# 1. Climate Catastrophe

What is climate change? Is it a product of natural cyclical variations in the Earth's ecological systems, or is it a consequence of human activities? What are the implications of climate change for the international system? How serious are the ramifications of climate change for the continuity of modern industrial civilization? This chapter begins by confronting the major public-media debates regarding the causality of climate change, reviewing the main arguments that challenge the idea that contemporary global warming is due to fossil fuel emissions and therefore human-induced (anthropogenic). The relevant scientific literature is explored to discern whether we can be sure that climate change is happening, and why.

I then explore the implications of climate change for national security, finding that a variety of Western security agencies recognize that climate change will drastically alter the global security landscape for the foreseeable future without significant preventive action. The focus of this analysis is not to list the specific conflicts that might arise (an exercise performed frequently elsewhere),[1] but to assess the overarching ramifications of global warming for the *ability of modern industrial civilization in its current form to survive*. The analysis then extends to a critical examination of the conventional narrative of the rate of global warming as described by the United Nations Intergovernment Panel on Climate Change (IPCC), and as generally endorsed by Western states. I argue that cutting-edge scientific research provides compelling evidence that the current rate of global warming is far faster, and bigger, than the UN models predicted. Integrating the impact of positive feedbacks in the Earth's climate systems, suggests the probability of a worst-case climate scenario well before the end of the 21st century – unless significant preventive and mitigating actions are taken.

But such actions must go far beyond the mere question of reducing emissions. Emissions reductions have largely been addressed in a socio-political and economic vacuum, divorced from the real-world systemic changes required to drastically reduce energy consumption in general, and utilise cleaner and more energy-efficient technologies based on renewable energies in particular. Yet this inattention to the global systemic origins of the ecological

crisis is part of a long-term trend, evidenced by the fact that policymakers have largely ignored several decades of dire warnings issued by the world's leading climate and environmental scientists. Therefore, for civilization to survive beyond the 21st century will require fundamental *global systemic change* at the very heart of modern industrial social relations. Only in the context of such systemic change can the prospect of a post-carbon civilization that is no longer dependent on the unrelenting exploitation of hydrocarbon energies be realized.

## 1.1 A Debate Resolved? Current Climate Change is Unequivocally Anthropogenic

### *The Scientific Consensus*

Human-emissions generated climate change is perhaps the most prominent global crisis in public consciousness – its existence is now readily acknowledged by most governments including the United States, even if reluctantly, and it is generally recognized that urgent steps are required to prevent the prospect of mass extinction. What is missing from the official discourse on climate, however, is not simply an acknowledgement of the real extent and gravity of the civilizational catastrophe it poses, but the corresponding measures required to prevent or avert such catastrophe.

**Figure Global Temperature Land-Ocean Index. Source: NASA Goddard Institute for Space Studies (11 January 2008)**

Since 1900 there has been an approximately 0.7 degree Celsius (C) rise in global average temperature (see Figure 1). But as Figure 2 depicts, this increase cannot be accounted for by natural variations of solar and volcanic activity, nor by human-induced sulphate emissions, which act to reduce global temperature. It is only by including the impact of human-induced carbon dioxide ($CO_2$) emissions that climate models are able to accurately simulate the rise in global temperatures over the previous century of industrial civilization.

**Figure Climate Change Attribution. Source: Stanford Solar Centre, Stanford University (2008)**

Industrial civilization derives almost all its energy from the burning of fossil fuels, pumping carbon dioxide into the atmosphere – with the exception of approximately 2-3 per cent from renewable and nuclear sources. The emissions of primarily $CO_2$ – but also nitrous oxide, methane, chlorofluorocarbons, among other greenhouse gases – from the industries that drive our economies and sustain our infrastructures, are the main engine of global warming in the last few decades. This does not mean that all climate change is solely due to human-induced $CO_2$ emissions. Scientists acknowledge that there are many other factors involved in climate change, such as solar activity, as well as periodic changes in the Earth's orbit. Yet they have overwhelmingly confirmed that these are not the primary factors currently driving global warming.

Global warming skeptics often point to the fact that human-induced $CO_2$ emissions are tiny compared to natural emissions from ocean and vegetation. What they forget, however, is that natural emissions are balanced by natural absorptions by ocean and vegetation. This natural balance has become increasingly unstable due to additional $CO_2$ emissions from human industrial activities. In terms of natural emissions, consumption of vegetation by animals and microbes accounts for about 220 gigatonnes of $CO_2$ per year. Respiration by vegetation emits around 220 Gigatonnes (Gt). The ocean releases about 330 Gt. This totals to about 770 Gt of natural *emissions*. In terms of natural *absorption*s, land plants absorb about 440 Gt of carbon per year and the ocean absorbs about 330 Gt, again roughly totaling at about 770 Gt. This emission-absorption parity (770 Gt released and 770 absorbed) ensures that natural atmospheric $CO_2$ levels remain in overall balance even as emissions and absorptions fluctuate over time. In comparison human emissions are only around 26.4 Gt per year. The problem is that this seemingly small addition of $CO_2$ into the atmosphere by industrialization *cannot be absorbed by the planet*. Only about 40 per cent is actually absorbed, largely by oceans, leaving 60 per cent in the atmosphere. Worse still, the oceans are increasingly losing their ability to absorb $CO_2$, with the Southern Ocean and North Atlantic both approaching saturation point in 2007. This means that with time, unprecedented concentrations of $CO_2$ are accumulating in the Earth's atmosphere. Just how unprecedented can be gauged by a simple example – while a natural change of 100 parts per million (ppm) takes between 5,000 and 20,000 years, the recent increase of 100 ppm took only 120 years.[2]

The majority of scientific studies show that climate sensitivity to $CO_2$ emissions is high, or in other words that $CO_2$ emissions induce large increases in global temperature. Despite the media images of a raging debate among climate scientists, the fundamentals are agreed on – the direct connection between $CO_2$ and global temperatures has been empirically observed by analysis of ice cores, paleoclimate records, observations of ocean heat uptake, and temperature responses to the solar cycle, among other data. The empirically-focused studies including published research from the 1990s to 2009, show that doubled $CO_2$ emissions would contribute to warming at least within the range of 1.4 to 4 degrees C.[3]

The origins of current climate change are therefore no longer a matter of serious scientific debate. The landmark declaration came in 2007, when the United Nations Intergovernmental Panel on Climate Change (IPCC) published its Fourth Assessment Report, based on a meta-analysis of the scientific literature, projecting the rise in temperatures due to global warming by 600 scientists from 40 countries, peer-reviewed by 600 more meteorologists. The report confirmed that human-induced global warming is "unequivocally" happening, and that the probability that climate change was due to human $CO_2$ emissions is over 90 per cent.[4]

Yet the waters have been increasingly muddied by the perception that there is no real scientific consensus about climate change – either that global warming is not happening, or that if it is, it has little or nothing to do with human activities. In fact, this self-styled 'skeptical' agenda has revolved around a network of ideological and advocacy organizations funded largely by leading players in the fossil fuel industry. Between 1998 and 2005, ExxonMobil has funneled about $16 million to such groups with the task of manufacturing uncertainty about even the most indisputable scientific evidence. This has not only generated considerable confusion in the media about climate change, it has also influenced US government policy.[5]

It is therefore important to recognize that claims by skeptics that there is no scientific consensus on climate change are deeply misleading. The scientific consensus can be discerned not only from the IPCC, but from other meta-analyses of the peer-reviewed literature. In 2004, US geoscientist Naomi Oreskes, Professor of History and Science Studies at the University of California, San Diego, conducted a survey of the 928 peer-reviewed scientific papers on global climate change from 1993 to 2003. She found that 75 per cent explicitly or implicitly accepted the consensus view, while 25 per cent took no position and dealt purely with methods or paleoclimate:

> "Remarkably, none of the papers disagreed with the consensus position... Many details about climate interactions are not well understood, and there are ample grounds for continued research to provide a better basis for understanding climate dynamics. The question of what to do about climate change is also still open. But there is a scientific consensus on the reality of anthropogenic climate change. Climate scientists have repeatedly tried to make this clear. It is time for the rest of us to listen."[6]

Efforts to disprove the existence of this scientific consensus remain poor. For instance, although social anthropologist Benny Peisner attempted to refute Oreskes' findings in his own survey of the same peer-reviewed papers, he managed to flag-up only 34 studies which he claimed raised doubts about anthropogenic global warming. This is a tiny fraction – only 3.6 per cent – of the scientific papers from this period. Close inspection of the actual abstracts shows not only that the vast majority do *not* reject the scientific consensus at all, but that those few which can be interpreted as casting some doubt were not actually peer-reviewed.[7] In the end, Peisner himself was forced to retract his criticisms: "Only few abstracts explicitly reject or doubt the AGW (anthropogenic global warming) consensus which is why I have publicly withdrawn this point of my critique… I do not think anyone is questioning that we are in a period of global warming. Neither do I doubt that the overwhelming majority of climatologists is agreed that the current warming period is mostly due to human impact."[8] Indeed, when pressed to clarify which specific papers he thought expressed doubt about anthropogenic climate change, he was able only to identify one – which was not peer-reviewed.[9]

Outside the realms of scientific research, there have been several efforts by vested political interests to demonstrate not only a lack of scientific consensus about anthropogenic climate change, but further that an alternative scientific consensus undermines it. In December 2007, Senator James Inhofe, the ranking minority member of the US Senate Committee on Environment and Public Works, released a list of over 400 "prominent scientists" including "current and former participants in the UN IPCC" who allegedly "disputed man-made global warming claims" that year.[10] His list was widely publicized by the media. Yet Senator Inhofe has by the time of writing received at least a million dollars in campaign contributions from individuals and companies linked to the US oil and gas industry.[11] Detailed analysis of Inhofe's list of scientists and their actual research on climate change reveals other awkward facts: 1) 84 individuals listed had either taken money from, or were connected to fossil fuel industries or think-tanks founded by them; 2) 44 are television weathermen; 3) 20 are economists; 4) 70 simply have no expertise or qualifications in climate science; 5) increasing numbers of scientists cited as 'man-made climate skeptics' in the Senate report have since

been found to support anthropogenic climate change and despite repeated efforts to dissociate themselves from the report, continue to remain on the list.[12]

Examples of flagrant misrepresentation in the report are rife. On the list, for instance, is "prominent scientist" Ray Kurzweil – not a scientist but an inventor. Worse, Kurzweil is not even a global warming skeptic. Rather, he argued that Al Gore's arguments about climate change were "ludicrous" for failing to account for the potential of new technologies. : "… nanotechnology will eliminate the need for fossil fuels within 20 years ... I think global warming is real but it has been modest thus far."[13] Kurzweil, in other words, is not a climate scientist, accepts the climate science behind global warming, but only believes that continued warming is preventable due to technological progress. Another example of a "prominent scientist" in the report is Steve Baskerville, a "CBS Chicago affiliate" and "Chief Meteorologist", who expressed "skepticism" about a consensus on man-made global warming. Yet Baskerville's alleged qualifications in climate science amount only to a Certificate in Broadcast Meteorology from Mississippi State University.[14] Other examples include: Thomas Ring, who has a degree in chemical engineering from Case Western Reserve University, with no peer-reviewed climate science publications to his name; George Waldenberger, not a climate scientist but a meteorologist, who has repeatedly requested to be removed from the Inhofe list reiterating his support for anthropogenic climate change, but who still remains on the list; Gwyn Prins and Steve Rayner, real climate scientists who, however, are misrepresented as skeptics when in fact they state: "We face a problem of anthropogenic climate change, but the Kyoto Protocol of 1997 has failed to tackle it"; and so on. These and numerous other examples are discussed at length in an ongoing regular column, "The 'Inhofe 400' Skeptic of the Day", by Andrew Dessler, a Professor of Atmospheric Sciences at Texas A & M University, where he continues to demonstrate the fraudulent nature of Inhofe's list.[15]

