

A satellite view of Earth at night, showing a dense network of city lights across the continents. The lights are primarily yellow and orange, with some brighter white spots. The dark blue of the oceans and the black of space are visible in the background.

Tim Collins

RCRC

Dec 8 2019

State of the Climate Report

Outline

- Some effects of humans on creation
- Climate change
- *Next week: What to do about the above (Juli Elliot)*

What we won't discuss for most of the presentation:

Is global warming anthropogenic?

Fun Fact: Climate change divides the US church, but not the global church

(source: Peter Harris, cofounder of A Rocha, an international Christian nature organization; see Quick To Listen podcast, 10/17/2018)

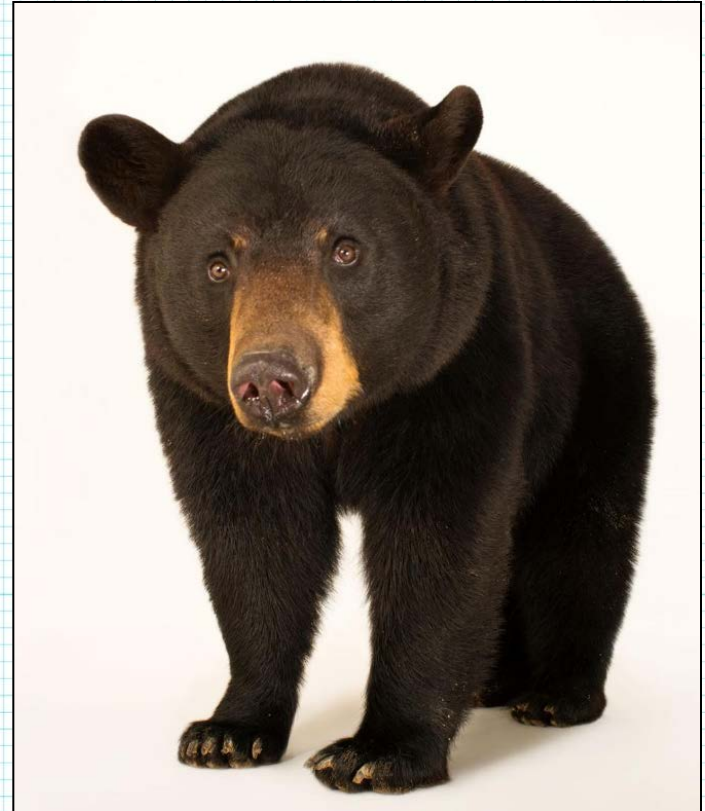
Sources

- **Moo and Moo (esp. for non-warming data)**
- **Creation Stewardship Task Force Report (courtesy Anthony)**
- **Ed Hull's presentation (2012; draws heavily from CSTF)**
- **"Can Climate be Predicted," talk by R. S. Knox, U. Rochester Dept. of Physics and Astronomy**

(See slides at the end of this talk for a complete list of resources.)

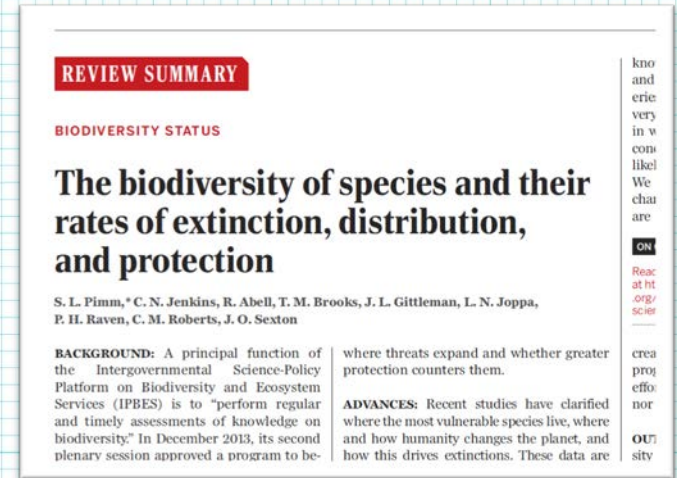
Because this won't be easy to hear, a word of hope

- **Through careful efforts, humans have successfully brought many animals back from the brink of extinction**
- **The Louisiana black bear, a subspecies of the American black bear was declared endangered through its range in 1992**
- **More than 700,000 acres of habitat have been restored and ~750 now exist in the wild**



Biodiversity is being lost at an alarming rate

- The estimate for the present extinction rate is ~1,000 times the background (“natural”) rate
- The rate is increasing
- World Wildlife Fund estimated in 2014 that from 1970 to 2010 the total number of animals, birds, reptiles, amphibians and fish dropped by 52%
- There have been five mass extinction events in history; some scientists consider this a sixth
- This biodiversity loss is primarily due to habitat loss (secondarily due to warming)
- This is not inevitable; choices esp. by FWCs can have significant impact



There's a lot of us

- The world population has grown from ~250 million people at the time of Jesus to 7.4 billion today, and climbing
- Over half the earth's surface has been physically modified by humans
- Every year humans move more of the earth than all natural erosion processes combined
- Human agriculture has replaced 70% of the world's grasslands, 50% of the savanna, 45% of temperate deciduous forests, 27% of tropical forests
- In 2014 alone, 45 million acres of tree cover (greater than the size of ND) were lost worldwide, largely to agriculture
- This feeds the biodiversity loss and impacts the chemical atmospheric composition



Global changes impact marine life

- Since 1970 there's been an estimated 49% decline in marine vertebrates, including half those fish species used by humans)
- ¼ of all marine life depends on coral reefs
- Half the world's reefs have now been destroyed
- Causes range from pollution, trawling and other fishing techniques, warming seas and acidification due to increased CO₂ levels
- ~8 million metric tons of plastic waste are dumped into the oceans each year
- Artificial nitrogen fixation techniques, a boon to agriculture, produce runoff which results in artificially increased nutrient levels and collapse of O₂ levels
- Each year an area the size of CT, devoid of life, forms in the Gulf of Mexico, due to runoff
- Modern agriculture is also causing a loss of topsoil at a rate 10-40x that at which is it naturally made; degraded topsoil also causes loss of fresh water

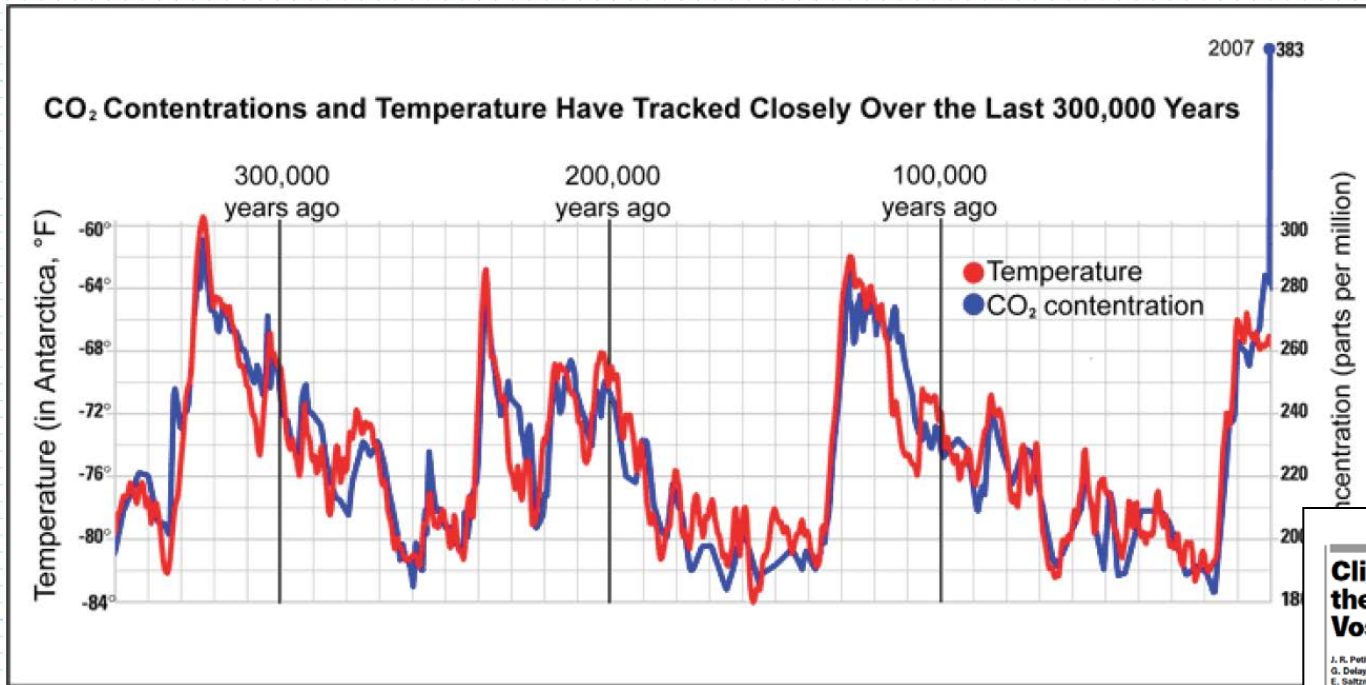


Przewalski's horse

- Last of the truly wild horses
- Used to roam free in Asian steppes, now reintroduced into Mongolia
- Currently ~1,900 in the wild



