

Announcements

Today (Lecture): Contemporary Climate Change: Is the climate changing and how do we know what we know?

Tomorrow (Lab): Estimating the “Global Average Temperature”

Thursday (Discussion): Local Weather Variations and Exploring IPCC Data

- ▶ Next Week: Energy and Equilibrium

Today's lecture is adapted from Nadir Jeevanjee's "Science on Tap" bar talk *How do we know what we know?*

Today's Reading Quiz (3 min)

On your own sheet of paper...

Discuss temperatures in Houston vs. Amarillo, TX, including the meaning and use of *temperature anomaly*.

Turn in to Blackboard as scanned pdf.

Temperature Anomalies

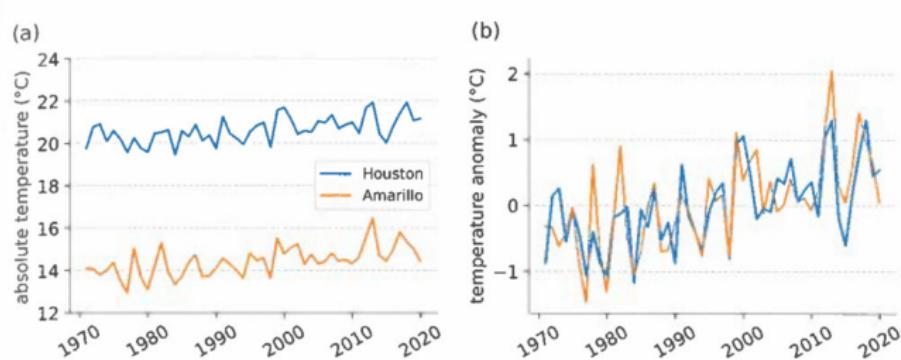
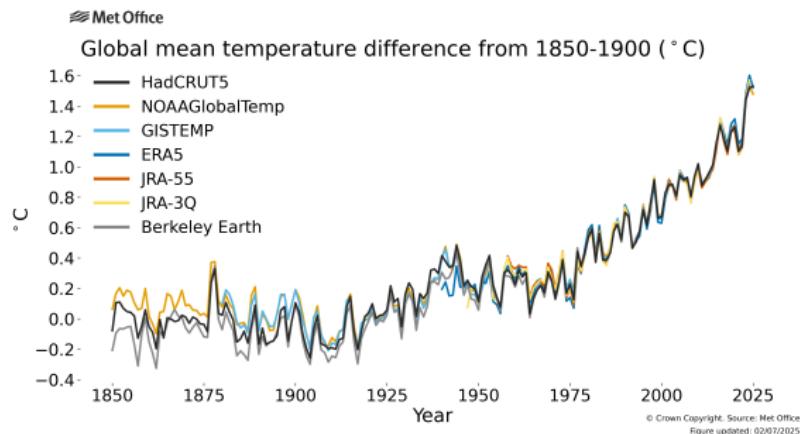


Figure 2.1 (a) Annual temperatures ($^{\circ}\text{C}$) in Houston, TX (Bush-IAH station) and Amarillo, TX (Amarillo International Airport station). (b) Temperature anomalies ($^{\circ}\text{C}$) at these stations, relative to the 1980–2010 average. Data are derived from breakpoint-adjusted monthly station data from Berkeley Earth (<http://berkeleyearth.org/data/>, retrieved May 21, 2020).

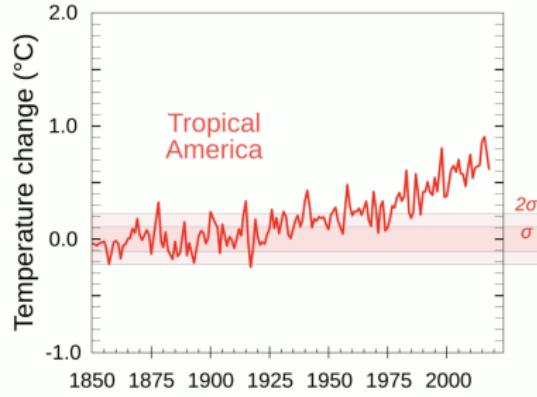
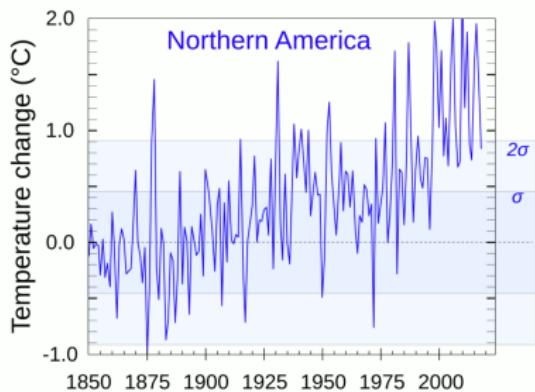
- ▶ Average annual temperatures are significantly different at the gulf coast and the border with Oklahoma!
- ▶ Temperature anomalies are taken in reference to some chosen average value (here: 1980–2010).
- ▶ That reference point is always *local*: Each location has an anomaly with respect to its average reference point.

