Is Future in the North?

Climate Change in the Arctic Region

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14 January 2008

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Abstract

The Arctic is an ecosystem with considerable natural and social value that transcends local boundaries. Of all the regions undergoing climate change, this valuable ecosystem is experiencing the most notable transformations as a result of its rapid warming. Local communities are witnessing a number of geographic changes which are affecting fundamental aspects of Inuit life both socially and economically. A large number of experts attribute Arctic warming to man-made greenhouse gas (GHG) emissions, and forecast even more regional climatic changes that could have drastic local and global consequences. On the other hand, climate change sceptics challenge the concept of human intervention and attribute much of Arctic warming to natural processes. They also refute climate forecasts based on the argument that predictions are products of uncertain and hence unreliable climate simulation models. Nevertheless, from a risk management viewpoint, current scientific findings and future forecasts provide useful tools that could help reduce many potential dangers due to climate change. By putting Arctic change into its social, economic, scientific, and political context, many parallels could be drawn to enhance our understanding of the global climate change situation. From a local perspective, the Arctic is a changing universe. For the rest of us, it could be a glimpse of our future.

Context: Climate Change in the Arctic Region

Climate change is a natural phenomenon that characterizes Earth's history. To reach its current liveable state known as "The Long Summer", the planet had undergone considerable evolution through numerous stages of climatic transformations (Flannery 2006). These transformations have typically been caused by natural phenomena. However, recent human activity since the industrial revolution is believed to have bred an additional factor that could be speeding up climate change in unnatural ways (Le Treut, et al. 2007; Flannery 2006). Debates over the changing climate have attracted much hype in recent years, immersing world leaders in persistent economic, social, environmental and political concerns. Scientists have continued to refine their search for evidence; some to reinforce the belief that our planet is undergoing unprecedented transformations due to human activity and others to disprove the man-made elements of climate change all together.

As debates continue, the Arctic is experiencing some of the most drastic climatic changes of all regions. Rising temperatures in recent years are believed to be changing the geography of the region in ways that could pose serious social, economic, environmental and political crises (ACIA 2004). This paper aims to emphasise the crucial value of the Arctic for both local and global interests. It presents some of the scientific debates pertaining to climate change in the region, explores major consequential implications, and questions Canada's political role in the Arctic and among the international community regarding global climate change. It is worth noting, however, that changes occurring in the Arctic are diverse and complex and will not be discussed in full detail. Instead, only some major phenomena will be explored to highlight the magnitude of what could be at stake due to Arctic change.

The findings of the Intergovernmental Panel on Climate Change (IPCC)[1] and the Arctic Climate Impact Assessment (ACIA)[2] are the main sources used in this paper to represent climate change advocates. Where useful, references to individual scientists are made to support certain scientific arguments. In addition, there is special emphasis on arguments presented by climate change sceptics for the comparative purpose of this paper. It is worth noting, however, that the ratio of sources used to make the cases of climate change advocates versus sceptics is by no means representative of the ratio that constitutes the actual climate change debate. Sources that advocate climate change have been considerably easier to find due to their greater prevalence in comparison to sceptic literature.

[1] The IPCC is a "scientific intergovernmental body set up by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP)." IPCC work is a contribution of hundreds of scientists from countries all over the world that participate as authors, contributors, and/or reviewers. The panel is open to all governments of all member countries of WMO and UNEP. (IPCC 2007)

[2] ACIA is "an international project of the Arctic Council and the International Arctic Science Committee (IASC), to evaluate and synthesize knowledge on climate variability, climate change, and increased ultraviolet radiation and their consequences." The Arctic Council is a "high-level intergovernmental forum," with members including Canada, the United States, Russia, Denmark, Iceland, Finland, Norway and Sweden. IASC is an NGO that "facilitates cooperation in all aspects of arctic research." (ACIA 2004)

1.0 Introduction: Masses of Wealthy Lands

> *Arktikós* is the ancient Greek origin of the term Arctic, meaning the country of the Great Bear. The term is derived from the Ursa Major (Great Bear) constellation, which forms the stars surrounding Polaris; the North Star. (ACIA 2004)

Communities have inhabited the Arctic for millennia, with evidence suggesting human activity as early as 30,000 years ago (ACIA 2004). Early settlers are believed to have arrived in waves, starting with prehistoric journeys into the New World via Beingia; an intercontinental land bridge that emerged due to extreme glaciations caused by the last ice age (Chance 2007). Today, indigenous northerners continue to practice the traditions that have safeguarded the survival of their ancestors in spite of severe northern conditions. Extreme changes in Arctic climate could mean the disappearance of the Arctic's indigenous way of life (Watt-Cloutier 2005).

Indigenous northerners are not the only people inhabiting the region. The Arctic is divided into territories that form parts of Canada, the United States, Russia, Denmark, Iceland, Norway, Sweden, and Finland, with close to 90% of its four million inhabitants comprised of non-natives. Government and military services, tourism, and natural resources are the main contributors to Arctic economy (ACIA 2004). In Canada, hydropower produced in northern Quebec adds to the economic value of the region (Watt-Cloutier 2005). The Arctic also accommodates a rich wildlife with numerous species both on land and in water (ACIA 2004).

Furthermore, the region contains a wealth of geological data that has helped scientists learn a great deal about Earth's history and climate change. Many researchers embark the Arctic every year for exploration and discovery (Watt-Cloutier 2005). Researcher and University of Toronto Professor, Richard Peltier, believes the region to be ideal for exploring "how climate change has changed in the past and what that can tell us about the future" (CFCAS 2007).

Finally, and perhaps most importantly, the Arctic has been a critical contributor to the maintenance and stability of "Long Summer[3]" conditions on Earth due to the reflective role of its surfaces (snow, ice, glaciers, etc.) in controlling the solar energy absorbed by Earth. Thus, climate change in the north could have drastic climatic consequences for the entire planet (Flannery 2006). Regardless of whether the Arctic is undergoing climate change naturally or due to human activity, its local wealth, national interest, and critical contribution to global climatic stability make the region worthy of prime consideration. What is at stake, when discussing climate change in the Arctic, is much more than masses of snow and ice-covered lands.

[3] The Long Summer is the climatic period of the last 8000 years following Earth's last ice age. According to Flannery, this climatic period is characterized by temperate conditions that allow for the comfortable existence of humans on Earth. All known aspects of human civilization, including agriculture, have thrived during this era. (Flannery 2006)

2.0 *Arktikós*: Ancient Land in Modern Change

> "…what is happening in the Arctic is a snapshot of the future of the planet, and that, indeed, we are all connected. Climate change is a matter of survival of humanity as a whole. It is the most important global issue we face today. Protect the Arctic and we will save the planet." – Sheila Watt-Cloutier, Chair of the Inuit Circumpolar Conference (2005).

Is the Arctic really melting away? Are we already witnessing manifestations of a doomsday scenario foretold by climate simulation models? According to the Arctic Climate Impact Assessment (ACIA), the Arctic is experiencing a clear overall warming trend. In some areas, such as Alaska and western Canada, temperatures have risen by 3 to 4°C in the past 5 decades. Other areas have witnessed less warming, and "a few areas" have "slightly" cooled down. In addition, the regional climate has experienced changes in the frequency and characteristics of precipitation. For example, a significant increase in rain-on-snow events is experienced across the Arctic. In Russia the rate has increase by "50% over the past 50 years" (ACIA 2004).

A number of geographic changes provide evidence for Arctic warming. "The area of the Greenland Ice Sheet that experiences some melting has increased about 16% from 1979 to 2002," with record-breaking melting in 2002. "The average extent of sea-ice cover in the summer has declined by 15-20% over the past 30 years." The extent of snow cover has also "declined about 10% over the past 30 years," and glaciers are experiencing considerable melting. (ACIA 2004)

It is safe to conclude from available evidence that Arctic warming is a matter of visible fact. The cause of this warming, however, is subject to different scientific interpretation. Is Arctic warming a natural trend, or is human activity causing changes beyond the natural capacity of the Arctic ecosystem?

