The Case of the Mislabeled Axis

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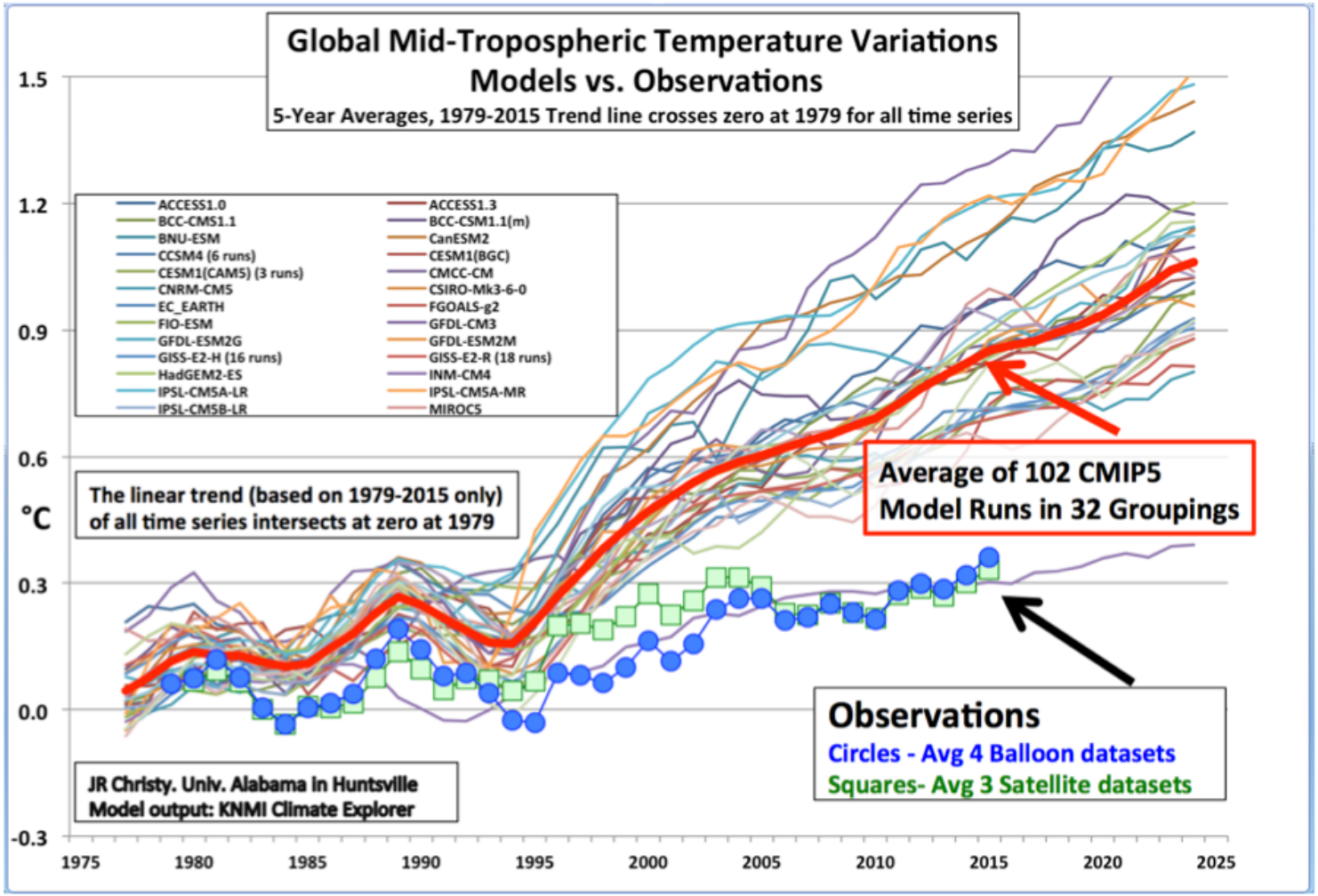
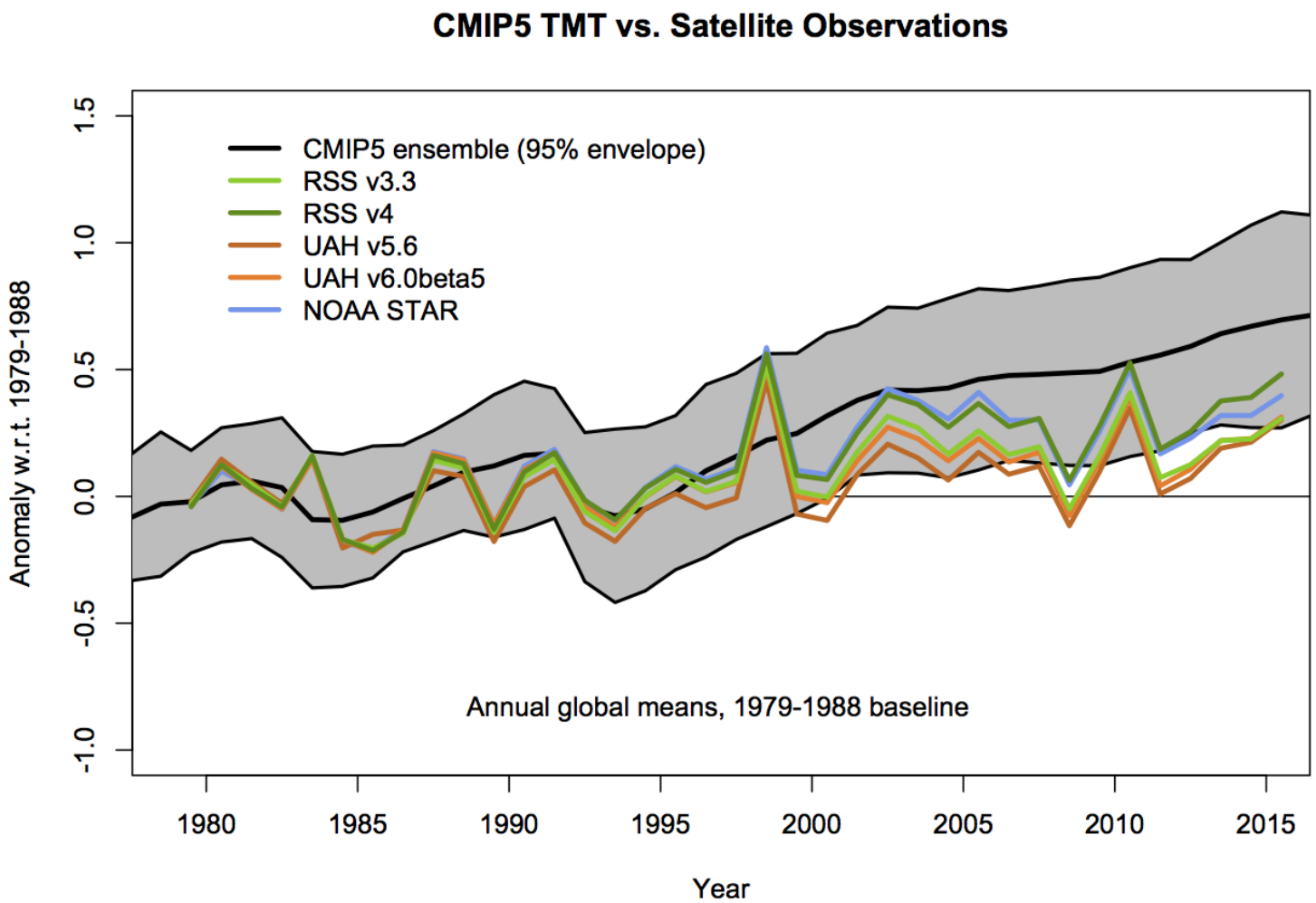
A controversial graph



Originally from John Christy's 2015 congressional testimony; presented in Schmidt (2016).

The same data



From Schmidt (2016).

What gives?

- Are these just different "perspectives" on the same data?
- Is one of them **right**?
- If so, which one, and how do we tell?
- In what sense is the other **wrong**?
  (Is it **false** or just **misleading**?

