Climate Change Update

By John Benson

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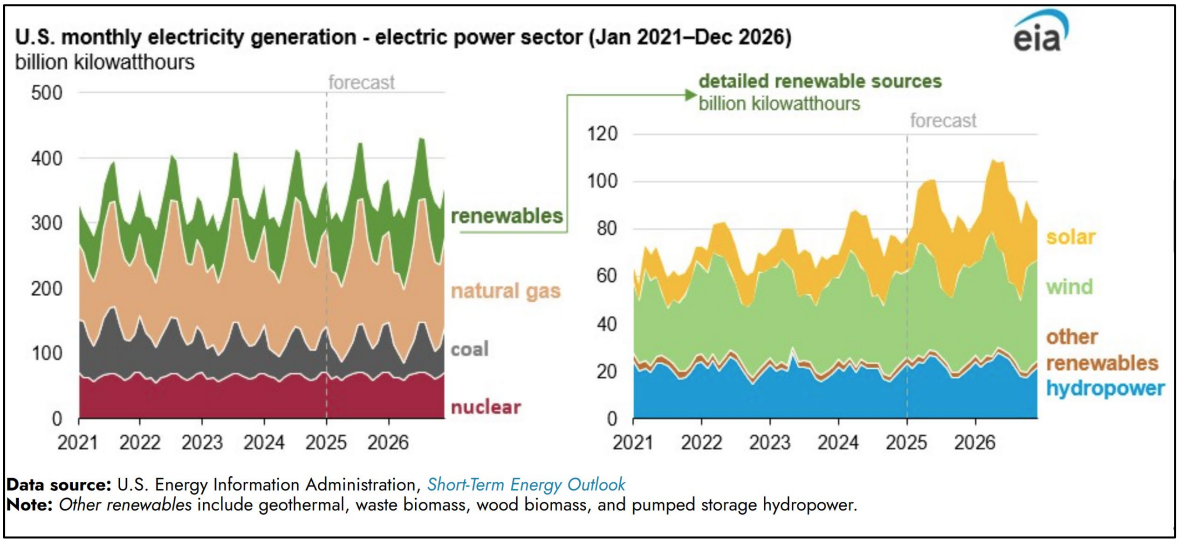
1. Introduction

It is very difficult to measure the main metric directly driving climate change, the amount of greenhouse gasses (GHGs) in earth's atmosphere, because this varies at different altitudes, regionally and over short-time-frames as various sources and sinks (human-caused and natural) emit and absorb GHGs. However, we can measure human-caused emissions at their source pretty accurately, especially in the U.S. This suits your author just fine, as I like to stay close to home. Furthermore, if you want to the most direct metric for GHG emitted when generating electric energy, the basic technology used for every kilowatt-hour of electric generation is more direct and accurately measured. Even though this varies seasonally, it is still easy to see long-term trends.

The federal agency charged with monitoring the "…technology used for … electric generation…" in the U.S. and their latest findings are referenced at the end of this sentence and shown in the two graphs below.[1]



As you can see from the above, solar generation (mostly photovoltaic, a.k.a. PV) increases at a reasonable rate from the peak in 2023 to the peak in 2024, ditto wind. Note that the yearly peaks are mainly caused by increased air-conditioning loads in summer. Furthermore, note that solar- & wind-electricity's increase is forecasted to continue through 2025 and 2026. Also note that nuclear and natural gas generation are mostly holding steady and coal is declining. Beyond 2026 it is hoped that nuclear will slowly increase to displace natural gas and coal generation so the former will decline slowly and the latter will continue to decline more rapidly.

[1] Katherine Antonio, U.S. Energy Information Administration, "In-brief analysis, New solar plants expected to support most U.S. electric generation growth," January 24, 2025, https://www.eia.gov/todayinenergy/detail.php?id=64364

Additional Information from the reference below*: "The Biden Administration's multibillion-dollar push to boost clean energy was costly, but it worked. Electric power generation from renewable, carbon-free sources hit a record 24% last year and should supply 25% this year. Solar panel production and deployment were the highest ever."* [2]

2. EVs

Americans bought 1.3 million electric vehicles (EVs) in 2024, a new record. A late sales surge helped, as EV sales spiked 15.2% year-over-year in the fourth quarter.[3]

In the final tally, EV sales rose 7.3% from 2023 numbers, according to Kelley Blue Book data. Sales growth has slowed – 2023's figure was 49% higher than 2022's. But sales have never stopped growing, and the percentage of new cars sold powered purely by gasoline continues to slip.

