ENVR 200 Global Environment: A Systems Approach
Assignment 3: Global Carbon Cycle and Emission Scenarios

Due Date: Monday, November 18, 2013

MEMORANDUM

TO: Science Advisor to the Prime Minister of Canada

FROM: Prime Minister's Office (PMO)

SUBJECT: The scientific argument for how much greenhouse gas emission reduction is needed.

Canada formally withdrew from the Kyoto Protocol in late 2011. We were clear that Canada was not going to make a 6% reduction relative to our 1990 emissions target of the KP. In its place we agreed, as part of the 2009 Copenhagen Accord, to reduce our emissions to 17 % below Canada's 2005 emission level by 2020. This was the same target the USA agreed to. While it looks like the USA will meet our exceed their reduction targets, the Minister of the Environment recently has informed me that it looks like we will exceed our target by 122 megatonnes (Mt) of CO_2.[1] Our 2020 projected emissions are 734 Mt CO_2 and our target is 612 Mt CO_2. However, the Firth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) that was release a few weeks ago shows that our emissions targets are far less than what is needed to avoid dangerous climate change (see http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_TechnicalSummary.pdf for the Technical Summary).

I need your advice on what level of reductions we should aim balancing the need to avoid 'dangerous' climate change and need to sustain our economic growth, which is quite dependent of the extraction, refinement, transport and ultimately the sale and consumption of fossil fuels. It is clear now that our lack of progress on the climate file is hurting us internationally. We are negotiating the final text of a free-trade agreement with Europe and the EU has very ambitious greenhouse gas (GHG) reduction goals. We are also running into significant option at home to the proposed Keystone pipeline, and at home to the Gateway pipeline. We have to be seen to be serious about getting our own GHG house in order. Dangerous climate change is thought of being the point where the global mean temperature increase over pre-industrial levels reaches 2°C and I am told this means a stable atmospheric concentration of CO_2 of 550 ppmv or less. The President of the USA reminded me that some of his government scientists believe the concentration of CO_2 to avoid dangerous climate change is much lower. Dr. James Hansen (NASA GISS) thinks a CO_2 concentration > 350 ppm will lead to dangerous climate change (http://pubs.giss.nasa.gov/docs/2007/2007_Hansen_2.pdf or for a more detailed technical version of this argument see http://arxiv.org/ftp/arxiv/papers/0804/0804.1126.pdf). I need not remind you the present-day concentration of CO_2 is very close 400 ppmv – 50 ppmv > Hansen's dangerous level and only 150 ppmv below the IPCC limit.

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[1] Note: the masses are in megatonnne (Mt) of CO2 equivalents. This is all greenhouse gases combined and convert using their global warming potentials into CO2 equivalents. The IPCC and most global carbon observations and models express the emission is unit of carbon, rather than CO2. The conversion between CO2 and C is done by multiplying the CO2 by the proportion of the molecule that is carbon. The molecular weight of CO2 is ~ 44 g (two oxygen atoms of 16 g and one carbon atom of 12 g) so the conversion is 12/44, or 0.27. This means that 1Mt CO2 equivalent = 0.27 Mt C.

Our current plans (http://www.climatechange.gc.ca/default.asp?lang=En&n=72F16A84-0) are clearly not enough. I need to get some insight to what the problem is and what reduction is enough? As one of my science advisors I need you to address three questions to inform me on what do suggest for Canada's future GHG emissions. I would like you answer my questions based on the global carbon model you developed run for the following six scenarios:

#	Name	Brief description
1	IS92A BAU	The IS92A scenario from the 1995 IPCC Scientific Assessment. This is called the "business as usual" scenario. This scenario is actually below emissions given the growth rate of the economies of China and India, but the 2008 recession provided some relief. http://www.globalcarbonproject.org/carbontrends/index.htm
2	Present Day Constant	This scenario assumes countries find a way the stabilize emissions at their current levels.
3	Kyoto	What if all the parties to the Kyoto Protocol met their prescribed targets? http://www.cbc.ca/news/background/kyoto/timeline.html
4	Canadian Government	Our 2020 17% reduction relative to 2005 with no further agreements so we return to a growth rate in emissions similar to that of the IS92A. http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=0590640B-1
5	Optimistic Climatologists	This scenario includes what some climate scientists tell us we need to do to stabilize climate change and what some optimists feel we can obtain through life-style changes and alternate energy technologies.
6	Zero Emission	This scenario assumes we eliminate all greenhouse gas emissions by 2010.