2.1 The Greenhouse Effect

Many world leading scientists including the IPCC believe the warming Arctic to be a result of rising levels of man-made greenhouse gases (GHGs) in the atmosphere (Flannery 2007; Le Treut, et al. 2007). This, according to these scientists, is due to the greenhouse effect caused by heat absorbers in Earth's atmosphere. As explained by Bryant, "an absorber is any gas molecule or particle which intercepts radiation at a particular wavelength, and then re-emits that energy at a longer wave-length. In the process of absorption, the gas or particle itself heats up" (Bryant 1997). GHGs are the most critical atmospheric absorbers, of which water vapour and carbon dioxide (CO_2) are the most important. They act as a "partial blanket" by absorbing longwave radiation reflected by Earth's surface, and causing a "natural greenhouse effect" (Le Treut, et al. 2007).

Absorption is a natural process critical to maintaining the liveable temperature of Earth's atmosphere (Bryant 1997). However, even though GHGs are natural components of the atmospheric composition, the IPCC suggests that GHGs have been rising primarily due to unnatural reasons, with up to 35% increase in CO_2 during the industrial era. This has led many scientists to conclude that Earth's warming trend is due to an unnatural greenhouse effect caused by our continuous burning of fossil fuels over the years (Le Treut, et al. 2007). However, research professor of environmental sciences at the University of Virginia, Patrick Michaels, argues that CO_2 is only a "minor" greenhouse enhancer, resulting in one-tenth of water vapour's contribution to surface warming. Nevertheless, he states that slight warming due to CO_2 induces a positive feedback by increasing the vapour pressure of water over the planet's oceans, hence raising the atmosphere's water vapour content and causing more warming. According to Michaels, the effect of this positive feedback is very difficult to quantify which results in inconsistent forecasts for future warming by computer simulations (Michaels 2004).

Michaels also mentions other man-made GHGs including methane (CH_4) and chlorofluorocarbons (CFCs). The former, he claims, is believed to "currently exert an additional warming increment amounting to about 25 percent of the current greenhouse enhancement due to CO_2," while the latter exert about 10 % "over the CO_2 fraction" despite the fact that CFCs have been phased out due to their ozone depleting effects (Michaels 2004). The IPCC also acknowledges the abundance of CH_4 and its contribution to the greenhouse effect. Ice core measurements show a drastic increase in CH_4 abundances from the "range of 400 to 700 ppb seen over the last half million years of glacial-interglacial cycles" to about "1,745 in 1998 and 1,774 ppb in 2005." The IPCC also mentions rises in nitrous oxide (another GHG). "The 1998 abundance of 314 ppb, rising to 319 ppb in 2005, is also well above the 180-to-260 ppb range of glacial-interglacial cycles." For CFCs, no traces have been found in historic atmospheric compositions, according to the panel. Based on this evidence, the IPCC concludes that these GHGs have risen due to human activity (Le Treut, et al. 2007).

The ACIA report claims that approximately 80% of global energy supply comes from fossil fuel combustion, with continuous rise in GHG emissions. The global average temperature has already risen by approximately 0.6°C since the industrial revolution, and the IPCC predicts additional warming of 1.4 to 5.8°C during this century (ACIA 2004). This global warming trend is believed to be particularly critical for the Arctic region. As early as 1938, G. S. Callendar solved equations seeking to link GHGs to climate change.

His findings suggested that “a doubling of atmospheric CO_2 concentration resulted in an increase in the mean global temperature of 2°C, with considerably more warming at the poles” (Le Treut, et al. 2007).

Are measured warming trends exclusively linked to a human-induced greenhouse effect?

2.2 Has Nature Lost Control?

Climate change sceptics call attention to other natural processes that may contribute to the warming of the Arctic. According to Timothy Ball, environmental consultant and former professor of climatology at the University of Winnipeg, none of the phenomena occurring in the Arctic are beyond what is “natural and normal” (Ball 2007). The Natural Resources Stewardship Project (NRSP)[4], which is chaired by Ball, states that “CO_2 is very unlikely to be a substantial driver of climate change,” insisting that climate change is a “natural phenomenon” (NRSP 2007).

Ball attributes the Arctic warming trend to natural processes in the region such as the Rossby Waves. He explains that the Polar Cell (shown in figure 1), which is the dome of cold air surrounding the North Pole, determines climatic boundaries in the Arctic. These boundaries undergo periodic changes due to variations in the Polar Front caused by Rossby Waves, which, as demonstrated in figure 2, vary according to two main

[4] NRSP is a “federally incorporated, non-profit, non-partisan organization” that aims to “promote responsible environmental stewardship.” NRSP’s current campaign; *understanding climate change*, assumes the mission of helping “balance the debate on the environment in Canada and abroad.” The campaign’s 2006/07 goals are: 1) dispel “the notion that Canada needs CO_2 reduction plans”, 2) become recognized “as the most reputable voice for promotion of science-based climate change policy,” 3) “identify and track positions of MPs and MLAs across the country in order to identify, and assist, politicians willing to support developing climate and pollution policy based on the most up-to-date science, engineering and economic, 4) impact on the public’s understanding of climate change. (NRSP 2007)

flows: Zonal and Meridional. According to Ball, "Zonal Waves create relatively stable weather patterns and conditions and appeared to dominate from 1940 to 1980, [while] Meridional Waves create unstable weather patterns… [and] dominated from 1900 to 1940 and again from 1985 to the present." He also states that the pattern is now switching back to Zonal Flow. (Ball 2007)

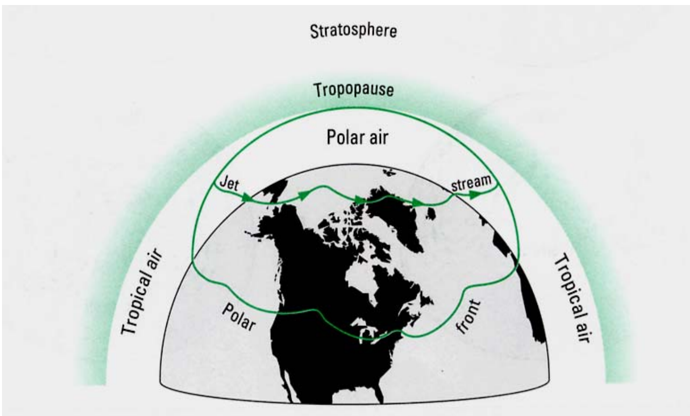

Figure 1: The Polar Cell (source: Ball, 2007)

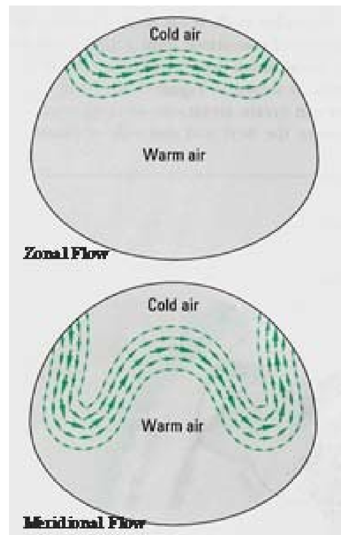

Figure 2: Rossby Waves (source: Ball 2007)

Ball also points out the contribution of other natural factors to climate change such as the Milankovitch effect (i.e. changes in orbit, tilt and precession of Earth around the sun); changes in surface winds that alter ocean flow patterns and result in temperature changes that could induce ice thinning; and the effects of solar spots, which is a factor also voiced in Michaels' work. According to Michaels, most climate change had been driven by the sun until near the end of the 20^{th} century. "A sun with many spots is a hotter sun because the dark regions are surrounded by larger, whiter areas that are more energetic than the quiescent state" (Michaels 2004).