Tesla essentially built the EV market in the U.S. but has lost ground as more competitors enter the market. Tesla sold more than 37,000 fewer cars in 2024 than in 2023 – roughly matching the volume GM added.

The two best-selling EVs were, once again, Tesla's Model Y SUV and Model 3 sedan. But the list is changing quickly as new models arrive. Honda's Prologue SUV finished seventh despite making its first sale in March. The Prologue was the best-selling non-Tesla EV in the fourth quarter.

Top 10 Best-Selling EVs in 2024:

1. *Tesla Model Y*
2. *Tesla Model 3*
3. *Ford Mustang Mach-E*
4. *Hyundai Ioniq 5*
5. *Telsa Cybertruck*
6. *Ford F-150 Lightning*
7. *Honda Prologue*
8. *Chevrolet Equinox*
9. *Cadillac Lyriq*
10. *Rivian R1S*

2.1. EVs in 2025

Analysts from Kelley Blue Book parent company Cox Automotive predict continued EV sales growth in 2025. With improving charging infrastructure, heavy factory-sponsored discounts, and more new vehicles scheduled to enter the market, they predict that EVs could exceed 10% of all new cars sold in 2025.

One in four new cars sold, Cox Automotive predicts, will be electrified in some way – a hybrid, plug-in hybrid, or EV.

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[2] Alan Ohnsman Senior Editor, Forbes, Current Climate, January 27, 2025 Edition.
[3] Sean Tucker, Kelly Blue Book, " America Set EV Sales Record in 2024," 01/14/2025, https://www.kbb.com/car-news/america-set-ev-sales-record-in-2024/?msockid=234c177cbb1d6cca0f6904bcba996d70

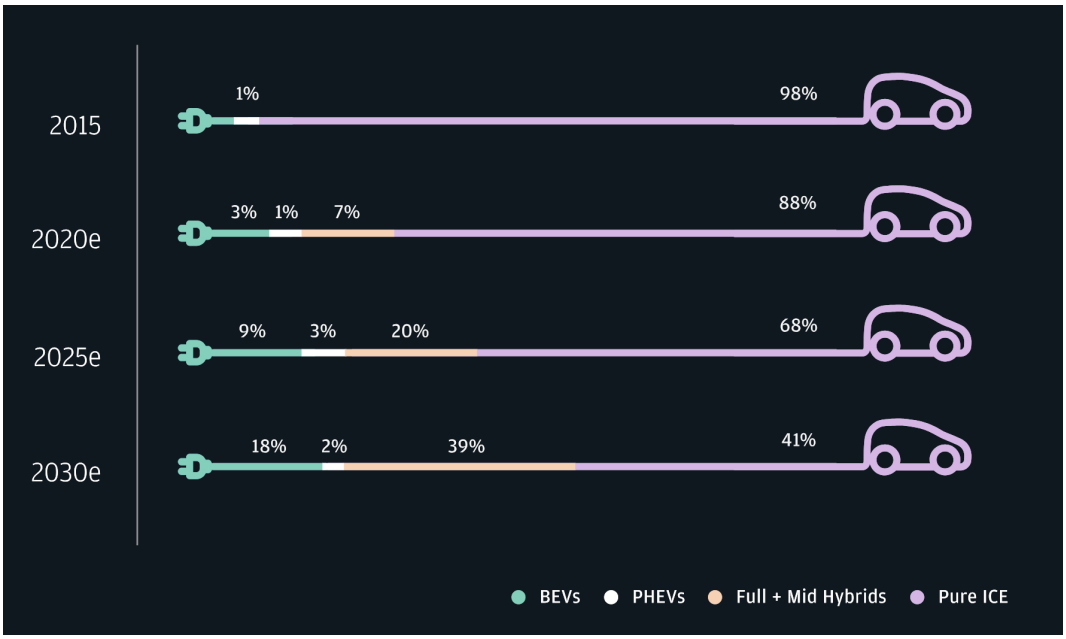
President-elect Donald Trump has said he may attempt to end the $7,500 tax rebate that helps many Americans buy a new EV. But that may prove impossible, as it would require an act of a closely divided Congress. See additional comments under "Battery Industry Forecast 2025" in section 2.3.

