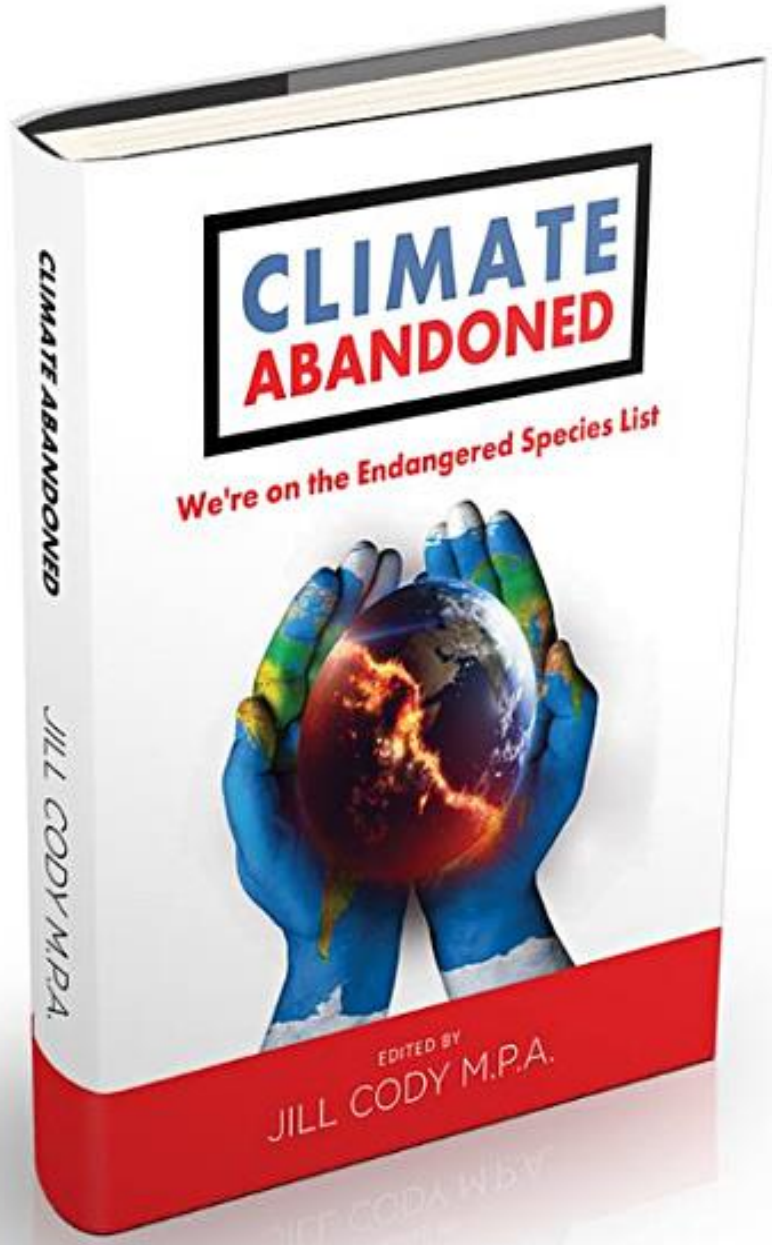
"Climate Abandoned: Will Human Civilization and its Thermodynamics Permit Sustainability and Climate Stability?"

Dr. Richard Nolthenius

May 16, 2019
Cabrillo College, California
Erica Schilling Auditorium



Summarizing and Expanding upon my chapter

"The Climate Crisis: Civilization's Unacknowledged Energy Economic Constraints"

in the new anthology

"Climate Abandoned"

by Jill Cody

Outline for Tonight

- Civilization as a thermodynamic system
- Why is the Garrett Relation obeyed? – the human animal.
- Implications for atmospheric CO2
- Indirect GHG from Post-IPCC AR5 science
- Growth on a finite planet.
- Techno-fixes, the double-bind with growth
- Policy necessities
- Is there hope, given the Civilization System and its programming?

My Goals: I'm Not a Salesman!

- I'm not here to manipulate you,
- …but instead to present the evidence: for the physics, the human motives, the civilization dynamics, and a framework for safe climate strategies for those who are evidence-oriented and just want straight talk.
- I'm not trying to convince Republicans of the error of their ways. We'll see why that is wasteful of time we don't have.
- I assume my audience is literate, accepts human-caused climate change, but doesn't realize the full extent, nor the fatal flaws of many agenda-oriented "solutions".

Civilization as a Thermodynamic System

Bear With Me… for a little math

Here's my own framing of the logic in applying Thermodynamics to Civilization…

- In physical thermodynamics (remember your college science?)… the incremental change of energy d**E**, which includes internal energy, external energy being input, and the Gibbs energy **dW** of **useful energy** ("work" **W**) done on, or extracted from the system, is accompanied by the production of **entropy S** ("disorder") which, at constant temperature **T** is…

- $dE = TdS$

And So Over Time…

- (*i.e.* differentiate over time), we see that…

The rate of <u>entropy change</u> in a system is associated with a proportional rate of <u>energy consumption</u> (=<u>Power</u>)

In Civilization's Market Economy…

- …Spending to pay for an "ordering" of things, in general, has a close relationship to **cost**, given competition and hence typically thin profit margins.
- We infer, then, that **cost** is proportional to the amount of **change** (effort) needing to be effected upon our physical and mental states to achieve our civilized ("ordering") goals.
- Laborious, time-consuming effort to make a high reduction in Civilization's entropy $\mathbf{S_c}$ therefore incurs high **cost**, and requires proportionally high physical **ENERGY** consumption to power it.

Now in the Context of Civilization… "Primary Energy"

- The correspondent of "total energy" is called **"Primary Energy"**
- It is the raw energy provided by Nature.
- A portion; **"Useful Energy";** accomplishes human values – powering the networks of our relationships to each other and to material things, enhancing the growth of civilization.

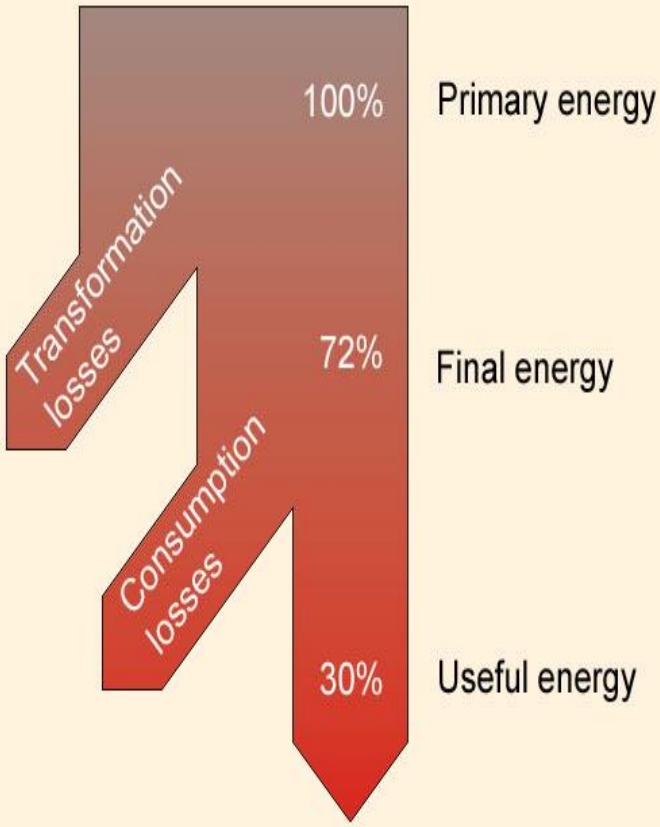


Figure 1: Energy flow for world-wide conversion losses from primary energy to useful enery

The Analog for Physical Entropy S, is the Amount of Disorder S_c in the Civilization + Environment System

- **Growth** in Civilization means "ordering" materials to serve human purpose, and so must correspond to a **reduction** in Civilization's portion of $\mathbf{S_c}$
- **The 2nd Law of Thermodynamics says** this will happen at the expense of greater disorder in $\mathbf{S_c}$ in the total environment system, powered by the expenditure of physical ENERGY).

Human Purposes… Just What IS “Wealth”?

I’ll give you a hint: It’s not Cash

…and it’s not Stuff

Tim Garrett's Key Insight: The Nature of Economic Value

- Conventional economics links value to two things: Labor, and Capital, by a rather arbitrary fitting function (the Cobb-Douglas function, below) with adjustable parameters to force a fit.
- Don't worry about the math here; it's dimensionally wrong, and it misses the point…

In its most standard form for production of a single good with two factors, the function is

$$Y = AL^{\beta}K^{\alpha}$$

where:

- Y = total production (the real value of all goods produced in a year or 365.25 days)
- L = labor input (the total number of person-hours worked in a year or 365.25 days)
- K = capital input (a measure of all machinery, equipment, and buildings; the value of capital input divided by the price of capital) [clarification needed]
- A = total factor productivity and your usual depreciation by utility in day after [clarification needed]
- α and β are the output elasticities of capital and labor, respectively. These values are constants determined by available technology.

Note that Energy is Entirely Missing! It's Taken for Granted

- But Garrett realized that <u>value is manifest only along **active networks**</u>, linking people to people, and people to materials.
- **Action = Value. Stillness = Death, Valueless**

And Active Networks Require CONTINUOUS Energy Consumption: (*i.e.* Power)

- **Power** – to overcome friction
- **Power** – to maintain against the 2nd Law's decay
- **Power** – to move people in trains, planes, and cars, energy through wires, fluid through pipes
- **Power –** for communications, flows of money and materials…
- **Power** – to access new energy reserves and enable more growth

But the Networks of Today…

- …are the combined work of **all past civilizing** of the raw Earth.
- The power we must consume today is not merely proportional to the new networks built today, but to support the sum total of **all** civilizing that has ever been done.
- Even things long turned to dust – a ghost of them lives on in the growth they enabled, which has compounded over time.
- **Which brings us to the key relationship: What I call <u>"The Garrett Relation"…</u>**

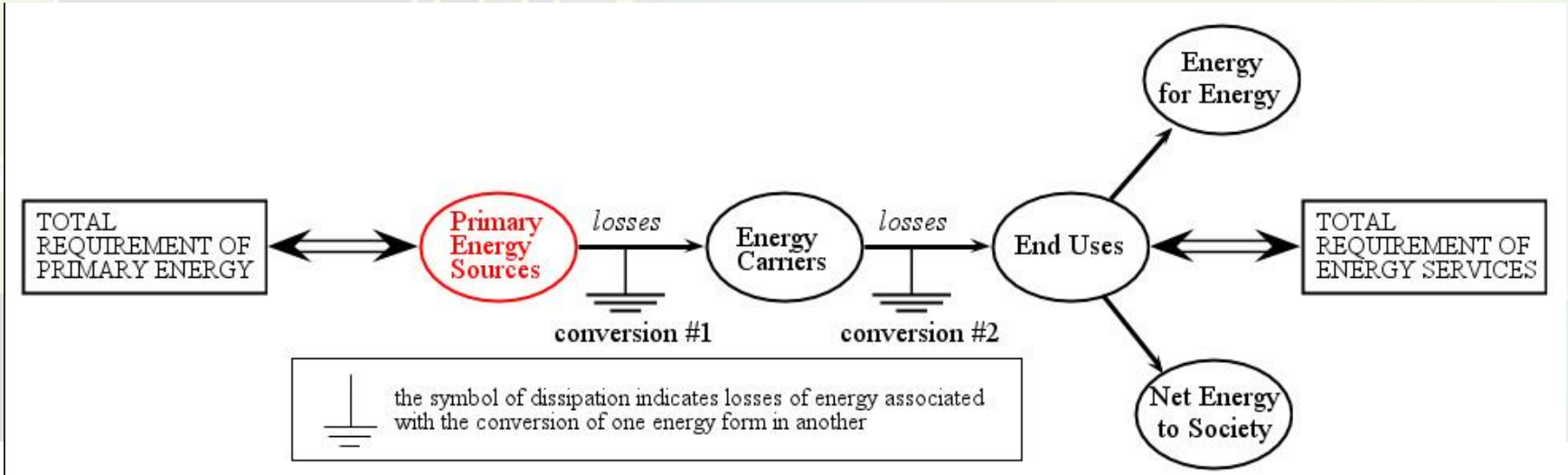
The Garrett Relation (my Wiki Article)

The Current Rate of Primary Energy Consumption Today is Directly Proportional to The Sum Total (==Wealth) of all Past Global Inflation-Adjusted Gross Domestic Product (GDP)

The CO_2 production per unit energy consumed (the "carbonization") can, of course, change by human efforts, so let this be a variable in the quantitative relationships.

Again: The relevant energy must be **PRIMARY Energy** = Raw energy provided by Nature. Why? Because converting to usable energy will involve both energy LOSSES and COSTS which we are responsible for covering.

Beware of promotional graphs which only present our progress in terms of processed energy (*e.g.* electricity) and may be cheery, but are unrealistic in true cost



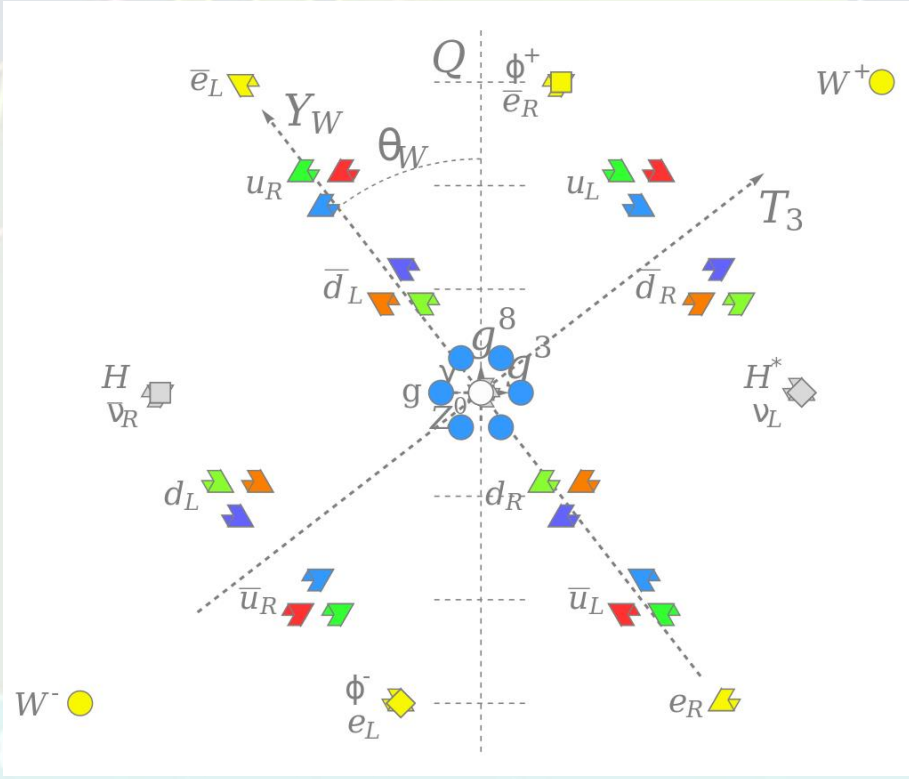
Why Global? Because The Garrett Relation Can ONLY Apply for a CLOSED Economic System

Looking Only at Individual Countries or Regions Ignores Trade!

- The flow of materials, energy, and money across borders is both **massive** and **rapid,** compared to the evolution time scale of civilization.
- We won't get a fair accounting by cherry-picking your favorite countries in isolation (as policy promoters are only too fond of doing).
- **The Garrett Relation** between energy consumption rate and spending MUST, and will ONLY, obey this simple conservation law for the globe as a whole.

It's Elegant... Since Physical Thermodynamic Laws are also Simple Only in a CLOSED System.

- The great discovery moments in physics have come from the realization and appreciation of elegant symmetries obeyed in Nature.



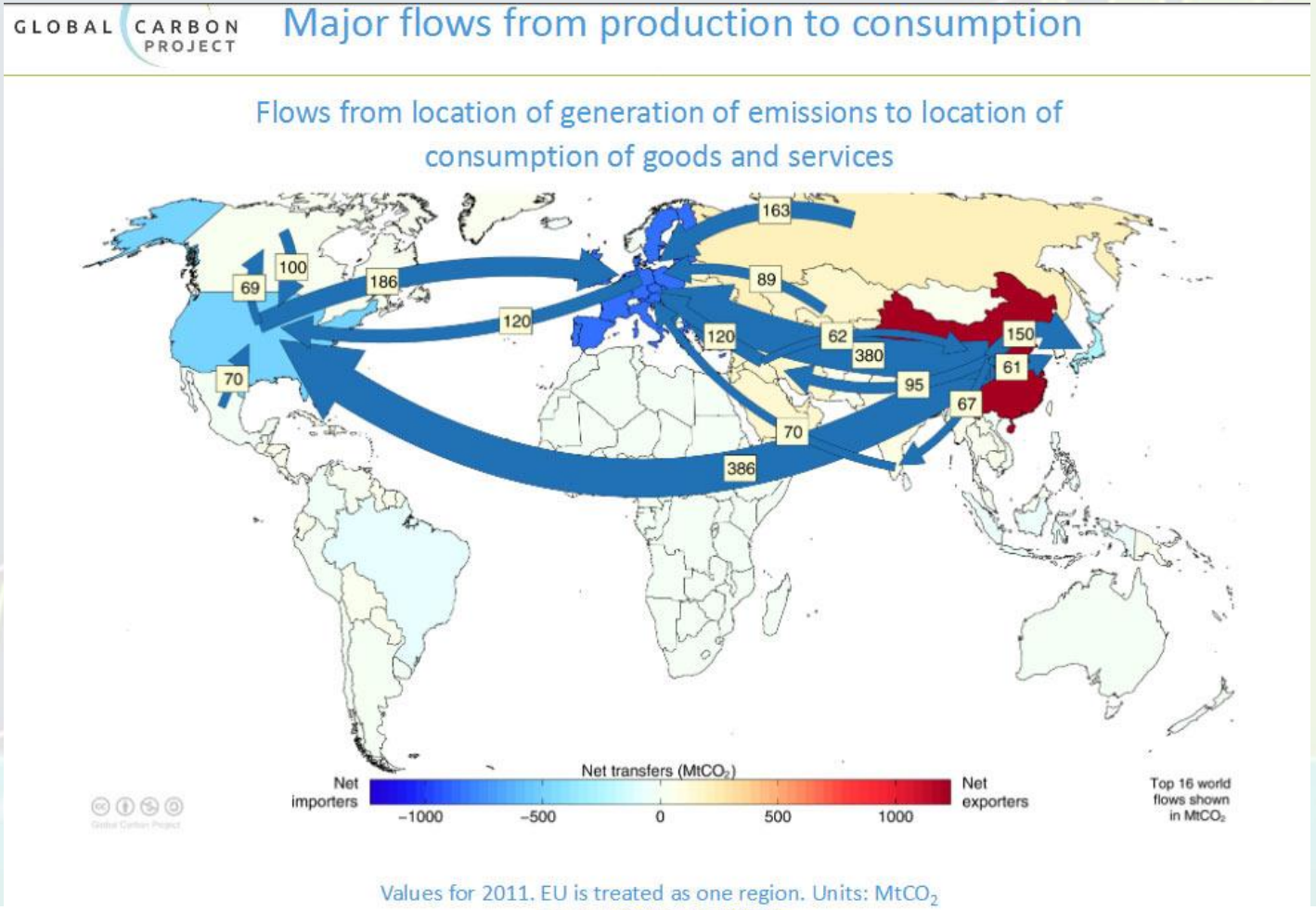
Symmetries and Conserved Quantities: They Go Together

Noether's Theorem

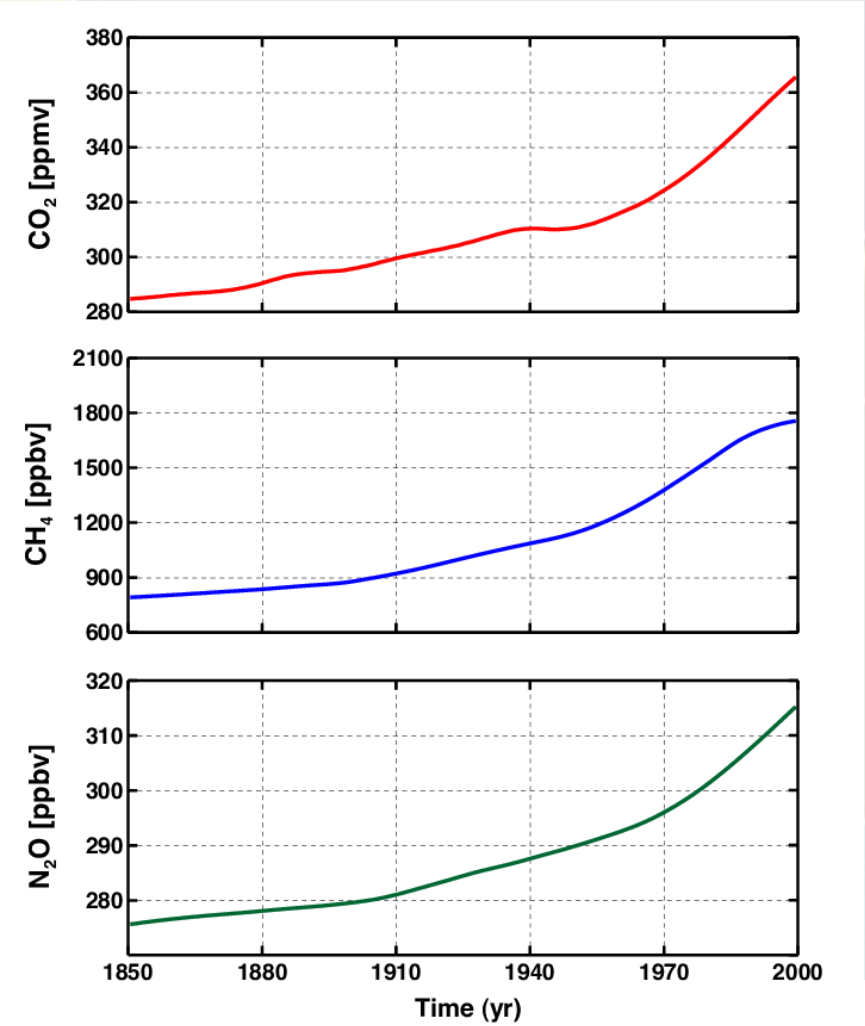
If a property of a system has a continuous symmetry, then there are corresponding quantities whose values are conserved in time.

Emmy Noether
1882 – 1935

Should we be surprised that one product of Nature – Humans and Human Civilization – might also obey elegant simplicities when the artificial borders important to most economists are removed?



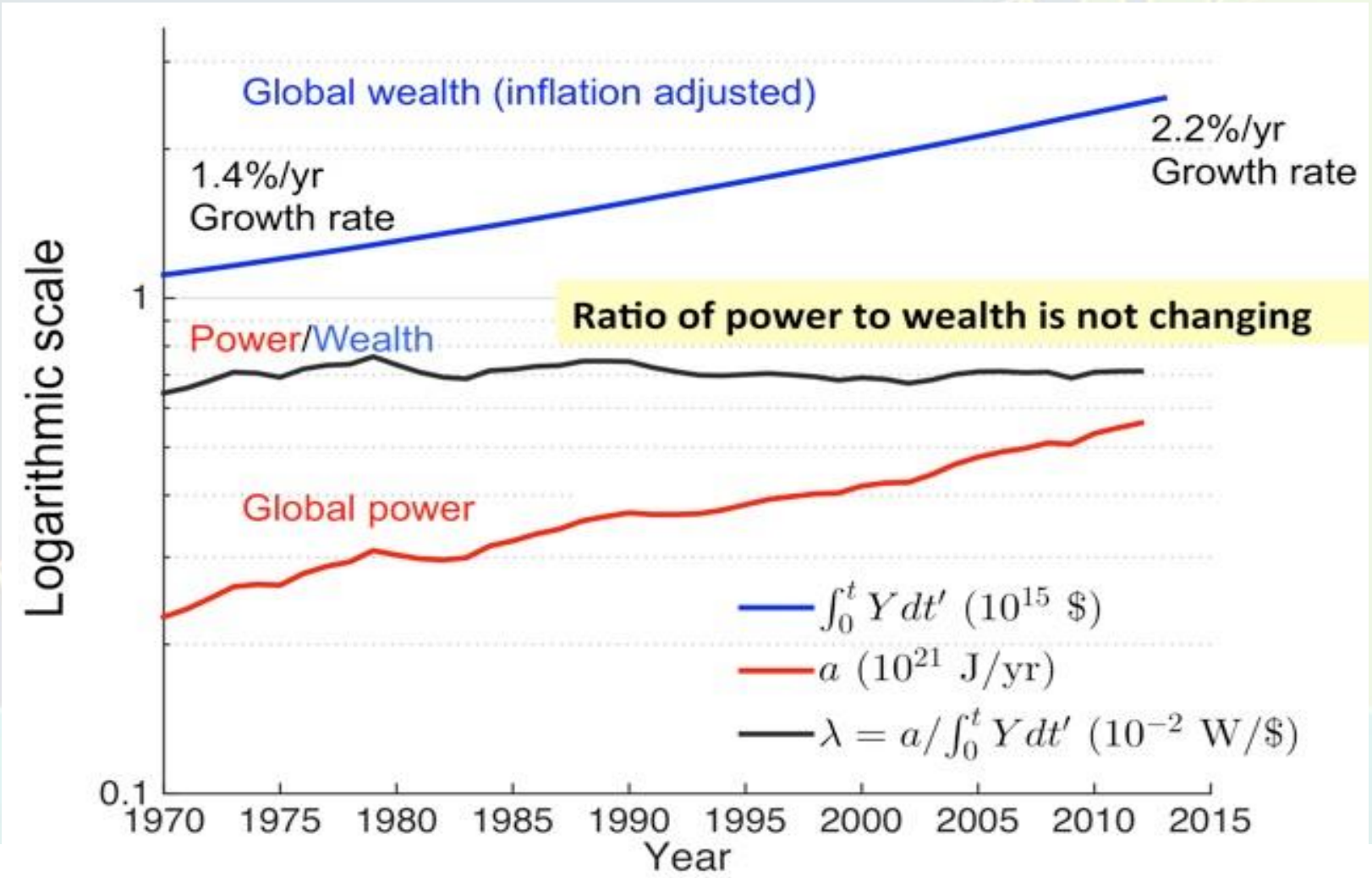
We'll Ultimately Relate this to CO2 and Greenhouse Gases – and they're Globally Well Mixed too.



- CO2 emitted anywhere spreads around the globe **in weeks**, so it doesn't matter which country emits it.
- Flows of energy, money, materials… and greenhouse gases are all "Well Mixed"
- **Climate and Relevant Economics are <u>both</u> linked GLOBALLY**

So, Is the Garrett Relation Verified in Actual Data? Let's See…

Historical energy consumption rate (power) and total accumulated global Wealth. Result? They're directly proportional; *i.e.* the ratio (black curve) is flat. <u>Every year, λ=7.1 mW of power is required to support every dollar of global GDP ever spent</u> (inflation-adjusted 2005 dollars).



The Garrett Relation Simplified: "Power Consumption Today is Proportional to Past Accumulated Wealth"

- *"The ratio of these two quantities remained essentially unchanged in each year between 1970 and today (2010), with a* ***standard deviation of just 3%*** *over a time period when wealth increased by 111% and global GDP increased by 238%"* (Garrett 2014).
- **Let's look in more detail why should this hold…**

What About Before 1970?

- Annual data for each country is only available for each country going back to 1970.
- Before that, **The Maddison Project** has figures going back to ancient times. Spottier, but sufficient to do the sum of Wealth needed, but not good enough for early points-in-time calculations of the Garrett Ratio
- **But realize, roughly 60% of all of Global Spending ever done, has been done since 1960**

Are You Thinking That This Totally Ignores the Power of Energy Efficiency to Change the Game?

- Glad you asked!
- Let's re-think what energy efficiency really means for civilization

Classic Jevons' Paradox

- *Improving the efficiency of coal-burning steam engines will not result in lower coal consumption, but instead result in higher consumption* – **William Stanley Jevons, "The Coal Question" - 1865**

Narrowly Applied for One Commodity, Jevons' Paradox is Not Always Obeyed

- **Example:** Double the miles per gallon of your car and you're very unlikely to drive twice as far, just because you can now afford to.

But this narrow form is irrelevant for global economics and global climate! The key point is – those savings WILL be spent on something. And The Garrett Relation shows that ALL spending results in higher future energy consumption.

This Leads to what I will call "Generalized Jevons' Paradox", or in some moods "Jevons' Revenge"

Generalized Jevons' Paradox

Any increase in energy efficiency will lead to savings. Those savings will not be destroyed but rather they will be spent, and the Garrett Relation shows that ALL spending requires the ongoing consumption of new energy to support the resulting civilizing against decay, while also expanding our ability to discover and exploit new energy at a faster rate. These combined effects more than offset the efficiency-gained reductions in power. Future global power consumption goes up, not down.

But Wait! You Say…

- "Money I save through efficiency might be spent in less energy-intensive ways. Maybe I'll take the money saved and buy more vacation days, and on my vacation days I could go trail running or just reading."
- Fine! But even ideas which stimulate less growth will stimulate less additional power consumption; they won't violate the Garrett Relation.
- What you spend for **does** make a difference to civilization.
- But realize too that it's only the weighted average of **all** people that climate cares about.

If those dollars spent don't add to civilization and hence its energy needs…

- …they produce a mis-match between global "wealth" and total money. This aspect is reflected in the inflation term. Again, we are not violating the Garrett Relation.
- In either case, history shows we're relentless about spending to enhance growth. Those dollars go towards enhancing your life, health, relationships, and therefore your ability to spend in the future. Inflation today is low. **They're not quite the savings to Civilization's ongoing power needs as you may think.**

Even those running shoes are helping you to become a better, healthier, happier, more expansive person and thereby increasing your future energy needs

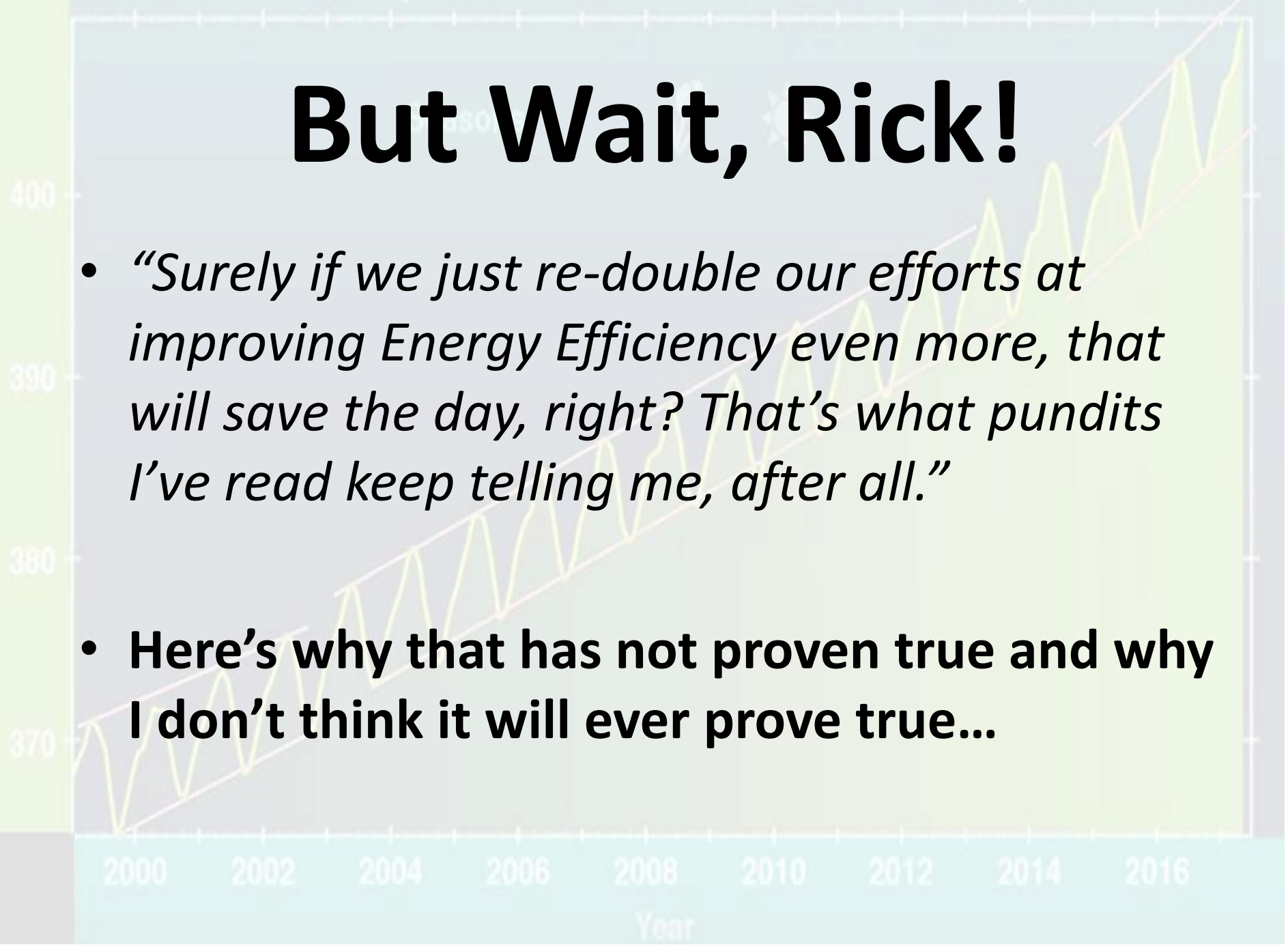
- In other words, the consideration above is already reflected in the historical data – the same data that confirms the **Garrett Relation**.

Heck, for evidence, look at me at age 64, solo-running a 17 mile wilderness trail in those running shoes. I could live to be 100 at this rate, and at 17 tons of CO2/yr for the average American, I'll out-CO2-impact my shorter-lived compatriots by a significant amount, while they are Cheetoh'ing and beer-guzzling their way to a CO2-conserving early grave!

But Wait, Rick!

- *"Surely if we just re-double our efforts at improving Energy Efficiency even more, that will save the day, right? That's what pundits I've read keep telling me, after all."*

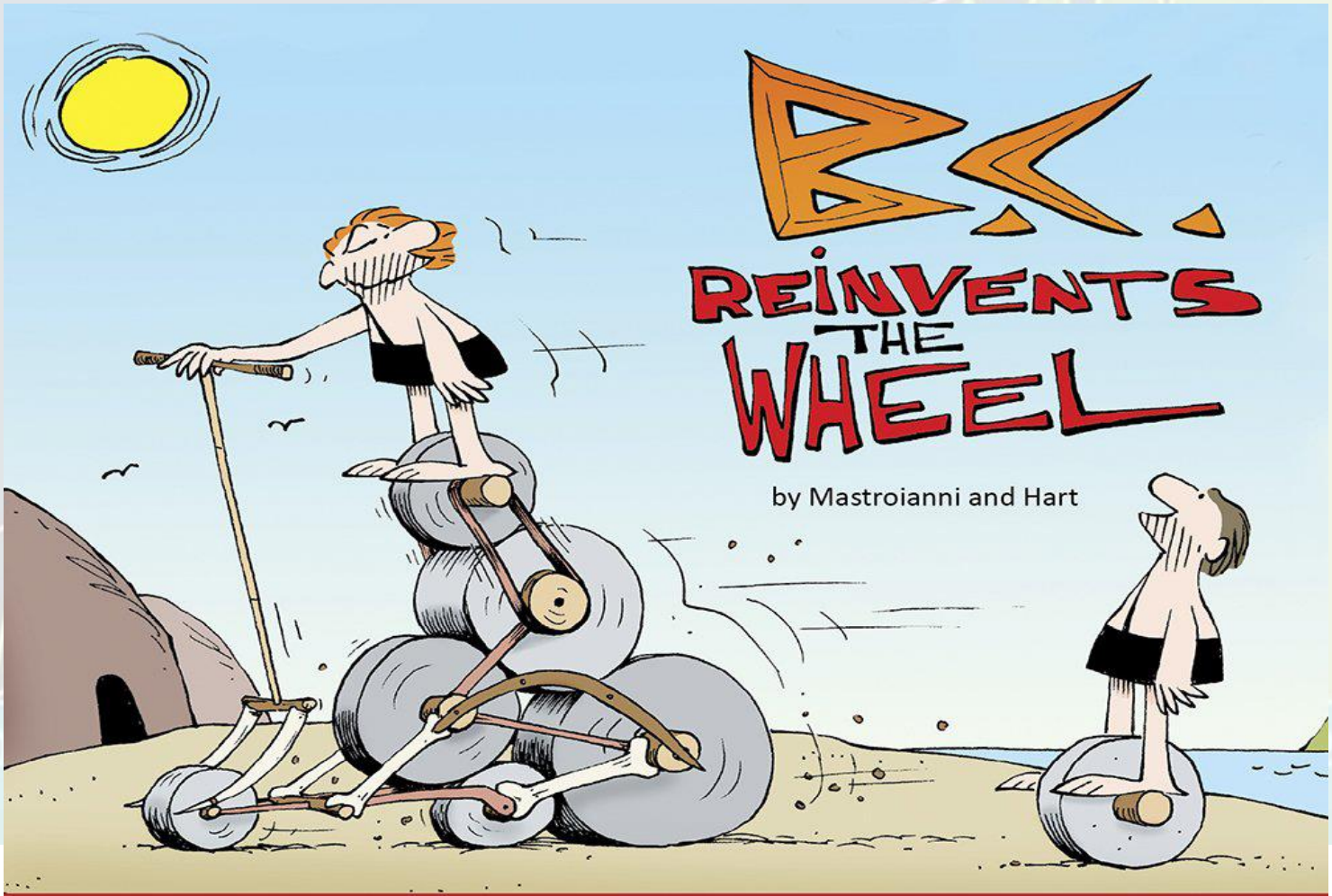
- **Here's why that has not proven true and why I don't think it will ever prove true…**



We've All Heard the Urgings from the Eco-friendly Progressives…

- … if only we can mandate lighter vehicles instead of those heavy steel cars of old!
- … if only we would raise our mandated mileage standards for vehicles!
- … if only we can eliminate those darn "vampire power" losses in our appliances!
- … if only we would outlaw incandescent light bulbs and go to all LED bulbs!
- …if only we can eliminate cars and go to PRT community vehicles!

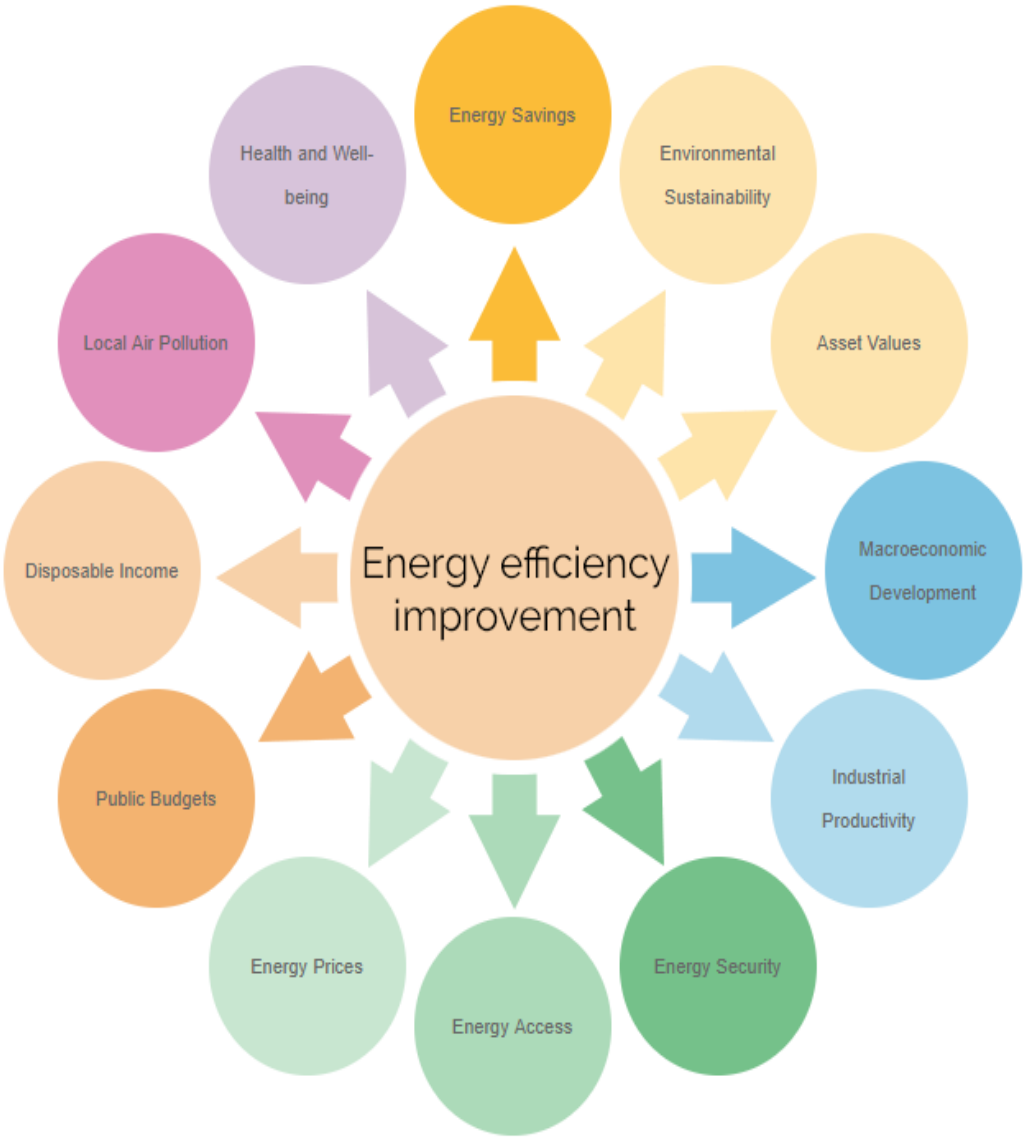
Please Realize – we've been continually and dramatically increasing energy efficiency ever since the invention of the wheel. We're "optimal foragers", as are all other animals, seeking to lower our energy spent per unit of economic utility gained.



Don’t be a “checkers thinker”! You MUST look several moves ahead to get the full picture. Investor/philanthropist George Soros attributes his success to a deeper understanding of what he calls “Reflexivity”. <u>You act on the system, but that induces the system to act back on you, influencing your next action, which then causes additional back-reaction… etc.</u>

Here, your claim of savings implicitly assumes the “dollars” saved in efficiency <u>are never spent</u>. It assumes, essentially, that the wealth created by that savings, denominated by that money, is **<u>destroyed.</u>**

The Key Reason Improving Energy Efficiency is Not An Argument Against the Garrett Relation..

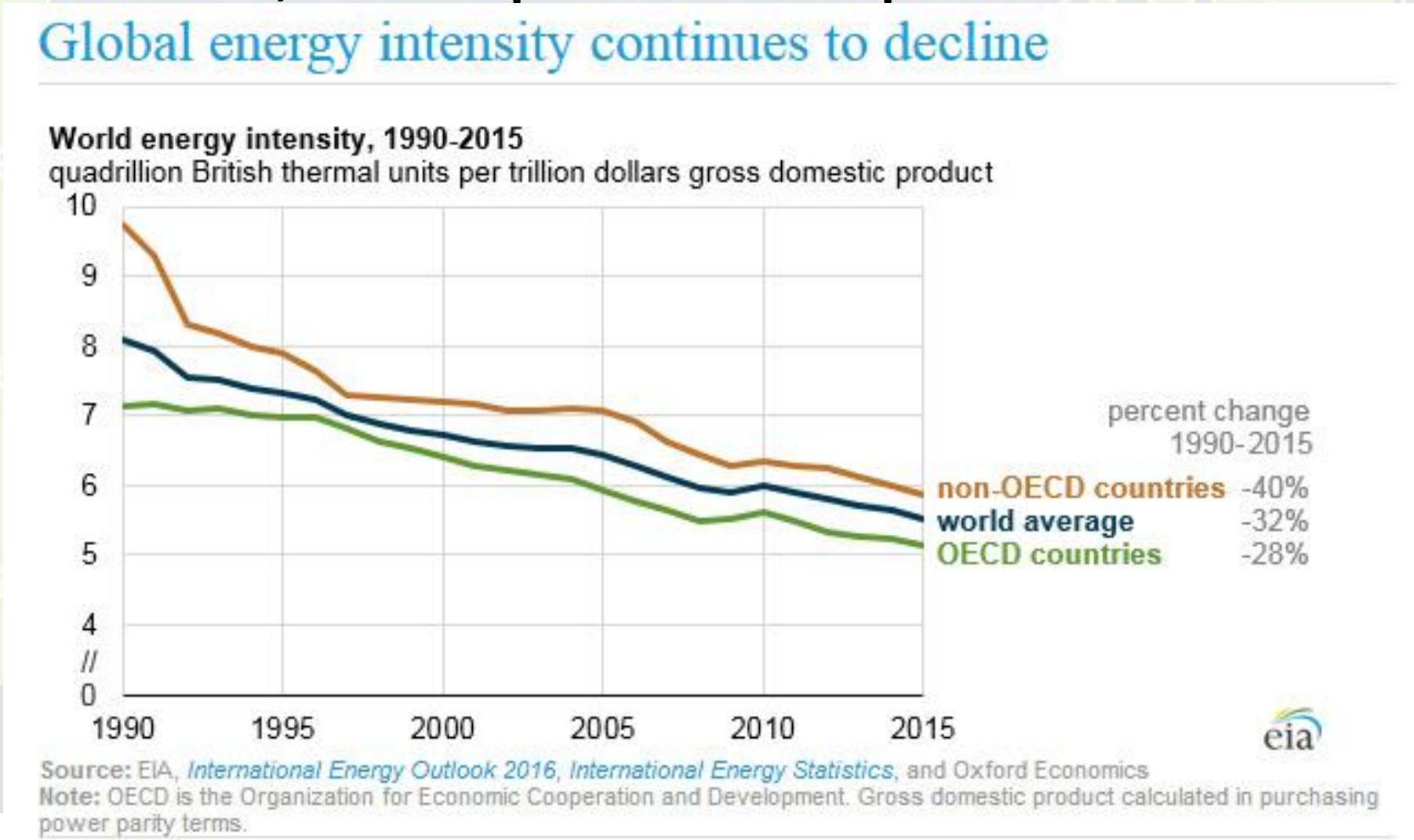


… is because <u>improving efficiency</u> has ALWAYS been a win/win for civilization's growth – <u>so our commitment to it has been strong, continuous, and always.</u>

We've <u>Always</u> Pursued Energy Efficiency with our Best Efforts Possible. <u>It's Nothing New!</u>

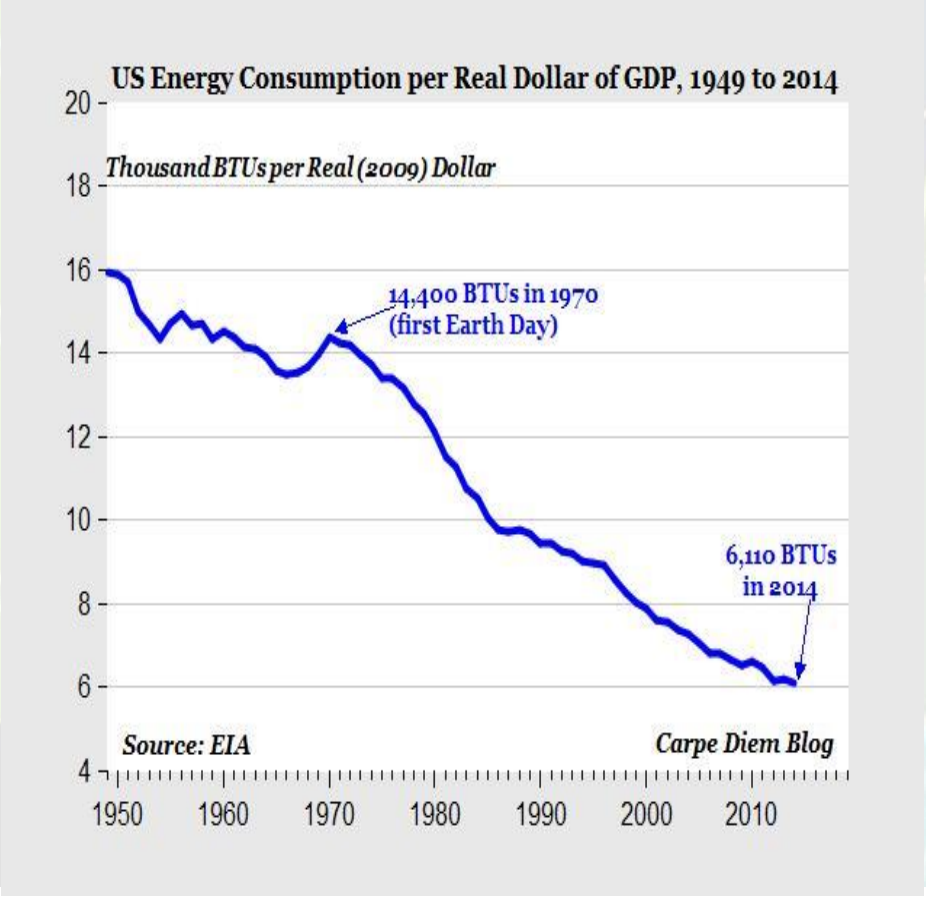
- Promoters talk as if we've never tried improving energy efficiency. **False!** We've done it with dogged determination, and we've done it FOREVER!
- ***<u>There is no reason to suppose that the rate of improvement is going to take a sudden slope change for the better, because the motivations have always been in place to insure we pursue efficiency as strongly as we can muster.</u>***
- **Let's see the actual data…**

Look at the steady "World Average" Curve of Continually Improved Energy Efficiency. <u>The Constancy of the Slope Argues We're Working at it With Maximum Effort</u>. Therefore, Don't Expect Radical Improvements in Trend.

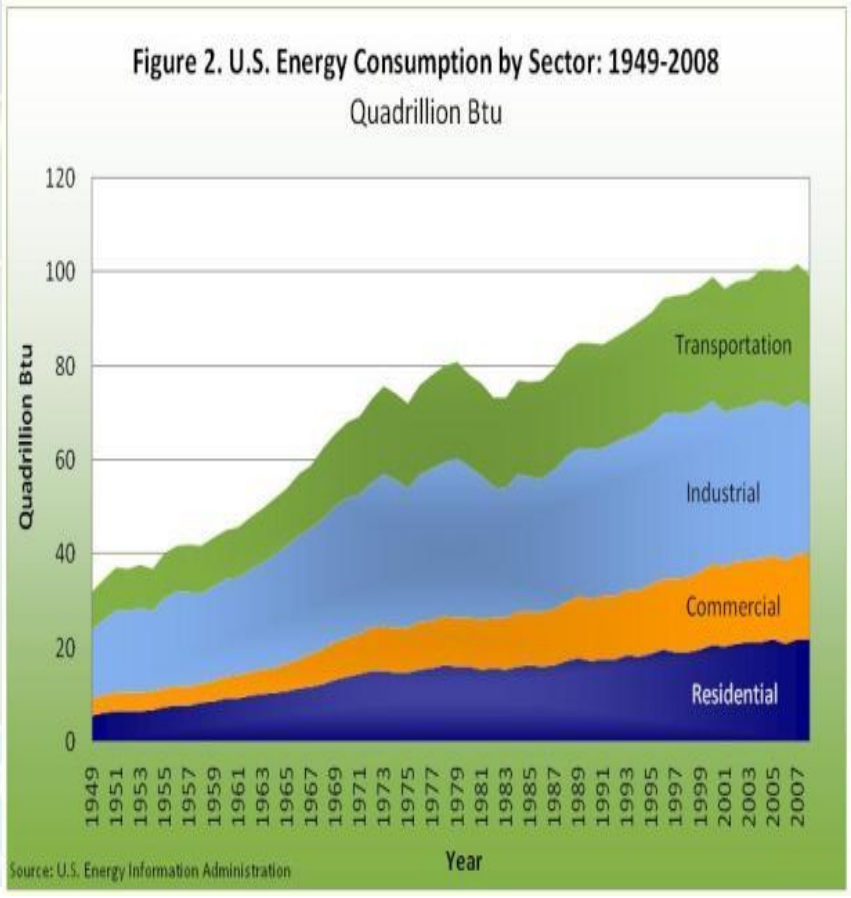


U.S. Energy Efficiency since 1950…

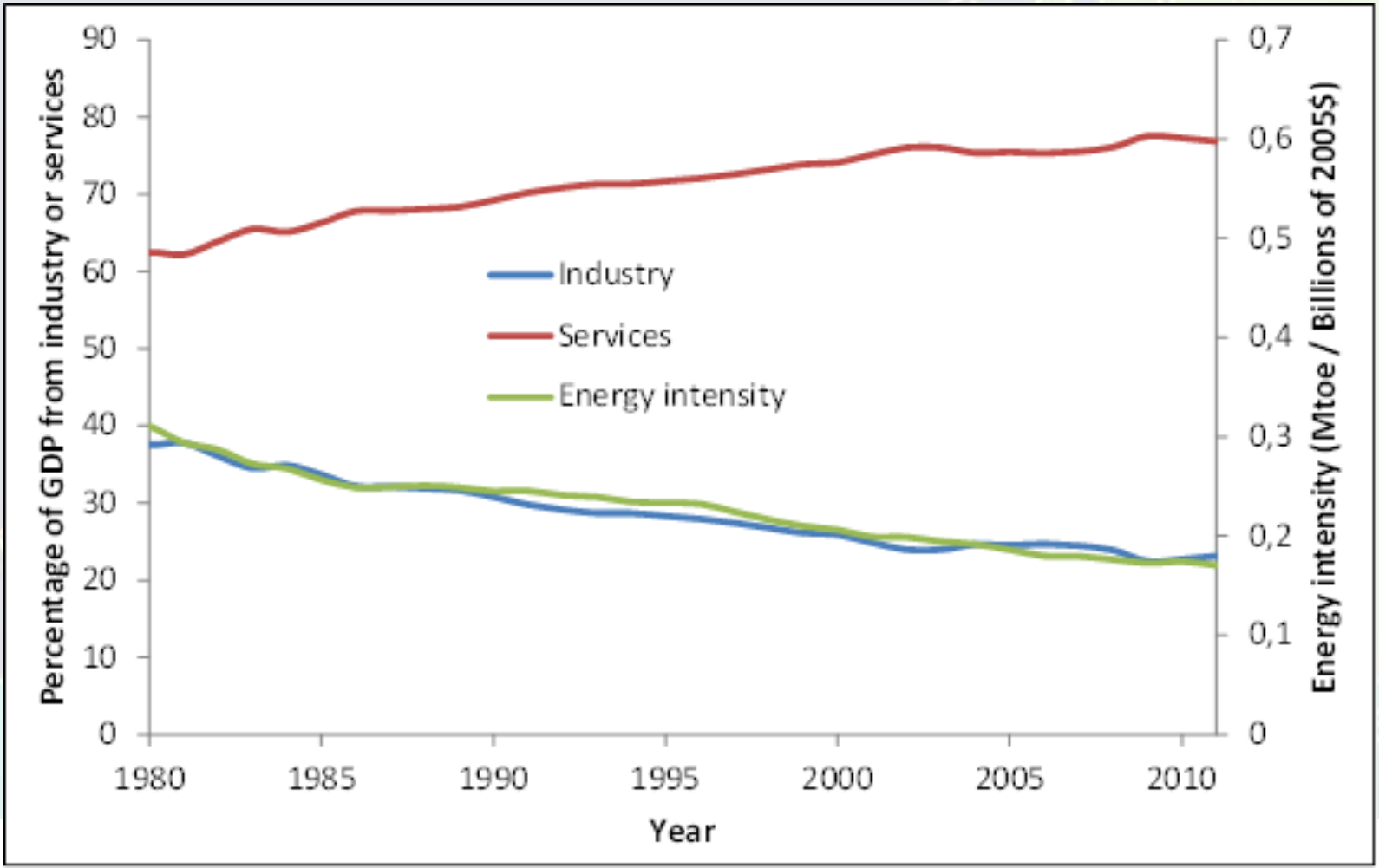
Spectacular 62% increase in energy efficiency! Except during the oil-shock recessions of '70-'74, steady trend improvement! Has it lowered our consumption?...



