Environmental and Energy Study Institute

Fact Sheet

Short-Lived Climate Pollutants: Why Are They Important?

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Carbon dioxide (CO_2), the primary driver of climate change, is responsible for slightly more than half of the total current warming impact from human-caused emissions. CO_2 emissions remain in the atmosphere for hundreds of years, creating a legacy warming effect that would maintain current warming levels even if new CO_2 emissions dropped to zero. Therefore, while strategies to reduce CO_2 are vital, mitigation efforts focused solely on CO_2 will not be enough to reverse or even substantially slow climate change in the next few decades. Because of the critical need to slow the rate of climate change, momentum is building for fast-action climate mitigation strategies that provide more sizeable short-term benefits than CO_2 reductions. These strategies include efforts to reduce short-lived climate pollutants (SLCPs), the set of gases and particulates that are primarily responsible for the half of global warming not caused by CO_2 and that have atmospheric lifetimes of less than 20 years.[1]

These pollutants, including black carbon, methane, tropospheric ozone, and hydrofluorocarbons (HFCs), have relatively short atmospheric lifetimes but significant warming impacts on the climate, particularly in the Arctic and other vulnerable regions. Unlike long-lasting CO_2, reductions in SLCPs would lead to short-term drops in atmospheric concentrations and quickly reduce warming impacts. Paired with global efforts to reduce CO_2 emissions to mitigate long-term warming, action on SLCPs offers important opportunities to slow climate change over the next several decades, while also providing important co-benefits to public health and food security.

COMPARING WARMING IMPACTS

While tools have been developed to compare the warming effects of different climate pollutants, the large impact of SLCPs over short periods often goes misunderstood by those who use the tools.

Global Warming Potential

Greenhouse gases (GHGs) are often compared to one another using their warming potency. For example, methane is a more powerful warming agent than CO_2. In most GHG accounting, one ton of methane is equal to 25 tons of CO_2. This, however, assumes a 100-year period. Because methane only lasts in the atmosphere for 12 years, the impact ratio changes as a variable of time: over a period of 20 years, for example, one ton of methane has the warming effect of 72 tons of CO_2.[2] The warming impact of a climate pollutant over a designated timeframe, as a ratio of an equal mass of CO_2, is known as Global Warming Potential (GWP). GWPs of 20 years or less are better indicators of the short-term climate impact of emissions.

Radiative Forcing

While a ton-for-ton comparison of emissions is useful, it is more helpful to understand the overall influence each type of emission has on climate change. The best method to compare the total effect of very different climate pollutants is radiative forcing. This measures the change in Earth's energy budget (i.e., the warming effect) caused by the total atmospheric concentration of a GHG or particulate. The radiative forcing of CO_2 (over pre-industrial conditions) is 1.66 watts per square meter (W/m^2)*. Methane's radiative forcing is 0.48 W/m^2. In other words, the current atmospheric concentration of methane causes a warming effect equal to 29 percent of the effect caused by the current concentration of CO_2.[3]

*Radiative forcing measures the change in energy, in watts, at the top of the atmosphere averaged over each square meter of the planet. Emissions that have a cooling effect, such as sulfates, have a negative radiative forcing.

BLACK CARBON

Black carbon, or soot, is a form of particulate matter (PM) and, therefore, behaves much differently than GHGs. It does not become well-mixed in the atmosphere; particles remain suspended in the air until they settle back on the surface, become washed out by rain, or contribute to cloud formation. The average atmospheric lifetime of a single soot particle is only two or three weeks. As a dark mass, black carbon particles absorb abundant amounts of energy, trapping heat and warming the climate. Like methane, black carbon warms the climate more intensely than CO_2 over a short time frame, but to greater extremes. Despite lasting in the atmosphere for less than one month, one ton of black carbon has a warming effect equal to 1,000-2,000 tons of CO_2 over a 100-year period. Over a 20-year span, one ton of black carbon likely has an impact greater than 4,000 tons of CO_2.

Black carbon's radiative forcing is an area of active research. The Intergovernmental Panel on Climate Change (IPCC) lists its value at 0.44 W/m^2, but this is based on older models. A widely-cited 2008 study approximates black carbon's radiative forcing at 0.9 W/m^2 – a warming effect equal to 54 percent of CO_2.[4] A 2013 study estimated this value to be 1.1 W/m^2.[5] While black carbon radiative forcing estimates all have large ranges of uncertainty, there is growing evidence that black carbon has the second largest warming impact of all climate pollutants. Black carbon is co-emitted with other forms of PM, some of which have significant cooling impacts that offset a portion of black carbon's full warming impact. The emissions ratio of black carbon to cooling particulates varies by source, giving some mitigation strategies (i.e. cleaner diesel engines) a greater potential climate impact. All PM reduction strategies, however, provide important public health benefits.

