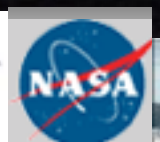
Earth: The Operators' Manual
Good news in unexpected places

Richard B. Alley

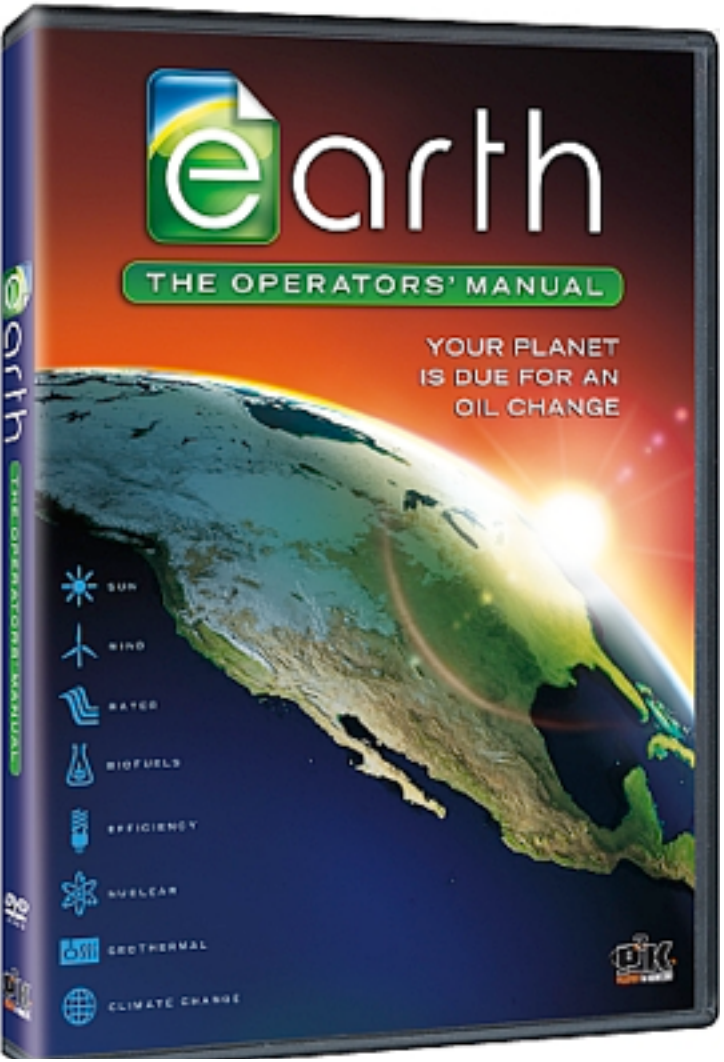
Climate Literacy Network (CLN)

March 27, 2012

Please note: I work for Penn State University, And help UN IPCC, NRC, etc., But I am not representing them, just me.

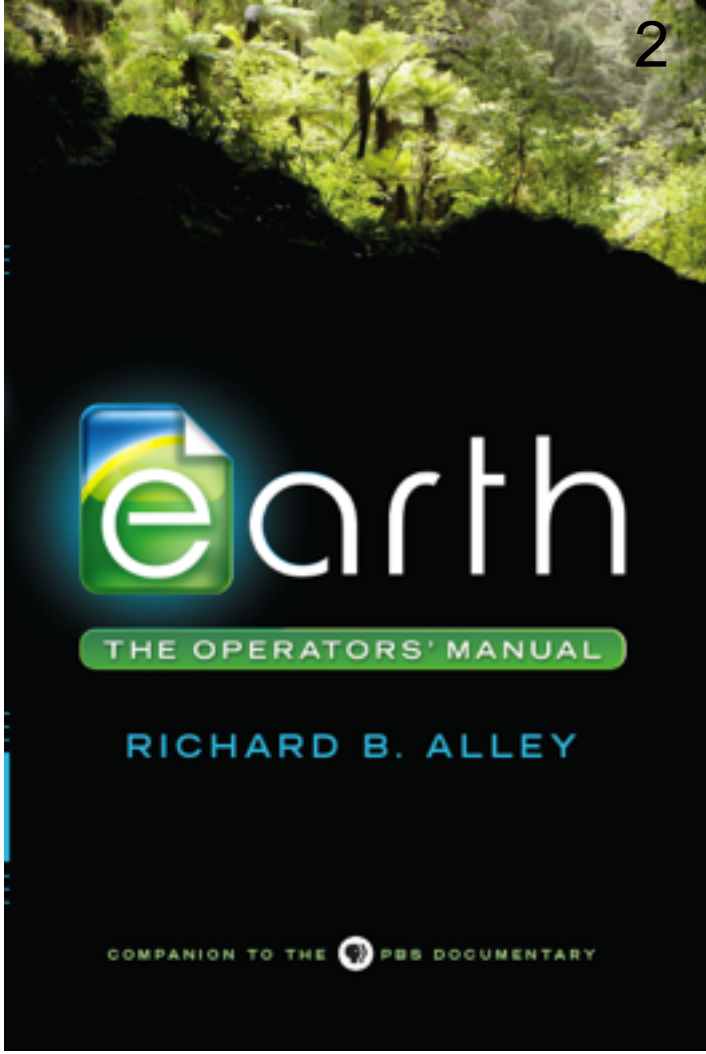


G. Comer Foundation

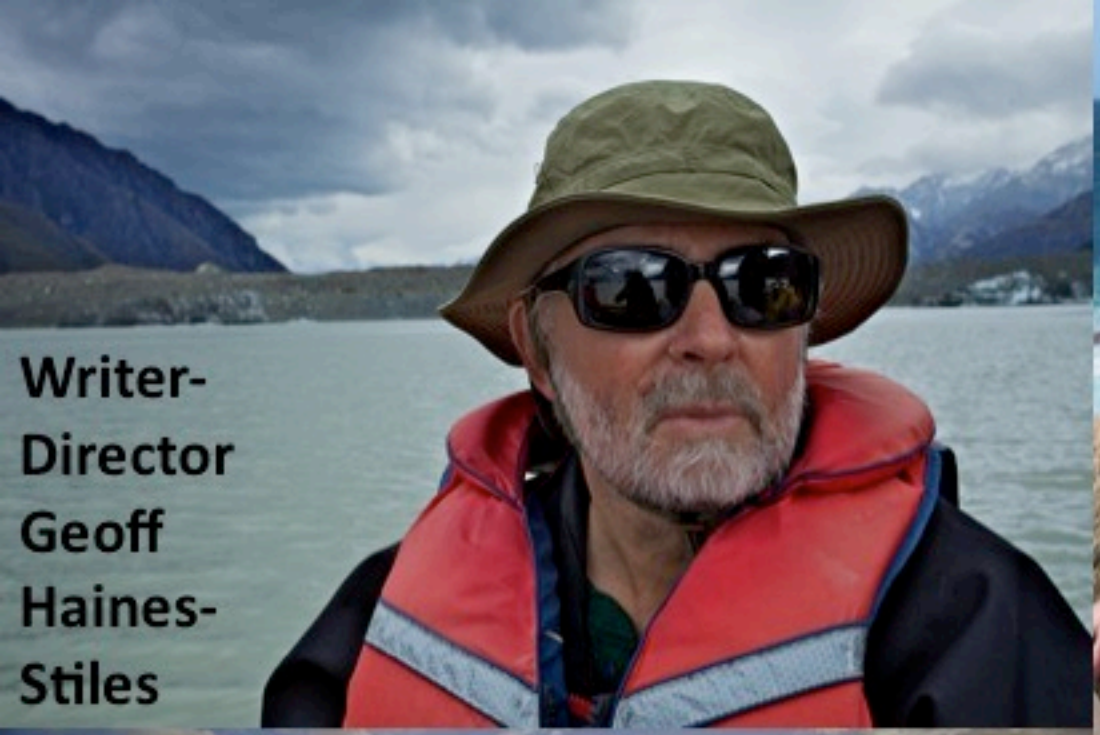


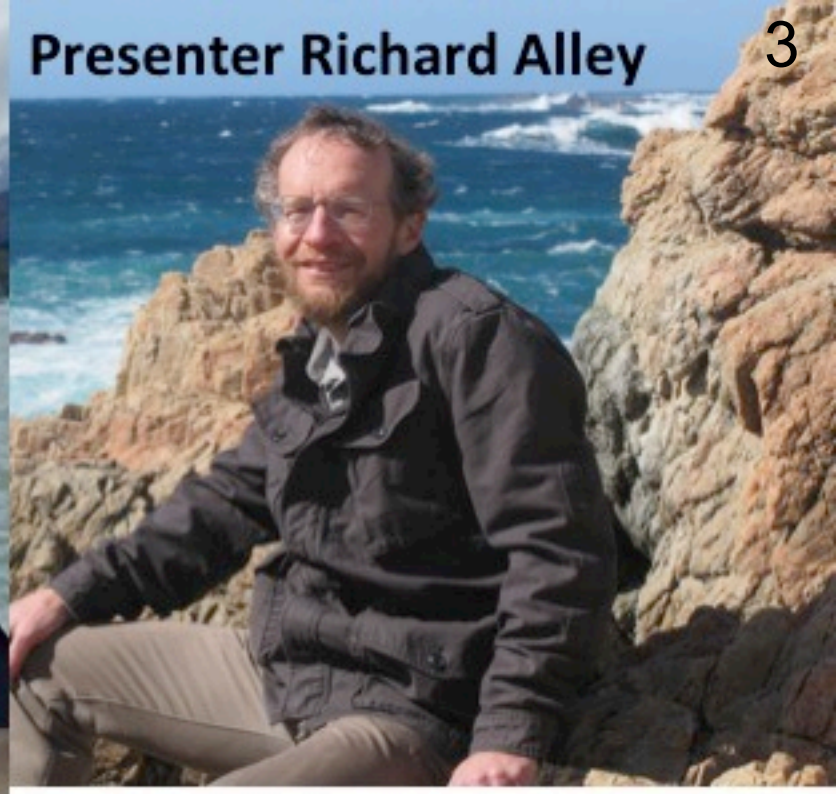
First hour shown nationwide on PBS last spring

Full three-hour version in April
Stay tuned…



NSF Funded, TV, web, museum tour, book
**Accessible, apolitical, authoritative, and a lot of fun
**Streaming at www.earththeoperatorsmanual.com and PBS
Geoff Haines-Stiles & Erna Akuginow, Passport to Knowledge





From the Tasman Glacier, to Morocco, to Big Sur, to show the opportunities in energy and climate.