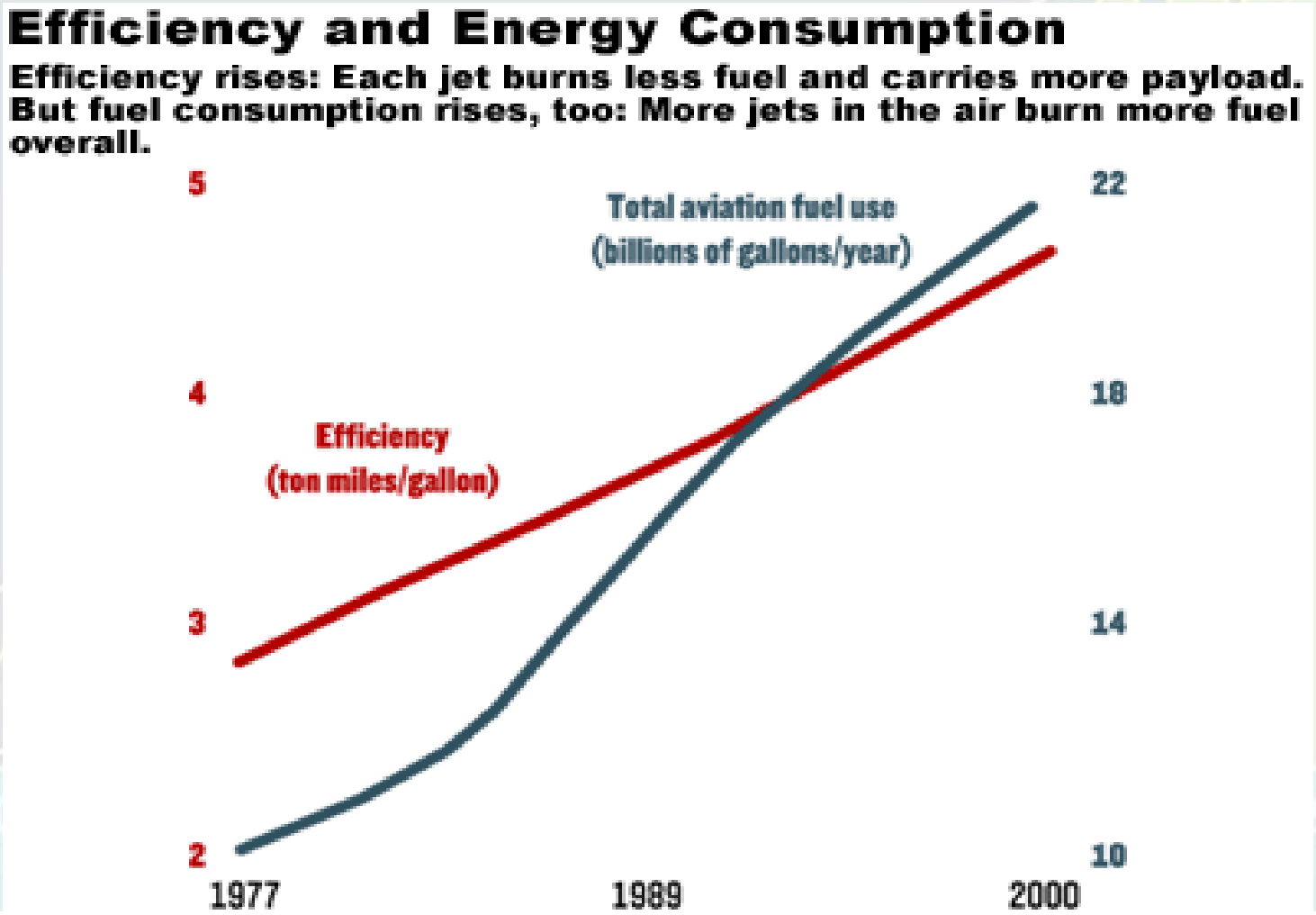
Not one bit! Energy consumption is up 300%, even given our off-shoring of much manufacturing



Interestingly, there is a strong correlation over time between the off-shoring of U.S. industrial manufacturing and the improving energy intensity of GDP (green and blue curves)



Another: Miles/gallon for jet airplanes show striking improvements, enabling yet more, not less, jet fuel burned

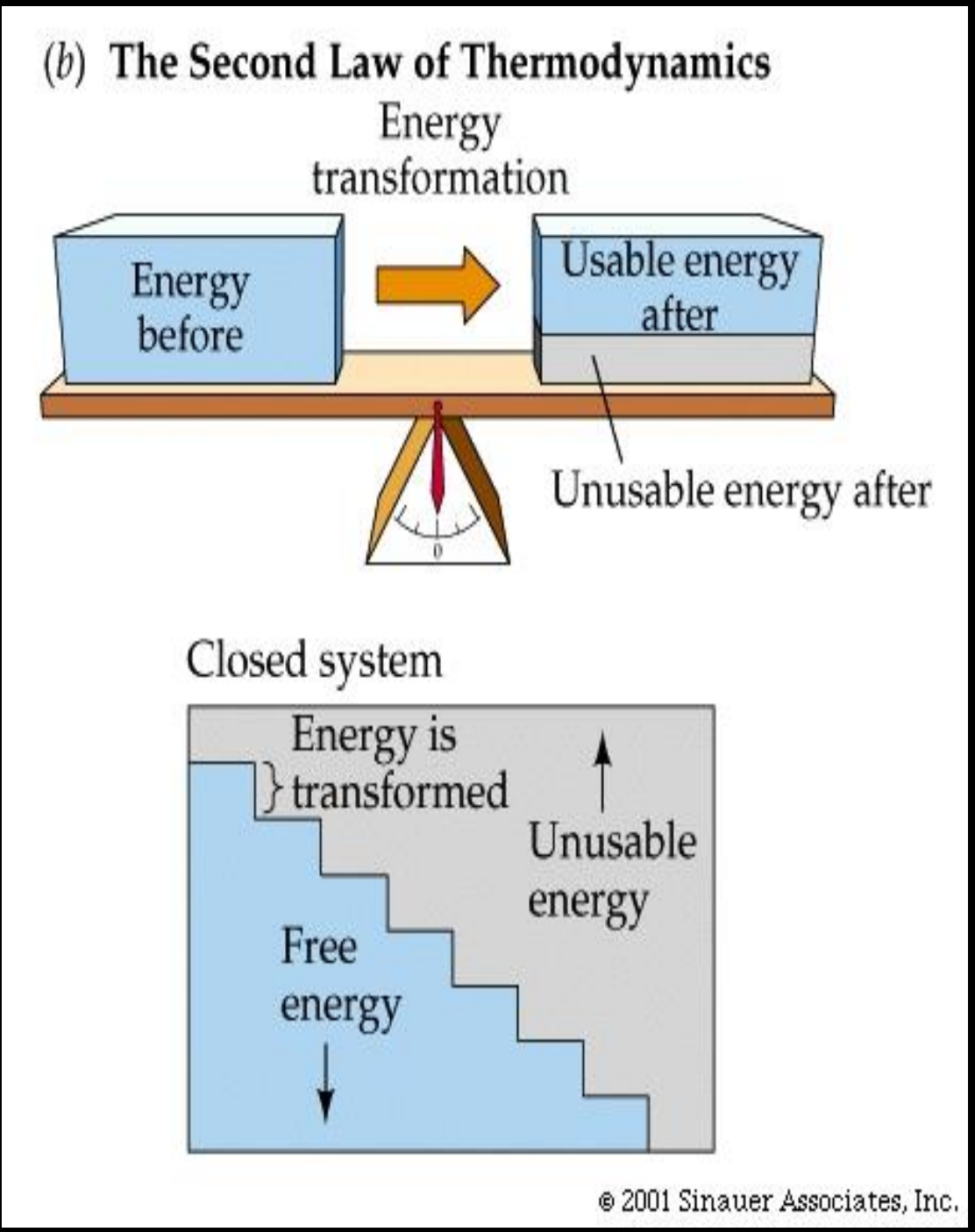


Then there's the Holy Grail of Energy: More Storage

- Surely, energy storage is showing the way to lower CO2 emissions – right?
- **No**. It's showing the way to **HIGHER** energy consumption and **HIGHER** CO2 emissions. *"It's difficult for storage to NOT increase emissions"* – **Vox Article – Dave Roberts 2018**

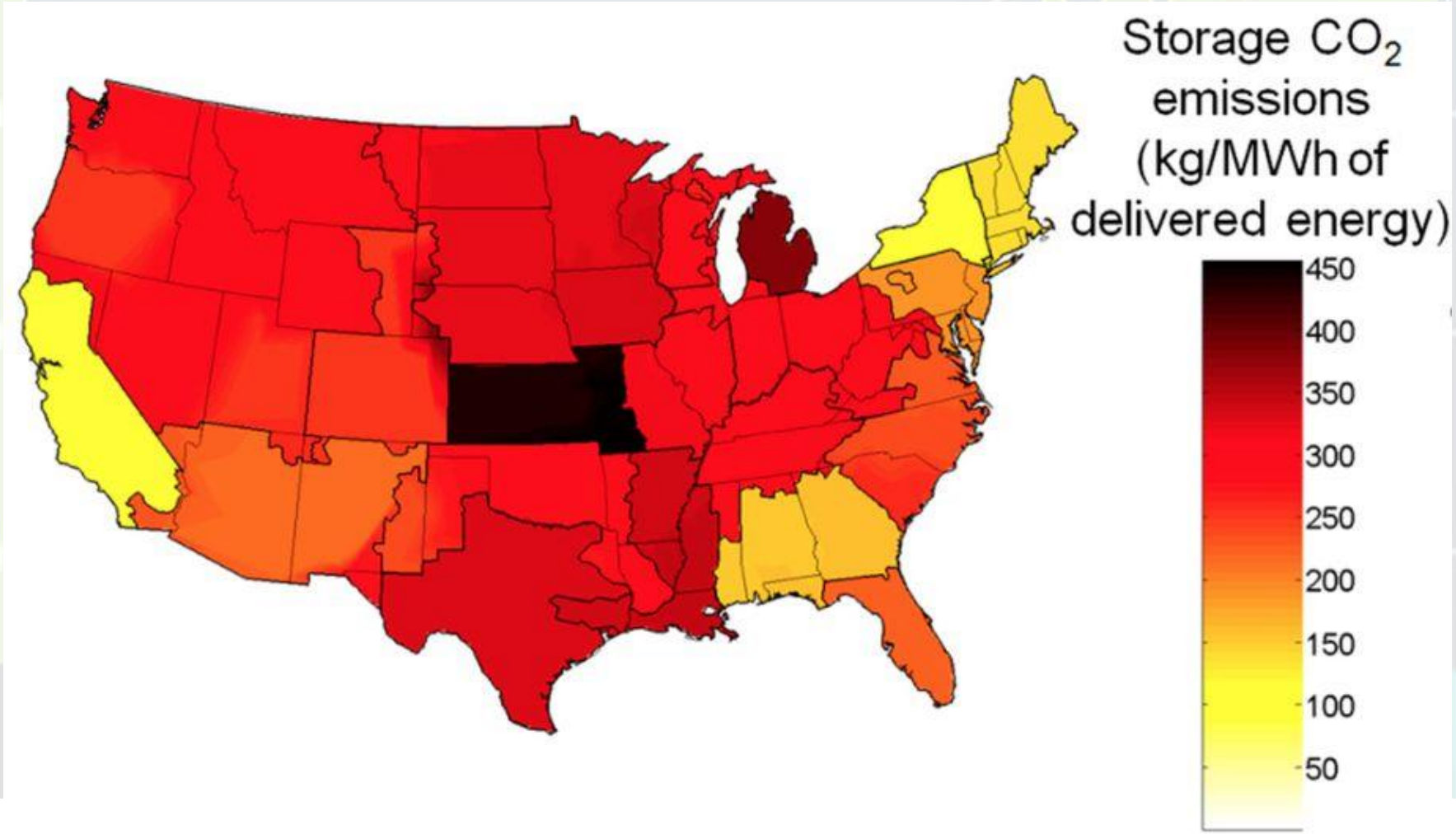
What?! How can that BE?

- Energy Arbitrage is the **first reason**: Storing energy when it is cheap and plentiful (coal plants operating late at night, currently) enables, with storage, selling it when it is more valuable (during the work day). This both enables and encourages higher coal mining and coal utilization.
- **Using storage increases the value of the source it draws from, and decreases the value of what it competes against (in this case, solar!).**

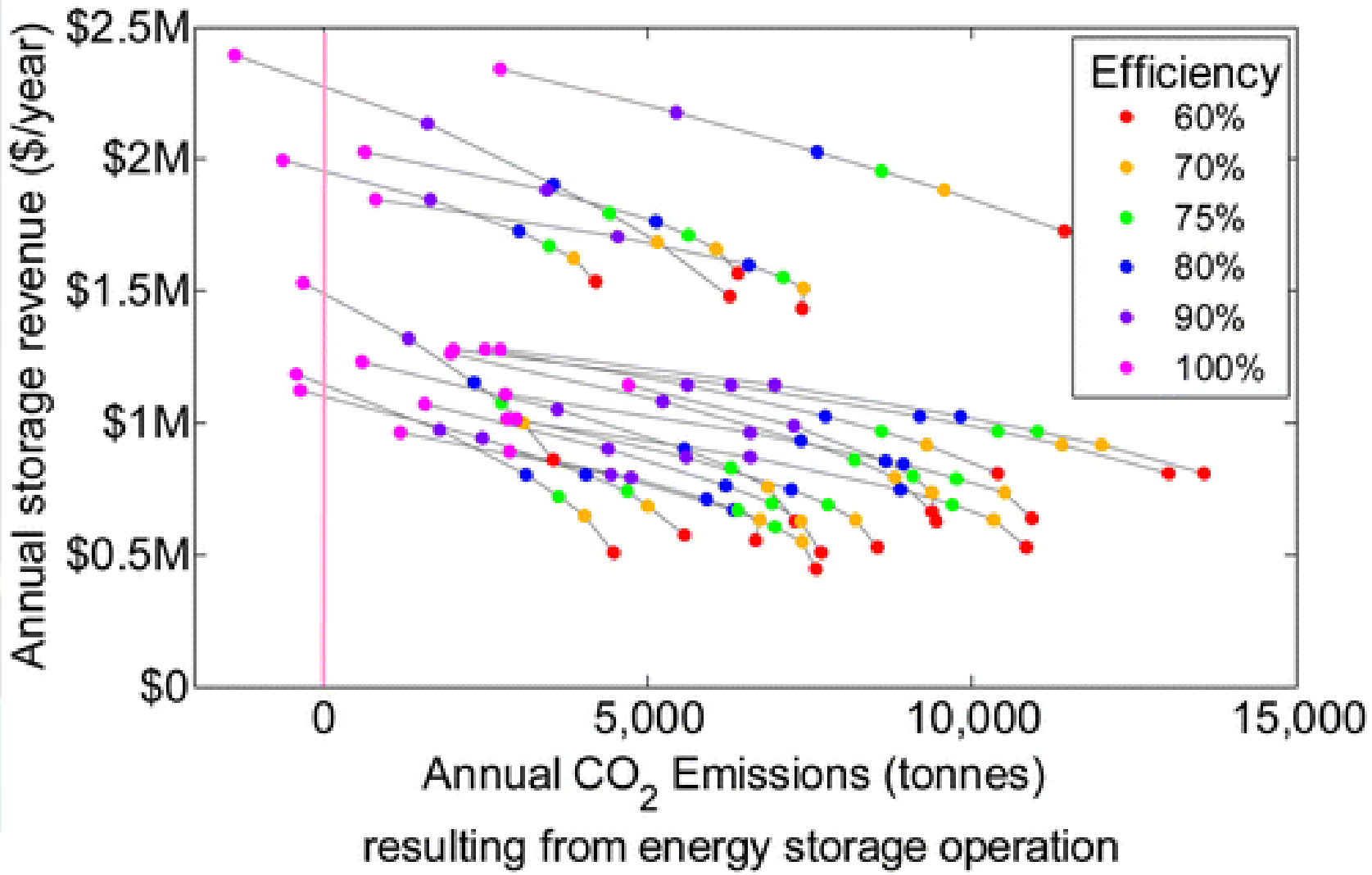


The **Second Reason:** Unavoidable energy losses during storage, and again at discharge. The **2nd Law of Thermodynamics** demands its pound of flesh!

Even paired with solar PV, storage today INCREASES CO2 emissions, when the full accounting is done (Fares and Webber 2017), and Hittinger and Azevedo 2017)



Energy Storage leads to higher CO2 emissions in all 20 U.S. grid regions, except under the assumption of perfect (therefore unobtainable) lossless storage efficiency (Hittinger & Azevedo 2017) (left-most point)

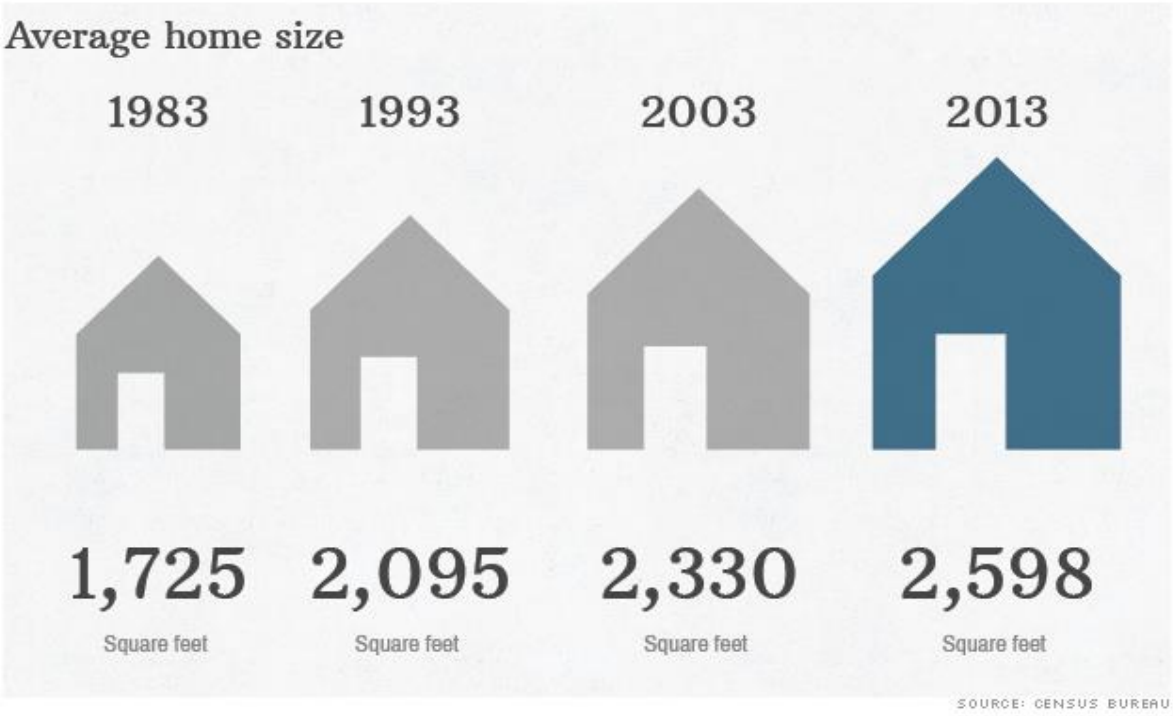


None of this Means We Should Not Pursue Better Energy Storage

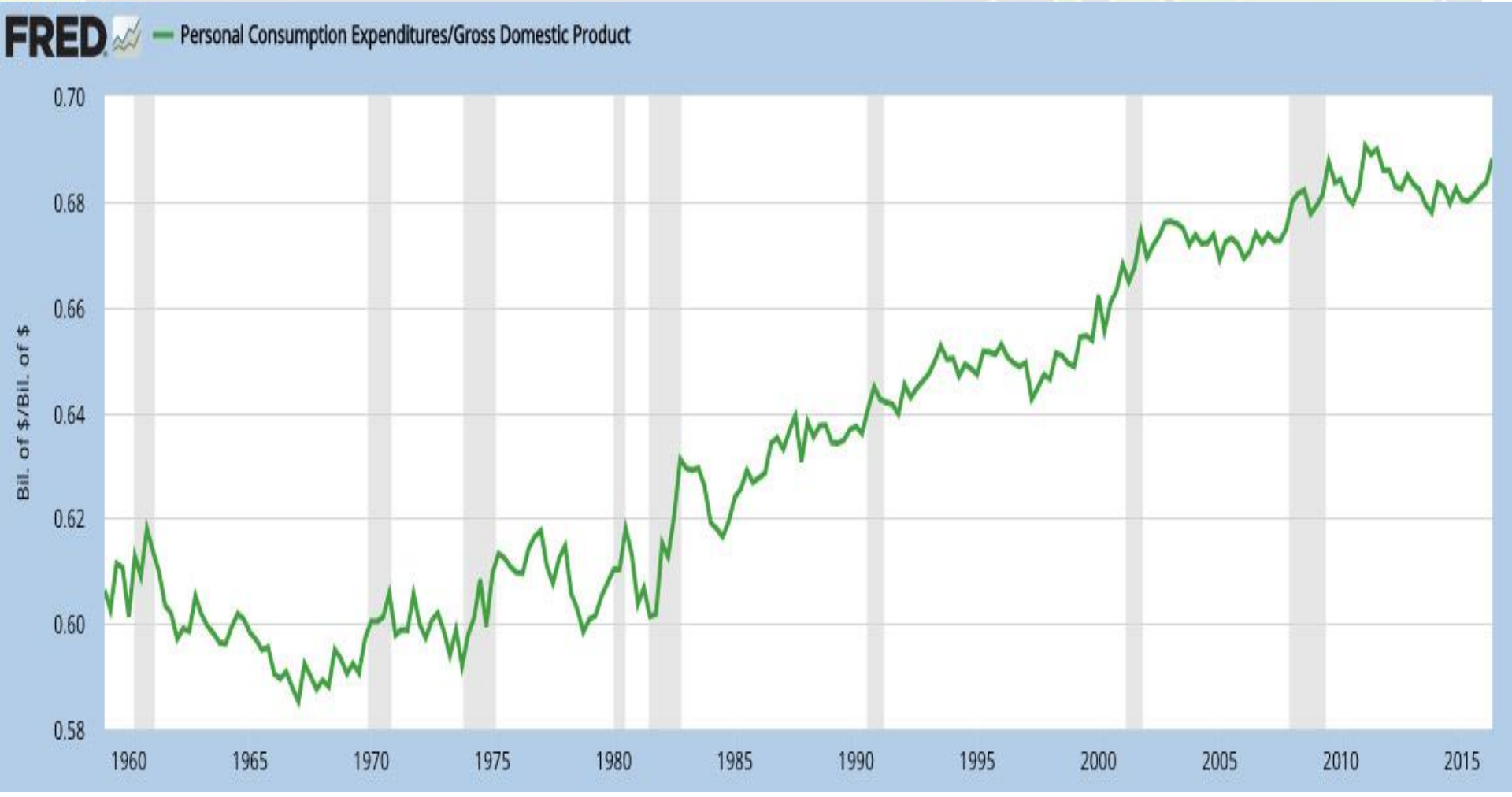
- But it points out that the cost to the environment of transforming our energy system is much higher than you'll see acknowledged by most entrepreneurs and policy people.
- They're "checkers thinkers" – in part because they value economic growth in the "now" and let the knock-on effects be someone else's problem**. Despite posturing, a concern for a long view sustainable Earth is not what their advocated actions reflect.**

Now, what do we DO with All Those Savings? We certainly don't <u>save</u> them, that's clear…

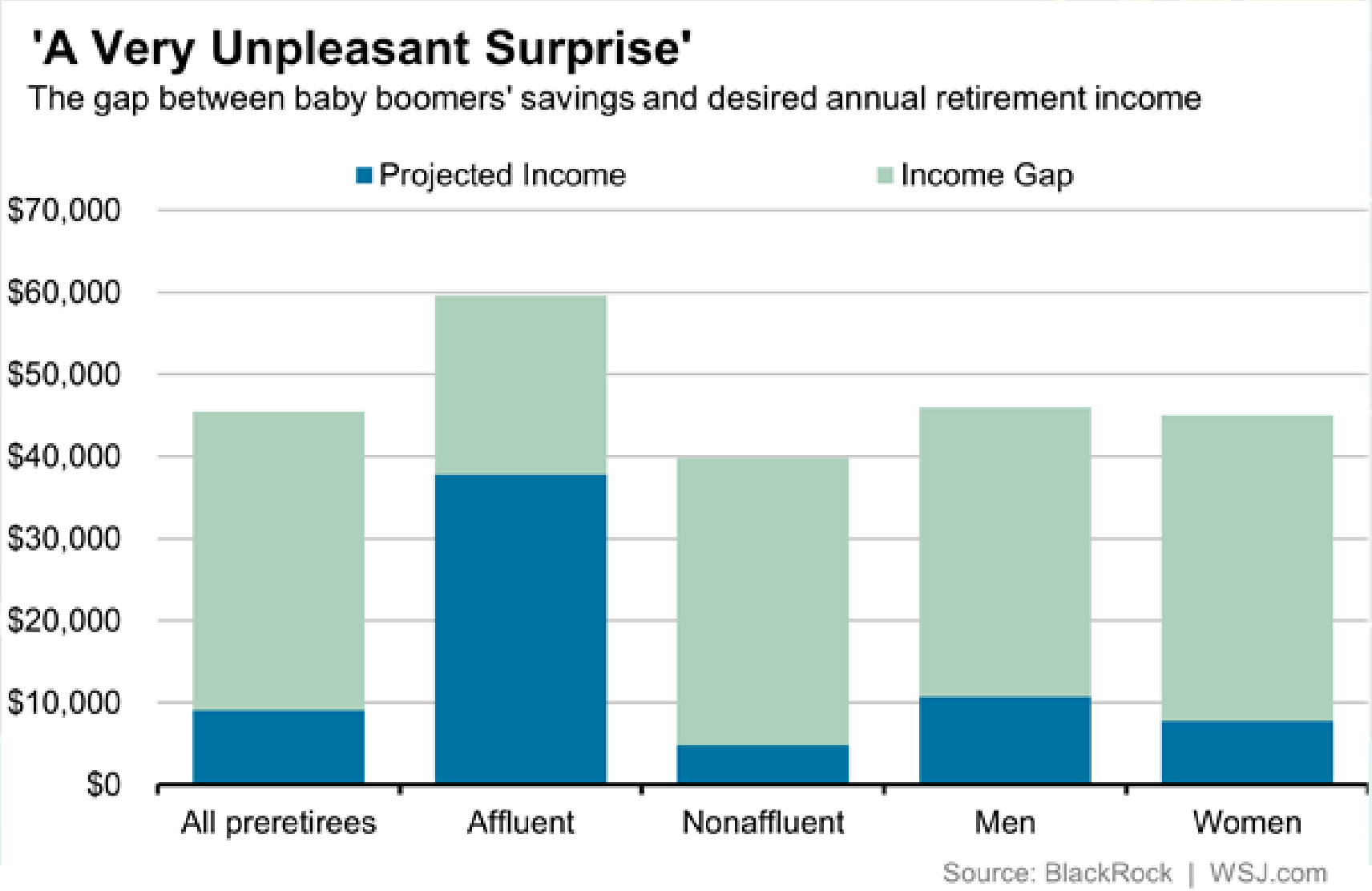
We SPEND them; on Bigger Homes…



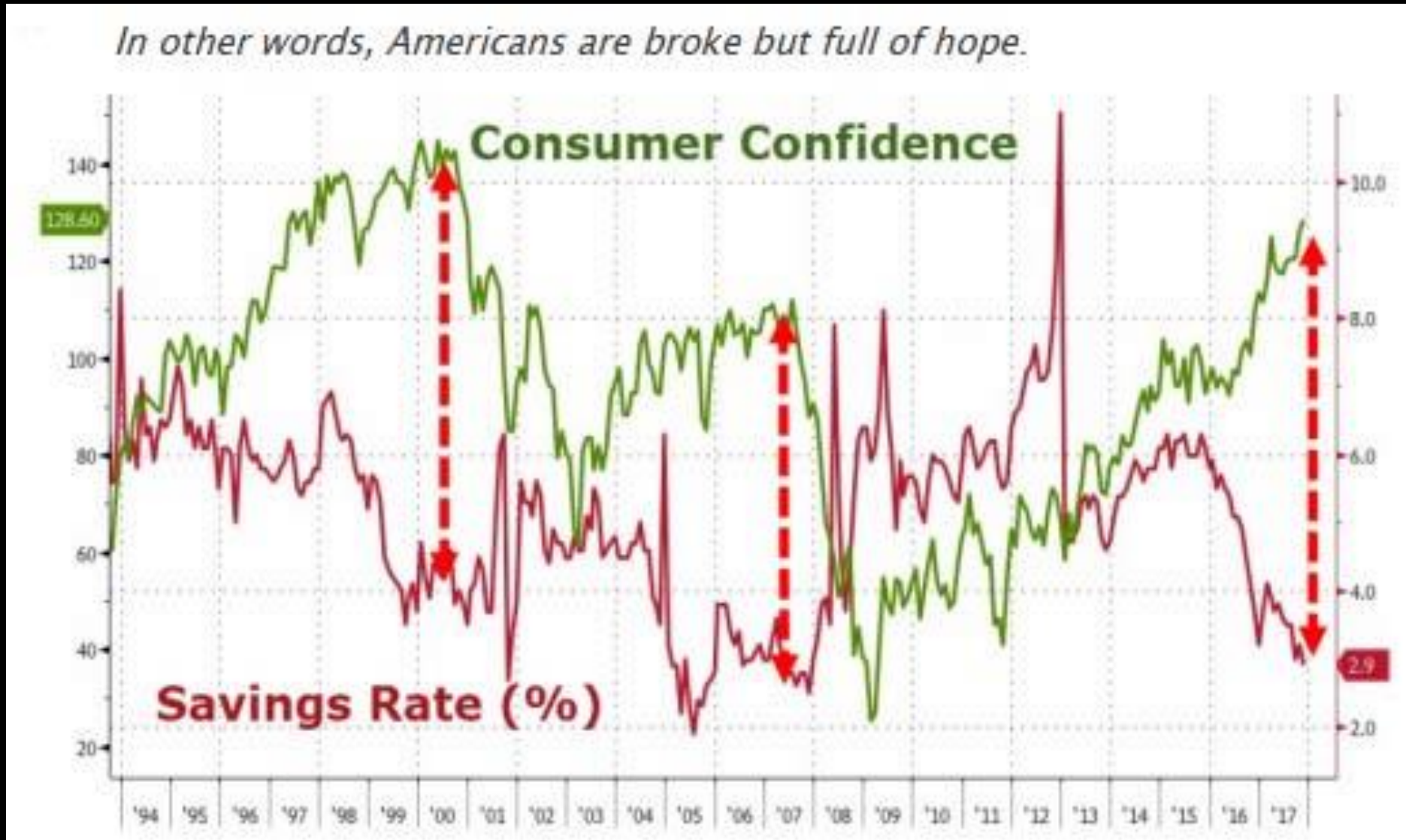
…on more consumption spending per $ of GDP



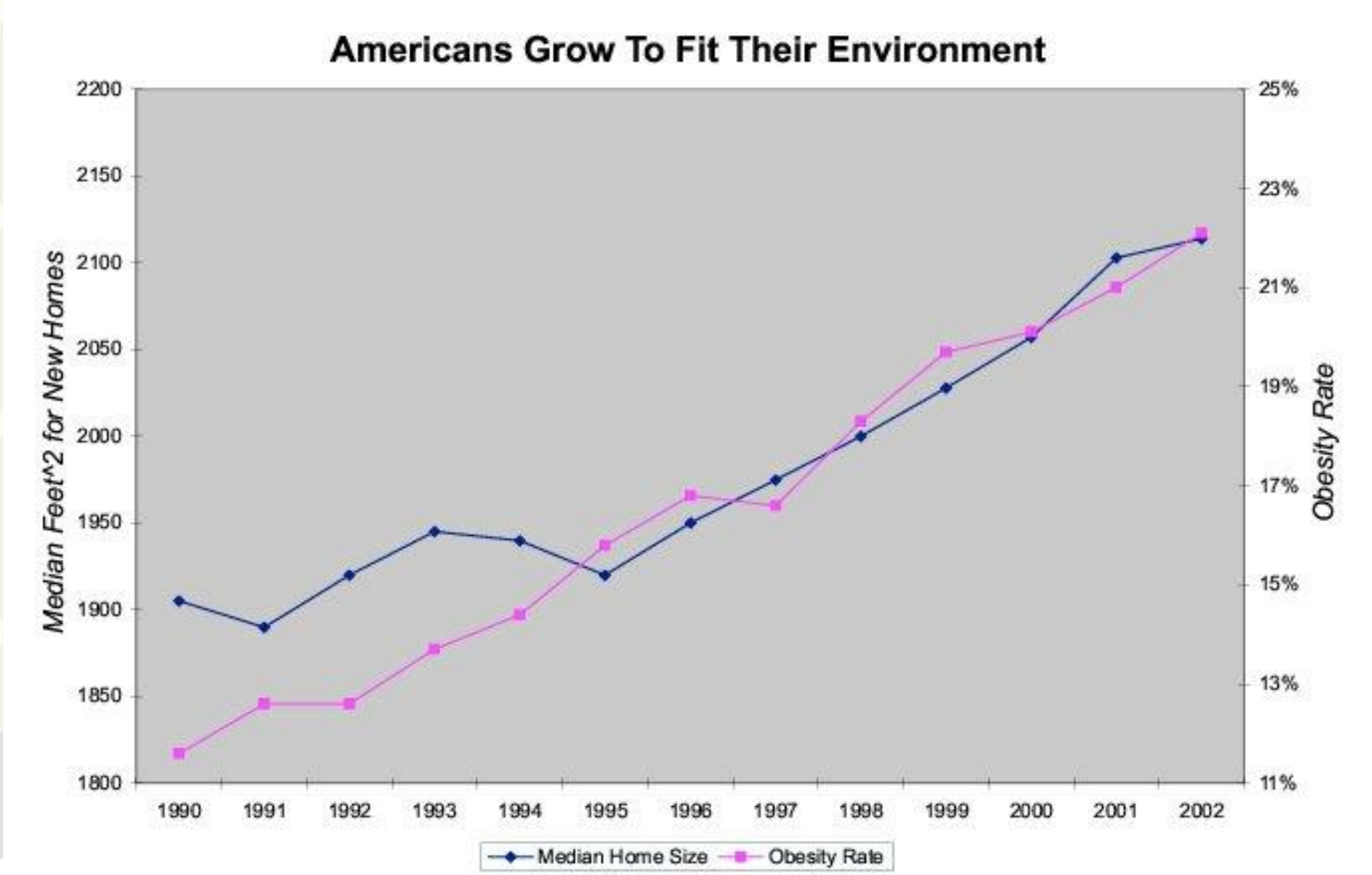
We're NOT net Savers. Even for our own Retirement



We're "Broke, but full of hope"



We're Increasingly Obese, and "Livin' Large"



In Case You Think New Research and Education has slowed the Worsening Obesity Trend…

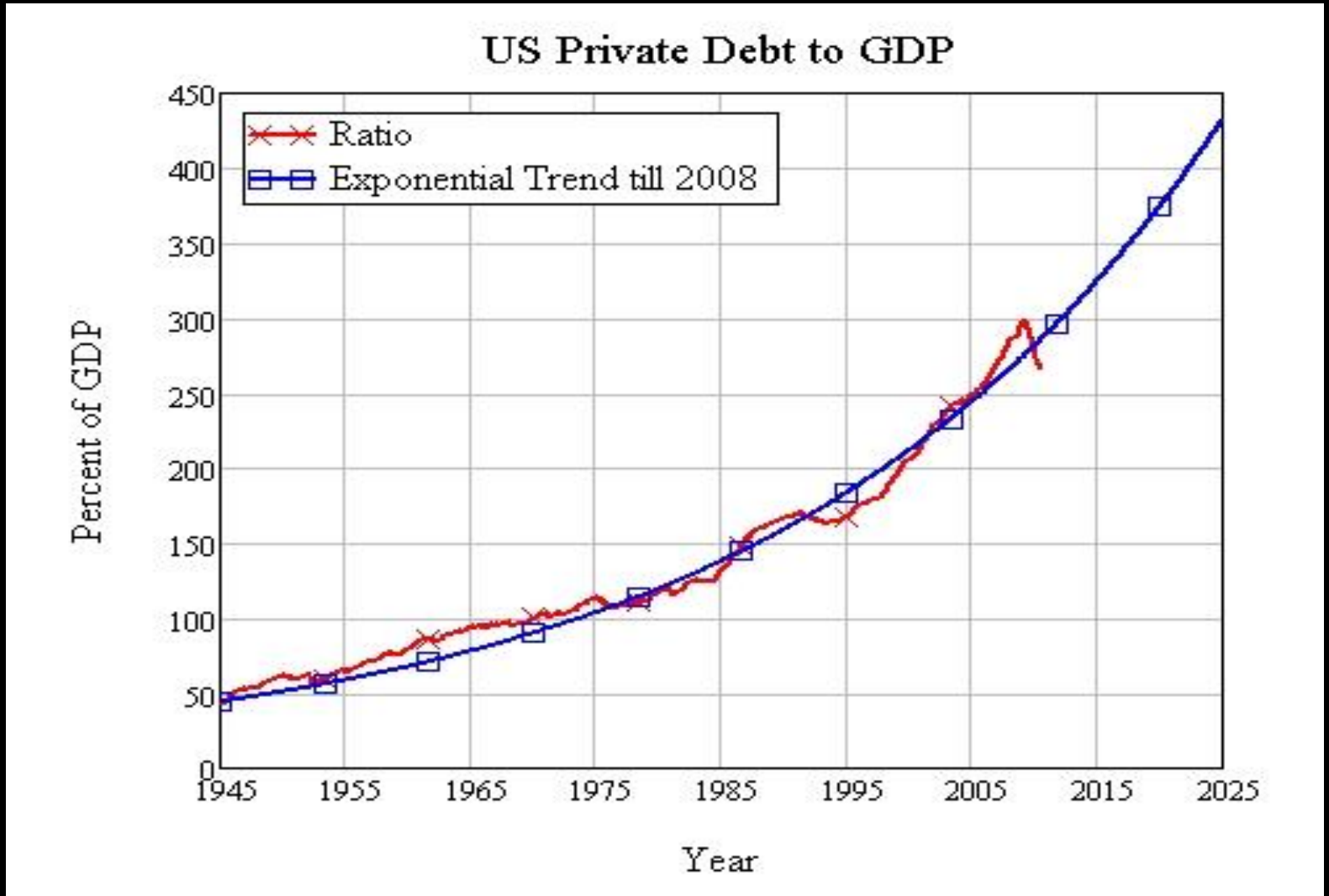
- ***No.*** It continues up through the present (**Hales *et al.* 2018**). Obesity rates among youth has gone up 10% in just the past decade, and even more – by 18% - among adults.
- People **know** eating carb-heavy junk food causes obesity, but they give in to their cravings anyway. **People do what they WANT to do, helped by corporate advertising and their own brain's sugar-damaged leptin and dopamine reward receptors.**

This has everything to do with the Thermodynamics of Civilization

- **…and Generalized Jevons' Paradox**
- We are programmed by Natural Selection for optimal foraging (energy efficient pursuit of resources) and maximized growth.
- This programming is through our hormones. To fight against those urges takes additional real biological energy which few can muster for long, and no one can exert continuously without eventual exhaustion.
- So, alas…

We're Livin' Large!

Even if we have to borrow from future generations, impoverishing them, to afford to do it. Private Debt is now 350% of GDP, exponentially Increasing. (Govt. debt rising even faster)



"Being able to falsify a result lies at the core of the scientific method. It must be possible to set up a test that could lead to a model being discarded." – Tim Garrett

- The above is from Garrett's article with the blunt and provocative title **"Is Macroeconomics a Science?"**
- **"Current global rates of energy consumption growth and GWP growth can be accurately predicted based on conditions observed in the 1950's, knowing only the key thermodynamic civilization relations and without appealing to any observations in the interim, with skill scores >90%.** (Garrett - from same article).

- For a more detailed study of Garrett's work, see key papers linked **near the top of this page** of mine. The most mathematically detailed paper is **Garrett 2014**

Well, what if I just leave my energy efficiency savings in the bank?

- **Won't help!** The bank uses those dollars as an asset base, enabling them to lend out a multiple of those dollars (newly minted money out of thin air) to others who will spend them.
- Thus, if you're going to avoid expanding energy generation rates, you have to "destroy"… …**Destroy what? The savings?**
- **Would even that be enough?...**

Must We Essentially BURN our piles of efficiency-gained cash??

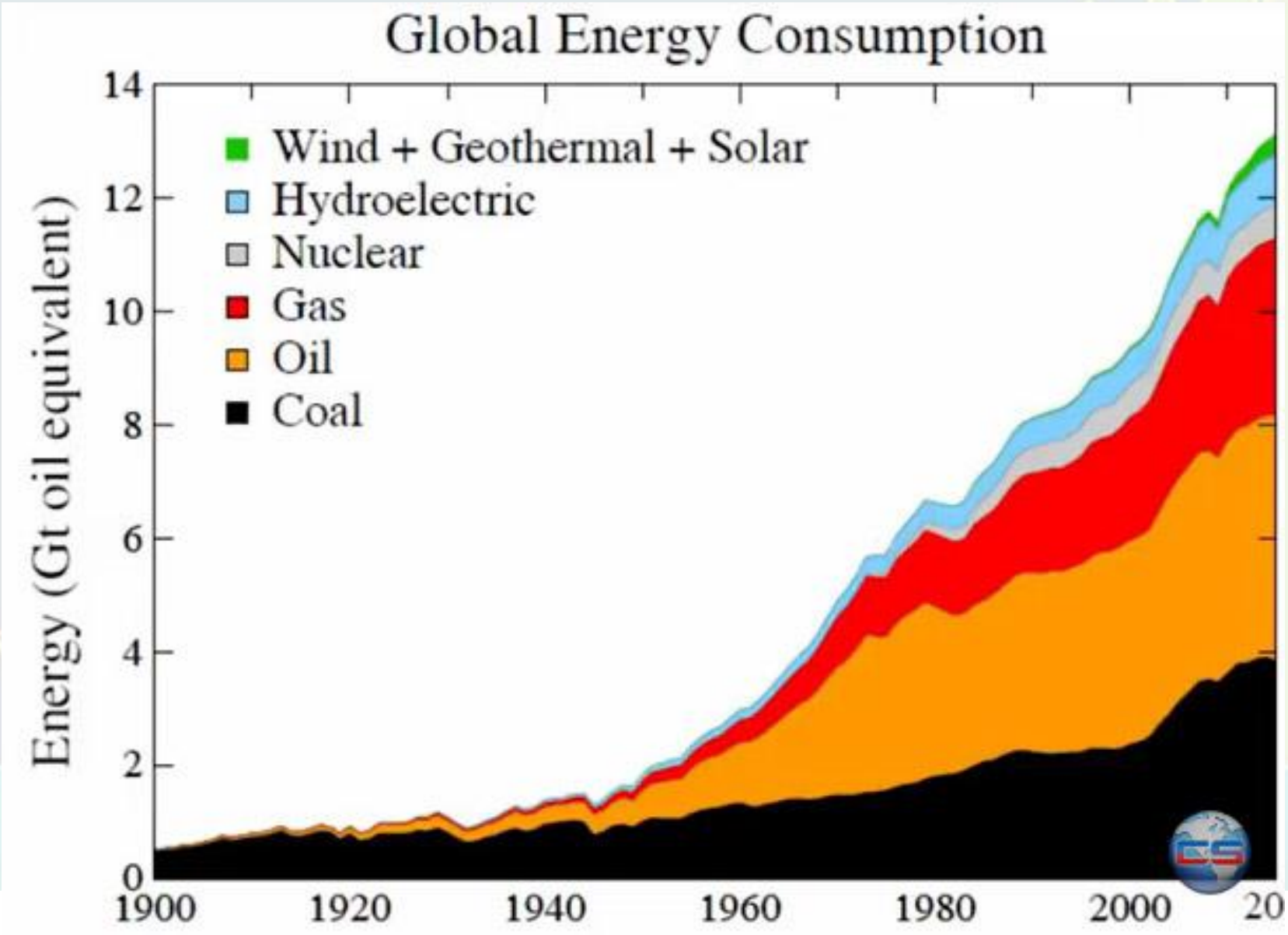
I Wish it Were That Easy… No, it's Worse

- The cash only denominates the Wealth, and if the wealth remains, the ability and reality it enables - that of further growth in energy consumption - remains.
- Burning the cash only makes for **"negative inflation"**.
- Negative inflation **adds** value to already existing savings, nullifying the effect of burning the cash denominating the new savings. **No, it doesn't help us halt our growth.**

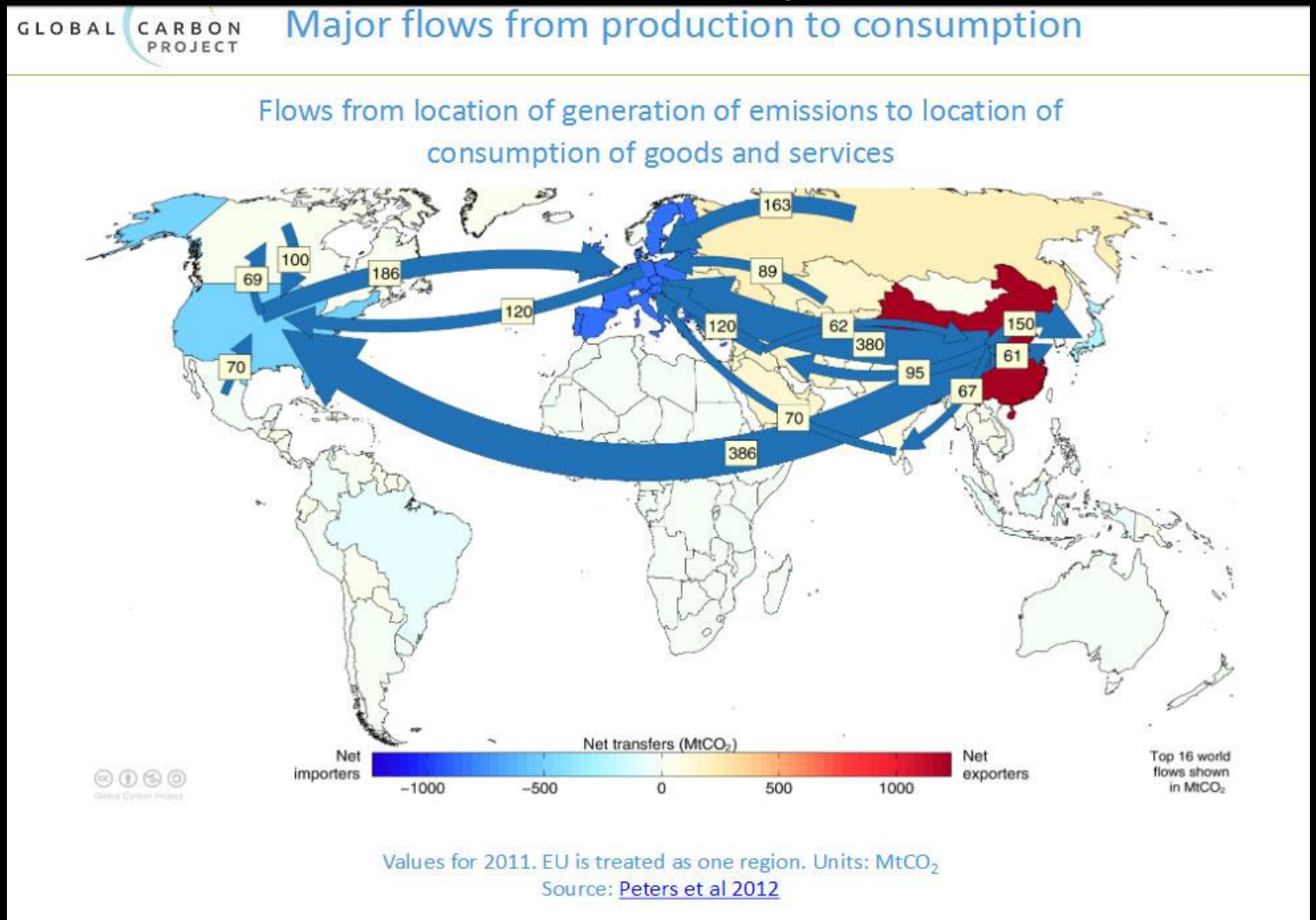
We Need to Cripple Civilization, not Merely the Money Denominating it.

- We need to actually cripple civilization's ability to grow, or else voluntarily halt that growth by policy action or (impossibly hard) universal and continually summoned (biological energy intensive!) human will power against our desires.
- In a competitive world, this would seem ***extremely*** unlikely
- **Economic Power = Political Power so don't expect countries to do this, especially in an increasingly desperate, competitive world.**

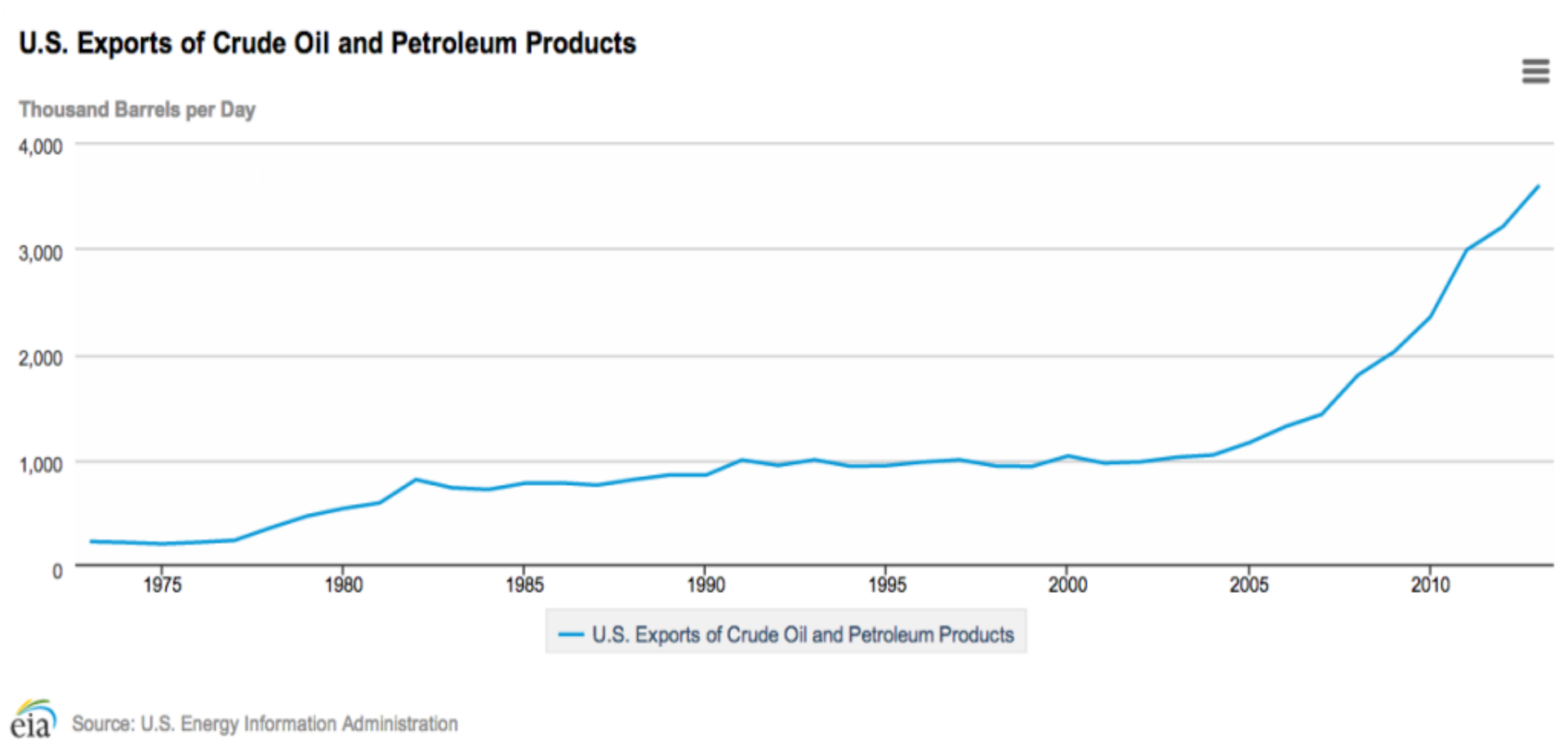
Global energy consumption, including fossil fuels, continue to skyrocket (2017 data)



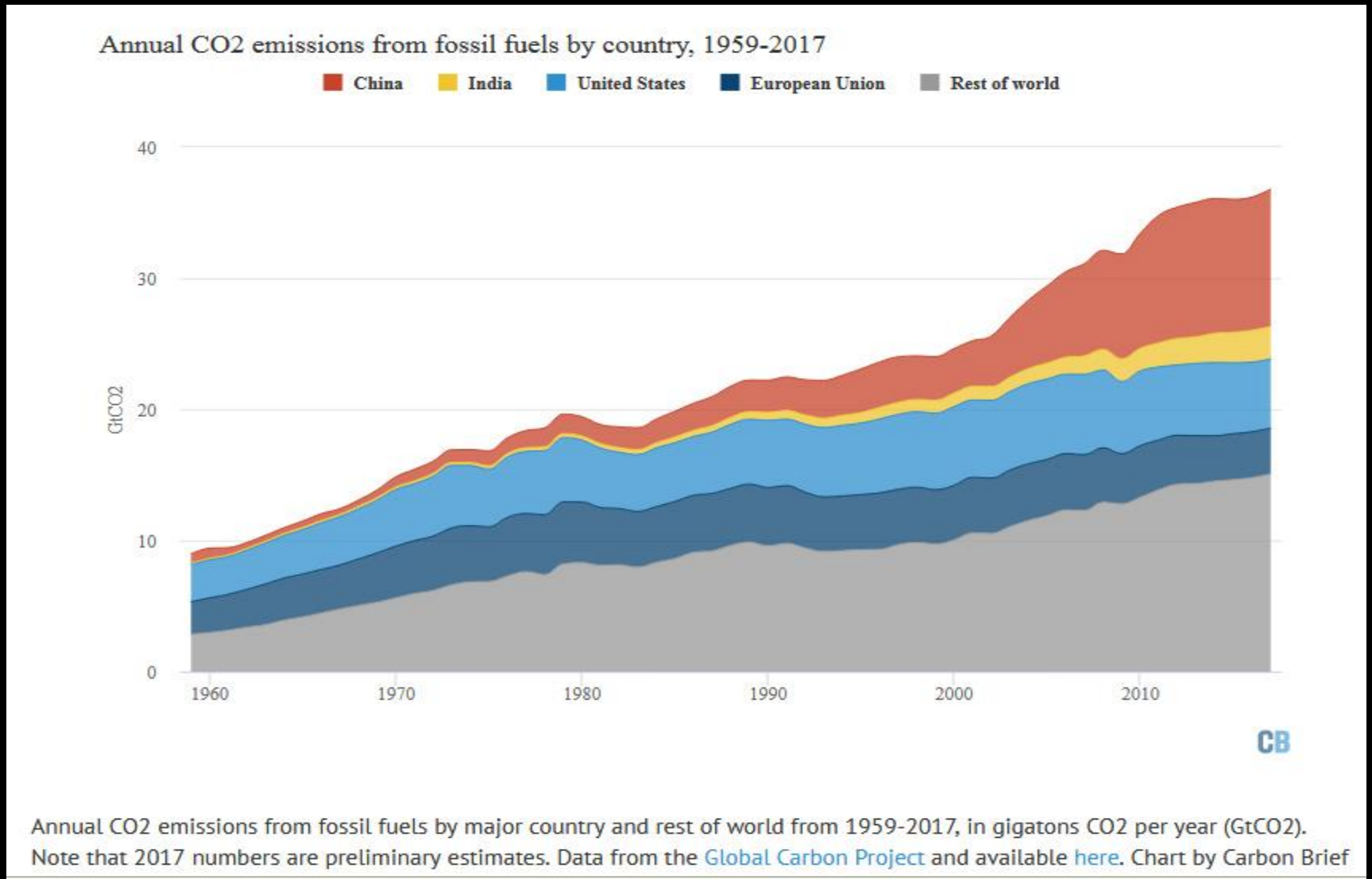
Strong CO2 Emissions in Asia generated by manufacturing goods flowing to the U.S. and Europe. We get the goods, they get the carbon guilt. An inconvenient fact not highlighted by policy people. The U.S. trade deficit, mostly with China, set a new record $50 billion as I write this in early '18



So, while we in the U.S. have long since leveled off emissions… instead we're rapidly accelerating the exporting of our fossil fuels to other countries, especially Asia, and THEY burn it. Burned is burned - climate doesn't care WHO burned it. No Stranded Assets Left Behind!

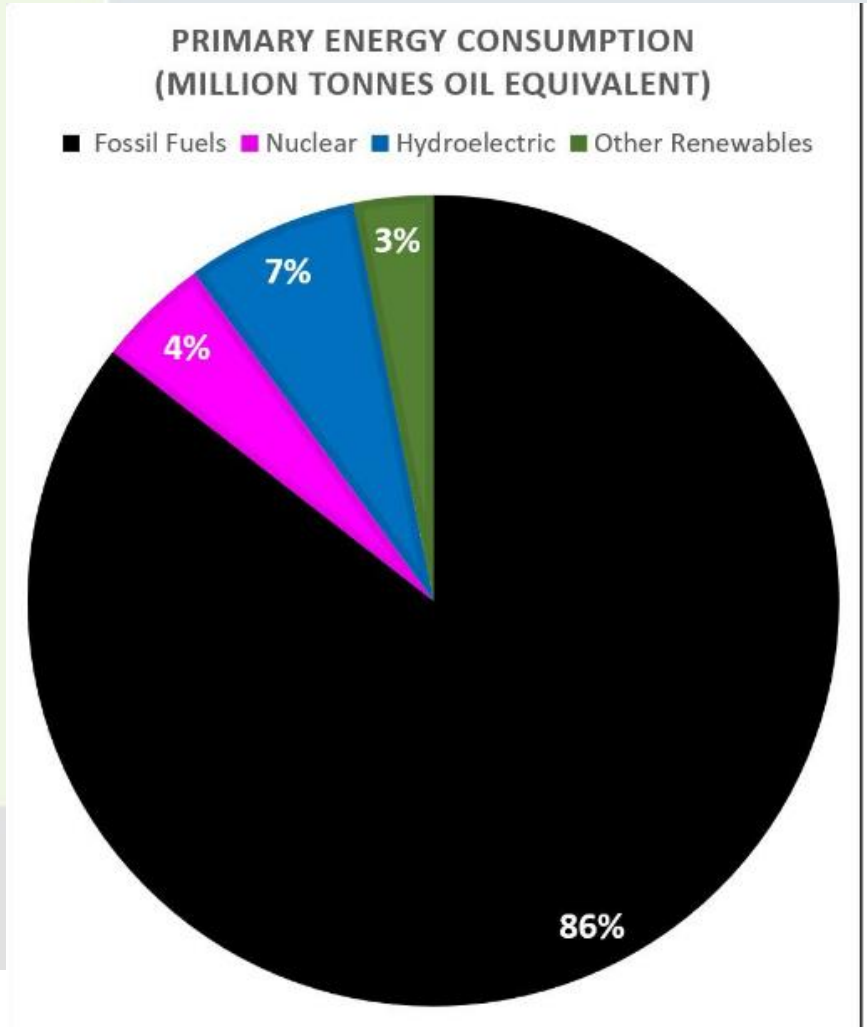


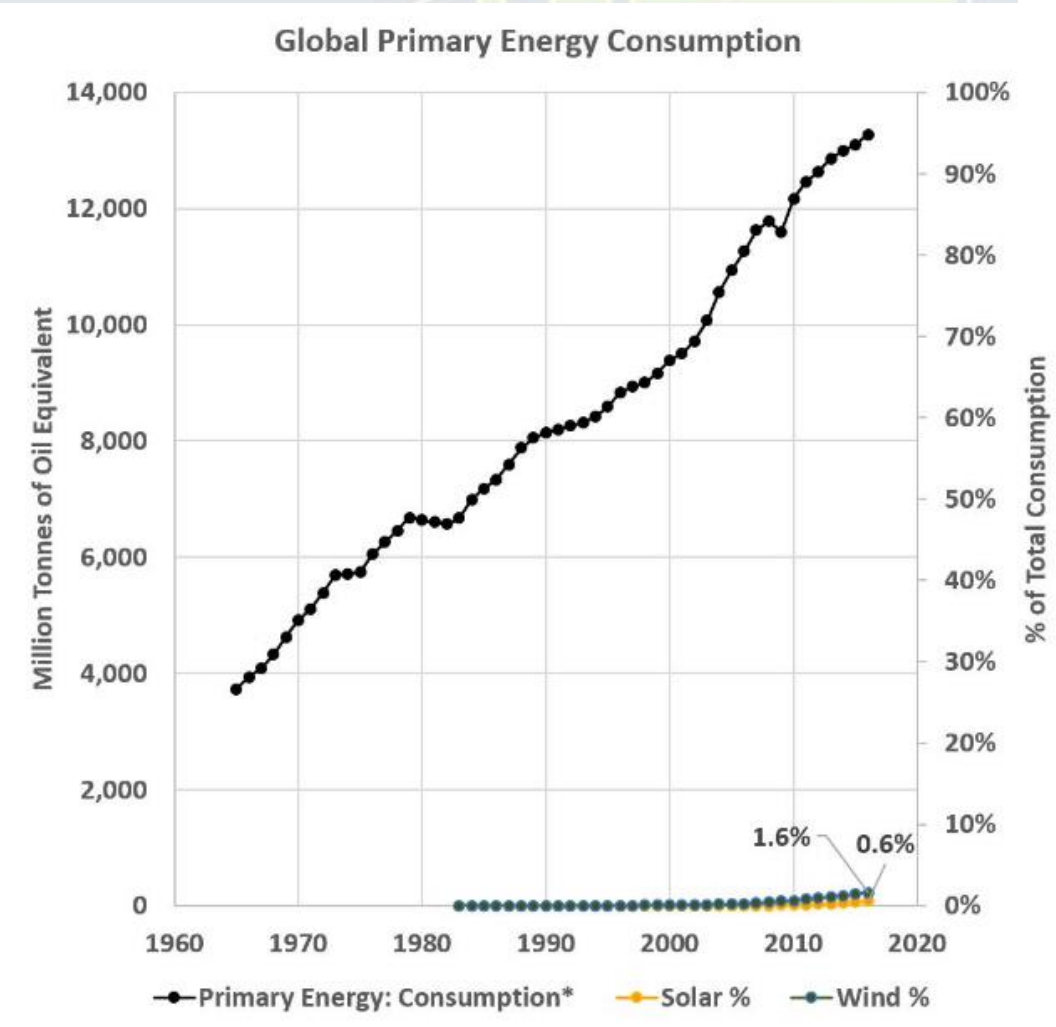
“Peak Emissions” Celebration? Put Away the Party Hats - 2017 CO2 Emissions Rise +2%, Led by China’s +3.5%. Repeated in 2018



Annual CO2 emissions from fossil fuels by major country and rest of world from 1959-2017, in gigatons CO2 per year (GtCO2). Note that 2017 numbers are preliminary estimates. Data from the Global Carbon Project and available here. Chart by Carbon Brief

Rising Total Primary Energy, mostly Fossil Fuels, is out-running Solar and Wind (2016). Don't be fooled by percentage rise claims. A small percent gain on a large base still beats a large percent on a very small base.