Flannery, who recognizes the importance of factors such as orbital variations and solar spots, explains how they affect the climate differently than GHGs: "solar radiation warms the upper level of the stratosphere through the ultraviolet rays that are absorbed by ozone," while GHGs warm the bottom of the troposphere. Examining the climatic variations caused by these two different factors explains the nature of their distinguishable consequences. Stratospheric temperature changes affect "circulation in the troposphere, thereby heating and cooling parts of the Earth in a complex, patchy manner." On the other hand, the planet's fossil record is "characterized by sudden shifts from one steady, long-lasting climatic state to another." (Flannery 2006)

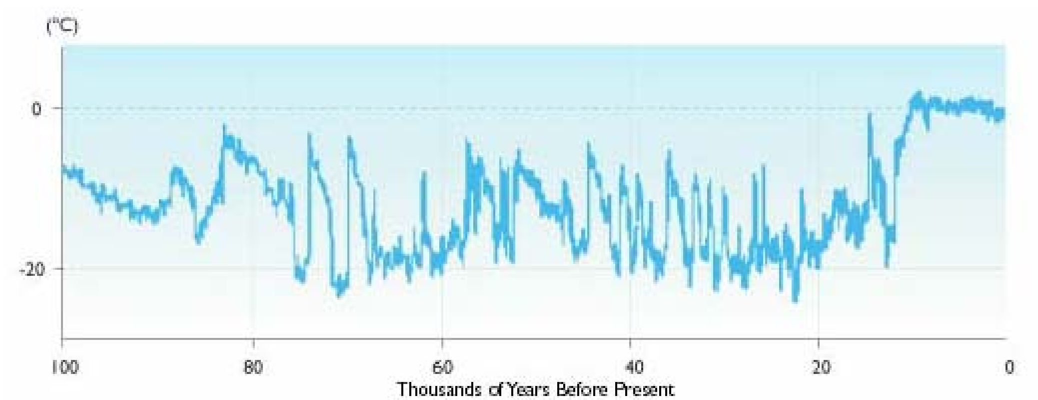

Figure 3: 100,000 years of temperature variation in Greenland (source: ACIA 2004)

Michaels acknowledges that humans have "something to do with" global warming. However, he argues that we can neither stop it nor sufficiently measure our contribution to it. He argues that climate change science is based on too many assumptions in a complex natural system that is not understood enough (Michaels 2004). Climate change advocates acknowledge the vast complexity of the natural system, and the critical need for more research in the area of climate change (ACIA 2004; Le Treut, et al. 2007). Their main concern, however, is that the Arctic warming trend (and global warming in general) has gone beyond historic conditions. The graph presented in figure 3, is a record of temperature variations obtained according to measurements made on a Greenland ice core. The ACIA uses this data to state that "there is concern that the rapid warming caused by the increasing concentrations of greenhouse gases due to human activities could destabilize [the “unusually stable” state of the past 100,000 years]” (ACIA 2004). The IPCC expresses a similar conclusion in regards to the global effects of the warming trend, and based on “a wide range of fingerprint studies conducted over the past 15 years” that suggest that “observed climate changes cannot be explained by natural factors alone” (Le Treut, et al. 2007).

The many efforts by different scientists to study the root causes of climate change have significantly enhanced our knowledge of the Arctic’s current warming situation. Such scientific knowledge may be able to teach us about future climatic trends and help facilitate human adaptation to climate change.

2.3 Climate Simulation Models: Fact or Fiction?

Essential to climate change research and the findings related to Arctic warming are efforts to predict the future climatic state of the planet. This is typically done by means of numerical models that replicate Earth’s climate system to a certain degree of complexity and with a certain degree of accuracy. Future climate scenarios are generated according to these models and used to predict social and natural changes that are likely to occur (Le Treut, et al. 2007). Climate simulation models have undergone considerable evolution throughout the years with progressively increasing sophistication (Flannery 2006). They also represent a major component of the climate change narrative and are at the heart of the climate change debate.

In the Arctic, and according to ACIA, climate change is “expected to be among the largest and most rapid of any region.” Projected changes outlined in the report include the following:

1. *Climatic changes including*: further temperature rise; 10 to 20% additional decline in snow cover by 2070; increased precipitation; further increases in river discharge to the ocean; "near total loss of sea ice in summer" by the end of this century; and "an addition half meter of sea-level rise [] during this century" (sea level is already 10 to 20 centimetres higher than 100 years ago) (ACIA 2004).
2. *Changes to the regional natural system including*: draining of wetlands and lakes in some areas and creation of new wetlands elsewhere; northward shift of vegetation zones; more forest fires and insects; decline (or even extinction) of Arctic species; and migration of southern species into the region (ACIA 2004).
3. C*onsequential social and economic changes* that are discussed below.

Climate change sceptics argue against the validity of these predictions, insisting that climate simulation models have too many uncertainties to generate any normative forecast on the regional or global climate. Timothy Ball argues that all climate models are built based on "the unproven assumption that CO_2 is the main driving force for climate change and that it will increase because of human activity." His report also states that there is "no evidence to support [the] claim" that "human CO_2 is causing global warming." Consequently, according to Ball, since the outcomes of all climate models are based on the same "assumption," consensus among the models is expected and does not make climate change predictions any more believable (Ball 2007). It is worth noting, however, that this point of criticism is rare in climate change literature. Based on the discussions of various sources (including some climate change sceptics), it is safe to assert that the warming effect of CO_2 is no longer an "assumption," but rather an historically established climatic finding with prevalent scientific consensus (Bryant 1997; Flannery 2006; Michaels 2004; Le Treut, et al. 2007).

However, the uncertainty debate on CO_2 goes beyond the question of whether or not the GHG warms the climate. According to Michaels, the amount of time CO_2 remains in the atmosphere before being sequestered back into Earth is a complex variable that requires simplifying assumptions in climate models. Factors such as the "rate of uptake by plants, which means their response to weather and climate, [or] [] the rate of decay of dead plant matter" have varying estimates that could cause CO_2's atmospheric lifetime to be anywhere between 25 and 150 years. Michaels explains two main assumptions made in climate models. The first, which he endorses, is that the temperature response to CO_2 follows a logarithmic behaviour, damping off as atmospheric concentration increases. "That means that first increments of [CO_2] create the greatest warming." The second assumption, which Michaels thinks is a "gross overestimate," is that CO_2 follows an exponential increase. Thus, models assume that CO_2 emissions "will not damp off, but will rise in concentration forever and ever." As a result of these assumptions the future impact of CO_2 converges in climate models, as Figure 4 demonstrates, which results in erroneous representations of climate forecasts. (Michaels 2004)

