On the Brink: The Melting of Earth’s Polar Ice Caps

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Recommended Citation
Available at: https://uknowledge.uky.edu/kaleidoscope/vol7/iss1/14

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I am a freshman scholar at the University of Kentucky, where I double major in Arts Administration, with a concentration in music performance, and Psychology. I plan to continue to gain a comprehensive education while attending the University by pursuing extracurricular activities outside of my primary area of learning; the research and study put into this article “On the Brink: The Melting of Earth’s Polar Ice Caps” prove to be some such activities. Throughout the course of writing this submission, I have eagerly acquired knowledge surrounding the subjects of global warming causation and effects, in addition to obtaining valuable research and composition skills while under the guidance and instruction of University of Kentucky faculty member Dr. David Atwood. I am also an avid musician and study clarinet under the direction of Dr. Scott Wright.

Faculty Mentor: Prof. David Atwood, Department of Chemistry

Ms. Kelley was a student in my Discovery Seminar course: “Energy and Our Global Environment.” She was a valuable participant in the class throughout the semester and did exceptionally well on all of the exams and assignments. It was clear to me that Ms. Kelley developed a deep understanding of how the world’s energy consumption could affect our environment. This understanding was demonstrated in her in-class presentation on the melting of the world’s polar ice caps, in particular the dramatic ice reduction observed in the Arctic. Her presentation and attendant written assignment were of such high quality and originality that I encouraged her to develop the topic further for possible publication in Kaleidoscope. She and I felt that it was important to explain in detail what is taking place at the poles of the earth, most likely due to human-induced global warming. This submission to the Journal is the outcome of this effort.

Abstract
Research indicates that earth’s polar ice caps are melting at a faster rate than ever before, a product of continued global warming. Unfortunately, side effects of this melting may negatively impact the lives of humans who dwell on this planet. Consequences may include: a significant loss of albedo, a considerable rise in sea levels, damage to aquatic ecosystems, and/or an ice age resulting from the shutdown of major oceanic currents. Although the situation is not yet imminent and the causes not yet pinpointed, the present outlook is too grim to ignore.

Essay
The media rarely leave their audience hanging — there’s occasionally something fresh, every so often something unusual, and always a story that is in high-demand. Viewers can usually count on the news networks to discuss up-to-the-minute events every minute of every day. Imagine flipping on the television to a news channel covering a breaking story about a governmental forum on our planet’s rising temperature and the effects it has on worldwide environment. Lobbyists and other public speakers hotly debate the causes, but all agree: it is unlikely that any person even partially educated in the field of climatology can deny global warming exists.

An astonishingly large number of scientists and researchers recognize the evidence for our planet’s increasing temperature, which has risen about 1.4 degrees Fahrenheit since 1880. In fact, today’s population currently boasts the record for the hottest two decades (1980 and 1990) in the last
400 years (National Geographic, 2007). Unfortunately, a warming earth induces a number of harmful side effects. Many of the more unfortunate repercussions occur far away from CNN and Fox News headquarters — indeed, far away from the borders of any continental state in the U.S. Polar ice is a significant, natural reflector of sunlight; this quality is especially important in the current day and age because it aids in global cooling. In addition, fresh water from ice caps harbors the potential to raise sea levels, damage aquatic ecosystems, and initiate an abrupt ice age. The melting of earth’s polar ice caps has effects that are far broader (and more newsworthy) than one might initially presume.

Unlike breaking stories, the breaking of entire blocks of ice does not usually take place overnight — unless the time span is being measured against the entire history of recorded temperature, which, if one observes ice core data in some areas, is a really long time. Just a few month ago, researchers in Antarctica unearthed a core detailing what they hope to be at least 100,000 years of climate record (National Science Foundation, 2008). But exceptions exist to all general trends and, increasingly, the so-called ‘anomaly’ of swift melting is occurring over shorter and shorter time periods. Scientists often use the Larson B ice shelf as a popular illustration of abrupt melting. Located on the eastern side of Antarctica’s most prominent peninsula, this 220 mile-thick shelf began a rapid collapse into the ocean starting on January 31, 2002. The suddenness and magnitude of this event stunned scientists and researchers around the world; in a mere 35 days, the shelf lost a total of 3,250 square kilometers — larger than the state of Rhode Island, which contains a mere 2,171 square kilometers of land mass (National Data Center, 2002). Although unexpected, developments prior to this incident — and the ways they presumably established themselves in order to prompt the actual outcome — do not present many surprises.