We live in an interglacial period



Note the strong correlation between CO₂ and temperature

CSTF Report, Appendix A (p82); see also Figure from A. V. Fedorov et al., *Science* 312, 1485 (2006); original data from J. R. Petit et al., *Nature* 399, 429 (1999)

articles

Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica

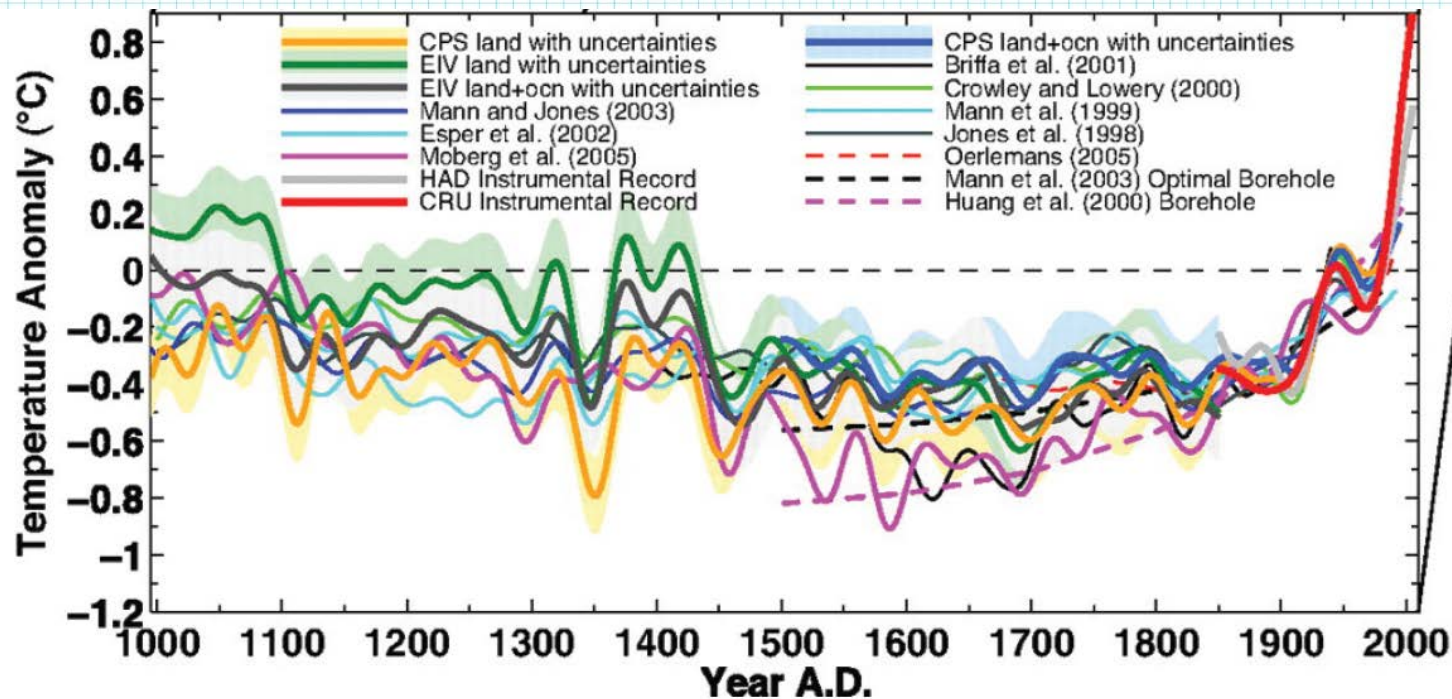
J. R. Petit¹, J. Jouzel¹, D. Raynaud¹, N. I. Barkov¹, J.-M. Barnota¹, I. Basile¹, M. Bender¹, J. Chappellaz¹, M. Davis¹, G. Delaygue¹, M. Delmotte¹, V. M. Kotlyakov¹, M. Legrand¹, V. Y. Lipenkov¹, C. Lorius¹, L. Pepin¹, C. Ritz¹, E. Saitama¹ & M. Stouffer²

¹ Laboratoire de Climatologie et de Géophysique de l'Environnement, CNRS, BRM, 91191, Saint Martin d'Éry, Cedex, France
² Laboratoire des Sciences du Climat et de l'Environnement (UMR 8122), Centre de Métrie, Bât. 709, CEA Saclay, 91191 Gif sur Yvette Cedex, France
³ Arctic and Antarctic Research Institute, Bering Street 38, 19002, St. Petersburg, Russia
⁴ Department of Geosciences, Princeton University, Princeton, New Jersey 08542, USA
⁵ Rosenstam School of Marine and Atmospheric Science, University of Miami, 5000 Rickenbacker Causeway, Miami, Florida 33149, USA
⁶ Institute of Geography, Tomsk State University, 630091, Tomsk, Russia

The recent completion of drilling at Vostok station in East Antarctica has allowed the extension of the ice record of atmospheric composition and climate to the past four glacial-interglacial cycles. The successions of changes through each climate cycle and termination were similar, and atmospheric and climate properties oscillated between stable bounds. Interglacial periods differed in temporal evolution and duration. Atmospheric concentrations of carbon dioxide and methane correlate well with Antarctic air temperatures throughout the record. Present-day atmospheric burdens of these two important greenhouse gases seem to have been unprecedented during the past 420,000 years.

The late Quaternary period (the past one million years) is punctuated by a series of large glacial-interglacial changes with cycles that last about 100,000 years (ref. 1). Current interglacial climate over recovered, reaching a depth of 5623 m (ref. 17). Drilling then stopped ~120 m above the surface of the Vostok lake, a deep subglacial lake which extends below the ice sheet over a large area.

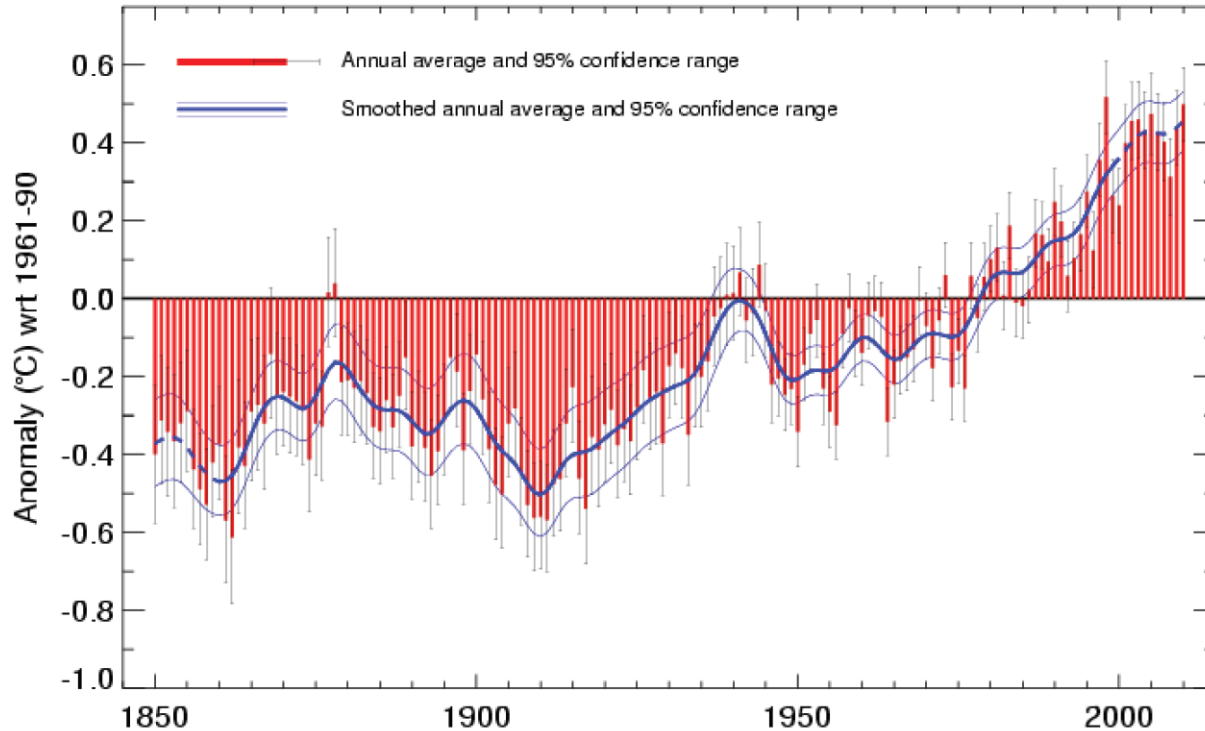
More granularity (and proxies): Just the last thousand years



