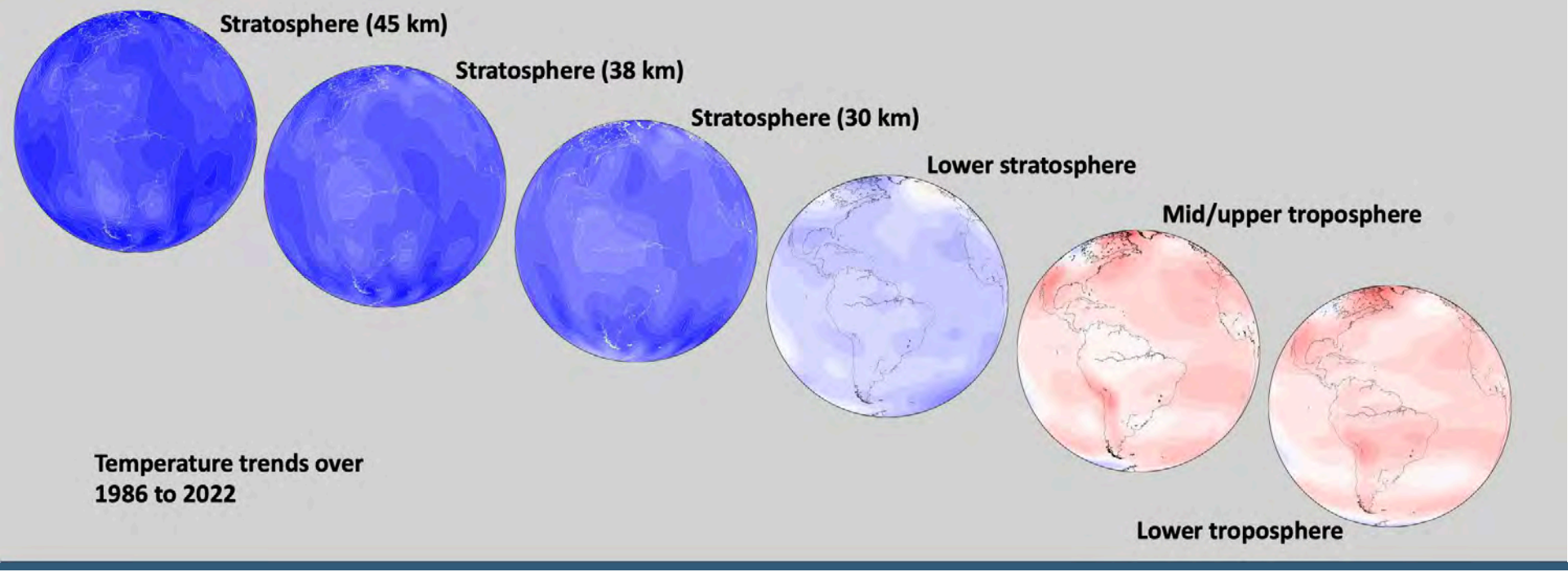


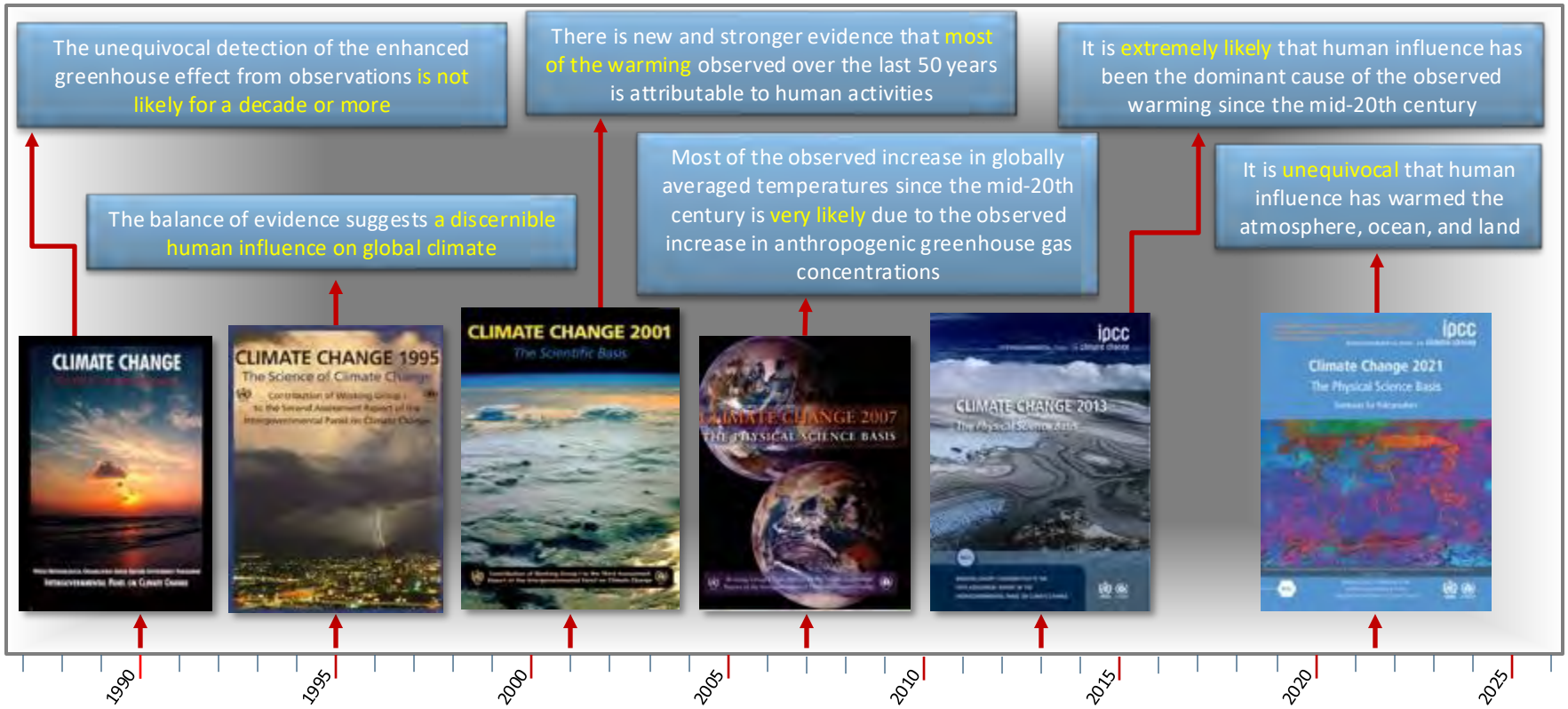
On human fingerprints of climate change

Ben Santer, Susan Solomon, David Thompson, Qiang Fu, and Yaowei Li

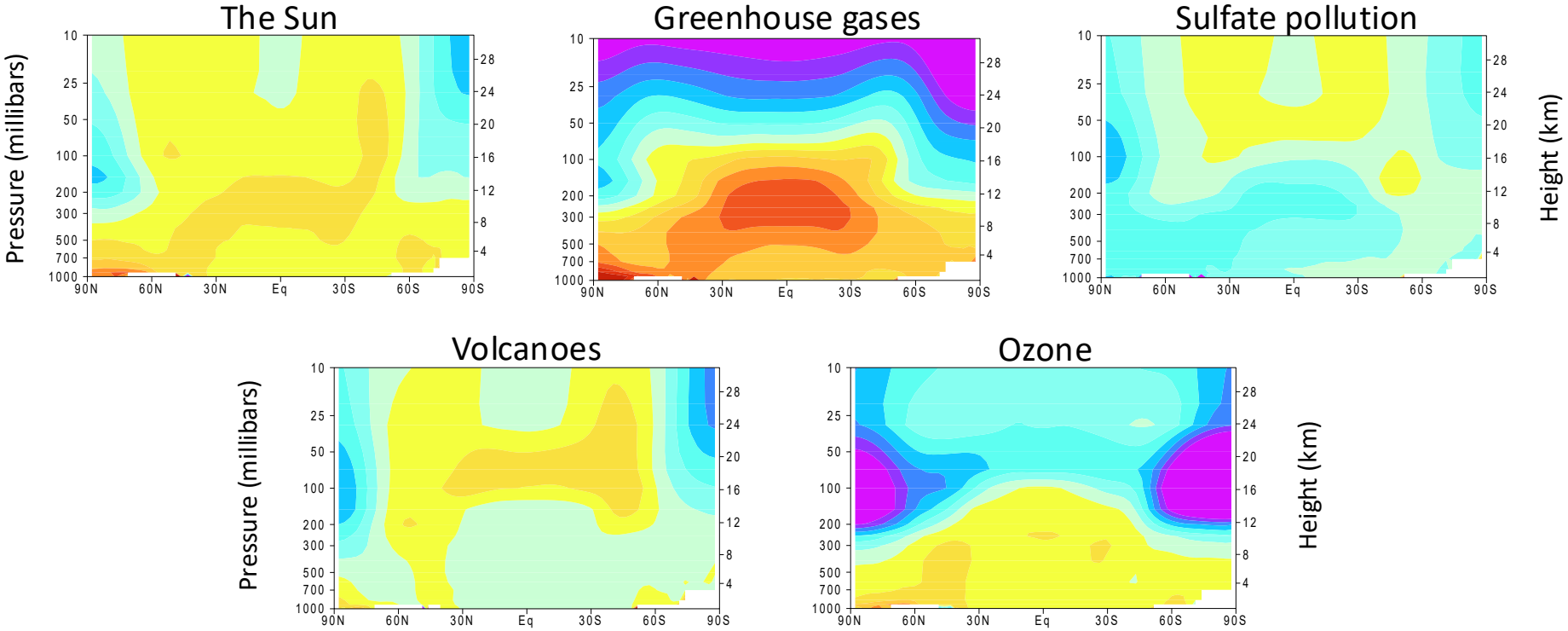
Busan, Korea

July 18th, 2025

The arc of history…



Natural and human fingerprints on climate



Updated from CCSP SAP 1.1 (2006)

Internal consistency of fingerprint evidence

- Surface temperature
- Atmospheric temperature
- Tropopause height
- Atmospheric water vapor
- Ocean heat content
- Snowpack depth
- Runoff
- Cloud properties
- SST changes in hurricane formation regions
- Seasonal cycle of tropospheric temperature
- Seasonal cycle of ocean surface temperature
- Drought properties

Changes in these and many other climate variables are internally and physically consistent (and independently monitored)

