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485 Million Years - Sharp Temperature Changes

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[Today's study picks up directly from CSSG-2.41 A Fresh Look at Old Times - 485 Million Years which we saw last week. If you were not able to join that discussion, please take a few minutes to go over that material.]

Orange Triangles of Sharp Temperature Changes

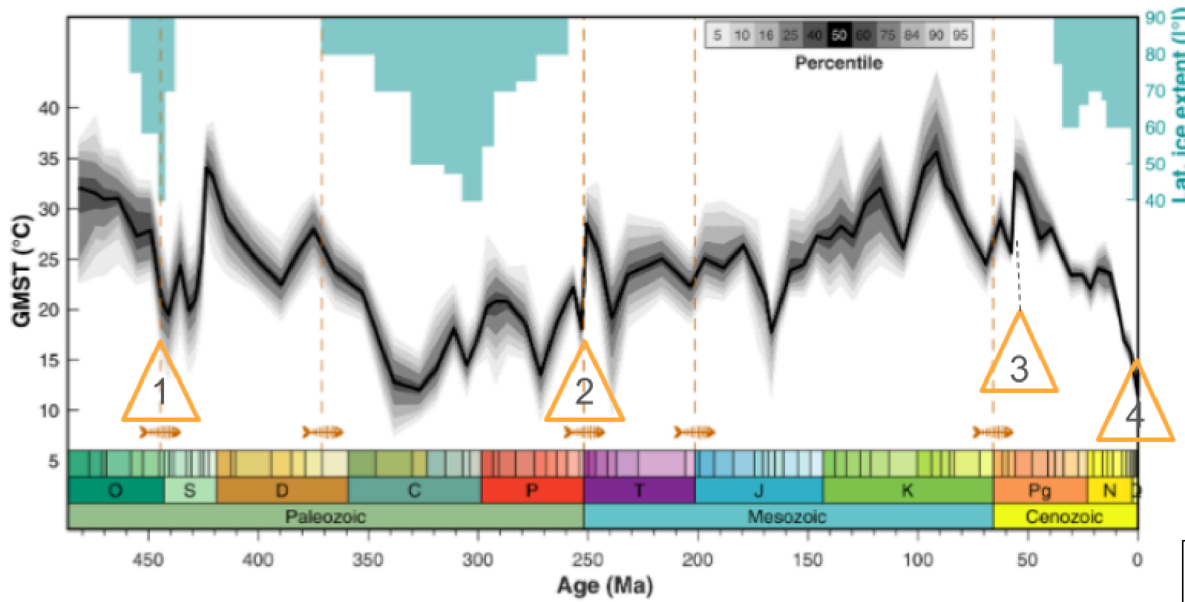

Fig. 2. Phanerozoic temperature history.
PhanDA reconstructed GMST for the past 485 million years. Black line shows the median, shading corresponds to the ensemble percentile. Blue rectangles show the maximum latitudinal ice extent (2), and orange dashed lines show the timing of the five major mass extinctions of the Phanerozoic (36).

Some points of interest in today's CSSG-2.42 discussion

This first chart, from the original paper, is useful for getting oriented, though we won't be discussing all these interesting things.

- The fish bones mark mass extinctions
- The blue rectangles coming down from the top indicate the polar ice sheets and how far down the planet they reached. 40 degrees is the latitude of Washington D.C.. You can see we're at one of the coldest global temperatures in the last 1/2 billion years.
- **We'll focus more on the Orange Triangles where we experienced sharp temperature changes.**

