

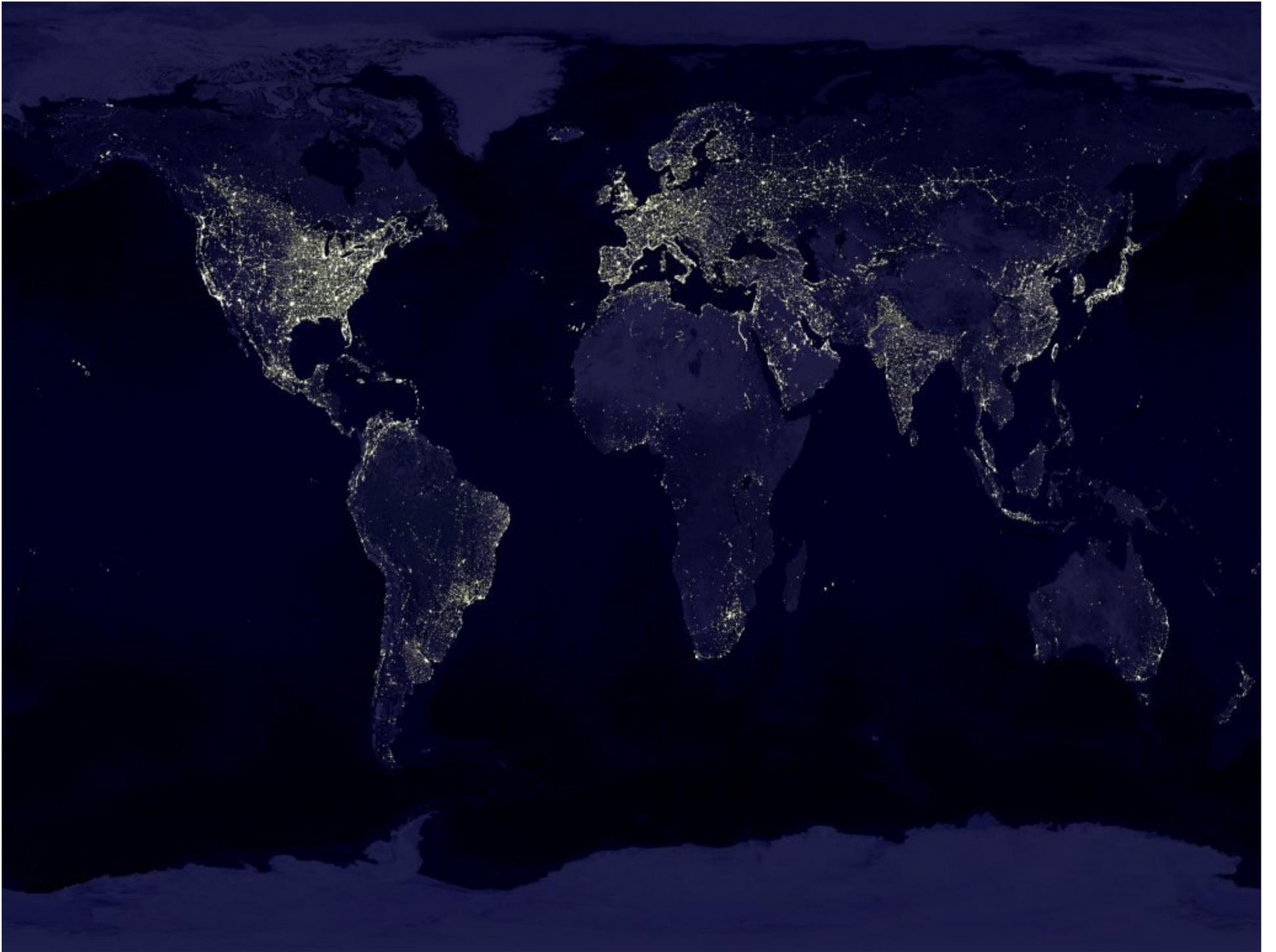
Sustainability

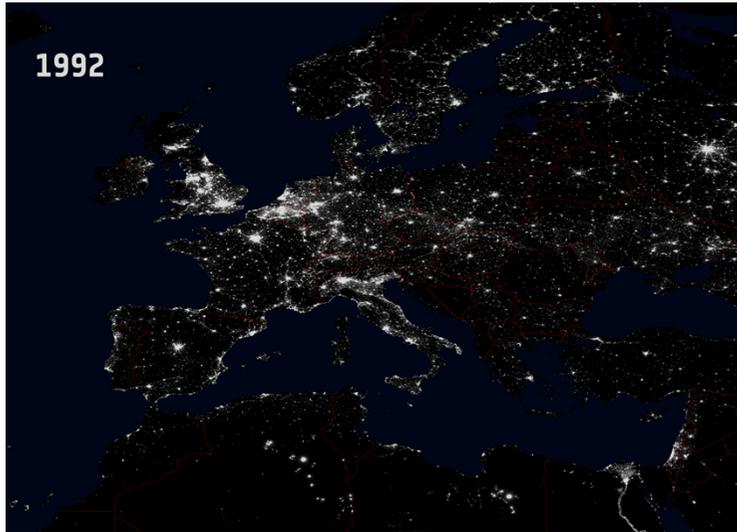
An Introduction to Facing Reality

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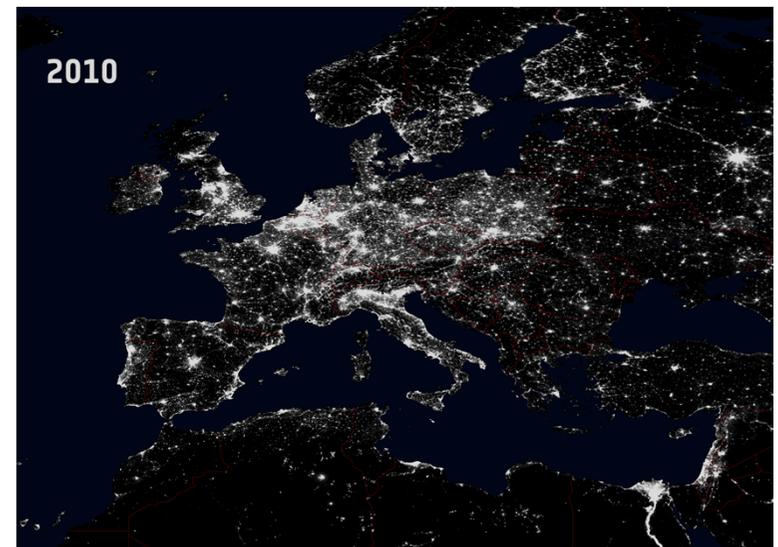




Times have changed

- We live in truly historic times
- We have sought dominion over the earth for as long as we have been a species

*In the last 30 years,
we have
demonstrably
achieved that goal*



Times have changed

- While all previous generations saw the earth as limitless in some way, all future generations will need to consider planetary limits
- **Sustainability** is our common goal
- To achieve that goal, we must understand how our planet functions

