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Arctic Melting Sounds the Alarm for Life on Earth

By John Dillon

Well into the 20th century, coal miners relied on canaries to signal the presence of toxic gases, especially methane, in mine shafts. The sensitive birds alerted the miners that they had to evacuate quickly before being overcome by the odourless gas.

Today humanity lacks an escape route in the face of millions of tons of methane leaking from melting Arctic permafrost – and billions more could be released if global warming accelerates. Our planet could be rendered uninhabitable by drastic climate change. Lacking alternate habitable destinations, our only hope is to curtail greenhouse gas emissions before it is too late.

The speed at which climate change is already occurring in the Arctic is particularly troubling. Many scientists warn that it is near a point of no return, after which it will unleash unstoppable climate devastation. The purpose of this briefing paper is to summarize some of the most recent scientific evidence on climate change in the Arctic and its consequences for life on Earth.

We begin by reviewing evidence of fast-rising temperatures and their consequences for sea ice and the Greenland and Antarctic ice sheets. Next we look at two sources of methane leaking into the atmosphere: thawing permafrost and undersea methane hydrates. Finally we examine the consequences for life on Earth if these phenomena lead to what climatologist James Hansen calls "the Venus syndrome" where a runaway greenhouse effect would make our planet too hot to support life as we know it.

Arctic Temperatures Rising Fast

Arctic temperatures are increasing twice as fast as elsewhere on Earth. By 2007, they had risen by 2 degrees Celsius above their historic 1961-2000 average.

The international Arctic Monitoring and Assessment Program (AMAP), an advisory body serving eight Arctic nations (the U.S., Canada, Russia, Denmark, Norway, Sweden, Iceland and Finland) has found that, "Arctic temperatures in the past six years were the highest since measurements began in 1880, and that feedback mechanisms believed to accelerate warming in the climate system have now started kicking in."[1]

Researchers at the University of California, Los Angeles, have observed that Arctic temperatures are rising faster than the global average. Using a sophisticated model developed by the National Center for Atmospheric Research, they found that whereas "the planet is expected to see a two to four degree Celsius gain in temperature by the end of the century, projections show the Arctic temperature increasing by two to nine degrees – and as much as 11 degrees in winter."[2] One consequence will be that Northern communities in Canada will no longer be

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able to depend on winter ice roads across frozen terrain to deliver supplies.

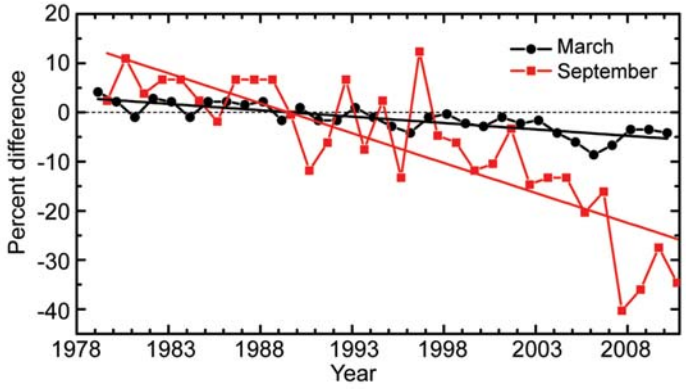
Dangerous Feedback Loop from Loss of Sea Ice

A study published in Geophysical Research Letters indicates that climate change in the Arctic may have already reached its point of no return.[3] Melting Arctic ice creates a dangerous feedback loop as open waters absorb more than 90% of incoming sunlight whereas white ice reflects sunlight back into space.

A decade ago, scientists' climate change models predicted the Arctic Ocean would be ice free by 2100. As new evidence has become available, scientists have revised their predictions to 2050. The AMAP report also states that Arctic ice is disappearing faster than had been predicted by the UN Intergovernmental Panel on Climate Change: "The level of summer ice coverage has been at or near record lows every year since 2001, predicting that the Arctic Ocean will be nearly ice free in summer within 30 to 40 years."[4]

Figure 1 illustrates that Arctic sea ice, as measured at the end of winter in March of each year, has declined by around 10% between 1978 and 2010. September measurements, marking the end of summer, show a much more dramatic decline in excess of 40%.