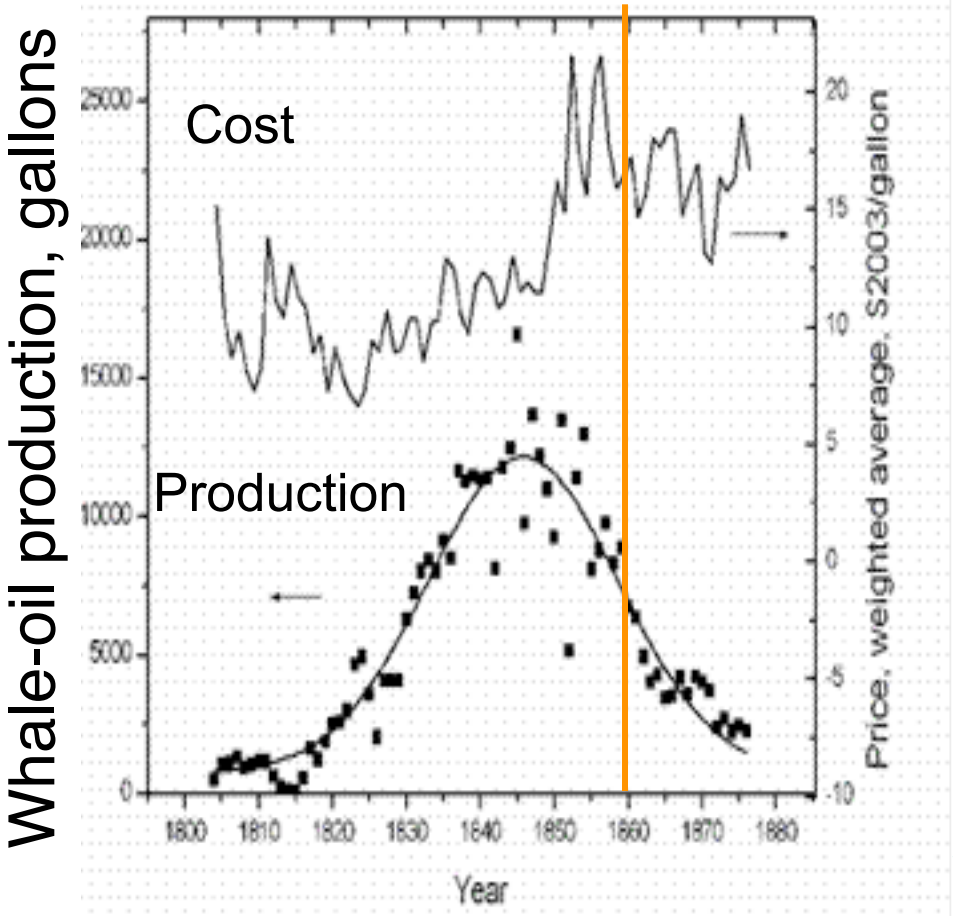
NSF

earth
THE OPERATORS' MANUAL

We get much good from energy use, but tend to use so much we cause problems as we run out, and suffer damaging price shocks before finding new sources

"GRAND BALL GIVEN BY THE WHALES IN HONOR OF THE DISCOVERY OF THE OIL WELLS IN PENNSYLVANIA", VANITY FAIR, 1861

Drake Well, 1859



"…suggests that central banks cannot fully insulate their economies from the consequences of oil-price shocks…" S Leduc, K Sill, 2004, J. Monetary Econ. 51, 781

Prices & Production over a complete Hubbert Cycle.. 2004, Ugo Bardi, http://www.aspoitalia.net/aspoenglish/documents/bardi/whaleoil/whaleoil.html Data from A. Starbuck, History of the American whale fis Seacaucus, N.J. 1878

We're heading toward repeating history…

~85% of energy use is from fossil fuels

We're using them ~1 million times faster than nature saved them for us

Published estimates I've found: entire frackable gas reserve <5 to ≈25 years of total US energy use (gas ~1/4 of use now)

Big energy-system change in <30 years very difficult…gas has much energy, many $$, NOT sustainable.

High scientific confidence:

If we burn, then learn, we will have changed climate in ways that make our grandchildren's lives much harder

And risked really big price shocks

If we learn while we burn, we can sustainably have a better economy with more jobs and greater national security

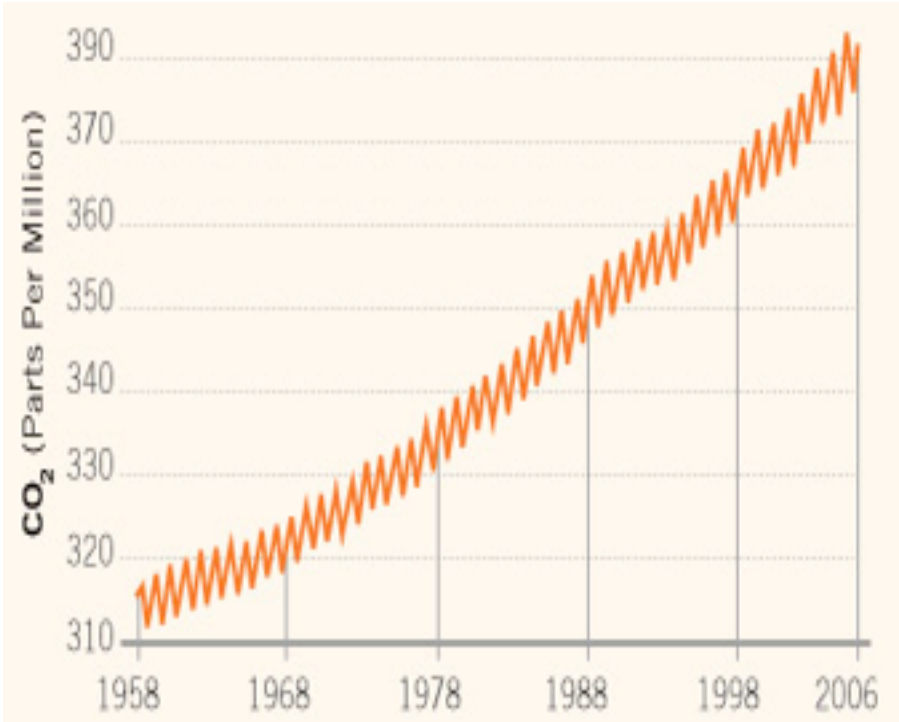
Barriers are not in science or engineering (the wisdom of Pogo comes to mind…)

CO_2 is rising, fossil fuels main cause:
→Bookkeeping (we see CO_2 we emit in air and moving into ocean)
→No other source big enough (volcanoes 1-2% of human source)
→Fingerprints—dropping oxygen, ^{13}C and ^{14}C show CO_2 from burning of something that was alive but has been dead a long time—fossil fuels.

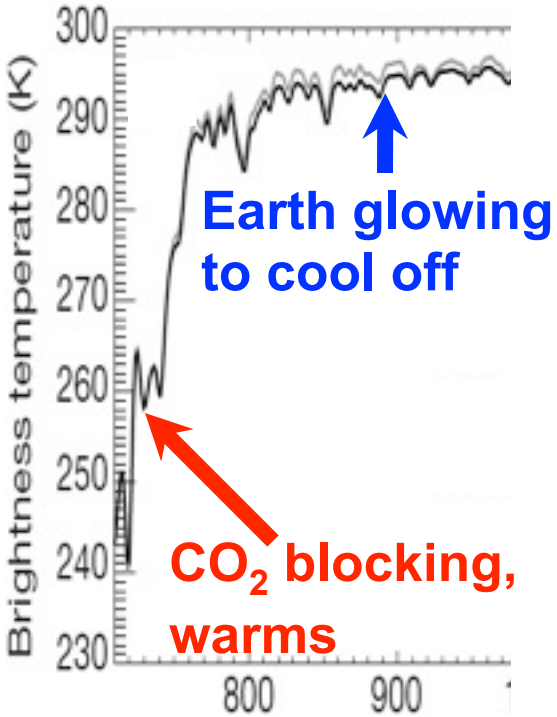
If CO_2 came out of tailpipes as horse ploppies:

→ 1 pound/mile for a typical car
→ Would cover every road in US an inch deep in 1 year

(See "It's us" in first hour of ETOM)



http://www.npr.org/templates/story/story.php?storyId=9885767



"Color" in infrared (wavenumber cm^{-1})

Harries et al., 2001, Nature

Basis for expecting global warming:

→Is PHYSICS

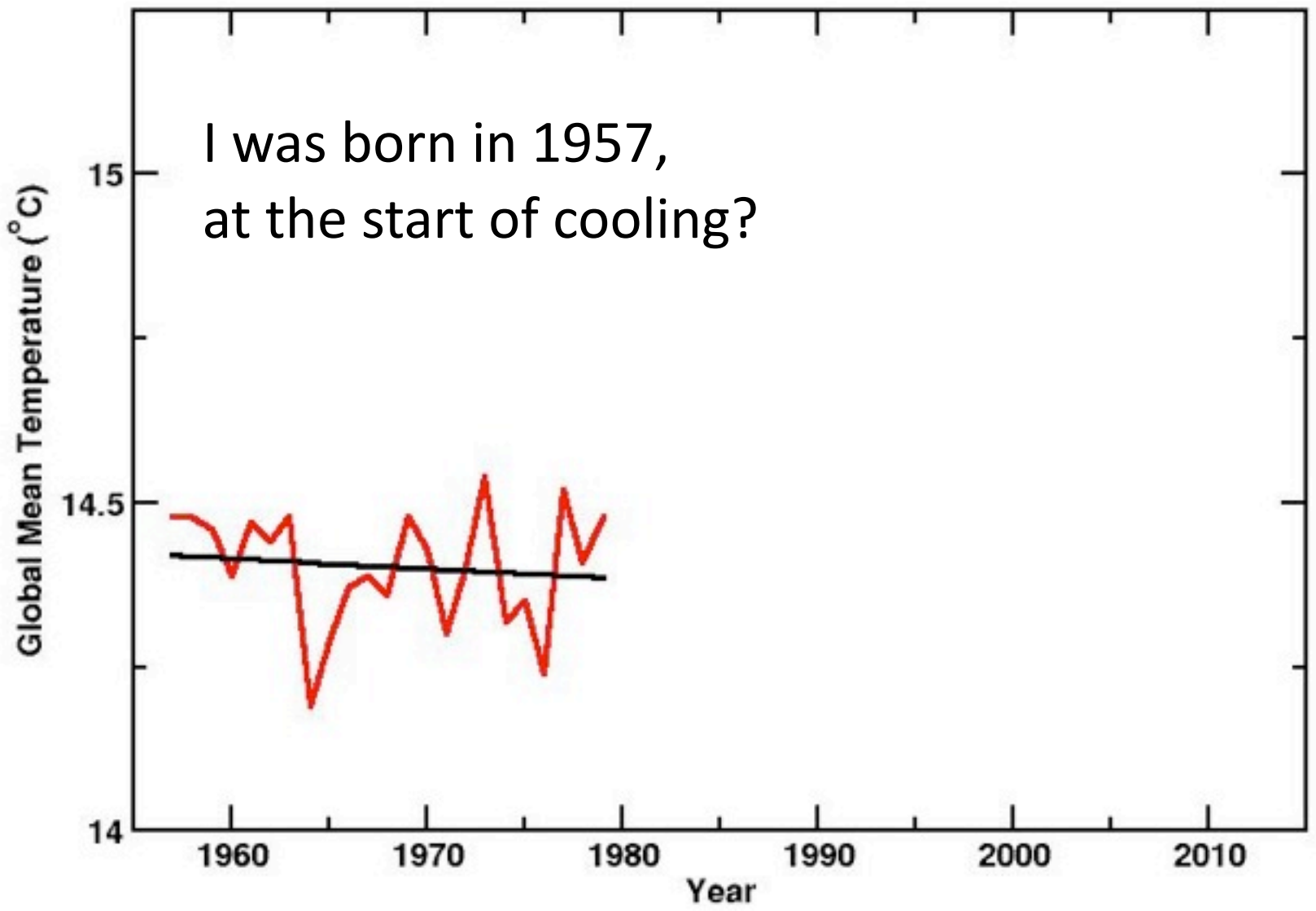
**Known for over a century

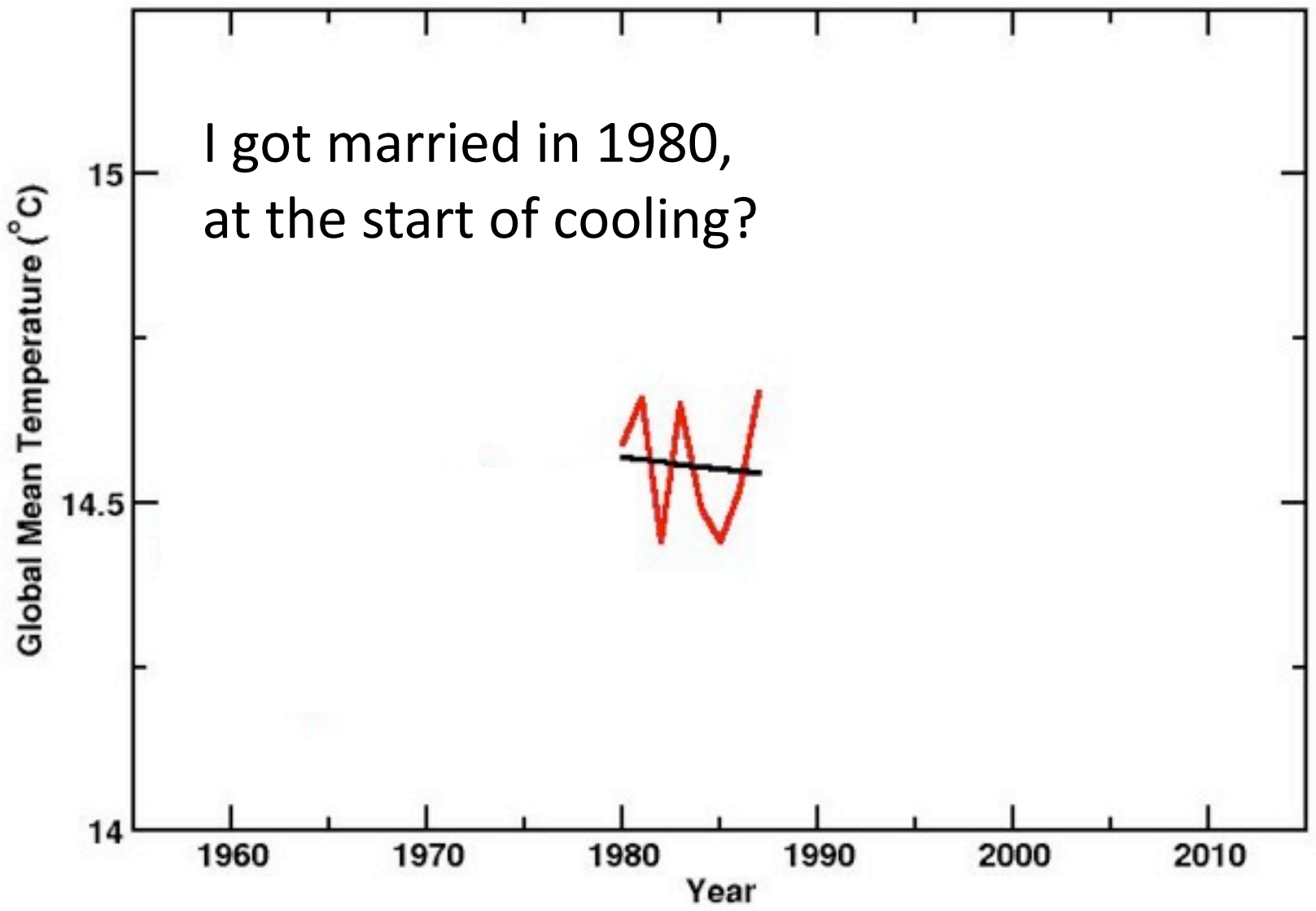
**Refined by Air Force after WWII (operations, communications, and heat-seeking missiles)

**Confirmed by history

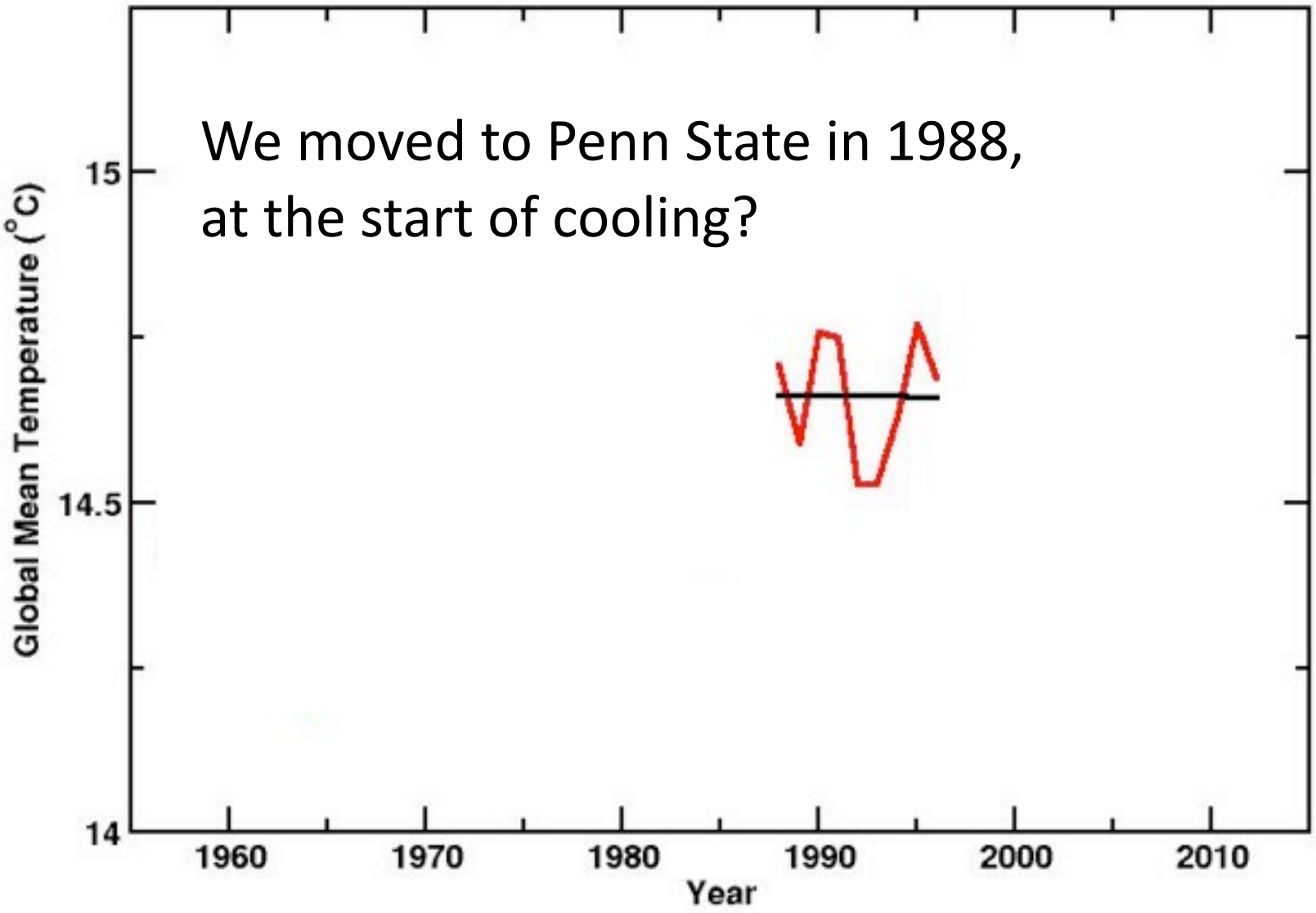
**Observed today (satellites, etc.)

