"The fatal consequences of atmospheric CO_2-e levels higher than 450 ppm"

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INTRODUCTION

The aim of this submission is to indicate that, given CO_2 levels of 387 ppm by 2008, (or 455 – 465 ppm CO_2-e including methane and nitric oxides), <u>atmospheric levels of carbon gases are already within the high danger zone</u>, requiring attempts at fast track reduction in order to avert further climate change and related extreme weather events.

Estimates of atmospheric CO_2 levels based on CPRS emission reduction schemes of 5, 15, 25 and 40 percent for 2020 relative to 2000 indicate the continuing emission of CO_2, coupled with feedback effects, will move the atmosphere into increasingly dangerous territory well above CO_2-e level of 450 ppm.

The above is detailed below in sections concerned with:

A. The connection between recent extreme weather events in Australia and global climate change trends.

B. The relations between industrial carbon gas emissions and atmospheric CO_2 levels from 1950. It is shown that proposed CPRS measures to date are unable to prevent further dangerous climate change.

C. The consequences of atmospheric CO_2-e levels above 450 ppm and corresponding mean global temperatures.

D. The carbon reduction scenarios discussed by Anderson and Bowes, 2008 ("Reframing the climate change challenge", Phil. Trans. R. Soc. doi:10.1098/rsta.2008.0138), raising the specter of Earth warming at the maximum of IPCC projections, as is indicated by Rahmstorf (2007) and the recent climate congress in Copenhagen. http://climatecongress.ku.dk/newsroom/congress_key_messages/

EXECUTIVE SUMMARY

The scale and urgent nature of the of dangerous climate change leave law makers only two options:

Option A: Business a usual, leading to unacceptable consequences of current climate change, including extreme weather events (drought, fire, floods, cyclones) and sea level rise

Option B: Urgent deep reductions in Carbon gas emissions coupled with fast track development of CO2 draw-down technologies, possibly coupled with geo-engineered atmospheric albedo enhancement aimed at gaining time.

Stretching from the equator to increasingly dry mid-latitudes, the Australian continent is particularly vulnerable to extreme weather events arising from climate change. We recommend a multi-pronged effort at mitigation and adaptation, including:

A. Fast deep reduction in carbon emissions – the root cause of global warming, setting Australia as a leader of new climate mitigation technology.

B. Fast-tracking alternative energy sources, including base grid solar-thermal and geothermal energy, wind, tide and hydrogen utilities.

C. Construction of long-range water conduits and irrigation networks, powered by renewable energy, for channeling water from the north to southern Australian agricultural zones and cities, sea water desalination plants, water-from-wind technology and drip farming technology.

D. Government grants for invention and application of CO2 filtering technology and atmospheric CO2 draw-down sequestration.

Whereas the current global economic woes are hopefully reversible, it will not be of much help if economic recovery takes place on a rapidly warming Earth – a process which we are concerned may not be reversible within the lifetime of many generations to come.

Indeed the current global financial crisis provides a unique opportunity to rapidly phase out-of-date carbon intensive industries and develop innovative forward-looking renewable energy and carbon-efficient industries. These are the new growth industries and will provide more jobs.

A. The connection between recent extreme weather events in Australia and global climate change trends.

Consistent with projections made by numerous climate research institutions, global warming is leading to intensified droughts, fire conditions, hurricanes, ice melt, and emission of methane from permafrost, sediments and tropical bogs. The recent and ongoing tragic fires in the State of Victoria, droughts in southern Australia, and floods in northern New South Wales and Queensland, constitute extreme weather events closely associated with the rapid progression of global climate change beyond reasonable doubt [**Attachment A**]. There is evidence that fire frequency in the past has been higher during periods of rapid climate change.

Rising land temperatures related to a pole-ward shift of climate zones, estimated at about 400 km, combined with warm air currents derived from the Indian Ocean northwest of Australia, result in tinder-box conditions in southeast Australia forests, which are adapted to cooler and wetter mid-latitude conditions, and to wetter conditions in northern Australia.

These developments are related to the rise of mean global temperature by about 0.8°C since the 19th century, with fastest mean temperature rise in the poles (**Figure 1**). Since 1990 CO_2 levels, mean temperature and sea level have been tracking at the top of IPCC projections **(Figure 2)**. By 2008 atmospheric CO_2 levels (387 ppm) have already risen some 38 percent relative to the maximum CO_2 levels of 280 ppm, which allowed the development of agriculture and thereby development of civilization some 8000 years ago.

The evidence for global acceleration of climate change is profound and extensive, including cyclones and floods in the Caribbean, southwest Pacific, Indian Ocean, droughts and bushfires in Australia, California and Borneo, southern Europe, the threat to the Amazon forest ("lungs of the Earth"), near-disappearance of Arctic Sea ice, collapse of west Antarctica ice shelves and accelerated warming and melting of the Greenland and Antarctica ice sheets. While none of these individual events or changes can be definitely explained by global climate change, enough evidence is now available to connect the dots, namely attribute these events to trends and patterns inherent in global warming.

The onset since ~AD 1750 of anthropogenic forcing, consequent on emission of >300 Gigaton carbon, threatens to lead the atmosphere to temperatures above those at which the large ice sheets, which govern the Earth's temperatures, remain stable, and out of the delicately balanced environments in which numerous species and human agriculture can survive (**Figures 3 – 5**).

There is now a large body of evidence that the Earth's atmosphere is acutely sensitive to even minor rises in mean global temperatures. Through human history temperature changes an order of magnitude smaller than current climate change have brought the collapse of civilizations.

Current CO_2 rise rates over 2.0 ppm/yr are near five times the rate of increase earlier in the 20th century, and more than an order of magnitude higher than during glacial terminations **(Table 1).**

Although climate model projections to date can hardly define the precise timing of climate tipping points, the increased intensity of extreme weather events around the globe may signal a tipping point is near. When "in the eye of the storm" one may be not fully aware of the nature of the event in its entirety.

B. The relations between industrial carbon gas emissions and atmospheric CO2 levels from 1950

A rise of emission rates between 1950–2000 (1.5–7.0 GtC/year) increased to 8 GtC/year by 2007. Between 1950–2000 total emission of ~210 GtC and related feedback effects resulted in a rise of atmospheric CO_2 from ~310 to ~370 ppm (Hansen et al., 2008), i.e. 0.28 ppm CO_2 per 1 GtC.

The above relates to industrial emissions only, not including the effects of land clearing, agricultural methane emissions and other factors. These relations may change in future due to carbon cycle and ice/water interaction feedbacks with time.