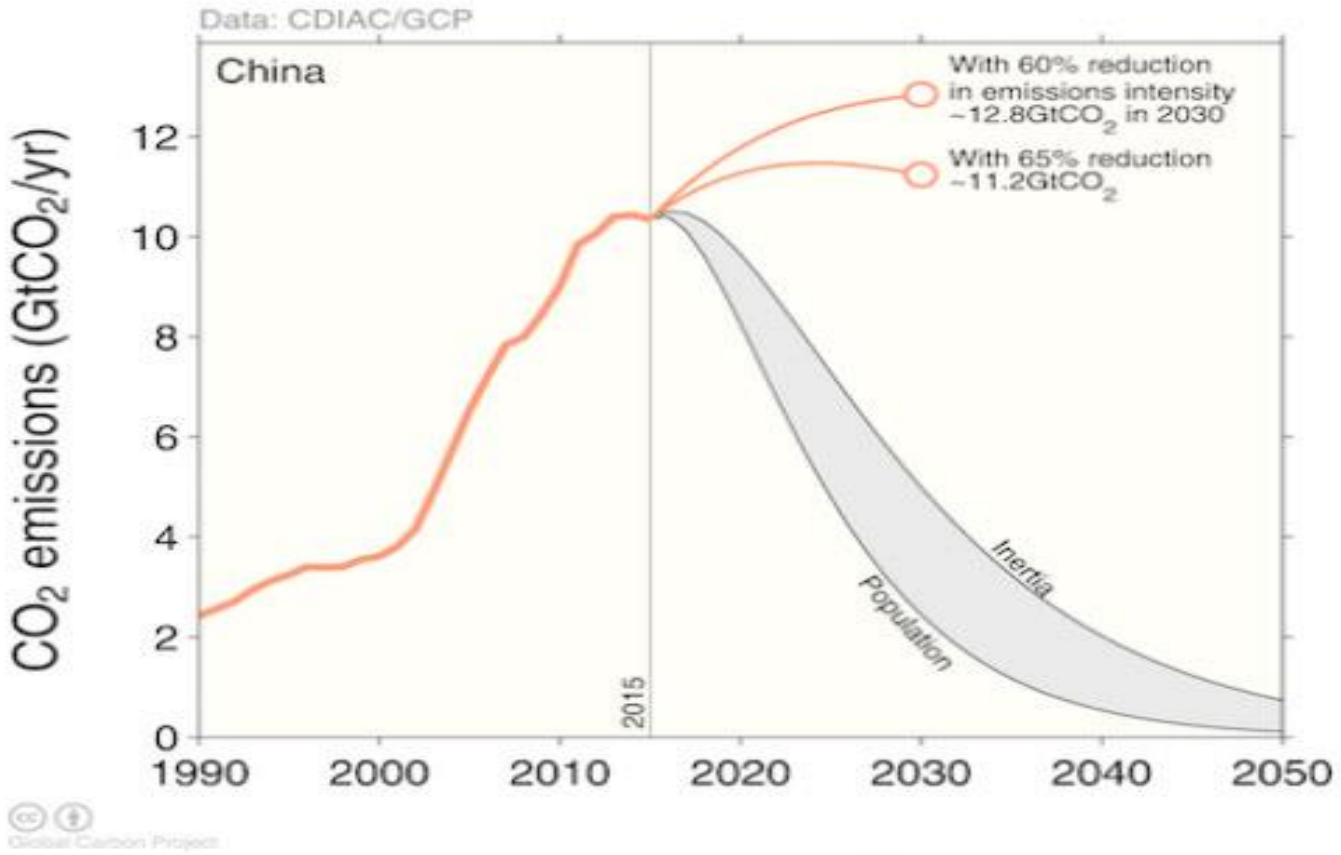
And now China too is outsourcing its CO2 intensive manufacturing…

- They have a growing middle class and rising wages and are themselves under increasing financial pressure to outsource CO2-intensive manufacturing to yet cheaper-wage countries. First to **Vietnam**, Thailand and Cambodia and now to more primitive countries in **Africa**, with higher carbon intensities.
- Expect to continue to chase the carbon pollution sources down the developing countries list.
- **These decisions are clearly dictated by pursuit of economic wealth in the "now", not concern for the future Earth and future generations.**

Much Press has been made of China's Recent Promises to "Lower CO2 Emissions"

- But Glen Peters in **ClimateChangeNews (2017)** looks deeper and **advises strong skepticism,** based on under-reporting, boom/bust construction, and the unique way the numbers are reported.
- *"A recent **study** estimated that a **decline in construction activity explained about three-quarters of the decline in coal use**. This is since construction requires energy-intensive inputs of products such as cement and steel.*
- *"Economic woes are behind the recent slowdown in Chinese coal consumption and emissions, but growth in renewables and concerns about air pollution contributed."*
- **So - Economic woes, not increasing energy efficiency, accounted for most of the decline in coal use. Consider…**

China's pledge of 60-65% reduction in CO2 emissions per $ real GDP by 2030 sounds *Planet-Savingly Dramatic*… until you convolve with their growth. Do the math and see what it means: CO2 Annual Emission Rates Keep Rising (circles)

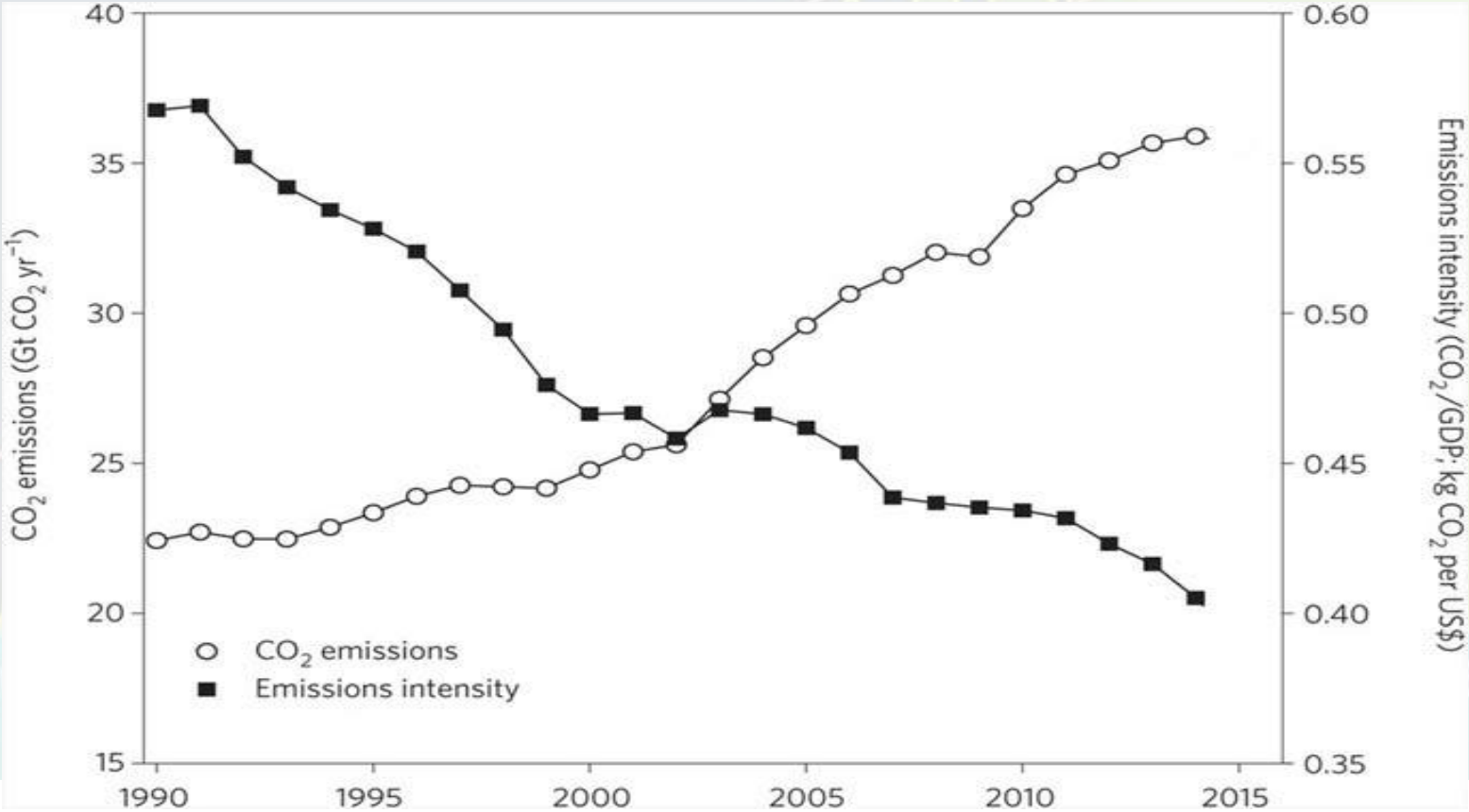


The Chinese emission pledge (orange lines after 2015) is inconsistent with the recent slowdown in emissions growth (orange lines before 2015). The grey band shows where Chinese emissions need to go to remain consistent with a 2°C temperature limit. (Source: Cicero)

Let's Make Sure You Understand That Last Slide…

- A promised 60% reduction in carbon intensity of GDP by 2030 means each dollar of GDP contributes only 40% of the CO2 that it did in 2017. That corresponds to an exponential halving time $\mathbf{t_{1/2}}$ of only **14 years!**
- **Very Impressive** – (perhaps impossibly so), *vs*. 180 yr halving time globally for decarbonization achieved in the 20th century with hydro, nuclear deployment.
- We'll see how strikingly rapid that is, and certainly impossible without decommissioning perfectly working fossil fuel fired power plants – something wasteful which we don't do; so be skeptical of the promise.
- **<u>Yet even so; their CO2 emissions per year remain on the same rising trend set in 2000, right through 2030!</u>**

Policy People Keep You Complacent By Focusing on the Right Side Axis = Lowering CO2 per $GDP. Scientists keep pointing out climate doesn't care; only the LEFT axis (Total CO2 Emissions) Matter!



And so – The climate forcing due to our GHG's is not only rising, the growth rate of rising is itself rising since 2002 (from Hansen *et al.* 2017). Climate forcing rise rate by GHG's has risen an astounding 50% in just 13 years, and accelerating. That's dramatic exponential growth.

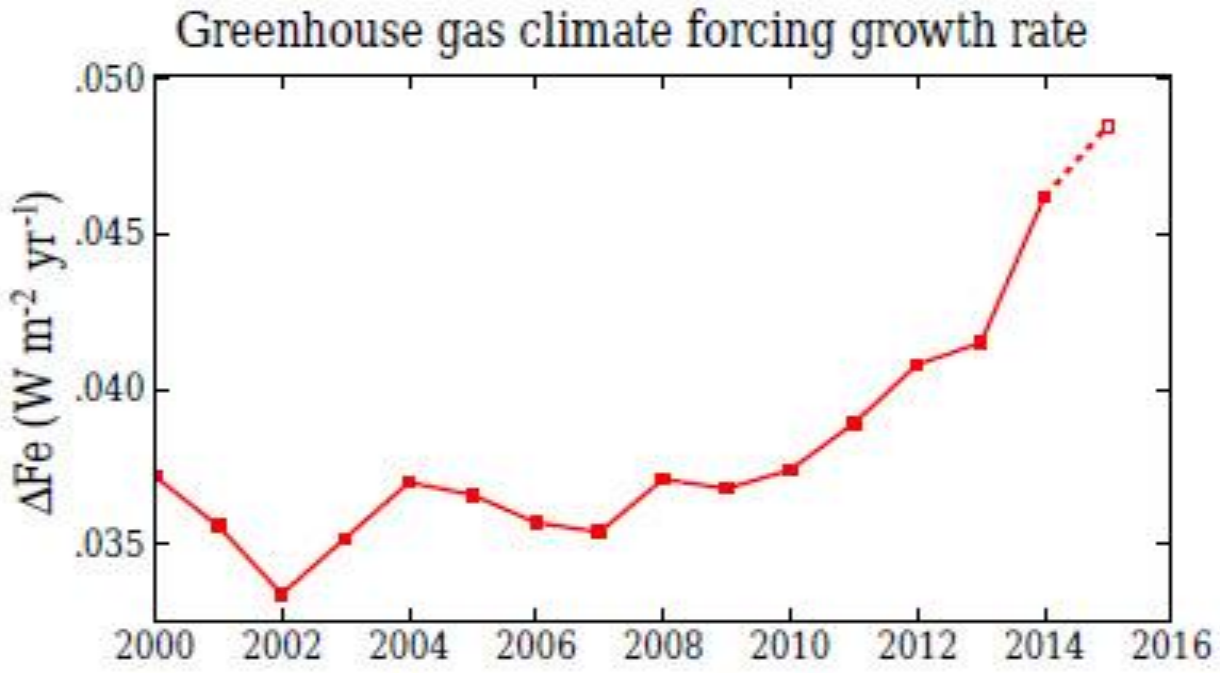
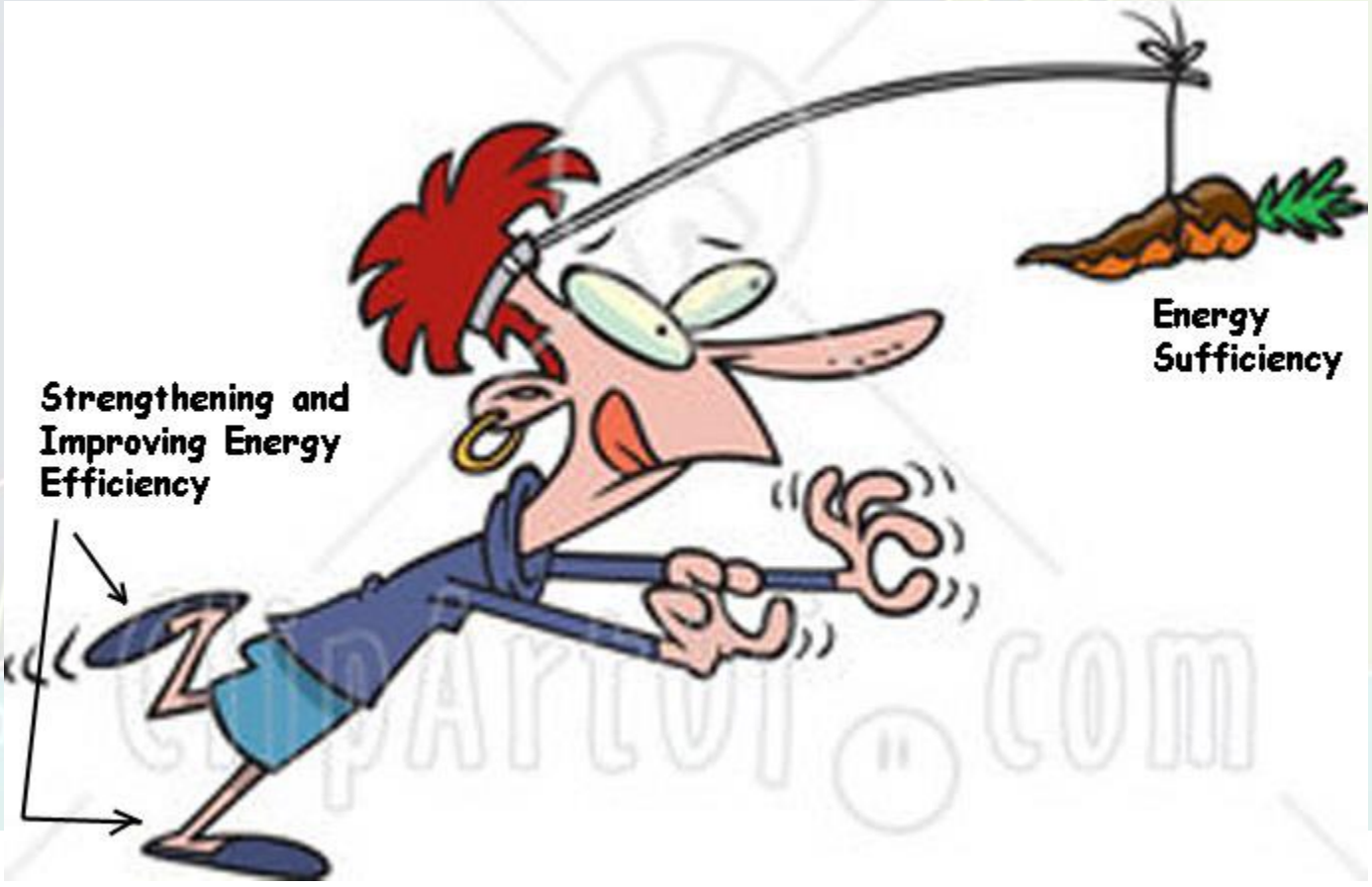


Figure 14. Recent growth rate of total GHG effective climate forcing; points are 5-year running means, except for 2015, which is a 3-year mean. See Fig. 8 for individual gases.

Policy People and Profit-hunting promoters of their schemes, will narrow your attention to the CO2 per person in cherry-picked countries slightly going downward, like this couple on these stairs…

…Diverting you from realizing, like these confused shoppers, you're walking 5 mph down a CO_2 escalator running upwards 10 mph

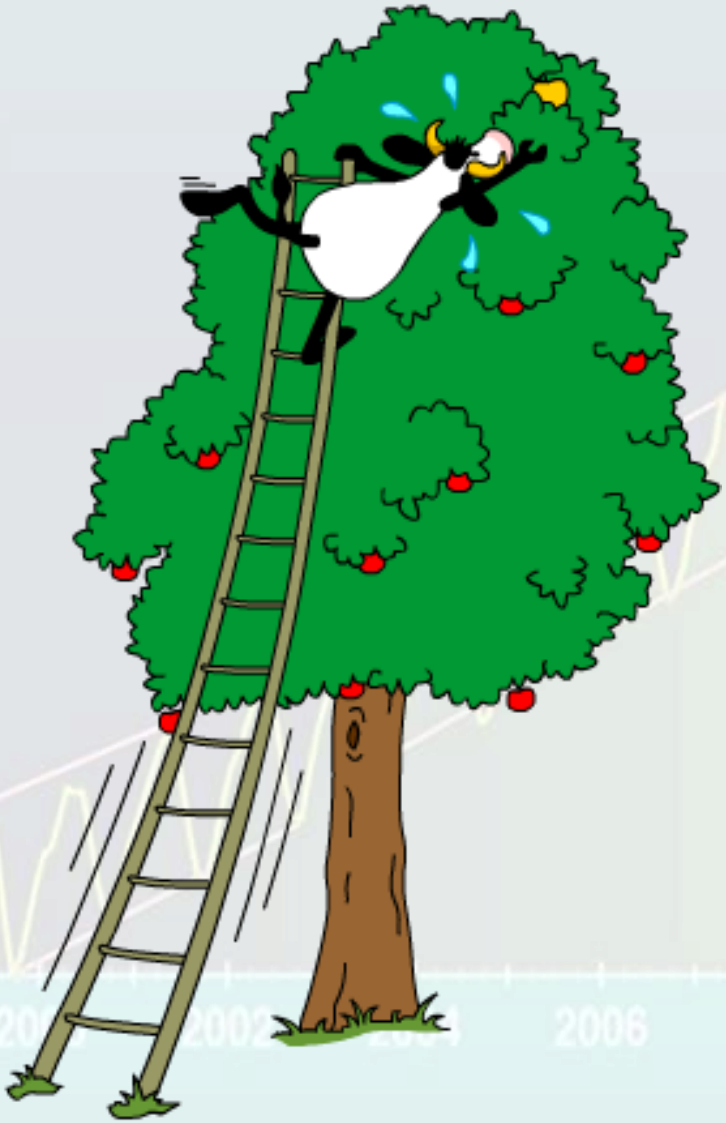
It is the very accomplishment of an improvement of energy efficiency which pushes the carrot of Energy Satiation further forwards, and continually out of reach. We refuse to face this, and so we keep running harder to catch up to the carrot.



Another Aspect: Increasing Complexity

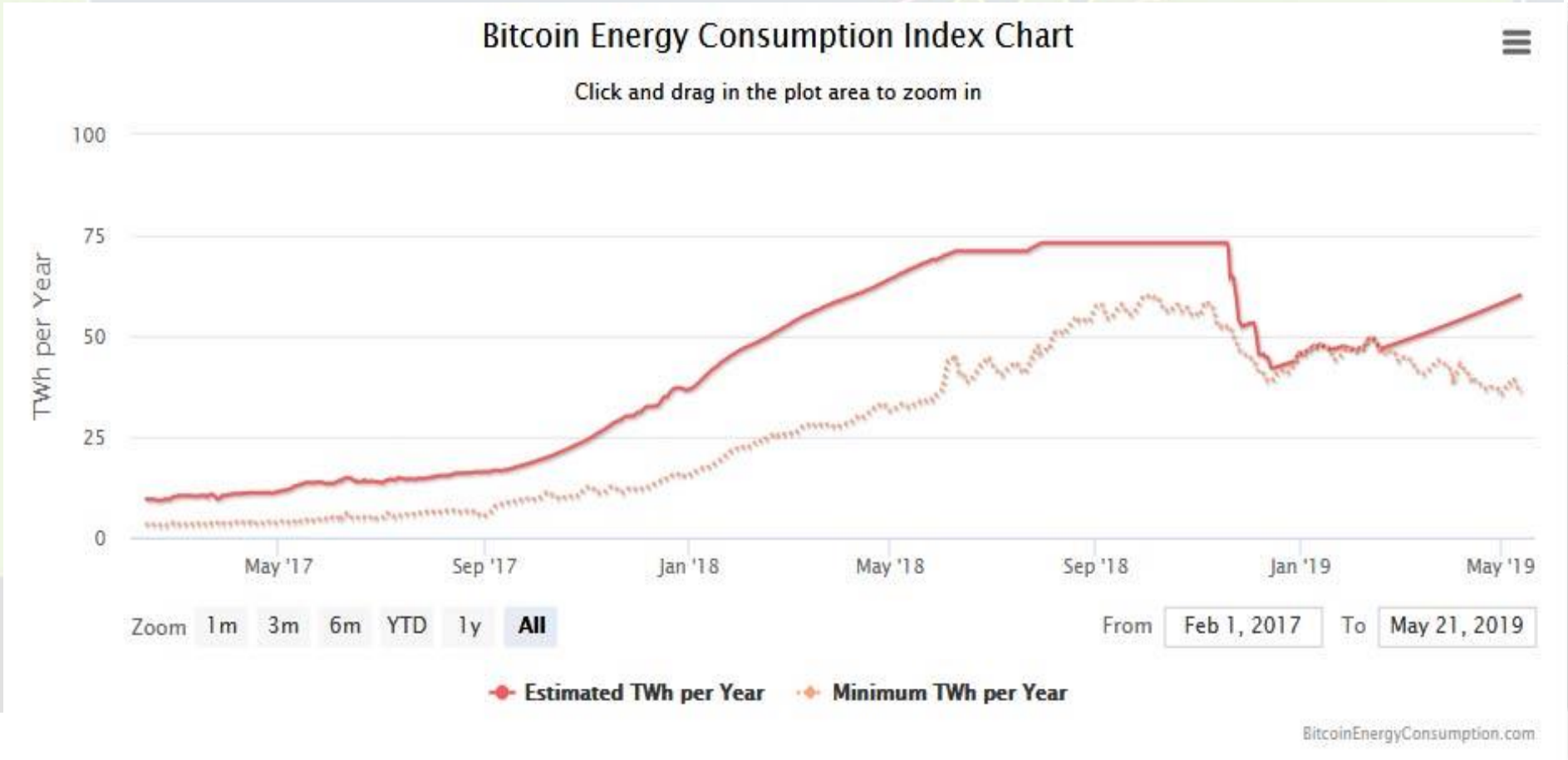
- We are adding complexity to Civilization at a high rate. It buys us a bit more cost-savings.
- But it also adds significantly to our energy burdens and effort burdens to stretch the frontier further.
- As we crawl out onto skinnier and skinnier limbs to access the last fruit from the tops of the trees (the low-hanging fruit having long been picked)…

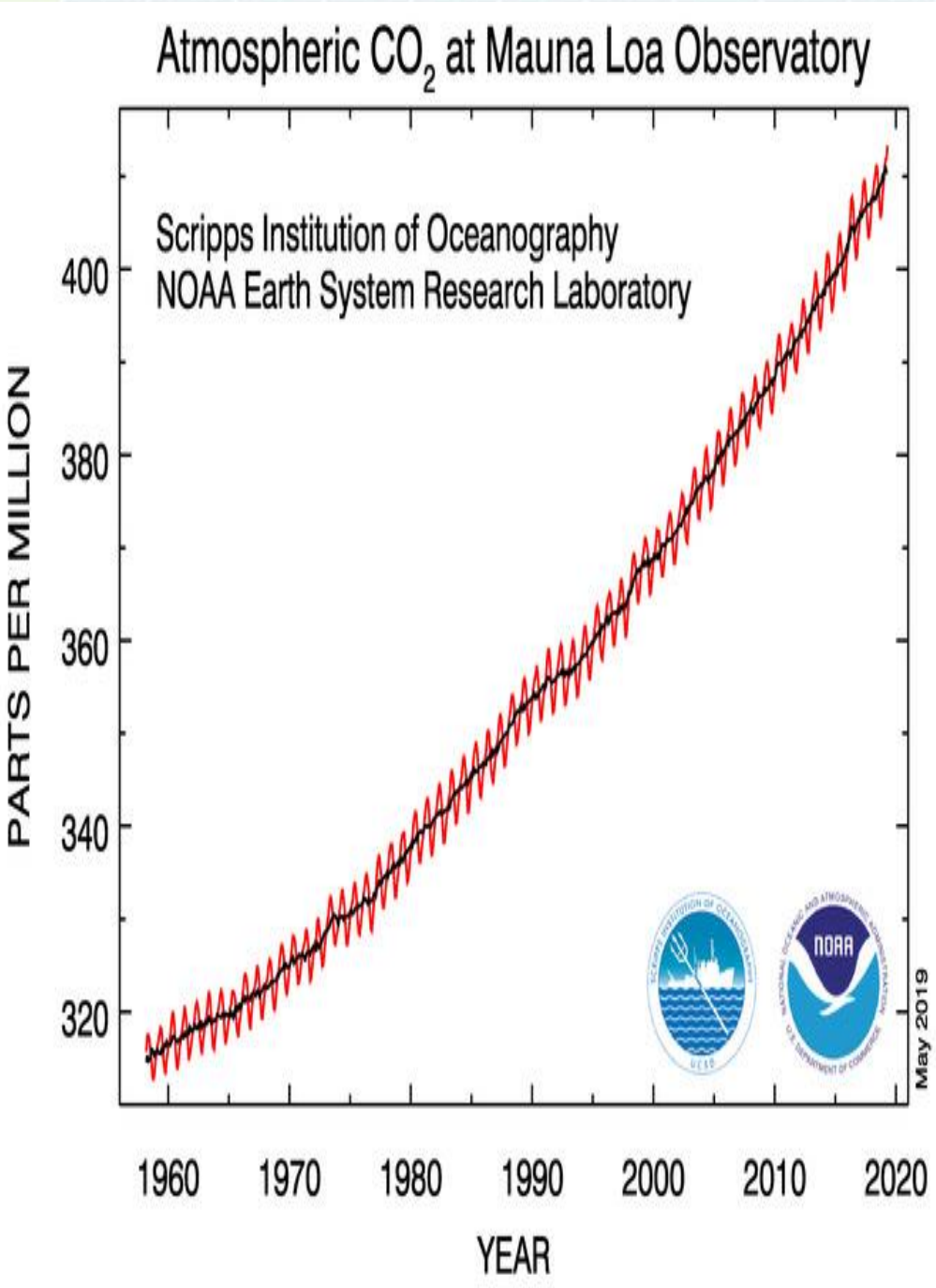
We Increasingly Risk Societal Collapse



- … when, for example, *"Just-in-time manufacturing"* increasingly grinds to a halt due to a single missing part from a riot-closed factory…
- …When gizmos you used to be able to fix yourself, now are too complicated and expensive to fix at all.
- It's said that no city is more than a week away from **food riots**, for this reason

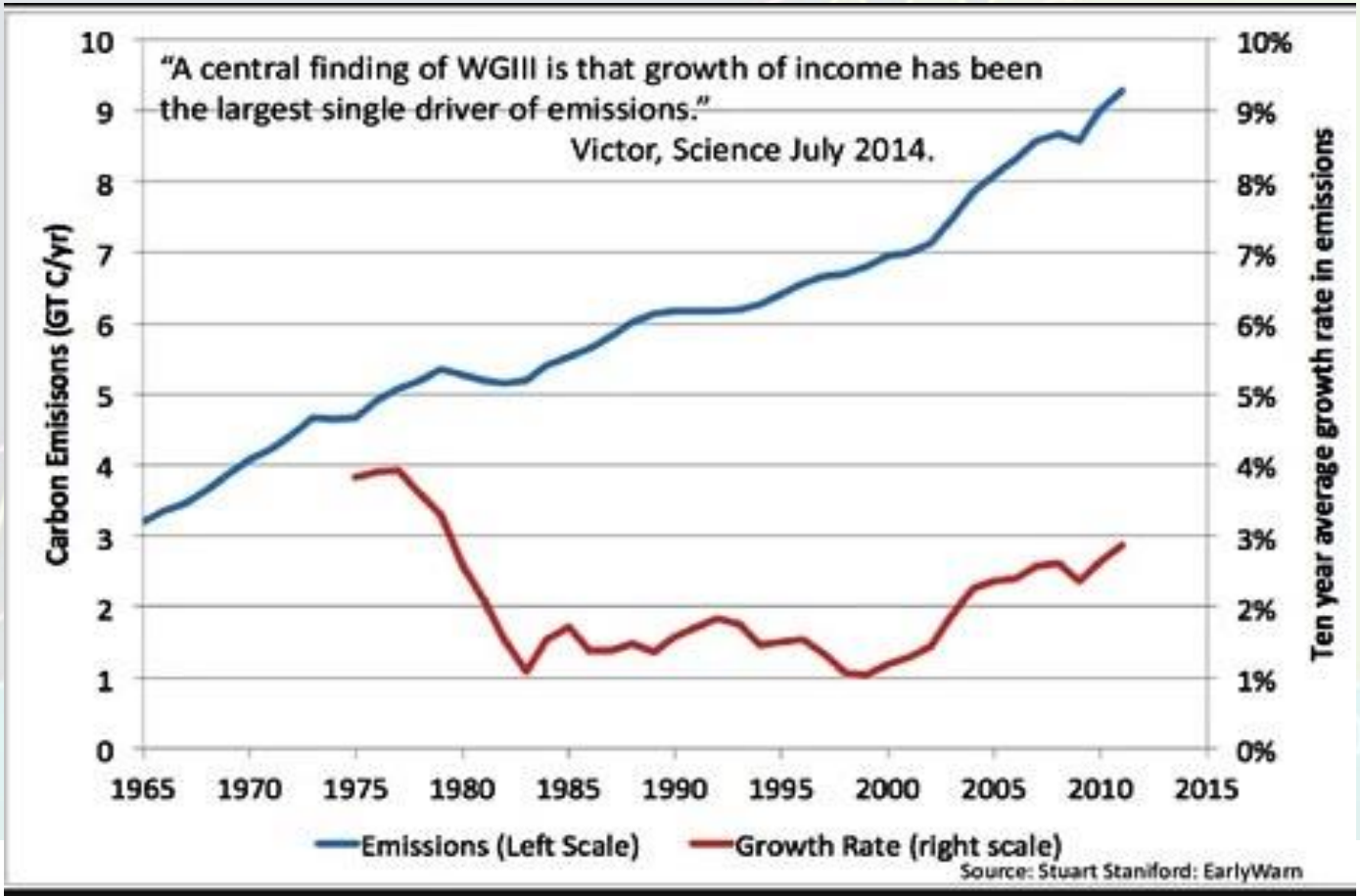
Bitcoin: Sign of the times? Bitcoin mining seeking the next blocks in the block chain consume electricity at the same rate as the entire country of Chile. Every single bitcoin-enabled transaction (1 block) puts 500 lb of CO_2 into the atmosphere, as of May 2019





CO2 remains on an exponential rising curve. Now over 414 parts per million (Apr '19). Not just CO2 levels, but the acceleration rate of atmospheric CO2 sets new records each of the past few years. We've been increasing energy efficiency for millennia. So PLEASE - Let's STOP being delusional about what increasing energy efficiency GETS US. It results in HIGHER ENERGY CONSUMPTION RATES, not LOWER.

The IPCC Working Group III (on the science) found that the single biggest determiner of the growth in GHG emissions – is income growth. Not surprisingly, the UN policy people who must sign off on what's published, deleted this from the IPCC "Summary for Policy Makers" (ScienceDaily 2014)



Can We Find Flaws in the Garrett Relation?

- **After all, the conclusions are grim!**
- **I'd LIKE to find flaws. I've tried!**
- **I've examined… inflation biases, GDP *vs.* total spending, the Recession-GDP Bias, currency calibration between countries: PPP *vs.* MER**

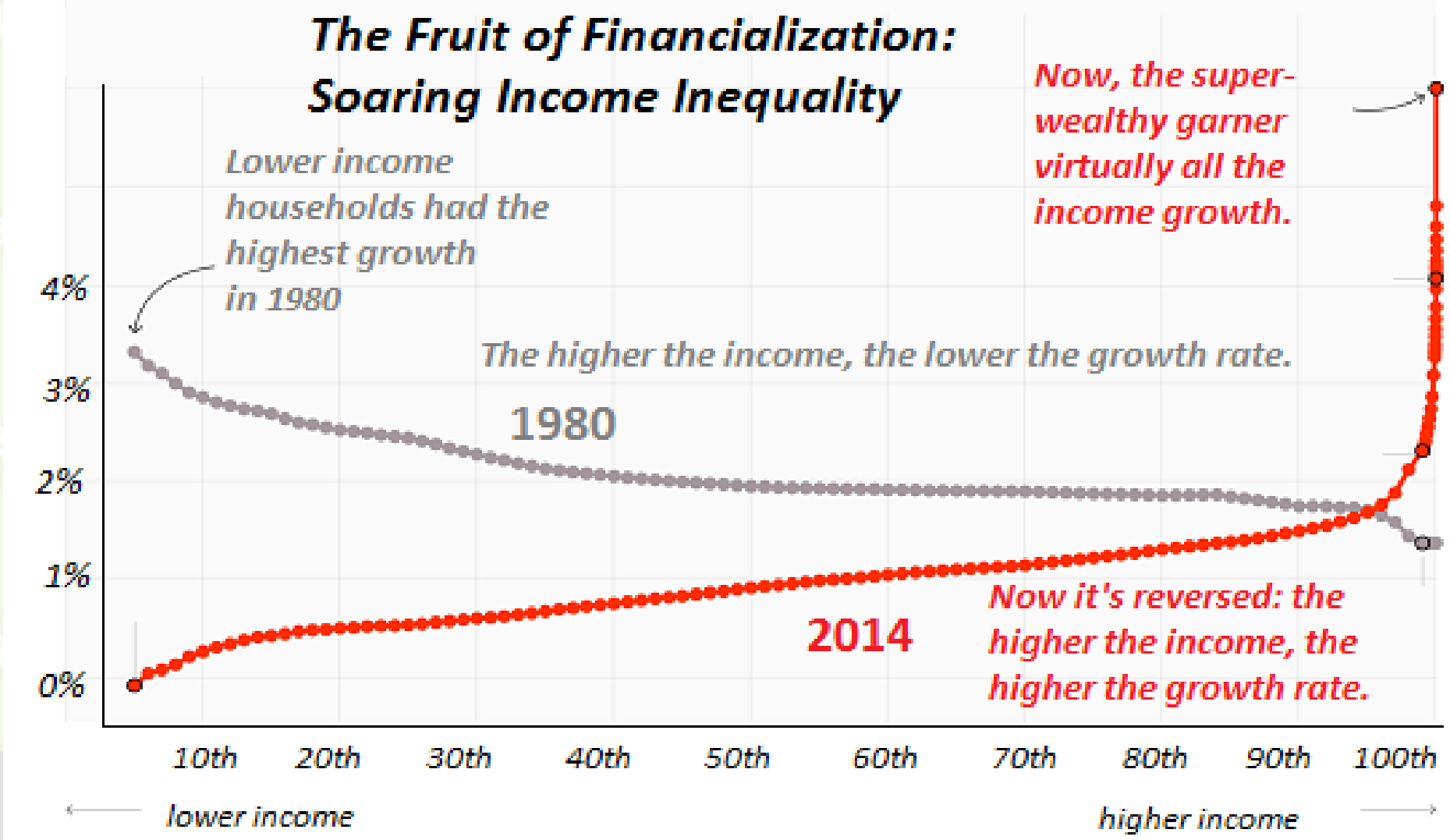
True Inflation

= A mismatch between the growth of true **Wealth**, and the **money supply** which denominates it.

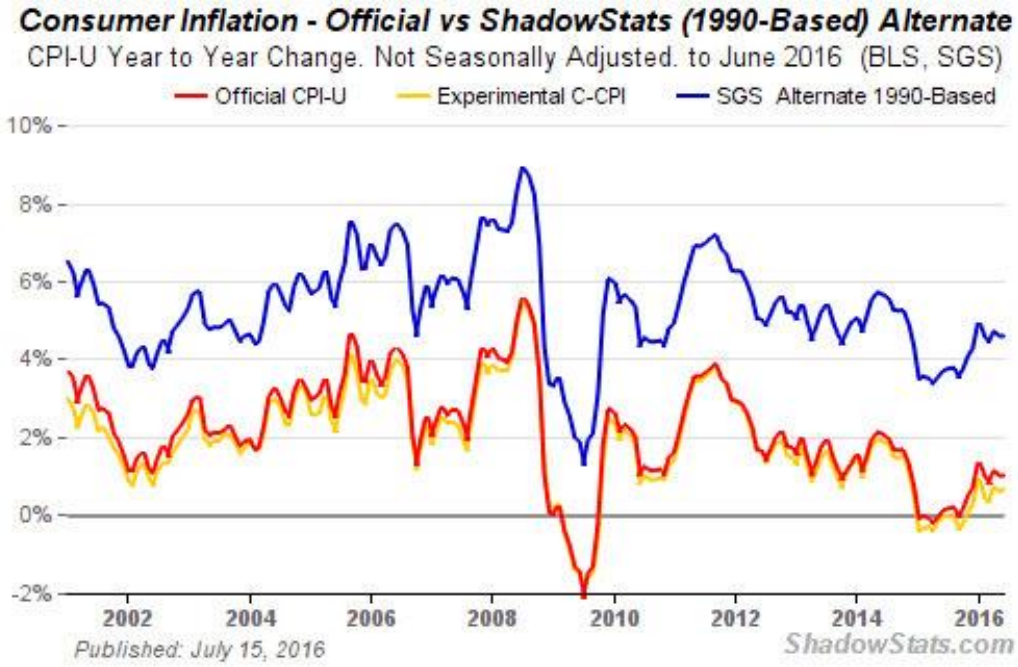
But Western Governments are On the Hook…

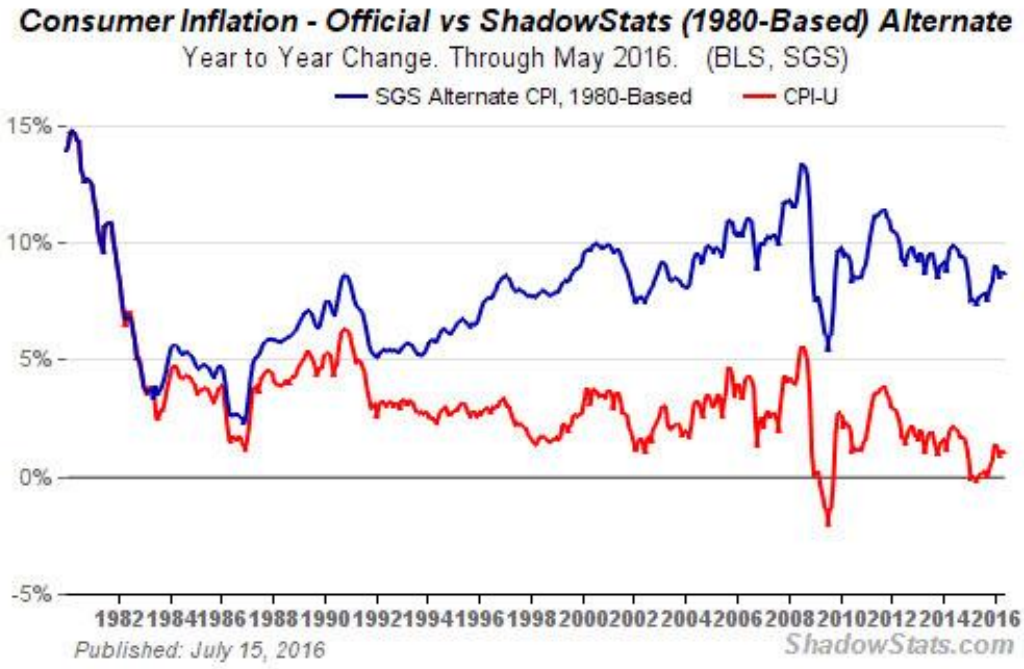
- For COLA adjustments to huge unfunded liabilities: Social Security, Medicare, etc…
- ~70 trillion dollars of U.S. government liabilities - that's $200,000 **per person!** - are indexed to CPI-derived inflation.
- So they WANT to find a way to understate inflation. The **Boskin-Moynihan Commission in mid '90's** accomplished exactly that. One change was to continually adjust the basket of goods indexed.
- **But as people migrate down the economic ladder, expensive goods get replaced by cheaper goods. This will UNDERSTATE true inflation**.

Yes, most of us <u>are</u> migrating down the economic ladder



source: New York Times 8/7/17

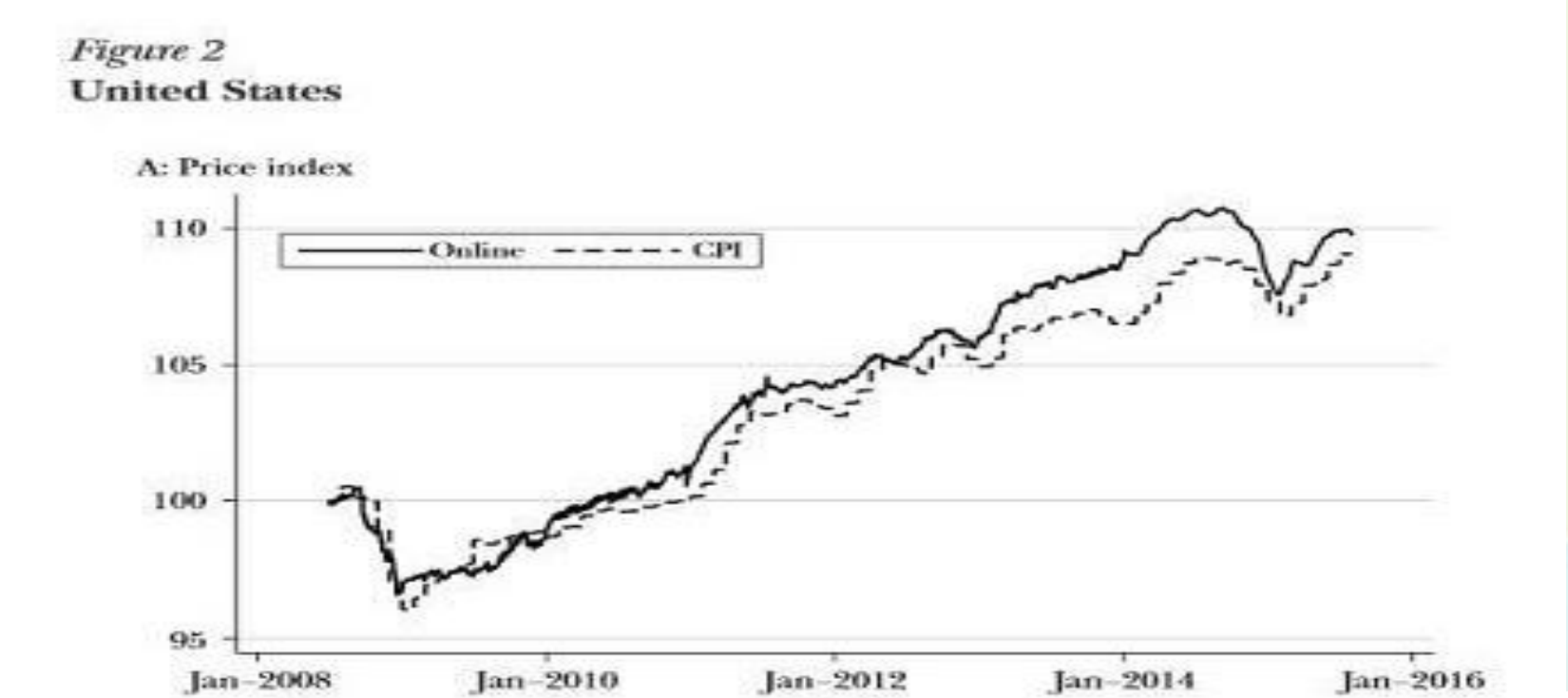




Therefore: CPI is Biased low:

ShadowStats makes an attempt to remove the bias mentioned, and claims the actual U.S. CPI rate is consistently as much as 3.5-4% per year above headline CPI. As a ratio of percents, that's roughly 2x higher than the stated CPI. While ShadowStats CPI has been criticized as "absurdly" high, the real issue is a difference in the nature of inflation.

MIT's BillionPrices Project uses a much wider range of global online prices to compile a more complete CPI. They too find official annual CPI (CPI_o) is understated (dashed curve), but by a much smaller amount: Official U.S. CPI since 2009 has averaged 1.567%, and BillionPrices CPI has averaged 1.826% per year); 17% higher. However, their methodology doesn't fix the inherent bias in a changing basket of goods, and so is likely still an under-estimate. Still, I've adopted it for a revised Garrett Relation graph to come, as a global estimate.



How to Calibrate Between Countries' Differing Currencies? Two Methods Have Been Used…

- **PPP: Purchasing Power Parity; *e.g.* the "Big Mac Index"**
- **MER: Market Exchange Rates**

- Some economists prefer PPP. But PPP accounting numerically improves developing countries' growth (interestingly, providing a justification for reducing foreign aid, some have noted).

Use MER, not PPP…

- The core of the Garrett Relation is that the accumulated **past** spending in building civilization's networks encumbers **current and future** energy consumption to support the growth enabled.
- And, given the exact same spending on a given good or service, civilization's network absolute growth will be enhanced more strongly in a rich country than in a poor country, because the enhanced networks facilitating this growth are already in existence in the richer country.

A Big Mac eaten by a higher powered New York CEO will do more for spurring future economic growth than will the identical Big Mac eaten by a village farmer in a poor country.

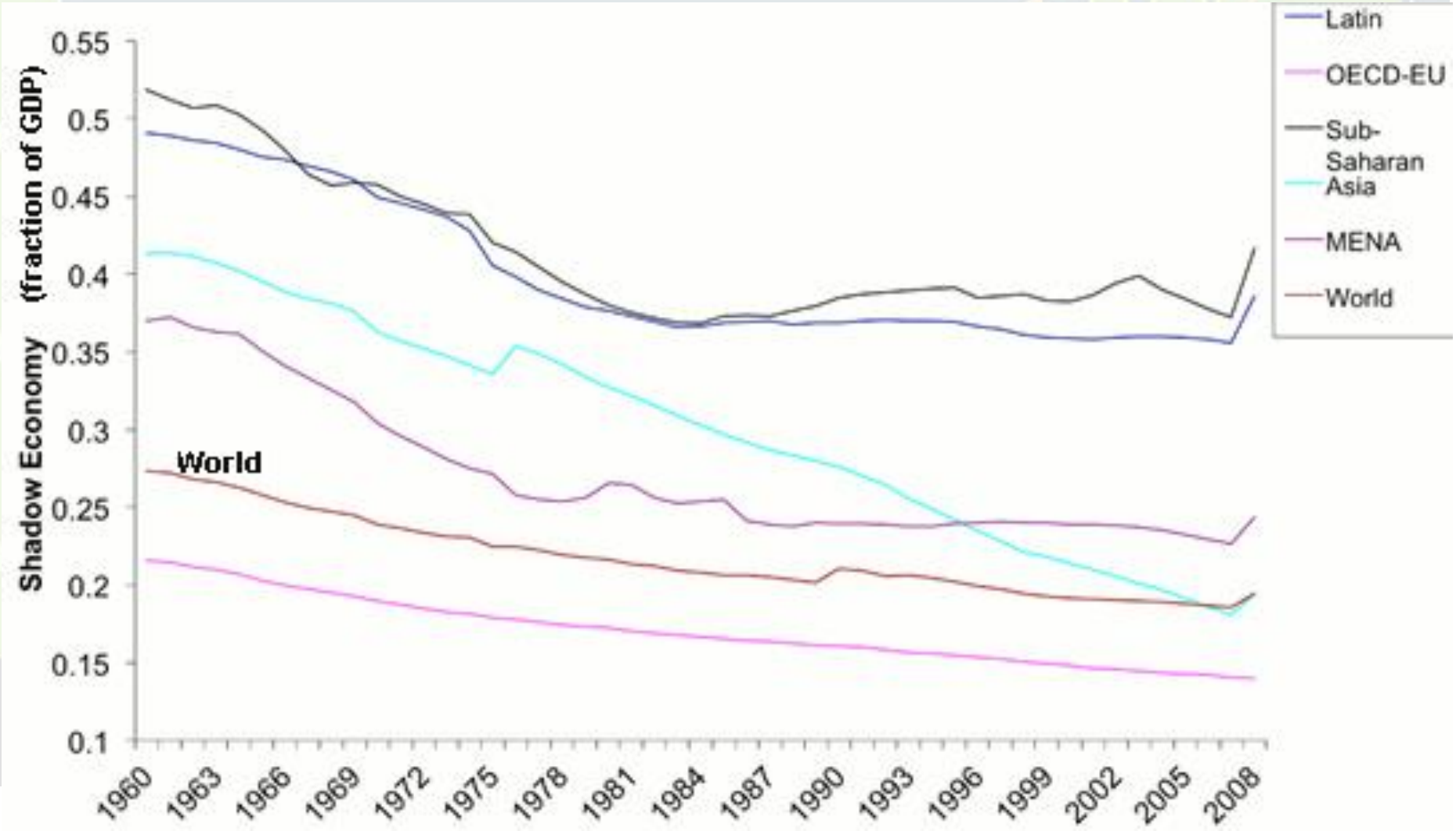
- Now, **The Garrett Relation** couples PAST spending to CURRENT and FUTURE power consumption. **Time matters!**
- …and currency traders (and commodity and equity traders, too, in fact) will factor in the anticipated future value of the asset in bidding on present price.
- MER includes this. PPP does not**. USE MER (as Garrett did).**

Next: GDP, Total Spending and The Thermodynamic Rationale for the Existence of the Garrett Relation…

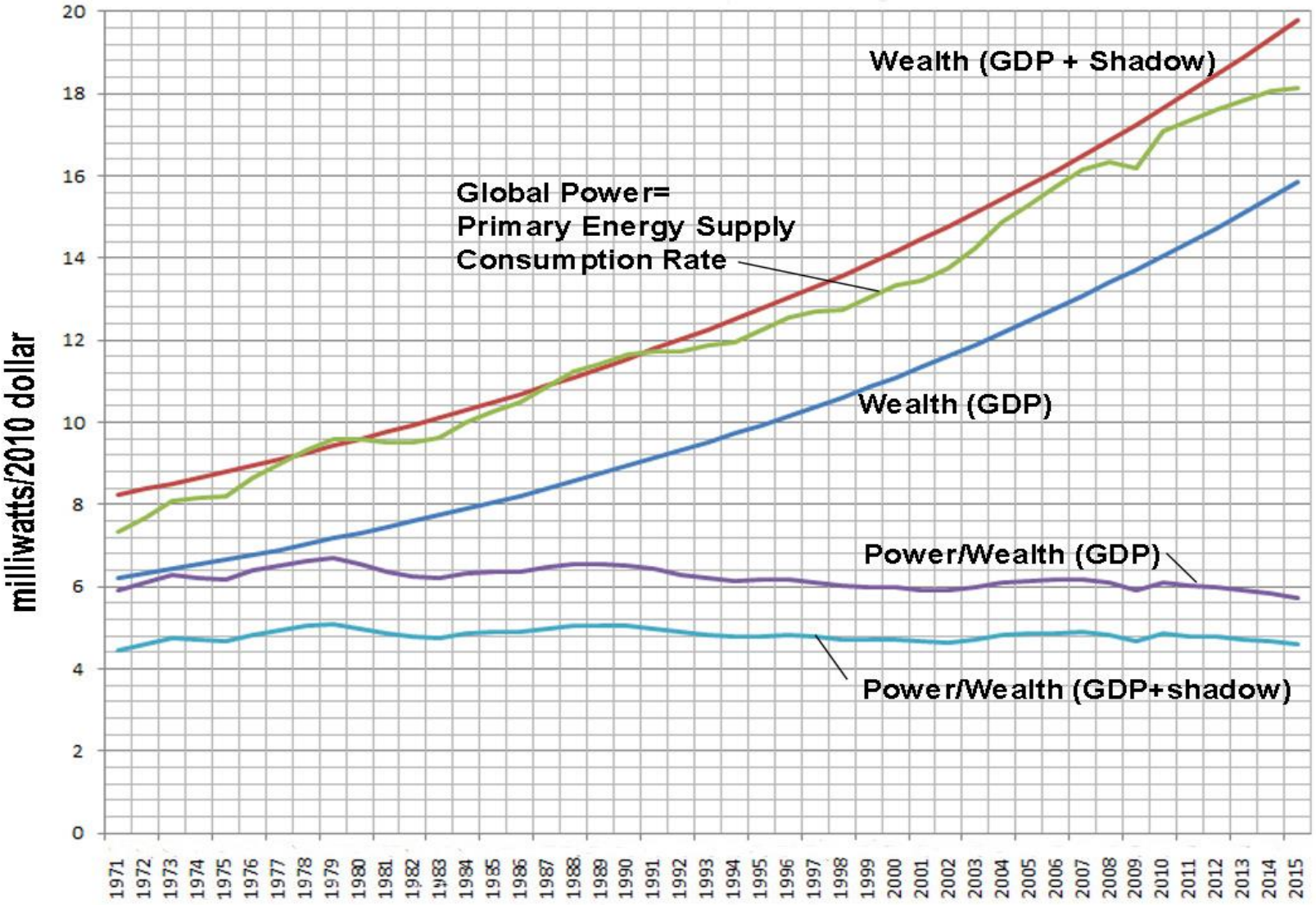
- …argues that we need to include ALL spending, since ALL spending lowers civilization entropy and encumbers new power to maintain that.
- NOT just GDP spending, as Garrett has done. GDP does not include… housework, barter, black markets…, nor even housing, properly done.
- **We need to include…**


THE
SHADOW
ECONOMY

The Shadow Economy as % of global GDP dropped more steeply from 1960 to ~1975, shallowing afterwards (Elgin and Oztunali 2012). The "World" curve is falling gently with some bumps, while the OECD minus EU countries (bottom curve) fall gently but consistently. I'll now include the Shadow Economy and MIT's revised global inflation…



The Garrett Relation is even flatter using Total Spending (light blue) *vs.* GDP alone (purple). Both curves include dGDP from MIT's Billion Prices Project. Result: The Garrett Relation is Confirmed Valid in Real Data



The Recession – GDP Bias and the Bitter Implications if the Garrett Relation Remains True

- This is the name I give to a certain bias we see in reported GDP Data.
- **GDP is overstated during recessions** in at least some (most? all?) countries. Published data is sparse, so at this point it's a qualitative statement…

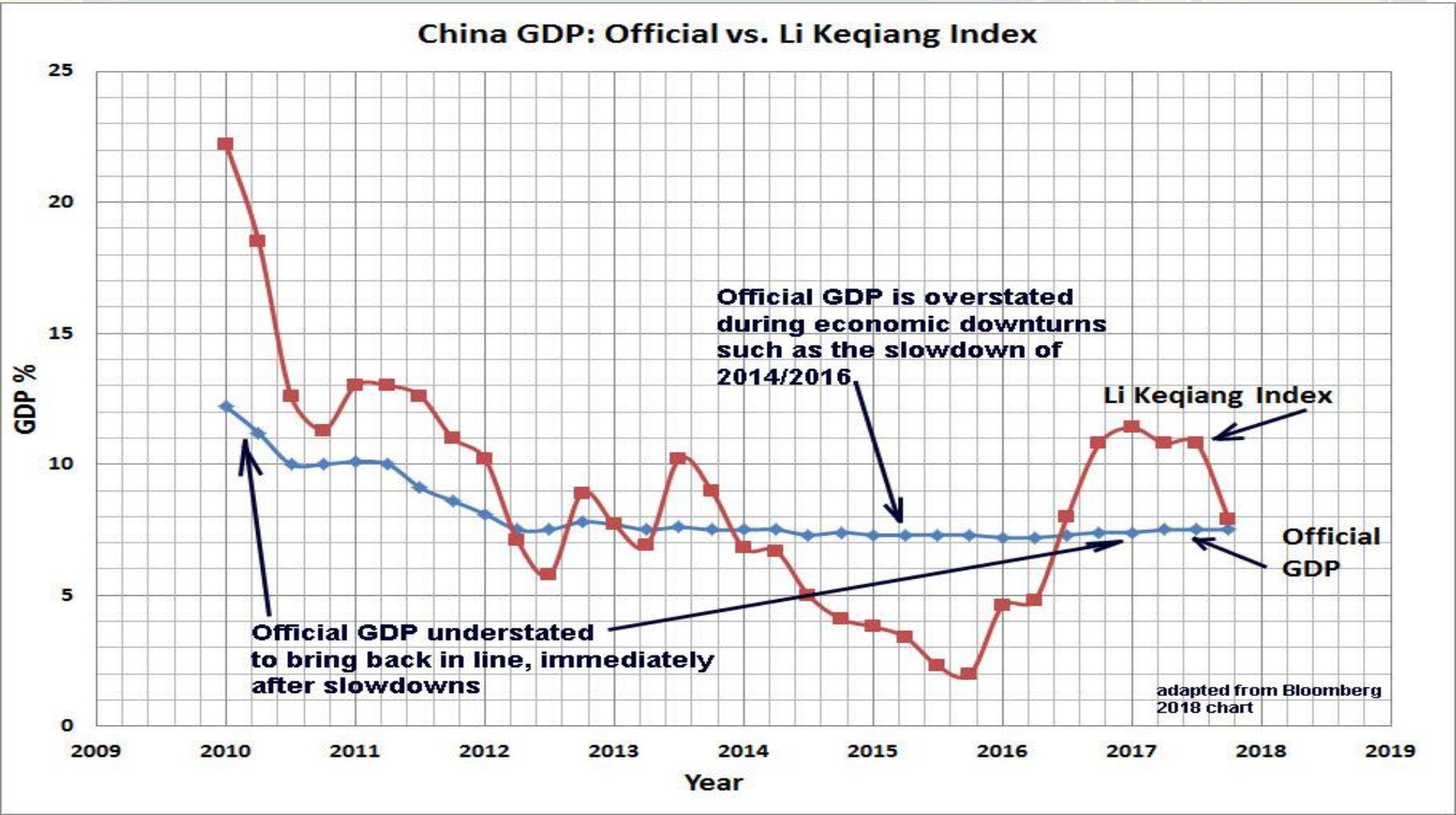
Bias in Reported GDP Figures from Emerging Countries

- There are political and financial market motivations for government officials to overstate their GDP figures because Wall St. bids prices for equities on the basis of their earnings GROWTH RATE, closely connected to GDP.
- And in China, local Communist Party officials charged with achieving certain economic growth figures by Beijing, usually report the figures they are commanded to achieve, regardless of the facts, finds a Federal Reserve study.

