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Your File *Votre référence*

Our File *Notre référence*
A-2007-00279 / cl

FEB 25 2008

Ms. Clare Demerse
164 Wellington Street
Gatineau, Québec
J8X 2J4

Dear Ms. Demerse:

We have completed processing your request under the Access to Information Act (the Act) for:

> "All documents or analysis prepared concerning a "2 degree Celcius" threshold limit for global warming (Time period: Jan 1, 2006 - August 28, 2007).
>
> Revised January 14, 2008
>
> The two most recent briefing notes from the documentation provided in response to this request."

Attached please find the complete release package in response to this request.

Please be advised that you are entitled to complain to the Information Commissioner concerning the processing of your request within sixty days of the receipt of this notice. In the event you decide to avail yourself of this right, your notice of complaint should be addressed to:

Information Commissioner
Tower B, Place de Ville
112 Kent Street, 22nd Floor
Ottawa, Ontario
K1A 1H3

If you have any questions regarding this request, please do not hesitate to contact Carol Lafontaine at (819) 953-5689.

Yours sincerely,

Pierre Bernier
Access to Information
and Privacy Coordinator

Enclosure

Environment Canada / Environnement Canada

DM-100919

MEMORANDUM TO DEPUTY MINISTER

JUN 0 1 2007

SCIENCE PERSPECTIVES ON LIMITING GLOBAL WARMING TO 2°C ABOVE THE PRE-INDUSTRIAL LEVEL

(For Information)

PURPOSE

Germany, as host of the G8, is seeking consensus among countries for the EU's goal of limiting global warming to 2°C above the "pre-industrial (pre-20th century) level". This note provides some perspectives on whether or not such a target is supported by the science on the impacts of climate change, based primarily on the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

SUMMARY

- The world has already warmed over the past century, by about 0.74°C. Impacts are already being observed and some of these have been at least partially attributed to anthropogenic climate change, including increases in human mortality, loss of glaciers and increases in the frequency and/or intensity of extreme events.
- It is certain that impacts will become more serious with increased warming. Therefore, aiming to limit the global average temperature increase to around 3°C will undoubtedly impose more severe and costly impacts on society than would aiming to limit the increase to around 2°C. However, thresholds above which impacts become 'significant' are difficult to identify and involve value judgments.
- Some thresholds are of particular importance, however, from a science perspective because they indicate points at which irreversible changes may occur. From this perspective, there are two significant conclusions from the IPCC Fourth Assessment reports with particular bearing on the proposed 2°C target:
  1. a sustained global warming (over millennia) beyond about 2°C above the pre-industrial level could lead to irreversible melting of the Greenland Ice Sheet with an associated sea level rise of about 7m. This would cause major reconfigurations of coastlines around the world and displacement of vast numbers of people; and
  2. approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction for global average temperature increases exceeding 2.0-3.0°C above pre-industrial values.
- Current scientific knowledge indicates that if serious risks such as the extinction of significant numbers of species globally or a sea level rise of 7m from the irreversible melting of the Greenland Ice Sheet are to be avoided, then it would be desirable to avoid a global temperature increase of greater than approximately 2°C above pre-industrial. The exact level at which such risks become significantly elevated remains uncertain. However, it is clear that risks are substantially greater for greater warming.

CURRENT STATUS

Canada has not, to date, supported any specific global temperature target as a threshold for limiting anthropogenic impacts on the climate system.

The Intergovernmental Panel on Climate Change (IPCC) has avoided making a statement about whether or not their findings support any particular target over another. Although the IPCC's work does provide critical input to such decision-making, decisions about appropriate targets are inherently political rather than scientific.

No Canadian assessment has been undertaken on what the regional impacts across Canada might be for different amounts of global warming. An Assessment of impacts, vulnerability and adaptation to climate change in Canada is currently in preparation, under the leadership of the department of Natural Resources. Environment Canada is contributing to this effort in various ways. This assessment is projected for release in Fall 2007 and will provide important information that would assist in understanding what global temperature increases Canada would wish to avoid from a perspective of national impacts of concern.