Starting point

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1. The "meaning" of graphs.
2. Returning to the existing debate
3. Learning something new about Christy's graph

What a graph means

Encoding

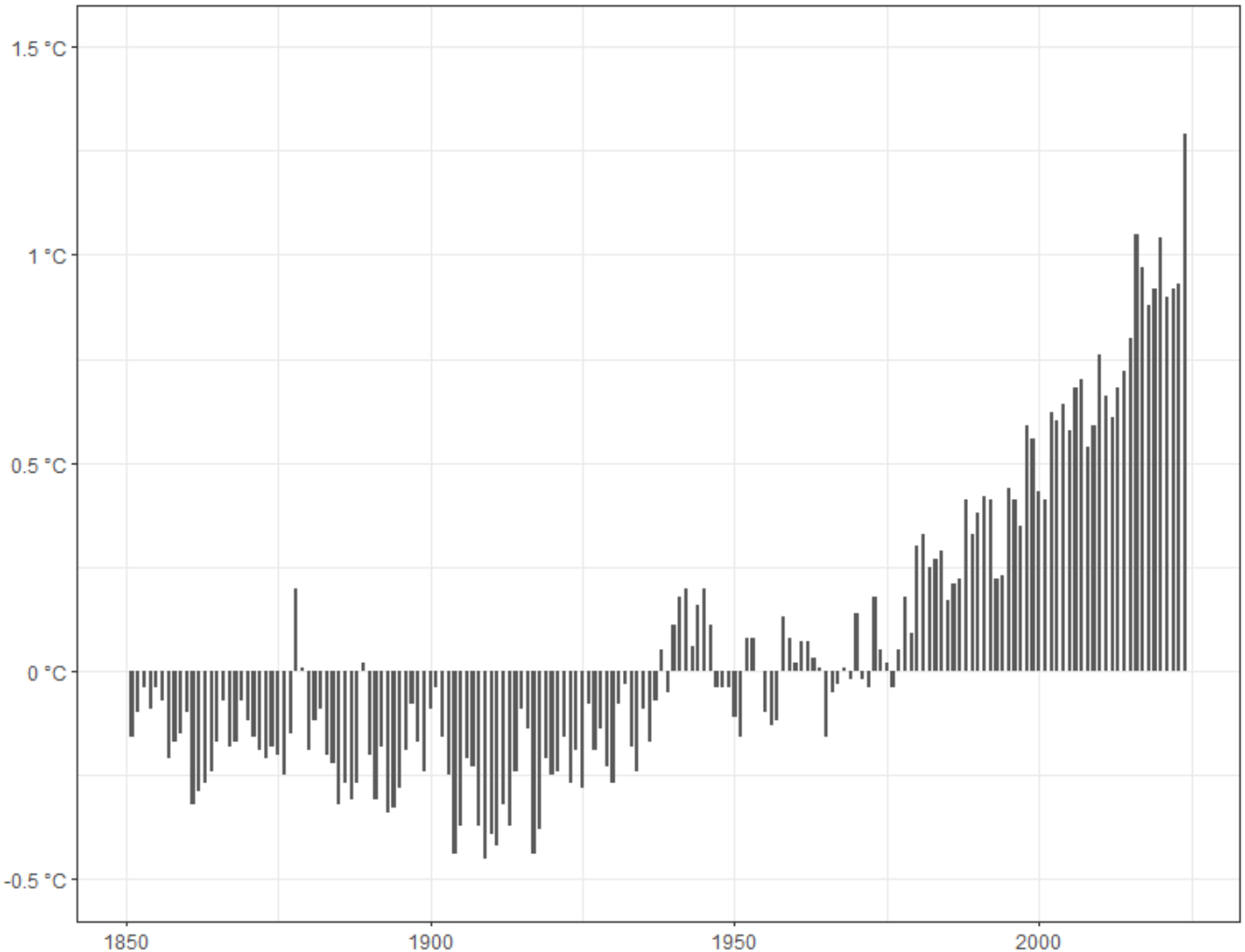
A graph is a means of displaying information that's been "encoded" using mathematical objects.

Graph*ing* involves:

1. "Translating" a message into one or more mathematical objects.
2. Displaying those objects geometrically (i.e., on a Cartesian plane).

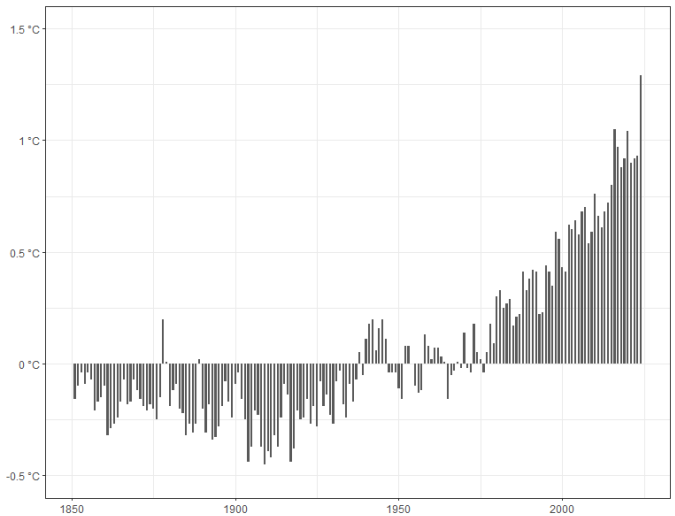
Good graphing practice involves picking an encoding that makes the message obvious to the viewer.

An exemplar



Created using data from National Centers for Environmental Information (2024).

An exemplar

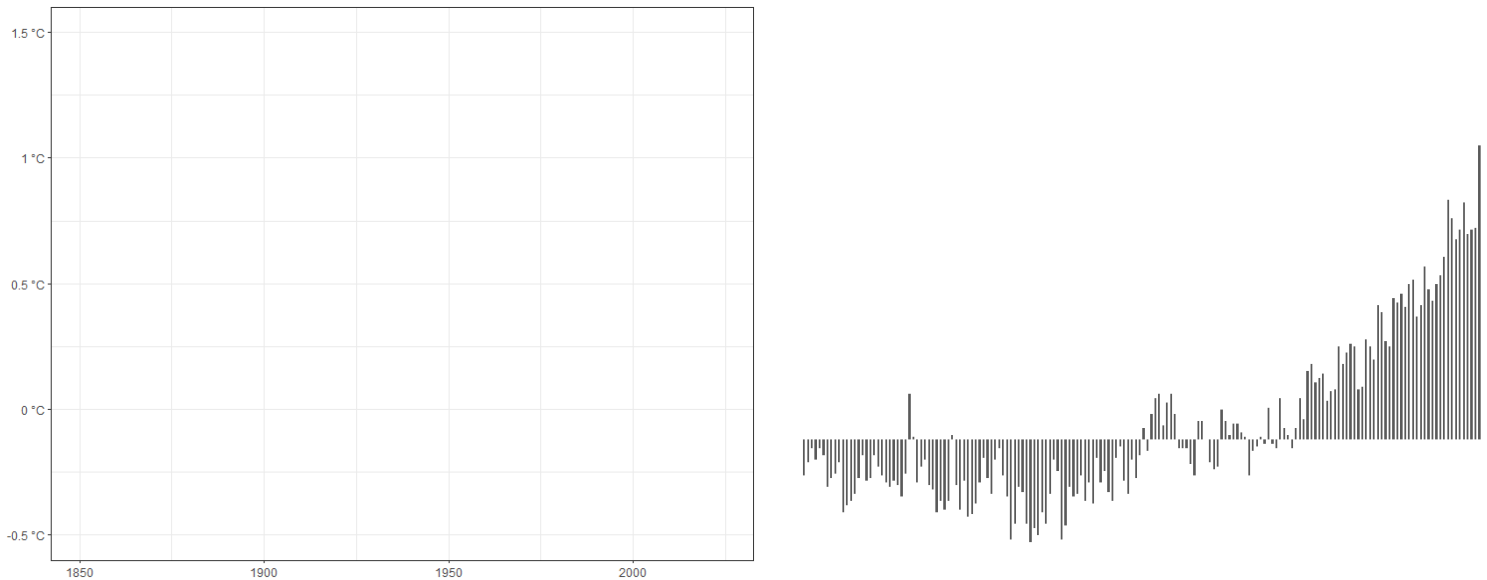


1. Take data from NCEI.
2. Encode that data as a series of coordinate pairs $\langle \text{year}, \text{temp} \rangle$.
3. Display those coordinate pairs visually.

A first pass

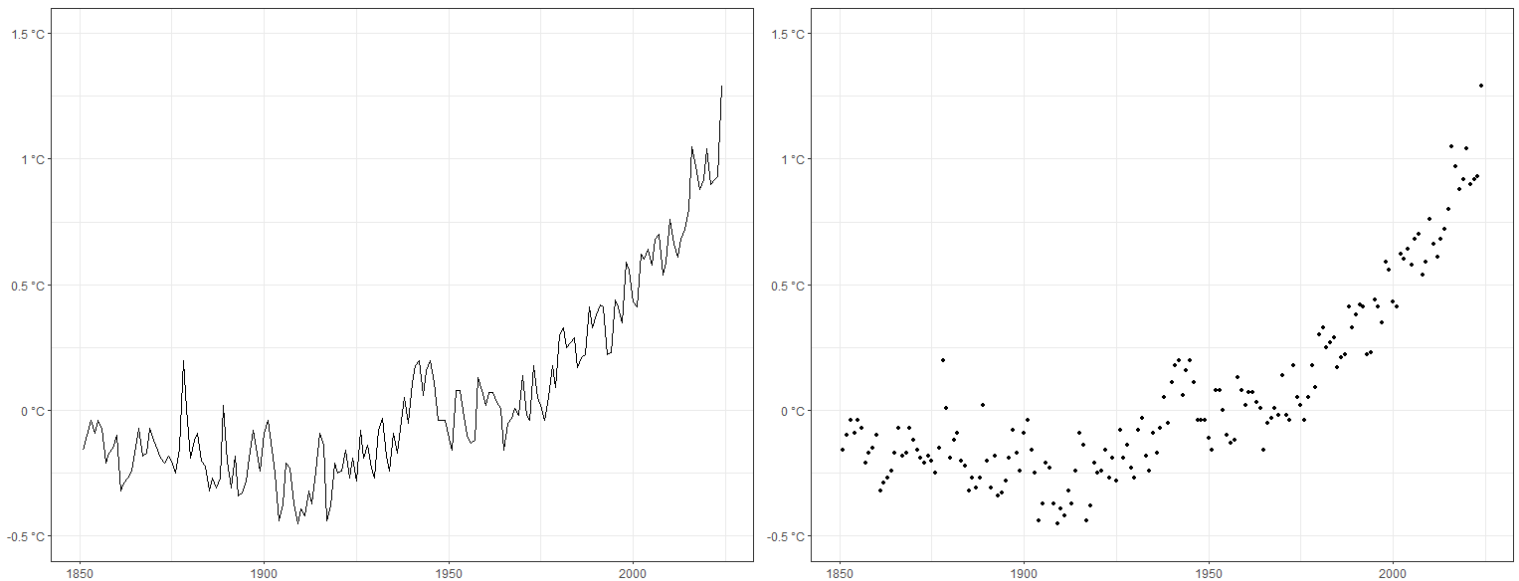
The content of a graph just is the properly decoded message.