Unfortunately, this did not stop Senator Inhofe from releasing an updated list a year later in December 2008, including the original 400, of now "more than 650 international scientists" who "dissent over man-made global warming claims."[16] It was not long before the credibility of this list was also undermined. By way of example, on Inhofe's new list is IPCC scientist Erich Roeckner, a renowned climate modeler at the Max Planck Institute. Roeckner is cited in the new report as saying that there are kinks in climate models, and telling *Nature*: "It is possible that all of them are wrong" – supposedly implying that he is questioning the validity of anthropogenic models of climate change in general. However, as the *New Republic* reported:

> "But he's not! Roeckner was referring to the IPCC's emissions scenarios, which involve assumptions about the rate of growth of greenhouse-gas emissions… We already know that emissions are growing faster than the IPCC's worst-case scenario, and that's bad news, not good.
>
> Anyway, Roeckner's as far as you get from a 'dissenter'… Roeckner is quoted in multiple news stories sounding downright alarmist about the consequences of man-made warming. 'Humans have had a large one-of-a-kind influence on the climate... Weather situations in which extreme floods occur will increase,' he informed Deutsche Welle in 2004. 'Our research pointed to rapid global warming and the shifting of climate zones,' he told ABC News in 2005. Quite the heretic, that one."[17]

The pattern was the same: listing people who are not experts on climate science, and who lack peer-reviewed publications in the field; including non-scientists; and misrepresenting established climate scientists who actually do accept man-made global warming.[18] Indeed, it is instructive to compare Inhofe's fraudulent list of "650" to the official warning issued by the world's largest society of Earth scientists, the American Geophysical Union, *with a membership of 50,000 scientists*, agreeing that:

> "The Earth's climate is now clearly out of balance and is warming. Many components of the climate system – including the temperatures of the atmosphere, land and ocean, the extent of sea ice and mountain glaciers, the sea level, the distribution of precipitation, and the length of seasons – are now changing at rates and in patterns that are not natural and are best explained by the increased atmospheric abundances of greenhouse gases and aerosols generated by human activity during the 20th century."[19]

Unsurprisingly, Senator Inhofe was also one of the first to jump on the 2009 climate email bandwagon, when thousands of emails over a period of more than ten years from the University of East Anglia's Climatic Research Unit were obtained by hackers. One of the emails most cited by 'skeptics', by head of the Unit, Professor Phil Jones, reads: "I've just completed Mike's Nature trick of adding in the real temps to each series for the last 20 years (ie from 1981 onwards) amd from 1961 for Keith's to hide the decline."[20] Inhofe's press blog commented that the email "appears to show several scientists eager to present a particular viewpoint – that anthropogenic emissions are largely responsible for global warming – even when the data showed something different."[21] But the Union of Concerned Scientists (UCS), analyzing this and other leaked emails, explained the language and scientific context in detail:

> "Jones is talking about how scientists compare temperature data from thermometers with temperature data derived from tree rings. Comparing that data allows scientists to derive past temperature data for several centuries before accurate thermometer measurements were available. The global average surface temperature since 1880 is based on thermometer and satellite temperature measurements...
>
> In some parts of the world, tree rings are a good substitute for temperature record. Trees form a ring of new growth every growing season. Generally, warmer temperatures produce thicker tree rings, while colder temperatures produce thinner ones. Other factors, such as precipitation, soil properties, and the tree's age also can affect tree ring growth.
>
> The 'trick,' which was used in a paper published in 1998 in the science journal Nature, is to combine the older tree ring data with thermometer data. Combining the two data sets can be difficult, and scientists are always interested in new ways to make temperature records more accurate.
>
> Tree rings are a largely consistent source of data for the past 2,000 years. But since the 1960s, scientists have noticed there are a handful of tree species in certain areas that appear to indicate temperatures that are warmer or colder than we actually know they are from direct thermometer measurement at weather stations.
>
> 'Hiding the decline' in this email refers to omitting data from some Siberian trees after 1960. This omission was openly discussed in the latest climate science update in 2007 from the IPCC, so it is not 'hidden' at all.
>
> Why Siberian trees? In the Yamal region of Siberia, there is a small set of trees with rings that are thinner than expected after 1960 when compared with actual thermometer measurements there. Scientists are still trying to figure out why these trees are outliers. Some analyses have left out the data from these trees after 1960 and have used thermometer temperatures instead. Techniques like this help scientists reconstruct past climate temperature records based on the best available data."

Another email from scientist Kevin Trenberth laments that "we can't account for the lack of warming at the moment", describing this as a "travesty" due to the fact that "Our observing system is inadequate." UCS points out that he is talking about short-term internal climate variability, in particular the year 2008 "which was cooler than scientists expected, but still among the 10 warmest years on record." Yet another email by Jones construed by 'skeptics' as evidence of scientists manipulating peer-review to squeeze out legitimate climate dissenters, objects to a paper on solar variability in the climate published in *Climate Research*, and calls for scientists to boycott the journal until a change in editorship. Yet as UCS clarifies:

> "Half of the editorial board of Climate Research resigned in protest against what they felt was a failure of the peer review process. The paper, which argued that current warming was unexceptional, was disputed by scientists whose work was cited in the paper. Many subsequent publications set the record straight, which demonstrates how the peer review process over time tends to correct such lapses. Scientists later discovered that the paper was funded by the American Petroleum Institute."

Thus, UCS rightly concluded that whoever stole the emails "could only produce a handful of messages that, when taken out of context, might seem suspicious to people who are not familiar with the intimate details of climate science."[22]

The conclusion is simple: claims that global warming is not happening, or if happening has nothing or little to do with human activities, fall outside the existing scientific consensus, and often come from people with vested political or economic interests, for whom the study of climate is outside their professional qualifications and field of expertise. The 'skeptic' strategy is simple: to misquote, quote of context, and/or misrepresent the statements and findings of real climate scientists. Yet despite their lack of credibility, these claims and the bad science they rest on, frequently receive widespread media coverage. Before examining the impacts of climate change, I critically review some of the most prominent 'skeptical' approaches to anthropogenic climate change which try to deny the role of human activities, finding them to be deeply unscientific.

## *Solar Activity and Climate Variation*

One of the most common misconceptions cited by 'man-made climate' skeptics (hereafter referred to simply as 'climate skeptics' or 'skeptics') is that the Sun is the primary cause of contemporary global warming. The Earth's climate history does evince a close correlation between solar activity and global temperature change. Although the sun plays a crucial role in climate change, scientific studies confirm that recent global warming on the Earth could not be caused by solar activity. One study by scientists from Finland and Germany, commonly used by climate skeptics, concludes that the sun has been more active in the last 60 years than in the preceding 1150 years. The scientists argue that "long-term climate variations are affected by solar magnetic activity." Yet the same study points out that the correlation between solar activity and temperature *ceased in 1975*, after which global average temperatures escalated despite solar activity remaining stationary: "Note that the most recent warming, since around 1975, has been considered in the above correlations. During these last 30 years the solar total irradiance, solar UV irradiance and cosmic ray flux has not shown any significant secular trend, so that at least this most recent warming episode must have another source."[23]

Similar conclusions have been reiterated independently throughout the scientific literature. More recently in 2008, a study published by *Nature* noted that "the level of solar activity

during the past 70 years is exceptional" and "may indicate that the Sun has contributed to the unusual climate change during the twentieth century." Yet it goes on to confirm that "solar variability is unlikely to be the prime cause of the strong warming during the last three decades... even under the extreme assumption that the Sun was responsible for all the global warming prior to 1970, at the most 30 per cent of the strong warming since then can be of solar origin."[24] And in 2007, the *Proceedings of the Royal Society* published a paper concluding that while there is "considerable evidence for solar influence on the Earth's pre-industrial climate and… in post-industrial climate change in the first half of the last century," over the previous 20 years, "all the trends in the Sun that could have had an influence on the Earth's climate have been in the opposite direction to that required to explain the observed rise in global mean temperatures."[25]

## *The Earth's Natural Climate Cycles*

Another general misconception promulgated by climate skeptics is that contemporary global warming can be explained entirely by the fact that the Earth undergoes periodic natural fluctuations in its climate. Climate change, the argument goes, is therefore simply a natural cycle, not a result of human-activities. This perspective is not entirely false, but it is misleading. According to the geological record, the Earth has certainly experienced long cooling and warming trends throughout the last million years. These trends adhere to an approximate 100,000-year cycle consisting of ice ages broken by shorter warm periods known as interglacials. The onset of glaciation and the subsequent interglacial periods are brought on by changes in the Earth's orbit around the Sun, known as Milankovitch cycles. However, the last 12,000 years was the beginning of a continuing warm interglacial period, whose *current* trend in the Milankovitch cycle is toward a gradual cooling down towards an ice age. This gradual cooling phase of the current Milankovitch cycle explain the current trend of global warming. Scientists estimate that the present interglacial period is likely to continue for tens of thousands of years naturally. Indeed, so unnatural is the current phase of global warming that Andre Berger, one of the world's leading experts on quaternary climate change and honorary president of the European Geosciences Union, calculates that current industrial fossil fuel emissions could continue long enough to potentially suppress the next natural glacial cycle entirely.[26]

Linked to this misconception is the claim that global warming has *stopped since 1998*. The argument is that due to the lapse in sunspot activity as well as cyclical variations of global warming and cooling, the coming decades will constitute a period of prolonged *global cooling* (also see next sub-chapter). American geologist Don Easterbrook attributes the current period of global warming to a natural global weather cycle of warming and cooling. In a 2001 paper presented at the Geological Society of America, he argues: "Advance and retreat of glaciers in the Pacific Northwest show three distinct oscillations, each having a period of ~25 years. Glaciers retreated rapidly from ~1930 to ~1950-55 (warm cycle), readvanced from ~1955 to ~1977 (cool cycle), then retreated rapidly from ~1977 to the present (warm cycle)." This correlates with the period of global warming which therefore appears to be an outcome of such oscillations. "If the trend continues, the current warm cycle should end soon," and global warming will be over for another 25 years.[27] By implication, global warming is nothing to worry about! In the next section, we look at this question – did global warming stop in 1998 (or 2001) – in more detail, but before that, it is important to understand the deeper misconceptions underlying Easterbrook's approach.

Firstly, he proffers a rather eccentric argument, indeed, a lone voice in the scientific community, with no wider corroboration in the relevant peer-reviewed literature. Secondly, his paper itself was not peer-reviewed and remains unpublished in any recognized relevant physical science journal. These problems should obviously raise our initial suspicions. Thirdly, further examination of one of Easterbrook's own examples, the Pacific Decadal Oscillation (PDO) vindicates them. According to Easterbrook, along with other oscillations the PDO, which occurs primarily in the North Pacific, is responsible for most of the climate change over the last century, including the phase of accelerated warming that began in the 1970s. Although Easterbrook depicts these oscillations of warm and cool phases occurring over clearly demarcated periods of about 25-30 years, in reality they can stay in one phase for between 10 and as much as 40 years. Further, these long periods can also be broken by intervals when it switches phases for anything between 1 and 5 years. Thus, in 1905, the PDO switched to a warm phase as global warming began. In 1946, the PDO switched to a cool phase as temperatures cooled mid-century. In 1977, the PDO switched to a warm phase around the same time as the modern global warming period. These correlations, for Easterbrooke, prove that global warming is nothing more than the function of natural oscillations in the Earth's climate that will inevitably give way to global cooling, before giving rise to another cycle of warming.

However, as Figure 3 shows, while the PDO does have some degree of correlation with short term variations in global temperature, *this is starkly outweighed by the contrast*. While the PDO oscillates between positive and negative values roughly along the same level, *global average temperatures in the same period display an unambiguous long-term warming trend*.[28] To account for global temperature increases since the dawn of the twentieth century requires totalling the impact from all relevant forcings including solar, aerosols, $CO_2$ emissions, and so on. By itself, the PDO does not provide an adequate explanation for global warming.