2.2. More Future EV Projections

The car industry is undergoing a radical transformation, with most carmakers agreeing the next 10 years will bring more change than the two previous decades. The next target date cited by automakers as a tipping point is 2025, when everything from materials and fuel to cost and the companies that build cars are set to look dramatically different. In this report, the J.P. Morgan Research team explores the rise of the electric vehicle and what the industry will look like by 2025.[4]

Automakers are preparing to phase out cars powered solely by internal combustion engines (ICEs) as governments look to tackle fuel emissions.

GLOBAL ELECTRIC VEHICLE FORECAST:



For both North America and Europe, hybrids and BEVs are set to lead over the next decade as plug-in hybrids are not proving too popular in either region.

Over that time period, J.P. Morgan forecasts sales of plug-in electric vehicles in Japan and Korea will reach 384,000 vehicles, representing a market share of 6%, while HEVs will approach 1.8 million vehicles or 27% of total sales.

Meanwhile in the U.S., tougher fuel economy regulation will likely push automakers to expand their EV offerings, but not with the same degree of urgency as in Europe, where there are looming carbon dioxide emissions targets and fines. Nevertheless, overall EV sales – including BEV, PHEV and hybrids – are estimated to account for over 30% of total sales in 2025.

[4] JPMorgan Chase & Co., "Driving into 2025: The Future of Electric Vehicles," 2025, https://www.jpmorgan.com/insights/global-research/autos/electric-vehicles

2.3. EV and BESS Batteries

Batteries are the major cost component for both EVs and BESS, so they deserve a closer look.

Battery production hit an all-time high in 2024, especially in battery storage and EV production. According to market research firm Research and Markets, the global market for Electric Vehicle Battery is projected to reach US $84.5 Billion by 2030, growing at a CAGR[5] of 15.5% from 2023 to 2030.[6]

Battery Industry Forecast 2025

The Inflation Reduction Act (IRA) and the Bipartisan Infrastructure Law (BIL) will endure, despite the uncertainty. First, they are legislatively challenging to dismantle. And second, 75% of the grants have been allocated to Republican districts, with 50% awarded in swing states, ensuring — if somewhat tenuous — bipartisan support.

The US Cleantech sector will undergo a shakeout. (The sector includes industries focused on developing and implementing technologies aimed to minimize negative environmental impacts by promoting energy efficiency, sustainable resource usage, and environmental protection activities). Only the strongest players with true technical differentiation will survive, while those who jumped on the bandwagon without a clear competitive edge will be pushed out in 2025.

Global EV growth will slow, but this could provide a window for adopting next-generation technologies like Sodium-ion, Solid-State Batteries, and Dry Battery Electrode (DBE) technologies.[7]

More battery makers will announce their involvement with Dry Battery Electrode (DBE) technology or committing to its adoption in the near future. This builds on Tesla's pioneering work in DBE and LG Energy Solution's plan to commercialize it by 2028.

"Made in America" will become a major theme in the Cleantech space, since the new administration will build physical and financial walls around the US that attract investment in US production and possibly other functions.

2.4. Medium & Heavy Electric Trucks & Buses

A disproportional percentage of medium and heavy electric trucks and buses cost are the batteries. Also, these have a major impact on reliability and warranty. I've been covering EVs in general and medium and heavy EVs for over a decade, so I am well aware of the importance of BYD in the US medium and heavy electric truck and bus market.

