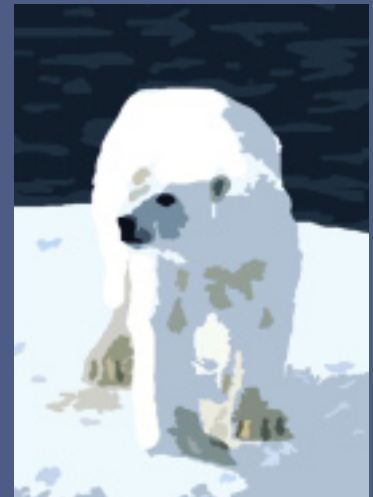


CLIMATE SCIENCE TO POLICY AND BACK TO SCIENCE

Gordon McBean

The earth's climate is changing and human activities are the principal cause, writes Gordon McBean, one of Canada's leading climate scientists. Due to the long lead time for climate adjustment, it will continue to change through this century. There is need for an integrated response of reducing greenhouse gas emissions while adapting to the changing climate. Under the Climate Convention, Canada has obligations to do both. Neither Bill C-30 nor the new Turning the Corner approach fully meets these needs, notes McBean. Further research is needed to support this adaptation strategy and to guide longer-term emission reductions.

« Le climat terrestre est en mutation et l'activité humaine est la première cause de ce changement », une situation qui se poursuivra tout au long du siècle étant donné la période nécessaire aux ajustements climatiques, écrit Gordon McBean, un des climatologues canadiens parmi les plus réputés. Il nous faut donc une solution intégrée pour réduire les émissions de GES tout en nous adaptant à l'évolution du climat. Le Canada a d'ailleurs l'obligation de faire l'un et l'autre selon la Convention-cadre sur les changements climatiques. Mais ni le projet de loi C-30 ni la nouvelle approche d'adaptation ne répondent vraiment à ces exigences, observe Gordon McBean. Aussi devons-nous étoffer les recherches pour appuyer cette stratégie d'adaptation et guider la réduction à plus long terme des émissions de GES.



Fifty years ago, in 1957, I stood on my front porch in Vancouver and watched as a small light moved across the sky. That light was Sputnik, the first human-created satellite to orbit the world. Nineteen fifty-seven was also the International Geophysical Year — proposed and implemented by scientists and national scientific funding agencies to look at the planet as a whole. Scientists started the first systematic global measurements of the ozone layer and of atmospheric carbon dioxide, in both cases because leading scientists saw not only the scientific interest but also the need for such observations as a basis for public policy development. After looking at the initial data, Professor Roger Revelle stated, “Human beings are now carrying out a large-scale geophysical experiment for which we do not know the consequences. We are returning to the atmosphere and oceans the concentrated organic carbon stored in the sedimentary rocks over hundreds of millions of years.”

Less than 30 years later, those continuing ozone measurements provided the basis for demonstrating that the collapse of the Antarctic ozone layer was not a natural phenomenon but, as predicted by scientists, one resulting from human-generated ozone-depleting substances. We now have 50 years of direct and globally comparable carbon dioxide measurements to confirm the increase from 320 ppm (parts per million) to the present 379 ppm.

Canada and Canadians have played major roles in global atmospheric, oceanographic and climate science. The World Climate Research Programme was initiated in 1980 with the objectives “to determine the predictability of climate; and to determine the effect of human activities on climate.” When I was chair of the WCRP Scientific Committee, from 1988 to 1994, I knew that we could make major global scientific experiments successful if we had the participation of a small number of key countries — Canada was one of them. With the erosion of the scientific capacity of governmental laboratories through the 1990s, only partially offset in terms of capacity in universities, Canada is no longer one of the countries that must be at the table for these international scientific endeavours.

A little over a year ago, on April 20, 2006, former prime minister Brian Mulroney was feted as Canada's greenest prime minister, for his leadership during this important environmental era in Canadian history. As he noted in his acceptance speech: “Under Jean Charest's inspired leadership, at the Rio Conference in 1992, we helped bring the United States on board in support of the Convention on Climate Change, and we were the first industrialized nation to sign on to the Bio-Diversity Accord. Canada's international identity was strongly affirmed as a result of the brilliant contribution of Jean

Charest at this seminal conference.” Mulroney was, of course, the Canadian leader who actually signed the UN Framework Convention on Climate Change (the Climate Convention).

