

# What Is New About Global Warming?

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By  
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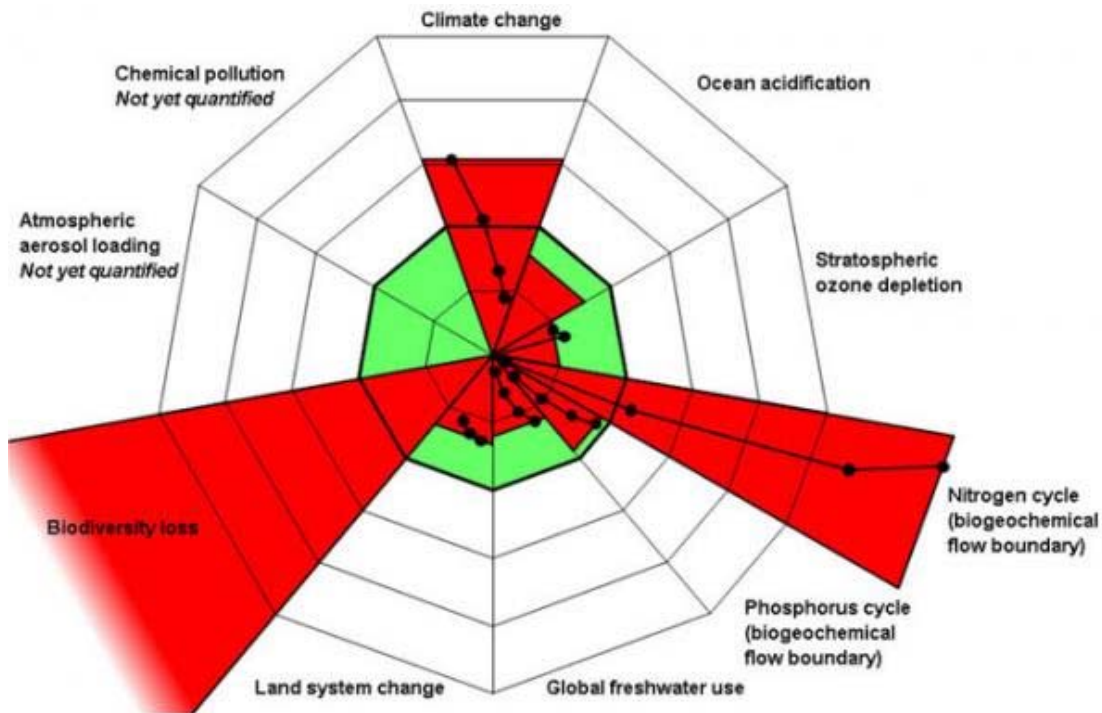
## Abstract

In this paper I will look at some of the recent developments regarding global warming and see if there is anything we can do about it. The situation seems a lot grimmer than when I discussed this more than a year ago.

## Introduction

There is no surprise about the planet getting warmer. This has been widely discussed for the last 30 years. However, there is one hallmark that should give us pause. The scientists have been getting more vocal in their concerns. Those, not in the employ of the oil companies or stuck in Kubler Ross's stage one of dealing with really bad news, have been steadily shortening the time scale for things to happen, broadening the range of phenomena, and increasing the magnitude. Tonight I hope to communicate some of my growing concerns on this subject and outline some aspects of the probable future.

Perhaps a simple way to demonstrate my concern is the following figure generated by a very large community of European scholars<sup>1</sup>.



Source: *NATURE* | Vol. 461, 24 September 2009

The red areas indicate regions where we have over run the estimated green safe limits on which to operate the planet. The two missing ones simple have not yet been evaluated. Three are clearly unsafe and five more are well on the way. It is hard to be optimistic about the way the remaining two are likely to turn out with the recent announcement of the discovery of mercury (including methyl mercury) at the mouth of the Mackenzie River<sup>2</sup>.

Now how did I get here? Let me begin with a somewhat political event that happened about a year ago<sup>3</sup>. In August 2008 the Department of Energy announced that it was devoting a large number of its resources to computing models of Abrupt Climate Change<sup>4</sup>. I still do not know what triggered that announcement and study in an administration where the very words "Abrupt Climate Change" would not be expected to be heard. The resources allocated include Lawrence Livermore, Lawrence Berkley, Los Alamos, Oak Ridge, Argon, and Pacific North West. This is a very formidable group of government laboratories and none of the 'usual suspects' like NOAA or NCAR or NSF were included this was to be exclusively a DOE operation. They defined "Abrupt Climate Change" to mean climate change that happens faster than we can mitigate or adapt to its effects.

