The scientific case for CCS- recent developments

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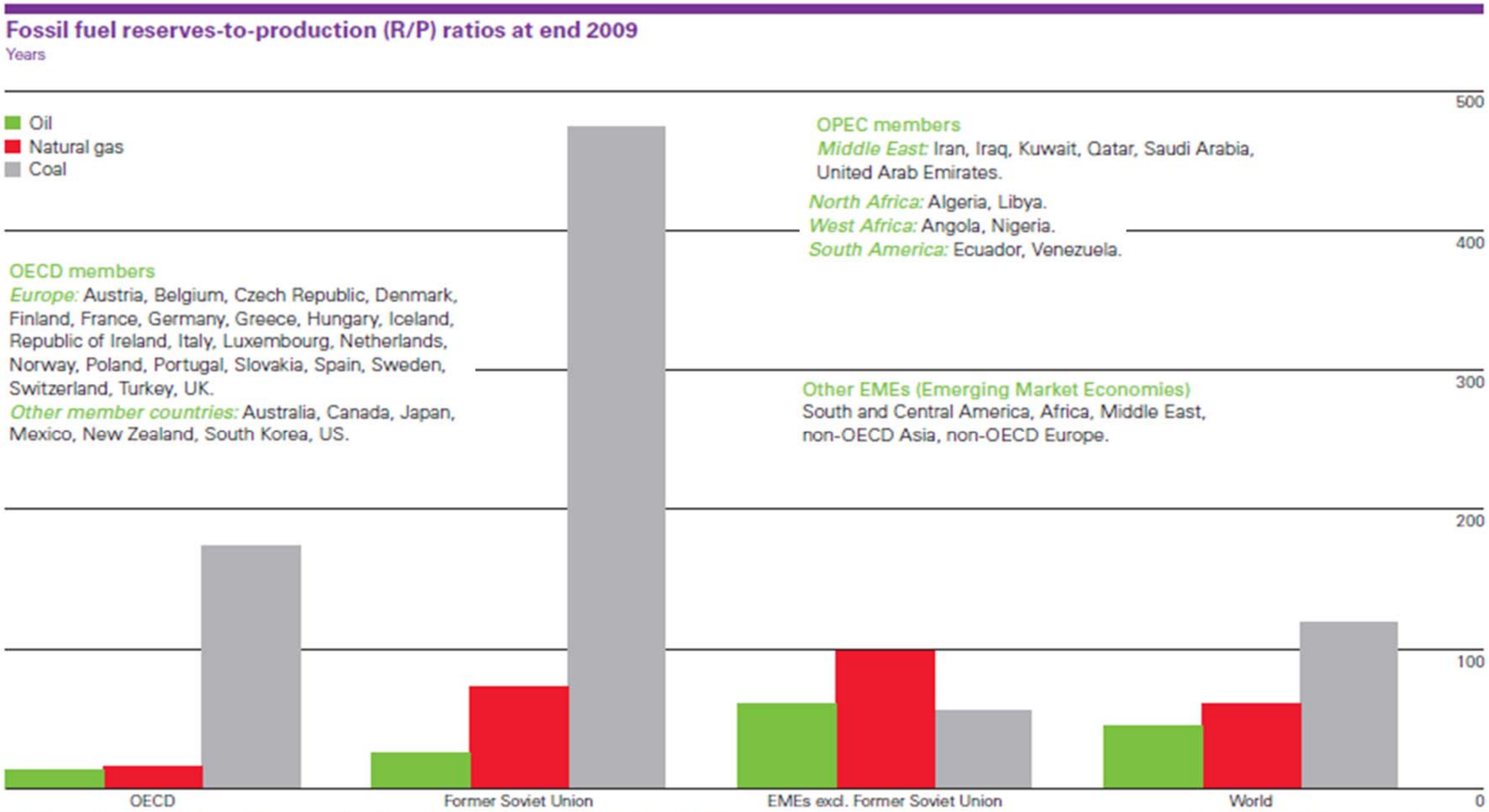
Why CCS?

