Climate for Kids



What's Happening to Our Planet (and What We Can Do)

Sarah Whitman

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by Sarah Whitman

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CHAPTER I

Weather vs. Climate: What's the Difference?

You checked the weather app this morning. Maybe you grabbed a jacket, or swapped it for shorts. That tiny decision — umbrella or no umbrella? — is all about weather. But somewhere in the background of that app, behind today's little sun icon, is a much bigger, slower story. That story is climate. And understanding the difference between the two is the first step to understanding everything that's happening to our planet right now.

Here's the simplest version: weather is what's going on outside this afternoon. Climate is the pattern that shapes what outside usually looks like where you live — not today, not this week, but across many decades.

Weather changes fast. Wildly fast. On January 22, 1943, the temperature in Spearfish, South Dakota shot up 49 degrees Fahrenheit in just two minutes, driven by a sudden warm wind called a Chinook. That's the kind of jaw-dropping swing that weather is capable of. Climate doesn't do that. Climate is the reason people in Phoenix, Arizona expect scorching July afternoons — around 106°F (41°C) on average — while people in Anchorage, Alaska absolutely do not. Climate is the background music. Weather is whatever song happens to be playing right now.

Mood vs. Personality

Here's a comparison that might stick with you.

Imagine your friend Mia. On Monday she's bouncy and excited because she aced a math test. On Thursday she's grumpy because she missed the bus. On Saturday she's laughing the loudest at a birthday party. Her mood shifts constantly. But you know Mia — really know her — because you know her personality. She's generally cheerful, pretty stubborn when she thinks she's right, and always the first one to crack a joke at lunch. That personality doesn't flip around the way her moods do.

Weather is like Mia's mood. Climate is like her personality.

A stormy week in July doesn't change the fact that your region's climate is warm and dry in summer. One record snowstorm doesn't erase the bigger pattern. And here's the part that trips people up constantly, even adults who really should know better: one cold winter — even a brutally cold one — does not contradict global warming. Not even a little.

In February 2021, a vicious cold snap hit Texas. Pipes froze solid. The power grid collapsed. Millions of people sat in the dark without heat for days. Some people pointed at the ice and said, "So much for global warming." Understandable reaction. Wrong conclusion. One extreme week in one state is weather. Global warming is about what Earth's average temperature has been doing across 150 years of measurements. And it

has been rising. A single cold snap doesn't erase that curve any more than one good day erases a pattern of anxiety.

That's exactly the kind of single-event thinking that climate science asks us to resist.

How Scientists Think About Time

When climate scientists want to understand a region's climate, they don't look at last Tuesday. They don't even look at last year. They look at at least 30 years of data.

NOAA — the National Oceanic and Atmospheric Administration, the U.S. agency responsible for tracking weather and ocean conditions — publishes something called "climate normals." These are averages calculated over 30-year stretches. The current set covers 1991 to 2020. If you want to know how warm March is supposed to be in Boston, Massachusetts, you look at 30 years of March temperatures in Boston and find the middle ground. That average is a normal. That's climate.

Thirty years is long enough to smooth out the bumps. A single unusually cold winter gets folded in with the other 29. It doesn't disappear from the data — it's still in there — but it doesn't dominate the picture either. Think of it like your grades over a whole school year. One bad test doesn't ruin your average if everything else was solid. One great test doesn't rescue it if the rest were rough. The full record tells the true story.

And the full record, going back to the mid-1800s when scientists first began systematically measuring surface temperatures, tells a clear story. Earth's average surface temperature has risen about 1.1 degrees Celsius — roughly 2 degrees Fahrenheit — since the late 1800s. That number comes from the IPCC, the Intergovernmental Panel on Climate Change, a body of thousands of scientists from around the world who gather and review all available climate research. Their 2021 report, the Sixth Assessment Report, represents as close to "everyone examined all the evidence, and here is what it shows" as science ever gets.

1.1°C doesn't sound dramatic. You might be thinking: I can barely feel one degree when I walk outside. But that's the global average — the mean of every spot on Earth's surface, including deep oceans, frozen poles, and equatorial tropics, blended together. Moving that number by even a fraction of a degree requires an enormous amount of energy. Imagine trying to heat a bathtub full of water. Now imagine heating all of Earth's oceans. Shifting the global average by 1.1°C is a very, very big deal.

Why the Difference Actually Matters

You might be wondering: why spend so much time separating weather from climate? They're related, right? They are. Weather is what happens; climate is the pattern that weather tends to follow over time. But they answer completely different questions.

"Will I need my rain boots on Friday?" Weather question.

"Is this region getting drier than it was 50 years ago?" Climate question.

"Should we build a seawall around this coastal city?" Definitely a climate question.

Mixing them up has real consequences. When someone hears about one cold day and concludes that global warming is fake, they've made a weather observation and tried to use it to answer a climate question. That's like watching one person eat a candy bar and concluding that sugar doesn't cause tooth decay. The single observation doesn't work as evidence for the larger pattern.

Scientists are careful about this distinction. Researchers at NASA's Goddard Institute for Space Studies in New York City have been tracking global temperature data since 1880 — a painstaking archive built from thousands of weather stations and ocean buoys spread across the planet. They're measuring the slow curve of the line over decades, not the daily zigzags. The zigzags are weather. The curve is climate. And the curve is what we have to watch.

Here's one more way to picture it. Imagine standing on a beach, watching the ocean. Waves come and go — big ones, small ones, choppy days, glassy days. Those waves are weather. But the tide is also rising. Slowly, steadily, the water creeps up the sand. That rising tide is climate. You can get completely knocked over by a wave — a massive blizzard, a record heat wave — while the tide is still climbing beneath your feet. The wave got your attention. The tide is the bigger story.