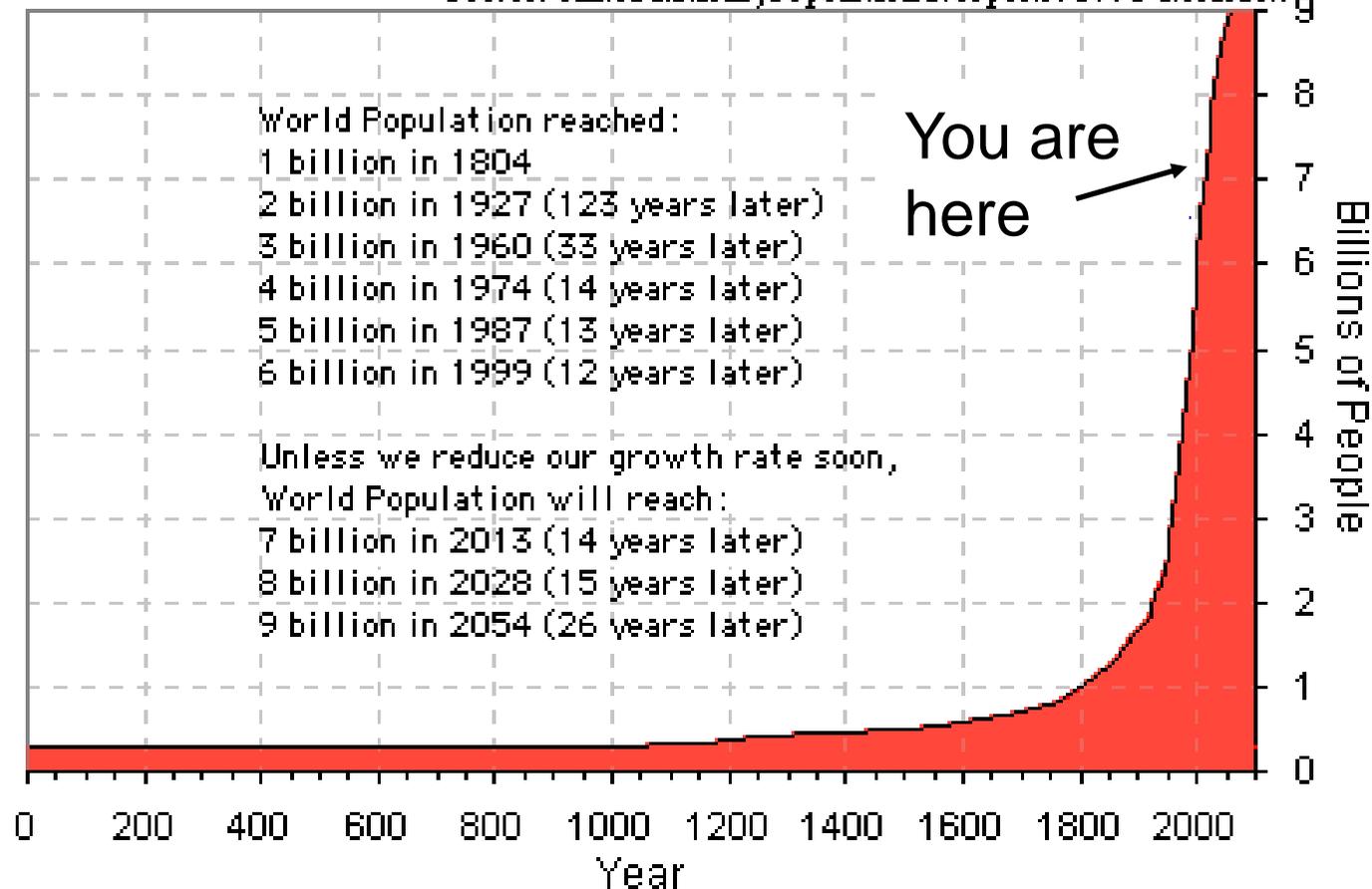
Is it surprising that humans are changing the planet?

- Simply put...we are impressive, the biggest cause of change on the planet.
- We have altered the Earth's energy balance *and changed climate*
- We cause 10 times more erosion *than all natural processes*
- We make more fertilizer *than all bacteria in the world*
- We make more sulfate *than all ocean phytoplankton*
- Our current energy needs equal *all harvestable wind energy in the atmosphere*

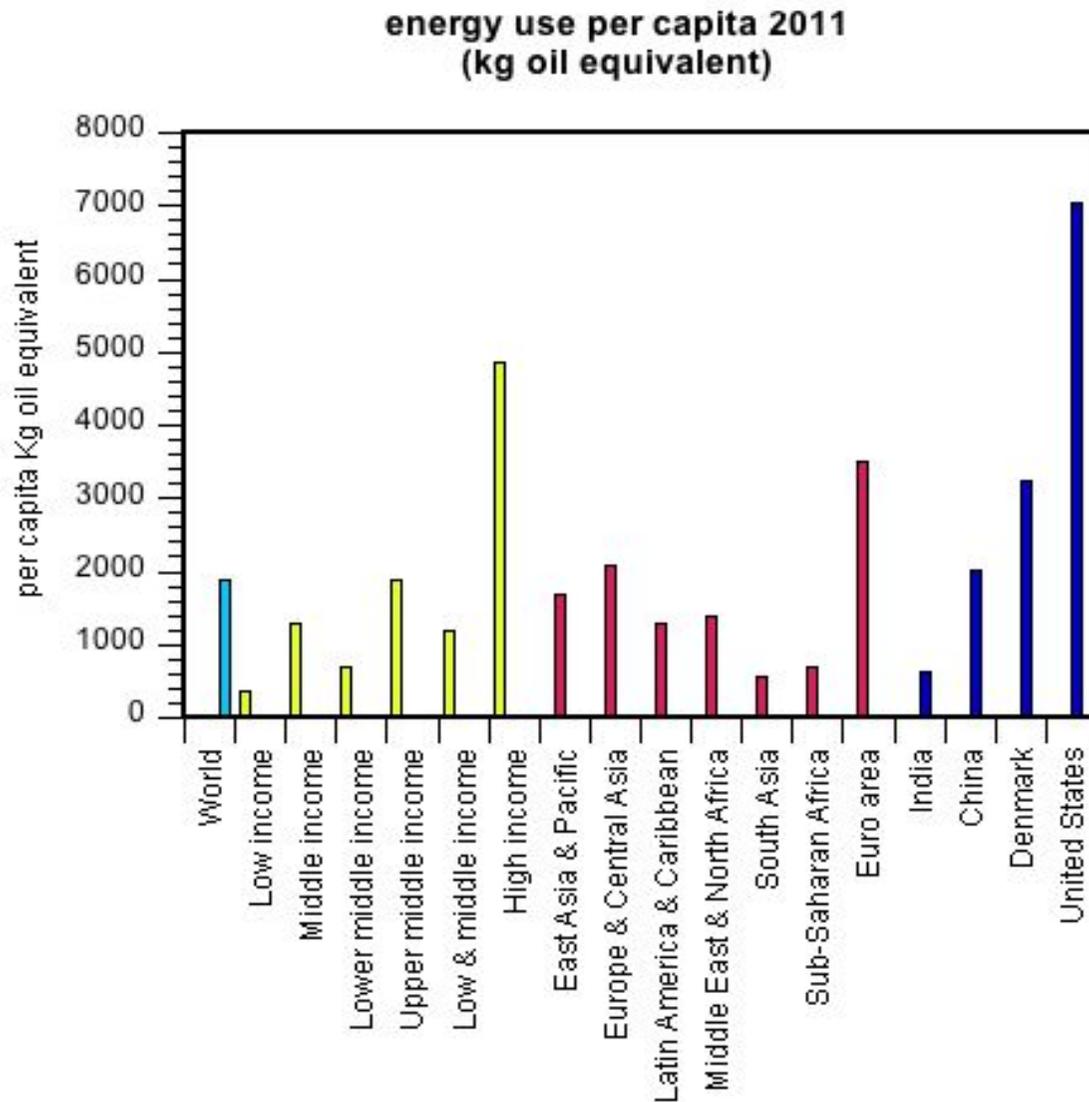
How is this possible?... the power of the exponential!

