Short-lived climate forcers (SLCFs)

The fatal disregard of short-lived gases

new strategies with their consideration

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18 November 2021

1. Introduction

"Short-lived climate forcers" (SLCFs) are anthropogenically emitted, short-lived gases with atmospheric lifetimes ranging from hours to a few years. Methane (CH4), sulfur dioxide (SO2), nitrogen oxides (NOX), and carbon monoxide (CO) are significant.

- **Methane** is a very potent greenhouse gas that degrades in the atmosphere within 12 years.
- **Carbon monoxide** is a moderately potent greenhouse gas with a lifetime of 3 months.
- **Sulfur dioxide** leads to the formation of sulfate aerosols in the atmosphere, which inhibit solar radiation and have a lifetime of a few hours.
- **Nitrogen** oxides trigger chemical reactions in the atmosphere that break down methane in particular and thus mitigate climate heating. They have a lifetime of only a few hours.

In the latest IPCC Report 6, short-lived gases are considered comprehensively for the first time in a separate main chapter [1].

2.1 The effects of greenhouse gases and aerosols

The current effects of greenhouse gases and aerosols emitted between 1750 and 2019 are presented (a.) by their radiative forcing and (b.) by the resulting temperature increases at the Earth's surface [2].

Methane degrades within 12 years via chemical processes that produce other greenhouse gases, such as ozone and CO2, and contribute to the radiative forcing of methane. Therefore, the total radiative forcing and temperature effect of methane relative to CO2 is about 58%. Aerosols (purple) have mainly a cooling effect. The strongest aerosol is produced by sulfur dioxide (SO2), which reduces the total effect of all anthropogenic greenhouse gases by about 25% and thus currently mitigates climate heating by approximately 0.5 C°.

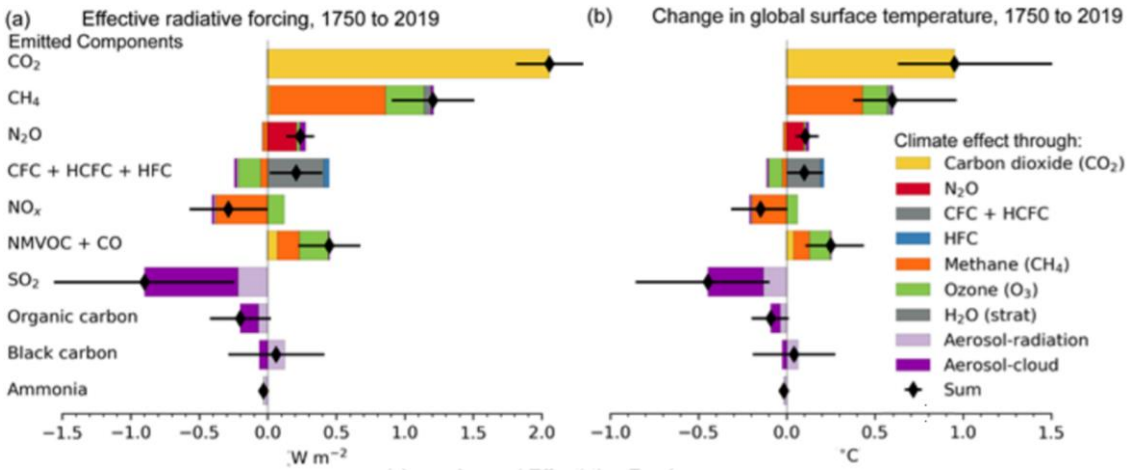

Figure 1: Current effects of greenhouse gases and aerosols emitted between 1750 and 2019, (a.) based on their radiative forcing and (b.) based on the resulting temperature increases at the surface of the Earth

2.2 The problem of ignoring short-lived gases

Due to the fact that short-lived gases heat and cool very strongly and for a very short time, they are of outstanding importance in maintaining threshold values, such as the potential tipping points at 1.5 or 2.0 degrees. Failure to take into account the effects of these gases leads to the threshold values being exceeded quickly and for many years and can thus trigger uncontrollable feedback loops.

The current strategy with the almost exclusive focus on a phase-out of fossil industries will reduce CO2 emissions and thus the increase of solar radiation in the long run, but first the temperature will increase due to the elimination of large parts of the cooling aerosols. The reason is that most and the strongest cooling aerosols are produced by the combustion of fossil fuels.

