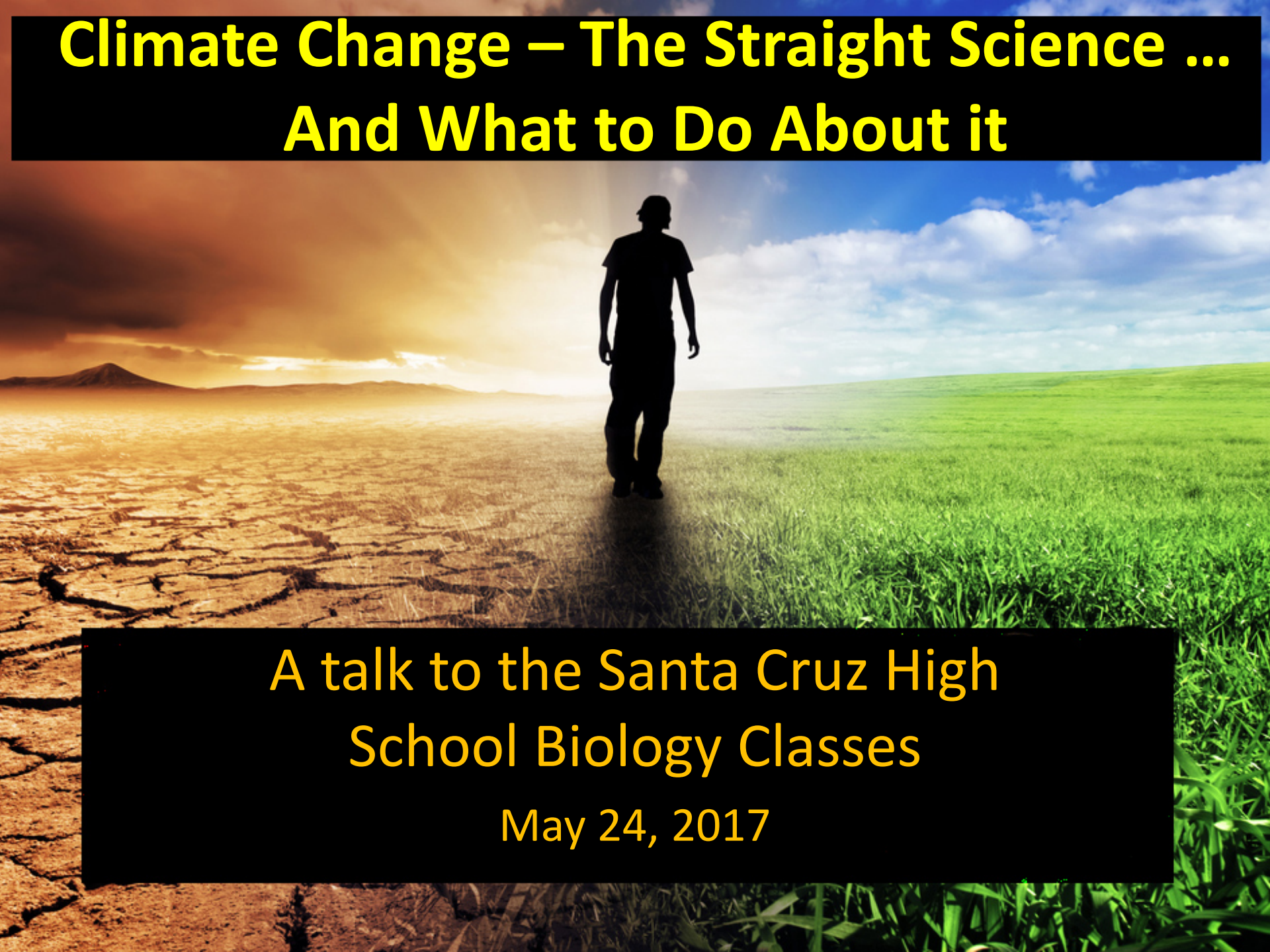
Climate Change – The Straight Science … And What to Do About it



A talk to the Santa Cruz High School Biology Classes

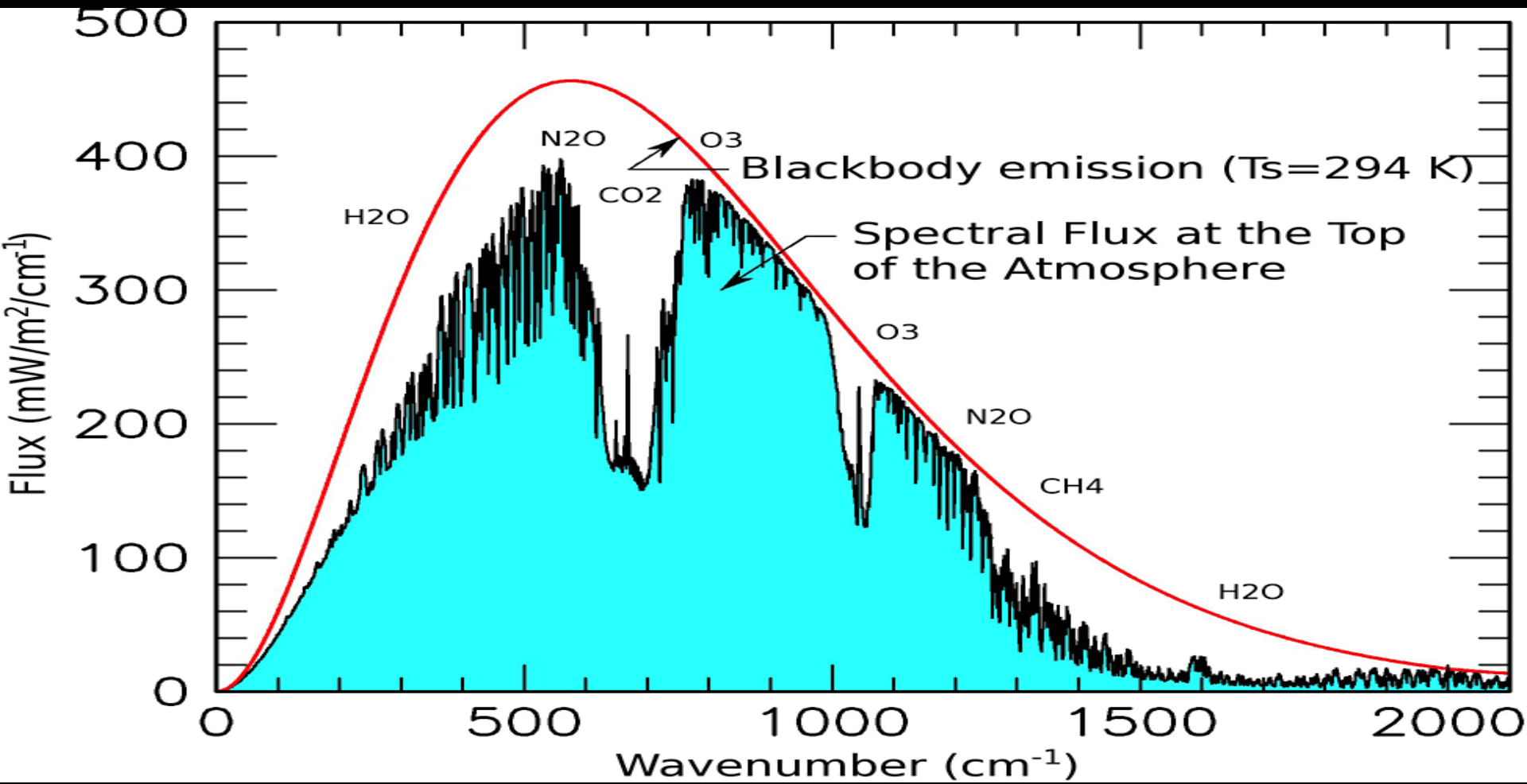
May 24, 2017

Rick Nolthenius – Chair of the Astronomy Department at Cabrillo College

- M.S. Aerospace from U. Arizona
- PhD Astronomy and Astrophysics from UCLA
- Thermal analyst and designer in the Atlas/Centaur Rocket Program at General Dynamics – Convair Space Division

For the past 7 years, my prime focus has been investigating and teaching planetary climate, and especially current Earth Climate Change

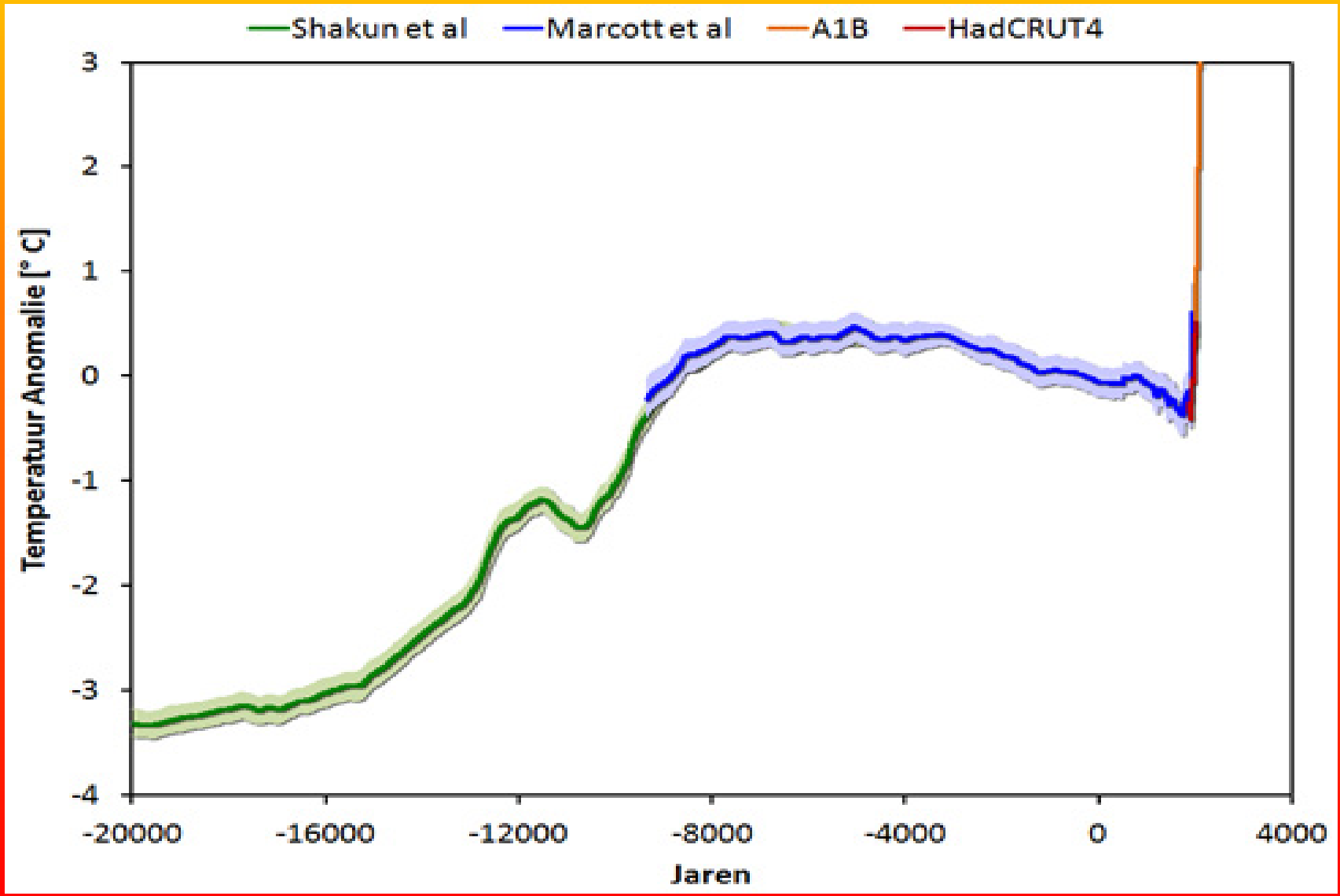
The Greenhouse Effect: Sunlight comes in at short wavelengths. The warmed Earth tries to radiate back to space to reach an equilibrium temperature, but rising GHG's increasingly absorb those long wavelengths. Just like adding insulation to your walls will allow your home to warm inside until the outer walls are in equilibrium with the outdoors, so too the Earth's surface is forced to be warmer before we can radiate away as much heat as we still get from the sun. CO2 is a tough little molecule – It's the Prime Driver of Climate Throughout Geologic History



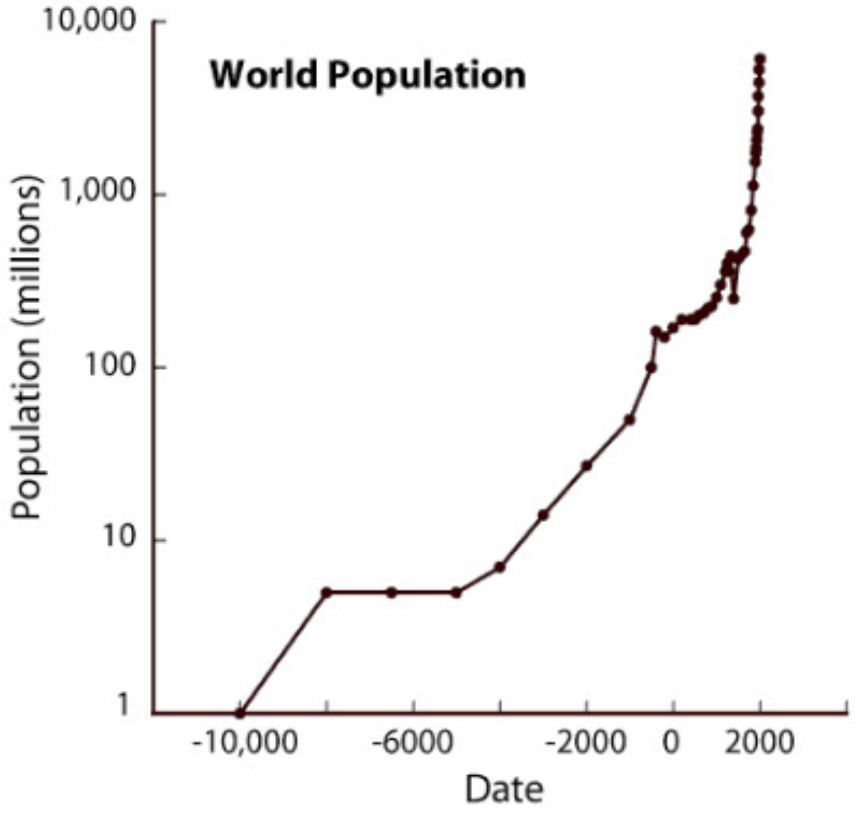
Climate is a SYSTEMIC Problem: Not a Geophysics problem, not a Technology problem, not a Policy problem, not an Economics problem, not a Behavior problem

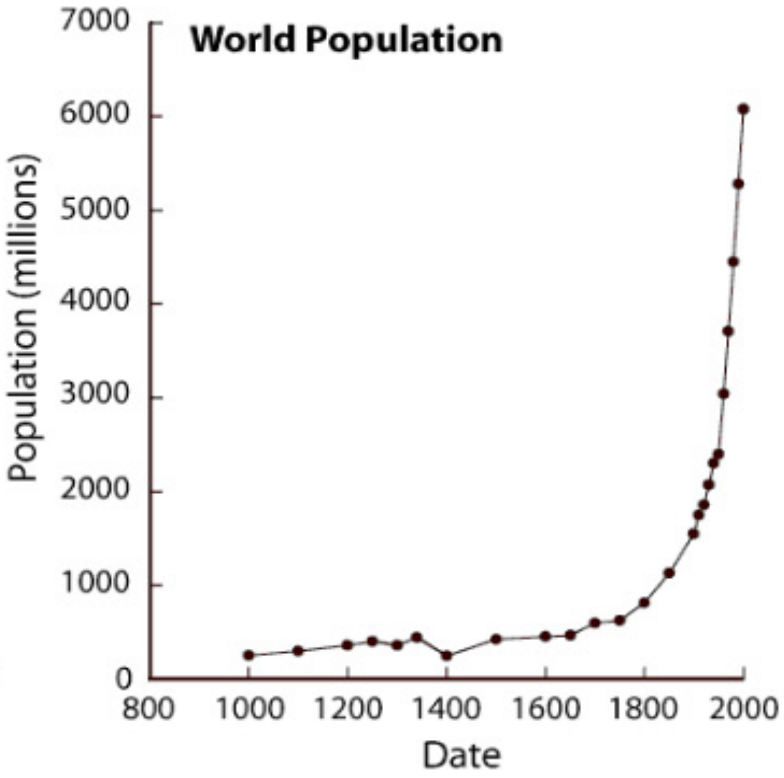
- **It's ALL, it's EVERYTHING**
- **I can't over-emphasize how important Climate is!**
- **Rapid Climate Change - It is THE disaster which has generated all 5 of Earth's Great Extinctions, and the 6th which we have begun now**
- **All of Human Civilization was made possible by the 10,000 years of stability we enjoyed – up until the beginning of your lives now - after emerging from the last Great Ice Age**
- **It is THE issue which determines the livability of planets in our universe – THE STABILITY of their Global CLIMATE**

But Earth's Climate Stability is Ending, Thanks to Us



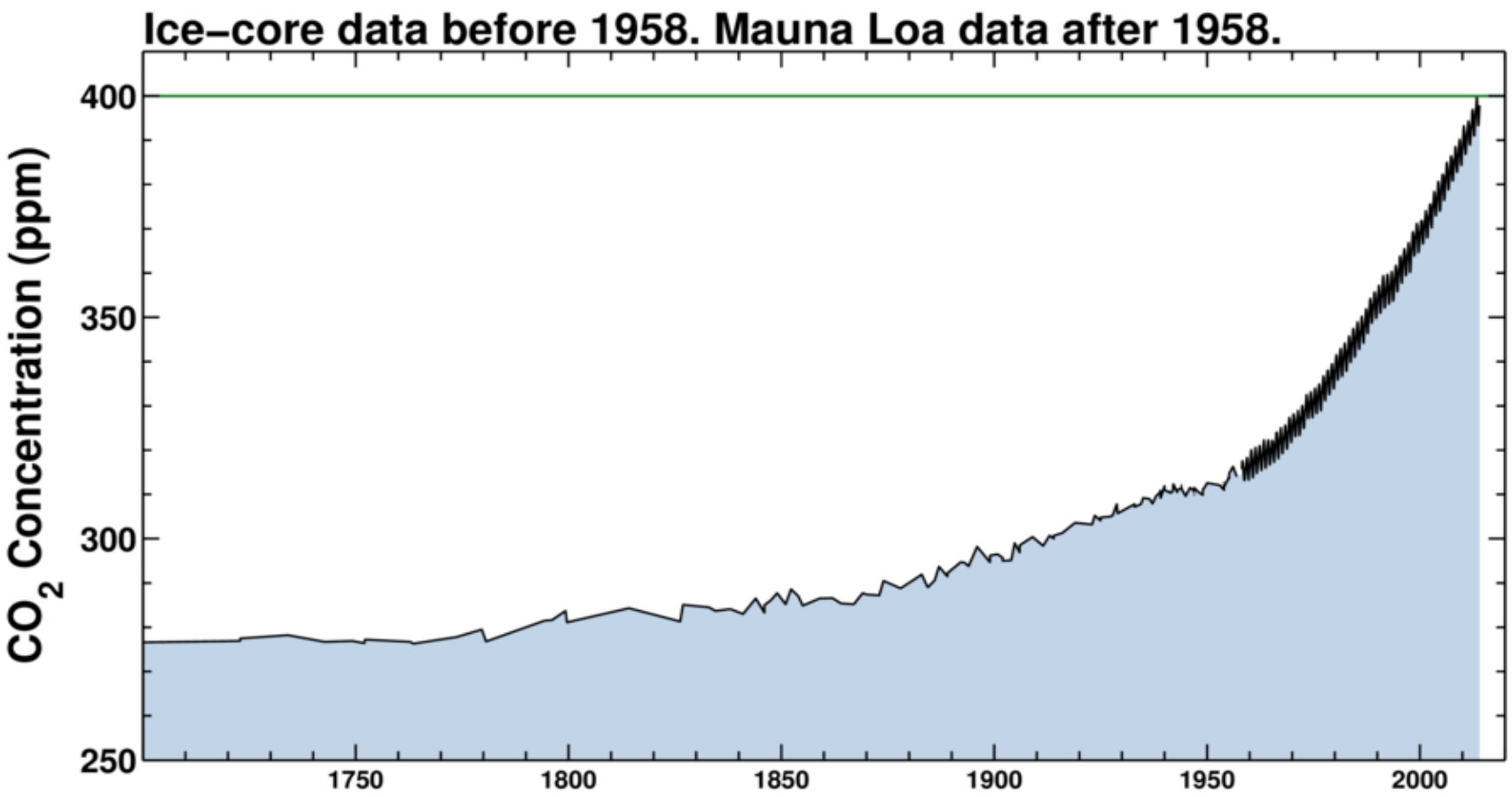
The Discovery of Tens of Millions of Years (Carboniferous Era) Worth of Fossilized Solar Energy Permitted Explosive Population Rise… in just 150 yrs.





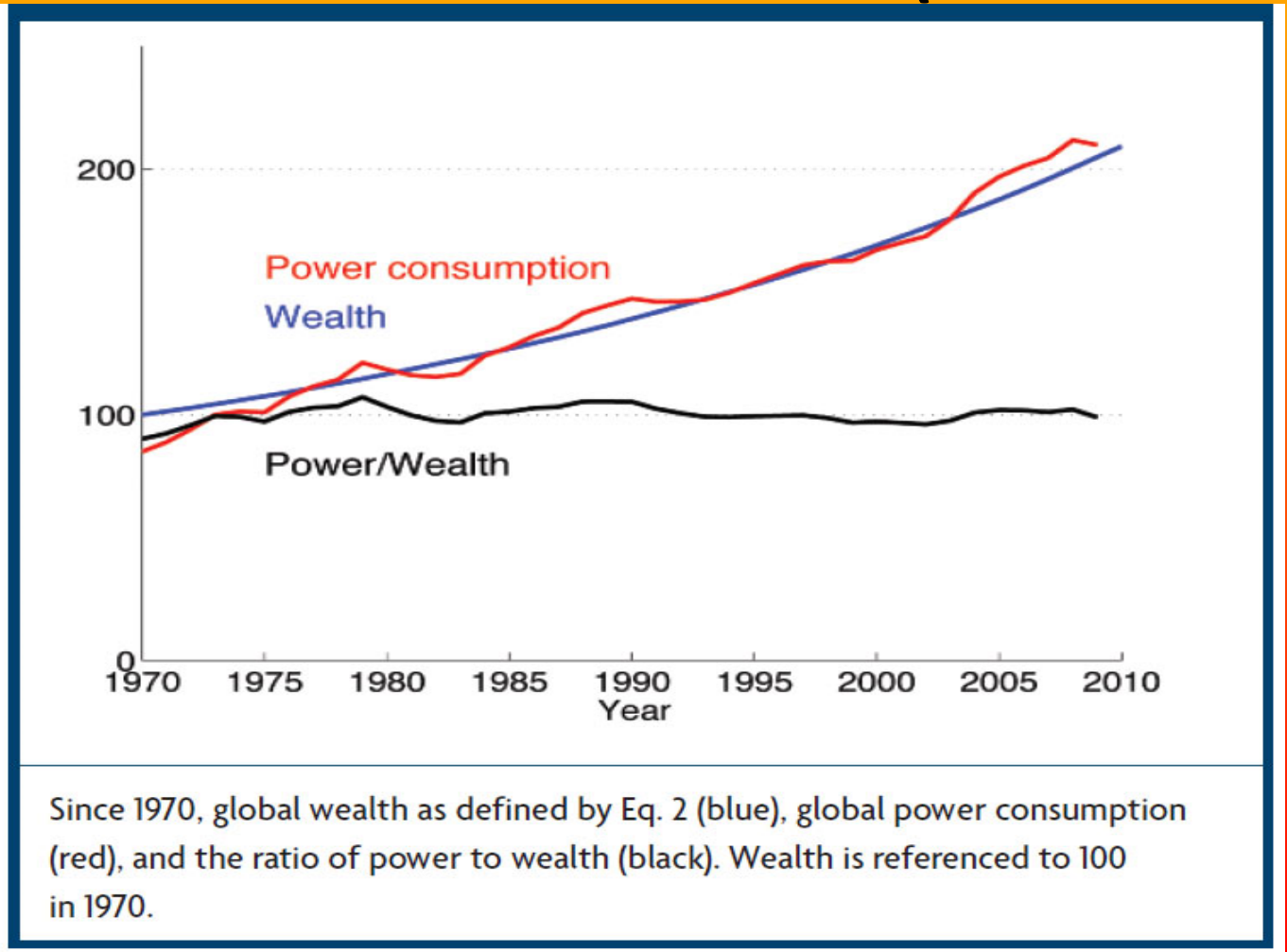
World Population: Left: *Since prehistoric times (log scale),* **Right:** *Since 800 AD (linear scale). Drawn using data from US Census Bureau, Historical Estimates of World Population, and World Population 1950–2050. The recent, rapid increase of population led to the anthropocene. Note that the population is now increasing at the rate of one billion people every 13 years.*

Atmospheric CO2 is 46% higher than pre-industrial levels – driven by human industrial emissions. Now at 410 ppm and continuing to accelerate upward, despite growing solar and wind alternative energy……. Why?