Population

Source: United Nations, Population Prospects: 2004 Revision



Use per capita: the multiplier

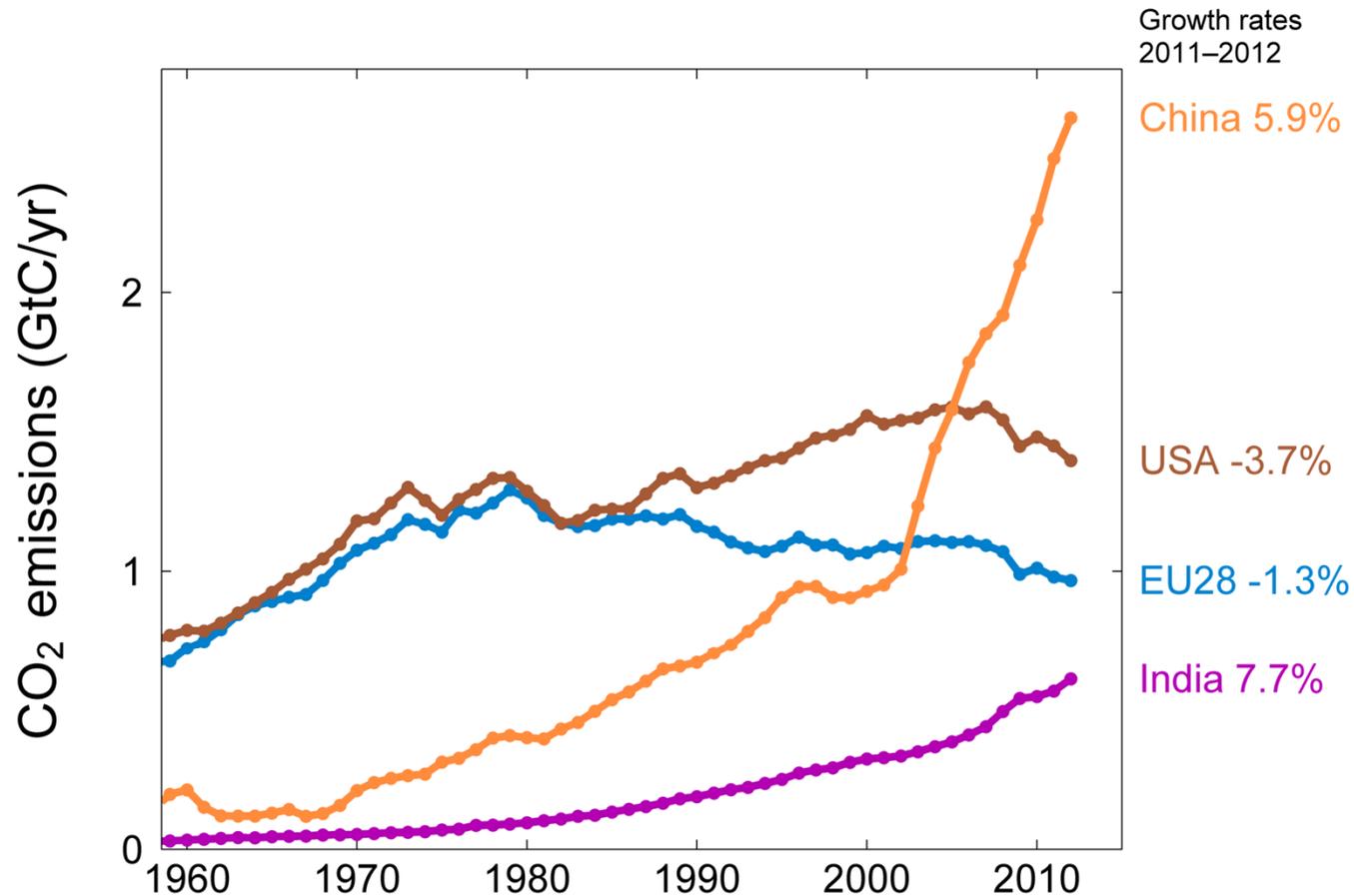


Low income: 3.5 times below middle income
India, South Asia: 5 times below Denmark
China: 1.6 times less than Denmark

The Nasty Dilemma:
we want others to live well, but if they do, the energy and resource needs will be staggering

A changing world

Top four emitters in 2012 covered 58% of global emissions
 China (27%), United States (14%), EU28 (10%), India (6%)



With leap year adjustment in 2012 growth rates are: China 5.6%, USA -4.0%, EU -1.6%, India 7.4%.

Source: [CDIAC Data](#); [Le Quéré et al 2013](#); [Global Carbon Project 2013](#)