These "graphs" have no content



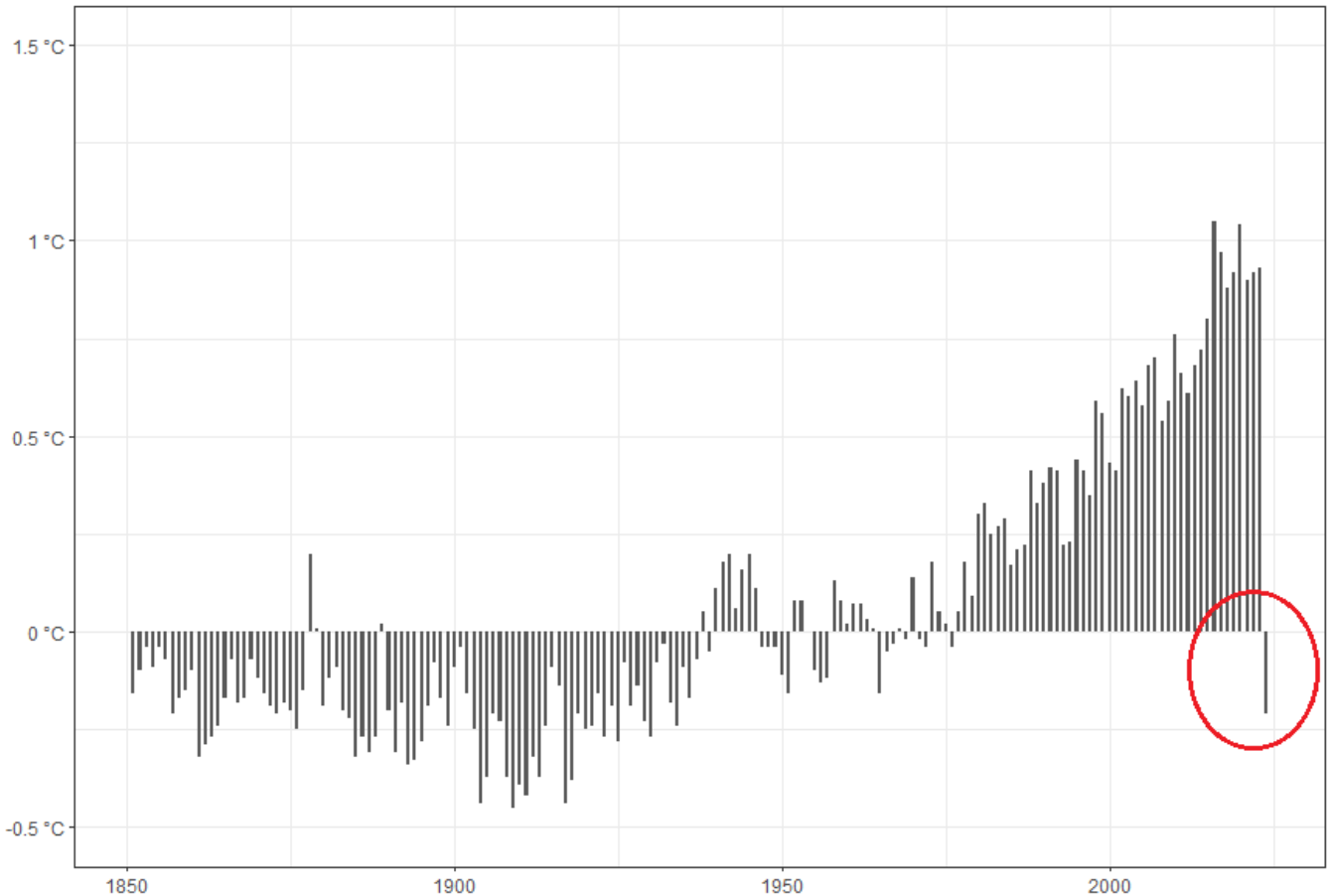
If you can't decode the message, there's no content.

These graphs say the same thing



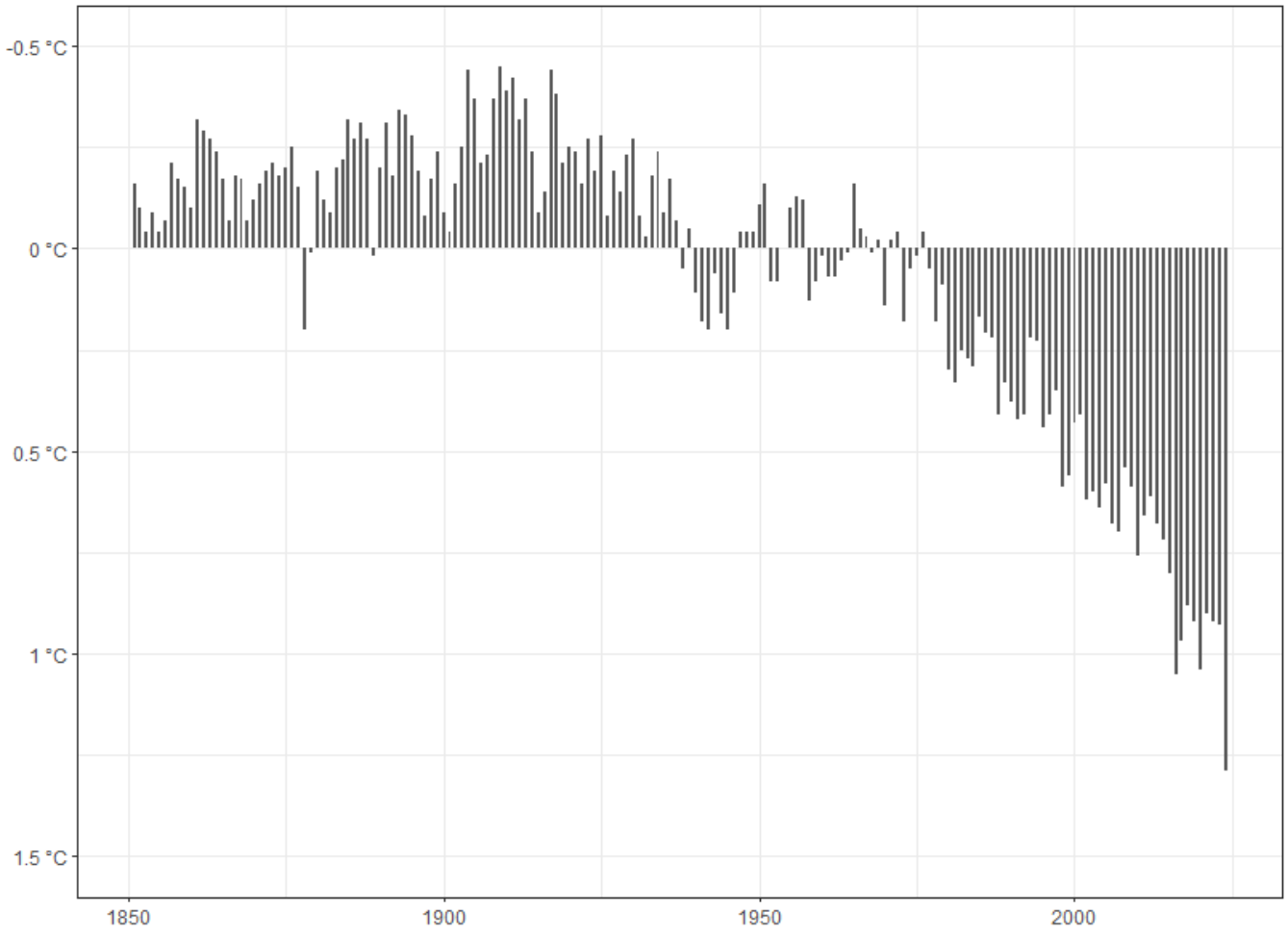
If two graphs share a decoded message, then they have the same content.

This graph is wrong



There's something wrong with a graph if the decoded message is false.

So is this one



But a graph can also be wrong if the message is presented in the wrong way.