Ted Scambos, a researcher at the National Snow and Ice Data Center, suggests that the primary cause of the Larson B shelf collapse was due to melt water residing in pools on top of the ice, an effect of the warmer-than-usual climate. He, along with other experts, believe that some of the melt water trickled down moulins (cracks in the ice), expanding them until they grew large enough to cause the ice to splinter completely. In addition, more cracks were created from this process, thereby increasing the rate of fracture (National Data Center, 2002).

Although the collapse of a single Antarctic ice shelf does not necessarily prompt a major rise in sea level, such a collapse does have a pronounced effect on something that very well could: glaciers. Because glaciers are, by definition, situated on land and therefore do not already contribute to the volume of the ocean, their retreat into the sea does, in fact, raise water levels (as opposed to sea ice, which, because it floats on ocean water, does not). Glacier melt also contributes to a number of other fresh-water-meets-salt-water issues.

The National Snow and Ice Data Center does an exceptional job of describing the important roles ice shelves play in relation to glaciers:

Ice shelves act as a buttress, or braking system, for glaciers. Further, the shelves keep warmer marine air at a distance from the glaciers; therefore, they moderate the amount of melting that occurs on the glaciers’ surfaces. Once their ice shelves are removed, the glaciers increase in speed due to melt water percolation and/or a reduction of braking forces, and they may begin to dump more ice into the ocean.

Obviously, barriers such as Larson B are extremely vital to the health and longevity of our polar ice caps. Unfortunately, the breaking up of an ice shelf isn’t a one-time occurrence. Similar events have happened elsewhere since the Larson B incident, and will almost certainly occur again, particularly when considering the warming our planet is experiencing. Not only are the temperatures in Eastern Antarctica rising more rapidly than ever before (Gore, 2006, p. 102), but the other side of this delicate continent could find itself approaching a melting point as well. This possibility is of major concern; if the ice shelf on the western side of Antarctica ever detaches itself and the surrounding sheets slide into the ocean, sea levels could rise six to ten inches in a mere century (Flannery, 2005, p. 149).

To avoid charges of exaggeration, it would be worthwhile to mention that, normally, the amount of Antarctic and Arctic ice is lowest near mid-summer, the time immediately after the summer-melt season. Shortly after this period, it enters a phase of “recovery,” which takes place throughout the winter months, as most of the remaining melt refreezes and becomes part of the ice sheets once again. On September 21, 2005, scientists determined that nature followed the early part of this trend exceptionally well. Although there were still increases in ice during the previous winter, they were smaller than those of any former winters and 2005’s summer onset of melting was, in an unfortunate circumstance, notably earlier. As a result, only 2.05 million square miles of ice were documented by satellites — the lowest amount on record (O’Connor, 2005).

Evidence of continual melt, reminiscent of the incident in 2005, comes in the form of satellite images from the National Aeronautics and Space Association (NASA), which illustrates the reduction of the polar ice cap with shocking clarity. “The area of permanent ice
cover is contracting at a rate of 9 percent per decade. If this trend continues, summers in the Arctic could become ice-free by the end of the century” (Natural Resources Defense Fund, 2005). In the summer of 2007, the Antarctic as a whole experienced an ice loss totaling the area of six Californias (Revkin, 2007), evidence that the clock counting down the last days of our polar ice caps in the present interglacial period may have already begun ticking.