The Two Words You'll Need

Keep these two definitions close as you read the rest of this book:

Weather is the short-term condition of the atmosphere in a specific place — temperature, rain or snow, wind, humidity — measured in hours, days, or weeks.

Climate is the long-term average of weather patterns in a region, typically calculated over 30 years or more.

Both are real. Both matter. But they operate on completely different timescales, and mixing them up is one of the most reliable ways conversations about our planet break down — people shouting about snowstorms at people who are talking about sea levels. You'll hear it happen. You'll recognize it now.

That's actually a significant thing to carry around. A lot of adults don't have this distinction clear in their own minds, and it shows.

You do.

What comes next is the question of why Earth's climate is changing — the physics behind it, the chemistry of it, the story of a natural process that humans have pushed too far. It involves invisible gases, sunlight, and the baking interior of a parked car on a summer afternoon. The pieces fit together in a way that, once you see it, you won't be able to unsee. That's where we're headed.

CHAPTER II

The Greenhouse Effect: Earth's Invisible Blanket

Picture the last really hot day you spent near a car park.

Maybe it was a summer afternoon at the grocery store, or a school pickup line that seemed to go on forever. You walk past a black sedan that's been sitting in the sun since morning, and the air around it shimmers. You touch the door handle and yank your hand back fast. Now imagine someone left a dog inside — or, worse, a younger sibling — and you understand instantly, in your bones, why that's dangerous.

That car is basically a model of planet Earth. And understanding why it gets so hot is the first step to understanding one of the biggest stories in science right now.

Why the Car Gets Hot (and Why That Matters)

Sunlight pours through glass easily. Short-wave radiation — the kind that travels from the sun — passes right through a car's windshield and heats up the dashboard, the seats, the air inside. But heat trying to escape works differently. The longer-wave radiation that bounces back off those warm surfaces can't get back out through the glass as freely as sunlight got in. So the heat builds up. The inside of a car on a 70°F (21°C) day can reach 104°F (40°C) in just 30 minutes, according to the National Highway Traffic Safety Administration.

Earth's atmosphere does something similar. Not with glass, but with gas.

The Invisible Blanket

Here is the cycle, step by step. Think of it as a diagram you can read.

Step one: The sun sends energy toward Earth as sunlight — bright, short-wave radiation traveling 93 million miles in about eight minutes.

Step two: Some of that sunlight bounces straight back off clouds and bright surfaces like snow and ice. About 30 percent of it never even enters the system. Gone. Reflected.

Step three: The other 70 percent gets absorbed. The land, the ocean, your asphalt driveway — they all soak up the sun's energy and warm up.

Step four: Warm surfaces release that energy back upward as infrared radiation. Think of it as invisible heat rays rising off the ground. You've felt this before — stand next to a brick wall in the evening after a hot day, and it radiates warmth back at you even though the sun went down an hour ago.

Step five: Here's where it gets interesting. Most of that infrared radiation tries to escape to space, but certain gases in the atmosphere absorb it. They grab the heat, hold it briefly, and radiate it in all directions —

including back down toward Earth. This is the greenhouse effect. These gases act like a thick blanket wrapped around the planet.

Step six: The surface warms up a little more than it would from sunlight alone, which is exactly what makes Earth livable.

That last part is important. The greenhouse effect is not a villain. It is, quite literally, the reason you exist.

Without It, We'd All Be Frozen

Here is a number worth knowing: without any greenhouse effect at all, Earth's average surface temperature would be about -18°C (roughly 0°F). Instead, thanks to that atmospheric blanket, the average temperature is about +15°C (59°F). That's a 33-degree difference — the entire margin between a frozen rock and a planet teeming with life.

Mars, for comparison, has a very thin atmosphere with almost no greenhouse gases. Its average temperature hovers around -60°C (-80°F). Venus went the other direction — its atmosphere is 96 percent carbon dioxide, creating a runaway greenhouse effect that pushed surface temperatures to 465°C (870°F). Hot enough to melt lead. Hot enough that the Soviet Venera probes sent to its surface in the 1970s lasted only about an hour before being crushed and fried.

Earth sits in the sweet spot. It took billions of years to get here. The greenhouse effect is the reason it worked.

The Gases Doing the Work

Not every gas in the atmosphere traps heat. Nitrogen and oxygen — which together make up about 99 percent of the air you breathe — are largely transparent to infrared radiation. The heat just passes right through them.

The greenhouse gases are a much smaller fraction of the atmosphere, but they punch way above their weight.

Water vapor is the most abundant greenhouse gas and the most powerful contributor to the natural greenhouse effect. When the ocean warms slightly and more water evaporates, that extra vapor in the air traps even more heat — which warms things further — which evaporates more water. Scientists call this a feedback loop. Water vapor amplifies warming that other gases start.

Carbon dioxide (CO_2) is the greenhouse gas you hear about most. It's a molec and two oxygen atoms, and it's extremely good at absorbing infrared radiation. Every time something burns — a campfire, a candle, a car engine, a coal power plant — carbon that was locked in fuel combines with oxygen from the air and becomes CO_2. It floats up into the atmosphere and st weeks. For centuries.

Methane (CH_4) is less famous than CO_2, but worth understanding. Molecule fo roughly 80 times more effectively than CO_2, over a 20-year period, according Report. It comes from cattle digestion, landfills, and leaks from natural gas pipelines. It breaks down faster

than CO, — decades rather than centuries — but while it's up there, it hits h

There's also nitrous oxide from fertilizers, and various industrial gases, but humans are adding at the most alarming rate.

When the Blanket Gets Too Thick

Here is what changed.

For most of human civilization — roughly the last 10,000 years — CO, in the about 260 and 280 parts per million (ppm). That means for every million molecules of air, about 280 were carbon dioxide. Stable. Balanced. The blanket stayed the right thickness.

Then, in the mid-1700s, the Industrial Revolution began. Humans started burning coal to run factories. Then oil to run cars. Then natural gas to heat homes. And with every tank of gas burned, every power plant running on coal, CO, got added to the atmosphere faster than natural processes could

In 1958, a scientist named Charles David Keeling began measuring CO, level Observatory in Hawaii — a high, remote location away from local pollution sources. His measurements, now called the Keeling Curve, are one of the most important datasets in climate s was at about 316 ppm. By 2024, NOAA's measurements at Mauna Loa recorded a new record: over 426 ppm. That's more than 50 percent higher than pre-industrial levels. Higher than at any point in at least 800,000 years, as we know from ancient air bubbles trapped in Antarctic ice (more on that in the next chapter).

The blanket got thicker. And a thicker blanket means a warmer planet.

Not Complicated. Just Physics.

Some people want to make this feel complicated. Controversial. Uncertain.

It isn't.

The physics of CO, absorbing infrared radiation has been understood since th named Eunice Newton Foote conducted experiments showing that CO,-filled a air in sunlight. Her work was published in 1856. That's not new knowledge. That's knowledge older than the lightbulb.

Since then, thousands of scientists across dozens of countries, using different methods and independent data, have confirmed the same basic mechanism over and over. The IPCC's Sixth Assessment Report, published in 2021 and compiled from the work of hundreds of researchers, put it plainly: it is "unequivocal that human influence has warmed the atmosphere, ocean and land."

Unequivocal. That's scientist-speak for we are sure.

A Blanket That's Hard to Take Off

The frustrating part isn't understanding the greenhouse effect. That part's actually not so hard. The frustrating part is this: CO_2 doesn't disappear when we stop adding it. A significant frac released today will still be in the atmosphere in the year 2200. You can think of the atmosphere like a bathtub — we've been running the tap for 250 years, and the drain is much, much slower than the tap.

That means what we do in the next decade matters enormously. Not because it's too late to do anything, but because every bit of CO_2 we don't add is warming we don't lock in.

The blanket is thicker than it should be. We made it that way, mostly without meaning to. But understanding how it works — sunlight in, heat trapped, temperature up — is the foundation for everything else. The changes already happening, the solutions already working, the choices still ahead of us.

You can't fix something you don't understand. Now you understand this.

CHAPTER III

How Do We Know? The Science Behind the Numbers

Imagine you just moved to a new town and you want to figure out whether the old oak tree in the backyard has always been there or was planted recently. You could ask one neighbor. But what if that neighbor was wrong, or just guessing? You'd ask several people. You'd look for old photographs. Maybe check property records at the county office. The more independent sources that told the same story, the more confident you'd feel — even if no single source was perfect.

Climate scientists do exactly that. Except instead of one oak tree, they're studying an entire planet. Instead of old photographs, they drill into glaciers that are hundreds of thousands of years old. And instead of a few neighbors, they're consulting evidence gathered by thousands of scientists in dozens of countries over more than a century.

Here's how they actually do it.

Bubbles in Ancient Ice

In East Antarctica, the ice is so deep and so old that scientists can drill down and pull up cylinders of compressed snow and ice — called ice cores — that were laid down long before humans existed. The EPICA project (European Project for Ice Coring in Antarctica) drilled a core 3,270 meters long from a site called Dome C. That ice holds a continuous record of Earth's atmosphere going back 800,000 years.

Eight. Hundred. Thousand.

Here's the remarkable part. When snow falls and slowly compresses into ice over centuries, tiny air bubbles get sealed inside — literally samples of the atmosphere at the moment that snow hit the ground and never opened until a scientist in a cold laboratory carefully cracked them free. Analyzing the gases inside those bubbles tells you exactly what was in Earth's air at any given point in ancient history.

What did scientists find? For the entire 800,000-year record, carbon dioxide levels in the atmosphere bounced between roughly 180 and 280 parts per million (ppm). Down during ice ages, slightly up during warmer periods. A natural rhythm. Then something changed. Right around the start of the Industrial Revolution in the 1800s, CO, began climbing steeply. Today it sits above 422 ppm — higher th 800,000 years of frozen data.

Ice cores aren't perfect. Drilling is expensive, slow, and dangerous in some of the most remote places on Earth. The very deepest layers get compressed over time and lose some fine detail. Scientists are honest about these limits. But when you look at an 800,000-year graph and see a nearly vertical spike at the end — rising

at exactly the moment humans started burning enormous quantities of coal and oil — the signal doesn't require much interpretation.

What Trees Remember

Trees keep diaries. Not in words, but in wood.

Every year a tree grows, it adds one ring just under its bark. A good year, full of rain and warmth, produces a wide, pale ring. A drought year, or a cold summer near the Arctic, leaves a narrow, dark one. Scientists called dendrochronologists can take a cross-section from a tree trunk and read decades — sometimes centuries — of climate history written in those rings. You can count the rings to find the tree's age and read the widths to understand the years it lived through.

The oldest known living trees are bristlecone pines growing in California's White Mountains, some of them more than 5,000 years old. Researchers have also matched ring patterns from living trees against ancient dead wood preserved in bogs, lakebeds, and old timber buildings, building continuous records stretching back more than 10,000 years in some regions of the world.

By comparing ring widths across thousands of trees from Europe, Asia, North America, and Siberia, scientists can reconstruct average summer temperatures going back many centuries. This work contributed to one of the most talked-about images in climate science: the so-called "hockey stick" graph, first published by scientist Michael Mann and colleagues in the journal Nature in 1999. It showed relatively stable global temperatures for roughly nine centuries, followed by a sharp upward swing through the twentieth century — shaped, unmistakably, like a hockey stick lying on its side.

Tree rings have real limits. They capture conditions during the growing season, not the whole year. They reflect local conditions, so you need trees from many places to build a global picture. Scientists know this, which is why tree rings are one tool among many — never the only one.

The Ocean Floor Remembers Too

The ocean bottom is a time capsule nobody planned.

Tiny creatures called foraminifera — "forams" for short — spend their lives floating in seawater, build delicate shells of calcium, and when they die, drift down to settle on the seafloor in layers. Oceanographer Cesare Emiliani worked out in the 1950s that the chemical composition of a foram's shell changes depending on the water temperature when the creature was alive. Cold water leaves a different chemical fingerprint than warm water. Every shell is a tiny, ancient thermometer.

Drill a core from the ocean floor and you can read temperature changes going back millions of years. The International Ocean Discovery Program has drilled thousands of sites across the world's oceans. The results are consistent: a coherent record of how Earth's climate has shifted across geological time, and a clear picture of how today's conditions compare to the deep past. Warmer ocean water also

sediment cores and ice cores cross-check each other. When both records agree, confidence in the data climbs.

Satellites and the View from Space

Those tools read the past. Satellites watch the present in real time — and they never sleep.

Since 1979, NASA and NOAA have operated a continuous chain of satellites measuring temperatures at Earth's surface and in the atmosphere. The GRACE mission — Gravity Recovery and Climate Experiment, launched in 2002 — detected tiny changes in Earth's gravitational field caused by melting ice sheets in Greenland and Antarctica. It was essentially weighing ice from orbit and found that Greenland alone was losing about 280 billion tons of ice per year during the 2000s and 2010s. NASA's Aqua satellite measures ocean surface temperatures across the entire planet every 48 hours. Others track sea ice extent, forest cover, and the heat radiating outward from Earth.

All that satellite data gets compared, constantly, against thousands of surface measurements. NOAA's Global Historical Climatology Network pulls temperature readings from more than 100,000 weather stations on land. Independent research groups in the United States, the United Kingdom, and Japan each process the raw data separately, using different methods and making different choices about how to handle gaps. They get the same answer. That matters. A lot.

And then there's the Keeling Curve. In 1958, scientist Charles David Keeling began making precise daily measurements of CO, at the Mauna Loa Observatory in Hawaii — high above exhaust, about as clean an atmospheric sample as you can get on land. He kept measuring. Colleagues continued after him. The result is an unbroken record now spanning more than 65 years: a slow, steady, relentless climb from 316 ppm in 1958 to over 422 ppm today. Every year adds another data point. No gaps. No guesses. Just numbers, checked and rechecked.

Why All of Them Together Changes Everything

Here's the thing about evidence. Any single source might be wrong. Ice cores can have gaps. Tree rings reflect local forests, not global averages. Old weather-station thermometers drift out of calibration. Scientists take these possibilities seriously — they're trained to find and fix errors, and they publish their methods publicly so other scientists can check their work.

But when ten independent sources, using completely different techniques, developed by separate teams in different countries over more than a hundred years, all point to the same conclusion — that is not coincidence. That is what scientific certainty actually looks like.

That's precisely where climate science stands today. The IPCC — the Intergovernmental Panel on Climate Change — published its Sixth Assessment Report in 2021, drawing on work from thousands of scientists reviewing tens of thousands of studies. The report opens with a statement that is, by the measured standards of scientific writing, unusually direct: "It is unequivocal that human influence has warmed the atmosphere,

ocean and land." Unequivocal. Not "likely." Not "possible." Unequivocal.

This certainty was earned slowly. Swedish chemist Svante Arrhenius calculated in 1896 — with pencil, paper, and rough tables of figures — that doubling CO_2 in the atmosphere co temperature by several degrees Celsius. Modern climate models running on supercomputers produce almost the same number. That's not a lucky coincidence. It's more than a century of scientists checking, correcting, and improving on each other's work, and arriving at the same destination.

"We Know" Is Not an Opinion

When someone tells you that scientists know Earth is warming because of human activity, that's not a belief, not a political position, and not a guess. It's the conclusion supported by ice cores, tree rings, ocean sediments, satellite observations, weather-station records, atmospheric measurements, and ocean heat content data — gathered by thousands of researchers across dozens of countries, spanning more than a century of independent investigation, all pointing the same way.

Does that mean every detail is settled? No. Scientists still debate exactly how fast sea levels will rise over the next fifty years, or how much the Amazon rainforest might shift if temperatures keep climbing. Good scientists are supposed to argue about details. That's how the process works.

But the core finding — Earth is warming, humans are the cause, and changes are already measurable — rests on a mountain of overlapping evidence that gets harder to dispute with every passing year.

Right now, somewhere in Antarctica, a drill bit is grinding deeper into ancient ice. Somewhere in a California mountain range, a researcher is counting rings on a 4,000-year-old pine. Somewhere overhead, a satellite is taking the ocean's temperature again.

They all keep working. They all keep talking to each other.

And they all keep telling the same story.