Environment Canada's Science and Technology Branch was asked to provide advice to International Affairs Branch to support development of a negotiating position for a G8 Sherpa meeting during which Germany sought support from countries for a proposed "2°C above pre-industrial" target.

This note provides some perspectives on whether or not such a target is supported by the science on the impacts of climate change, based primarily on the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

CONSIDERATIONS

Rate of Climate Change

There is evidence that some systems have 'tipping points' or thresholds above which the system will shift abruptly from one state to another, with consequences that can be far-reaching. Identification of such climate thresholds is difficult, however, and not many are yet known.

Even in the case of gradual climate change, there can be a point at which an individual impact, or aggregate impacts, could be judged to have passed a critical level of damage. Such judgments are not, however, based on science, but involve value-based decisions about what is significant and what not.

There is general agreement, though, that the rate of change will be an important determinant of how severe resulting impacts are because adaptation, both in nature and by humans, is generally easier for slower rates of change. When the rate of change surpasses a system's capacity to adapt, we can expect the consequences to be more severe.

In the recently released Fourth Assessment Report, the IPCC reported that the world has warmed substantially – by 0.74°C over the past century - and that the rate of warming over the last 50 years (0.13 °C per decade) has been nearly twice that for the last 100 years. This rate of change is expected to increase further. For the next two decades, a warming of about 0.2 °C per decade is projected, a result that is influenced strongly by historic emissions and is relatively insensitive to emissions over this time period.

Over the long term, the amount of global warming is strongly influenced by ongoing emissions of GHGs, with higher emissions resulting in greater eventual warming.

Global Impacts

Although the IPCC WGI report does not identify many thresholds for changes in the climate system, it is certain that impacts would become more serious with increased warming. As the global temperature increases, the following changes are expected:

- Contraction of snow cover and sea ice
- Increase in the depth of thaw of permafrost
- Increased frequency of heat waves and other hot extremes over most land areas
- Increased frequency of heavy precipitation events
- Increased area affected by drought
- An increase in intense tropical cyclone activity
- An increase in extreme high sea level (includes storm surges)

A significant conclusion from the IPCC WGI Fourth Assessment is that a sustained increase in global average temperature (relative to pre-industrial values) of 1.9 to 4.6°C could lead to the melting of the Greenland Ice Sheet over millennia and a consequent global sea level rise of about 7m. This result is above and beyond the IPCC global sea level rise estimates of 18-59 cm for 2100.

IPCC Working Group II (Impacts, Adaptation and Vulnerability) further reports that impacts are already being observed and some of these have been at least partially attributed to anthropogenic climate change, including increases in human mortality, loss of glaciers and increases in the frequency and/or intensity of extreme events. Global mean temperature change of up to about 2.5°C above pre-industrial would exacerbate such impacts and cause others. Beyond this level, an increasing number of impacts at all scales can be expected.

A significant conclusion from the IPCC WGII Fourth Assessment is that 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction for global average temperature increases exceeding 2.0-3.0°C above pre-industrial values. The irreversible nature of extinction makes this impact of particular concern.

Canadian Impacts

On average, Canada has warmed by about 1.3°C over the last 59 years, a rate of warming that is about twice that of the global average. This trend is expected to continue in the future, with warming greatest during the winter months and over the Arctic region.

Already, impacts have been observed in Canada in response to recent warming. These are mainly linked to the cryosphere: melting of glaciers, declining snow pack, thinning and reduction of sea ice extent, and thawing of the permafrost. Other important impacts already observed include recent trends towards lower levels in the Great Lakes, increased wildfire frequency, enhanced outbreaks of forest insect infestations, and increased coastal erosion in the Maritimes, Quebec and the North. Such impacts are expected to increase in response to further increases in regional temperatures and associated climatic changes.

IPCC WGII concluded that human settlements in polar regions are already being adversely affected by reduction in ice coverage and coastal erosion and that future climate change is very likely to result in additional disruption of traditional cultures and loss of communities.