BYD was founded in 1995, as a diversified electronics and battery manufacturer. However, in 2008 Warren Buffett's Berkshire Hathaway purchased 10% of BYD for $230 Million. Five years later (2013) BYD became the first company from China to announce it will produce vehicles in the United States. It then planned to build as many as 1,000 plug-in electric buses a year at in the City of Lancaster, California.

[5] CAGR = Compound annual growth rate

[6] Kristen Kazarian, Powder & Bulk Solids Weekly newsletter, January 22, 2025, https://www.powderbulksolids.com/chemical/battery-manufacturing-predictions-for-2025-and-beyond

[7] See https://www.nature.com/articles/s44359-024-00018-w

"We truly are making history," Lancaster Mayor R. Rex Parris said. "*Our community looks forward to working hand in hand with BYD as they develop and perfect their e-bus and energy-storage technology.*"

Expansion

BYD held the Grand Opening of Phase 3 of its Lancaster, California Bus and Coach Factory expansion on October 6th, 2017, with numerous company officials, dignitaries, and employees on hand to celebrate…

The event was held at BYD's Lancaster Factory in one of the newly added sections of the factory. The increase in capacity added around 300,000 square feet to the factory, bringing it up to 450,000 square feet in total. BYD has owned the facility for 4 years and has continually increased the number of employees and the size of the location in that time. This addition… accommodates making electric trucks.

BYD Sells the following products in the US:

- **Solar Modules:** Although BYD appears to offer their own solar modules in the US, my best guess is that this is part of a start-up "solutions" business for a wide range of solar generation markets. Their main offering in this space is the next bullet.
- **Battery Energy Storage Systems (BESS):** BYD is the leading manufacturer of BESS, with solutions for utility, commercial and residential use. BYD's integrated battery energy storage solutions feature safe, reliable Lithium-ion Iron-Phosphate (LFP) battery technology.
- **EV Infrastructure:** BYD and its partners know how to meet the challenges of high costs and operational complexities. BYD can provided total and affordable solutions that will help municipalities, universities and businesses rapidly migrate to electric vehicles to help achieve their fiscal and environmental goals.
- **Vehicle-to Grid Technology:** BYD's smart technology allows for bi-directional charging. Vehicles can be charged overnight when energy demand is low, and energy can be fed back into the grid from the vehicle when demand is high.
- **EV Charging Systems:** BYD offers a wide range of charging options including AC, DC, overhead and inductive charging. BYD's 150kW DC fast charger for buses and trucks has been certified by Underwriters Laboratory (UL), the highest capacity, single-unit charger ever certified by UL.
- **Electric Buses:** BYD offers the most diverse line of any electric bus manufacturer throughout North America and is the world's leading battery-electric bus manufacturer. Having deployed over 50,000 electric buses on the road globally, and more than 1,000 electric BYD buses are on the road or in production throughout the United States. Their American electric bus customers have logged over 20 million miles of zero emission operations, the equivalent of 750 trips around the Earth or 40 trips to the moon and back.

- **Electric Trucks:** Headquartered in Los Angeles, California, BYD, is leading in commercial electric truck deployments. BYD offers a full line of medium and heavy-duty battery-electric trucks that are in operation now. BYD Trucks, assembled by union workers in Lancaster, California,[8] are industry-proven to deliver the highest efficiency and reliability in the harshest commercial operations. All BYD trucks come standard with BYD's most advanced Iron Phosphate Battery Systems[9] — the safest, longest lasting and highest reliability commercial electric truck battery systems in the world.

Note that BYD was the world's second-largest EV battery producer in 2023, accounting for 15.8% of global production output.

As I mentioned above, the EV vendor with the most experience and the best technology can offer the best battery warranty. BYD's battery warranty is below. Note this from a BYD California distributer's site.

BYD Warranty:

The lithium iron phosphate battery (FE battery) is warranted to charge and discharge normally and have a remaining capacity of 65% or greater by the end of ten (10) years or 20,000 hours, whichever comes first.[10]

3. The H_2 Solution

This post started off talking about renewables role in generating electricity and morphed into battery electric EVs (BEVs). Both are partial solutions to climate change, especially if very-low GHG electricity is used to charge the batteries in BEVs, but that certainly is not guaranteed.