Given the historical level of integrity of those involved in such areas

- …it's not surprising that figures are exaggerated (Clark *et al.* 2017 from the New York Federal Reserve Bank), albeit by a difficult to quantify amount. Different proxies give different results, but overstatement of GDP is widespread.
- However, the Li Keqiang Index is considered by economists to be the most reliable proxy for true GDP in China.
- It is important to notice that GDP growth is MOST overstated during recessions (Mayger 2018, also see Owyang and Shell 2017, Heubl 2018.)

<u>The Recession – GDP Bias</u>. In China's command economy, local party officials tend to report the production numbers they were mandated by Beijing to make, not the reality (best approximated by the Li Keqiang Index, say economists). So in recessions, GDP is over-reported, but then to compensate during the boom times, they tend to under-report.



Below is a chart showing the declared GDP growth of Inner Mongolia since 2011, and the contraction of 2016, assuming no other revisions.

An even more dramatic example is Inner Mongolia. During the 2016 contraction, official GDP was +7% but the *Financial Times* calculations show it was actually more like -10%. [Additional article].

So it Seems More Likely That Energy Efficiency Improvements Actually Do Reverse During Recessions

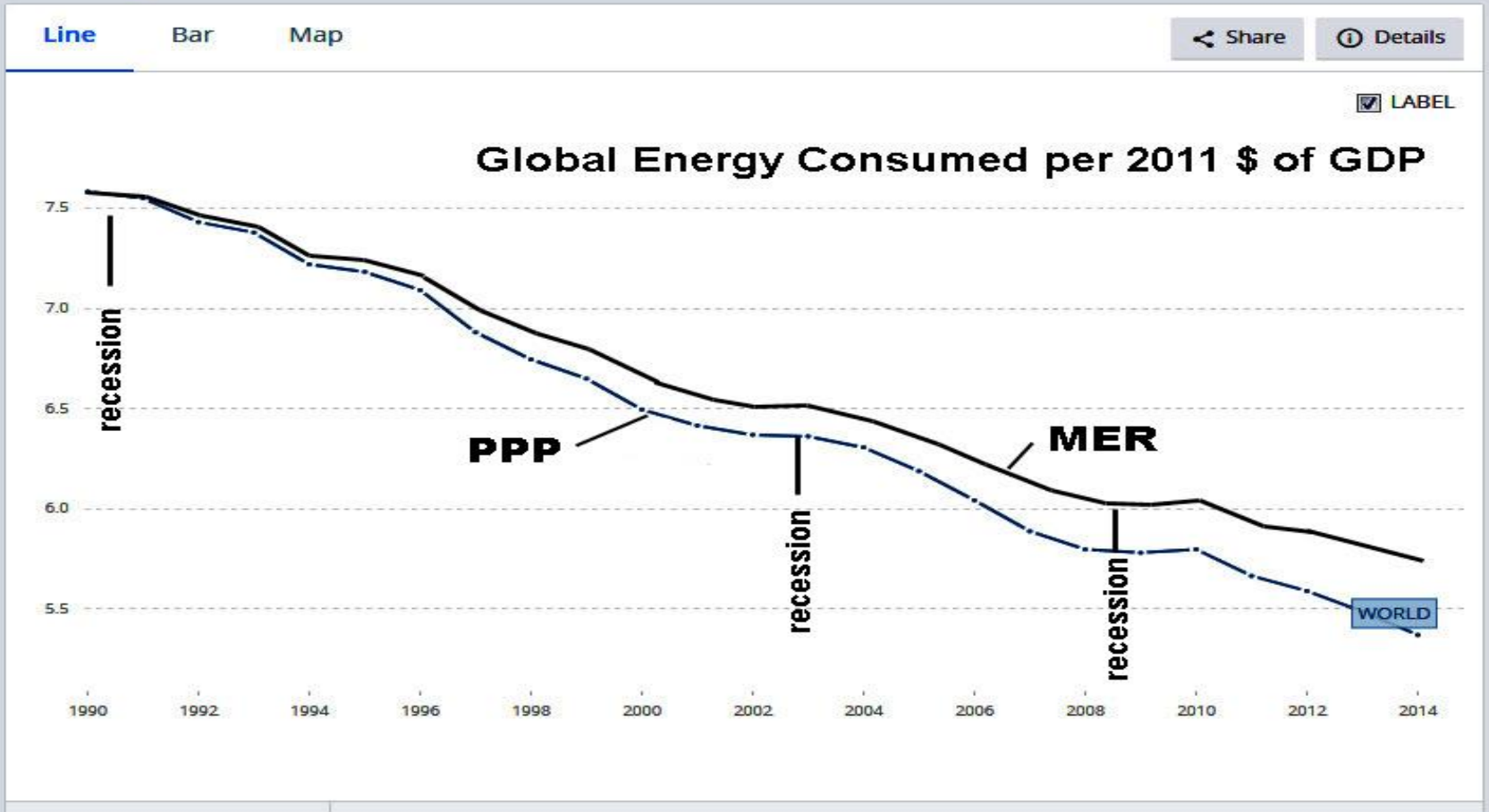
- Let's follow the reasoning and assume the Garrett Relation remains true as we consider instituting a long term global de-growth recession to solve our CO2 emissions problems…

f(t) == P(t)/G(t): **Primary Energy Consumption Rate (*P*) per unit of global GDP (*G*) is an approximately linearly dropping function. But note that during recessions (1990, 2001 and 2008/2009) *f(t)* went flat, so that the slope went to zero. But did it in fact tilt up (worsening EE?)**

Energy intensity level of primary energy (MJ/$2011 PPP GDP)

World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program.

License: Open



Sorry. Bear With Me - for a little more math I've done…

The World Bank data on the previous slide shows ***f;*** the global primary energy consumption rate (power ***P***) per unit of officially reported inflation-adjusted global GDP ***G***. ***f*** is a declining function so the slope is usually negative.

(1) $$f(t) \equiv P(t)/G(t)$$

Differentiating with respect to time **t** gives…

(2) $$\frac{\partial P}{\partial t} = G\frac{\partial f}{\partial t} + f\frac{\partial G}{\partial t}$$

Now, the Garrett Relation is…

(3) $$W(t) = \int_0^t G(t')dt' = \lambda P(t)$$

Differentiating with respect to time **t** gives…

(4) $$\frac{\partial P}{\partial t} = \frac{G}{\lambda}$$

and substituting this into (2) then gives

(5) $$\frac{1}{\lambda} = \frac{\partial f}{\partial t} + \frac{f}{G}\frac{\partial G}{\partial t}$$

And So…

$$\frac{1}{\lambda} = \frac{\partial f}{\partial t} + \frac{f}{G}\frac{\partial G}{\partial t}$$

- **Left side:** ALWAYS positive (λ = power per $ of Wealth)
- **Right side:** But during recessions the last term is negative), that **means that $\partial f/\partial t$ must be positive = upward tilt to our curve**.
- **<u>If the Garrett Relation remains true, it says we cannot simultaneously de-growth and also continue to improve the energy efficiency (EE) of global GDP</u>, so that $\partial f/\partial t$ would have to turn positive. In other words - we'd be struggling with merely maintaining past growth's Wealth, so current energy consumption would be growing FASTER than GDP, as hinted in the last recession, and starkly in the mid '70's recessions.**
- **<u>We Just Saw that the Real Data Supports this.</u>**
- Averaged over the noisy (and unreported error limits of the economists' data) boom and bust economic periods, the equation holds true (**Garrett 2010**).

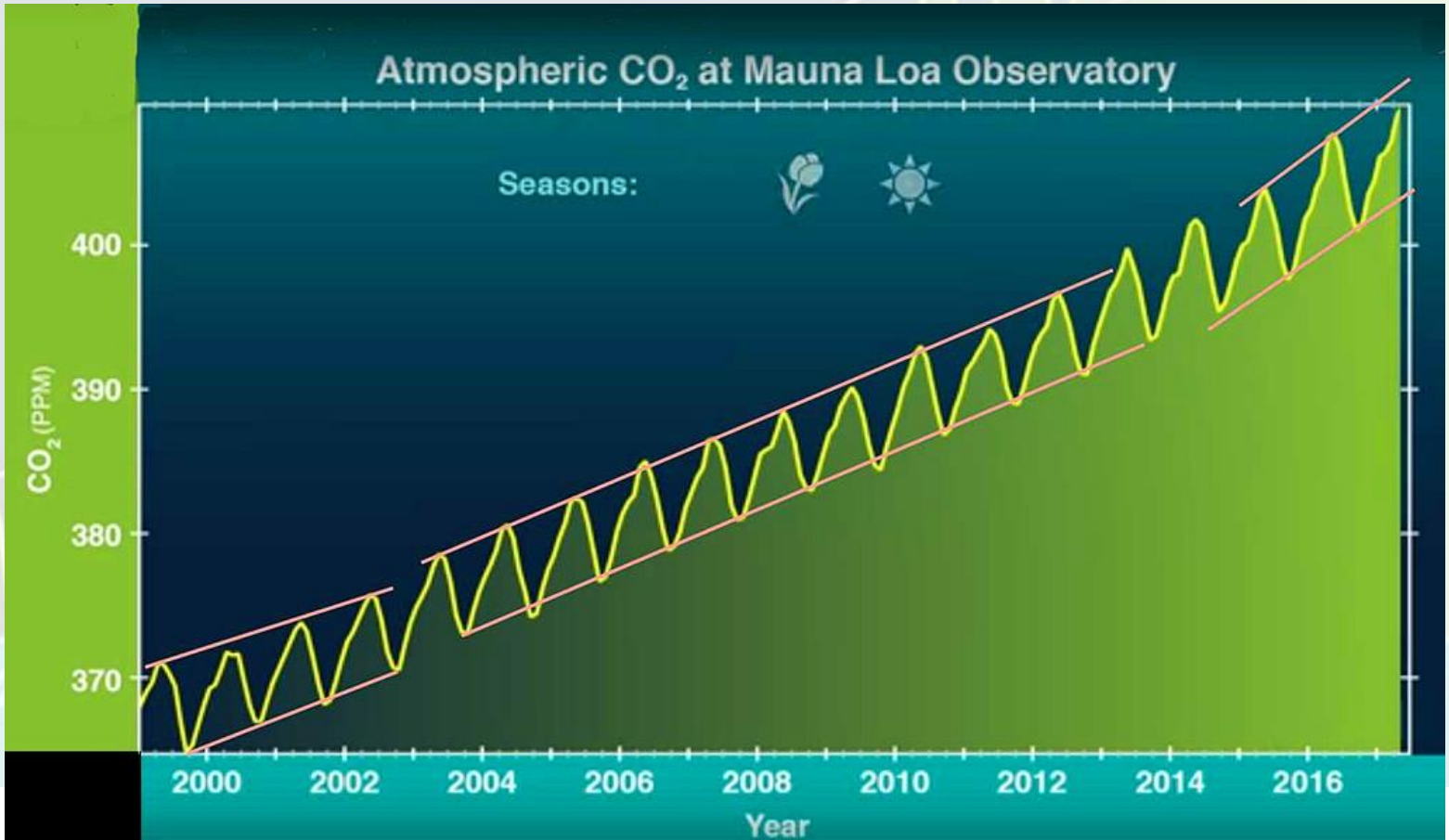
The Dire Implications for Policy of this Recession-GDP Bias

- We'll see that, absent Geo-Engineering, only declining global economic growth, ultimately to zero, leads to stabilized atmospheric CO2, even with unprecedented aggressive decarbonization of our energy consumption.
- But if the Garrett Relation remains true during recessions, it also says that energy efficiency reverses to become increasing energy **Inefficiency** during these recessions; as we hunker down, cutting investment in improving efficiencies (as I interpret it, not necessarily Garrett's view).

This implies a "No Win" situation, given the human system (Garrett agrees with this)

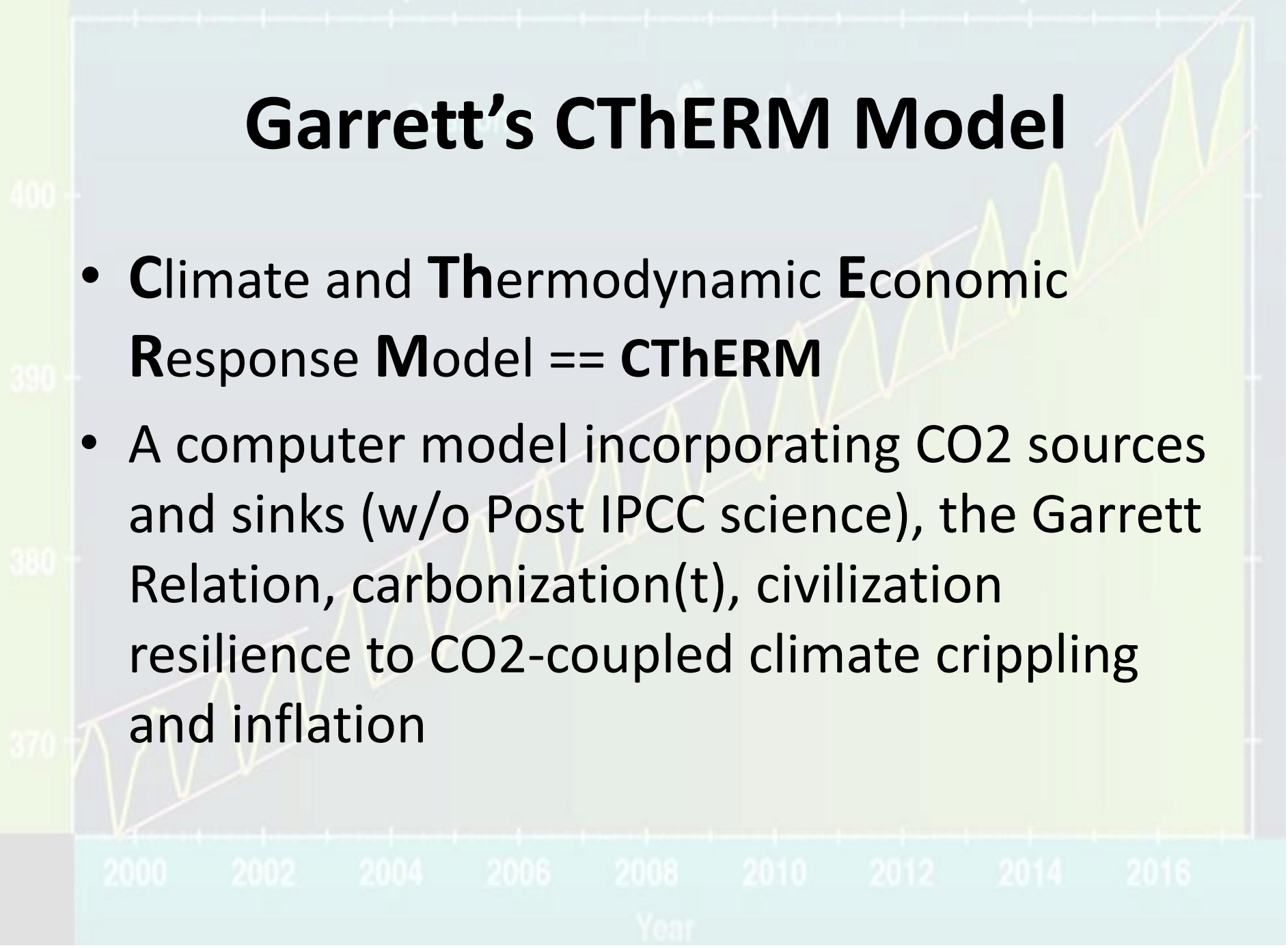
What's needed is both radically improving energy efficiency AND an end to economic growth, and this requires a different human animal than is consistent with all historical data, and even with the psycho-biology of the human/civilization system (Lustig 2018).

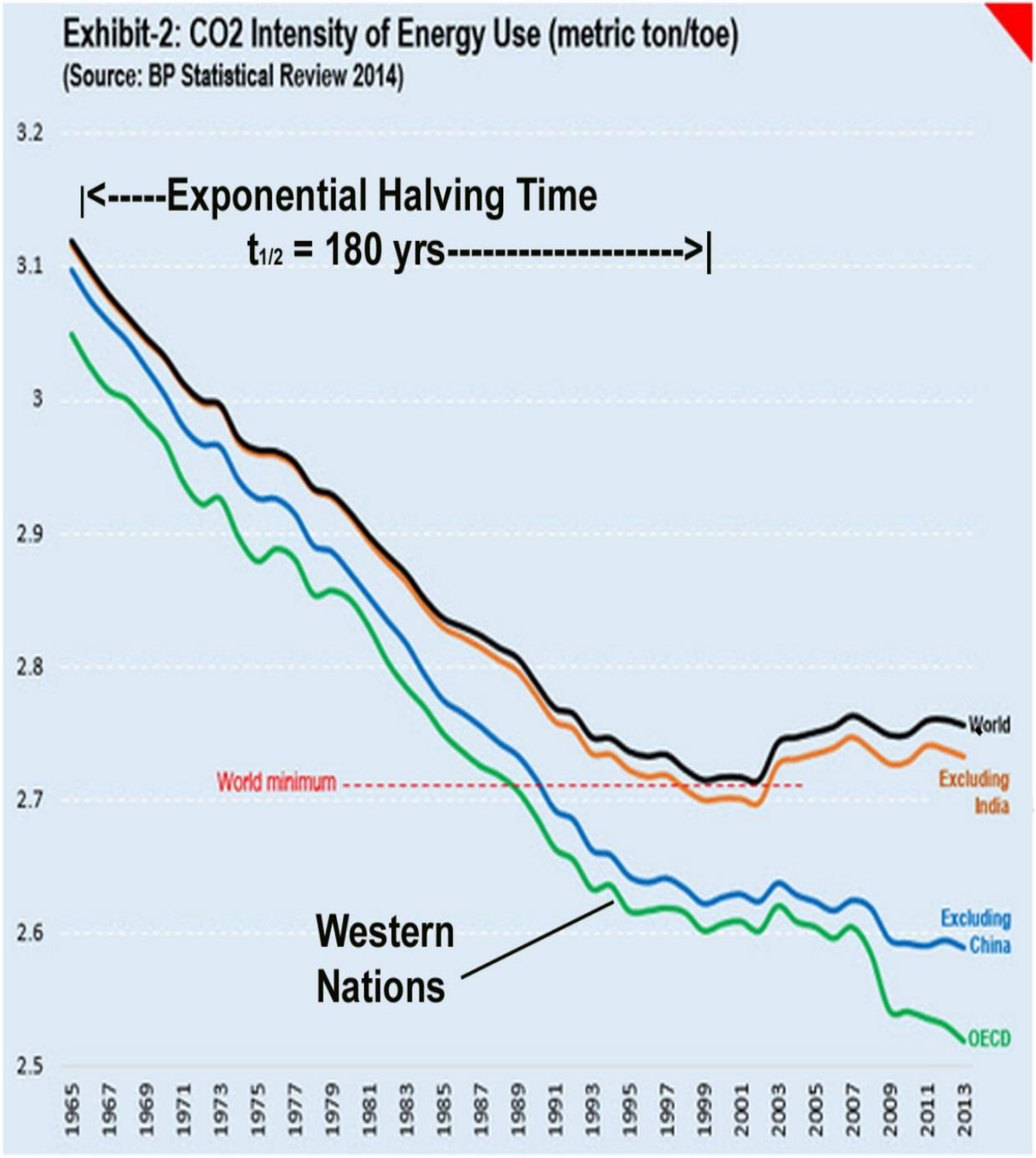
What Are The Implications of the Garrett Relation for Future Atmospheric CO2 Levels?



Garrett's CThERM Model

- **C**limate and **Th**ermodynamic **E**conomic **R**esponse **M**odel == **CThERM**
- A computer model incorporating CO2 sources and sinks (w/o Post IPCC science), the Garrett Relation, carbonization(t), civilization resilience to CO2-coupled climate crippling and inflation





Climate cares ONLY about the global data ("World" in black)

<u>Modelling the Future:</u> First assume Carbon Intensity of Energy Holds to 21st Century Trend (flat). I think that's too pessimistic, but let's see what it gives…

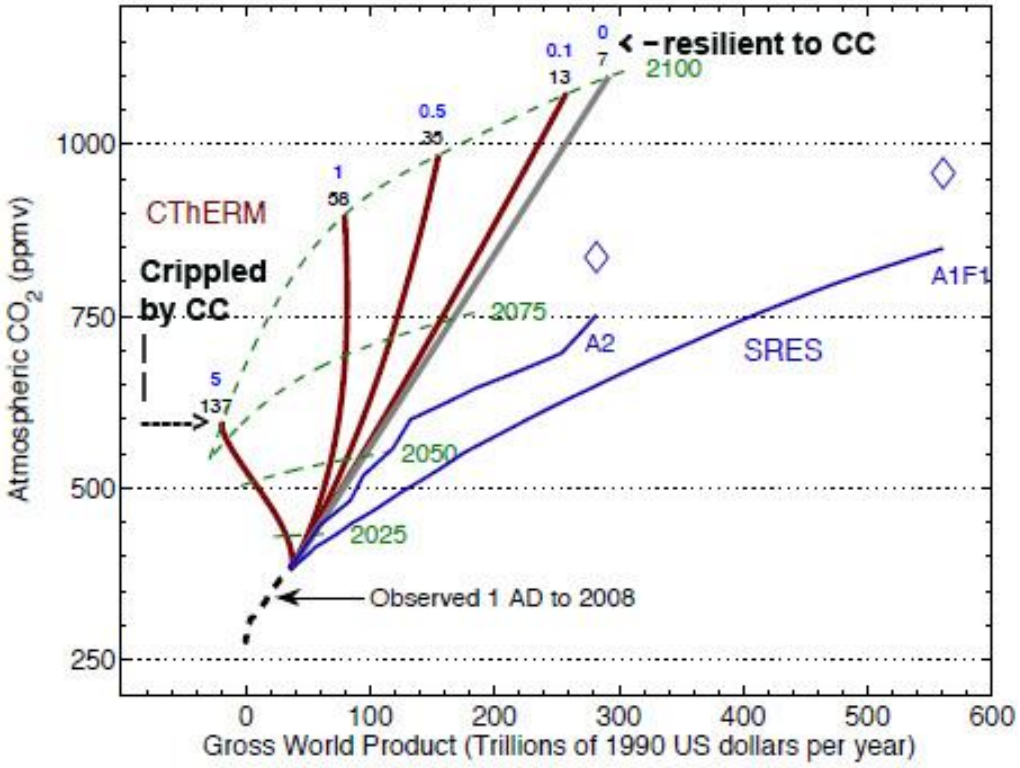


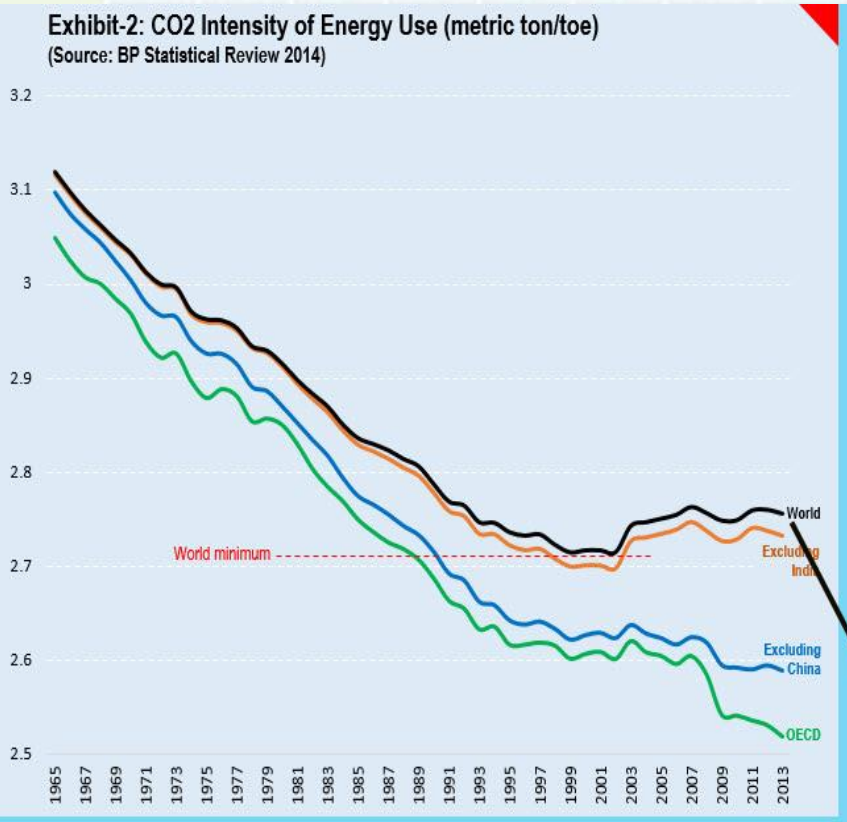
Fig. 6. As for Fig. 5, except for CThERM trajectories calculated out to 2100, with the model initialized with conditions in 2008 and assuming that $d\beta/dt = 0$ and $dc/dt = 0$ for a range of values of inverse resilience $1/\rho$ (blue numbers expressed in % yr^{-1} change in the decay coefficient γ per CO_2 doubling). Small numbers in black correspond to the calculated inflationary pressure $i = \gamma/\beta$ (Eq. 25) in year 2100. Green dashed lines represent the modeled year. Shown for comparison are the IPCC SRES A1F1 and A2 scenarios based on the CThERM linear sink model for CO_2. CO_2 concentrations for these scenarios using the Bern carbon cycle model are shown by blue diamonds. Historical data from 1 AD to 2008 is added for reference (see Appendix C).

Even when civilization is assumed most crippled by climate change (CC curve), with strong decay corresponding to 137%/yr inflationary pressure, with global GDP growth falling below zero (civilization in decline), still atmospheric CO2 rises 50% above current levels by 2100 and still rising.

Do You Prefer high resilience? That Means more growth, worse CO2.

From Garrett 2012

- ***"There are no plausible, thermodynamically supported solutions that avoid inflation rates less than 100% per year, and lead to stabilized atmospheric CO2 concentrations within this century"*** **(assuming decarbonization rates of ~0 in the 21st century, as has so far been the case, albeit I believe not likely to continue this grim)**
- Inflation, realize, can either happen through excess printing of money, or through the progressive destruction of the wealth which that money denominates (or a combination of both). **>100%/year - means the decline of civilization; Total Wealth is progressively destroyed. (but see here why I think this should be framed in terms of "decay" and not "inflation").**
- In other words: without decarbonization, civilization must contract (something it has never done), **rapidly, just to slow the further rate of increase of atmospheric CO2**



trend of linear approximation to exponential halving time of 50 years

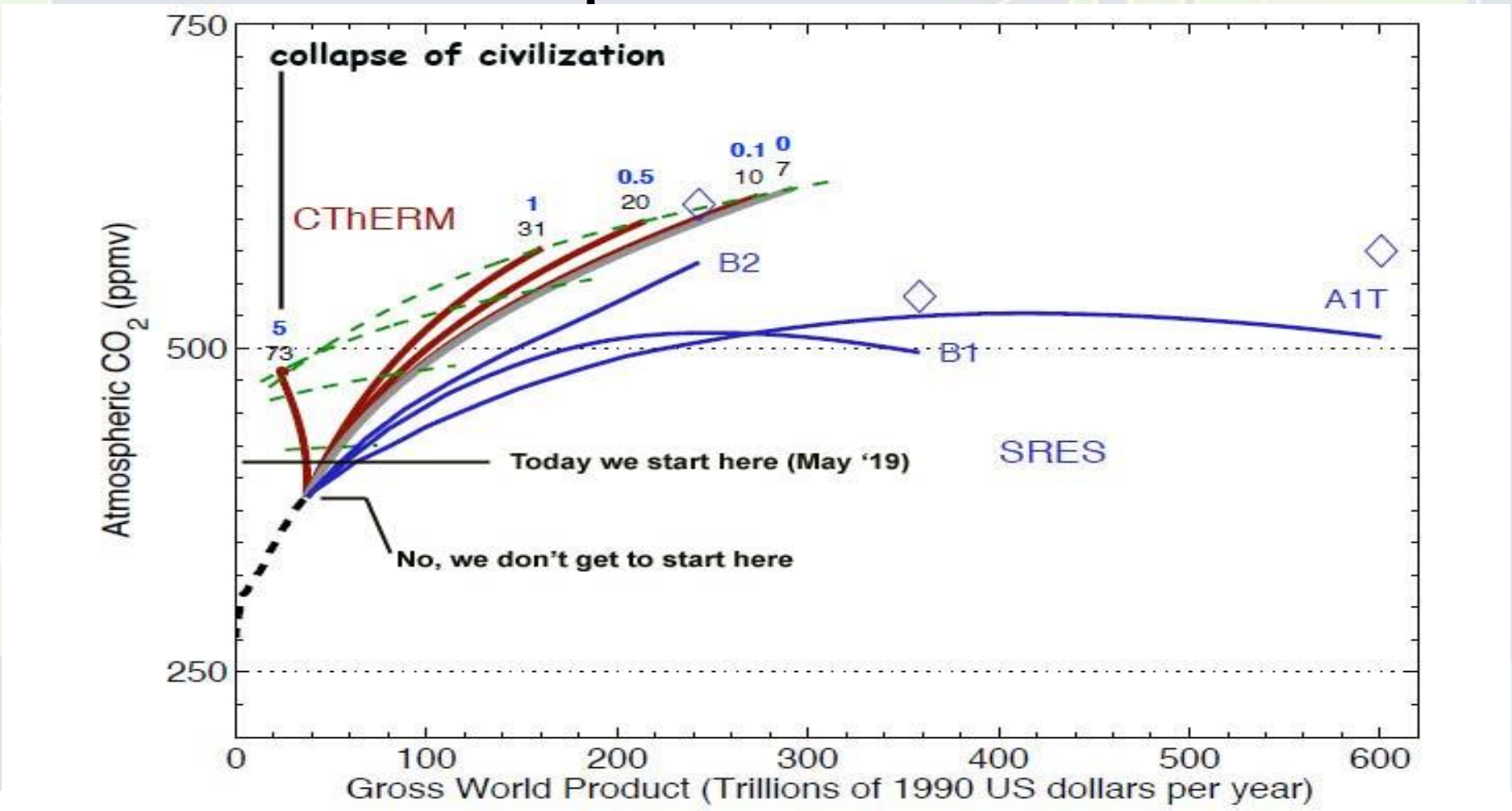
Modelling the Future: Case 2:

Assume now we STEEPLY decarbonize energy, with exponential halving time of 50 years

Reminder of the Meaning of the "Resilience" of Civilization to Climate Change…

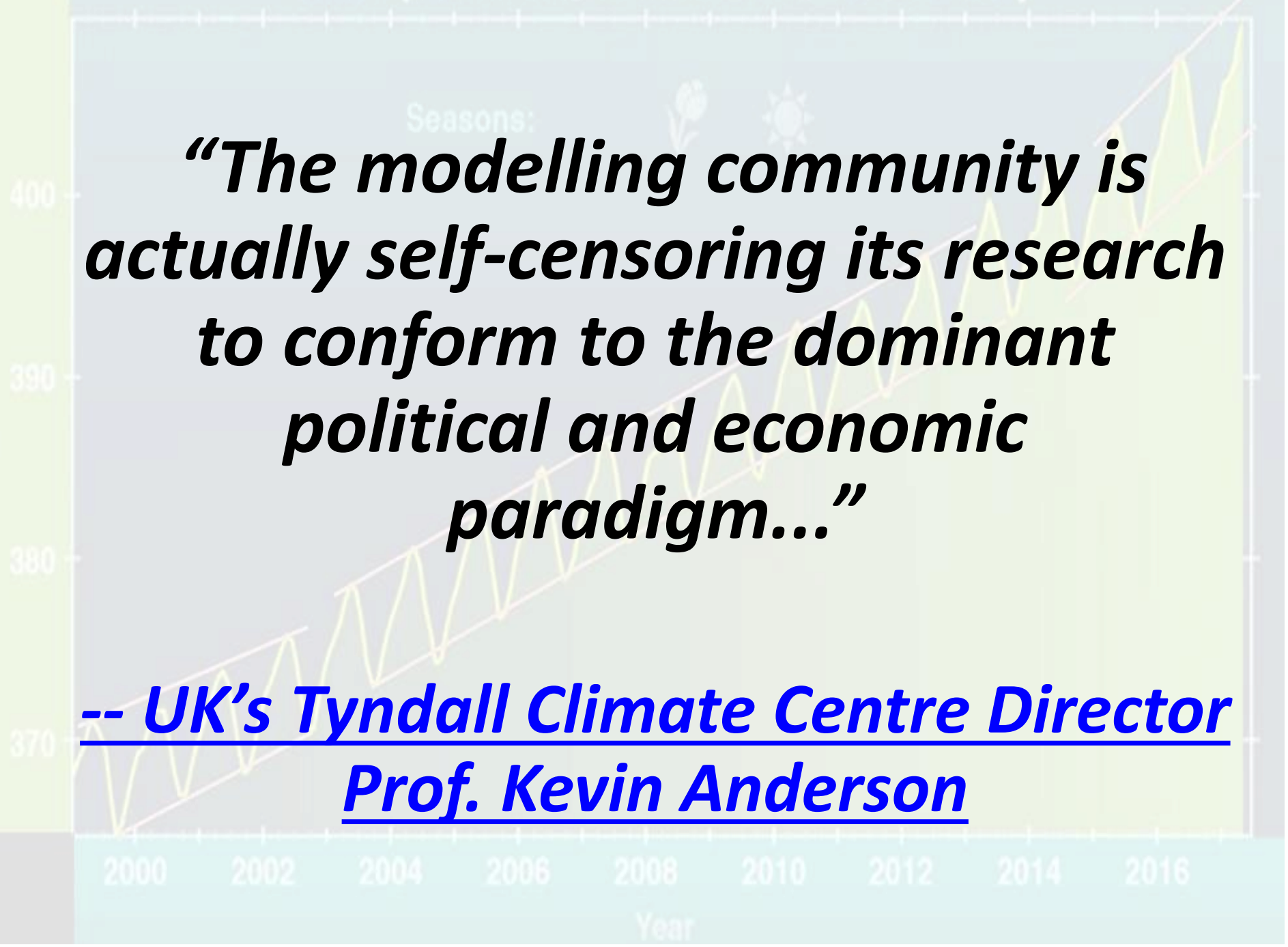
- …the curves that have the strongest resilience, therefore the BEST economic growth in a climate-challenged world, and the LOWEST inflation (decay), are precisely the scenarios that therefore have the **WORST atmospheric CO2 red curves**.
- In other words - If we hope for lower and slower CO2 rise, we need to hope civilization is CRIPPLED by climate change so that it is FORCED **against our will** to grow more slowly, ultimately to enter long term civilization contraction.

CO2 levels never drop for CThERM scenarios except the most crippled, and not till 2100. Economic growth is far less, and CO2 far worse, than the simple IPCC scenarios which were commanded by UN political forces to include unrealistic assumptions and no Garrett Relation.



But Garrett's CO2 Curves Only Include Direct Human Emissions Related to Energy Consumption

Unfortunately, There Are Indirect Emissions We Must Add in… and They Don't Get the Notice from Policy and Techno-schemers That They Deserve



"The modelling community is actually self-censoring its research to conform to the dominant political and economic paradigm..."

-- UK's Tyndall Climate Centre Director Prof. Kevin Anderson

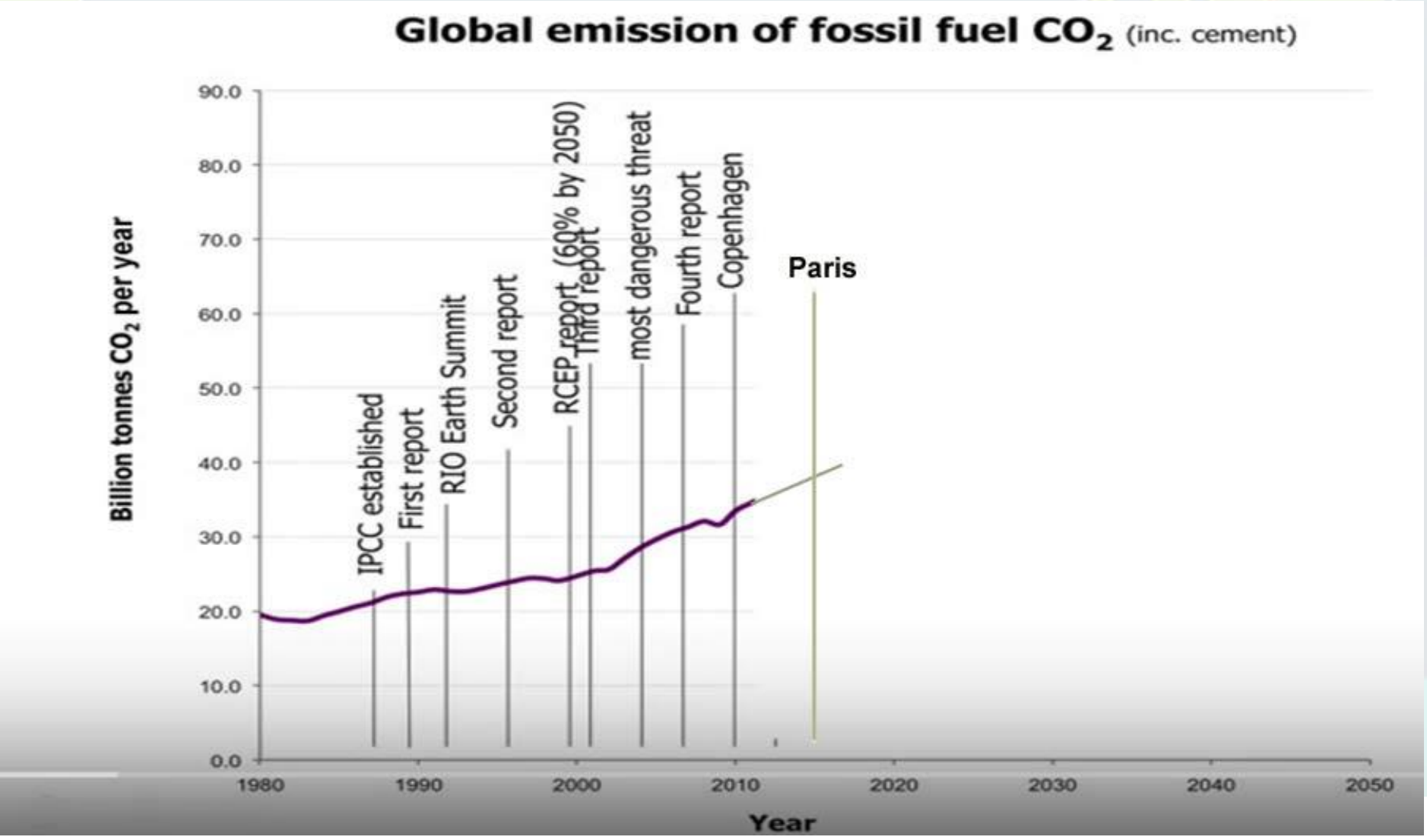
"We've reached a point where we have a crisis, an emergency. But people don't know that. There's a big gap between what's understood about global warming by the scientific community, and what is known by the public and policymakers"

-Prof. James Hansen, 2008

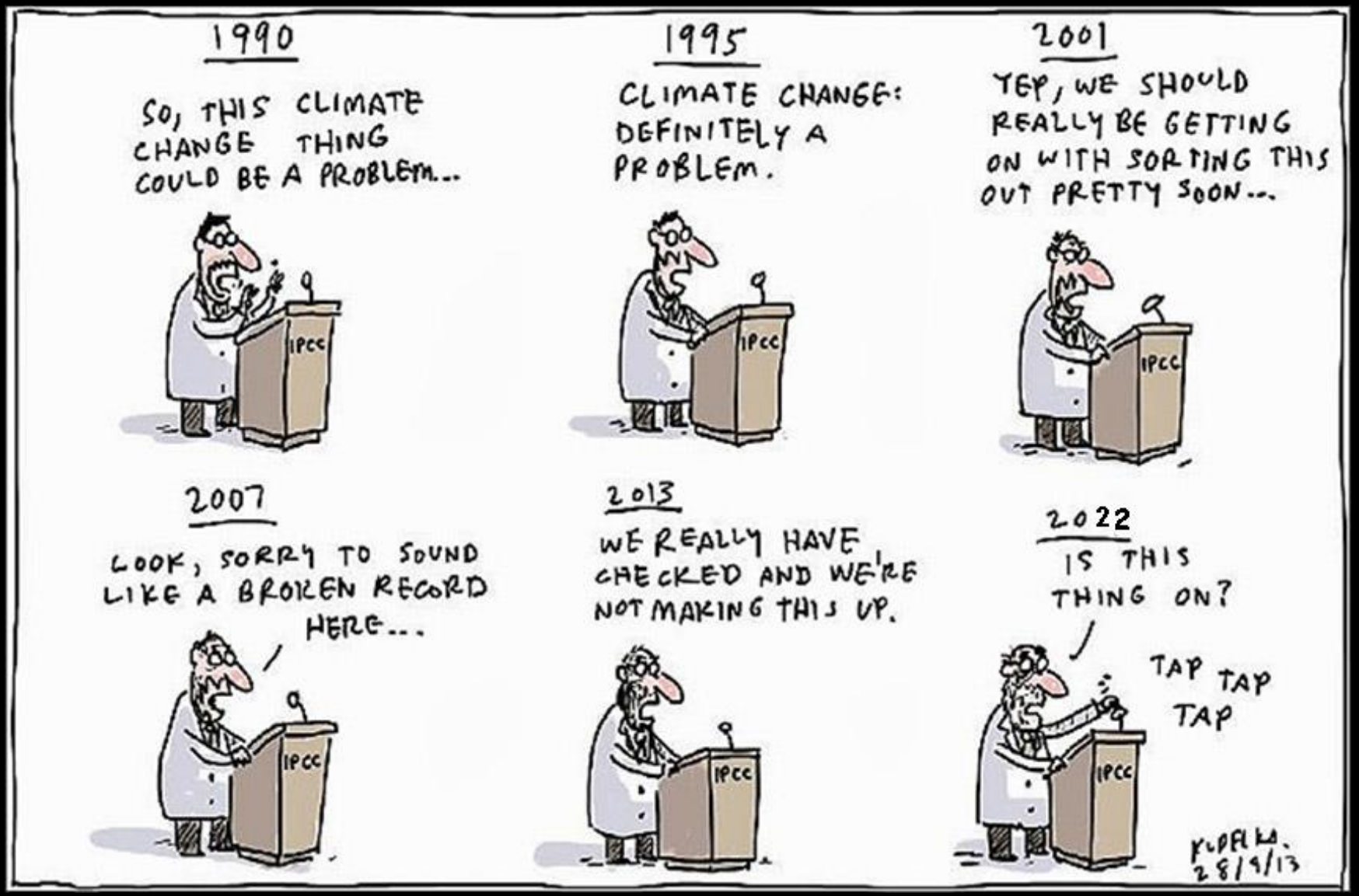
"As a public health professional (and as a human), I find the prospect of 3 or 4 degree C of global warming to be nothing short of terrifying… people are not nearly as worried as the situation warrants."

-Ed Maibach, director of the George Mason University Center for Climate Change Communication

Total Policy Failure: The Garrett Relation in Real Life. Emission Rates Keep Rising



The IPCC scientists (with rare exceptions) have not been forceful communicators



This is vital - Climate speakers send a message when they under-play the dire science…

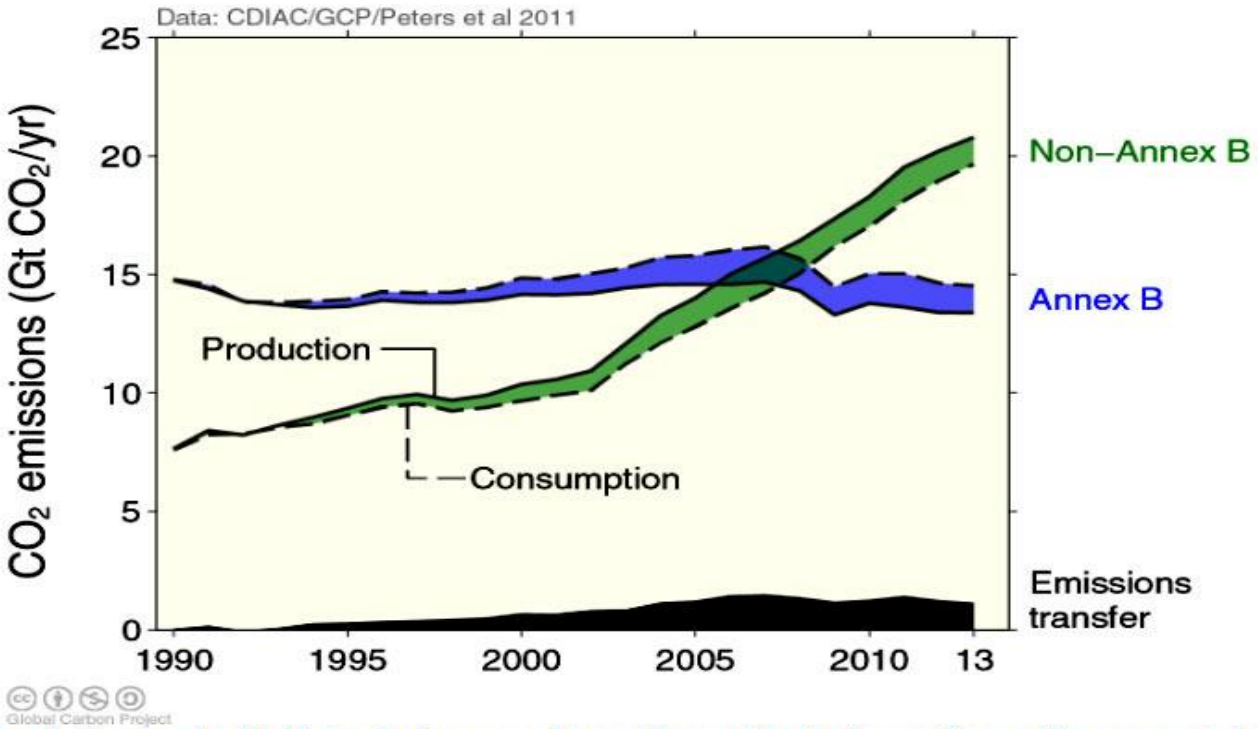
- When they are…
- …dispassionate on frightening facts
- …join into the happy-talk policy people's agenda of looking good to their paymasters
- …Indulge their self-medication to cheer themselves up by promoting ***"have cake/eat too: Economic growth/End climate change too!"*** belief systems
- It encourages what people naturally want to do – **Be complacent**, believe that smart people in a lab somewhere are going to figure out how to let us have it all.
- And so we continue to do nothing.

Prof. David Victor, supported by many other scientists in the IPCC Process

- *"(scientists)… included clear statements about the difficulty of achieving the 2 °C goal. But the governments — led by the EU and a bloc of developing countries —* ***pushed for a more optimistic assessment*** *in the final IPCC report.*
- ***"We got a lot of pushback, and the text basically got mangled****," Victor says."* ***(from this Nature article "Is the +2C World a Fantasy?" (Tolleson 2015)***

Increasingly the emissions are coming from the Developing World (non-Annex B) who manufacture our (Annex B) stuff. Yet they're the ones MOST desperate for Our lifestyles

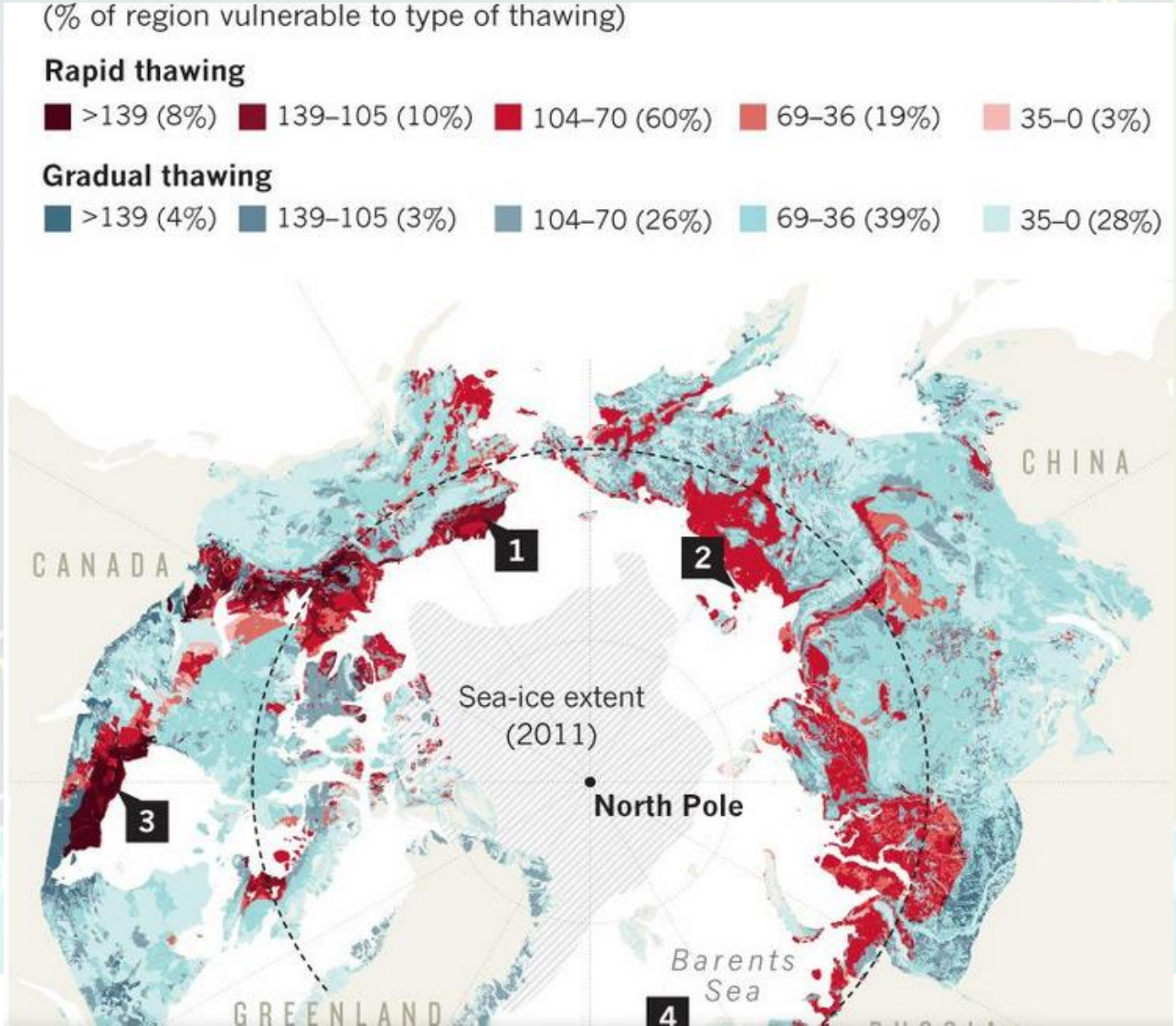
The net emissions transfers into Annex B countries more than offsets the Annex B emission reductions achieved within the Kyoto Protocol



Transfers of emissions embodied in trade from non-Annex B countries to Annex B countries grew at about 20% per year between 1990 and 2007, but have since declined at about 3% per year.

Source: CDIAC; Peters et al 2011; Le Quéré et al 2015; Global Carbon Budget 2015

Indirect CO2 Emissions: Missing Physics and Post-IPCC AR5 Dire Science



ECS == Equilibrium Climate Sensitivity to a Doubling of CO2

ECS = How Much Does Global Avg Temperature Rise, to Short Term ~Equilibrium, after Doubling CO2 from Pre-Industrial Temperatures?

It is a Key input to all climate models, and one with a worrying trend in the varying data…

Hansen and Sato 2012 find that an <u>average</u> ECS=3.0C (black) fits Earth climate (red) going into and out of Ice Ages for the past ~million years, *i.e.* for CO2 ranges from 170-280ppm.

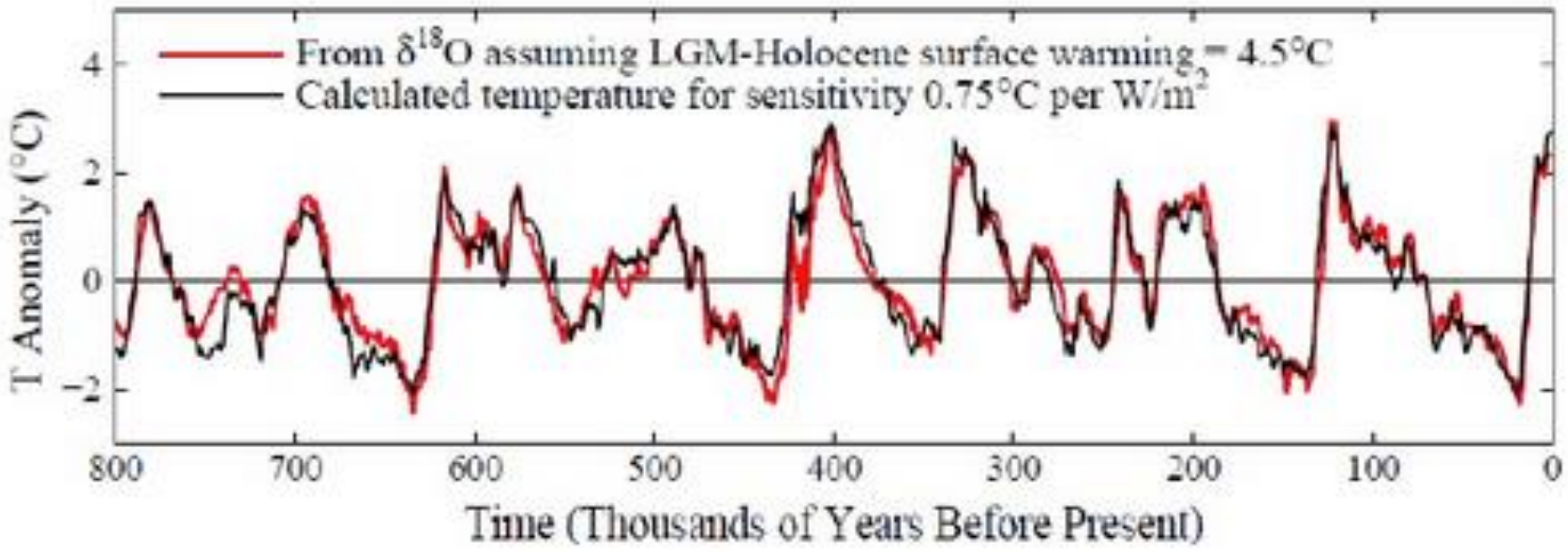
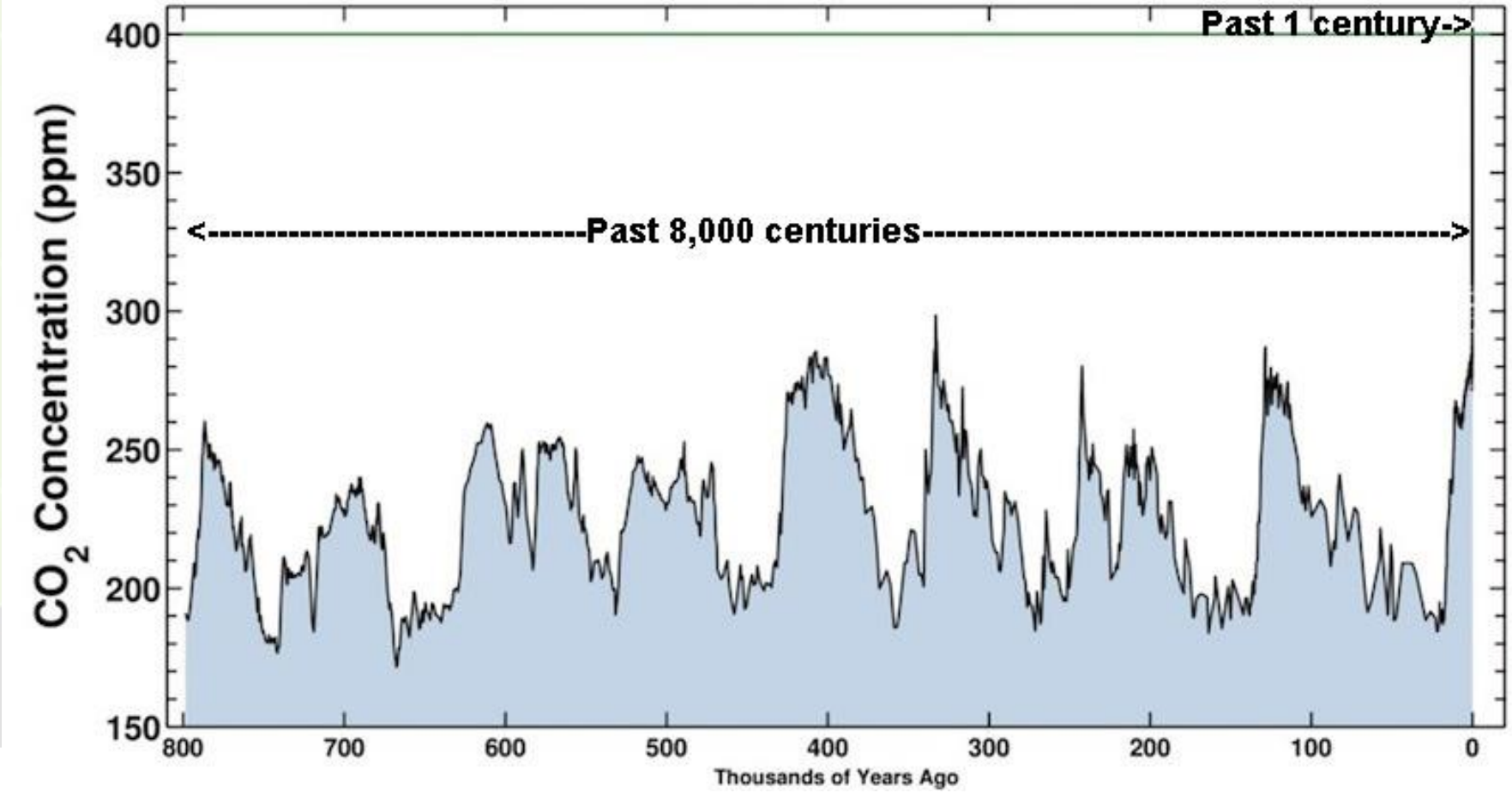


Figure 3: Black curve: calculated surface air temperature change for climate forcings HS12 and climate sensitivity 0.75°C per W/m2. Red curve: estimated global surface a temperature change based on deep ocean temperatures and assumption th LGM-Holocene surface temperature change is 4.5°C. Zero point is the 800 ky mean Figure 6 from HS12.

