Effective Radiative Forcing Changes

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

Background

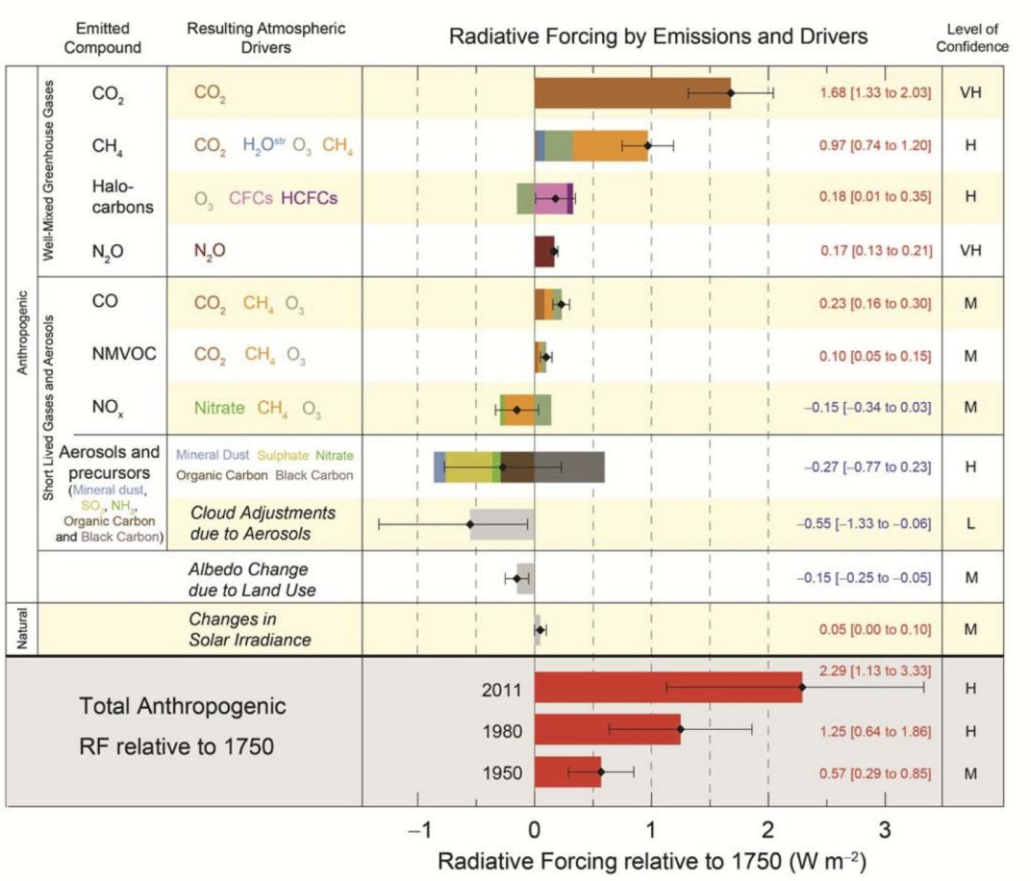
The recently signed COP21 Paris Agreement calls for all nations to curb their CO2 emissions with the goal of avoiding the most dangerous effects of climate change. The agreement's main aim is to keep a global temperature rise by 2100 well below 2° C and to drive efforts to limit the temperature increase to 1.5 ° C above pre-industrial levels. The agreement also assumes that the temperature will stabilize after the target is met. Unfortunately the models used by the IPCC do not appear to have taken into account the additional warming from natural causes (feedbacks) stemming from a warming planet. These include (1) the decreased albedo from the melting of summer-time ice in the Arctic Ocean, (2) the decreased albedo from the reduced snow cover in the Northern Hemisphere, and (3) the increased emissions of CO2 and methane from peat bogs, thawing permafrost, and forests[1]. ***The warming from the feedbacks will likely be significant and should be taken into account when estimating future temperature increases.***

Table 1 provides estimated values for the effective radiative forcings (ERF) of the major components of the climate system for 2100, using an aggressive emissions reduction effort resulting in net-zero greenhouse gas emissions by 2060 to determine the expected effect of future anthropogenic emissions.