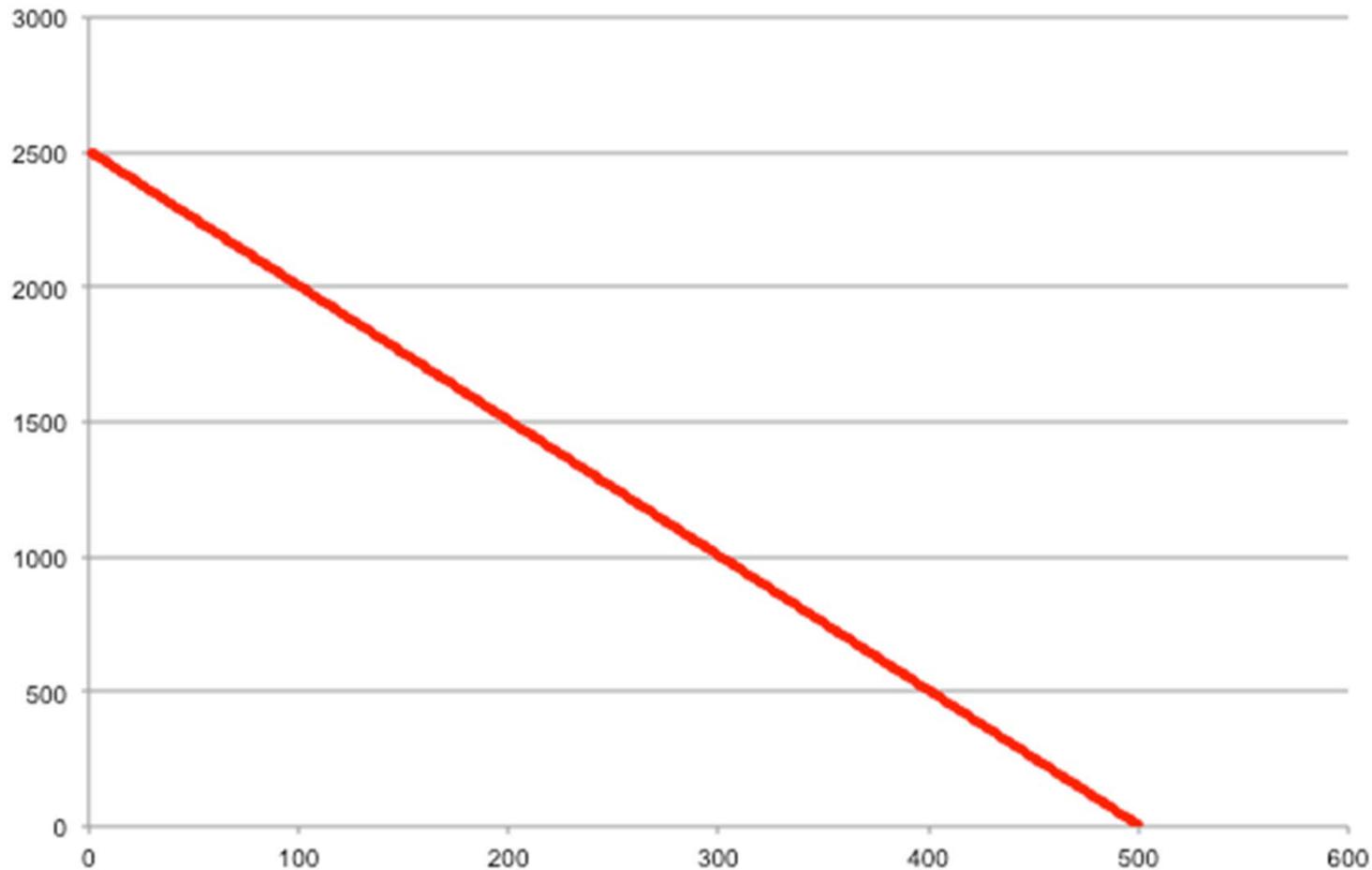
The challenge of global domination



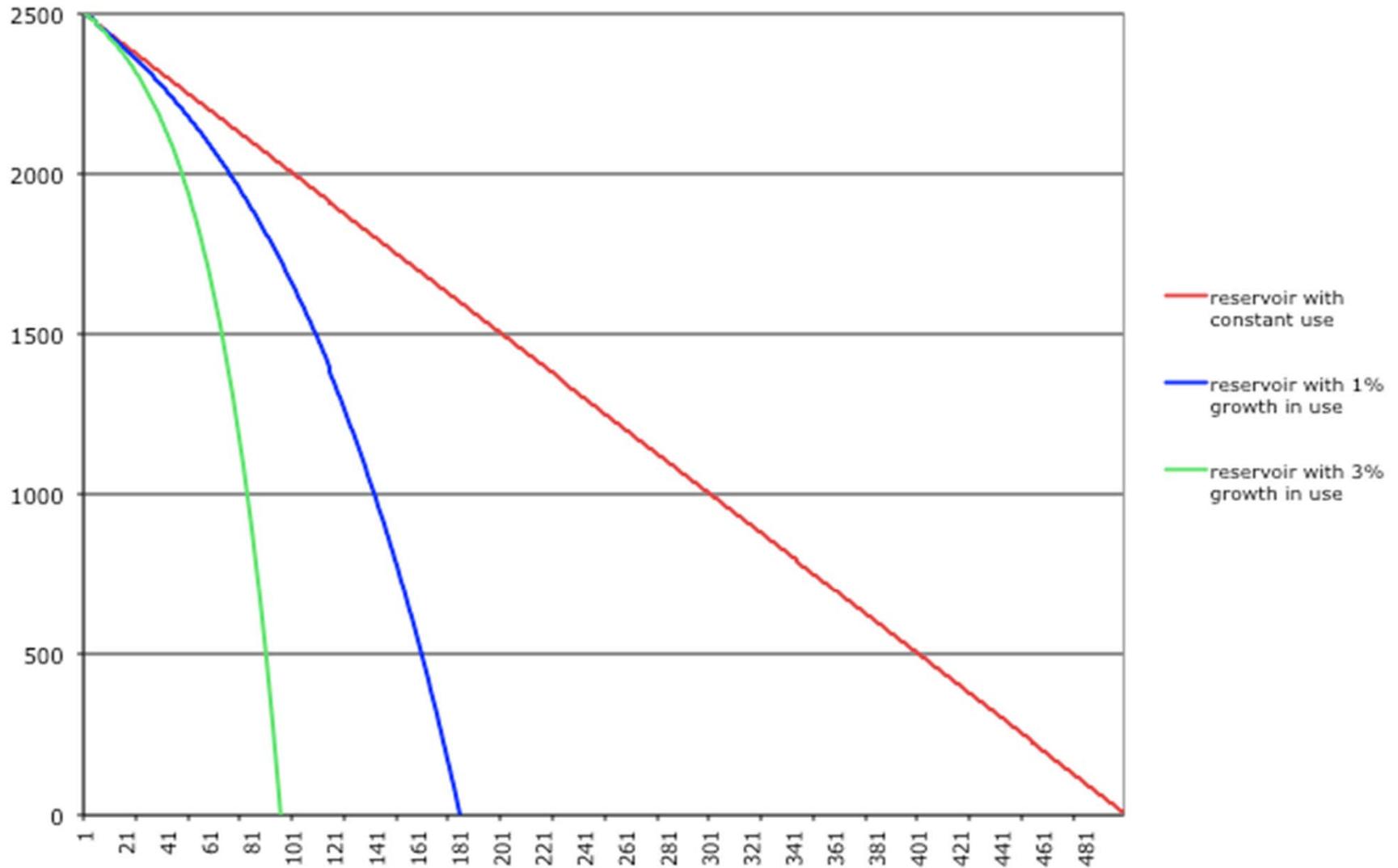
- **Unintended consequences**
 - Fertilize crops in central US: Mississippi Delta Dead Zone
 - Global commerce: species spread and ecosystem destruction
 - Fossil fuel energy: climate change
- **Costs of management**: replace ecosystem services
- **Costs of change**: mismatch of resource availability and need/use
- **Shrinking adaptation time**: coal example

The exponential: a hypothetical example

Coal Lifetime: 500 yrs, no growth in use



Coal Lifetime: 500 yrs, growth in use



Sobering thoughts...

Kyoto was passed in 1997...

Since then, CO₂ levels are ~ 20% higher...

in other words, about a fifth of all FF' s
ever burned were burned since 1997...