Current atmospheric CO_2-equivalent (including methane and nitrous oxide) levels are already about 450 ppm, the level at which the Antarctic ice sheet was forming in the late Eocene (34 Ma) **(Figure 5).**

Projections of atmospheric CO_2 increases from 2020 based on the above indicate that for cuts of 5%, 15%, 25%, or 40% of GtC/year relative to 2000 emissions, atmospheric levels of 450 ppm CO_2-e will be exceeded by mid-century, as follows:

Scenario	Rate	CO2 rise from 2020	CO2 levels by 2050	CO2-e levels by 2050 (+50 CO2-e)**
5% emission reduction by 2020 relative to 2000	~6.6 GtC/yr	1.84 ppm/yr	442 ppm	492 ppm
15% emission reduction by 2020 relative to 2000	~6.0 GtC/yr	1.68 ppm/yr	437 ppm	487 ppm
25% emission reduction by 2020 relative to 2000	~5.2 GtC/yr	1.45 ppm/yr	430 ppm	480 ppm
40% emission reduction by 2020 relative to 2000	~4.2 GtC/yr	1.2 ppm/yr	423 ppm	473 ppm

* Assuming a rise of 2 ppm/year between 2009-2020 reaches 411 ppm by 2020
** Assuming addition of methane as ~50 ppm CO_2-equivalent

From the above, cuts in continuing emissions of between 5% and 40% of 2000 emissions are not sufficient to prevent atmospheric CO2-e rises above the dangerous level of 450 ppm toward mid-21st century. Even at emission cuts of 40% relative to 2000, further rises in atmospheric CO2 are likely due to feedback effects.

For the above reasons, if the growth in atmospheric CO2 levels is to be averted, a combination is required of the following actions:

1. Deeper cuts in emissions to levels which do not exceed emissions earlier in the century, i.e. 1.5 GtC year (1950).
2. Fast track development of technology aimed at reducing the present levels of CO2 from the current level (387 ppm by 2008, or **455 – 465 ppm CO2-e** including methane).
3. Fast track development of geo-engineering methods aimed at reducing the Earth albedo for transient periods, for example using mini-mirrors in space, in order to gain time for development of CO2 draw-down technology.

C. Consequences of atmospheric CO2-e levels above 450 PPM

- The emission of over 305 billion ton of carbon (GtC) into the atmosphere since the down of the industrial age, over half the original atmospheric inventory of 590 GtC, is driving a fundamental change in the state of the atmosphere, the oceans and the biosphere, with far reaching consequences for human civilization.

- Empirical observations around the globe, consistent with the physics and chemistry of the atmosphere, demonstrate the current overshoot from natural maximum CO2 levels of 280 – 300 ppm to the current level of 387 ppm, rising at a rate over 2 ppm/year, when combined with methane and nitric oxides (455–465 ppmv CO2-e), is leading toward tipping points out of human control. Such concentrations of greenhouse gases trigger carbon cycle and ice/melt water interaction feedbacks, threatening to release methane from permafrost, bogs and sediments.

- Further rise in atmospheric carbon gases will result in advanced melting of the polar ice and an irreversible shift out of the conditions of the Holocene (since 10,000 years ago) which allowed development of agriculture and of civilization.

- It is unlikely that limited reductions in greenhouse gas emissions would be sufficient to stabilize CO2 levels of the atmosphere. Due to feedbacks, atmospheric CO2-e targets of 450 or 550 ppm spell disaster for the biosphere and for civilization.

- The unacceptable consequences of a continuation of human business-as-usual inertia in terms of extreme weather events—droughts, fires, cyclons and sea level rise—require urgent deep cuts in carbon gas emissions and fast track development of alternative energy utilities and carbon down-draw technology aimed at reduction of atmospheric CO2-e levels to below 350 ppm.

D. Dangerous climate change

1. Climate change post-1750 is driven by total radiative forcing tracking toward about 3 Watt/m2, near-half the forcing of 6.5±1.5 Watt/m2 associated with the last glacial termination (about 14.7–11.7 kyr).

2. Geological records show that, on current trajectories of CO2-e increase, we are likely to see sea level rise by around 25 meters, with temperatures 2-3°C higher and permanent El Nino conditions. This expectation is based on records of conditions in earlier eras. Around 34 million years ago CO2 levels were 450-500 ppm and there was no Antarctic ice sheet. 2.8 million years ago.

3. A return of semi-permanent El Nino condition would ensue in extensive droughts through southern Australia, India and east Africa.

4. Little account has been taken of the effects of methane release from permafrost and shallow polar ocean sediments and the synergy of carbon cycle feedbacks and ice melt/water feedbacks, as indicated by the recent climate history of Earth. Depending on the degree of methane (CH4) release from sediments, permafrost and tropical bogs, developments analogous to the PETM (Paleocene-Eocene Thermal Maximum, 56 Million years-ago; + 6^{o}C) and attendant mass extinction may ensue.

5. The 450 and 550 ppmv CO2-e levels considered in the Garnaut-2008 Report imply terrestrial environments fundamentally different from those in which Neolithic agriculture and human civilization have evolved over the last 10,000 years.

6. Assumption of CO2 and climate ‘stabilization’ and possible reversal on decadal time scale are difficult to reconcile with the sharp transitions between climate states observed in the recent history of the atmosphere.

7. Sea level rise projections by the Intergovernmental Panel for Climate Change (IPCC) 2007 underestimate ice melt and sea level rise parameters, where a temperature rise of about 1 degrees C results in at least 5 meters sea level rise.

8. The opening of an ice-free Arctic ocean and slow-down or abortion of the North Atlantic thermohaline circulation lead to a new climate regime in the Northern Hemisphere, possibly similar to events about 8.2 kyr when ice-melt currents resulted in several degrees cooling and freezing of Europe.

9. In so far as it may be too late to arrest climate change by reduced carbon emission alone (Anderson and Bows, 2008), humanity needs to fast-track development of techniques for atmospheric CO2 down-draw to levels about 350 ppmv and below (Hansen et al., 2008).

E. A shift in the state of the atmosphere

Observations to date indicate that climate change trajectories are at, or exceed, the higher level estimates of the IPCC (Rahmstorf, 2007) (**Figure 2**).