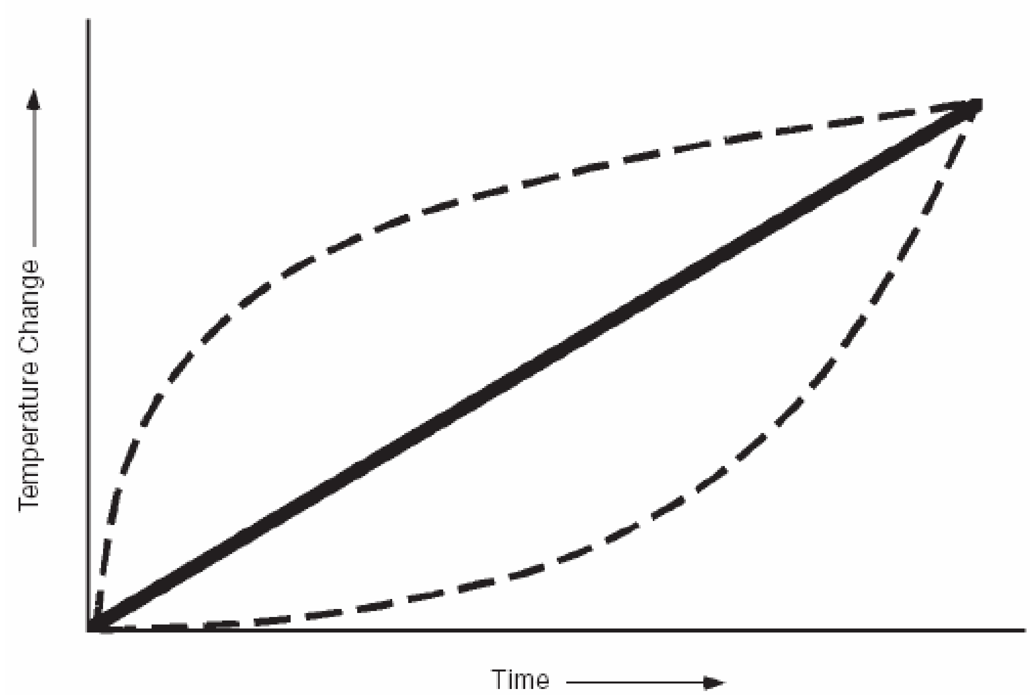

Figure 4: Convergence of an exponential increase in CO_2 emissions coupled with a logarithmic temperature response from the atmosphere (Michaels 2004)

Additional criticisms of climate simulation models relate to the difficulty (or even impossibility) of replicating Earth's complex natural system given the limited scientific knowledge of some of its processes. For example, climate models predict changes such as shifts in vegetation even though, according to Michaels, there is little clarity regarding the relationship between precipitation and vegetation. He states that "some equally wet and warm environments have radically different vegetation, depending upon other factors, including soil, drainage, and seasonality of precipitation." With numerous other "interacting processes [] partially understood, the mathematics for each depends on the choice of the modeling team. As a result, different GCMs [Global Climate Models] produce different patterns, rates, and distributions of warming resulting from human alteration of the atmosphere" (Michaels 2004).

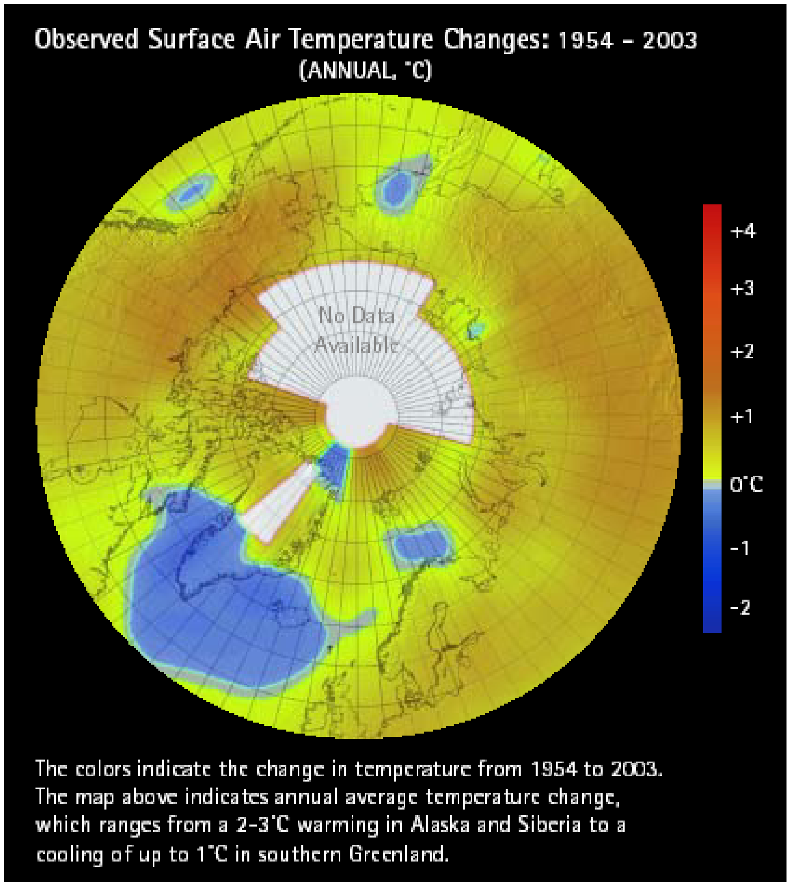

Figure 5: ACIA representation of temperature changes in the Arctic (ACIA 2004)

Climate forecasts in the Arctic are specifically criticized for their uncertainty due to a lack of sufficient knowledge of the region. According to Ball, "the computer models used by the IPCC omit major mechanisms, [and] have inadequate database for their mathematical construction." Ball reiterates Michaels' concerns regarding the deficient understanding of certain climatic mechanisms, and emphasises uncertainty in Arctic forecasts due to the lack of data, particularly from the Arctic Sea, to explain past patterns (Ball 2007). Figure 5, which is obtained from the ACIA, shows how temperature data is presented with "No Data Available" in some areas.

It is important to note, however, that scientific research is inherently uncertain. ACIA does not claim to have all the answers. The report clearly states that its findings represent “the first effort to comprehensively examine climate change and its impacts in the Arctic region. As such, it represents the beginning of a process” (ACIA 2004). Climate change advocates generally acknowledge (and even reinforce) the uncertainty challenges faced by climate simulation models. IPCC literature goes into great depth explaining the evolution and increasing sophistication of climate change models. Yet, it clearly affirms that these models are not completely accurate representations of reality (as no model could be):

> “There is [] a continuing awareness that models do not provide a perfect simulation of reality, because resolving all important spatial or time scales remains far beyond current capabilities, and also because the behaviour of such a complex nonlinear system may in general be chaotic… In addition, many of the key processes that control climate sensitivity or abrupt climate changes (e.g., clouds, vegetation, oceanic convection) depend on detail in the context of global models, and scientific understanding of them is still notably incomplete.” (Le Treut, et al. 2007)

Even though, according to Flannery, new scientific findings are constantly causing climate models to change, models undergo considerable testing before they acquire sufficient credibility. Four major tests outlined by Flannery include: compliance with the laws of physics (such as conservation laws); the ability to simulate present climate; the ability to simulate the “day to day evolution of the weather systems that make up our climate;” and the ability to reproduce previous climates (Flannery 2006). Thus, it is reasonable to argue that current models deserve at least some credibility in their forecasts. Even if not accurate, these forecasts could at least be used as a tool to assess the various risks associated with climate change.

Figure 6: Scale used to express the likelihood of climate forecasts in the Arctic (ACIA 2004)

According to a lecture by Brian Baetz, Civil Engineering Professor at McMaster University, risk can be defined as the product of the probability of the occurrence of some event and the consequences of such event using the following equation (Baetz 2007):

Risk = **P**robability x **C**onsequence

This emphasizes the importance of climate models in quantifying the probability of climate forecasts for the purpose of risk management. As shown in figure 6, ACIA provides a scale in order to facilitate the communication of its scientific findings and express the likelihood of various climate forecasts in the Arctic. However, the extent to which these terms are justifiable in relation to their associated percentages is debatable. For example, Ball claims the scale is a "vague classification" that allow the IPCC and ACIA to make strong statements regarding climate forecasts that influence public and policy opinion (Ball 2007).

The debate regarding the future of climate change is inherently uncertain and discusses what is beyond the realm of human experience. Scepticism is a valuable objective if aimed to enhance the overall understanding of the natural processes and the forecasting expertise of climate models. In any case, forecast is by no means the only evidence for Arctic warming.