The Garrett Relation

***The current rate of consumption of global energy is directly proportional to the total inflation-adjusted spending integrated backwards over ALL TIME* (call it "Wealth")**

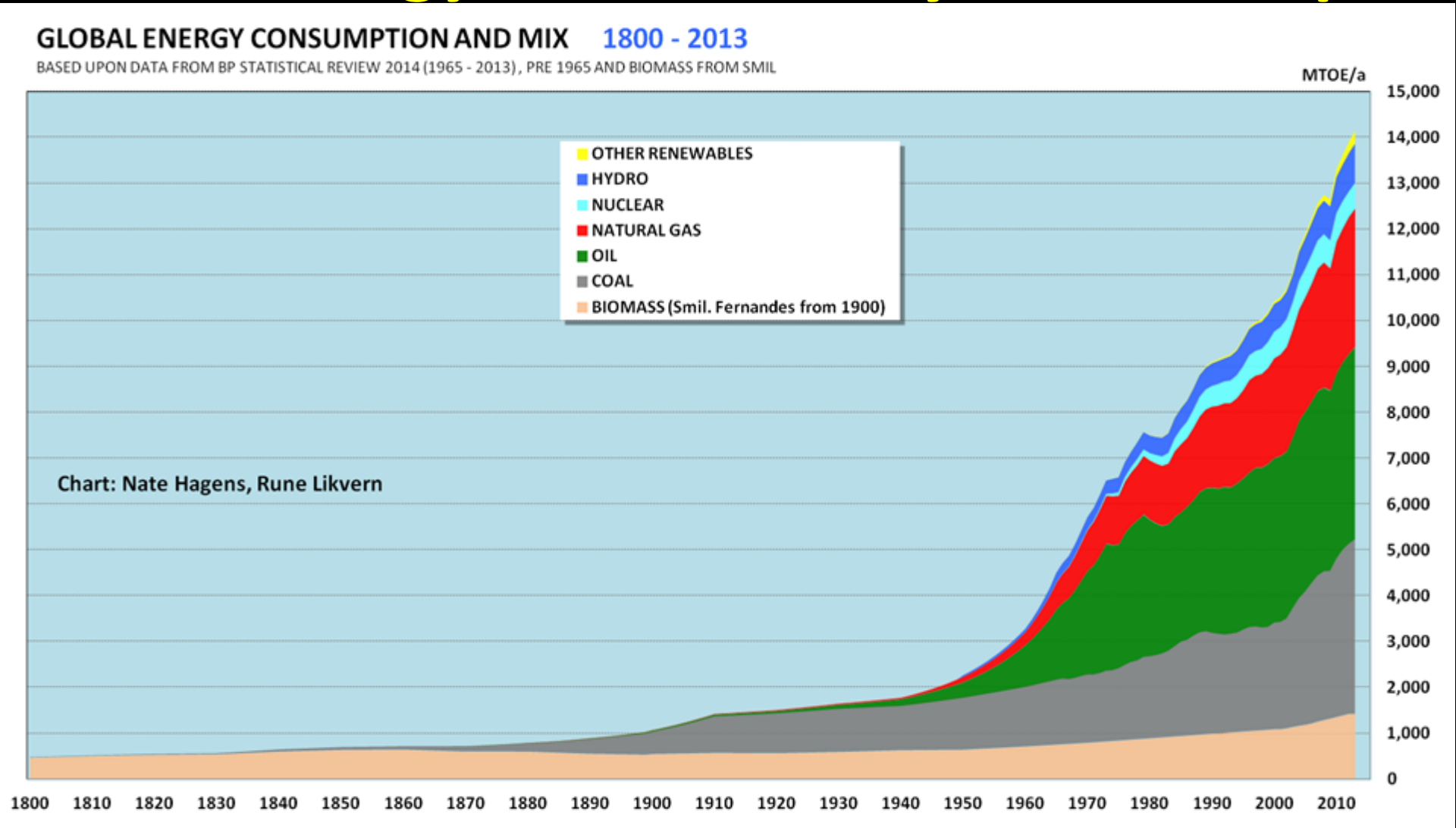


Since 1970, global wealth as defined by Eq. 2 (blue), global power consumption (red), and the ratio of power to wealth (black). Wealth is referenced to 100 in 1970.

Since the past cannot be changed, we've put ourselves into a deep dilemma

- We've created a vast civilization which requires vast energy just to continue - even if we screech halted to zero growth - let alone to grow further
- **Consequence:** We use EVERY joule of energy we can lay hands on. We spend every $ we make, and more – going deep into debt which must be repaid by future generations.
- **Consequence:** We do not de-commission fossil fuel power plants; not until they are at the end of their useful life. Especially in Asia, this will not happen for many decades as their power plants are quite recent

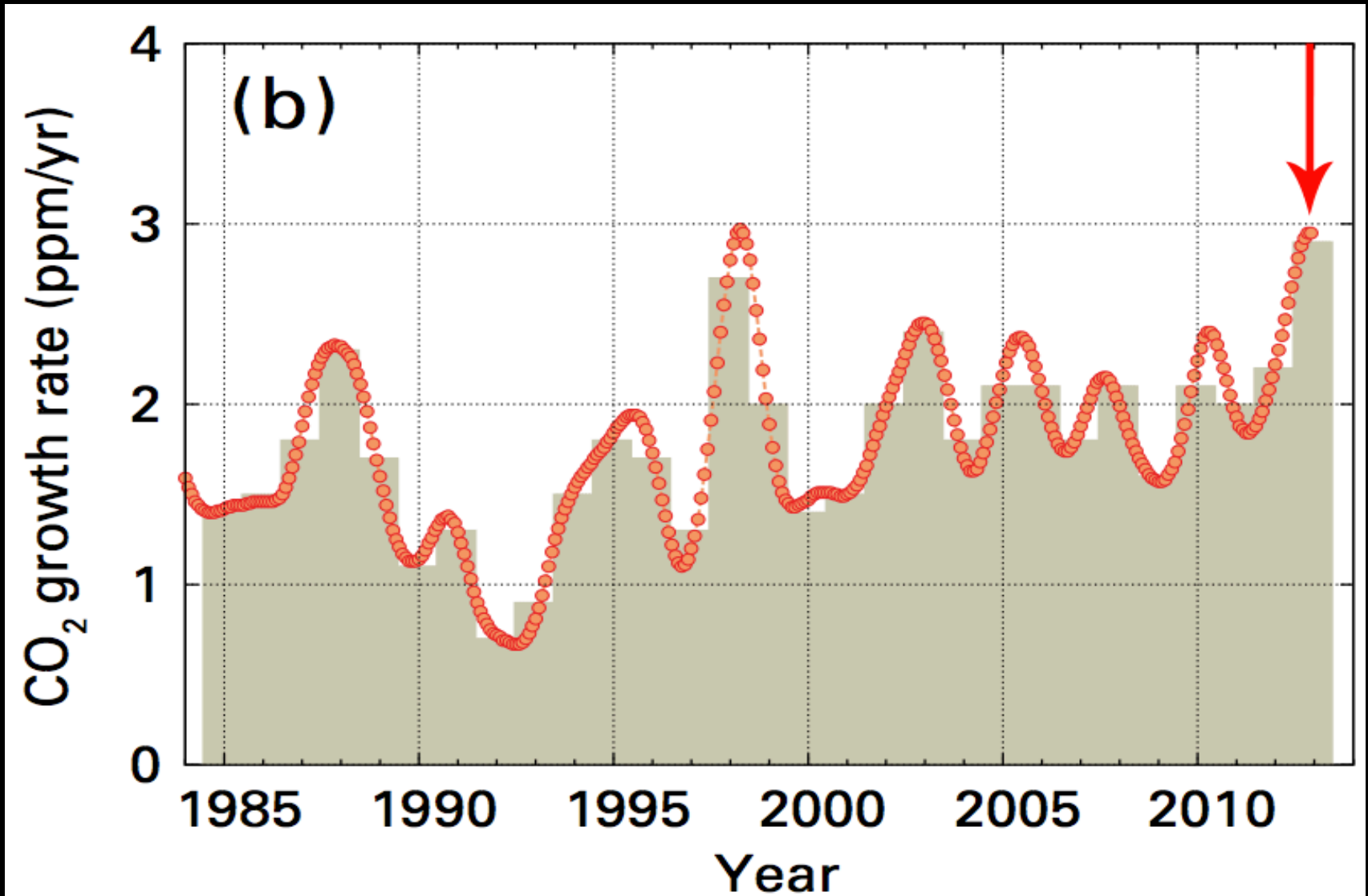
Consequence: Renewable energy is only being added ON TOP of still growing fossil fuel energy. See it? Thin yellow at top



Don't Be Misled by Energy Efficiency

- Garrett's work demonstrates the validity of a version of Jevons' Paradox I call "Generalized Jevons' Paradox" or lately I've come to call – **Jevons' Revenge** (!)
- **Jevons' Revenge = Increasing energy efficiency leads to savings, and those savings are, and will be, spent, and never mind that it's NOT necessarily in the arena where you increased efficiency.**
- The Garrett Relation shows ALL spending expands civilization and therefore expands its new energy needs.
- Example: Double the gas mileage of your car and while you won't double your driving, yet you WILL save $ which WILL be spent. It can be spent ANYwhere, and the evidence shows ANY spending expands civilization, and results in expanded future energy consumption rates.

Not Just Atmospheric CO2 Levels, but the actual RATE of RISE of CO2 is itself rising!



Pop Quiz!

Let's be Dramatically Optimistic: If we turn a key and END our entire global industrial civilization's Greenhouse gas (GHG) emissions tomorrow, What would Global Temperatures Do?….

- **A)** Continue to rise, for centuries, albeit at a slower rate than today
- **B)** Stop rising, but stay constant at today's value
- **C)** Slowly decline. The Earth would heal, slowly
- **D)** Temperatures would reasonably quickly go back down, and would be back to pre-industrial temperatures by the end of the century

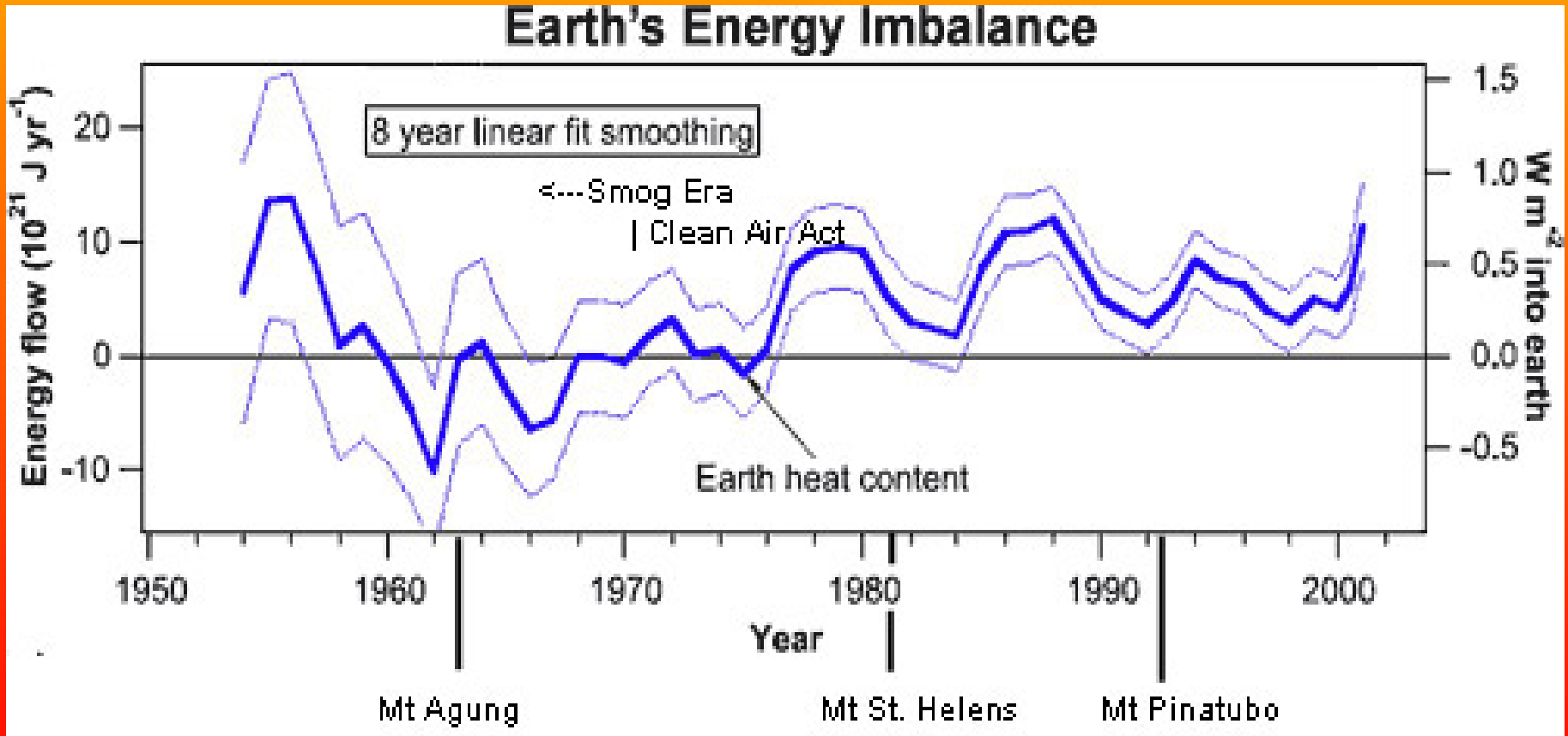
The Highly Unfortunate

Answer is: (A)

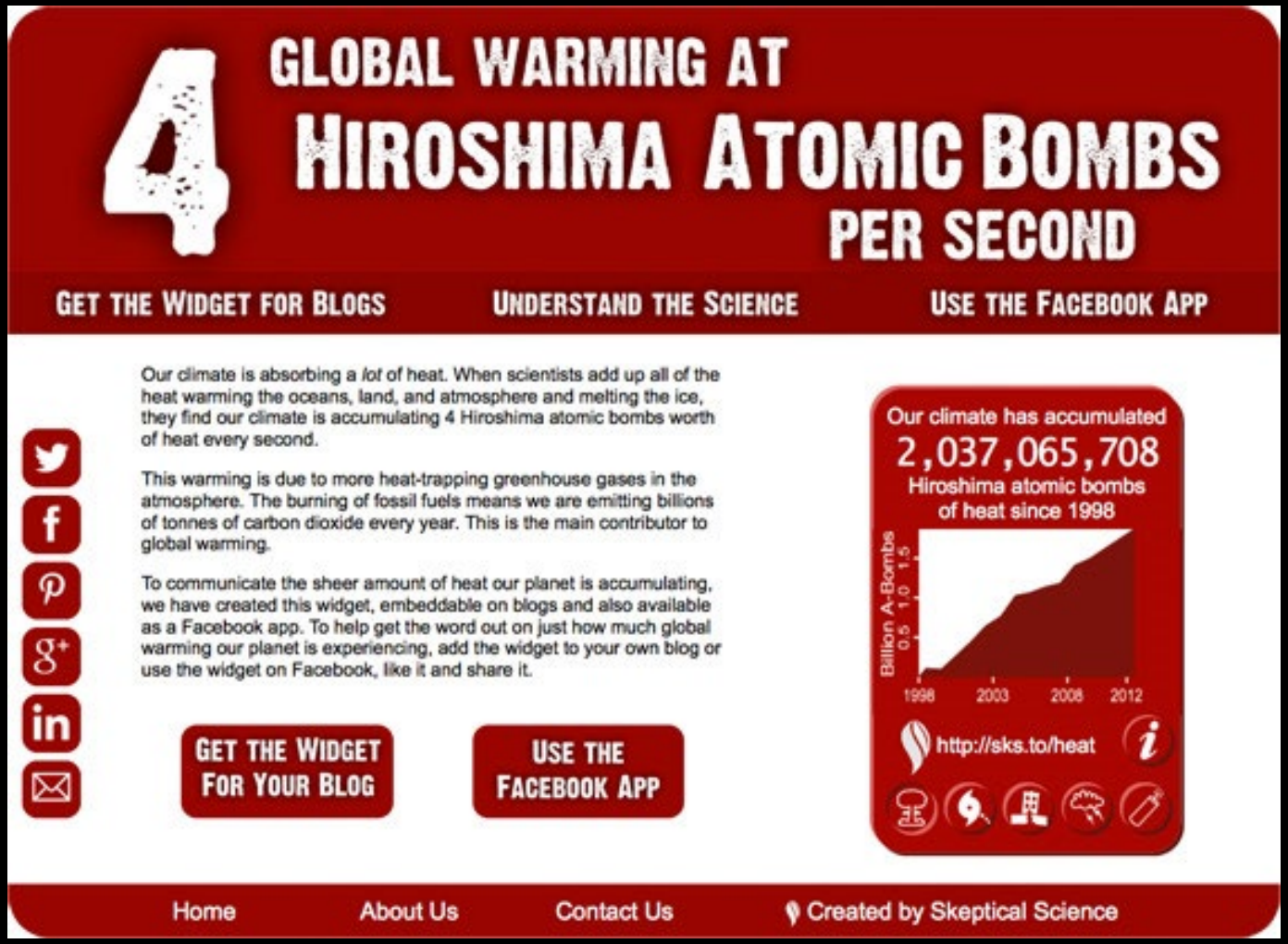
Temperatures will continue to rise.

Why?

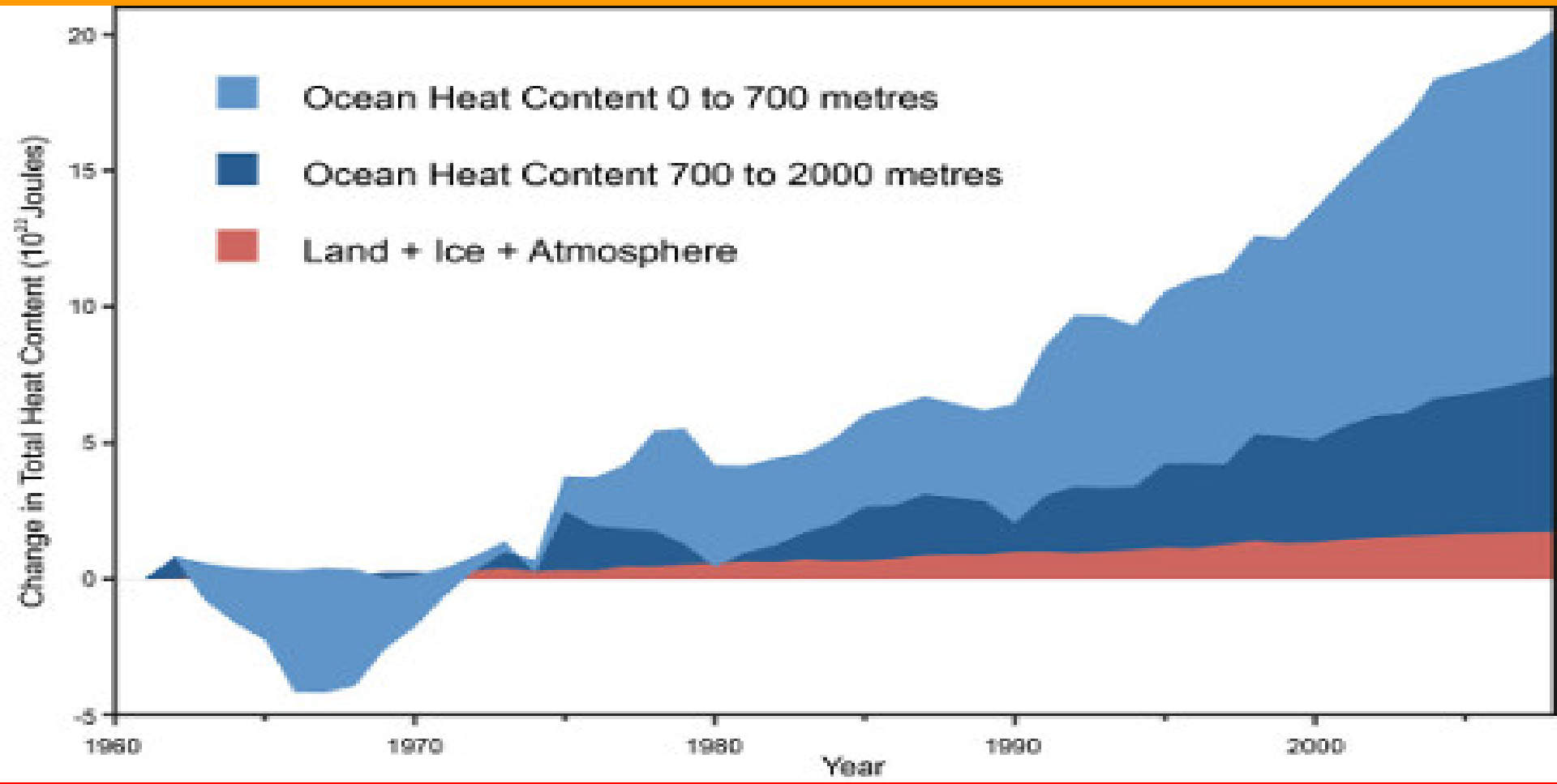
#1. The Earth hasn't yet caught up to be in equilibrium with the GHG's we've ALREADY emitted; so every square meter of Earth is able to radiate to space through our existing CO2 by fully 0.6 watts less than that square meter GETS from the sun.