But, Hansen *et al.* point out this ECS shouldn't necessarily be used for projections in our future since we are now quite above the past Interglacial's 280 ppm



Does the Background Climate State Matter for ECS?

- For an assumed idealized over-simplified Earth with only CO2 determining climate, then ~no. Because of “band saturation” at CO2’s primary absorption near 10 microns wavelength, ECS is fairly constant over a reasonable range of background temperature.
- **But, that isn’t the REAL Earth.**
- **So… Does Background Climate State Matter for ECS?**
- **YES!**

Different studies, different methods, but within each study the trend is *higher ECS at hotter climate* (von der Heydt *et al.* 2016) - here as "Sensitivity" S *vs.* deltaT (background temperature). See Pfister and Stocker 2017 for the ECS connection. Upward slope tells tale.

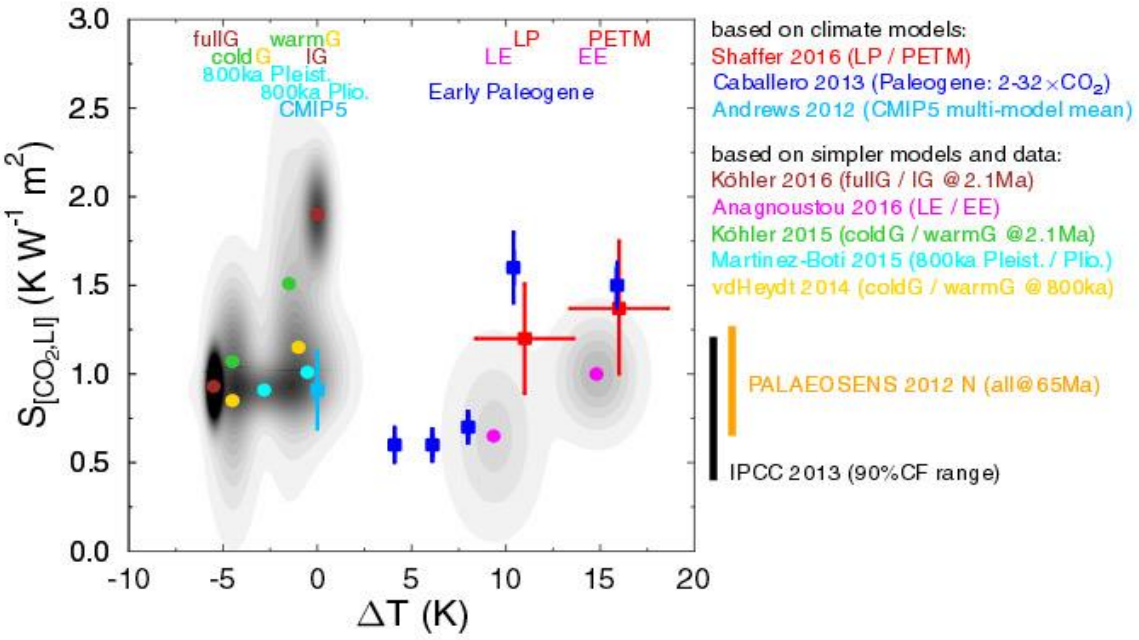
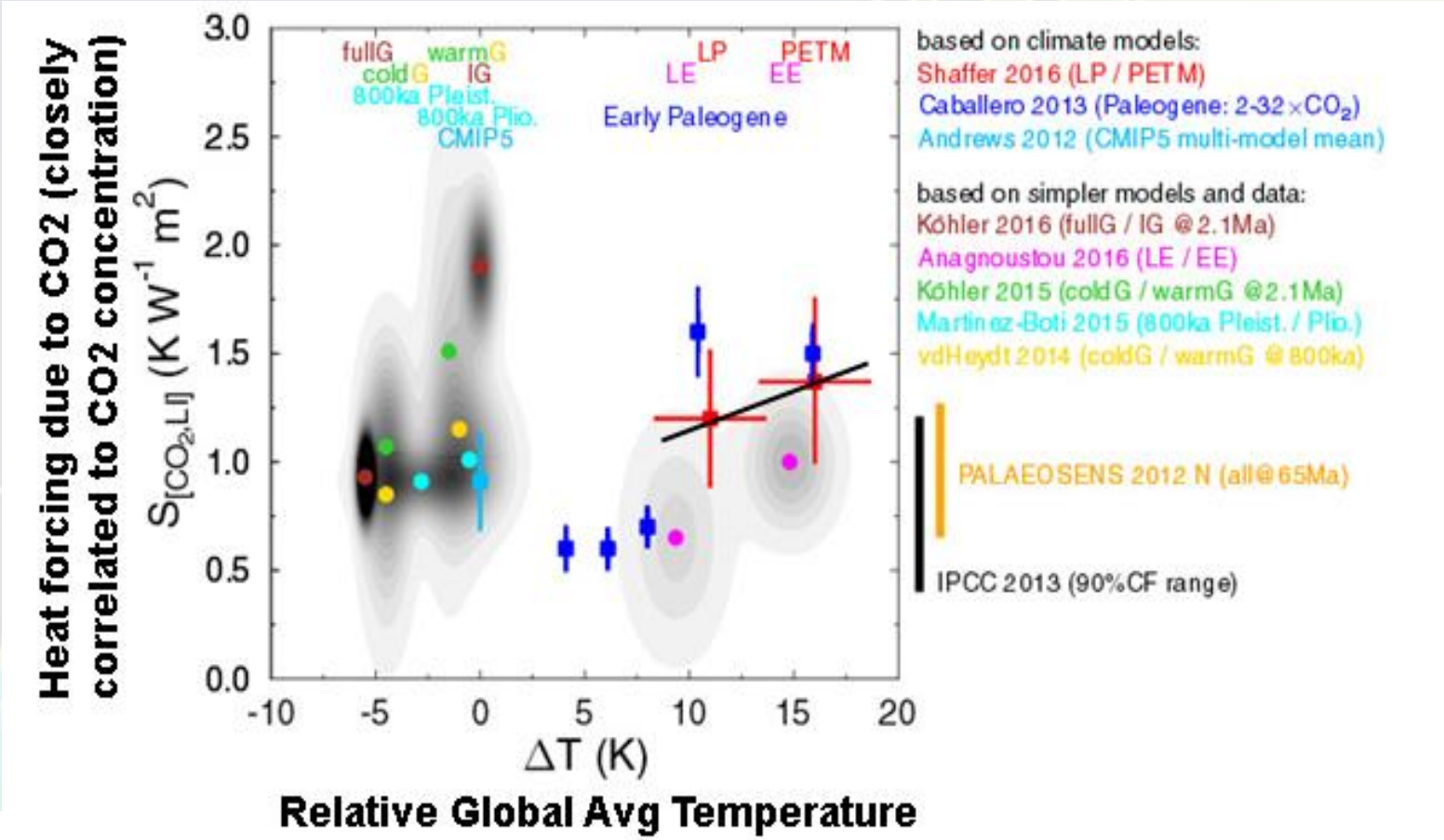
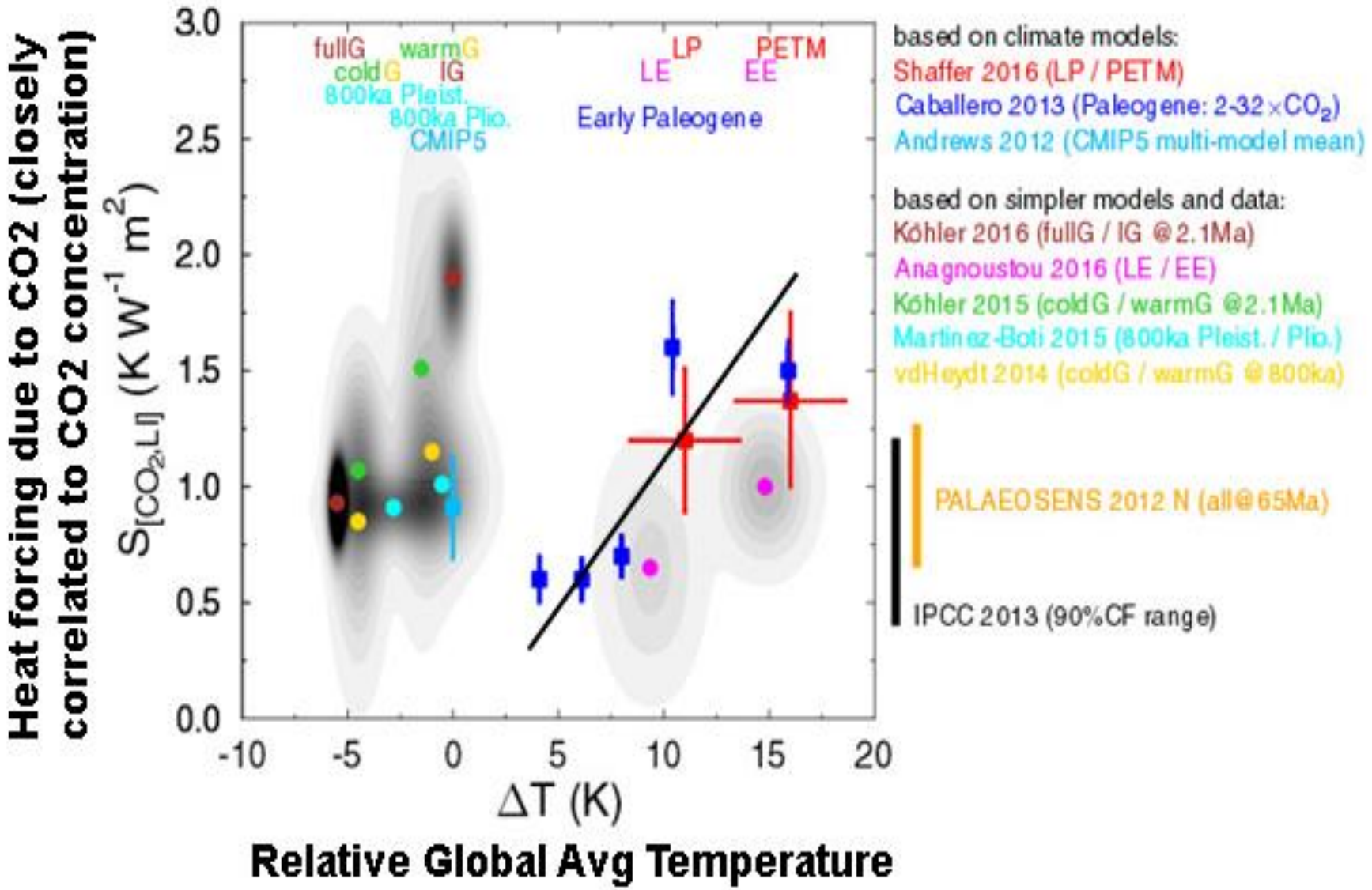


Fig. 1 Published paleo-based values of $S_{[CO_2,LI]}$ (specific equilibrium climate sensitivity parameter caused by CO_2 radiative forcing and corrected by variations in land-ice (LI) feedbacks) indicating its state dependence. Only studies published after the PALAEOSENS review paper [21] are considered. For comparison, the state-independent values from PALAEOSENS, and from the IPCC report [3], and the CMIP5 multi-model mean for present day [41] are also shown. All values of $S_{[CO_2,LI]}$ were given as mean (*or most likely*) $\pm 1\sigma$, apart from IPCC, which is the 90 % confidence (CF) range. Climate background states are given by ΔT from pre-industrial and are marked as estimated ranges (or $\pm 2\sigma$). In [42], further corrections for other slow feedbacks have been calculated, which has been ignored here, leading to different values of ΔT than published. To increase the clarity of the figure, the data-based results are visualised by *colour-coded circles* (mean values), while their uncertainties are combined in a cumulative probability density distribution (*grey shading*) assuming normal distributed values. Results based on climate models are shown by *colour-coded squares* (mean) including their uncertainties (*bars*). *G* glacial, *IG* interglacial, *LE* late Eocene, *EE* early Eocene, *LP* pre-PETM/late Paleocene, *PETM* Paleocene-Eocene thermal maximum. Reference numbers of the given citations: IPCC 2013 [3], PALAEOSENS 2012 [21], Andrews 2012 [41], Caballero 2013 [43] vdHeydt 2014 [20], Martinez-Boti 2015 [44] Köhler 2015 [32], Anagnoustou 2016 [42], Köhler 2016 [45], and Shaffer 2016 [46]

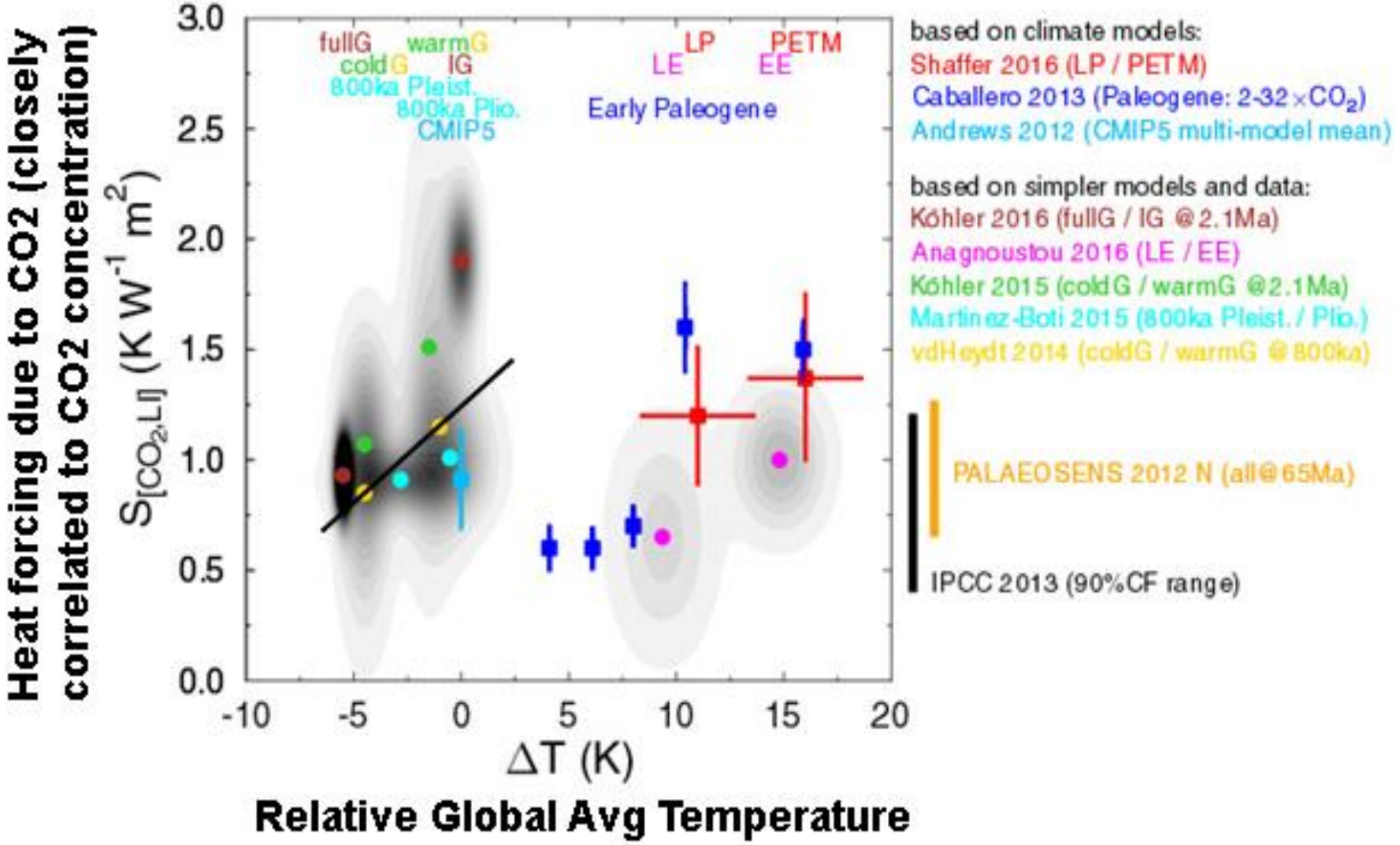
Shaffer *et al.* 2016 (red dots), looking at the Late Paleocene (LP) compared to the Paleocene/Eocene Thermal Maximum (PETM): **Warmer climate=Higher ECS**



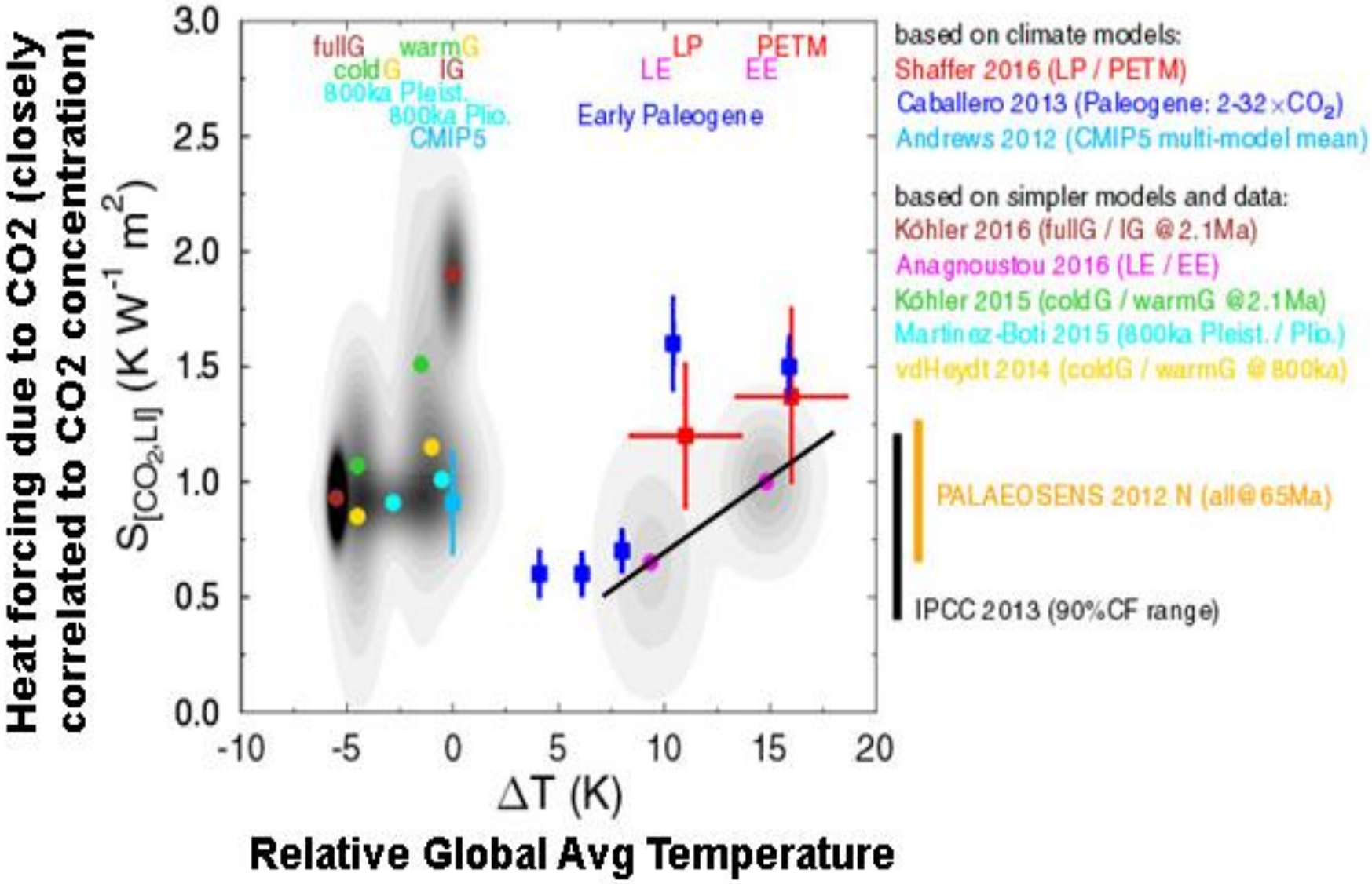
Caballero 2013 (blue): Warmer=Higher ECS



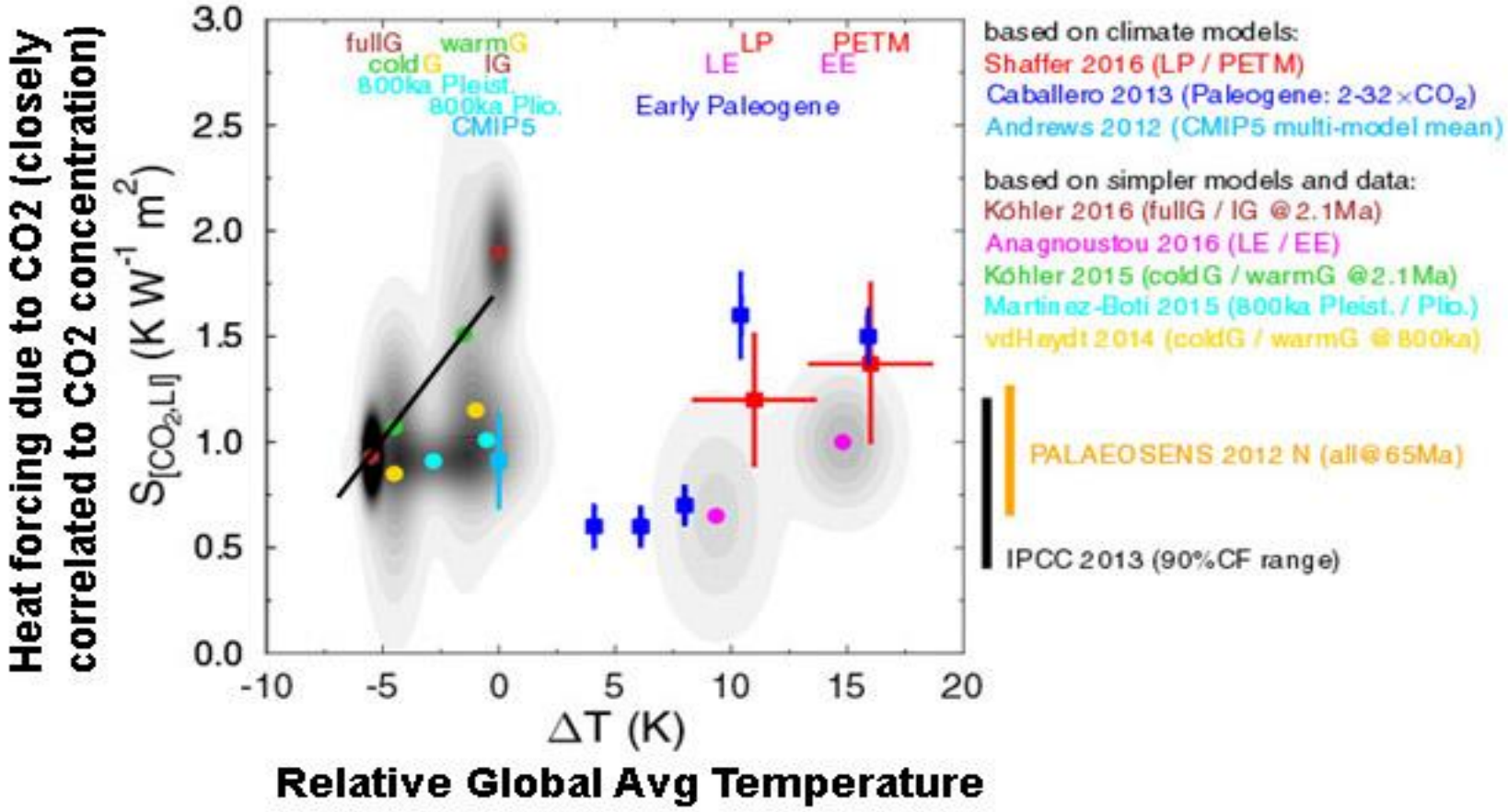
Andrews 2012 (yellow), using CMIP5 computer models: **Warmer = Higher ECS**



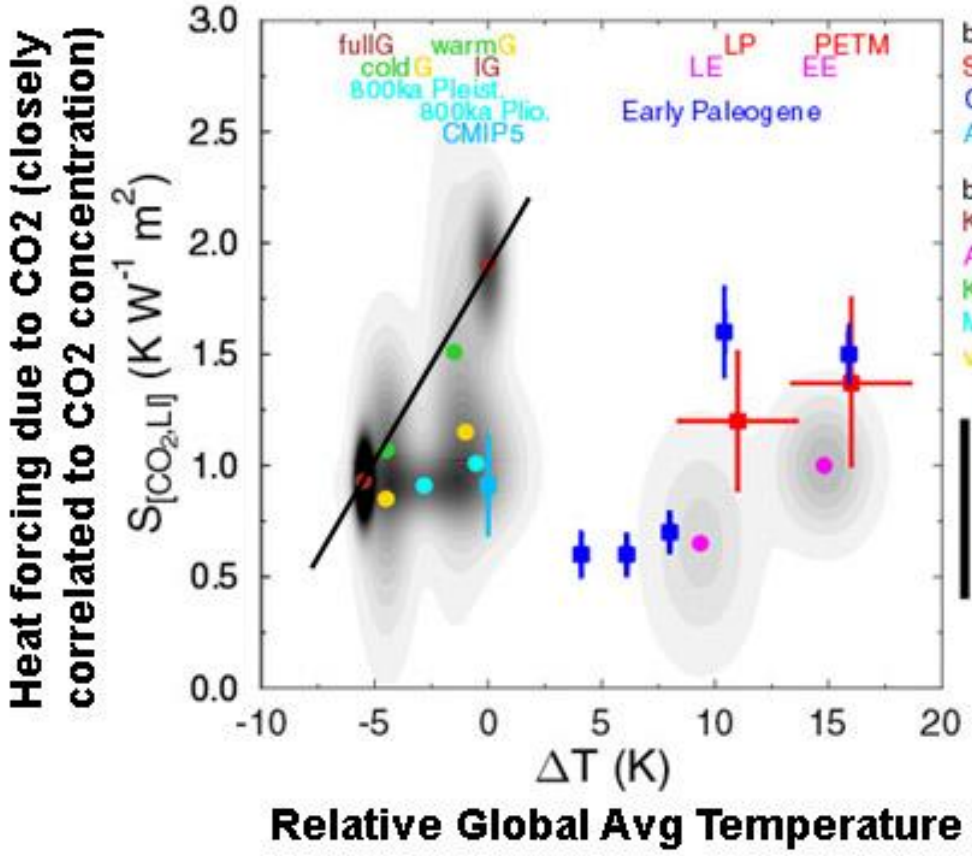
Anagnostou *et al.* 2016 (purple), in the Cenozoic period: **Warmer = Higher ECS**



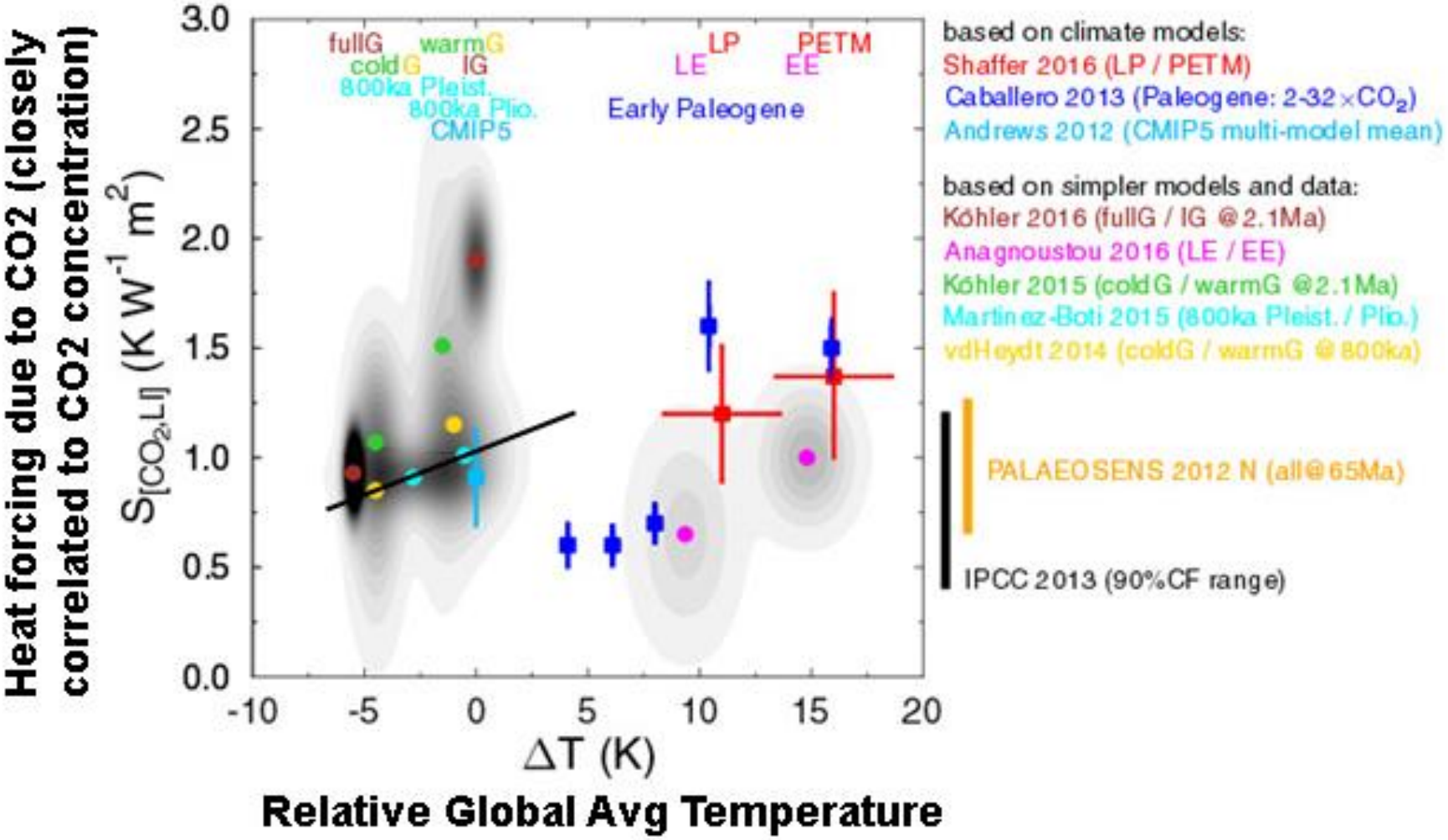
Kohler *et al.* 2015 (green), using just cold glacial *vs*. warm interglacial at 2 million years ago: **Warmer= Steeply Higher ECS**



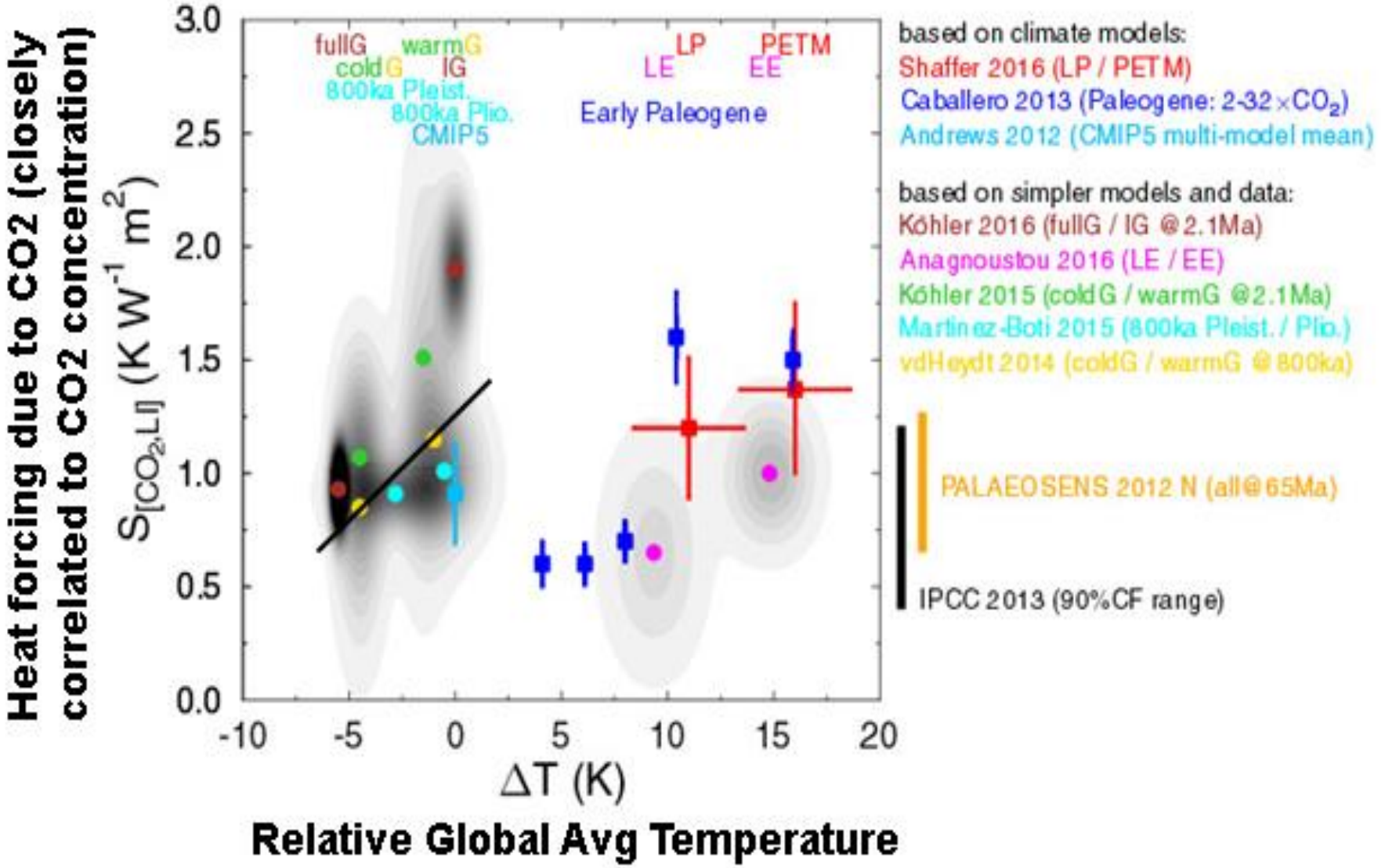
Kohler *et al.* 2016 (brown-gray clouds) using all glacial/interglacial data 2.1 million years ago: **Warmer = Steeply Higher ECS**

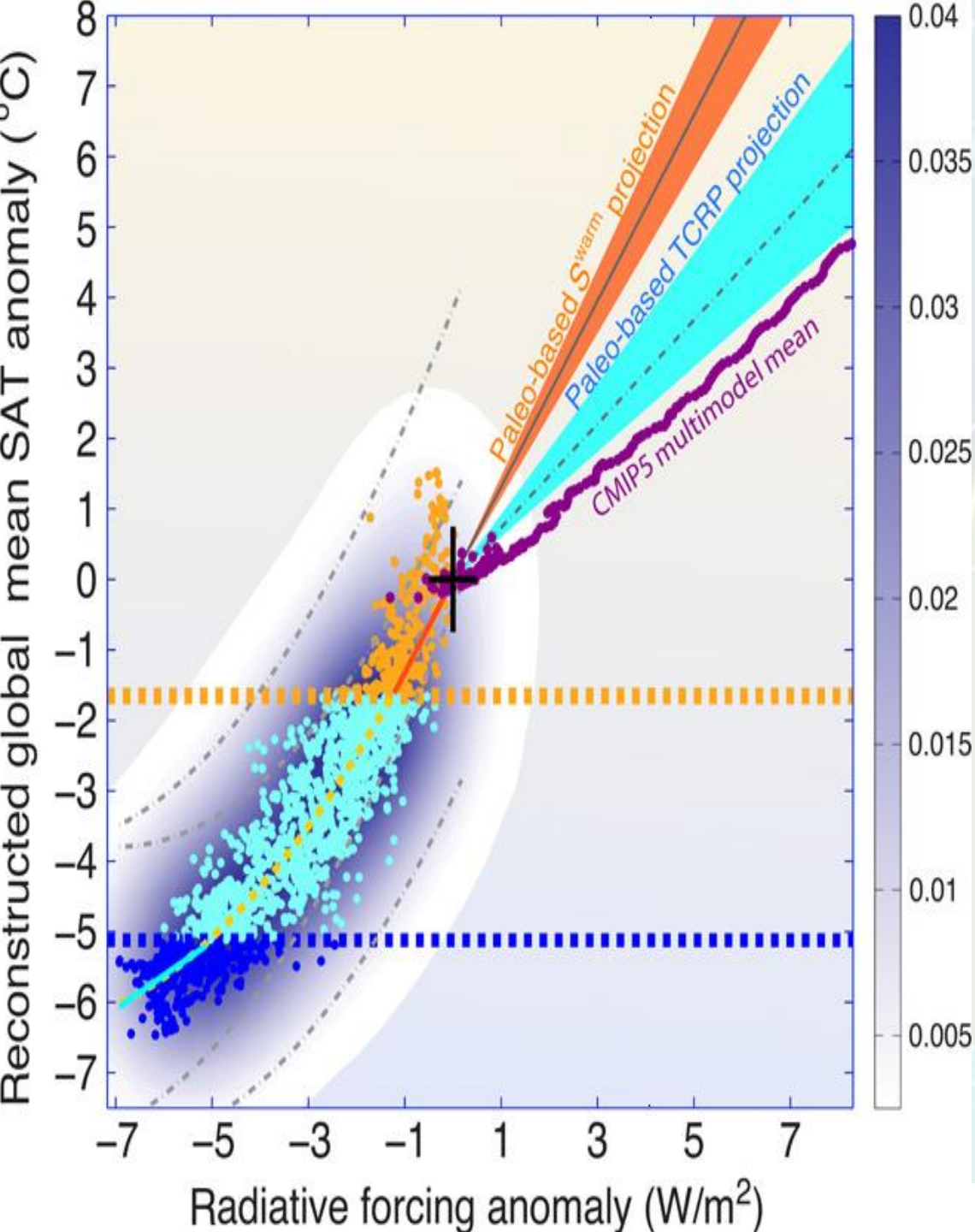


Martinez-Boti *et al.* 2015 (light blue), comparing the Pleistocene and Pliocene climate sensitivity: **Warmer=Higher ECS**



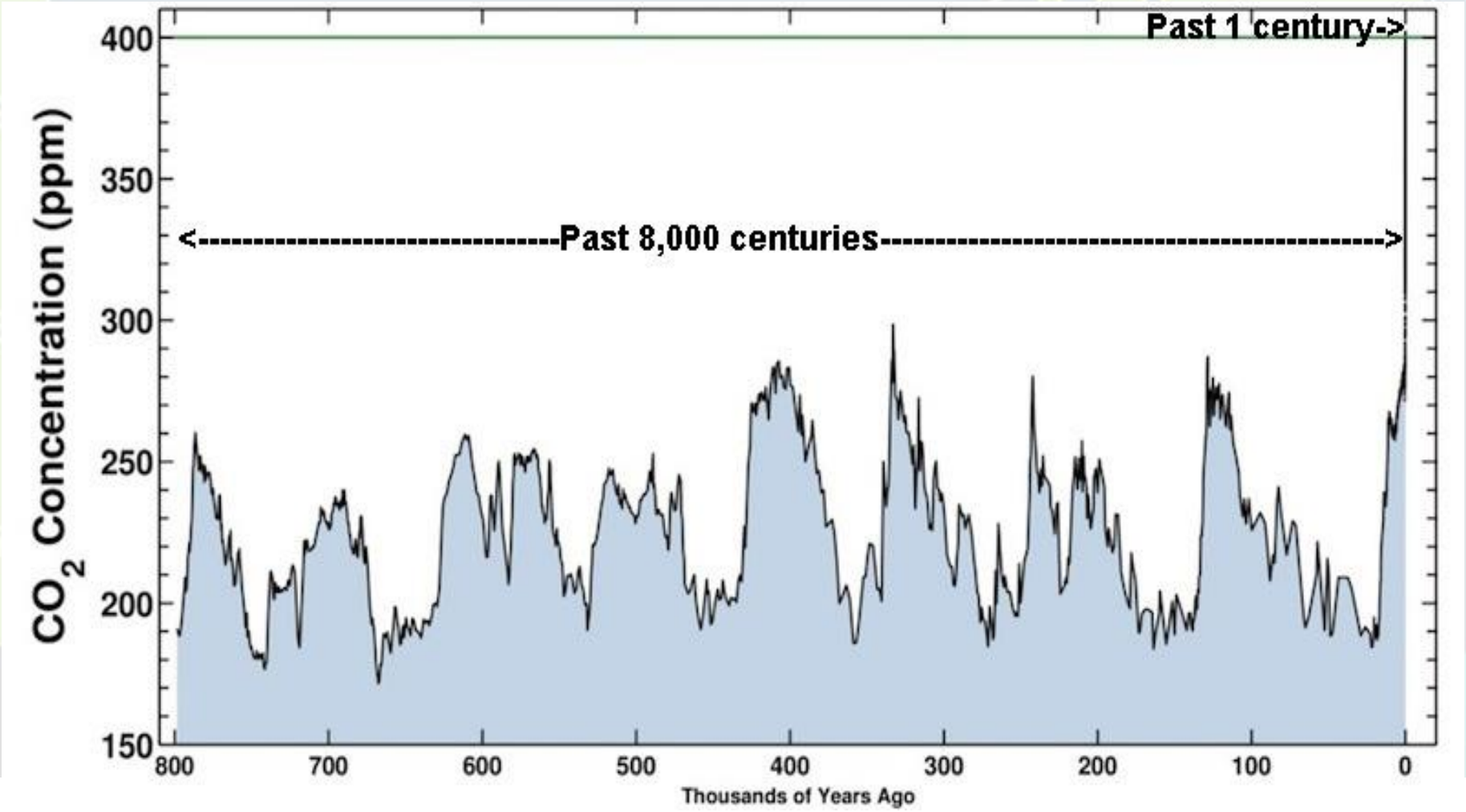
von der Heydt *et al.* (2014), yellow, 800,000 years ago: **Warmer=Higher ECS**



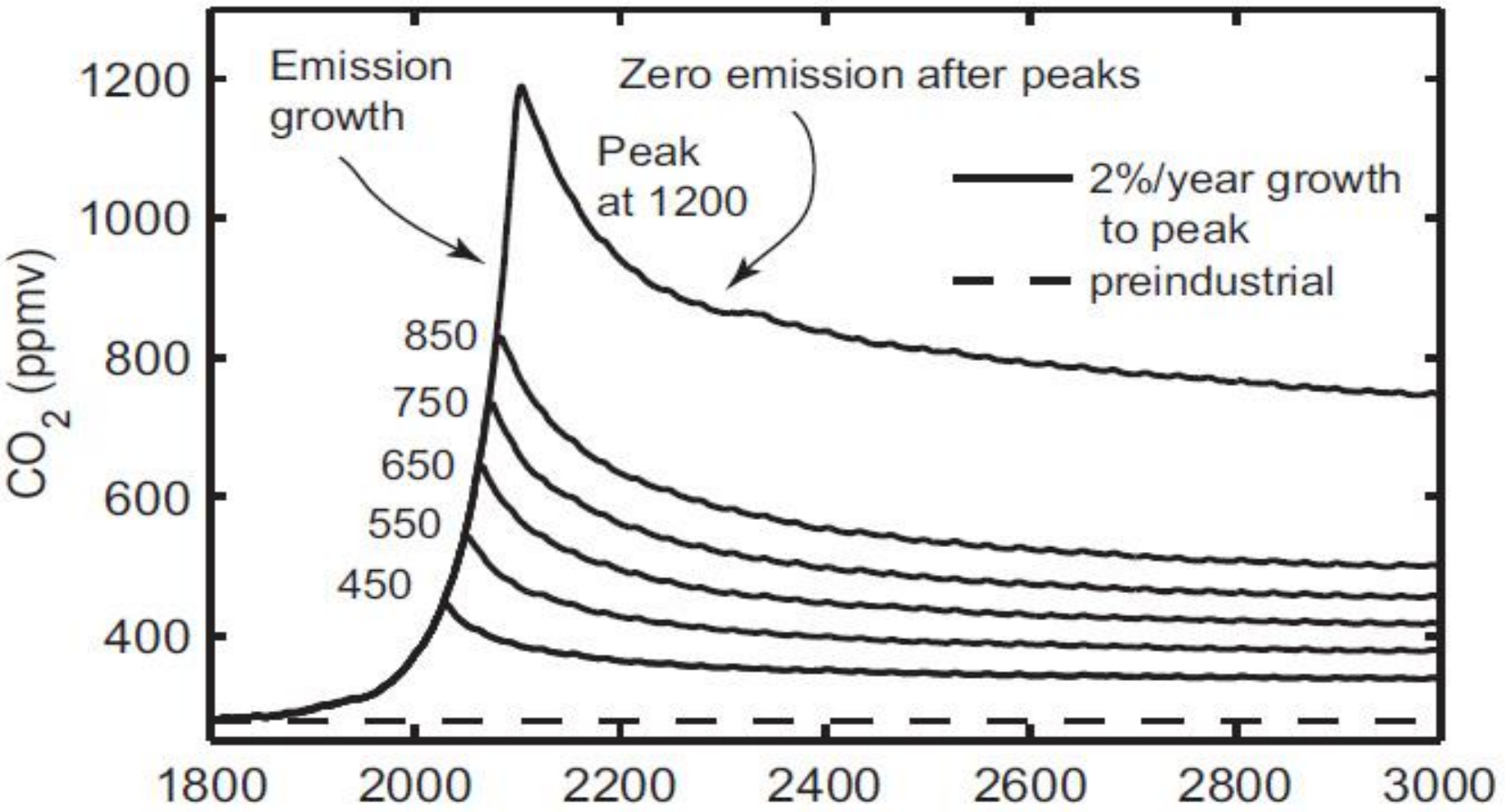


The Best Study is the Most Recent: Friedrich *et al.* (2016), who agree with Hansen that the million yr avg is 3.22 C. But they find ECS during the Interglacial warm periods is much higher; a dire +4.9C. Lead IPCC author Prof. Michael Mann has studied this paper, and concludes the work is *"sound, and quite defensible".*

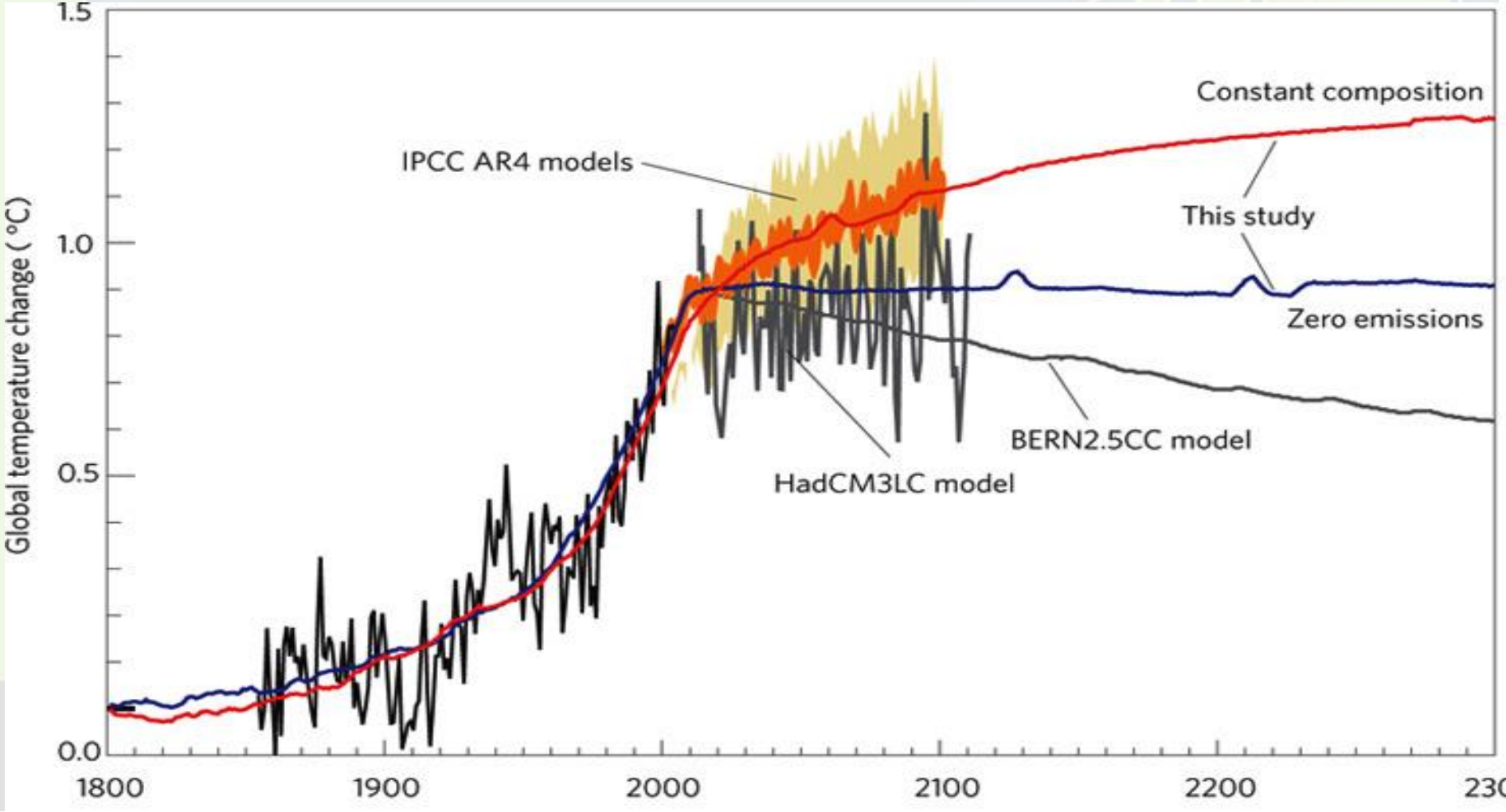
But again; Today we're FAR Above those Interglacial CO2 levels. So ECS may even be higher than +4.9C going forward



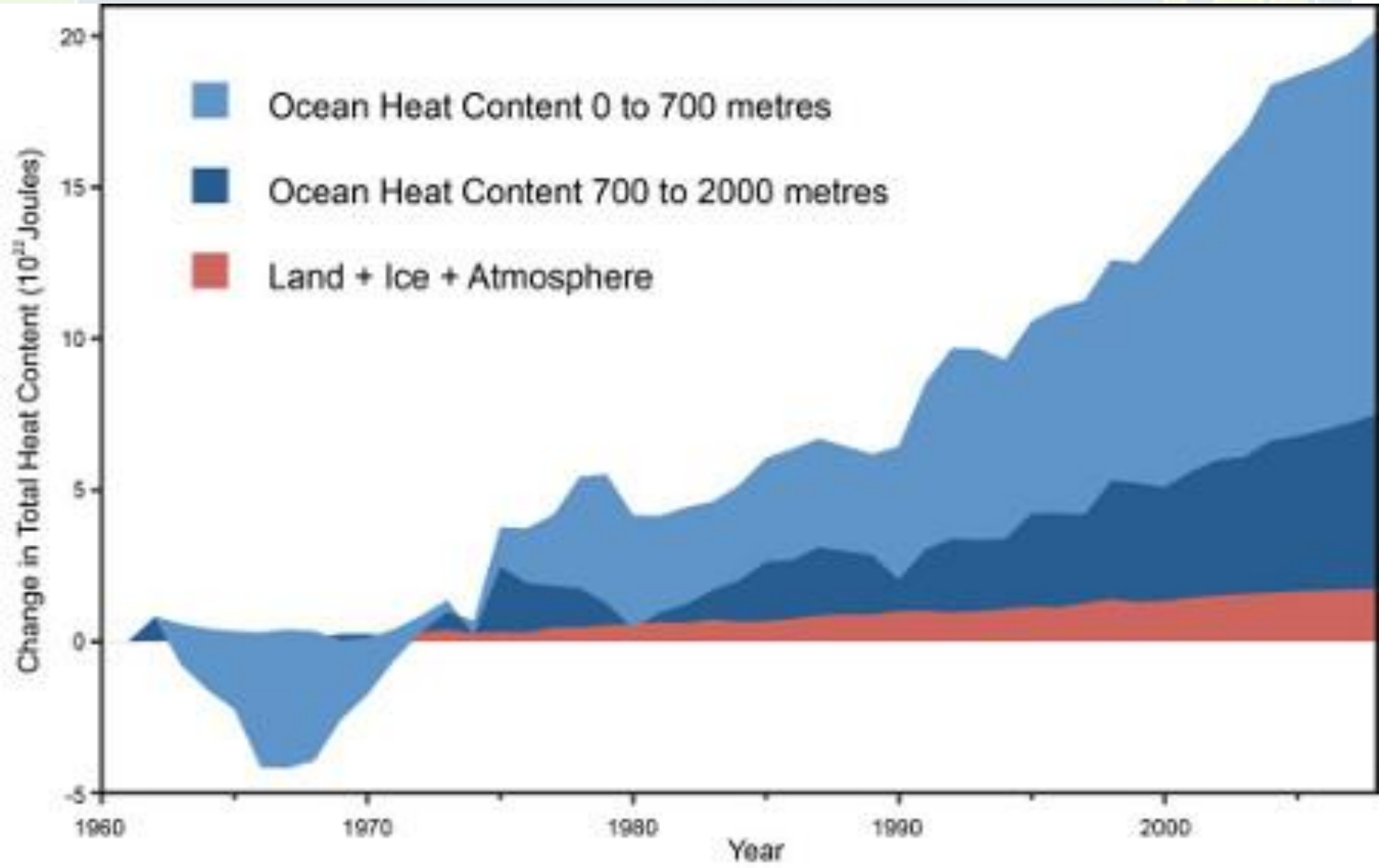
The last IPCC AR5 relied on obsolete assumptions w/o these indirect emissions. Solomon *et al.* 2009, a key pioneering work, showed atmospheric CO2 dropping if human emissions end .



Yet even that dropping CO2 doesn't give us dropping temperatures. Ocean thermal inertia and +0.6W/m² Radiative imbalance combine to neutralize dropping CO2. And that's WithOUT the indirect emissions we now know.



93% of our Greenhouse heating has gone into the oceans, where it will reside for thousands of years.



