

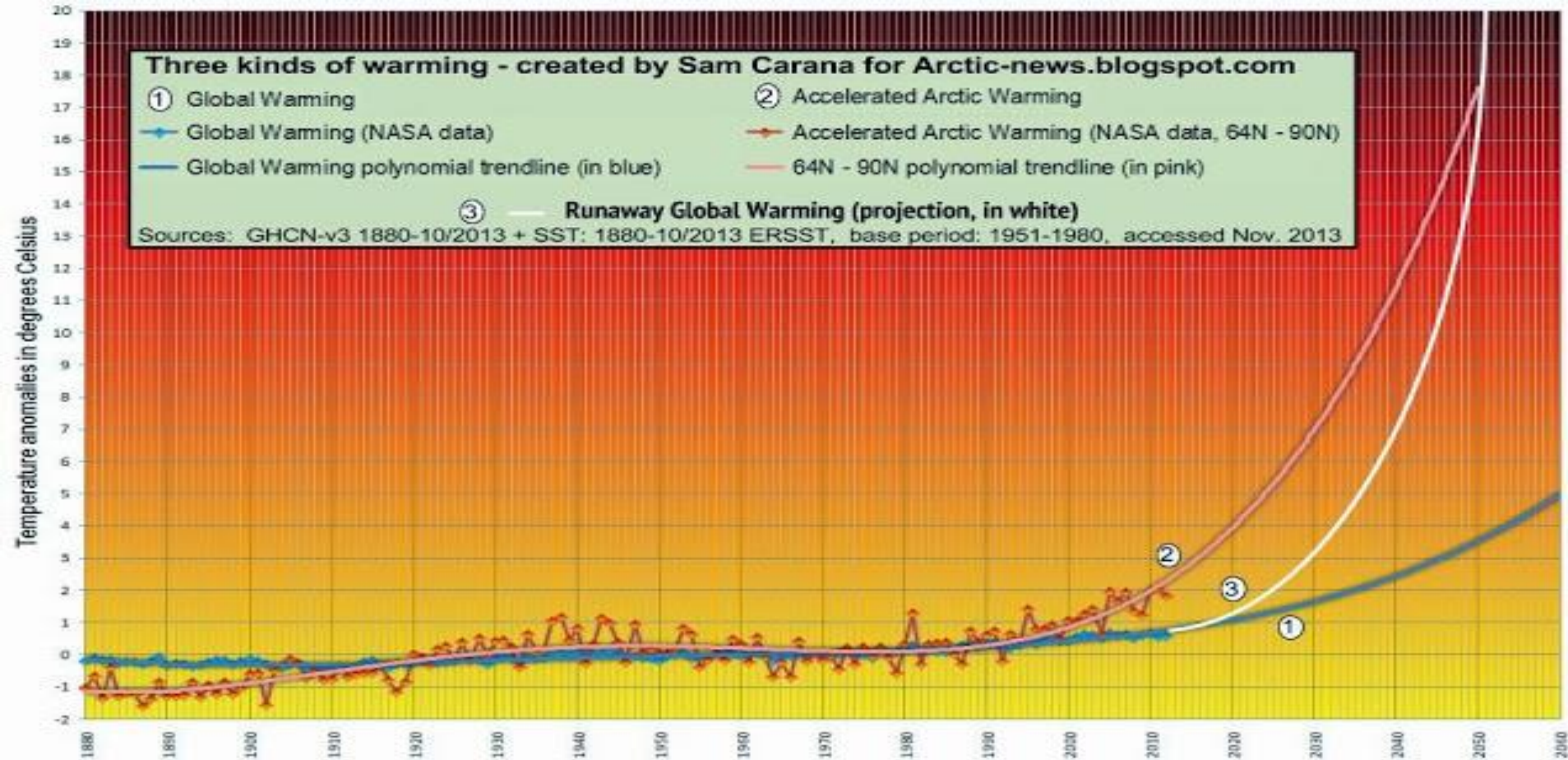
THE FUTURE CLIMATE OF EARTH: HOW GRIM, REALLY?

Are We Headed for Near
Term Human Extinction
(NTHE)?

Richard Nolthenius, PhD – Astronomy – Cabrillo College

Guy McPherson's Claims

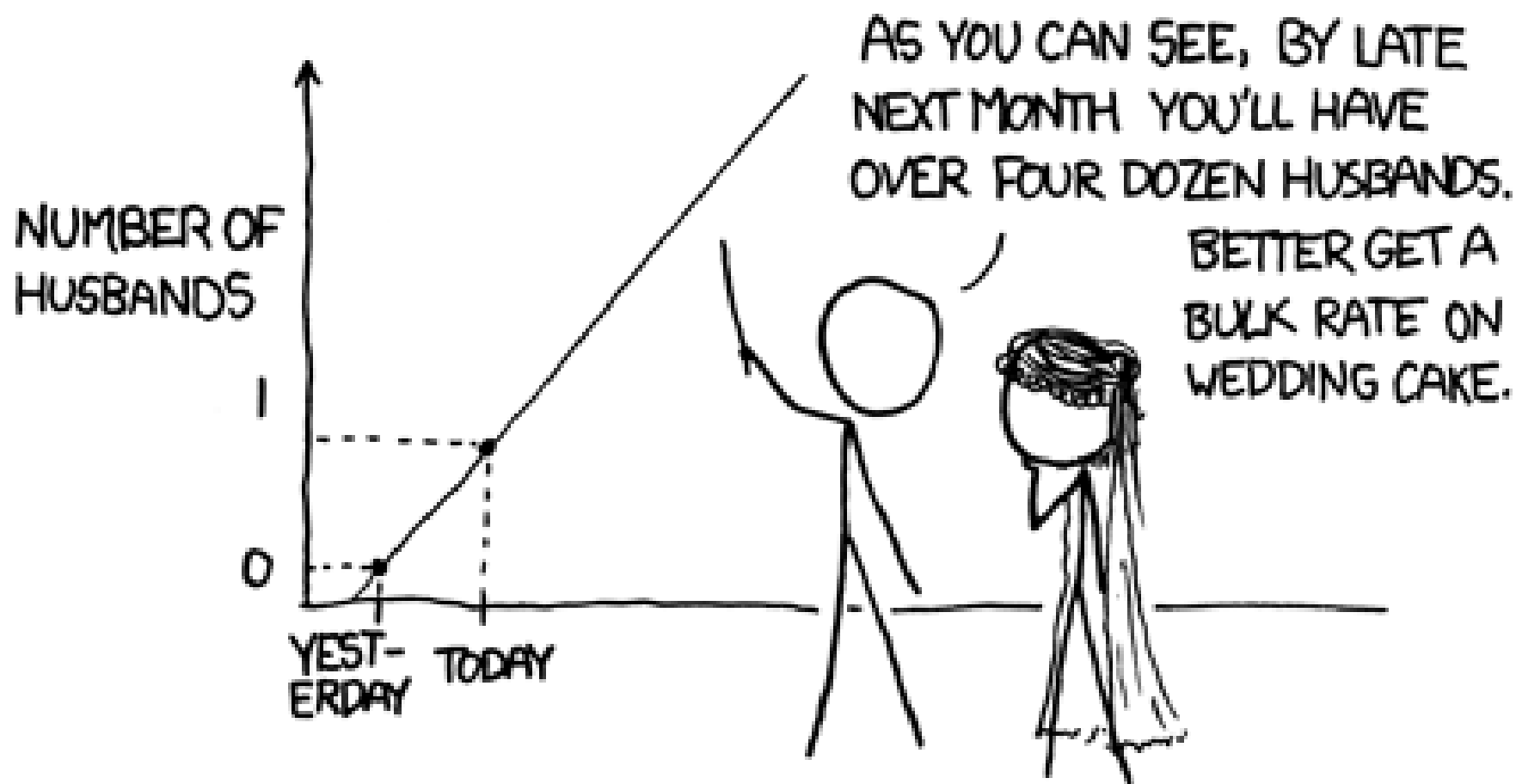
- ▣ Former University of Arizona professor of Ecology Guy McPherson has many YouTube interviews (you can start here, [for example, in 2015](#)) making the claim that climate change will destroy all of humanity within just a couple of decades
- ▣ **Near-Term-Human-Extinction**
- ▣ Let's look at the claims, and the actual science, and then some more insightful evidence on what we face and what we can do about it



- ❑ Sam Carana (not a scientist. Arctic News blogger) created this polynomial fit to 20th century temperature data. It is meaningless beyond 2011, yet is repeatedly cited as key evidence for NTHE by McPherson.
- ❑ Polynomials not only have no physical basis for use here, but the higher order polynomial needed to fit the mild wiggles in the actual data, guarantees that the poly will do exactly what they are famous for – zooming to infinity, or negative infinity, or both, outside the data range. It's shamefully manipulative.
- ❑ "There's lies, damn lies, and then statistics" - Mark Twain. Ah men!
- ❑ **If this is the centerpiece of the NTHM thesis, it is embarrassingly not credible!**

The Dangers of Extrapolation

MY HOBBY: EXTRAPOLATING



McPherson has said “There is no DOUBT we have Triggered the Methane Clathrate Gun”. Have we? No.

- ❑ Clathrates form and can exist only at high pressure and low temperature. Any clathrates existing today are at these conditions.
- ❑ At ~1 C temperature (ocean bottom temps), methane hydrates are only stable at pressures found deeper than ~330m depth, and this places them BELOW the bottom of the Arctic Ocean’s Siberian continental shelf (avg depth 100m), deep into sediments (Archer 2012)
- ❑ It is much deeper than the ~50m-150m depths of the Siberian continental shelf, or even the ~90m depth where seasonal heat transfer can happen through turbulent mixing.

Being buried deep in sediments means surface heat, even the small amount which makes it to the ocean bottom, can only penetrate the sediments by conduction, which is very slow and will take centuries.

- ▣ Arctic Ocean methane releases have not been monitored for long, and are still very small. Most likely explanation is they are from thawing vegetation making methane on the ocean bottom, having warmed as sea level rose at the end of the last Ice Age 15,000 years ago – and have been ongoing for a long time.
- ▣ Arctic methane is still only ~5% of global total methane sources. ([Archer 2013](#))
- ▣ Methane release on long time scales like this means the large majority will oxidize into CO₂ before it can build up and cause catastrophic rapid warming such as McPherson claims

We see no Paleo evidence of methane clathrate destabilization – Arctic or elsewhere - during the periods in the past 200,000 years when the Arctic was warmer than today ([Sowers *et al.* 2006](#)), even though these warm episodes lasted for thousands of years at a time.

- ▣ 4 of the 5 prior mass extinctions (all except the K-Pg event 65 million years ago, triggered by asteroid impact), are strongly suspected to be due to climate change happening faster than species can adapt. But these were (most? All?) associated with MASSIVE volcanic eruptions, likely triggering massive GHG release causing this climate change.
- ▣ Today's is caused by us, and we are not an infinite source of CO₂; if we cut back civilization either voluntarily or involuntarily, our CO₂ emissions rate will go down. That's not to say we're saved as a civilization, but only that total EXTINCTION of humans is not in the cards. We're too quick to adapt to change for that.
- ▣ McPherson's NTHE claim really rests on massive methane release causing massive warming in a few decades time scale

What About PETM (55ma)? And End Permian Extinction (250ma)?

