Natural Emissions Expectations

Bruce Parker

September 19, 2018

http://ccdatacenter.org/documents/ NaturalEmissionsExpectations.pdf

Many of the emissions from natural feedbacks are temperature-dependent. Given a likely temperature increase of at least 2° C by 2050 (see http://ccdatacenter.org/documents/TempIncreaseExpectations.pdf) it seems reasonable that cumulative emissions through 2100 from natural feedbacks will likely be in the range of 120-200 GTC (not including methane from methyl hydrates).

GHG Source	Carbon Store (GTC)	Notes	Likely Temp Change by 2100 (°C)	Likely Temp Change by 2200 (°C)
Feedbacks - GHGs				
Permafrost	1,600	Cumulative permafrost and wetland emissions (about 55 GTC) could cut 1.5C carbon budget 'by five years'[1,2] Cumulative permafrost emissions could be 120 GTC by 2100[3,4,5,6,7]	.5	1.5
Soils		Cumulative emissions from soil carbon could be as high as 55 GTC through 2050[8]		
Peat[9,10]	270 to 370	40% loss by 2100 (100 GTC) 80% loss by 2200 (220 GTC)	.2	.5
Surface waters		Cumulative methane emissions from reservoirs could be about 30 GTC through 2060 and 60 GTC through 2100[11] "[G]lobally, lakes and manmade "impoundments" like reservoirs emit about one-fifth the amount of greenhouse gases emitted by the burning of fossil fuels" "[S]cientists have found that this surge in aquatic plant growth could double the methane being emitted from lakes [(to 40% of current fossil fuel emissions)] ... over the next 50 years."[12]		
Forests		Forests will likely turn from sources to sinks[13,14]		
Methyl Hydrates[15.16]	5,000 to 20,000			
Amazon	86			

Footnotes

1 Permafrost and wetland emissions could cut 1.5C carbon budget 'by five years'

That means accounting for the impacts of permafrost and wetlands takes around five years off the 1.5C budget. And, as the table below shows, the budgets for the 1.5C overshoot and 2C scenarios are similarly reduced.

	Control		Feedbacks included	
	Tonne of CO2	Years of emissions	Tonne of CO2	Years of emissions
1.5C	720-929bn	20-25	533-753bn	14-20
1.5C overshoot	723-947bn	20-26	522-771bn	14-21
2C	1592-1974bn	43-54	1372-1776bn	37-48

Table shows remaining carbon budget (from 2018 to 2100) for three temperature pathways for the "control" (left) and "feedbacks included" (right) scenarios. Carbon budgets are shown as tonnes of CO2 and as total years of emissions (based on 2017 global emissions). Table adapted from Comyn-Platt et al. (2018)

Note: Including feedbacks for permafrost and wetlands decreases the budgets by about 200 GTCO2 [55GTC]

https://www.carbonbrief.org/permafrost-wetland-emissions-could-cut-1-5c-carbon-budget-five-years

2 **Study reveals what natural greenhouse emissions from wetlands and permafrosts mean for Paris Agreement targets**

July 9, 2018 by Simon Williams, Centre for Ecology & Hydrology

Global fossil fuel emissions would have to be reduced by as much as 20% more than previous estimates to achieve the Paris Agreement targets, because of natural greenhouse gas emissions from wetlands and permafrost, new research has found.

The additional reductions are equivalent to 5-6 years of carbon emissions from human activities at current rates, according to a new paper led by the UK's Centre for Ecology & Hydrology.

The 2015 Paris Climate Agreement aims to keep "the global average temperature increase to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels".

The research, published in the journal Nature Geoscience today (July 9, 2018) uses a novel form of climate model where a specified temperature target is used to calculate the compatible fossil fuel emissions.

The model simulations estimate the natural wetland and permafrost response to climate change, including their greenhouse gas emissions, and the implications for human fossil-fuel emissions.

Co-author Dr. Sarah Chadburn, of the University of Leeds, said: "We found that permafrost and methane emissions get more and more important as we consider lower global warming targets.

"These feedbacks could make it much harder to achieve the target, and our results reinforce the urgency in reducing fossil fuel burning."