They planed to look at four possible causes including stoppage of the Meridional Overturning Circulation (Gulf Stream and friends), destabilization of the polar ice sheets, sudden release of methane from the frozen methyl hydrates in the world's oceans, and lastly the onset of a protracted drought in the southwest U.S. The overseer from Lawrence Berkley, William Collins, (no relative) labeled these as the Four Horseman of The Apocalypse.

The initial view was that number 1 was unlikely to happen, not much was known about number 2, number 3 was a cause for some concern, but probably wasn't likely to happen, but number 4 was already under way. Since their announcement, I have come to agree with their view of numbers 1 and 4, but have become less confident about their initial views of numbers 2 and 3. I suspect that the results of their studies may well have led the current Secretary of Energy to say last February 3rd, "I don't think the American public has gripped in its gut what could happen," he said. "We're looking at a scenario where there's no more agriculture in California." And, he added, "I don't actually see how they can keep their cities going either"<sup>5</sup>. More on the 4th horseman later.

There seems to be a general consensus that the Meridional Overturning Circulation won't stop in this century, but it may slow down somewhat depending on what happens to the Arctic Sea Ice. Fresh water from the sea ice could reduce the salinity of the north flowing ocean current and reduce the rate at which it sinks. This will slow the northward flow down, but is unlikely to stop it. There is one interesting side effect. The decrease in salinity will reduce the water pressure in the North Atlantic which is about 4 feet lower than the water of the Pacific at the same latitude. This would result in a small sea level rise unaccounted for in other models. This is described in an online paper in *Nature Geoscience*<sup>6</sup>. This should be added to the general concern that it will take only a category 3 hurricane moving up the east coast to produce a 20 ft. storm surge that would flood the lower half of Manhattan making it essentially unusable for a very long time. I only recently became aware that something like this has already happened in lower Manhattan during the 'Nor-Easter' of 1992<sup>7</sup>. The sea walls on lower Manhattan are about 4 feet.

The second horseman, the destabilization of the polar ice sheets, leading to a major rise in sea level, is less easy to dismiss. However, a year and a half ago I would have written this off as unlikely

in my lifetime. I am no longer so sure. Several things have made me less optimistic. The first is a small pedagogical thing. When sea level rises are quoted in the literature they assume that the water is uniformly distributed around the planet's oceans. But remember, the earth is spinning so the majority of melted water will flow to lower latitudes. This means that you should add 10%-20% to all quoted numbers for the Gulf of Mexico and lower East Coast<sup>8</sup> (see also<sup>9</sup>). This latter reference deals explicitly with the effects of the collapse of the Western Antarctic Ice Sheet (WAIS). Perhaps this may play some role in the current increase in the rate of sea level rise along the North Carolina coast to three times that of the last 500 years<sup>10</sup>. Now remember more than 50% of the refining capacity of the U.S. resides along the Gulf Coast between New Orleans and Houston and is about 4 feet above sea level<sup>11</sup>. If you think gasoline is expensive now, imagine importing the refined product from the world market. It doesn't take a huge collapse of either polar ice sheet to bring this about. The Pine Island Glacier in the Antarctic is melting at about 20 times its ancient rate<sup>12</sup>. A more recent study confirms this result indicating that this glacier has been thinning at a rate four times that of a decade ago<sup>13</sup>. This glacier is roughly the size of Scotland and the loss of it and the two glaciers it pins would lead to a world sea level rise in excess of four feet drowning much of the U.S. refining capacity. NASA has become increasingly concerned about this and they plan a specific research trip to the WAIS to determine the extent that the sea is accelerating its collapse, particularly the Pine Island Glacier<sup>14</sup>. This glacier has been called the "soft underbelly of the WAIS" and could lead to its destabilization in 50 years<sup>15</sup>. The WAIS is generally considered the most unstable of the polar ice sheets and its destruction would lead to a 20 foot sea level rise flooding most of the coastal cities in the U.S. But let's not forget Greenland.