Is the Climate Changing?



- ▶ What can we say about uncertainty from instruments/methods over time? (Compare independent measurements)
- ▶ What can we say about natural variability?
- ▶ Is there a *change* in global average temperature from 1850–1975? from 1975–2025?

More on uncertainty from natural variation

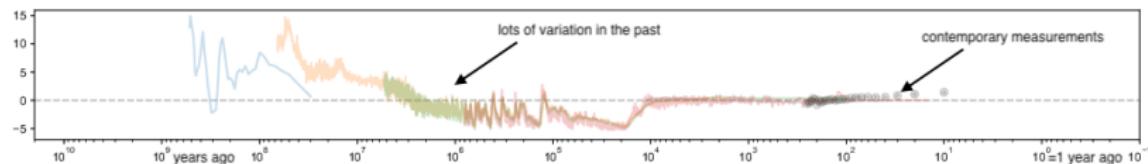


From [Wikimedia: Emergence of temperatures...](#)

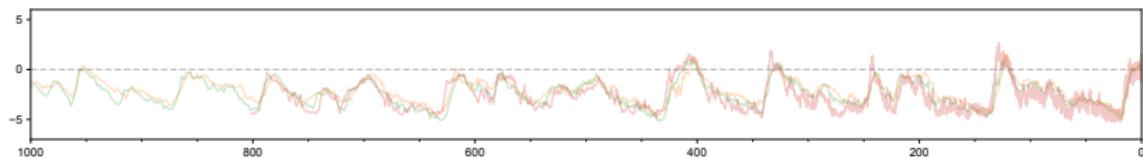
- ▶ Note differences in two sets of measurements: in variation, and magnitude of change.
- ▶ Uncertainty (here: from observed natural variation) gives us a *standard deviation*. Departure from that range indicates the identification of an effect.

Perhaps not enough time to see variations?

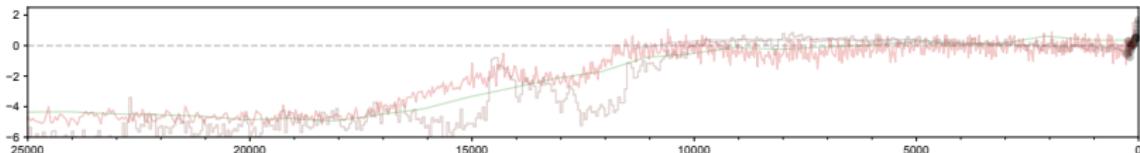
Last week in Discussion we saw large variations in temperature over the history of Earth:



Particularly in the ice-ages/interglacials (past one million years):



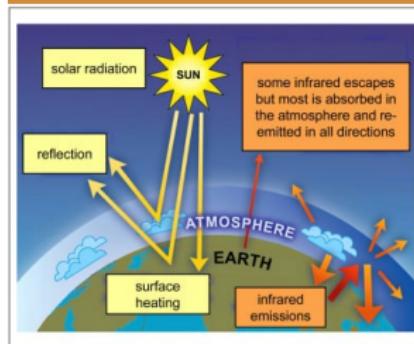
But look at the time *since* the last ice age (25,000 ya):



Why is the temperature increasing?