One last zoom: 1850 to the present time



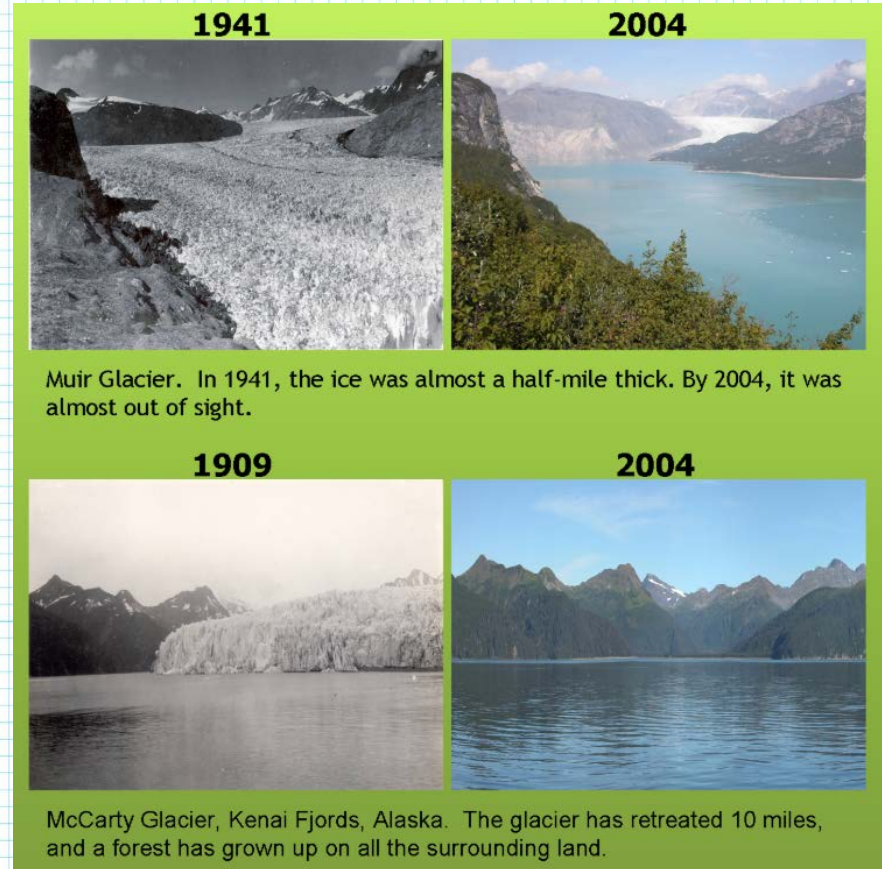
Global average temperature 1850-2010
Based on Brohan et al. 2006



Evidence for global warming from natural systems

- Glacial retreat
- Increased summer melt back of sea ice
- Ice sheet reduction (Greenland & Antarctica)
- Lengthened growing seasons
- Shift in migration patterns

CSTF Report



Muir Glacier

1880's



2005



Here's another pair of shots of Muir Glacier taken from exactly the same spot. Today, Muir Glacier has retreated more than 31 miles and is completely out of the field of view. The glacier in the distance to the right center of the photograph is Riggs Glacier. Formerly a tributary to Muir Glacier, it is approximately 26 miles away. Note the abundant vegetation on the west side of the inlet.

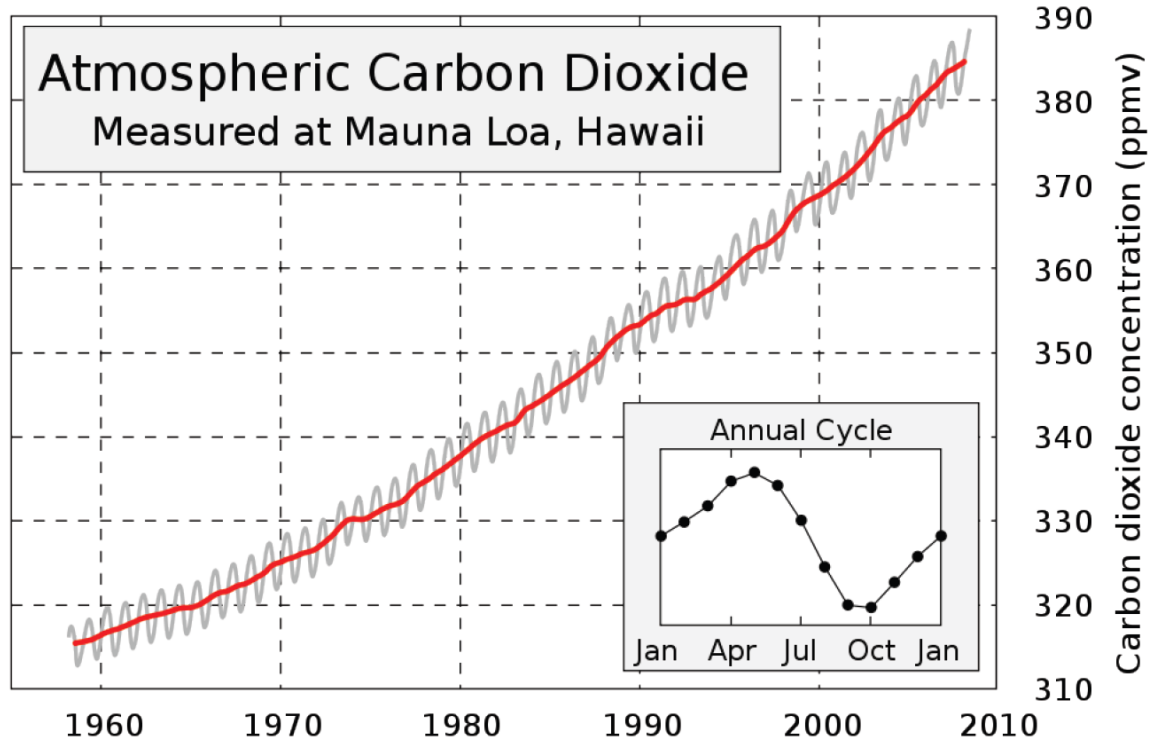
CSTF Report

Vancouver Island marmot

- A “comically large rodent” found in the mountains of Vancouver Island
- Brought back from the verge of extinction to ~200 marmots