CHAPTER IV

What Is Already Changing: Oceans, Ice, and Storms

Something is happening right now, as you read this sentence.

Not in a computer model. Not in a forecast for 2050. Right now, today, the ocean is a little warmer than it was yesterday, and a little more acidic than it was last year. A glacier somewhere is losing more ice than it gains. A coastal city is watching the tide creep higher than the old tide charts expected.

This chapter is about what we can already measure — the changes that show up in real data, collected by real scientists, from satellites and ocean buoys and ice cores and coral surveys. Some of these facts are uncomfortable. But you are old enough to know them, and understanding them clearly is the first step toward doing something about them.

The Ocean Is Warming — and Absorbing the Punishment

The ocean covers about 71 percent of Earth's surface, and it is doing something remarkable and costly: absorbing more than 90 percent of the extra heat that greenhouse gases have been trapping since the Industrial Revolution. That figure comes from the IPCC's Sixth Assessment Report, published in 2021 — the largest coordinated review of climate science in history. In plain terms, the ocean has been acting like a giant sponge for heat, and that has slowed the warming you feel on land. But it has not come for free.

Warmer water expands. It bleaches coral. It shifts the routes that fish travel, pulling them toward the poles where water is cooler. The top 2,000 meters of the global ocean have been warming steadily since at least the 1970s. The surface of the ocean hit record-high temperatures in 2023, according to NOAA — the National Oceanic and Atmospheric Administration, which has tracked ocean heat for decades.

The most visible victim so far? Coral reefs.

The Great Barrier Reef, off the coast of Queensland, Australia, is the largest coral reef system on Earth — roughly the size of Italy. In 2016, a marine heat wave killed about 30 percent of its coral in a single event. Then it happened again in 2017. And again in 2020. And again in 2022. When scientists surveyed the reef in 2022, they found bleaching across 91 percent of the individual reefs they studied. Bleaching doesn't always mean death — coral can recover if the water cools quickly enough — but repeated bleaching without recovery time is devastating. Four major events in six years leaves very little time to recover.

A More Acidic Sea

Heat isn't the only problem. The ocean is also absorbing carbon dioxide directly from the air. About one-quarter of all the CO, humans release ends up dissolving into seawater, form carbonic acid. This process is called ocean acidification.

Before the Industrial Revolution, the average pH of the ocean's surface was about 8.2. Today it sits at about 8.1. That might sound like a tiny difference, but pH works on a logarithmic scale — a drop of 0.1 represents roughly a 26 percent increase in acidity. The ocean is measurably more acidic now than at any point in the last 800,000 years, according to IPCC analysis of ice core and sediment records.

For creatures that build shells — oysters, clams, certain sea snails called pteropods — this is a serious problem. Their shells are made of calcium carbonate, and calcium carbonate dissolves in acid. Scientists have already documented pteropod shells dissolving in parts of the Southern Ocean. It is not a future risk. It is happening now, in the cold waters at the bottom of the world.

Ice: Less of It, Every Year

Stand in Glacier National Park in Montana and you are surrounded by mountains. In 1910, when the park was established, those mountains held about 150 glaciers. Today, fewer than 26 remain — and all of them are smaller than they once were. USGS researchers have tracked them with repeat photography since the late 1800s. The before-and-after photos are stark: bare grey rock where walls of blue-white ice used to stand.

The Arctic is changing even faster.

Since 1979, when satellites began providing reliable measurements, the Arctic Ocean's summer sea ice extent has shrunk by about 13 percent per decade, according to NASA. September 2012 set the record for the smallest summer ice extent ever measured — about 3.4 million square kilometers, roughly half of what it covered in the 1980s. Polar bears depend on sea ice to hunt seals. Without a stable platform to hunt from, some populations are showing measurable signs of stress: thinner body weights, lower survival rates for cubs.

Greenland is losing ice, too. The Greenland Ice Sheet holds enough frozen water to raise global sea levels by about 7 meters if it all melted — which would take centuries, not years. But right now it is shedding roughly 280 billion tons of ice per year, according to the Ice Sheet Mass Balance Inter-comparison Exercise, a multinational research effort that combines satellite gravity measurements with on-the-ground surveys. That meltwater flows into the ocean. And it raises the sea level.

Rising Seas

Since 1900, the global average sea level has risen by about 20 centimeters — roughly 8 inches. That might not sound dramatic. It is. Because that rise is not spread evenly around the globe, and because even a few extra centimeters of water turns ordinary high tides into flooding events.

In Miami Beach, Florida, city engineers have spent over a billion dollars raising roads and installing pump stations to fight what locals call "sunny day flooding" — streets that fill with seawater not because of a storm,

but simply because the tide is higher than it used to be. No hurricane. No rain. Just the ocean, arriving uninvited on a clear afternoon.

In the Pacific, the island nation of Tuvalu — home to about 11,000 people spread across nine low-lying atolls — is watching its land disappear beneath rising water. The average elevation of Tuvalu is less than 2 meters above sea level. King tides already submerge parts of the main island for days at a time. Tuvalu's government has begun negotiating agreements with other countries to allow its citizens to relocate if the islands become uninhabitable. The people of Tuvalu have contributed almost nothing to global greenhouse gas emissions. They are among the first to face the consequences.

The rate of sea level rise is accelerating, too. In the early 1990s, the ocean was rising at about 2.1 millimeters per year. Now the rate is approximately 3.7 millimeters per year, according to satellite altimeter data compiled by NOAA. The pace is picking up.

Extreme Weather: More Frequent, More Intense

A single heat wave, flood, or wildfire cannot be blamed on climate change alone. That distinction matters. What climate scientists can now do — using a growing field called attribution science — is calculate how much more likely or more severe a particular event became because of extra heat in the system.