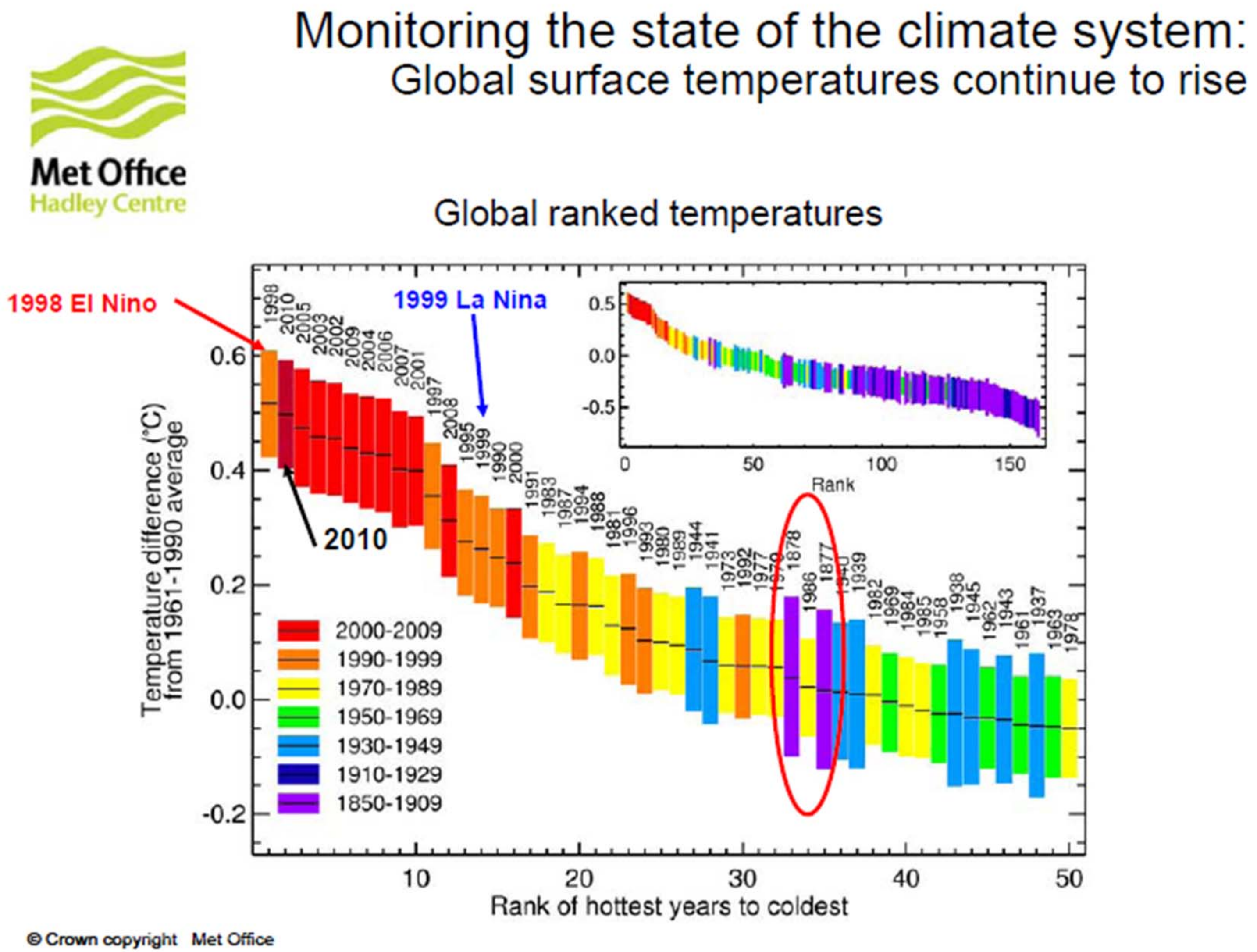
- The only justification for CCS is to mitigate emissions from fossil fuel use in order to reduce the risk of atmospheric & oceanic build up fossil fuel derived green house gases (especially CO2).
- There is no economic case for CCS without this justification.
- So what is recent scientific evidence telling us?