**Figure  Pacific Decadal Oscillation Compared to Actual Global Average Temperature Rise. Source: John Cook, Skeptical Science (3 May 2008) based on data from Joint Institute for the Study of the Atmosphere and the Ocean, Washington University**

Another natural phenomenon that skeptics see as contributing to imminent global cooling, rather than warming, is the Atlantic Multidecadal Oscillation (AMO), closely related to warm currents that bring heat from the tropics to European shores about every 60 to 70 years. Yet when German researchers attempted to incorporate the impact of the AMO into computer models of projected climate change, they found that the AMO may temporarily ameliorate the impact of fossil fuel emissions for about a decade, before giving way to rapidly rising temperatures thereafter. The scientists argued that their findings, published in *Nature*, did not contradict the consensus around anthropogenic climate change, but suggested that increased warming would occur later rather than earlier due to the AMO, possibly with a heightened impact due to greenhouse gases accumulated in the interim. This relates to a phenomenon known as 'internal climate variability' (variations in climate trends due to internal natural fluctuations).[29]

Leading climate scientists from the online climate information network *Real Climate* – namely Stefan Rahmstorf, Michael Mann, Ray Bradley, William Connolley, David Archer, and Caspar Ammann – interrogated the study's forecast of 'no warming for a decade' and argued that it severely underestimated actual global warming trends.[30] But their criticism perhaps overlooked the most disturbing implications of the *Nature* study.

As noted by American physicist Joseph Romm, executive director of the Center for Energy and Climate Solutions, the study was widely misrepresented by the mainstream media, which interpreted it as supporting the case for global cooling. In fact, the *Nature* study confirmed exactly the opposite. Citing correspondence with the lead author of the paper, Noel

Keenlyside, Romm pointed out that the researchers did not expect a rise in "*mean* temperature" between 2005 and 2015, but that this did not preclude any rise in, for example, global surface temperatures. The study, rather, explains why global average temperatures "have not risen very much in recent years, and, perhaps, why ocean temperatures have also not risen very much in the past few years." In the correspondence, Dr. Keenlyside explicitly acknowledges that their data implies a rapid rise in global average temperature after 2010: "However, as you correctly point out, our results show a pick up in global mean temperature for the following decade (2010-2020). Assuming a smooth transition in temperature, our results would indicate the warming picks up earlier than 2015."

**Figure  Projected Global Mean Surface Temperatures. Source: BBC News (1 May 2008)**

In summary, global average temperature is likely to fluctuate along a rough plateau, until it rises sharply in the decade after 2010. Given that observed global mean temperatures have actually been higher than the study's simulated prediction with ocean data, it is clear that its prediction is very likely to be conservative, and overall global warming trends will be worse even accounting for the role of the AMO. Romm thus points out that the *Nature* study remains consistent with the following predictions:

1) The "coming decade" (2010 to 2020) is poised to be the warmest on record, globally.
2) The coming decade is poised to see faster temperature rise than any decade since the authors' calculations began in 1960.
3) The fast warming would likely begin early in the next decade.
4) The mean North American temperature for the decade from 2005 to 2015 is projected to be slightly warmer than the actual average temperature of the decade from 1993 to 2003.[31]

## *Global Cooling?*

Contributing to further pubic confusion is the bizarre idea, mentioned above, that global warming stopped in 1998. We discussed Easterbrook's approach to this, noting that the argument is not supported by research published in the peer-reviewed scientific literature. Although Easterbrook attempted to underpin the idea of global cooling with a variety of extrapolations about the Earth's various internal weather cycles in different regions, the idea

that we have definitely entered a period of global cooling has been endorsed by several other non-climate scientists. For instance, in 2006 the *Telegraph* carried a piece by Bob Carter, an Australian geology professor, arguing that "for the years 1998-2005 global average temperature did not increase (there was actually a slight decrease, though not at a rate that differs significantly from zero)."[32] Former BBC science correspondent and fellow of the Royal Astronomical Society David Whitehouse similarly wrote in the *New Statesman*:

> "The fact is that the global temperature of 2007 is statistically the same as 2006 as well as every year since 2001. Global warming has, temporarily or permanently, ceased. Temperatures across the world are not increasing as they should according to the fundamental theory behind global warming – the greenhouse effect. Something else is happening and it is vital that we find out what or else we may spend hundreds of billions of pounds needlessly."[33]

The reason these arguments find no substantiation in the actual scientific literature is simple: they are false. According to the UK Met Office's Hadley Centre for Climate Change: "A simple mathematical calculation of the temperature change over the latest decade (1998-2007) alone shows a continued warming of 0.1 °C per decade." As noted, there has been a recent slight slowing of warming due to internal variability. This is not only due to the PDO or AMO, but more significantly due to the role of the El Niño Southern Oscillation, a periodic atmospheric and oceanic change in the tropical Pacific region, which has two phases: 'El Niño', the period when water in that region is warmer than average; and 'La Niña', the period when the water in the tropical Eastern Pacific is colder than average. The Met Office refers to "a shift towards more-frequent La Niña conditions in the Pacific since 1998. These bring cool water up from the depths of the Pacific Ocean, cooling global temperatures." La Niña conditions late this decade thus played a major role in cooler temperatures. In contrast, the El Niño can warm global temperatures by about 0.2 degrees C in a single year, affecting ocean surface and air temperatures over land. The El Niño event during 1998 broke previous warming records, making subsequent temperatures appear flatter. Thus, El Niño created much warmer conditions in 1998 while La Niña generated cooler conditions toward 2008, forming the appearance of a flatter temperature curve.[34]

Nevertheless, datasets from the National Climate Data Center (NCDC) and NASA's Goddard Institute for Space Studies corroborate the Met Office's findings, and display a continuing, if slower, global warming trend from 1998 to 2007. The Hadley (Met Office) dataset is flatter because it ignores parts of the Arctic which have experienced strong warming.[35]

**Figure Global Warming Trend 1998-2007. Source: Robert Fawcett, Bulletin of the Australian Meteorological and Oceanographic Society (2007)**

It is therefore clear that the apparent cooling trend witnessed from around 2007 was an outcome of several major factors including not only the PDO and AMO, but also more significantly, the role of La Niña. The UN's World Meteorological Organisation (WMO) confirmed in early 2008 that the cold La Niña ocean current in the Pacific would lead to slightly colder temperatures for 2008 as compared to 2007. Yet it also noted that the 2008 global mean temperature was still "well above the average for the last 100 years", and that "the decade from 1998 to 2007 was the warmest on record." According to WMO Secretary-General Michael Jarraud, "La Niña is part of what we call 'variability.' There has always been and there will always be cooler and warmer years, but what is important for climate change is that the trend is up; the climate on average is warming even if there is a temporary cooling because of La Niña."[36] It thus transpired that already by mid-2008 the La Niña cooling effect had begun weakening.

Prior to this recovery in temperature rise, the La Niña effect had contributed to a temporary drop in temperature from January 2007 to January 2008 of around 0.6°C, documented by meteorologist Anthony Watts who described the phenomenon as "an anomaly with a large magnitude" coinciding with "other anecdotal weather evidence."[37] Climate skeptics jubilantly reported this as yet further evidence of global cooling, rather than warming. For instance, *DailyTech* reported Watt's finding as "a value large enough to erase nearly all the global warming recorded over the past 100 years. All in one years time. For all sources, it's the single fastest temperature change ever recorded, either up or down."[38] *DailyTech* then suggested that this global cooling was due not to La Niña, as documented by the scientific community, but rather to reduced solar activity. The suggestion, once more lacking substantiation from the peer-reviewed scientific literature, was that the sun is currently in its weakest cycle (23), with cycle 24 purportedly refusing to start. Skeptics point out that a similar event occurred 400 years ago in the form of a solar event known as a Maunder Minimum, precipitating a 'Little Ice Age' consisting of a sharp global temperature drop. This proves, according to *DailyTech*, that the Earth is on the verge of a prolonged phase of global cooling due to yet another Maunder Minimum.[39]

Yet there is a serious problem with this idea. For diminished solar activity to be the direct cause of the 0.6°C drop in global temperature over a single year would require a dramatic

reduction in Total Solar Irradiance (TSI) – that is, the total amount of radiant energy emitted by the Sun hitting the top of the Earth's atmosphere, measured in watts per square metre ($W/m^2$). According to Charles Camp and Ka Kit Tung from the Department of Applied Mathematics at the University of Washington, in a paper in *Geophysical Research Letters*, the solar cycle contributes *just under 0.2°C (to be precise, only 0.18°C) cooling* to global temperatures as the sun moves from maximum to minimum – over three times smaller than the 0.6°C necessary in this case.[40] The solar cycle therefore simply cannot explain the level of cooling occurring from 2007 to 2008, which was correlated instead with aforementioned oscillations in ocean conditions.

Indeed, contradicting the speculation that solar cycle 24 would fail to kick-in leading to a period of prolonged global cooling for several decades, the solar cycle did begin in early 2008 – exactly as had been predicted by leading solar scientists for some years. The scientists had already pointed out years earlier that the cycle would start later than normal, but would be between 30 and 50 per cent stronger than the previous cycle, reaching its peak in about 2012.[41] Unfortunately, this is likely to exacerbate the impact of fossil fuel emissions on global warming over the coming decades. This example illustrates the key lesson that climate change cannot be understood simply by emphasizing inevitable fluctuations and variations in weather over short time-periods, but by analyzing the long-term trends over decades.

## 1.2 National Security Alert

### *Abrupt, Rapid Climate Change: Plausible*

So the global warming sceptics are unequivocally wrong. But how grave is the danger from climate change? One of the first explicit indications that the Western national security establishment recognized that climate change may well pose a more dangerous threat to national security than terrorism was a Pentagon study commissioned by the legendary US Department of Defense planner Andrew Marshall. Made public in January 2004, the report was authored by Peter Schwartz, a CIA consultant and former planning head at Shell Oil, and Doug Randall, a senior consultant at the Global Business Network in San Francisco. Titled "An Abrupt Climate Change Scenario and Its Implications for United States National Security", the report for the Department of Defenses' Office of Net Assessment drew on interviews and research from leading climate scientists to project a particularly dangerous

global scenario that "is plausible, and would challenge United States national security in ways that should be considered immediately." Climate change, the report urged, "should be elevated beyond a scientific debate to a US national security concern." Dismissing doubts about the scientific validity of climate change, the report argued that:

> "There is substantial evidence to indicate that significant global warming will occur during the 21st century… Recent research, however, suggests that there is a possibility that this gradual global warming could lead to a relatively abrupt slowing of the ocean's thermohaline conveyor, which could lead to harsher winter weather conditions, sharply reduced soil moisture, and more intense winds in certain regions that currently provide a significant fraction of the world's food production. With inadequate preparation, the result could be a significant drop in the human carrying capacity of the Earth's environment."[42]

Concerns over the national security implications of climate change were also aired in Europe. In early 2008, a high-level European Union (EU) report to 27 heads of governments warned of the probability of "significant potential conflicts" in coming decades due to "intensified competition over access to, and control over, energy resources." Written by Javier Solana, the EU's foreign policy chief, and Benito Ferrero-Waldner, the EU commissioner for external relations, the report argued that global warming would precipitate major security issues for Europe, such as mass migrations, failed states and political radicalization. In particular, it noted that the quickened thawing of the Arctic due to accelerating climate change would lead to intensified geopolitical contestations between Russia and NATO, and potentially even military conflict, over access to the region's large reserves of untapped oil and gas reserves. The EU report also highlighted intensified North-South tensions due to global warming, particularly the volatility of regions in the Middle East and Central Asia holding large energy reserves and mineral deposits.[43]

## *Increased Probability of Resource Conflict*

Such concerns were already emphasised in the Pentagon's earlier report, which had warned that rapid climate change could fundamentally "destabilize the geo-political environment, leading to skirmishes, battles, and even war" due to three categories of resource constraint:

1) Food shortages due to decreases in net global agricultural production;
2) Decreased availability and quality of fresh water in key regions due to shifting

precipitation patterns, causing more frequent floods and droughts;
3) Disrupted access to energy supplies due to extensive sea ice and storminess.