Theory and early modeling

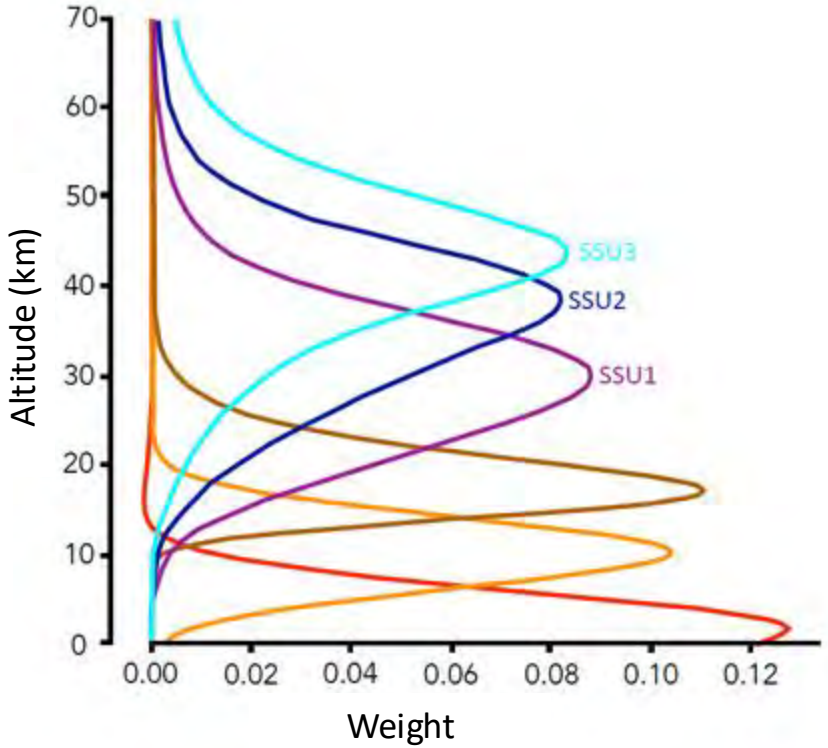
Thermal Equilibrium of the Atmosphere with a Given Distribution of Relative Humidity

SYUKURO MANABE AND RICHARD T. WETHERLAND

Geophysical Fluid Dynamics Laboratory, ESSA, Washington, D.C.

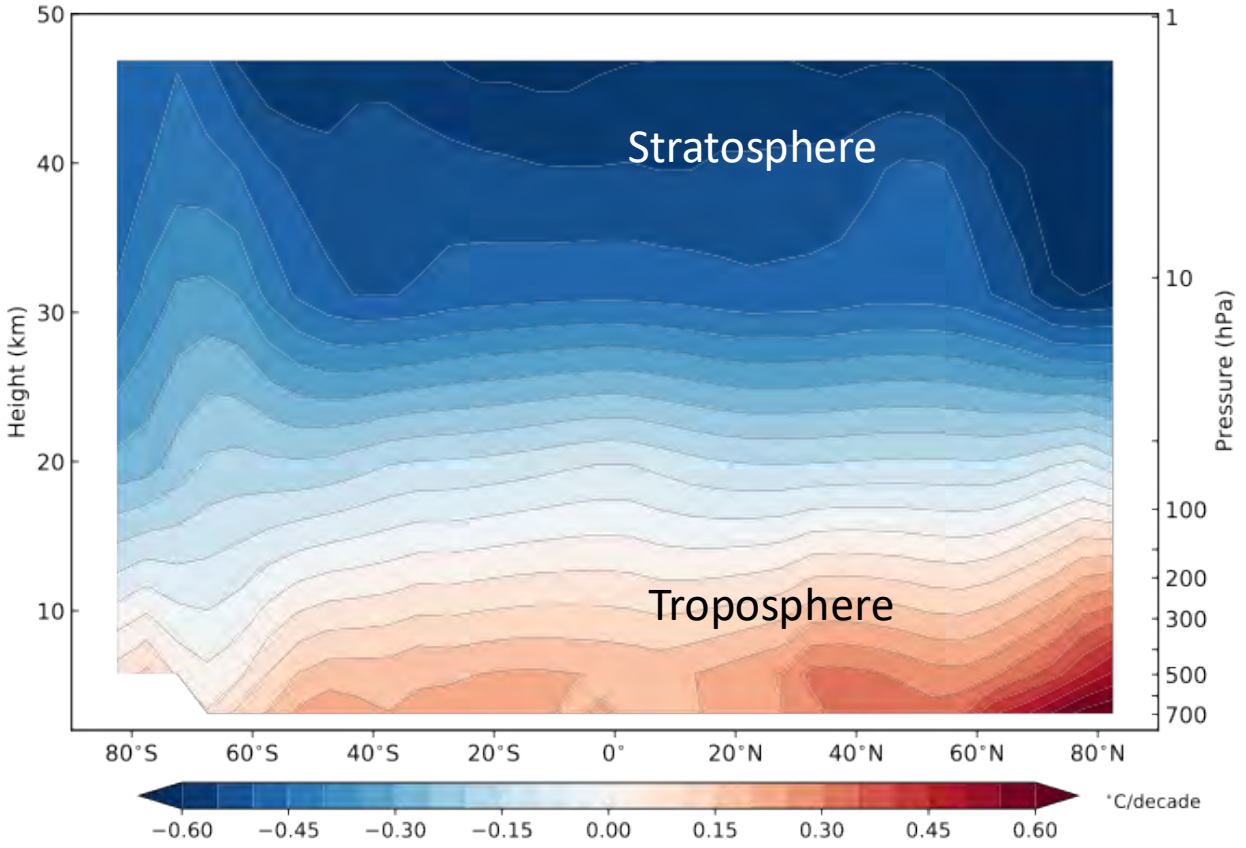
(Manuscript received 2 November 1966)