Atmospheric CO2-e levels above 350 ppm pose dangers for the biosphere. The onset of ice age conditions about 34 million years (Ma) ago (end-Eocene), allowing the growth of the Antarctic ice sheet, was related to the decline of atmospheric CO2 levels to below 450 parts per million (ppmv), with further development of the Arctic Sea Ice from about 2.8 Ma (mid-Pliocene) when CO2 levels declined below about 400 ppmv (Zachos et al., 2008; Hansen et al., 2008; Glikson, 2008) (**Figures 3 - 5**).

The rise of atmospheric CO2 from about 280 ppmv to 387 ppmv between 1750 and 2008, the highest level since almost 3 million years ago, proceeding at a rate of 2.0 ppmv/year, threatens to return the climate to pre-ice age conditions.

A rise of atmospheric CO2-e to levels of 550 and 650 ppmv, with corresponding mean temperature increases of 3 to 4^{o}C above pre-industrial levels IPCC-2007), threatens mass extinction of species and a demise of civilization.

The current climate trend commenced with a sharp accentuation of temperature rise rates from the mid-1970s. Prior to this state the superposed effects of greenhouse gas (GHG), solar forcing, ocean currents, the El-Nino Southern Oscillation (ENSO) cycle and aerosol albedo effects on mean global temperatures were difficult to separate. Since 1975-76, while solar radiation continues to oscillate according to the 11 year-long sunspot cycle, rapid warming at a rate of 0.018 degrees C/year (10 times the mean 1880-1970 rate) exceeds the rate of the last glacial termination (14,700 – 11,700 years-ago) by an order magnitude (Table 1).

Climate change developments to date include:

1. Late 20th century and early 21st century CO2 rise rate average +1.45 ppmv/yr, rising to 2.2 ppmv/yr in 2007. The trend exceeds 1850-1970 rates by factors of about 4 to 5 and is two orders of magnitude higher than mean CO2 rise rates of the last glacial termination (about 0.014 ppmv/yr) (Rahmstorf, 2007; Global Carbon Project, 2008).

2. Methane (CH4), which after about 20 years has 23 times the greenhouse warming effect of CO2, rose by 10 ppb during 2007 (http://web.mit.edu/newsoffice /2008/techtalk53-7.pdf), exceeding the 1850-1970 rise rate (about 5.4 ppb/yr) and orders of magnitude faster relative to the last glacial termination. Methane deposits potentially vulnerable to climate change reside in permafrost (about 900 Billion ton Carbon - GtC), high latitude peat lands (about 400 GtC), tropical peat lands (about 100 GtC), vulnerable vegetation (about 650 GtC) and methane hydrates and clathrates in the ocean and ocean floor sediments (> 16,000 GtC). These exceed the atmospheric level of carbon (about

750 GtC), carbon emissions to date (about 305 GtC) and known economic carbon reserves (>>4000 GtC). Recently elevated methane release from Arctic Sea sediments and sub-Arctic permafrost were recorded (Walter et al., 2005; Rigby, 2008)

3. A rise of mean global temperature by more than 0.6 degrees C since 1975-6. Mean temperature rise rates of 0.016 degrees C/year during 1970 - 2007 were about an order of magnitude faster than during 1850-1970 (0.0017C) and during the last glacial termination. As indicated by deuterium studies of Greenland ice cores, abrupt tipping points during the last termination (14.7 – 11.7 kyr) resulted in temperature changes on the scale of several degrees C in a few years (Steffensen et al., 2008).

4. The rise of mean Arctic and sub-Arctic temperatures in 2005-2008 by near +4.0C since 1970.

5. Arctic Sea ice melt rates of about 5.4% per-decade since 1980, increasing to >10% per year during 2006-2007 (National Snow and Ice Data Centre [NSIDC], 2008).

6. West Antarctica warming and ice melt rates >10% per decade culminating in mid-winter ice shelf breakdown (Wilkins ice shelf; June, 2008, NSIDC, 2008).

7. Advanced melt of Greenland ice of 0.6% per year between 1979 and 2002 (Steffen and Huff, 2002; Frederick et al., 2006) and see http://climatechangepsychology.blogspot.com/2008/11/wwf-warning-on-2-degree-rise-causing.html

8. Slow-down of the North Atlantic thermohaline conveyor belt and down-welling water columns (NASA, 2004; Bryden et al., 2005), with attendant danger of its cessation analogous to conditions about 8.2 kyr ago (Alley et al., 1997).

9. Temperature projections for the North Atlantic Ocean (Keenlyside et al., 2008) may reflect the effect of Greenland ice melt waters, possibly leading to transient cooling similar to events recorded in ice cores about 12,900 – 11,700 and 8200 years-ago (Steffensen et al., 2008). This may be corroborated by slow-down of Greenland glaciers (http://www.sciencemag.org/cgi/content/summary/323/5913/458a) relative cooling since 2007 associated with the current La-Nina phase

10. Increased frequency and intensification of categories 4 and 5 hurricanes (Webster et al., 2005).

11. Mean sea level rise rate of about 0.32 cm/yr during 1988-2007 more than doubled relative to the mean about 0.14 cm/yr rate of 1973-1988 and three times those of 1850-1970 (Rahmstorf, 2006). In so far as doubling of sea level rise rates continues at this rate through the 21st century, they may approach rates similar to those of the last glacial termination (1.3 – 1.6 cm/yr) before mid-century, with sea level rise by several metres toward the end of the century as estimated by Hansen et al (2007).

The last glacial termination, triggered by insolation peaks, involved a total rise of radiative forcing by about 6.5 $Watt/m^2$, including about 3.0+/-0.5 $Watt/m^2$ induced by rising greenhouse gases (GHG: CO2, CH4, N2O) and 3.5±1.0 $Watt/m^2$ induced by lowered albedo associated with melting of ice sheets and spread of vegetation. Both factors, including their feedback effects, result in mean global temperature rise of about 5.0±1.0 degrees C (Hansen et al., 2008).

Given the onset of the Antarctic ice sheet at or below 450 ppmv CO2 at about 34 Ma (late Eocene), and of the Arctic Sea ice below 400 ppmv at 2.8 Ma (mid-Pliocene) (Haywood and Williams, 2005), the projected consequences of CO2 trajectories toward 450 ppmv and higher threaten to trigger serious environmental consequences, including extreme weather events and meters-scale sea level rises.