Rapid climate change, leading to catastrophic droughts, famines and rioting, would thus effect mounting national and international tensions, mediated through defensive and offensive strategies that could escalate into a terrifying arc of global conflicts, oriented around deadly competition over control of increasingly scarce resources: "Nations with the resources to do so may build virtual fortresses around their countries, preserving resources for themselves. Less fortunate nations especially those with ancient enmities with their neighbors, may initiate in struggles for access to food, clean water, or energy." The Pentagon study thus suggests not only that the threat to national security posed by rapid climate change is potentially far worse than terrorism, but further that the future arc of conflict will be about "resources for survival rather than religion, ideology, or national honor."[44]

Yet the Pentagon warning is only the tip of a rapidly melting iceberg. Over the last decade alone, scientific studies have increasingly homed in on the dynamics, contours, and impacts of climate change. And the implication is not merely that climate change could dramatically undermine national security, but that it could endanger the very survival of civilization itself.

## *Existential Threat: Fatal Disruption to Industrial Civilization by End of 21st Century*

Outlining six climate change scenarios, the landmark February 2007 Fourth Assessment Report by the United Nations Inter-Governmental Panel on Climate Change (IPCC) shows that even the least-case scenario would be greatly destabilizing. But the worst-case scenario for the first time demonstrated more bluntly than ever that climate change could mean the end of life on Earth, in our own lifetimes. The report projected that by 2100, the average global temperature could rise by 6.4°C, leading to drastic ecological alterations that would make *life throughout most of the Earth impossible*.[45] Even a rise of 3°C produced by a doubling of $CO_2$ production from pre-industrial levels to 550 parts per million – not a worst case scenario and advocated by the British government's former chief scientific adviser Sir David King as a realistic upper limit at which $CO_2$ levels could be stabilized – would generate conditions unsupportable by society.

The IPCC report generated alarm bells around the world about the gravity of climate change and its potentially fatal impact for life on Earth. Going further, British ecologist Mark Lynas translated the IPCC's temperature rise scenarios into a detailed analysis of the scale of global warming at each degree. In his book *Six Degrees: Our Future on a Better Planet* – winner of the Royal Society Science Book Prize – Lynas reviewed thousands of peer-reviewed scientific studies and climate models, to try and show how each degree level increase in the global average temperature is likely to change the face of the Earth:[46]

1°C Increase: Ice-free sea absorbs more heat and accelerates global warming; fresh water lost from a third of the world's surface; low-lying coastlines flooded

2°C Increase: Europeans dying of heatstroke; forests ravaged by fire; stressed plants beginning to emit carbon rather than absorbing it; a third of all species face extinction

3°C Increase: Carbon release from vegetation and soils speeds global warming; death of the Amazon rainforest; super-hurricanes hit coastal cities; starvation in Africa

4°C Increase: Runaway thaw of permafrost makes global warming unstoppable; much of Britain made uninhabitable by severe flooding; Mediterranean region abandoned

5°C Increase: Methane from ocean floor accelerates global warming; ice gone from both poles; humans migrate in search of food and try vainly to live like animals off the land

6°C Increase: Life on Earth ends with apocalyptic storms, flash floods, hydrogen sulphide gas and methane fireballs racing across the globe with the power of atomic bombs; only fungi survive.[47]

**Figure 6. Graphical Presentation of UN IPCC Scenarios for Global Warming By Degrees Celsius. Source: Stop Climate Change (2008) based on Stern Review of the Economics of Climate Change**

Climate change, in other words, does not simply mean more wars, social chaos, and political upheaval. In the long-term, global warming threatens the survival of modern industrial civilization.

## 1.3 Rapid Climate Change

### *Positive Feedbacks and Runaway Climate Change by Mid-Century*

As dismal as these projected scenarios are, increasing scientific evidence strongly suggests that even the IPCC's worst-case scenario of a 6 degree Celsius rise in world average temperature by 2100 could be overly optimistic, if current rates of increase of fossil fuel emissions continue unabated.

At the end of 2006, the Global Carbon Project (GCP) announced its findings that between 2000 and 2005, $CO_2$ emissions had *grown four times faster* than in the preceding 10 years. GCP executive director Josep Canadell warned: "On our current path, we will find it extremely difficult to rein in carbon emissions enough to stabilise the atmospheric $CO_2$ concentration at 450 parts per million [limiting global warming to 2°C] and even 550 ppm [3°C] will be a challenge."[48] Similarly, according to a paper in the *Proceedings of the National Academy of Sciences* in April 2007, concurrent $CO_2$ emissions are worse than all six scenarios contemplated by the IPCC: "The emissions growth rate since 2000 was greater than for the most fossil-fuel intensive of the Intergovernmental Panel on Climate Change emissions scenarios." This implies that the IPCC's worst-case six degree scenario is a conservative underestimate of the most probable climate trajectory under current rates of emissions.[49]

Indeed, due to environmental inertia (by which the environment stores up part of the energy generated by greenhouse gas emissions, only releasing it to the atmosphere later on), even with the complete cessation of human emissions, atmospheric carbon dioxide would continue to rise for up to a century, and therefore global temperatures would continue to increase for two or more centuries. So climate change could occur more rapidly than expected by many current studies.[50] This underscores the stark inadequacy of demands to stabilise $CO_2$ emissions at 1990 levels (the Kyoto Protocols); and to allow countries to produce their own arbitrary targets for emissions reductions (Copenhagen).

A further GCP study in 2008 found that in the preceding year, carbon released from burning fossil fuels and producing cement had increased 2.9 percent over that released in 2006, to a total of 8.47 Gigatons (Gt.). This output is at the highest end of the IPCC's worst-case scenario. Similarly, in October 2008, another paper published in the *Proceedings of the National Academy of Sciences* showed that even if humans stopped generating greenhouse gases immediately, the world's average temperature would "most likely" increase by 2.4 degrees C by the end of this century – potentially enough to trigger irreversible, and potentially even runaway climate change, as we will show below.[51]

**Figure 7 World Energy-Related CO2 Emissions by Fuel Type, 1992-2030. Source: US Energy Information Administration (EIA), International Energy Annual 2004 (May-July 2006); EIA, System for the Analysis of Global Energy Markets (2007)**

One of the most widely-cited climatic models exploring the potential impact of such environmental inertia was by the Met Office's Hadley Centre for Climate Change. It was one of several new studies recognizing that the global climate system is in a state of unstable equilibrium, in which surface heating caused by $CO_2$ can act as a trigger for an accelerating process of global warming driven by amplifying "positive feedbacks", eventually leading to a process of runaway climate change completely beyond human control. The further we move away from unstable equilibrium due to human-generated emissions, the more powerful becomes the positive feedback system, and thus the faster the rate of climate change. David Wasdell, lead scientist on feedback dynamics of complex systems for the Global System Dynamics and Policies Project of the European Commission, has taken such findings much further. He finds that many current global warming estimates focusing on the alleged safety of the 2°C limit could be quite off the mark, and that runaway climate change could begin by mid-century.[52] In this case, rather than global warming constituting a gradual, linear increase, with greenhouse gasses being absorbed and retained by the atmosphere, the billions of years' worth of carbon and methane could be incontinently released in blazing surges that would drown or incinerate whole cities. Polar ice would melt rapidly, and the Amazon rainforest could collapse in a few decades. A vicious, irreversible and self-reinforcing spiral would begin which would threaten not just our way of life but the very existence of our own and every other species on Earth.[53]

The United Nations IPCC report has commendably shifted the debate on climate change by publicly affirming firstly an overwhelming scientific consensus on the reality of human-emissions generated climate change, and secondly a startling set of scenarios for how global warming will affect life on Earth by the end of this century if existing rates of increase of $CO_2$ emissions continue unabated. But according to a growing body of scientific evidence, the IPCC's findings in 2007 were far too conservative – and dangerous climate change is more likely to occur far sooner, with greater rapidity, and higher intensity, than officially recognized by governments.

## *Inaccuracies in the Intergovernmental Panel on Climate Change 2007 Report*

A number of British researchers expressed grave reservations shortly after the release of the UN IPCC Fourth Assessment Report. In particular, David Wasdell, who was an accredited reviewer of the IPCC report, told the *New Scientist* that early drafts prepared by scientists in April 2006 contained "many references to the potential for climate to change faster than expected because of 'positive feedbacks' in the climate system. Most of these references were absent from the final version." His assertion is based "on a line-by-line analysis of the scientists' report and the final version," which was agreed in February 2007 at "a week-long meeting of representatives of more than 100 governments." Below we highlight three examples from Wasdell's analysis:

1) In reference to warnings that natural systems such as rainforests, soils and oceans would be less able in future to absorb greenhouse gas emissions, the scientists' draft report of April 2006 warned: "*This positive feedback could lead to as much as 1.2 degrees Celsius of added warming by 2100*". The final version of March 2007 though only acknowledges that feedback exists and says: "The magnitude of this feedback is uncertain."

2) The April 2006 draft warned that global warming will increase the amount of water vapour released into the atmosphere, which in turn will act like a greenhouse gas, leading to an estimated *"40-50 percent amplification of global mean warming".* In the final March 2007 report this statement was replaced with "Water vapour changes represent the largest feedback".

3) In relation to the acceleration of breakup of arctic and antarctic ice sheets, the April 2006 draft paper talked about observed rapid changes in ice sheet flows and referred to an *"accelerated trend" in sea-level rise.* The government-endorsed final report of March 2007 said that "ice flows from Greenland and Antarctica … could increase or decrease in future."[54]

4) The conclusion that *"North America is expected to experience locally severe economic damage, plus substantial ecosystem, social and cultural disruption from climate change related events"* was removed from the final version.[55]

In other words, the IPCC Fourth Assessment Report excluded and underplayed direct reference to the overwhelming probability of the rapid acceleration of climate change in the context of current rates of increase of $CO_2$ emissions and positive feedbacks. Wasdell put it down to possible political interference, and there are reasonable grounds for this conclusion. As noted by Mike Mann, director of the Earth System Science Center at Pennsylvania State

University, and a past lead author for the IPCC: "Allowing governmental delegations to ride into town at the last minute and water down conclusions after they were painstakingly arrived at in an objective scientific assessment does not serve society well."[56]

The possible watering-down of the IPCC's 2007 Fourth Assessment Report is part of a wider pattern. In the same month, a joint survey by the Union of Concerned Scientists and Government Accountability Project concluded that 58 per cent of US government-employed climate scientists surveyed complained of being subjected to: 1) "Pressure to eliminate the words 'climate change,' 'global warming', or other similar terms" from their communications; 2) editing of scientific reports by their superiors which "changed the meaning of scientific findings"; 3) statements by officials at their agencies which misrepresented their findings; 4) "The disappearance or unusual delay of websites, reports, or other science-based materials relating to climate"; 5) "New or unusual administrative requirements that impair climate-related work"; 6) "Situations in which scientists have actively objected to, resigned from, or removed themselves from a project because of pressure to change scientific findings." Scientists reported 435 incidents of political interference over the preceding five years.[57] Such large-scale systematic political interference with climate science lends credence to the concern that climate scientists feel unable to voice their real views about the urgency posed by global warming.