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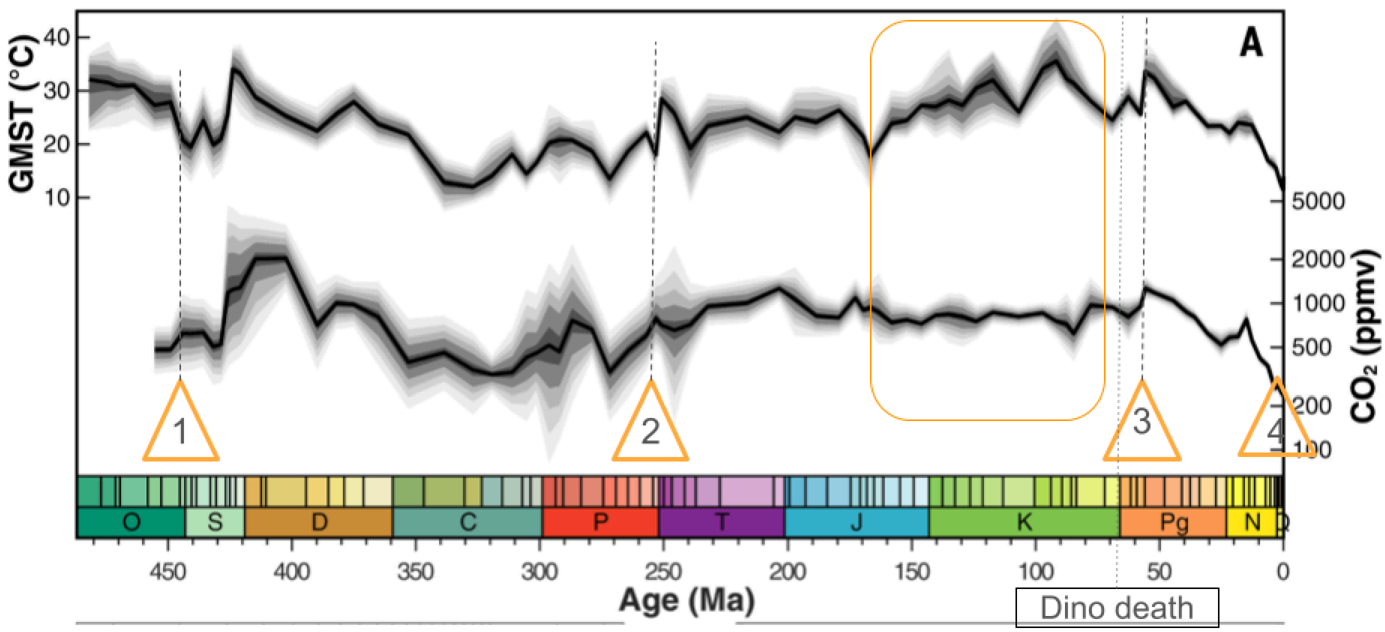
Last time, we noted how CO2 and global temperatures were more highly correlated than earlier studies were able to discern. As I pointed out, this new chart brings up fresh questions as well:

- What might be happening in sharp disruptions, such as the radical increase in temperature at around 250 million years ago (Mya)?
- How do we approach the few periods when CO2 levels and temperature changes seem less correlated, such as when CO2 was apparently pretty stable from 150-50 Mya, while temperatures appear to be increasing and jumping around a bit? (Not answering this one today, but radical changes in continental positions come to mind.)



As always, when we see a sharp change of behavior, or something that doesn't "seem right", it's time to ask "WHY?". (The answers, of course, may not be immediately forthcoming. Perhaps more research will suss it out… But sometimes the evidence from long ago has been destroyed by plate tectonics or something, so we are left with best guesses.)

While the original article at A 485-million-year history of Earth's surface temperature | Science is far more comprehensive, the Washington Post did a great job in presenting some of the findings in a more accessible form at Scientists calculate Earth's temperature changes over 485 million years - The Washington Post.

The rest of this study will feature a few excerpts from the Washington Post article, which is provided in full in CSSG-2.42supplement. In addition, I've included a helpful article from The Guardian Birth of North Atlantic Ocean 55m years ago caused rapid global warming | Science | The Guardian.

485 million years of temperature turmoil

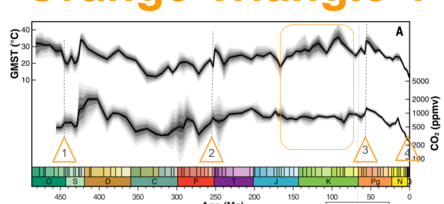
The timeline encompasses almost all of the Phanerozoic — the geologic eon that began with the emergence of multicellular, non-microscopic organisms and continues today.

