

Does the IPCC Underestimate the Amount of Warming We Should Expect?

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(<http://ccdatacenter.org/documents/DoestheIPCCUnderestimatetheAmountofWarmingWeShouldExpect.pdf>)

The Earth's atmosphere is warming for many reasons, and sophisticated climate models probably do a reasonable job of estimating the future warming based on the estimated radiative forcing associated with the many current climate factors and feedbacks. However, it is known that today's climate models are likely to both underestimate the impact of some factors (e.g., Arctic sea ice melt¹, etc.) and to exclude other factors (e.g., the thawing of permafrost², etc.). Since most planning on reducing the amount of future warming is based on IPCC's 1000 GTC (gigatons of carbon) budget, it is imperative that the various feedbacks be analyzed so that the carbon budget can be adjusted appropriately.

Unfortunately, all we have been told about the carbon budget is that 20% is allocated for non-CO2 factors, and that after accounting for historical emissions *only about 220 GTC* remain in the budget³. Since we have not been provided with any details as to what forcings were included and what their size was, the only way to estimate the effect of the known feedbacks is to make assumptions about what was included. The following table⁴ provides an estimate of a possible set of adjustments that might need be made to temperature increase estimates that are based mostly on anthropogenic activities:

	Adjustments for 2060			Adjustments for 2100		
	Change from 2015	Equivalent Emissions (GTC)	Temperature Increase (°C)	Change from 2015	Equivalent Emissions (GTC)	Temperature Increase (°C)
Arctic Sea Ice melt	0.16 W/m-2	40	0.07	0.25 W/m-2	80	0.13
NH Snow line retreat	0.14 W/m-2	35	0.06	0.22 W/m-2	70	0.11
Peat/soils	45 GTC	45	0.08	85 GTC	85	0.14
Reservoirs	30 GTC	30	0.05	60 GTC	60	0.10
Permafrost	30 GTC	30	0.05	120 GTC	120	0.19
Total		180	0.31		415	0.67

Notes:

- These estimates assume that there is no sequestration from afforestation, soil management, BECCS, or DAC
- Surface albedo changes (due primarily to Arctic sea ice melt and Northern Hemisphere (NH) snow line retreat) likely account for about 5-10% of the radiative forcing included in a climate sensitivity of 3°C for a doubling CO2⁴. The change in radiative forcing in the table above is for the additional amount expected by the year indicated.

There will probably be significant greenhouse gas emissions from thawing of permafrost this century since the temperature increase by mid-century will likely be over 2.0°C⁵ and a global temperature rise of 1.5°C is enough to start permafrost thaw in Siberia⁶. In addition, the arctic is clearly warming much faster than the Earth as a whole. Based on the above, not only has the IPCC significantly underestimated future warming but also *it appears that the entire 220 GTC budget will be used up by non-anthropogenic sources.*

If carbon sequestration costs are between \$150-\$350/ton C⁷ and the feedbacks in the table above are taken into account, the cost to sequester CO2 (if even possible at scale) to meet the IPCC's budget is in the \$100 Trillion range. And to reduce the temperature below 2°C will cost around \$10-20 Trillion for each 0.1°C of reduction (90 GTC of CO2 needs to be removed to reduce the temperature 0.16°C⁴).

1	http://ccdatacenter.org/documents/ClimateSensitivityandArcticSealceMelt.pdf
2	http://ccdatacenter.org/documents/FeedbackFromPermafrost.pdf
3	https://docs.google.com/spreadsheets/d/1odltJu_rxabdVXv_pACMBNIRiFskc_HqJn-V8z0av2w/edit#gid=731498129
4	http://ccdatacenter.org/documents/HowImportantareNaturalCausesintheTemperatureIncreasesExpected.pdf http://ccdatacenter.org/documents/EstimateofRadiativeForcingfromAlbedoChangeintheIPCCModels.pdf
5	1.1°C now + 0.5°C from aerosols + several decades at .18°C + .25°C from adjustments (See Page 8 of #4 above)
6	https://www.theguardian.com/environment/2013/feb/21/temperature-rise-permafrost-melt
7	http://www.earth-syst-dynam-discuss.net/esd-2016-42/ (Hansen - Page 20)