

Climate Uncertainty: The Coolest Year for the Rest of Our Lives?

with Zeke Hausfather | Episode 236

Show Notes and Links to Learn More

The TGS team puts together these brief references and show notes for the learning and convenience of our listeners. However, most of the points made in episodes hold more nuance than one link can address, and we encourage you to dig deeper into any of these topics and come to your own informed conclusions.

Guest:

[Zeke Hausfather: Works](#)

Grab-and-Go Resources:

New? Start here:

- [The Great Simplification \(32-minute film\)](#)
- [How to Think About the Future, Part 1 \(Frankly #138\)](#)

From the Archive:

- [Ep 105: Leon Simons, Aerosol Demasking & Global Heating](#)
- [Ep 219: Tad Patzek, Why Each American Lives Like a 40-Ton Whale](#)
- [Ep 134: Johan Rockström, Planetary Boundaries](#)

Episode Foundations:

- [The Climate Brink Dashboard](#) by Zeke
- [CMIP7 scenarios for the Seventh Assessment Report \(ScenarioMIP\)](#)
- [Recent strengthening of eastern Pacific ENSO in the last millennium paleorecord](#)
- [The real energy use of agentic AI](#)

Next Steps:

- [NOAA Climate Prediction Center ENSO diagnostic discussion](#)
- [Rewiring America home electrification planner](#)
- [Citizens' Climate Lobby](#)

Resources by Timestamp:

- 02:35 - [Efficiency 2.0, PhD in energy and resources](#)
- 02:47 - [Berkeley Earth, Stripe Climate, Frontier, The Climate Brink, Carbon Brief](#)
- 03:06 - [Lead author, chapter two of the IPCC Seventh Assessment Report](#)
- 03:39 - [Research-to-deployment gap in climate solutions](#)
- 04:21 - [Human macroecology as a lens on the climate predicament](#)

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- 04:50 – [Persistence of behavior change from home energy reports](#)
- 05:10 – [Set-and-forget efficiency: LED bulbs](#), [Efficient appliances](#), [Electric vehicles](#)
- 05:55 – [Social norms and peer pressure as drivers of energy behavior](#)
- 06:12 – [Zeke's Climate Dashboard](#), [Global heating updates, histories, and projections](#)
- 06:39 – [Calculating global mean surface temperature](#), [Sea surface temperature from ship bucket measurements](#), [Evaporative cooling bias from deck height](#)
- 07:26 – [*No substantial Antarctic station network before the 1957–1958 International Geophysical Year](#), [Kriging for spatial gaps](#)
- 07:50 – [Independent global surface temperature datasets](#), [Berkeley Earth temperature record](#)
- 08:21 – [Wider spread between records in the 19th century from sparse sampling](#)
- 08:37 – [1.44 C of warming in 2025 relative to 1850–1900](#)
- 08:43 – [Proposed multi-dataset temperature ensemble for IPCC AR7](#), [10,000-member global mean surface temperature ensemble](#), [Peter Thorne](#)
- 09:52 – [Intergovernmental Panel on Climate Change \(IPCC\)](#), [Seventh Assessment Report](#)
- 10:06 – [Three IPCC working groups](#)
- 10:29 – [IPCC is policy-relevant but not policy-prescriptive](#)
- 10:45 – [AR6 Working Group I assessed more than 14,000 scientific papers](#)
- 10:58 – [Is global warming accelerating](#), [Have we passed 1.5 C](#), [Climate sensitivity](#), [Plausible future warming pathways](#)
- 12:04 – [IPCC shifting toward adaptation as well as mitigation](#)
- 12:28 – [Working Group I: physical science basis](#), [Working Group II: impacts and adaptation](#), [Working Group III: mitigation](#)
- 13:13 – [Nate's Frankly series on scenario planning for Earth social systems](#)
- 13:30 – [Representative Concentration Pathways \(RCPs\)](#), [Shared Socioeconomic Pathways \(SSPs\)](#)
- 14:12 – [Scenario choice as ~54% of the uncertainty in end-of-century warming](#)
- 14:27 – [Future coal demand](#), [Solar and renewable cost declines](#), [Carbon pricing](#)
- 15:01 – [IS92 scenarios \(1992\)](#), [SRES scenarios \(2000\)](#)
- 15:24 – [CMIP7 scenarios released for the Seventh Assessment Report](#)
- 16:10 – [Backcasting emission pathways from an end-of-century temperature target](#)
- 16:53 – [RCP8.5, RCP6.0, RCP4.5 and RCP2.6](#), [Radiative forcing in 2100, in watts per square meter](#)
- 17:27 – [New scenario names: high, medium, low and very low](#)
- 17:55 – [Forcings versus feedbacks](#)
- 18:41 – [Emission scenarios extended to 2150](#)
- 19:13 – [Ocean acidification](#), [Carbonate and bicarbonate partitioning](#)
- 19:28 – [CO2 fertilization of plant growth](#), [Wildfire, drought and drier soils releasing carbon](#)
- 19:55 – [Carbon cycle feedbacks](#)
- 20:09 – [Climate models moving from prescribed concentrations to a dynamic carbon cycle](#)
- 21:12 – [Cloud feedback](#), [Water vapor feedback](#), [Snow and ice albedo feedback](#)
- 21:25 – [Equilibrium climate sensitivity assessed at 2.6 to 3.9 C \(66% range\)](#)