The effects of the above processes on the Australian continents follow from projections of temperature and rainfall variation charts by the Australian Bureau of Meteorology from the mid-1970s. Major factors include:

1. Southward migration of climate zones toward the pole by about 400 km, associated with the contraction of the Antarctic wind vortex, resulting in increase in temperature and decrease in rainfall in much of southern Australia, in particular the southwest and the southeast.
2. Increased frequency of the El-Nino events of the ENSO cycle, resulting in increased draughts in northeast Australia, India and parts of east Africa.
3. Increased intensity of northwestern cyclones, penetrating west-central Australia with consequent rise in mean precipitation.
4. An overall increase in the intensity of extreme weather events, i.e. cyclones, floods and fires associated with high summer temperatures.
5. Sea level rise, threatening coastal regions and cities.

Inherent in the IPCC-2007 and Garnaut Review-2008 climate change projections are gradual changes including stabilization of CO2 rise trends related to reductions in carbon emissions. However, carbon feedbacks and ice melt/water interaction feedbacks are neglected in the IPCC-2007 report on which the Garnaut report relies to a large extent. The IPCC-2007 Report states: "The emission reductions to meet a particular stabilization level reported in the mitigation studies assessed here might be underestimated due to missing carbon cycle feed-backs (see also Topic 2.3) AR4 caption to Table 5.1".

The concept of <u>stabilization</u> is difficult to reconcile with sharp transition between climate states observed in the last glacial termination 11.7 – 14.7 thousand years ago (Steffensen et al., 2008). The recent history of the atmosphere betrays little evidence for stabilization scenarios. Instead, glacial-interglacial cycles culminate with runaway warming and tipping points preceding sharp or gradual temperature declines (Broecker, 2000; Alley et al., 1997, 2003; Braun et al., 2005; Roe, 2006; Hansen et al., 2007, 2008; Steffensen et al., 2008; Kobashi et al., 2008).

Climate models, effective in modeling 20th and early 21st century climate change, tend to underestimate the magnitude and pace of global warming (Rahmstorf et al., 2007). According to Hansen et al. (2008) "*Climate models alone may be unable to define climate sensitivity more precisely, because it is difficult to prove that models realistically incorporate all feedback processes. The Earth's history, however, allows empirical inferences of both fast feedback climate sensitivity and long term sensitivity to specified greenhouse gas change including the slow ice sheet feedback*."

The Earth atmosphere is already tracking toward conditions increasingly similar to the mid-Pliocene about 3.0 Ma, with temperatures higher than mean Holocene temperatures by + 2 to 3^0C, ice-free Arctic Sea, tens of metres sea level rise and a permanent El-Nino (Dowsett et al., 2005; Haywood and Williams, 2005; Gingerich, 2006).

Additional anthropogenic GHG forcing and methane emission threaten conditions approaching those of the Paleocene-Eocene Thermal Maximum (PETM) 56 Ma, when the eruption of some 1500 GtC (Sluijis et al., 2007), inferred from low δ^{13}C values (-2 to 3‰ ^{13}C), resulted in global warming of about 6°C, development of subtropical conditions in the Arctic circle (sea temperatures 18 – 23°C - Sluijis et al., 2007), ocean acidification and mass extinction of 30-35% of benthic plankton (Panchuk et al., 2008). The recent history of the atmosphere, and the presence of thousands of GtC in metastable methane hydrates, clathrates and permafrost, suggests a CO2-E trajectory toward 550 or 650 ppmv, projected by Anderson and Bowes (2008), may lead toward breakdown of global civilization (Stipp, 2004) and mass extinction of species.

F. Future scenarios according to Andreson and Bowes (2008)

Should a combination of deep cuts in emissions, outlined in Section A, combined with fast-tracked geo-engineering efforts aimed at draw-down of atmospheric CO2 and reduced albedo, not be undertaken, the scenarios outlined by Anderson and Bowes (2008) apply, as below.

These authors state:

"Given the assumptions outlined within this paper and accepting that it considers the basket of six gases only, incorporating both carbon-cycle feedbacks and the latest empirical emissions data into the analysis raises serious questions about the current framing of climate change policy. In the absence of the widespread deployment and successful application of geo-engineering technologies (sometimes referred to as macro-engineering technologies) that remove and store atmospheric CO2, several headline conclusions arise from this analysis.

- *If emissions peak in 2015, stabilization at 450 ppmv CO2-e requires subsequent annual reductions of 4 per cent in CO2-e and 6.5 per cent in energy and process emissions.*

- *If emissions peak in 2020, stabilization at 550 ppmv CO2-e requires subsequent annual reductions of 6 per cent in CO2-e and 9 per cent in energy and process emissions.*

- *If emissions peak in 2020, stabilization at 650 ppmv CO2-e requires subsequent annual reductions of 3 per cent in CO2-e and 3.5 per cent in energy and process emissions.*

These headlines are based on the range of cumulative emissions within IPCC AR4 (for 450 ppmv) and the Stern report (for 550 and 650 ppmv), with the accompanying rates of reduction representing the mid-values of the ranges discussed earlier. While for both the 550 and 650 ppmv pathways peak dates beyond 2020 would be possible, these would be at the expense of a significant increase in the already very high post-peak emission reduction rates.

These conclusions have stark repercussions for mitigation and adaptation policies. By association, they raise serious questions as to whether the current global economic orthodoxy is sufficiently resilient to absorb the scale of the challenge faced.

The 450 ppmv figure is from AR4 (IPCC 2007a), while the 550 and 650 ppmv figures are from Jones et al. (2006) and include carbon-cycle feedbacks (used in Stern's analysis). Although the Jones et al. figures are above the mid-estimates of the impact of feedbacks, there is growing evidence that some carbon-cycle feedbacks are occurring earlier than was thought would be the case, e.g. the reduced uptake of CO2 by the Southern Ocean (Raupach et al. 2007).

It is increasingly unlikely that an early and explicit global climate change agreement or collective ad hoc national mitigation policies will deliver the urgent and dramatic reversal in emission trends necessary for stabilization at 450 ppmv CO2-e. Similarly, the mainstream climate change agenda is far removed from the rates of mitigation necessary to stabilize at 550 ppmv CO2e. Given the reluctance, at virtually all levels, to openly engage with the unprecedented scale of both current emissions and their associated growth rates, even an optimistic interpretation of the current framing of climate change implies that stabilization much below 650 ppmv CO2e is improbable.