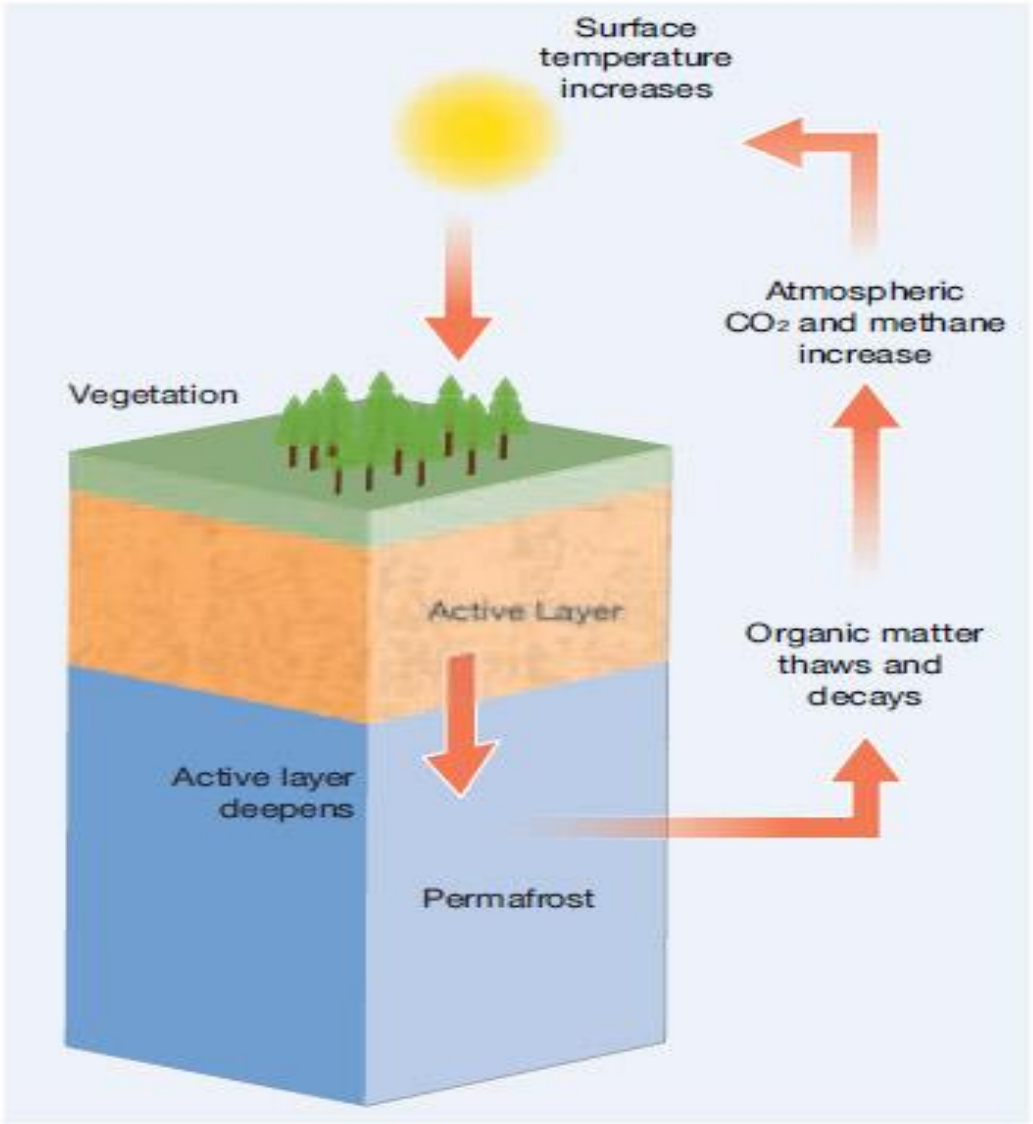
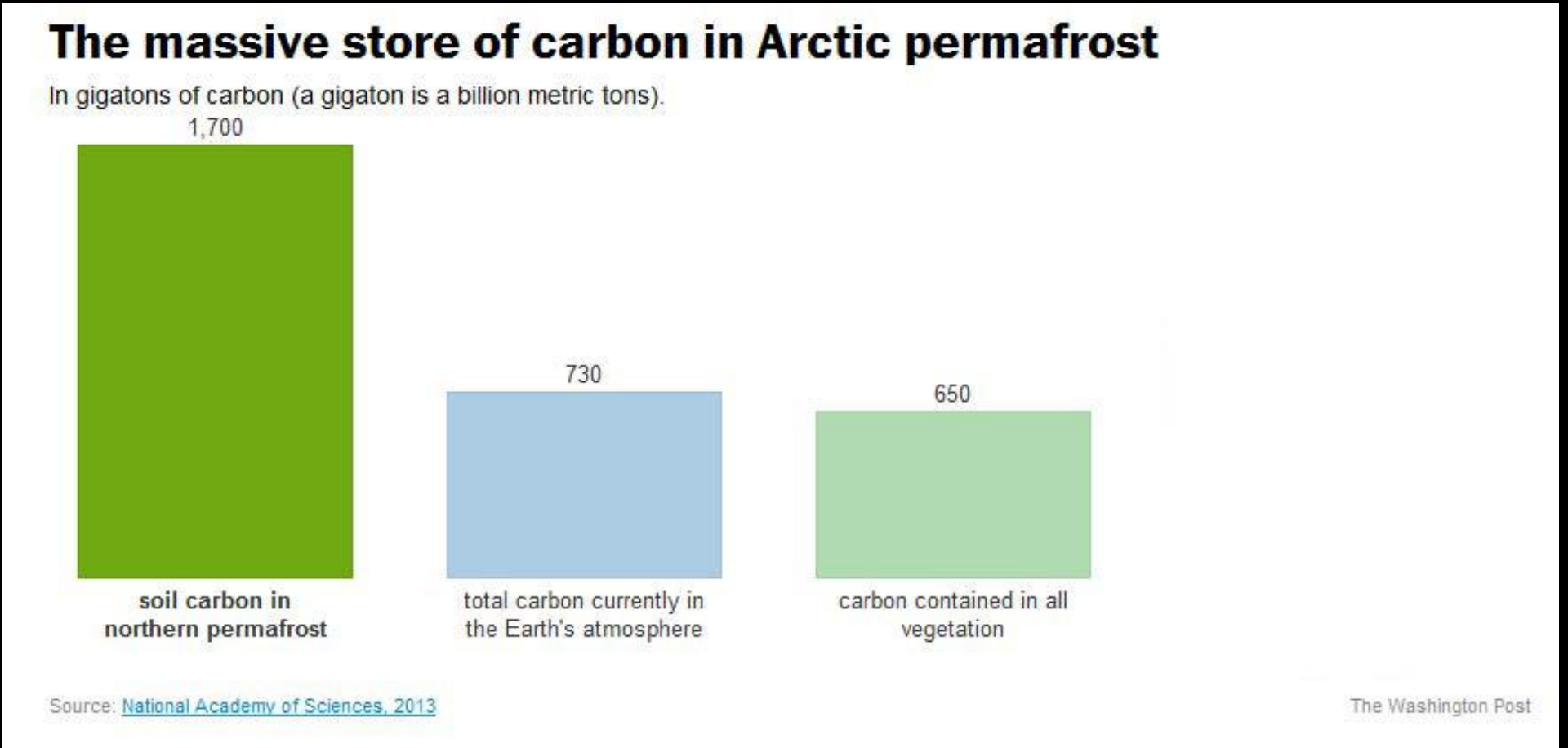


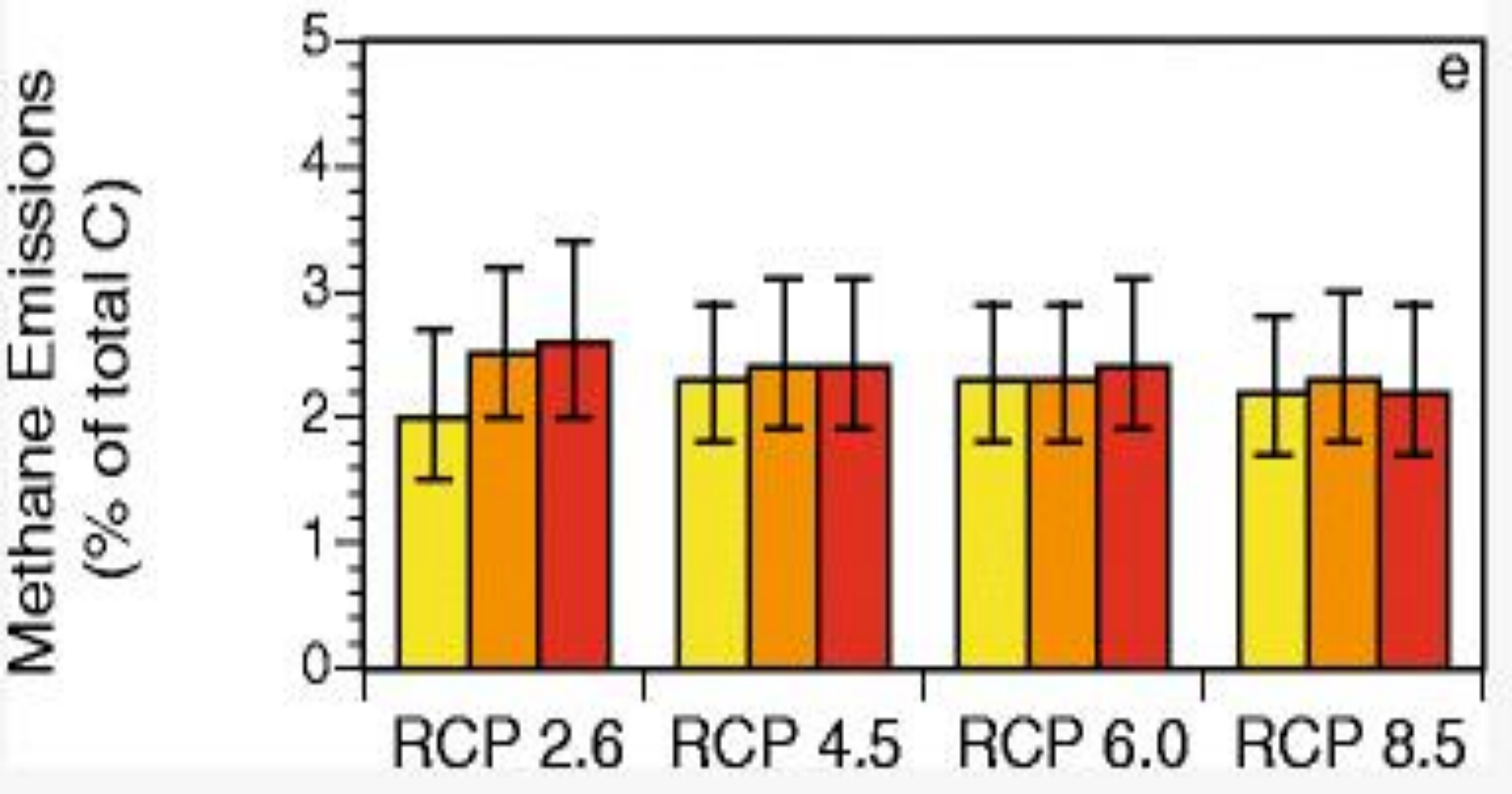
Figure 21: The permafrost carbon feedback is an amplification of surface warming due to the thaw of organic material currently frozen in permafrost, which will then decay and release CO_2 and methane into the atmosphere.

The Permafrost Carbon Feedback

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



Schuur *et al.* 2013 , surveying dozens of permafrost experts, find a consensus that 2.3% of the permafrost's emerging carbon is in the form of methane - regardless of human emission scenario (bar colors are for year 2040, 2100, 2300).



The latest data makes clear the acceleration of methane emissions since 2006. Most from tropical wetlands and cattle, so far…

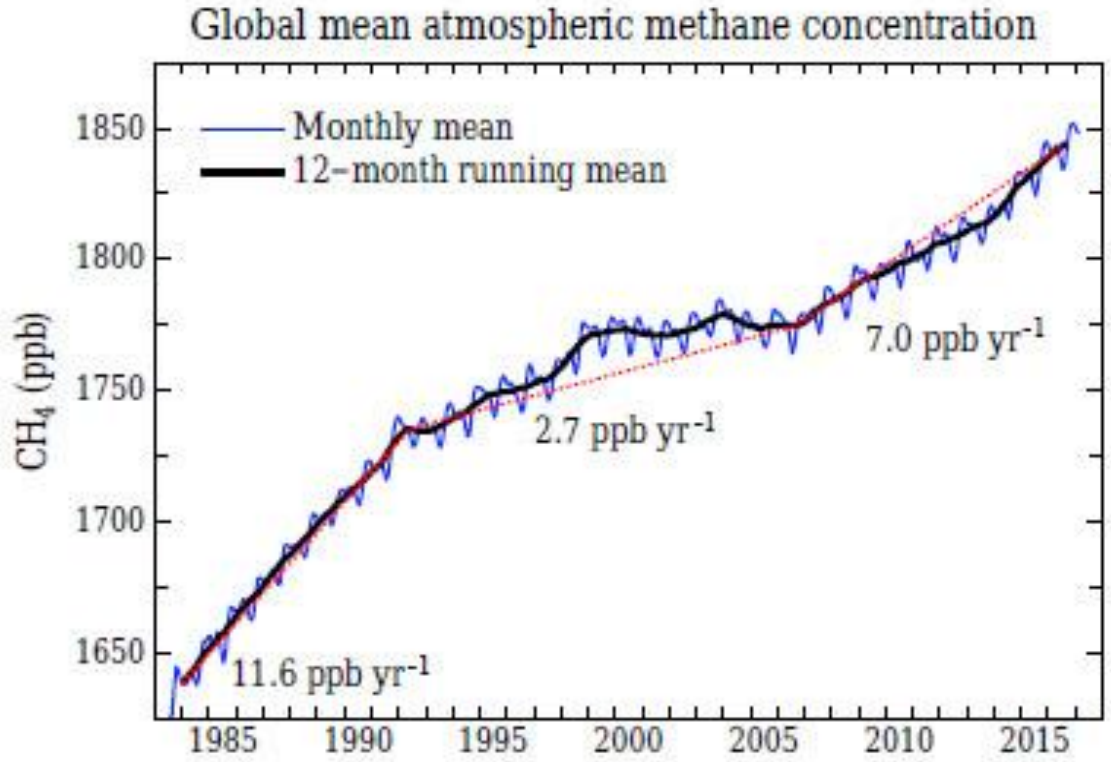


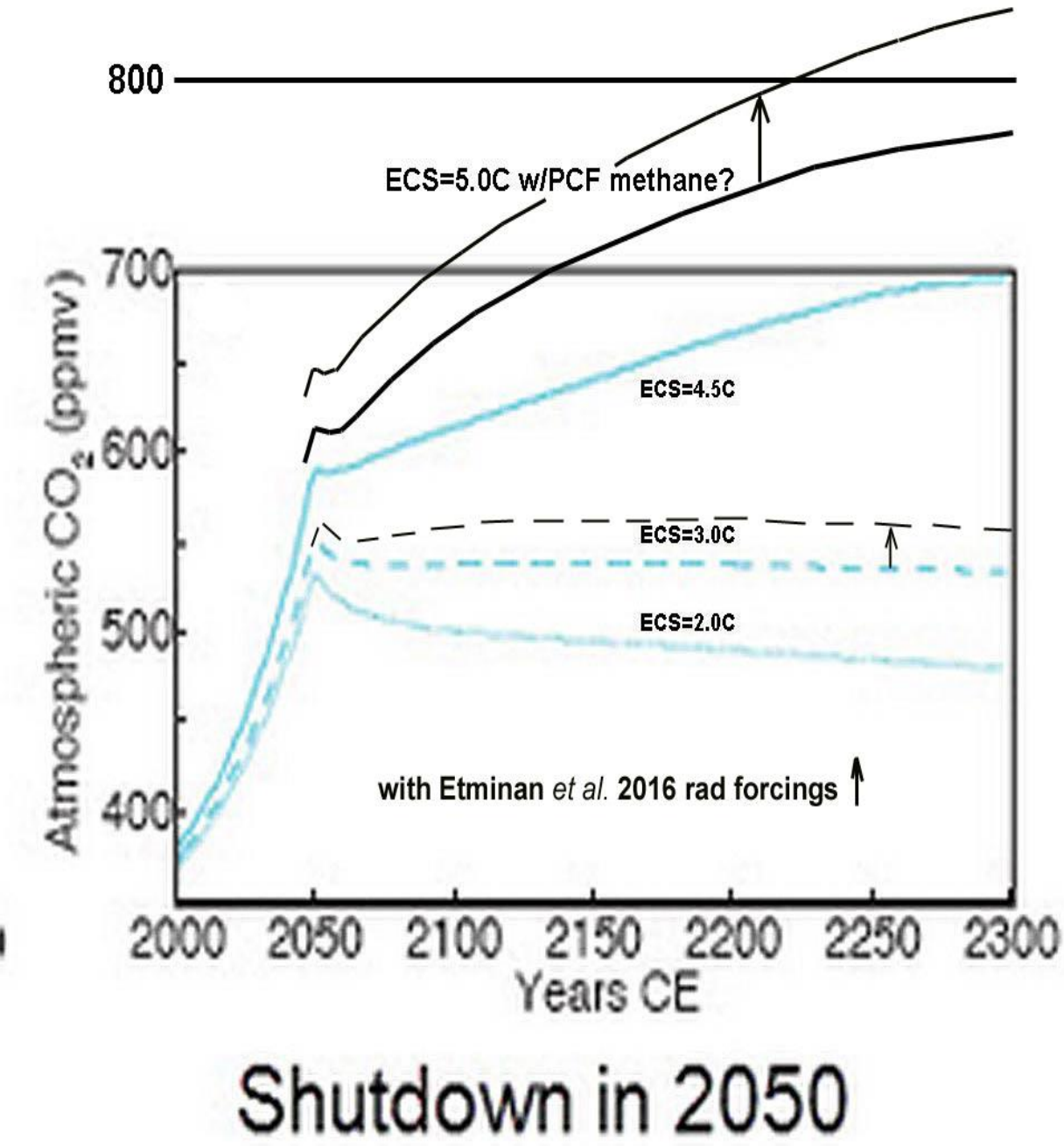
Figure 7. Global CH_4 from Dlugokencky (2016), NOAA/ESRL (http://www.esrl.noaa.gov/gmd/ccgg/trends_ch4/). End months for three indicated slopes are January 1984, May 1992, August 2006, and February 2017.

MacDougall *et al*. 2012 Studied How Atmospheric CO2 Would Change if we Include the Permafrost Carbon Feedback

- Their work is valuable for showing the range of results with differing assumptions of ECS
- **1. Good news:** Their assumed depth of the Active Layer (annual freeze/thaw) was too large. It may be only 60% as large (MacDougall and Knuti 2016).
- **2. Bad news:** Computer code includes no methane
- **3. More bad…** nor thermo-karst lakes, yedoma soils, stream erosion… all of which could double the CO2 equivalent values beyond what I'll show…
- I'll show estimates if we make rough corrections only for **(1.)** and **(2.)**

But wait – New research shows it is worse still. Etminan *et al.* 2016 recalculated the radiative forcings of methane and N_2O

- They included new data on short-wavelength absorption bands not included in the prior calculations like those used in the IPCC assessment reports syntheses.
- They showed that both of these GHG's have radiative forcings to climate that are **about 23% higher than previously thought.**



Shutdown in 2050

My Etminan *et al.* - based new (arrow) estimates in black. I've merely added 23% conservatively onto my ECS=3C and ECS=5C black curves roughly estimated from newer work on active layer depth and including missing methane as CO2 equivalent, and neglecting nonlinear amplifying, thermo-karst, etc.

Now, ECS=5C atmospheric CO2 is driven over 800 ppm and rising, by 2300. Temperatures would likely rise to +8C and beyond…

<u>All, without any human CO2 emissions starting just 21 yrs from now.</u>

Too Rosy?

- As the highly respected award-winning site "SkepticalScience"'s **summary** of the work says… ***"Unfortunately, there are several good reasons to consider the outlook in MacDougall et al. as rosy; as the authors themselves make clear."***

Could it be MUCH Worse? Warming causes stronger soil carbon loss…

- …And heating; if it does not escape fast enough to damp combustion, then run-away combustion initiates with catastrophic carbon release rates
- **Luke and Cox (2011)** find that for the vast peat areas of the Earth, including in the Arctic, the **critical warming rate is 0.088C per year**
- Warming rates faster than this trigger the **"Compost Bomb Instability"**.
- This would be bad.

Research articles

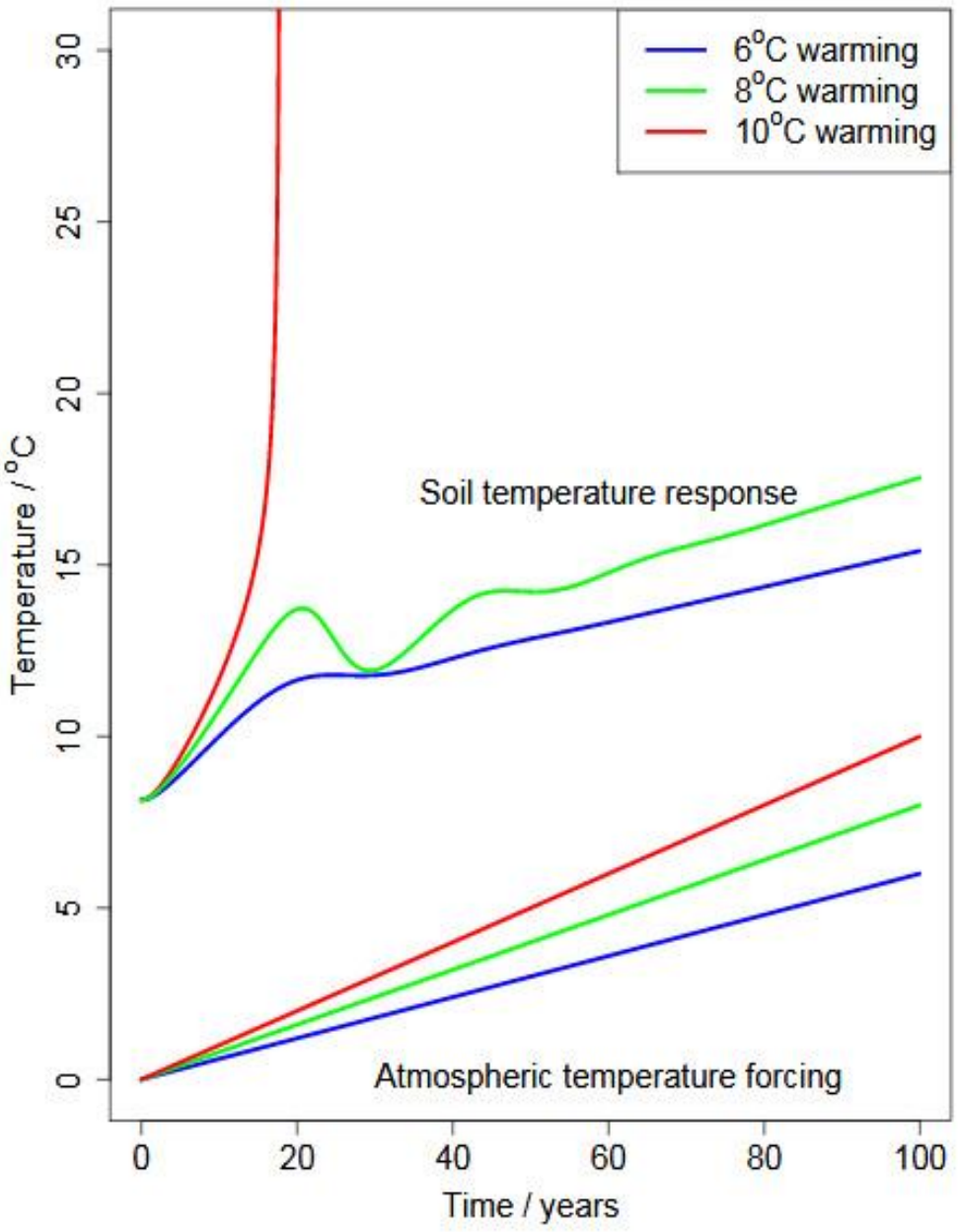
Excitability in ramped systems: the compost-bomb instability

S. Wieczorek, P. Ashwin, C. M. Luke and P. M. Cox

Published: 24 November 2010 https://doi.org/10.1098/rspa.2010.0485

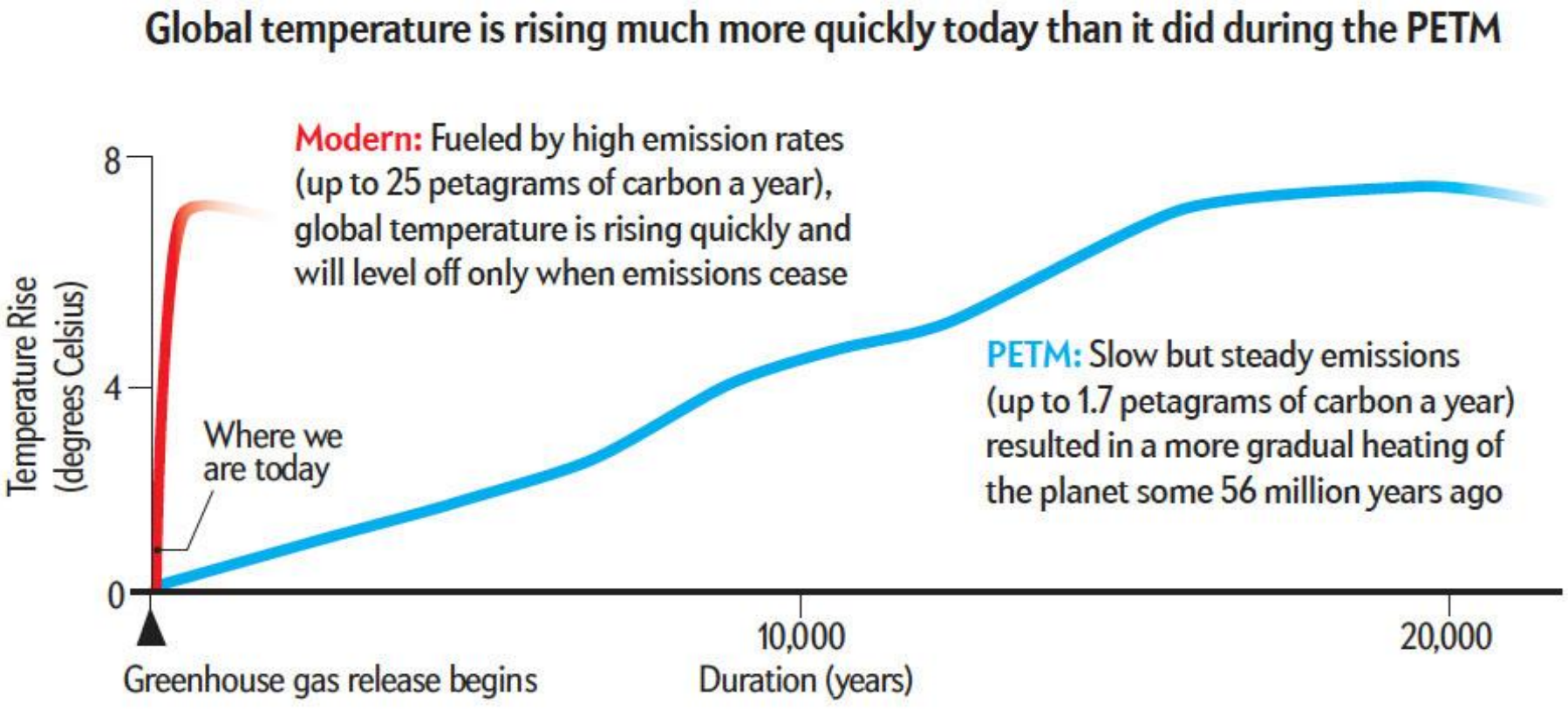
Abstract

The paper studies a novel excitability type where a large excitable response appears when a system's parameter is varied gradually, or ramped, above some critical rate. This occurs even though there is a (unique) stable quiescent state for any fixed setting of the ramped parameter. We give a necessary and a sufficient condition for the existence of a critical ramping rate in a general class of slow–fast systems with folded slow (critical) manifold. Additionally, we derive an analytical condition for the critical rate by relating the excitability threshold to a canard trajectory through a folded saddle singularity. The general framework is used to explain a potential climate tipping point termed the 'compost-bomb instability'—an explosive release of soil carbon from peatlands into the atmosphere occurs above some critical rate of global warming even though there is a unique asymptotically stable soil carbon equilibrium for any fixed atmospheric temperature.



When the atmospheric temperature rise rate exceeds 0.088C per year, then within 15 years soil carbon in buried peat ignites, setting off the "Compost Bomb" and catastrophic rapid carbon release to the atmosphere

Such Arctic rise rates are possible, especially given the Crowther *et al.* 2016 studies showing soil carbon loss as high as 17% that of human emissions. The rate at which we are forcing climate is unprecedented in Earth history – over 100x faster than even the PETM (Cui et al. 2011), for which this instability is a suspected cause. (although new work indicates the PETM may have been vastly faster)



Is this Just Doomist Poppycock?

- **A New research report** in 2019… finds a 3-5C temperature rise in the Arctic is "locked in" by 2050. (Fascinating look at the **UN's pushback on the conclusions of the scientists**. I can only read it to mean the reality is worse still). Let's do a ballpark calculation…
- 5C (2050) – 2C (today) in 30 years = 3C/30 yrs = **0.100 C/year temperature rise rate**
- That's above the **.088C/yr limit** for the **Compost Bomb Instability.**
- So yes; this looks like a real risk. While complexities and uncertainties in soil conductivity etc. no doubt exist, if triggered, it could be quite devastating beyond anything so far talked about except by the doomists.

Dramatic IPCC underestimation of Arctic sea ice loss, and ignoring Greenland Ice Melt…

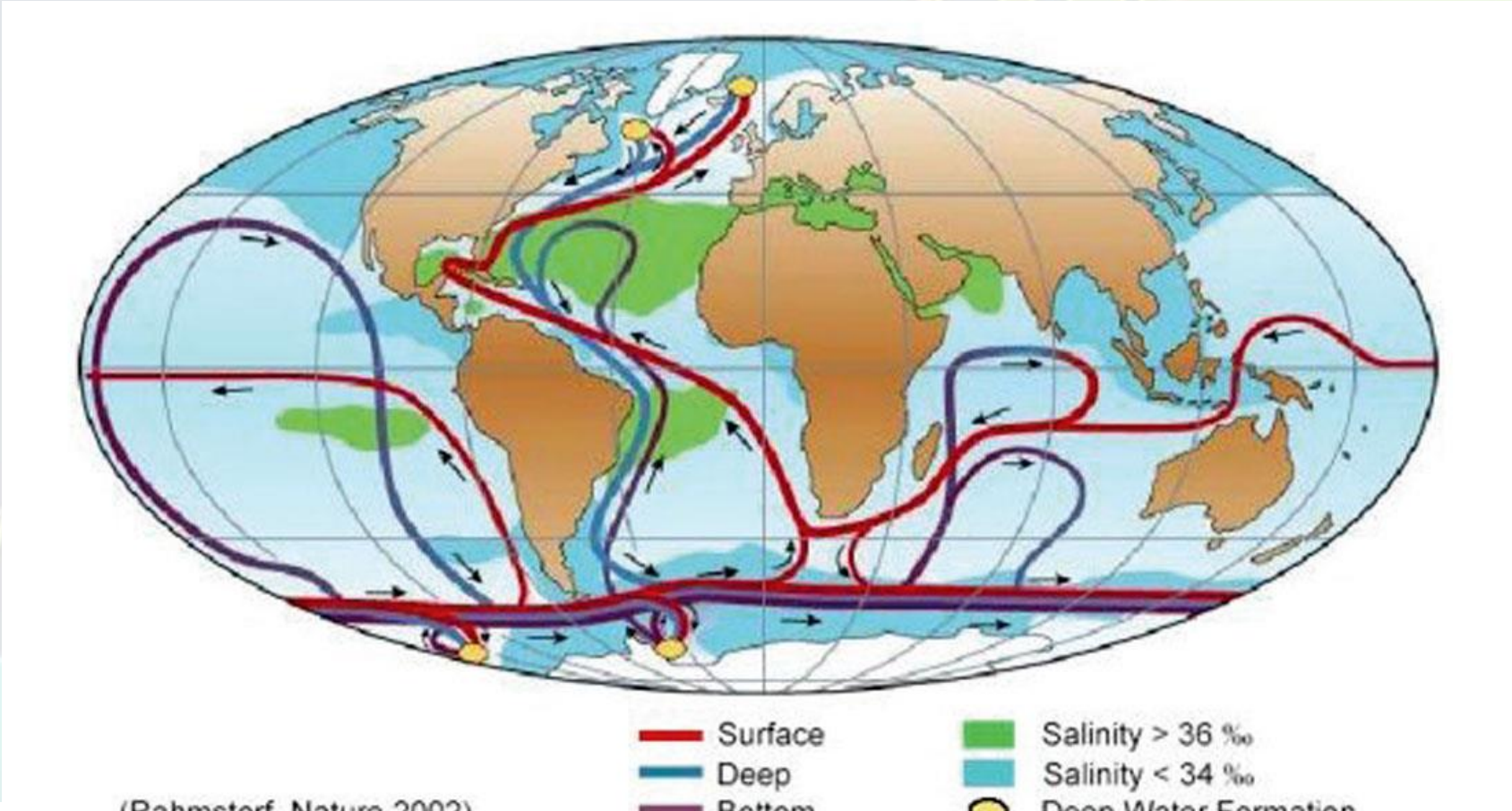
MINIMUM ANNUAL ARCTIC SEA ICE: **IPCC MODELS** VS **OBSERVATIONS**

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/

At Today's 400 ppm CO2, Paleo Earth Sea Level was ~24 m (80 ft) Higher than Today

- **Foster and Rohling (2013)** published a work consolidating evidence from the past ~40 million years at many locations to determine sea level rise at thermal equilibrium (when climate has finally stabilized at a given new CO2 level) for various CO2 levels
- ***They find that at CO2 of 400 ppm (10ppm lower than today's level), sea level will rise at least 9m and most likely ~24m above present levels***, due to complete melting of Greenland, the West Antarctic Ice Sheet (WAIS), and part of the remainder of Antarctica as well. **24m is 80 feet.**
- **It would take centuries to get there, most likely**

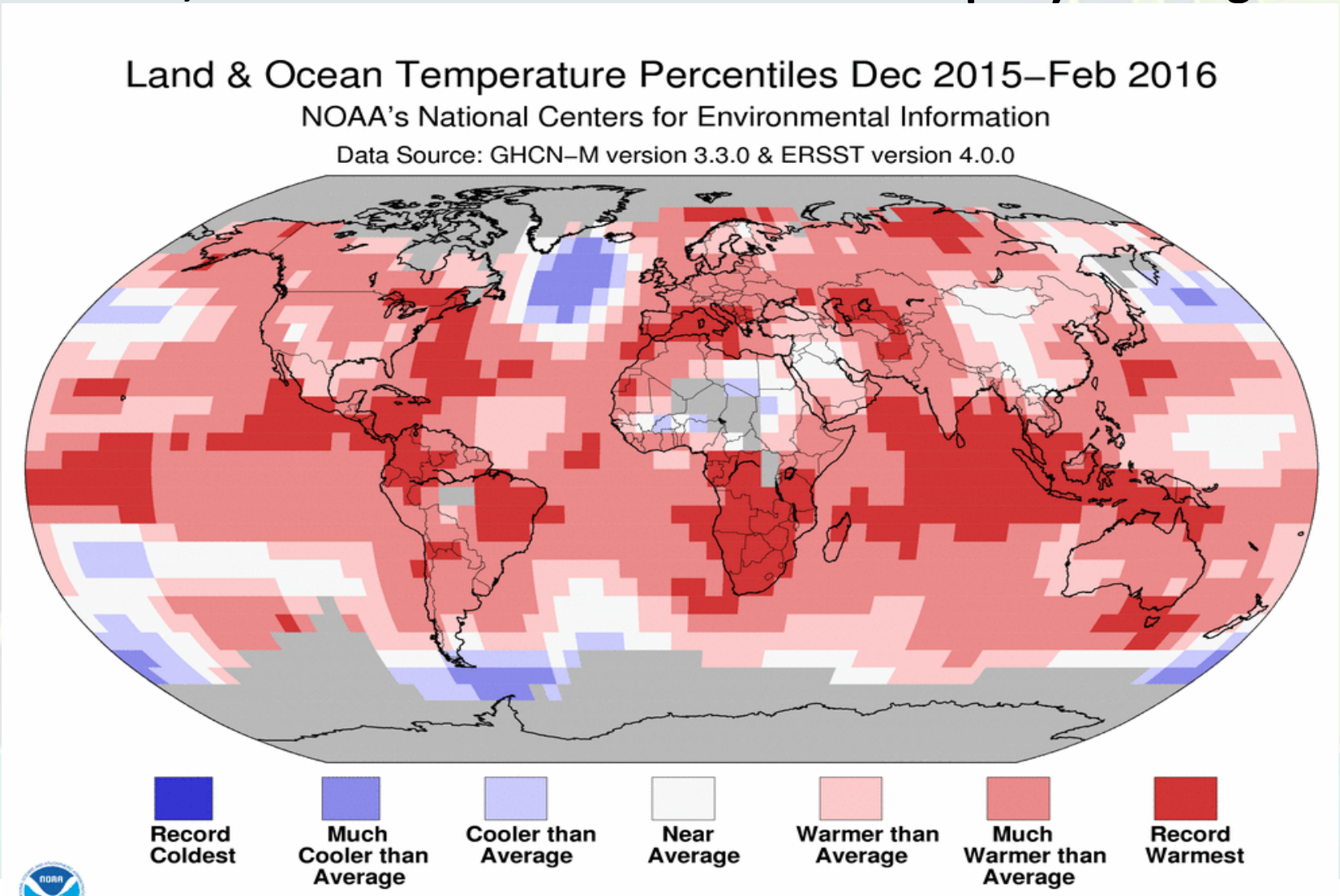
Next: Global Ocean Circulation - Deep Water forms only at 4 places: two off Greenland, and two straddling the Antarctic Peninsula (yellow dots)



That Deep Water Forms…

- …because the warm surface waters can cool to the atmosphere, evaporating and raising their salinity so that by the time they get to Greenland, they're salty enough and cool enough to have higher density than the deeper cool waters, and so they sink.
- But what if those warm waters are cut off from the surface so they can't cool and instead low density fresh water sits on top?...

"It's Happening", **much sooner than expected… Note the cold patch (blue) below Greenland, due to Greenland meltwater. Another at the Southern Ocean's deep water formation points off the Antarctic Peninsula, where the Larsen Ice Shelves are rapidly disintegrating**



Result: Cold Stagnant Water in North + Hot Stagnant Water in Tropics => Large Scale STEEP Temperature Gradient => Super Storms

- It is steep temperature GRADIENTS which power winds, which power storms and storm waves
- **An era of Super Storms is the theoretical prediction…**
- **…and the observational confirmation in paleo data – Hansen *et al. 2016* find that during the Eemian Period (the last interglacial), at temperatures similar to today induced ice melt and sea level rise several meters higher than today. And… Super Storms.**

Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2 °C global warming could be dangerous

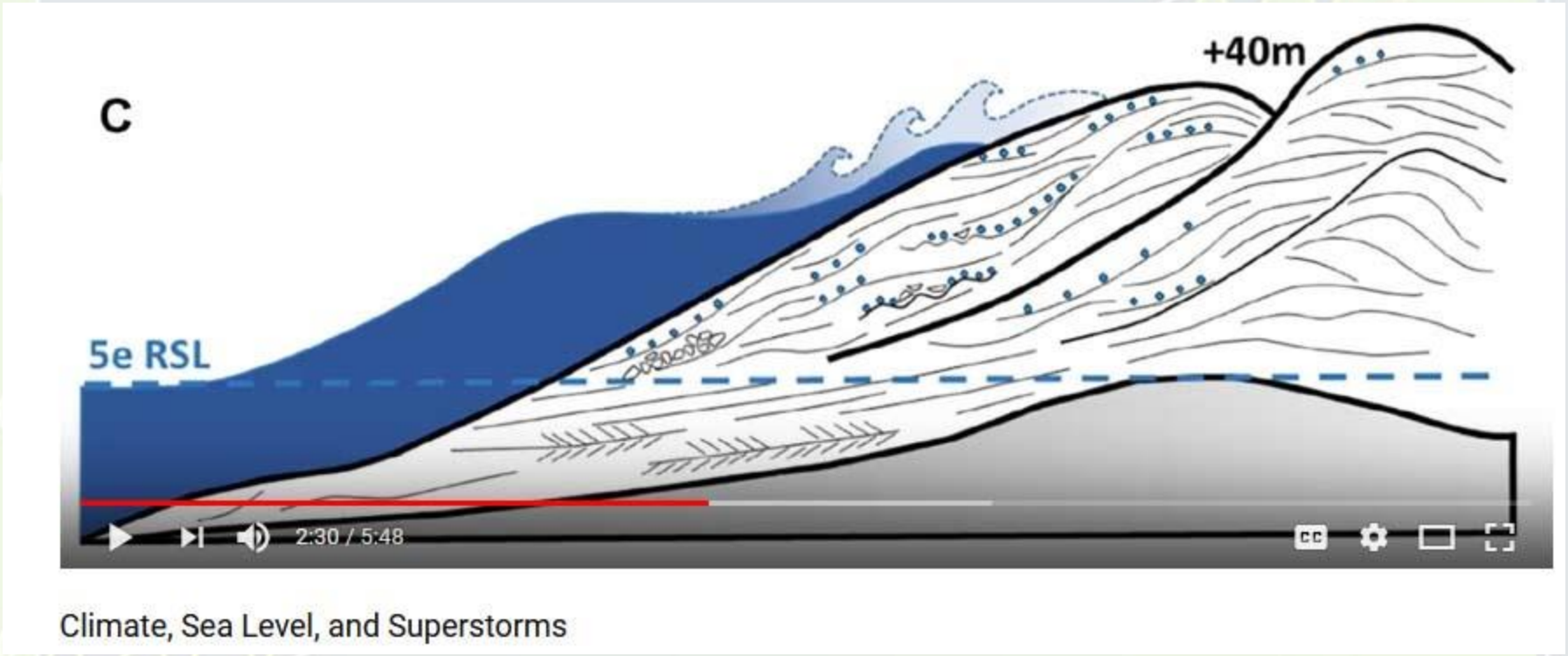
James Hansen[1], Makiko Sato[1], Paul Hearty[2], Reto Ruedy[3,4], Maxwell Kelley[3,4], Valerie Masson-Delmotte[5], Gary Russell[4], George Tselioudis[4], Junji Cao[6], Eric Rignot[7,8], Isabella Velicogna[7,8], Blair Tormey[9], Bailey Donovan[10], Evgeniya Kandiano[11], Karina von Schuckmann[12], Pushker Kharecha[1,4], Allegra N. Legrande[4], Michael Bauer[4,13], and Kwok-Wai Lo[3,4]

[1]Climate Science, Awareness and Solutions, Columbia University Earth Institute, New York, NY 10115, USA
[2]Department of Environmental Studies, University of North Carolina at Wilmington, NC 28403, USA
[3]Trinnovium LLC, New York, NY 10025, USA
[4]NASA Goddard Institute for Space Studies, 2880 Broadway, New York, NY 10025, USA
[5]Institut Pierre Simon Laplace, Laboratoire des Sciences du Climat et de l'Environnement (CEA-CNRS-UVSQ), Gif-sur-Yvette, France
[6]Key Lab of Aerosol Chemistry & Physics, Institute of Earth Environment, Chinese Academy of Sciences, Xi'an 710075, China
[7]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA
[8]Department of Earth System Science, University of California, Irvine, CA 92697, USA
[9]Program for the Study of Developed Shorelines, Western Carolina University, Cullowhee, NC 28723, USA
[10]Department of Geological Sciences, East Carolina University, Greenville, NC 27858, USA
[11]GEOMAR, Helmholtz Centre for Ocean Research, Wischhofstrasse 1–3, Kiel 24148, Germany
[12]Mediterranean Institute of Oceanography, University of Toulon, La Garde, France
[13]Department of Applied Physics and Applied Mathematics, Columbia University, New York, NY 10027, USA

Correspondence to: James Hansen (jeh1@columbia.edu)

Received: 11 June 2015 – Published in Atmos. Chem. Phys. Discuss.: 23 July 2015
Revised: 17 February 2016 – Accepted: 18 February 2016 – Published: 22 March 2016

Here is a recent 6 min video on this, from Yale Climate Connections



The waves required for such 43m high run-up deposits… are ~ 170 ft high (!)

These ~1,000 ton boulders were tossed up from the ocean offshore during the Eemian interglacial in the Bahamas by Super-Storms, powered by the same AMOC shutdown we may be initiating with our fossil fuel burning. Caption includes "chevron ridges" … (next slide).

Fig. 1. Two boulders (#1 and #2 of Hearty, 1997) on coastal ridge of North Eleuthera Island, Bahamas. Scale: person in both photos = 1.6 m. Estimated weight of largest boulder (#1, on left) is ~ 2300 tons.

Enormous boulders tossed onto an older Pleistocene landscape (Hearty, 1997; Hearty et al., 1998; Hearty and Neumann, 2001) provide a metric of powerful waves at the end of stage 5e. Giant displaced boulders (Fig. 1) were deposited in north Eleuthera, Bahamas near chevron ridges and runup deposits (Hearty, 1997).

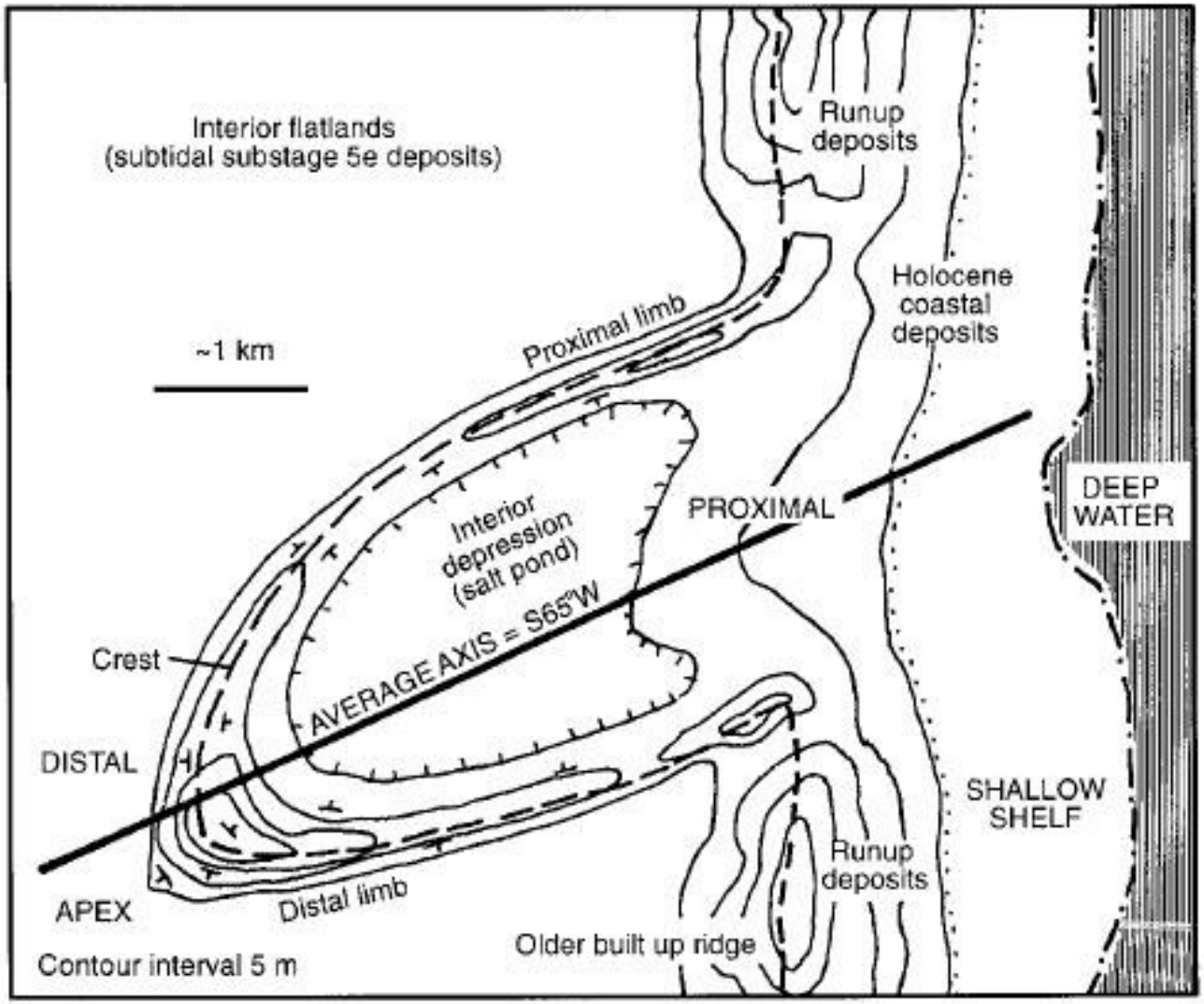


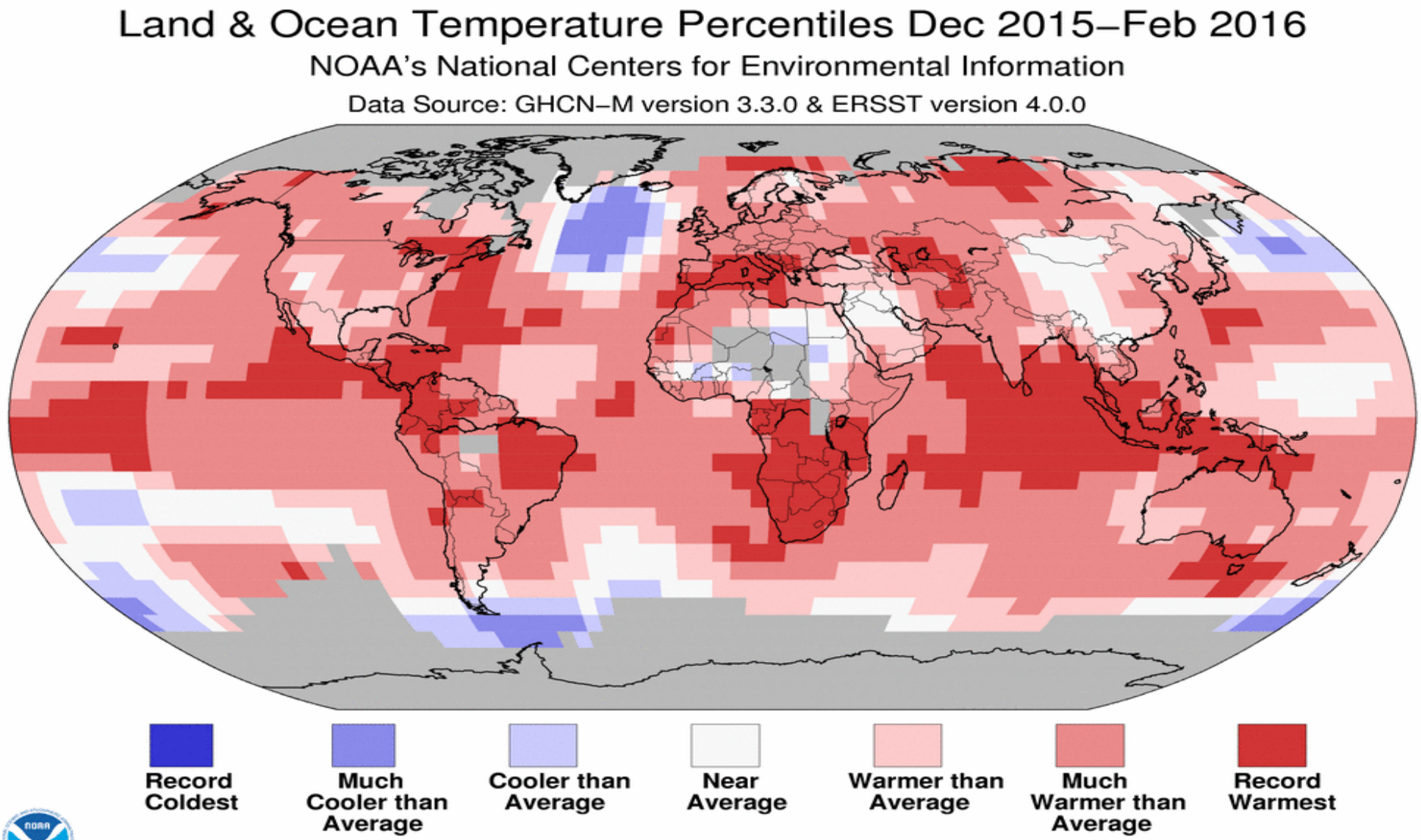
FIG. 1. Schematic map of chevron beach ridge.

Giant Super Storm Waves of the Eemian created chevron deposits 50 ft high and 2 miles long, when washing back to sea. They're all along the shorelines of the Bahamas. Requiring waves nearly ~200 ft high.

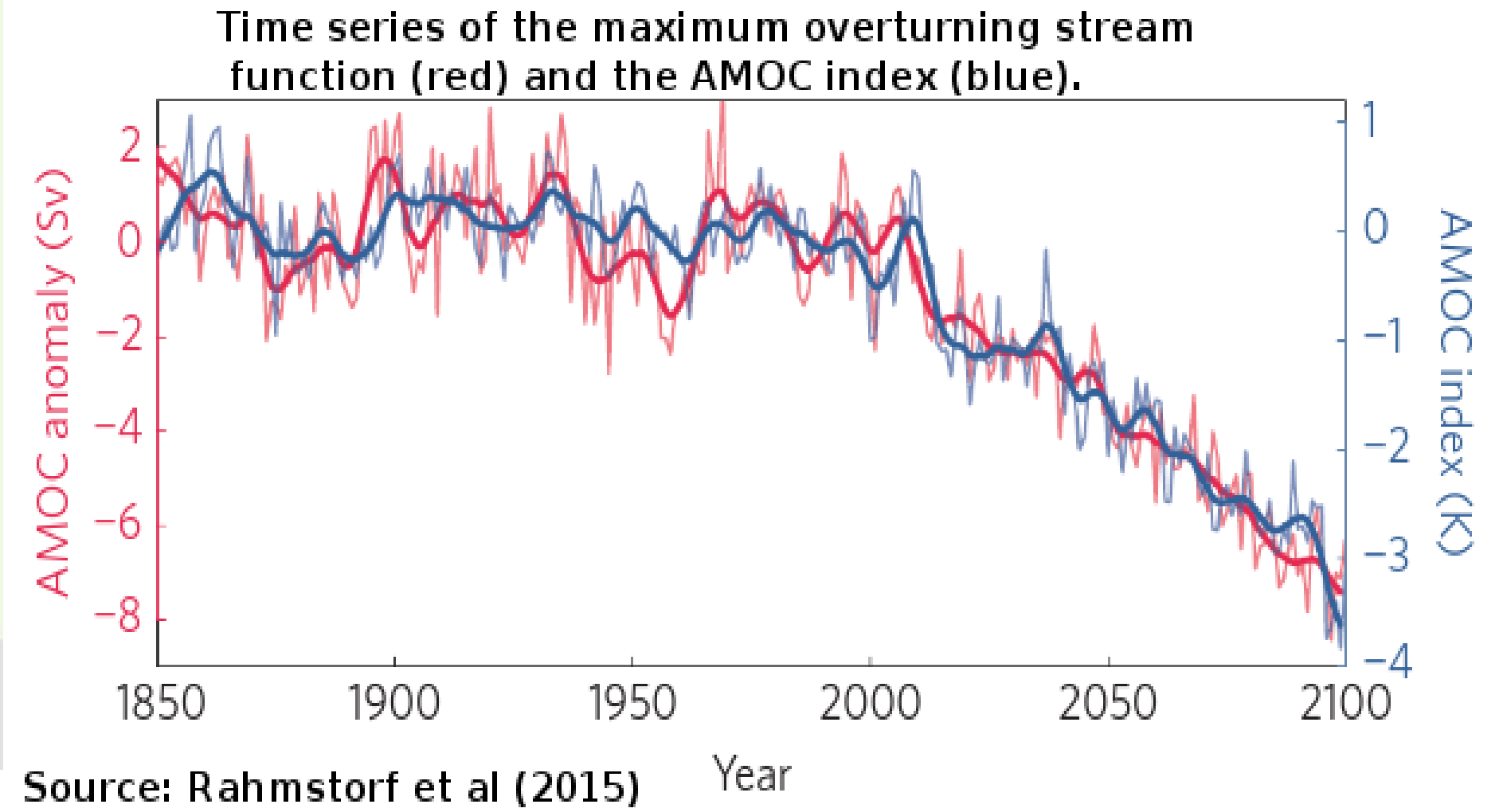
Remember the Waves in the Movie *"Interstellar"?* That's the flavor

Such Waves Could Entirely “Wipe Clean” Many Caribbean Islands

Observed Data. Growing cold patch (blue) off Greenland, and straddling the Antarctic Peninsula – cold cap of low density fresh water is now inhibiting high density drop through the thermocline and deep water formation

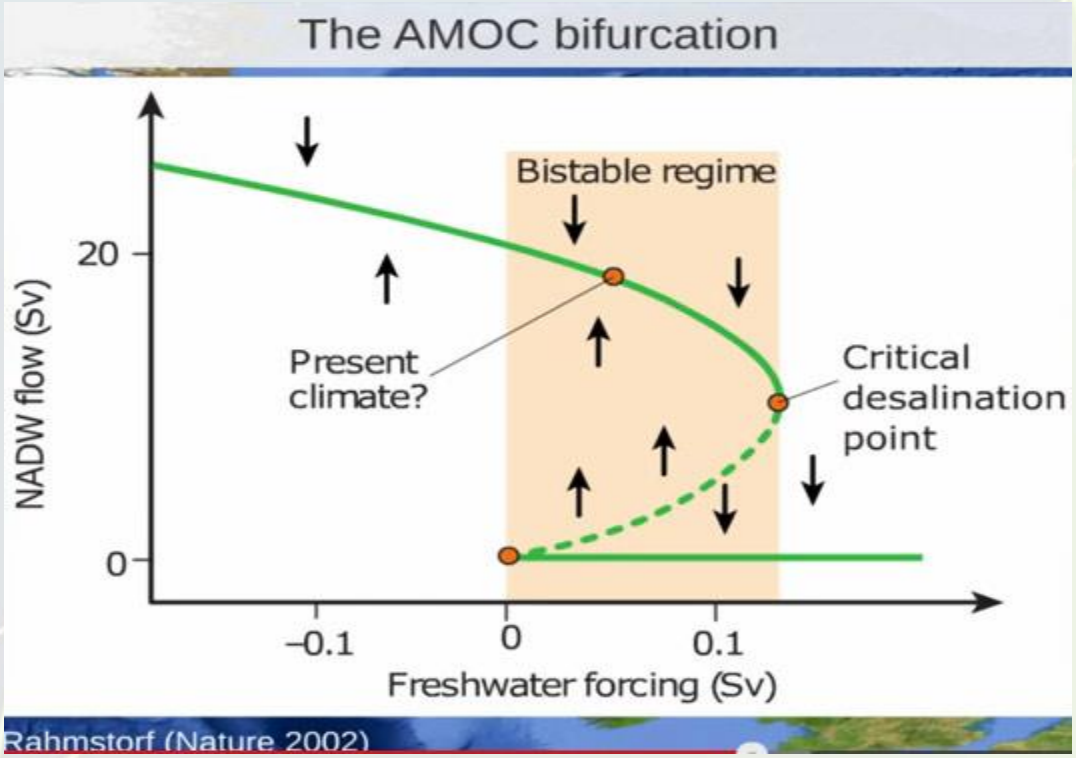


<u>Could this Really Happen?</u> The strength of the AMOC <u>is</u> declining, and predicted to continue (Rahmstorf *et al.* 2015). When will Super-Storms Arrive? The cold melt surface has clearly begun. Perhaps the strong Hurricanes of '17 and '18 are a small taste.