## 1.4 Abrupt Change through "Tipping Points"

### *Earth Does Not Do Gradual Change*

The probability of the rapid acceleration of climate change at current rates of increase of $CO_2$ emissions is therefore a pivotal issue. In the last few years, the weight of the available scientific evidence increasingly suggests that climate change will occur not through a long, protracted linear process of gradual intensification, but in the form of abrupt shifts through "tipping points." As noted by Fred Pearce, an editor at the *New Scientist* and author of *The Last Generation*, the majority of climate scientists now accept that their old ideas about gradual change simply do not represent how the world's climate system works. "Climate change did not happen gradually in the past, and it will not happen that way in the future. Planet Earth does not do gradual change. It does big jumps; it works by tipping points**."**[58]

In 2002, a comprehensive study by the US National Academy of Sciences described a "new paradigm of an abruptly changing climatic system", that is now "well established by research over the last decade." But the new paradigm "is little known and scarcely appreciated in the wider community of natural and social scientists and policy-makers." The report warned that:

> "Abrupt climate changes were especially common when the climate system was being forced to change most rapidly. Thus, greenhouse warming and other human alterations of the earth system may increase the possibility of large, abrupt, and unwelcome regional or global climatic events. The abrupt changes of the past are not fully explained yet, and climate models typically underestimate the size, speed, and extent of those changes. Hence, future abrupt changes cannot be predicted with confidence, and climate surprises are to be expected."[59]

There is thus "a growing fear among scientists that, thanks to man-made climate change, we are about to return to a world of climatic turbulence, where tipping points are constantly crossed." The last five years alone of scientific research has unearthed previously unknown tipping points that could trigger rapid climate change.[60]

### *The Two Degree Limit?*

At the June 2005 UK government conference on "Avoiding Dangerous Climate Change" at the Met Office in Exeter, scientists reported an emerging consensus that global warming must remain "below an average increase of two degrees centigrade if catastrophe is to be avoided." It was argued that this requires ensuring that carbon dioxide in the atmosphere stays below 400 parts per million (ppm). Beyond this level, dangerous and runaway climate change is likely to be irreversible.

It is commonly believed that the current concentration of $CO_2$ in the atmosphere is about 385 ppm. However, about two weeks after the government conference warning of the minimum threshold, the London *Independent* commissioned an investigation by Keith Shine, Head of the Meteorology Department at the University of Reading. Using the latest available figures for 2004, Professor Shine calculated that "the $CO_2$ equivalent concentration, largely unnoticed by the scientific and political communities, has now risen beyond this threshold." Unlike other calculations, Shine accounted for the effects of methane and nitrous oxide, finding that the total concentration of greenhouse gasses contributing to global warming (i.e. the equivalent concentration of $CO_2$) is now 425ppm and fast rising. In the absence of

mitigating strategies to reduce the amount of $CO_2$ already in the atmosphere, this *guarantees that the global mean temperature will rise by 2 degrees* before the end of this century. Consequently, Shine argued, some of the worst predicted effects of global warming, such as the destruction of ecosystems and increased hunger and water shortages for billions of people in the South, could be unavoidable unless drastic action is taken to not only reduce emissions, but to remove $CO_2$ from the atmosphere.[61]

Shine's findings were corroborated by the IPCC in October 2007, concluding that the level of greenhouse gases in the atmosphere in mid-2005 had *reached 445 ppm*, a level not expected for another 10 years. Macquarie University climate scientist Tim Flannery remarked: "We thought we had that much time. But the new data indicates that in about mid-2005 we crossed that threshold. What the report establishes is that the amount of greenhouse gas in the atmosphere is already above the threshold that could potentially cause dangerous climate change."[62]

When asked about the implications, Tom Burke CBE, a former British government environment adviser for 14 years,[63] told the *Independent*:

> "The passing of this threshold is of the most enormous significance. It means we have actually *entered a new era – the era of dangerous climate change***.** We have passed the point where we can be confident of staying below the 2 degree rise set as the threshold for danger. What this tells us is that we have already reached the point where our children can *no longer count on a safe climate*."[64]

The 2 degree limit has been adopted by the European Union as the maximum limit that humanity can risk. "Beyond that," notes Paul Brown, "as unwelcome changes in the earth's reaction to extra warmth continue, it is theoretically possible to trigger runaway climate change, making the earth's atmosphere so different that most of life would be threatened."[65]

A 2005 joint task-force report by the Institute for Public Policy Research (IPPR) in the UK, the Center for American Progress in the US, and the Australia Institute, argues on the 2 degree basis that the point-of-no-return may be reached as early as 2015. The report finds a two degree temperature rise would trigger an irreversible chain of climatic disasters:

> "The possibilities include reaching climatic tipping points leading, for example, to the loss of the West Antarctic and Greenland ice sheets (which, between them, could raise sea level more than 10 meters over the space of a few centuries), the shutdown of the thermohaline ocean circulation (and, with it, the Gulf Stream), and the transformation of the planet's forests and soils from a net sink of carbon to a net source of carbon."[66]

However, it is now becoming clear that the 2 degree-450 ppm EU limit is far too high, a political figure adopted against sound scientific advice. After studying core samples from the bottom of the ocean to track the effect of $CO_2$ levels millions of years ago, James Hansen, head of the NASA Goddard Institute for Space Studies, concluded in April 2008 that the absolute upper limit for acceptable $CO_2$ emissions is *350 ppm – a limit that has already been surpassed*: "If you leave us at 450ppm for long enough it will probably melt all the ice – that's a sea rise of 75 metres. What we have found is that the target we have all been aiming for is a disaster – a guaranteed disaster." At levels as high as 550ppm, Hansen's team found that the world would warm by 6°C, double that of previous estimates. In other words, the impact of $CO_2$ emissions is likely to be *double* the intensity and severity of the conservative scenarios outlined by the IPCC. This is due to the positive feedbacks that were insufficiently incorporated into IPCC assessments. It is necessary therefore not simply to stop fossil fuel emissions, but to apply technologies to safely extract carbon from the atmosphere and store it safely, allowing the atmospheric concentration to return to a safe level. Yet Hansen warns that even these technologies are seriously inadequate by themselves, and over the long-term other methods to increase soil carbon storage capacity should be explored, such as extensive reforestation and more creative carbon sequestration techniques like 'biochar' – a charcoal produced from biomass which could provide long-term carbon storage while improving soil quality and agricultural productivity.[67]

**Figure 8 $CO_2$ Reductions with Coal-Carbon Phaseout by 2030. Source: James Hansen , et. al. (2030)**

It should be emphasised, then, that even the 350 ppm upper limit was not proposed by Hansen as a *target* for emissions reductions, as it would not prevent massive climate change with potentially uncontrollable and irreversible consequences. As noted by Philip Sutton, who teaches Global Warming Science at the University of Melbourne:

> "The total loss of the Arctic sea-ice in summer, the loss over the next few decades of all the ice in the Himalayas, the loss over 100 years of all the permafrost stored carbon, the acidification of the ocean, the overheating of the oceans, the loss of the Amazon rainforest, the loss of most of the Greenland ice sheet, the destabilisation and major loss of the West Antarctic ice sheet are all issues that have severe ramifications and require lower $CO_2$ levels than 350 ppm."[68]

The problem is that each of these effects, probable even below 350 ppm, have their own positive feedback impacts, each with potentially irreversible consequences. A safe level of emissions is somewhere below 330 ppm – most likely, according to Professor John Schellnhuber of the Potsdam Institute, between 280 and 300 ppm.[69] *We appear to have now passed the tipping point, and at current rates of increase of $CO_2$ emissions, we are well on our way to breaching temperatures of 2°C and even 3°C at minimum*. Since 2005, increasing evidence that several major climate sub-system tipping points have thus been breached with potentially irreversible consequences has emerged. These consequences, in turn, may trigger the breaching of further tipping points, the cumulative impact of which could push the whole Earth climate system into a self-reinforcing runaway warming process.

## *The Gulf Stream and the Arctic Ice Cap*

In May 2005, climate scientists working under Peter Wadhams, Professor of Ocean Physics at Cambridge University, announced they had found signs of a slowdown in the Gulf Stream, otherwise known as the thermohaline circulation (THC) – a huge convection system that transports warm water from the tropics to the poles and send cool water back through the depths of the oceans. One of its driving "engines," the sinking of supercooled water in the Greenland Sea, had "weakened to less than a quarter of its former strength" due largely to global warming, likely to precipitate a drop in temperatures in the UK and northwest Europe. Wadhams and his team also predicted that the slowing of the Gulf Stream might have other effects, such as the complete summer melting of the Arctic ice cap by "as early as 2020 and almost certainly by 2080."[70] By December 2005, scientists on an expedition to the Atlantic Ocean, measuring the strength of the current between Africa and the American east coast, found that the circulation had slowed by 30 per cent since a previous expedition 12 years ago.[71] More recent research suggests that this may not be as serious as originally suspected, and that the downward trend is less pronounced than hitherto believed.[72]

The fear is that higher temperatures caused by global warming could add fresh water to the northern North Atlantic by increasing the precipitation and by melting nearby sea ice, mountain glaciers and the Greenland ice sheet. This influx of fresh water could reduce the surface salinity and density, potentially slowing down the Gulf Stream. The southern hemisphere would become warmer and the northern hemisphere would experience cooling, but this cooling effect would probably be counter-balanced by overall excess warming.[73]

Although a large shift in the THC was the main variable studied in the Pentagon's apocalyptic scenario of abrupt climate change, climate scientists are accustomed to view a collapse of the Gulf Stream or THC as a very slim probability. But as time has passed, the probably has increased dramatically. According to Michael Schlesinger, Professor of Atmospheric Sciences at the University of Illinois at Urbana-Champaign:

> "Absent any climate policy, scientists have found a 70 percent chance of shutting down the thermohaline circulation in the North Atlantic Ocean over the next 200 years, with a 45 percent probability of this occurring in this century. The likelihood decreases with mitigation, but even the most rigorous immediate climate policy would still leave a 25 percent chance of a thermohaline collapse."

He added that: "The shutdown of the thermohaline circulation has been characterized as a high-consequence, low-probability event. Our analysis, including the uncertainties in the problem, indicates it is *a high-consequence, high-probability event*."[74] Since then, increasing evidence indicates that other climate systems are even closer to tipping points toward serious instability.

In August 2005, scientists reported that Arctic sea ice had reached its lowest monthly point on record, dipping an unprecedented 18.2 per cent below the long-term average. Sea ice naturally melts in summer and reforms in winter but for the first time on record, this annual rebound did not occur.[75]

By March 2007, the traversal of this tipping point was no longer in doubt. Mark Serreze, then at the US National Snow and Ice Data Centre (NSIDC) warned that the Arctic would soon be almost totally ice-free within the next few decades, with a dramatic impact on weather patterns across the northern hemisphere. "I think there is some evidence that we may have reached that tipping point, and the impacts will not be confined to the Arctic region," he noted. "With this increasing vulnerability, a kick to the system just from natural climate fluctuations could send it into a tailspin."[76]

**Figure 9 Arctic Sea Ice Loss. Source: Chris Rowan, University of Johannesburg (2007)**

The potential impact within this century is not entirely predictable, but the broad contours are clear. NASA's James Hansen has noted that in the context of the rapid melting of the Greenland and Antarctic ice sheets, sea levels are already rising at an unprecedented rate, and could end up increasing by one meter every 20 years. "That is a real disaster, and that's what

we have to avoid", he warned. According to Eric Lindstrom, NASA's head of oceanography, satellite data shows that: "If the (polar) ice sheets really get involved, then we're talking tens of metres of sea level – that could really start to swamp low-lying countries," including large areas of Britain, Western Europe and the United States.[77]

But the rate of annual retreat of Arctic ice is likely to intensify as the loss of ice exposes the darker ocean, which absorbs more of the sun's energy leading to increased melting of ice. Thus, with each year, the predictions of climate scientists turn out to be not too alarmist, but to the contrary, far too conservative. Thus by December 2007, NASA satellite data showed that Arctic ice was disappearing so fast that "an irreversible tipping point has already been reached because of global warming." Between 2002 and 2006, the volume of Arctic ice had halved, while the Greenland ice sheet had lost almost 19 billion tonnes. According to NASA climate scientist Jay Zwally:

> "*At this rate, the Arctic Ocean could be nearly ice-free at the end of summer by 2012*, much faster than previous predictions. The Arctic is often cited as the canary in the coal mine for climate warming. Now as a sign of climate warming, the canary has died. It is time to start getting out of the coal mines… *It's getting even worse than the climate models predicted*."[78]

By the end of 2008, NSIDC scientists declared that the rate of Arctic melting had probably already breached the tipping-point. Regional air temperatures were higher than expected during the autumn due to accumulating heat in the ocean as more sea ice melts. This process of 'Arctic amplification', a self-reinforcing positive feedback, was not expected for another 10-15 years, and is occurring at a pace faster than accounted for in any of the IPCC's models.[79] A summer 2009 study of the thickness of the Arctic ice, rather than just surface area, found that it had thinned by 40 per cent since 2004.[80] The accelerating Arctic melt also increases the probability of a slow-down of the Gulf Stream or THC, as discussed above:

1 Surface currents carry warm, salty water from the tropics.

2 The water cools, its density increases and it sinks to the deep ocean.

3 The cold water flows back to the equator, driving the 'ocean conveyor' which in turn contributes to the North Atlantic current, the continuation of the Gulf Stream, that warms northern Europe.