Another solution is zero-carbon fuels. One of those is hydrogen, which is pretty widely available, even in hydrogen fueling stations, but mainly in my home-state (California). Also, large- and medium-sized hydrogen-fueled fuel-cell EVs are starting to be sold in reasonable quantities (hundreds to thousands per year, ditto regarding California).

But there is a long-range problem. "*For the moment, production at North America's largest plant making hydrogen with renewable energy stinks. At SoHyCal's facility near Fresno, California, manure from more than 7000 cows at the Bar 20 dairy ranch is channeled to a covered lagoon, where bacteria convert much of it to methane-rich biogas that's run through fuel cells to generate electricity. Some of that power is shunted to SoHyCal's electrolyzer, a railcar-size device that splits water into hydrogen and oxygen gas. The result: about 300 kilograms of "green" hydrogen a day, which is used to power a pair of Fresno city buses and a smattering of local hydrogen-fueled cars.*[11]

[8] Lancaster, California is about 50 miles north of downtown Los Angeles.
[9] LFP-chemistry lithium-ion batteries.
[10] https://www.1smh.com/byd_warranty.html
[11] Robert F. Service, Science Magazine, "The parting of water," Jan 24, 2025 issue, https://www.science.org/content/article/will-new-generation-water-splitting-devices-help-green-hydrogen-replace-fossil-fuels

This year, the plant will start to draw extra power from nearby solar farms, boosting output to 1 ton of hydrogen per day, says Pedro Pajares, who runs the U.S. offshoot of H2B2, the Spanish firm behind the project. But as for scaling up beyond that, Pajares says, "I have worries."

Hydrogen is often touted as the future of green energy, and the allure is clear. When burned or run through a fuel cell, the fuel produces water as exhaust, not carbon dioxide (CO_2). It is energy-rich enough to drive semitrailer trucks, cargo ships, and other heavy-duty vehicles that are tough to power with batteries. And for many industrial processes requiring high-temperature reactions, such as fertilizer production and steel manufacturing, hydrogen is basically the only alternative to fossil fuels, says Kathy Ayers, a water electrolysis expert at Nel Hydrogen, a Norwegian electrolyzer producer. "Low-carbon hydrogen is absolutely essential if we are going to address the climate crisis."

But if the scale of SoHyCal is any indication, that future remains a long way off. According to the International Energy Agency, the world needs to churn out more than 300 million tons of green hydrogen annually if it is to have a shot at limiting global warming to 1.5°C by 2050. Yet today, operating green hydrogen plants, mostly in Europe and China, produce just 1 million tons per year. "There is a big mismatch," Pajares says.

Production is meager not because hydrogen is some exotic energy source. Manufacturers already produce some 97 million tons of it, largely to make fertilizer and refine oil. But almost all of it comes from steam methane reforming, which is far from green. It uses high-pressure steam to break apart methane—the main ingredient in natural gas—into CO_2 and hydrogen. Every year, the process spews roughly 1 billion tons of CO_2 into the atmosphere—equivalent to Japan's emissions—to make so-called gray hydrogen.

Green hydrogen comes instead from electrolyzers powered by renewable electricity. As at SoHyCal, the devices turn out relatively small volumes of hydrogen at high prices. But governments worldwide have begun a push to scale up green hydrogen production. Earlier this month, for example, the U.S. Department of the Treasury finalized a $3 per kilogram tax credit for producers of green hydrogen. Meanwhile, researchers are trying to drive down the cost of electrolyzers—which accounts for roughly one-third of the cost of green hydrogen—and boost their efficiency. The U.S. Department of Energy (DOE) alone set aside $1 billion this decade to improve electrolyzer technology. "The money is there," Ayers says. "The issue is can we actually get systems installed."

Final author's comment: Is the above excerpt pointed out, steam methane reforming is used to produce a large majority of hydrogen used in the U.S., and this applies to the hydrogen used for refueling stations, even if California. However, there is hope that this will change in the future.

