



CLIMATE AND CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

SCIENTIFIC ADVISORY PANEL BRIEFING

Short-Lived Climate Pollutants in the Fifth IPCC Assessment Report Working Group I The Physical Science Basis

This briefing has been developed by the Scientific Advisory Panel of the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (CCAC).

This document and more information on the CCAC are available at: www.unep.org/ccac/

Short-Lived Climate Pollutants in the Fifth Assessment Report of the IPCC – Working Group I: The Physical Science Basis

Introduction

The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) provides the latest comprehensive evaluation of the factors driving climate change. Regarding short-lived climate pollutants (SLCPs), AR5 finds larger contributions to climate change from methane and carbonaceous aerosols than the previous IPCC assessment while noting that uncertainties in the influence of aerosols remain large.

The AR5 highlights the difference in the climate impacts of SLCPs and long-lived gases (such as carbon dioxide (CO₂)). It reports that although simple metrics are commonly used to assess the relative impact of different pollutants (e.g. under the Kyoto Protocol), metric “values are very dependent on metric type and time horizon”, especially in comparing SLCPs and CO₂. The AR5 therefore does not endorse any single metric or time horizon as preferable for characterizing the impacts of pollutants, instead concluding that impact analyses need to consider multiple endpoints, such as both near-term and long-term climate change and rates of climate change. These conclusions imply that SLCPs should not be traded against CO₂ as any method to establish ‘equivalence’ in a particular impact would not hold for other impacts, and they support the CCAC’s focus on SLCPs as complimentary to, but not substituting for, actions to reduce CO₂ emissions.

The AR5 also features a Frequently Asked Question (FAQ 8.2) “Do Improvements in Air Quality Have an Effect on Climate Change?” It concludes that they do, and illustrates the effects that both ozone and particulate matter pollution controls may have on climate (see Figure 1). It also notes “controls on anthropogenic emissions of methane to lower surface ozone have been identified as ‘win-win’ situations”, with the ‘wins’ referring to improved air quality and reduced climate change. These conclusions broadly support the foci of the CCAC.

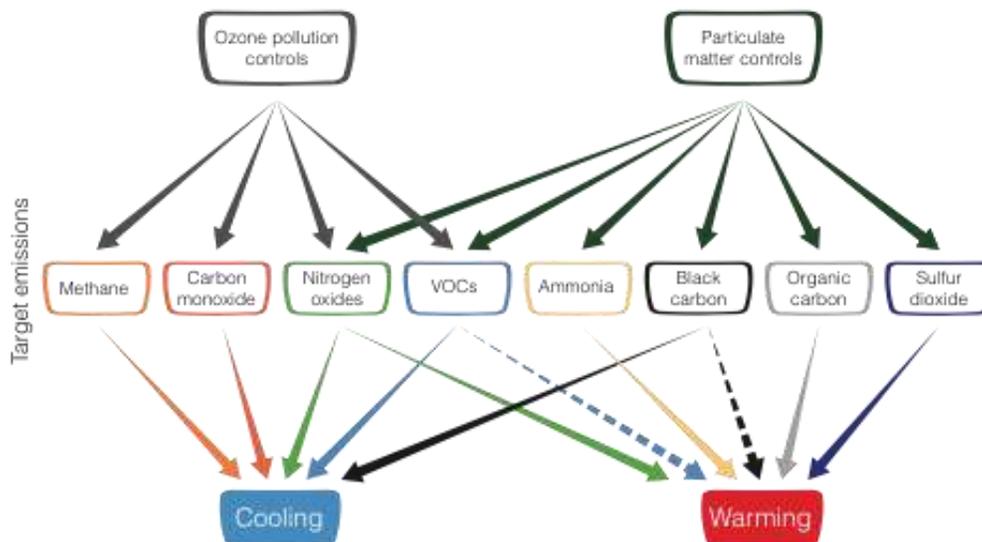


Figure 1, showing that ozone and particulate matter controls affect individual pollutant emissions and how those changes in turn influence climate. Solid black lines indicate known processes; dashed lines indicate possible processes (not net impacts). Reprinted from IPCC AR5, Chapter 8, FAQ 8.2.

Technical Summary of SLCPs in AR5 WGI

IPCC AR5 discusses all the factors driving climate change, including the many natural and anthropogenic emissions of gases, aerosols and their precursors. This brief discusses the anthropogenic emissions. These emissions are grouped into two categories (Box 8.2): (1) well-mixed greenhouse gases (WMGHG) and (2) near-term climate forcers (NTCF), with methane being included in both categories. The AR5 term ‘near-term climate forcers’ is equivalent to short-lived climate pollutants (and was used as the scientific community has not traditionally considered methane to be short-lived).