The analysis presented within this paper suggests that the rhetoric of 28C is subverting a meaningful, open and empirically informed dialogue on climate change. While it may be argued that 28C provides a reasonable guide to the appropriate scale of mitigation, it is a dangerously misleading basis for informing the adaptation agenda. In the absence of an almost immediate step change in mitigation (away from the current trend of 3% annual emission growth), adaptation would be much better guided by stabilization at 650 ppmv CO2e (i.e. approx. 48C).14 However, even this level of stabilization assumes rapid success in curtailing deforestation, an early reversal of current trends in non-CO2 greenhouse gas emissions and urgent decarbonization of the global energy system.

Finally, the quantitative conclusions developed here are based on a global analysis. If, during the next two decades, transition economies, such as China, *India and Brazil, and newly industrializing nations across Africa and elsewhere are not to have their economic growth stifled, their emissions of CO2e will inevitably rise. Given any meaningful global emission caps, the implications of this for the industrialized nations are bleak. Even atmospheric stabilization at 650 ppmv CO2e demands the majority of OECD nations begin to make draconian emission reductions within a decade. Such a situation is unprecedented for economically prosperous nations. Unless economic growth can be reconciled with unprecedented rates of decarbonization (in excess of 6% per year15), it is difficult to envisage anything other than a planned economic recession being compatible with stabilization at or below 650 ppmv CO2e.*

Ultimately, the latest scientific understanding of climate change allied with current emission trends and a commitment to 'limiting average global temperature increases to below 48C above pre-industrial levels', demands a radical reframing16 of both the climate change agenda, and the economic characterization of contemporary society."

Conclusions

The scale and urgent nature of the of dangerous climate change leave law makers only two options:

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Option B: Urgent deep reductions in Carbon gas emissions coupled with fast track development of CO2 draw-down technologies, possibly coupled with geo-engineered atmospheric albedo enhancement aimed at gaining time.

Stretching from the equator to increasingly dry mid-latitudes, the Australian continent is particularly vulnerable to extreme weather events arising from climate change. We recommend a multi-pronged effort at mitigation and adaptation, including:

1. Fast deep reduction in carbon emissions – the root cause of global warming, setting Australia as a leader of new climate mitigation technology.
2. Fast-tracking alternative energy sources, including base grid solar-thermal and geothermal energy, wind, tide and hydrogen utilities.
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Whereas the current global economic woes are hopefully reversible, it will not be of much help if economic recovery takes place on a rapidly warming Earth – a process which we are concerned may not be reversible within the lifetime of many generations to come.

Indeed the current global financial crisis provides a unique opportunity to rapidly phase out-of-date carbon intensive industries and develop innovative forward-looking renewable energy and carbon-efficient industries. These are the new growth industries and will provide more jobs.

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Attachment [A]

1. CLIMATE CHANGE IN AUSTRALIA – CSIRO
http://www.climatechangeinaustralia.gov.au/

In 2007 the Intergovernmental Panel on Climate Change (IPCC) released their fourth assessment report, concluding that: Warming of the climate system is unequivocal Humans are very likely to be causing most of the warming that has been experienced since 1950. It is very likely that changes in the global climate system will continue well into the future, and that they will be larger than those seen in the recent past. These changes have the potential to have a major impact on human and natural systems throughout the world including Australia.

The IPCC reports provide limited detail on Australian climate change, particularly when it comes to regional climate change projections. For this reason the Australian Greenhouse Office, through the Australian Climate Change Science Programme, engaged CSIRO and the Bureau of Meteorology to develop climate change projections for Australia.

Climate change in Australia is based upon international climate change research including conclusions from the IPCC's fourth assessment report. It also builds on a large body of climate research that has been undertaken for the Australian region in recent years.

Climate change in Australia provides essential tools for government, industry and the community to understand the likely magnitude of climate change in Australia and the possible impacts.

2. IPCC AR4 2007 http://ipcc-wg1.ucar.edu/wg1/FAQ/wg1_faq-3.3.html

Has there been a Change in Extreme Events like Heat Waves, Droughts, Floods and Hurricanes?
"*Since 1950, the number of heat waves has increased and widespread increases have occurred in the numbers of warm nights… In several regions of the world, indications of changes in various types of extreme climate events have been found. The extremes are commonly considered to be the values exceeded 1, 5 and 10% of the time (at one extreme) or 90, 95 and 99% of the time (at the other extreme). The warm nights or hot days are those exceeding the 90th percentile of temperature, while cold nights or days are those falling below the 10th percentile… In the last 50 years for the land areas sampled, there has been a significant decrease in the annual occurrence of cold nights and a significant increase in the annual occurrence of warm nights. Decreases in the occurrence of cold days and increases in hot days, while widespread, are generally less marked. The distributions of minimum and maximum temperatures have not only shifted to higher values, consistent with overall warming, but the cold extremes have warmed more than the warm extremes over the last 50 years. More warm extremes imply an increased frequency of heat waves.*"

3. Running, 2006. Originally published in *Science* Express on 6 July 2006
Higher spring and summer temperatures and earlier snowmelt are extending the wildfire season and increasing the intensity of wildfires in the western United States.

4. Climate change and wildfire in and around California: fire modeling and loss modeling. California Climate Change Centre. Westerling et al., 2006. Science, 18 August 2006, pp.927- 928 and 940-943).
and: http://ulmo.ucmerced.edu/~westerling/pdffiles/06CEC_WesterlingBryant.pdf
Using statistical models, wildfire risks are described as a function of climatic variables such as temperature and precipitation, and of hydrologic variables simulated using temperature and precipitation. Wildfire risks for the GFDL and PCM models and the A2 and B1 emissions scenarios are compared for 2005–2034, 2035–2064, and 2070–2099 against a 1961–1990 reference period to examine climate change scenarios ranging from neutral to lower precipitation and higher temperatures in California and neighboring states. This study considered changes in the wildfire risks for the larger region, for California, and for northern and southern California. Outcomes for the GFDL model runs, which exhibit higher temperatures than the PCM model runs, diverged sharply for different kinds of fire regimes, with increased temperatures promoting greater large fire frequency in wetter, forested areas, via the effects of warmer temperatures on fuel flammability. At the same time, reduced moisture availability due to lower precipitation and higher temperatures led to reduced fire risks in some locations where fuel flammability may be less important than the availability of fine fuels. Property damages due to wildfires were also modeled using the 2000 U.S. Census to describe the location and density of residential structures. Structure values were determined from census property values and empirically derived ratios describing the fraction of property values ascribed to structures and the fraction of structures within a fire perimeter that are, on average, destroyed in a fire. This analysis indicated that the largest changes in property damages under the climate change scenarios occurred in wildland/urban interfaces proximate to major metropolitan areas in coastal southern California, the Bay Area, and in the Sierra foothills northeast of Sacramento.

