ERS 201: Global Environmental Change

Summative assessment

Is there justification for reducing carbon emissions during the 21st century?

In this assessment, you will explore the relationship between atmospheric CO_2 and temperature (i.e., climate sensitivity) over the 21st century, and then evaluate other potential impacts of carbon emissions on the Earth system.

Goal #1: Estimate temperature in 2100 AD based on the RCP 8.5 emissions scenario

Your ***first goal*** is to use the short-term carbon cycle model we developed in Problem Set 4, and *estimate the atmospheric temperature in the year 2100*. To do so, we will assume that RCP 8.5 represents the most likely emission trajectory during this century. This may or may not prove to be a valid assumption, but at the moment it seems like a good hedge. To estimate temperature change during the 21st century, you will need to estimate what the best value for climate sensitivity is based on a literature review. Read the papers listed below as a start. They provide an overview of climate sensitivity concepts, and estimates of equilibrium climate sensitivity based on data covering a range of timescales (e.g., modern, last millennium, last glacial maximum, and the Pliocene). There are many other papers dealing with this topic, and we encourage you to dig deeper to develop a more informed opinion regarding which value to use in your model. To change the climate sensitivity parameter in the model, use the slider (the default setting is 3.5).

The outcome should be a single graph with time on the x-axis (in years, 0 to 100, corresponding to 2000 to 2100), and CO_2 concentration *and* temperature on the y-axis.

NOTE: The assumptions, potential errors, and decision-making process that go into your model parameters and results are critical. Please be sure to describe these in your written argument.

Climate sensitivity reading (available on BB):

Charney et al., 1979, Carbon dioxide and climate: A scientific assessment, Climate Research Board, National Research Council, 21 pp.

Hegerl, G.C., et al., 2006, Climate sensitivity constrained by temperature reconstructions over the past seven centuries, *Nature*, 440, 1029-1032.

Knutti, R., and Hegerl, G.C., 2008, The equilibrium sensitivity of the Earth's temperature to radiation changes, *Nature Geoscience*, 1, 735-743.

Lunt, D., et al., 2009, Earth system sensitivity inferred from Pliocene modeling and data, *Nature Geoscience*, 3, 60-64.

Pagani, M., et al., 2009, High Earth-system climate sensitivity determined from Pliocene carbon dioxide concentrations, *Nature Geoscience*, 3, 27-30.

Moss et al., 2010, The next generation of scenarios for climate change research and assessment, *Nature*, 463, 747-756.

Schmittner, A., et al., 2011, Climate sensitivity estimated from temperature reconstructions of the Last Glacial Maximum, *Science,* 334, 1385-1388.

PALAEOSENS Project Members, 2012, Making sense of palaeoclimate sensitivity, *Nature*, 491, 683-691.
IPCC Fifth Assessment Report, 2013. The Working Group 1 (WG1) Summary for Policymakers and Chapter 12 (Long-term Climate Change) are on FC. The full report can be found at: https://www.ipcc.ch/report/ar5/wg1/
Huber, M., 2013, A sensitivity to history, *Nature Geoscience*, 6, 15-16.
Martinez-Boti, M., et al., 2015, Plio-Pleistocene climate sensitivity evaluated using high-resolution CO_2 records, *Nature*, 518, 49-57.
Lea, D., 2015, Climate sensitivity in a warmer world, *Nature*, 518, 46-48.
Alley, R.B., 2016, A heated mirror for future climate, *Science*, 352, 151-152.
Tan, I., et al., 2016, Observational constraints on mixed-phase clouds imply higher climate sensitivity, *Science*, 352, 224-227.

Goal #2: Evaluate a potential impact of 21st century carbon emissions

Through our investigation of the carbon cycle, carbon emission scenarios, and climate sensitivity, you have now estimated temperature in the year 2100. This is obviously important, but is merely one potential impact of changing 21st century carbon emissions. For example, your STELLA models of the carbon cycle and carbon isotopes show that a portion of carbon emitted to the atmosphere from fossil fuel burning will end up in the terrestrial biosphere and the ocean. Your ***second goal*** is to explore an additional impact of 21st carbon emissions, and provide an argument addressing the question posed above – namely, are the potential consequences of the impact you are looking at enough to justify reducing carbon emissions from the RCP 8.5 scenario? If so, why?

Possible impacts (merely suggestions, there are many more):

Ocean acidification
Ecosystem change (e.g., rate of photosynthesis, enhanced plant growth, invasive species)
Sea level rise
Extreme weather events
Ocean warming
Agriculture and food security
Marine ecosystems/fisheries
Precipitation/Drought
Human health
Animal/plant migration
Wildfires
Insect vectors
Arctic sea ice
Northern Hemisphere snow cover

Suggested impacts reading (as a start):

IPCC Fifth Assessment Report (AR5; 2013-2014) – The Summary for Policymakers (SPM) from Working Group 1 (The Physical Science Basis), Working Group 2 (Impacts, Adaptation, and Vulnerability), and Working Group 3 (Mitigation of Climate Change) are on BB. The Full AR5 report, and all resources, are available at the IPCC website (www.ipcc.ch).

National Academy of Sciences/Royal Academy of Sciences report (2014), Climate Change:Evidence and Causes, http://nas-sites.org/americasclimatechoices/events/a-discussion-on-climate-change-evidence-and-causes/ and available on BB

Goal #3 Written argument

See all the information on Blackboard for guidance. Your final written argument in is ***due in BB by 5pm, May 5***.

Goal #4: Presentation

Each of you will make a short presentation to the class, summarizing the key features of their argument. You are limited to three (3) slides and five (5) minutes to make your case.