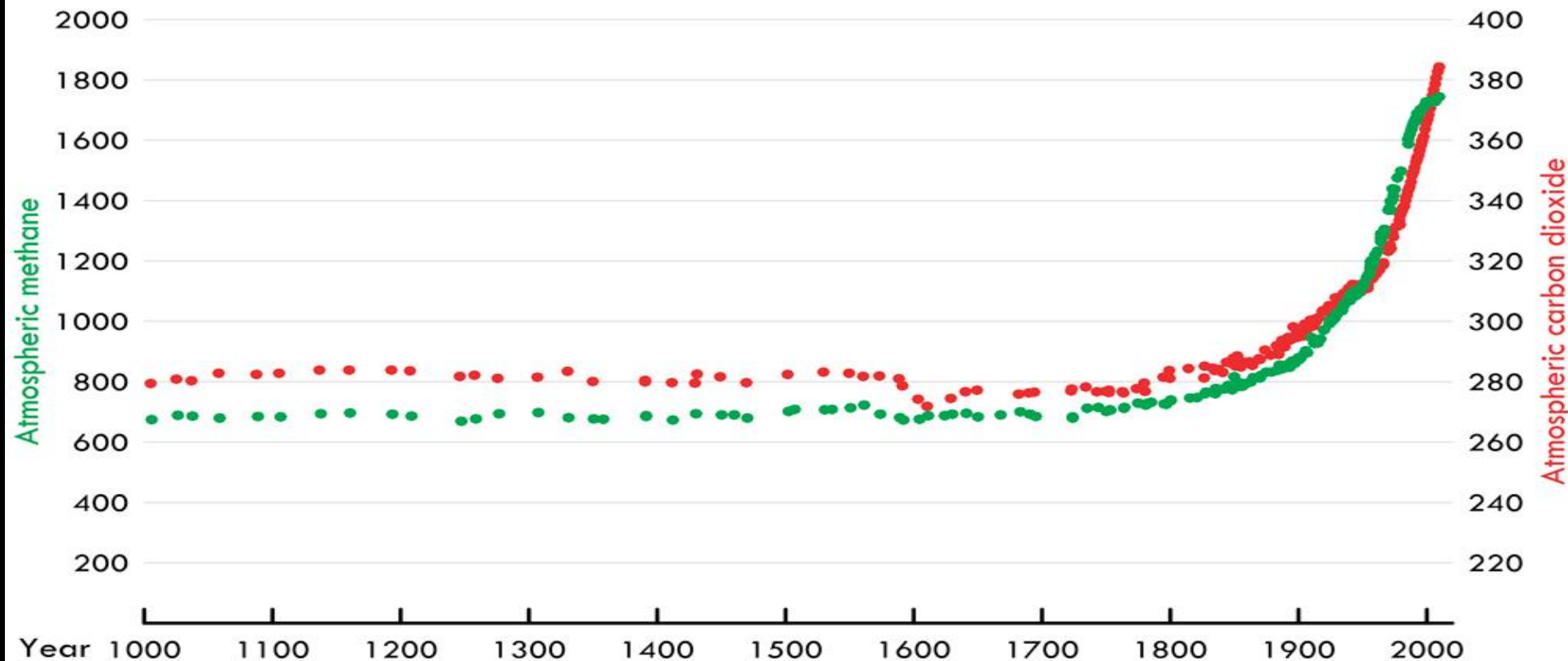
- [Clathrate destabilization](#) is quite possible here.
- But it would take ~ 2,000 years for the heating to reach and destabilize the clathrates at their stability depth, although rapid sea level drop or an extraterrestrial impact could speed this up greatly.
- PETM has many hypothetical causes, but there are significant problems with ALL current explanations, including the “clathrate bomb” hypothesis.
- End Permian is more dramatic, killing 95% of all life on Earth. Associated with massive volcanism in Siberia – lots of possible mechanisms could work. CO₂ alone is sufficient to warm climate, shut down the ocean thermohaline circulation, forcing the ocean to go anoxic, creating hydrogen sulfide which escapes and kills most life (see Peter Ward’s work). Clathrates could be involved, but we just don’t know enough yet.
- Continent positions different 250ma, but Siberia at similar latitude then as today.

Methane Oxidizes to CO₂ and Water Vapor with Half-Life of only ~9 years

- ▣ So for the Methane Apocalypse to play out, you need massive amounts of methane release in a time scale of a decade or so, or less.
- ▣ This looks extremely unlikely in the judgment of nearly all climate scientists, and explained well by Dr. David Archer of U. Chicago – a geochemist specializing in climate, and peer-reviewed paper [here](#)
- ▣ Methane currently is only 1/250th the concentration of CO₂.
- ▣ So McPherson's Claim: "There is NO QUESTION we have triggered the Methane Clathrate Gun" is a vast mis-statement highly unsupported by the evidence.

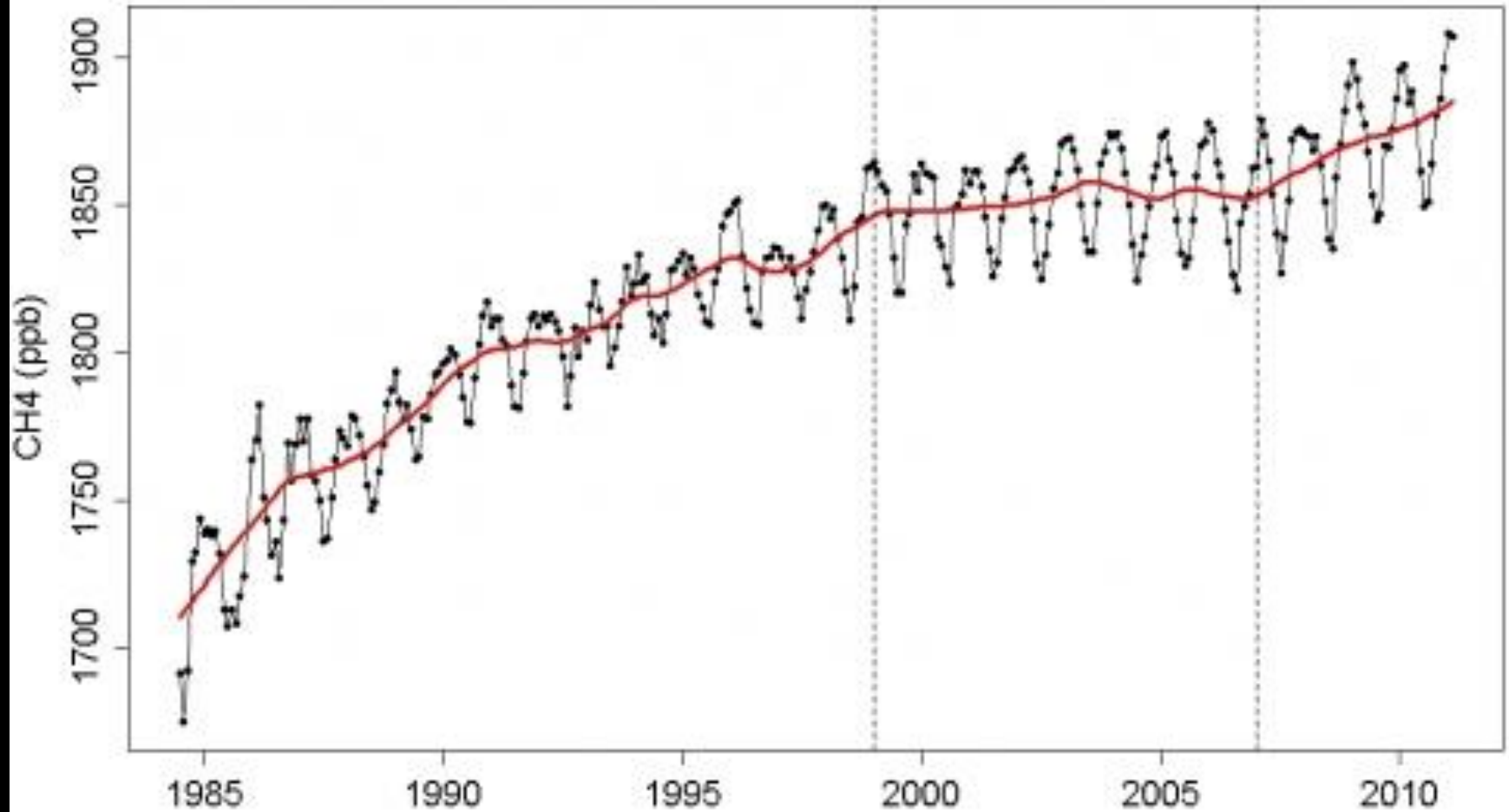
Do We See Rising Methane in the Atmosphere? Yes. But Relative to CO2 (red), Methane (green) had been Decelerating until recently...

Atmospheric Carbon Dioxide (parts per million) and Methane (parts per billion)



updated: May-2010

Methane rise resumption. But past 8 years consistent with modest linear rise so far, due to continued melt of seafloor permafrost in Arctic Ocean, expansion of tropical dams, cows. C13/C12 ratios in the methane argue it is not clathrates...



NTHE Believers Say its Arctic Methane is about to Rocket Higher

- ▣ But it is more likely due to an accelerating population of ruminants (cows, sheep, etc.) and tropical wetlands flooded vegetation creating additional methane, a process very sensitive to rising temperature.
- ▣ Added to by an estimated \$1.5B in leaks due to fracking and the natural gas boom that started about this time (see [“Years of Living Dangerously”](#) for example).
- ▣ And also, methane from Arctic tundra, and occasional local spikes (“dragon breath”) in methane from Arctic sites, due not to clathrates, but trapped sediment methane from decaying vegetation entombed long ago, and warmed slowly by rising ocean temps flooding over much colder land during the low sea levels of the last Ice Age

**Arctic methane emission
is only ~5% of Global
methane emissions**

In Order to Have a “Methane Bomb” ...

- ▣ McPherson invokes [taliks](#) penetrating undersea permafrost to get at the hydrates. But the physics is wrong:
- ▣ 1. Taliks only form where there is steep temperature extremes to crack the permafrost – that can happen ABOVE ground summer/winter. Unlikely in ocean bottom where water temperatures are very constant during the year
- ▣ 2. Ignores that methane must first absorb latent heat of formation before it can melt and release methane – no “bomb”, it’s just like an ice cube taken out of the freezer does not “explode” into vapor; it takes much absorbed heat before melting

In 2007, Just After End of This Graph, Methane Levels Began Rising Again, as ruminant populations rose

Global large ruminant equivalence and atmospheric methane concentrations

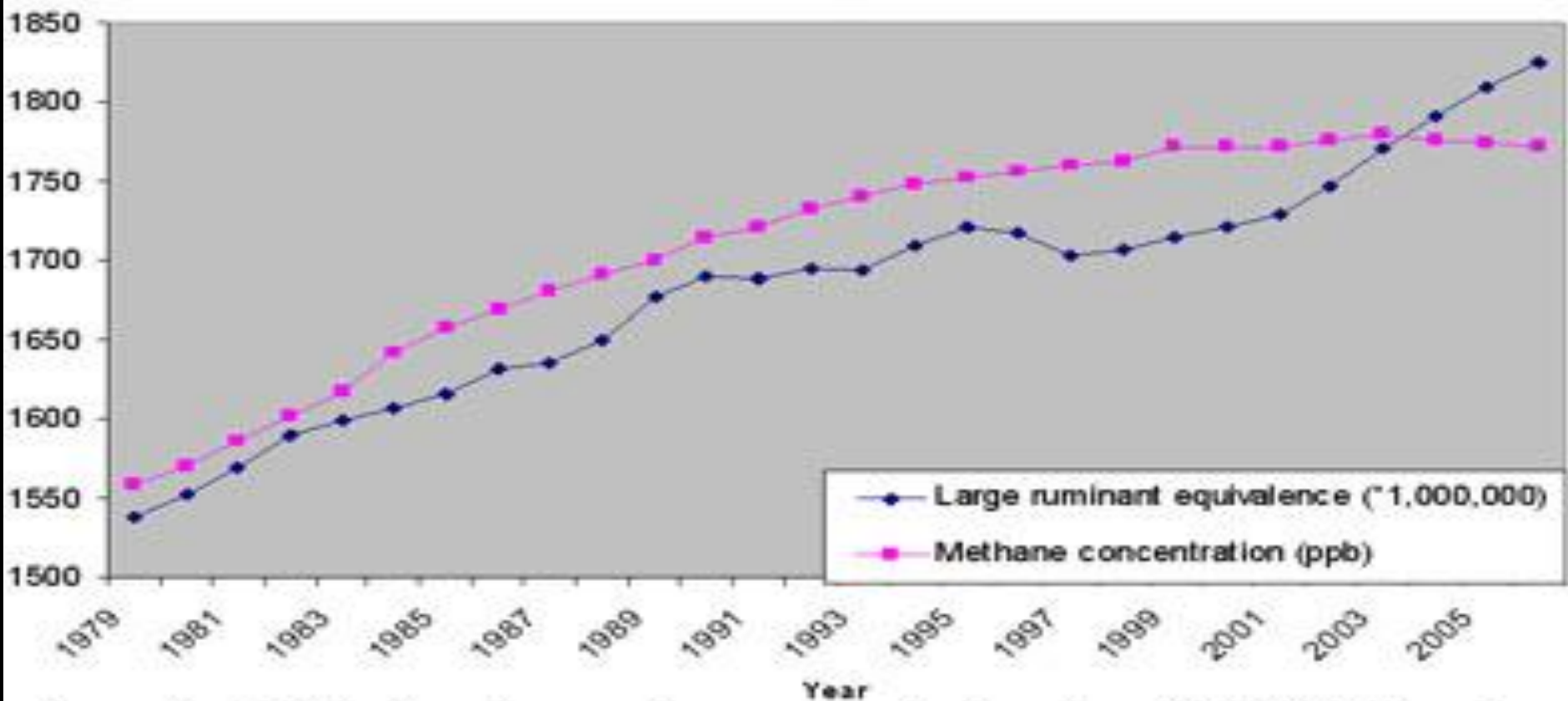


Figure 1. Global atmosphere methane concentrations from NOAA (2007) and cattle equivalents from FAO (2007). Large ruminant equivalences are calculated using 8 sheep or goats as being equivalent to a large ruminant.