5. Ummenhofer et al., 2009: Since 1995, a large region of Australia has been gripped by the most severe drought in living memory, the so-called ‘‘Big Dry’’. The ramifications for affected regions are dire, with acute water shortages for rural and metropolitan areas, record agricultural losses, the drying out of two of Australia’s major river systems and far reaching ecosystem damage. Yet the drought’s origins have remained elusive. For Southeast Australia, we show here that the ‘‘Big Dry’’ and other iconic 20th Century droughts, including the Federation Drought (1895–1902) and World War II drought (1937–1945), are driven by Indian Ocean variability, not Pacific Ocean conditions as traditionally assumed. Specifically, a conspicuous absence of Indian Ocean temperature conditions conducive to enhanced tropical moisture transport has deprived southeastern Australia of its normal rainfall quota. In the case of the
‘‘Big Dry’’, its unprecedented intensity is also related to recent higher temperatures.

6. An article by Prof Barry Brook at "http://bravenewclimate.com/2009/02/03/is-there-a-link-between-adelaides-heatwave-and-global-warming/

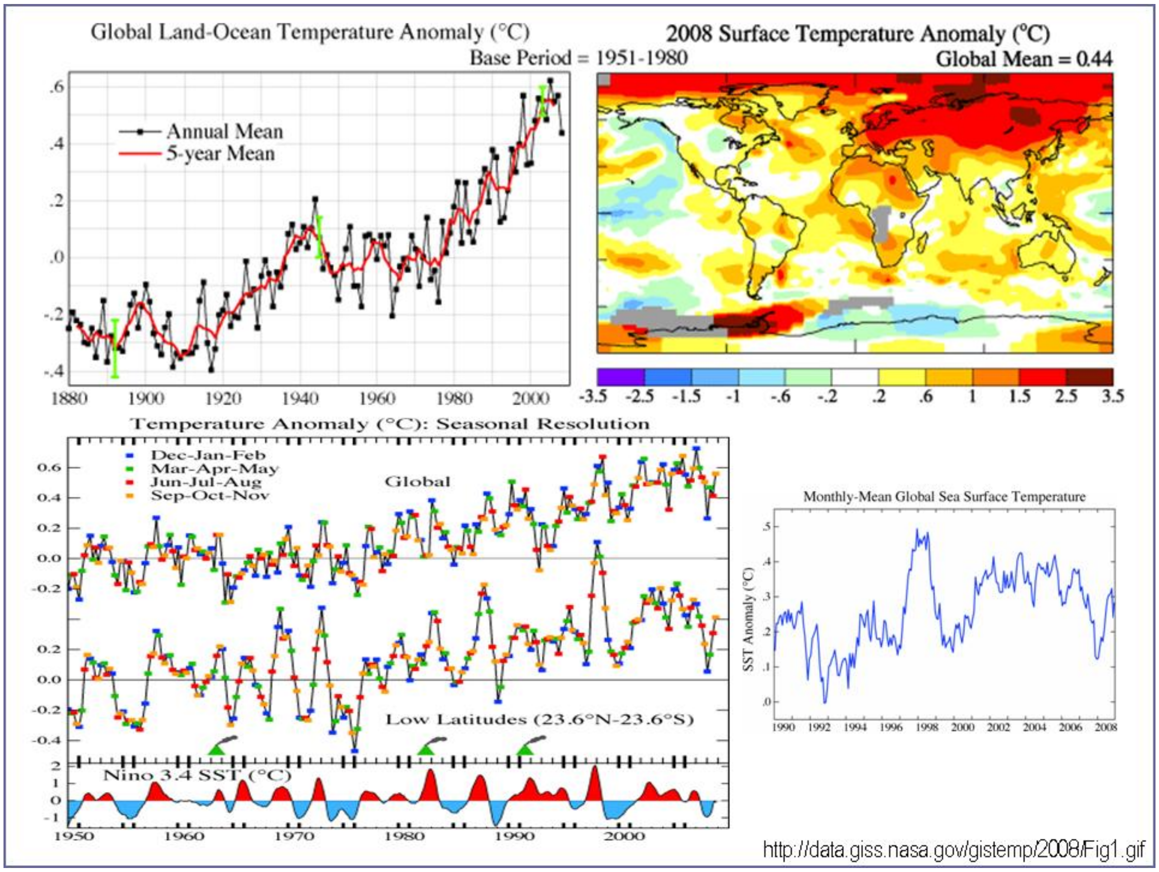

Figure 1. NASA Godard Institute of Space Science annual and seasonal land and sea temperature variations, and ENSO cycle plots, 1950 – 2008
http://data.giss.nasa.gov/gistemp/2008/

CLIMATE CHANGE OBSERVATIONS COMPARED TO IPCC 2007 PROJECTIONS RANGE

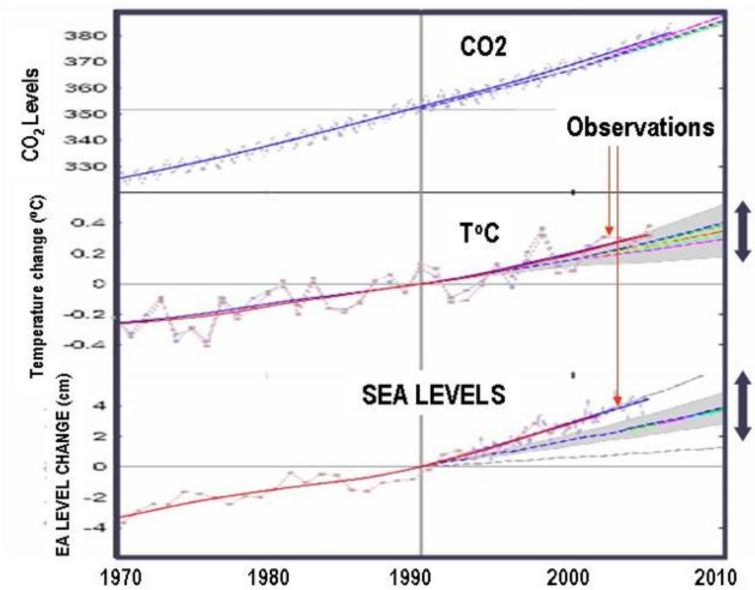

Figure 2. Changes in key global climate parameters since 1973, compared to the scenarios of the IPCC [shown as dashed lines (A1FI, light blue; A1B, purple; A1T, blue; A2, red; B1, yellow; and B2, green) and gray ranges in all panels]. **(a)** Monthly carbon dioxide concentration and its trend line at Mauna Loa, Hawaii (blue) up to January 2007, from Scripps in collaboration with NOAA. **(b)** Annual global-mean land and ocean combined surface temperature from GISS (red) and the Hadley Centre / Climatic Research Unit (blue) up to 2006, with their trends. **(c)** Sea-level data based primarily on tide gauges (annual, red) and from satellite altimeter (3-month data spacing, blue, up to mid-2006) and their trends (Rahmstorf, 2007).