“Vertical fingerprinting” with satellite temperature data



Source of weighting function information: Carl Mears and Cheng-Zhi Zou. Graphic: Steve Po-Chedley

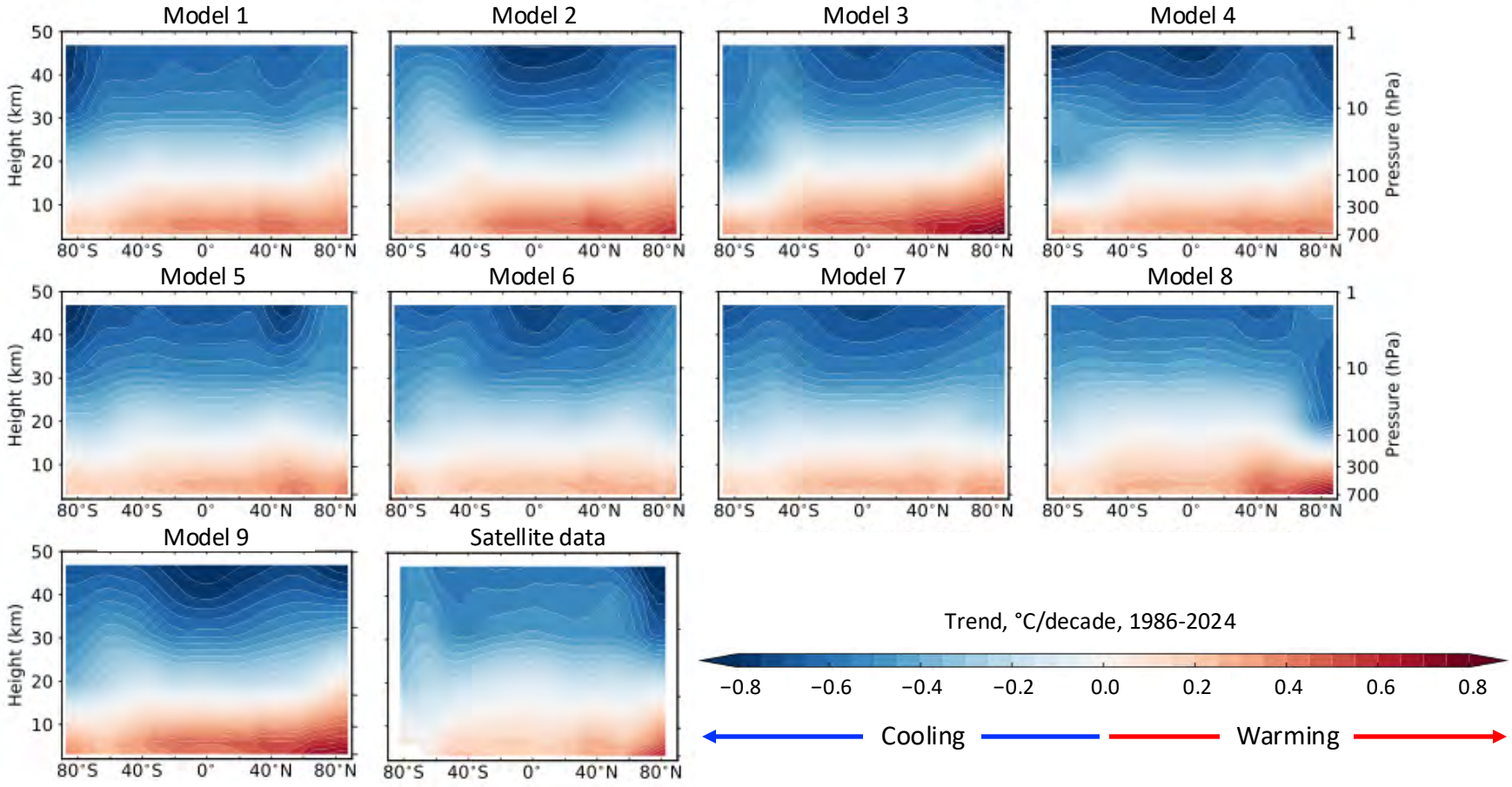
Data



Temperature trend over 1986 to 2024

Source: Santer et al., PNAS (2023; updated)

The human-caused “vertical fingerprint” is robust across a range of climate models



A simple thought experiment

- Imagine a world in which humanity had, as early as 1860, the capability to accurately measure global changes in tropospheric and stratospheric temperature from space

- When could we have first detected, with high confidence, a “discernible human influence” on global climate?

A simple thought experiment

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CLIMATE

Scientists looked back in time to find the first signs of human-caused global warming. It's far earlier than previously thought

