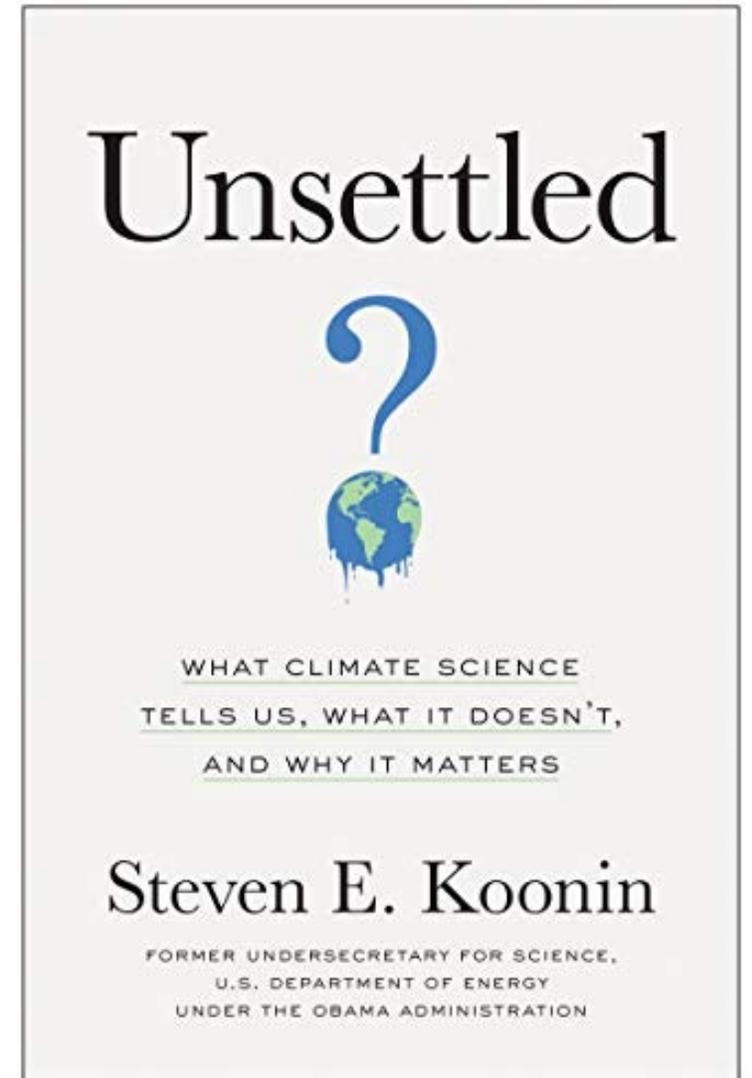


*“Lack of transparency is a huge political advantage. It was really, really critical to getting the [ACA] passed. [At least one key provision was a] very clever **basic exploitation of the lack of economic understanding of the American voter.**”*

- J. Gruber, MIT (November, 2014)

## Misrepresenting the science to persuade rather than inform

- Usurps the right of the public to make fully-informed decisions
- Distracts from more urgent needs
- Tarnishes science inputs to other important policy matters
- Depresses young people



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# Koonin's recommended course forward

- Cancel the “climate crisis”, but acknowledge the task/challenge of reducing human influences
  - Better representations of the science/technologies to non-experts (“red team” reviews)
  - Energy and climate literacy for the public and decision makers
- Better observations and understanding of the climate
- Do not constrain the Developing World's energy supply, nor the development of fossil fuel resources
- A greater focus on adaptation (framework, costs)
  - Promote development and resilience in developing countries
- Develop and demonstrate emissions-lite technology
  - Fission, grid storage and management, batteries, non-carbon chemical fuels, ...
- Formulate graceful decarbonization pathways that incorporate technology, economics, regulation, behavior
  - Implement as necessary

# Comments? Questions?

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