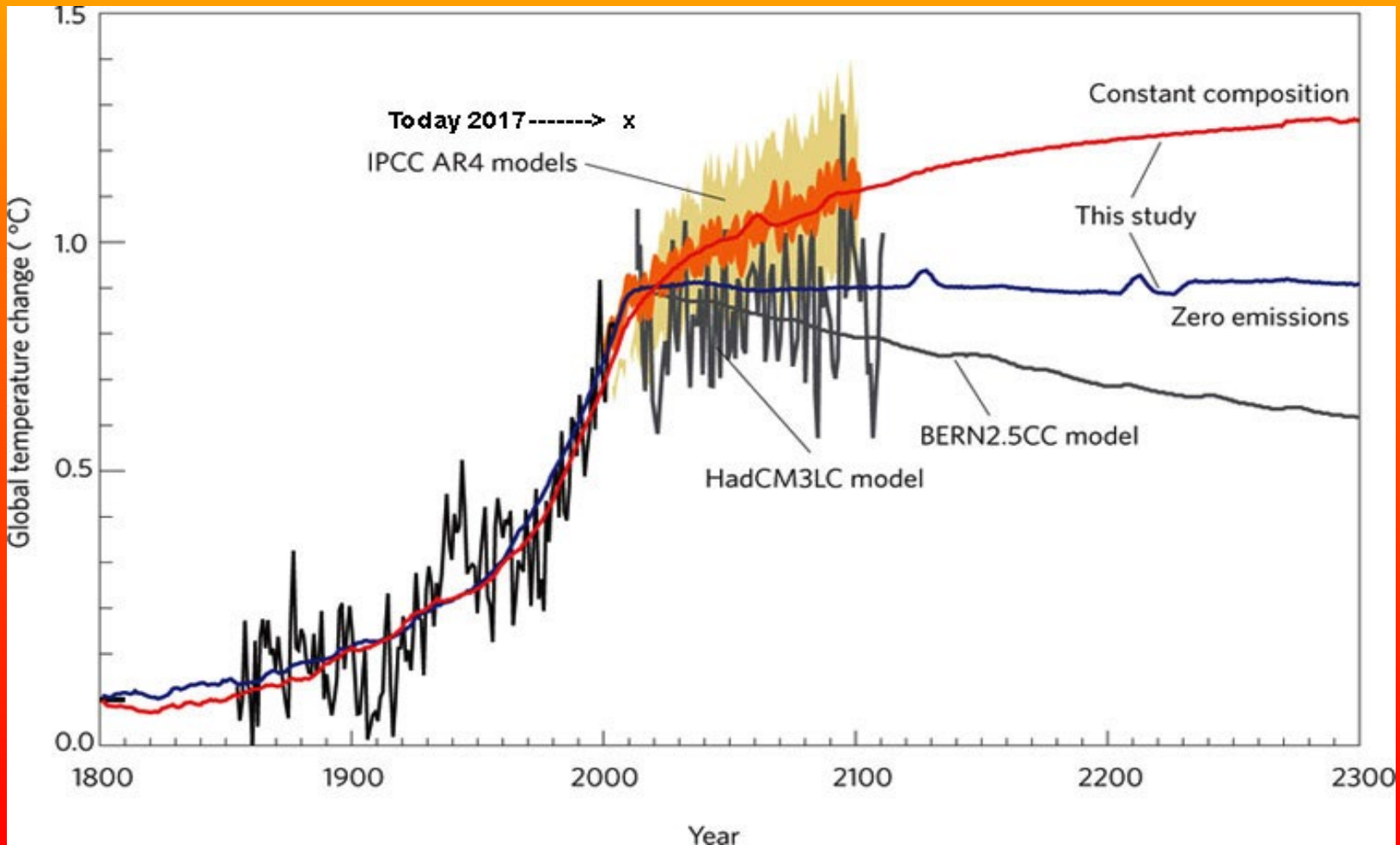
This radiative imbalance is continually heating the Earth, as incoming sunlight will not change, but outgoing re-radiation is more and more impeded. It's the equivalent heating of 4 Hiroshima A-Bombs of energy per second



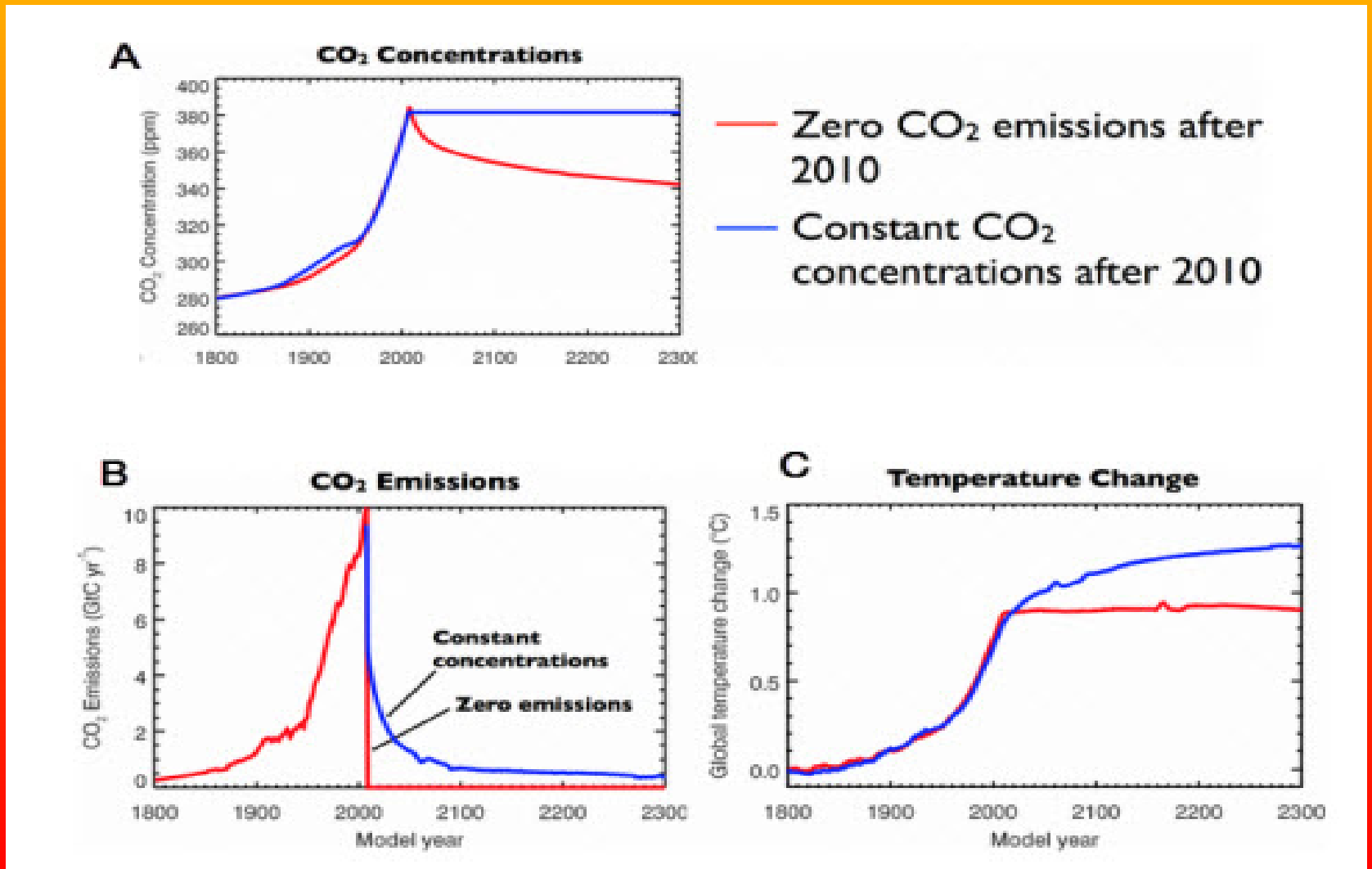
2. The Ocean has absorbed 93% of our greenhouse heat. If we try to cool the atmosphere, it will give that heat back to the atmosphere, therefore preventing atmosphere cool down (the ocean has 700x more thermal capacity than the atmosphere! – picture a BB trying to cool while sitting on a massive hot iron skillet which can't change its temperature quickly.



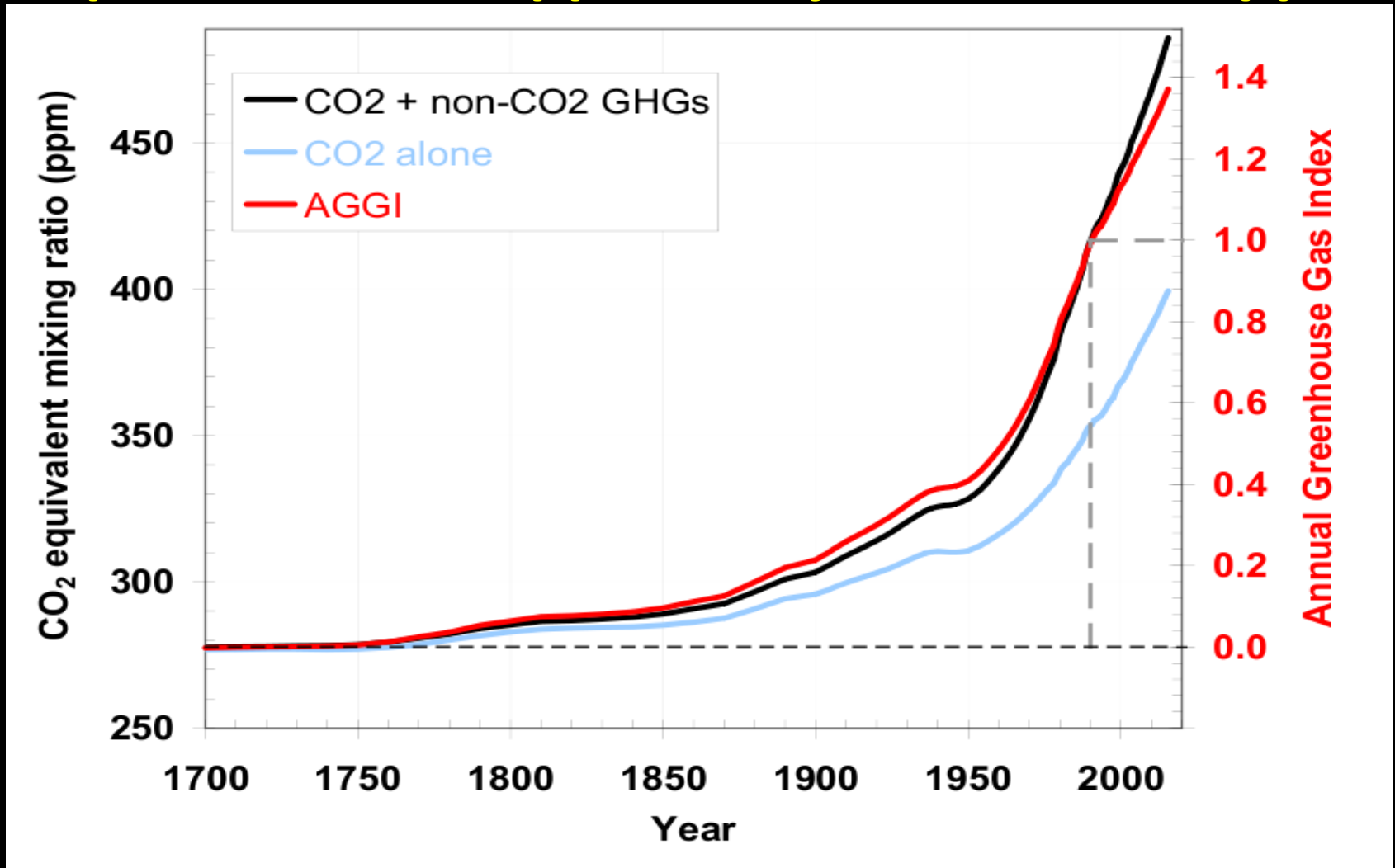
We HAD thought: Ending all human GHG emissions would lead to no worse than CONSTANT future temperatures, e.g. Matthews & Weaver (2010) below. But we were wrong, as I'll soon show - we had neglected tipping points caused by <u>indirect</u> human-caused emissions.



So: what is required to halt rising temperatures (red curve)? Ending all GHG emissions – direct and indirect human _ - so that ocean and land CO2 absorption causes atmospheric CO2 to drop (top graph). Then temps stay constant (right).



Also remember we're also emitting other industrial GHG molecules: methane, Ozone, CFC's, HFC's, N_x0 from agriculture, and others. The total CO2 equivalent = 500 ppm, not just CO2's 410 ppm



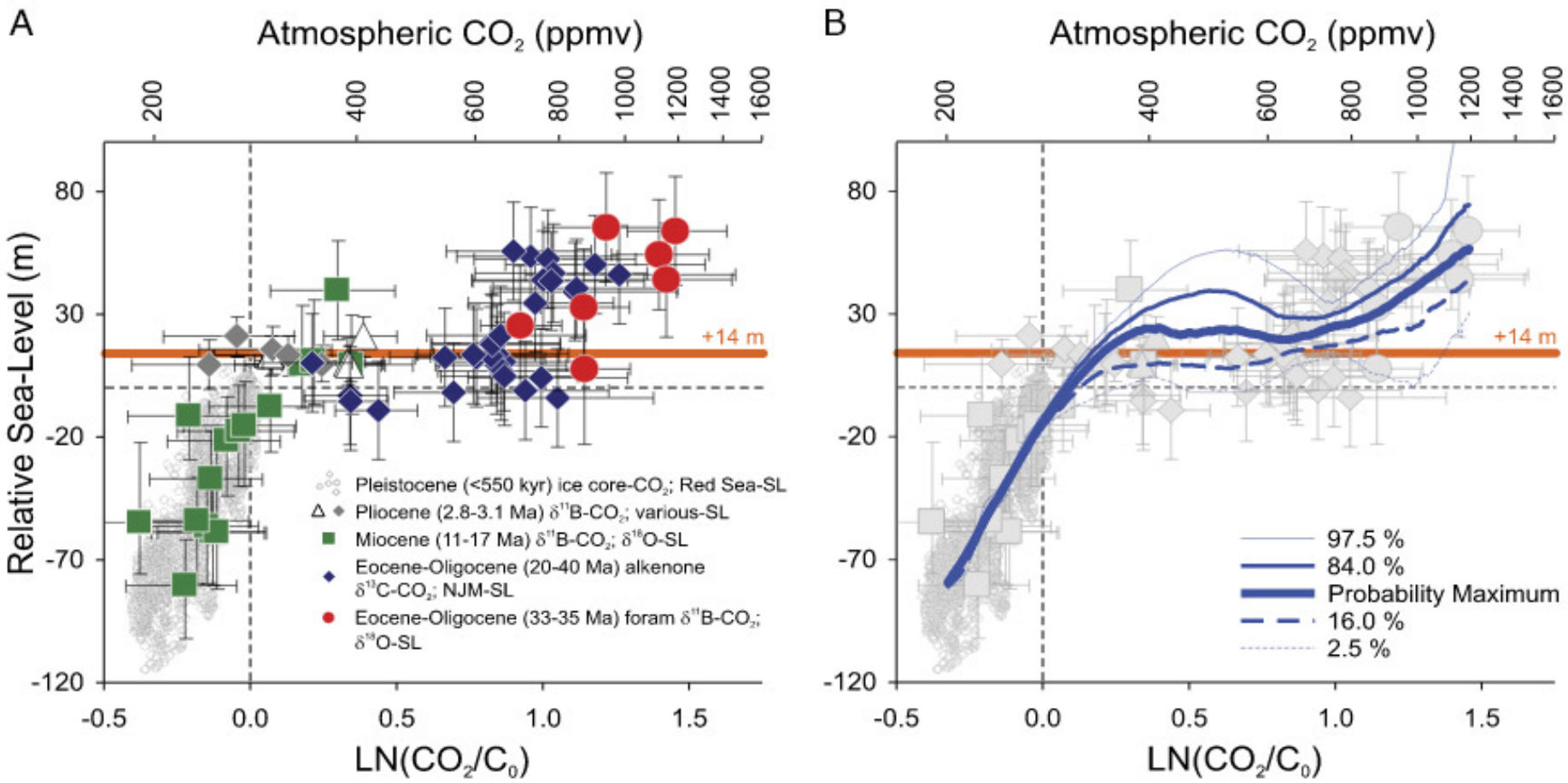
Indirect Human-caused GHG Emissions

- We'll now set up the facts so we can discuss the GHG's that we can't directly control, but are instead triggered by our heating of the planet.
- This problem will be much tougher to control, because we can't, by simple legal action, prevent these emissions from happening once the amplifying climate feedbacks really gets going.

Question: How long before temperatures are TOO high and we're past key tipping points?

- **Answer**: The past few years of research, which published after the latest (2013) **IPCC Assessment Report AR5**, is discovering that we're ALREADY crossing those tipping points now…

Foster & Rohling 2013 – Paleo Climate data shows that even halting atmospheric CO2 at 400 ppm CO2 leads to final sea level rise of ~24m (80 ft) above today's, and conclude "Our results imply that to avoid significantly elevated sea level in the long term, atmospheric CO_2 should be reduced to levels similar to those of preindustrial times." (That's 280 ppm, vs. today's 410 ppm). 350.org's original goal of 350 ppm is NOT NEAR ENOUGH

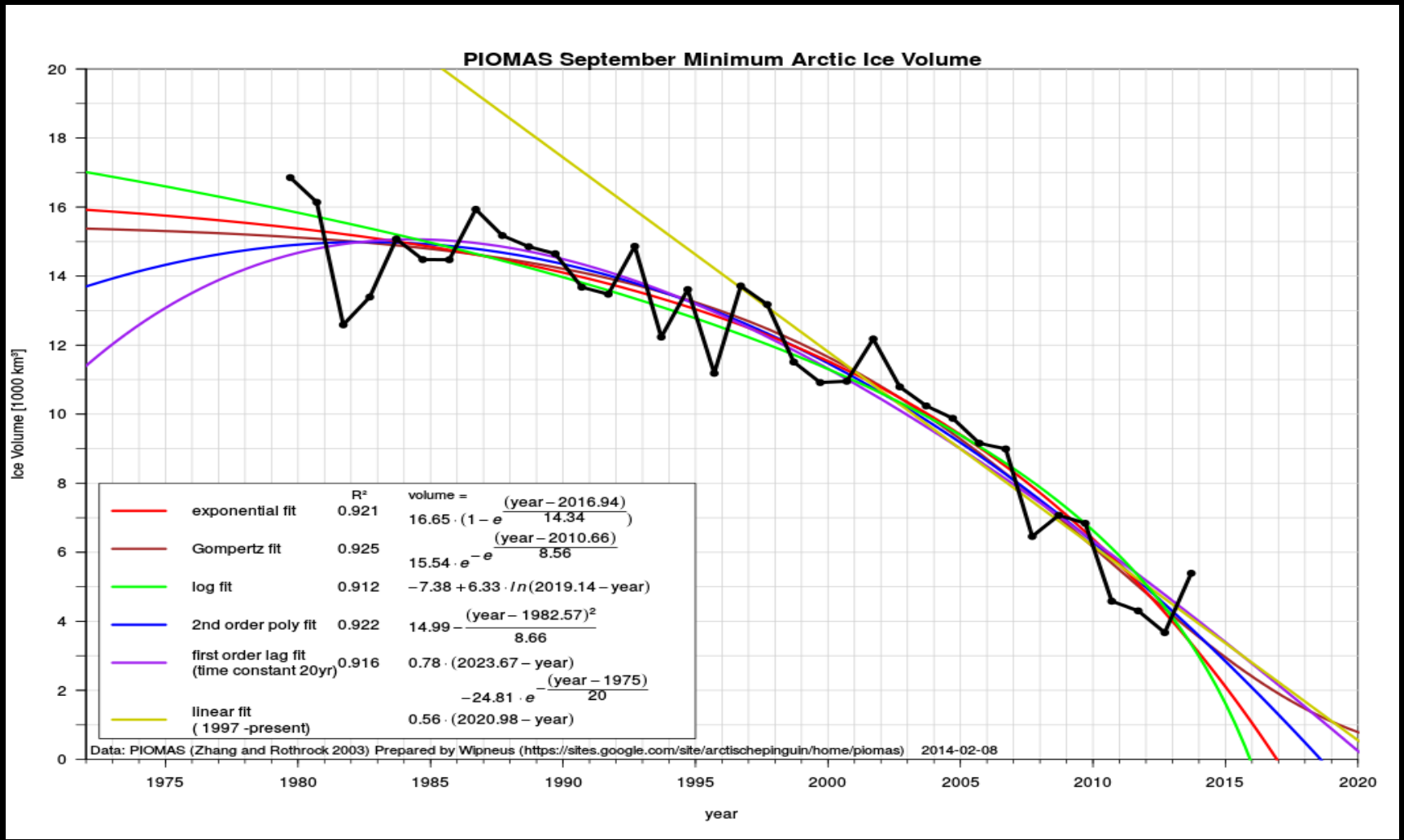


IPCC climate models did not include many key permafrost and ice dynamic processes, leading to dramatic underestimation of sea ice loss

MINIMUM ANNUAL ARCTIC SEA ICE: **IPCC MODELS** VS **OBSERVATIONS**

base chart: http://www.realclimate.org/index.php/archives/2012/04/arctic-sea-ice-volume-piomas-prediction-and-the-perils-of-extrapolation/
modified by Barry Saxifrage (VancouverObserver.com and VisualCarbon.org) to include orange line showing PIOMAS volume data
in 1,000s of km3 from http://psc.apl.washington.edu/wordpress/research/projects/arctic-sea-ice-volume-anomaly/data/

The melting Summer Arctic Ocean has turned it from reflective white, to heat-absorbing dark blue = Albedo Feedback

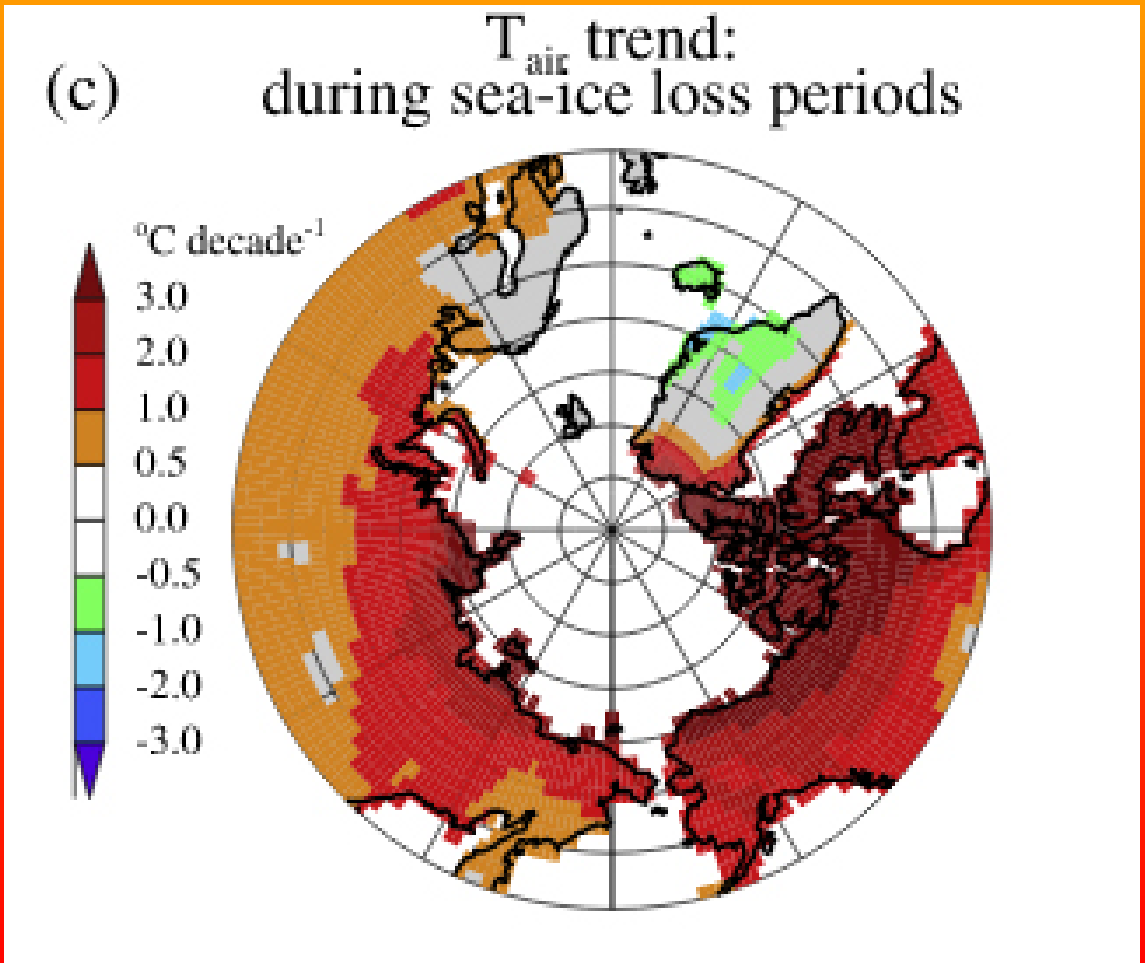


Melted Arctic Ocean Fundamentally Changes Earth's Heat Balance, Leads to the Permafrost Melt