UPDATED JAN 10, 2025

By Andrew Freedman

PNAS RESEARCH ARTICLE EARTH, ATMOSPHERIC, AND PLANETARY SCIENCES

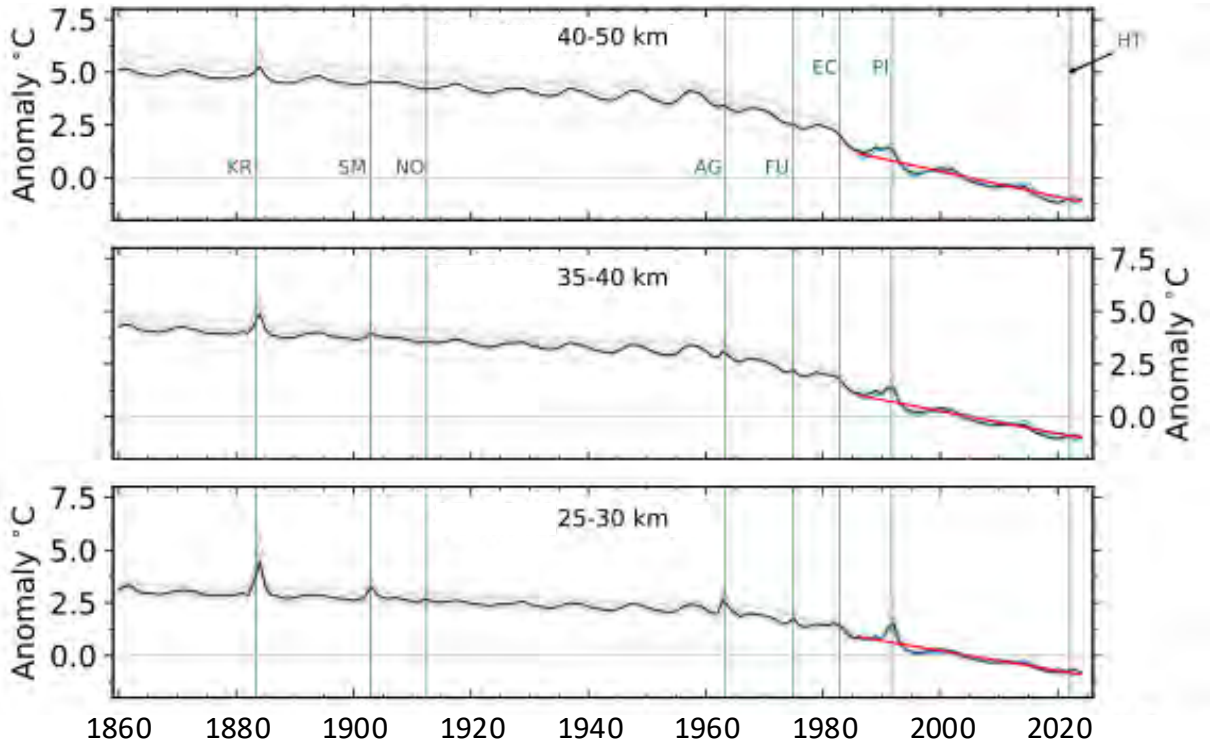
Human influence on climate detectable in the late 19th century

Benjamin D. Santer, Susan Solomon, David W. J. Thompson, Qiang Fu, and Xiaolan Li

Affiliations are included on p. 11.

Edited by Ralph F. Keeling, Scripps Institution of Oceanography, La Jolla, CA; received January 13, 2025; accepted April 22, 2025; by Editorial Board Member Mark H. Thiemens