Model projections also show that warming in summer will be greatest in the interior of the continent. This region is also expected to be drier in the future, especially in the west, with an enhanced risk of drought. This implies more difficult agricultural conditions, enhanced wildfire risks, and increased competition for water among agricultural, municipal, industrial and ecological users.

Impacts associated with precipitation extremes are expected to be among the impacts of most concern to Canadians. Recently, Environment Canada scientists published a paper projecting that over North America, the risk of a 'fixed-size' (e.g. 20 yr or 100 yr) event could increase by approximately 50% mid-century relative to current climate. The implications are that flash flooding, for example, will occur 50% more frequently and thus urban water supply and waste water infrastructure will be stressed and/or damaged much more frequently.

CONCLUSIONS

On the basis of current scientific understanding, as represented by the recently released IPCC Fourth Assessment reports, it is clear that substantial global and Canadian impacts can be expected for a global average temperature increase above 2°C relative to the pre-industrial value. Adaptation will be able to reduce impacts to some extent, in some cases. However, adaptation is not expected to ameliorate all impacts, and will be especially challenging for natural systems.

The identification of thresholds in non-linear systems (such as the climate system) beyond which essentially irreversible changes (on human timescales) are triggered provides very relevant guidance to decisions about what an appropriate target might be for limiting the increase in global average temperature. Current scientific knowledge indicates that if serious risks such as the extinction of significant numbers of species globally or a sea level rise in excess of 7m from the irreversible melting of the Greenland Ice Sheet are to be avoided, then it would be desirable to avoid a global temperature increase of greater than approximately 2°C above pre-industrial.

The exact level at which such risks become significantly elevated remains uncertain. However, it is clear that risks are substantially greater for greater warming.

Brian T. Gray
ADM - Science and Technology Branch

PROTECTED

DM-100918

MEMORANDUM TO DEPUTY MINISTER

LINKING GLOBAL TEMPERATURE STABILIZATION WITH THE EMISSIONS AND ATMOSPHERIC CONCENTRATIONS OF GREEN HOUSE GASES

(For information)

PURPOSE

Germany, as host of the G8, is seeking consensus among countries for the EU's goal of limiting global warming to 2°C above the "pre-industrial (pre-20th century) level". This note provides a science perspective on the attainability of such a target, based on the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report.

SUMMARY

- It is imperative to stabilize global atmospheric greenhouse gas (GHG) concentrations in order to prevent a 'run-away' greenhouse effect.
- Stabilizing atmospheric GHG concentrations requires that emissions of these gases peak and then decline thereafter. The eventual stabilization level is affected by the timing and magnitude of the emissions peak, and the decline in emissions rates thereafter. An earlier, lower peak and more rapid subsequent decline would allow a lower stabilization level.
- The best estimate of the eventual global mean temperature increase under the most stringent emissions scenarios assessed by the IPCC (atmosphere stabilizing at 445-490 ppm $CO_{2\,eq}$[1]) is 2-2.4°C above pre-industrial. Meeting such a target would require CO_2 emissions to peak before 2015 and then drop to 50 - 85% lower than 2000 levels by 2050.
- Uncertainties in how the climate system will respond to changes in GHG concentrations imply that the uncertainty range on the eventual global temperature increase under stabilization at 445-490 ppm $CO_{2\,eq}$ is much greater (1.3-3.7°C) than the 2-2.4°C range of best estimates.
- Decisions made with respect to emissions reductions should take uncertainties in the response of the system into account. This uncertainty implies that an emissions reduction that targets, for example, a best estimate temperature response of 2°C may result in a warming that is greater than that target. Thus if avoiding a 2°C warming were determined to be very important, it would be prudent to target a lower temperature response to avoid a risk of overshooting the 2°C threshold.

[1] $CO_{2\,equivalent}$: This is defined as the concentration of carbon dioxide that would cause the same amount of radiative forcing as a given mixture of carbon dioxide, other greenhouse gases, and aerosols.