4 As ice melts, freshwater dilutes the warm salty water from the tropics.

5 The water becomes less dense so does not sink as fast, weakening the 'conveyor' and therefore possibly disrupting the Gulf Stream.[81]

While potentially contributing to cooling in northern Europe, a slow-down of the Gulf Stream would simultaneously lead to increasing droughts in other areas. This process is already well underway and getting worse. According to the US National Center for Atmospheric Research (NCAR) the percentage of Earth's land area stricken by serious drought more than doubled from the 1970s to the early 2000s, from about 10-15 per cent to 30 per cent, largely due to rising temperatures. Widespread drying occurred over much of Europe and Asia, Canada, western and southern Africa, and eastern Australia.[82] Global warming is not only melting the Arctic, it is melting the glaciers that feed Asia's largest rivers – the Ganges, Indus, Mekong, Yangtze and Yellow. Because glaciers are a natural storage system, releasing water during hot arid periods, the shrinking ice sheets could aggravate water imbalances, causing flooding as the melting accelerates, followed by a reduction in river flows. This problem is only decades, possibly even years away, potentially resulting in hundreds of millions of Africans and tens of millions of Latin Americans being short of water. By 2050, more than 1 billion people in Asia could face water shortages, and by 2080, water shortages could threaten 1.1 billion to 3.2 billion people. Some climate models show sub-saharan Africa drying out by 2050.[83] By other projections, as early as 2025 some 5 billion people globally could be suffering from serious water shortages, half a billion of them due to climate change.[84]

While Arctic sea ice is rapidly disappearing, the last 20 years have seen an apparently anomalous build-up of sea ice in West Antarctica. From 1979 to 2006, Antarctic wintertime ice extent increased by 0.6 per cent per decade. The average year-round ice has also increased in this period.[85] Climate sceptics often claim that this is evidence against global warming. However, actually it proves the opposite. Once again, it is necessary to account for longer-term climate trends and internal variability to understand what is happening. A 2003 study published in *Science* finds that detection of long-term change in Antarctica is masked by large fluctuations from decade-to-decade. These decadal fluctuations have produced the apparent short-term increases in Antarctic sea ice from recent satellite data. The *Science* study finds that since the 1950s, there has been *a large overall reduction of approximately 20 per cent* in the northern extent of Antarctic sea ice in the region south of Australia.[86] Furthermore, *overall* ice loss in the Antarctic has been detected even over shorter time-periods. A NASA mission in 2006, based on the first ever survey of the entire Antarctic ice sheet on land,

"found the ice sheet's mass has decreased significantly from 2002 to 2005", raising global sea levels by about 1.2 millimetres – about 13 per cent of the overall observed sea level rise for this period.[87]

In addition, the temporary increase of Antarctic sea ice has been *predicted* as a consequence of global warming, rather than its anti-thesis. Researchers have long known that snow builds glaciers. In 2005, a team of scientists combined snow-thickness measurements with modelling studies and found that snow may also build Antarctica's sea ice. Publishing their findings in the *Journal of Geophysical Research*, they argued that as climate change is intensifying global warming, more moisture has made its way to high latitudes, leading to heavier snowfalls in the Antarctic in particular. With increased snowfall, a sufficiently thick snow layer would push the ice underwater. The seawater in the snow-ice boundary would freeze, thickening the floe. "Some of the melt in the Arctic may be balanced by increases in sea ice volume in the Antarctic", noted lead scientist Dylan C. Powell.[88]

Another factor is ozone depletion. As global warming in the near-surface lower atmosphere (troposphere) accelerates in correlation with increased output of greenhouse gases, this warmer air becomes trapped in the lower troposphere as the $CO_2$ acts as a blanket, preventing the heat from entering the upper atmosphere (stratosphere) which thus begins to cool. Thus, higher surface temperatures due to global warming are correlated with lower temperatures in the upper atmosphere. In the Antarctic, high-altitude colder temperatures in the region intensify the impact of ozone destruction by Chloroflourcarbons (CFCs), emitted from so many industrial technologies. These lower temperatures thus counter the overall impact of global warming in the region.[89]

Adding to these explanations, research published in 2008 dissolved any further possible ambiguity. A new study in *Nature Geoscience* found that both the Arctic and the Antarctic are over the long-term "getting less icy because of global warming." The study, comparing temperature records and four computer climate models, found a warming in both polar regions that could only be explained by a buildup of greenhouse gases, mainly from burning fossil fuels, rather than natural forcings. In both polar regions, the observed warming could only be reproduced in climate models by including human influences via fossil fuels.[90]

### *More Positive Feedbacks*

The levels of warming in the polar regions are merely isolated signifiers of the momentous scale of climate changes that scientists are racing to keep up with. Scientists have isolated a total of 12 eco-system "hotspots" including the above, which they consider to be especially vulnerable to human-intervention. According to John Schellnhuber of the Potsdam Institute, we have barely begun to recognize the danger of triggering large-scale, rapid and irreversible changes across the entire planet, due to stress in these crucial systems which act as massive environmental regulators. "We have so far completely underestimated the importance of these locations. What we do know is that going beyond critical thresholds in these regions could have dramatic consequences for humans and other life forms." Breaching of tipping points in these climate sub-systems could also have uncontrollable consequences that could, in turn, increase the probability in breaching a tipping point in the global climate system, which could lead to runaway warming.[91]

When accounting for the potential impacts of positive feedbacks, the 2 degree C limit is simply too high. Even above 1°C, the probability of runaway climate change due to positive feedbacks is greatly increased, and above 2°C, where we are currently heading at existing rates of emissions, the probability is immeasurably magnified. According to James Hansen and colleagues:

> "If the [additional] warming is less than 1°C, it appears that strong positive feedbacks are not unleashed, judging from recent Earth history. On the other hand, if *global warming gets well out of this range*, there is a possibility that *positive feedbacks could set in motion climate changes far outside the range of recent experience*."[92]

Among the most dangerous positive feedbacks is the melting of Arctic permafrost, which contains far more carbon than previously believed. Arctic permafrost contains more carbon in the form of methane than in the entire atmosphere today, three times all industrial emissions.[93] Once the permafrost melts, the increased run-off of warmer water melts sub-ice methane clathrates, releasing methane into the atmosphere. For the past five years, Alaskan and Siberian permafrost has been melting, releasing five times more methane than previously estimated.[94] Thus, the more global warming melts permafrost, the increasing amount of methane is being released. Methane is 20 times more powerful a greenhouse gas than $CO_2$. In September 2008, an expedition organized by the International Siberian Shelf Study being prepared for publication by the American Geophysical Union confirmed that millions of tonnes of sub-sea methane are being released due to rapidly melting Arctic permafrost.[95] An estimated 1,400 Gt of carbon is trapped as methane under the Arctic permafrost, 5-10 per cent

of which has been punctured due to melting. Scientists say that a "release of up to 50 Gt of predicted amount of hydrate storage [is] highly possible for abrupt release at any time" – a quantity equivalent to doubling current levels of $CO_2$.[96] According to former US Energy Department geologist John Atcheson, the release of this methane signals the impending danger of a runaway greenhouse effect with extinction-level consequences:

> "A temperature increase of merely a few degrees would cause these gases to volatilize and 'burp' into the atmosphere, which would further raise temperatures, which would release yet more methane, heating the Earth and seas further, and so on. There's 400 gigatons of methane locked in the frozen arctic tundra – enough to start this chain reaction – and the kind of warming the Arctic Council predicts is sufficient to melt the clathrates and release these greenhouse gases into the atmosphere.
>
> Once triggered, this cycle could result in runaway global warming the likes of which even the most pessimistic doomsayers aren't talking about… The most recent of these catastrophes occurred about 55 million years ago in what geologists call the Paleocene-Eocene Thermal Maximum (PETM), when methane burps caused rapid warming and massive die-offs, disrupting the climate for more than 100,000 years.
>
> The granddaddy of these catastrophes occurred 251 million years ago, at the end of the Permian period, when a series of methane burps came close to wiping out all life on Earth... *If we trigger this runaway release of methane, there's no turning back. No do-overs. Once it starts, it's likely to play out all the way*."[97]

Another potential source of positive feedbacks are trees and forests, which are not always capable of acting as sinks which absorb carbon in the atmosphere, but instead can act as net sources of carbon. In the case of the pine forests of western North America, global warming created a perfect climate for bark beetles, leading to massive outbreaks of beetle population rise. This in turn weakened the ability of the northern forests to act as a carbon sink, as documented in *Nature*:

> "During outbreaks, the resulting widespread tree mortality reduces forest carbon uptake and increases future emissions from the decay of killed trees. The impacts of insects on forest carbon dynamics, however, are generally ignored in large-scale modelling analyses... This impact converted the forest from a small net carbon sink to a *large net carbon source* both during and immediately after the outbreak... Insect outbreaks such as this represent an important mechanism by which *climate change may undermine the ability of northern forests to take up and store atmospheric carbon*."[98]

Moreover, the tropical forests of the Amazon, the Congo and Borneo are nearing critical resiliency due to decreased rainfall from global warming.[99] A study by the Massachusetts-based Woods Hole Research Centre in Amazonia concluded that the rainforest cannot sustain three consecutive years of drought without breaking down. In year three, sample trees studied

by the scientists started dying, literally came crashing down, exposing the forest floor to the drying sun. By the end of the year the trees had released more than two-thirds of the carbon dioxide stored during their lives, thus accelerating climate change. The Amazon rainforest contains 90 billion tonnes of carbon, enough in itself to *increase the rate of global warming by 50 per cent*.[100] As global temperatures rise, the Amazon is thus increasingly at risk. Recent research shows that intensifying droughts in the Amazon are linked to warmer sea surface temperatures in the tropical Atlantic Ocean. Hence climate models increasingly forecast a dire future for the Amazon rainforest. As the tropical Atlantic warms, the southern Amazon is likely to see higher temperatures and less rainfall.[101] Further, due to the impact of deforestation, logging, fires, and drought, the Amazon could be reduced by 55 per cent by 2030. The impact of this massive loss of rainforest will result in emissions of 15-26 Pentagrams (Pg) of carbon in less than three decades – that is, *15-26 billion metric tonnes of carbon*.[102] The massive influx of carbon could accelerate global warming by as much as 1.5°C on top of the preceding temperature increase. With each rise in temperature, positive feedbacks such as this would be intensified with irreversible impacts. These in turn would increase the probability of an unstoppable escalation of global temperatures.

