

A Brief History of Climate - the last 66 million years

Earth's Geological Time

- *Pre-Cambrian* era 4,500 - 541 mya
- *Paleozoic* era 541 - 252 mya
- *Mesozoic* era 252 - 66 mya
- K-T Extinction 66 mya
- *Cenozoic* era 66 mya - Today

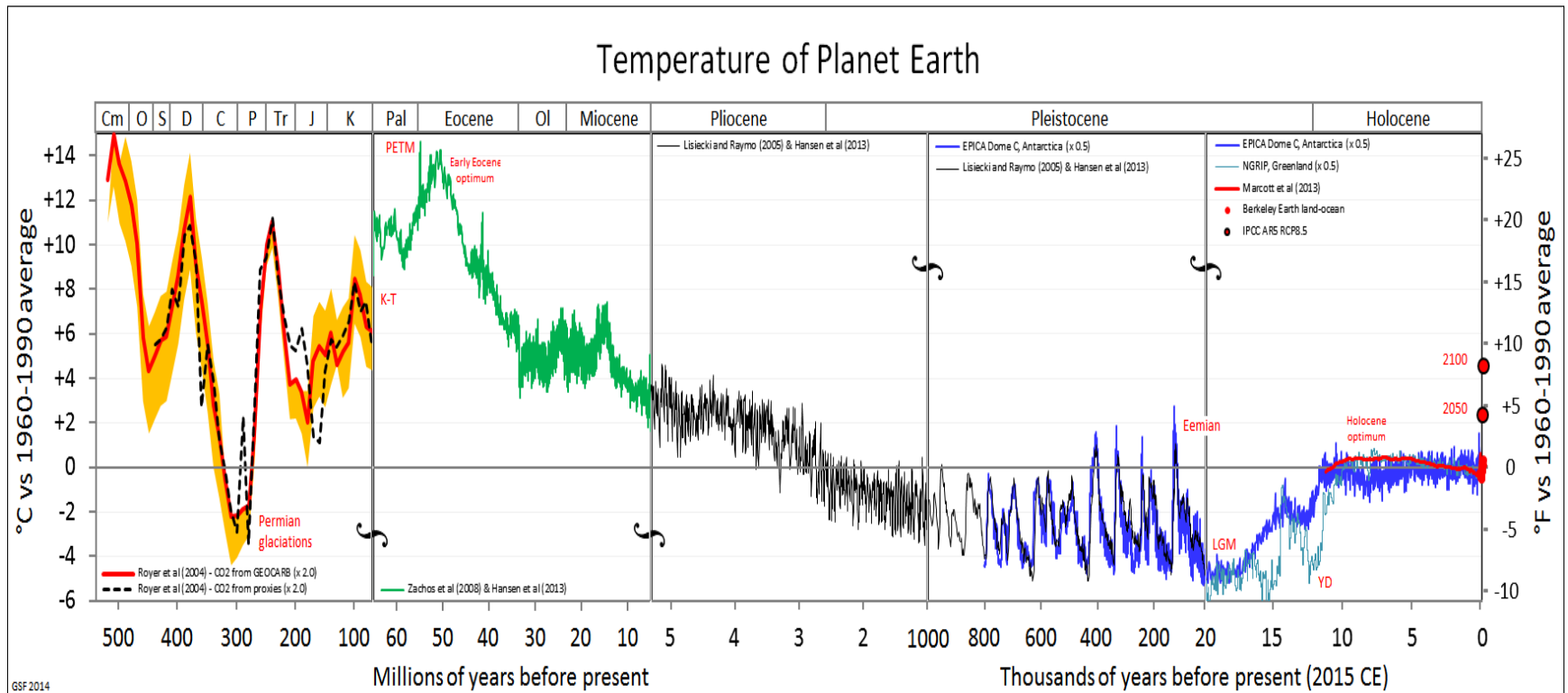
K-T Extinction

66 million years ago (mya)

- Defines end of mesozoic era and start of cenozoic era
- Asteroid (10 to 15 km diameter) hits earth
- Debris in atmosphere causes an “impact winter”
 - reduced sunlight
 - significant drop in temperature
 - may have lasted years
- Causes extinction of 75% of all plant and animal species
- No land animal species bigger than 10 kg survives
- But.....no long term influence on climate