CURRENT STATUS

- Canada has not, to date, supported any specific global temperature target as a threshold for limiting anthropogenic impacts on the climate system.
- The Intergovernmental Panel on Climate Change (IPCC) has avoided making a statement about whether or not their findings support any particular target over another. Although the IPCC's work does provide critical input to such decision-making, decisions about appropriate targets are inherently political rather than scientific.
- Environment Canada's S&T Branch was asked to provide advice to the International Affairs Branch to support the development of a negotiating position for a G8 Sherpa meeting during which Germany sought support from countries on the proposed "2°C above pre-industrial" target.
- This note provides a science perspective on the attainability of such a target primarily on the basis of the 2007 IPCC Fourth Assessment (AR4).

CONSIDERATIONS

- The Third Assessment Report of the IPCC, published in 2001, reported a global temperature increase for the period 1860-2000 of 0.6°C[2]. If emissions were held at year 2000 levels, we would be committed to an additional warming of about 0.6°C in the present century (IPCC WGI AR4 SPM). Therefore, the "2°C above pre-industrial" target allows for relatively little warming – approximately 0.8°C - beyond what has been experienced or is "committed".
- This limited 'allowable warming' is reflected in results from the IPCC assessment reports which show that only stringent emission scenarios for this century are capable of keeping the global average temperature rise to within the proposed 2°C target.
- The reports of Working Groups I and III both support this conclusion based on different approaches. Working Group I (WGI) evaluated the consequences for the climate system of a standard suite of 'non-mitigation' emission scenarios (the so-called SRES scenarios[3]). These scenarios represent different possible futures that may unfold in the absence of specific climate change policies[4]. Results from Global Climate Models were assessed to provide projections of future climate change under these scenarios, including, but not limited to, changes in global average temperature. In contrast, WGIII evaluated a

[2] Note that the recently released report of the IPCC WGI (Science) updated the global temperature trend for the period 1906-2005, and reported it to be 0.74 °C/100 years.
[3] The SRES scenarios are documented in the IPCC Special Report on Emission Scenarios.
[4] IPCC WG1 regards all SRES scenarios as equally plausible, and does not determine whether any one scenario is more or less likely than any other scenario.

suite of 'mitigation' scenarios, expressed as different atmospheric GHG stabilization levels.

- The IPCC WGI report provided, for the first time, a *likely*[5] range for global temperature change by 2100 for each of the six "marker" SRES emission scenarios (See Table 1 attached). This *likely* range is an important advance in projections of future climate change from the IPCC's Third Assessment Report, at which time no probabilities were attached to temperature projections under different emission scenarios. The *likely* range incorporates results from a large number of climate models, including the Canadian model, as well as new information regarding the nature of feedbacks from the carbon cycle, as well as constraints on climate response from paleoclimate data.

- Scenario B1 has the lowest "forcing" (least emissions) among the six different SRES scenarios described in Table 1. The eventual warming relative to pre-industrial under this scenario would probably be greater than 2°C. The best estimate of global warming over the next century under scenario B1 is 1.8°C above 1980-1999 levels. However, the 1980-1999 period was approximately 0.54°C[6] warmer than pre-industrial levels. Thus the best estimate of global warming at year 2100 under the B1 scenario, relative to pre-industrial levels, is 2.3°C and the *likely* warming range is approximately 1.6-3.4°C. The eventual warming relative to pre-industrial would be substantially greater than this range.

- The B1 scenario is ambitious in terms of emission reductions and has atmospheric CO_2 concentrations over the 21st century stabilizing at just below double the pre-industrial CO_2 levels – in other words, just below about 550 ppm CO_2. If the radiative forcing of other GHGs and aerosols were included, the resulting atmospheric concentration expressed as $CO_{2\,eq}$ would be about 600 ppm (IPCC WGI AR4 Technical Summary). The current CO_2 concentration is 379 ppm. Over the past decade, the rate of growth has been about 2ppm per year. The best estimate of the $CO_{2\,eq}$ concentration for current atmospheric concentrations of all GHGs and aerosols is 375 ppm[7].