#	ERF (W/m-2) 2060	ERF (W/m-2) 2100	Radiative Forcing Components
	Anthropogenic changes from 1870 - 2011		
1	2.29	2.29	ERF in 2011 (IPCC)[2]
	Anthropogenic changes from 2012 to 2100		
2	0.41	0.65	Due to the reduction of aerosols and precursors (IPCC AR5: total of -0.82 in 2011, mostly due to the burning of fossil fuels; for 2060, 50% of the value is used; for 2100, 80% of the value is used)[2]
3	0.80	0.80	Due to 1240 GTCO2 of CO2 emissions from an aggressive emission reduction scenario (emissions peak in 2025 and go to zero in 2055, resulting in increasing atmospheric CO2 by about 72 PPM)
4	-0.19	-0.37	Due to the reduction of atmospheric concentrations of CH4, N2O, and halocarbons (IPCC RCP 2.6: -0.37 in 2100; for 2060, ½ the estimated value is used)[3]
5	??	??	Other – land use changes, atmospheric changes, sequestration, etc.
	Additions from natural feedbacks[4] (represents the equivalent of about 1,700 GTCO2 in 2100)		
6	0.14	0.25	Arctic Ocean - linear change in Arctic Ocean sea ice extent
7	0.12	0.18	Retreating snowline - linear change in Northern Hemisphere snow cover extent
8	0.06	0.32	Permafrost thawing (for 2060, 20% of the 120 GTC expected by 2100 (88 GTCO2, or 5 PPM CO2); for 2100, 440 GTCO2 or 25.5 PPM CO2)
9	0.14	0.27	Peatlands and Peat Bogs (4 GTCO2 per year: for 2060, for 50 years – 200 GTCO2, or 11 PPM; for 2100, 90 years – 360 GTCO2 or 21 PPM)
10	??	??	Other – methane hydrates, forests, soils, etc.
	Total Changes in ERF		
	3.81	**4.43**	Total Change in ERF from preindustrial times

Table 1. Radiative forcing of the major components of the climate system for 2060 and 2100

Footnotes *(links to articles cites are provided at the end of each footnote)*

1	**Models do not account sufficiently for climate feedbacks** From an April 2015 article in the Washington Post: "It 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, [Dr. Kevin] 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 [Dr. Robert Max] Holmes. But by 2100, the "mean" estimate for total emissions from permafrost right now is 120 gigatons [440 GTCO2], says Schaefer. http://www.washingtonpost.com/news/energy-environment/wp/2015/04/01/the-arctic-climate-threat-that-nobodys-even-talking-about-yet Also, see http://www.thomhartmann.com/bigpicture/last-hours-humanity-warming-world-extinction-1 See http://www.thomhartmann.com/bigpicture/last-hours-humanity-warming-world-extinction-1
2A	 IPCC AR5 – Radiative Forcing Components http://www.realclimate.org/index.php/archives/2013/10/the-evolution-of-radiative-forcing-bar-charts/
2B	Aerosol reduction from burning coal would add about 0.5°C to the net warming – Huffington Post

While greenhouse warming [from CO2] would abate, the cessation of coal burning (if we were truly to go cold-turkey on all fossil fuel burning) would mean a disappearance of the reflective sulphate pollutants ("aerosols") produced from the dirty burning of coal. These pollutants have a regional cooling effect that has offset a substantial fraction of greenhouse warming, particularly in the Northern Hemisphere. That cooling would soon disappear, adding about 0.5°C to the net warming.

http://www.huffingtonpost.com/michael-e-mann/how-close-are-we-to-dangerous-planetary-warming_b_8841534.html

Note: The above was reported on several blogs without identifying the original source. However, the IPCC reported that the total radiative forcings due to aerosols and precursors was about -0.82 W/m-2 (see Figure above), so if two thirds of that is due coal, then the aerosols from coal reduce the radiative forcing by about 0.55 W/m-2; so the aerosols from coal could easily be masking 0.5°C. And since the burning of other fossil fuels and biomass also contribute to the aerosols, an 80% reduction in the aerosol "masking" is probably reasonable.

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	ERF Change Since 1750		
	2011	RCP2.6	Difference
CO2	1.816	2.220	0.404
CH4	0.425	0.270	-0.155
N20	0.195	0.230	0.035
Halocarbons	0.395	0.142	-0.253
CH4, N20, Halocarbons	1.015	0.642	-0.373
Greenhouse Gases	**2.831**	**2.862**	0.031

IPCCPhysicalBasisAR5.pdf

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Feedbacks

The significance of the magnitudes of the positive feedbacks from global warming is not widely appreciated. This is most likely because (1) modeling the expected magnitudes through the end of the century is very difficult; (2) most analyses of the feedbacks look only at what has happened so far; and (3) the feedbacks are usually looked at individually.

The results of a simple analysis are shown in the table below. The analysis for the albedo changes are based on data from the National Snow and Ice Data Center (Arctic sea Ice extent) and from the "Snow Lab" at Rutgers University (Northern Hemisphere snow cover extent). The estimate for the permafrost is based on the "mean" estimate for total emissions from permafrost (120 GTC) reported by Kevin Schaefer of the National Snow and Ice Data Center. The estimate for peatlands and peat bogs assumes that the emissions will remain at the current rate (4 GTCO2/year) through 2100.

Feedback	Likely Change 2011- 2100			
Albedo Changes	Rad. Forcing (W/m-2)	Atmos. CO2e Change (PPM)	Total Equiv. Emissions	Temp Increase
Arctic Ocean	.34	26.1	452	0.20
Retreating snowline	.31	24	409	0.18
GHG Emissions				
Permafrost	.33	25.5	440	0.19
Peatlands and Peat Bogs	.30	23.0	400	0.17
Total	1.28	98.6	1701	0.81[#]
# Temperature increases are not "additive", so the total temperature increase is based on the total radiative forcing				

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