One major concern regarding ice barriers and melting glaciers involves the northern island of Greenland. Here, a thin shelf separates the Arctic Ocean from a vast 2.85 million cubic kilometers of ice cap (Pearce, 2007), portions of which are already making their way toward the ocean at alarming rates. The sheer mass of these glaciers could increase sea levels by a shocking twenty-three feet (Flannery, 2005, p.144).

Although it is uncertain whether the Greenland Ice Cap will slide into the sea or, if it does, if it will do so as quickly as the Larson B Ice Shelf, the possibility looms in a not-so-distant future. The Jakobshavn Glacier, one of the many outlet glaciers for the Greenland Ice Cap, is advancing toward the ocean at an astonishing 135 feet per day (Struck, 2007). Large portions of the Petermann glacier in Northern Greenland have already broken off into the ocean. More recently, a large crack has appeared further inland, widening with each subsequent year; it threatens to break off another 56 to 60 square miles of ice (Byrd Research Center, 2008). Jonathon Gregory, a climatologist at the University of Reading, UK, claims that an irreversible melting process could begin in less than half a century; “The only good news,” states the reporter interviewing him, “is that a total meltdown is likely to take 1,000 years” (Pearce, 2007). Clearly, mankind has reason to be concerned with the rate at which Greenland’s ice is thawing.

As previously suggested, a serious consequence of melting glaciers is the amount of sea-level rise that might occur. Tim Flannery blames the escalating pace of increase, stating that the rate of sea level rise has doubled throughout the 1990s (Flannery, 2005, p. 145). As of 2005, he estimated that two out of every three persons lived along the shoreline (Flannery, 2005, p. 143). These situations in combination present serious concerns about the relocation, financial burdens, and survival of oceanfront dwellers. The stress of circumstances such as these might easily compare with those experienced by the 2005 Hurricane Katrina victims in New Orleans.

Unfortunately, sea level rise has the potential to reach well beyond individuals and small groups; even a slight rise could endanger entire populations around the world —those in the major cities of Shanghai and Lagos, for example, both of which lie a mere six feet above sea level (Defense Council, 2005). Such an incident would once again raise concerns about refugees, economic stress, and the continued existence of cities, but on a much larger, more difficult scale.

The entrance of glaciers into the oceans wouldn’t reserve its adverse effects for the human population only; marine life would be negatively affected as well. Ice, when liquefied, produces fresh water, and when an aquatic population with a propensity for high salinity is exposed to large amounts of fresh water, the effects are almost always extremely detrimental. Currently, these effects can be exemplified by the ocean’s krill population, which seems to have declined in direct correlation with decreasing amounts of Arctic sea ice (Flannery, 2005, p. 97). The reduction of this particular population seems to be having a greater-than-normal effect on marine life as a whole, most likely due to its placement toward the bottom of the food chain, which makes it as vitally important and abundant as vegetation is in a land-based ecosystem.

Another undesirable effect of earth’s melting polar ice caps is the potential halt of the North Atlantic Conveyor Belt, a product of the “thermohaline circulation” (“thermo” for heat and “haline” for salt) See Figure 1 (p. 70). This chain of moving water is a key factor in regulating temperatures in Europe. To grasp fully the significance melting glaciers have on this “conveyor belt,” it is necessary to understand the basics of how the system works. First, heat near the equator warms ocean water, lowering its density and, in some cases, making it light enough for northward-running currents (namely, the Gulf Stream) to drive the water in the direction of the Arctic pole. As the current moves northwards, heat from the water is transferred to the air, warming temperatures above any landmasses it bypasses.

At this point, it is worth to reiterating that glaciers are masses of frozen freshwater; the ice in the glaciers is a result of the build-up of snow over many years. The snow originated in the evaporation of ocean water; the salt is left in the oceans when the water evaporates. It is this salt-rich water that will flow toward the poles in the North Atlantic Conveyor Belt mixes with. In turn, the flowing water suddenly becomes denser due to its colder temperature and higher salinity and, thus, starts to sink. It eventually moves back toward the equator, where the process begins again.