BP statistical review 2010



While coal remains the world's most abundant fossil fuel, with an R/P ratio of 119 years, proved reserves of oil and natural gas increased in 2009 and have tended to rise over time. OECD countries account for less than 10% of global proved reserves for oil and natural gas, but 42.6% of proved coal reserves.

Average Annual Global Surface Temperature Rankings

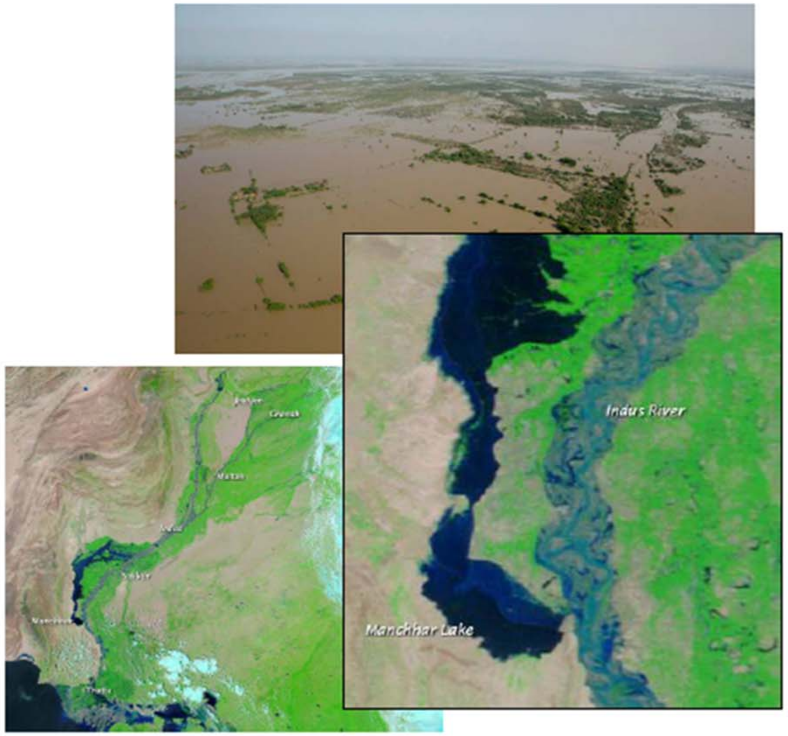


Solar Forcing

Lockwood & Fröhlich (2007) demonstrated that since 1987 the long-term changes in solar outputs, which have been postulated as drivers of climate change, have been in the direction opposite to that required to explain, or even contribute to, the observed rise in Earth's global mean air surface temperature (GMAST). Since then, the solar trends noted by these authors have continued. By the end of solar cycle 23, the annual mean of the open solar magnetic flux (deduced from geomagnetic activity) had fallen to a value last seen in 1924, in the minimum between sunspot cycles 15 and 16 (Lockwood *et al. 2009). Other aspects of this* decline in solar activity are reviewed by Russell *et al. (in press). In this paper (Lockwood et Al 2010),* we study the implications.

2010- an exceptional year for global climate impacts

Met Office



Pakistan Floods

Worst flooding since 1929

- 1781 people dead
- 2966 people injured
- 20 million people affected in more than 11000 villages
- Area size of England affected
- Destroyed 23% of national crop ($2.5bn agriculture lost)
- 1.9m houses damaged
- $5bn wiped off expected growth

2010- an exceptional year for global climate impacts

Russian Heatwave and Wildfires

Met Office

Worst drought since record began (130 years)

- 558 active forest fires, consuming 180 ha
- Moscow temperature record 37.4°C (99.3°F)

- 52 dead, 3000 homeless
- Grain harvest reduced by 30%.
- Global wheat prices risen 50% from June to August 2010 (fastest rise since 1973).

2010- an exceptional year for global climate impacts

Chinese Summer Floods and Landslides

Met Office

- Worst flooding in a decade
- 25 rivers at record high levels
- Three Gorges dam near capacity

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- Millions displaced nationwide
- 645,000 houses toppled
- $21bn estimated total damage
- 1.36m hectares of crops affected
- 1,117 people dead, more than 600 missing in Gansu landslide

2010- an exceptional year for global climate impacts

Queensland Flooding

- Cost to Australian economy of at least A$10 billion
- Farmers expected losses from the floods to top $1.5billion (£948m)
- Coal sector loses sales worth A$2,3-billion due to flooded mines
- Stockpiles of coking coal exhausted in late January 2011 due to reduced rail capacity
- Cotton farmers lose one-third of their crop…. but look forward to a bright season in 2011-12, with high levels of moisture in soil and irrigation systems!