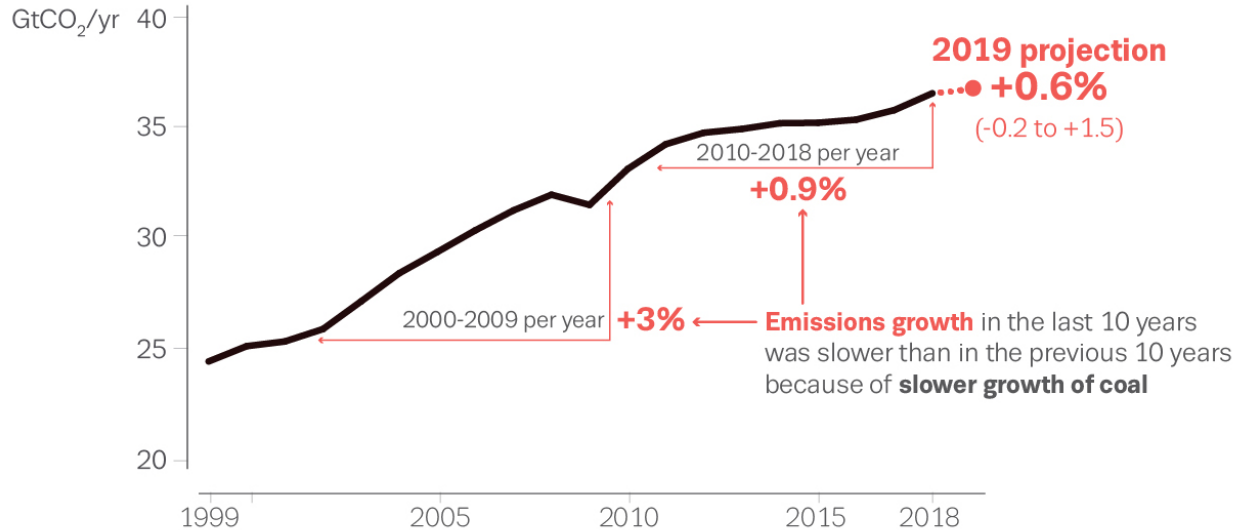
Atmospheric CO₂ concentrations are increasing (and accelerating)



About half of atmospheric CO₂ ends up in the top 100 m of the oceans, so the oceans are acidifying
CSTF Report, Appendix A (p69)

CO₂ emissions are growing but the rate is slowing

Fossil CO₂ emissions grow more slowly... but do not yet decline



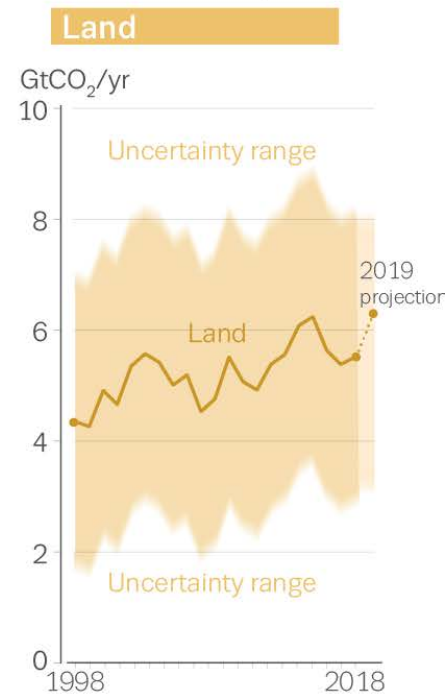
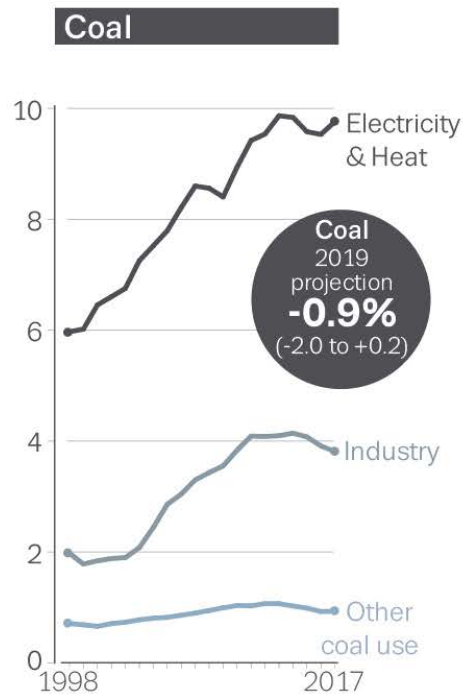
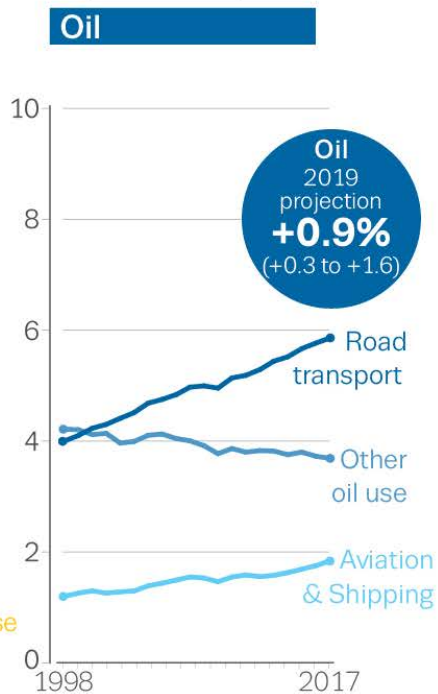
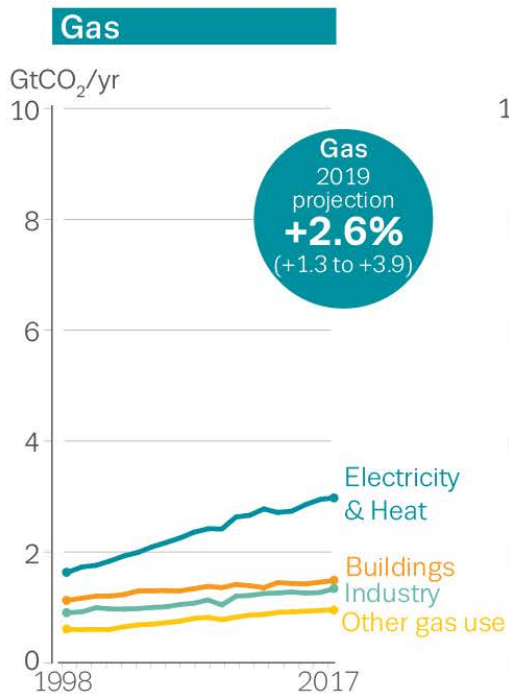
Source: Global Carbon Project based on UNFCCC/CDIAC/BP/USGS. Units: Billion tonnes of carbon dioxide per year (GtCO₂/yr)

CO₂ emissions need to decline rapidly to net-zero around mid-century to pursue the Paris Agreement 1.5°C goal

Natural gas and oil now drive global emissions growth

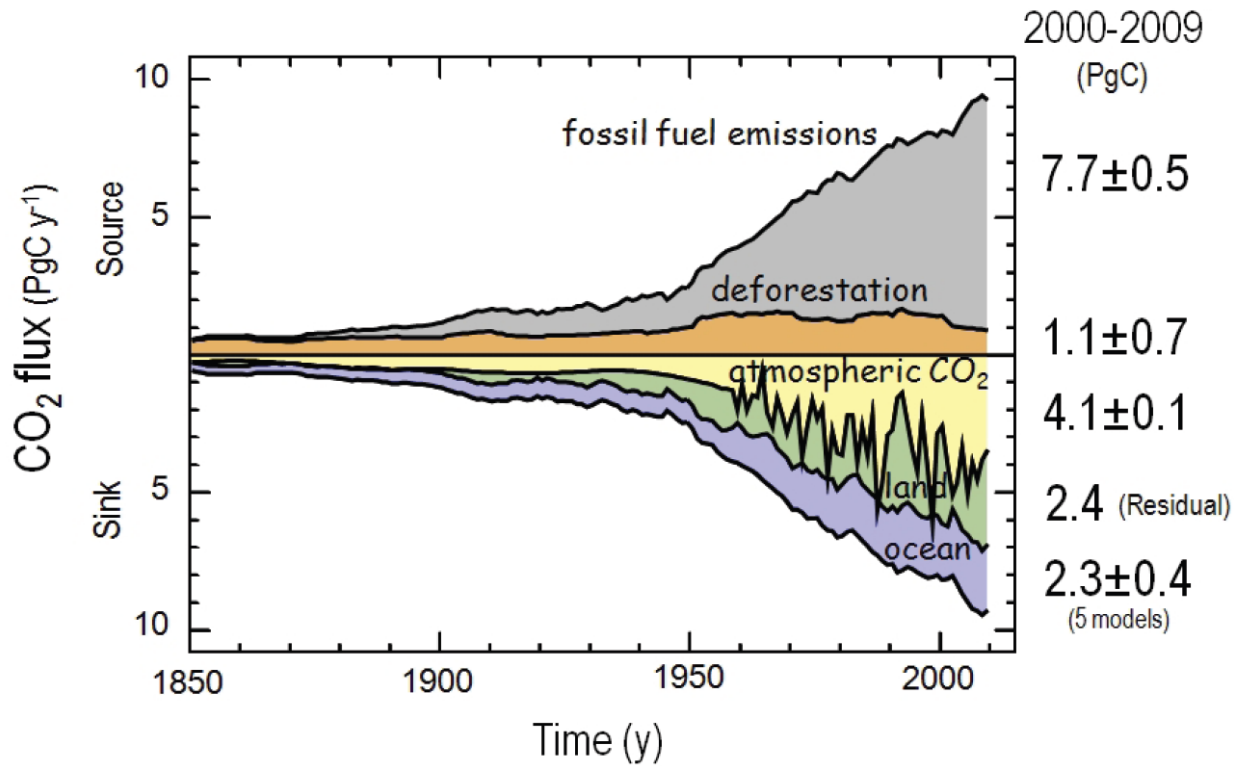
Continued support for low-carbon technologies needs to be combined with policies that phase out fossil fuels.