Methane Bubbles in Arctic Lakes: This source could increase rapidly, being close to surface. But total amount is tiny fraction of that in the Clathrates. It'll hurt, but not KILL US ALL

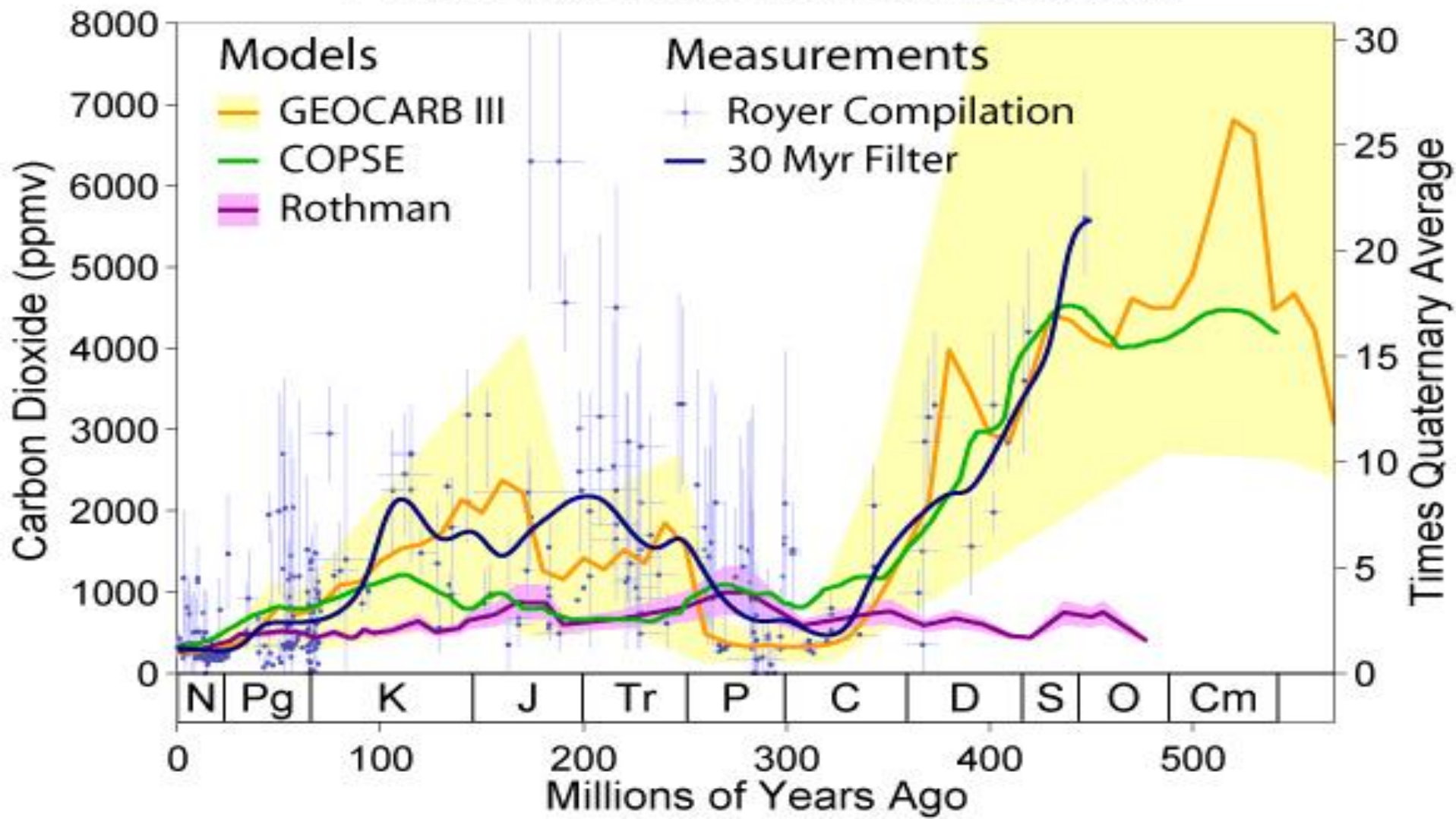


Much Talk about Amplifying (Positive) Feedbacks

- ❑ But feedbacks must be modelled correctly to get reasonable answers
- ❑ e.g. as Arctic Ocean ice goes below 50%, the coefficient in the feedback term will drop, eventually to near zero as there's no more ocean ice left to melt
- ❑ Greenland darkening will only go so far, since fresh white snow will continue to fall every winter.
- ❑ One can't simply assume every amplifying feedback takes you to infinity and Doom.
- ❑ While we're at it: I call on the IPCC Scientists to put into those ~35 Global Climate Models in use around the scientific world, every amplifying feedback we know. A good-faith best estimation, however approximate, so we are NOT looking just at cross-fingers-assume-they're-zero, but instead what is the most-likely given all we know.
- ❑ And divorce yourself from the UN. Let the scientists and ONLY the scientists voice THEIR consensus, not the government and industry meddlers in the UN process

Until Humans - CO2 Levels Had Been Dropping for ~120+ Million Years

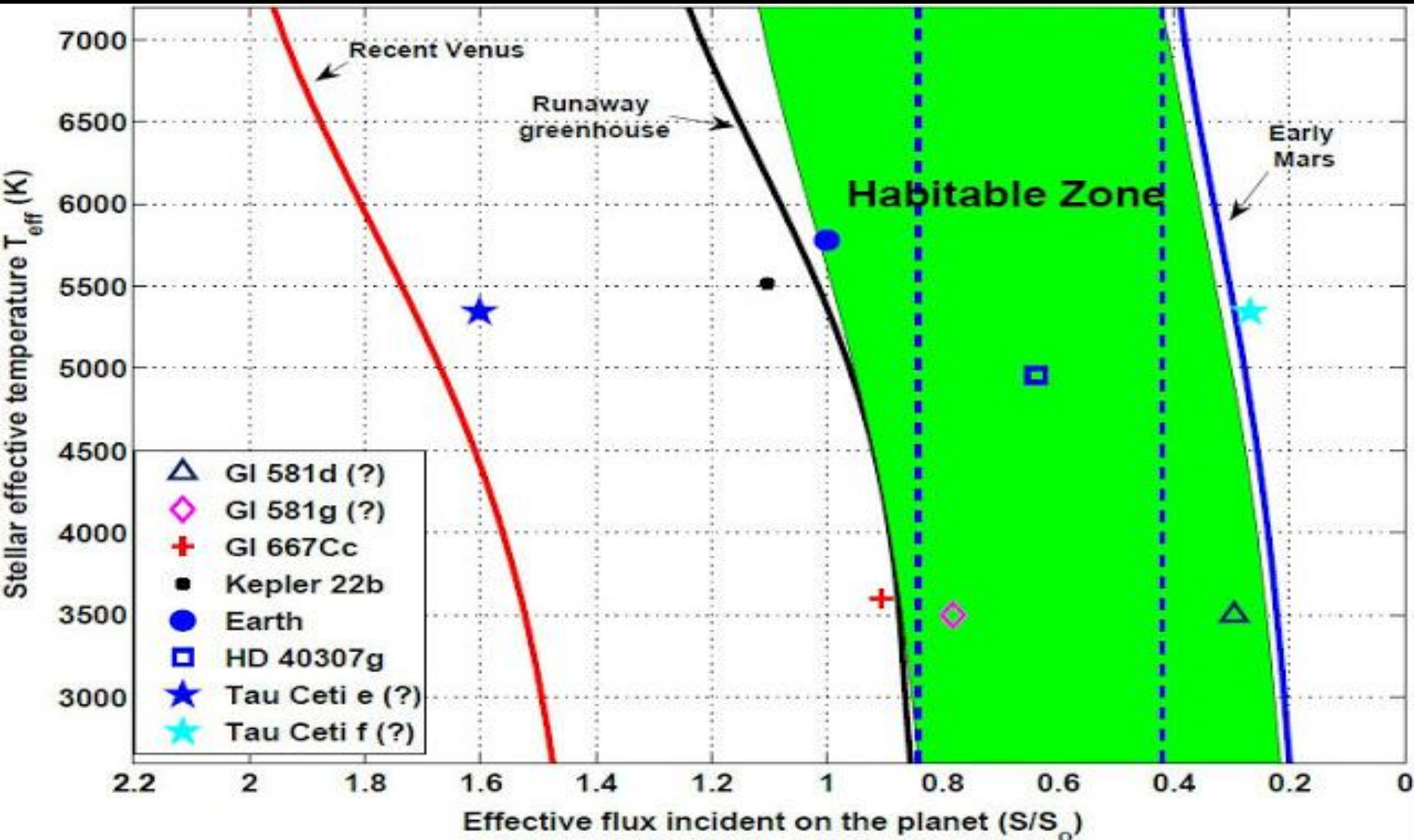
Phanerozoic Carbon Dioxide



So CO₂ has been MUCH higher than anything forecast for coming centuries, for almost all of the past 100 million years, and no “Venus Syndrome”

- ▣ McPherson hammers DOOM out of a recent paper showing a plot showing the Habitable Zone for solar systems, including ours...
- ▣ Perfect for terrifying people
- ▣ It looks pretty scary! But, let's look closer:

From Kopperapu *et al.* 2013. McPherson says (paraphrase): We're on the ragged edge, just 1% away from a Runaway Venus Syndrome



Are we? NO! If you Actually Read the Paper...

- ❑ ...it's meant to define a very conservative Habitable Zone around other main sequence stars and alien planets.
- ❑ For this purpose, they use a 1-dimensional climate model and assume an unrealistic CLOUD-FREE world.
- ❑ The authors explicitly state that adding clouds will extend the habitable zone significantly in BOTH directions. And Earth has clouds. Lots of them.
- ❑ For us, near the inner edge, clouds act mainly to reflect more sunlight and cool the planet. It's a significant effect which moves the inner HZ edge aWAY from us in a safe direction
- ❑ The implication that we're teetering on the edge of a Runaway Greenhouse Venus Syndrome is just wrong.
- ❑ Climate models all show we are very unlikely to go that route regardless of our CO2 emissions, for many millions of years.

Other Problems with NTHE Claims

- ▣ **Claim:** that since humans have never lived in a +3.5C temperature world, we'll all die – but last time the Earth was that hot, humans had not yet appeared as a species – so this is not fair to claim we couldn't have survived. There will ALWAYS be places on Earth where temperatures are just fine (like Canada and Russia even if “business as usual” continues till 2100).
- ▣ **Claim:** 440 nuclear reactors around the world will all go into melt-down with societal collapse. But they CAN be safe-mode'd, if we just try. Even if not, implication we'll all die of radiation is gross extrapolation not supported by radiation effects and the dilution globally. But perfect for scaring the hell out of nuclear-ignorant but terrified public.