It portrays a global climate that was more dynamic and extreme than researchers had imagined, said Jess Tierney, a climate scientist at the University of Arizona and co-author of the study. Compared with graphs based solely on climate models, which tend to depict smaller and slower swings in temperatures, the new timeline is full of sudden spikes and abrupt shifts.

But, in keeping with decades of past research on climate, **the chart hews closely to estimates of carbon dioxide in the atmosphere, with temperatures rising in proportion to concentrations of the heat-trapping gas. "Carbon dioxide is really that master dial," Tierney said. "That's an important message … in terms of understanding why emissions from fossil fuels are a problem today."**

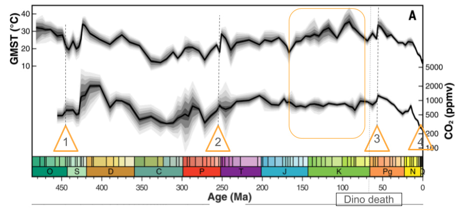
At the timeline's start, some 485 million years ago, Earth was in what is known as a hothouse climate, with no polar ice caps and average temperatures above 86 F (30 C). The oceans teemed with mollusks and arthropods, and the very first plants were just beginning to get a toehold on the land.

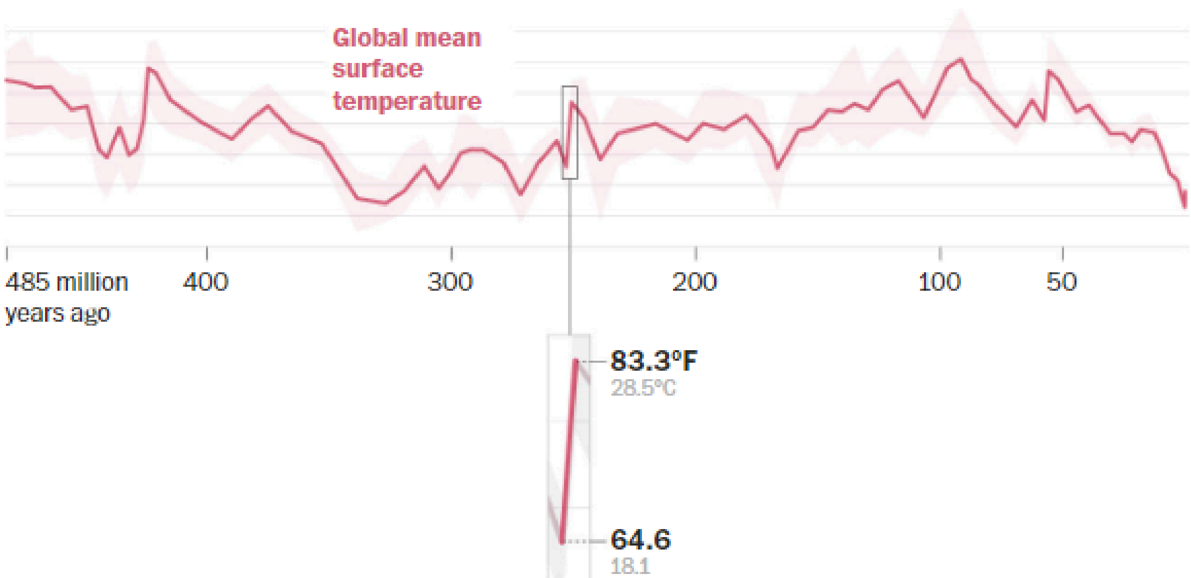
Orange Triangle 1



Temperatures began to slowly decline over the next 30 million years, as atmospheric carbon dioxide was pulled from the air, before plummeting into what scientists call a **coldhouse state around 444 million years ago**. Ice sheets spread across the poles and global temperatures dropped more than 18 degrees Fahrenheit (10 degrees Celsius). **This rapid cooling is thought to have triggered the first of Earth's "big five" mass extinctions — some 85 percent of marine species disappeared as sea levels fell and the chemistry of the oceans changed.**

Orange Triangle 2





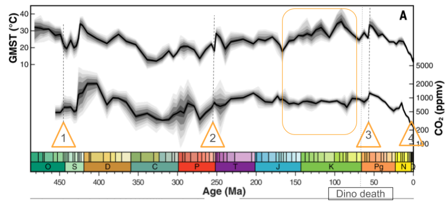
An even more dramatic shift occurred at the end of the Permian period, ***about 251 million years ago. Massive volcanic eruptions unleashed billions of tons of carbon dioxide into the atmosphere, causing the planet's temperature to shoot up by about 18 F (10 C) in roughly 50,000 years.*** Acid rain fell across the continents; marine ecosystems collapsed as the oceans became boiling hot and depleted of oxygen.