The Selma Morning Times,
SELMA, ALA., - WEDNESDAY, OCTOBER 16, 1912

Hint to Coal Consumers.
A Swedish professor, Svend Arrhenius, has evolved a new theory of the extinction of the human race. He holds that the combustion of coal by civilized man is gradually warming the atmosphere so that in the course of a few cycles of 10,000 years the earth will be baked in a temperature close to the boiling point. He bases his theory on the accumulation of carbonic acid in the atmosphere, which acts as a glass in concentrating and refracting the heat of the sun.



The Rodney & Otamatea Times

WAITEMATA & KAIPARA GAZETTE

PRICE—10s per annum in advance
WARKWORTH, WEDNESDAY, AUGUST 14, 1912.
3d. per Copy.

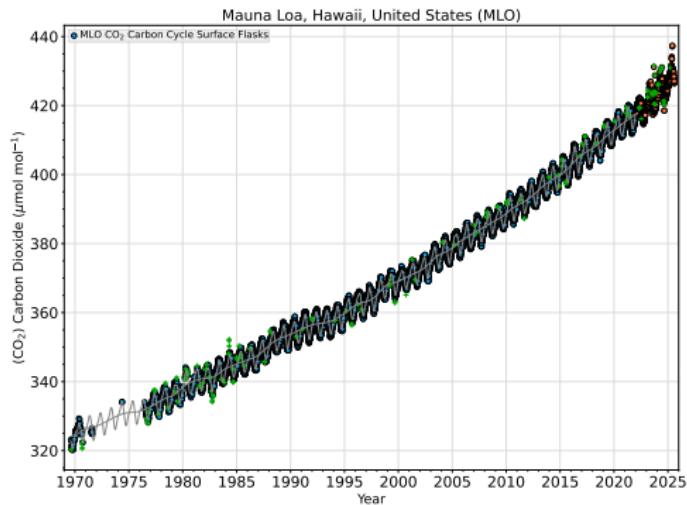
Science Notes and News.

COAL CONSUMPTION AFFECTING CLIMATE.

The furnaces of the world are now burning about 2,000,000,000 tons of coal a year. When this is burned, uniting with oxygen, it adds about 7,000,000,000 tons of carbon dioxide to the atmosphere yearly. This tends to make the air a more effective blanket for the earth and to raise its temperature. The effect may be considerable in a few centuries.

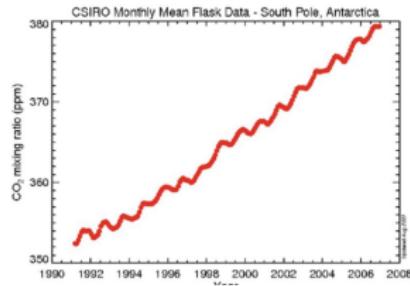
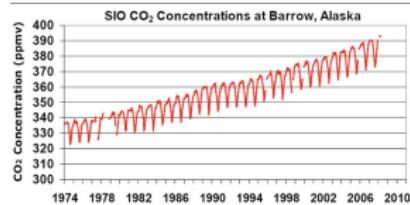
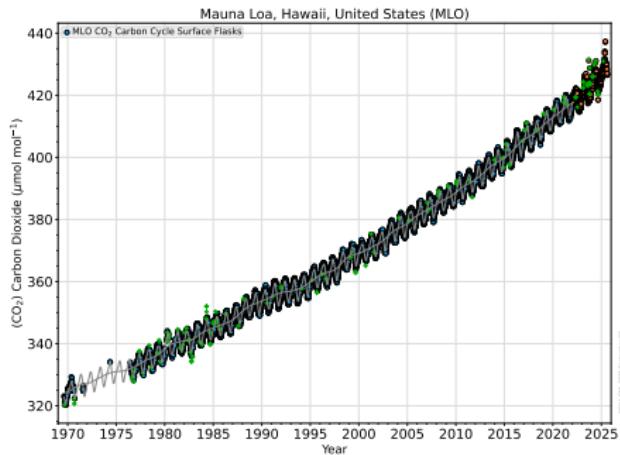
- ▶ Answer: primarily due to the “greenhouse effect” from “greenhouse gases” (CO_2 , methane)

How do we know that CO₂ is increasing?