Here is what that looks like in practice.

On June 29, 2021, the small town of Lytton, in British Columbia, Canada, hit 49.6 degrees Celsius — 121.3 degrees Fahrenheit. Hotter than any temperature ever recorded in Canada, and hotter than Las Vegas has ever been in summer. The next day, a wildfire destroyed most of the town. A team of researchers published findings within weeks showing that the heat dome responsible was virtually impossible without human-caused climate change — they estimated the event would have been at least 150 times rarer in a pre-industrial climate.

In the summer of 2022, roughly one-third of Pakistan was submerged under floodwater. Glacial melt in the north, combined with historically intense monsoon rains, displaced 33 million people. Entire villages vanished beneath the water. Pakistan emits less than 1 percent of global greenhouse gases. Its people bore the weight of a crisis they did almost nothing to create.

Droughts are intensifying, too. The Horn of Africa — covering parts of Ethiopia, Kenya, and Somalia — experienced its worst drought in 40 years between 2020 and 2023, with five consecutive failed rainy seasons. By 2022, more than 22 million people faced severe food insecurity, according to United Nations reporting.

Heat waves in Europe killed tens of thousands during the summer of 2003, and again in 2022, when temperatures in the UK exceeded 40 degrees Celsius for the first time in recorded history. Wildfires burned across France, Portugal, and Greece that same summer.

These are not projections. They happened. The dates are real. The numbers are verified. The science connecting them to a warming atmosphere is well-established and peer-reviewed.

What "Right Now" Really Means

None of this was inevitable. And none of it has to continue accelerating at the same pace — the future depends on choices being made now, by governments, by companies, and by people like you and the adults around you.

But before you can make good choices, you need to see the situation clearly. Not through panic. Not through denial. Just clearly.

The ocean is warmer and more acidic than it was a century ago. Glaciers that took thousands of years to form are retreating in decades. Sea levels are rising faster than at any point in at least 3,000 years. Extreme weather events are becoming more intense and more frequent.

These are facts. They belong to you as a citizen of this planet.

And as it turns out, the next question — what is actually being done about all this — has some genuinely good answers.

CHAPTER V

What's Already Working: Solutions in Action

Here is a piece of good news nobody talks about enough.

The world is already changing course. Not fast enough — scientists are clear about that — but faster than most people realize. Real solutions are running right now, in real countries, on real power grids, in real forests. They are measurable. They are documented. And some of them are flat-out stunning.

This is that chapter. No wishful thinking. Just what is actually happening.

The Solar Revolution Nobody Saw Coming

In 2010, building a solar power plant cost about $378 per megawatt-hour of electricity produced. By 2023, that figure had fallen to around $29. That is a drop of more than 90 percent in roughly a decade.

Read that again. Ninety percent.

The IPCC's Sixth Assessment Report — the big scientific summary published between 2021 and 2022 — confirmed this price collapse and called it "unprecedented in the history of energy systems." Even the most optimistic energy analysts of the early 2000s didn't predict it would happen this fast.

Why does the price matter? Because cheap clean energy gets used. When solar and wind cost less than burning coal or gas, power companies switch without anyone having to twist their arms. That is exactly what is happening. In 2023, renewables — solar, wind, and hydro combined — produced about 30 percent of the world's electricity, according to the International Energy Agency. Solar alone added more new power capacity in 2023 than all other energy sources put together.

Think about what that means in practical terms. A coal plant burns coal, rele
stays in the atmosphere for hundreds of years. A solar panel on a rooftop or in a field makes electricity from sunlight and releases nothing. When a coal plant closes and a solar farm opens in its place, that is millions of tons of carbon dioxide that never gets released.

Denmark is a good example. In 2023, wind turbines supplied roughly 55 percent of Denmark's total electricity — more than any other country its size. On some especially windy days, Danish turbines actually produced more electricity than the country needed, and Denmark sold the extra to its neighbors. The whole country of 5.9 million people, powered mostly by moving air.

The Electric Vehicle Surge

In 2020, about 3 million electric vehicles were sold worldwide. In 2023, that number hit 14 million. That's not a slow climb. That is a near-vertical spike on a graph.

Norway gets brought up constantly in conversations about electric cars, and for good reason. In 2023, about 82 percent of all new cars sold in Norway were fully electric. Not hybrid. Fully electric. The government got there through a combination of tax breaks, free parking, and letting EVs use bus lanes — carrots, not sticks. It worked. Most Norwegian kids your age have probably never ridden in a new gas-powered car and never will.

China is the largest EV market in the world right now, with roughly 8 million sold in 2023 alone. The United States sold about 1.2 million. Those numbers are only going up.

Why does this matter for the climate? Transportation — cars, trucks, ships, planes — accounts for about 16 percent of global greenhouse gas emissions, according to IPCC data. Cars and trucks are a big chunk of that. Every petrol car replaced by an electric one driven on clean electricity means roughly two to three tons of CO_2 not released per year, per vehicle. Multiply by millions of cars, and you close attention to this shift.

Electric vehicles are not a perfect solution on their own. Manufacturing the batteries requires mining materials like lithium and cobalt, which carries its own environmental costs. And an EV charged on electricity from a coal-fired power plant is cleaner than a petrol car, but not as clean as one charged on wind or solar. The solutions stack on top of each other — cleaner cars work better when the grid is also getting cleaner, and the grid is getting cleaner. That's the point.