What of the Claim that Shutting off Coal Burning will Cause a Sharp Temperature Rise?

- ▣ That one is true. Aerosols provide a cooling, and humans dominate the source of aerosols. They are the second most powerful human climate forcing, right after CO₂ as a warming force.
- ▣ But this effect is already in climate models which simulate the future with reduced or zero fossil fuel burning (*e.g.* MacDougall et al 2012 and later).
- ▣ It's not happy, but it's not INSTANT DEATH either.

More False Claims...

- ▣ **Claim:** That once the Arctic Ocean ice is gone, the lack of a buffer in the form of latent heat of fusion of ice, will cause instant massive warming of the Arctic Ocean.
- ▣ **Truth is:** that effect is tiny. The volume of ice on the Arctic Ocean now is comparable to a few snow flakes still drifting on a large tumbler of cold water. The loss of those flakes will cause a barely noticeable rate of increase in heating. The latent heat of fusion is much smaller than the latent heat of vaporization; maybe he's confusing the two??
- ▣ And to counter balance that, will be the loss of the albedo feedback (you can't have LESS THAN ZERO ice. When it's gone, it's gone. No more feedback!)

Why is McPherson So Adament about Terrifying Everyone?

- ▣ Perhaps, inner rage at an uncaring human population bent on continuing a mass extinction of innocent species?
- ▣ Perhaps inner rage at those who have done him wrong while he was at U. of Az?
- ▣ I don't know – but I do know this...
- ▣ Those who are most likely to BELIEVE his stories of DOOM, are the young and naïve who are most innocent - what is THEIR guilt?

**The Young and Innocent Will Suffer
the most... like these friends and
family**



Kindergarten Class

Savannah
Alejandro
Thi Sun
Braden
Victoria
Adrianna



**But These People? Less so. So
just where's the emotionally
satisfying justice in that?**



I have a Much Stronger Criticism to Deliver to McPherson and NTHE Video Publishers...

- ▣ Pause and emotionally connect with the flat-out statement: **“You, your children, and all your descendants – DEAD! In 20 years! EVERYone’s children – DEAD! in 20 years!”**
- ▣ My God! Guy McPherson – what if people actually BELIEVE you?
- ▣ Mass suicides due to depression? Riots now, not later? What else?
- ▣ Before making such a statement, one must be DEAD sure of the science supporting this
- ▣ To persist in doing so when he so badly misrepresents the actual evidence, and when there has been such easily available fatal criticisms out there now for several years.... is inhumane. One can only speculate on why he does this.
- ▣ People deserve truth. They ALWAYS deserve truth and nothing else. When you are shown to be wrong, you publicly acknowledge it – IMMEDIATELY – and apologize if necessary.
- ▣ **This we do not see from McPherson.**

“When the facts change, I change my mind. What do YOU do, sir?!” – John Maynard Keynes

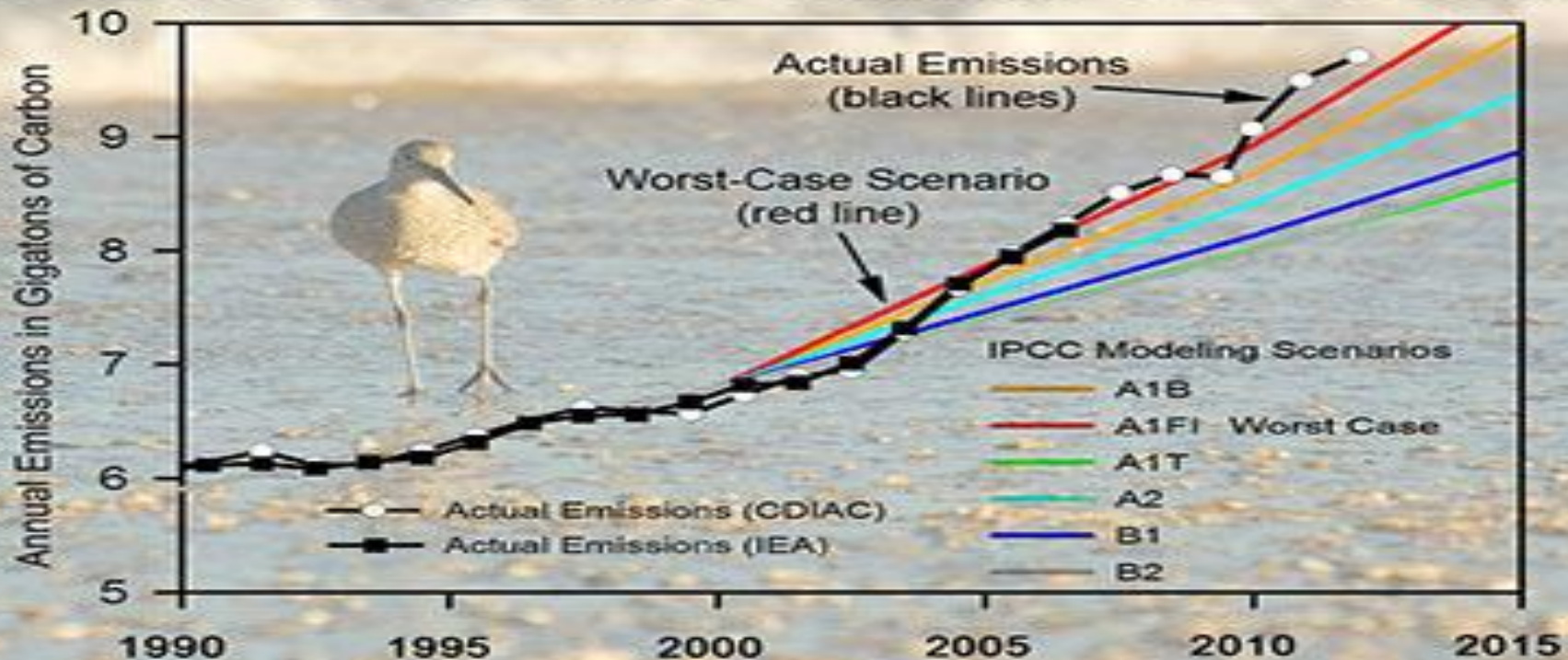
- ▣ To use whatever stature McPherson can muster from his prior career as a university biology professor to get people to BELIEVE this totally unsupported horror – is vast cruelty
- ▣ I’m no Pollyanna – anyone who’s heard me speak or taken my Climate course at Cabrillo College can attest to that.
- ▣ I don’t believe in promoting rosy scenarios which are do-able, but yet vastly inadequate to the task, just because of the human desire for comfort and complacency
- ▣ I struggle to get it right, at the risk (it certainly seems) of pleasing no sides in this drama, and update my material constantly to reflect new evidence.

Without Near-Term Human Extinction and perhaps without Abrupt Climate Change – Are our Prospects Bright?

- ▣ No.
- ▣ National Academy of Sciences Fellow Professor Sandra Faber (and co-author with me on several cosmology papers) gave a talk on Earth's long term future at UCSC in 2014, which included this...
- ▣ *"We got here according to the laws of physics and we are subject to those laws and must live within them," she said. "We can't be guilty of magical thinking in predicting our future."*
- ▣
- ▣ Growth must end. Soon. The 21st Century will almost certainly be ugly... but
- ▣ When asked whether Climate Change would cause Near Term Human Extinction – Faber answered immediately - "Not even close!"

CO2 is Rising Faster than Even the Worst-Case IPCC Models of late '90's

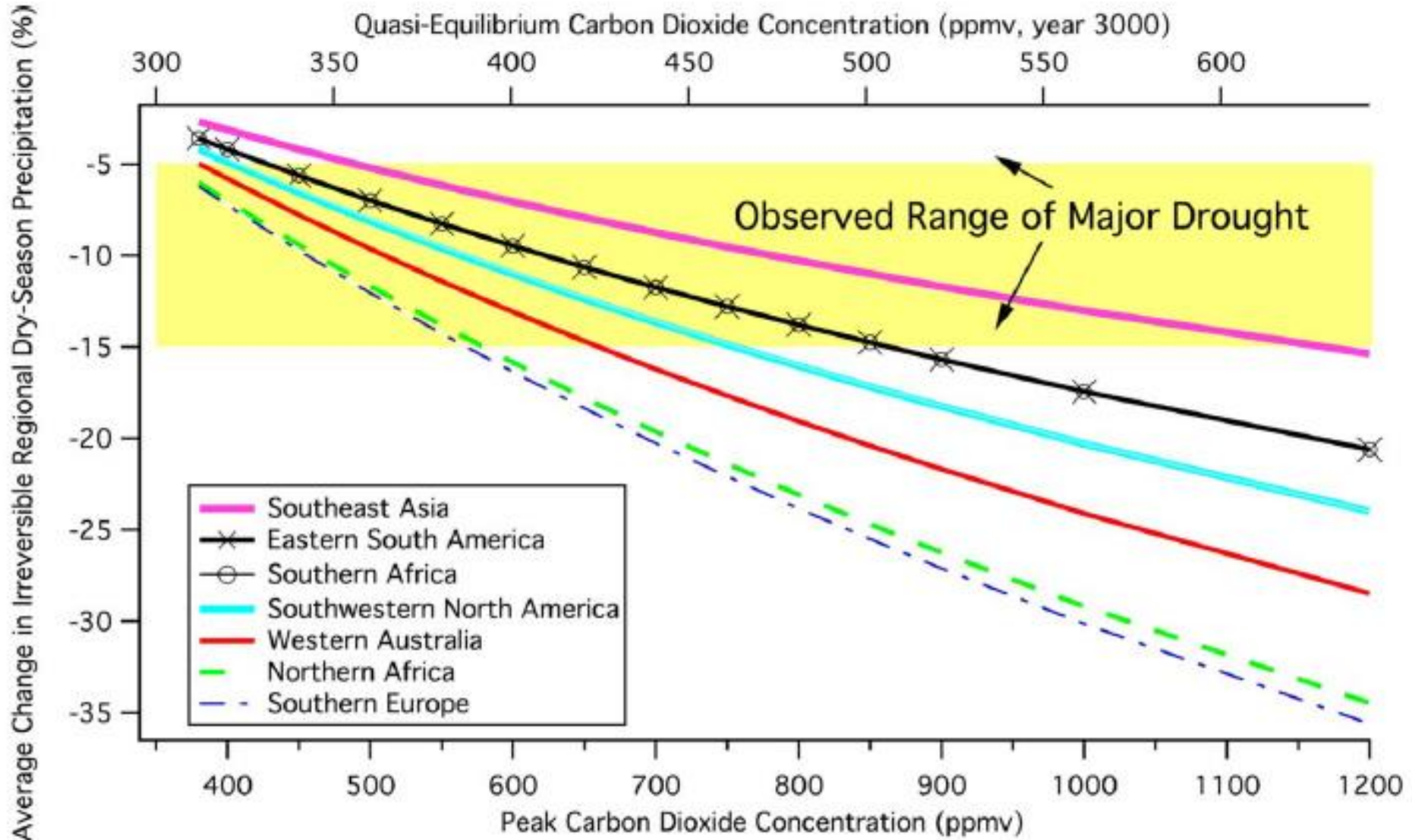
IPCC Model Scenarios vs. Actual CO2 Emissions