Relative Global Average Surface Temperature

chart by Glen Fergus 2014



Early Cenozoic Climate

66 to 49 mya

- *Hothouse*
 - high temperature; global average temp almost double today
 - high rainfall
 - no ice; sea level almost 200 metres higher than today
 - all land rain forest
- Warming trend driven by high concentration of CO₂ in atmosphere

Early Eocene Thermal Maximum

Azolla Event - 49 mya

- *Azolla*
 - genus of freshwater aquatic fern
 - lives in symbiosis with a bacteria
 - fixes Nitrogen and CO₂ from atmosphere
 - can double biomass in 2-3 days
- Enclosed sea at north pole
 - stratified
 - freshwater surface layer
 - sterile bottom layer
 - 4 million square kilometres
- 800,000 years
- “Carbon capture and storage”
- CO₂ concentration in atmosphere reduced from 3000+ ppm to 650 ppm

Early Eocene to start of Pleistocene

49 to 2.6 mya

- Cooling and drying trend for this whole period
 - driven by reduced level of CO₂ in atmosphere
 - forest retreats and grassland develops
 - mammal species bigger than 10 kg evolve
 - first polar ice 10 mya
 - CO₂ concentration falls to 400 ppm 4 mya
- 2.6 mya enter *ICE AGE* earth
 - permanent ice caps at both poles
 - CO₂ concentration 250 ppm

Pleistocene and Holocene Epochs

2.6 mya to Present

- A relatively stable *ICE AGE* earth
- CO₂ concentration average 250 ppm
- Periodic maximum and minimum glaciations
 - Milankovitch cycles governed by earth's orbit
 - approx 100,000 years
- Only six degrees separates max and min glaciations
- Current epoch (Holocene) is near minimum glaciation
- Genus *Homo* evolves - but early extinction of all *Homo* species except *Homo Sapiens*
- *Homo Sapiens* has lived through two maximum glaciations, earlier *Homo* species maybe up to ten
- *An increase of more than 2 degrees from the 1961-1990 baseline will take the climate outside the Six Degree stable range of the last 2.6 million years*

Holocene Epoch

- The Entire History of Human Civilisation from Stone Age to Smart Phone in 11,000 years
- During this period the Earth's temperature has been remarkably stable within a range of One Degree
- UNTIL Humans began to mine and burn Fossil Fuels releasing CO₂ into the atmosphere
- *The resulting warming has already taken the climate outside the One Degree stable range of the last 11,000 years*

Margaret Thatcher

Speech to United Nations Nov 1989

- Of all the challenges faced by the world community ... one has grown clearer than any other in both urgency and importance ... The threat to our global environment.
- It is life itself – human life, the innumerable species of our planet – that we wantonly destroy.
- What we are now doing to the world ... is new in the experience of the earth. It is mankind and his activities which are changing the environment of our planet in damaging and dangerous ways.
- The result is that change in future is likely to be more fundamental and more widespread than anything we have known hitherto ... change which could alter the way we live *in the most fundamental way*.
- We have to look forward not backward and we shall only succeed in dealing with the problems through *a vast international cooperative effort*.
- Each country has to contribute, and those countries who are industrialised *must contribute more to help those who are not*.

Margaret Thatcher

Speech to United Nations Nov 1989

- We also have the example of the tragedy of Easter Island, where people arrived by boat to find a primeval forest. In time the population increased to over 9,000, and the demand placed on the environment resulted in its eventual destruction as people cut down the trees. This in turn led to warfare over the scarce remaining resources and the population crashed to a few hundred people without even enough wood to make boats to escape. The difference now is in the scale of the damage we are doing.

Preliminary Assessment

- In the last 30 years little or nothing has been achieved – production and consumption of fossil fuels has accelerated
- The climate is already outside the one degree range of the last 11,000 years
- CO₂ concentration in the atmosphere is already higher than it has been for 2.6 million years
- By the end of this century the climate will be outside the six degree range of the last 2.6 million years

Question

- *How Many People Can the Earth Support at What Reasonable Standard of Living Without Degradation to the Environment ?*
-
- By Who and How can this Question be Answered ?
- If it can be Answered, How can the Answer be Implemented ?
- *There is No Will or Political Structure to deal with this.*

Paris Agreement Dec 2015

- Goal of holding global warming to well below 2 degrees C compared to pre-industrial levels
- And of pursuing efforts to limit warming to 1.5 degrees C compared to pre-industrial levels
- Excludes international air and sea trade
- Each country to contribute with a Nationally Defined Contribution (NDC)

UN Emissions Gap Report 2017

- The NDCs that form the foundation of the Paris Agreement cover only approximately one third of the emissions reduction needed for the goal of staying below 2 degrees C
- Full implementation of the NDCs is consistent with a temperature increase of about 3.2 degrees C by 2100
- There is a significant distance between the current collective ambitions and commitments and what is required to meet the goals of the Paris Agreement

Case Study - Australia

- Almost a desert country – very vulnerable to climate change
- Recent countrywide temperature average over 40 degrees
- 2008 report, commissioned by the Australian government, predicted the impact of climate change on Australia
- Now experiencing horrendous bush fires which a senior politician says is “nothing to do with climate change - Australia has always experienced bush fires”
- Australia has an NDC plan to reduce emissions of CO2
- *BUT.....Australia is the world's biggest coal exporter with one third of all exports.....and it has plans to INCREASE exports by 30%*

UK Met Office

- Projections for three time periods - 2020s, 2050s, 2080s
- Three emissions scenarios - low, medium, high
- Various Probability Percentages - 10,30,50,67,90
- Regional Breakdown
- 2080s, medium emissions scenario, 50% probability
 - *SE England will have climate of 20th century Corsica*

New York Times Magazine Article 2018

Losing The Earth by Nathaniel Rich

Prologue

The World has warmed more than 1 degree C since the Industrial Revolution.

The Paris Climate agreement – the nonbinding, unenforceable, and already unheeded treaty – hoped to restrict warming to 2 degrees. The odds of succeeding, according to a recent study based on current emission trends, are 1 in 20.

2 degree warming has been described as ‘a prescription for long-term disaster’. Long-term disaster is now the best case scenario.

3 degree warming is a prescription for medium-term disaster.

It is now considered that 3 degree warming is the realistic minimum.

4 degree warming – Europe in permanent drought, vast areas of China, India, and Bangladesh claimed by desert, Polynesia swallowed by the sea, the American Southwest largely uninhabitable.....

5 degree warming has prompted some to warn of the end of human civilisation.

New York Times Magazine Article 2018

Losing the Earth by Nathaniel Rich

Epilogue

We know that if we don't act to reduce carbon dioxide emissions we risk the collapse of civilisation.

We know that whatever happens will be worse for our children, worse still for their children, and even worse for their children's children, whose lives, our actions have demonstrated, mean nothing to us.

We are incapable of sacrificing present convenience to forestall a penalty imposed on future generations. We have trained ourselves, whether culturally or evolutionarily, to obsess over the present, worry about the short (and maybe medium) term, and cast the long term out of our minds.

No single crisis can ever command the public interest for long, yet climate change requires sustained disciplined effort over decades.

Democratic societies are constitutionally incapable of dealing with the climate problem.

YouTube

- *A History of Earth's Climate*
 - *SciShow* Talk (4.5 billion years in 11 minutes)
- *How Ice Ages Happen; the Milankovitch Cycles*
and
Where Are We in the Milankovitch Cycles
 - two of a series *Its Just Astronomical*
- *Climate Change is Simple*
 - TED Talk by journalist David Roberts
- *Carbon Capture - Humanity's Last Hope*
 - one of a series *Real Engineering*

Conclusion – Human Time Scale

- Population 7 billion, forecast to grow to between 9 and 11 billion by 2100
- 35 billion tons of CO₂ added to atmosphere each year, forecast to increase to 40 billion tons by 2040
- Fossil fuel production plans for 2030
 - 50% more than consistent with 2 degree limit
 - 120% more than consistent with 1.5 degree limit
- CO₂ concentration now over 400 ppm, forecast to increase to between 600 and 900 ppm by 2100
- Average temperature now more than one degree above pre-industrial level, forecast to increase to between 4 and 6 degrees by 2100

Conclusion – Geological Time Scale

- 49 million years ago the *Azolla* fern, by changing the level of CO₂ in the atmosphere, triggered a cooling trend which turned the earth from *Hothouse* to *Ice Age*
- Today are humans, by changing the level of CO₂ in the atmosphere, triggering a warming trend which will turn the earth from *Ice Age* to *Hothouse* ?