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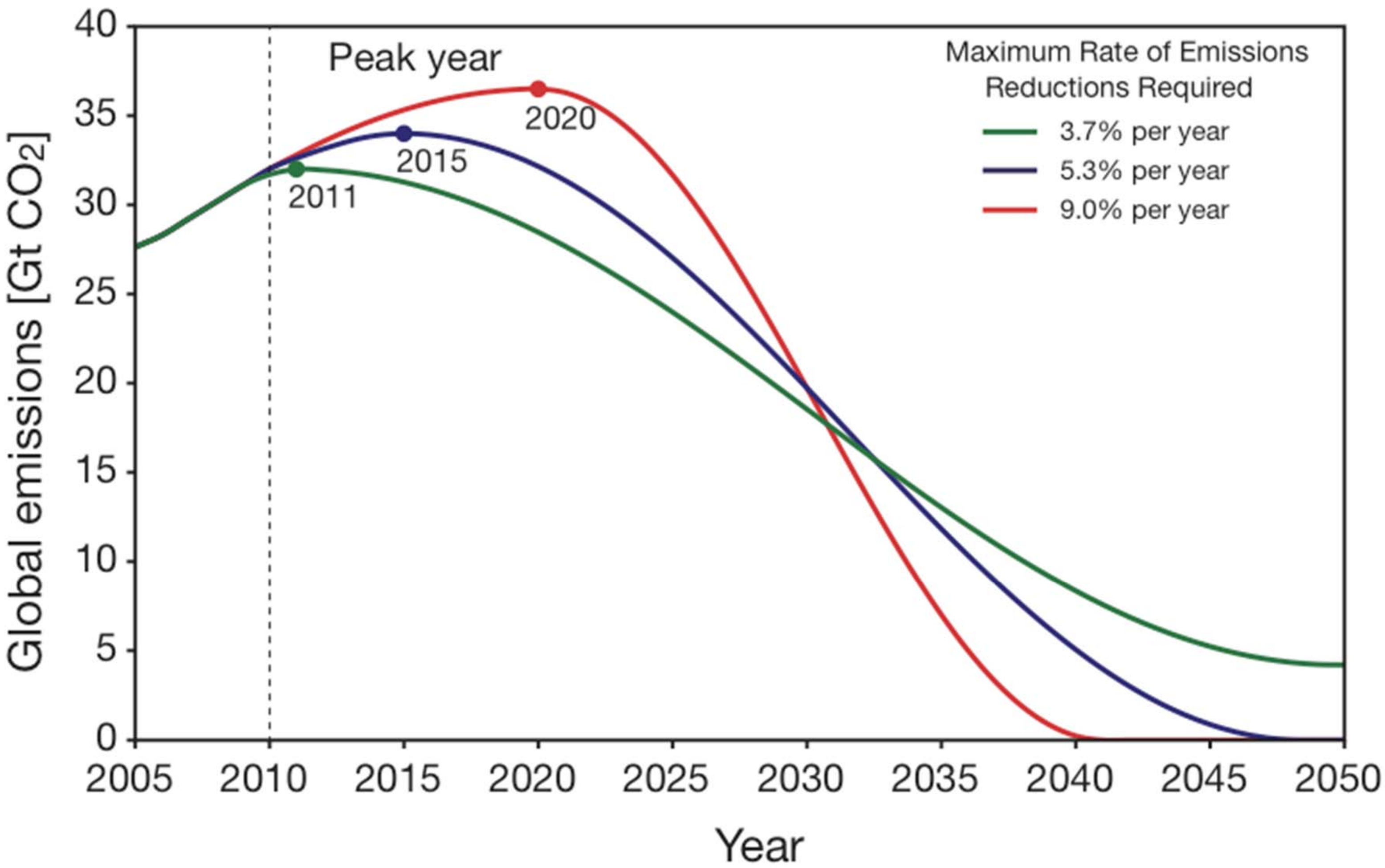
Emissions pathways to give 75% chance of limiting global warming to 2ºC