Just as trees may well end up contributing further to climate change as global warming accelerates, the same also applies to soil. One quarter of our carbon emissions are now being absorbed by the soil, but its capacity to do so is decreasing. As global warming increases, soil is increasingly liable to release its stored carbon. There is some 300 times as much carbon trapped in the soils as we release each year from burning fossil fuels. From 1978 to 2003, 13 Mts of carbon held in UK soils has been released each year.[103] As global warming accelerates microbial activity in the soil, the latter will release large quantities of carbon.[104]

Another major positive feedback is from water vapour, which in fact is the dominant greenhouse gas. Because water vapour enters the atmosphere via evaporation, the level of water vapour correlates with temperature. Temperature rise increases the rate of evaporation, and thus the quantity of water vapour in the atmosphere. Water vapour absorbs heat and this also warms the air, which in turn can cause further evaporation. The warming effect of $CO_2$ emissions amplifies all this by causing more water to evaporate. This in turn increases the amount of atmospheric water vapour which holds more heat, increasing the warming process. Water vapour can roughly double or, in tandem with other positive feedbacks, even triple the impact of $CO_2$ warming.[105]

The cumulative impact of positive feedbacks like melting permafrost, failing forests activated soil, and water vapour on climate change is difficult to imagine, but it is clear that

they pose the danger of triggering rapid, irreversible changes to key climate sub-systems once greenhouse gases above 350ppm are in the atmosphere for a prolonged period (we are currently approximately 75 ppm above this level). Beyond this limit, the impact of such rapid and irreversible changes makes it increasingly probable that the global climate system itself will be tipped over into a process of runaway warming.

Conventional climate models tend to omit the impact of such positive feedbacks. When incorporated, the findings are disturbing. Scientists at the Massachusetts Institute of Technology (MIT) in a study published by the *Journal of Climate* projected that between 2091 and 2100, global average temperature would rise to 5.1°C.[106] Similarly, a December 2008 Met Office study concluded that the world could warm by between 5-7°C by 2100 at the current rate of emissions increases.[107] On the way, before 2060 we could reach an average global temperature of 3-4 degrees.[108] One of the most comprehensive yet least publicised studies by climate scientists at Lawrence Berkeley National Laboratory and the University of California at Berkeley concluded that "global temperatures at the end of this century may be significantly higher than current climate models are predicting," with *global warming reaching as much as 8°C*. "If the past is any guide," said Margaret Torn from the Berkeley team, "then when our anthropogenic greenhouse gas emissions cause global warming, it will alter earth system processes, resulting in additional atmospheric greenhouse gas loading and additional warming."[109] Given that 6°C is already recognised as a wholly unacceptable level of warming implicating the potential destruction of most life on the planet, the prospect that temperatures may rise by 8°C within this century at current rates of fossil fuel emissions signals the necessity of urgent preventive action.

## 1.5 A Systemic Failure

### *A Record of Early Warnings*

The landmark 2007 UN IPCC report follows a long spate of diverse scientific assessments recognizing that our civilization's overexploitation of fossil fuels could lead to the demise of civilization itself. But they were for the most part ignored by policymakers. We will review a few examples here. Consider, for instance, the 1992 "warning report" produced by the Union of Concerned Scientists, signed by over 1,500 members of national, regional and

international science academies, representing 69 nations from around the world, including each of the twelve most populous nations and the nineteen largest economic powers, with the full list including a majority of the Nobel laureates in the sciences. The warning report announced that: "Human beings and the natural world are on a collision course. Human activities inflict harsh and often irreversible damage on the environment and on critical resources." These practices constitute a "serious risk" to human society and the plant and animal kingdoms, threatening to "so alter the living world that it will be unable to sustain life in the manner that we know." The report condemned "massive tampering with the world's interdependent web of life – coupled with the environmental damage inflicted by deforestation, species loss, and climate change," and noted that such practices "could trigger widespread adverse effects, including unpredictable collapses of critical biological systems whose interactions and dynamics we only imperfectly understand…

> "No more than one or a few decades remain before the chance to avert the threats we now confront will be lost and [with them] the prospects for humanity... The developed nations are the largest polluters in the world today. They must greatly reduce their over consumption, if we are to reduce pressures on resources and the global environment... No nation can escape from injury when global biological systems are damaged. No nation can escape from conflicts over increasingly scarce resources."[110]

Just under a decade on, such conclusions were reiterated in the *Global Environment Outlook 2000* (GEO-2000), launched by the United Nations Environmental Programme based on contributions from UN agencies, 850 experts and 30 environmental institutes. The report described a variety of full scale emergencies: The world water cycle is unlikely to cope with demands in coming decades; land degradation has negated many advances made by increased agricultural productivity; air pollution is at crisis point in many major cities; dangerous global warming is inevitable. A survey for GEO-2000 conducted by the Scientific Committee on Problems of the Environment found that according to 200 leading scientists in 50 countries, water shortage and global warming constituted the two gravest problems, followed by desertification and deforestation at national and regional levels. But GEO-2000's most key finding is encapsulated in the following conclusion: "The present course is unsustainable and postponing action is no longer an option."[111]

The 2005 Millennium Assessment report by the United Nations – a synthesis of the research of 1,300 experts from 95 countries hailed as the most comprehensive survey of the planet's natural life-support systems – found that 15 of 24 global eco-systems were already in severe decline; human civilization is absorbing the Earth's natural resources at unsustainable

break-neck speed; and as a consequence, we are in danger of destroying *two-thirds of the Earth's ecosystems*.[112] The UN report warned that the Earth is faced with the emergence of new diseases, sudden changes in water quality, the creation of coastal 'dead zones,' the collapse of fisheries and drastic shifts in regional climate. This combination of new diseases, absence of fresh water, continuing decline of fisheries and unpredictable weather was already having increasingly fatal results. For example, half of the urban populations of Africa, Asia, Latin America and the Caribbean suffer from diseases directly associated with global environmental decline, *already leading to a death toll of approximately 1.7 million people a year*. Similarly, whole species of mammals, birds and amphibians continue to be made extinct at nearly 1,000 times the natural rate.[113]

These reports showed clearly that our 'way of life' associated with modern industrial civilization is deeply implicated in the destruction of our environment. They acknowledged that the ecological damage wrought by anthropogenic climate change is intimately tied to the structure of the global political economy; that global warming, ozone depletion, species extinction, pollution, and so on, are ultimately symptoms of modern industrial civilization's disruption of the Earth's life-support systems, implemented in the pursuit of an amoral, unrestrained drive for economic growth.[114] Accordingly, the GEO-2000 prescribed the necessity of "a shift in values away from material consumption. Without such a shift, environmental policies can effect only marginal improvements."[115] This echoed one of the earliest warnings from the Club of Rome, that avoiding "global catastrophe" required "fundamental changes in the values and attitudes of man... such as a new ethic and a new attitude towards nature."[116]

## *Market Failure from Kyoto to Copenhagen: Too Little, Too Late*

The response of governmental policymakers to such warnings has been decidedly indifferent. Not only have governments displayed reluctance to implement adjustments *within* the system; they show no intention whatsoever of effecting the necessary changes *to* the system itself. Yet greater numbers of environmental experts from the UN to independent NGOs and scientists are beginning to realize that we need some kind of systemic transformation. Indeed, this is precisely the issue that remains thoroughly under-investigated. Civilization, in other words, is in denial.

The Kyoto Protocol – an international legally-binding treaty established in 1997 and coming into force in 2005 – demanded that industrialized countries reduce their emissions by only 5.2 per cent compared to 1990 emissions levels by the year 2012. Apart from not being ratified by two of the larger emitters, the US and Australia, the Protocol also treated China and India, both major fossil fuel emitters, as 'non-industrialized' countries. The Protocol also lacked enforcement mechanisms for reduction targets which were already far too modest. As Professor Gwyn Prins of the London School of Economics noted, actual emissions of the EU – the leading proponent of Kyoto – had risen by at least 10 per cent, a figure which was "massaged" partly by "including off-sets purchased under the UN Clean Development Mechanism (CDM): off-sets that were not real and, in many cases, fraudulent."[117] The CDM facilitated an international carbon trading scheme which, although intended to reward less developed countries investing in renewable energy technologies, in practice "is handing out billions of dollars to chemical, coal and oil corporations and the developers of destructive dams - in many cases for projects they would have built anyway." Two-thirds of the recorded 'emission reduction' credits produced by the CDM from such off-sets "are not backed by real reductions in pollution", but calculated from purchases of carbon offsets "rather than by decarbonising their economies." For example, if a "Chinese mine cuts its methane emissions under the CDM, there will be no global climate benefit because the polluter that buys the offset avoids the obligation to reduce its own emissions."[118]

In theory, the idea of carbon quotas and trading – where each country is assigned an emissions quota with permits issued to the biggest carbon emitters (such as power firms) – seems workable. Those companies that reduce emissions and use less than their quota can sell leftover permits to others which fail to. Each year the quota is reduced, so market forces push the penalty for emitting greenhouse gases higher. Outside of the CDM under Kyoto, Europe has already established an emissions trading network, and at least nine US states have started trading carbon dioxide among themselves.[119] But in practice, fossil fuel emissions have continued to escalate without relief. For instance, the EU's Emissions Trading Scheme (ETS) was from the outset compromised by corporate power, which pressured states to over-allocate emissions rights to the very industries most responsible for fossil fuel pollution. Consequently, the price of carbon dropped by over 60 per cent, reducing incentives to invest in renewable energies. Britain's heaviest polluting industries together earned £940 million profits from the first year of the scheme.[120]

Given the impotence of the Kyoto Protocol, hopes were high that the Copenhagen summit in 2009 might produce a deal with more teeth. Unfortunately, this was not to be. The resulting

Accord between the US, China, India, Brazil and South Africa, although "recognized" by the 193 countries present, was not legally-binding. The document "recognizes the scientific view that" global average temperatures should not rise beyond 2 degrees Celsius – although as noted the scientific evidence supports a far lower maximum temperature range within about 1 degree. But despite this recognition, no year for the peak of carbon emissions is indicated, nor are countries compelled to pledge emissions reductions necessary to respect even the 2 degree limit. Rather, they are expected to simply declare their own 2020 emissions reduction targets, and no penalties are established even to enforce these.[121]

Stated emissions pledges were minimalist. President Obama pledged to reduce emissions by only 17 per cent from 2005 levels by 2020 – 4 per cent below the more conventional 1990 benchmark, and still far too insignificant to prevent dangerous climate change. Similarly, the EU pledged a roughly 20 per cent reduction from 1990 levels – better than the US, but still ineffective. Under the Climate Change Act passed in 2008, the UK had already pledged to a 34 per cent reduction in carbon dioxide emissions by 2020, and an 80 per cent reduction by 2050 (against the 1990 baseline).[122] Yet the UK example illustrates exactly the ineffectiveness of pledges subject solely to the domestic discretion of respective national governments. The Climate Change Act, for instance, grants the Secretary of State the power to *amend* the 80 per cent reduction target, and to *amend* the base year against which it is measured. It currently excludes emissions from aviation and international shipping. In June 2008, the British government dropped the demand for UK companies to declare their annual carbon emissions; and the necessity for 70 per cent of the targets to be met by actual emissions cuts, rather than through buying carbon off-sets from less developed countries, although commendably the five-year carbon budget scheme will limit the latter.[123]

Overall, the international carbon trading and offset schemes at the focus of government efforts to deal with climate change are increasingly an arena by which powerful vested interests can exploit fears about global warming to consolidate unprecedented profits – and London is at its centre. According to the *New York Times*, "British companies were the leading global investors in carbon projects" and "more carbon was traded in London than in any other city." The newspaper noted that emissions management is "one of the fastest-growing segments in financial services, and companies are scrambling for talent. Their goal: a slice of a market now worth about $30 billion, but which could grow to $1 trillion within a decade." Louis Redshaw, head of environmental markets at Barclays Capital, predicted that: "Carbon will be the world's biggest commodity market, and it could become the world's biggest market overall."[124] Similarly, Andrew Ager, head of emissions trading at Bache