2.4 Reality Check

> "First it snows, then it melts, like it would be summertime. And this all over again. First there is a big snowfall, then it warms up and then it freezes. During winter now it can rain, as happened last New Year. Before it never rained during wintertime. Rain in the middle of winter? To the extent that snow disappears? Yes, it is true. Rain, and snow melts!" – Vladimir Lifov, Lovozero, Russia, 2002 (ACIA 2004)

On March 30, 2005 in Washington DC, Sheila Watt-Cloutier, Chair of the Inuit Circumpolar Conference, stated that Inuit observations confirm the scientific findings on climate change in the Arctic: "climate change is happening now, it is getting worse, it is causing environmental change, and northerners are trying to adapt to it already" (Watt-Cloutier 2005). The Inuit culture, which has resided the Arctic for thousands of years, is shaped by the northern climate. Northerners have developed very accurate skills to predict and adapt to their environment, and have passed on these skills over many generations. This ancient accuracy is no longer dependable. (ACIA 2004)

Watt-Cloutier lists a number of phenomena reported by Inuit hunters and elders that confirm the findings of ACIA and the IPCC, including: "melting permafrost causing beach slumping and increased coastal erosion; longer sea-ice free seasons;" invasion of new species in the region (including birds, fish and even insects); "unpredictable sea-ice conditions; and melting glaciers creating torrents in place of streams" (Watt-Cloutier 2005). ACIA adds to these observations with reference to specific communities in the Arctic including: increased thunderstorms and lightning (previously rare occasions) for the Inuvialuit of north western Canada; "dramatic changes in weather, vegetation, and animal distribution patterns over the last 50 years" for the Athabaskan people of Alaska and Canada; variations in navigation winds normally relied on by Norwegian Saami reindeer herders (to the extent of requiring them to change traditional travel routes); and general weather instability for various peoples across the Arctic. In addition, “local landscapes, seascapes, and ices caps are becoming unfamiliar” for the inhabitants of the region (ACIA 2004).

There has also been a reported decline in the availability of some species for hunt due to climatic changes in the Arctic. For example, Inuit are unable to hunt for seals as much as they used to due to decreased sea ice (ACIA 2004). Some experienced hunters have even lost their lives hunting in areas that used to be considered safe (Watt-Cloutier 2005). For Inuit, hunting is not only vital in an economic and dietary sense, but also represents “a fundamental basis for social identity, spiritual life, and cultural survival.” (ACIA 2004)

An important question to consider at this point is: are Northern inhabitants the only people threatened by climate change in the Arctic?

3.0 Melting the Planet's Shields

> "The long summer that has been the last 8000 years is without doubt *the* crucial event in human history. Although agriculture commenced earlier (around 10,500 years ago in the Fertile Crescent), it was during this period that we acquired most of our major crops and domestic animals, the first cities came into being, the first irrigation ditches were dug, the first words written down, and the first coins minted… Before our long summer was 5000 years old, cities had sprung up in Western Asia, East Asia, and central America, and their similarities are astonishing. Whether they were built by Egyptians, Mayans or Chinese, temples, houses and fortifications are all identifiable as such. It is as if the human mind had sheltered a template for the city all along, and was just waiting until conditions permitted to manifest it… In a few societies writing developed, and in even the earliest of these jottings – clay tables from ancient Mesopotamia – we recognise life as it is lived in a great metropolis." – Tim Flannery (2006)

3.1 The Value of the Poles

Many scientists and climatologists stress the importance of the poles in maintaining Earth's climatic balance. As discussed earlier, the natural system has its ways of managing and sustaining the amount of solar energy within Earth's system. Just as the atmosphere plays a role by absorbing energy through GHGs, Earth's surface also plays a role in controlling solar energy. In the case of planetary surfaces, however, scientists discuss the process as reflectance rather than absorption. Earth's poles, both northern and southern, contribute largely to the process of reflectance, and hence are considered critical regions for the sustainability of the solar energy balance on Earth (Flannery 2006; Gore 2006).

In climate change science, the term albedo – which means 'whiteness' in Latin – is often used to refer to the percentage of short radiation reflected by different surfaces (Flannery 2006). White surfaces such as snow or ice are good light reflectors with a high albedo, while darker surfaces such as oceans are poor reflectors with low albedo. The following are numerical examples of albedoes for different surfaces: more than 90% for new ice; 75-90% for fresh snow; 45-75% for old snow; 30-60% for sand; 5-25% for grassland; 4-18% for tropical forests; and 4% for water exposed to a 90° sun angle (Bryant 1997). Hence, the widespread glaciers, snow and ice in the Arctic are extremely valuable to the global climate due to their contribution to the planetary albedo (Flannery 2006; Gore 2006).

The geography of the Arctic is characterized by its frozen terrain. Whether it is snow, ice, glaciers, permafrost, or a large frozen ocean, the common outcome of heating a frozen ecosystem is always going to be one of melting. Considering the borderless influences of the vast territory that comprises the Arctic, melting in this case is more than a matter of changing state.

3.2 Building for the Future

The most critical climatic consequences discussed in Arctic and global warming literature are associated with the shrinking of the cryosphere, which includes the "ice sheets of Greenland and Antarctica, continental (including tropical) glaciers, snow, sea ice, river and lake ice, permafrost and seasonally frozen ground" (Le Treut, et al. 2007). By understanding the effects of shrinking the cryosphere on the Arctic ecosystem, a number of undesirable climate change consequences could be reduced or even avoided. This argument applies regardless of whether climate change is entirely natural, man-made, or a mix of both. A good discussion point to exemplify risk management in the case of Arctic warming is the thawing of permafrost. While some consequences maybe beyond human control, there could be room for precaution and risk avoidance.

The term permafrost refers to "soil, rock, or sediment that has remained below 0°C for two or more consecutive years." Permafrost underlies most land surfaces in the

Arctic, varying from a few meters to several hundred meters thick." In the summer, the "active," top layer of permafrost melts then refreezes again during the winter. When average temperatures rise, this active layer does not completely refreeze after the warm season, resulting in permafrost "degradation" (ACIA 2004). A more detailed explanation of this phenomenon is presented in appendix A. Over the past few decades, average ground temperatures have increased over most of the sub-Arctic region by "several tenth of a °C up to 2°C," as demonstrated in figure 7. If the warming trend experienced in the Arctic persists, permafrost would experience more melting that could result in natural consequences with both local and global implications.

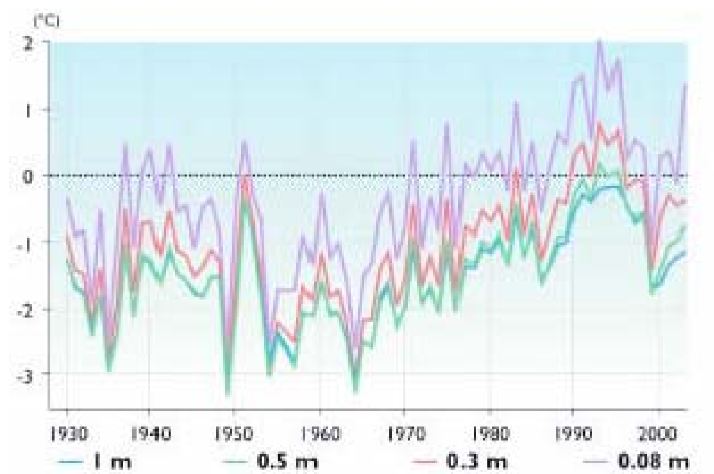

Figure 7: Average ground temperature in Fairbanks, AK from 1930 to 2003 (ACIA 2004)

One of the major ecological concerns with the thawing of permafrost is associated with its positive feedback loop regarding climate change. According to the IPCC, approximately one-quarter of the global total amount of soil carbon is sequestered in permafrost and seasonally thawed layers. Permafrost degradation causes GHGs (especially CO_2 and CH_4) to be released to the atmosphere, which increases the greenhouse effect and hence triggers more global warming and permafrost thawing. This feedback loop is particularly problematic in the Arctic given the faster rate of climatic warming in higher latitudes (Le Treut, et al. 2007).