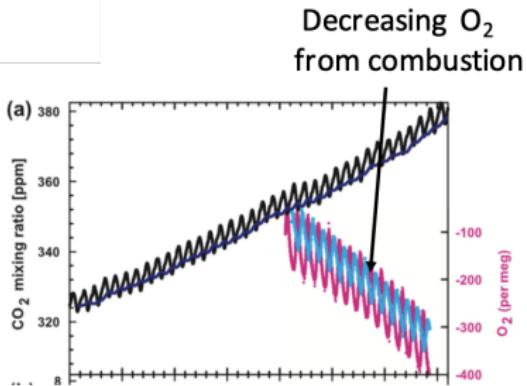
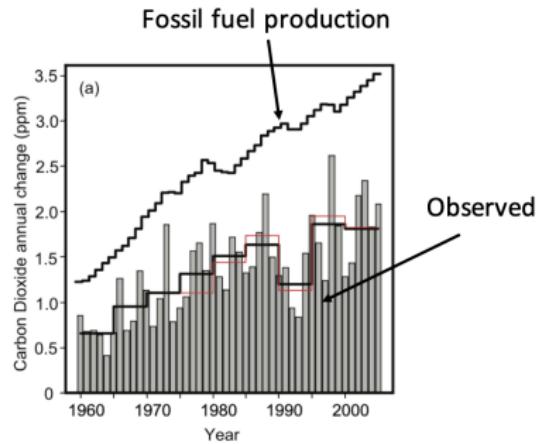
- ▶ Answer: We have been measuring for over 50 years!

How do we know that CO₂ is increasing?



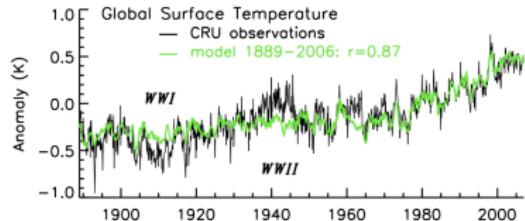
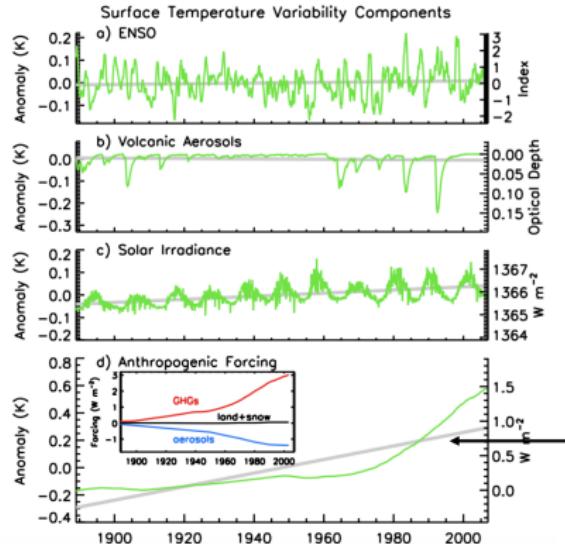
- ▶ Each station shows approximately an 1–2 parts per million (ppm) increase in atmospheric CO₂ per year.
(What is “ppm” anyway? What part of the air is this?)

How do we know that humans are causing the increase?



- ▶ What does the comparison of human CO₂ production (line on left graph) and annual atmospheric increase (bars) tell us?
- ▶ Combustion is: C_xH_y + O₂ → H₂O + CO₂

What about other effects, though?



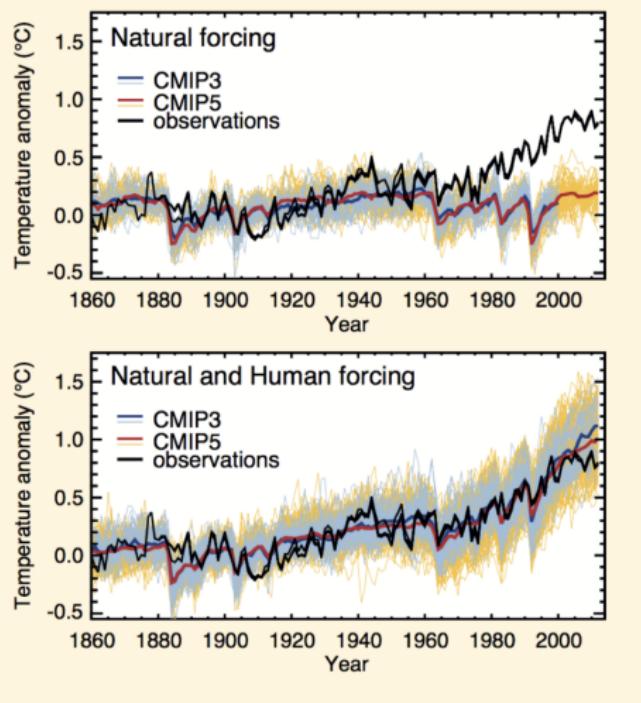
Linear regression suggests that most of the warming trend comes from GHGs