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- 21:34 - [Very likely range of 2 to 5 C with a best estimate of 3 C](#)
- 22:08 - [Equilibrium climate sensitivity, Transient climate response, Earth system sensitivity](#)
- 22:32 - [*Transient response at CO2 doubling, averaged over 20 years centered on doubling; equilibrium response after the climate system equilibrates](#)
- 23:18 - [Doubling CO2 from a pre-industrial 280 ppm to 560 ppm](#)
- 24:29 - [Ice sheet loss exposing darker surfaces over millennia](#)
- 24:53 - [Oceans storing an estimated 91% of the excess heat trapped in the climate system](#)
- 25:05 - [Zero emissions commitment: a 50-year multi-model mean of -0.07 C after emissions cease](#)
- 25:30 - [Carbon dioxide removal, Climate engineering](#)
- 25:49 - [Strong El Niño and the 2026-2027 temperature outlook](#)
- 26:25 - [Three to five month lag between El Niño peak and peak global temperature, 1997-1998, 2015-2016 and 2023-2024 El Niño analogues](#)
- 27:30 - [*2027 forecast around 1.71 C above pre-industrial, against a 1.5 C record](#)
- 28:02 - [Strong El Niño as a preview of average global temperatures a decade from now](#)
- 28:19 - [A very strong El Niño adding up to 0.2 C to the following year's global temperature](#)
- 28:27 - [Human-induced warming rising 0.27 C per decade over 2016-2025](#)
- 28:43 - [SSP3 regional rivalry as the scenario that feels close to home](#)
- 28:57 - [SSP1 sustainability, SSP2 middle of the road, SSP4 inequality, SSP5 fossil-fueled development](#)
- 29:31 - [Resurgent nationalism, weakened cooperation and regional conflict, Adaptive capacity](#)
- 30:11 - [Persistent poverty in sub-Saharan Africa limiting adaptation](#)
- 30:33 - [*CMIP7 high scenario reaching 55 gigatons of CO2 a year in 2100](#)
- 30:57 - [Global fossil CO2 emissions up 31% from 2001 to 2010, 25 to 33 gigatons](#)
- 31:21 - [RCP8.5 and SSP5-8.5 as implausible high-emission baselines](#)
- 32:00 - [Embodied energy in wind and solar infrastructure, Rebuildables](#)
- 32:16 - [*Global solar generation up from 256 TWh in 2015 to 2,778 TWh in 2025, Fossil fuel consumption over the long run](#)
- 32:56 - [Global coal demand at a record 8.85 billion tonnes in 2025, plateauing to 2030](#)
- 33:25 - [Close to 30% of cars sold globally in 2026 set to be electric](#)
- 33:37 - [Middle East conflict raising oil prices](#)
- 33:51 - [Wind and solar out-generating gas worldwide for the first time in April 2026](#)
- 34:11 - [Fossil CO2 emissions up 1.0% in 2025, China's CO2 emissions on a plateau for more than two years since a March 2024 peak](#)
- 34:31 - [U.S. energy-related CO2 emissions down about 18% from 2005 to 2025, UK emissions down 2.4% in 2025 as coal hit a 400-year low, UK phase-out of coal power](#)
- 34:49 - [Around 2.6 C of warming by 2100 under current policies](#)
- 35:05 - [Global mean atmospheric CO2 at 427.6 ppm in June 2026, Atmospheric CO2 rising linearly while emissions stay flat](#)
- 35:45 - [Land and ocean sinks absorbing about half of emitted CO2 each year](#)