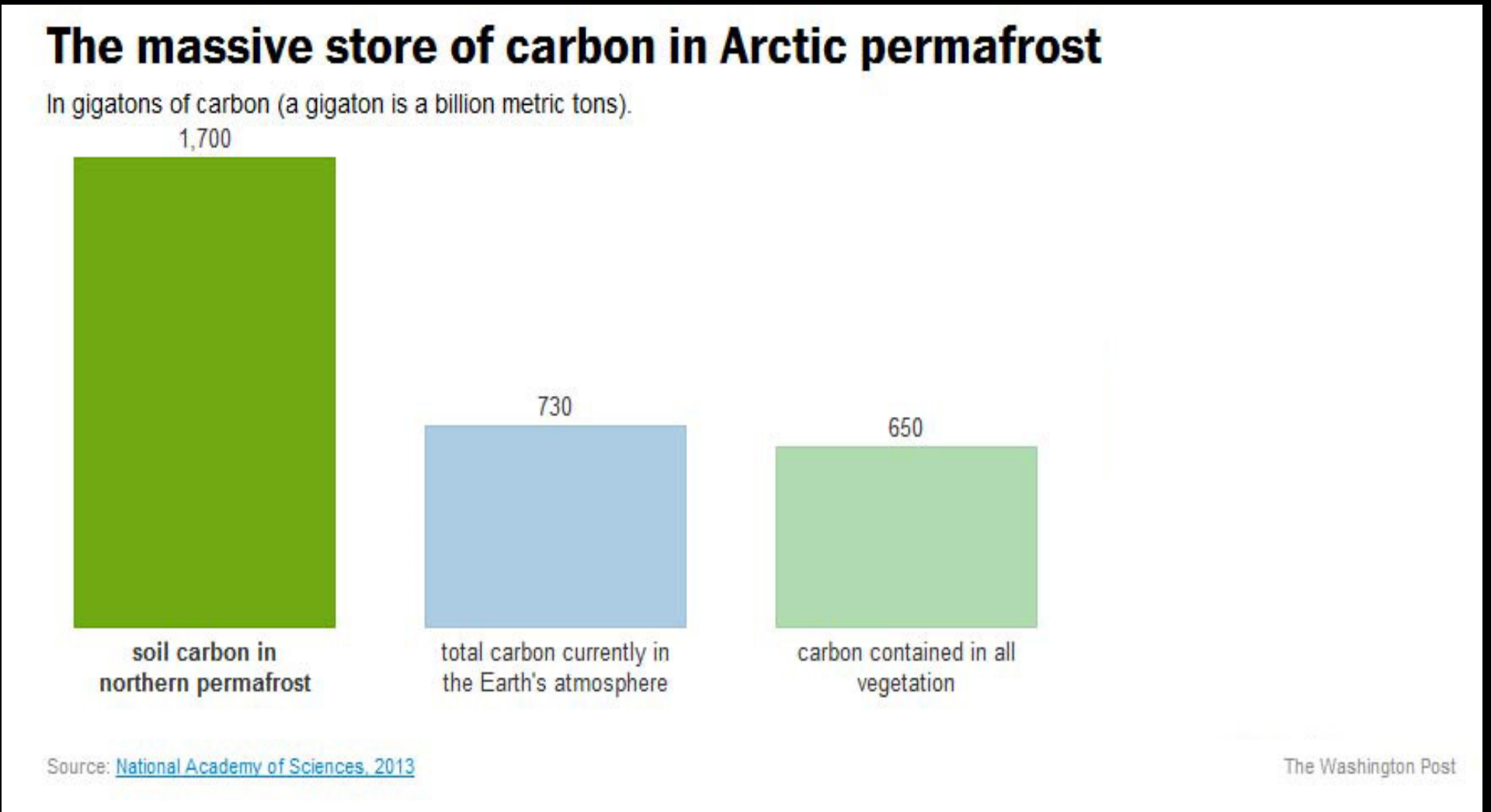
- ***Vaks et al.* 2013** show that at or before **+1.5C** equilibrium temperature, most or all permafrost will melt. (His most recent work makes that less certain as North Atlantic temperatures factor in importantly, however)
- Once it gets going, the permafrost melt is very likely unstoppable without dramatic geo-engineering action to immediately cool the planet
- **How much room does that leave us before +1.5C?..... None.**

It is the Loss of the Arctic Ocean's Ice …Ice which once REFLECTED ~90% of sunlight, turns to open ocean which now ABSORBS ~90% of sunlight. Lawrence *et al.* 2008 show this sends a pulse of heat 1500 km south of the shorelines throughout the Arctic Permafrost.

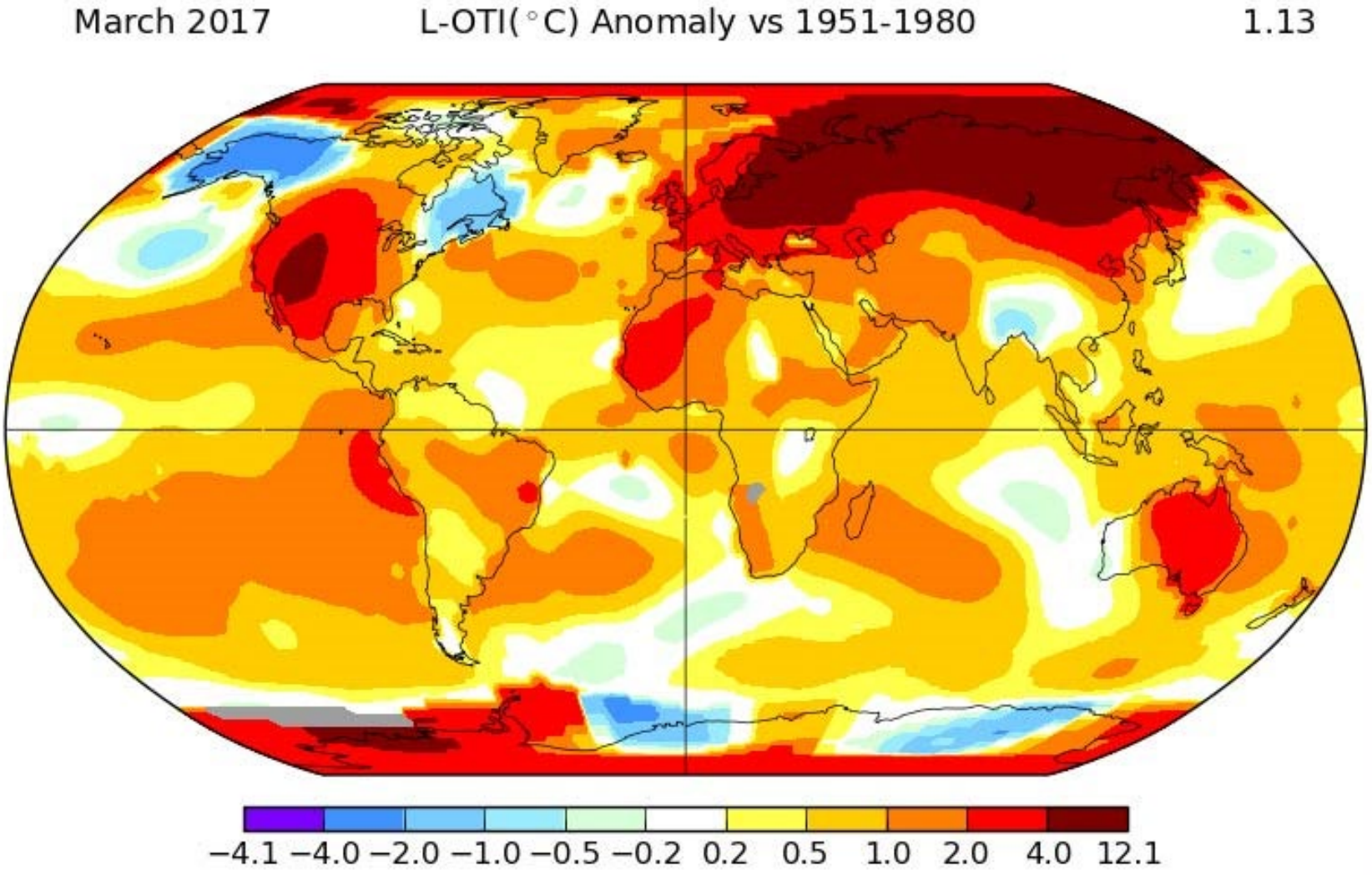
Below: temperature trend map. Sharp rise in Siberia, even sharper in North America. So if Siberia melts, North America will as well, and sooner



There's more carbon in the permafrost than in the entire atmosphere plus the entire biosphere's vegetation, combined



In 2017 we're at +1.4C (1.13C + 0.254C to convert to Pre-Industrial), and rising very rapidly. The Siberian Permafrost is warming much more (deep red)



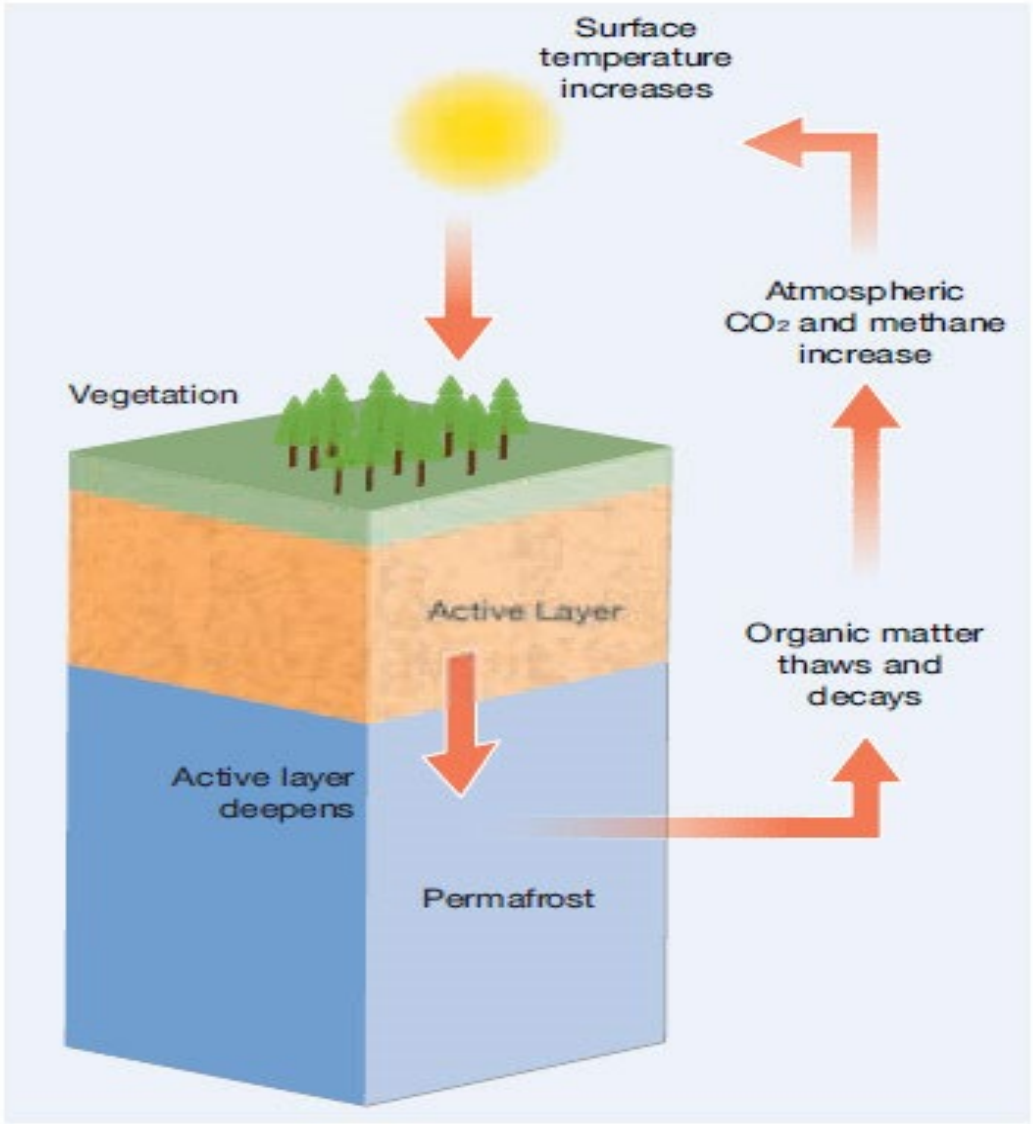


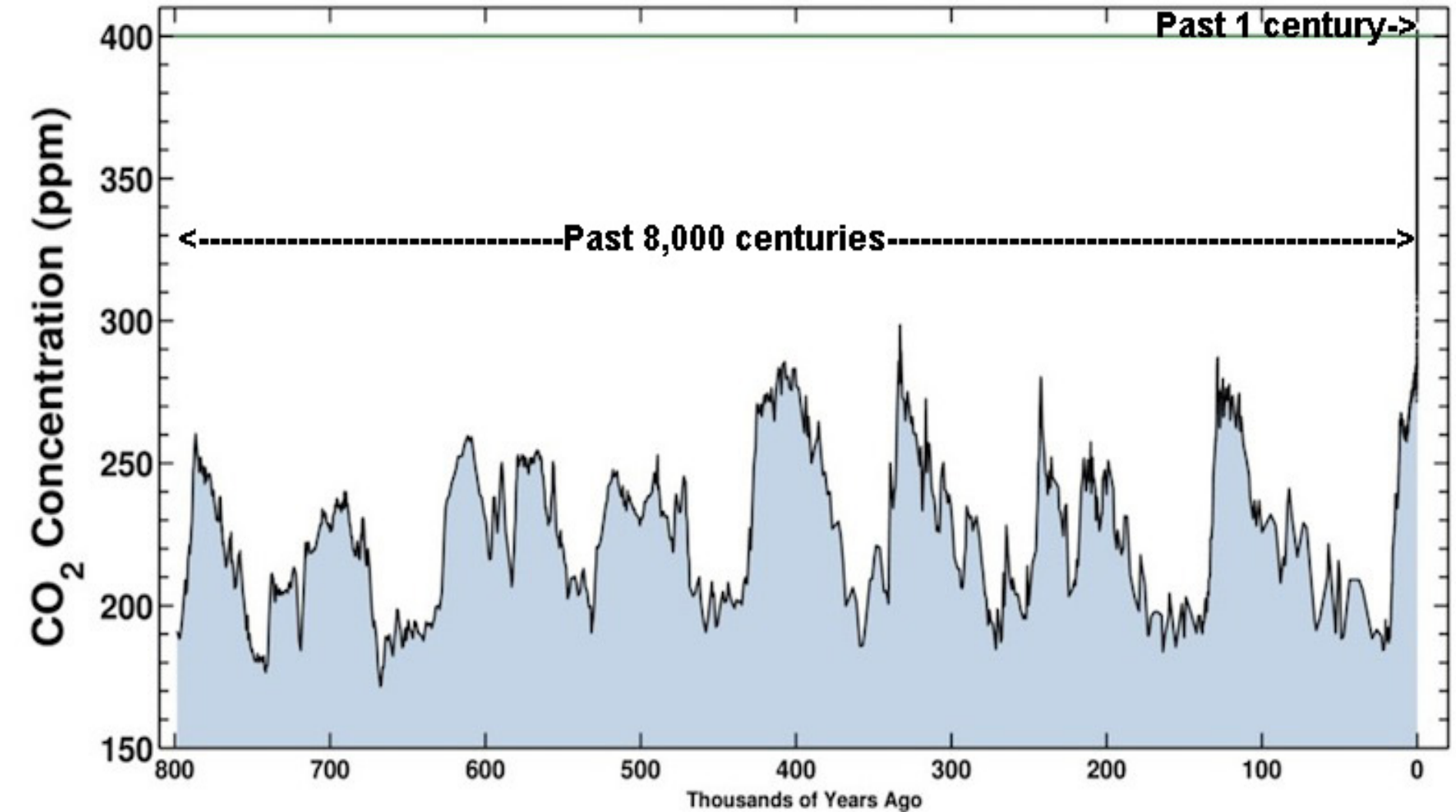
Figure 21: The permafrost carbon feedback is an amplification of surface warming due to the thaw of organic material currently frozen in permafrost, which will then decay and release CO_2 and methane into the atmosphere.

The Permafrost Carbon Feedback (the PCF)

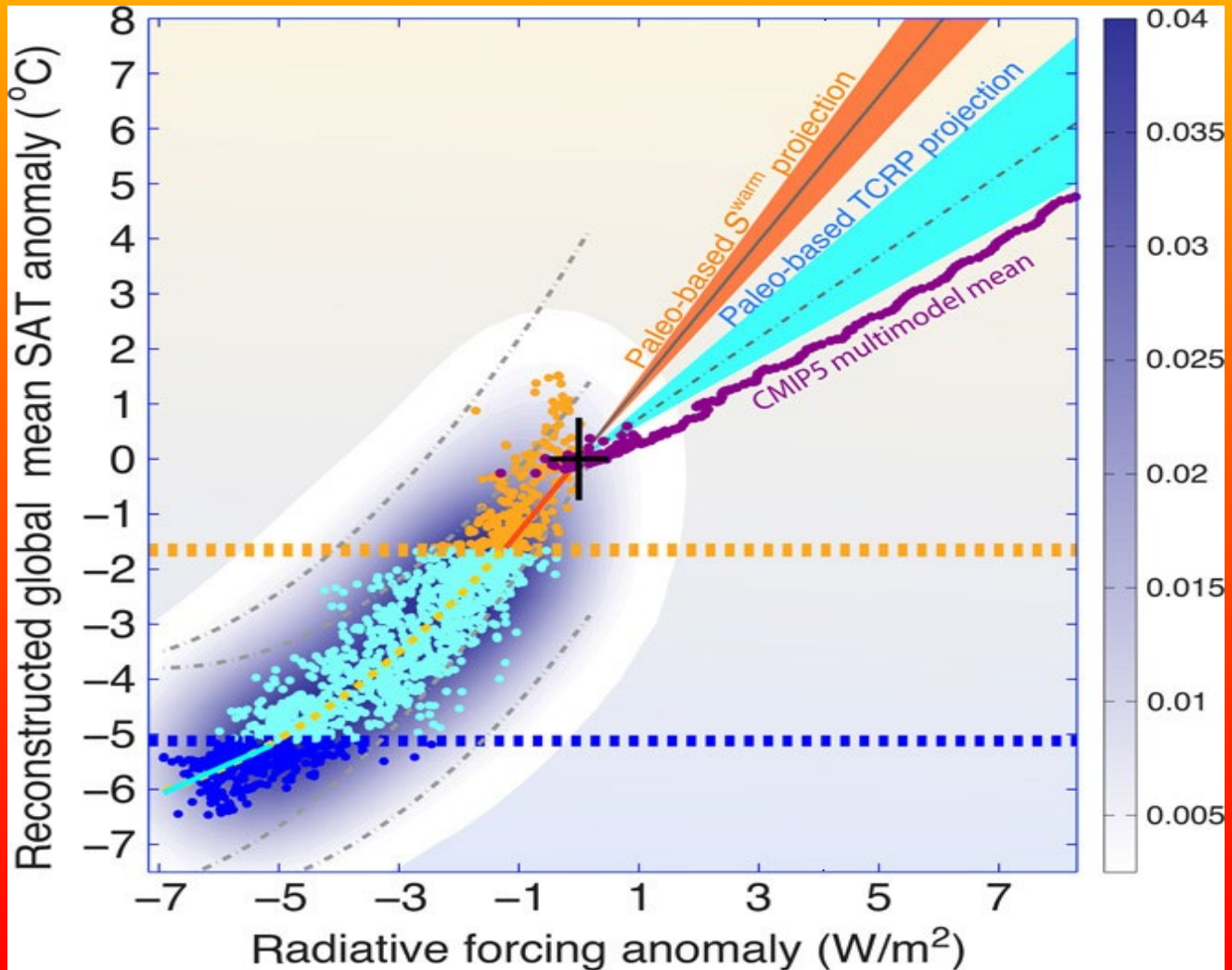
ECS=Equilibrium Climate Sensitivity

- **A convenient number to express how much the global temperature rises with rising CO2**. The pre-industrial atmospheric CO2 concentration was 280 ppm. Now double that to 560 ppm, then keep it at 560 ppm for centuries until climate reaches a new, higher equilibrium temperature. **That rise in temperature is called ECS.**
- Averaged over the past million years of Ice Ages and interglacials, the observed value is ECS= +3 C, says a number of good studies.

But that entire period had CO2 levels stay between 180 ppm and only 280 ppm, and now we're far above that, at 410ppm. So should ECS still be only 3C?



Several new studies say NO – ECS is significantly higher. This is bad. Example: Friedrich *et al.* 2016 – finds <u>ECS=4.9C</u> during past interglacial periods, such as we're in now (and even those had CO2 only at 280ppm, so this 4.9C may be an underestimate. This high ECS is not just an outside chance - It's very likely to be true). Consequences?...



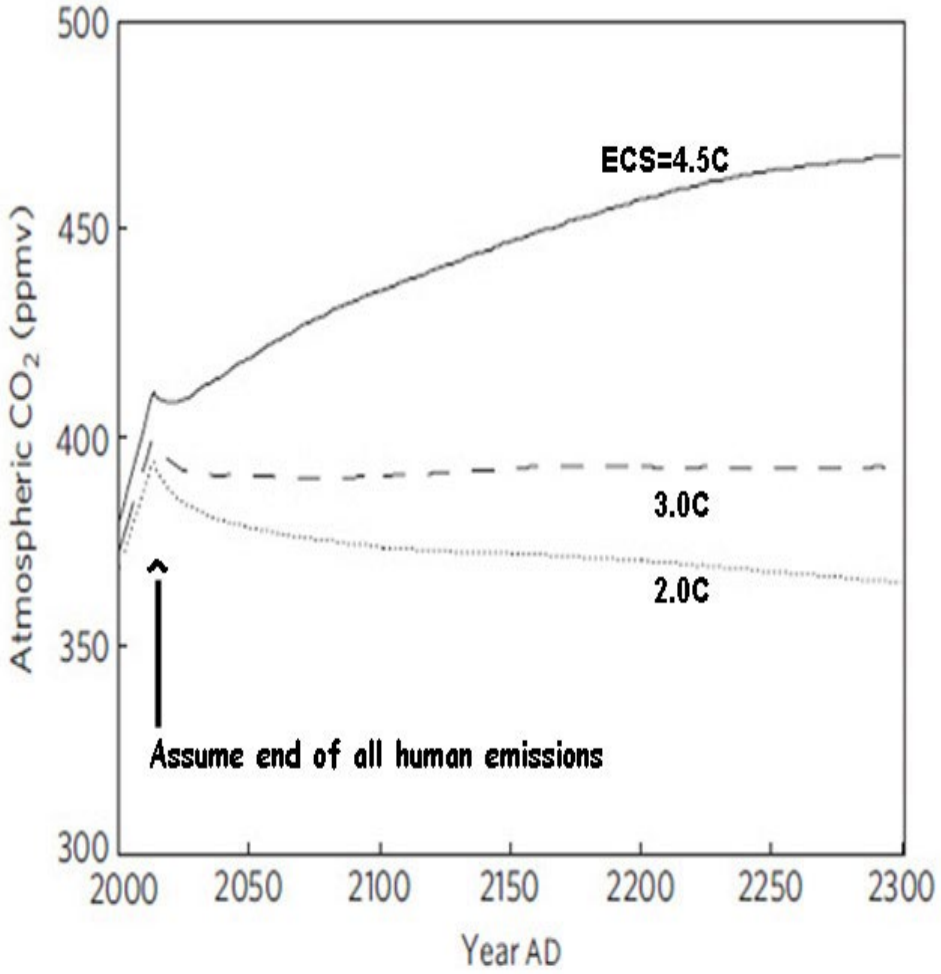
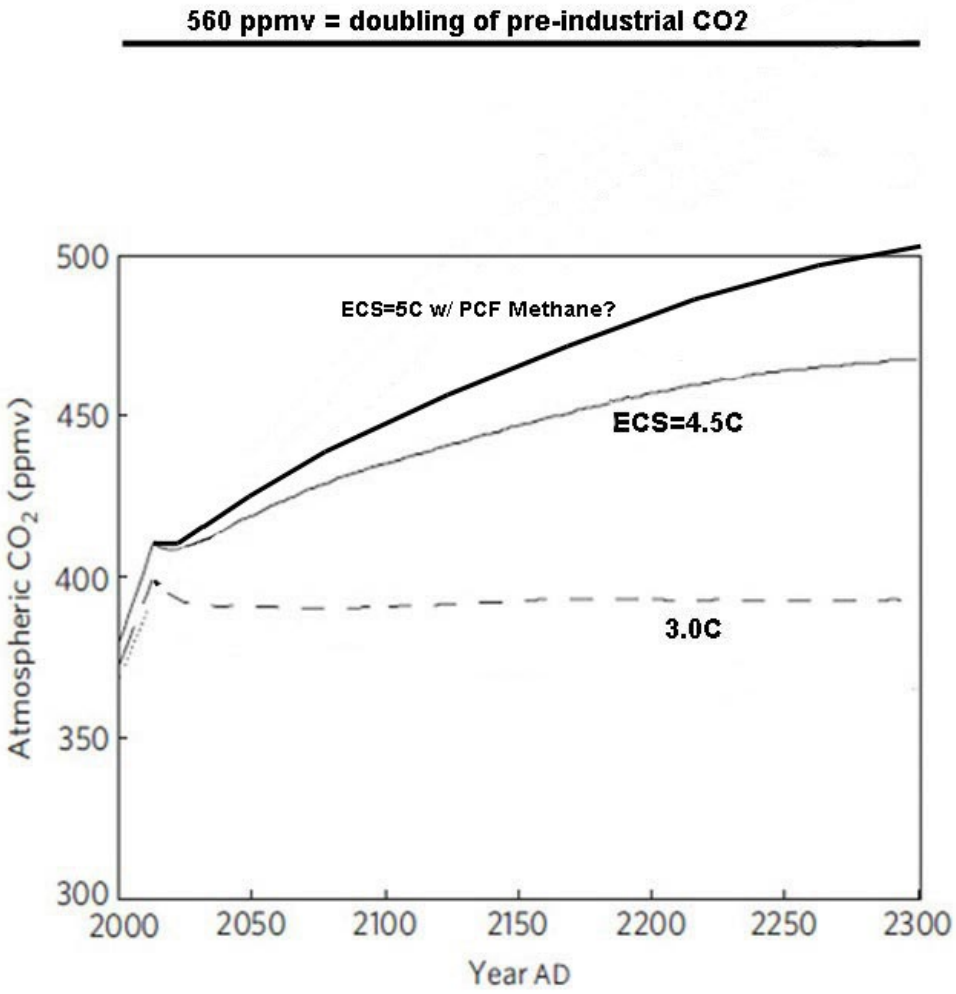


Figure 3 | Evolution of atmospheric CO_2 concentration in response to a cessation of anthropogenic CO_2 and sulphate emissions in the year 2013. The dotted line represents the response for a climate sensitivity (to a doubling of CO_2) of 2.0 °C, the dashed line a climate sensitivity of 3.0 °C and the solid line a climate sensitivity of 4.5 °C.