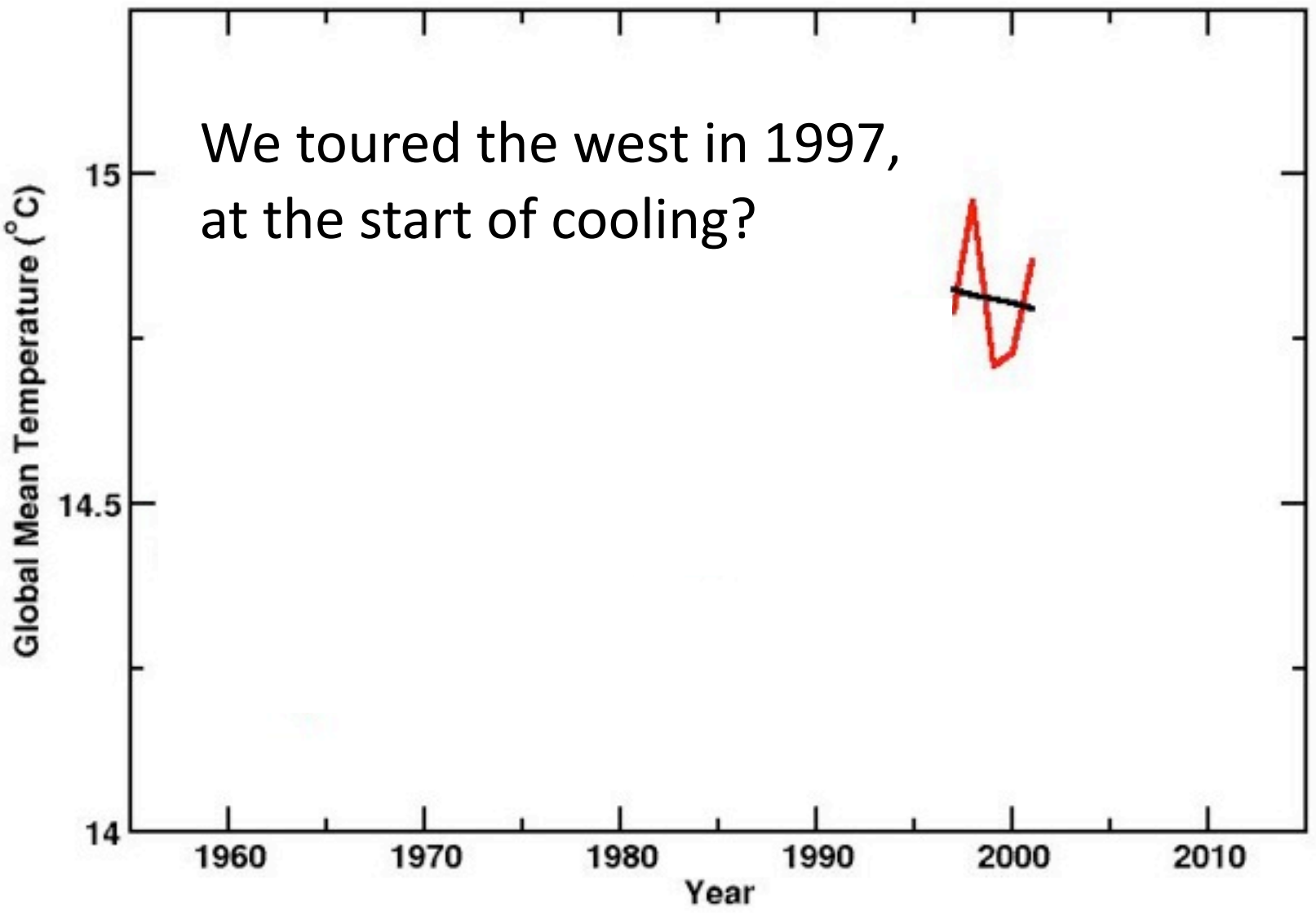
So is it warming?

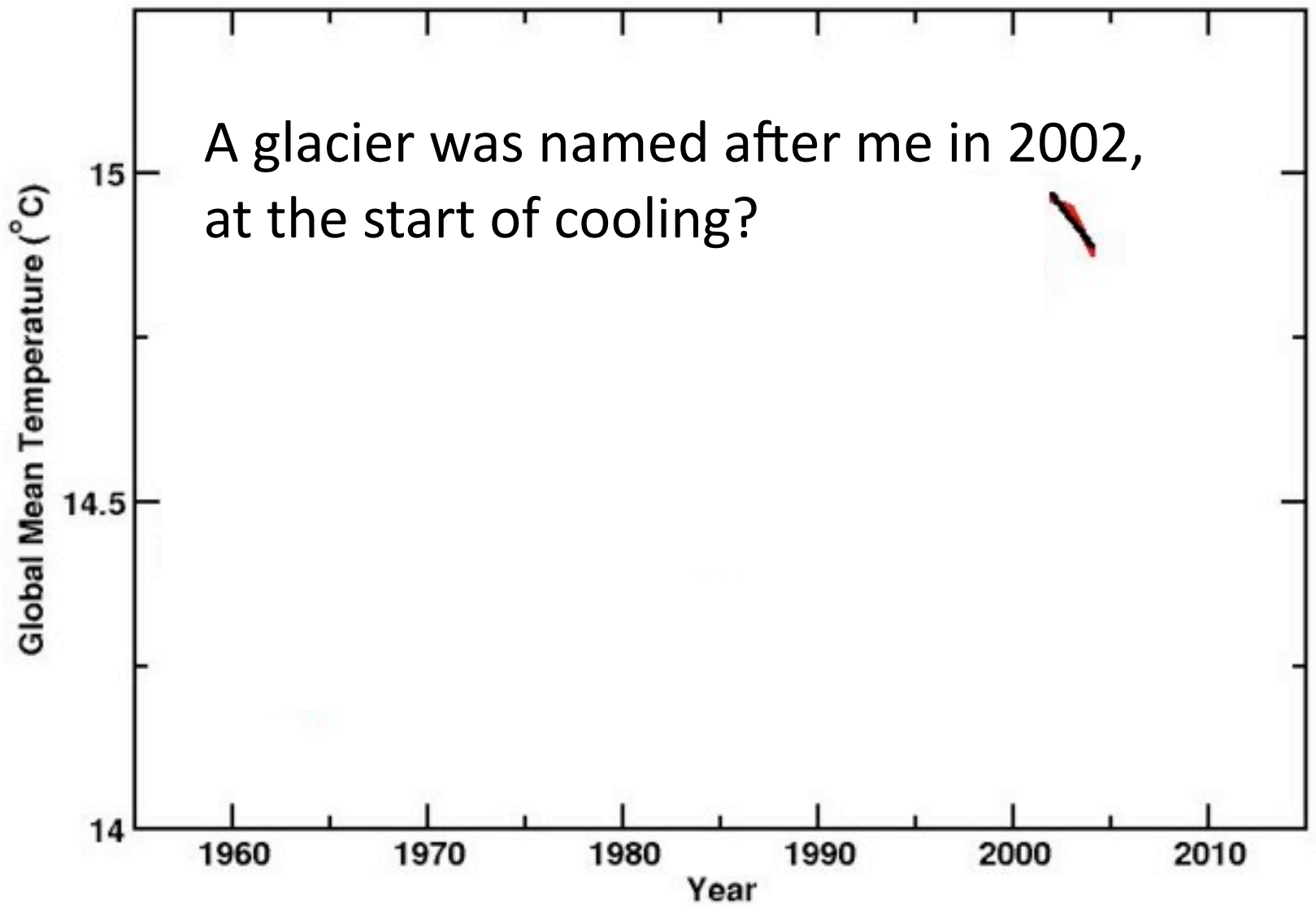


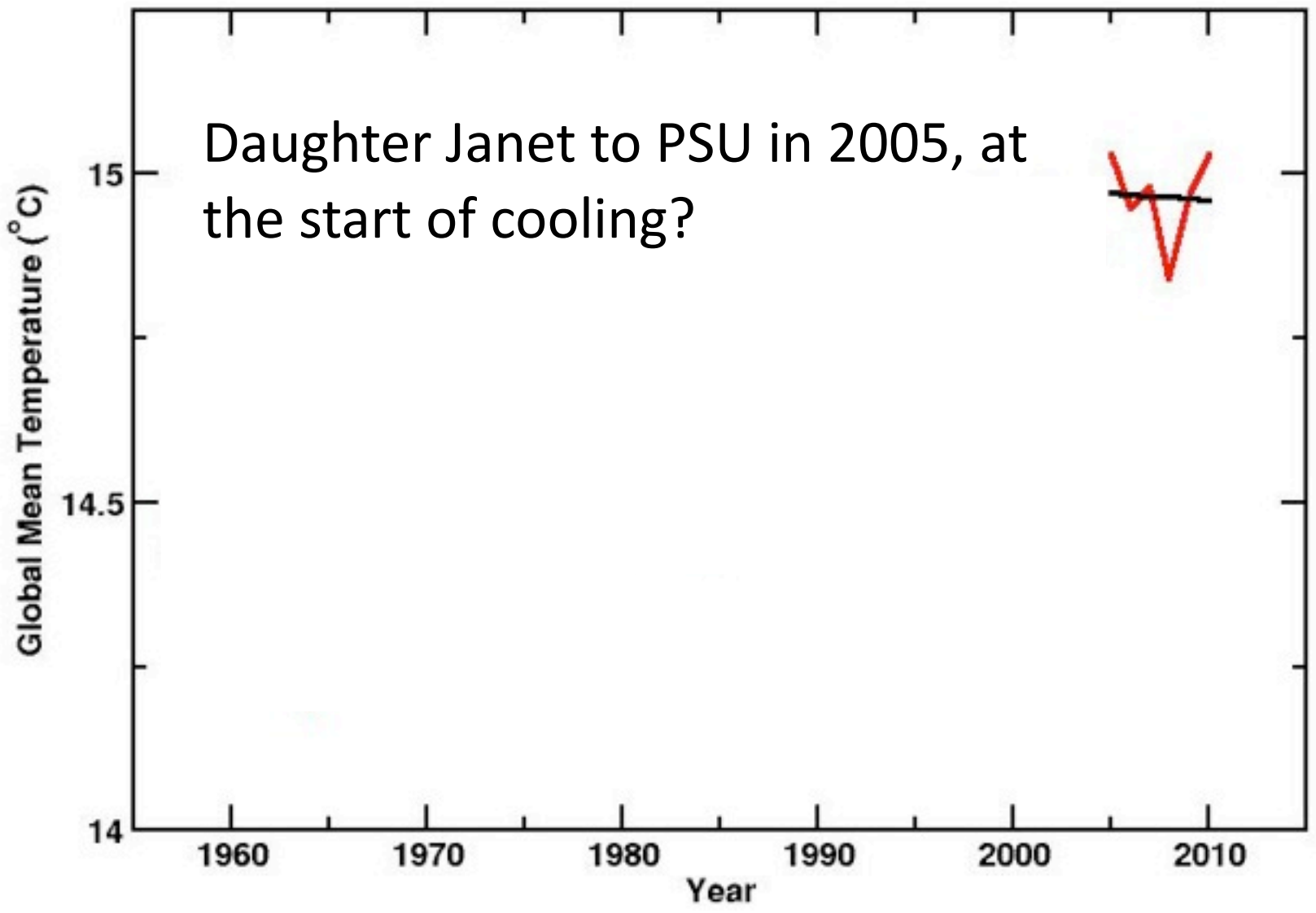

I got married in 1980,
at the start of cooling?
Global Mean Temperature (°C)
15
14.5
14
1960
1970
1980
1990
2000
2010
Year

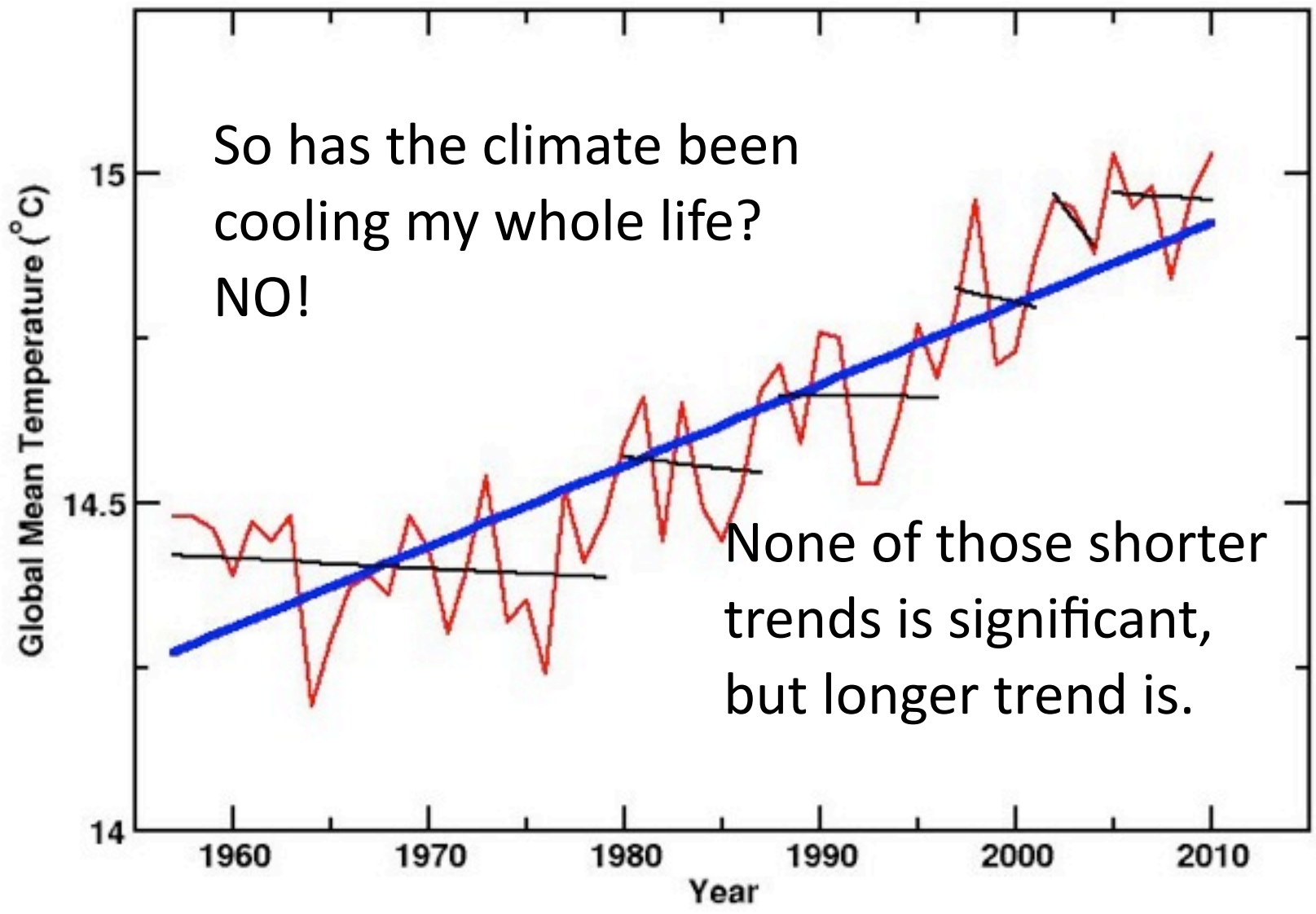
We moved to Penn State in 1988,
at the start of cooling?




We toured the west in 1997,
at the start of cooling?
Global Mean Temperature (°C)
15
14.5
14
1960
1970
1980
1990
2000
2010
Year


A glacier was named after me in 2002,
at the start of cooling?
Global Mean Temperature (°C)
15
14.5
14
1960
1970
1980
1990
2000
2010
Year


Daughter Janet to PSU in 2005, at the start of cooling?
Global Mean Temperature (°C)
15
14.5
14
1960
1970
1980
1990
2000
2010
Year


So has the climate been cooling my whole life?
NO!
None of those shorter trends is significant, but longer trend is.
Global Mean Temperature (°C)
15
14.5
14
1960
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1980
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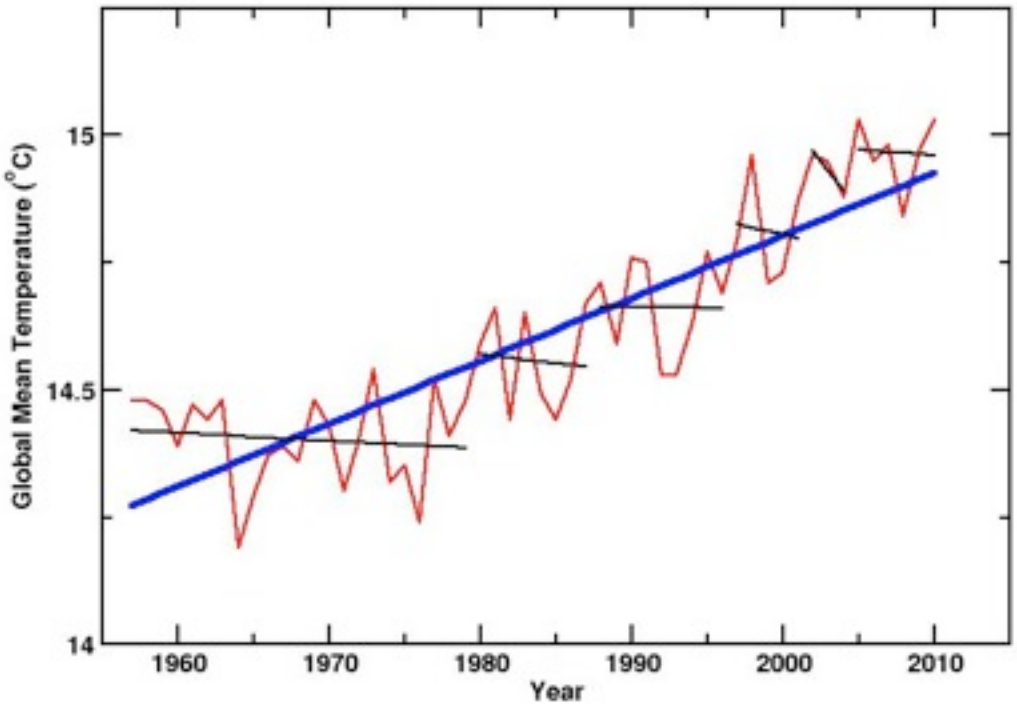
2010
Year

It is getting warmer (e.g., IPCC, 2007):

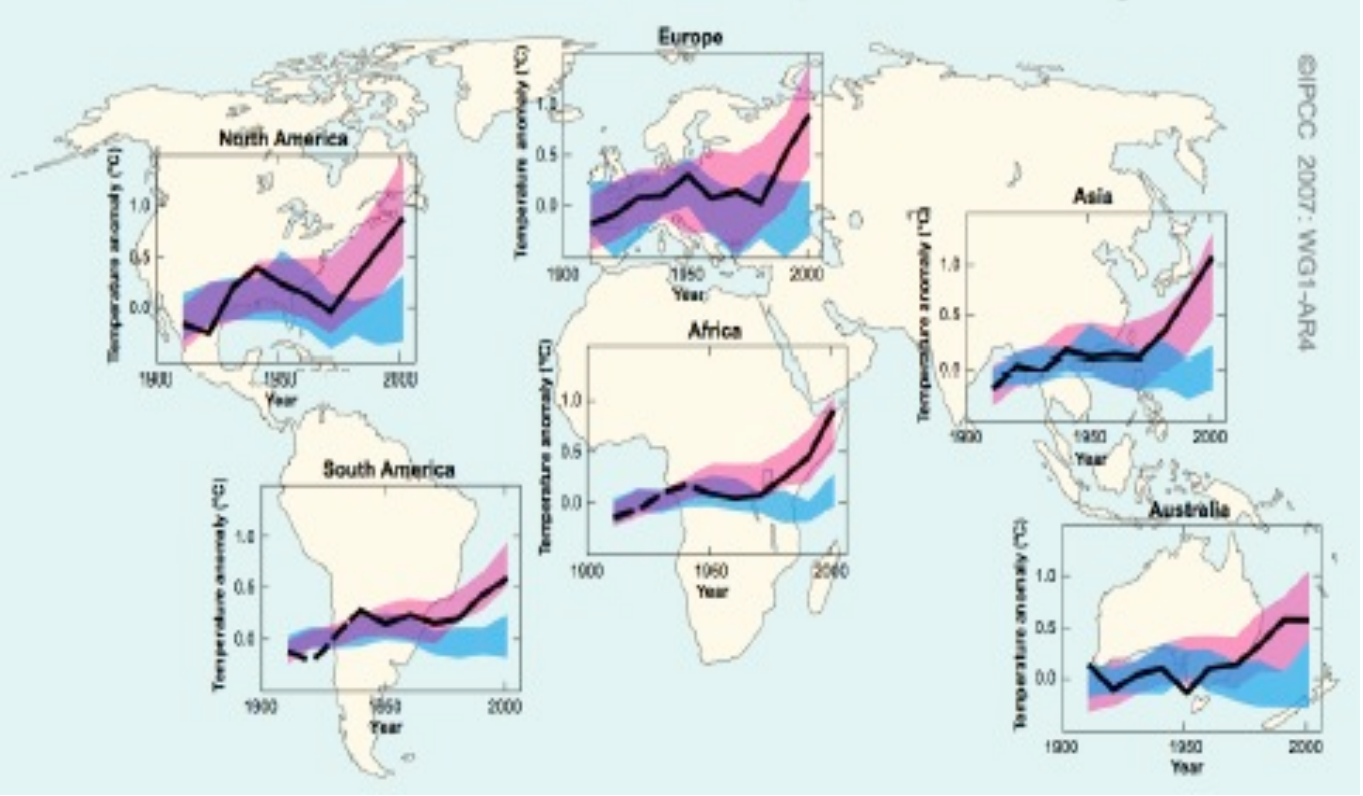
Thermometers (including outside cities, and analyzed by NOAA, and NASA, and British, and Berkeley, and…)