Global-mean stratospheric temperature changes: 1860 to 2024

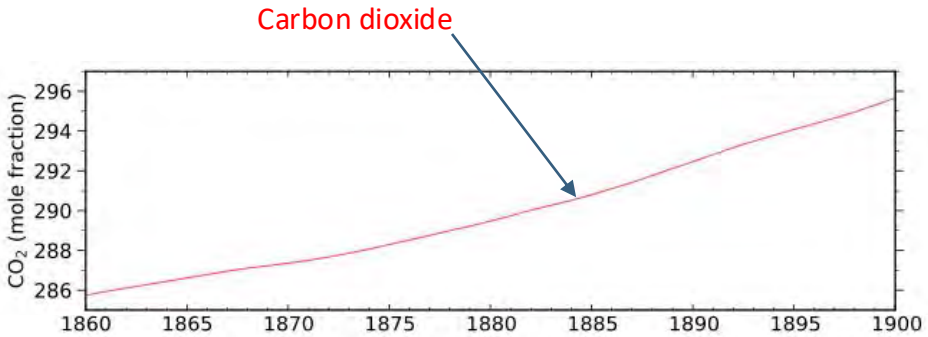


Blue = Satellite data

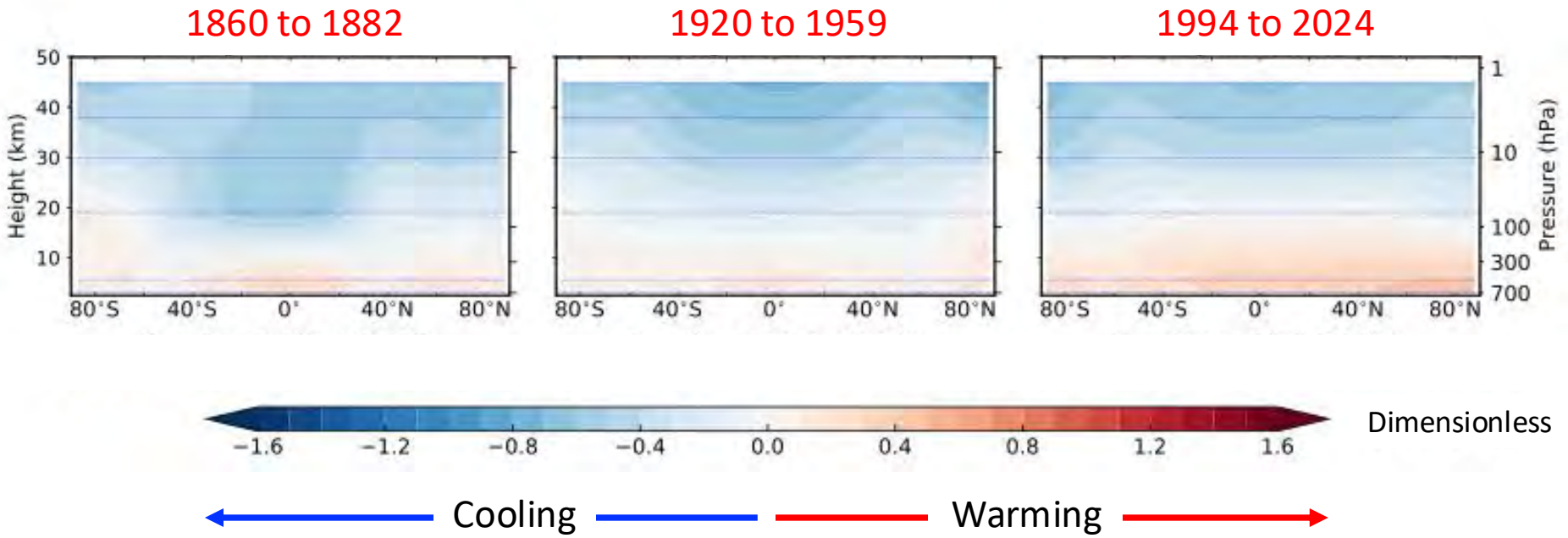
Red = Trend in data

Black = Model average

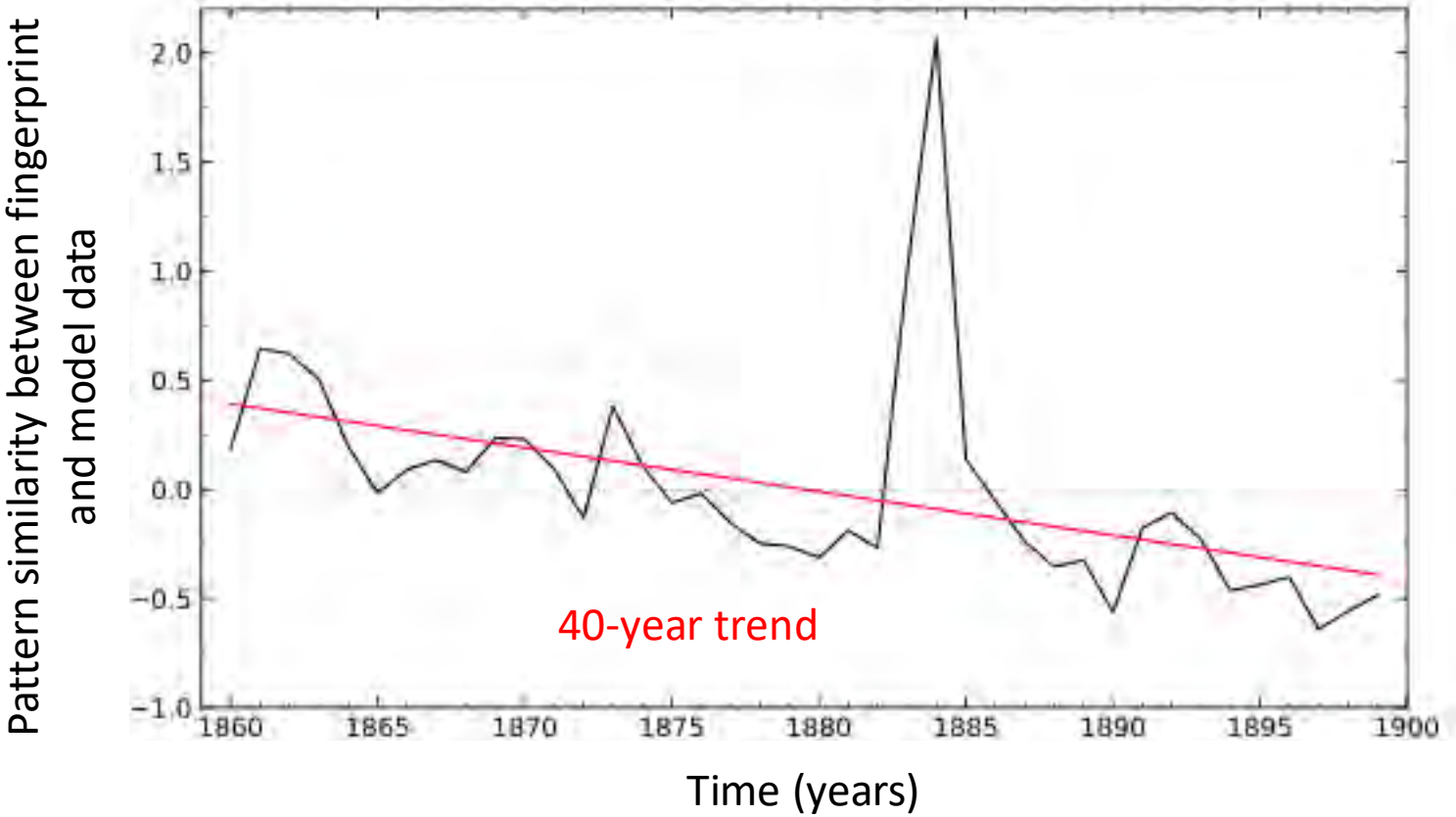
Early CO_2 and stratospheric temperature changes