Our energy and economic study groups say that scenarios 2, 5 & 6 are unrealistic given current technology and we have already made it clear that we will not meet our revised targets that we committed to in Copenhagen. All of these will cost our economy too much!

I need you to summarize the results of the six scenario for me by completing the attached table, providing me with some quantitative estimates to place our policy on firm scientific basis, and by briefly answer the questions listed below (*Maximum 1-2 pages in total - 250 words per question*).

It is important to realize that the models simulate climate changes from 1990 onward. We accept the IPCC statement that past anthropogenic emissions have raised the global mean temperature by somewhere between 0.7 and 1.0^{o}C over the last 100 – 150 years. Be sure the factor in this existing increase in your answers.

1. **Where does the anthropogenic carbon ultimately end up for each scenario**? How much stays in the atmosphere and how much goes into the terrestrial biosphere and oceans relative to the amount emitted? Does the proportion of emitted carbon going into and remaining in the atmosphere, terrestrial biosphere and oceans differ substantially among the first five scenarios? In scenario 6 what happens to the carbon in the various reservoirs?

2. **Assuming the IS92A 'business as usual' scenario is a reasonable projection of the future if we do nothing what is the net benefit of Kyoto if everyone met the targets?**

3. **Can our plan (meaning the Canadian government's) prevent dangerous climate change?** By comparing the results of the Canadian government scenario with the low-emission scenarios (i.e. present day constant, zero emission, and optimistic climatologists), **what level of reductions do we need to avoid dangerous climate change?**

I need your response to my questions on my desk by 12:35, November 18, 2013.

Instructions for the Assignment

Workshops for this assignment will be held in BH 511 on the 5th floor of Burnside Hall. There will be five 2-hr workshops over a period of one week. **(Workshop times are posted on the home page on WebCT)**. Please register for one workshop on the home page of WebCT prior to attending a workshop.

You can work in pairs to produce a single reply, i.e. **2 STUDENTS CAN HAND IN ONE ASSIGNMENT FOR THE SAME GRADE**. Make sure both your names are on the assignment.

Instructions for using the model

1. Go to the BH 511 for the workshop you signed up for, or if you did not sign up for a workshop at any time the computers are free. Stella is also available on 40 of the computers in the open library part of the fifth floor of BH. In addition to BH there are also up to 20 copies of Stella that can be used at any of the McGill library branches at one time (https://home.mcgill.ca/library/library-using/computers/software/).

2. In BH 511 sign on to the computers using the using your Minerva username and password. Start the program STELLA 10.3 and go to the file menu. On the mgm shared drive go to the Courses folder and then the ENVR 200 folder and open the file Global_emissions_C_Model_ENVR200_2013.stmx. Once the model appears on the screen it is self-explanatory. Read the three text boxes on the introductory screen.

Or alternatively if one of the library computers that has Stella sign on as you normally would. Go to your *myCourses* and download the model Global_emissions_C_Model_ENVR200_2013.zip and extract it for use. Start the STELLA program – you may need to look for it under programs.

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Name(s) and Student Number(s):

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Results from the Model Simulations

Compartment/ Variable	**Initial 1990**	**IS92A 2100**	**ISp2A 2100 - 1990**	**Present Day Constant 2100**	**Present Day Constant 2100 - 1990**	**Kyoto 2100**	**Kyoto 2100 - 1990**
Fossil Fuels							
Atmosphere							
Terr. Veg.							
Soils							
Surf. Ocean							
Deep Ocean							
CO_2							
Temperature							

Compartment/ Variable (continued)	**Canadian government 2100**	**Canadian government 2100 - 1990**	**Optimistic Climatologist 2100**	**Optimistic Climatologist 2100 - 1990**	**Zero Emission 2100**	**Zero Emission 2100 -1990**
Fossil Fuels						
Atmosphere						
Terr. Veg.						
Soils						
Surf. Ocean						
Deep Ocean						
CO_2						
Temperature						

Attach this table to your 750 word (or less) answers to the three questions. Please type and double space your written material. You may print double sided.

<u>The assignment is due at the beginning of class on 18th November, 2013.</u>