The Climate Convention, which was signed and within a few years ratified by almost all countries, has as its objective the “stabilization of green-

By the end of this century, global mean temperatures, based on “best estimates,” are projected to rise between 1.8 and 4.0°C, relative to the 1980-99 period, based on six different emission scenarios. With these temperature changes will come rising sea levels and increased frequency of heat waves, heavy precipitation events and intense tropical cyclones and areas affected by droughts.

house gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.” An important socio-political issue is: What constitutes “dangerous interference”? Dangerous to whom and dangerous in what way? This makes it a classic case for science-policy interactions — with each asking questions of the other.

Most of the political attention in the climate change debates has focused on emission reduction targets. Hence, it is important to note that the Climate Convention has other commitments. Article 3 is on the importance of addressing climate change through policies and measures that are “comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation, and comprise all economic sectors.” Article 4 commits countries to:

(b) Formulate, implement, publish and regularly update national ... programmes containing measures to mitigate climate change by addressing anthropogenic emissions ... and measures to facilitate adequate adaptation to climate change;

(e) Cooperate in preparing for adaptation to the impacts of climate change;

(g) Promote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system and intended

to further the understanding and to reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude and timing of climate change and the economic and social consequences of various response strategies.

Science played an important role leading to the Climate Convention. In 1985, a scientific meeting of the World Meteorological Organization, the UN Environment Programme and the International Council of Scientific Unions, chaired by another Canadian, J.P. Bruce, agreed on a concluding statement: “Many important economic and social decisions are being made today on long-term projects, all based on the assumption that past climatic data, without modification, are a reliable guide to the future. This is no longer a good assumption.”

The Intergovernmental Panel on Climate Change (IPCC) was formed in November 1988, not to do research but to assess and synthesize the policy-relevant results of peer-reviewed published research. As a participant at the founding meeting, I recall that the leads of national delegations were from Environment Canada, the US State Department and the Japanese Ministry of Industry, Trade and Innovation. It is interesting to reflect now how the climate agenda would

have played out in Canada if the issue had been seen as a fundamental issue of the economy and trade and foreign policy, which it is, rather than “just” an environmental issue. The IPCC First Assessment Report in 1990 provided input to the 1992 Rio Conference.

Where are we now? On February 2, 2007, governments approved the Fourth Assessment Report’s IPCC Working Group I (physical climate system) Summary for Policy Makers (WGI), focusing on understanding the human and natural drivers of climate change, determining how the observed climate has changed and why and providing estimates of future climate change. On April 6, 2007, governments agreed on the Working Group II Summary for Policy Makers on climate change impacts, adaptation and vulnerability (WGI). On May 4, 2007, the IPCC Working Group III on the mitigation of climate change, analyzing emission reduction strategies, will release its report.

What conclusions can we draw from the reports of WGs I and II? First, “warming of the climate system is unequivocal” (WG I) and “many natural systems are being affected by regional climate changes” (WG II), based on analysis of observations of temperatures and other factors in the atmosphere, oceans and glaciers, and of climatic impacts on natural ecosystems. Although there are still some who claim evidence of warmer periods in the past millennium, the IPCC concluded “the warmth of the last half century is unusual in at least the previous 1,300 years.” While the average rate of global temperature change was 0.06°C per decade, averaged for the 20th century, the warming trend over the past 50 years is about twice as large, 0.13°C per decade. With these warming temperatures likely have come higher frequencies of heavy precipitation events and increases, in many regions, in areas affected by droughts and, in some regions, in intense tropical cyclone (hurricane) activity. In the terminology

of the IPCC, “likely” means greater than 66 percent confidence in the statement, based on expert judgment.

The WG I summary goes on to say, “Most of the observed increase in global average temperatures since the mid-20th century is very likely (greater than 90 percent confidence) due to the observed increase in anthropogenic greenhouse gas concentrations.” In making this statement, the IPCC notes that the climate change of the past 50 years is “very likely” not due to natural causes (volcanoes, solar variations, etc.) alone. Without the increased anthropogenic greenhouse gases, the climate would have been cooling or at least stable over the past 50 years. Whereas previous assessments had been able to examine climate change only on a global scale, this assessment concluded that significant anthropogenic warming could be identified on every continent, including North America, except Antarctica.