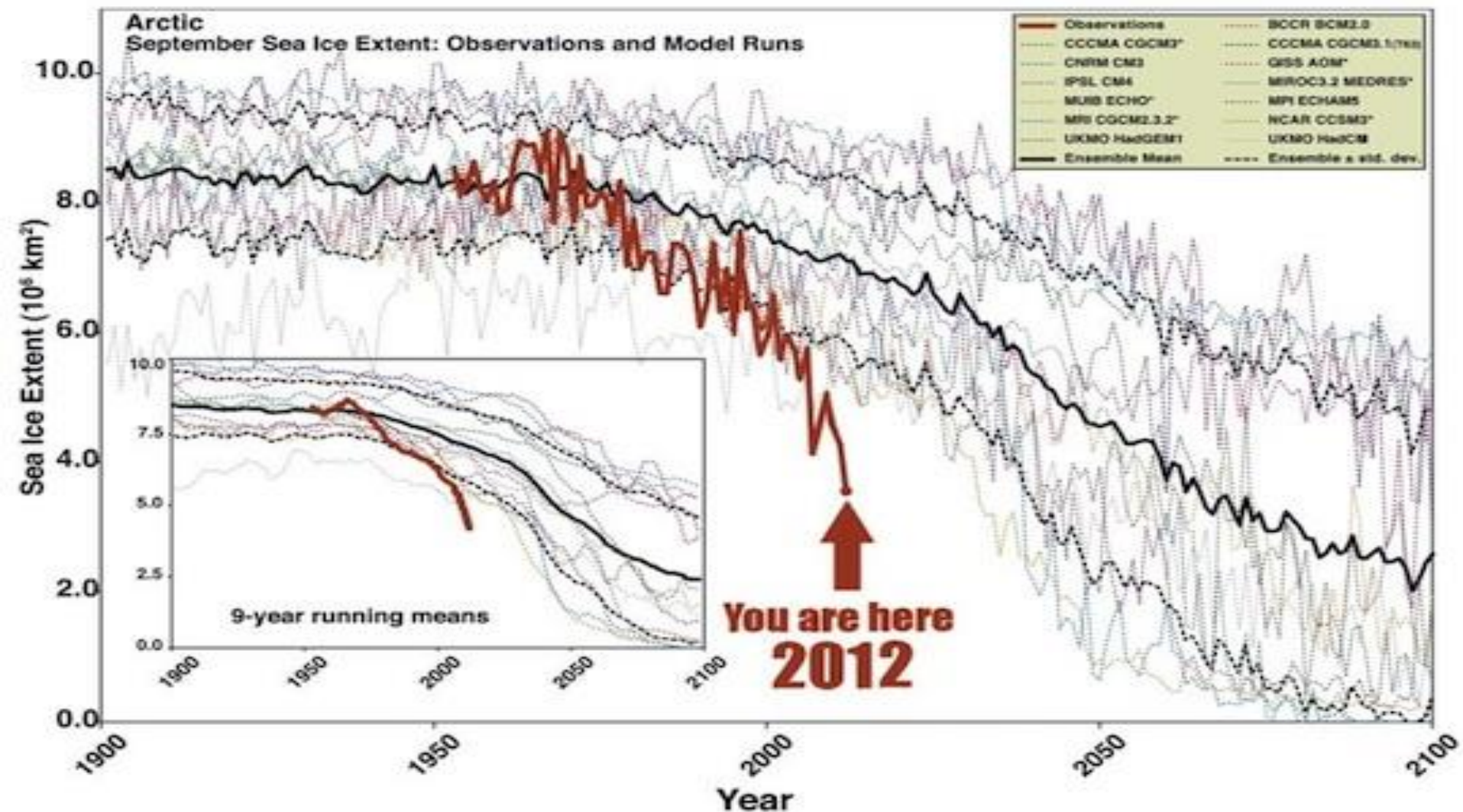
Observed global fossil-fuel and industrial CO2 emissions compared with averages of 6 scenario groups from the IPCC Special Report on Emissions Scenarios (colored lines). The Carbon Dioxide Information and Analysis Center (CDIAC) and the International Energy Agency (IEA) provided the observations of CO2 emissions.

Source: 1) Synthesis Report, *Climate Change, Global Risks, Challenges and Decisions*, Climate Change Congress, International Alliance of Research Universities, University of Copenhagen, March 2009. 2) *Raupach and Canadell, Carbon and the Anthropocene, Current Opinion in Environmental Sustainability*, August 2010. Updated to 2012 by the author.

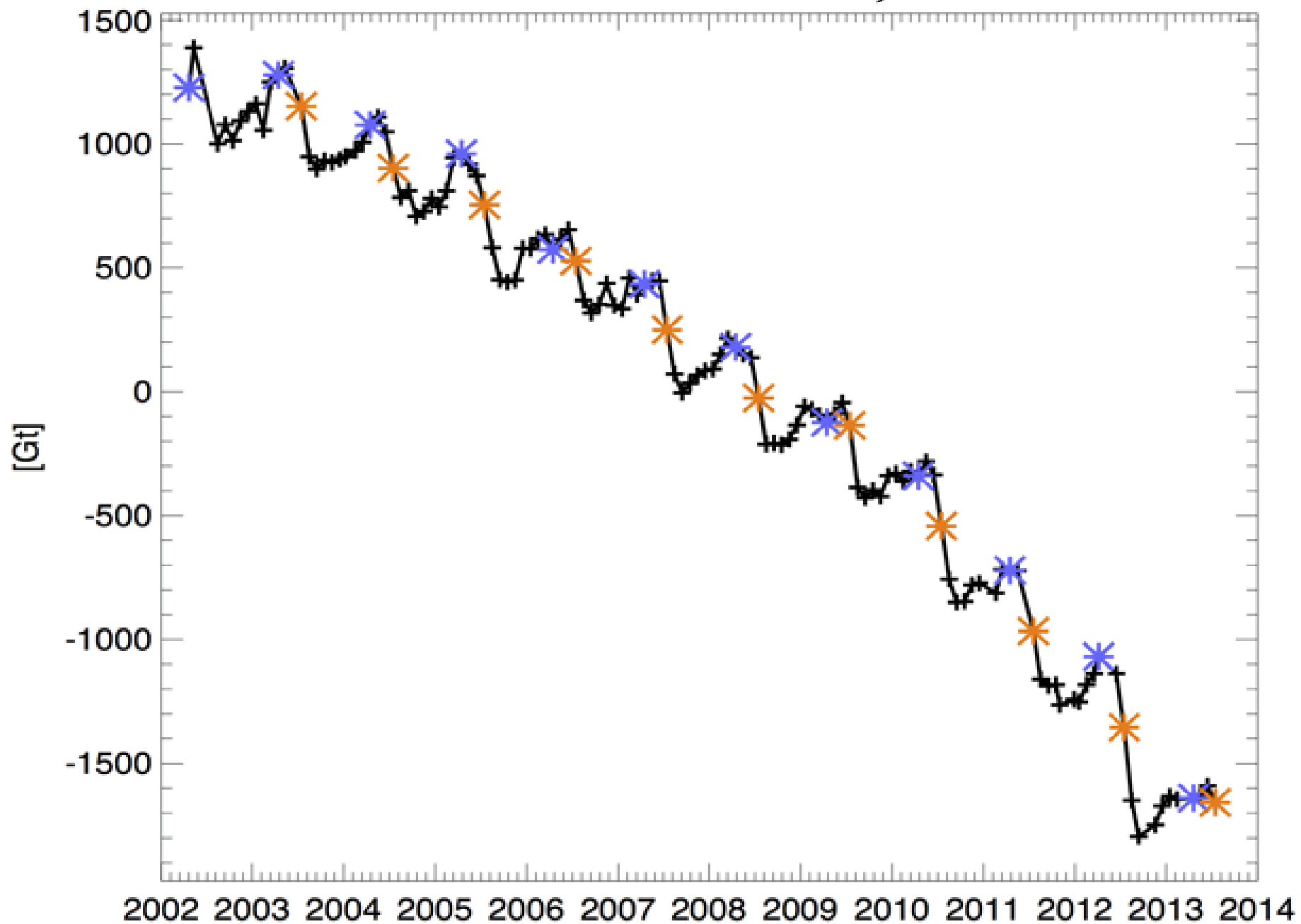
Drought is in our Future



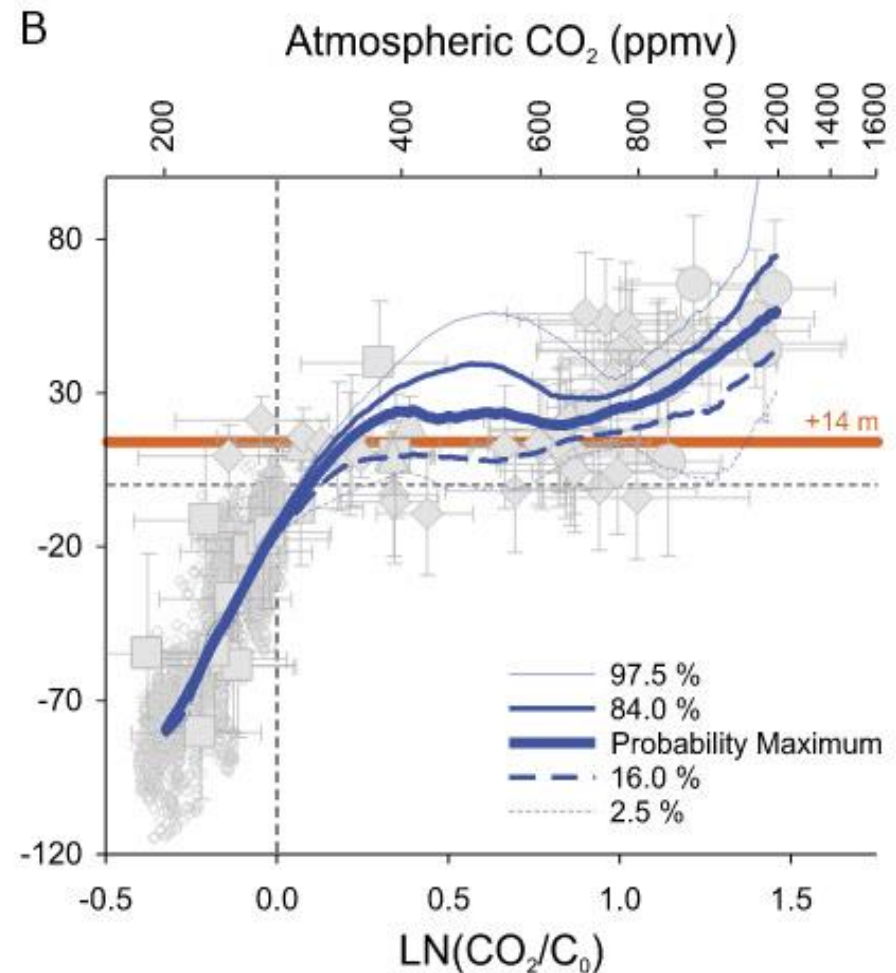
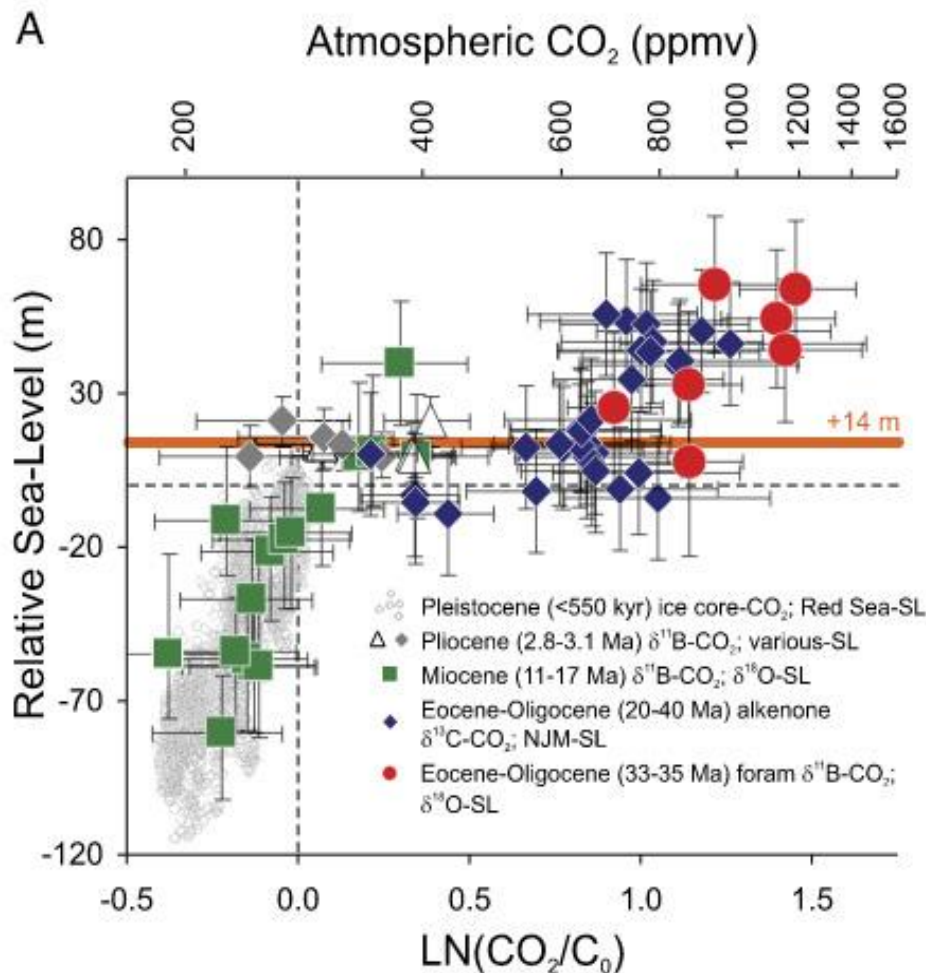
Arctic Sea Ice Area (Volume even worse) in Collapse. Now, so is the West Antarctic Ice Sheet