Thermometers in oceans, in ground, on balloons, and on satellites, analyzed in different ways by different groups

Snow and ice (temperature-sensitive times and places)—seasonal snow, lake and river ice, seasonally frozen ground and permafrost, glaciers, etc.—and where creatures live and when they do things



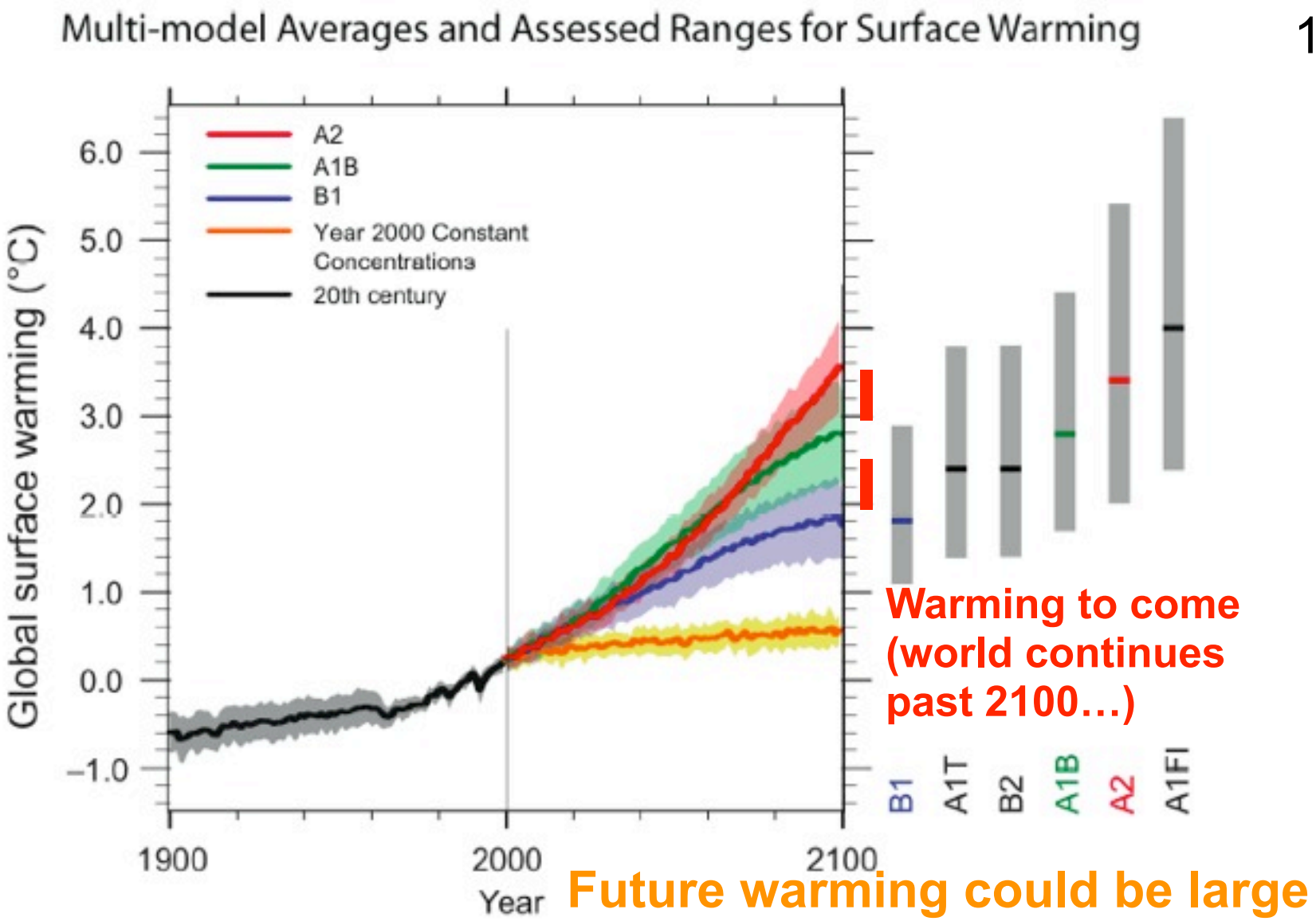
Many people are fooled by short wiggles (the black lines) in the temperature history (GISTEMP, red), but the significant trend is WARMING (blue)—people lose money in Vegas and on Wall Street based on the same confusion!



How much of recent warming is from CO_2 and other greenhouse gases? Most likely answer is: more than all of it. We have cooled with sun-blocking particles, sun has dimmed a bit, yet we see warming…

Blue=Nature Only Pink=Humans+Nature Black=Data

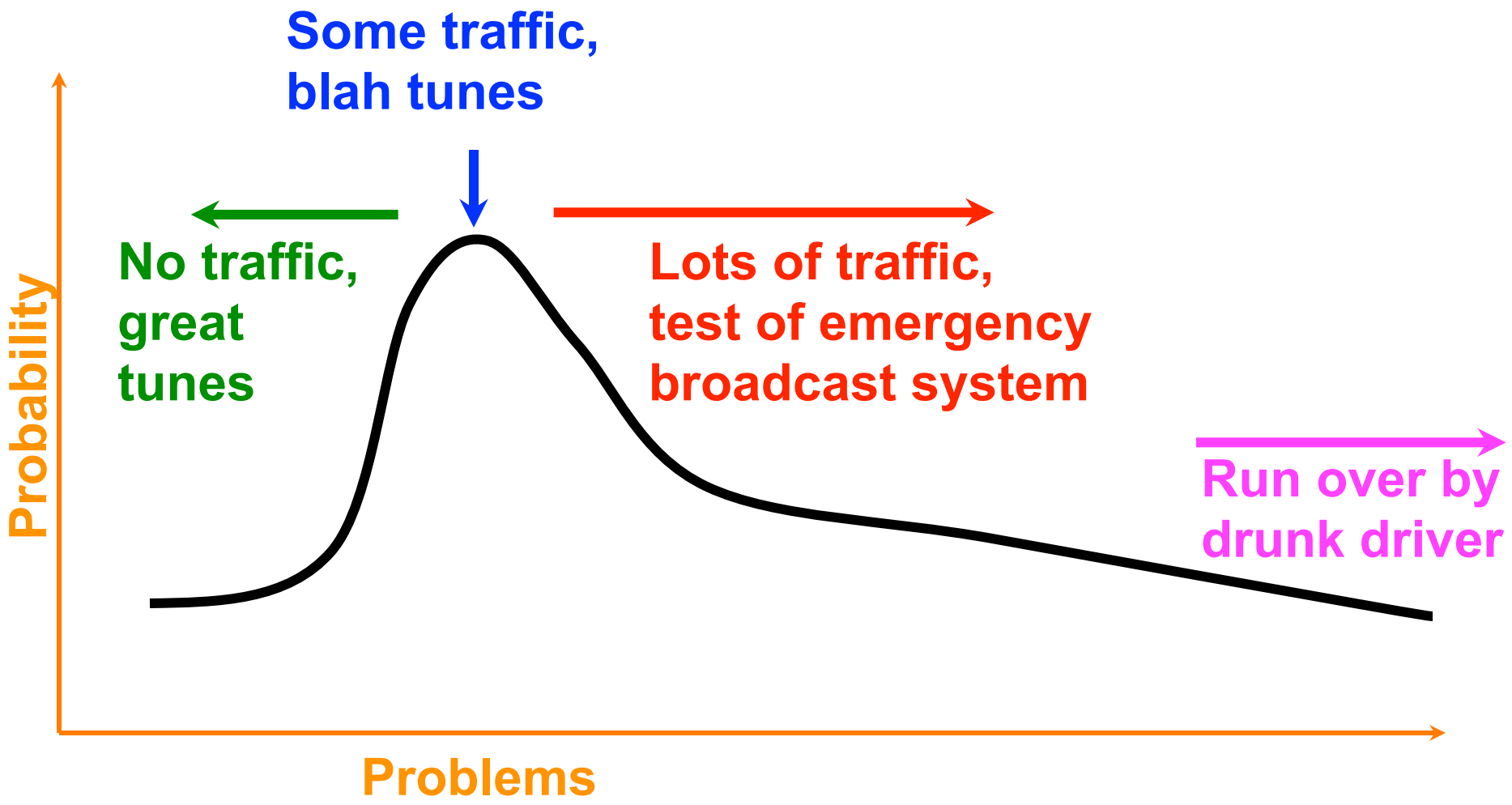
The warming occurring is not explained by nature. Changes are occurring as expected from early climate-science projections, including patterns such as upper-stratospheric cooling with surface warming, and even changes in hydrologic cycle—climate science is successfully predictive as well as explanatory.