(Copenhagen Diagnosis)

Global CO2 emissions

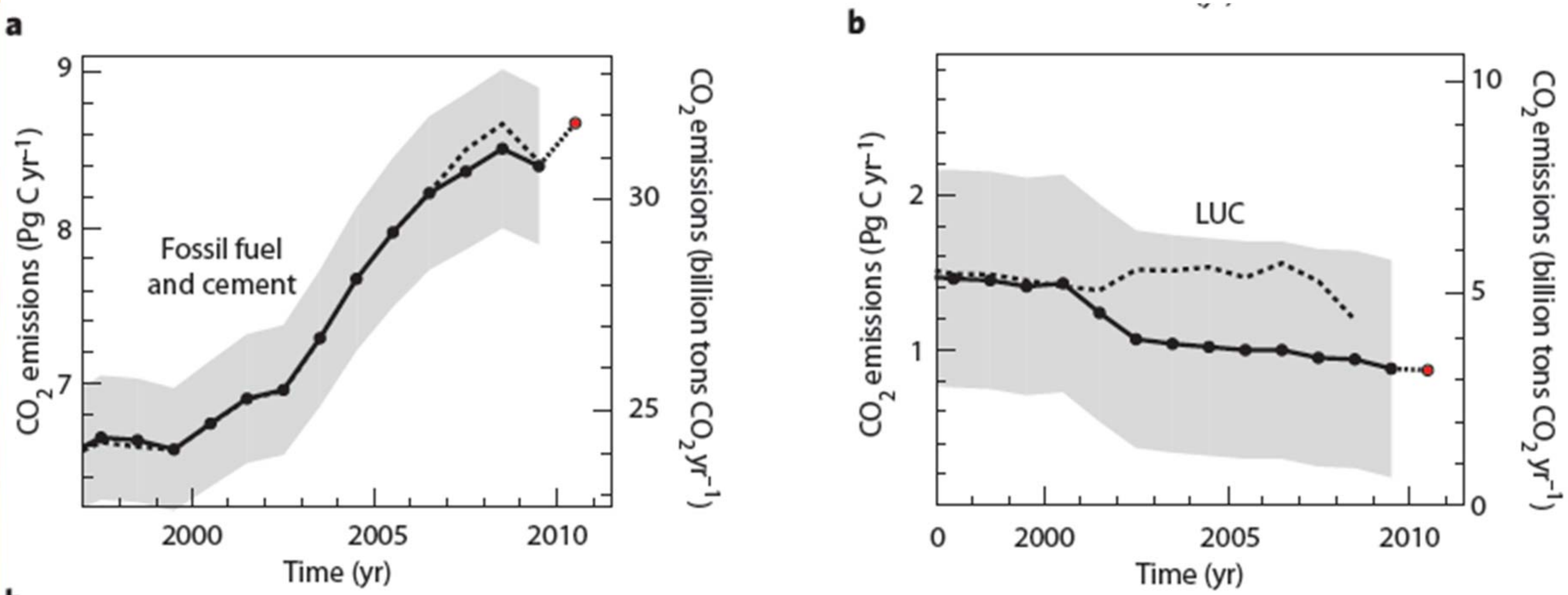


Figure 1 | Global CO_2 emissions since 1997 from fossil fuel and cement production (**a**) and LUC (**b**). Fossil fuel CO_2 emissions were based on United Nations Energy Statistics to 2007, and on BP energy data from 2007 onwards[6,7]. Cement CO_2 emissions are from the US Geological Survey. LUC CO_2 emissions were based on the revised statistics of the Food and Agricultural Organization[5,9]. Both sources of emissions are updated from ref. 1 (shown in black dashed line). Projections for 2010 are included in red.