Deforestation fires in 2019 drive emissions up on land

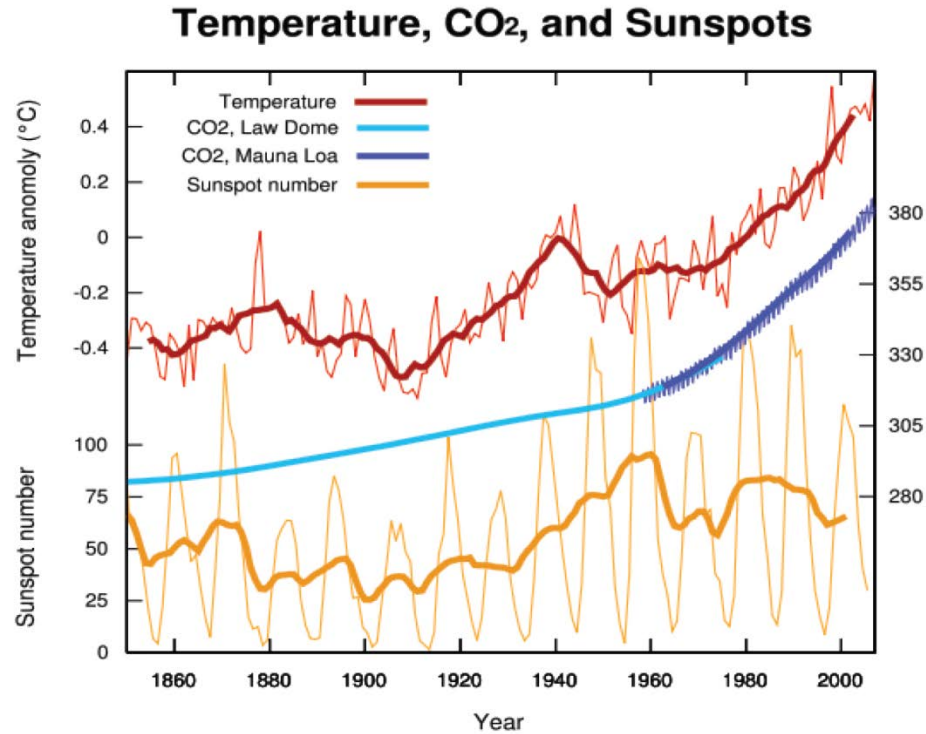


Source: 2019 projection by the Global Carbon Project. Trend to 2017 based on data from the IEA (2019) CO₂ Emissions from Fuel Combustion, www.iea.org/statistics. All rights reserved.

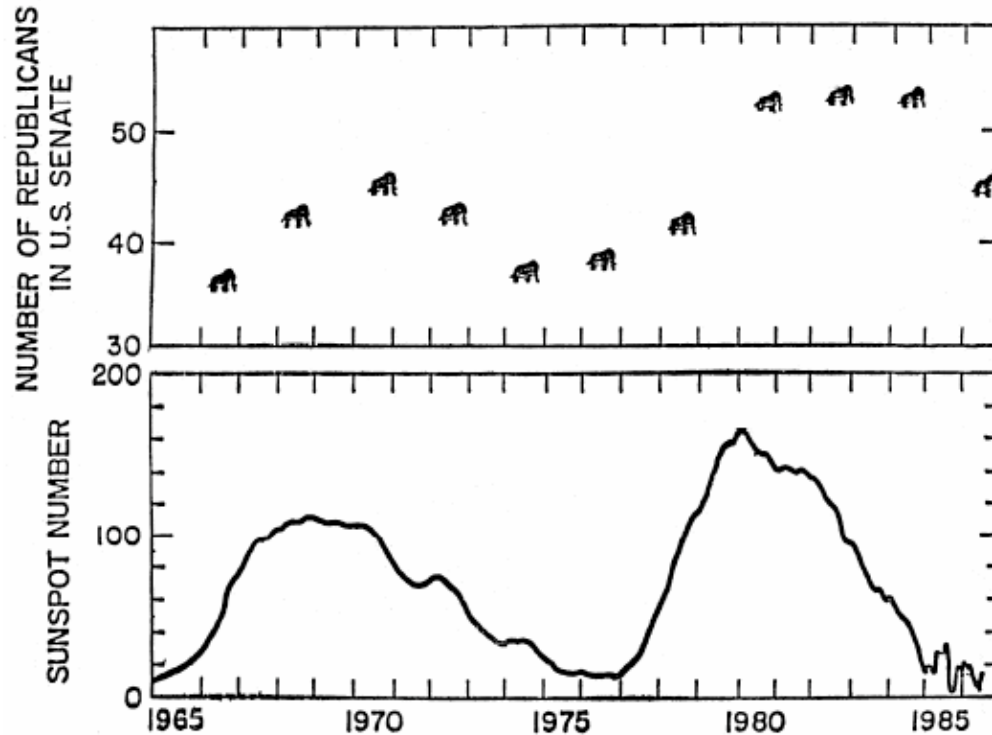
Where's it all going?