Black carbon does not warm only the atmosphere. Some emissions settle on snow, glaciers, and sea ice, darkening their surfaces. This significantly reduces the reflectivity, or albedo, of the surface, causing it to absorb more solar energy and accelerating ice melt. The globally-averaged effect of this process is estimated at 0.1 W/m^2, but in reality, this impact is concentrated at much higher rates in a few very climate-sensitive regions, including the Arctic and the Himalayas. Additionally, black carbon is a primary contributor to both indoor and outdoor air pollution, which together cause more than three million deaths annually.[6]

Black carbon emissions are the result of incomplete combustion of biomass or fossil fuels. Closed combustion makes up 59 percent of emissions; open burning is responsible for the rest. Major sources of black carbon include inefficient biomass cooking stoves, diesel and two-stroke engines, and open-air-vented coal furnaces. Black carbon emissions from closed combustion came primarily from the United States and Europe for most of the 20th century. These emissions have declined for the past several decades as a byproduct of broader policies to reduce PM, put in place to improve local air quality and public health. Emissions, however, are on the rise in other parts of the world.[7] Black carbon reduction technologies are available for most sectors, many of which are cost-effective.

METHANE

Methane (CH_4) has an atmospheric lifetime of 12 years, but it has significant warming potential during that time. The GWP of one ton of methane is equivalent to 21 tons of CO_2 over 100 years and equivalent to 75 tons of CO_2 over 20 years. Methane has a direct radiative forcing of 0.48 W/m^2. Besides having a high warming impact of its own, methane also serves as a major contributor to the production of tropospheric ozone, another SLCP.[8]

Methane is one of the six gases covered by the Kyoto Protocol, though that framework uses only 100-year GWPs and places no emphasis on short-term climate benefits. Separately, the Global Methane Initiative (GMI) was founded in 2004 to create a partnership of nations, private businesses, banks, and other organizational stakeholders to build capacity and promote strategies to reduce and recover methane emissions, as well as to develop pathways to energy markets.

The largest contributor to methane emissions is the production of oil and gas. Methane has the potential to leak during a number of phases in the production process, including during drilling and at transfer points along pipelines. Other major contributors include coal extraction, wastewater, landfills, and agriculture (e.g., food and agriculture waste). The good news is that captured fugitive methane emissions from these sources can then be harnessed to provide affordable heat and power.[9]

TROPOSPHERIC OZONE

Unlike the other GHGs, tropospheric ozone (a primary component of smog) is not directly emitted, but is instead the product of the atmospheric reaction of a number of precursor pollutants, including methane, nitrogen oxides (NOx), volatile organic compounds (VOCs), and carbon monoxide (CO). Strategies to mitigate the formation of tropospheric ozone are primarily based on methane reduction. Tropospheric ozone has a radiative forcing of 0.35 W/m^2, but lasts only a few hours to a few days in the atmosphere.[10]

Tropospheric ozone affects the climate beyond increased warming, including impacts on evaporation rates, cloud formation, precipitation levels, and wind patterns. It also impairs the ability of plants to absorb carbon, thereby suppressing crop yields and harming ecosystems. These impacts mainly occur within the regions where tropospheric ozone precursors are emitted, and so disproportionally affect the Northern Hemisphere.[11]

HFCs

Hydrofluorocarbons (HFCs) are a group of chemicals manufactured for use in refrigeration, insulation foam, and aerosols. They were created to replace ozone-depleting chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which were phased out as part of the Montreal Protocol. There are many varieties of HFCs, each with a different atmospheric lifetime and warming impact. For example, HFC-134a has a GWP-100 of 1,300 and an atmospheric lifetime of 14 years. Not all varieties are considered SLCPs; HFC-23 lasts 270 years and has a GWP-100 of 14,800.[12] The average HFC lifespan, weighted by their respective emissions, is 15 years. The combined radiative forcing of all HFCs is currently at 0.012 W/m^2. Although small, this figure is expected to spike significantly, as HFCs are the fastest growing set of GHG emissions, on pace to double within a decade. HFC emissions can be reduced through the use of lower-GWP substitutes, coolant leakage repairs, and refrigerant reclamation programs.[13]

For further information see:

Integrated Assessment of Black Carbon and Tropospheric Ozone. United Nations Environment Programme, 2011.

Primer on Short-Lived Climate Pollutants. Institute for Governance & Sustainable Development, 2013.

Report to Congress on Black Carbon. U.S. Environmental Protection Agency, 2012.

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The Environmental and Energy Study Institute (EESI) is a non-profit organization founded in 1984 by a bipartisan Congressional caucus dedicated to finding innovative environmental and energy solutions. EESI works to protect the climate and ensure a healthy, secure, and sustainable future for America through policymaker education, coalition building, and policy development in the areas of energy efficiency, renewable energy, agriculture, forestry, transportation, buildings, and urban planning.

[1] Primer on Short-Lived Climate Pollutants. Institute for Governance & Sustainable Development, 2013.
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[5] Bond, T. et al. Bounding the role of black carbon in the climate system: A scientific assessment. *Journal of Geophysical Research: Atmospheres*. 2013.
[6] Air quality and health. World Health Organization. 2011.
[7] Report to Congress on Black Carbon. U.S. Environmental Protection Agency, 2012.
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[9] Global Methane Emissions and Mitigation Opportunities. Global Methane Emissions. Apr. 2011.
[10] Blasing, T.J. Current Greenhouse Gas Concentrations. Carbon Dioxide Information Analysis Center. Feb. 2012.
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[12] Direct Global Warming Potentials. *IPCC Fourth Assessment Report*. 2007.
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