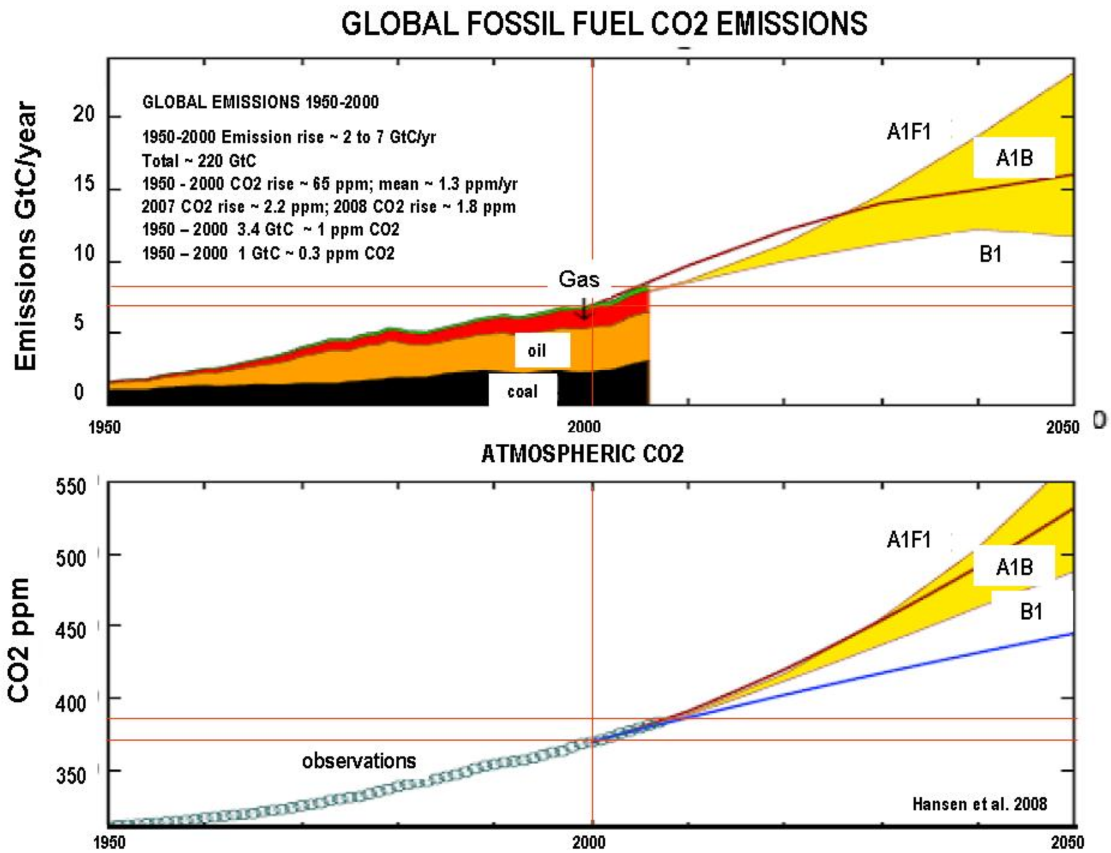

Figure 3. Growth of carbon emissions and atmospheric CO2 levels between 1950 and 2007, including future projections based on IPCC-2007 emission scenarios (after Hansen et al., 2008). Inserted data and projections of emission (GtC) – atmospheric CO2 relations are based on Table 1.

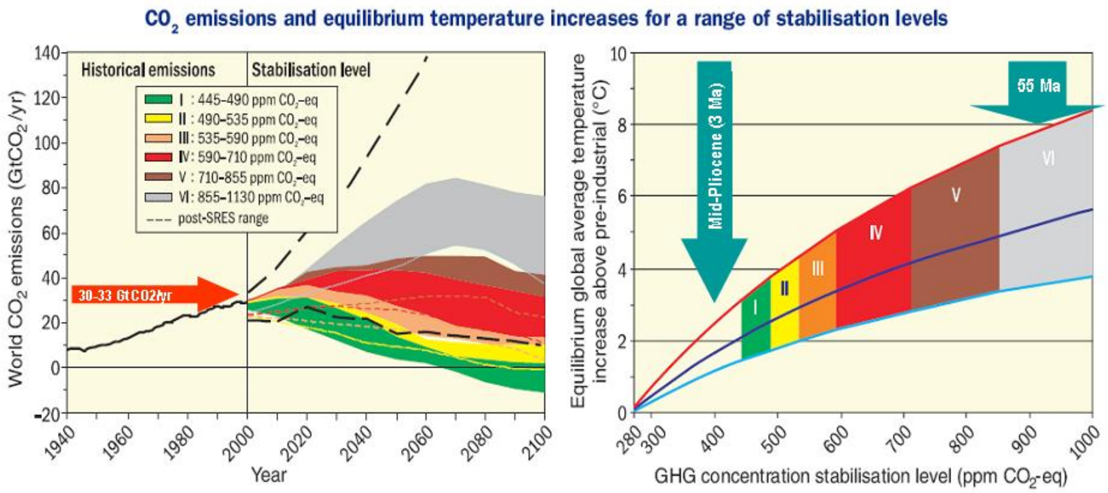

Figure SPM.11. Global CO_2 emissions for 1940 to 2000 and emissions ranges for categories of stabilisation scenarios from 2000 to 2100 (left-hand panel); and the corresponding relationship between the stabilisation target and the likely equilibrium global average temperature increase above pre-industrial (right-hand panel). Approaching equilibrium can take several centuries, especially for scenarios with higher levels of stabilisation. Coloured shadings show stabilisation scenarios grouped according to different targets (stabilisation category I to VI). The right-hand panel shows ranges of global average temperature change above pre-industrial, using (i) 'best estimate' climate sensitivity of 3°C (black line in middle of shaded area), (ii) upper bound of likely range of climate sensitivity of 4.5°C (red line at top of shaded area) (iii) lower bound of likely range of climate sensitivity of 2°C (blue line at bottom of shaded area). Black dashed lines in the left panel give the emissions range of recent baseline scenarios published since the SRES (2000). Emissions ranges of the stabilisation scenarios comprise CO_2-only and multigas scenarios and correspond to the 10th to 90th percentile of the full scenario distribution. Note: CO_2 emissions in most models do not include emissions from decay of above ground biomass that remains after logging and deforestation, and from peat fires and drained peat soils. {Figure 5.1}

http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf

Figure 4.