In today's early market, hydrogen is supplied primarily from industrial gas companies that produce hydrogen from natural gas (using steam methane reforming). Since fuel cells are so much more efficient than gasoline powered engines, the overall greenhouse gas emissions are much lower (at least half) no matter which hydrogen production method is used.[12]

[12] California Air Resources Board (CARB), Hydrogen Fueling Overview, 2025 https://driveclean.ca.gov/hydrogen-fueling

California is leading the way in producing 100% renewable hydrogen fuel, and several initiatives are in place working toward that mission.

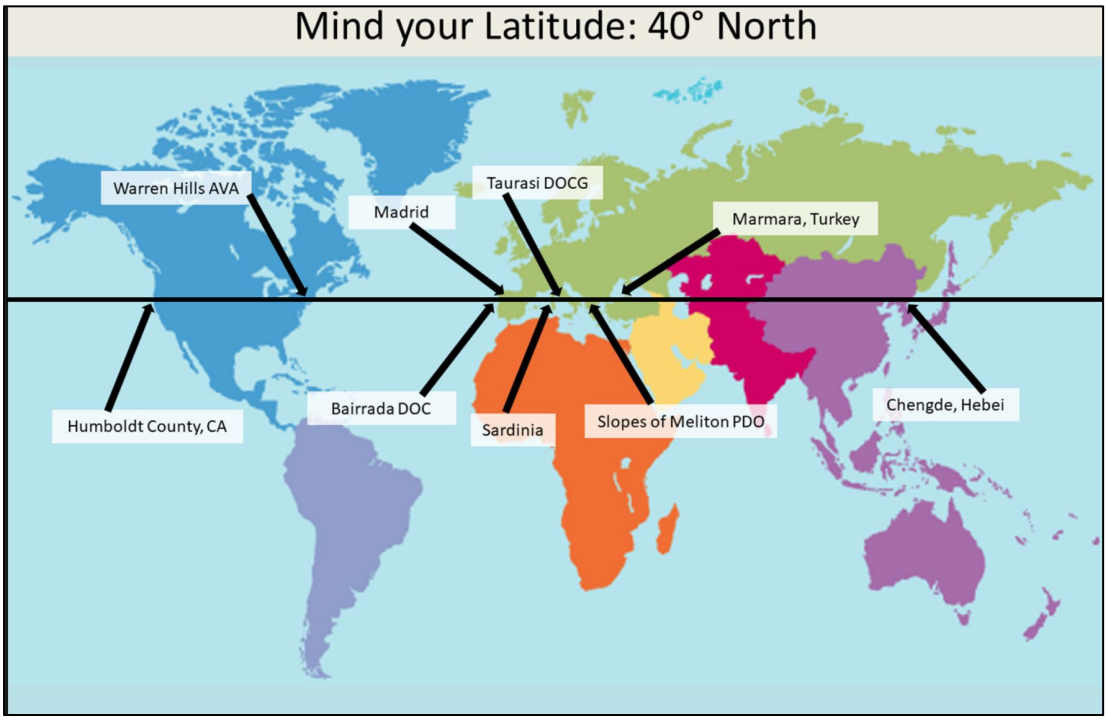
4. Increased Flooding

There is a primary and secondary effect of climate change. The primary effect in "global warming," where the global average temperature will likely increase 2° to 4°C by 2100. The secondary effect is that the warmer air can hold, and release more moisture. The primary effect can lead to more frequent and longer droughts, and ironically, the secondary effect can lead to more severe flooding.

You author hasn't been paying attention to the flooding issue latterly, so thought I would see if this has already started to ramp up.

Extreme weather events are becoming more frequent as a result of climate change. River floods such as those along the Ahr and Meuse valleys in 2021, the Central European floods of last September and the recent floods in Valencia, Spain, are caused by so-called cut-off lows. The Wegener Center at the University of Graz has now for the first time investigated how these storms could change with climate change.[13]

"We expect that persistent cut-off lows north of 40 degrees latitude and in East Asia will occur earlier in the year (see map below). Canada, northern Europe, Siberia and China in particular will have to prepare for more heavy and prolonged heavy rainfall in spring," says project leader Douglas Maraun. The results of the study have just been published in the journal Communications Earth & Environment.