Source: [Lean 2008, GRL](#)

- ▶ Could solar variations explain warming?
- ▶ Could natural ocean cycles (El Nino, La Nina)?
- ▶ The effect of aerosols (causing cooling)?

How do models take all of this into account?

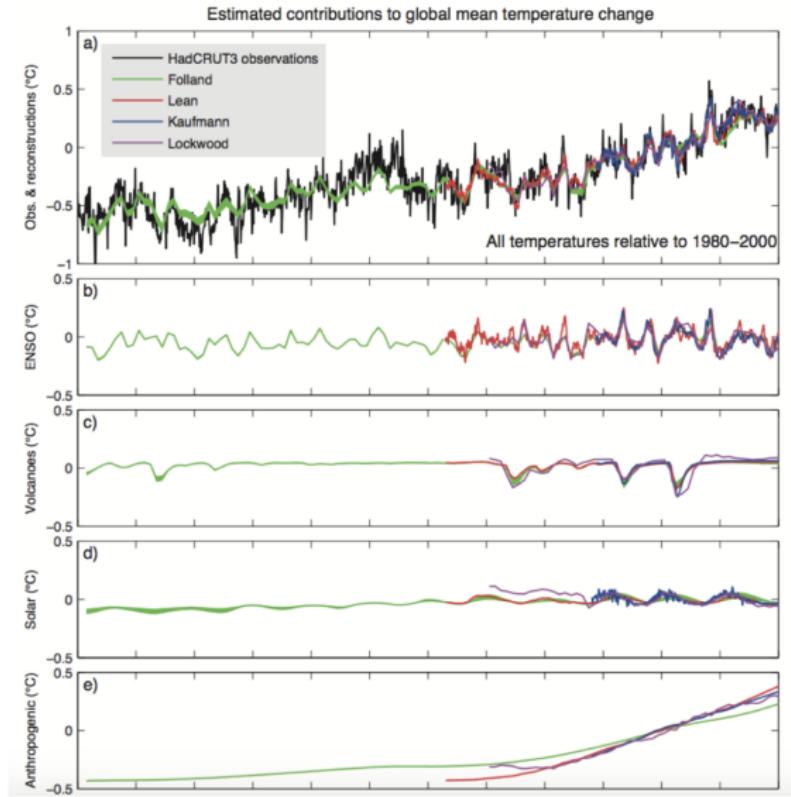
CMIP = International ensemble of global climate models



Source: [Bindoff et al. 2013](#) (IPCC AR5 WG1 Ch.10)