Commodities in London predicts that the carbon market "could grow to around $3tn compared to the £1.5tn market there is for oil."[125]

The problem is that by accepting neoliberal capitalist markets as a given, carbon trading overlooks the systemic origins of climate change. Such market-oriented solutions are inspired by Aubrey Meyer's 'Contraction & Convergence' (C&C) model of action for global emissions reductions. 'Contraction' requires the adoption of a safe target for atmospheric $CO_2$, as the basis for calculating a declining progression of annual global emissions toward that target by a specific target year, as agreed on the basis of climate science. 'Convergence' requires the assignment of annual emissions quotas to each country which converge toward a common level of per capita emissions by the target year. Added to this is a market-based carbon-trading plan to permit wealthier, high emitters to purchase emissions rights from poorer, low emitters.[126]

The problem with the C&C model is not the model itself – which certainly identities one viable path of global action – but the lack of attention to the socio-political and economic structures that prevent policymakers from *genuinely* implementing the C&C model in the first place. Inattention to the deeper structural and systemic issues means that the current policy processes inspired by the C&C model in practice work to sustain inequitable political and economic structures, while continuing to escalate fossil fuel emissions. Indeed, a damning 2009 report from Deutsche Bank's Asset Management Division reports that carbon markets are unlikely to contribute to significant emissions reductions "for the foreseeable future", and will not encourage sufficient investments in renewable energy. The report called instead for governments to introduce stronger incentives such as feed-in tariffs.[127] Given that market-mechanisms alone are bound to fail, the question remains as to why governments are reluctant to go beyond them. Overall, Western government attitudes to climate change – as principally a problem of reducing $CO_2$ emissions by introducing new market mechanisms that penalize carbon emission – are premised on a remarkable self-deception: that we can continue hydrocarbon exploitation, and the pursuit of economic growth, while simultaneously saving the climate.

This failed paradigm is evident from one of the most celebrated contributions to debate, the *Stern Review on the Economics of Climate Change*, on which much UK and Western government climate policies are based. It concludes that by investing one percent of global GDP (revised upwards to two per cent in 2008) it would be possible to avoid the worst effects of climate change, while failure to do so could damage global GDP by up to twenty percent. To his credit, report author Sir Nicholas Stern, then head of the UK Government Economic

Service, recognized this failure would constitute the most monumental *market failure* the world has ever seen. Yet as illustrated by the corporate co-optation of the global carbon market seen above, this would be less a market failure than an *integral function of market behaviour under neoliberal capitalism* motivated by short-term profit maximization. In this context, Stern's recommendation to introduce market mechanisms that would generate incentives for carbon cuts are wide off-the-mark.[128]

The problem is that neither Kyoto nor Copenhagen provide a clear plan for *how* the world is to re-configure its energy supply to renewable sources and reduce consumption premised on hydrocarbon-dependency. While offering no meaningful impact on curtailing our trajectory toward climate catastrophe, current policies do provide a way of piling huge costs on the public, drastically increasing state revenues, and facilitating corporate profiteering – without actually solving the causes of the climate problem. This unfortunately feeds the suspicion that Western governments are exploiting climate hysteria to consolidate their own questionable political and economic programmes. *In summary, current emissions reductions policies will effectively escalate $CO_2$ emissions further, at levels liable to propel global warming onwards well after the 2 degree tipping point and into the realm of increasingly dangerous and rapid climate change*.

Unfortunately, it appears that alarming strategic decisions have already been made. In 2008, the British government's chief scientific advisers publicly asserted that *a 4°C rise in global temperatures is most probably inevitable and irreversible*, and that the task for governments now is not so much preventing dangerous climate change, as is adapting to the extreme conditions it will unavoidably bring. The government's chief scientific adviser to the Department of Environment, Food & Rural Affairs, Professor Bob Watson described the 2°C tipping-point as an unrealistic upper limit: "But given this is an ambitious target, and we don't know in detail how to limit greenhouse gas emissions to realise a 2 degree target, we should be prepared to adapt to 4°C." The government's former chief scientific adviser Sir David King backed Watson's position, arguing that "even with a comprehensive global deal to keep carbon dioxide levels in the atmosphere at below 450 parts per million there is a 50 per cent probability that temperatures would exceed 2°C and a 20 per cent probability they would exceed 3.5°C."[129]

This indicates that Northern governments have accepted as inevitable the catastrophic consequences of global warming well after 2°C, after which irreversible climate change becomes increasingly probable, and have even settled for accepting the consequences of global warming up to 4°C, *at which level rapid, runaway warming becomes a foregone and*

*irreversible conclusion*. Some of the consequences of these scenarios were outlined by environment writer Mark Lynas, summarising the findings of his book, *Six Degrees*:

> "The impacts of two degrees warming are bad enough, but far worse is in store if emissions continue to rise. Most importantly, 3°C may be the 'tipping point' where global warming could run out of control, leaving us powerless to intervene as planetary temperatures soar. The centre of this predicted disaster is the Amazon, where the tropical rainforest, which today extends over millions of square kilometres, would burn down in a firestorm of epic proportions.
>
> Computer model projections show worsening droughts making Amazonian trees, which have no evolved resistance to fire, much more susceptible to burning. Once this drying trend passes a critical threshold, any spark could light the firestorm which destroys almost the entire rainforest ecosystem. Once the trees have gone, desert will appear and the carbon released by the forests' burning will be joined by still more from the world's soils. This could boost global temperatures by a further 1.5°C – tipping us straight into the four-degree world.
>
> Three degrees alone would see increasing areas of the planet being rendered essentially uninhabitable by drought and heat. In southern Africa, a huge expanse centred on Botswana could see a remobilisation of old sand dunes, much as is projected to happen earlier in the US west. This would wipe out agriculture and drive tens of millions of climate refugees out of the area. The same situation could also occur in Australia, where most of the continent will now fall outside the belts of regular rainfall.
>
> With extreme weather continuing to bite – hurricanes may increase in power by half a category above today's top-level Category Five – world food supplies will be critically endangered. This could mean hundreds of millions – or even billions – of refugees moving out from areas of famine and drought in the sub-tropics towards the mid-latitudes. In Pakistan, for example, food supplies will crash as the waters of the Indus decline to a trickle because of the melting of the Karakoram glaciers that form the river's source. Conflicts may erupt with neighbouring India over water use from dams on Indus tributaries that cross the border.
>
> In northern Europe and the UK, summer drought will alternate with extreme winter flooding as torrential rainstorms sweep in from the Atlantic - perhaps bringing storm surge flooding to vulnerable low-lying coastlines as sea levels continue to rise. Those areas still able to grow crops and feed themselves, however, may become some of the most valuable real estate on the planet, besieged by millions of climate refugees from the south."[130]

Yet even these catastrophic scenarios, now considered inevitable, may be deeply conservative. Kevin Anderson from the Tyndall Centre for Climate Change Research at Manchester University argues that it is "improbable" that the atmospheric concentration of $CO_2$ could be restricted to *650 ppm* even with "draconian emission reductions within a decade."[131] At 650 ppm, according to Hansen's analysis taking account of positive feedbacks underplayed by the IPCC, the Earth's average temperature would *rise well beyond 6°C, creating an uninhabitable world potentially a decade before 2100*. And with governments

and corporate emitters continuing business-as-usual, even this is a conservative scenario, suggesting that we may trigger a runaway warming process as early as mid-century.

All this raises fundamental questions about the nature of state contingency-planning for the impact of climate change from a national security framework, which entails not merely the local impacts of global warming, but also the wide-ranging ramifications in terms of massive migrations, food shortages, water shortages, greater propensity for competition and conflict over resources, and the magnified danger of civil unrest. From a *national security* outlook, climate change becomes an issue of mobilizing state resources to protect existing structures of political and economic power, by controlling increasingly volatile domestic and international populations. Classified studies by the US intelligence community have already red-flagged "regional partners" of the US in key strategic regions in Africa, Central Asia and the Middle East, who are likely to face severe problems, and whose identities remain confidential to avoid diplomatic frictions. Climate change is thus viewed as a "threat-multiplier" to traditional security issues such as "political instability around the world, the collapse of governments and the creation of terrorist safe havens." By implication, climate change will serve to amplify the threat of international terrorism, particularly in regions with large populations and scarce resources.[132]

The focus, then, is not on avoiding dangerous or even catastrophic climate change, but on maintaining business-as-usual while developing new security-frameworks to sustain the fundamental structures of the global political economy, despite the massive human and social costs. The climate change discourse endorsed by Western officialdom 1) evades the mounting evidence of the exponential *acceleration* of climate change within the next few decades long before the 2100 mark; 2) overlooks the question of our civilization's relations of energy production, that is our fundamental *dependence on hydrocarbon energy sources*, like oil, gas and coal; and 3) ignores the global political economy's structural imperative for unlimited economic growth leading to unsustainable levels of fossil fuel exploitation.

For while the worldwide consumer demand for energy will continue to rise, the necessity of slashing our $CO_2$ emissions obviously requires a corresponding drastic drop in energy consumption. How governments will continue to sustain the booming energy requirements of their societies, while still reducing hydrocarbon energy consumption to reduce emissions without re-arranging the structure of the economy, remains a mystery. Without addressing the specific mechanisms by which societies will eventually cease to rely on the exploitation of hydrocarbon energies though a multi-billion dollar crash programme to transform the global energy system, meaningful $CO_2$ reduction is wholly impossible.

Correspondingly, the question of reducing world consumption of hydrocarbon resources is also tied to issues around sustaining industrial agriculture, which is fundamentally dependent on supplies of *cheap petroleum*. The imperative to reduce oil-dependency to cut $CO_2$ emissions raises questions about how *world food production* can simultaneously be maintained to feed a growing planetary population. Given that climate change threatens to generate intensifying water shortages and droughts affecting the world's leading agricultural regions, a business-as-usual approach suggests that a permanently altered climate will involve a future of grossly inadequate food and water supplies. There is no doubt, then, that the fallout of a business-as-usual approach to climate change would be catastrophic – indicating the need to dispense with the neoliberal model of unlimited growth. *Ignoring the instrumental role of the 'growth imperative' as a systemic pressure rooted in the structure of the global political economy guarantees the continuation of global warming.*

As British environmentalist George Monbiot points out, to avoid dangerous climate change the entire world must dramatically reduce greenhouse gases by no less than 90 per cent by 2030 (in fact, it should be *before 2020*, with further efforts to remove carbon from the atmosphere through carbon sequestration to capture and store it safely, among other methods, according to Hansen). Doing so, he shows, would require large-scale changes in the infrastructure of Western societies to downsize energy consumption and revert to renewable energies. Monbiot focuses, for instance, on a combination of state-led technocratic solutions designed to transform markets and impose strict regulations on all emissions-generating activities, including: finding improved ways to build homes and other buildings based on an optimal combination of renewable and non-renewable energy sources; radically changing land transportation but without reducing mobility; firmly curtailing air travel; and massively curbing greenhouse gas emissions of the retail and cement industries; backed-up by a comprehensive emissions trading plan and international carbon-rationing scheme.[133] Whatever the shortfalls of some of these policy solutions, the overarching obstacle to their implementation is that both states and markets concurrently operate in the context of the *unequal structure of the global political economy;* the "psychological grip of capitalist consumption patterns"; and are *both subject to the pressures of powerful vested interests* – like the "fossil fuel lobby, heavy industry, airlines", and so on. Government policies are currently tied closely to these structures, and cannot shift sufficiently unless they are transformed.[134] It is therefore essential to account for the central necessity of fundamental transformation in the socio-political, economic, ideological and ethical structure of the global system – starting with the extent to which vested financial interested are tied to the global hydrocarbon energy system: a hierarchical structure of geopolitical domination by core Northern states over a network of peripheral states in regions like the Middle East, Central Asia and West Africa containing the bulk of the world's strategic oil and gas reserves.

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