MacDougall *et al.* 2013, (discussed here) assumed immediate end to all human GHG emissions and studied how permafrost carbon release would affect atmospheric CO2. Note that if ECS is higher than 3.0C, as Friedrich *et al.* 2016 and other studies now indicate - CO2 continues to rise for centuries, due to the Permafrost Carbon Feedback. This causes continued rising global temperatures for many centuries more.

But MacDougall's Permafrost Model Does Not Include Permafrost Methane

- It's just not included. But they acknowledge it certainly exists.
- How much of the permafrost carbon should emerge as methane, which is 100x more powerful, pound for pound, as CO2?
- **Schuur *et al.* 2015** did a meta-study of permafrost experts, finding 2.3% of the carbon atoms will emerge at methane, nearly doubling the heat forcing of CO2 alone, at emission.
- Let's include that in the next graph…



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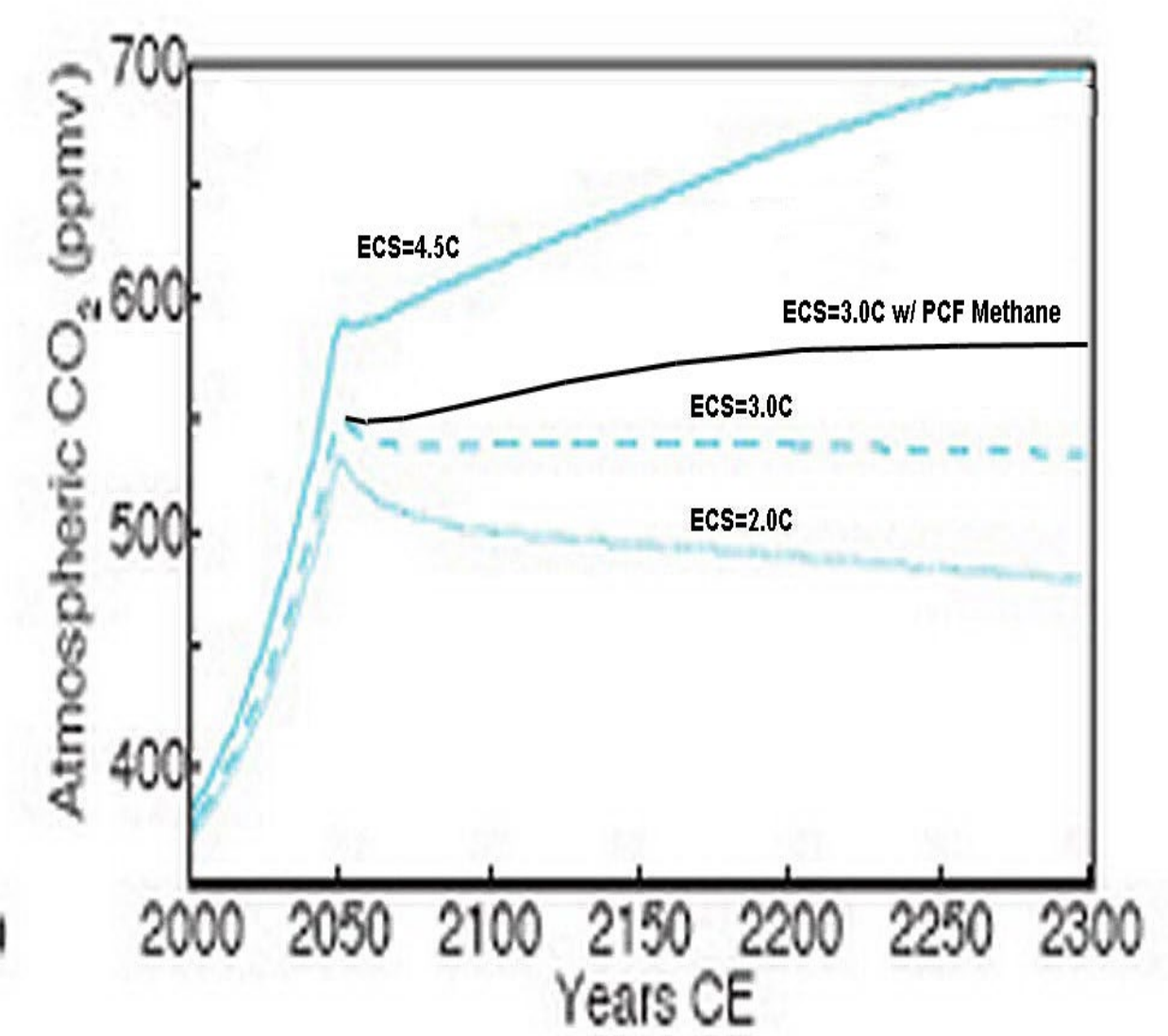
For ECS=5C, include methane, correct for shallower freeze/thaw layer (MacDougall and Knutti 2013) gives the black curve… Then CO2-equivalent warming is faster still. We're facing the real possibility of +4-5C global temperatures even if we turn off ALL human GHG emissions tomorrow. This would lead to large areas of Earth uninhabitably too hot, a civilization in steep collapse, and death in the hundreds of millions, or more

And finally, what if we DON'T shut off carbon-based Civilization tomorrow morning? (hint: we won't) What then?



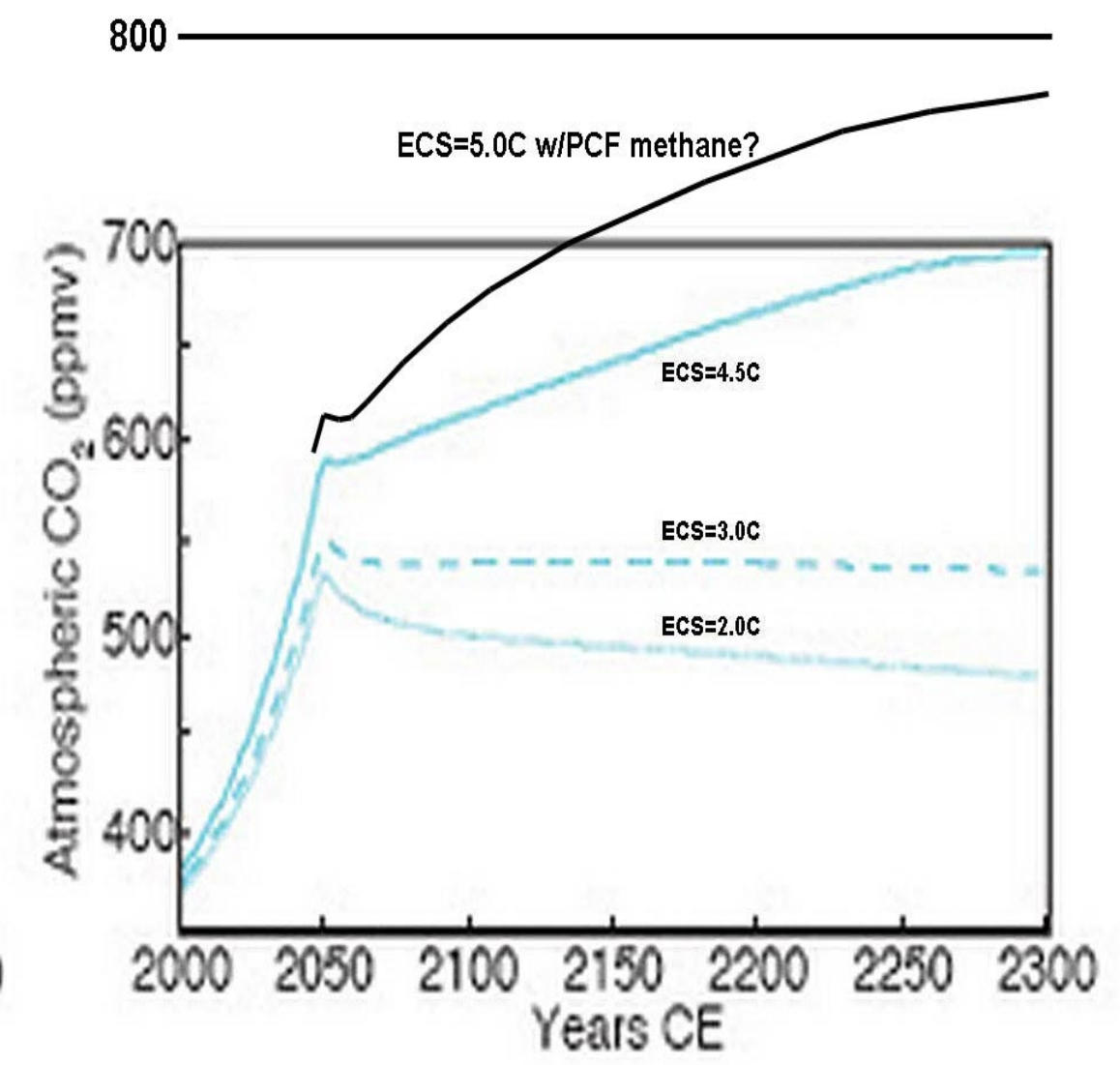
Shutdown in 2050

Here, MacDougall *et al.* approximate a concerted effort to end GHG emissions by following "Business as Usual" till 2050, then zero emissions thereafter.

Blue includes PCF as pure CO2 (and overestimated freeze/thaw layer), and black includes estimated permafrost methane and corrected freeze-thaw depth, for ECS=3C

The Meaning of the Last Slide

- Even if we try very hard to reduce and then eliminate direct human GHG emissions in coming decades, and even if ECS is only +3C, we quickly climb to ~560 ppm CO2 equivalent heating, and therefore can expect +3C global temperatures at barest most optimistic minimum.



Shutdown in 2050

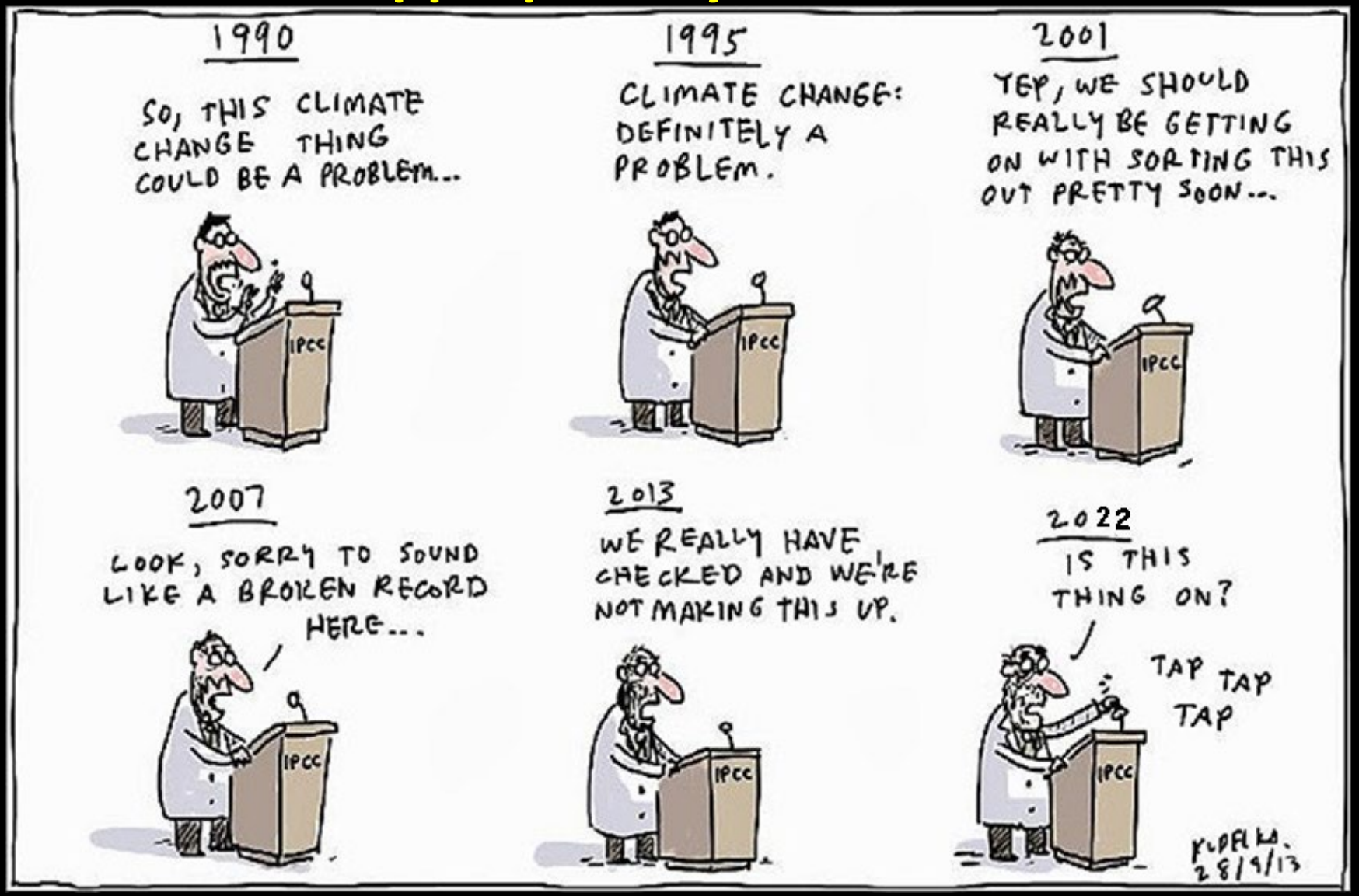
If ECS is actually +5C, then we instead reach past 700 ppm CO2 equivalent and therefore global temperatures of +8C or beyond, just from the outgassing of melting permafrost carbon. +8C would result in perhaps Earth's worst mass extinction ever, and most humans likely would die.

What we're doing is <u>sheer madness</u>

So: Unlike many of Earth's environmental problems – merely stopping our hurting of the Earth… will NOT be enough to permit the Earth to heal.

Not for 10's of thousands of years

When the stakes are climate chaos and mass extinctions, the IPCC scientists (with rare exceptions) haven't been appropriately forceful communicators



Threatened scientists have been slow to speak with the Cognitive/Emotional/Moral force necessary for effective communication

- This is not controversial – they know it, they admit it, and it's due not just to the intimidation, threats, and hatred they've been subjected to by the right wing climate denial community, and the political meddling in the IPCC process…
- It's also due to the science culture: the unemotional, "rational" ethos which initially was inviting to young people who were attracted to science after fleeing the irrationality common in much of everyday life.
- Glaciologist **Dr. Eric Rignot** expresses it well (AGU '14 interview (4:29)) and even more poignantly **here**, by Jet Propulsion Labs Earth scientist **Dr. Peter Kalmus**. Key quotes on following slides…

Writes Dr. Kalmus…

- *"**I'm afraid to publish this article.** Why? Because I'm a climate scientist who speaks out about climate change, and in speaking out I may be risking my career. But I do so anyway, out of love—love for my two young sons, for others' kids, for wild animals, for this beautiful planet…*
- *"But **many scientists—myself included—worry that standing up for what we know to be true**, or advocating for a particular action in response to anthropogenic change that we find deeply disturbing, will make us look biased or unprofessional. We're afraid that if we speak out, we'll lose our funding or be labeled as politicized or alarmist."*

- *“And when we have something scary to say, we employ the dry and precise language of science….”*
- *“However,* ***when climate scientists don’t speak out, we’re inadvertently sending a message that climate change isn’t urgent. If the experts—the scientists on the front lines, the people who know—are so calm, dispassionate, and quiet, how bad can it really be?”***
- ***“I experience a surreal tension between the terrifying changes unfolding within the Earth system and the Spock-like calm maintained within the scientific community****.”*
- *“Following a formal scientific talk about dying forests or disappearing glaciers, for example, audiences commonly ask a few questions on instrumentation or methodology, and then quietly shuffle out.”…*

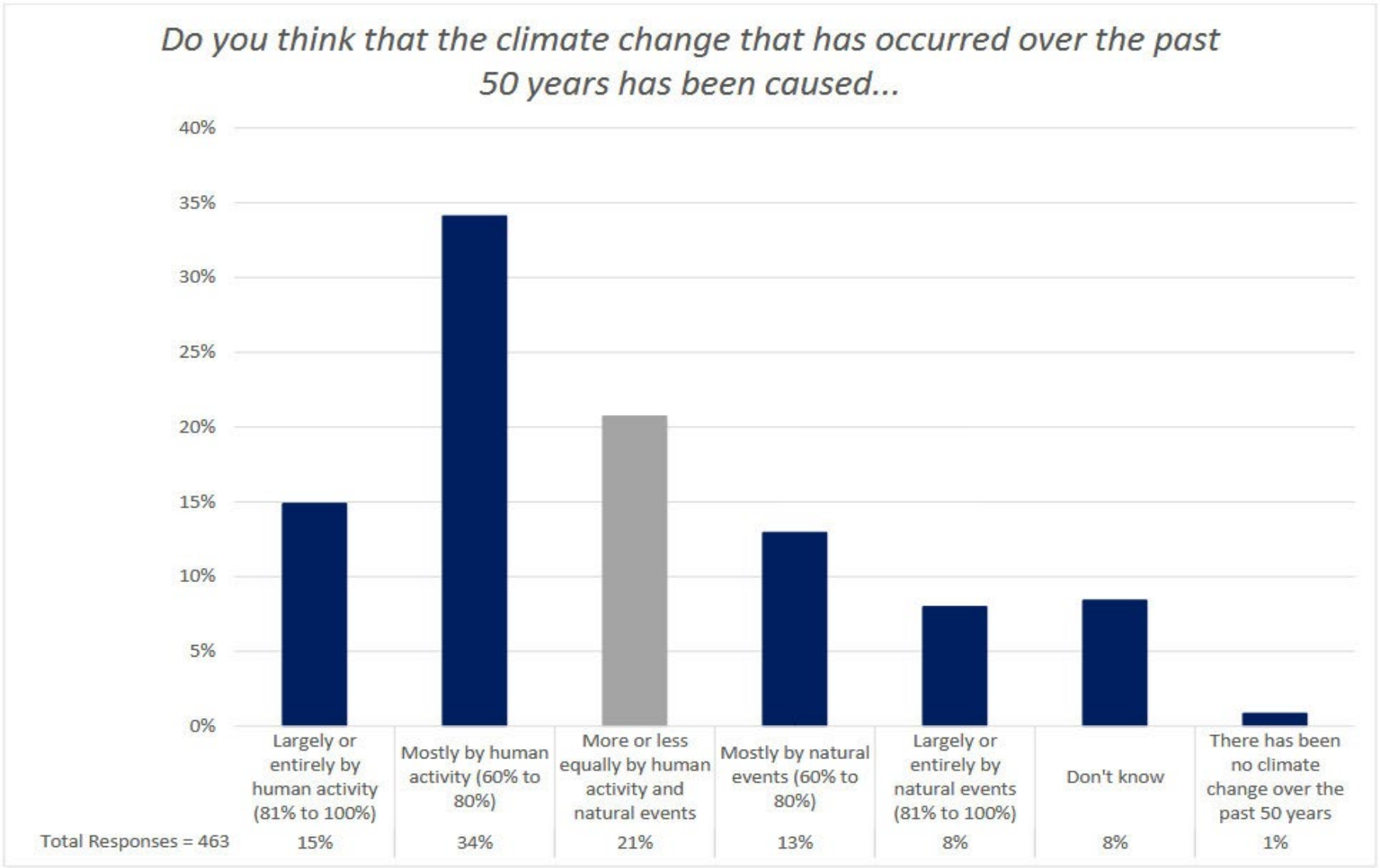
From this talk by Prof. Kevin Anderson, in conversation with climate policy senior political people…

- **Political scientist** (at request left un-named): *"Too much has been invested in +2C for us to say it's not possible – it would undermine all that's been achieved. It'll give a sense of hopelessness, that we may as well just give in"* – (30 min into **the talk**)
- **Anderson:** *"Are you suggesting we have to lie about our research findings?"*
- **Political scientist:** *"Well, perhaps just not be so honest – more **dis**honest…"*