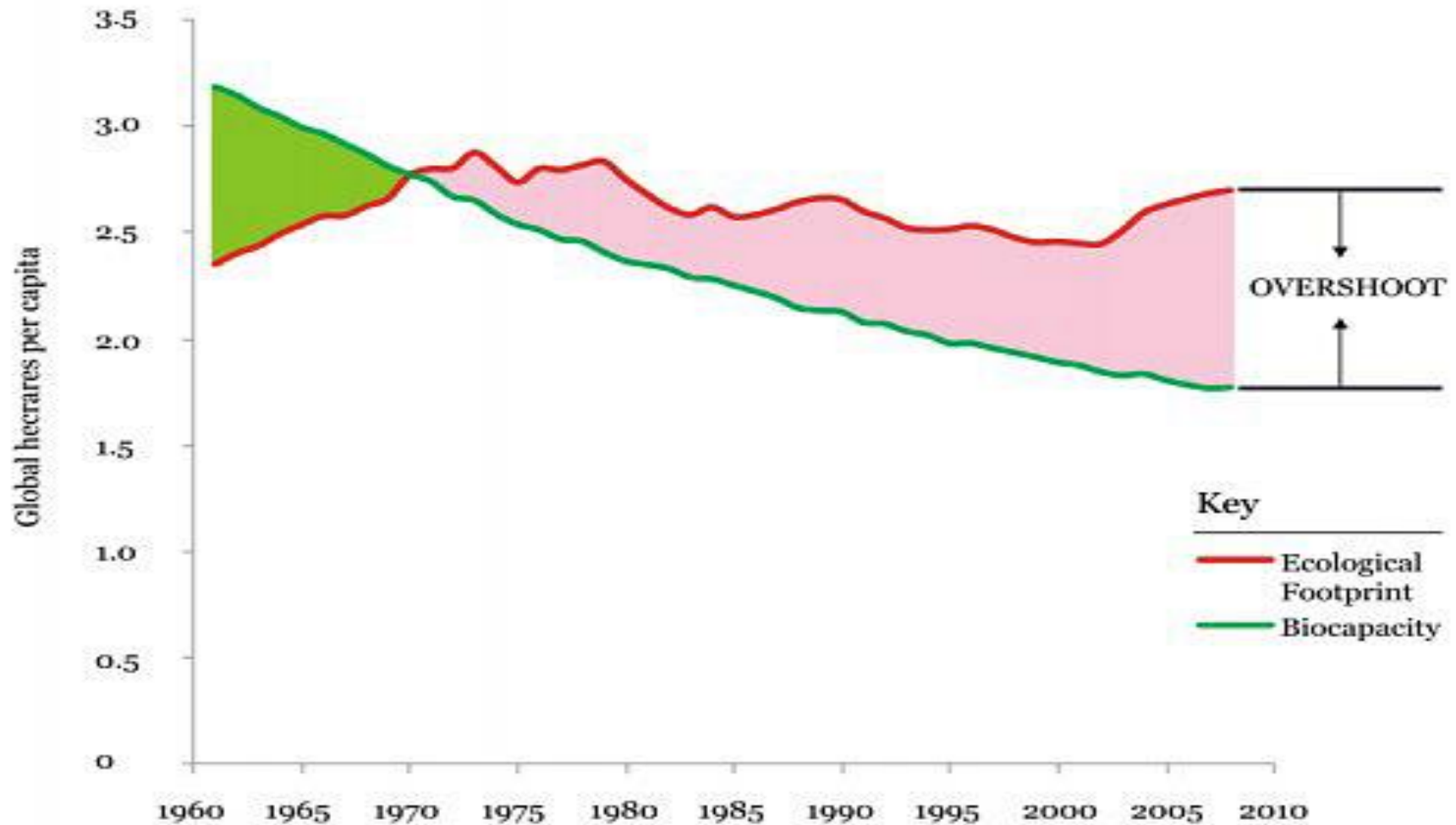
Greenland Ice Mass Loss, 2002 - 2013



Resulting in Rising Sea Levels (~24+ meters eventually. Even near term's +1.2m ruins 25% of today's cropland productivity) and No Stable Coastlines for Thousands of Years (So How do We Build Ports?)



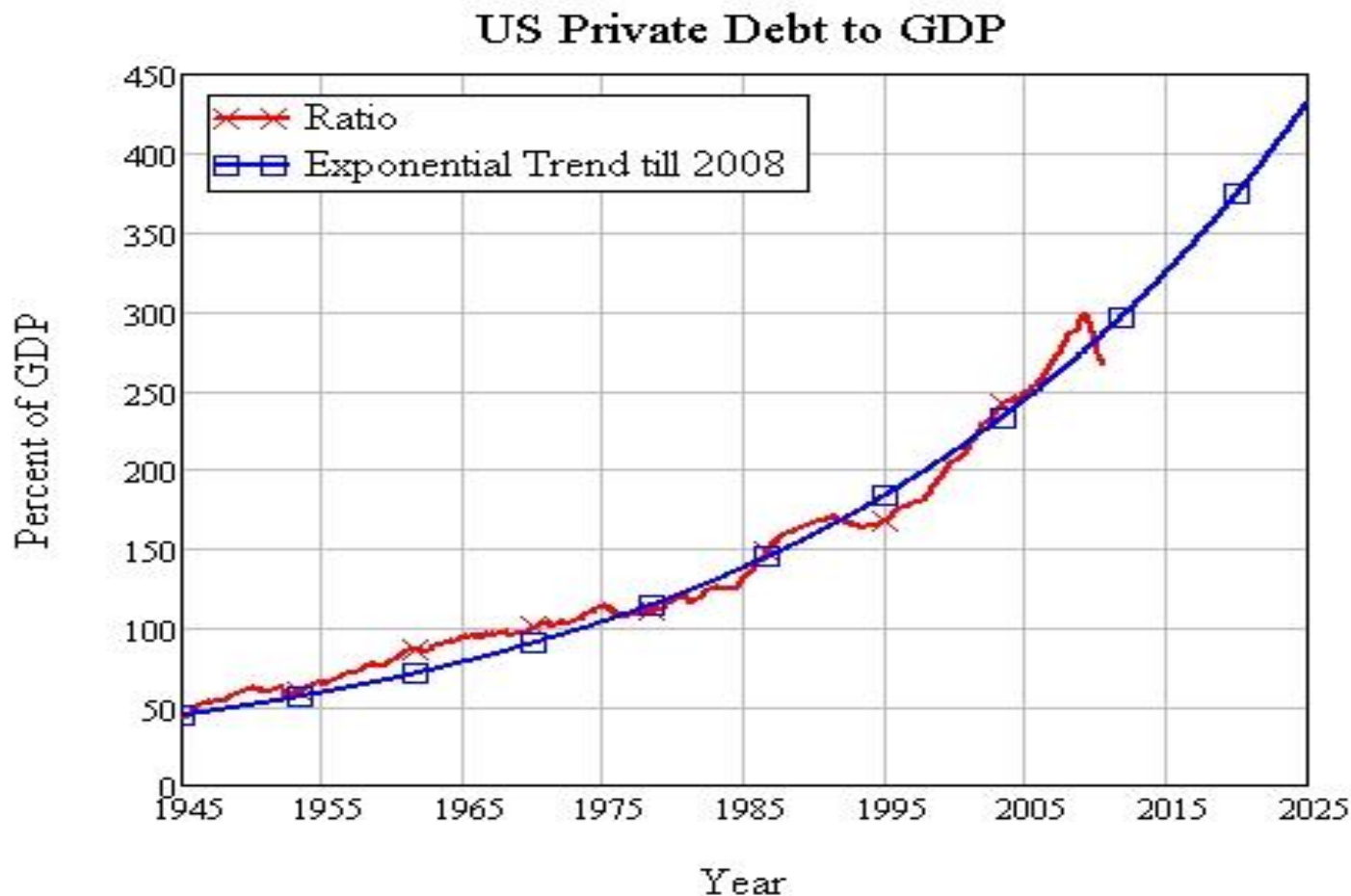
Our Populations are living 70% (as of '14) Beyond the Earth's Increasingly Crippled Capacity



How Have We Gotten Away with it?

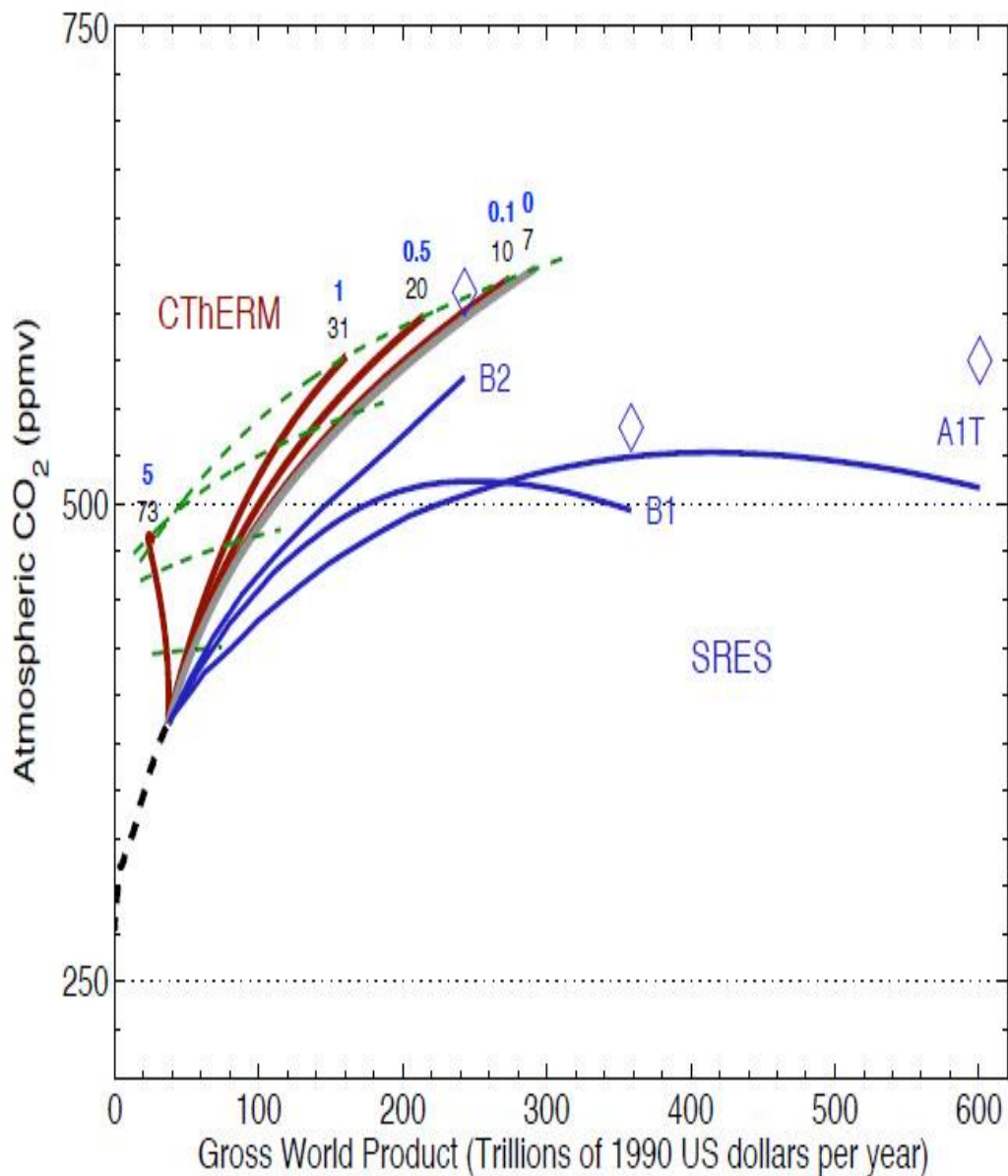
- ▣ Eating our “seed corn”, basically.
- ▣ 90% of all large fish are already gone
- ▣ Virtually all arable land on Earth is already turned to crops and other human use.
- ▣ Tropical forest being bulldozed and burned at a rate of more than a football field’s worth per SECOND.
- ▣ We’ve dug deep into our ancient aquifers. Already ~250,000 farmers in India have committed suicide in the past 20 years, with debt being a prime cause, and because of financial inability to dig deeper wells as aquifers .
- ▣ And financially.....