These changes are not correlated with solar activity

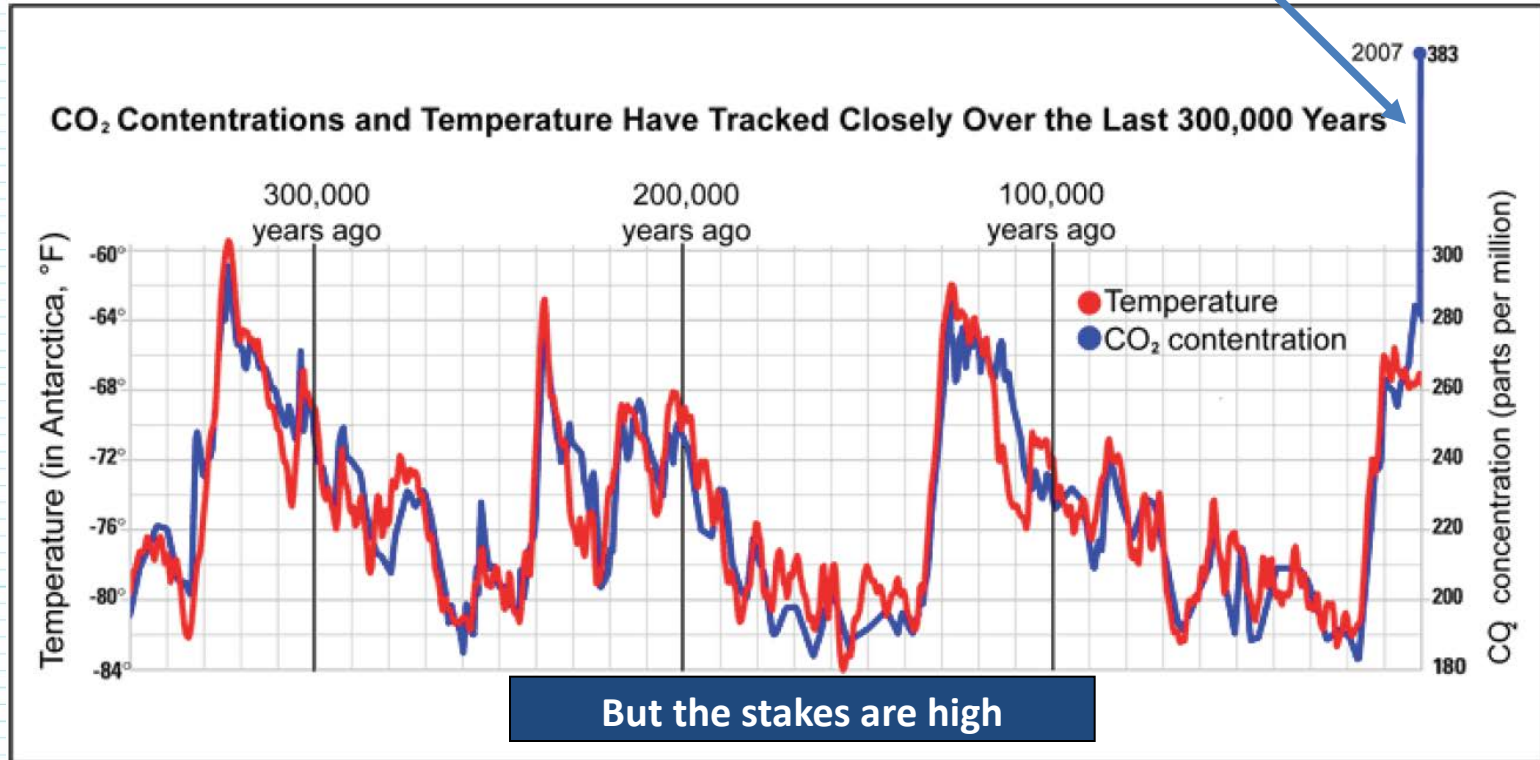


Correlation is not causation: Senate Republicans vs. Sunspot count

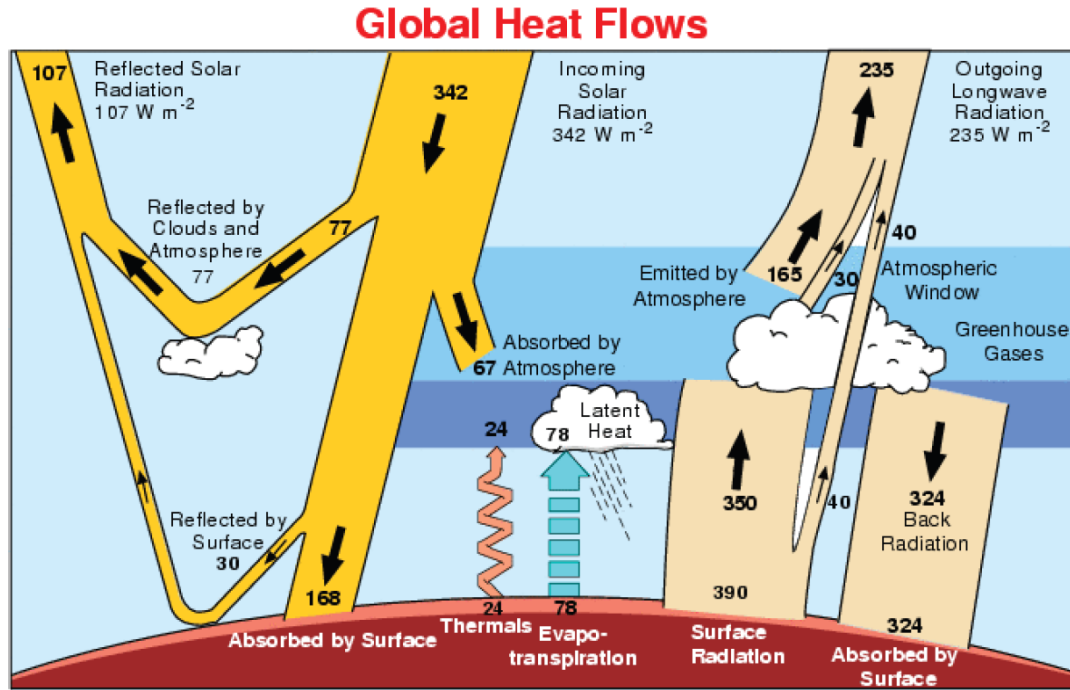


Reproduced without permission from R. Lindzen, Erice talk (2005)

So, past performance *may* not be indicative of future results...