What graphs mean

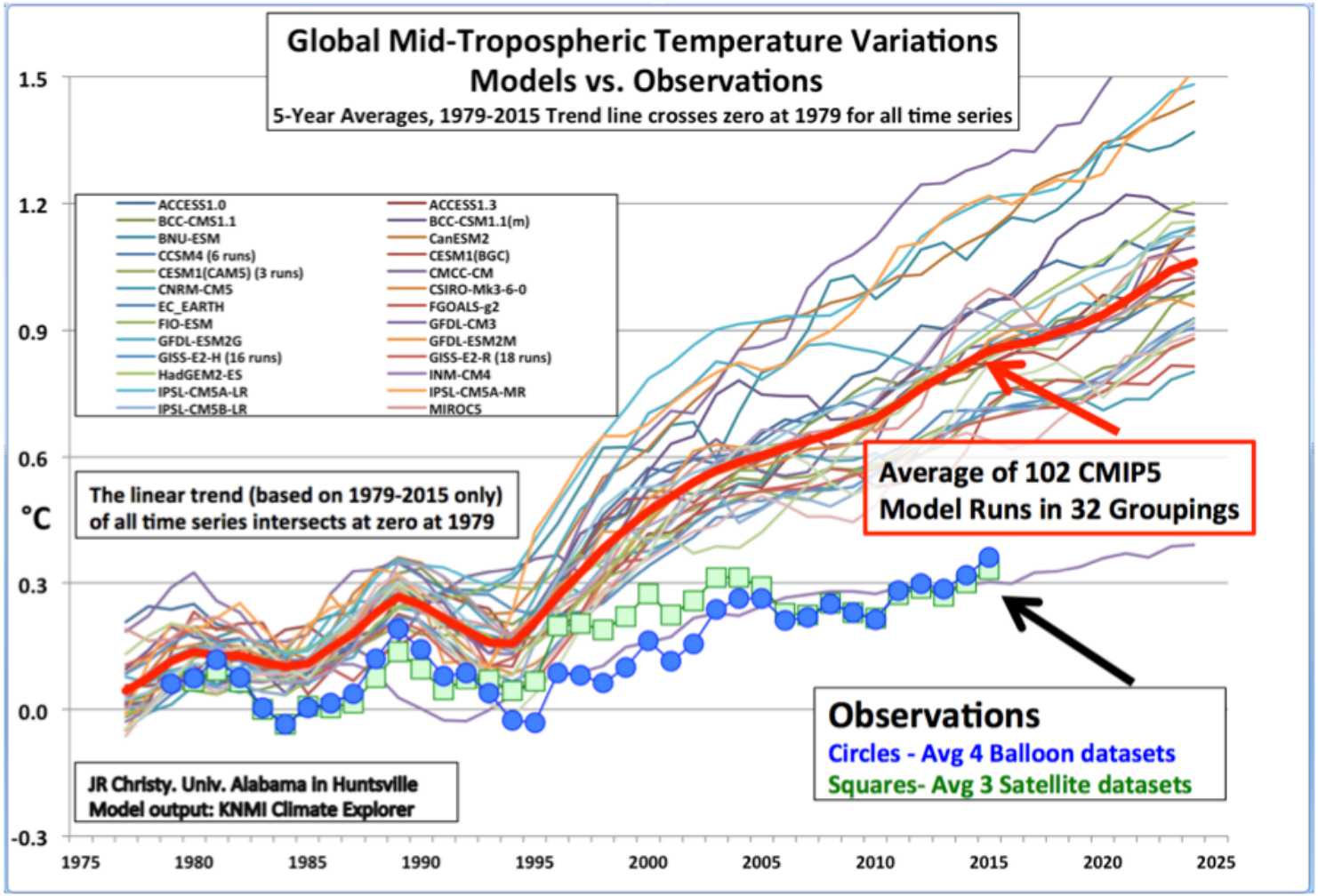
The distinction between *semantics* and *pragmatics* is helpful here.

Roughly, *semantics* is about what words mean; *pragmatics* about what's communicated.

Graphical semantics is about the properly decoded information; *graphical* pragmatics is about what people see when they look at it.

The existing debate is about pragmatics

Return to Christy's graph



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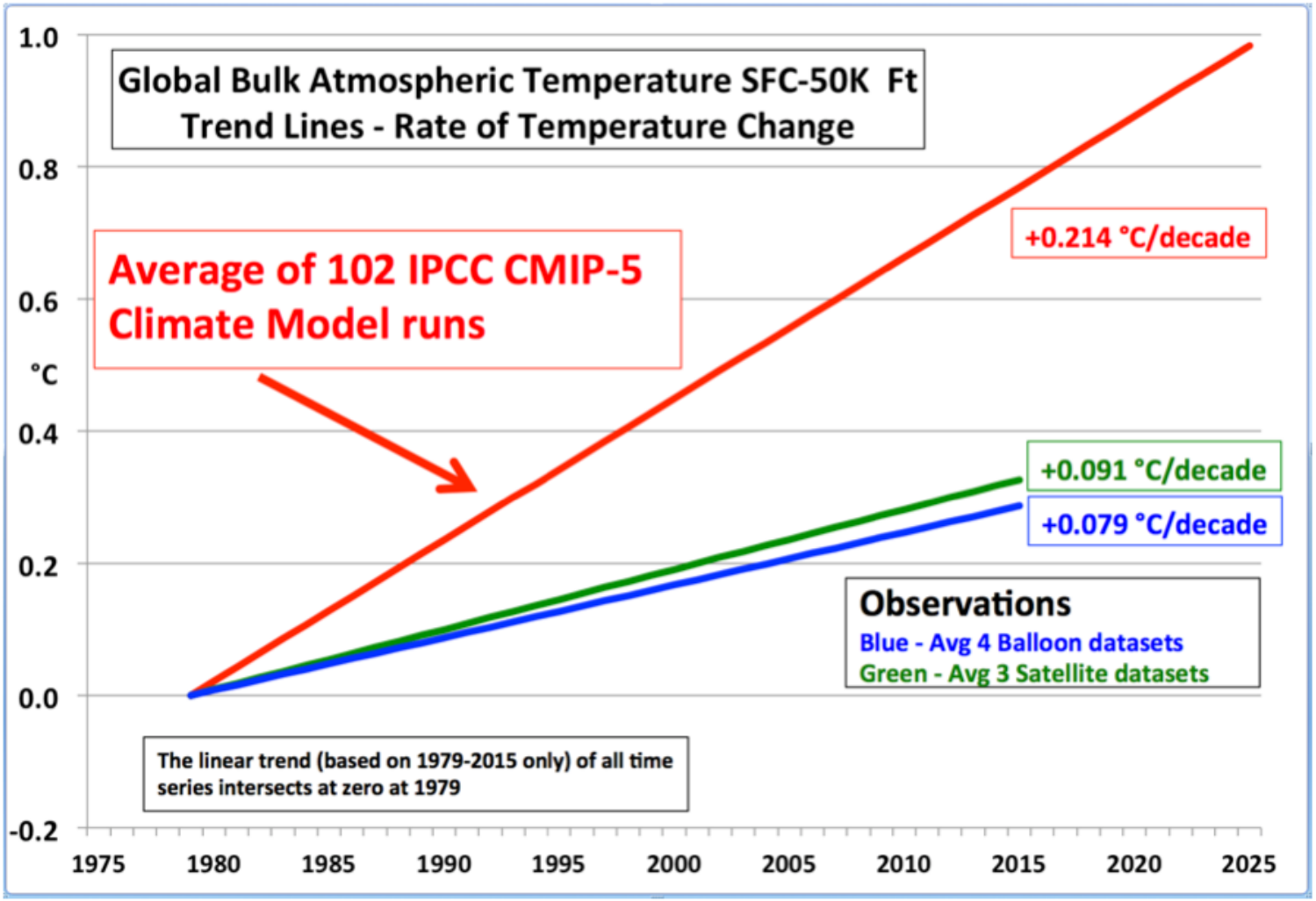
Christy's graph part 2



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Baselines, part 1: anomalies

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First: a summer's day in Boston $\neq$ a summer's day in Phoenix.

Second: climate models make more reliable predictions about anomalies than about absolute temperature.