~ All Countries are Printing Money At a Furious Rate, and Then Borrowing Against THAT. So Our Numbers Make us “Feel” Richer, but We Aren’t



Cloud Physicist Prof. Tim Garrett has Done Pioneering Interdisciplinary Work which has not gotten the Attention it Deserves

- ▣ Shows civilization consumes energy at rate proportional not to growth, but to the integrated total of all growth over all time (the large majority has been in the past century)! And...
- ▣ He shows this makes thermodynamic sense (see his papers and my separate PowerPoint on his work)
- ▣ Implications are sober: decarbonizing civilization will be much harder than rosy simplistic current publications assume
- ▣ NO scenario studied leads to anything but rising atmospheric CO₂, except steep decarbonization together with severe economic reversal of growth for civilization



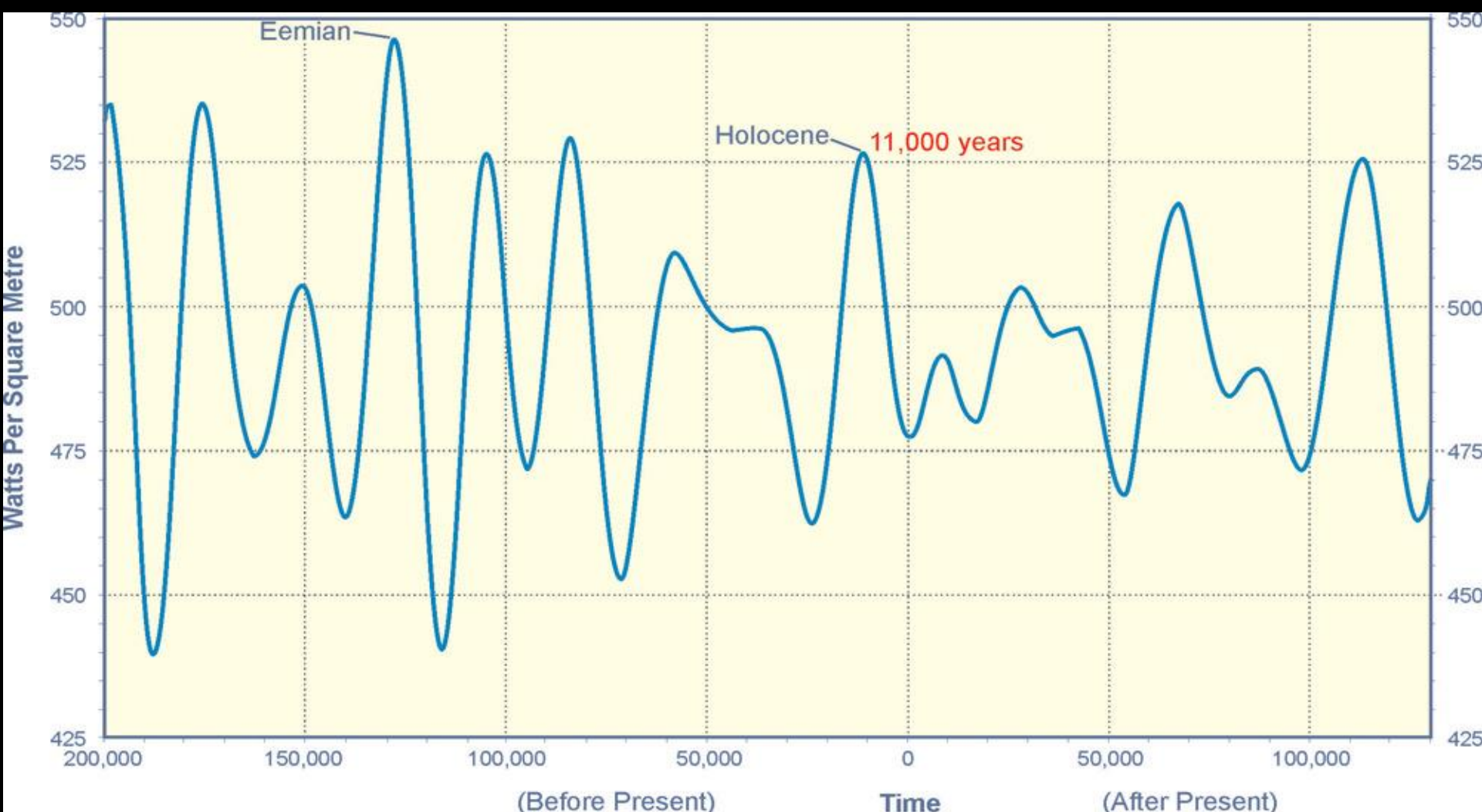
Even assuming global carbonization of energy production drops with a half-life of 50 years (far more optimistic than our current pace), all scenarios (red) lead to higher atmospheric CO₂, even assuming climate change cripples global economic growth rates to near zero (left curve). More naïve eco-friendly IPCC scenarios w/o including the thermodynamics of civilization itself, are in blue.

Fig. 7. As for Fig. 6 except that it is assumed that the value of carbonization c has an assumed halving time of 50 years. For comparison, the IPCC SRES trajectories that are considered are the A1T, B1 and B2 scenarios.

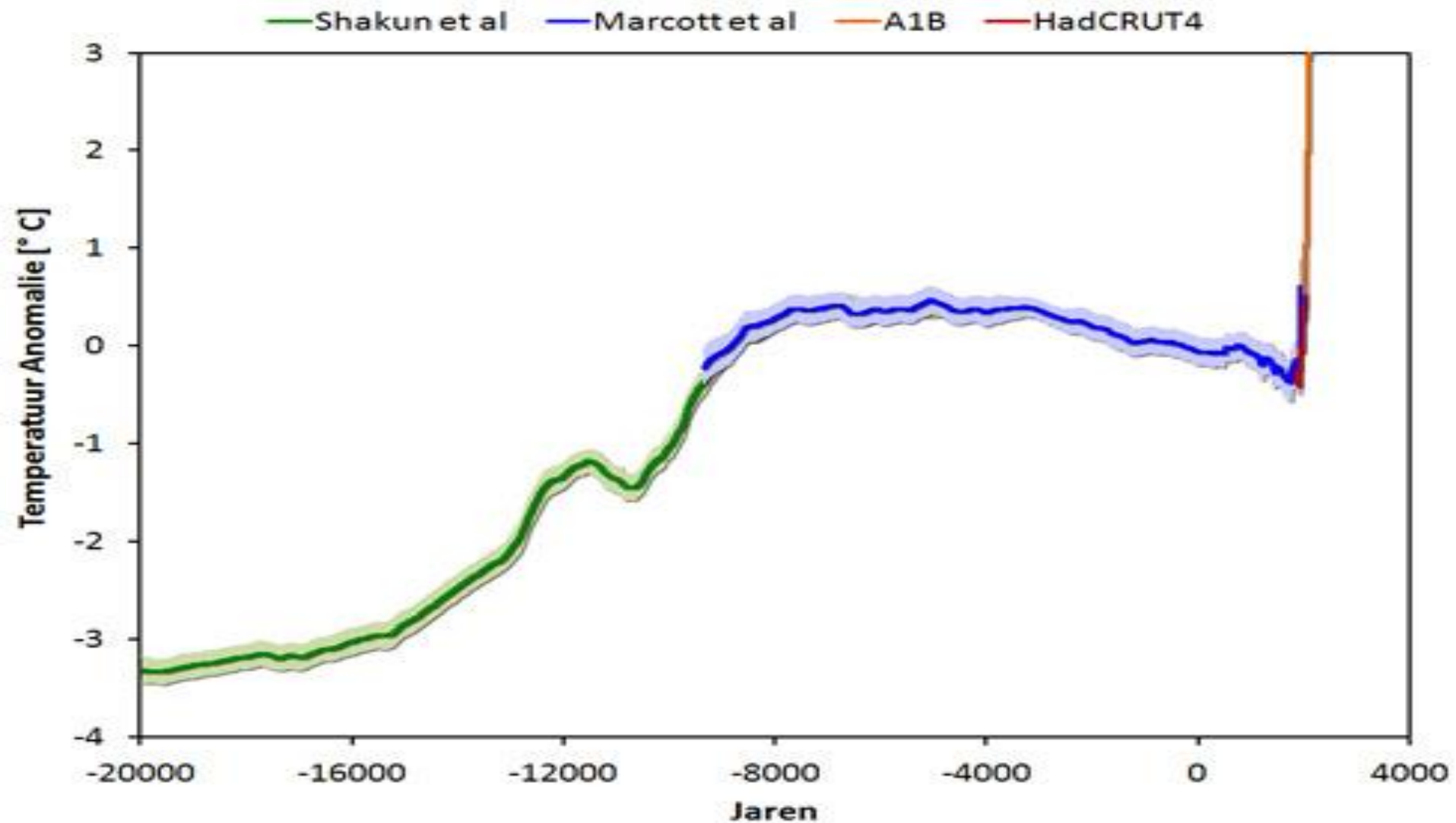
Longer Term...

- ▣ Human Civilization has been cradled and coddled by a 10,000 year period of stable climate, stable unchanging coastlines, and just the right amount of ice on the continents
- ▣ We're rudely dumping ourselves out of that cradle, and into the frying pan.
- ▣ And geologically soon, the Milankovich cooling isn't going to help us stay cool like it has so far, not for a 10's of thousands of years.