The local consequences of permafrost thawing are expected to be even more catastrophic. In December 2003, the U.S. Arctic Research Commission released a report urging the U.S. government to take action regarding thawing permafrost in the north. According to the report, "permafrost regions occupy approximately 24% of the terrestrial surface of the Northern Hemisphere" and cover most Arctic land. If current warming trends continue, thawing permafrost could have serious effects on civil infrastructure including "roads, bridges, buildings, utilities, pipelines, and airstrips" (U.S Arctic Research Commission Permafrost Task Force 2003). Widespread infrastructure damage has already been witnessed in Yakutsk, Russia where "thaw-induced settlement" triggered the damage of over 300 buildings. Climate warming is believed to be the main reason behind these damages. Yet, some argue that "better construction practices and maintenance could have prevented much of the trouble." Thawing permafrost is also likely to increase floods and slides (since soil slopes would be less stable), which would put infrastructure in more risk (ACIA 2004). Such damage would evidently trigger both social and economic risks.

Given current knowledge regarding the anticipated dangers due to thawing permafrost, governments have a responsibility to protect their people by taking immediate measures to prepare more appropriate development strategies in the Arctic region. The U.S Arctic Research Commission report outlines a number of useful recommendations including (U.S Arctic Research Commission Permafrost Task Force 2003):

1. more political attention and governmental research programs regarding the issue;
2. increased research, monitoring and data collection to improve current understanding of permafrost and keep track of important trends/changes; and
3. emphasis on applied permafrost research by developing cold-regions engineering criteria "to enhance the design, construction, and maintenance of infrastructure."

These initiatives are crucial and should be adopted, not only by the U.S. government, but by all governments with jurisdiction over the Arctic. The sooner we can start building with climatic changes in mind, the more security we would provide for future generations and economic growth. However, using current knowledge to prepare for our changing environment may only be partially sufficient, as other climate change outcomes could be beyond the capacity of human response.

3.3 Point of No Return?

The shrinking of the cryosphere could have more drastic consequences than those outlined in relation to thawing permafrost. As discussed earlier, the Arctic is a vital contributor to planetary albedo and thus climatic stability. By melting snow, ice and glaciers in the Arctic, less reflective surfaces such as water and land are exposed which causes the albedo of the planet to decrease. This results in a positive feedback loop for global warming since a smaller albedo means less reflectivity and thus more absorption of solar energy into Earth's system (Flannery 2006; Gore 2006; Le Treut, et al. 2007).

Figure 8 demonstrates the melting trend by means of satellite images of Greenland's ice sheets taken in 1992 and 2002.

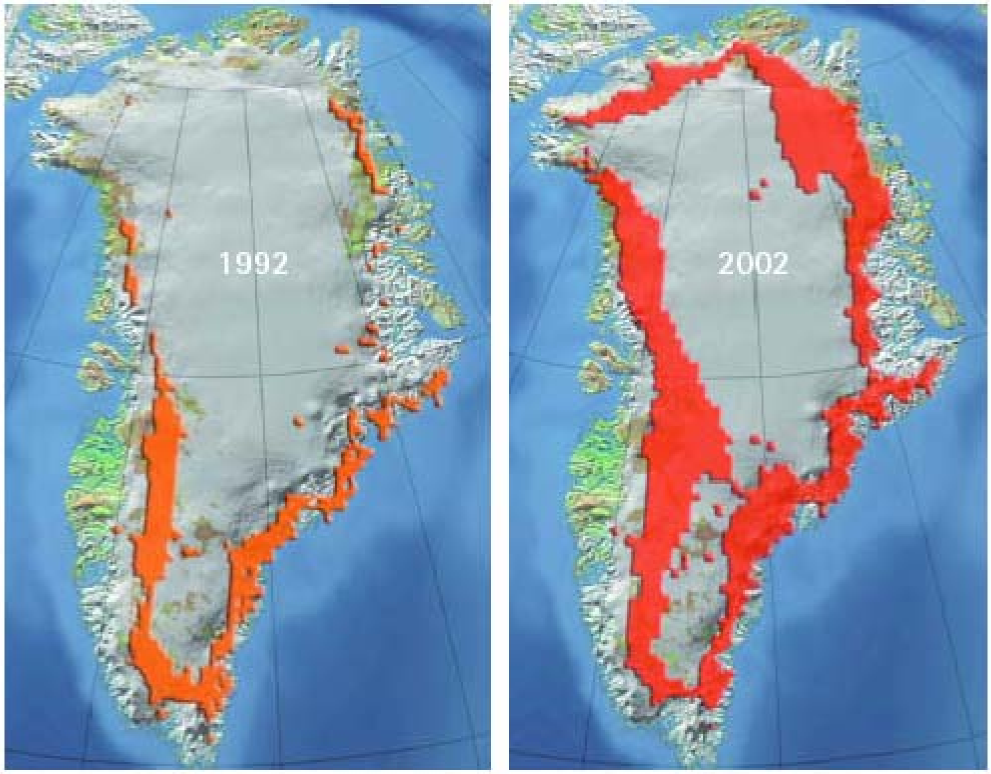

Figure 8: Melting trend shown in satellite images of Greenland's ice sheets (ACIA 2004)

In addition, the cryosphere affects the climate in other crucial ways due to "its potential for affecting ocean circulation (through exchange of freshwater and heat) and atmospheric circulation (through topographic change), [and] its large potential for affecting sea level (through growth and melt of land ice)" (Le Treut, et al. 2007). The global consequences of a shrinking cryosphere could therefore be quite catastrophic. One possible scenario that has previously occurred, according to geological evidence, is the "slowing down the Gulf Stream as a result of fresh water from melting ice accumulating in the north Atlantic." This could result in sudden changes in global climate causing "persistent drought over critical agricultural regions, and a plunge in average temperatures of more than 3°C for Europe, just under 3°C for North America, and 2°C increases for Australia, South America and southern Africa." Other possible outcomes include global sea level rises, and various other climatic changes that could have unpredictable consequences on the global system and drastic implications for all aspects of life on Earth. (Flannery 2006)

Since these forecasts are products of climate simulation models, they are subject to scientific controversy and may never materialize as described. However, discussing the global influence of the Arctic demonstrates the fragile nature of current climatic conditions. Given the intricate complexity of the natural system, future climatic changes could jeopardise many aspects of human existence on Earth. Consequently, climate change research and adaptation deserve central prioritization on both national and global levels and for the sake of future generations.

4.0 Chasing the *True North*

> "For the most part, Inuit live in the "developed world." Yet our circumstances – birth and death rates, health, and incomes etc. – are akin to the developing world. We have feet in both camps. In this sense we, the residents of the Arctic, can bridge perspectives that currently divide the world." – Sheila Watt-Cloutier (2005)

Recent media coverage has given the Arctic considerable attention. Catchy headlines, news series and documentaries that call attention to the major environmental risks in the changing north have been widely available through large media sources such as CBC, Toronto Star and CNN. At the same time, we have also been presented with news that draws attention to some of the political and economic concerns associated with climate change in the Arctic. The most discussed of these concerns in Canada's political rhetoric is the issue of Arctic sovereignty which encompasses border and security issues with neighbouring Arctic countries, sovereignty conflicts over the North Pole, and competition over the vast oil reserves that would become increasingly available due to regional melting (Struzik 2007). As reported on CTV news, "the U.S. Geological Survey estimates that 25 per cent of the world's undiscovered oil and gas reserves are on the floor of the Arctic Ocean" (CTV 2007). Furthermore, ACIA outlines additional economic benefits including the expansion of marine shipping, which would increase tourism and marine transport in the region; and productivity improvement of some major marine fisheries (ACIA 2004). Russia has already made an alarming political move by planting a "territorial flag" on the North Pole's seabed, and Imperial Oil and Exxon Mobil bid $585-million for development rights in the Beaufront Sea (Struzik 2007).