Source: Rahmstorf et al (2015)

Rahmstorf *et al.* (2002) Had Already Shown the System Stability Trajectory. Odds of AMOC Shutdown This Century Have Been Rising with Each New Study

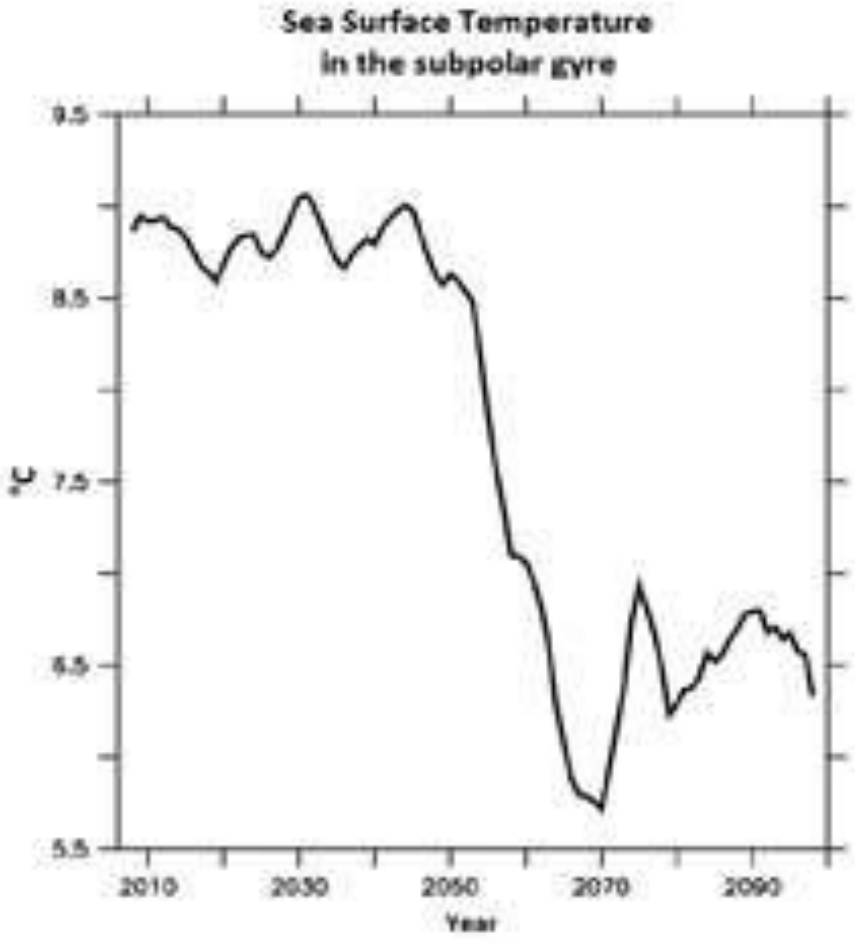


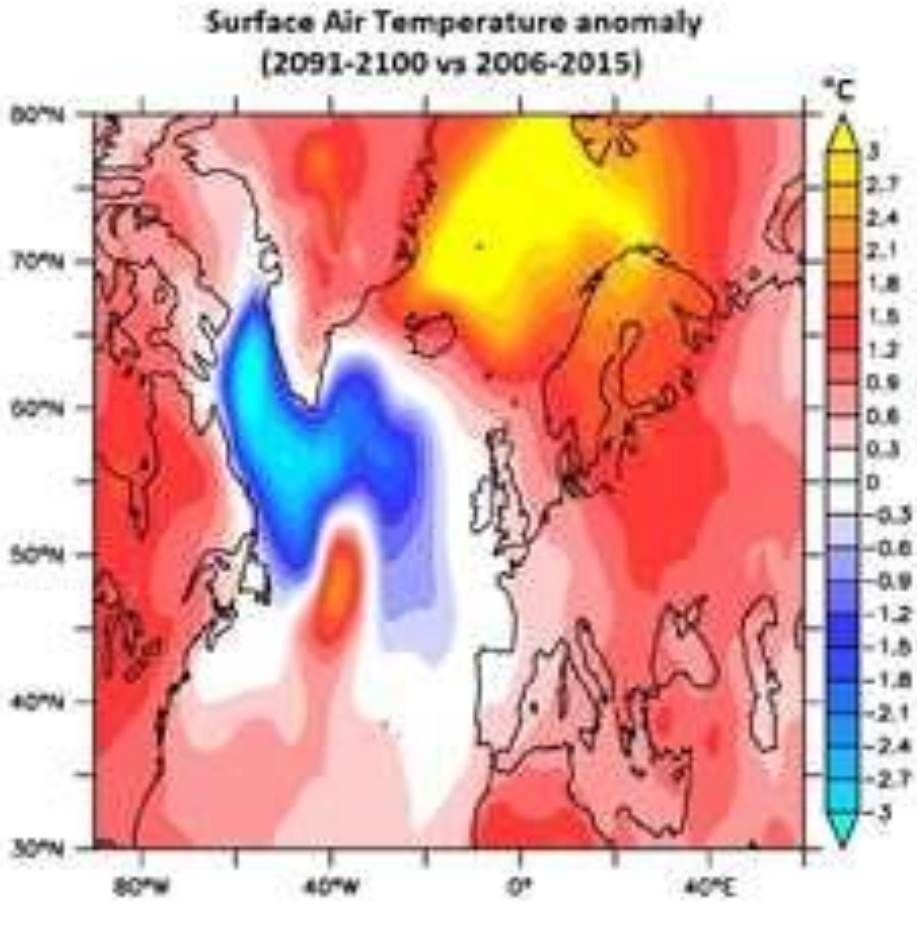
We're already in the salinity regime of <u>two</u> stable solutions, one being total shutdown. If melt increases and salinity declines further, a critical desalinization point is reached and the current shuts down. Then, only drastic re-salinization (re-freezing Greenland) can push it all the way back to a point where the current can resume**. Re-starting the global current would take centuries even if temperatures dropped immediately, according to James Hansen.**

Remember "*The Day after Tomorrow*" and the breathless *"Well… I THINK IT'S HAPPENING!"* ?

- A new paper finds that rapid AMOC slowdown due to a convective failure of the North Atlantic Subpolar Gyre (SPG) is much more likely than IPCC AR5 had thought **(Sgubin *et al.* 2017) (*Nature* paper)** (related **video summary**)
- **Half of their most realistic models lead to AMOC shutdown, and abrupt climate change in as little as 1 decade** (see next slide…).
- The authors **note**… ***"contrary to a potential AMOC disruption, no assessment has been made of the possibility of a local SPG convection collapse in the latest IPCC AR5***

Predicted Rapid Drop in North Atlantic Sea Surface Temperature Caused by Failure of the Sub Polar Gyre Due to Impenetrable Stratification (AMOC shutdown). Estimated 45% Odds This Century





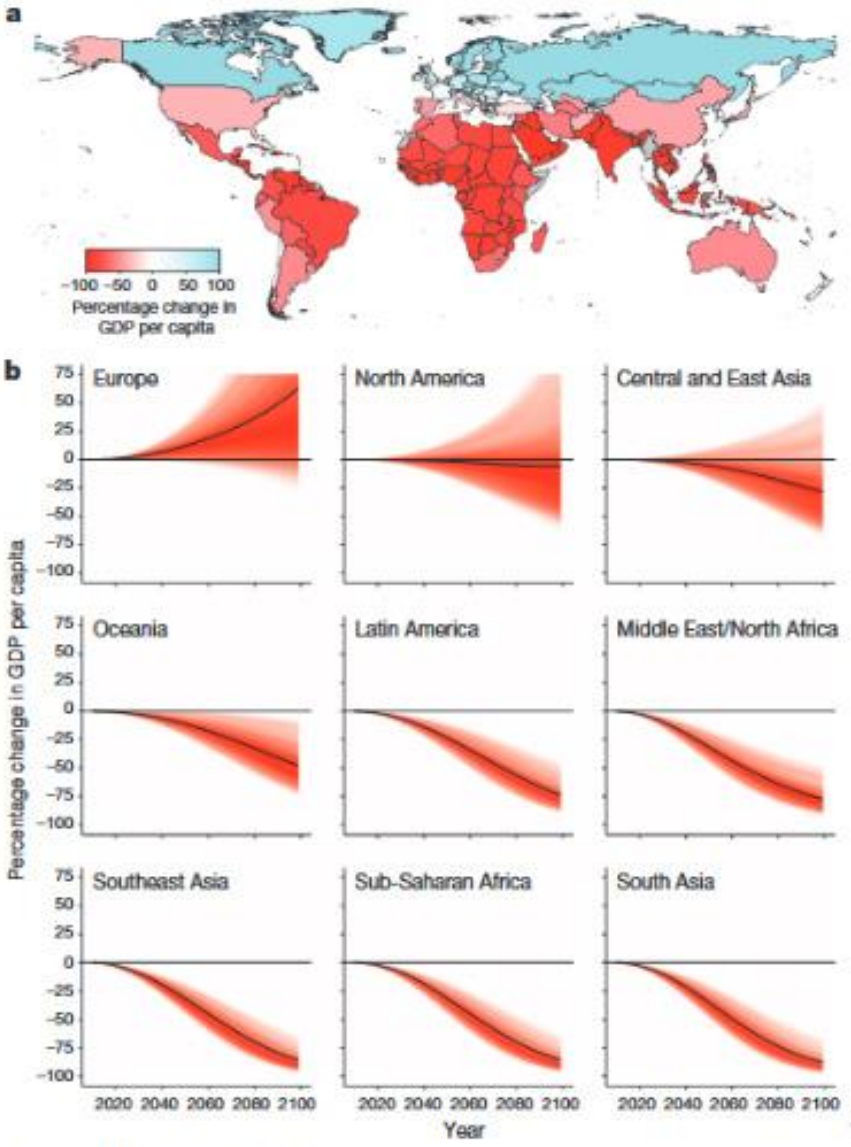


Figure 4 | Projected effect of temperature changes on regional economies. **a**, **b**, Change in GDP per capita (RCP8.5, SSP5) relative to projection using constant 1980–2010 average temperatures. **a**, Country-level estimates in 2100. **b**, Effects over time for nine regions. Black lines are projections using point estimates. Red shaded area is 95% confidence interval, colour saturation indicates estimated likelihood an income trajectory passes through a value[27]. Base maps by ESRI.

Economic Collapse in a +4C World in 2100…

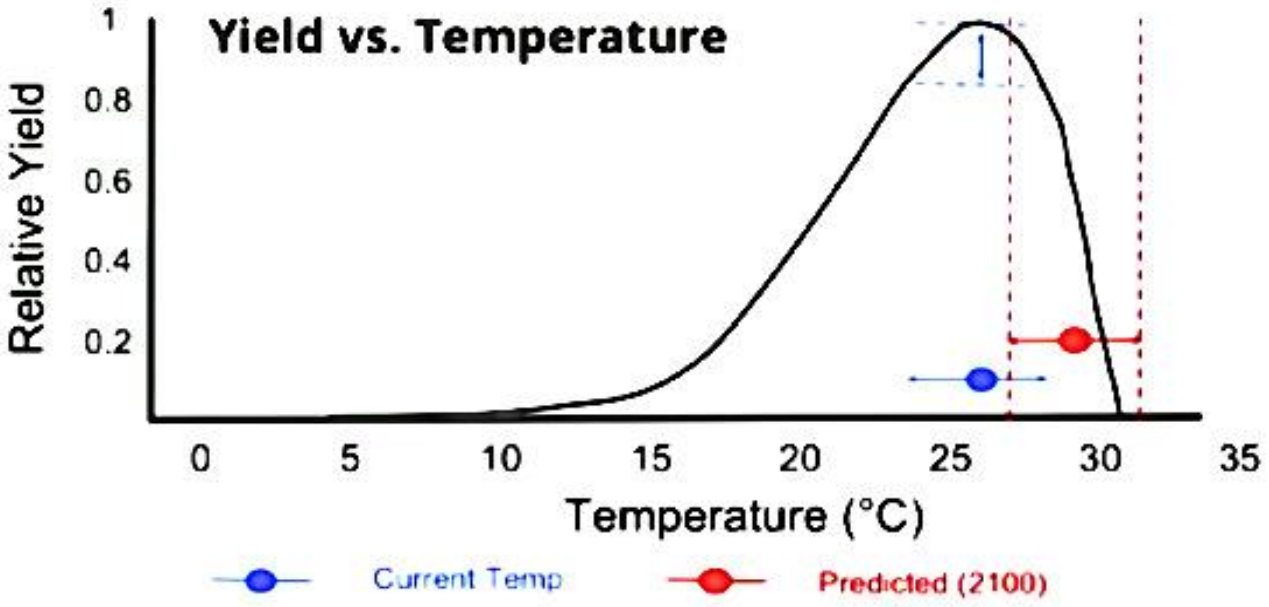
Russia is the relative "winner". The tropical countries utterly collapse, essentially leaving the system, and Russia's main competitors – the U.S. and China, both suffer relatively more. This study (Burke *et al.* 2015), however, can't include the non-linear tipping points of global wars and trade collapse, so it's likely too optimistic about all countries

Mass Starvation? The Staple Crops (corn, wheat, rice) Originated in Mid-Latitude Ecosystems, Now Grown by Equatorial Countries to Feed Their Populations

- But Biology is extremely temperature sensitive, and despite 30 years of major efforts, there has been NO success at breeding heat-tolerant staple crops (**1:04:50 into this talk by atmospheric scientist Dr. David Battisti in 2016**)

As temperatures rise, even mid-latitude crop yields (and carbon sequestration in soil), plummet. Note that one heat wave can completely kill an entire region's yield, with temperatures later this century

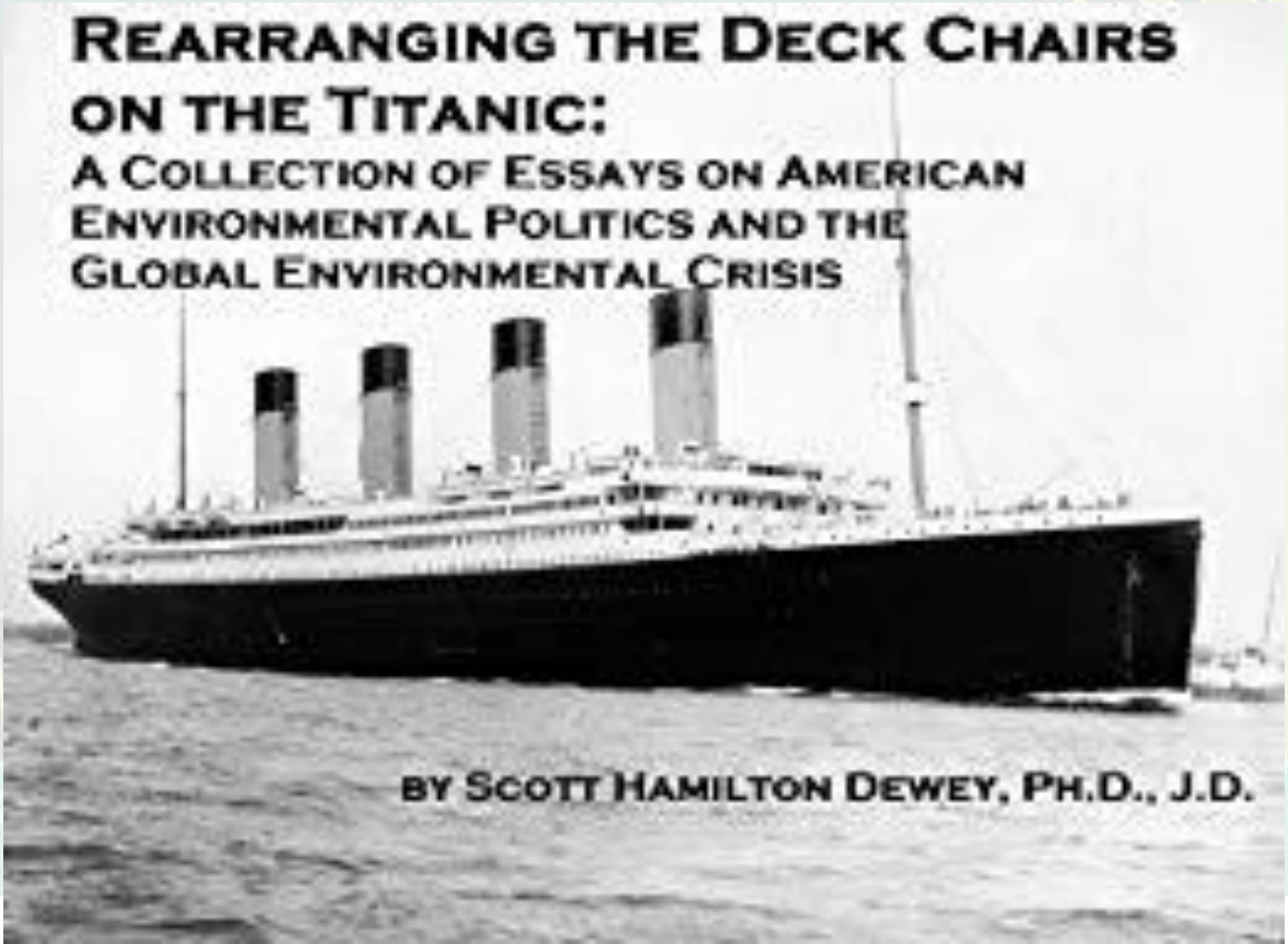
Higher Mean Temperature Increases Volatility in Mid-Latitude Yields



After Tewksbury et al 2008; see also: Urban et al. 2012, Climatic Change 112: 525-533

What Can We Do About This?

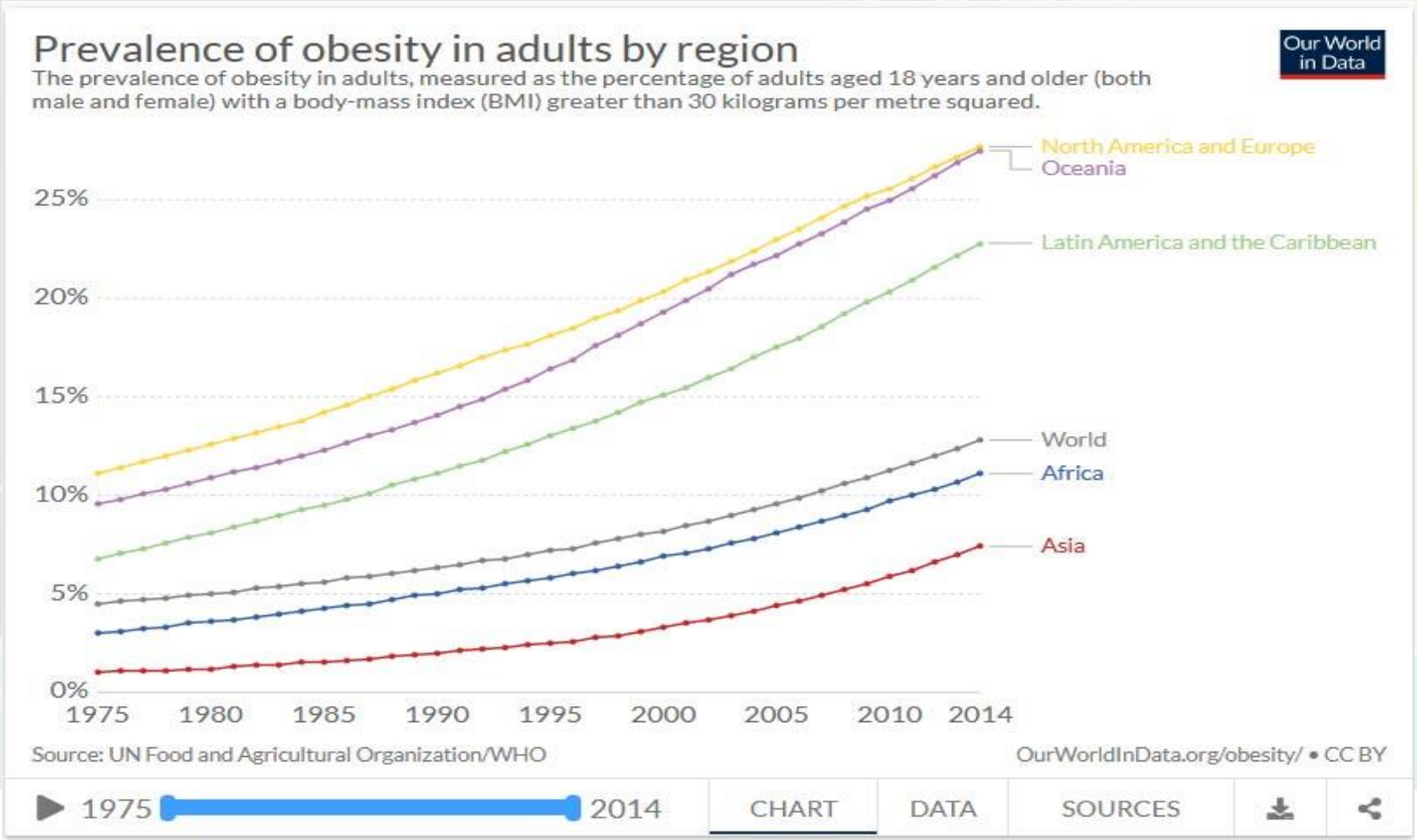
Unfortunately, This What I See Going on Around Me…



Some Progressives <u>Believe</u> That…

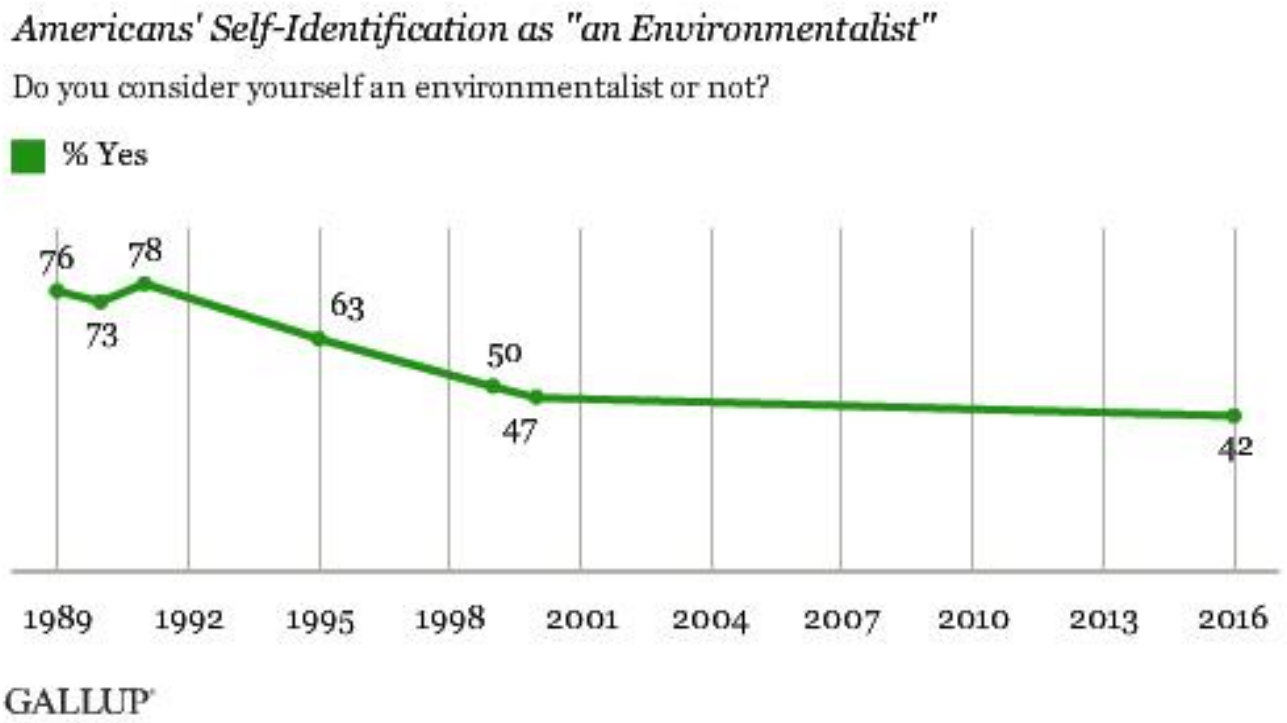
- …individually, by the billions, we will summon the will power to voluntarily engage in severe carbon-limiting behavior, even if it's an economic hardship for ourselves and those that depend on us (as it must be designed to do), and even though our actions, **individually** make not the slightest difference to climate…
- **Frankly, this <u>belief makes no sense</u>.**

We can't control the voluntary actions of others, but we CAN control our <u>own</u> health to a very large extent. **Yet** high-carbon people by the hundreds of millions refuse to summon that discipline by better eating, exercise. And the WORST obesity countries are the wealthiest, most educated. So this Utopian New Age fantasy that voluntary self-deprivation will save the future is in flat contradiction to the evidence



Clearly, The Desire for Immediate Gratification & Economic Growth Derailed the Environmental Bandwagon Long Ago.

PRINCETON, N.J. -- As Americans observe Earth Day, Gallup finds 42% of Americans identifying themselves as environmentalists, down from an average of 76% in the late 1980s and early 1990s.



In Michael Moore's "Fahrenheit 11/9"

He Asks Trump Strategist Steve Bannon How They Beat the Democrats in 2016

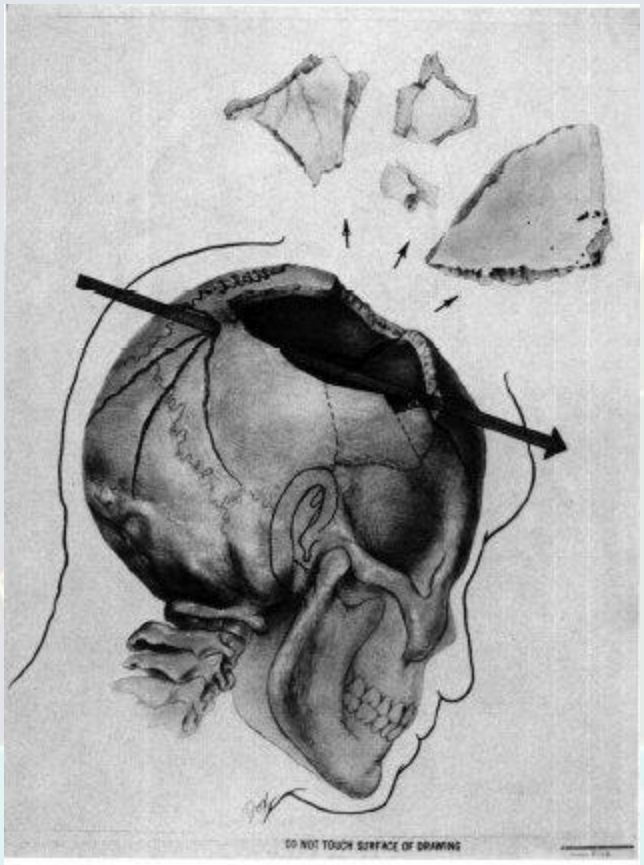
- 

FIGURE 29.—Scale drawing of the frontal and right side of a human skull, which depicts the displaced bone fragments and the extensive fragmentation of the skull.

- His answer…?
- ***"We go for the head wound…"***

"…while your side (the Democrats) has pillow fights"

I don't see liberals fully grasping how much Trumpist conservatives despise them, are exasperated by what they see as timid and infuriating weakness.

"We're (Trump Republicans) at war. You guys (the Liberals) don't know that yet. You're not at war. We're already at war."

- Steve Bannon

If Liberals think they'll win over Republicans on climate…

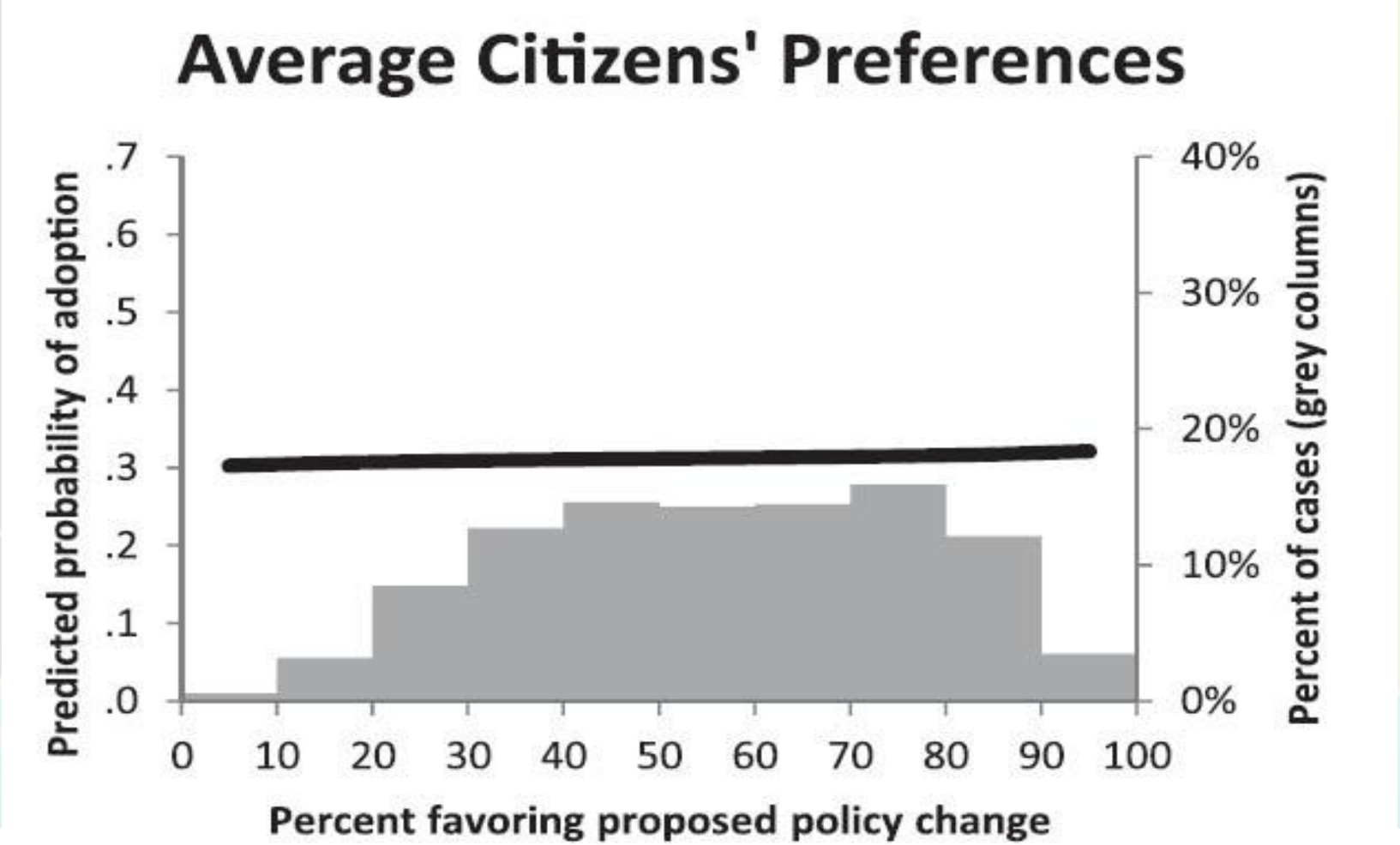
- …or anything else, by trying ever harder to exemplify their New Age ever-so-kind, ever-respectful, gentle, we-love-EVERYone ways, they are mistaken.
- History indicates they will only drive Republicans that much more extremely to the opposite side – as I'll show we've already done with trying to educate them on climate.

Shall We Write Sternly Worded Letters to Our Congressman? I say to my gentle Progressives…

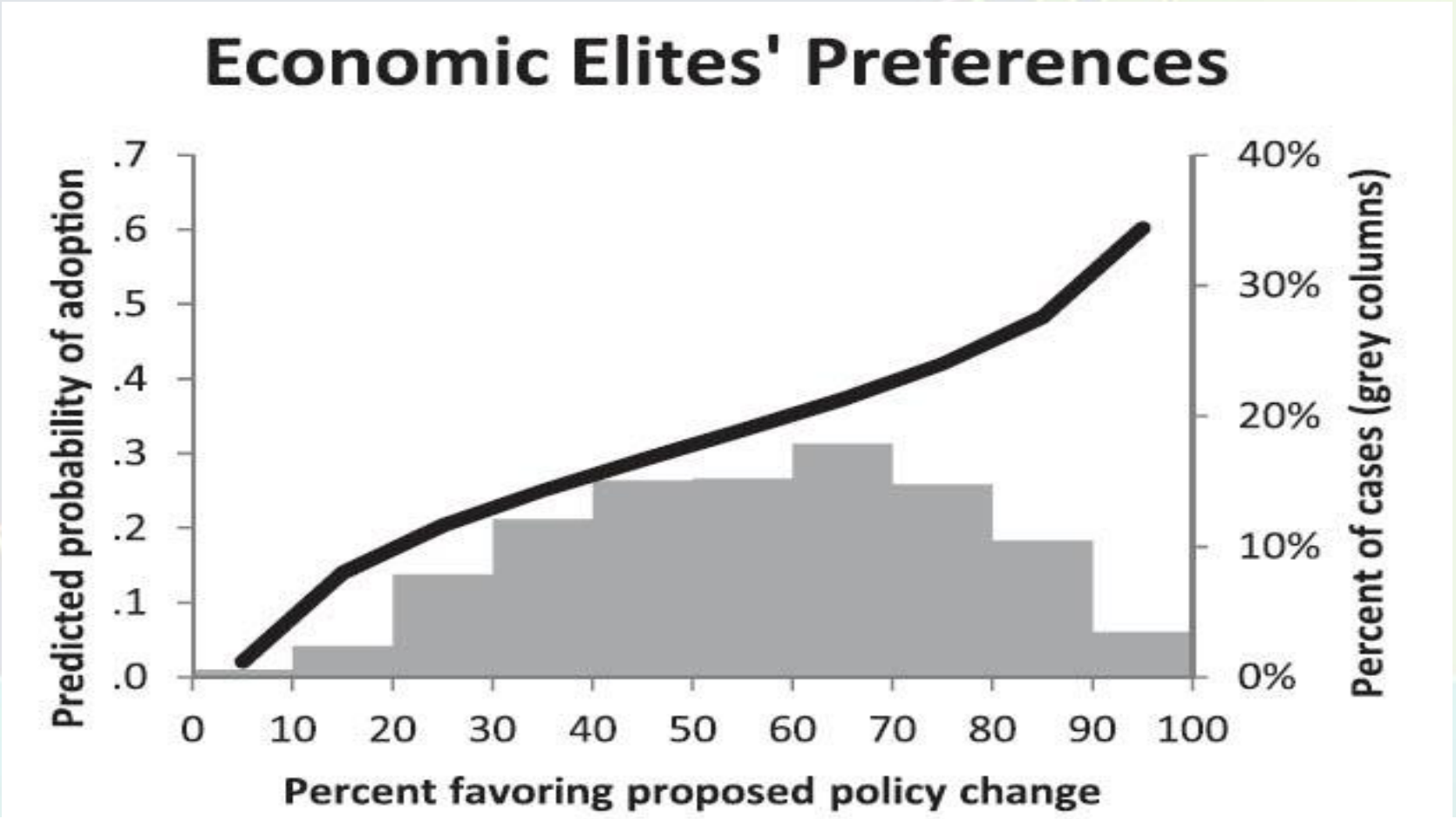
Wake Up!

You Don't Know Who You're Dealing With!

There's ZERO correlation between what legislation is desired by average citizens, and what actually gets enacted (Gilens and Page 2014). 20 years & 1800 legislative bills during both Democratic and Republican Administrations & Congresses



…And near-perfect correlation between what legislation the Economic Elites want and what gets adopted. This is a deep systemic dysfunction.



To Clarify the Gilens & Page (2014) Findings…

- Their goal was to measure the **independent influence** of these groups on the probabilities of legislation being enacted, so they calibrated out the cross-correlations when the different groups both wanted a given legislation.
- Criticisms **here**, were debunked by the authors **here**.

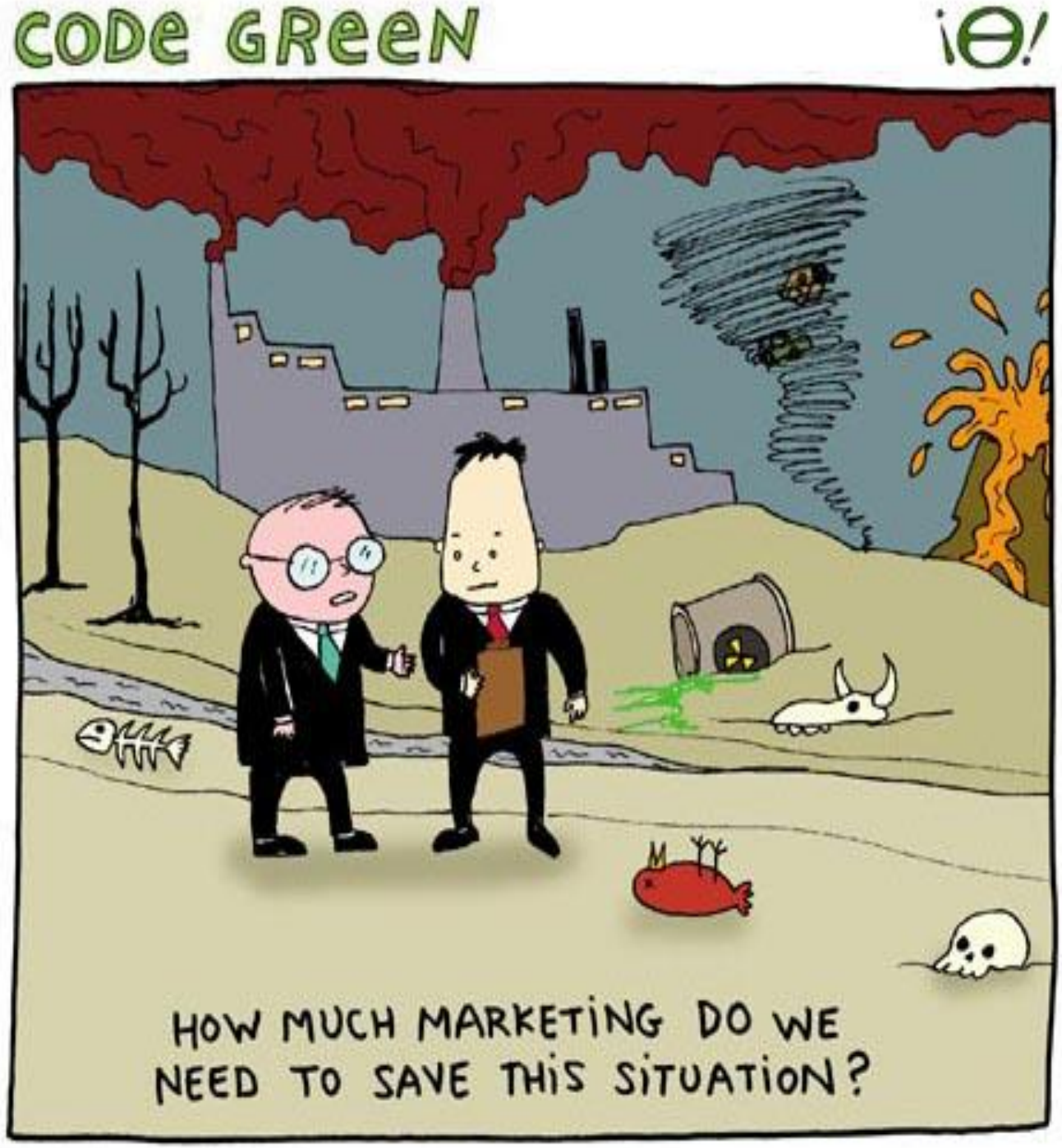
So. The CEO's and Economic Elites Run Our Country

So Can We Trust Them?

- I leave that as a brief thought experiment for a few seconds…
- Now, the answer…

21% of Corporate CEO's Fit the Diagnosis as Psychopaths

- Brooks *et al.* 2016, scheduled to be published in ***The European Journal of Psychology***) finds fully 21% of Corporate CEO's fit the diagnostic criteria as **psychopaths.**
- **This is the same fraction as found in prisons.**
- **By the same criteria, in the general population, the rate is only 1% (one wonders, is that 1% the CEO's among us?)**



Beyond just getting you to buy "Green Crap", Greenwashing lulls the consumer into thinking that the planet is now on a good course, and so defuses the sense of urgency and emergency which the facts show is entirely appropriate

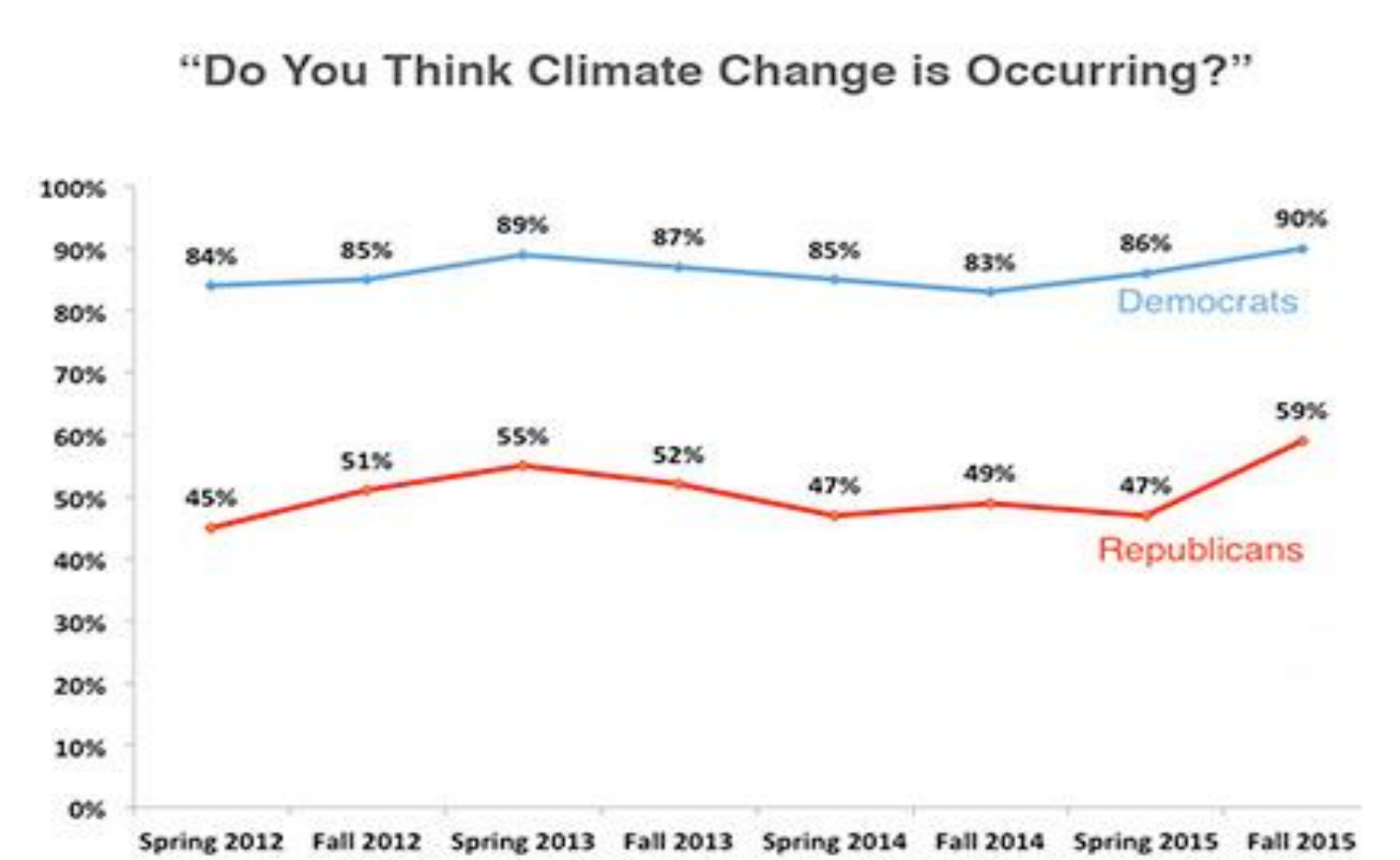
Since Reagan, there has been a massive transfer of wealth from the bottom 90% to the top 0.1%, along with the political power that wealth buys

Figure 2 **Distribution of Wealth in the US, 1917–2015**

Source: BofA Merrill Lynch, Emmanuel Saez & Gabriel Zucman

How Do We React to Dire Dangers? With deep and increasingly pervasive psychopathologies

So That, While Increasingly Admitting Climate Change is Happening (as of Fall ’15)…



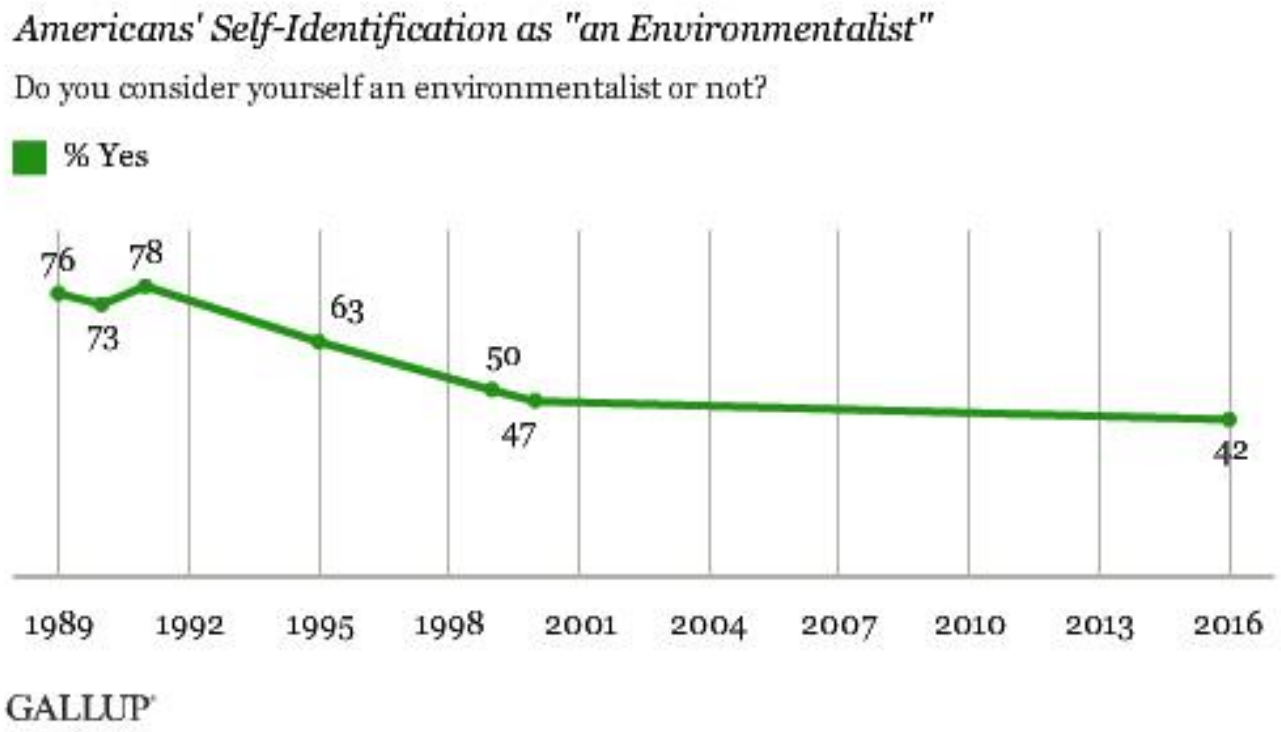
…We're Unwilling to Pay for Doing Anything About it

- **A 2019 poll** showed that 70% of Americans believe in the reality of climate change and find it "*personally concerning*".
- **56% believe climate change will harm their family.** That's a rising number, and good. But here's what's appalling:
- **Yet 70% of Americans also say they're unwilling to pay even just $10/month to do something about it. 40% won't pay even $1/month.**

Repeat: Even though most believe climate change will harm their family, 70% of people won't spend even the cost of a single burrito per month to do anything about it. Amazing.

"Follow. The Money" …The fraction of Americans Identifying as Environmentalists Continues to Drop

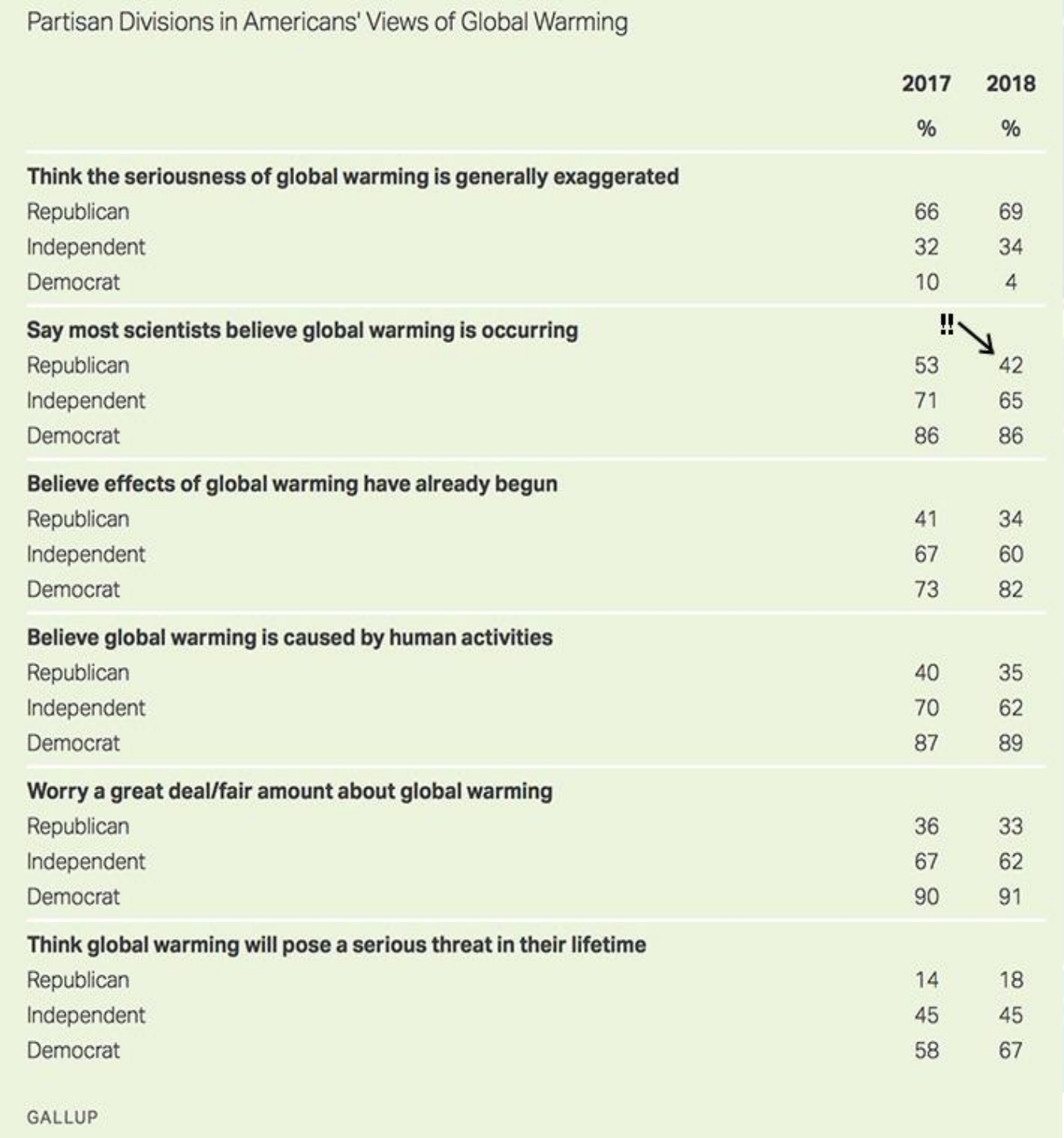
PRINCETON, N.J. -- As Americans observe Earth Day, Gallup finds 42% of Americans identifying themselves as environmentalists, down from an average of 76% in the late 1980s and early 1990s.



"We have only two modes - complacency and panic."

— James R. Schlesinger, the first U.S. Dept. of Energy secretary, in 1977, on the country's approach to energy

I'll add: **We've tried complacency. It has failed.**



Partisan Divisions in Americans' Views of Global Warming

	2017	2018
	%	%
Think the seriousness of global warming is generally exaggerated		
Republican	66	69
Independent	32	34
Democrat	10	4
Say most scientists believe global warming is occurring		
Republican	53	42
Independent	71	65
Democrat	86	86
Believe effects of global warming have already begun		
Republican	41	34
Independent	67	60
Democrat	73	82
Believe global warming is caused by human activities		
Republican	40	35
Independent	70	62
Democrat	87	89
Worry a great deal/fair amount about global warming		
Republican	36	33
Independent	67	62
Democrat	90	91
Think global warming will pose a serious threat in their lifetime		
Republican	14	18
Independent	45	45
Democrat	58	67

GALLUP

<u>Divorce from Reality Remains</u>.

Note that only 42% of Republicans will even acknowledge that most <u>scientists</u> are convinced global warming is occurring, showing strong disconnection from reality

Worse, in our Government

- ***"Last year PolitiFact*** *could find only* ***8 Republicans*** *in Congress, out of 278 in the caucus, who had made on-the-record comments accepting the reality of man-made global warming. And as of 2015, most of the contenders for the Republican presidential nomination are* ***solidly in the anti-science camp*****."**
- We will see the relevant brain studies correlated with political orientation in this Presentation…

"Until you make the unconscious conscious, it will direct your life, and you will call it 'fate'" – Carl Jung

- When one has habitually avoided the challenge and effort of thought on issues that bring up realizations that threaten one's ego …
- **…this fear of mental inadequacy is to be expected. <u>It is well earned</u>.**

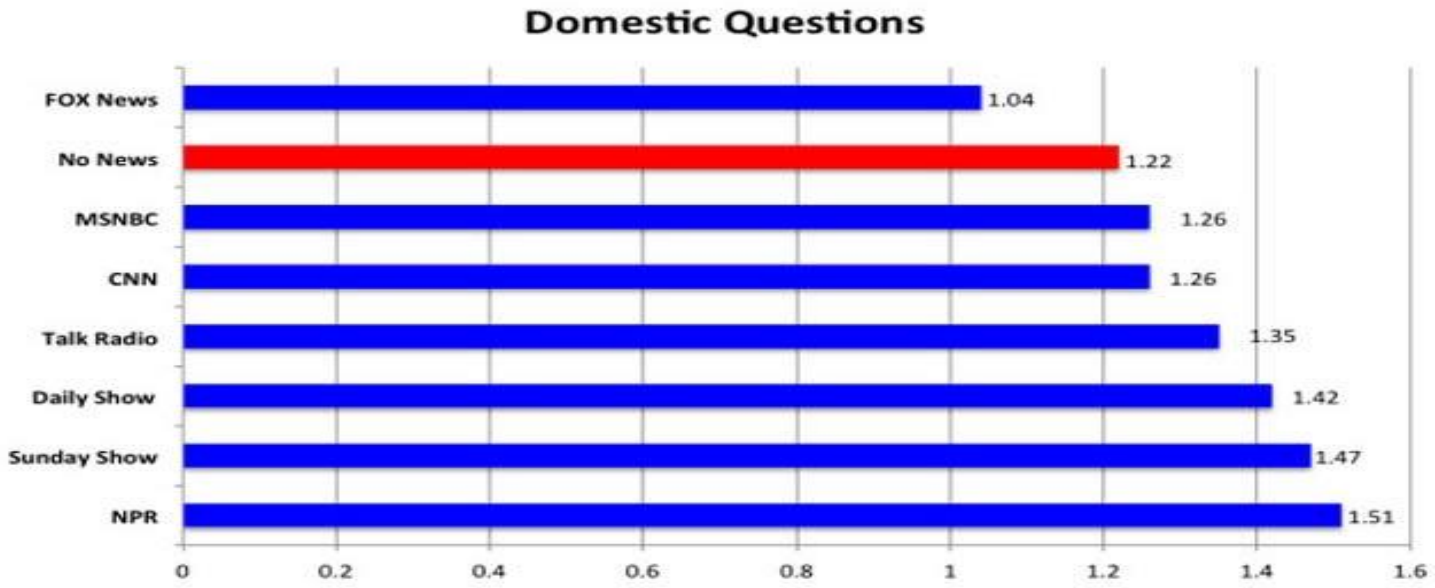
Studies show political conservatism is linked with low intelligence and low self-confidence in the ability to cope…

- Low IQ in childhood is **predictive of conservative attitudes, and racism** later as adults (Hodson and Busseri **2012**) and relevant quote ***"…for those who lack a cognitive ability to grasp complexities of our world, strict right wing ideologies may be more appealing."***
- Republican states have **lower high school graduation rates**
- College students are **increasingly liberal** but also increasingly despairing of political involvement (which is a reasonable reaction, given **Gilens and Page 2014**)

A Study from Dickinson University finds watching arch-conservative Fox News makes one even less informed than those who watch no news at all

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.

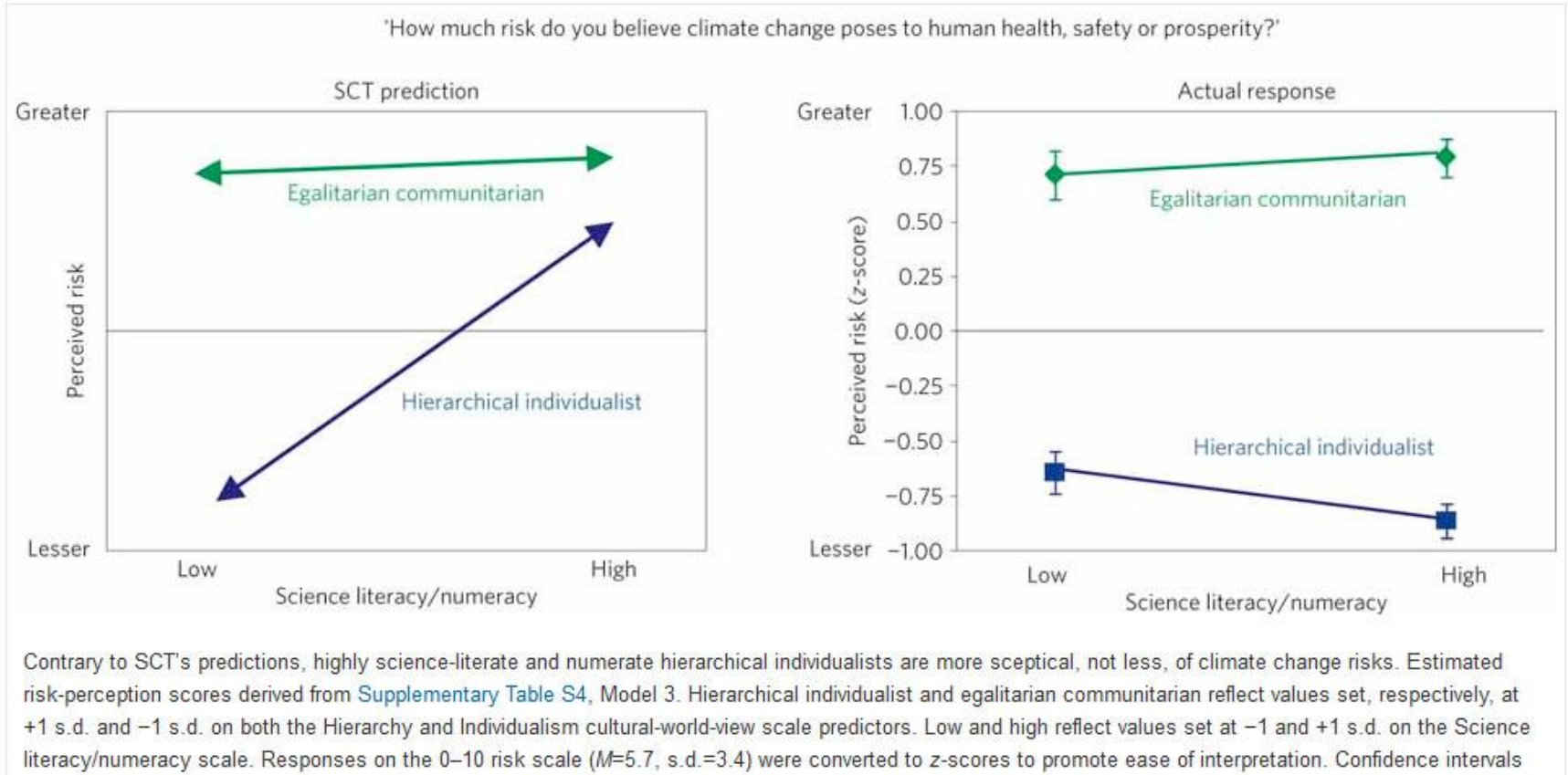


Five questions were asked, and those who watch Fox News exclusively got 1.04 correct, on average. Individuals watching MSNBC, on the other hand, got 1.26. NPR listeners? They got an impressive 1.51. The Daily Show? Surely a "fake news" program couldn't make you more informed than "the most watched cable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

Shall We Educate the Republicans So They Can Make More Sane Judgments?