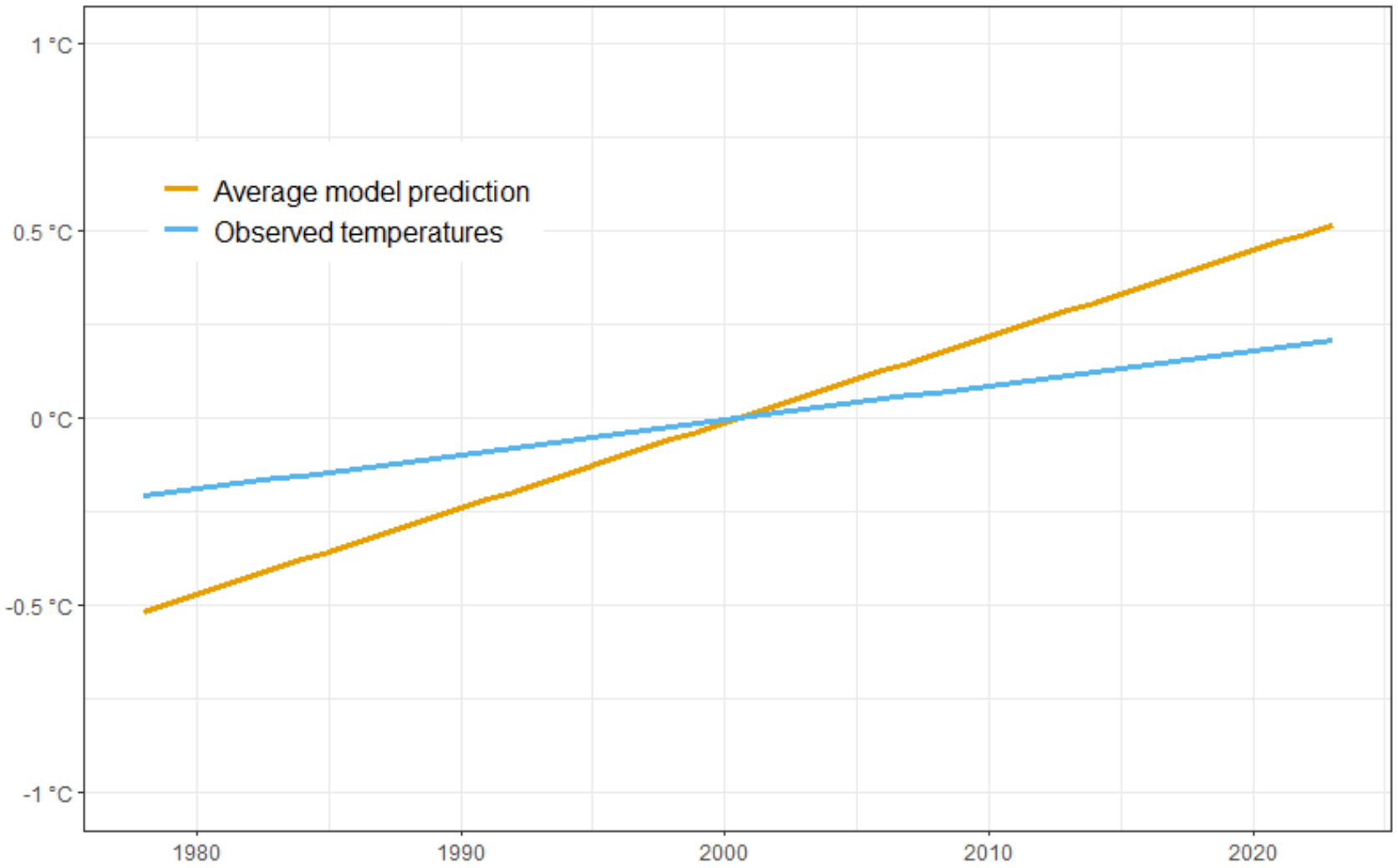
A nice overview can be found in Schmidt (2014).

Baselines, part 2: the comparison

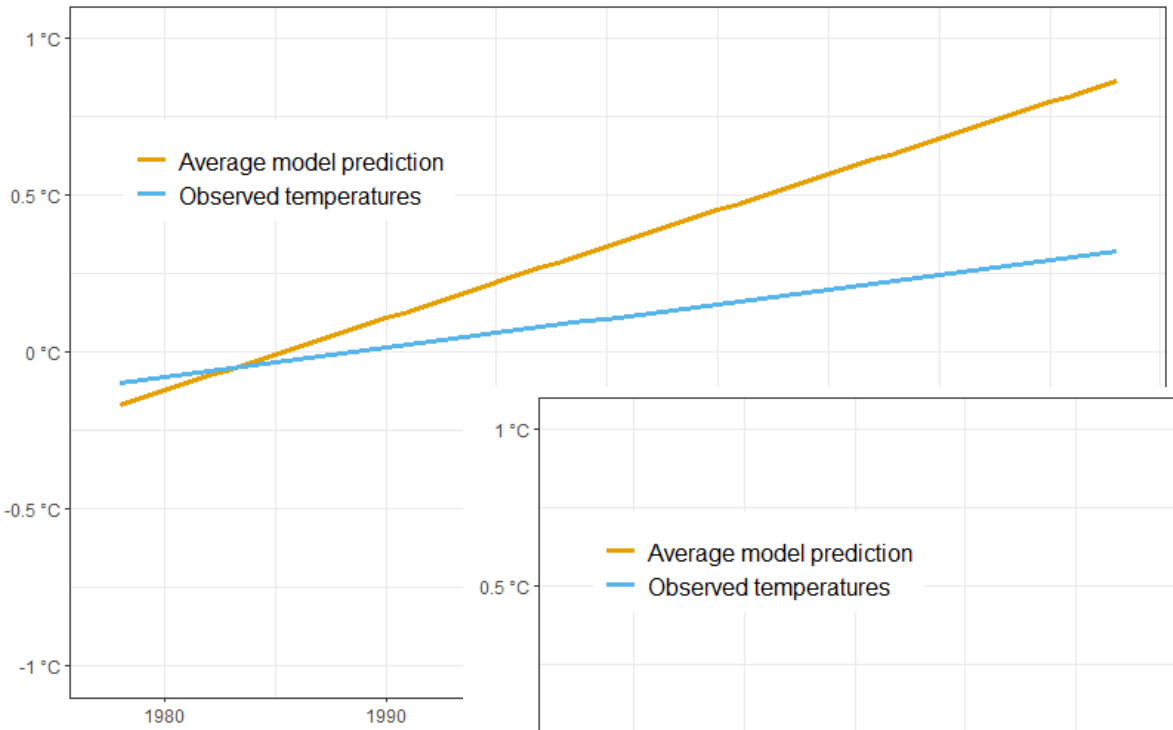
This means: when visually comparing climate models to observations, we can only put them on the same scale if the two sets of anomalies are relative to the same "baseline."

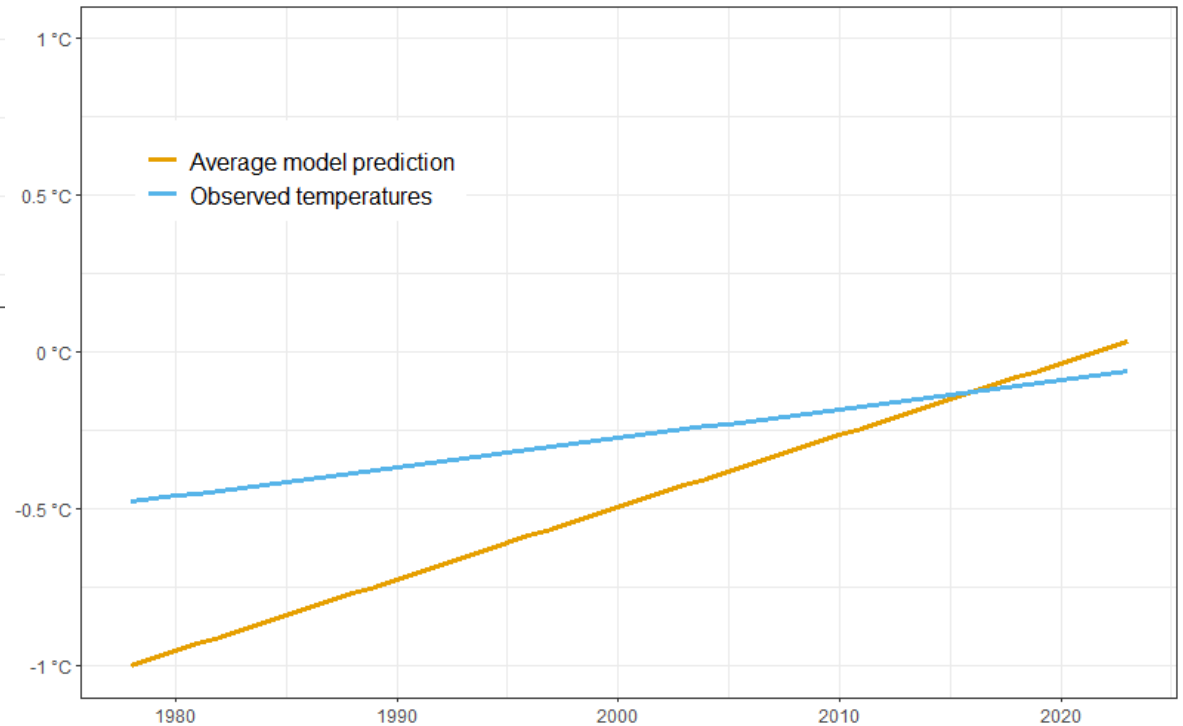
The standard way to set a shared baseline is to take some time frame that both trends range over, average over that time frame, and then set the averages equal to each other.

For example


1 °C
0.5 °C
0 °C
-0.5 °C
-1 °C
Average model prediction
Observed temperatures
1980
1990
2000
2010
2020