Co-author Prof Chris Huntingford, of the Centre for Ecology & Hydrology, said: "We were surprised at how large these permafrost and wetland feedbacks can be for the low warming target of just 1.5°C."

https://phys.org/news/2018-07-reveals-natural-greenhouse-emissions-wetlands.html

3	"It [(permafrost thawing)] was first proposed in 2005. And the first estimates came out in 2011." Indeed, the problem is so new that it has not yet made its way into major climate projections, Schaefer says." …"None of the climate projections in the last IPCC report account for permafrost," says Schaefer. "So all of them underestimate, or are biased low." … "It's certainly not much of a stretch of the imagination to think that over the coming decades, we could lose a couple of gigatons per year from thawing permafrost," says Holmes…. But by 2100, the "mean" estimate for total emissions from permafrost right now is 120 gigatons, say Schaefer. http://www.washingtonpost.com/news/energy-environment/wp/2015/04/01/the-arctic-climate-threat-that-nobodys-even-talking-about-yet
4	**CO_2 loss by permafrost thawing implies additional emissions reductions to limit warming to 1.5 or 2 °C** Eleanor J Burke1,4, Sarah E Chadburn2, Chris Huntingford3 and Chris D Jones1 Published 9 February 2018 • © 2018 The Author(s). Published by IOP Publishing Ltd Environmental Research Letters, Volume 13, Number 2 Abstract Large amounts of carbon are stored in the permafrost of the northern high latitude land. As permafrost degrades under a warming climate, some of this carbon will decompose and be released to the atmosphere. This positive climate-carbon feedback will reduce the natural carbon sinks and thus lower anthropogenic CO_2 emissions compatible with the goals of the Paris Agreement. Simulations using an ensemble of the JULES-IMOGEN intermediate complexity climate model (including climate response and process uncertainty) and a stabilization target of 2 °C, show that including the permafrost carbon pool in the model increases the land carbon emissions at stabilization by between 0.09 and 0.19 Gt C year^{-1} (10th to 90th percentile). These emissions are only slightly reduced to between 0.08 and 0.16 Gt C year^{-1} (10th to 90th percentile) when considering 1.5 °C stabilization targets. This suggests that uncertainties caused by the differences in stabilization target are small compared with those associated with model parameterisation uncertainty. Inertia means that permafrost carbon loss may continue for many years after anthropogenic emissions have stabilized. Simulations suggest that between 225 and 345 Gt C (10th to 90th percentile) are in thawed permafrost and may eventually be released to the atmosphere for stabilization target of 2 °C. This value is 60–100 Gt C less for a 1.5 °C target. The inclusion of permafrost carbon will add to the demands on negative emission technologies which are already present in most low emissions scenarios. http://iopscience.iop.org/article/10.1088/1748-9326/aaa138/meta [For 2 °C ,] including the permafrost carbon pool in the model increases the land carbon emissions at stabilization by between 0.09 and 0.19 Gt C year^{-1} ... [B]etween 225 and 345 Gt C ... are in thawed permafrost and may eventually be released to the atmosphere for stabilization target of 2 °C. This value is 60–100 Gt C less for a 1.5 °C target. The inclusion of permafrost carbon will add to the demands on negative emission technologies which are already present in most low emissions scenarios.
5	**Ancient low–molecular-weight organic acids in permafrost fuel rapid carbon dioxide production upon thaw** A new study for the first time quantify the process by which dissolved organic carbon released from thawing permafrost and released into streams and rivers is rapidly broken down by microbes into carbon dioxide and released to the air. The scientists estimate by 2100, between 5 to 10 Tg of organic carbon will be released from northern permafrost soils every year. Proceedings of the National Academy of Sciences September 28, 2015 http://www.pnas.org/content/early/2015/10/21/1511705112.short
6	**Significant contribution to climate warming from the permafrost carbon feedback** According to our simulations, permafrost soils will release between 68 and 508 Pg carbon by 2100. We show that the additional surface warming generated by the feedback between permafrost carbon and climate is independent of the pathway of anthropogenic emissions followed in the twenty-first century. We estimate that this feedback could result in an additional warming of 0.13–1.69 °C by 2300. We further show that the upper bound for the strength of the feedback is reached under the less intensive emissions pathways. We suggest that permafrost carbon release could lead to significant warming, even under less intensive emissions trajectories. https://www.nature.com/articles/ngeo1573?WT.ec_id=NGEO-201210