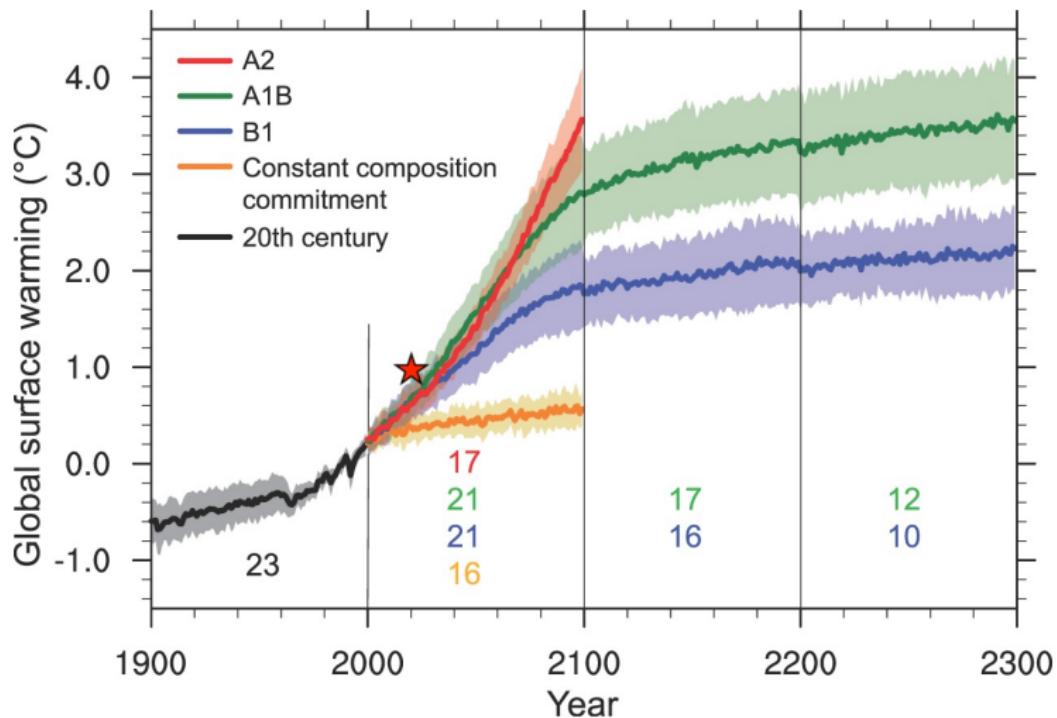
- ▶ Models without human effects vs. those with.

Different models agree on the contributing factors



Sources: IPCC WG1 Chapter 10 (From Jeevanee talk)

What do models predict for the future?



Sources: IPCC Global Climate Predictions 2007 (Figure 10.4)

What's in the news?

Oceans

Collapse of critical Atlantic current is no longer low-likelihood, study finds

Scientists say 'shocking' discovery shows rapid cuts in carbon emissions are needed to avoid catastrophic fallout

Damian
Carrington
*Environment
editor*

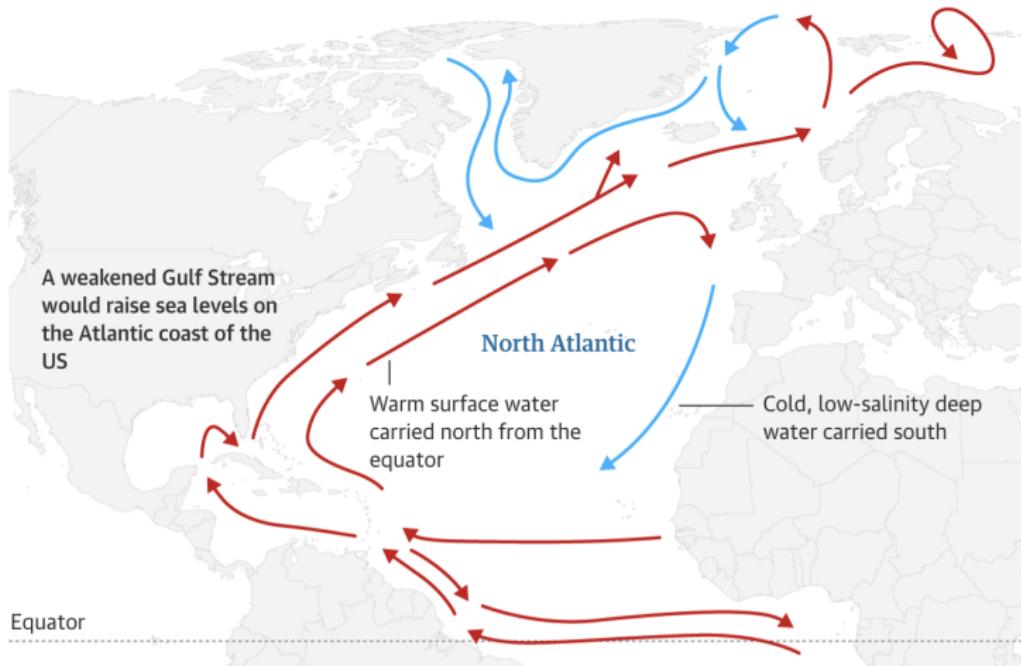
Thu 28 Aug 2025 11.00
EDT

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AMOC

The Atlantic meridional overturning circulation is weakening and has collapsed in the distant past



Guardian graphic. Source: Noaa, S Rahmstorf et al from the Potsdam Institute for Climate Impact Research (PIK)