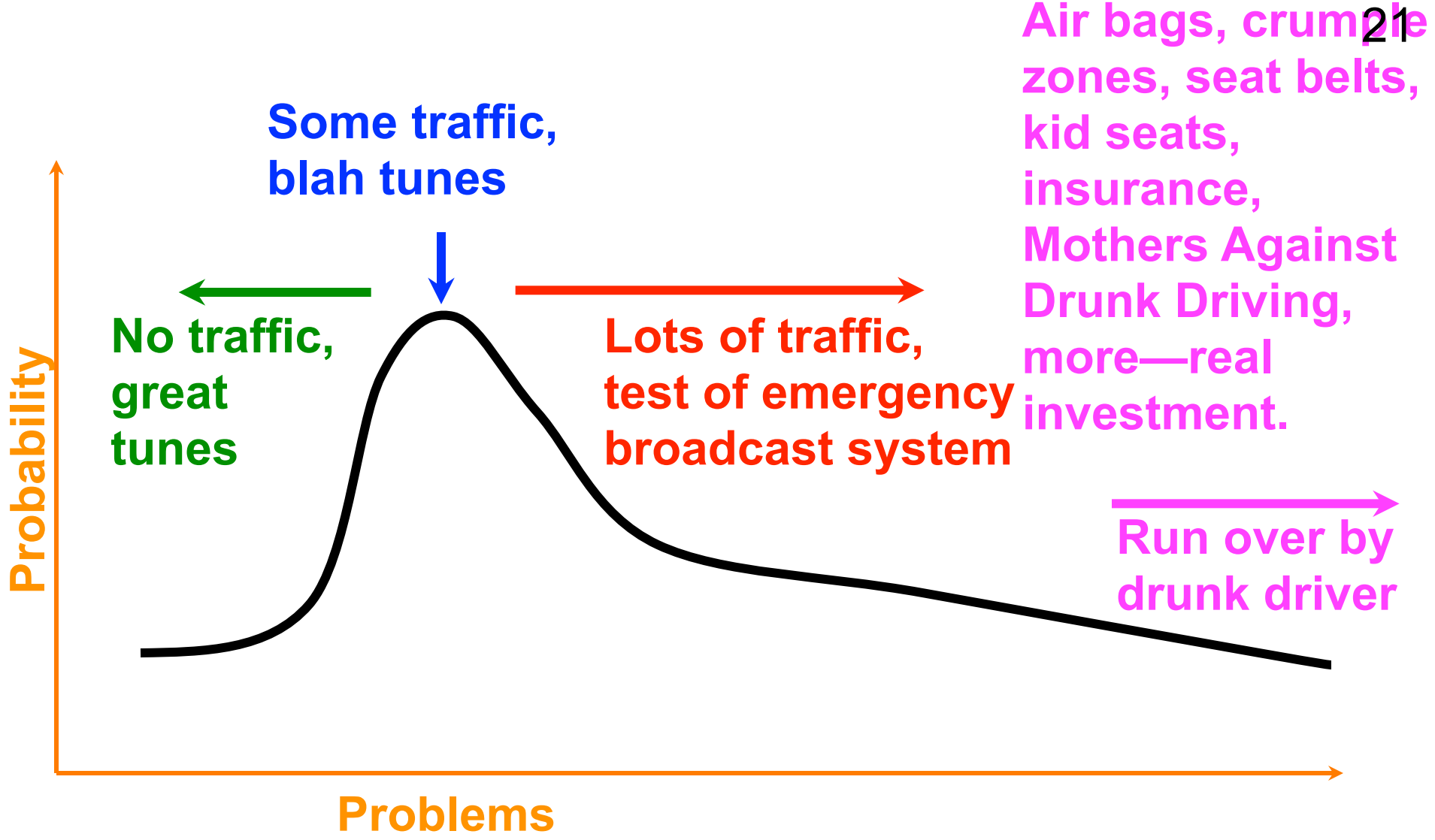
Changes to date confirm our scientific understanding, which shows future changes if we keep burning will be much larger than past changes.

Rear Admiral David Titley, Oceanographer of the Navy and Navigator of the Navy

“. . . climate change, energy security, and economic stability are inextricably linked. Climate change will contribute to food and water scarcity, will increase the spread of disease, and may spur or exacerbate mass migration.” US Pentagon QDR



Suppose you have to drive somewhere. What are you likely to encounter, and what do you plan for?



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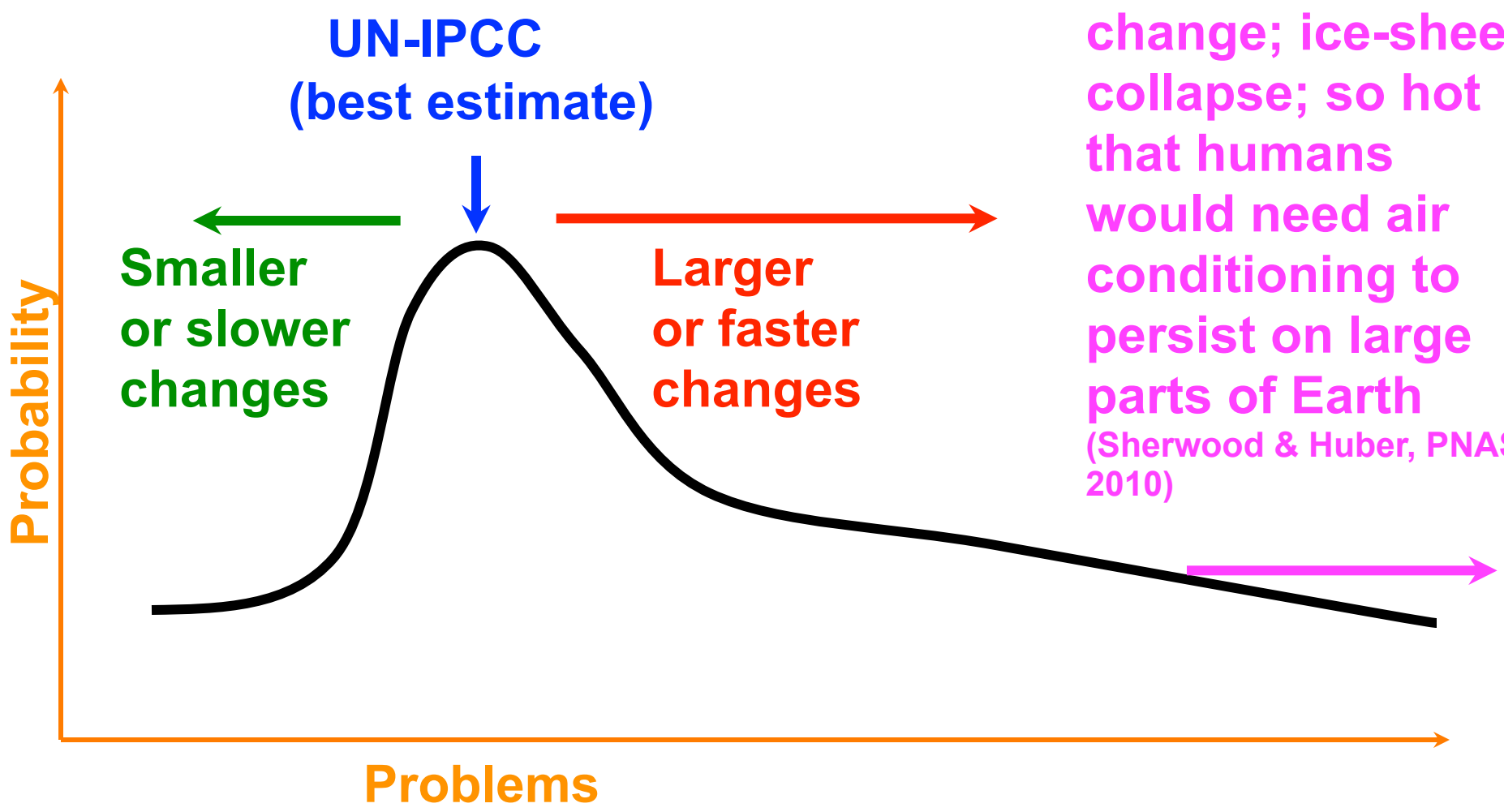
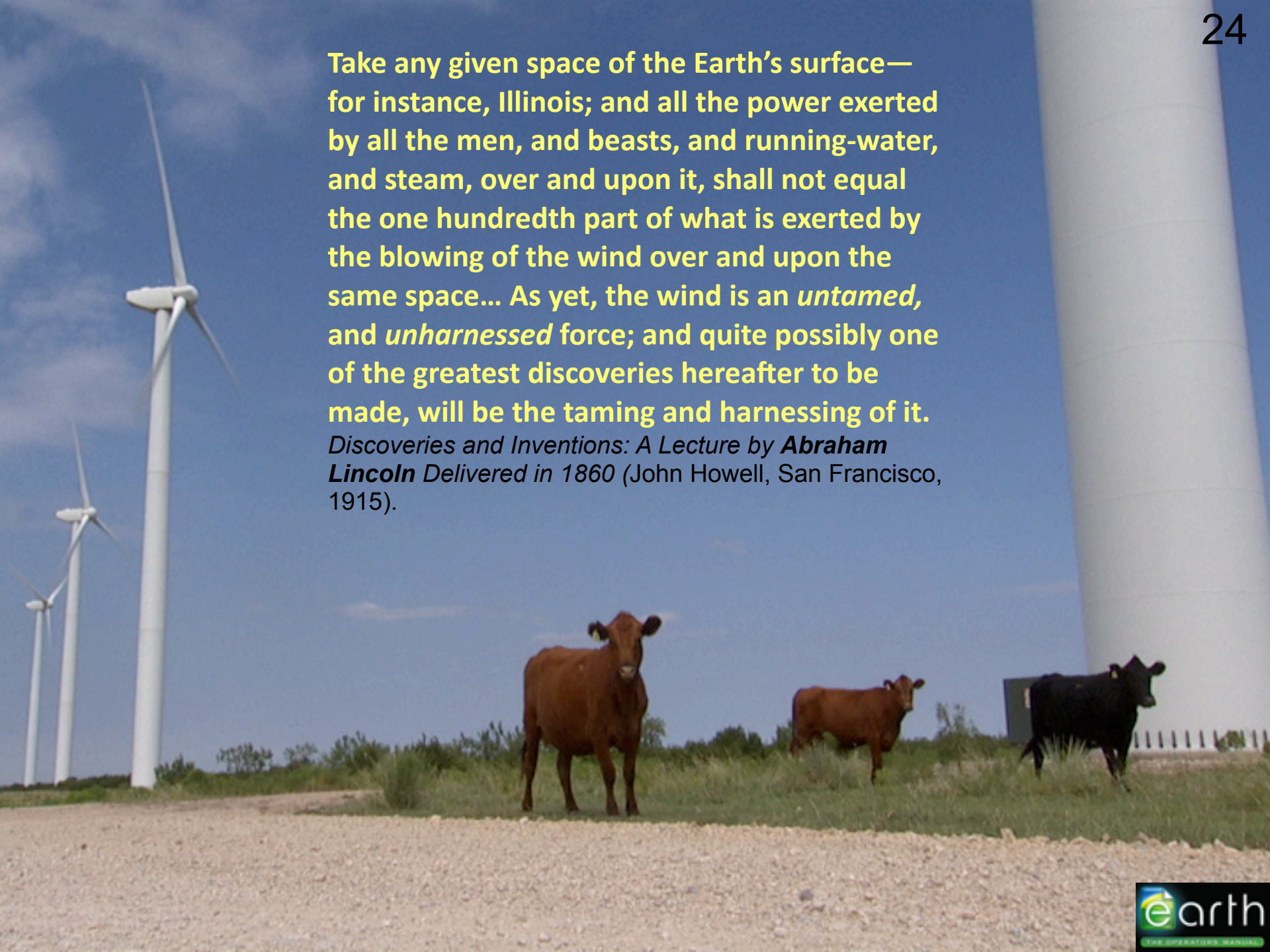


My interpretation of probability of various levels of future problems.