NASA with its satellite GRACE has measured the annual loss of ice from the Greenland Ice Sheet for the past several years<sup>16</sup>. More recently an extensive modeling of snow melt and acquisition suggests that the ice sheet is melting rather faster than expected<sup>17</sup>. A very recent effort by Shepherd et al<sup>18</sup> find that the mass loss is tightly connected to the summer melting and subsequent run off. Very recently the British Antarctic Survey has used lazars to determine the thinning of both the Greenland and WAIS and has found them accelerating in the rate of melt<sup>19</sup>. It would be a mistake to assume that sea level rise will not be significantly affected by melting of the Greenland ice sheet. The same argument that was made for the sea level rise due to the reduction of the salinity in the North Atlantic is raised by Hu et al.<sup>20</sup> regarding the melt water from the Greenland polar ice sheet.

The third horseman is even more scary than the first two since either one is unlikely to constitute "Abrupt Climate Change". The third horseman focuses on the possible release of very large quantities of CO<sub>2</sub> and Methane from the Arctic and the oceans. Methane is more than 20 times the greenhouse gas CO<sub>2</sub>. It is also quite light and can rise rapidly to the stratosphere where it is widely distributed around the world. It will eventually react with ozone and produce carbon dioxide and other products. It has been known for some time that large quantities of carbon dioxide and methane reside in the frozen tundra. The gases result from the decomposition of living material from a much earlier time which are held in place by the overlying ice and frozen material.

The melting has indeed been going on. There are buildings in eastern Siberia where you now enter at the second story since the permafrost on which the foundation rests has melted to a degree that the building has sunk a full story. There are reports of foundations cracking in Fairbanks and other indications that there are problems with the tundra. A recent issue of Nature<sup>21</sup> showed wide spread fires started by lightening that have ignited the methane in the tundra and causing extensive fires. The current state of things in Alaska is given by the state government as:

*As of August 1, 2009 the Alaska Interagency Coordination Center (AICC) reports 469 fires have burned 2,097,293 acres across the state in 2009. At this time in 2008, 334 fires had burned 90,893 acres.*

It is likely that things are even worse in Siberia, but the Russians are very reluctant to discuss the matter. The role of fire in the present world climate is unclear, but it is a major source of CO<sub>2</sub><sup>22</sup>. Apparently NOAA is becoming aware of the recent increase in methane<sup>23</sup>.

Researchers have been concerned for years about the release of methane from the frozen Arctic as it warms for there is more carbon stored there than is presently in the atmosphere. If it were all suddenly released with a large part being in the form of methane, it would lead to a wide spread extinction event. However, in addition to the large store of carbon in the tundra of North America and Russia, there is an even more deadly form of methane stored in the oceans. It is called methyl hydrate and there is more methane tied up in this methane-water ice than all of the fossil fuels we have used. If it is kept cold and under pressure the solid phase is stable. It can be found in large amounts at the outer boarder of the continental shelves around the world. Should the deep ocean warm just a few degrees, the methyl hydrate would decompose into water and methane. Much of the methane would be absorbed by the ocean water as it rose to the surface, but some would not.

With the Arctic warming three times faster than the planetary average, there has been concern that the permafrost would melt and release much of this gas. Could this lead to an unrestrained planetary warming? There is some evidence that something like this may have happened in the not too distant past<sup>24</sup>. The claim is that since there is no significant increase in the methane in the ice cores, the warming didn't result from methane release. However, remember that methane rises very fast and most of it could reside in the stratosphere where little if any snow is formed. What is more distressing is the events of the past year that suggest the methyl hydrates in the ocean may be becoming unstable.

Late summer Orjan Gustafsson of Stockholm University in Sweden led a research expedition aboard the Russian research vessel Jacob Smirnitskyi toward the end of the ship's trip Dr. Gustafsson became so concerned with what they had been observing he sent an email of the results to the British Paper *The Independant*. A quote from the article led to the title *The Methane Time Bomb*. "At some locations, methane concentrations reached 100 times background levels. These anomalies have been seen in the East Siberian Sea and the Laptev Sea, covering several tens of thousands of square kilometers, amounting to millions of tons of methane", said Dr Gustafsson<sup>25</sup>. I suspect he has not been invited back by the Russians who have been rather quiet about all this.