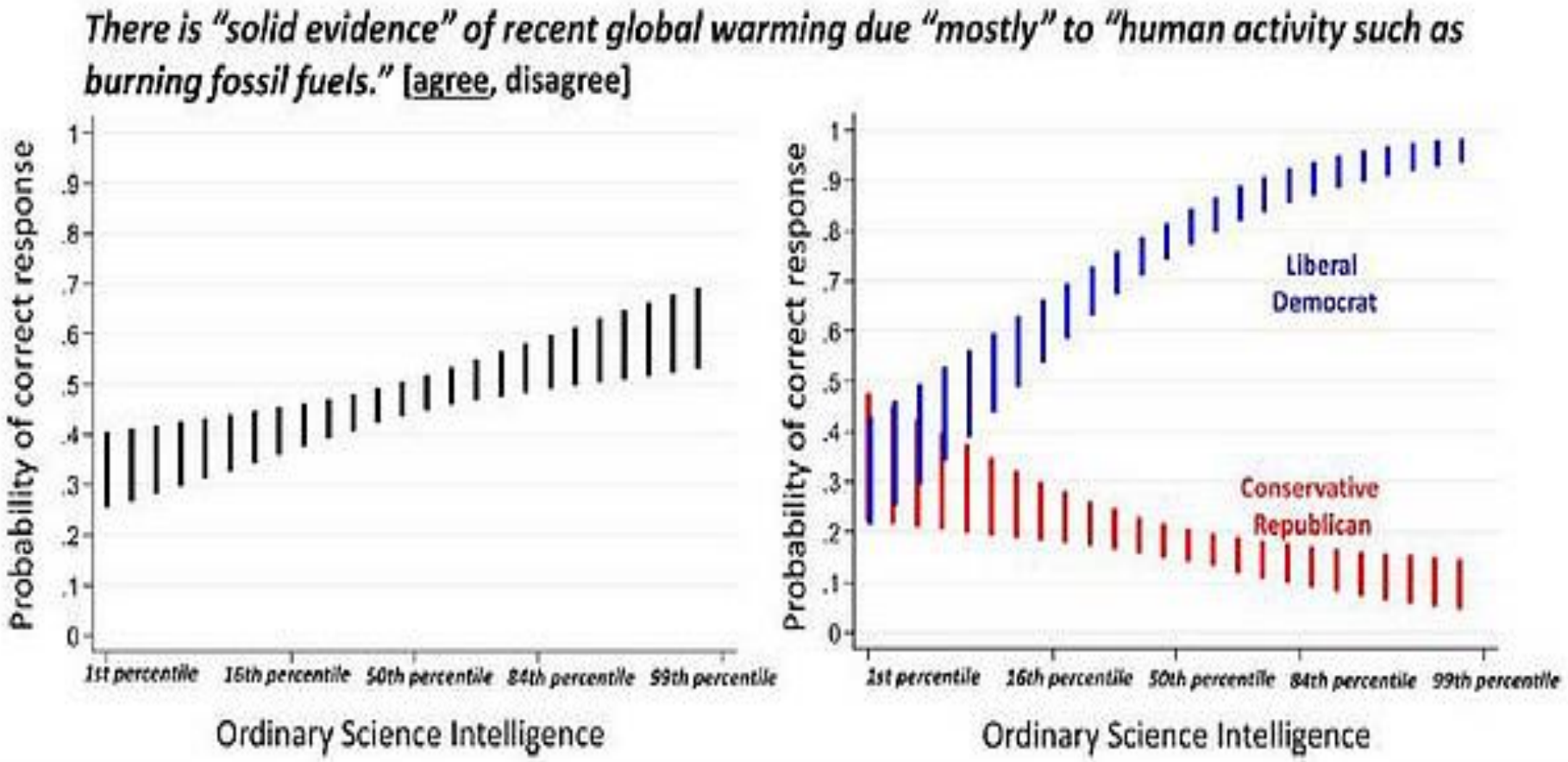
- It's worse than futile, it's actually COUNTER productive. The MORE they are exposed to valid science, the MORE they reject it.
- We'd be better off leaving them out of the equation. Go AROUND them, not THROUGH them, seems to be a necessary ingredient to any strategy with hope.

The higher the scientific and mathematical literacy of "egalitarian communitarians" (politically liberal), the higher their acceptance of the dangers revealed by climate science. It was opposite for "hierarchical individualists" (Conservatives) (source: Kahan *et al.* 2011). Studies like these are a stark revelation that attempting to reason with, and educate, climate denialists will not work. Their resistance is tenacious.



Contrary to SCT's predictions, highly science-literate and numerate hierarchical individualists are more sceptical, not less, of climate change risks. Estimated risk-perception scores derived from Supplementary Table S4, Model 3. Hierarchical individualist and egalitarian communitarian reflect values set, respectively, at +1 s.d. and −1 s.d. on both the Hierarchy and Individualism cultural-world-view scale predictors. Low and high reflect values set at −1 and +1 s.d. on the Science literacy/numeracy scale. Responses on the 0–10 risk scale (M=5.7, s.d.=3.4) were converted to z-scores to promote ease of interpretation. Confidence intervals reflect the 0.95 level of confidence.

Even more striking, from a newer paper by Kahan *et al.* 2015. (discussed here). For Liberals, the more scientifically intelligent they are, the more convinced they are of human-caused global warming. It's the opposite for Conservatives.

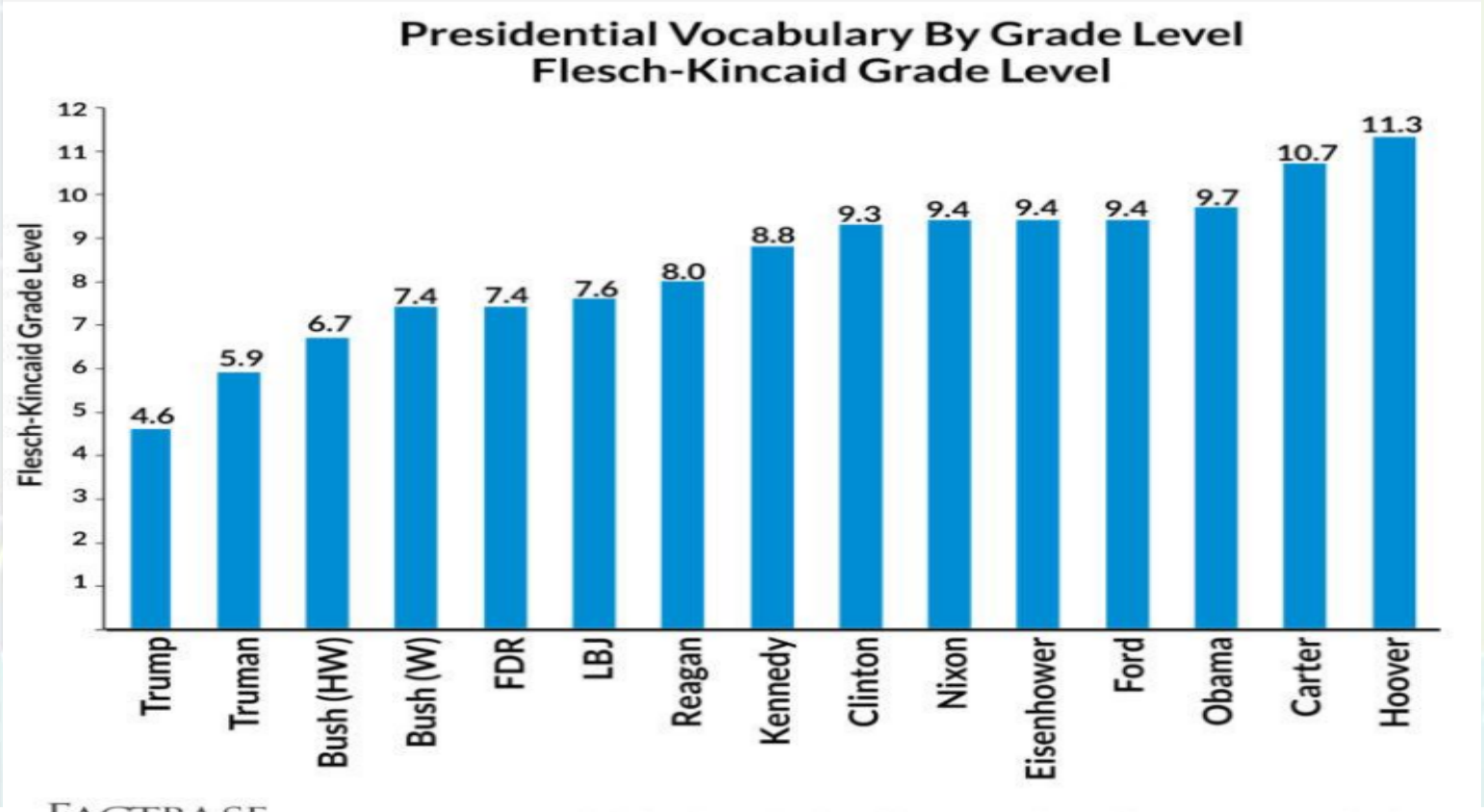


A Stunning Example of All the Foregoing, is Our President

- In the uncanny words of Conservative George F. Will…
- ***"…the problem isn't that he does not know this or that, or that he does not know that he does not know this or that. Rather, the dangerous thing is that he does not know what it is to know something"*** *(Washington Post 5/3/17).*
- A petition written by 800 professional psychologists and psychiatrists, signed by 60,000 as of Sept '16, asks that, under the 25th Amendment to the Constitution, **President Trump be removed, as mentally unfit to hold office**.

Trump reminded people that he was elected to the presidency "*on my first try. I think that would qualify as not smart, but genius....and a very stable genius at that!*" He also tweeted that *"throughout my life, my two greatest assets have been mental stability and being, like, really smart."* (*source*)

It's clear the Dunning-Kruger Effect is in play here



This connection between chronic fear and political Conservatism is backed up by brain studies

- Kanai *et al.* 2011, in their paper ***"Political Orientations are Correlated with Brain Structure in Young Adults"***, find that conservatives show larger brain mass in the **right amygdala -** which is primarily involved in the emotion of **fear.**
- Conversely, the **anterior cingulate cortex (ACC)** of liberal students had more gray matter than their conservative counterparts. The ACC is most active in coping with **complexity**, and especially in **error-detection**
- **For much more, see my Presentation "The Psychopathologies of Climate Denial"**

A Failure of the Normal Maturity Path

- **As an infant**, we see Mother as the source of all satisfactions. If we are unhappy, we cry and she'll make it better somehow
- **As a child**, we begin learning our own capabilities and that there's a larger world
- **As a teenager**, we begin to think conceptually, engage the neocortex, project a future using principled thought, and find fascination in understanding the power of ideas.

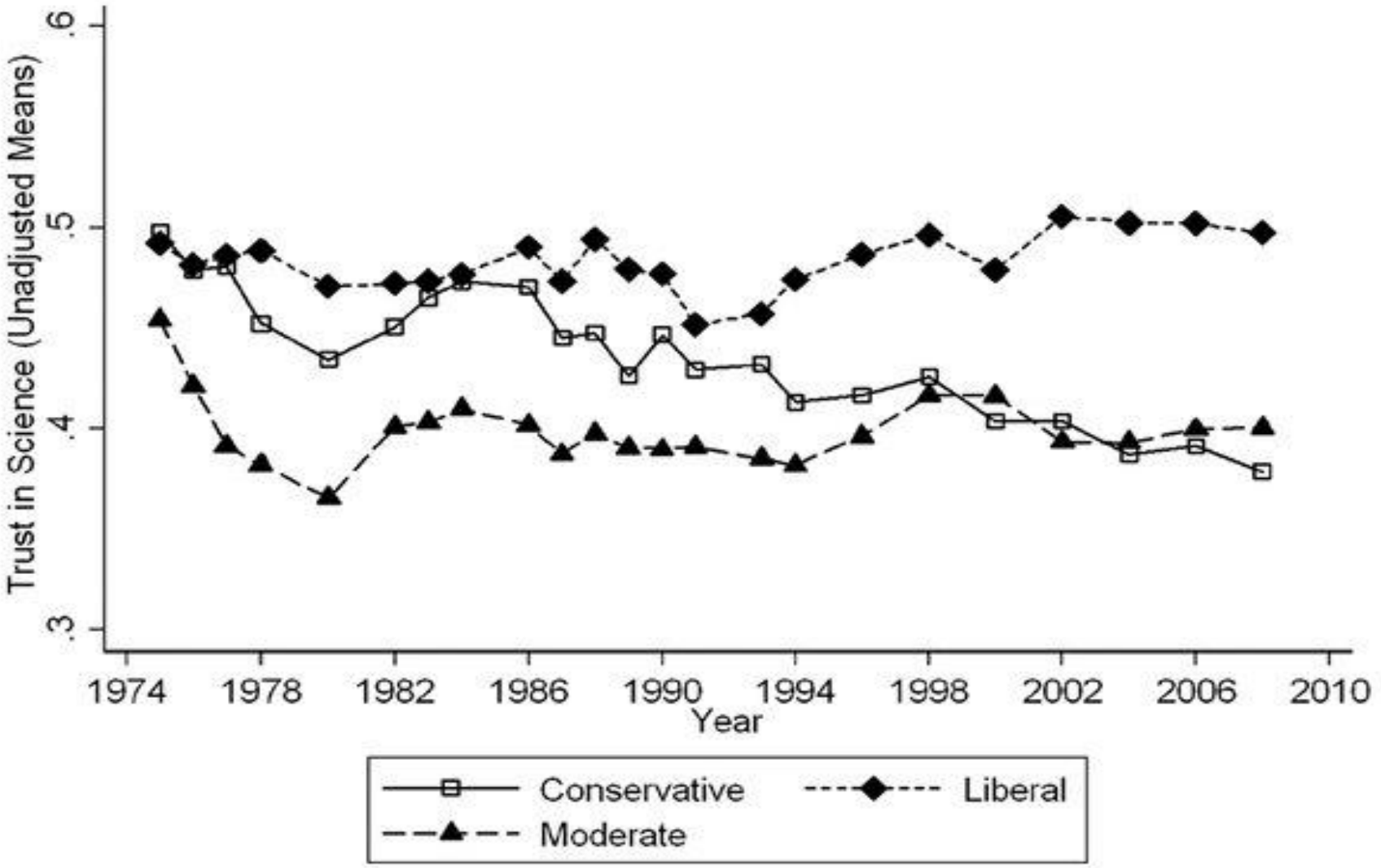
We begin to learn that the World does not owe us a living

- … and that Nature has laws which are unchanging across all space and all time, regardless of temper tantrums.
- **As an adult**, we learn that our task as humans is to master the understanding of those laws, and the laws of human psychology and biology as well, as part of the fundamental requirements for finding a path to a happy life, and that a moral compass is essential for genuine self-esteem, and that integrity is the most precious thing we have, in order to preserve that sense of self-worth.
- Alas, some of us fail by default, <u>even fail by choice</u>; somewhere along this multi-stage enterprise

Some people simply refuse to grow up

They refuse to accept that their wishes are not all-powerful, that life requires effortful thought, and that success is not guaranteed simply by wishing it so. Perhaps over-indulgent parents dis-incentivize the normal maturity path, or perhaps it is simply their choice.

Unlike Liberals or Moderates, Conservatives' trust in science (open squares) shows a steady decline for the past 35 years (Gauchat 2012), discussed here



What is Manifestly Clear…

- …is that our political / economic paradigm empowers the **worst**, the **most corrupt**, the **most ruthlessly amoral** among us into positions of control over others - **in Corporations, and in Politics**
- Diagnosis and cure of this systemic disease must happen before there is any hope to save ourselves. Climate change is only a symptom of this deeper pathology.

Politics

- …from the root “Poly”
- meaning “many”, and…

“Tics” – Meaning “small blood sucking bugs”

When genuine self esteem is missing, one can feel compelled to attach to a group or ideology which promises "rightness" with only minimal effort

- Minimal… often nothing more than blind faith.
- But going this route amplifies the negative spiral, as reasoned thought further retreats, and fear becomes even more pervasive as one thereby **develops a now well-earned self judgment of intellectual inadequacy**.
- **Neuroplasticity** shows that one's choices will change brain structures in order to re-enforce them. It is an amplifying feedback.
- **This strongly suggests that it is a downward spiral of choices that explains the larger amygdala (fear) and smaller ACC (critical thinking) in Conservatives.**

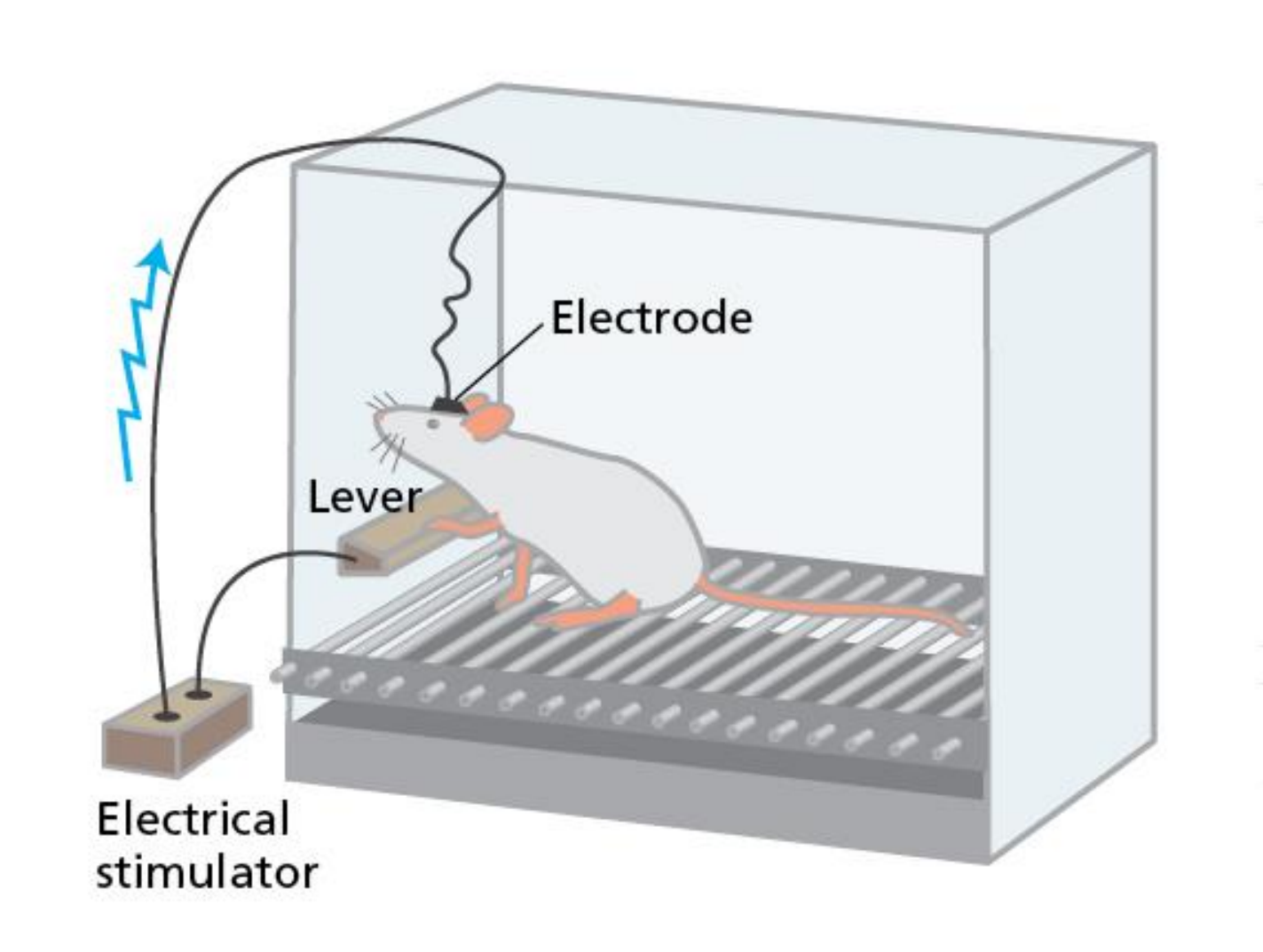
"It is difficult to get a man to understand something, when his salary depends upon his not understanding it."

—**Upton Sinclair**

All of the major oil companies knew

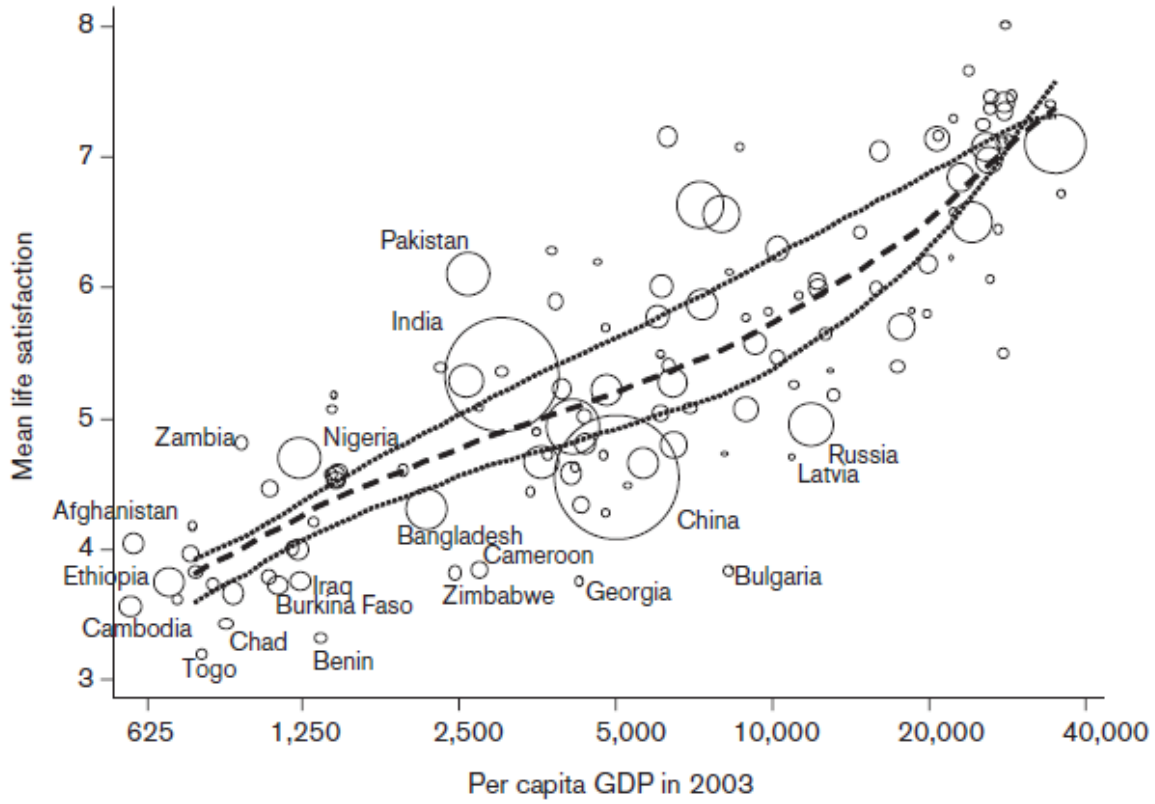
- **Shell Oil** knew. More on **Shell's internal scientists reporting**, and suppression by management, of dire implications of their business.
- Their own climate scientists did high quality work in the 1960's and '70's demonstrating this, just as scientists in academia have been warning about for many decades. And now the Pulitzer Prize winning organization **Inside Climate News** has uncovered the documents showing that not just Exxon, but **all** of the major oil companies knew explicitly how "**catastrophic"(their own words)** their business model would be to future generations.
- **They knew**, and yet reacted by de-funding their climate scientists then spending $500 million funding climate denialist dis-information campaigns as a strategy to manufacture a false "debate" and paralyze policy action until it was too late (**Brulle, 2013**)

Rats will hit the bar stimulating the pleasure center hundreds of times per hour, until exhaustion. What about us?



The Rat Race. Your Income Must go Up Exponentially (x-axis log scale) merely to get the same "Life Satisfaction" (y-axis linear) increment of reward

Each Doubling of GDP Is Associated With a Constant Increase in Life Satisfaction



Source: Penn World Table 6.2.

Note: Each circle is a country, with diameter proportional to population. The scale on the x-axis is logarithmic. The middle line shows average life satisfaction for each level of per capita GDP while the outer two lines show the same thing, but for two age groups, ages 15 to 25 — the upper line for most of the figure — and ages 60 and over — which is usually the lower line. GDP per capita in 2003 is measured in purchasing power parity chained dollars at 2000 prices.

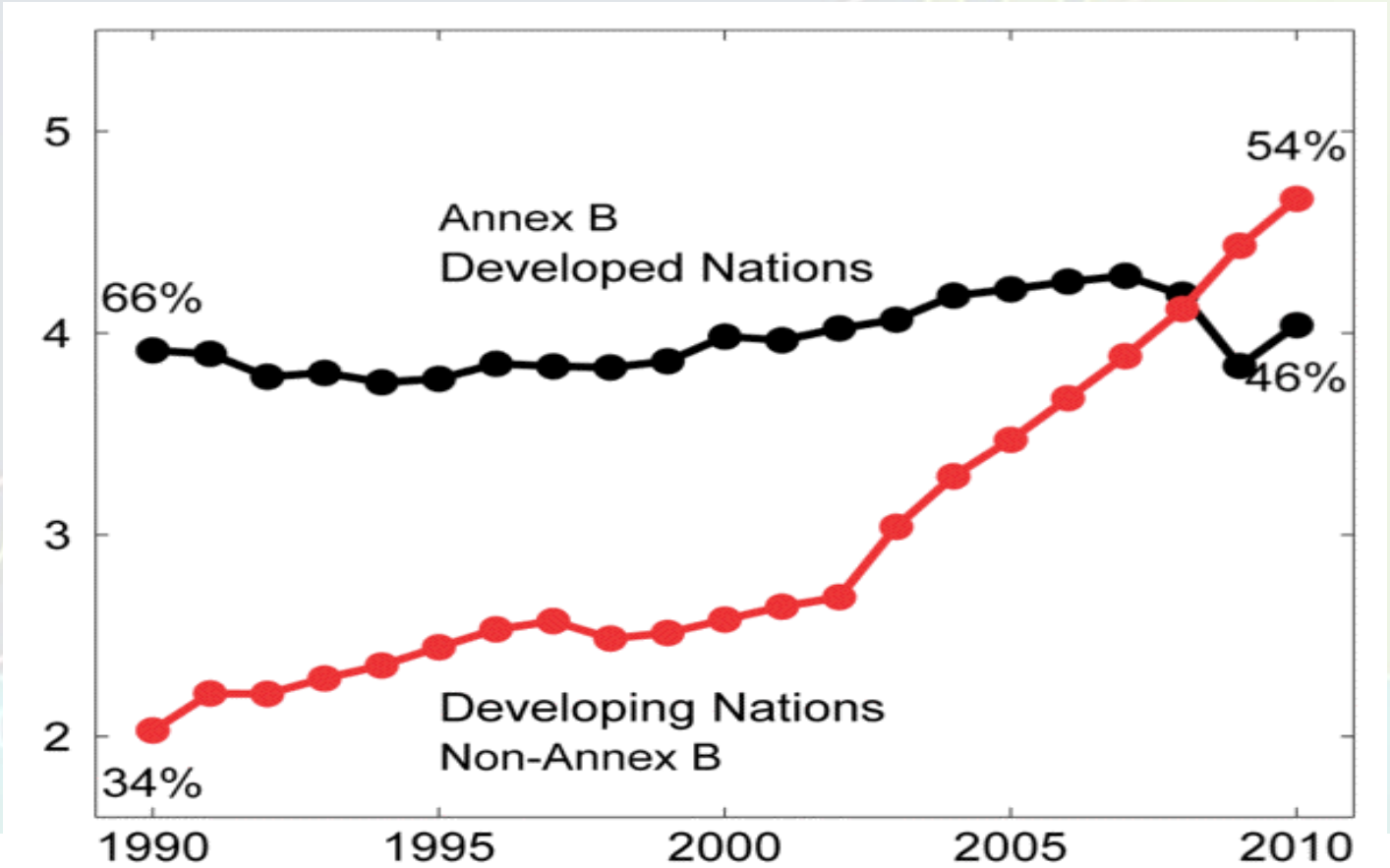
Even environmental NGO's are getting in on the 'take', and trading in their environmental mission goals… for cold hard cash.

Green NGOs cannot take big business cash and save planet

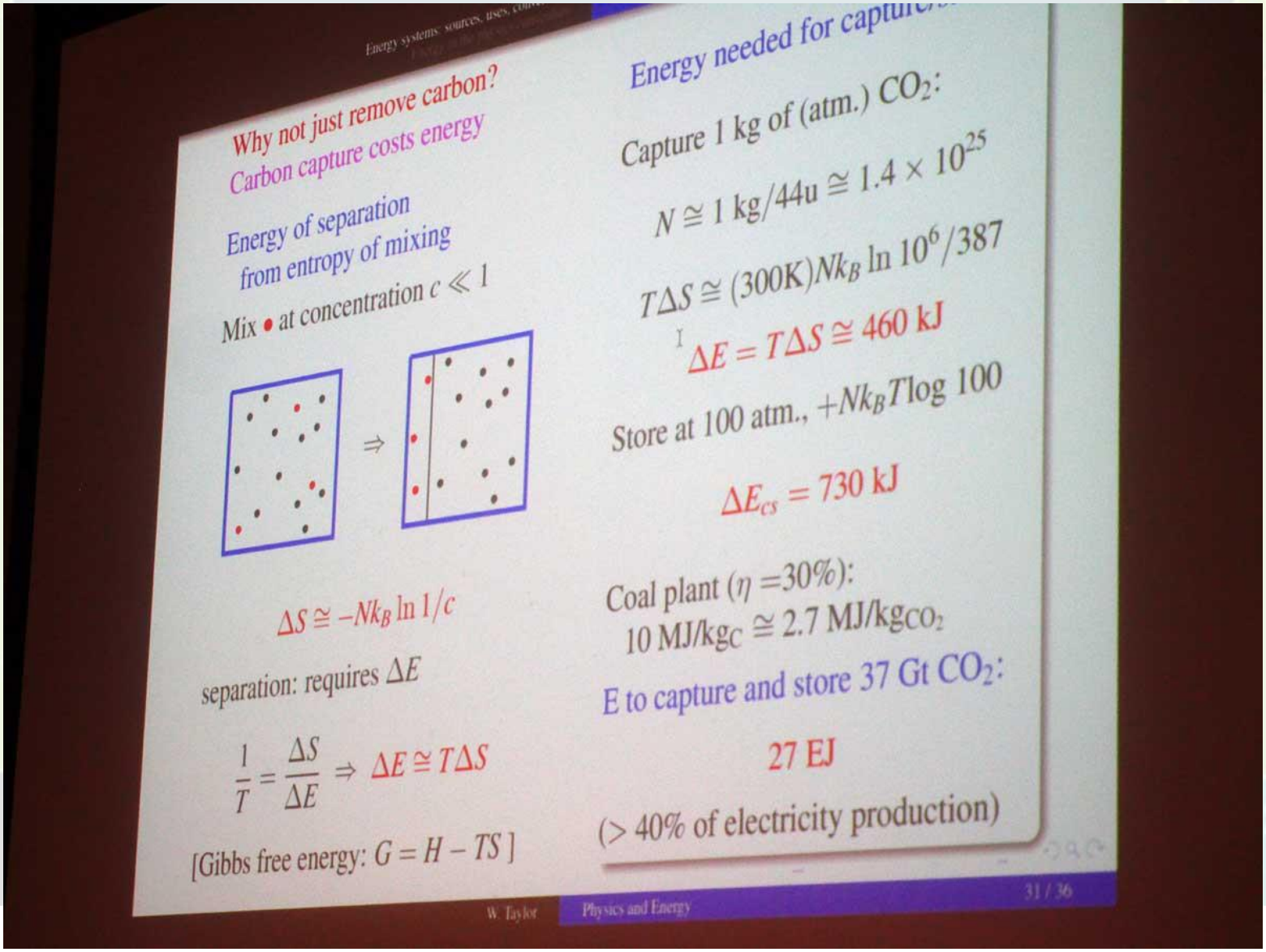
September 30, 2013 9.44am EDT

Hands up for the environment. Cathal McNaughton/PA

More and more; it's the developing world that needs minds transformed too. They're the Ones MOST Desperate for THEIR Days of Wealth



From "The Physics of Energy" by MIT's Jaffe and Taylor



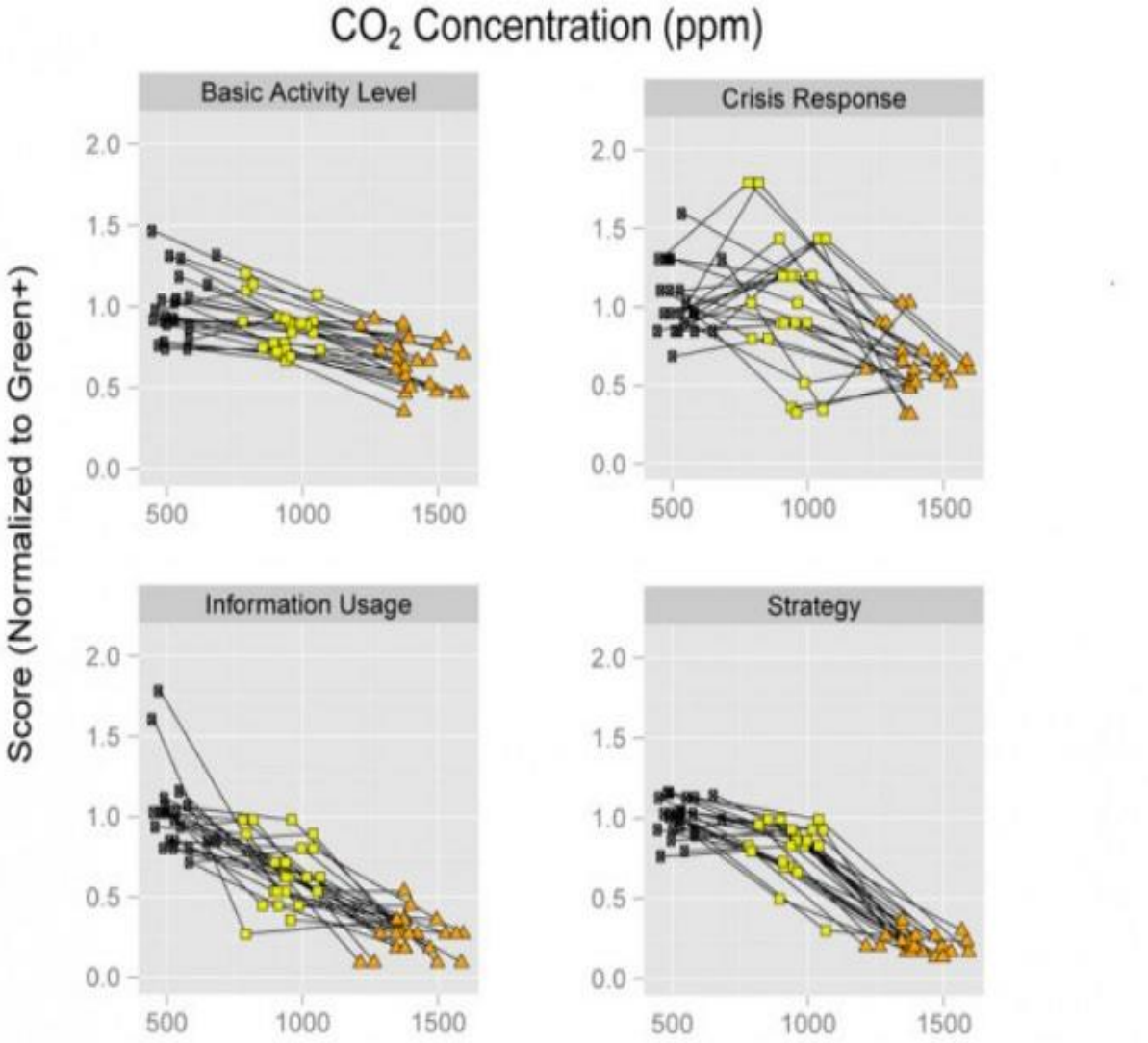
The Bare Minimum Energy Cost Alone of Pulling out Atmospheric CO2 at the Same Rate We're Emitting it…

- **27 EJ/yr** to separate and sequester 37 Gt CO2/year = 7.5e12 kwh per year or 856 million kw or 0.856 Tw or about 40% of current global electricity production.
- At 10c per kwh that's $750 billion per year.
- $750B/ 37B tons CO2 = **$20/ton bare min for the energy.**
- Now add in infrastructure costs and maintenance, labor, insurance, cost of capital, etc. and the total goes up much higher.
- Still – with will power, it's not impossible.

Will We Solve Climate Change?

- I think the odds are only about 5%, maybe 10% if I throw in the “unknown unknowns” and hope they’re happy ones.
- Rather than rise to the challenge, we’re turning to **psychopaths** who stroke our delusional egos as they **lie**, **cheat**, and scapegoat their way to brutally consolidate power.
- Not just here, but in Brazil, and growing in Europe, in Russia, in desperate countries of the mid-East, as walls go up and trust disappears.
- Meanwhile, we cascade through climate tipping points so that the cost of solving rises even farther beyond what we’re willing to pay.

We May Be the ONLY Planet with Intelligent Life in the Entire Galaxy (Fermi's Paradox). Let's Not Go Out Like This.



Normalized cognitive function scores by participant and corresponding CO2 levels in their cubicle. The Green+ case had CO2 in the 500 ppm range due to high levels of outside air. It was compared to office settings in the 930 ppm range (yellow squares) and in the 1400 ppm range (orange triangles).

Just When We Need to Focus Most Clearly… Rising CO2 Will Cause Mental handicaps for all - not just Conservatives. Yet thinking straight is already too big a burden for too many

I'm Quite Sure…

- Expecting globally ~all people to suddenly become Enlightened and transformed, is futile.
- But a minority who actually do function rationally and have (some) answers, and morality, might yet seize the vacuum and turn political power, or at least I hope so.
- Tim Garrett thinks I'm too optimistic (he's the only one who's accused me of that!)
- **What do I Recommend?**

No Time to Detail Techno-Ideas Here

- See my Presentation "**Strategies: Technology**", and "**Strategies: GeoEngineering**" for more.
- Also, I find techno-fixes far too seductive for people. They just get complacent and hopeful that someone else will let them **Have Cake/Eat Too**.
- **No. On a finite world, GROWTH WILL END. Far better it be sooner than later.**

The "Circular Economy" – That'll Save us. Right?

- Sounds wonderful – recycle everything!
- But the **2nd Law of Thermodynamics** has something to say about that, and it only "kicks the can" down the road a while further.
- …Making the ultimate cost to the future harsher.
- *"In order to reconcile the circular economy with the **Second Law** we have to apply not only changes to the way we use materials, but how we consume them. Moreover, that implies **such a large reduction in resource use**[29] by the most affluent, developed consumers, that in no way does the image of the circular economy, portrayed by its proponents, **match up to the reality**[30] of making it work for the majority of the world's population."*

Beam me up? *"As is so often the case with feel-good eco-stories, the 'Today' programme's[1] interviewer was all light and fluffy; and obviously flummoxed because they did not have the confidence to ask any basic, challenging questions of the interviewee"*

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

- **<u>All EFFECTIVE strategies must either</u>**

* **A.** Reflect additional sunlight back to space, or

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

All SAFE strategies should…

- **1. …Have no hysteresis.** In other words - take 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.

No Hysteresis Means…

- **…Should NOT** involve global changes to weather, eco-systems, Earth systems in general… 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 do NOT run off in new directions, seduced by profit-hunters focused on near-term high profit schemes that may well ruin the Earth

To Be SAFE: They must Take the Earth Systems back along the ~same Trajectory that GOT us here

- **Dangerous failures** of this criterion: iron seeding of the surface oceans, sulfate aerosols into the stratosphere, many others.
- **Safer ideas:**
- --re-icing the Arctic ocean using wind-powered pumps in winter.
- -- Pull CO2 from the atmosphere, pump it underground for permanent sequestration. In salt domes? In sedimentary oil-bearing clay-capped formations? Combine 50:1 as carbonated water and pump into basalt formations?

Safety Criterion #2

- Leave the SURFACE of the Earth as untouched and compatible with existing Eco-systems as possible. So…
- Pump excess CO2 underground for storage? – **YES.**
- Paint everything white? **NO!**
- Re-Ice the Arctic? **YES!**
- BECCS: Plant U.S.-sized land areas (where??) with weeds to repeatedly harvest and burn to capture/sequester the carbon, denuding the soil nutrients? **NO!**

THE Worst Idea I've Heard… OTEC Pipes to Cool Earth

- OTEC ("ocean thermal energy conversion") Pipes to pump cold ocean water from 1km down, beneath the thermocline, to the surface to cool the atmosphere.
- This radically violates the "safe" criteria for ecosystems, ocean currents, weather patterns... For just about **everything**.
- Worse, it traps ocean heat which MUST be allowed to escape or it will build up and overheat the future. Several studies out of Stanford University and elsewhere demonstrate this, at all scales big and small.
- OTEC also out-gases CO2 for most ocean locations, especially the most thermally useful ones, in the tropics.
- If you hear anyone trying to seduce your money to pay him and others to study such a scheme, get educated! (**GeoEngineering pdf)** and **counsel others to hold on to their wallets!**

Can We Trust *Laissez Faire* Capitalism to Solve Our Climate Situation?

- The mantra from market economists is ETERNAL ECONOMIC GROWTH.
- **On a finite planet, this is suicide.**
- To the Asteroids, To Mars… ! To Infinity!
- **No**, we'll soon likely be too crippled to have the money for such foolishness. Better prove they can steward OUR planet before invading others.
- **To Hammer Home the point…. Continue!**

My Best Analogy for *Laissez Faire* Capitalism, is -"The Terminator"

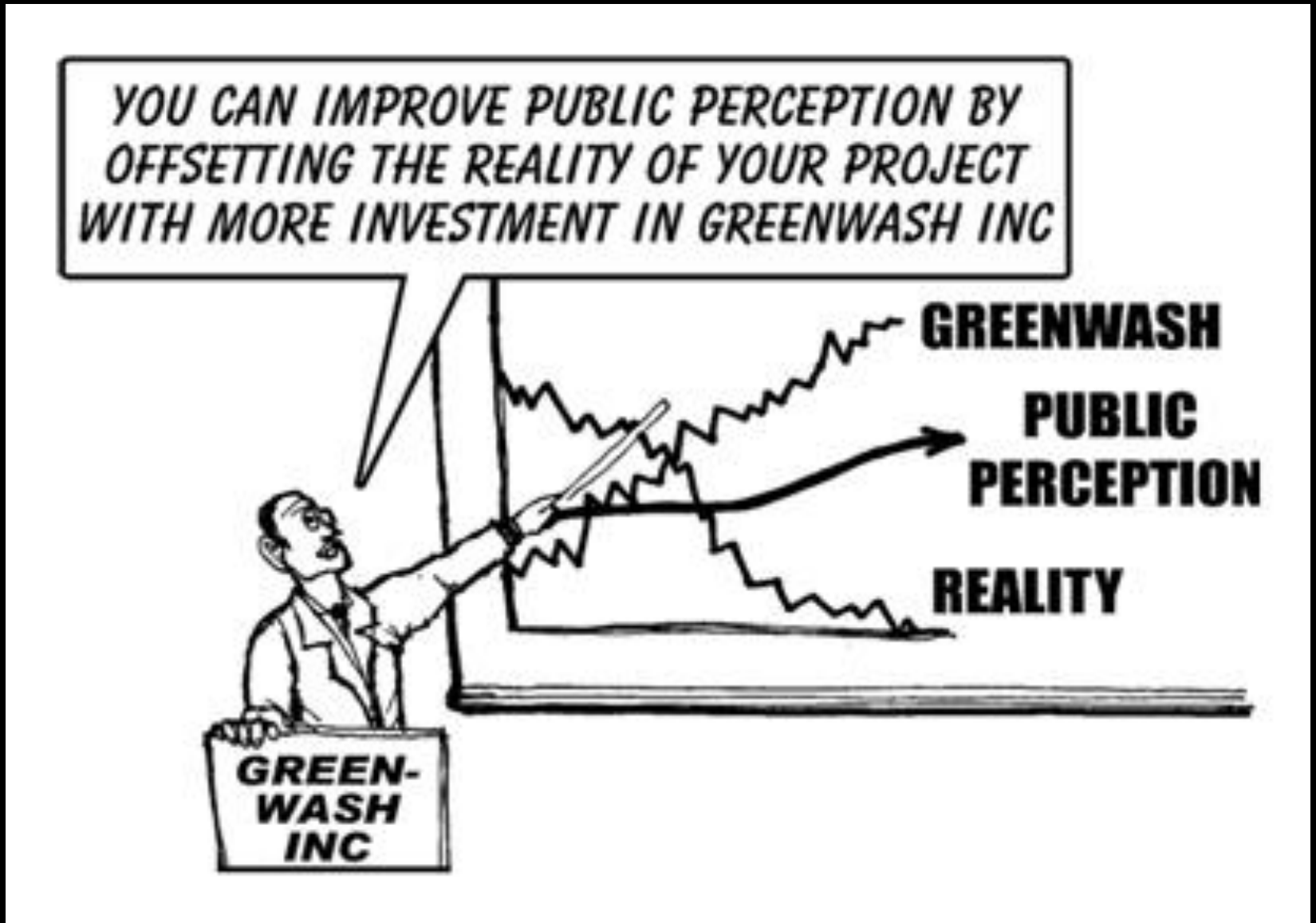
“Listen, and Understand…”

- ***“…that Terminator is <u>out</u> there! It can’t be bargained with! It can’t be reasoned with! It doesn’t feel pity! Or remorse! Or fear! And it absolutely WILL not STOP. <u>EVER</u>! Until you are <u>DEAD</u>!” (video)***

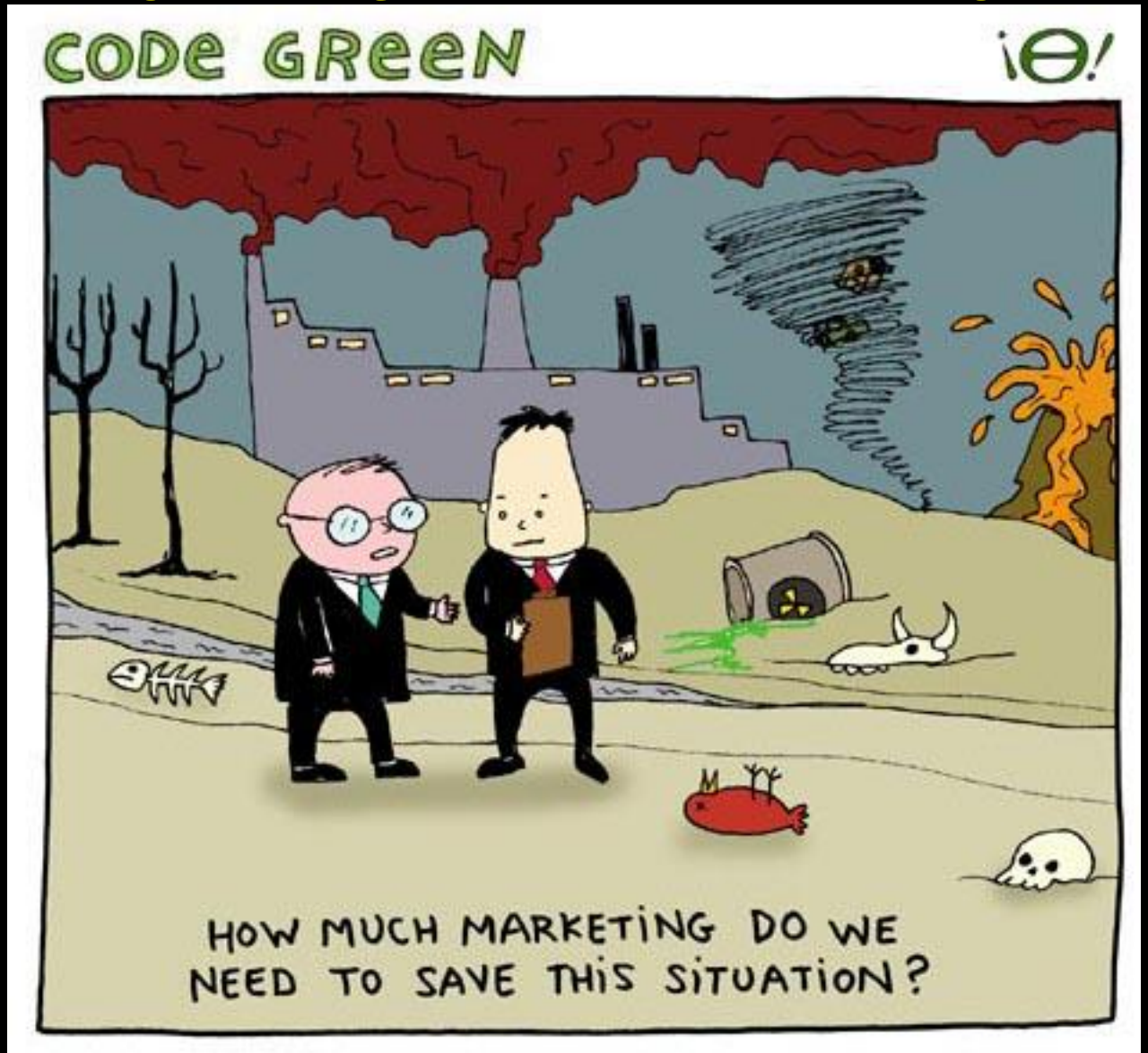
To Paraphrase for Capitalism…

- It doesn't **CARE** for your well-being
- It doesn't **CARE** what is good for Earth's future!
- It doesn't **CARE** about future generations of humans or other species!
- It doesn't **CARE** what laws you want! (see Gilens and Page 2014)
- It **doesn't feel pity** for the poor it may impoverish!

It doesn't feel remorse for its lies,



It doesn't feel remorse for its phony salesmanship



It doesn't feel remorse for its outrageous violations of science

Independent Science Shows Harmful Effects from BPA, while Industry Science Shows None

A recently-published review of scientific studies shows that, in the last 7 years (through November 2005), 151 studies on the low-dose effects of BPA have been published.(37) None of the 12 studies funded by the chemical industry reported adverse effects at low levels, whereas 128 of 139 government-funded studies found adverse effects. These many studies were conducted in academic laboratories in the U.S. and abroad. Even the 12 industry-funded studies have flaws, however. Of the industry studies, two had their positive controls fail—an indication that the entire experiment had failed, not that BPA had not caused an adverse health effect.

	Adverse health effect	*No effect*
Plastics Industry funded	*0*	*12*
Government funded	*128*	*11*

Another industry study concluded BPA caused no adverse effect, but an independent analysis of the experiment's data by scientists convened by the National Toxicology Program of the U.S. Department of Health & Human Services concluded that in fact there was an adverse effect. Industry scientists had misreported their own results. The chemical industry relies on an incomplete review of scientific studies by an effort funded by the American Plastics Council at the Harvard Center for Risk Analysis. The panel funded by the American Plastics Council only considered 19 studies in concluding in 2004 that the weight of the evidence for low-dose effects of BPA was weak.(38) As of November 2005, there were 151 published studies on the low-dose effects of BPA.

It doesn’t feel pain for what it does to the Earth

It will fund dis-information campaigns

It will Slash the Budgets to, and Duct-Tape the Mouths of, its Own Scientists…

EXXONKNEW

1979
Major fossil fuel companies met regularly as part of a task force to discuss the science and implications of climate change.

1982
Roger Cohen, director of the Theoretical and Mathematical Sciences Laboratory at Exxon wrote a memo stating "Temperature increase of this magnitude would bring about significant

1983
Exxon cut funding for climate research from $900,000 per year to $150,000. Exxon pivoted from the cutting edge of early climate change science to the forefront of climate denial.

1996
Mobil engineers noted that "An estimated rise in water level, due to global warming, of 0.5 meters may be assumed" in their planning for exploration and production facilities

It will buy Politicians…

It Will Poison Us with Addictive Foods

Ultra-processed foods linked to increased risk of death and disease

Katherine Martinko feistyredhair

May 31, 2019

Whether it produces valuable products good for the long term health of people and the Earth…

Or irreparable scars generating poisons that pollute the entire Earth... It does not matter. <u>There is ONLY ONE PRIORITY</u>

Its Singular Priority is: to ACCRUE MONEY to the Corporations and the Major Shareholders

"It's What it DOES!

It's ALL, it DOES!"

– Reese, from "The Terminator"

Reminder, so I don't get BLASTED…

- *Laissez Faire* Capitalism **isn't** Immoral, **it's Amoral,**
- **In other words, in free and unfettered capitalism, morality just doesn't enter the equation.**
- **It enters only if Governments enact moral laws forbidding bad behavior.**
- Still, there ARE a few business billionaires trying to both make money, and do good for people and the Earth.
- Tom Steyer, Elon Musk come to mind. There are others, of course.

And Still - Accruing money is PRIORITY OVERRIDE #1. Anything gets in the way … then something gets TERMINATED!

Sustainability Needs a <u>New</u> <u>Rebel Alliance</u>

(led by **Our Students. Oldsters** got them INTO this mess and resist reconsidering strategies)

I Offer This: Occupy DC with 100,000 to 1 million Strong, and Not Leave Until They…

- **Pass a 28th Amendment to the Constitution, guaranteeing unspoiled commons to future generations (oceans, air, great forests…)**
- **Pass a Carbon Tax and Dividend, at ~$300/ton CO2 level just for starters**
- **End subsidies to Fossil Fuel interests (5% of global GDP!)**
- **Institute 1-child-per-family.**
- **Support lawsuits against government for discriminatory failure to protect the young, and the most vulnerable among us**
- **End "Citizens United"**
- **Fund research and deployment of CO2 air capture and other climate interventions which safely trace us backwards along the system trajectory we followed to get here.**
- See my ***.pdf* on "Policy"** for much more…

Why Would "Occupy DC" Work?

- A small weekend march is soon forgotten.
- A determined march by a few gets more attention, but soon they're arrested, dispersed, or otherwise "disappeared"
- **But a half million cannot be arrested** – there's not enough jail cells.
- DC "Business as Usual" cannot continue to function, yet the citizens are only exercising their 1st Amendment right to peaceably assemble and present redress to their government – entirely constitutional.
- So any police violence committed against marchers would likely galvanize action from the best among the millions of Americans watching it on the news.
- **Corporate news downplays and ignores many small climate skirmishes, but they could not ignore the media ratings THIS occupation would promise!**

Most important: While your congressmen may be corrupt at this point…

- …somewhere there may yet be an honorable bone left in their bodies, or at least a real desire to be a better person, buried somewhere in their unconscious.
- But they will not poke their individual heads out of the foxhole of corporate sponsorship only to get shot at by their corporate paymasters.
- However if ALL legislators are confronted with **"Occupy DC"**, they now have the perfect excuse to disobey, support the legislation, and begin the long road back to some sort of self respecting behavior.

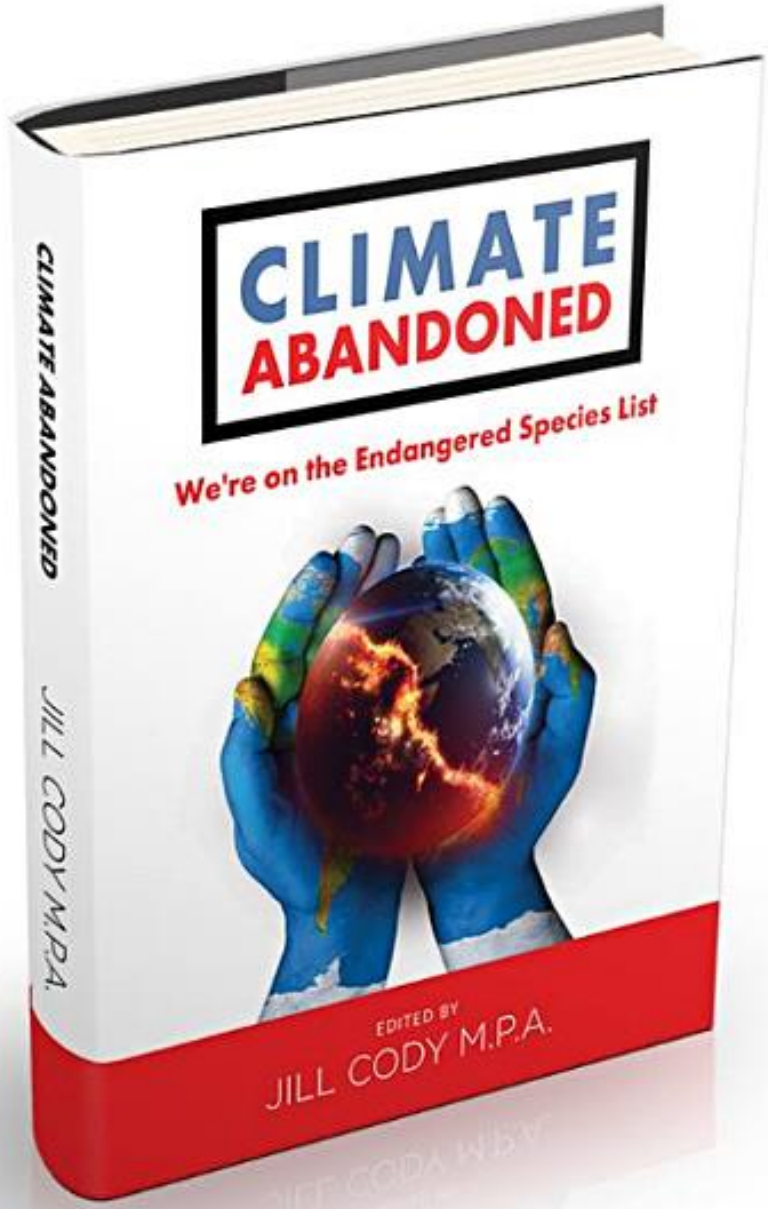
The 3.5% Rule

- Harvard political scientist Erica Chenoweth (**discussed here**) found that once 3.5% of a society participates in active (and non-violent) protests, the ruling regime crumbles.
- 1 million in **Occupy DC** would be only 1/10 of this, but the support created by the spectacle could turn the tide.
- It's at least **possible!**

And Don’t Forget the Easiest Check Box of All. Vote! …to End this Kleptocracy

If You're Local Here in Santa Cruz

- … consider taking my course **"Astro 7: Planetary Climate Science".**
- It's offered **Tuesdays 2:45-5:50pm once a week**.
- It's the most comprehensive climate course I know of; not just the physical science, but economics, politics, denialism, psychopathologies, civilization thermodynamics, strategies in the forms of policy, technology, and geo-engineering.
- It's UC/CSU science transfer approved.



My co-authors have more ideas you might consider.