Other baselines



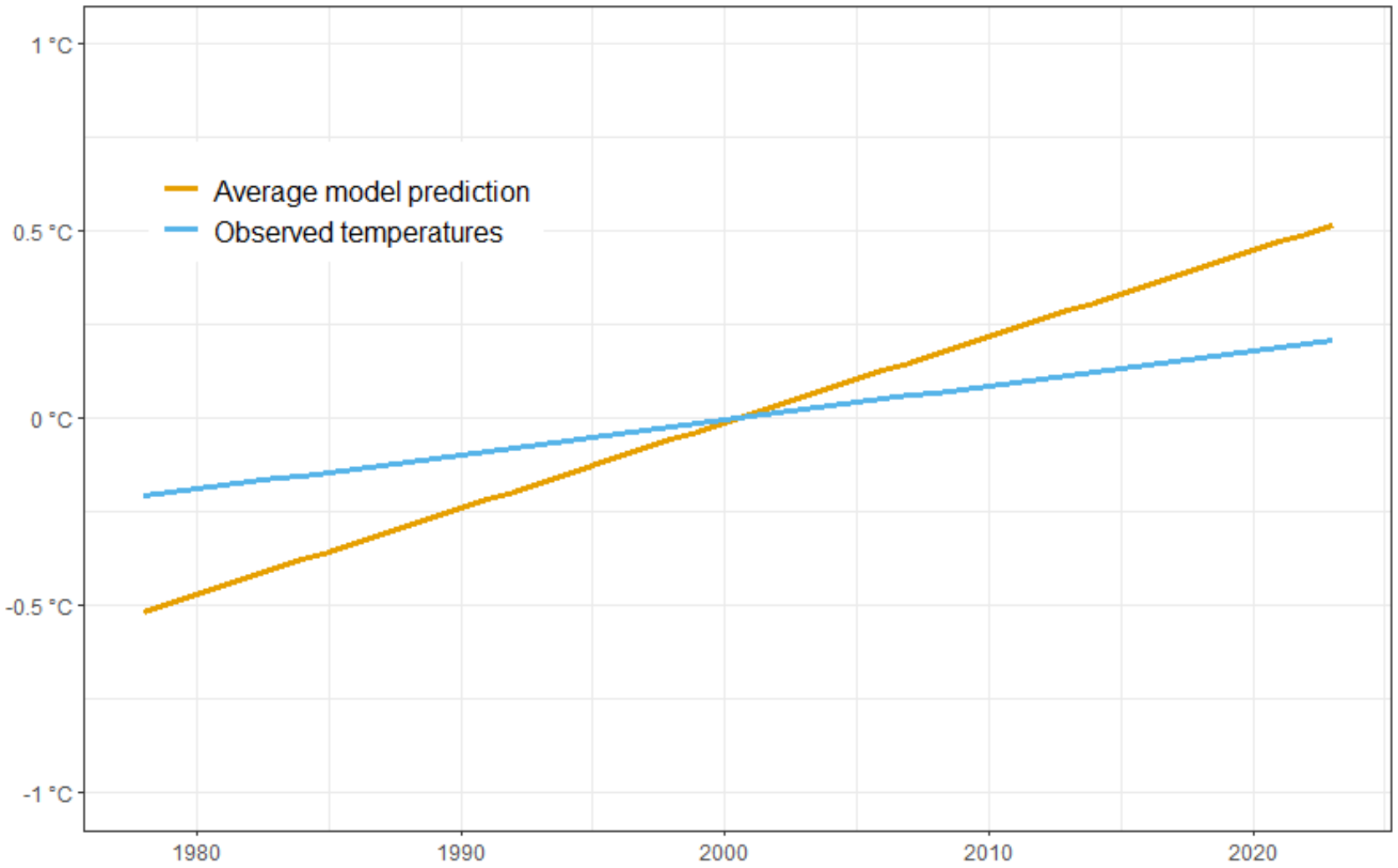


A disagreement about pragmatics

Schmidt: baselines too close to the beginning get the semantics right, but go wrong pragmatically by giving a false impression of divergence.

Christy: baselines too close to the center get the semantics right, but go wrong pragmatically by making the difference between the slopes appear smaller than it is.

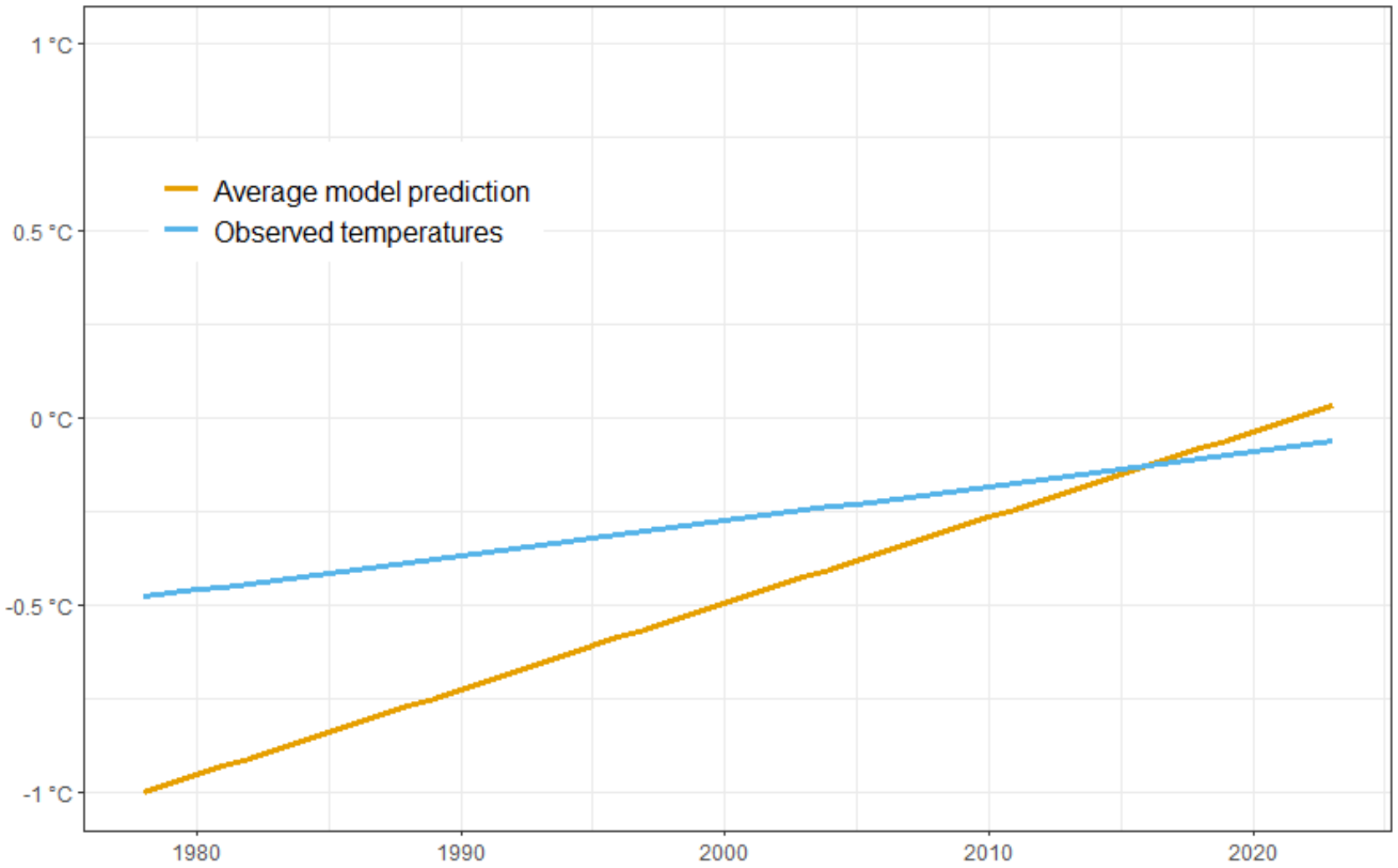
An average baseline



A diagnosis

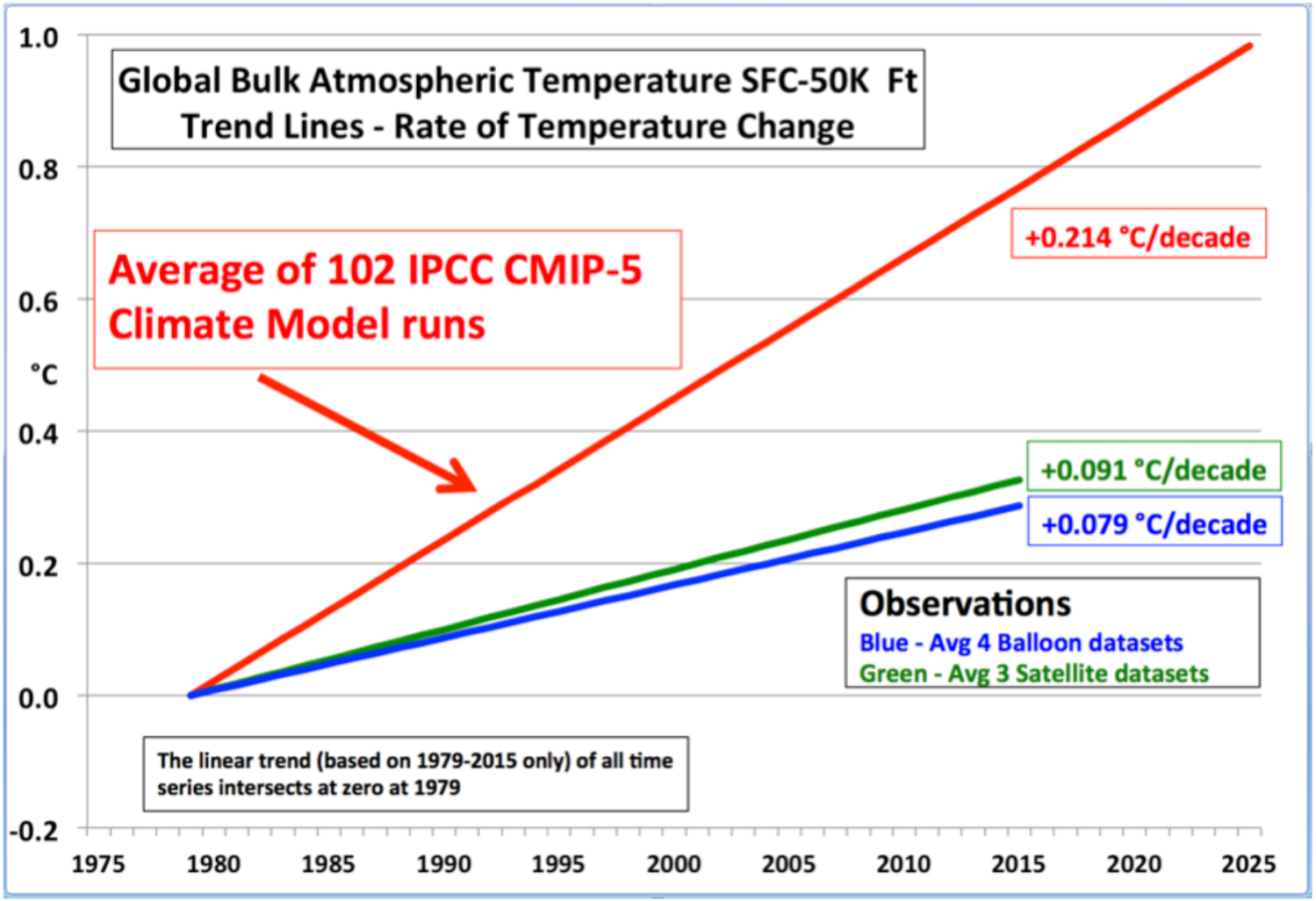
The disagreement is akin to disagreements over phrases like "black lives matter" or "all lives matter": everyone agrees what the words literally mean, but they disagree about what is *communicated* by the slogans.