Figure 1: Changes in Extent of Arctic Sea Ice 1978-2010



Source: National Oceanic and Atmospheric Administration, "The State of the Climate in 2010".

Melting of Greenland and Antarctic Ice Sheets

Scientists caution that temperature increases of as little as 2 degrees Celsius endanger the entire Greenland ice sheet. Richard Alley, a geosciences professor at Pennsylvania State University, warns: "Sometime in the next decade we may pass [a] tipping point … What is going on in the Arctic now is the biggest and fastest thing that nature has ever done."[5] The consequence of the disappearance of the Greenland ice sheet would be a rise in global sea levels of seven metres, wiping out small island states and coastal cities all around the world.

Scientists at the Danish Meteorological Institute suggest that the complete melting of the Greenland ice cover is nearly unavoidable. In a study published in *Hydrometeorology*, they predict that, "Greenland will reach a point of no return in 2040 at the latest."[6] Jens Hesselbjerg Christensen, one of the study's authors, says "Over the next 30 years the amount of snowfall will not compensate for melting. Based on our model, I would almost say that the point of no return has already been passed."

Similarly, a study by scientists at the Canadian Centre for Climate Modeling and Analysis, published in *Nature Geoscience*, looked at the effects on climate patterns over the next 1,000 years even if greenhouse gas emissions are eliminated completely by 2100. While stopping emissions would allow ocean surface temperatures to cool more quickly, deep ocean waters would remain warmer over a longer period. One result could be an increase in the average temperature of waters around Antarctica by as much as five degrees Celsius.[7] This would lead to the collapse of the huge West Antarctic ice sheet.

James Hansen and colleagues report that Antarctica is already losing more than 100 cubic kilometers of ice each year. Moreover, "Most of the West Antarctic ice sheet, which alone could raise sea level by six meters, is on bedrock below sea level, so it is the ice sheet most vulnerable to rapid change."[8]

Thawing Permafrost

Another consequence of Arctic warming is the melting of permafrost which releases methane, a greenhouse gas that is 25 times more potent than CO_2 over a 100-year period, according to the Intergovernmental Panel on Climate Change.

A study published in the September 7, 2006, issue of *Nature* by Katey Walter of the University of Alaska

and Jeff Chanton of Florida State University reports that greenhouse gases are already escaping into the atmosphere from melting permafrost at frightening rates. "When … permafrost melts, carbon buried since the Pleistocene era is bubbling to the surface and is dissipating into the atmosphere as methane…. [An estimated] 900 gigatons (billions of metric tonnes) [of carbon is frozen] in permafrost worldwide. This large store would more than double the amount of carbon in the atmosphere today if it is released."[9]

A more recent study by Kevin Schaefer, a scientist at the National Snow and Ice Data Center in Boulder, Colorado, found that between 29% and 60% of the world's permafrost will thaw by 2200, releasing 190 gigatons of carbon, "equivalent to half the amount of carbon that has been released into the atmosphere since the dawn of the industrial age."[10] Schaefer estimates this additional carbon would increase average Arctic temperatures by 8 to 10 degrees C and the Earth's average temperature by 3 degrees C in addition to other human-induced temperature increases. Schaefer warns that we are less than 15 to 20 years from the point "when the 13 million square kilometers of permafrost in Alaska, Canada, Siberia and parts of Europe become a major new source of carbon emissions."[11]

Methane Hydrates

In addition to the methane stored in permafrost, another huge quantity is trapped offshore on continental shelves in methane hydrates. These ice crystals consist of methane molecules trapped inside frozen water. When exposed to higher temperatures, the ice disintegrates releasing the trapped gas. Rising sea levels and ocean temperatures can cause a mass release of additional methane with catastrophic consequences. Over 50 million years ago, undersea landslides resulted in the release of methane from hydrates contributing to global warming lasting tens of thousands of years.[12]

