ZOOMING OUT IN TIME

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November 1, 2007

for more see http://math.ucr.edu/home/baez/madison/
All around we see hastening change:

Robert Fogel - *The Escape from Hunger and Premature Death, 1700-2100*
So far it relies on *burning carbon*:
Atmospheric Carbon Dioxide
Measured at Mauna Loa, Hawaii

Carbon dioxide concentration (ppmv)


Annual Cycle
Jan Apr Jul Oct Jan

Global Warming Art
So, the greenhouse effect is kicking in:
To understand what’s happening, we must *zoom out*:

Let’s look at two incidents:
- the ‘Little Ice Age’
- the ‘Younger Dryas’
During the ‘Little Ice Age’, roughly 1550–1850 AD, the temperature in Europe dropped about 1°C:

*A Scene on the Ice*, Hendryk Averkamp, Netherlands, 1608.
The ‘Younger Dryas’ began 12,900 years ago. In 20 years, the temperature in Europe dropped 7°C:

It lasted for about 1000 years, then suddenly ended!
Why? Some say the Gulf Stream warms Europe:
When the Ice Age ended, runoff from Lake Agassiz may have blocked the Gulf Stream and plunged Europe into a deep freeze.
Now Greenland and the Arctic are melting:

Could this trigger another ‘Younger Dryas’ event?
We don’t know. To get a better perspective we must zoom out more:

• **150 years ago:** Industrial Revolution, human-caused warming.
• **1,500 years ago:** widespread empires.
• **15,000 years ago:** tail end of the last Ice Age, first agriculture.
• **150,000 years ago:** tail end of the previous Ice Age.
• **1,500,000 years ago:** beginning of serious Ice Ages, first firemaking by humans.
• **15,000,000 years ago:** cooling of climate well underway; apes have split off from other monkeys.

... and look at climate change!
Barry Saltzman - Dynamical Paleoclimatology
Only by zooming out further do we see the full story:
65 million years ago, an asteroid 10 km (6 miles) across slammed into the Yucatan:
Millions of tons of rock were thrown into the atmosphere, with molten quartz setting wildfires around the globe:
It became too dark for plants to grow, and the dinosaurs died.
Afterwards, the biggest predators were 8-foot-tall ‘terror cranes’:
After 15 million years of warming, Antarctica separated from other land, and the Earth cooled:
Eventually Antarctica froze over:
and serious Ice Ages began:
Now it’s cold. What’s wrong with a little warming?
The problem is: it’s happening too fast!
Species have been migrating north at 6 kilometers per decade since 1950. They can’t keep up: since 1975, climate zones have been moving north at 4 kilometers per year!
We may be entering a new geological era: the *Anthropocene*.

We just passed the temperature record set 120,000 years ago, before the last Ice Age.

Just 1°C more, and the Earth will be hottest it’s been in 1.35 million years – when the Ice Ages began. We can expect this by 2050. By then, we may see the death of 15-37% of all species.

For comparable situations, we must zoom out more...

... to the Mass Extinction Events.
‘Luckily’, we’ll run out of oil in about a century:
But, there’s much more left to burn:

- Oil: 3 trillion barrels
- Natural gas: 1.1 trillion barrels
- Coal: 4.5 trillion barrels
- Tar sands: 4.3 trillion barrels
- Methane hydrates: 72,000 trillion barrels

Can we resist burning it all?

Many scientific observations point to the conclusion that the Earth is undergoing a period of relatively rapid change on timescales of decades to centuries, when compared to historical rates of change on similar timescales. Much scientific evidence indicates that these changes are the result of a complex interplay of several natural and human-related forces.

Notes by Philip Cooney, then chief of staff of the White House Council on Environmental Quality – now working for Exxon
In the long run, everything is okay.
A Mass Extinction Event is a sad thing...

...but life has a way of bouncing back, new and strange.
We’re unlikely to kill off life on Earth. Even if we do, there are 100 billion stars in our Galaxy:
and 10 billion galaxies in the observable Universe:
for a total of roughly

\[10^{21} = 1,000,000,000,000,000,000,000,000 \text{ stars.}\]

So, if we screw up, it’s no big deal... except for us, and our world!

Can we ‘zoom out’ in time?