A compromise?



Why Christy's graph is just false

Christy's graph (again)



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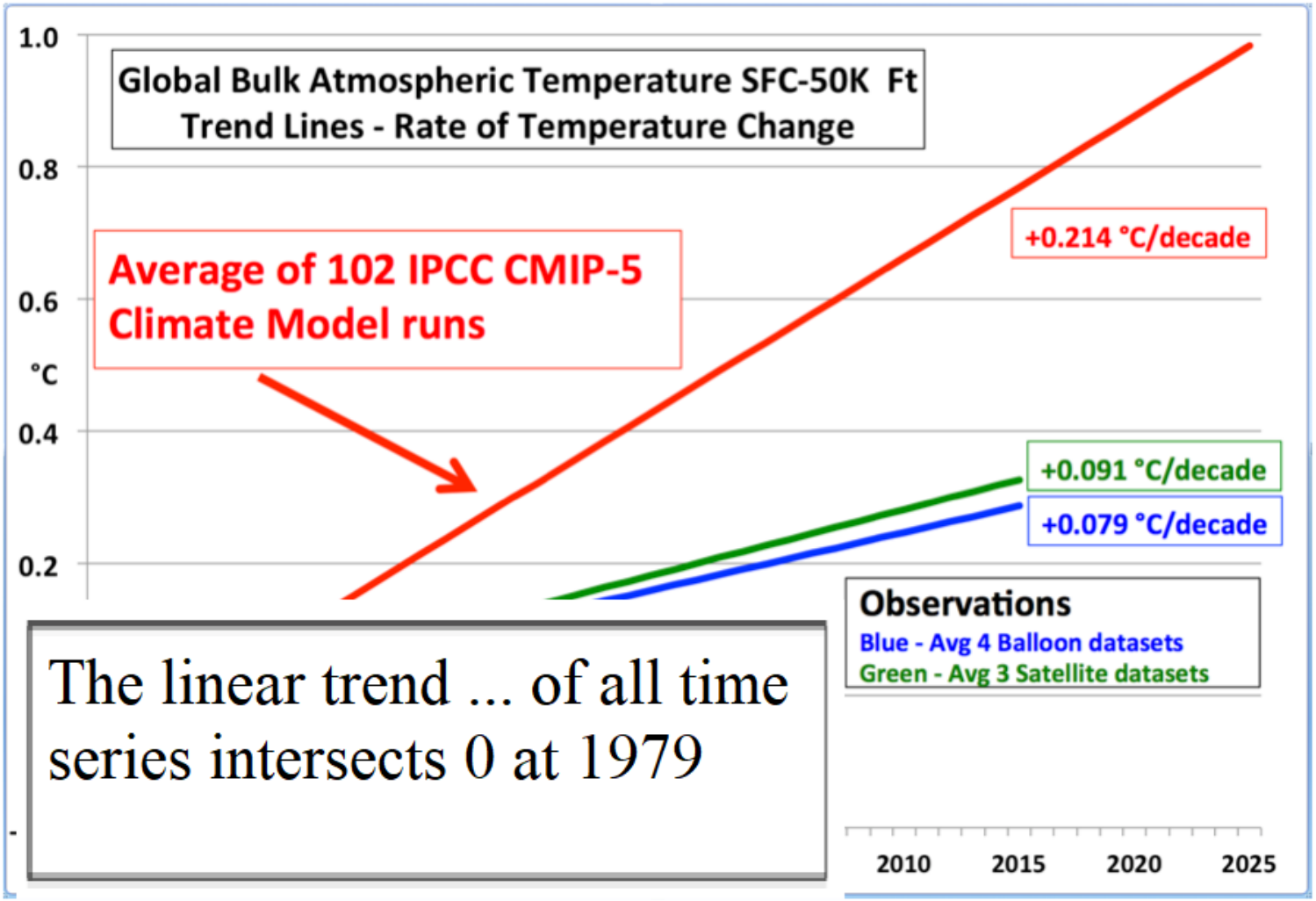
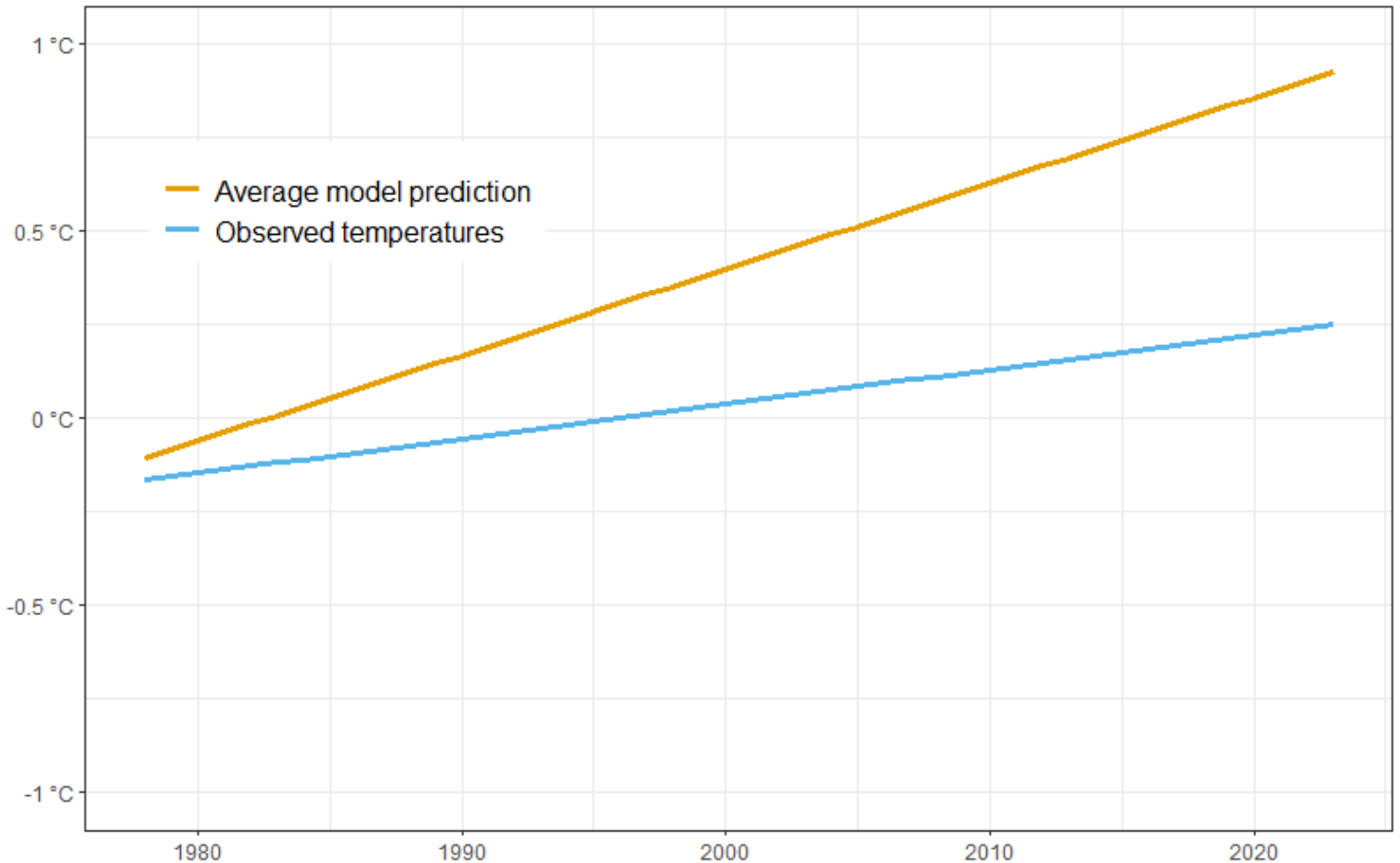