7	Researchers at the National Snow and Ice Data Center estimate that by 2200, 60% of the Northern Hemisphere's permafrost will probably be melted, which could release around 190 billion tons of carbon into the atmosphere. This amount is about half of all the carbon released in the industrial age. The affect this will have on the rate of atmospheric warming could be irreversible. At the very least, these estimates mean fossil fuel emissions will have to be reduced more than currently suggested to account for the amount of carbon expected to discharge from melting permafrost. https://www.wunderground.com/resources/climate/melting_permafrost.asp
8	We found that about 55 trillion kg of carbon could be lost [from soils] by 2050. This value is equivalent to an extra 17% on top of current expected emissions over that time. These losses are like having another huge carbon emitting country on the planet, accelerating the rate of climate change. https://medium.com/@Alex_Verbeek/another-reason-to-be-worried-about-climate-change-1bf1e21e78e#.bzhqdsrsz *(Note: the estimate might include some emissions from permafrost and peat)*
9	A 2008 Nature Geoscience study — "High sensitivity of peat decomposition to climate change through water-table feedback" — projected that "a warming of 4°C causes a 40% loss of soil organic carbon from the shallow peat and 86% from the deep peat" of Northern peatlands. On our current emissions path, the world is set to warm well beyond 4°C (7°F). According to the 2008 study, "We conclude that peatlands will quickly respond to the expected warming in this century by losing labile soil organic carbon during dry periods." http://thinkprogress.org/climate/2015/01/13/3610618/peat-wetlands-global-warming/
10	globalcarbonproject.org/global/pdf/pep/Limpens.2008.Peatlands& Carbon.BiogeosciencesDiscus.pdf
11	Methane emissions from reservoirs contribute about .7GTC of CO2 equivalent per year, resulting in about 30 GTC through 2060 and 60 GTC through 2100. http://www.climatecentral.org/news/greenhouse-gases-reservoirs-fuel-climate-change-20745
12	"[G]lobally, lakes and manmade "impoundments" like reservoirs emit about one-fifth the amount of greenhouse gases emitted by the burning of fossil fuels" "[S]cientists have found that this surge in aquatic plant growth could double the methane being emitted from lakes [(to 40% of current fossil fuel emissions)] ... over the next 50 years." https://climatecrocks.com/2018/05/17/in-lakes-cat-tails-and-algal-blooms-could-be-a-toxic-methane-feedback/
13	Global warming is shifting many forests from carbon sinks to carbon sources, thus increasing natural emissions and reducing the CO2 uptake in the biosphere From **What Lies Beneath** (download PDF from https://www.breakthroughonline.org.au/) (Page 25)
14	The US Forest Service now expects the US forests to shift from their current status of net sequesters of CO2 to become a significant emissions source in all future scenarios
15	Other potential positive carbon cycle feedbacks that are even more uncertain, but could be quite sizeable in magnitude, are methane feedbacks, related to the possible release of frozen methane currently trapped in thawing Arctic permafrost, and so-called "clathrate"—a crystalline form of methane that is found in abundance along the continental shelves of the oceans, which could be destablized by modest ocean warming. Since methane is a very potent greenhouse gas, such releases of potentially large amounts of methane into the atmosphere could further amplify greenhouse warming and associated climate changes. The key potential implication of a net positive carbon cycle feedback is that current projections of future warming ... may actually underestimate the degree of warming expected from a particular carbon emissions pathway. This is because the assumed relationship between *carbon emissions and* CO2 *concentrations* would underestimate the actual resulting CO2concentrations because they assume a fixed airborne fraction of emitted CO2, when, in fact,

	that fraction would instead be increasing over time. While the magnitude of this effect is uncertain, the best estimates suggest an additional 20-30 ppm of CO_2 per degree C warming, leading to an additional warming of anywhere from 0.1°C to 1.5°C relative to the nominal temperature projections shown in earlier lessons. https://www.e-education.psu.edu/meteo469/node/160
16	http://www.killerinourmidst.com/methane and MHs2.html
	Also, see http://ccdatacenter.org/documents/GlobalWarmingFeedbacks.pdf