In short, the climate, including the occurrences of extreme events, is changing and human activities are the primary cause. What is the outlook for the rest of this century? If some dramatic event happened and all human emissions of green-

house gases and aerosols were to stop, such that the atmospheric concentrations were to remain fixed at year 2000 levels, “a further warming of about 0.1°C per decade would be expected.” This is the climate system still adjusting to the total emissions that have previously been released into the system. If instead it is assumed that emissions will continue within any reasonably expected range, warming, for the next two decades, by “about 0.2°C per decade is projected.” By the end of this century, global mean temperatures, based on “best estimates,” are projected to rise between 1.8 and 4.0°C, relative to the 1980-99 period, based on six different emission scenarios. With these temperature changes will come rising sea levels and increased frequency of heat waves, heavy precipitation events and intense tropical cyclones and areas affected by droughts.

Around the globe there will be major impacts of this changing climate. Each will have impacts directly or indirectly on people, including Canadians, and Canada needs to have a response strategy. Some of the IPCC’s conclusions include:

- Projected climate-change-related exposures are likely to affect the health status of millions of people, particularly those with low adaptive capacity.
- Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s.
- The impacts on developing countries will be particularly significant. Will Canada provide focused overseas development assistance to help these countries through these events and help improve their adaptive capacity?
- Where extreme weather events become more intense and/or more frequent, the economic and social costs of those events will increase, and these increases will be substantial in the areas most directly affected. Climate change impacts spread from directly impacted areas and sectors to other areas and sectors through extensive and complex linkages.

Over the past decades the number of weather-related disasters around the world has increased from about 80



Courtesy Frédéric Lasserre

An iceberg on the move, north of the Arctic Circle, in October 2006. “The climate,” writes Gordon McBean, “is changing, and human activity is the primary cause.” More climate change ahead in this century, perhaps most dramatically in Canada’s Arctic region.

per year in the 1970s to 360 per year, about one per day, since the start of this century. The impacts, particularly on the poor, have been devastating. These increases are due to a mixture of causes including more people, poverty and exposure and, as the IPCC concluded, more extreme weather-related events.

Canada has seen its share of these weather — related events, and in the years to come, the number (storms, floods, droughts) will increase. Will there be in place the early-warning systems to reduce loss of lives and property? Will zoning and building codes be adjusted to recognize these realities? How will the decisions of individual Canadians be modified?

Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease. Approximately 20 to 30 percent of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C.

With increases in global average temperature exceeding 1.5-2.5°C and in concomitant atmospheric carbon dioxide concentrations, there are projected to be major changes in ecosystem structure and function, species' ecological interactions and species' geographic ranges, with predominantly negative consequences for biodiversity and ecosystem goods and services, such as water and food supply. Global temperature increases above 1-3°C or 1.5-2.5°C will be dangerous for food production, species and ecosystem structure. Are these changes dangerous and, if so, what level of greenhouse gas concentrations will prevent them?

In North America, there will be impacts. The IPCC highlighted some. It said, "Warming in western mountains is projected to cause decreased snow-

pack, more winter flooding, and reduced summer flows, exacerbating competition for over-allocated water resources." Moderate climate change in the early decades of the century is projected to increase aggregate yields of rain-fed agriculture by 5 to 20 percent, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or depend on highly utilized water resources. For western agriculture, particularly on the southwestern prairies, there will be even greater concerns, recognizing the costs

It is unfortunate that greenhouse gas emission reduction plans cannot be set against the reference year of 1990, as agreed in 1992 by the previous Conservative government. Further, since at least some of the plan refers to intensity targets and the targets seem to apply only to major industrial emitters, it will take some analysis to determine what will actually be the impact on actual emissions of greenhouse gases from Canada. What is still needed is a serious policy on greenhouse gas emission reductions, one that forms the basis for a comprehensive approach and will be in place through the decades to come.

of recent droughts, exceeding billions of dollars. In some areas, there are opportunities. How will the choices be made and what science is needed to reduce the uncertainty?

Disturbances from pests, diseases and fire are projected to have increasing impacts on forests, with an extended period of high fire risk and large increases in area burned. The western pine beetle has already made barren vast stretches of Canadian forests. West Nile virus is now in areas not previously seen. What strategies can be implemented to reduce these impacts?

Cities that currently experience heat waves are expected to be further challenged by an increased number, intensity and duration of heat waves during the course of the century, with potential for adverse health impacts. Elderly populations are most at risk. Climate model simulations by Environment Canada have projected that the number of days per summer in southwestern Ontario warmer than 30°C will increase from about 10 per summer in the past 30 years to about 30 by mid-century to more than 60 by the end of the century. There have already been impacts of heat waves, often accompanied by urban smog events, in Canada. What adaptation strategies will have been put into place by then?

Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution. Population growth and the rising value of infrastructure in coastal areas increase vulnerability to climate variability and future climate change, with losses projected to increase if the intensity of tropical storms increases. Current adaptation is uneven and readiness for increased exposure is low.

Will critical infrastructure that lines the shores of coastal communities be protected or moved in the coming decades?

Will water, sewage and transportation systems be modified? Will early-warning systems be improved to provide more accurate and timely warnings to reduce losses?

Arctic human communities are already adapting to climate change, but both external and internal stressors challenge their adaptive capacities. Despite the resilience shown historically by Arctic indigenous communities, some traditional ways of life are being threatened and substantial investments are needed to adapt or relocate physical structures and communities. There would, however, be some beneficial impacts, including

reduced heating costs and more navigable northern sea routes.

The rate of temperature change in the Arctic is already about twice that of the global average and will continue to be the most impacted in terms of temperature change of any part of the globe. The impacts on Canada's territories, their people and ecosystems will be very large. Opening of the North also raises issues of national sovereignty as well as servicing and policing the North. What plans are being made and which investments are the priorities?

The IPCC reported in 2007 that the observed greenhouse gas concentrations continue to increase, reaching 379 ppm in 2005, compared with the pre-industrial value of 280 ppm. Developed countries agreed in the Climate Convention to "the aim of returning individually or jointly to their 1990 levels these anthropogenic emissions of carbon dioxide and other greenhouse gases," and through the Kyoto Protocol to reduce their emissions, collectively, averaged for the period 2008-12 (not for 2012 as is often stated), by about 5 percent relative to 1990 levels. The IPCC's analysis shows that global annual carbon emissions have increased from an average of 23.5 GtCO₂ per year in the 1990s to 26.4 GtCO₂ for the period 2000-05. GtCO₂ means a billion tonnes of carbon dioxide or the radiative equivalent in other greenhouse gases, mainly methane and nitrous dioxide.

In 1990, Canada's emissions were about 600 MtCO₂ (Mt is a million tonnes) so that Canada contributed about 2.5 percent of global emissions. Canada's Kyoto Protocol commitment, ratified by Parliament in December 2002, was a reduction of 6 percent.

In this context, debate in Canada continues over emission reduction targets. The federal government introduced Bill C-30, the *Clean Air Act*, in the House of Commons in October 2006. The general intent was to strengthen federal mechanisms to reduce emissions of air pollutants which contribute to smog and acid

rain, and greenhouse gases, which contribute to climate change, thus linking clean air and climate change, which seems long overdue. The Bill also proposed, for the first time, long-term reductions in greenhouse gas emissions (45 to 65 percent reduction by 2050), recognizing what the scientific community had been saying since its first assessment in 1990, that over 50 percent emission reductions globally would be required to stabilize the atmospheric concentration of greenhouse gases.

The Bill did not, however, set any near-term targets and opposition party members and environmental groups criticized the Bill as too weak to adequately address the problem of climate change. A parliamentary committee significantly altered it and renamed it the *Clean Air and Climate Change Act*. The amended version includes implementing emission reduction targets set out in the Kyoto Protocol, as well as setting and implementing medium- and long-range targets for further emission reduction. These targets, all with respect to the 1990 reference level, are specified in the amended Bill: 6 percent below 1990 levels by 2008-12; 20 percent by 2020; and 60 to 80 percent by 2050. At the time of writing this paper, it is not clear what will become of these Bills, either modified or the original ones. Canadian emissions today are about 750 MtCO₂ and the business-as-usual projection puts them at about 900 MtCO₂ in 2020.

On April 26, Environment Minister John Baird introduced the "Turning the Corner" plan that "will stop the rise in greenhouse gases in three to five years." Further, "Once greenhouse gases have stopped rising, we will begin to reduce them, so that by 2020, Canada will have cut its greenhouse gas emissions by 150 million tonnes. This is 20 percent of our total emissions today." As noted above, Canada's emissions by 2020 will be about 900 MtCO₂ so the reduction is actually 17 percent of emissions

at that time. This would have the effect of bringing Canada's emissions in 2020 back to present levels: about 25 percent above 1990 levels. Different targets will be set for existing facilities and new facilities, which have a grace period. For existing facilities, "a 6 percent improvement each year from 2007 to 2010, giving an enforceable 18 percent reduction from 2006 emission intensity, starting in 2010, is required with a 2 percent annual improvement thereafter."