*One generation, the post WWII generation,
will burn nearly all of the oil and natural
gas economically available*

Beyond climate change



- Climate change is training wheels for sustainability
- Addressing this will require international cooperation, which will be needed to address bigger problems...
- *Every problem faced successfully is a step towards sustainability*

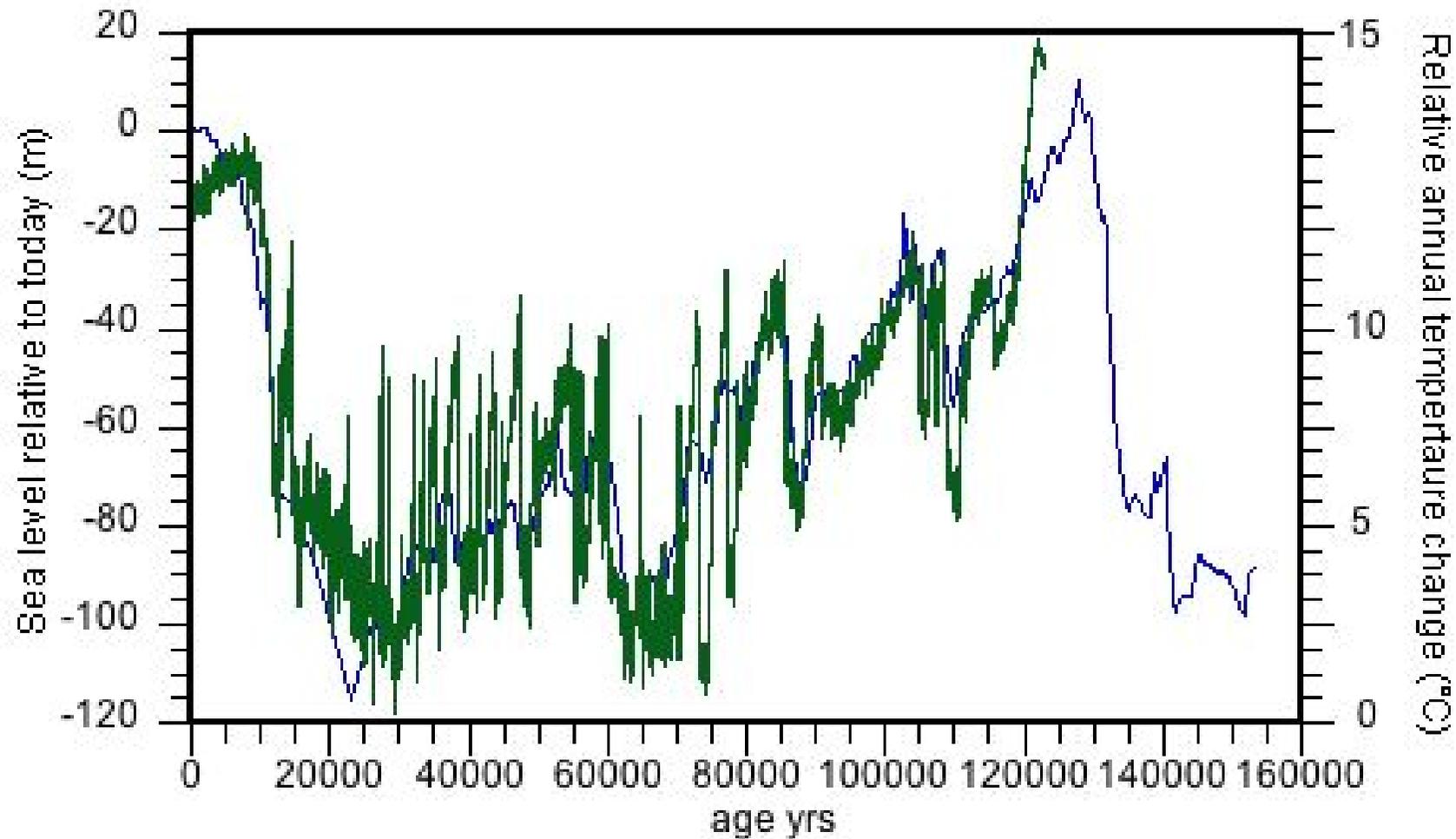


What keeps me up at night

- My personal list...
 - Abrupt climate change
 - Sea level rise
 - Freshwater and groundwater
- And others, of course, including food security, terrorism... but we only have a half hour.

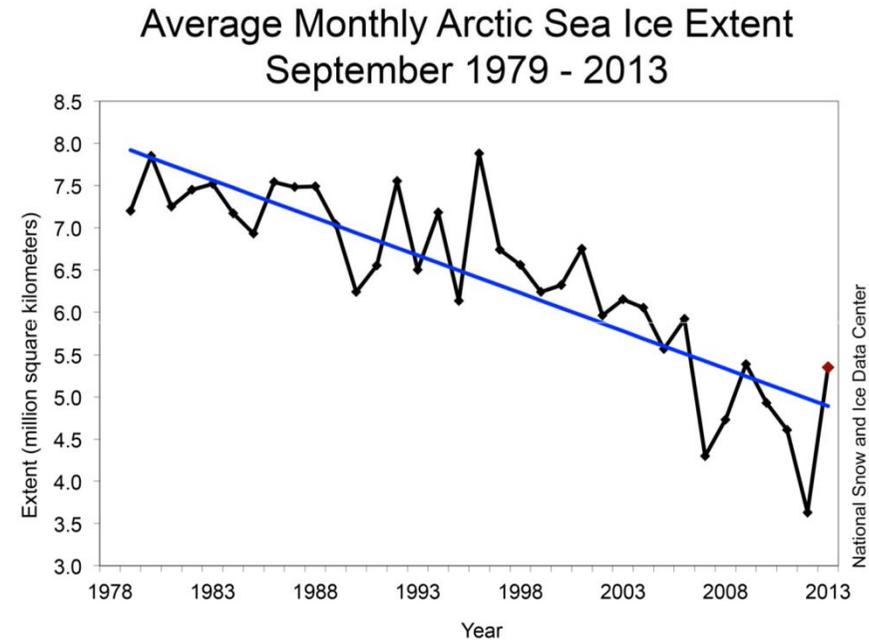
What keeps me up at night...

Abrupt climate change



Abrupt Climate Change is Happening TODAY

- Disappearance of summer time Arctic sea ice
 - Faster than anticipated
- Impacts on Arctic ecosystems, changes to shipping, coastal erosion



Abrupt change is happening NOW

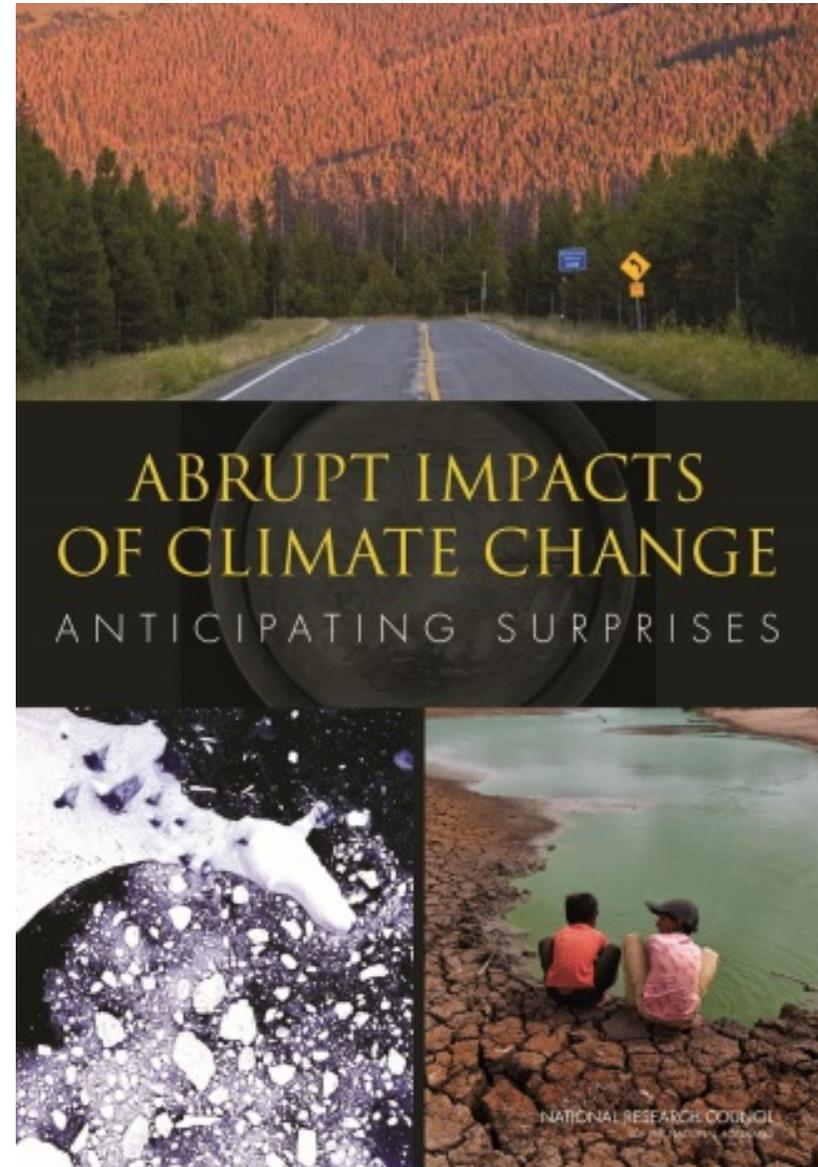
Arctic Sea Ice



Abrupt Impacts of Climate Change: Anticipating Surprises

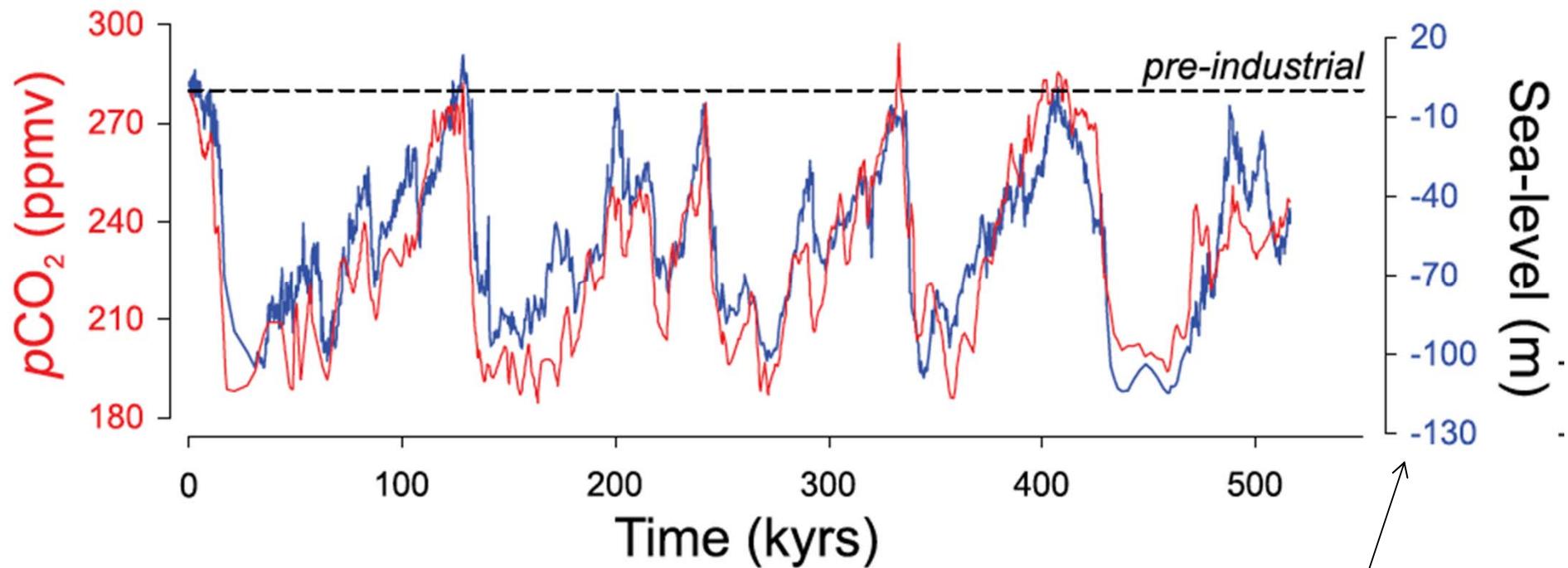
AmericasClimateChoices.o
rg

Twitter #abruptchange



What keeps me up at night...

It is normal on earth to trade sea water for land ice... very simple physics



Note the scale!!!

What keeps me up at night...

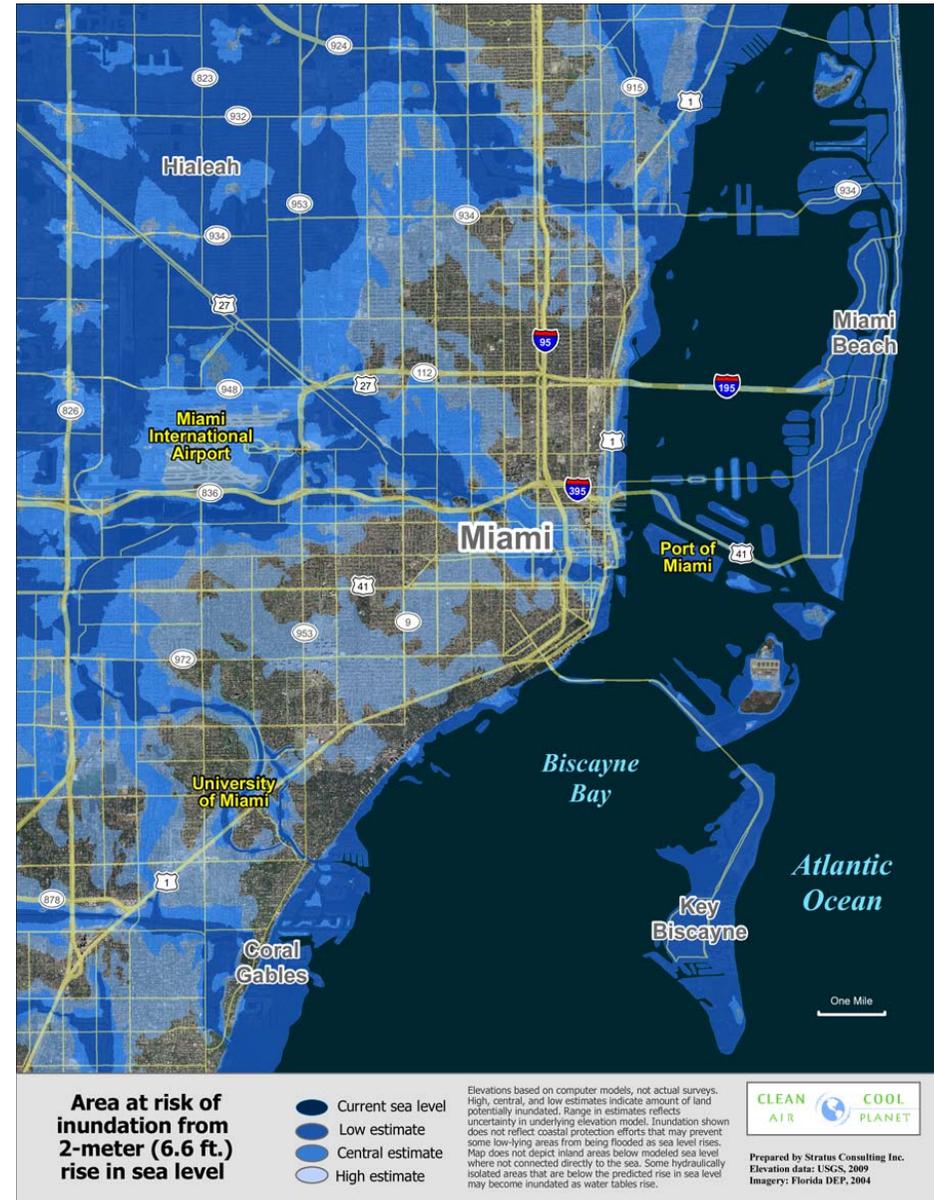
Sea level is rising: 1 meter by the end of this century is current estimate...
and it won't stop there...