[13] Science X staff, Phys.org, "Flood risk on the rise: Climate change models point to more persistent heavy rainfall," 2025, https://www.msn.com/en-us/weather/extreme-weather-events/flood-risk-on-the-rise-climate-change-models-point-to-more-persistent-heavy-rainfall/ar-AA1ziHz5?ocid=BingNewsSerp

A cut-off low is a low-pressure system located at an altitude of several kilometers that is cut off the polar front. Since it often stays in the same place for several days, it can lead to long periods of heavy precipitation in this region.

Despite their devastating consequences, there has been little research to date into how such storms could change in a warming climate. In cooperation with colleagues from the University of Reading, United Kingdom, and the Institute of Atmospheric and Climate Sciences in Bologna, Italy, scientists from the Wegener Center at the University of Graz have now conducted the first detailed study addressing this question.

Aditya Mishra, first author of the study, explains, "We analyzed 18 different climate models with regard to such storms. To do this we essentially read out weather maps from the models every six hours and used them to analyze the paths and intensity of such storms."

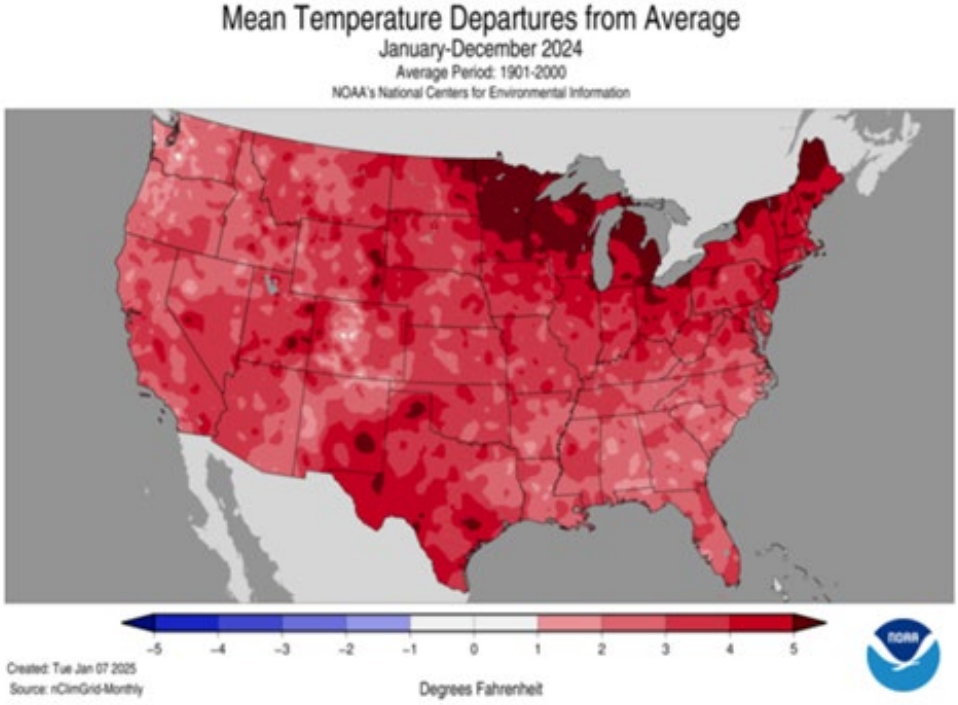
By comparing all 18 models, the scientists were able to estimate robust changes very well. "In general, these storms will occur more northward and their season expands from summer and autumn further into spring," Mishra summarizes. He is now a postdoc at the University of Uppsala in Sweden after completing his Ph.D. at the University of Graz.

Whether a heavy precipitation event turns into a disaster also depends on flood protection. "With targeted measures such as renaturation and a functioning early warning system, we can at least partially protect ourselves from extreme weather and the impacts of climate change," emphasizes Douglas Maraun.

4.1. U.S. 2024 Weather

My next question is how did the U.S. fare in 2024?