- IPCC Working Group III (Mitigation) assessed a number of different "stabilization scenarios". These are long term emissions scenarios that extend far beyond year 2100 and eventually result in stabilized atmospheric concentrations of a basket of greenhouse gases. WGIII considered scenarios with stabilization levels from approximately 450 to1150 ppm $CO_{2\,eq}$ (See Table 2 attached). The eventual warming under a given stabilization scenario is calculated on the basis of estimates of the "climate sensitivity", which is a measure of the climate system response to a prescribed change in radiative forcing[8]. This is different than using global climate models to project future climate change, as with the projections from the IPCC WGI report shown in Table 1.

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[5] In IPCC language, 'likely' means there is a probability of >66% of the outcome occurring.

[6] The 0.54°C is calculated from the linear temperature trend over the 20th century.

[7] Aerosol forcing exerts a cooling effect on climate and offsets some of the warming from GHGs. Under the B1 (and most other) emission scenarios, aerosol concentrations are lower in the future than at present which effects the value of the $CO_{2\text{-}eq}$ concentration relative to CO_2 alone.

[8] The values for the climate system response – 'climate sensitivity' – are taken from the IPCC WGI report.

- Of the scenarios assessed by IPCC WGIII, the most stringent scenarios - stabilizing atmospheric concentrations at 445-490ppm $CO_{2\,eq}$ - could limit global mean temp increases to 2- 2.4°C above pre-industrial, at equilibrium. This range is based in the best estimate of climate sensitivity from IPCC WGI. Not all of this warming will be realized by 2100.

- Uncertainties in how the climate system will respond to changes in GHG concentrations imply that the uncertainty range on the eventual global temperature increase under stabilization at 445-490 ppm $CO_{2\,eq}$ is much greater (1.3-3.7°C) than the 2-2.4°C range of best estimates. (See Figure 1.) This result underscores the risks associated with aiming for any particular global stabilization target. The *likely* increase in global average temperature encompasses a large range, much of which is greater than 2°C. The challenge of meeting a 2°C target is clearly demonstrated by Figure 2.

- To achieve a stabilization target in the 445-490ppm CO_{2eq} range would require CO_2 emissions to peak before 2015 and to be around 50 to 85% lower than 2000 levels by 2050. The lower the stabilization level, the more quickly this peak and decline would need to occur and the greater the decline would need to be. Mitigation efforts over the next two to three decades will have a large impact on opportunities to achieve lower stabilization levels.

CONCLUSIONS

- The IPCC WGI report provided, for the first time, an assessment of the temperature change that is *likely* to occur under specific emissions pathways. This is a significant advance in science that came about due to an unprecedented co-ordinated global modeling effort of which Canada was a part. IPCC WGI also provided, for the first time, a *likely* range for climate sensitivity (2-4.5°C). This range was used by IPCC WGIII to provide *likely* ranges of global temperature increase for different atmospheric stabilization levels. All of this work has shown very clearly that:

1. Meeting a target of limiting global average temperature increase to 2°C above the pre-industrial level would be challenging and would require global emission reductions to drop within a few decades to 50-80% below current levels.

2. While uncertainty has been better quantified in this IPCC AR4 report than in previous reports, there is still considerable uncertainty about the eventual climate system response to a given change in GHG emissions. There is more confidence in the lower bound for climate sensitivity than there is in the upper bound.

3. Decisions made with respect to emission reductions should take into account the risk of overshooting a temperature target that is implied by the uncertainty in the climate system response to changes in emissions.

Brian T. Gray
ADM-S&T

Drafting Officer's Name: Elizabeth Bush, with input from Francis Zwiers, Patti Edwards
Branch: Atmospheric Science Assessment and Integration (ASAI). S&T Branch
Phone No: 416-739-4332
Date Drafted: May 30th, 2007

TABLE 1 (TABLE SPM-2 IPCC WGI): Projected globally averaged surface warming and sea level rise at the end of the 21st century for different model cases. The sea level projections do not include uncertainties in carbon-cycle feedbacks, because a basis in published literature is lacking. Note that approximately 0.54 °[9]C should be added to get a value for global temperature change relative to pre-industrial levels.

	Temperature Change (°C at 2090-2099 relative to 1980-1999) [a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999)
Case	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations [c]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

Notes:

[a] These estimates are assessed from a hierarchy of models that encompass a simple climate model, several EMICs, and a large number of AOGCMs.