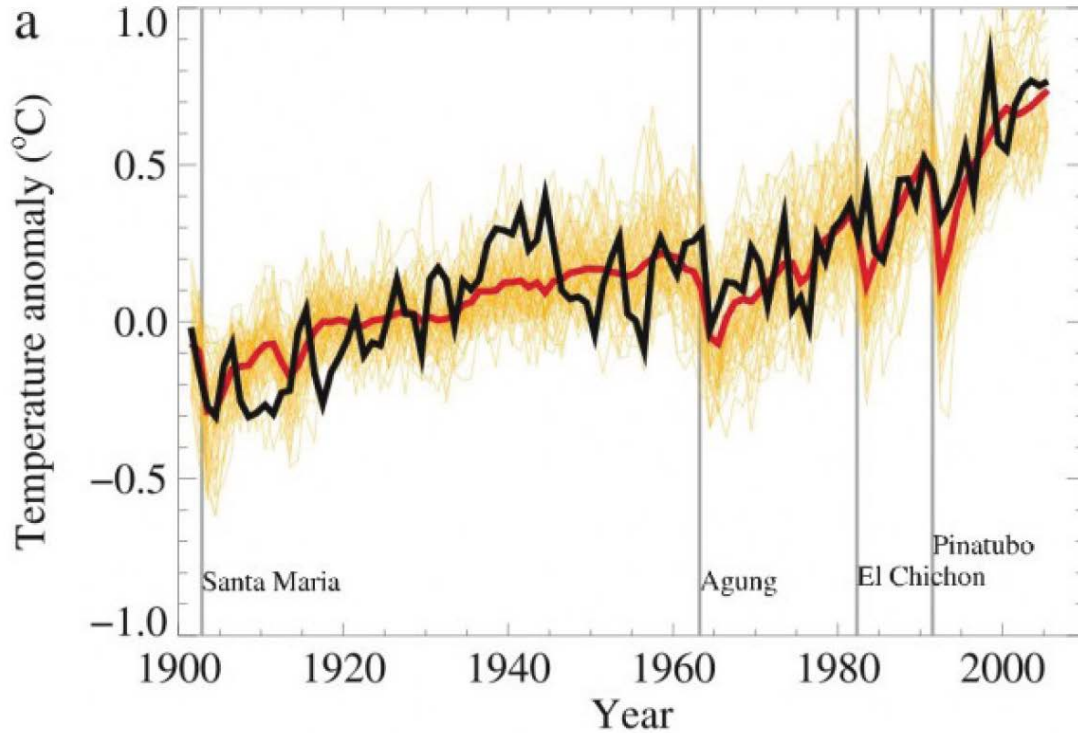


Even simple climate models must account for multiple processes

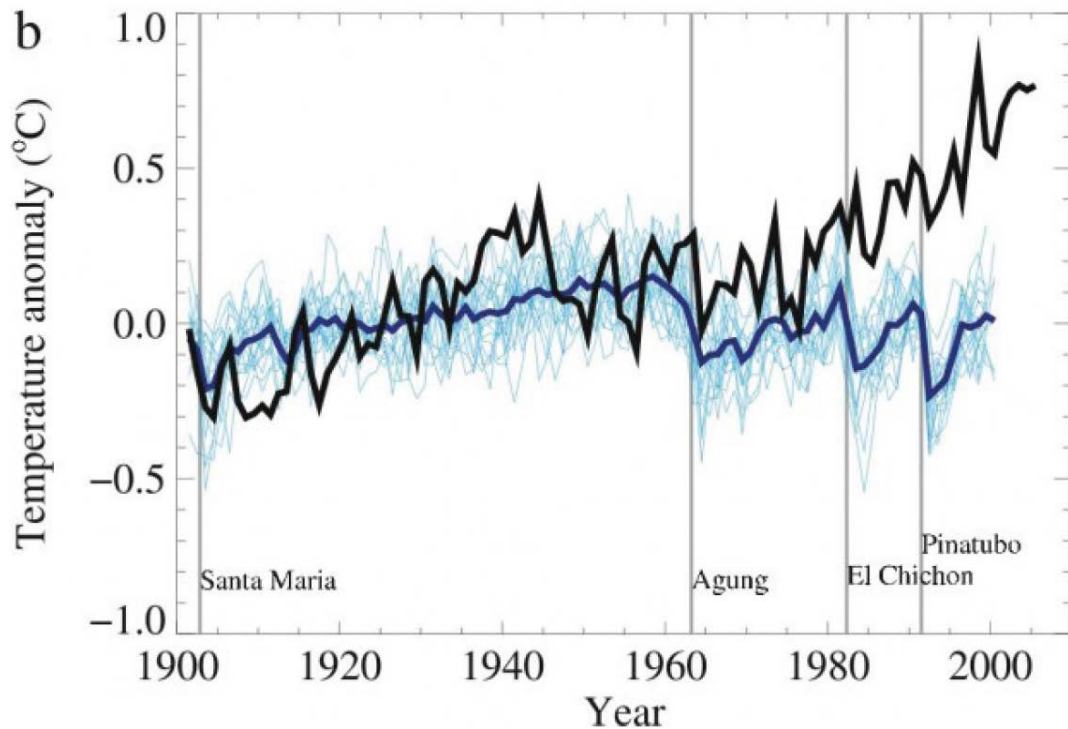


Kiehl and Trenberth 1997

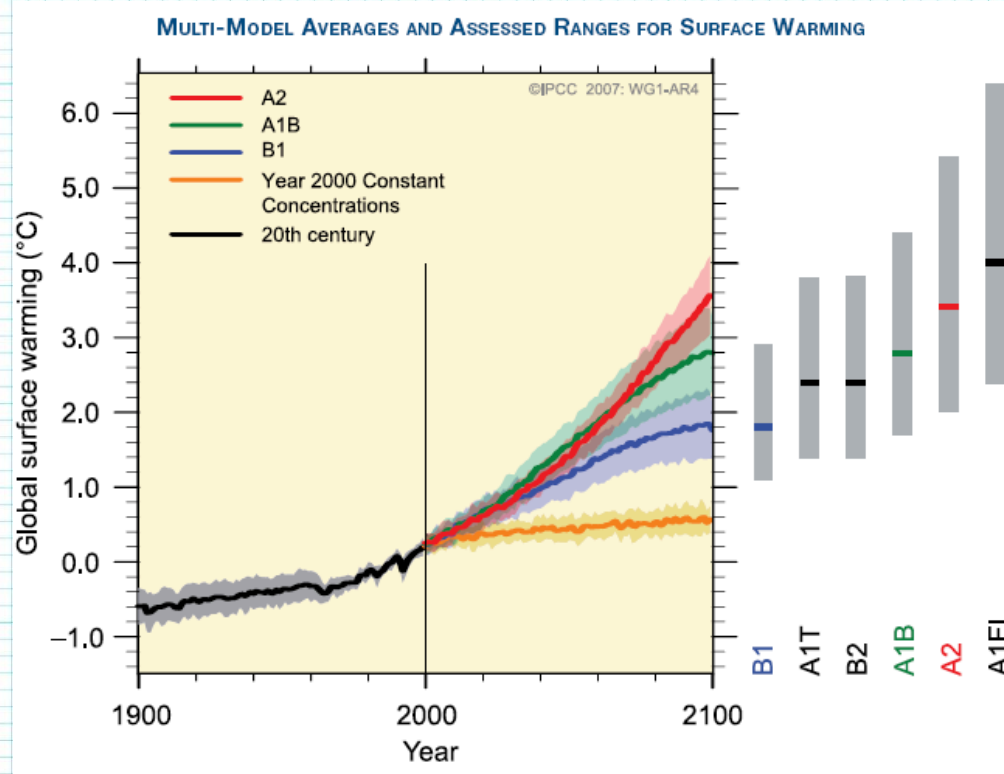
Models with CO₂ forcing “on”



Models with CO₂ forcing “off”

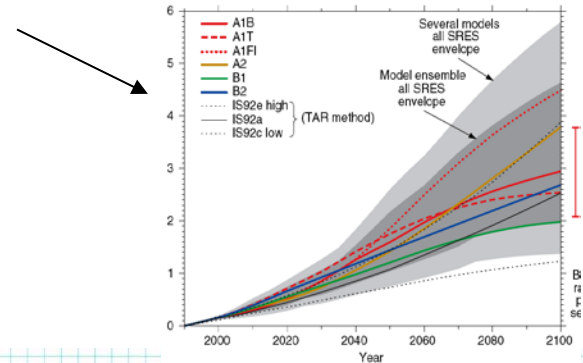
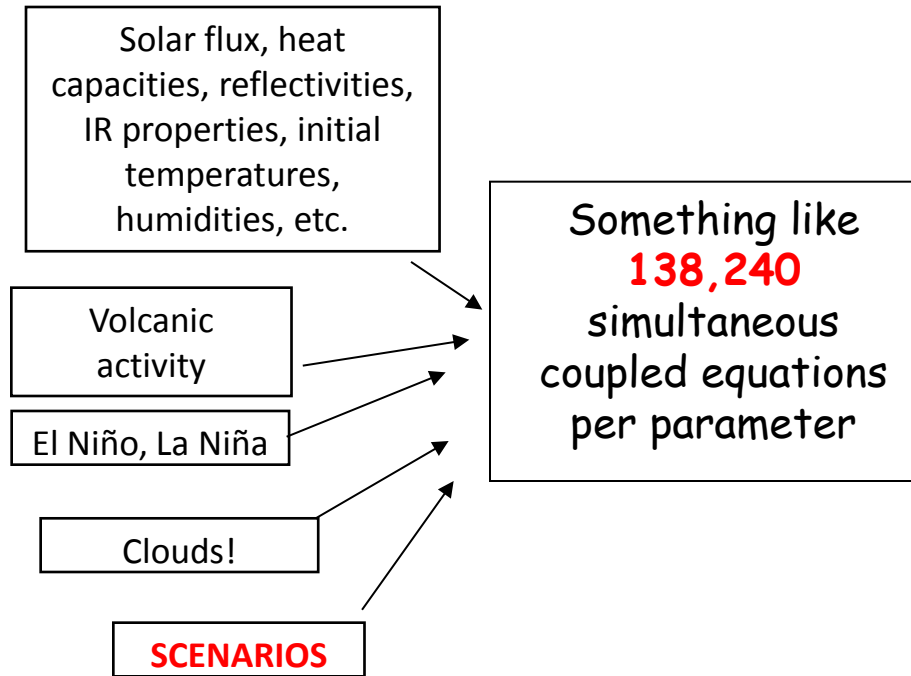


IPCC models predict rises of up to 4 °C



Source: IPCC AR4, Summary for Policymakers, p. 14 (2007); courtesy Bob Knox via Ed Hull

Models are very complicated and not all experts agree



Courtesy Dr. Robert Knox

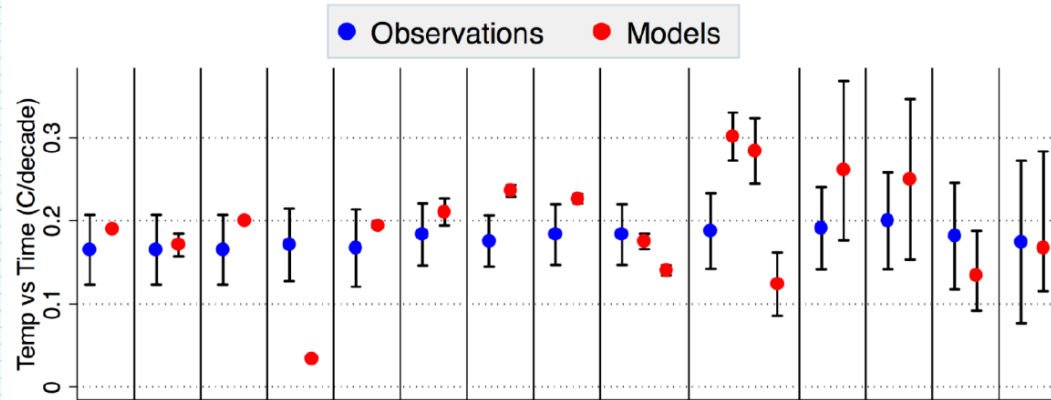
A skeptic's perspective (courtesy Bob Knox)

What The IPCC Models Don't Do Very Well:

- **Predict atmospheric temperature trends at elevation (ie, not just the surface)**
- **Successfully predict evolution of ocean heat content**
- **Estimate recent radiative imbalances**
- **Account for the uncertain effects of clouds**

However, many models have done a good job of postdicting temperature anomaly when correct forcing is used

“We find that climate models published over the past five decades were skillful in predicting subsequent GMST changes, with most models examined showing warming consistent with observations, particularly when mismatches between model-projected and observationally-estimated forcings were taken into account.”



Evaluating the performance of past climate model projections

Zeke Hausfather¹, Henri F. Drake^{2,3}, Tristan Abbott³, Gavin A. Schmidt⁴

¹ Energy and Resources Group, University of California, Berkeley, 310 Barrows Hall, A.