The government's 2007 Throne Speech identified Arctic sovereignty as a national priority:

> “The North needs new attention. New opportunities are emerging across the Arctic, and new challenges from other shores. Our Government will bring forward an integrated northern strategy focused on strengthening Canada’s sovereignty, protecting our environmental heritage, promoting economic and social development, and improving and devolving governance, so that northerners have greater control over their destinies.” (Jean 2007)

As reported on CTV news, the government has already assigned $7.5 billion for the construction and operation of “up to eight Arctic patrol ships” for the purpose of protecting Canadian sovereignty in the North (CTV 2007). In addition, Harper wants to “refurbish a seaport at Nanisivik in the Northwest Passage, and set up a military training base at Resolute” (Struzik 2007).

It is important at this point to consider what politicians are making of the Arctic situation. The swift political interest in defending Arctic sovereignty is a far cry from Harper’s attitude towards climate change. When it comes to environmental protection or emission cuts, the government’s stance is that climate change action would harm the economy. According to Geoffrey York’s reporting, Canada, Japan, and the United States appeared to have “formed an unofficial troika” by expressing anti-Kyoto rhetoric in the recent Bali conference. Canada backed up Japan’s position to “move beyond the Kyoto Protocol” and expressed support for the United States’ refusal to ratify the treaty. The co-ordinated message among all three countries, according to York, is that “economic growth is just as valuable as the environment” (York 2007). The Harper Government has been subjecting Kyoto to economic criticism ever since coming into office. In May 2006, Former Environment Minister Rona Ambrose said that “we will have to pull every truck and car off the street, shut down every train, and ground every plane to reach the Kyoto targets that the Liberals negotiated for Canada.” (CBC Newsworld 2006; Zakzouk 2007)

The government had promised to replace the treaty with a made-in-Canada plan in order to address climate change. The result was Bill C-30; The Clean Air Act, which was defeated in parliament by all opposition parties due to its inadequate climate change policies. One of the main criticisms of the bill was the proposal to assign “intensity-based” emission targets, meaning that GHG allowance would be relative to economic growth. Many critics interpreted this as a way to allow “heavily polluting industries, such as Alberta’s oilsands, to continue to grow and pollute, while remaining under government-imposed limitations” (CBC 2006; Zakzouk 2007). Some businesses also criticized the government’s environmental plan for its inadequate rewards to businesses that achieve early emission reduction. This concern has been specifically expressed to Environment Minister John Baird in a letter by Richard Paton, President and CEO of Canada’s Chemical Producers. The letter also outlines a number of recommendations by which the government could credit early action appropriately. Please see appendix B for a copy of the full document.

Similar arguments, pitting the environment versus the economy, are also expressed by a number of organizations with goals to challenge (and in some cases refute) climate change science. The sceptic scientific opinions discussed earlier are used to back up claims that climate change action would have negative economic consequences. According to a report by the Competitive Enterprise Institute (CEI), the fact that global warming is happening “does not mean that [it] will cause enough damage to the Earth and humanity to require drastic cuts in energy use, [which would be] a policy that would have damaging consequences of its own” (CEI 2007).

There is a wealth of literature that deems pitting the environment against the economy to be fundamentally short-sighted (Brown 2006; Stern 2006; Willard 2005). The changes witnessed in the Arctic already imply potential economic drawbacks regarding infrastructure as discussed earlier, and from a global perspective there could be drastic economic costs to climate change. The Stern Review, published in 2006 by former World Bank Chief Economist and Senior Vice-President, Nicholas Stern, explores the potential economic risks of climate change and estimates an annual loss of up to 20% of global gross domestic product (GDP), now and forever, if no action is initiated to respond to the issue. Conversely, an annual estimate of 1% of GDP could be enough if serious action is taken now (Stern 2006). The substantial difference between 20% and 1% is alarming. Even if Stern's estimates are based on uncertain climate models and encompass other calculation errors, there is a prevalent trend worth serious consideration.

When politicians adopt simplistic rhetoric that isolates economic progress from environmental concerns, it becomes difficult to see major issues such as climate change in their real context. There is no doubt that climate change action is a tough task with no obvious answers. There are still scientific, engineering, and economic challenges that stand in the way of technology solutions, not to mention the inherently complex culture of Canadian policy that is influenced by internal and external pressures due to factors such as the bureaucratic system, intergovernmental relations, and international trade relations (Brooks and Miljan 2003). Nevertheless, climate change is real, and its already pronounced effects in the Arctic emphasize the need for Canada to act timely.

The issue of Arctic sovereignty is a product of climate change and a cause for national concern. However, it is important to question the government's primary interest in protecting the north. In view of the “integrated northern strategy” in Harper’s 2007 Throne Speech, it is not clear how Canada’s environmental heritage would be protected without addressing environmental issues. Furthermore, economic and social development in the region requires the acknowledgment of the economic costs of climate change on Arctic communities.

Ottawa’s political rhetoric has put much emphasis on sovereignty and resources with little consideration of other consequences of arctic warming such as changes to Inuit culture, local climatic instability, risk management, and global climate change. Given the social and environmental value of the region, there needs to be a more comprehensive political approach for the government’s Arctic pursuit.

5.0 Concluding Remarks

Natural ecosystems are intricately interlinked and integrated in ways that affect every aspect of life on Earth. Arctic warming is a strong sign that climate change is well underway. How much of these changes are natural and how much are man-made may not be the most relevant debate at this time. Regardless of the root causes of climate change, it is imperative that we continue to understand its progress and enhance our knowledge of how we could adapt to it.

Further analysis of the climate situation could examine in greater detail the effects on native species, regional vegetation, oceanic circulation patterns, and atmospheric cycles. In addition, a more technical approach to climate simulation techniques may help elaborate the extent of uncertainty assumed by climate models.

There are also numerous political and economic inquiries that could help refine the scientific debate on climate change. For example, NewScientist.com claims that some sceptic organizations receive funding from Exxon Mobil (NewScientist 2005). How true these claims are and what they mean is not entirely clear. Future studies could investigate the *realpolitik* of climate change and how it manifests itself in scientific rhetoric. This would require the determination of the forces that promote climate change scepticism/advocacy, and whether organizations that specialize in climate change topics (such as IPCC, ACIA, NRSP, etc.) are influenced by hidden political agendas. Outlining the various consequences of reducing GHGs, advancing the Kyoto Protocol, or establishing a market for carbon credit may be useful to understand the multiple economic and political forces involved in global climate change controversy.

Further research could also investigate the *realpolitik* of the Arctic situation in Canadian politics. A number of potential forces worth exploring include: Canada's historic and cultural relations with Native communities; interprovincial relations between Ottawa and the Territories; potential constitutional limitations regarding federal jurisdiction in the Territories; oil companies in Canada and their contribution to the national economy; international relations between Canada and the United States – particularly the North American Free Trade Agreement (NAFTA) – and their implications on Arctic resources and climate change policy; the implications of climate change action on the Canadian economy; political pressures from the international community and environmental organizations, and how they affect Canada's international reputation; the public's stance on climate change and influence on Canadian politics; the ethical responsibilities associated with climate change from both national and global viewpoints; and the technical, social and economic feasibility of climate change solutions. By analysing the nature of these critical factors, policy options could be developed in better awareness of the true context of climate change policy in Canada.

Climate change is a crucial issue that stalls at the interface of science, technology, politics, and policy. Addressing its complexity is by no means a simple task. Yet it must be done.