It would be easy to write this off as a one time event until this year when the Norwegians and Germans observed much the same thing west of the Spitsbergen continental margin, in a depth range of 150–400m, at and above the present upper limit of the gas hydrate stability zone (GHSZ)<sup>26</sup>. They attribute this to a warming of the ocean flowing out of the Arctic Sea. Finally to give this horseman some punch, consider the following two recent references. First is to a MIT study which suggests that there are large methane reserves in gaseous form below the "gas hydrate stability zone"<sup>27</sup>. Now what can possibly make this picture scarier than this? There are those who are suggesting that we mine the oceanic methyl hydrates as a source of natural gas to replace coal<sup>28</sup>. The Japanese are particularly interested as they have no real access to energy within their country, but there are large quantities of methyl hydrates off the southern coast of the large island. Others have suggested that we retrieve the

methyl hydrates off the Atlantic coast of the U.S. Can this be done without breaking into the large gaseous regions of methane below the gas hydrate stability zone (GHSZ)? If not the methane release could easily be catastrophic and the third horseman succeeds where the first two have not. There is a recent analysis of the effects of methane that should increase anyone's concern. Shindell et al<sup>29</sup> show that the chemical interaction of methane with atmospheric aerosols leads to increased warming over methane alone. The chemistry is sufficiently complex that some feel simply cleaning the air will heat the planet<sup>30</sup>. So cleaning the air of mega-cities for health reasons may also lead to global warming<sup>31</sup>. Will there be anything left for the forth and last horseman of the apocalypse?

He is riding well ahead of the other three. The forecast of a protracted mega-drought in the Southwest United States has been around for some time. Views of the water consumption and production have made such a scientific prediction possible several years ago<sup>32</sup>. This was re-emphasized a few months later in *Science*<sup>33, 34</sup>. NOAA's long range forecast for the southwest has shown drought possibilities for several years before the above references. Essentially an increase warming of the planet leads to a northward movement of the larger atmospheric features related to the Hadley cells that determine the major wind features on the planet and which are required to move more energy toward the cooler poles. This leads to the sub-tropical dry zone moving north into the southern U.S. This is happened before during the medieval warm period from roughly 1100BCE to 1350 BCE, but we weren't around to observe it. However, there has been considerable research into reconstructing that period in the West. I recommend the book by Brian Fagan<sup>35</sup>. Before you dismiss this as just another alarmist book you should read it, particularly chapter 6. Brian Fagan is an anthropology professor emeritus from UC @ Santa Barbara and has an established record of the history of climate and man. His book is loaded with specific references to the anthropological literature.

During the medieval warm period when the Vikings got loose, the south west of North America suffered a succession of 100 year mega droughts. This is when the Anasazi, and Pueblo, left the south west and the Mayan civilization collapsed. The latter had actually engineered for 5 year droughts, but could not handle 100 year droughts. The south west U.S. became a Sahara-like desert and most Native Americans migrated into southern Canada and prospered. The large scale hall mark of the western world weather seemed to be the establishment of a rather permanent La Niña in the Pacific Ocean<sup>36, 37</sup>, which results in no rain in the southern U.S. and the storm tracks moving into southern Canada. Now the planet is actually hotter now than it was during the medieval warm period. A two and a half year long La Niña ended in late May 2009 to be followed by a rather weak El Niño which is strengthening and led to the mild summer. It is worth noting that NOAA forecasted the end of the La Niña in 90 days for a year and a half before it finally ended. We shall see how long the current El Niño lasts. The current forecast (September 2009) is for it to last through the northern winter which would make the winter milder than normal. All of this, which is rather well known to climatologists, is probably what led to the DOE looking into these possibilities. If the El Niño is short lived (less than a year) then one should be very wary of the following La Niña and hope that it does not become permanent.