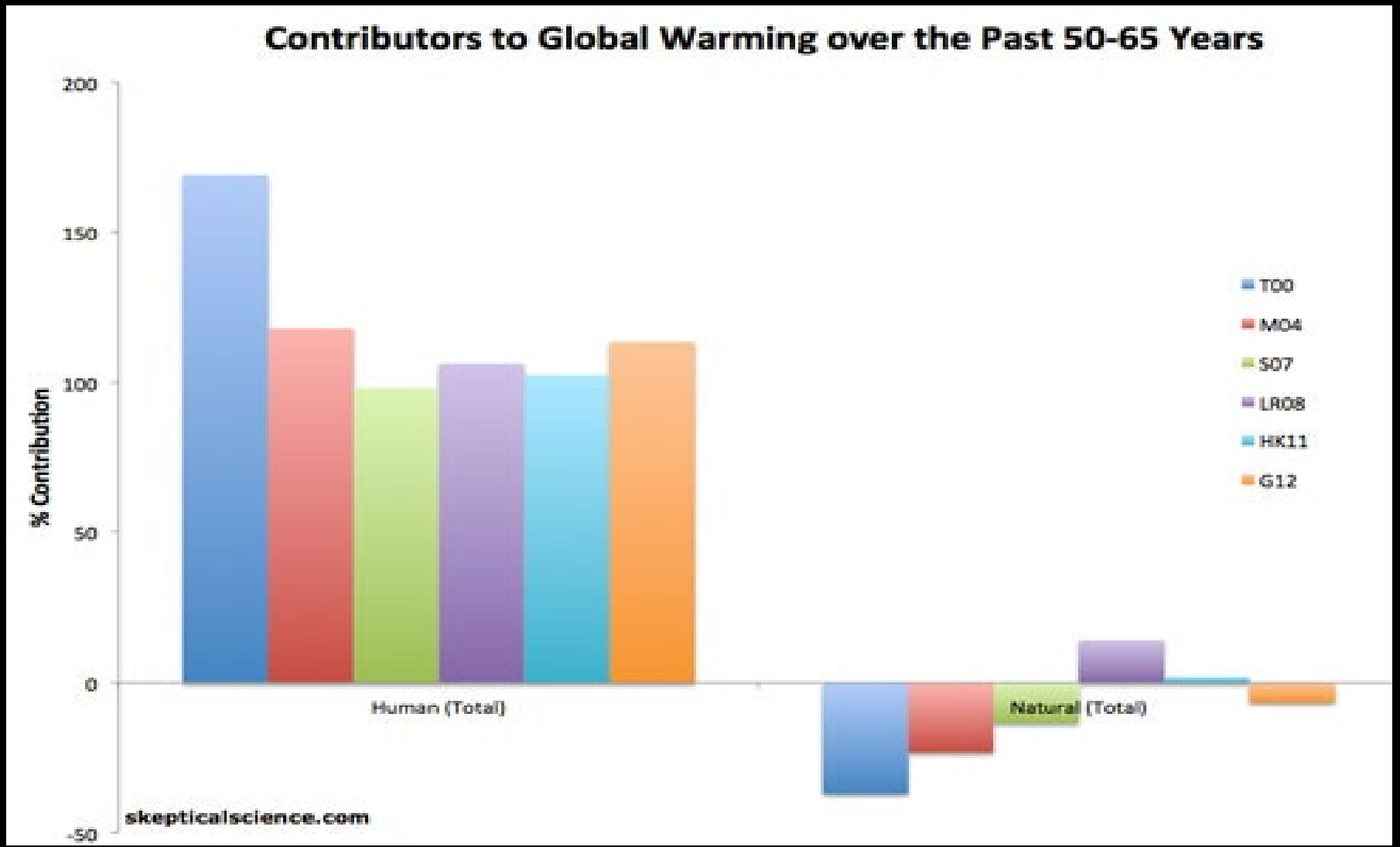
And a timid (at best), and more often a downright hostile media has crippled the public's appreciation of our true situation

- Most people, alas, get their trusted information about weather and climate from broadcast weathermen.
- Yet a new study shows **only 15% of broadcast meteorologists believe the last half century of climate change is caused largely by humans.**

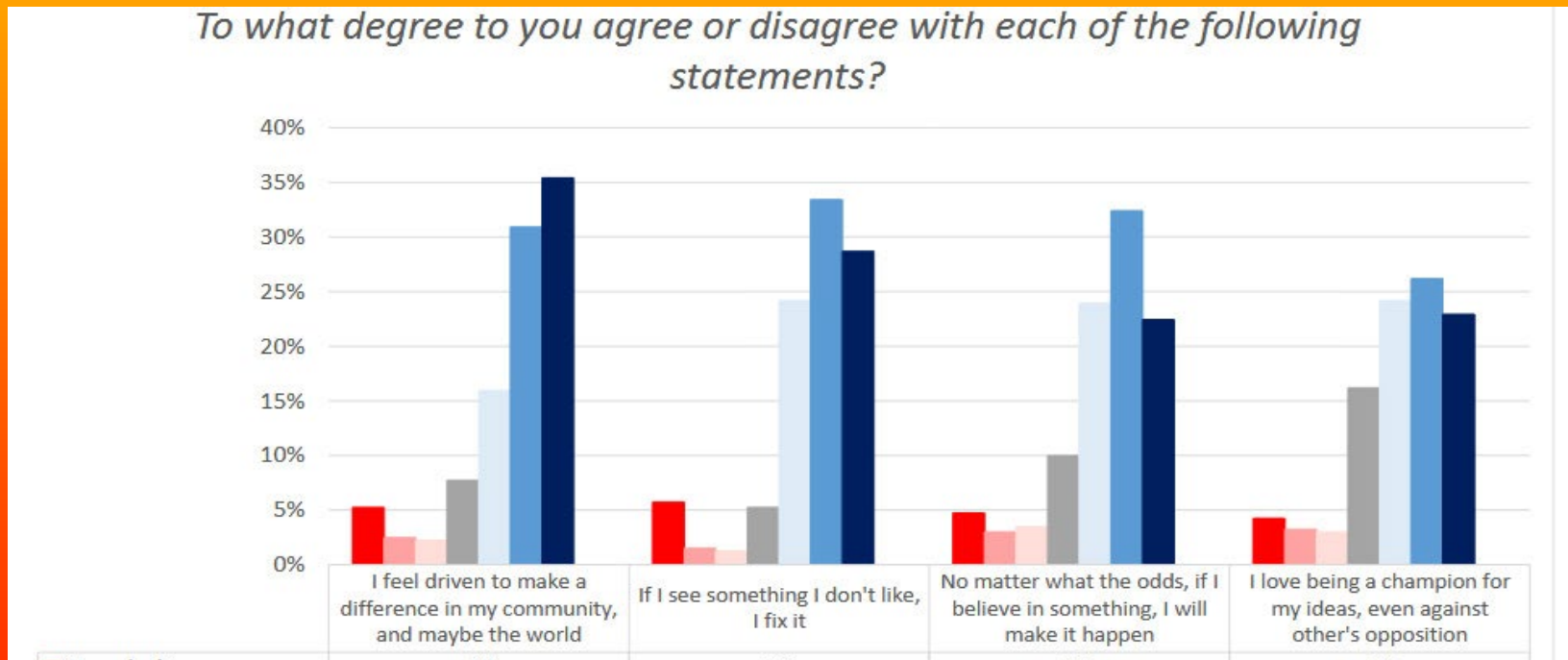
And barely 49% of broadcast media meteorologists think humans are responsible for even half of climate change… ([George Mason University Survey 2017])



Yet the truth is – Humans are responsible for more than 100% of global warming. 6 Different studies here (and there are more) conclude natural contributors are small and have been a net COOLANT to climate



Amazingly, the large majority of radio and TV weathermen proclaim their idealistic courage to persevere against any opposition and make a difference in their community and the world. So, what could possibly explain their failure to know the most easily accessible basic fact about THE most important science happening today, namely - human responsibility for dire climate change?

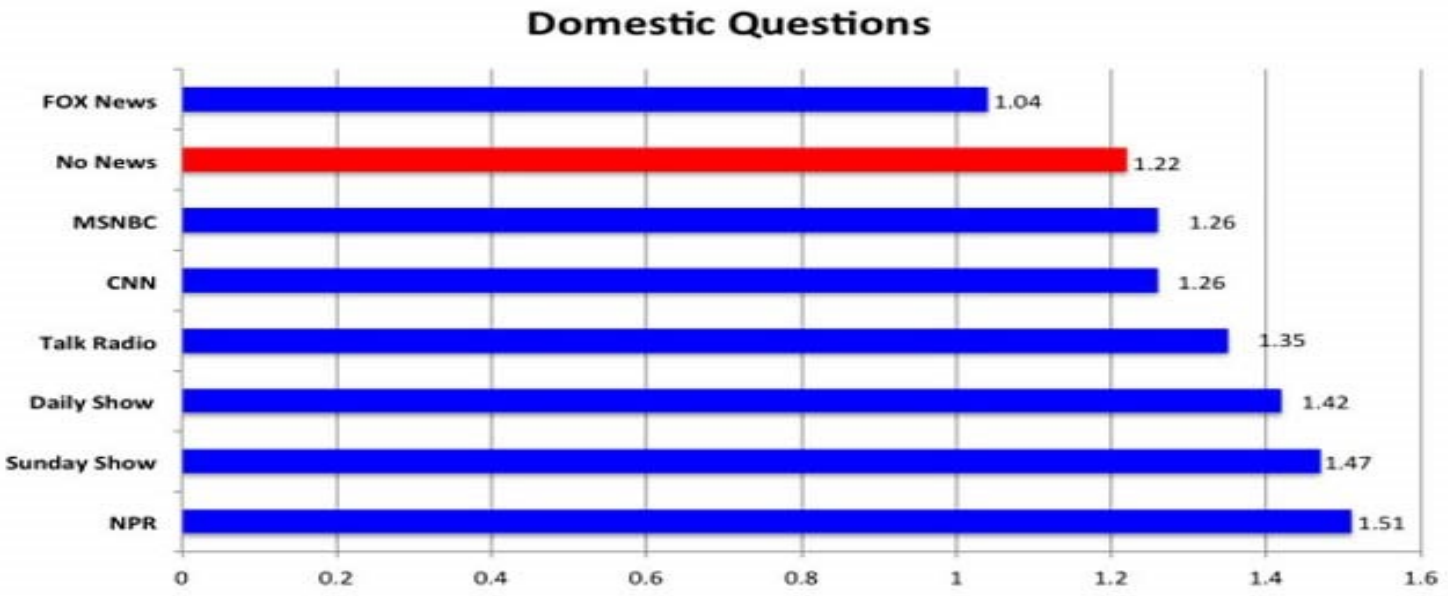


	I feel driven to make a difference in my community, and maybe the world	If I see something I don't like, I fix it	No matter what the odds, if I believe in something, I will make it happen	I love being a champion for my ideas, even against other's opposition
Strongly disagree	5%	6%	5%	4%
Moderately disagree	2%	2%	3%	3%
Slightly disagree	2%	1%	3%	3%
Neither agree nor disagree	8%	5%	10%	16%
Slightly agree	16%	24%	24%	24%
Moderately agree	31%	33%	32%	26%
Strongly agree	35%	29%	22%	23%
Total	401	401	401	401

Corporate media does not inform us, it promotes corporate agendas, for the most part. Consumers of the most popular network – Fox – are even less informed than if they'd watched no news at all. (Dickenson University study 2011)

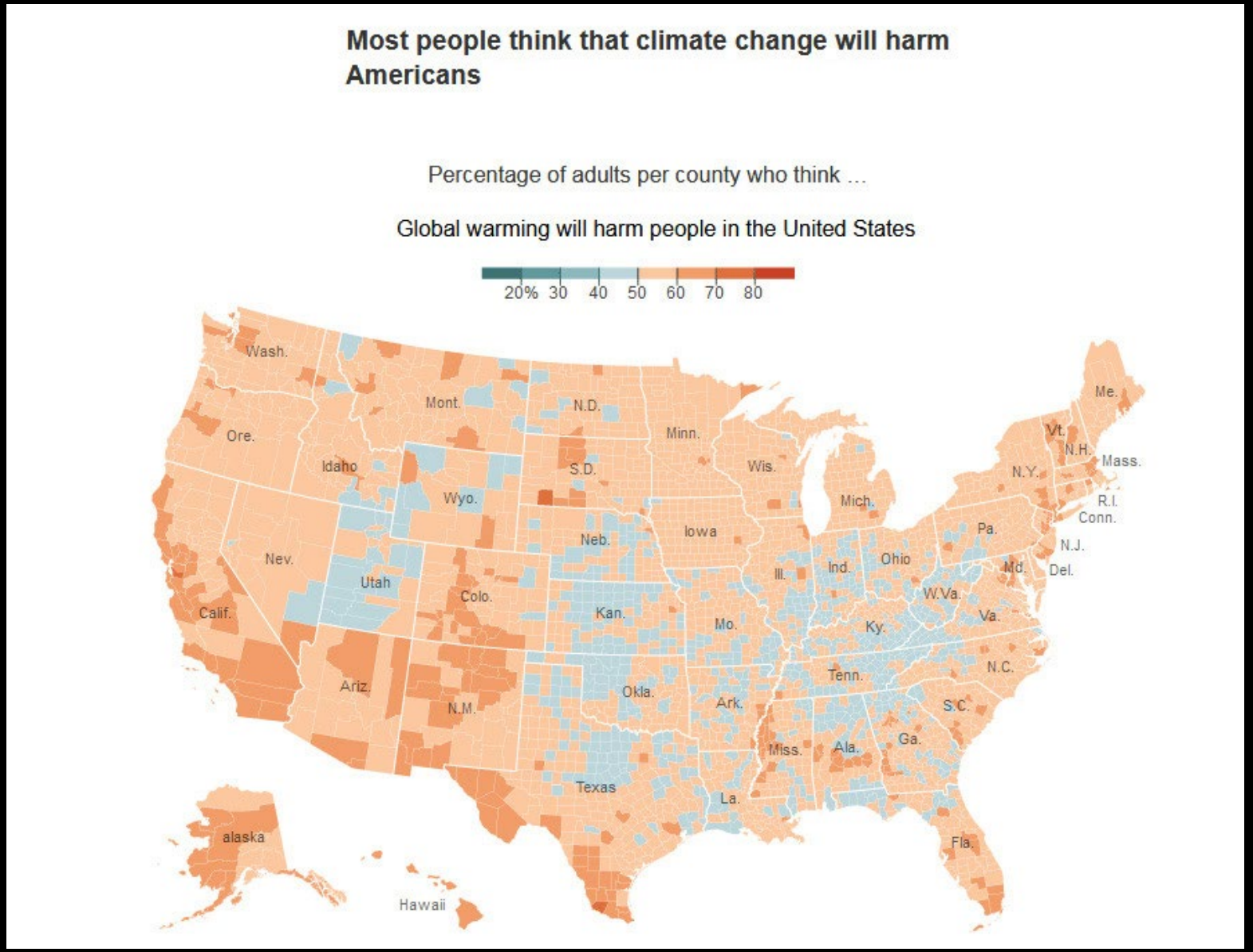
FOX NEWS MAKES YOU LESS INFORMED

It's not like we really needed a study to tell us this, but the **survey** "What You Know Depends on What You Watch," undertaken by Fairleigh Dickinson University, found that watching Fox News results in knowing less about the world. Researchers asked 1,185 respondents which news shows they consumed and then asked general questions about newsworthy events.

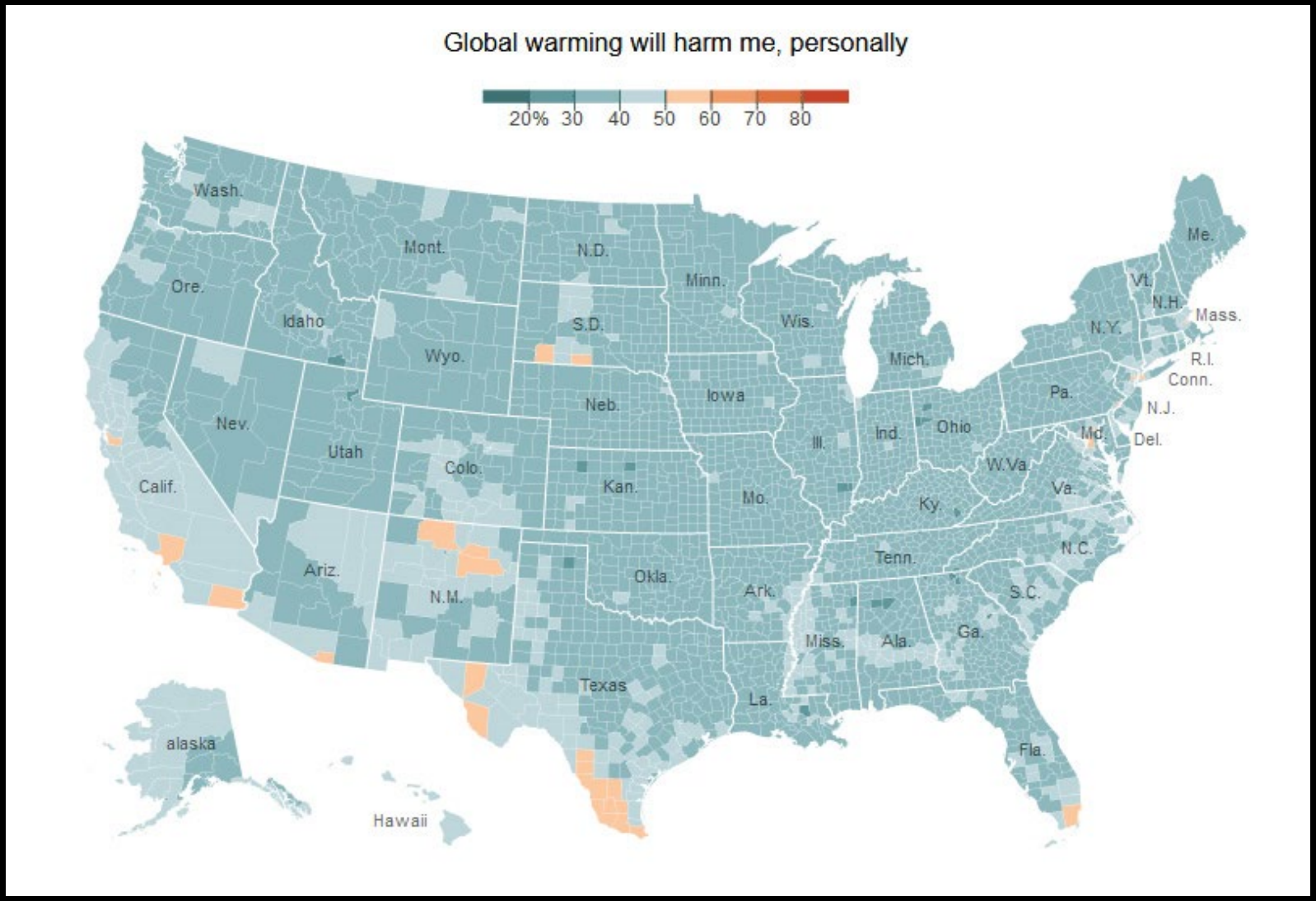


Five questions were asked, and those who watch Fox News exclusively got 1.04 correct, on average. Individuals watching MSNBC, on the other hand, got 1.26. NPR listeners? They got an impressive 1.51. The Daily Show? Surely a "fake news" program couldn't make you more informed than "the most watched cable news channel in America."

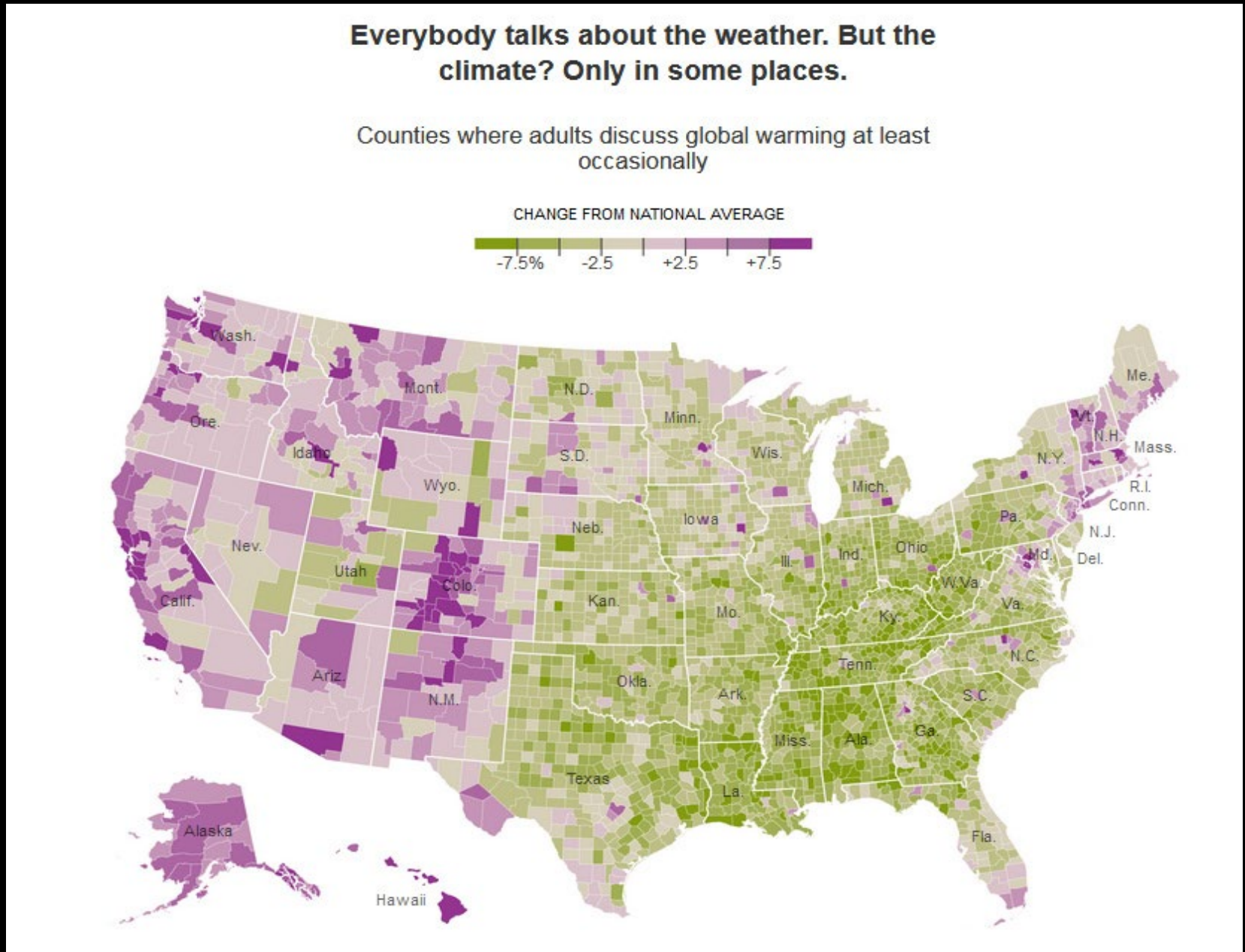
Most people agree – Global warming is real, and it will harm our future's children



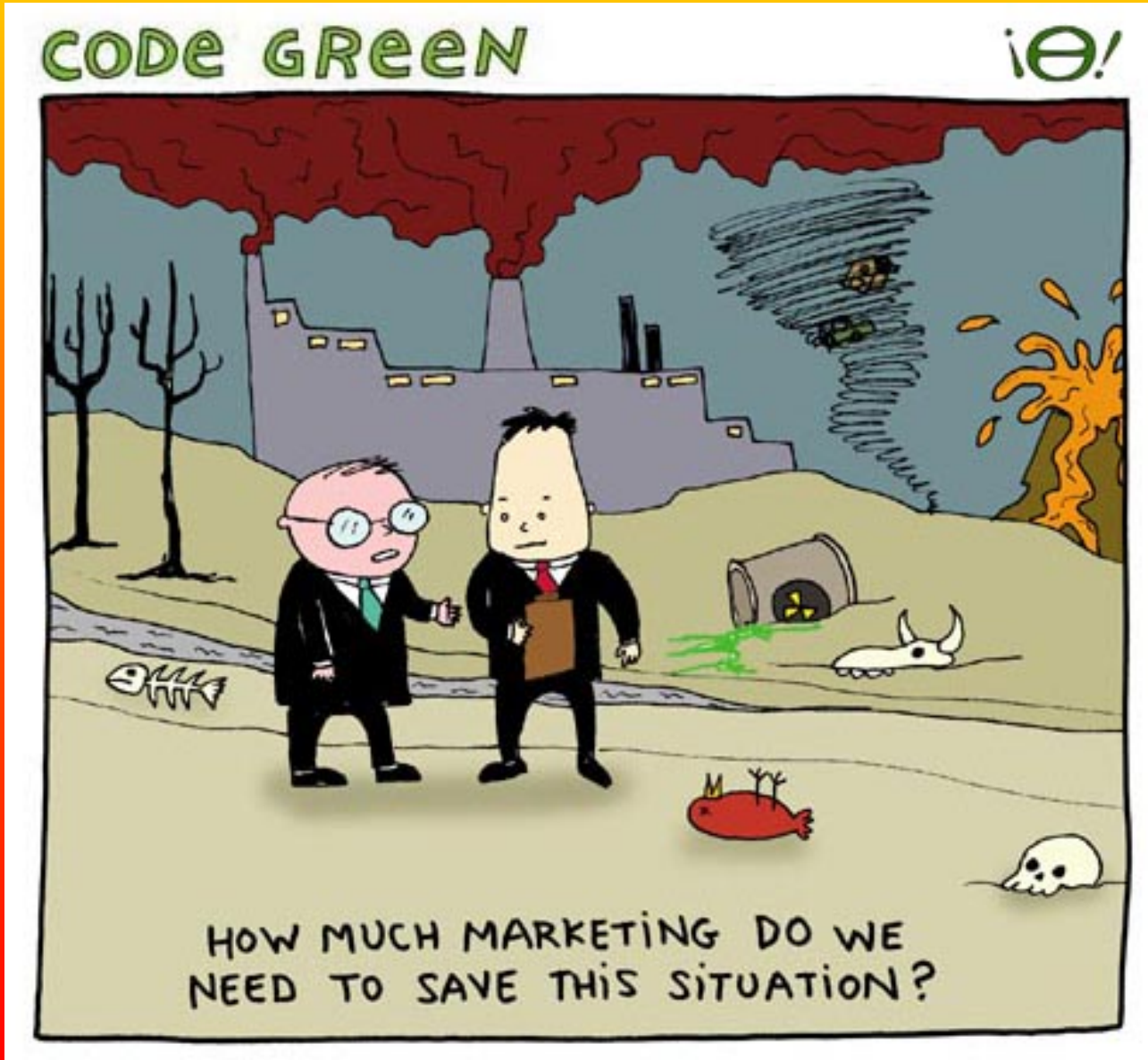
But, *"it won't harm ME. So, let's not do anything; certainly nothing expensive"* – That's our attitude



In fact, let's not even talk about it



For more insights, see "The Psychopathologies of Climate Denial"



“WE COULD HAVE SAVED IT, BUT WE WERE TOO DAMN CHEAP”

- Author Kurt Vonnegut, giving Stanford University’s Graduation speech, repeating a quote from Bergeron,

“…to be etched in the walls of the Grand Canyon for the flying saucer people to find”

So What Do We Do?