A. CO2 emission trajectories and related atmospheric CO2 rise levels. Current emission per-year levels indicate by the red arrow.
B. Relations between atmospheric CO2 levels and temperatures, assuming climate sensitivity of 3°C per doubling of CO2 concentrations. The green arrows indicate CO2 and temperature levels at 3 million years ago (mid-Pliocene) and 55 million years ago (Paleocene-Eocene Thermal Maximum).

IPCC 2007 WG4 Figure SPM.11

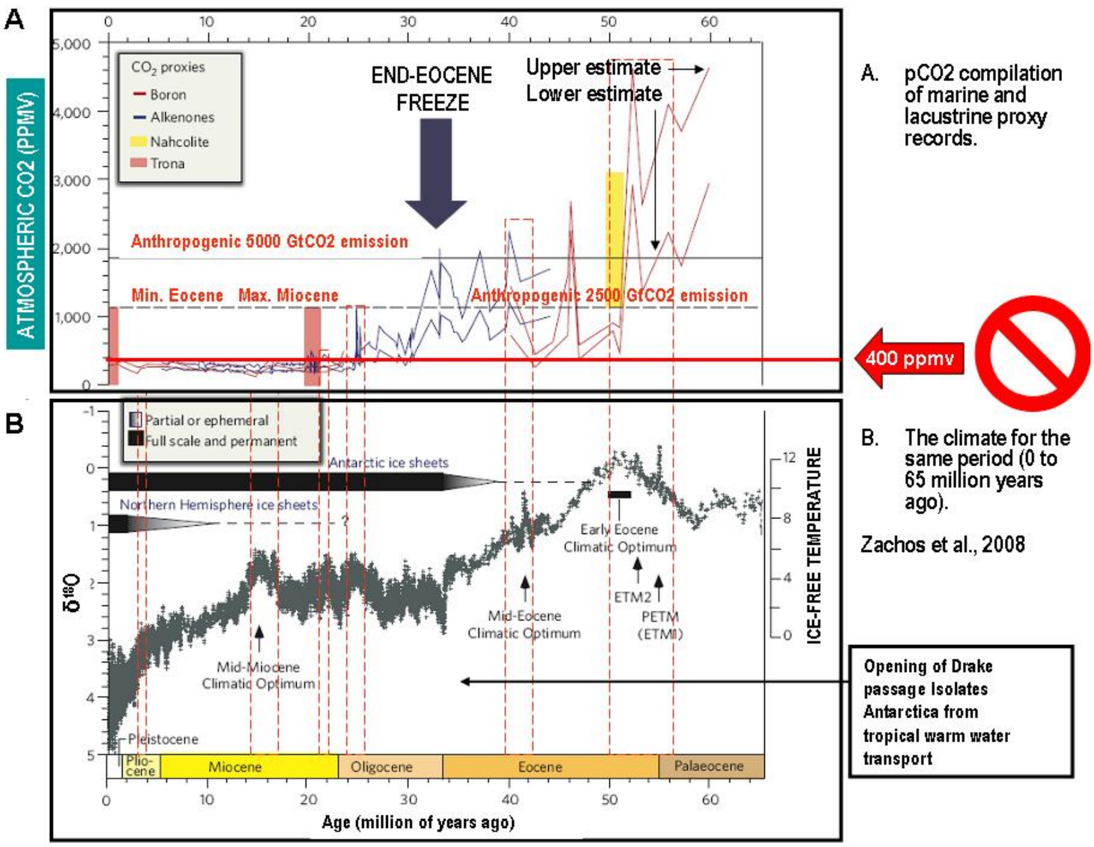

Figure 5. Evolution of mean global temperatures from the Paleocene (65 million years-ago) to the present based on deep ocean paleo-temperatures deduced from oxygen isotopes. The 400 ppmv CO2 level (red arrow) signifies the upper limit of the glacial/interglacial era.

Table 1. Greenhouse gas levels, greenhouse gas rise rates, mean CH_4, mean temperatures, temperature rise rates per CO_2, sea levels and sea level rise rates per year and per 1 °C for the late Holocene, glacial termination-I, Glacial termination-II and the mid-Pliocene.

Period	mean CO_2 ppmv	CO_2 rate ppmv/yr	Mean CH4 ppb	Mean T°C	Mean T°C/yr	T°C / 1 ppmv CO_2	Sea Level (cm, m) apl	SL cm/yr	SL m/1°C
A. Anthropocene / Holocene									
1970-2006/2008	~325-387	Mean 1.45 2006 1.8 **2007 2.2**	2007-8 10 ppb/yr; 1970-2006: 1400-1750 ppb; 9.7 ppb/yr	13.9 - 14.5	**0.016**	0.011	1970-2006 + 8 cm	1988-2007; 0.32 1973-1988 0.14	0.13
1850-1970	280-330	**0.42**	750-1400 5.4 ppb/yr	13.7 - 13.9	**0.0017**	0.004	1870-1970 + 11 cm	0.11	0.55
10kyr-1750	265-285	0.002	~700				7kyr-1750 Oscillating to near stable		
B. Glacial Termination-I									
11.5-8.5	~265-260	Decline In CO_2	~600-570	+1.0	0.0003	0.2	-62 to -12 (+50 m)	1.6	50
14–11.5	~235-265	17-11.5kyr 0.014 ppmv/yr	~450-600	+4.5	0.0018 14-8.5kyr 0.0007	0.15	-95 to -62m (+33 m)	1.32	7.3
C. Glacial Termination-II									
130-128	~190-290	139-130kyr **0.011** ppmv/yr 130-120kyr decline	~320-720	+1.2 °C global	0.0006	0.06	124-120 kyr +8 m (APLl)		5-6.7
D. mid-Pliocene									
3.29-2.97 Ma	360-400			+2-3°C apl; +5 °C apl			+25±12 ; 35 m APL [Florida]		5-17