Should this happen what would be the impact on the South West U.S? Essentially Secretary Chu's view would be sustained. It should be noted that water in the west has been mismanaged for over a century. In 1927 when the flow arrangement for the Colorado was established, the allocations were made on the basis of 120% of the average flow of the river. There are several predictions about the

future flow of the Colorado. The Colorado River system is presently enduring its 10th year in a drought that began in 2000, said lead study author Balaji Rajagopalan<sup>38</sup>. Essentially, if the water management practices that have been in place for a century are unchanged there is a 40% chance that Lake Mead will be dry by 2040<sup>39</sup>. The same authors (Barnet and Price) expand their investigation to look at the ability of the Colorado to meet delivery requirements under the assumption that the Bureau of Land Reclamation will require the Las Vegas intake of Lake Mead always be covered even should it require Lake Powell to be drained. They find that if the run off to the river declines by 10% by 2050 those deliveries will not be met 58% of the time and should the decline be 20% the failure rate will increase to 88% of the time<sup>40</sup>. To say that this would constitute a major water crisis for the South West is an understatement. However, it is exactly what one would expect if we are headed for a period as warm, or warmer than the medieval warm period.

Recently there has been a change in DOE's assignment of the horsemen, The first horseman has been replaced by expanding the third horseman into two separate problems, the methane release from the arctic tundra and the methane release from the oceanic methyl hydrates. So the ice sheet collapse becomes the first horseman. William Collins description shows a much larger level of concern than his remarks of a year ago. In a recent press release he details quite specifically how these problems are being dealt with<sup>41</sup>.

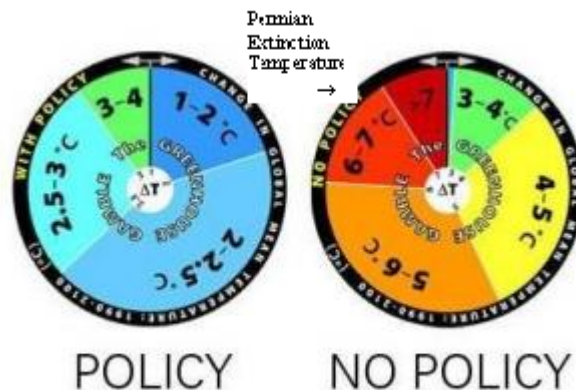
So what does the future hold? I fear we may well see the impact of the last three of the horsemen of the apocalypse sooner than anyone imagined. One of the great failures of climatologists for the last century has been a tendency to over estimate how long it will take for things to change. There are good and understandable reasons for this leading from the failure to recognize the large number of positive feedback effects that affect climate and an unwillingness to make estimates on the human impact since that lies in a field other than climatology. But it brings us now to a fairly scary time. I am not quite as pessimistic as James Lovelock who sees the end times approaching in his latest book<sup>42</sup>. But I would note that his earlier estimates of the fatal acidification of the ocean by 2050 were probably optimistic as they didn't include the increased rate of CO<sub>2</sub> production. Including just the next two derivatives would have lowered his estimate to 2035. However, he is no dummy and his concerns should be taken very seriously.

There is an aspect of the second horseman that concerns me a great deal. The same forces that are leading to the collapse of the polar ice sheets are also causing the mountain glaciers to disappear. Forty percent of the world's population depends on half of its water from snow melt or glacier melt<sup>43,44</sup>. Lonnie Thompson finds that the most recent ice in the Himalayas was formed before atomic bombs were used (i.e. about 1944)<sup>45,46</sup>. Seven of Asia's great river systems—the Brahmaputra, the Ganges, the Huang He, the Indus, the Mekong, the Salween and the Yangtze—will be affected. These river systems provide water and sustain food supplies for over 2 billion people<sup>47</sup>. As they disappear, water will become a major world crisis. There are those who say that this has already happened<sup>48</sup>. The reason for this is largely man made. The massive injection of aerosols into the atmosphere from the burning of coal, peat, and dung by China and India have changed the local climate all the way to Africa<sup>49</sup> and beyond. Rainfall in Western China has basically stopped and the black soot from the fires falling on the mountain glaciers have led to the ice rapidly disappearing from the Himalayas<sup>49,50</sup>. Five years ago Jared Diamond painted very dismal picture of the water management in China suggesting that it will cause serious problems very soon<sup>51</sup>. Even the light rainfall so important to agriculture has diminished in Eastern China<sup>52</sup> while the ground water is dropping a foot per year in Northern India<sup>53</sup>, and the

Indian monsoons are arriving later and are weaker<sup>54,55</sup>. This latter result is likely to be combined with a recent study that indicates that the Inter-tropical Convergence Zone (ITCZ) has been moving north during the past three centuries taking with it the rain belt that about a billion people depend on for water<sup>56</sup>. Such northward movement might encourage the monsoon zone to move south to join it. This appears to be what is worrying the Indian Chief Meteorologist<sup>55</sup>.