[c] Year 2000 constant composition is derived from AOGCMs only

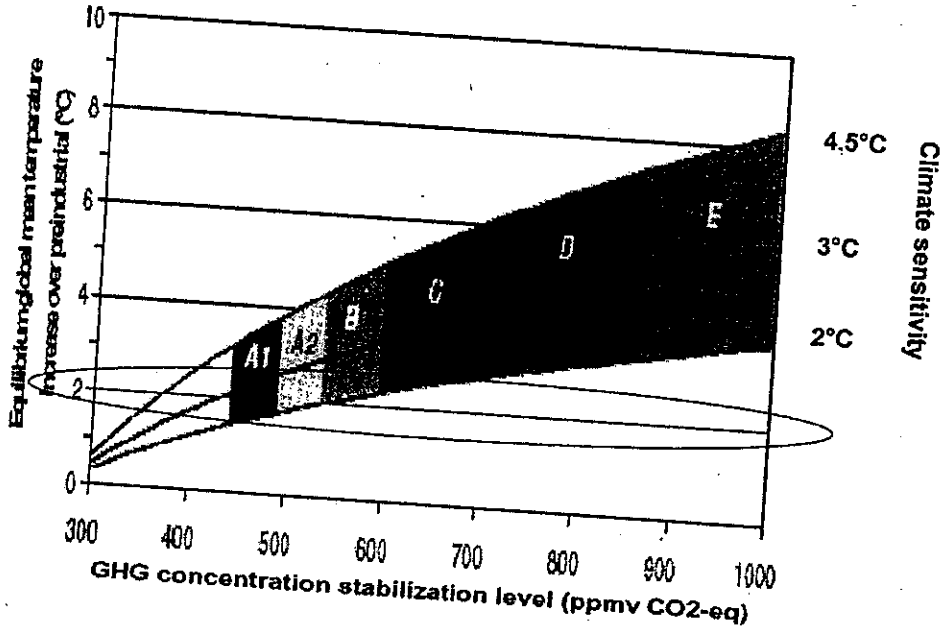
[9] The 0.54°C is calculated from the linear temperature trend over the 20th century.

Table 2 (Based on Table SPM-5 IPCC WGIII): Characteristics of post-TAR stabilization scenarios.

Stabilization Scenario Categories	Stabilization level (ppm CO2-eq)	Best estimate of global mean temp. increase above pre-industrial at equilibrium[1,2] (°C)	Year CO_2 needs to peak	% Reduction in 2050 compared to 2000
A1	445 - 490	2.0 - 2.4	2000 - 2015	-85 to -50
A2	490 - 535	2.4 - 2.8	2000 - 2020	-60 to -30
B	535 - 590	2.8 - 3.2	2010 - 2030	-30 to +5
C	590 - 710	3.2 - 4.0	2020 - 2060	+10 to +60
D	710 - 855	4.0 - 4.9	2050 - 2080	+25 to +85
E	855 - 1130	4.9 - 6.1	2060 - 2090	+90 to +140

Notes:
[1] Note that global mean temperature at equilibrium is different from expected global mean temperatures in 2100 due to the inertia of the climate system.
[2] These ranges are based on the "best estimate" climate sensitivity of 3°C (IPCC WGI SPM).

Figure 1 (Figure SPM-8 IPCC WGIII): Stabilization scenarios and their relationship to equilibrium global mean temperature change above pre-industrial, using (i) "best estimate" climate sensitivity of 3 °C (black line in middle of shaded area), (ii) upper bound of *likely* range of climate sensitivity of 4.5 °C (red line at top of shaded area) (iii) lower bound of *likely* range of climate sensitivity of 2 °C (blue line at bottom of shaded area). This *likely* range of climate sensitivity is a finding of the IPCC WGI Fourth Assessment. Coloured shading shows the concentration bands for stabilization of greenhouse gases in the atmosphere corresponding to the stabilization scenario categories presented in Table 1 above.



ANNEX I

SUPPLEMENTAL INFORMATION