It is unfortunate that greenhouse gas emission reduction plans cannot be set against the reference year of 1990, as agreed in 1992 by the previous Conservative government. Further, since at least some of the plan refers to intensity targets and the targets seem to apply only to major industrial emitters, it will take some analysis to determine what will actually be the impact on emissions of greenhouse gases from Canada. What is still needed is a serious policy on greenhouse gas emission reductions, one that forms the basis for a comprehensive approach and will be in place through the decades to come.

The Turning the Corner plan was entirely focused on emission reductions and lacked any mention of an adaptation strategy. Further, no mention is made about supporting any further research on climate change, as opposed to emission reduction technologies.

At the Climate Convention Workshop on the Adaptation Fund in spring 2006, Rona Ambrose, then environment minister, stated, "To be successful, greenhouse gas mitigation, coupled with adaptation measures, should be integrated into broader sustainable development objectives, such as economic development, energy security, public health, air quality and local environmental protection."

An adaptation strategy, based on a comprehensive vulnerability analysis, would be developed to reduce the negative impacts and capture the benefits of a changing climate. An adaptation strategy would provide Canadians with

information and advice and a regulatory regime to reduce vulnerability to dangerous or hazardous extremes in weather, climate and air pollution. It will also involve modifications to existing regulations and legislation. Proactive adaptation is usually the most cost-effective and efficient plan of action, which means direct intervention of government is appropriate. Whereas we must act globally to address emissions of greenhouse gases, adaptation strategies need to be developed locally and the full benefits of investments will come locally, a made-in-Canada approach.

Ambrose also spoke of sustainable development — “humanity has the ability to make development sustainable — to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs”, which was introduced by the Brundtland World Commission on Environment and Development in 1987. Prime Minister Mulroney noted that in 1988 Canada was the first Western government to endorse the recommendations of the Brundtland Commission and the first to embrace the language of sustainable development. Meeting the needs of future generations implies being able to predict, across the natural, socio-economic and health sciences, what will or might happen and how actions and decisions taken now result in differences in the future. These predictions should lead to actions that change the outcome; fate can become a choice and choices can make the prediction wrong. In reality, prediction is the process of looking ahead on the basis of incomplete knowledge of the present and with incomplete understanding of how the system works.

Let us look again at what science is telling us. For the past few decades, the rate of warming has been observed to be 0.13°C per decade; for the next few

decades it will be larger, 0.2°C per decade. By mid-century, the global emission reduction actions will start to take effect. If essentially nothing is done globally, and that is what matters to the climate, the warming rate could be much higher, as much as 0.8°C per decade; if significant actions are taken, the rate could lower to 0.15°C per decade, about what we have recently seen, with lower rates and eventually a restabilization of

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the climate at some new warmer state after 2100. Human actions will make a big difference. But it will take time. Meanwhile, for the rest of this century our climate will be changing.

Recall that for impacts on species, the critical temperatures were 1.5-2.5°C, say 2°C. For the scenario with the highest emissions, 2°C is reached by about 2060, while for the lowest-emissions scenario, it is reached only after 2100. So changing our emission scenario does make a difference. However, we also have to note that the uncertainty associated with each projection of temperature is significant, ranging from 2°C up to almost 4°C, meaning that the 2°C threshold, if that is the critical number, could be met two or so decades earlier or later than the mean estimate. A system as complex as the climate system has non-linear characteristics and possible tipping points. We need to know better where those are and their consequences as part of a comprehensive climate

change (and clean air) strategy. This is needed to guide our emission reduction targets for beyond 2020.

How much reduction is needed and how fast to avoid “dangerous interference”? To implement an adaptation strategy will require a full new scope of research on clarifying and quantifying detailed relationships between future global emissions, regional climate change and consequences for agricul-

ture, fisheries, forestry, transportation and all other climate-sensitive sectors. Science is providing considerable guidance and has made the case for action, but there is still considerable uncertainty in the details. The IPCC has shown us much insight but it has also laid out the challenges for the future in responding to this global threat. Canada, as a G8 country that wishes to be a leader in global endeavours, should make the investments to regain its position among the leaders in addressing the global climate change issue, including in its contributions toward global science. It has the fundamental resource, an outstanding cadre of scientists; it just needs the will and commitment to make it so.

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