Forests Fighting Back

Trees are among the most powerful carbon-capture machines on Earth. A single mature tree absorbs roughly 22 kilograms of CO_2 per year. Forests collectively absorb around 2.6 billion according to NOAA. That is a lot of work those trees are doing for free.

Deforestation is still a serious problem — particularly in parts of the Amazon and Southeast Asia — but large-scale replanting efforts are happening at the same time, and they are making a real difference.

In July 2019, Ethiopia launched a tree-planting campaign called the Green Legacy Initiative. Over the course of the summer that year, the country planted more than 3.5 billion seedlings. Yes, billion. The goal was to restore degraded land and bring back forests that had been cut down over generations. Ethiopia has continued planting every year since.

Meanwhile, across the top of Africa, eleven nations are building something called the Great Green Wall — an 8,000-kilometer belt of trees and restored land stretching from Senegal in the west all the way to Djibouti in the east. The goal is to restore 100 million hectares of degraded land by 2030. Millions of trees are already in the ground. Farmers in Senegal and Niger who were watching their fields turn to dust are now harvesting crops again in land that was technically desert a decade ago.

The Bonn Challenge, launched in 2011, is a global effort to restore 350 million hectares of deforested and degraded land by 2030. As of the mid-2020s, countries covering more than half that area have already made pledges and begun work. Not promises — actual, measurable restoration.

These efforts do not undo the damage already done to old-growth forests. Ancient forests store far more carbon than young planted ones, and that distinction matters. But restoration is real, it is happening at scale, and it is pulling carbon out of the air while rebuilding habitat for wildlife.

The Ozone Story: Proof That the World Can Fix Things

Some of you may have heard of the ozone layer — the thin shield of gas high in the atmosphere that blocks harmful ultraviolet radiation from the sun. In the 1980s, scientists discovered that chemicals called CFCs, used in aerosol sprays and refrigerators, were eating a hole in it over Antarctica. Skin cancer rates were rising. The situation looked genuinely alarming.

Then something remarkable happened.

In 1987, countries around the world signed the Montreal Protocol — an agreement to phase out CFCs and replace them with safer alternatives. All 197 countries on Earth eventually signed it. Every single one. Scientists began monitoring the ozone layer closely, and over the following decades, the hole slowly began to heal. NASA confirmed in 2023 that the ozone layer is on track to fully recover by around 2066.

That is not a small thing. Humans broke something in the atmosphere. Then humans fixed it. Working together, across national borders, using science as the guide.

The Montreal Protocol is the most successful environmental treaty in history. It proves the model works: identify the problem using data, agree on a solution, and enforce it globally. Climate scientists point to the Montreal Protocol often — not because fixing CFCs is the same as fixing CO woven into how the world economy works), but because it shows international cooperation is possible when the science is clear and the will is there.

Cities and Countries Already Hitting Their Targets

While national governments debate, cities and smaller countries are just doing it.

Costa Rica, a country of about five million people wedged between Nicaragua and Panama, has run on nearly 99 percent renewable electricity for most of the past decade. Its grid runs mainly on hydropower, with geothermal and wind rounding it out. Costa Rica has also been expanding its forests — tree cover went from 26 percent of the country in 1983 to about 60 percent by the 2020s, one of the most dramatic reforestation achievements anywhere on Earth.

Iceland heats about 90 percent of its homes using geothermal energy — heat pulled directly from underground volcanic rock. No coal, no gas. Just the earth itself.

In the United States, states like California and Texas have built so much solar and wind capacity that on some days, electricity prices on the wholesale market drop to zero because supply exceeds demand. In 2023, California broke its own record for renewable energy multiple times, briefly running on 100 percent clean electricity for parts of several days.

Hundreds of cities — from Copenhagen to Medellín to Chengdu — have set and, in many cases, already met binding targets for clean energy, electric buses, and tree coverage.

This Is Not the End of the Story

None of this means the climate crisis is solved. It is not. The IPCC is clear that emissions need to fall far faster and farther than they currently are. Warming is still happening. Some changes already baked into the system cannot be undone in your lifetime.

But here is what is also true: the tools exist. The prices have dropped. The policies have worked in some places and can work in others. Real people in real governments and real cities made decisions, and those decisions measurably changed what went into the atmosphere.

The story of climate change is not only a story of damage. It is also — already — a story of people figuring things out.

You are reading this chapter near the beginning of that second story. Not the end.

CHAPTER VI

Your Turn: What Kids Can Actually Do

Here is the truth, and it's one worth holding onto: you already know more about climate science than most adults did when they were your age. You know the difference between weather and climate. You understand the greenhouse effect. You've looked at the evidence — the ice cores, the tide gauges, the temperature records — and you didn't look away. That matters. Knowledge is the first tool, and you've got it.

Now comes the part where people sometimes say something unhelpful. They either tell you that every little action you take will save the planet, or they tell you the problem is so enormous that nothing you do could possibly matter. Both of those things are wrong. The truth is more interesting than either of them.

Let's Be Honest About What Individual Actions Can Do

Your personal choices — what you eat, how you get to school, whether you turn off the lights — do have a real impact on carbon emissions. But they don't have a large enough impact to fix climate change by themselves. No honest climate scientist would tell you otherwise. The IPCC's Sixth Assessment Report, released in 2021 and 2022, is very clear: the scale of change needed requires governments, energy companies, and entire industries to shift how they operate. That is not something a ten-year-old can do alone.

But here's what's also true. Individual actions aren't pointless. They build habits. They signal values to the people around you. They reduce the total amount of carbon going into the atmosphere, even if by a small amount. And they make you a more credible voice when you talk to the adults who do have the power to make big decisions.