Acknowledgments

I would like to thank Dr. Gail Krantzberg for supervising my research, and for her valuable help throughout the inquiry, writing and editing stages of this paper. I would also like to thank Mr. John Mills for helping me find contacts to assist me with my inquiry, Mr. James Drummond for directing me to some helpful research resources, and Mr. Timothy Ball for his valuable report on Arctic climate.

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Appendix A

The Ground Temperature Profile

Figure 1 shows a typical temperature profile through permafrost, from the ground surface to the base of the permafrost. Higher temperatures are to the right and lower to the left; 0°C is represented as a dashed vertical line. The heavier curves show current conditions. The summer profile curves to the right, indicating above-freezing temperatures near the ground surface. The winter profile curves to the left, indicating that the lowest temperatures are experienced at the surface, with higher temperatures deeper in the permafrost. The summer and winter profiles intersect at depth; below this point, temperatures are not affected by the seasonal fluctuations at the surface. The ground warms gradually with depth in response to the geothermal gradient. The base of the permafrost is situated where the temperature profile crosses 0°C. The *active layer* is a layer of earth material between the ground surface and the permafrost table that freezes and thaws on an annual basis.

In its simplest approximation, climate warming can be envisioned as a shift of the temperature profile to the right, as shown by the gray curves. The surface temperatures in summer and winter are higher, the active layer is thicker, and the mean annual temperature at the thermal damping depth is higher. In time, the base of the permafrost thaws and moves toward the surface. Thus, the permafrost body warms and thins as thaw progresses both above and below.

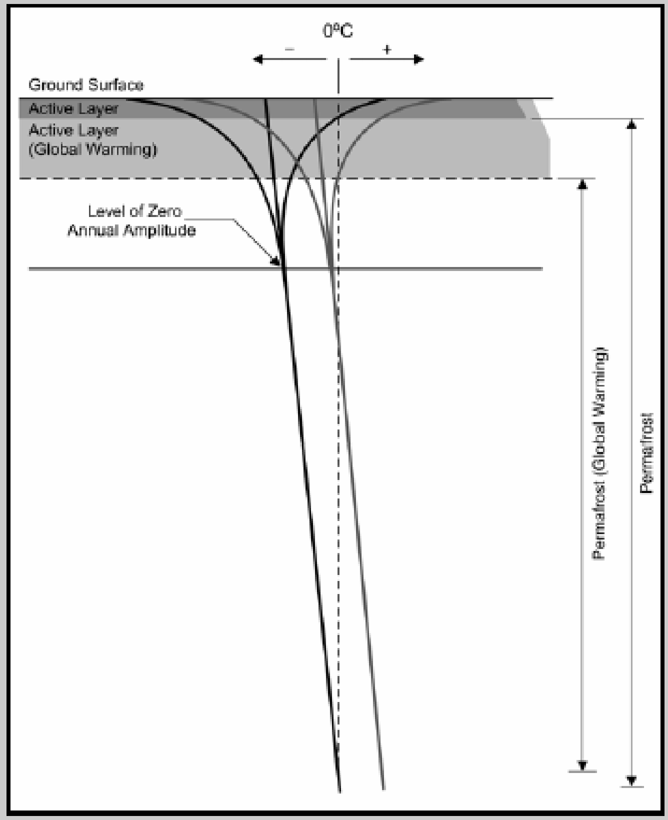

Figure 1. Ground temperature profile.

Source: U.S Arctic Research Commission Permafrost Task Force, 2003

Appendix B

Canada's Chemical Producers — Fabricants de produits chimiques du Canada

Chemistry – a part of everyday life. La chimie – au cœur du quotidien.

By Mail and E-mail

June 25, 2007

The Honourable John Baird, P.C., M.P.
Minister
Environment Canada
Room 458, Confederation Building
Ottawa, ON K1A 0A6

Dear Minister:

RE: Clean Air Regulatory Agenda and Credit for Early Action for Greenhouse Gases

As you know, the Canadian Chemical Producers' Association (CCPA), many others in industry and a number of provinces (particularly Quebec and Ontario) have been very concerned that the clean air regulatory agenda provides inadequate credit for early action for greenhouse gas (GHG) reductions. In fact, at a cross-cutting issues meeting in Vancouver, where Jasmine Igneski of your staff attended, there was also a call from environmental groups, including Greenpeace, to improve the credit for early action provisions and a recognition that to do otherwise would send perverse signals to industry that early action will be penalized instead of rewarded.

CCPA was very pleased that at the conclusion of the recent meeting of the Canadian Council of Ministers of the Environment (CCME) you indicated that you would have another look at what was proposed for credit for early action. We have considered a number of options as to how this could be done and would like to propose the following, which treats early actors similar to new facilities and builds on the design parameters that are already part of the Government's proposals as follows:

- An early actor's facility that had reduced its GHG emissions would not have to meet the 18% reduction requirement to the prorated extent that it had already reduced from 1992 to 2006. Here prorated means that after meeting your criteria for an eligible GHG reduction (more on this later), if early action improvement was 6% a facility would face a 12% requirement instead of 18%; a 9% early action improvement would translate to a 9% requirement; and 18% and above early action improvement to a 0% instead of 18% reduction requirement. *In effect, the 18% reduction requirement would be reduced to the extent that a facilities early action performance had earned the reduction.*
- As with new facilities, the 2% annual improvement requirement would apply with this starting in 2007. There would be no 3 year grace period as "start up" issues for early actors will have already been resolved in previous years of operation. As a result of this, if an early actor facility got full credit for early action (the 18% reduction requirement reduced to 0%), it would still face a 6% improvement requirement by 2010 due to the 2% annual improvement requirement for 2007, 2008 and 2009. But this would be instead of an 18% requirement in 2010. The facility would also face an additional 2% improvement requirement each year after 2010, as with all other facilities.

CCPA believes the above approach would be much fairer to early actors than what is currently proposed, would minimize "losses" to the Government's proposed system through imposing the 2% annual improvement requirement and pro rating the reduction of the 18% requirement according to what the facility has reduced and fits well with the system that is already proposed as it uses the same design parameters.

In terms of the eligibility criteria to claim credit for early action for GHG reductions, CCPA recommends that you not include a requirement that a facility must demonstrate that the reduction was "incremental". Points that were raised with your officials about incrementality at the Vancouver cross-cutting issues meeting included:

- To use incrementality to only credit reductions over and above what made business sense would be contrary to the concept of sustainable development that both industry and government have embraced where the objective is that what makes business sense and what makes environmental sense proceed together.
- There was some discussion by officials that only "real leaders" would get credit and those companies that had made good progress, but had not passed some "real leaders" test would not, or perhaps only those companies that had acted first would get credit. These ideas are unfair and arbitrary. It does not make sense that a company who achieved, for example, 25% early action GHG reductions would get credit and someone who achieved a 15% reduction would not. It would also be unfair and arbitrary if only the company that acted first got credit, but not the company that acted later to accomplish the same reductions.
- Introducing incrementality would significantly increase the bureaucracy and the regulatory tests involved in determining credit for early action, adding an additional layer of complexity which should be avoided.

CCPA hopes that the ideals in this letter will be useful to you and your officials as you determine how you will respond to the need to improve the credit for early action provisions for GHG reductions following your decision at the CCME meeting to relook at this issue.

Sincerely,

Richard Paton

Richard Paton
President and CEO

RP/glm

c.c. The Hon. Laurel Broten, Minister of Environment, Ontario
The Hon. Line Beauchamp, Minister of Sustainable Development, Environment and Parks, Quebec
The Hon. Rob Renner, Minister of Environment, Alberta
Cécile Cléroux, Assistant Deputy Minister, Environment Canada
Jasmine Igneski, Senior Policy Advisor, Environment Canada