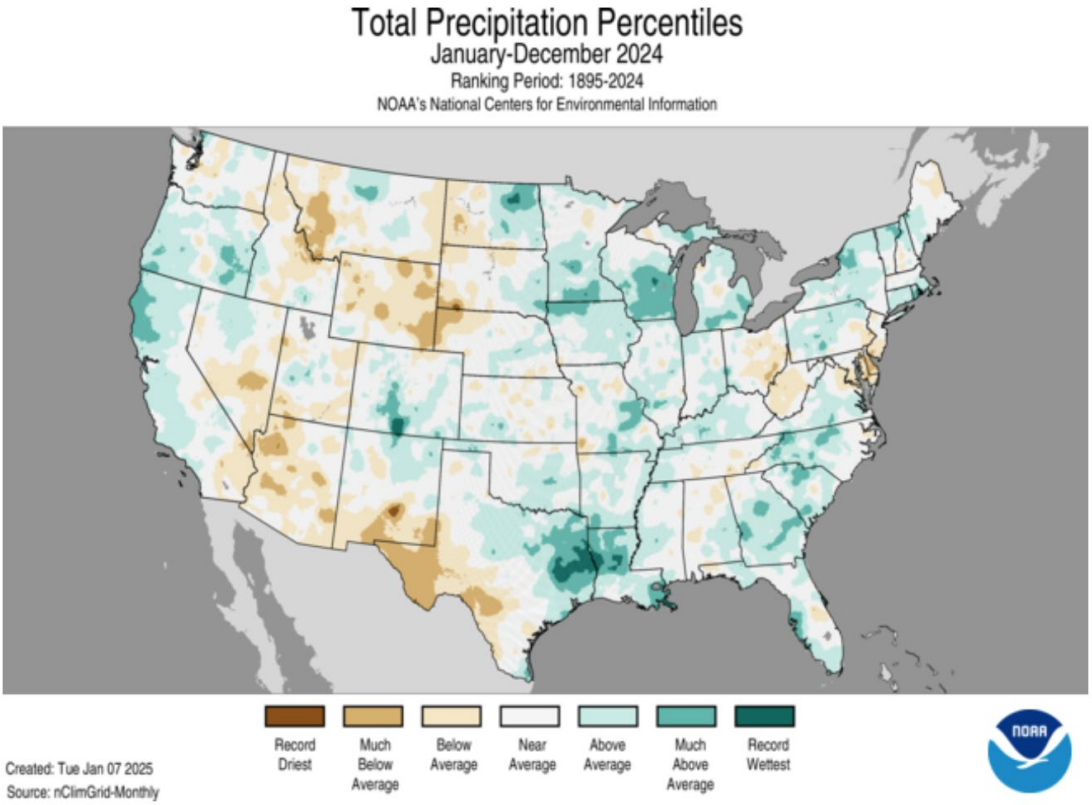
The average annual temperature of the contiguous U.S. was 55.5°F, 3.5°F above average and the warmest in the 130-year record. (see map below)[14]



[14] NOAA, "Assessing the U.S. Climate in 2024," https://www.ncei.noaa.gov/news/national-climate-202413

Annual precipitation for the contiguous U.S. was 31.58 inches, 1.66 inches above average, ranking in the wettest third of the historical record (1895–2024).

Precipitation



The Atlantic basin saw 18 named tropical cyclones and five landfalling hurricanes during 2024—an above-average season. Hurricane Helene was the seventh-most-costly Atlantic hurricane on record.

The tornado count for 2024 was second highest on record behind 2004 (1,817 tornadoes) with at least 1,735 confirmed tornadoes. When looking at EF-2+ tornadoes, 2024 was the most active year since the historic 2011 season.

Hurricane Helene's extensive damage topped the list of 27 separate billion-dollar weather and climate disaster events identified during 2024—the second-highest annual disaster count in the 45-year record.

Drought coverage across the contiguous U.S. ranged from a minimum extent of 12 percent on June 11—the smallest contiguous U.S. footprint since early 2020—to a maximum coverage of 54 percent on October 29.