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- 36:13 – [*In an idealized 1,000 PgC experiment, atmospheric CO2 fell a median 80 ppm 50 years after emissions ceased](#)
- 37:03 – [Water's heat capacity and ocean thermal inertia](#)
- 37:15 – [Land warmed 2.03 C versus 1.03 C for the ocean surface in 2025, Sparse observations suggest the ocean below 2,000 metres warmed roughly 0.01 C over two decades](#)
- 37:31 – [Heat transport from the ocean surface to the deep ocean](#)
- 38:45 – [Super El Niño events since 1877, El Niño events peaking between November and February](#)
- 39:15 – [El Niño as a warm pool in the tropical Pacific, Upwelling off the coast of Peru, Westerly wind bursts](#)
- 39:35 – [Niño 3.4 region](#)
- 40:22 – [*NOAA CPC reported a weekly Niño 3.4 anomaly of 2.0 C on 14 September 2026 and a 75% chance of a historic event, *Previous record ONI peaks of 2.6 C in 2015–16 and 2.4 C in 1997–98](#)
- 40:54 – [1877–1878 El Niño famines with fatalities likely exceeding 50 million, Roughly tied with 2015–2016 as the strongest event on record](#)
- 41:25 – [El Niño rainfall redistribution across the tropical Pacific, Drought risk in Southern Africa, India, Indonesia and Australia](#)
- 41:45 – [2027 and 2028 growing seasons at risk from the fertilizer crisis, Fertilizer shortfalls, Strait of Hormuz \(Frankly on such\)](#)
- 42:34 – [World Meteorological Organization's largest mobilization in its history, Kenya distributing livestock vaccines ahead of heavy rain, Southern African food stocks and drought-tolerant seed](#)
- 43:03 – [USAID funding cuts projected to cause more than 14 million additional deaths by 2030, European aid cuts](#)
- 43:39 – [El Niño as internal climate variability](#)
- 43:46 – [*Science paper: El Niños of the last 50 years stronger than any in a 1,000-year Galapagos coral record](#)
- 44:05 – [El Niño response to warming in climate models](#)
- 44:28 – [Acceleration of global warming](#)
- 44:38 – [Aerosols hiding about 0.5 C of warming that greenhouse gases have already caused](#)
- 45:24 – [The Day After](#)
- 46:11 – [Public concern about climate as thermostatic, Climate as a political luxury good](#)
- 47:07 – [Leon Simons on aerosol de-masking and bunker fuels](#)
- 47:36 – [Direct aerosol effect: sulfate particles scattering sunlight, Cloud condensation nuclei and low-lying cloud formation](#)
- 48:06 – [*Aerosols cooling the planet 0.50 C, with a 0.22 to 0.96 C range](#)
- 48:30 – [High climate sensitivity correlates with high aerosol masking in models](#)
- 48:55 – [*Global sulfur dioxide emissions down 40% since the mid-2000s, CEDS global emissions data](#)