A study by Natalia Shakhova from the University of Alaska's International Arctic Research Center and colleagues from the Russian Academy of Science estimates that eight million tonnes of methane are already bubbling to the surface each year from the East Siberian Arctic shelf. Dr. Shakhova says: "The amount of methane currently coming out of the East Siberian Arctic Shelf is comparable to the amount coming out of the entire world's oceans."[13] She notes that current atmospheric methane concentrations in the Arctic are the highest in 400,000 years. "If just one percent of Arctic undersea methane … reaches the atmosphere, it could quadruple the amount" already there, according to her colleague Dr. Vladimir Romanovsky at the University of Alaska.[14]

Some scientists maintain that the ocean ecosystem can contain methane releases through the action of microbes that capture and oxidize it. However, a study by scientists at the U.S. Department of Energy's Lawrence Berkeley National Laboratory has found that methane seeping into the Arctic Ocean "would gradually overwhelm the marine environment's ability to break down the gas."[15] Matthew Reagan from the laboratory's Earth Science Division explains: "Microbes cannot consume all of the methane because there isn't enough oxygen to fuel them." The study found that the amount of oxygen and nutrients needed by the microbes would decline each year. After three decades, much of the methane would reach the atmosphere accelerating to climate change.

A study by Dr. Micha Ruhl, an earth scientist at the University of Copenhagen, published in the journal *Science*, found that the mass extinction that killed half of all marine life at the end of the Triassic period two hundred million years ago was caused by the release of at least 12,000 gigatons of methane from the ocean floor.[16] Originally the extinction had been attributed to volcanic activity. Professor Ruhl's study found that volcanoes played a role by warming atmospheric and oceanic temperatures, but it was the release of methane that actually killed off most marine life over a period of just 10,000 to 20,000 years. Dr. Ruhl warns that a similar massive release of methane could occur in our time due to the release of carbon dioxide resulting from fossil fuel use.

The Venus Syndrome

If the feedback mechanisms unleashed by greenhouse gas releases from the Arctic continue unchecked, they threaten unstoppable climate change on the planet. In *Storms of my Grandchildren*, NASA climatologist James Hansen describes how Venus, which is almost as big as Earth, must have begun with a similar atmospheric composition, including

holding lots of water vapour. However, a runaway greenhouse effect took over on Venus, evaporating its oceans and drawing carbon dioxide from its crust to the point where its atmosphere is now 97% CO_2 and its temperature 250 degrees Celsius.

Hansen also describes how we can learn much from the Earth's paleoclimate record about the circumstances that brought on past episodes of global climate change. However, he cautions that we are in uncharted territory with respect to the speed that climate change will occur if we burn all the remaining fossil fuels thus far discovered. Hansen writes:

"Models are nowhere near the stage at which they can predict when major ice sheet disintegration will begin. Nor can we say how close we are to methane hydrate instability. But these are questions of when, not if. If we burn all the fossil fuels, the ice sheets almost surely will melt entirely, with the final sea level rise about 75 meters (250 feet), with most of that possibly occurring within a time scale of centuries … It is difficult to imagine how the methane hydrates could survive, once the ocean has had time to warm. …"

"After the ice is gone, would Earth proceed to the Venus syndrome, a runaway greenhouse effect that would destroy all life on the planet, perhaps permanently? While that is difficult to say based on current information, I've come to conclude that if we burn all reserves of oil, gas, and coal, there is a substantial chance we will initiate the runaway greenhouse. If we burn the tar sands and tar shale, I believe, the Venus syndrome is a dead certainty."[17]

Hansen's conclusion is that to ensure that human and non-human species will have a habitable home here on Earth, we must curtail our use of fossil fuels by phasing out coal and leaving unconventional fuels, particularly from the tar sands and shale rock formations, underground. Since we can't escape to another planet, weaning ourselves off of fossil fuels is our only escape route from a methane-fed disaster.

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Endnotes

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