- It's clear now – we have waited too long.
- Too many are still living in the '90's, when we thought that individual voluntary carbon-limiting… like higher gas mileage cars, LED light bulbs, eliminating "vampire" appliances, etc., that these are enough to give the Earth the chance to heal.
- ***But it won't. It's too late for small measures. And higher energy efficiency only leads to <u>higher</u> energy use, given human nature. Therefore, now, eliminating all human GHG emissions is just the start of what's needed.***

Inspiring Voluntary Actions?

- In a freedom-loving country, and in an eco-friendly place like Santa Cruz, this can feel promising
- It can also feel personally compelling – *"We're on a mission!"*
- And I'd never discourage anyone from acting to do what is right by limiting their carbon footprint in the many ways you probably already know.
- **But as a STRATEGY, as a #1 CHOICE of WEAPON in the battle against climate change, it is a very poor choice**
- **Conservatives are not reachable, says numerous studies. And eco-friendlies are a minority of Earth's population. And…**

Do the Math - Even if you convinced 1 billion of the richest, most carbon-generating people on Earth…

…to voluntarily cut their carbon footprint in half, you would still only cut global CO2 emissions by ~13%, which is making only a tiny dent in the problem

And cutting your carbon footprint in half is harder than you may think - Your personal idealistic spending is only the first stop for that $dollar. Those who receive your $ will do whatever they will, with the next steps in the economic chain.

And: the U.S. only emits 14% of Global CO2 emissions.

GHG's are globally well-mixed. And Climate is GLOBAL, and can ONLY be fixed by a GLOBAL effort

Here is THE Key Problem with Our Attitudes Towards Energy Transition

- **We refuse to do the uncomfortable thing.**
- Building wind and solar power plants while waiting for fossil fuel power plants to reach the end of their useful life - **is not enough**.
- Making new buildings "green" while leaving older energy inefficient buildings up until they fall down by termites or other necessity - **is not enough**
- Making electric cars or efficient hybrids while waiting for existing cars to live out their natural lives – **is not enough.**
- That process will take many decades to cut the majority of our carbon emissions – **not good enough!**
- **As long as our personal economic well-being rules civilizations decisions, we're dooming our children's future to a grim struggle in a hot, overcrowded world of wars and flooded cities.**

Atmospheres and Planets Have No Choice But to Obey the Laws of Thermodynamics, and to Obey Them Perfectly

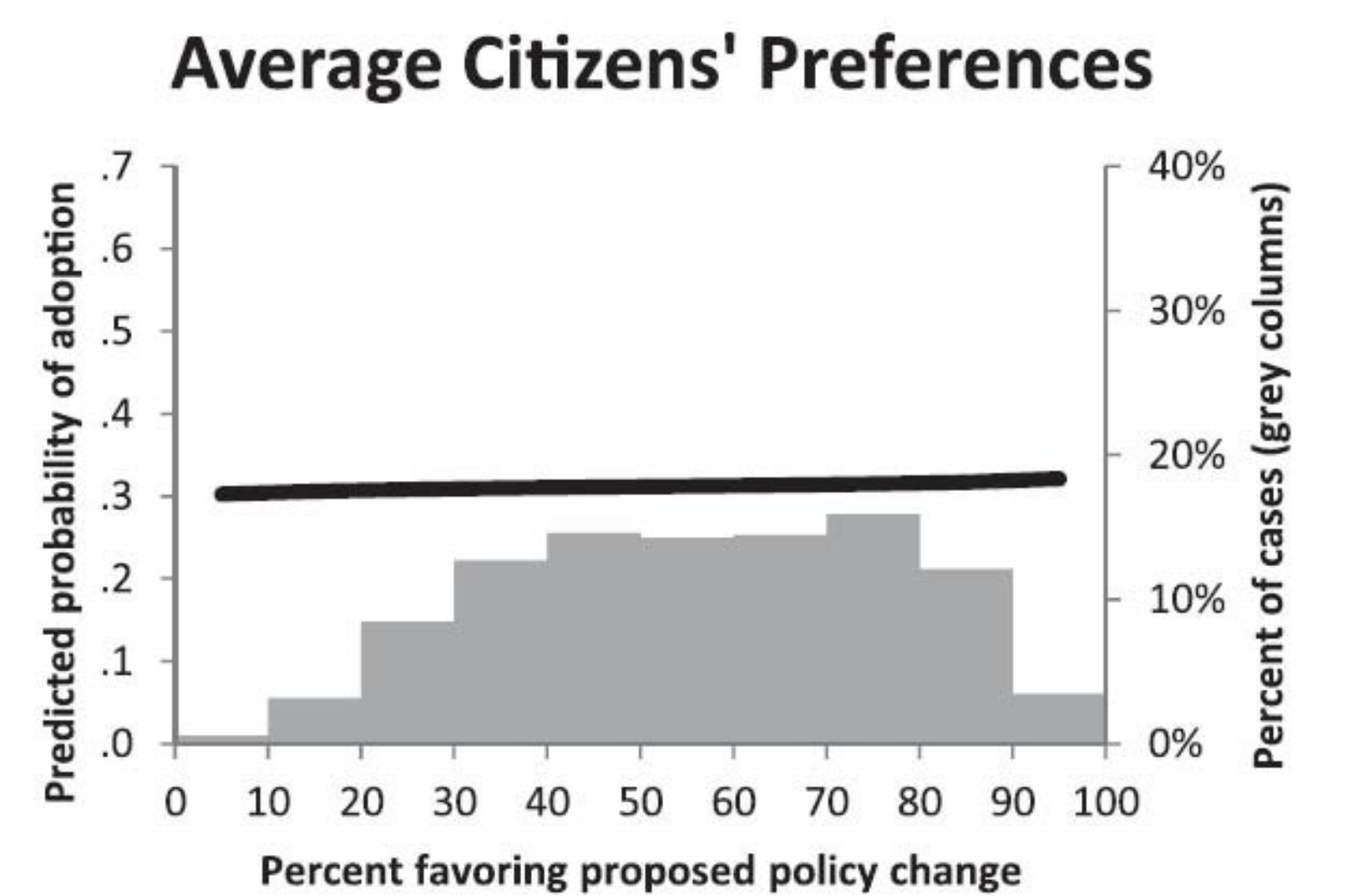
- But humanity DOES have choice. We CAN, by installing global government-enforced willpower, DO THE UNCOMFORTABLE THING
- Instead, we've empowered (or tolerated) demagogues, and those who would manipulate our desire for short-term gratification, and thereby crippled all future generations and other species on Earth.

We Need a New Rebel Alliance. That's YOU!

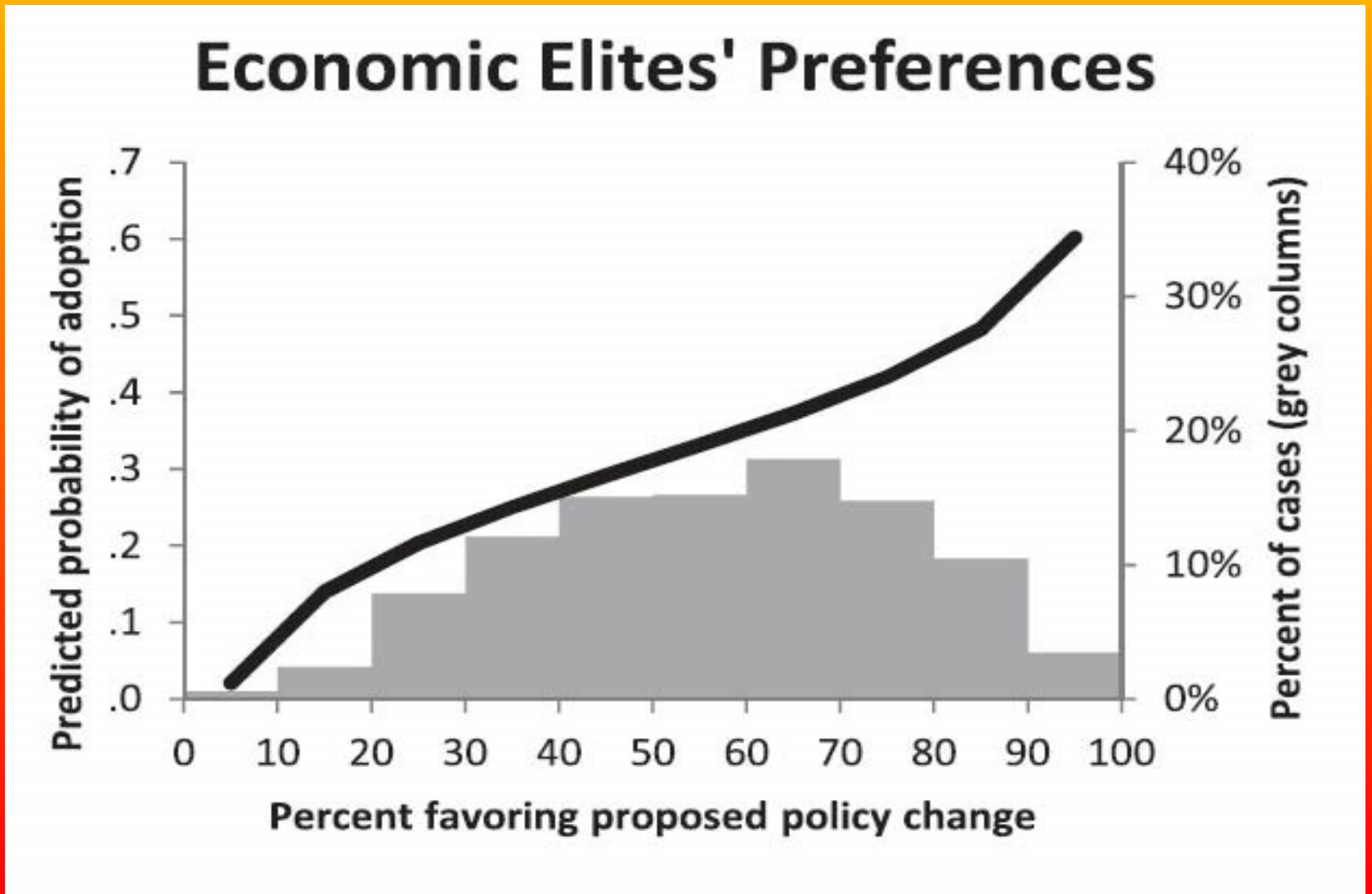
But, You… Doing What? Writing your Congressman?

- Alas, two Princeton researchers, **Gilens and Page**, published a landmark paper in 2014.
- It broke our population into 5 categories
- **1. Average citizens like you and me**
- **2. Mass-based lobbies (like Sierra Club, 350.org…)**
- **3. Business lobbies**
- **4. The Economic Elites and their lobbies**
- Then they studied all legislation introduced in Congress 1981-2002 – This covered both Democrat and Republican majorities in each of the 3 branches of government. And then correlated with the desires of these 4 groups with the legislation

They found: There is exactly ZERO correlation between what legislation is desired by average citizens, and what legislation actually gets enacted (Gilens and Page 2014): Whether you loved, or hated, a legislative proposal – the odds of adoption were the same: 30%



But Near-Perfect correlation between what the Economic Elites want and what gets adopted. And worse - legislation they hate NEVER gets enacted. This is a deep systemic dysfunction. Without fixing this, policy will continue as is.



Psychopaths in Corporate CEO Boardrooms

- So who are the Economic Elites and their corporate lobbies? Can we trust them?
- **This study** (**Brooks *et al.* 2016**, to be published in ***The European Journal of Psychology***) finds **~ 21% of Corporate CEO's fit the diagnosis for psychopaths.**
- **This is the same fraction as found in prisons.**
- **In the general population, the rate is only 1%, says the same study.**
- Lead author and forensic psychologist Nathan Brooks notes: *"For psychopaths, it [corporate success] is a game and they don't mind if they violate morals. It is about getting where they want in the company and having dominance over others."*

The Evidence is Overwhelming…

- **Your political influence, including climate policy - is ZERO!**
- Continuing to politely ask your congressman to "do the right thing" will continue to be ignored. **CONGRESS makes the laws that CONGRESS (and the rest of us) must obey**. And Congress does the bidding of those who line their pockets.
- **They, and their corporate overlords, are on the <u>inside</u>. YOU, are on the <u>outside</u>.**
- **I'm SORRY!..... DEAL WITH IT!**

If You're Alarmed and Outraged…

- **Congratulations!** That is exactly the healthy appropriate response!
- Nature gave us the capacity to energize and to rise up when key values are deeply threatened!
- And its indeed the response our survival requires! It means you're PAYING ATTENTION
- We're crossing irreversible tipping points NOW
- Not in 10, 20, 50 years. **NOW!**
- **The full effects won't start to really hurt many of us for 10, 20, 30+ years, but we're making them inevitable NOW.**

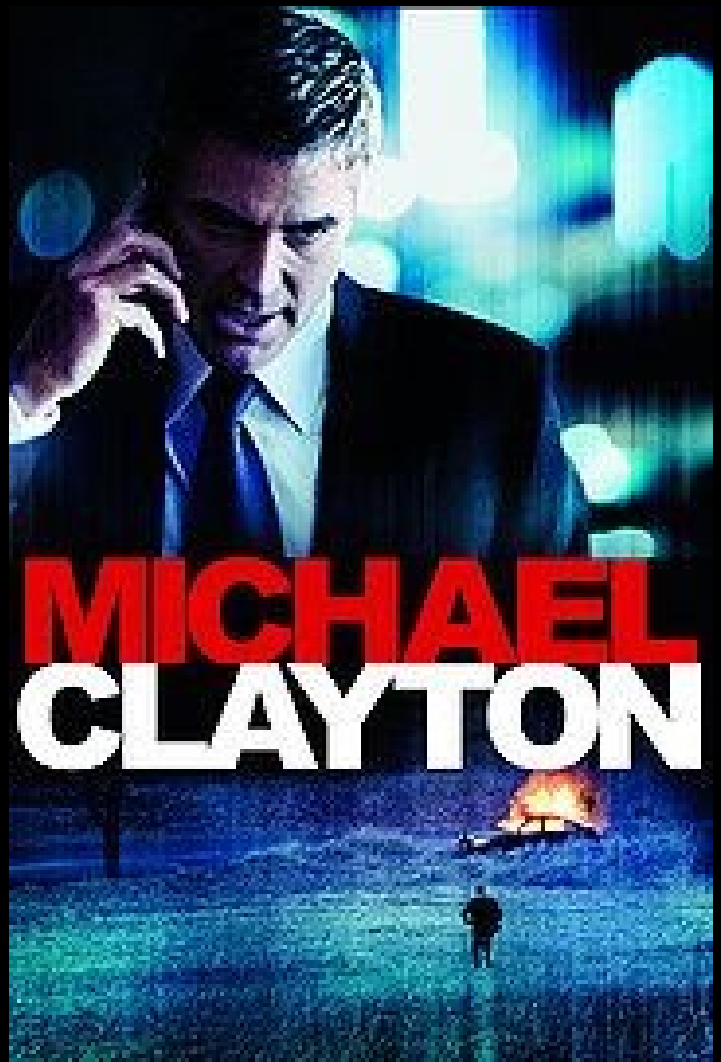
An Analogy to our Media-Induced Complacency Response So Far…

- Imagine the following "To do" list…

- 1. Take out the garbage.
- 2. Water the lawn.
- 3. Get groceries.
- …
- 10. Think about calling the fire department to deal with the raging fire burning down my house now.

- **Insane, right?**
- **Either we solve climate, or the rest hardly matters.**

Remember the classic line from George Clooney's character in **Michael Clayton** – *"DO I LOOK LIKE I'M NEGOTIATING!?"*



Consider: Occupy DC

- If there is any honor hiding beneath politicians' corporate funded personas – give that "inner hero" a chance to emerge! **How?**
- **A million person occupation, supported by those who will supply the occupiers with food, water, toilet paper, tents… continually from the borders of the City.**
- **PEACEFUL, NON-VIOLENT, and yes – let the occupiers be carried off to jail if the Authorities choose.**
- **An Occupation, not a March. It would be to present demands of our government – who should be working for us and our future - and not leave until they were met…**
- **Presented with such a Rebel Alliance, congressmen could legitimately go against their corporate sponsors. It's the perfect excuse for them to DO THE RIGHT THING.**
- **OK: Demand what? Key Climate Policy Demands…**

#1 Carbon Tax-and-Dividend Policy

- Tax carbon mining, **NOT emissions**! Tax it where it enters the U.S. (well-head, or ports), and return tax receipts to the citizens directly via monthly checks. ~$100/ton for starters, and rising annually.
- This would raise the prices of anything requiring carbon energy (most everything today), dis-incentivizing carbon use. Price rises would be lower on low-carbon energy uses, encouraging their further adoption. But mostly, it would rapidly motivate ending fossil fuel MINING, which is what is needed. **Taxing emissions mostly hurts the poor**. Cap-and-Trade **does NOT work**.
- Higher prices would be offset by monthly checks-in-the-mail for most of us.
- **CCL: Citizen's Climate Lobby** – grass roots organization whose sole purpose is to try to get such legislation passed. **Santa Cruz CCL** very active.

#2: A New Amendment to the U.S. Constitution

- I would propose a 28th Amendment to the Constitution…

- ***Congress shall permit no law denying the rights of present and future citizens to safe commons, including air, ground water, river water, and natural forest. Congress shall permit no laws which interfere with the existence of a natural environment in harmony with the right to life and the pursuit of happiness by future as well as present citizens.***

- **These policies incentivize the technological initiatives needed, despite their high costs**

#3. An ESSENTIAL Emergency Techno Stop-Gap

- We MUST prevent further melting of the permafrost, and therefore we MUST cool the Earth enough to bring back the Arctic Ocean's permanent ice cap, which is the cause of Permafrost melt
- **How?**

How To Judge Geo-Engineering Ideas You'll See Advertised

- **1. All EFFECTIVE strategies must either**

  A. Reflect additional sunlight back to space, or

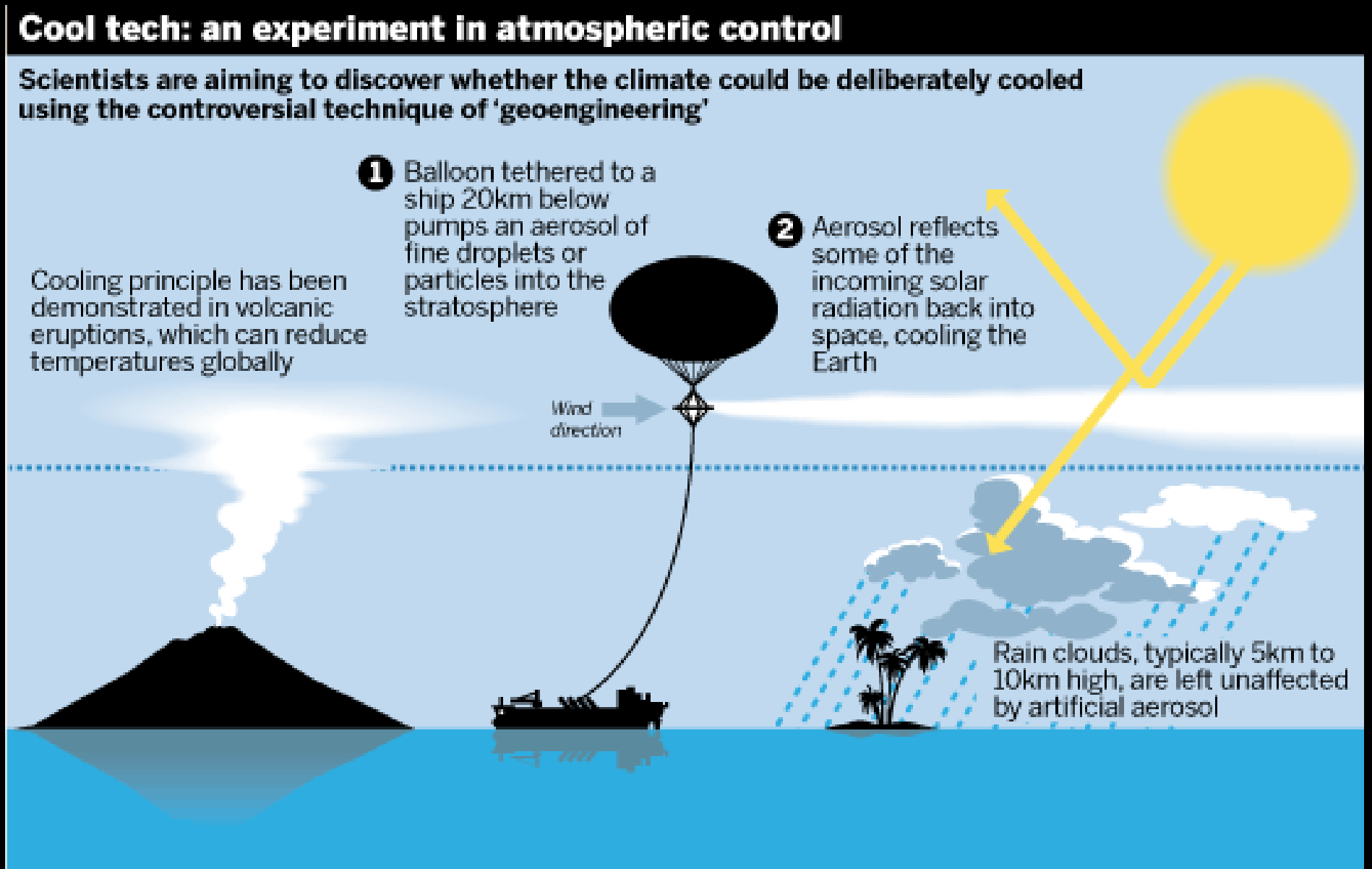
  B. Enhance Earth's ability to radiate heat to space

- **2. All SAFE strategies should have no hysteresis**
- In other words - take the us BACK along the same Earth system trajectory that got us here: Examples - reverse atmospheric GHG's, re-freeze the poles, re-grow tropical rainforests, let soils recover carbon-sequestering capability by ending current Big Ag practices.