"We know it to be the worst extinction in the Phanerozoic," Tierney said. "By analogy, we should be worried about human warming because it's so fast. We're changing Earth's temperature at a rate that exceeds anything we know about."

The study also makes clear that the conditions humans are accustomed to are quite different from those that have dominated our planet's history. For most of the Phanerozoic, the research suggests, average temperatures have exceeded 71.6 F (22 C), with little or no ice at the poles. Coldhouse climates — including our current one — prevailed just 13 percent of the time.
"We know that these catastrophic events … shift the landscape of what life looks like," Judd said. "When the environment warms that fast, animals and plants can't keep pace with it."

At no point in the nearly half-billion years that Judd and her colleagues analyzed did the Earth change as fast as it is changing now, she added: "In the same way as a massive asteroid hitting the Earth, what we're doing now is unprecedented."

Orange Triangle 3



Let's take a diversion from the Washington Post article to look at a similar event about 55 million years ago (look at the chart above) discussed in a Guardian article a year ago. **About 55 million years ago,** the remnants of the supercontinent, Pangea, ripped apart. North America went one way; Europe the other, and the North Atlantic Ocean flooded in to fill the gap. Global temperatures rose by more than 5C and many species went extinct. Quite why the world warmed so quickly has long been a puzzle, but a new study reveals that the rapid warming was driven by methane emissions associated with the ocean birth.

Scientists onboard an ocean drilling expedition collected rock samples from ancient volcanic vents that were active during the birth of the North Atlantic Ocean. Much to their surprise, analysis of the rocks showed that gas release from the vents happened in very shallow water – less than 100 metres. Their findings, which are published in Nature Geoscience, suggest that methane released from these hydrothermal vents would have escaped directly into the atmosphere, causing rapid global warming (unlike methane emitted from deep sea vents, which is mostly converted to carbon dioxide – a far less potent greenhouse gas – as it bubbles up through the water).

Birth of North Atlantic Ocean 55m years ago caused rapid global warming | Science | The Guardian