What keeps me up at night...

Think about it...

Miami has no future much beyond this century... and Miami is not alone.



“Deep time” sea level and temperature

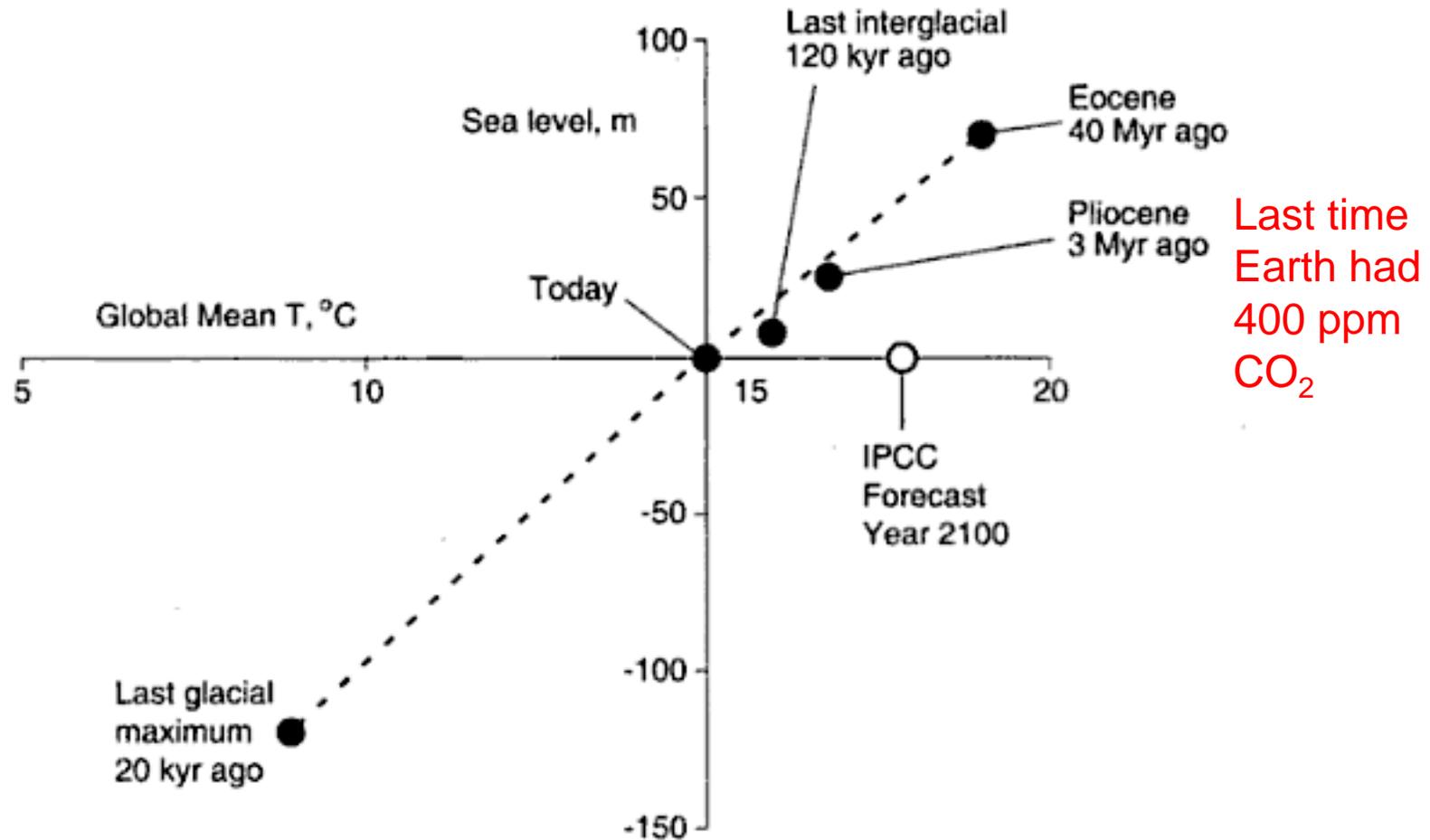
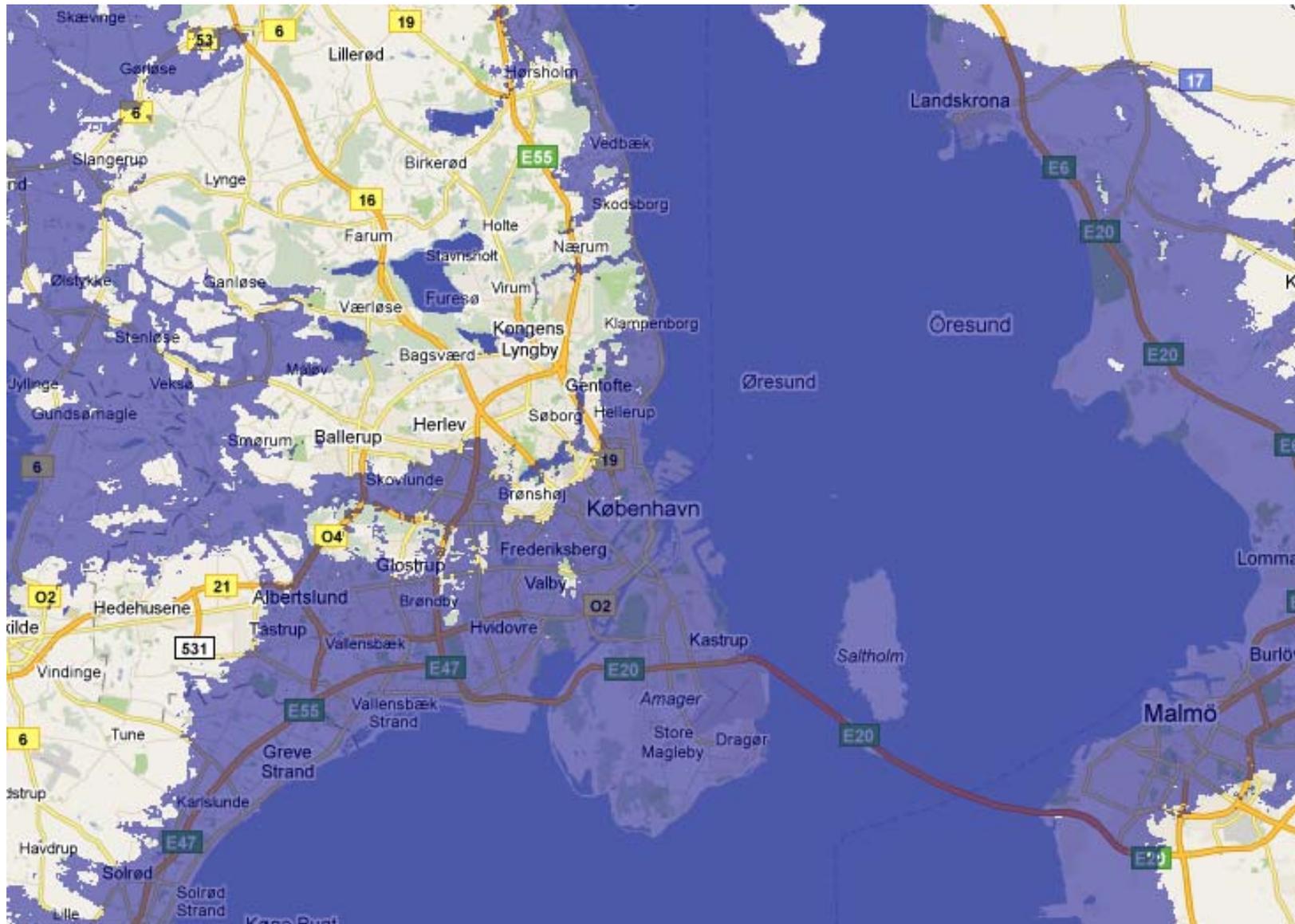