Safe Strategies…

- **…Should NOT** involve global changes to weather and eco-systems in ways significantly different than any we have seen. Highly dangerous!
- There are millions of species, and ecosystem interactions have been studied for only a few, and even those -incompletely.
- **When you discover you're in a mine field – you carefully retrace your steps. You don't run in new directions!**

Inject reflective sulfate or CaCO3 aerosols into the stratosphere continually? A "SunShade"



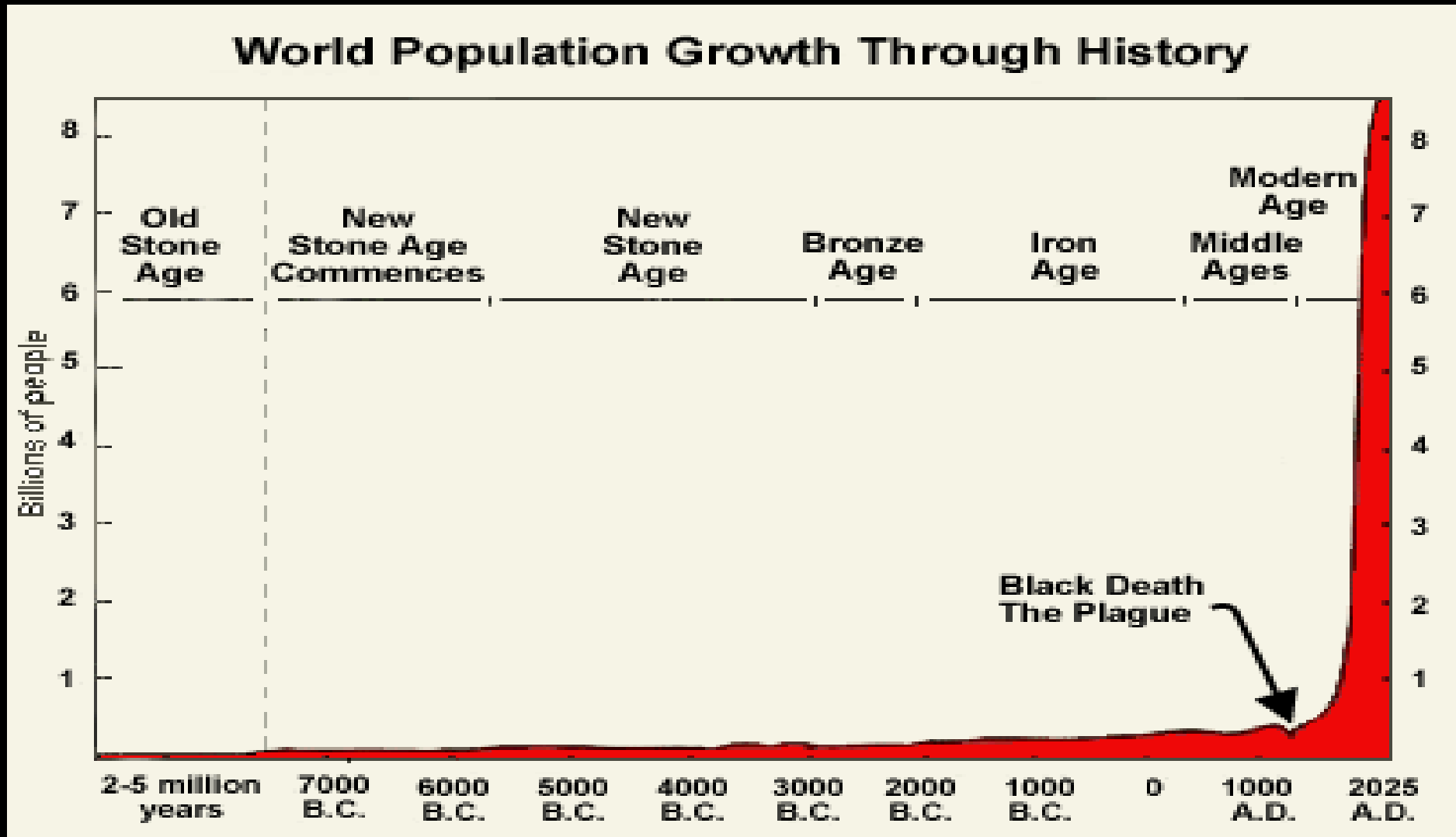
It's cheap, effective, and there's a chance it might be Relatively Safe

- Studies suggest this might be done for less than 1% of Gross World Product yearly.
- From volcanic eruptions into the stratosphere, we are confident it would indeed lower global temperatures
- But once started it must be continued until we can additionally pull CO2 back out of the atmosphere, else climate heating would skyrocket once halted.
- **Dangers:**
- --Would the droplets combine, worsening reflectivity and hastening fallout from the stratosphere, necessitating higher injection rates?
- Inject too much, and acid rain will cripple land systems
- Sulfates plus water vapor in the stratosphere causes ozone destruction. Might be minimal if droplet size after injection remains small. That gives more reflectivity per ton of sulfate.
- Ozone damage IS seen after major volcanic eruptions
- Can we substitute calcium carbonate aerosols, which would be ozone safe – but would they be reflective enough?

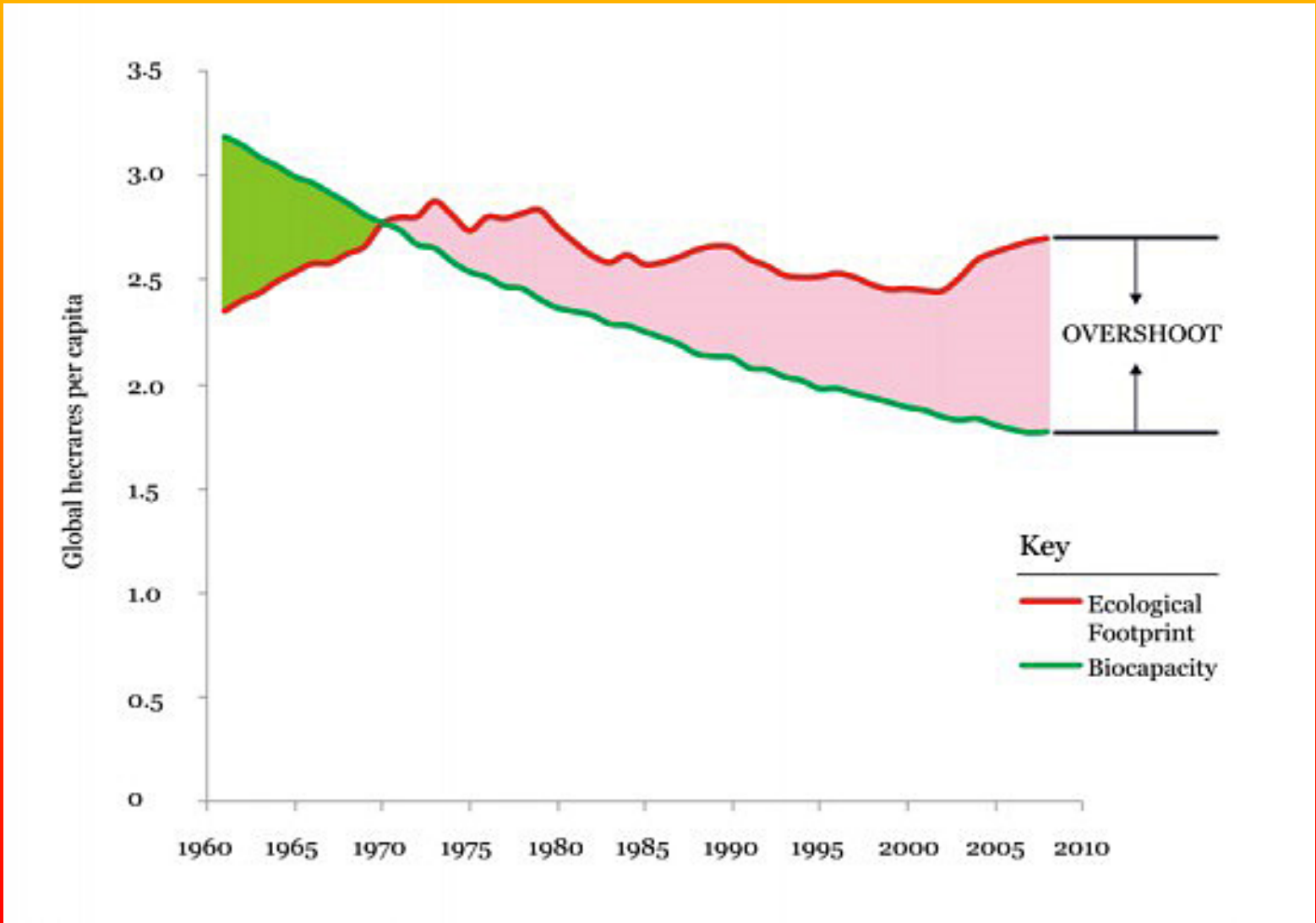
Let's Suppose it's Safe and it Works. OK, Now that we've Bought Time…

- What do we **do** with that time?
- **The #1 Global Policy Action to help the future – LIMIT POPULATION**
- People = Energy Consumption.
- And Energy Consumption = CO2 emissions.
- Merely building new renewable power while leaving existing carbon power, as we're doing, leaves us walking 3 mph down, on an escalator going **up** at 5 mph. **It's not enough**
- **Prof Kevin Anderson** – Tyndall Climate Centre head – has courageously gone on record with this truth, and that our goals can only be met by drastically REDUCING our energy consumption immediately – **something NO ONE wants to hear**

The discovery of millions of years of accumulated solar energy in the form of energy-rich hydrocarbon, allowed us to skyrocket domination of the planet



Beyond just climate, unrestrained population growth has impoverished our soils, stripped the oceans, and generally degraded Earth's ability to re-generate wealth (declining green line) at a rate of 1.5 Earth's worth today (red).

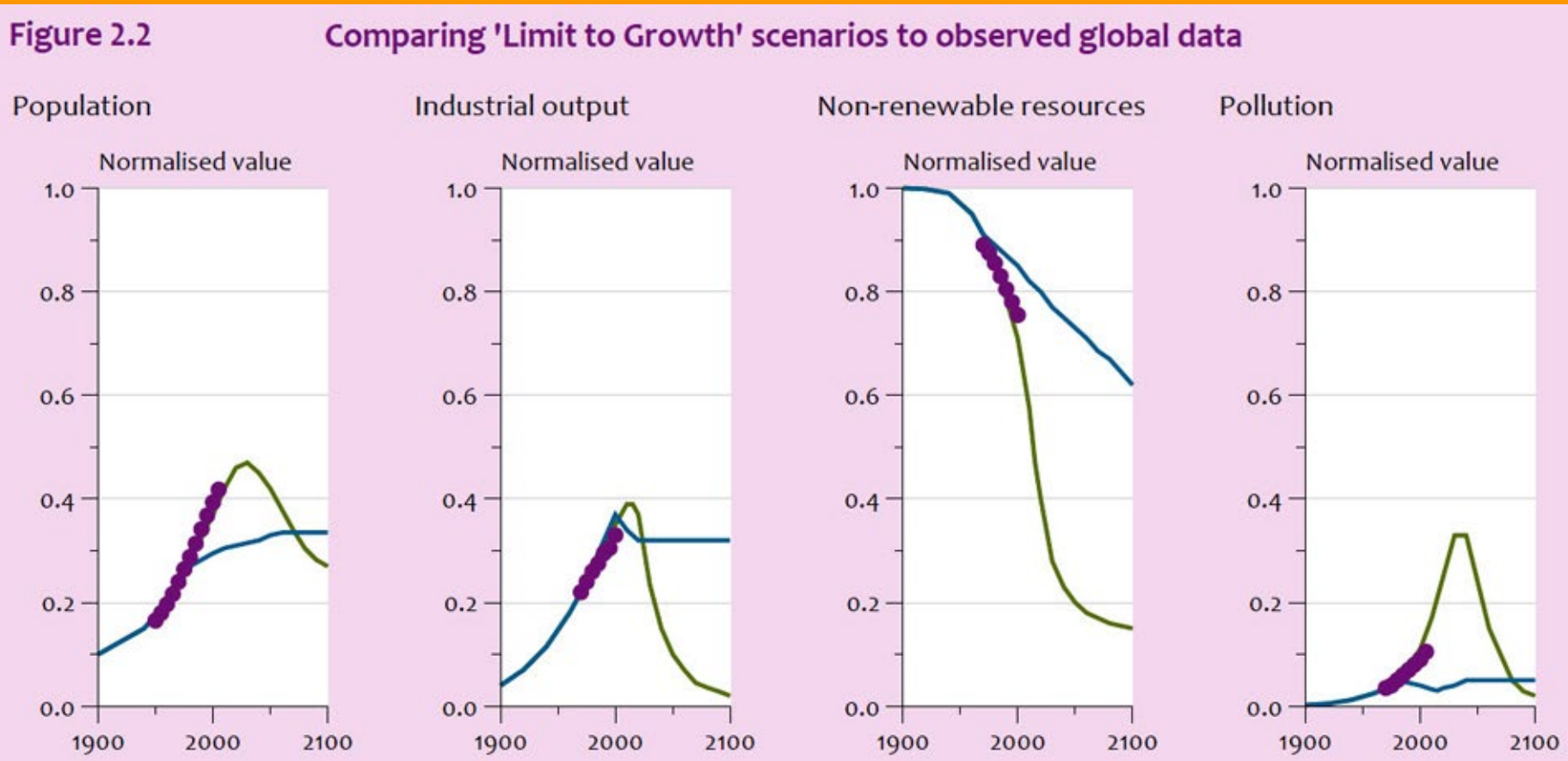


Politically impossible, but what's NEEDED is a **Global 1-Child-Per-Family Policy, strictly enforced**

Actually, we need even LESS than 1 child per family

- Even **1 child per family** instituted now, globally, keeps population rising till 2045, and is still as high as 4 billion at year 2100 (U. Adelaide study).
- Yet it's calculated we are deeply in bio-capacity debt, using up 1.5 Earth's to support ourselves on 1.0 Earths.
- **How's that possible? Because we're rapidly eating through our seed corn**, of topsoil, of ocean and land primary productivity (humans commandeer 36% already). Not sustainable. We'll pay – the hard way – unless we take major and unpopular actions

Studies done for the Netherlands Environmental Assessment Agency finds we're on "Overshoot and Crash" trajectories for Earth's Systems



Judging Other Climate Proposals and Geo-Engineering Ideas

- **OTEC Pipes to bring cool deepwater to surface:** But thus burying warm surface ocean to deeper layers, worsening heat imbalance, so Don't Do it! Fails both 1A,B and also 2A and 2B. It's incredibly damaging to the future.
- **Iron seeding** of surface ocean to stimulate algae and carbon capture. Fails 2A, 2B.
- **Plant Trees.** Honorable idea, but far too slow. We'd need to plant trees over an area bigger than the U.S. to have much effect. IPCC says tree-planting only helps us a few % towards our goal. End deforestation for starters! No more rainforest loss to add livestock for McDonalds burgers!
- **Go organic, help soil carbon capture.** Must be GLOBAL, remember! Good idea and necessary; topsoil loss is up to 1%/yr currently. Also, would cut nitrous oxide GHG from fertilizers. But at best, once soil is "topped up" with healthy carbon, it won't sequester more. **Will drive up cost of food with high risk of famine, revolution, starvation among the poor on Earth.**
- **Less meat, more vegetables**. Top-of-the-food chain agriculture is very expensive to our resources. We love meat, but we could do with less of it, and Earth most certainly could.

Longer Term: Must pull our CO2 back out of the atmosphere

- Liquify and inject underground? Hard, expensive. But satisfies both safety criteria. It's what we must do.
- Combine with limestone to make bicarbonate and dump into the ocean? Prof. Greg Rau at UCSC working on this but looks only possible on very small scales locally.
- Inject CO2 into basalt formations and let it form carbonate underground? See "CarbFix" on web.
- Artificial trees? Highly energy intensive, expensive ~$300/ton of CO2 at climate relevant scales? Once captured, what do you DO with that much CO2? We have much to learn here. But – what's our planet worth? Shall we start the bidding at INFINITY?

Wind-powered pumps in Winter Arctic Ocean to re-build Ice Cap?

- Intriguing because it **satisfies 1A and also 2A, 2B**. Looks both safe and effective, if techno challenges can be met, and we stop being cheapskates about our children's future.
- The idea is to use wind-power to pump sea water from beneath thin ice and spray it onto the colder Winter surface where it will freeze and thicken the ice enough that it doesn't all melt in summer. (**Desch *et al.* 2017**)
- Need **millions** of them.
- Cost: they estimate $50B/yr or 0.05% of Gross World Product. But suppose it's 50 times higher, = a couple of percent of world GDP. Now, ask - what's the future worth?
- Maintenance in harsh environment? Lifetime of given wind pump? Techno challenges to achieve goal… all are just in the beginnings of study.

Great Drama Writing and Screen Plays – Humans Love and Need Stories

- Story-telling is deep in our genes, from pre-civilized times
- We need to experience emotionally compelling human-driven meaning of climate change, portrayed in great films. Not just documentaries – but great stories.
- Think of **"On the Beach" (1958)**, by the great 20th century film director Stanley Kramer (no, it's not a beach-blanket romp from Disney – it's a story about the end of the world). Nobel Laureate Linus Pauling (Chemistry, and also Peace) credited this 1958 film with pulling us back from the brink of nuclear Armageddon.

Beyond New Techno's and Other Strategies… We Need FUNDAMENTAL Transformation

- NONE of these techno-strategies will save us in the longer run – UNLESS we fundamentally transform our notions of "success", of "wealth", of what is the source of GENIUNE HUMAN HAPPINESS
- Techno will only buy time until the inevitable ugly collapse.
- Think of rats that breed until finally they turn to cannibalism
- We MUST question "Growth *Uber Alles*" as a value. We MUST question how we empower (or tolerate) the appalling political/economic leaders who have ruled nearly all countries at nearly all times in history, and their psychopathological agendas.

<u>It's the most innocent – and that includes you</u> - who will bear the true cost of our refusal to face Reality


Sorry!
The lifestyle you
ordered is currently
out of stock

Here are a Selection of Other Presentations I've Put Together Recently

- The New Post-IPCC Climate Science – A Darker Frame for our Options
- Ice Melt, Sea Level Rise, and Super Storms – on the latest research from James Hansen
- Economic Growth and CO2 – Realism and Climate Policy from the Thermodynamics of Civilization
- The Psycho-pathologies of Climate Denial

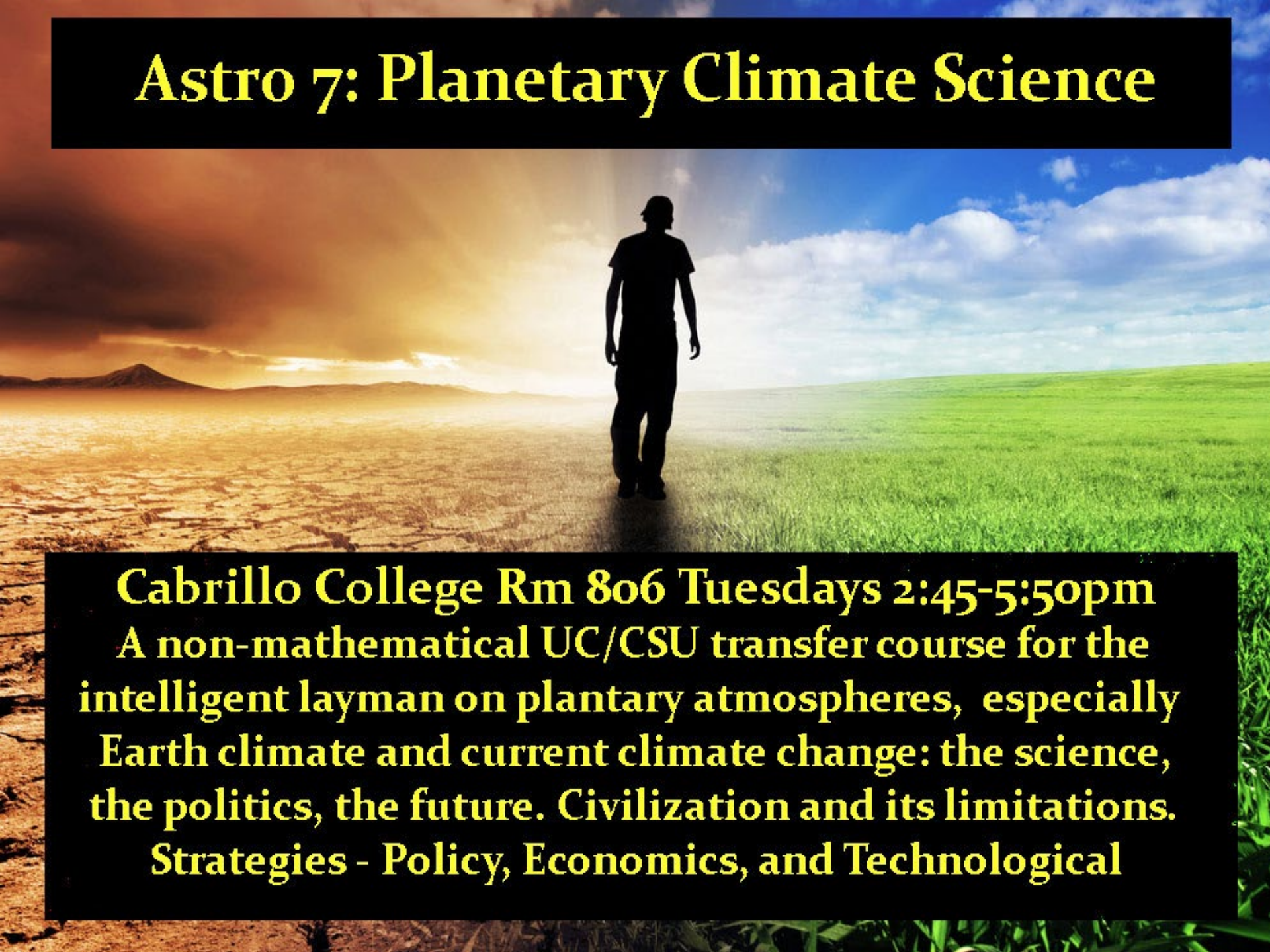
Cabrillo's 5 year $5 Million Grant to Strengthen its Environmental Sustainability Curriculum

- New efforts in Construction Engineering Management Dept, Engineering Dept, and Astronomy Dept, likely others
- Creation of a "Sustainability Certificate" for completion of a series of courses, including my **Astro 7 "Planetary Climate Science".**
- Likely creation of a dedicated **AA/AS in Sustainability**, but curriculum development is still a year or two away. We're at the beginning – details being pondered as we speak!
- **Astronomers are among the leaders in efforts to understand Planetary Climate, with on-going discoveries of thousands of exo-planetary systems and the new James Webb Space Telescope launch next year**

Learn Much More: Take my "Astro 7: Planetary Climate Science" Course

- It is Cabrillo's ONLY dedicated course in Climate, and has far more detail than the brief mentions given in the Environmental Science classes or the Meteorology class.
- Offered every semester
- This Fall, it's 2:45-5:50pm, once-a-week on Tuesdays
- No Prerequisites. High school students welcome
- I tell you explicitly in lecture what I'll ask on the quizzes and final exam and call attention to such moments clearly.
- Most students earn "A" grades if they attend and listen to every lecture.
- Why do I do this? Your climate education is my goal, and this is the best way to motivate coming to every lecture.

Astro 7: Planetary Climate Science



Cabrillo College Rm 806 Tuesdays 2:45-5:50pm

A non-mathematical UC/CSU transfer course for the intelligent layman on plantary atmospheres, especially Earth climate and current climate change: the science, the politics, the future. Civilization and its limitations. Strategies - Policy, Economics, and Technological

What's Covered in Astro 7?

-- Principles of clear thinking and Scientific method

-- modes of heat transfer, light and interactions with molecules, the Greenhouse Effect

-- climate for other planets

-- Paleo climate of Earth, atmosphere structure, carbon cycles, clouds/aerosols

-- **Current/future Earth Climate Change is most of the course:**

- Causes, proofs of human-causation of climate change
- Climate modelling, radiative forcings
- Ocean/atmosphere connection
- Changes: temperature, ice sheets, ocean acidification, deforestation, sea level rise, storms, other effects…
- Psychopathologies of climate denial, political aspects
- Debunking climate denialists bogus claims
- Future climate - the post-IPCC science is much more dire
- The Thermodynamics of Civilization itself and how constrains solutions
- Strategies: Govt Policy, economics
- Strategies: Technological and GeoEngineering