During the Past 8,000 years (i.e. Human Civilization), Our Warming Impacts Has Been Offset by Declining Sunlight at the Arctic Circle Summer Solstice, which Controls the Ice Ages... But Soon – No Longer. We’re On Our Own For Keeping Earth Cool, for ~40,000 years



Temperatures Rising Out of the Last Ice Age - And Today's



Our Choices Today: Disasters if We Work Hard, Catastrophe if We Do Not

- ▣ Our “To Do” List...
- ▣ 1. Grow up! Realize human well-being, not GDP, is the Gold Standard of virtue. Zero-Growth should be our ultimate goal, and NEGATIVE growth for some time beginning now.
- ▣ Design political empowering systems around Human Well-Being as the touch-stone. ALL systems in existence have failed miserably at this.
- ▣ Only drastic actions can hope to save us from likely societal breakdown
- ▣ --- ~0.2 child per family, worldwide. We’re going backwards here, as China has just abandoned its 1-child-per-family
- ▣ --- Tax-and-Dividend: motivates EVERYone to adopt low carbon lifestyle
- ▣ --- No tech fixes will allow us to “Have cake/Eat too”
- ▣ But tech fixes still essential:

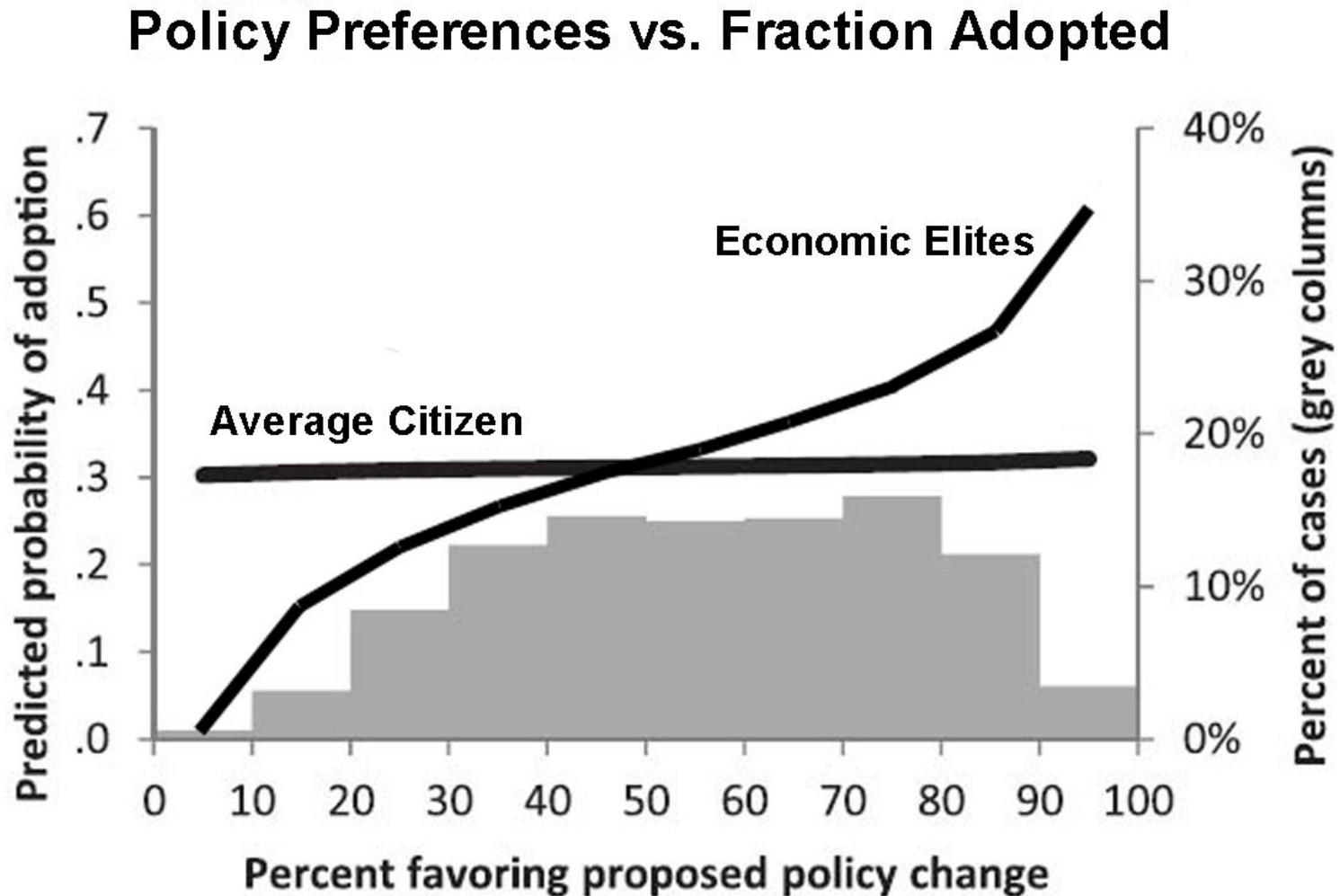
What's Needed... Policy! Legally Enforced Policy

- ▣ Massive deployment of solar PV to replace carbon, perhaps nuclear as well
- ▣ Massive conservation efforts
- ▣ Pull CO₂ from atmosphere (Klaus Lackner's artificial trees? Rau process and calcium bicarbonate? \$200/ton I've read, but seems optimistic). Nuclear powered artificial trees?
- ▣ Reducing atmospheric CO₂ to 350 ppm would require producing a cube of CaCO₃ the height of Mt. Everest
- ▣ Cost? **High!!** (don't believe the Stern Report – see Prof. Kevin Anderson on that).... But What's a Planet Worth?
- ▣ Can we DO IT?? It'll be harder than you think....

Princeton Study (2014) of 20 years of over 1770 Legislative Bills Finds...

- ❑ The correlation between the average voter's desires and the actual bills passed is zero... "Miniscule. Statistically insignificant". Powerfully financed lobbies run our government's decisions.
- ❑ We elect, but those elected then do as Lobby's dictate
- ❑ Concludes: We are not a Democracy. We're an Oligarchy (*i.e.* run by, and for, the tiny minority of powerful elites. In our case, corporations via their lobbies)
- ❑ "Writing your congressman" - would seem futile. It's gotten us nowhere so far. Painful to say to my friends, but I've yet to be shown otherwise.

Gilens and Page: Doesn't matter whether average citizens hated (left side) or loved (right side) a policy, odds of passage were the same. Economic Elites bought/paid for our "honorable" legislators



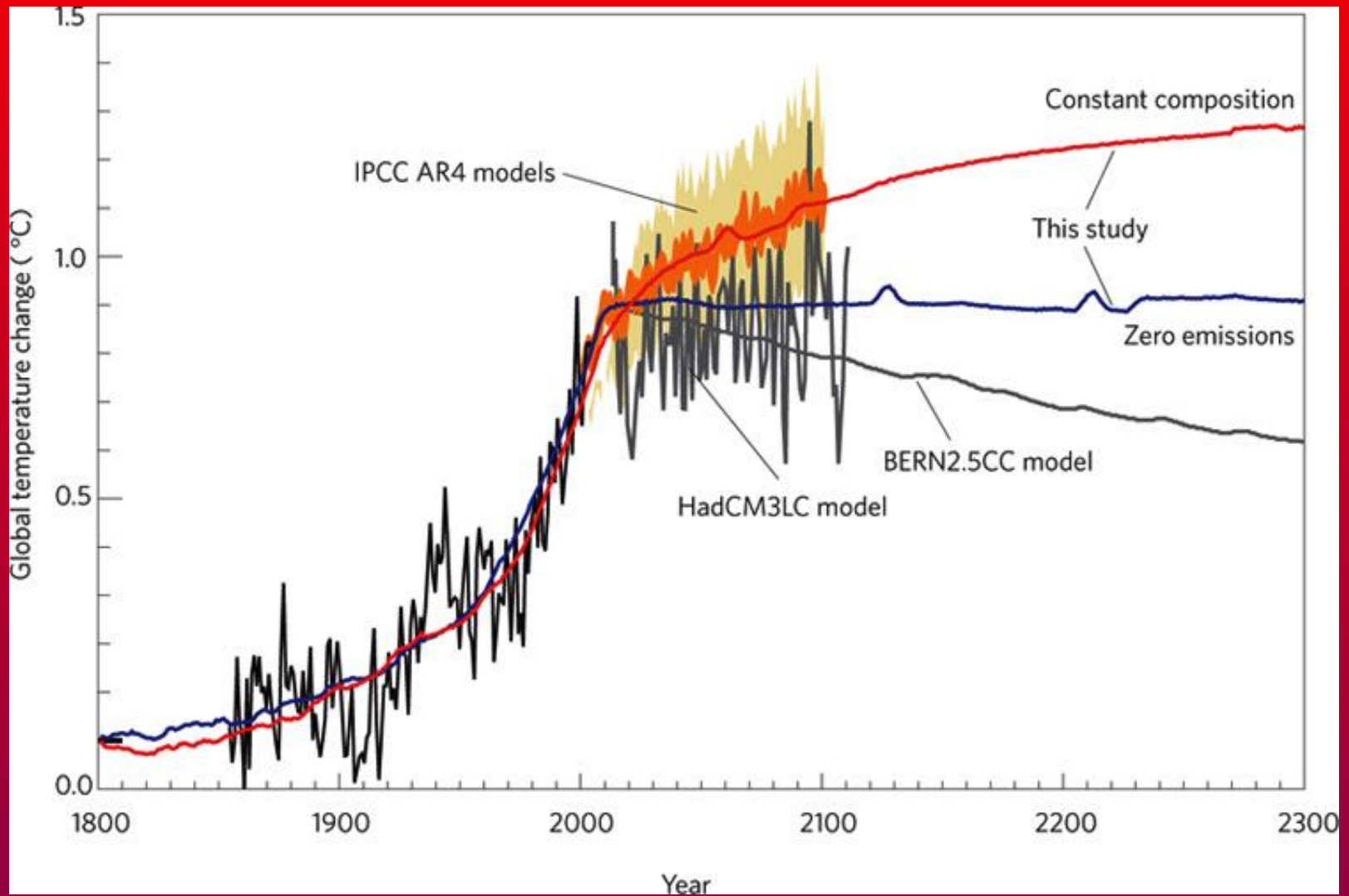
China 2012: Skynet (yes, they call it exactly that) went OnLine. Massive supercomputers, “hooked into everything”, connected to 20 million spy cameras, and soon to have facial recognition software to facilitate ID of “dissidents”. Will the U.S. allow a “Skynet Gap” or are we ahead of them in this?



Is This Our Future?? (Probably not, but Elon Musk and Nobel Prize winners are among those who are not 100.00% sure. John Conner - Please **Call!**



Even a Complete End of All Emissions – and Temperatures Still will NOT Go Back Down (Solomon et al 2009, [Matthews and Weaver 2010](#))



My Best Guess of the Future

- ▣ Rapidly rising food and especially water costs
- ▣ Resource wars
- ▣ Have-not countries suffer large loss of life
- ▣ Massive damage to, and migration away from, our coastal cities
- ▣ Possible societal breakdown, but far more likely in 2nd and 3rd World tropical countries than here.
- ▣ **Nolthenius' First Law: People Learn the Hard Way.**
- ▣ IF we do not suffer societal breakdown in U.S. and Europe and Japan, then there's always hope we'll wake up and devote a Manhattan Project level commitment to renewables, and to CO2 removal from the atmosphere, willing to pay ANYthing to make it happen – this perhaps by 2050? 2040?
- ▣ What will the Corporate Overlords do? That's a big unknown. If they lose control of elections in the 1st World, because of massive grassroots revolt, perhaps there's hope.

It May Take a Revolution By GrassRoots People in the Powerful Countries to Reclaim the Future

- ❑ Occupy DC, is my current opinion of the best strategy to force change in policy.
- ❑ Occupy Washington DC with a million people, or more. Preventing “business as usual” by sheer volume until:
 - ❑ 1. Steep carbon Tax-and-Dividend is Passed, with steeply rising carbon taxes
 - ❑ 2. Steep trade sanctions against any other country not passing their own Tax-and-Dividend
- ❑ 1 million is less than 1/3 of 1% of America. It might be do-able. Waiting for a voting majority to vote in better people in the current system shows NO hope of ever happening. Politicians are not working for you.

U. Chicago Climate Scientist Ends his Article with...

- ▣ “Could methane be a point of no return?”
- ▣ *Actually, releasing CO₂ is a point of no return if anything is. The only way back to a natural climate in anything like our lifetimes would be to anthropogenically extract CO₂ from the atmosphere. The CO₂ that has been absorbed into the oceans would degas back to the atmosphere to some extent, so we’d have to clean that up too. And if hydrates or peats contributed some extra carbon into the mix, that would also have to be part of the bargain, like paying interest on a loan.”*
- ▣ **So, we’ve got a huge amount of work to do – let’s NOT spend our time as McPherson urges – which is grief-counselling each other while we wait to die by heat-exhaustion**