The radiative forcing (RF) over the industrial era (1750 to 2011) is one of the many aspects of SLCPs evaluated in AR5 (Section 8.5). While this is a common way to compare the impact of various historical emissions, industrial-era RF does not relate directly to historical climate change or to the feasibility of future emissions mitigation. It is, however, relevant to the SLCP issue in that the total forcing has been used in many key studies of SLCP mitigation as a way to contextualize those results. For example, the fraction of a pollutant removed by a given emissions control measure has been analyzed, with the impact assessed according to that fraction and the best estimate of total forcing by that pollutant. Hence it is relevant to compare the AR5 values with AR4 to characterize changes in understanding of the total impact of particular pollutants on RF, and to compare with the 2011 UNEP/WMO Integrated Assessment of Tropospheric Ozone and Black Carbon to gauge the effects of the new AR5 values on prior SLCP mitigation estimates. The new AR5 values are generally fairly similar to those in the other Assessments, although values for both warming and cooling carbonaceous aerosols are greater, especially for fossil+biofuel emissions, due to improved understanding of aerosol properties and model biases (consistent with the conclusions in studies such as Bond et al., JGR, 2013, which is one of the many studies assessed in AR5). In particular, the net total impact of black and organic carbon (direct, non-microphysical or ‘semi-direct’ cloud response and BC albedo) is almost the same in AR5 (0.37 W m^{-2}) as in UNEP/WMO (0.40 W m^{-2}), as is the effect of methane (Table 1). Note that uncertainties in carbonaceous aerosol forcing remain quite large, especially accounting for their full impact on clouds (including microphysical or ‘indirect’ effects, which are not included in the AR5 values). This can lead to even larger values when those effects are included (e.g. Bond et al., JGR, 2013). While their contribution remains quite small, the RF of all HFCs nearly doubled between AR4 and AR5, from 0.01 to 0.02 W m^{-2} , due to increases in their abundance.

The portion of the AR5 that is probably the most relevant to SLCP mitigation policies is the evaluation of metrics (Section 8.7). The AR5 highlights that “The choice of metric and time horizon depends on the particular application and which aspects of climate change are considered relevant in a given context.” The AR5 therefore does not favor a particular time horizon or metric, reflecting the fact that pollutants have multiple impacts and hence any single metric or time cannot be comprehensive. It points out that “the name ‘Global Warming Potential’ may be somewhat misleading” as “the GWP does not lead to equivalence [with CO_2] for temperature or other climate variables”.

Table 1. Industrial Era RF attributed to emissions ($W m^{-2}$) in recent Assessments

	AR4	AR5	UNEP/WMO 2011
BC fossil & biofuel	+0.20 (+0.05 to +0.35)	+0.40 (+0.05 to +0.80)	
OC fossil & biofuel	-0.05 (0.00 to -0.10)	-0.09 (-0.16 to -0.03)	
Biomass burning BC & OC	+0.03(-0.09 to +0.15)	-0.0 (-0.20 to +0.20)	
BC all	0.34 (0.09 to 0.59)	0.54 (0.10 to 1.03)	0.45 (0.30 to 0.60)
OC all	-0.19 (+0.01 to -0.39)	-0.29 (-0.11 to -0.50)	-0.20 (-0.09 to -0.31)
BC albedo [effective]	0.1 (0.0 to 0.2)	0.04 (0.02 to 0.09) [\sim 0.12]	0.03 (0.01 to 0.05) [\sim 0.15]
CO	N/A	0.23 (0.17 to 0.29)	\sim 0.25
Methane	0.86	0.97 (0.81 to 1.13)	\sim 0.99

Aerosol forcings are direct (RFari) only except for the AR5 and UNEP values for total BC which include non-microphysical cloud responses (ERFari-RFari). The remaining RF due to aerosol-cloud interactions (ERFaci) was not separated into components in AR5. Values for BC albedo forcing in brackets include an adjustment for the enhanced efficacy of this process. For UNEP/WMO, the ‘central ranges’ were used in most calculations, and so are given here, but full ranges that are similar to those in AR5 were also reported. Ozone is not shown as it is not directly emitted, but substantial portions of the forcing due to CO and methane emissions are attributable to the resulting ozone formation. AR5 sources: Table 8.4; Sections 7.5 & 8.3; Tables 8.SM.6 & 8.SM.7.

It also discourages the use of CO₂ equivalence, stating “a metric that establishes equivalence with regard to one effect cannot guarantee equivalence with regard to other effects and over extended time periods”.