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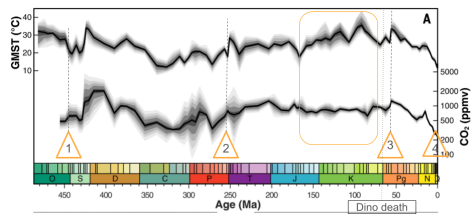
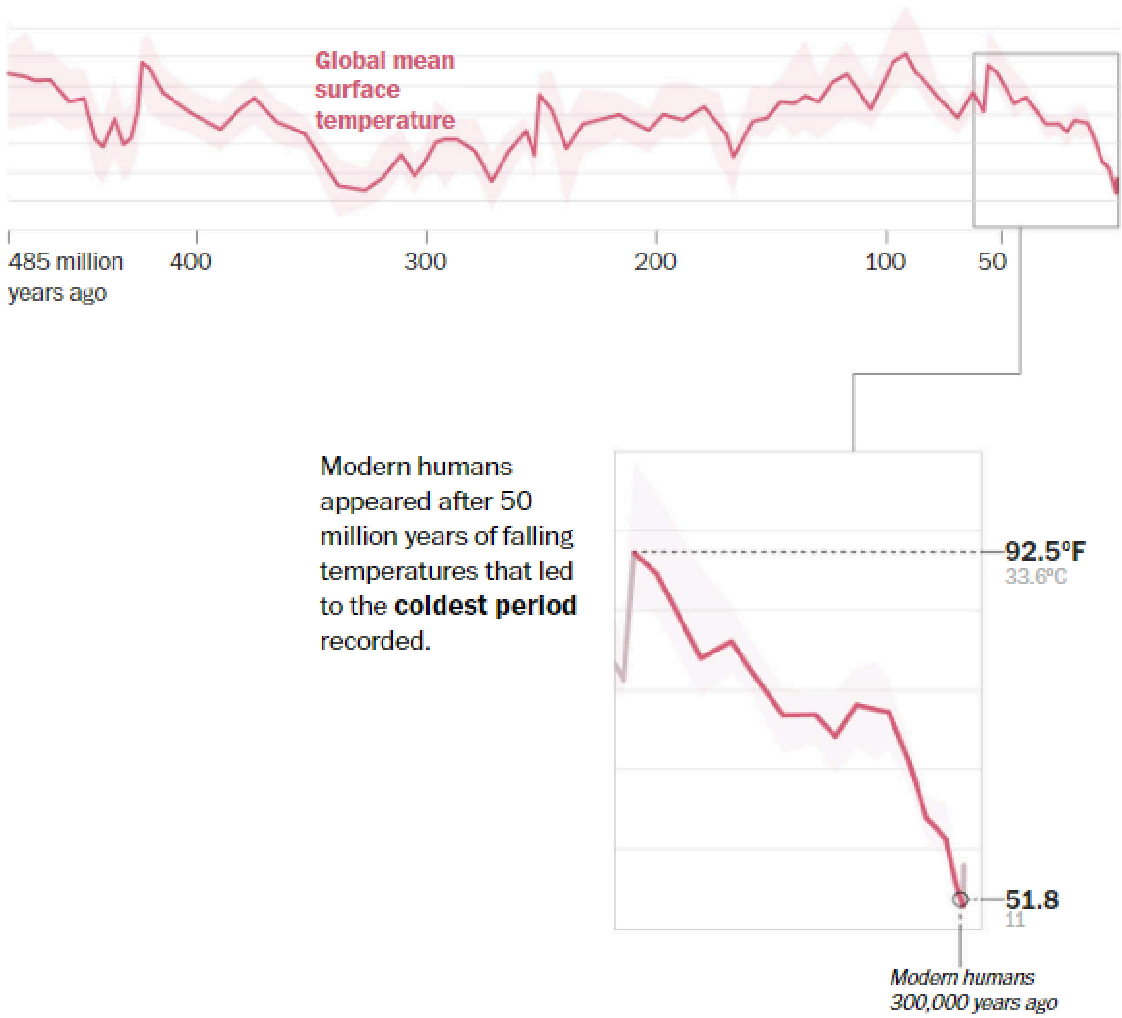
Orange Triangle 4

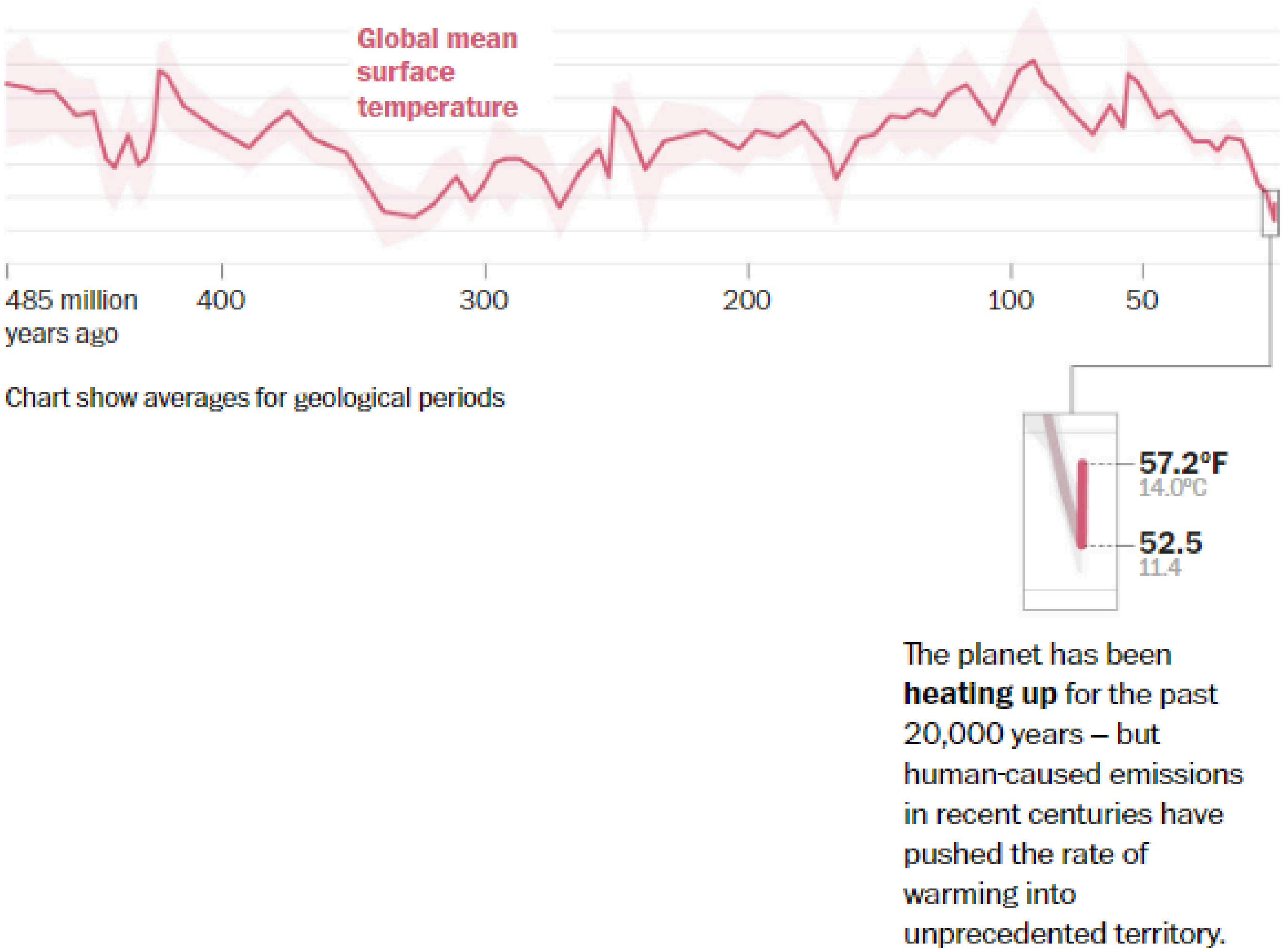


First, to set the stage, the last 50 million years have been remarkable. See CSSG-2.4 Paleo Part 3 - the latest 50 million years - the Big Cooldown where we got the big picture.



This is one of the more sobering revelations of the research, Judd said. Life on Earth has endured climates far hotter than the one people are now creating through planet-warming emissions. **But humans evolved during the coldest epoch of the Phanerozoic, when global average temperatures were as low as 51.8 F (11 C).**

Without rapid action to curb greenhouse gas emissions, scientists say, global temperatures could reach nearly 62.6 F (17 C) by the end of the century — a level not seen in the timeline since the Miocene epoch, more than 5 million years ago.



“We built our civilization around those geologic landscapes of an icehouse,” Judd said. “So even though the climate has been warmer, humans haven’t lived in a warmer climate, and there are a lot of consequences that humans face during this time.”

The rate of change of temperatures now is far faster than any ever seen in the long-term geologic record. [While not discussed here, there are sharp temperature changes in the last 3 million years which will be relevant to the present situation.]

PUNCHLINES

1. There is a strong correlation between CO2 and global temperatures
2. Sharp changes in temperatures can drive huge extinctions. The rate of change of temperature that we are now causing is far greater than was involved in past great extinctions.
3. We are now at the coolest the earth has likely ever been in the last half billion years, (averaging out the ice ages over the last 2-3 million years). We are now at the warmest in around 3 million years.
4. Increasing temperature will not wipe out everything, but they can be very disruptive to humans, who evolved in a cool era.
5. Obviously, scientific work sorting the past out will continue.

References for this Discussion:

The New Study for the Smithsonian
https://www.science.org/doi/full/10.1126/science.adk3705

And a fantastic analysis of that study in the Washington Post
https://www.washingtonpost.com/climate-environment/2024/09/19/earth-temperature-global-warming-planet/

The Guardian article
Birth of North Atlantic Ocean 55m years ago caused rapid global warming | Science | The Guardian.