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- 49:08 - [*China's sulfur dioxide emissions down 75% since 2007, Flue-gas desulfurization scrubbers, Diesel sulfur standards](#)
- 49:38 - [IMO 2020 low-sulfur bunker fuel rule, About 80% cut in shipping sulfur dioxide emissions after 2020](#)
- 49:57 - [*Shipping accounted for 4 to 9% of global anthropogenic sulfur dioxide emissions in pre-IMO 2020 estimates, Ship tracks over clean marine air](#)
- 50:20 - [Warming rate near 0.3 C per decade over the past 15 years, up from 0.18 C](#)
- 50:55 - [*4.2 million premature deaths a year from ambient air pollution, 6.7 million including household](#)
- 51:08 - [Tad Patzek on Earth's energy imbalance as ~20 times the human economy](#)
- 51:44 - [Earth's energy imbalance](#)
- 52:10 - [CERES satellite measurement of Earth's radiation budget](#)
- 52:18 - [Earth's energy imbalance rising, and rising faster in recent years](#)
- 52:40 - [Low cloud feedback, High-sensitivity models lose more low cloud](#)
- 53:23 - [Separating aerosol reductions from temperature-mediated cloud feedback](#)
- 53:53 - [Methane responsible for around 30% of the temperature rise since the industrial revolution](#)
- 54:31 - [Methane's short atmospheric lifetime and chemical sink, Hydroxyl radical oxidation of atmospheric methane](#)
- 55:19 - [Methane as a fast lever for cooling, Global warming potential and gas comparison](#)
- 55:38 - [Permafrost thaw and regional methane fluxes](#)
- 55:58 - [Wetland emissions behind much of the last decade's atmospheric methane growth](#)
- 56:12 - [Methanogenesis in tropical wetlands as a temperature-mediated feedback](#)
- 57:10 - [Feeding climate data to large language models](#)
- 57:27 - [Machine learning applied to physics-based processes](#)
- 58:01 - [AI weather forecasting models](#)
- 58:23 - [AI for downscaling and parameterizing cloud formation](#)
- 58:53 - [Large language models answering climate science questions, Grok](#)
- 59:47 - [Fragmentation of the information ecosystem, Climate change as a Chinese hoax](#)
- 1:00:11 - [Walter Cronkite and the loss of shared trusted sources, AI as a consensus machine recentring scientific expertise](#)
- 1:01:07 - [Zeke's analysis of AI energy use and environmental impact](#)
- 1:01:48 - [AI labs' lack of transparency about model energy use](#)
- 1:01:55 - [Median Gemini text prompt at 0.24 Wh, OpenAI CEO Sam Altman's estimate: an average ChatGPT query uses about 0.34 Wh, Google search at 0.0003 kWh in Google's 2009 estimate](#)
- 1:03:00 - [A reasoning model drawing 29 Wh on a long prompt](#)
- 1:03:31 - [AI agents spawning sub-agents and running for hours](#)
- 1:04:00 - [Zeke Hausfather's estimate: median Claude Code session at 0.6 kWh, ranging from 0.25 to 1.2 kWh](#)
- 1:04:39 - [Zeke Hausfather's estimate: an average day of agent use at 3.0 kWh, more than running two refrigerators](#)