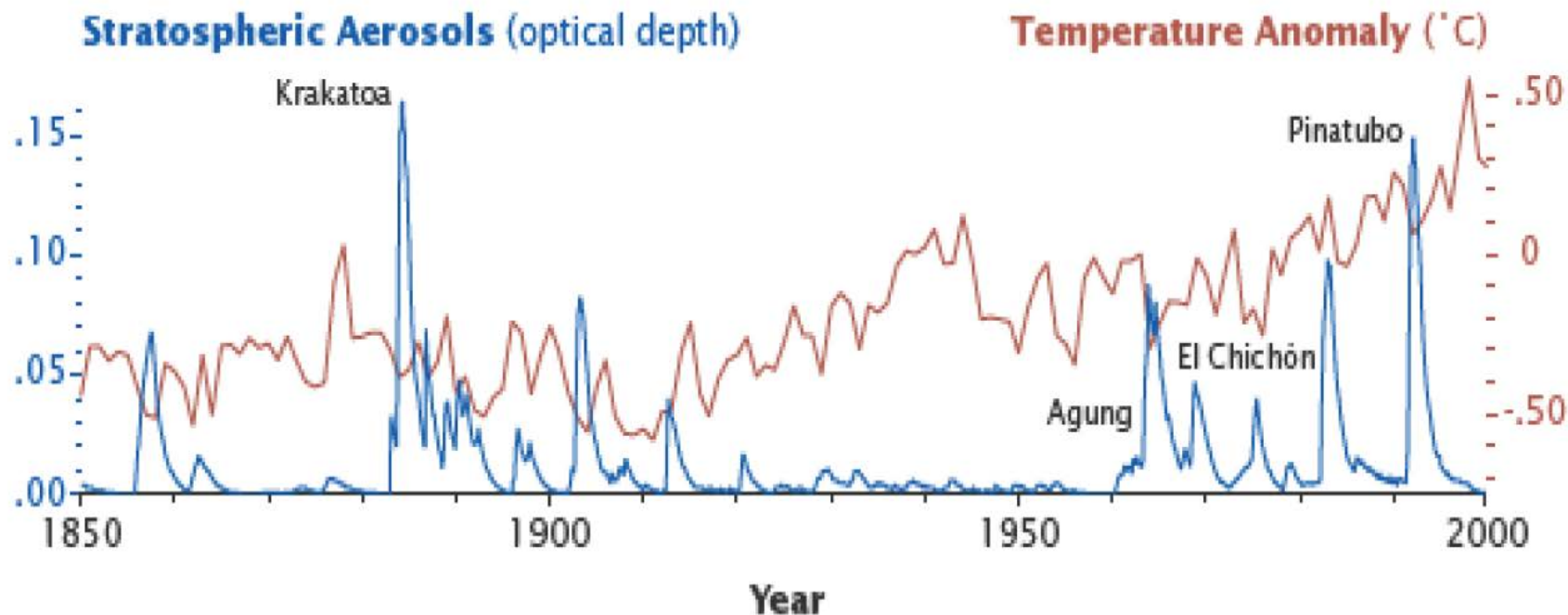
² MIT Center for Global Change Science, Massachusetts Institute of Technology / Woods Hole Oceanographic Institution Joint Program, Woods Hole, MA, USA.

³ Program in Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA, USA.

⁴ Program for Space Studies, 2880 Broadway, New York, USA.

Zeke Hausfather (hausfath@gmail.com)

Particulate emissions typically contribute a cooling effect



Our friend and his duck Lucky

- While going through chemotherapy, he found an abandoned duck egg and rescued it from freezing
- The duck imprinted on him
- Lucky is free to leave but chooses to stay



CRC's Position Statement on Climate Change

- 1. It is the near scientific consensus that climate change is occurring and is very likely due to human activity**
- 2. Human-induced climate change is an ethical, social justice, and religious issue**
- 3. Climate change poses a significant threat to future generations, the poor, and the vulnerable**
- 4. Climate change is a challenge to us all**
- 5. We are called to “commit ourselves to honor all God’s creatures and to protect them from abuse and extinction, for our world belongs to God” (Contemporary Testimony, par. 51).**

Summary: Evidence for climate change is strong

- Humans have had a strong impact on the climate independent of global warming
- Measured CO₂ levels are skyrocketing
- Global temperature has been historically correlated with atmospheric CO₂ concentration
- Models are not perfect but predict global warming will accompany increase CO₂
- *Response: to mitigate or to adapt?*
- *Christian response: stewardship of life, independent of whether global warming is due to human activity*

Useful resources

WARMING IMPACT:

- “Why half a degree of global warming is a big deal”: <https://www.nytimes.com/interactive/2018/10/07/climate/ipcc-report-half-degree.html>
- IPCC (Intergovernmental Panel on Climate Change) special report on the impact of 1.5 deg C: <https://www.ipcc.ch/sr15/>

HOPE:

- National Geographic article on animals rescued from extinction: <https://www.nationalgeographic.com/animals/2018/10/animals-endangered-back-from-brink-conservation-news/>
- ...and from the Guardian: <https://www.theguardian.com/environment/2017/apr/08/endangered-species-conservation-successes>
- NYT op-ed, “Maybe We’re Not Doomed After All”: <https://www.nytimes.com/2019/06/07/opinion/climate-change-hope-solutions.html>

SKEPTICS:

- Climate Depot, a climate-change skeptic web site: <https://www.climatedepot.com/>; http://www.cfact.org/pdf/ClimateDepot_A-Z_ClimateRealityCheck.pdf

GENERAL GLOBAL WARMING DATA, WEB SITES AND ARTICLES:

- “Creation Care: A Biblical Theology of the Natural World”, Moo and Moo, Zondervan Academic (2019)—excellent resource for the theology and for its chapter on global warming and human impact on the environment
- Global Carbon Budget: <https://www.globalcarbonproject.org/carbonbudget/>
- “Climate Change Is Accelerating, Bringing World ‘Dangerously Close’ to Irreversible Change”: https://www.nytimes.com/2019/12/04/climate/climate-change-acceleration.html?nl=todaysheadlines&emc=edit_th_191205?campaign_id=2&instance_id=14225&segment_id=19306&user_id=e40f8a00abc5f9f9d81c1b44b6049b25®i_id=224732791205
- “Carbon Dioxide Emissions Hit a Record in 2019, Even as Coal Fades”: https://www.nytimes.com/2019/12/03/climate/carbon-dioxide-emissions.html?nl=todaysheadlines&emc=edit_th_191204?campaign_id=2&instance_id=14224&segment_id=19268&user_id=e40f8a00abc5f9f9d81c1b44b6049b25®i_id=224732791204
- NOAA: <https://www.climate.gov/print/8431>
- Creation Stewardship Task Force Report of the CRCNA (*extremely* helpful): <https://network.crcna.org/crcna-and-synod/creation-stewardship-task-force-report>

Useful resources, continued

SCIENTIFIC ARTICLES:

- On biodiversity loss: “The biodiversity of species and their rates of extinction, distribution, and protection” Pimm et al., *Science* 344, 1246752 (2014): <https://science.sciencemag.org/content/344/6187/1246752/tab-pdf>
- Ice core data on temperature and CO2 concentration (THE plot): “Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica”, *Nature* 399 429 (1999) <https://www.nature.com/articles/20859>
- Climate modeling and post-diction: “Evaluating the performance of past climate model projections”, Hausfather et al., *Geophysical Research Letters*, 2019 <https://doi.org/10.1029/2019GL085378>; as reported on in *Science*: <https://www.sciencemag.org/news/2019/12/even-50-year-old-climate-models-correctly-predicted-global-warming> and *NYT*: <https://www.nytimes.com/aponline/2019/12/04/science/ap-us-sci-climate-models.html?searchResultPosition=1>
- Volcanoes v. coal for 1998-2008: “Reconciling anthropogenic climate change with observed temperature 1998–2008”, Robert K. Kaufmann et al., *Proceedings of the National Academy of Sciences* 108 (29) 11790 (2011); <https://wattsupwiththat.files.wordpress.com/2011/07/pnas-201102467.pdf>
- More on volcanoes: “Major influence of tropical volcanic eruptions on the stratospheric aerosol layer during the last decade”, Vernier et al., *Geophys. Research Letters* 38, L12807 (2011): <https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2011GL047563>