FIGURE 17. Covariation of sea level with global average temperature in the geologic past, compared with the IPCC forecast for sea level rise by the year 2100.

What does 20 meters (65 feet) of sea level rise look like?

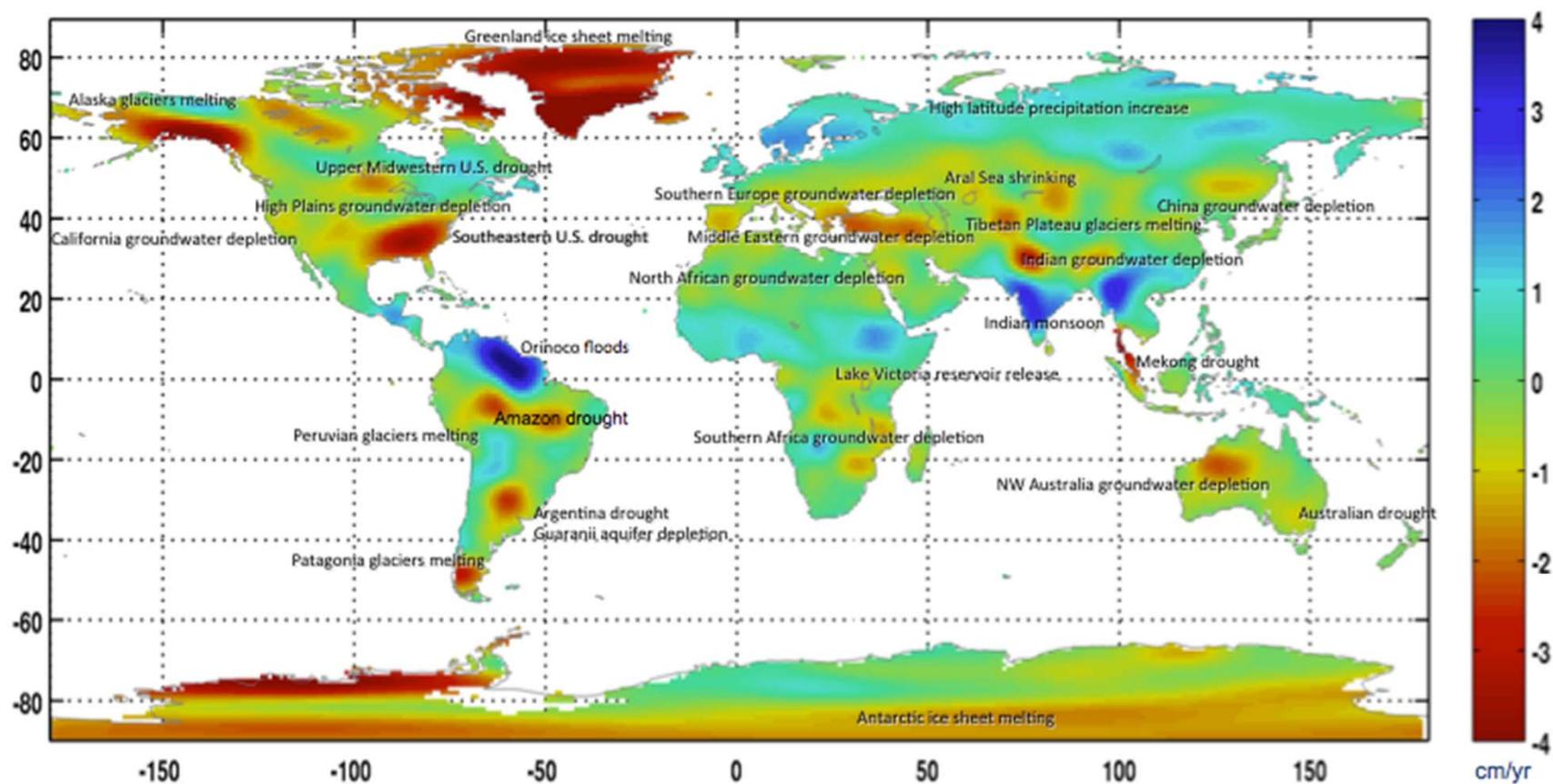


What does 20 meters (65 feet) of sea level rise look like?



What keeps me up at night...

Trends in groundwater storage: 2002-2010 GRACE



Adapt: Admit the inevitable

Its not just about energy... CH_4 and N_2O are food greenhouse gases... *some still think we can live without a large environmental footprint and that's not true.*

Mitigate: Do not go silently...

Hey! We're smart, resourceful, and fundamentally good. We can do better than an ostrich



Our children

The impacts come after the causes by 50 years or more: **ours is a water planet and it takes time to heat up the water...** *if cause and effect are not immediate, its hard to provoke action.*

Final comments: Responsibility



Ethics and economics

My 3 simple rules of sustainability:

1. Everything must cycle
2. Population must be controlled (equality of the sexes), and vary inversely with resource use per capita
3. Equity must be considered and acted upon