So the honest menu of things you can actually do has three parts. And the most powerful one might surprise you.

At Home: Small Changes With Real Numbers

Start with food. About one-third of all food produced for humans is lost or wasted, according to the United Nations Food and Agriculture Organization. In the United States alone, the average family of four throws away roughly 1,500 dollars worth of food every year. When that food rots in a landfill, it produces methane — a greenhouse gas that, over a twenty-year period, traps heat about eighty times more efficiently than carbon dioxide. Wasting less food is genuinely one of the most effective things a household can do.

You can't control what your family buys, but you can notice what gets thrown out and say something. Which leftovers always get forgotten? Which vegetables go soft before anyone touches them? Small observations turned into small habit changes add up.

Meat is a harder conversation, but it's worth knowing the numbers. Producing one kilogram of beef releases roughly sixty kilograms of greenhouse gases — more than driving a car about 150 miles. You don't have to become a vegetarian. But swapping beef for chicken, lentils, or eggs a few nights a week has a measurable effect. If your family is open to it, bring it up. Don't lecture. Just share what you've learned.

On energy: roughly half of a typical home's energy use goes to heating and cooling. You can't change the furnace or install a heat pump — that's your parents' call. But you can close doors to rooms nobody's using, not leave the refrigerator open while you think about snacks, and turn off lights and screens when you leave a room. These feel tiny. They are tiny. But they're also just good practice for a person who takes the science seriously.

One more thing worth knowing: LED light bulbs use about 75% less energy than old incandescent bulbs and last twenty-five times longer. If your house still has the old kind, you can mention it. Sometimes adults just haven't gotten around to switching.

At School: Finding Your People

Almost every kid who has ever done anything significant for the environment did it with other people. Not alone. With a group.

If your school has an environmental club, join it. If it doesn't, you can start one. That sounds harder than it is. You need a teacher who will serve as an advisor — often a science or social studies teacher is willing. You need a few classmates. And you need a specific goal, because vague groups that want to "help the environment" tend to drift and dissolve. Specific goals work. "We want the school to switch to recycled paper." "We want to start a composting program in the cafeteria." "We want the school board to install solar panels on the roof."

That last one might sound outlandish. It isn't. Schools across the country have added solar panels, often after student groups made persistent, researched arguments to school boards. In Tallahassee, Florida, a middle school student environmental group spent two years advocating for energy audits across their district. In Portland, Oregon, student activists helped push a school district toward a commitment to run entirely on clean energy by 2025. These aren't myths. They're documented cases of young people doing the unglamorous, repetitive work of showing up to meetings and making their case.

Starting a school garden is another option that sounds small but creates outsized ripple effects. Gardens connect kids to where food comes from. They reduce food miles for at least some of what gets served in a school. They become a place where climate conversations happen naturally, without anyone feeling lectured at.

Your Voice Is the Most Powerful Tool You Have

Here's the thing that surprises a lot of adults when they think about it clearly: young people change minds. Not because they're cute, but because they're credible. A kid who has read about climate science, who can explain what an ice core is and why sea level rise is measured in millimeters per year, and who cares enough to bring it up — that kid gets listened to.

Talk to your family. Not in a doom-and-gloom way. Just share what you've learned, the way you'd share anything you found fascinating. "Did you know that Arctic sea ice has shrunk by about 13% per decade since 1979?" That's a NOAA-documented fact, and it's genuinely startling. You're not attacking anyone. You're sharing something true and interesting.

Talk to your friends. Normalize the conversation. Climate change doesn't have to feel like a homework topic. It's literally the biggest story happening on Earth right now, and you're alive during it.

And talk to elected officials. Yes, you. Even if you can't vote yet. Elected officials track constituent contact because it tells them what people care about. A real letter — not a form email, but one you wrote yourself, in your own words — carries more weight than you might think. You can write to your city council member, your state representative, or your member of Congress. Tell them what you've learned. Ask them what their office is doing. Ask them to support specific policies — clean energy standards, funding for public transit, protections for forests. You don't have to be an expert. You have to be a person who cares and says so clearly.

Xiuhtezcatl Martinez was thirteen when he spoke in front of the United Nations on behalf of Earth Guardians, a youth environmental organization. He didn't have a law degree. He had knowledge, conviction, and the willingness to show up. Greta Thunberg was fifteen when she sat outside the Swedish parliament with a hand-painted sign. Whatever you think of where their paths led, the simple fact is that young people have always been part of the story of environmental progress. The adults who pushed through the Montreal Protocol in 1987 — the treaty that saved the ozone layer — were once teenagers who learned about environmental damage and decided it was worth their attention.

The Future Isn't Written Yet

The IPCC is clear on another thing: every fraction of a degree of warming that we avoid matters. The difference between 1.5 degrees Celsius of warming and 2 degrees is not small. It's hundreds of millions of people facing extreme heat. It's coral reefs surviving or not. It's whether certain low-lying cities stay above water. The choices being made right now — by governments, by companies, by voters, by people who learned about this when they were kids and grew up to care about it — will determine which version of the future we get.

You are nine or ten or eleven or twelve or thirteen years old. In ten years, you'll be old enough to vote. In twenty, you may be running for office, designing energy systems, writing laws, teaching, farming, building. The people making those decisions will be you and the people around you. What they know, what they care about, what they consider normal — that's being shaped right now, in classrooms and conversations and choices.

The future is not written. That's not a slogan. That's what the science actually shows: multiple possible outcomes still exist, and the path we end up on depends on what humans do in the next few decades.

You're not a bystander to that. You never were.