The problem posed by glaciers derives from their freshwater base. Either by directly sliding into the ocean and melting because of the warmer temperature, or by first forming lakes and then dumping all at once into the sea because of a broken ice dam, the added amount of freshwater tips the freshwater-saltwater balance dangerously. If enough freshwater dilutes the sea in that area, the salinity will become so low that the water does not sink and will almost immediately stop shifting back toward the equator. Such an abrupt shift may entirely eliminate heat flux to the northern landmasses, radically decreasing temperatures in the very populated countries of Europe (Quadfasel, 2005, pp. 565-566).

The shutdown of this current system is by no means a stretch of the imagination. In fact, this event occurred twice in the last 15,000 years — once 12,700 years ago, which triggered an ice-age in Europe that lasted 1,000 years; and again 8,200 years ago, which led to incredibly low temperatures in Greenland. Both times, the ice dams holding back glacial melt water in North America and Canada broke through. The enormous volumes of freshwater inundating the northern portion of the North Atlantic Conveyor Belt caused the failures (Flannery, 2005, p. 61).

Furthermore, the melting of these ice caps might actually contribute to future warming. Very large objects with high reflectivity possess the ability to bounce light from the sun back into space, which lowers temperatures on
our planet. Scientists use the term “albedo” to describe the level of sunlight an object reflects. Earth’s polar ice has the capacity to reflect significant amounts of sunlight — about ninety percent of the sun’s rays that enter through the atmosphere (Flannery, 2005, p. 144) — substantially decreasing global temperatures. When melted, this ice turns into its less reflective form, liquid water, thus lowering the albedo in melting regions. In addition, chances are that forests, which insulate land and store heat, will eventually replace the areas on which glaciers used to reside (Flannery, 2005, p. 99, 103), further lowering earth’s total albedo and increasing its heat-trapping capability. If the loss of this critical cooling agent continues, our planet may soon find itself stuck in a negative cycle of melting and heating.

The primary cause for earth’s global warming is under debate. Ideas range from the effects of sunspot activity to a natural phenomenon known as the Milankovitch Cycle, a cycle based on earth’s orbit around the sun, to a number of other possibilities and any combination thereof. Greenhouse gases are another commonly suspected cause — one that tends to be the subject of many climatic debates. The fact that humans cannot evade the consequences of the Milankovitch Cycle or sunspot activity is not cause for optimism. If, however, a chance exists that global warming does indeed stem either directly or in part from the large-scale release of greenhouse gases into our atmosphere, then it seems that humans have a moral obligation to reduce their emissions as a kind of homage to the continued health of our planet.

Perhaps the most direct avenue to improving this health would be to have groups of individuals doing their part to reduce carbon emissions, a key ingredient in greenhouse-gas warming. Biking, diminishing our energy usage, and pushing for our government to employ alternative energy sources are all ways in which we can make a difference. Countries such as the United States have left renewable resources such as wind, solar, and hydro power remarkably untapped and have progressively reduced funding for environmental research since the climate craze of the 1970s dissipated. Our government instead returned to the readily available and (temporarily) cheaper use of non-reusable, carbon-dioxide emitting coal.

However we change the direction of our planet’s temperatures, whether such an action is possible or not, humanity must hope for the best: for earth to cool enough so that the majority of ice cap melting stops. If the best doesn’t happen, we can adapt. Populations in countries where the sea level rises can be relocated, albeit with a large amount of economic hardship. Earth’s ecosystems are flexible enough to find a way to recover from a loss of marine life, even if it means dropping a few species along the way. If the North Atlantic Conveyor Belt shuts down, Europe and other portions of the globe will still maintain the ability to acclimatize to colder temperatures. But such adaptations could be crippling to a world that’s grown accustomed to moderate conditions. After all, when we’re on the brink of such a major climate shift with so many varied, sensational effects, how could the media possibly figure out which story is in highest demand?

Acknowledgement

I would like to thank Dr. David Atwood for his continual guidance, instruction, encouragement, and inspiration throughout the writing of this article. I would also like to thank my family, significant other, and friends for their unwavering support of my efforts in this pursuit as well as all others.

Works cited: