

## Is Last Year's Sudden Warming a "Change of Behavior"?

Last Time (CSSG-2.23), we got our “toes in the water” on the question “What happens if we **stop all emissions** TODAY? We’ll pick up on that question in later studies, but let’s divert to a key observation - Behaviors.



Our first “model” simply assumed:

Heating from the sun continues without change from the starting Equilibrium (when no more human-caused Greenhouse gasses were being emitted - Net Zero) until a new Equilibrium is reached, when the whole planet heats up enough to shed the excess heat (hotter things get rid of more heat). Some results included:

- “**Sea level**” increased only while “grounded ice” was melting; it stayed constant when only floating ice was melting. (Expansion of heating water was ignored.)
- “**Global surface temperature**” rose only once some of the heat was no longer dedicated to melting surface ice.
- These **changes in behavior** are tied to “**changes of state**” of the “planet”.

**Approximate “Cheat Sheet”:**

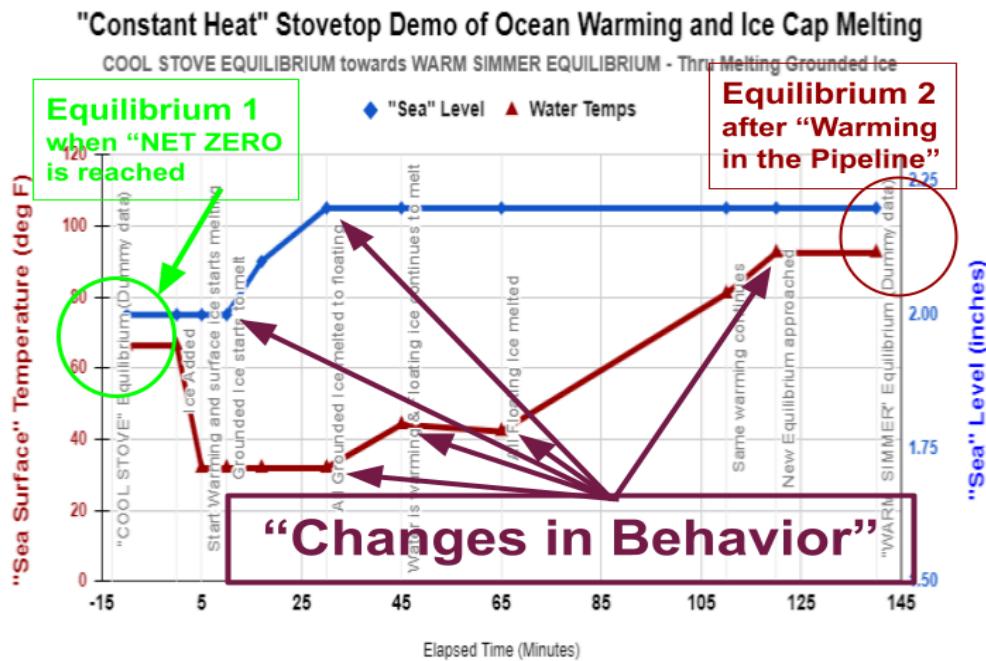
1 meter → 3 feet      1 degree Celsius (°C) → 2 degree Fahrenheit (°F)

ppm = parts per million      CO<sub>2</sub> = Carbon Dioxide

1 tonne = 1000 kilograms = 2205 pounds      1 gigatonne (1 Gt) = 1 billion tonnes

1 trillion tonnes (1Tt) = 1000 gigatons

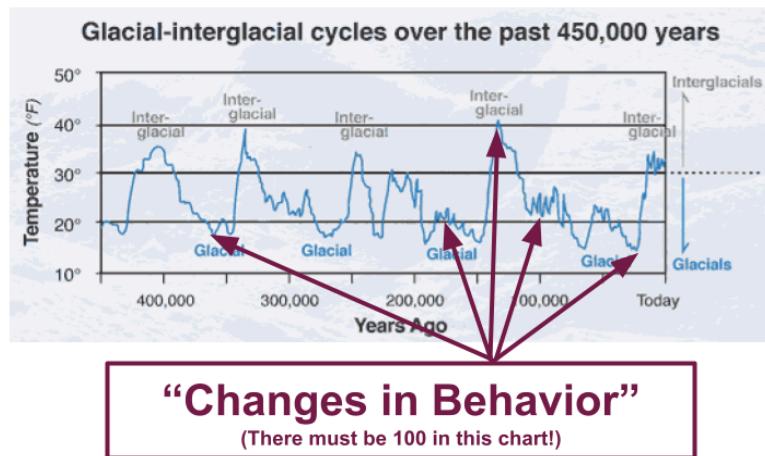
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The point here is: **when there is a notable change in behavior** in some major parameter (measurement) in the planet, **there may be some deeper (pun intended) reason**.

## Some examples:

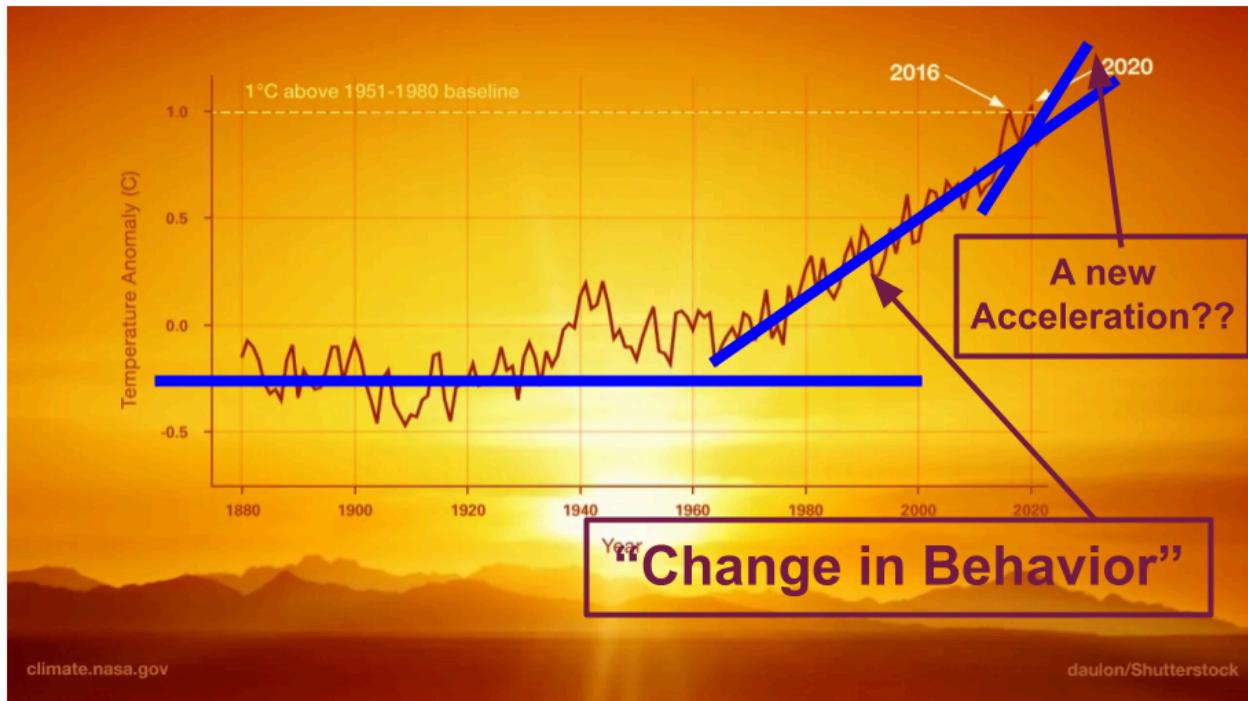
## ICE AGES and all the little changes along the way



Such big changes always have a big reason for happening...

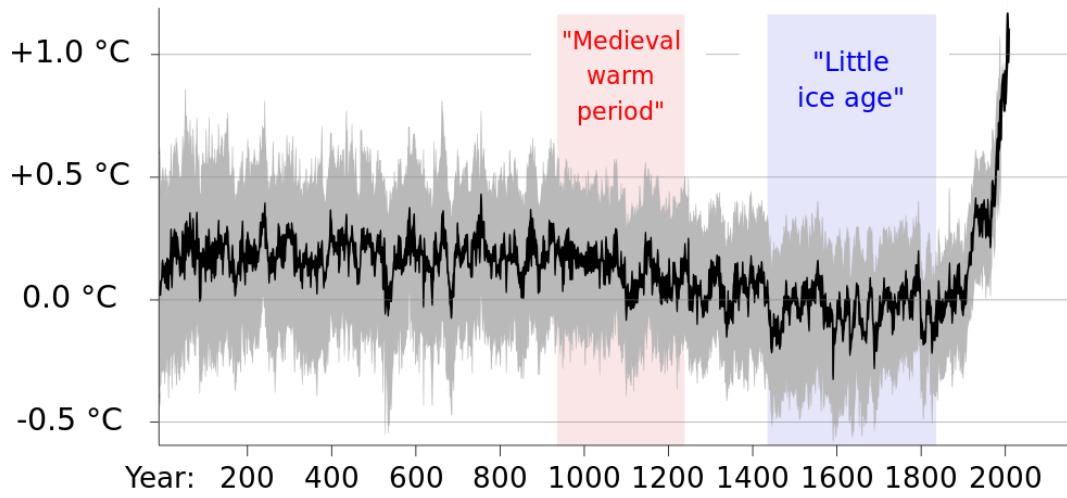
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### Global Temperatures over the last century



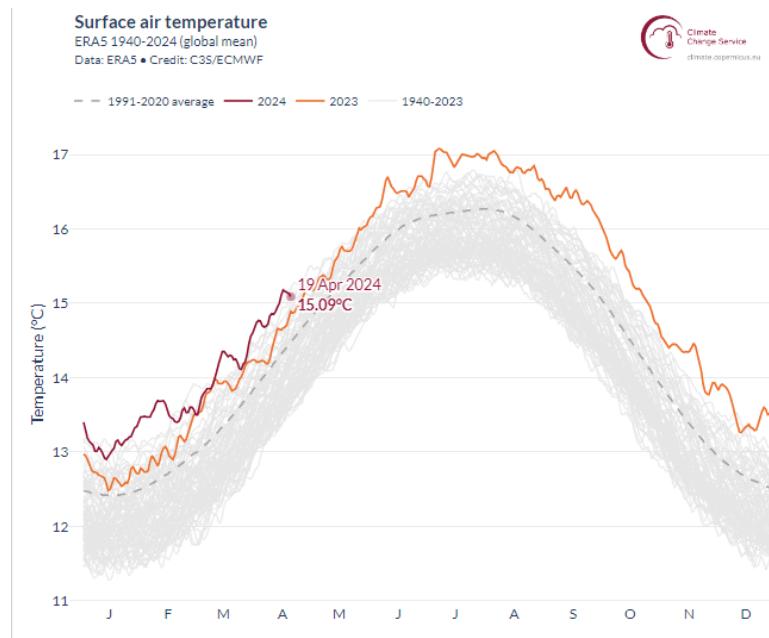
Or over a bit longer period:

### Global Average Temperature Change

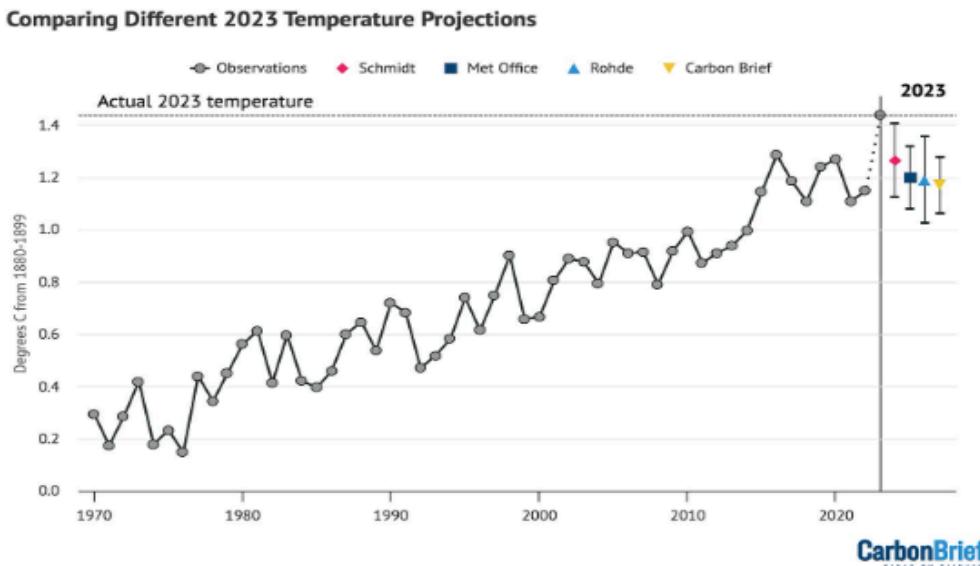


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And, the unexpected and unprecedented rise in global temperature in the last year:



Look at the projections at the far right of the chart below <https://skepticalscience.com/2023-unexplained-warming.html>:

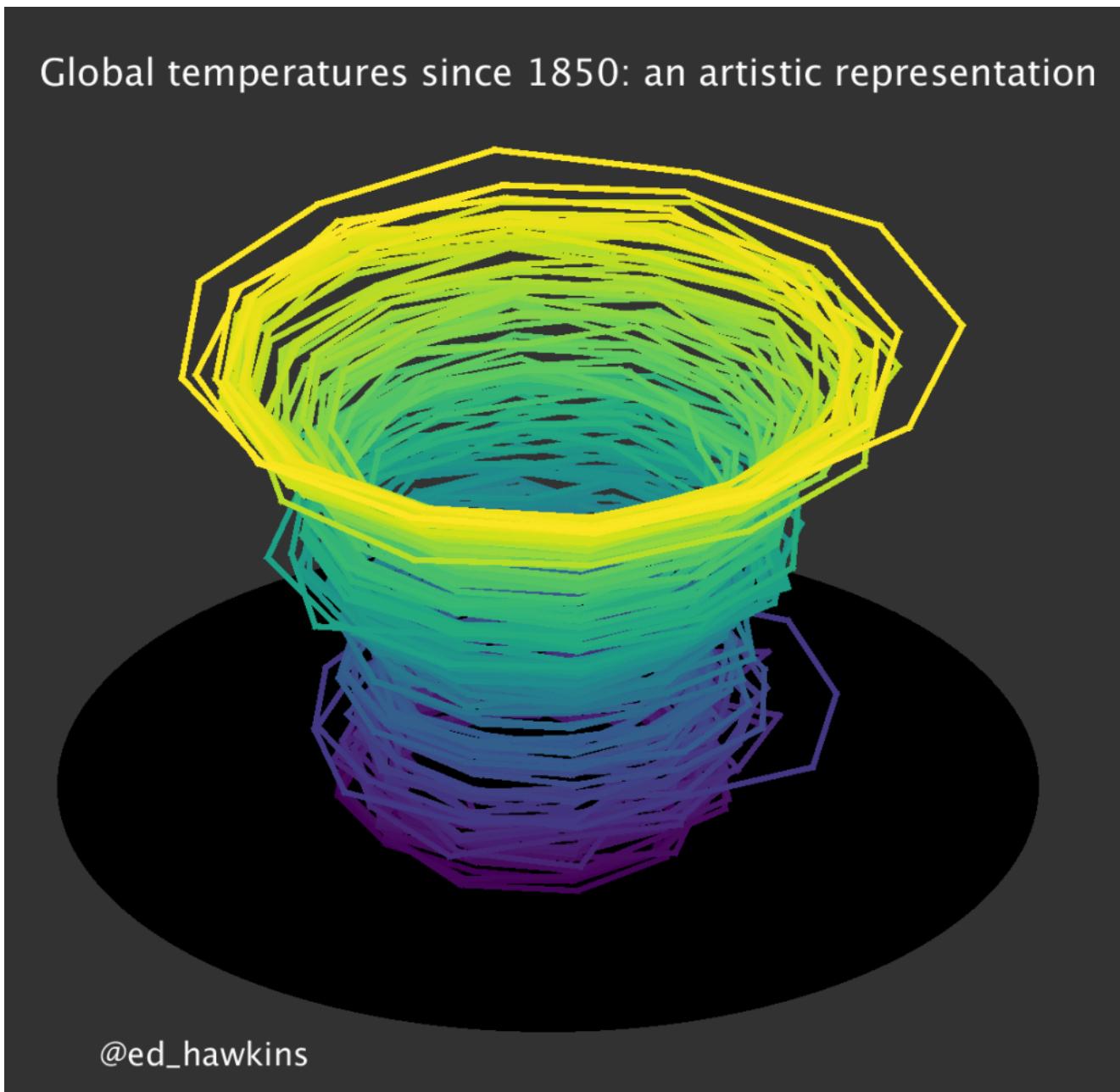


Temperature predictions for 2023 from the UK Met Office, NASA's Dr Gavin Schmidt, Berkeley Earth and Carbon Brief relative to pre-industrial (1880-99) temperatures. Chart by Carbon Brief.

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My favorites are the NASA Climate Spirals at: <https://svs.gsfc.nasa.gov/5190/>



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Materials Library at: <https://drive.google.com/drive/folders/1000YwNz92CbY-pC-aYEDrwJTxLj8JUZf?usp=sharing> maclankford@gmail.com

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Some Headlines:

# Global temperature increase in 2023 blew past all climate models

<https://www.earth.com/news/global-temperature-increase-2023-blew-past-all-climate-models/>

# Recent events that indicate Earth's climate has entered uncharted territory

<https://apnews.com/article/global-heat-climate-extremes-2023-95f6861b1312ead54ed941524fa7d2ab>

One of the most respected voices in Climate Science is Gavin Schmidt. He's the director of NASA's Goddard Institute for Space Studies, succeeding James Hansen (a major force in this area and the inspiration of the Climate Dice Game we created last year). His comments were interesting:

A personal take on science and society

## World view



By Gavin Schmidt

### Why 2023's heat anomaly is worrying scientists

Climate models struggle to explain why planetary temperatures spiked suddenly. More and better data are urgently needed.

When I took over as the director of NASA's Goddard Institute for Space Studies, I inherited a project that tracks temperature changes since 1880. Using this trove of data, I've made climate predictions at the start of every year since 2016. It's humbling, and a bit worrying, to admit that no year has confounded climate scientists' predictive capabilities more than 2023 has.

For the past nine months, mean land and sea surface temperatures have overshot previous records each month