Approximate "Cheat Sheet":

1 meter → 3 feet **1 degree Celsius** (**^{0}C**) → 2 degree Fahrenheit (^{0}F)
ppm = parts per million **CO_2** = Carbon Dioxide
1 tonne = 1000 kilograms = 2205 pounds **1 gigatonne (1 Gt)** = 1 billion tonnes
1 trillion tonnes (1Tt) = 1000 gigatons

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New Scientist

News

Our Natural World

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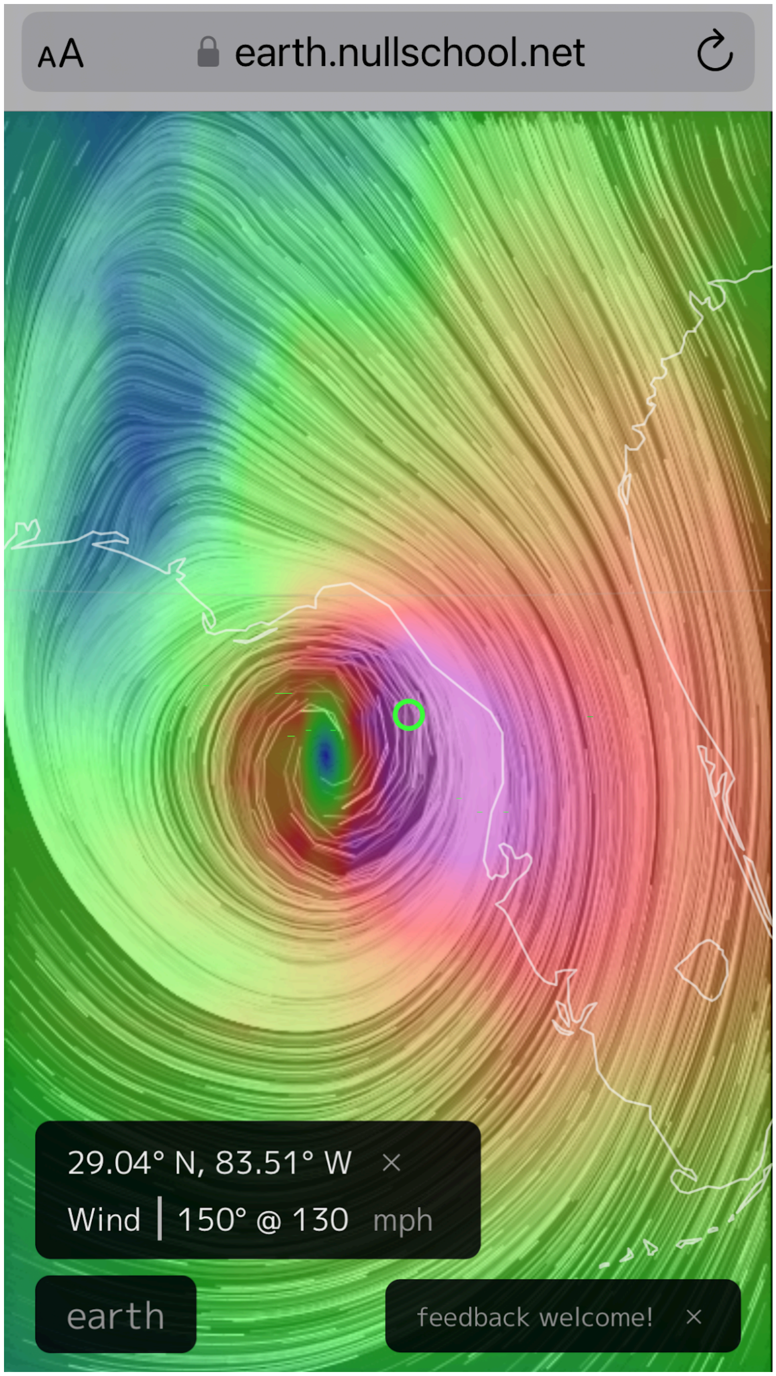

While its edges were experienced on Florida's east coast