In 2020, the global mean temperature increase was 1.2 °C compared to 1850, which is considered the pre-industrial reference value [3].

Excluding other emissions, an immediate phase-out of fossil fuel combustion would initially increase this temperature by about 0.44 °C to 1.64 °C. The cooling effect due to the decomposition of methane caused by the fossil industries would take 12 years to fully materialize and would reduce the temperature by 0.17 °C to 1.47 °C [4],[5].

SLCF	**Presence in atmosphere**		**Share of fossil industries**	**Temp °C**
SO_2	4	Days	83%	-0,42
NO_X	0,2	Days	90%	-0,14
CO	60	Days	87%	0,12
Cooling by short-lived aerosols				**-0,44**
CH_4	12	Years	33%	0,17
Cooling after breakdown of methane				**-0,27**

Figure 2: Temperature increase in the event of a phase-out of fossil fuel combustion

2.3 Reasonable exit strategies from the most harmful industries

In general, when phasing out climate-damaging industries, it makes sense to prioritize those that emit **few** cooling aerosols but **plenty** of short-lived greenhouse gases such as methane.

An assessment of the most harmful industries in this respect is depicted.

			Emissions by			
SLCF		**Impact**	**Natural gas**	**Oil**	**Coal**	**Animal AG**
cooling	SO_2	↑	→	→	↑	↓
	NO_X	↗	→	↓	↗	↓
	NH_3	↘	↓	↓	↓	↗
heating	CO	→	→	↗	↘	↓
	CH_4	↑	↗	↗	↗	↑

Figure 3: Assessment of industries with regard to emissions of short-lived greenhouse gases

The evaluation was performed using a scoring matrix. The scoring is based on the radiative forcing of short-lived greenhouse gases and aerosols [2] and the respective shares of the industries in their emissions [5],[6],[7],[8].

			Emissions by							
SLCF		**Effect**	**Gas**	**Score**	**Oil**	**Score**	**Coal**	**Score**	**Animal AG**	**Score**
Cooling aerosols	SO_2	5	3	15	3	15	5	25	1	5
	NO_X	4	3	12	5	20	4	16	1	4
	NH_3	2	1	2	1	2	1	2	4	8
Sum scoring				29		37		43		17
Evaluation of cooling				3		2		1		5
	CO	3	3	9	4	12	2	6	1	3
Warming GHG	CH_4	5	4	20	4	20	4	20	5	25
Evaluation of warming				4		5		4		4
Evaluation TOTAL				**3,5**		**3,5**		**2,5**		**4,5**

Figure 4: Scoring matrix to determine prioritization of industries to be terminated with respect to near-term climate heating (value 5 means very high impact/very high emissions/very high prioritization, value 4 high, value 3 medium, value 2 low, and value 1 very low)

A reasonable strategy would be an immediate phase-out of animal agriculture due to the high share of all methane emissions of 33% [8] and hardly cooling aerosols [5],[6]. This would reduce the temperature by about 0.2 C° within 12 years and thus at least partially compensate for the temperature increase due to the elimination of aerosols as a result of the phase-out of fossil industries.

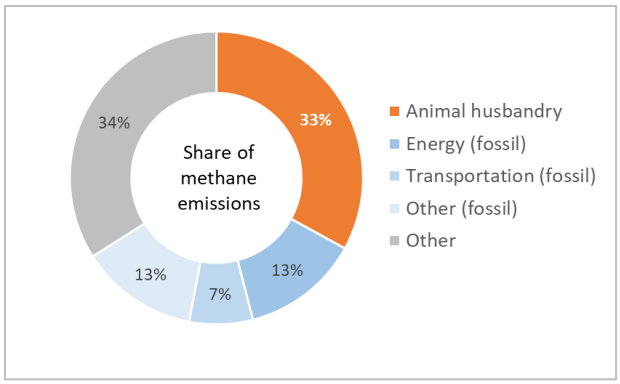

Figure 5: Shares of various industries in global methane emissions

When phasing out fossil industries, natural gas should be the top priority, followed by oil-consuming industries such as transportation, and finally coal combustion, which has the highest emission of cooling aerosols.

3. References

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