While the glacial water loss in Asia is dramatic and likely to affect huge numbers of people, the effects in Europe will not be negligible. Virtually all of the major rivers in Europe arise in the Alps. The glacier melt in the Alps is increasing at an alarming rate. The rate of glacial thinning doubled in just one year<sup>57</sup>. For a country like Switzerland where 84% of the power generation is hydroelectric, the impact will be dramatic. Within fifty years all the glaciers in the Iberian Peninsula will be gone<sup>58</sup>. If you want to know what to expect in the U.S., I recommend a very recent report produced by an advisory committee chartered under the Federal Advisory Committee Act, for the Subcommittee on Global Change Research, and at the request of the U.S. Government<sup>59</sup>. It is rather long and very complete and somewhat disheartening. There is a further aspect of the glacier melting that poses a threat from out of the past. For much of the 20th century we dumped large quantities of water soluble pollutants into the atmosphere. Where these fell as rain on mountain glaciers they became part of the glacier. Now that it is melting we are getting them back<sup>60</sup>.

Probably the most complete publication of the effects of global warming is given by Jim Hansen and colleagues<sup>61</sup>. But during the last year I have seen additional scholarly articles detailing with previously unappreciated positive feedback effects all of which enhance the effects of climate change. However, a much shorter version has been done by a group at MIT<sup>62</sup> and is shown in the following figure. The pie chart on the right shows the expected temperature rise if there is no global policy adopted and the one on the left shows what could happen if there is some worldwide policy adopted the range in each case depends on the levels of development and the nature of the policy. I have included a small arrow on the right pie chart to indicate the global temperature present during the Permian Extinction event which was the worst in the planet's history. However, they go on to say that quick, global emissions reductions would be required in order to provide a good chance of avoiding a temperature increase of more than 2 degrees Celsius above the pre-industrial level — a widely discussed target. This seems more or less in line with the view of the President of the IPCC who in July of 2008 said "**We Have Seven Years Left to Reverse the CO<sub>2</sub> Emissions Curve**"<sup>63</sup>.



source: Sokolov, A.P. et al. *Journal of Climate* (in press) DOI: 10.1175/2009JCLI2863.1

One of the implicitly scary reports comes from the British Royal Society recommending the impending need for Geoengineering<sup>64</sup>. For those of you unfamiliar with the term it involves physical intervention in the structure of the atmosphere so as to cool the planet. I find a number of things unsettling about Geoengineering the first of which is that I have seen nothing that deals with the CO<sub>2</sub> problem of acidifying the oceans. I regard this as a very serious problem in the long run as too much of the world depends on the oceans for food. Those at the top of the food chain ignore the bottom at their own peril. Then there is the "Law Of Unintended Consequences". Whose climate do you engineer for? Do you do more harm than good as suggested by references (28-30)?

In short, things are happening much faster than was anticipated even just a year ago. This is most dramatically emphasized by a very recent article in *Science* titled "*Looming Large Scale Failures and Missing Institutions*"<sup>65</sup> As the title suggests there are many problems arising on the world level from water to the acidification of the ocean and the loss of the life it supports to climate change and the problems that it includes and there don't seem to be any institutions available to deal with them. Virtually all of them require a world response and in my lifetime I have seen very few times when the world cooperated to do anything. We shall know in December 7-18, 2009 for there is a meeting in Copenhagen to try to set world policy. There was a meeting of scientists there in March 2009 where the scientists were very concerned that we have gone too far (see for example<sup>66</sup>). However, the likely hood of their concerns being addressed in December seems unlikely<sup>67</sup> since India has already decided that a failure in Copenhagen is not a disaster. The only positive sign I have found is a very recent report from the "Asia Society" on the way the U.S. and China could cooperate on the sequestration of carbon dioxide from burning coal<sup>68</sup>. However, it is not at all clear the extent to which China agrees with this report. So I have come to understand the true meaning of the **Chinese Curse** - "*May You Live In Interesting Times*".

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