Maximum Available Energy:

- Sun 173,000 TW
- Wind 1220 TW
- Plants 166 TW
- Waves & currents 65 TW
- Geothermal 44 TW
- Human use today 15 TW
- Tides 4 TW
- Hydroelectric 1.9 TW



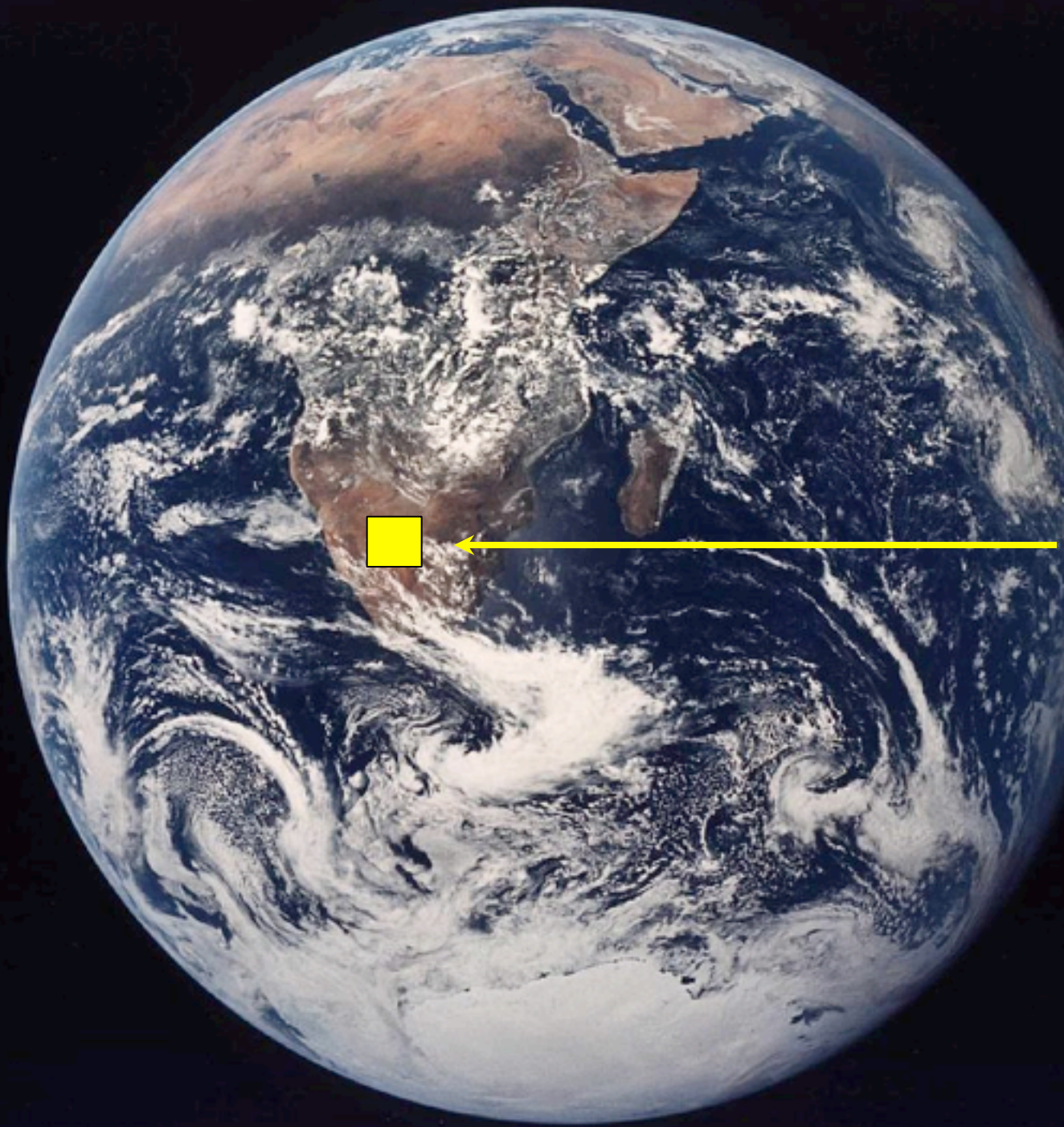
Take any given space of the Earth's surface—for instance, Illinois; and all the power exerted by all the men, and beasts, and running-water, and steam, over and upon it, shall not equal the one hundredth part of what is exerted by the blowing of the wind over and upon the same space… As yet, the wind is an *untamed,* and *unharnessed* force; and quite possibly one of the greatest discoveries hereafter to be made, will be the taming and harnessing of it.
Discoveries and Inventions: A Lecture by ***Abraham Lincoln*** *Delivered in 1860 (*John Howell, San Francisco, 1915).

For Energy :

- Building a wind farm on windy parts of deserts and plains would generate ~5x more energy than world use (On land that is not city, forest or ice, with enough wind to run at >20% capacity; Lu, McElroy and Kiviluoma, 2009, Global potential for wind-generated electricity, Proceedings of the National Academy of Sciences of the USA 106, 10,933-10,938)
- Some issues with batteries if a lot of wind is used, but wind is generally competitive now

The US rate of windmill installation a century ago, if repeated today with modern wind turbines, would supply 1/3 of WORLD energy use from wind in 30 years.

Photo by Geoffrey Haines-Stiles for Earth: The Operators' Manual, Texas



Global human energy use could be supplied by covering approximately this area of a tropical desert with solar cells converting 10% of sunlight to electricity.

Cinematographer Art Howard films basic physics of concentrated solar thermal power—it worked a century ago. And 0.01% of sun's energy would power humanity.

We aim to show how much good really is available…

here relating human-tapped to natural geothermal power in New Zealand.

From waves, currents, tides and ocean thermal energy…

to cellulosic ethanol and other biofuels, including accounting for the tradeoffs (here with Jim McMillan, National Renewable Energy Lab).

Economics consistently gives same answer:

If you believe in traditional economics, with traditional discount rate, and an economy that can grow a few percent per year forever

Then you still respond to climate change

Not with panic, but over 30 years or so (Nordhaus, etc.)

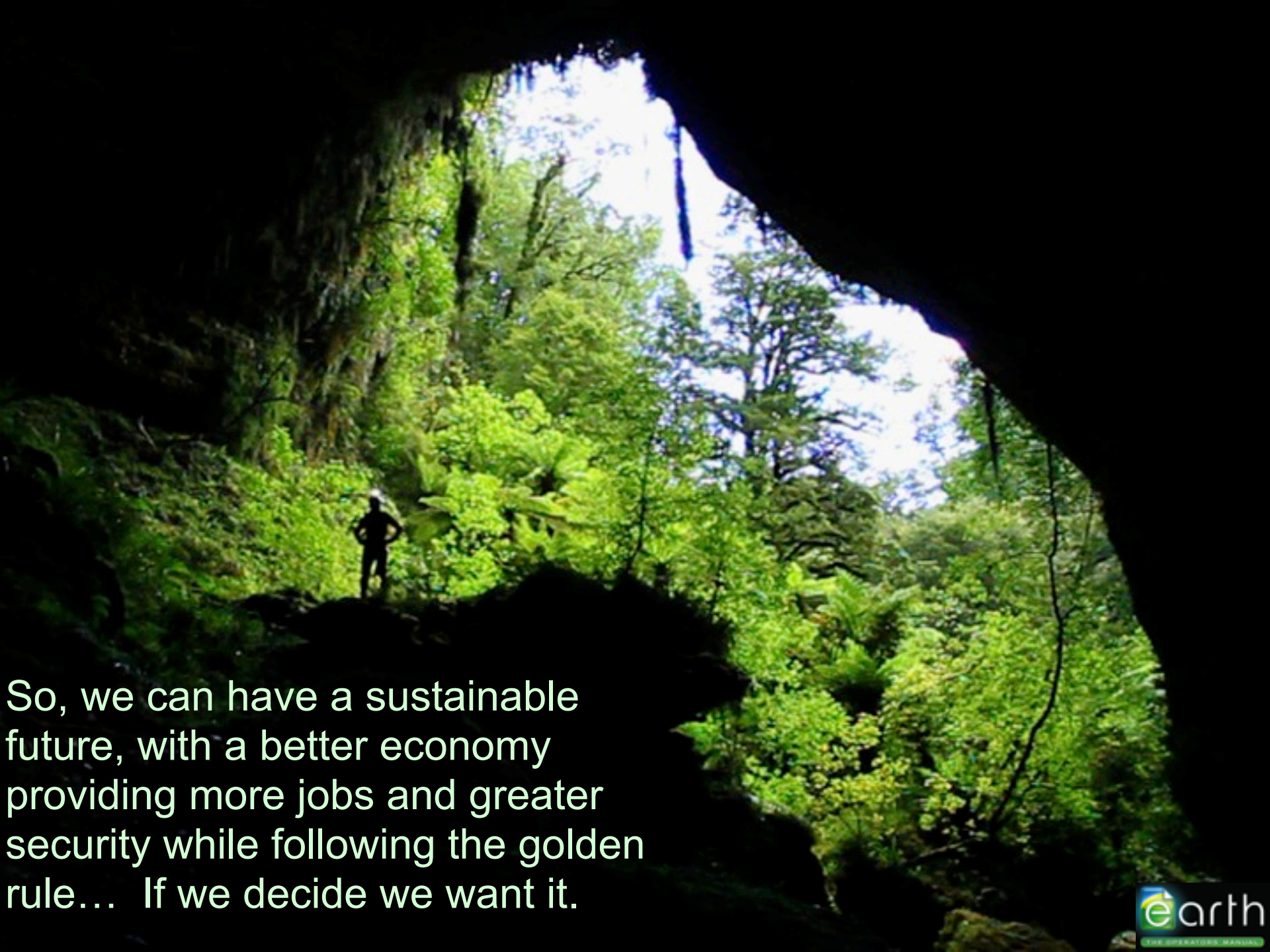
This is really important, I believe—hard-nosed economics says respond!

If you care about national security, the Pentagon says that you respond to this

How about jobs? Work ongoing, but papers I found indicate response gives more jobs, or at least similar numbers. (Paying "rent" to people whose ancestors settled atop fossil fuels may not be job-optimal.)

Golden rule: losers are especially poor people in hot places, and future people, who are not causing the changes

Failure to respond is unsustainable; response can be sustainable!


So, we can have a sustainable future, with a better economy providing more jobs and greater security while following the golden rule… If we decide we want it.
earth