Christy's method

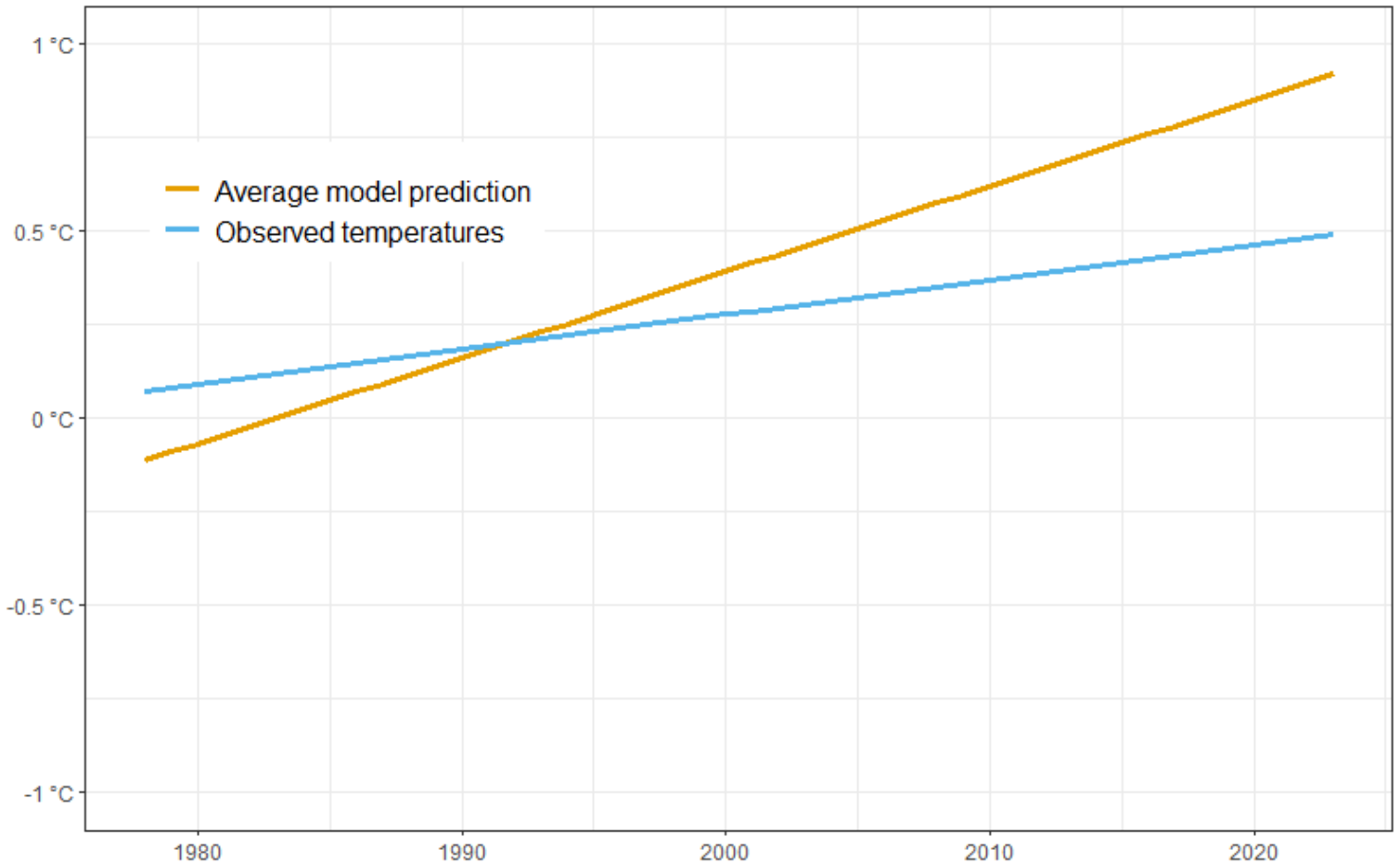
He doesn't use a baseline – at least not in any traditional sense.

With the baseline technique, we fix two sets of relative temperatures to a common point. There's no guarantee that the trendline will pass through that point.

1979 as a baseline



1978 as a baseline

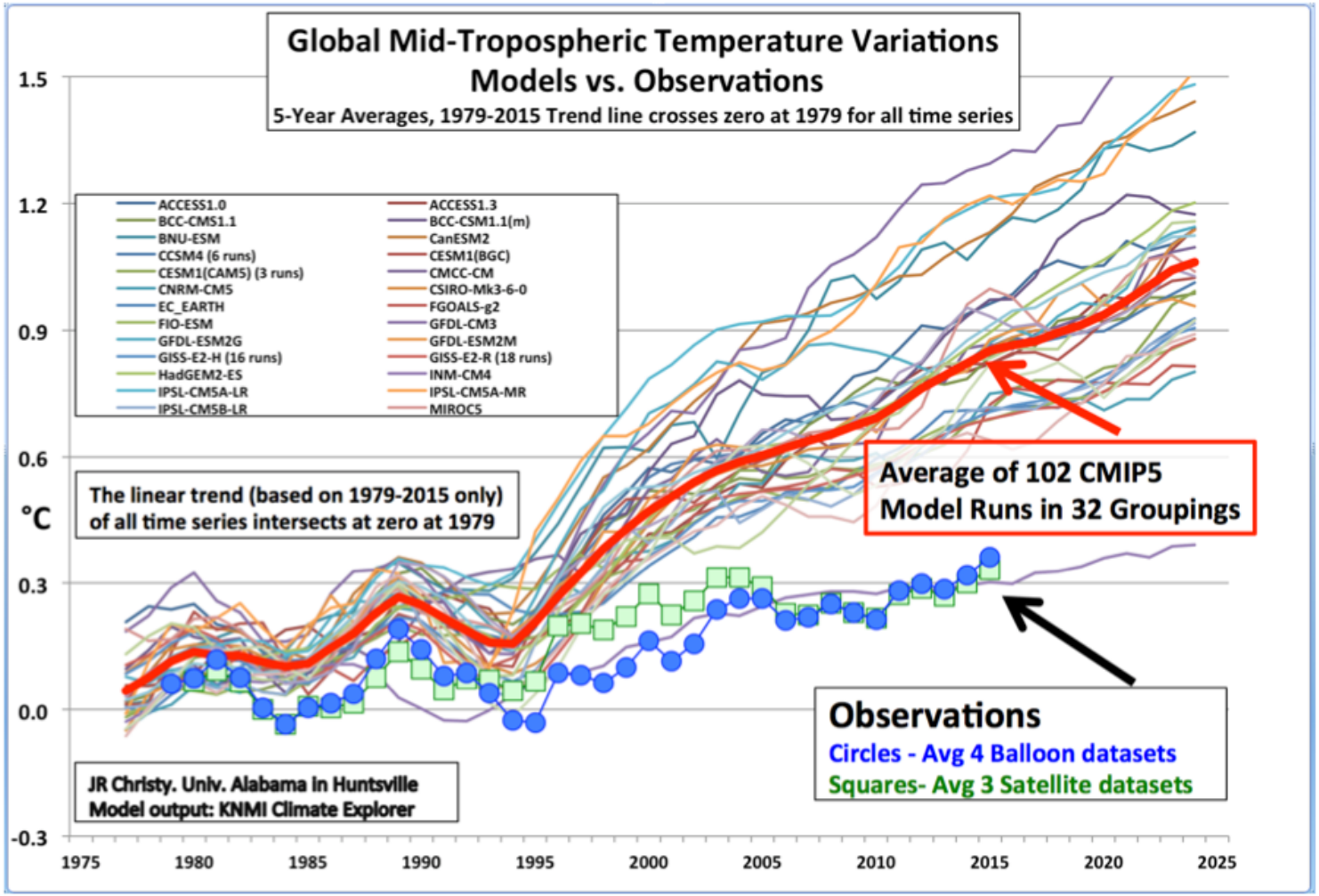


What Christy does instead

Christy takes the slope of the trend lines, starts them at 0 in 1979, and draws the lines from there.

Schmidt (2016): "To my knowledge this is a unique technique and I'm not even clear on how one should label the y-axis."

Christy's graph (one last time)



Spelling out the point, pt 1

To determine the literal meaning of Christy's graph:

1. Determine the mathematical objects that are displayed.
2. "decode" those mathematical objects according to the key provided by the axes.

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For Christy's graph:

1. The mathematical objects are equations of the form $y = 0 + m(x - 1979)$.
2. The key says that y is the temperature and the x variable is the years.

Spelling out the point, part 2

With a normal baseline, you get the line of best fit for years and temperature anomalies relative to some stipulated point of reference.

On Christy's method, by contrast, the lines of best fit have been *arbitrarily* transposed – there's no connection between the line and the temperatures recorded in the relevant years.

Or: for the graph to be right, either the y axis can't be actual temperatures or the x axis can't be actual years.

Upshot

Ultimately, I think this semantic defect is (relatively) minor: the pragmatic point made by Schmidt is the more important one.

The point I want to emphasize is the progress we can make in evaluating graphs with just a little bit of philosophical work.

End

Thank you!!

National Centers for Environmental Information (2024). *Climate at a Glance: Global Time Series*. URL: https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/global/time-series (visited on 06/13/2024).

Schmidt, Gavin A. (2014). *Absolute Temperatures and Relative Anomalies*. URL: https://www.realclimate.org/index.php/archives/2014/12/absolute-temperatures-and-relative-anomalies/ (visited on 09/02/2024).

— (2016). *Comparing Models to the Satellite Datasets*. URL: https://www.realclimate.org/index.php/archives/2016/05/comparing-models-to-the-satellite-datasets/ (visited on 04/02/2023).