**If the anomaly does not stabilize by August, then the world will be in uncharted territory."**

from stratospheric water vapour, and the ramping up of solar activity in the run-up to a predicted solar maximum. But these factors explain, at most, a few hundredths of a degree in warming (Schoeberl, M. R. *et al. Geophys. Res. Lett.* **50**, e2023GL104634; 2023). Even after taking all plausible explanations into account, the divergence between expected and observed annual mean temperatures in 2023 remains about 0.2 °C – roughly the gap between the previous and current annual record.

There is one more factor that could be playing a part. In 2020, new regulations required the shipping industry to use cleaner fuels that reduce sulfur emissions. Sulfur compounds in the atmosphere are reflective and influence several properties of clouds, thereby having an overall cooling effect. Preliminary estimates of the

<https://www.nature.com/articles/d41586-024-00816-z>

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So, is this change of such a magnitude that we might be into a real “**Change of Behavior**”?

If so, what might be happening? Let’s speculate on the types of things that could produce large new global temperature increases (not saying any of these has happened). These would be candidates if this should turn into a big deal - and not simply a statistical happenstance:

- The cloud cover at the lower altitudes, which reflect so much incoming sunlight, might have experienced a major reduction. This could have happened because of particulate reductions from ships which are moving to much cleaner fuels to cut air pollution. The polluting particulates usually help form clouds.
- The shipping fuel improvements might have reduced reflective aerosols as well, allowing more sunlight through.
- Recent volcanic eruptions may have dumped a huge amount of water vapor into the stratosphere, causing it to hold much more heat from escaping back into space.
- High altitude clouds might not be forming as much, letting more heat out.
- Greenhouse gas concentrations might have increased dramatically, perhaps methane or nitrous oxide, both of which are much more potent than CO<sub>2</sub> for near-term impacts.
- The ocean absorbs over 90% of incoming heat. Perhaps the conduction of heat to depth can’t flow down as well for some reason (e.g., cold layers below or slowdown of AMOC). This would be consistent with the very warm surface last year. If energy absorption slows, the surface would heat faster.
- Any other guesses??

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**It's HOT!!!**