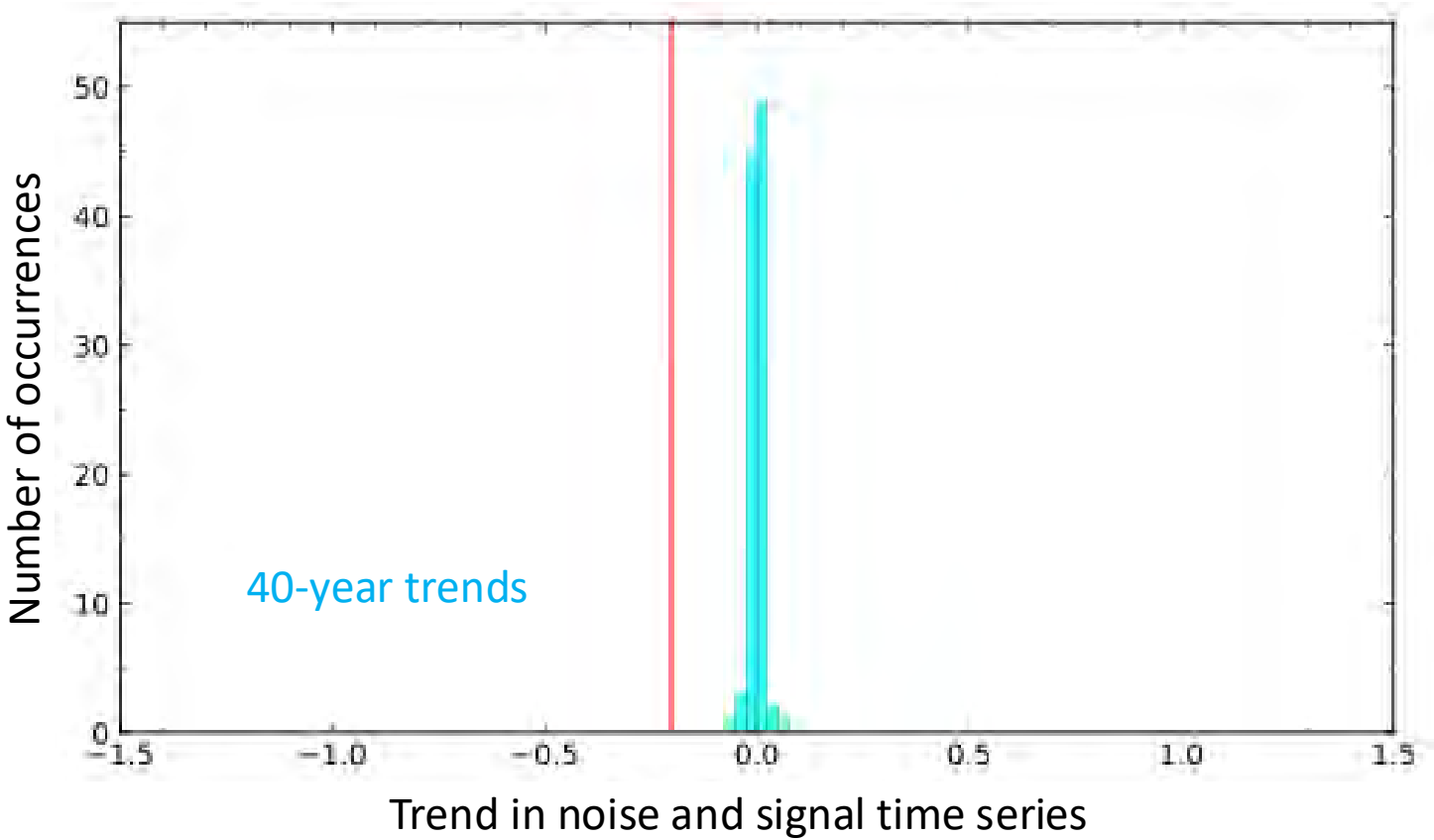
Early emergence of stratospheric cooling