(Global Carbon Project, 2010)

Arctic Warming

Arctic paleoclimate proxies in lake and marine sediments, tree rings, and ice cores indicate that from the mid-19th century the Arctic not only warmed by more than 1 °C average in comparison with the "Little Ice Age" (Overpeck et al., 1997), but also reached the highest temperatures in at least the last two thousand years (Kaufman et al., 2009). This warming sharply reversed the long-term cooling trend that had likely been caused by the orbitally-driven decreasing summer insolation with the positive feedbacks from ice and snow albedo (e.g., Otto-Bliesner et al., 2006b). Subglacial material exposed by retreating glaciers in the Canadian Arctic corroborates that modern temperatures are higher than any time in at least the past 1600 years (Anderson et al., 2008). An even longer perspective for the outstanding magnitude of the modern warming and related ice loss is provided by the history of ice shelves at the northern coast of Ellsemere Island, which are made of super-thickened landfast ice supported by pack ice in the adjacent Arctic Ocean. These ice shelves have been stable for most of the last 5.5 kyr based on driftwood ages (England et al., 2008), but declined by more than 90% during the 20th century and continue to break at a notable rate (Mueller et al., 2008).

(Polyak et al 2010 "The history of sea ice in the Arctic")

CLIMATE CHANGE

Human influence on rainfall

Rising concentrations of anthropogenic greenhouse gases in the atmosphere may already be influencing the intensity of rainfall and increasing the risk of substantial damage from the associated flooding. SEE LETTERS P.378 & P.382

LETTER

Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000

Pardeep Pall[1,2]†, Tolu Aina[3], Dáithí A. Stone[1,4], Peter A. Stott[5], Toru Nozawa[6], Arno G. J. Hilberts[7], Dag Lohmann[7] & Myles R. Allen[1,4]

LETTER

doi:10.1038/nature09763

Human contribution to more-intense precipitation extremes

Seung-Ki Min[1], Xuebin Zhang[1], Francis W. Zwiers[1]† & Gabriele C. Hegerl[2]

Increased flood risk linked to global warming

Likelihood of extreme rainfall may have been doubled by rising greenhouse-gas levels.

Figure 1 | The floods of autumn 2000. Geese take to the inundated streets of York, northern England.

2011

The Northern Hemisphere has had its most intense Spring stratospheric ozone hole yet observed.

The hole is a consequence of unusually low stratospheric temperatures.

This observation is consistent with rising green house gas concentrations in the troposphere below.

Ocean Acidification

CCS is needed to prevent fossil fuel emissions acidifying our oceans

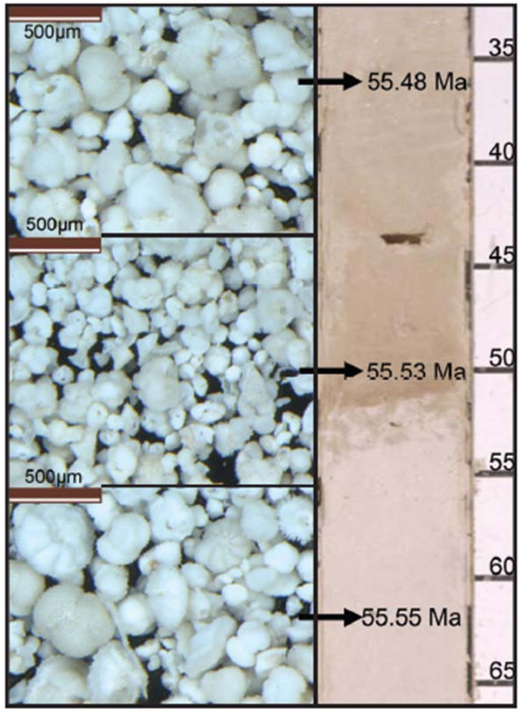


Figure 1: Core section from Shatsky Rise ODP Site 1210A, showing reduced carbonate preservation at the Paleocene-Eocene Thermal Maximum. During the PETM 30-50% of deep-sea benthic foraminifer species suffered extinction (Thomas, 1998). The scale bar on the right indicates depth of the core section in cm, which reflects on the lower sedimentation rate after the onset of the event. Picture credit: Laura Foster, University of Bristol; dates after Westerhold et al. (2008).

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