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- 1:06:06 – [Jevons paradox](#), [LED rebound effect in lighting demand](#)
- 1:06:47 – [Rebound effects in compute as AI gets cheaper and more capable](#)
- 1:07:53 – [Planetary boundaries](#) (*The Great Simplification* Ep highlighting such)
- 1:08:13 – [Uncertainties behind current-policy warming estimates](#)
- 1:09:16 – [Current-policy warming with a median of 2.7 C by 2100, 2.3 to 3.0 C](#)
- 1:09:37 – [42.4 gigatons of total anthropogenic CO2 emitted in 2024](#), [Record 57.7 gigatons CO2-equivalent including methane and nitrous oxide](#)
- 1:10:28 – [Tail risk in climate planning](#)
- 1:10:45 – [Climate tipping points](#)
- 1:10:50 – [Land warmed 1.59 C against a 1.09 C global average in 2011–2020](#)
- 1:11:00 – [CMIP7 high scenario at 3.3 C by 2100, range 2.5 to 4.4 C](#)
- 1:11:26 – [Intergenerational ethics of long-horizon warming](#)
- 1:12:40 – [Land and ocean sinks after emissions reach zero](#)
- 1:13:24 – [Biosphere response uncertainty growing with temperature](#)
- 1:13:37 – [*Land-use CO2 emissions averaged 1.4 gigatons of carbon a year over 2015–2024, Reforestation as a net sink](#)
- 1:14:10 – [Fuelwood harvesting under energy scarcity](#), [Illegal logging for fuel during the Greek financial crisis](#)
- 1:14:44 – [Ocean sink at 29% and land sink at 21% of total emissions over 2015–2024](#)
- 1:15:08 – [U.S. withdrawal from the IPCC](#), [Cuts to climate.gov](#), [Billion-Dollar Weather and Climate Disasters database](#), [*End of forward processing for one 47-year passive-microwave sea ice dataset](#)
- 1:15:42 – [Ocean observing sensors saved by congressional action](#)
- 1:15:52 – [NOAA climate data aggregation and public presentation](#)
- 1:16:13 – [Copernicus Climate Change Service](#)
- 1:16:34 – [Earth observation satellite data gaps](#)
- 1:17:40 – [Chinese hoax framing of climate science](#)
- 1:18:31 – [Politicization of climate and biosphere science](#)
- 1:19:00 – [Alarm fatigue and repeated crisis headlines](#)
- 1:19:24 – [Stephen Schneider \(referenced quote\)](#)
- 1:19:37 – [Existential framing of climate risk](#), [Parallels with the AI risk debate](#)
- 1:19:53 – [The world is awful, the world is much better](#), [Climate as a normal problem](#), [AI as normal technology](#)
- 1:20:25 – [Crisis-driven policymaking](#)
- 1:21:16 – [Political engagement, voting and contacting policymakers](#)
- 1:22:00 – [Early adoption of rooftop solar, electric vehicles and heat pumps](#), [Learning curves driving down technology costs](#)
- 1:22:57 – [Climate anxiety in young people](#)
- 1:23:23 – [91% chance that at least one year in 2026–2030 temporarily exceeds 1.5 C](#)
- 1:23:31 – [Climate doomism and apathy](#)
- 1:24:52 – [Growing political polarization worldwide](#)
- 1:25:37 – [Internalizing social costs into private costs](#), [Carbon pricing](#)

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- 1:26:28 – [Stripe's carbon removal purchases](#), [Frontier's carbon removal portfolio](#)
- 1:27:02 – [Nan Ransohoff's estimate: roughly 90% of the solution from emissions reductions, with removal at 5 to 10 gigatons a year by 2050](#)
- 1:27:19 – [Enhanced rock weathering](#)
- 1:27:26 – [Volcanism and silicate weathering as the long-term climate thermostat](#), [Basalt weathering, carbonate formation and the long-term carbon cycle](#)
- 1:27:38 – [Deccan Traps](#), [Siberian Traps](#), [Volcanism-driven mass extinctions](#) (Nate and DJ's book covering such)
- 1:28:20 – [Rock dust spread on croplands](#), [Soil acidity and crop yields](#)
- 1:28:48 – [River liming](#), [Legacy of acid rain in freshwater systems](#), [Carbon Run](#), [Salmon fishery restoration as carbon capture](#)
- 1:29:27 – [Ocean alkalinity enhancement](#), [Biomass carbon removal and storage](#), [Direct air capture](#)
- 1:30:09 – [\\$2.3 trillion of global energy transition investment in 2025](#), [~\\$5.6 billion of grant funding for carbon removal since 2005](#)
- 1:30:34 – [Counterfactual emissions reductions from renewable investment](#)