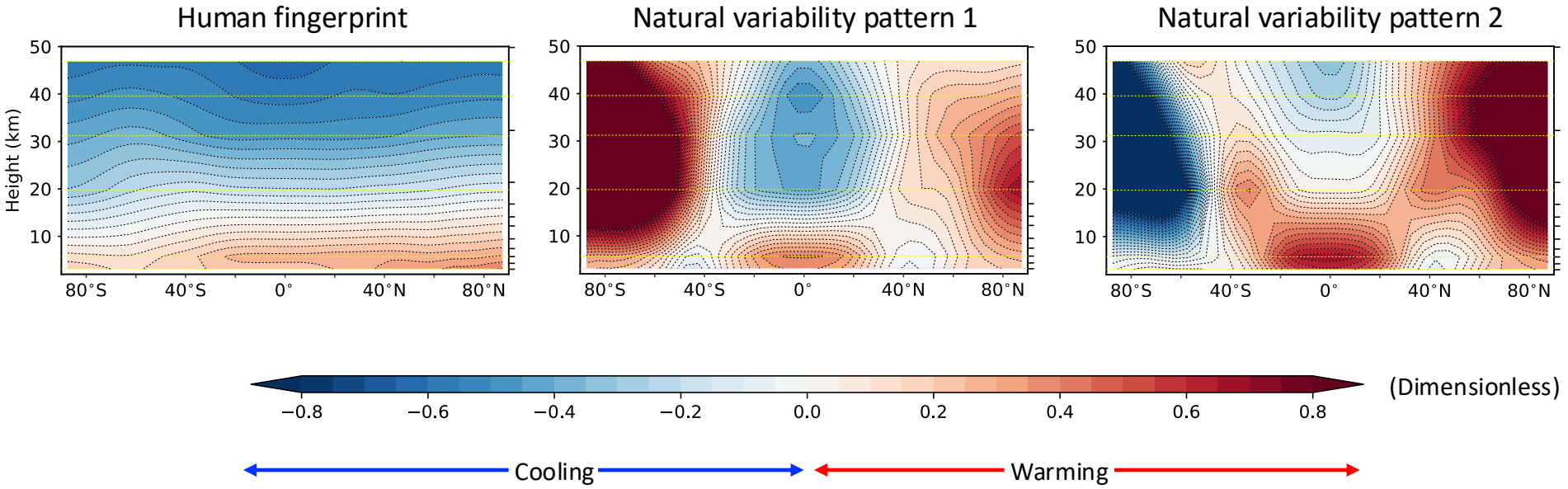
Calculating fingerprint detection times



Calculating fingerprint detection times



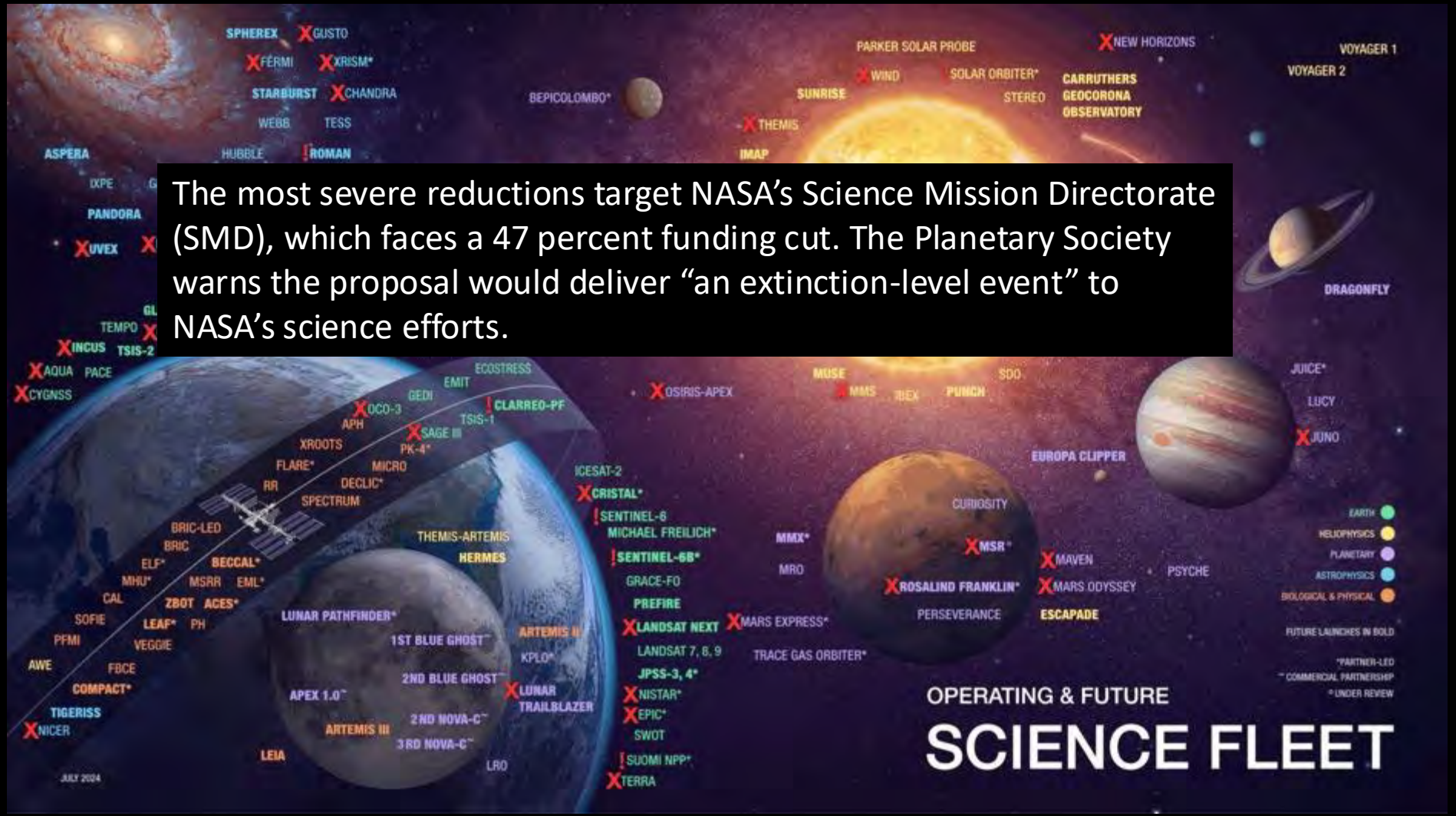
Why?



Source: Santer et al., PNAS (2023)

Bottom line

> A human-caused stratospheric cooling signal would have been identifiable by approximately 1885, before the advent of gas-powered cars. Our results suggest that a discernible human influence on atmospheric temperature has likely existed for over 130 years.


The most severe reductions target NASA's Science Mission Directorate (SMD), which faces a 47 percent funding cut. The Planetary Society warns the proposal would deliver "an extinction-level event" to NASA's science efforts.
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