After stressing the need for careful interpretation and usage of emission metrics, the AR5 then presents updated values (Section 8.7). An important bias in prior metric calculations is discussed in that whereas “the GWP for the reference gas CO₂ included climate-carbon feedbacks, this is not the case for the non-CO₂ gas in the numerator of GWP. This means that the GWPs presented in AR4 may underestimate the relative impacts of non-CO₂ gases.” The impacts in broad terms are described as follows, using the 100-yr GWP as an example:

“The effect of including this feedback for the non-reference gas increases with time horizon due to the long-lived nature of the initiated CO₂ perturbation. The relative importance also increases with decreasing lifetime of the component, and is larger for GTP than GWP due to the integrative nature of GWP. We calculate an increase in the CH₄ GWP100 of 20%. For GTP100, however, the changes are much larger; of the order of 160%. For the shorter time horizons (e.g., 20 years) the effect of including this feedback is small (<5%) for both GWP and GTP.”

Factors such as advances in characterizing indirect impacts of emissions also influence the final metric values. An example of the end results is the GWP values for fossil methane, which are 87 and 36 for the 20- and 100-year time horizons, respectively.

Metrics for SLCPs other than methane are also discussed, with the difficulty in determining metric values for emissions from different locations noted; e.g. for BC “there is not a robust relationship between the region of emission and the metric value”. A general conclusion on metrics in AR5 is that

“The confidence level is lower for many of the NTCF compared to WMGHG and much lower where aerosol–cloud interactions are important”. Nonetheless, tables of quantitative values for SLCPs are included, though these typically exclude aerosol indirect effects and a best estimate is not given other than for methane and HFCs.

Turning to climate change projections, the AR5 highlights the difficulty in forecasting emissions. In particular, it notes that “The effects of aerosols have a regional nature and are thus dependent on the future sources of pollution which are likely to vary geographically in the future and be difficult to predict”. Referring to the emissions scenarios from recent Integrated Assessment Models that are the primary source of scenarios for IPCC, the AR5 points out that “The scenarios emphasized in this assessment ... all assume a continuation of current trends in air pollution policies and thus do not cover the range of future pollutant emissions found in the literature, specifically those with higher pollutant emissions”. This leads to very similar SLCP projections (other than methane) in all the scenarios. For example, the range in SO₂ emissions across the scenarios is 17% at 2030, while it is 60% between previously published ‘current legislation’ and ‘maximum feasible reduction’ scenarios (Section 11.3). This assessment thus indicates that great care should be used in interpreting the impacts of emissions mitigation based on the particular reference scenario with which the mitigation policy is being compared.

The influence of the spatially inhomogeneous RF from SLCPs is discussed fairly extensively in AR5 (Section 8.6), which examines a substantial body of new work since AR4. AR5 concludes that work linking particular climate responses to the RF pattern is still in its early stages, but that there is confidence in several “qualitative but robust features, such as the damped warming of the NH and shifting of [tropical rainfall] from aerosols”.

While Working Group III will examine mitigation options in detail, Working Group I presents an analysis of the effect of current emissions by pollutant and by sector (Section 8.7). These perspectives are adopted to provide more policy-relevant information than analysis of forcing due to concentration changes (as highlighted, e.g., in AR4) since it is emissions rather than concentrations that can be directly addressed by policy, while the analysis by sectors acknowledges that activities often emit multiple pollutants. AR5 finds that “A single year’s worth of current global emissions from the energy and industrial sectors have the largest contributions to warming after 100 years. Household fossil fuel and biofuel, biomass burning and on-road transportation are also relatively large contributors to warming over 100-year time scales. Those same sectors, along with sectors that emit large amounts of methane (animal husbandry, waste/landfills and agriculture), are most important over shorter time horizons (about 20 years)” (see Figures). The AR5 notes, however, that for some sectors that emit multiple pollutants the “combined climate impact can be difficult to ascertain”.

The varying temperature response through time highlights the limitations of focusing solely on a value such as the preindustrial to present-day forcing. It is also clear that the impact of sustained emissions changes can be quite different from a short-term emission change (see Figure 2), so that analysis of the effects of emissions mitigation is quite sensitive to the assumed reference emissions in absence of mitigation (a topic that will be explored further in WGIII). Particular attention is also called to the role of methane in future air quality, for example in the conclusion that “By 2100, surface ozone increases by about 8 parts per billion globally in the doubled-methane scenario (RCP8.5) relative to the stable-methane pathways (RCP4.5/6.0; high confidence).” (Section 11.3).

This briefing on the results of Working Group I will be complemented by summaries of the SLCP-related results of WGII and WGIII after their release.

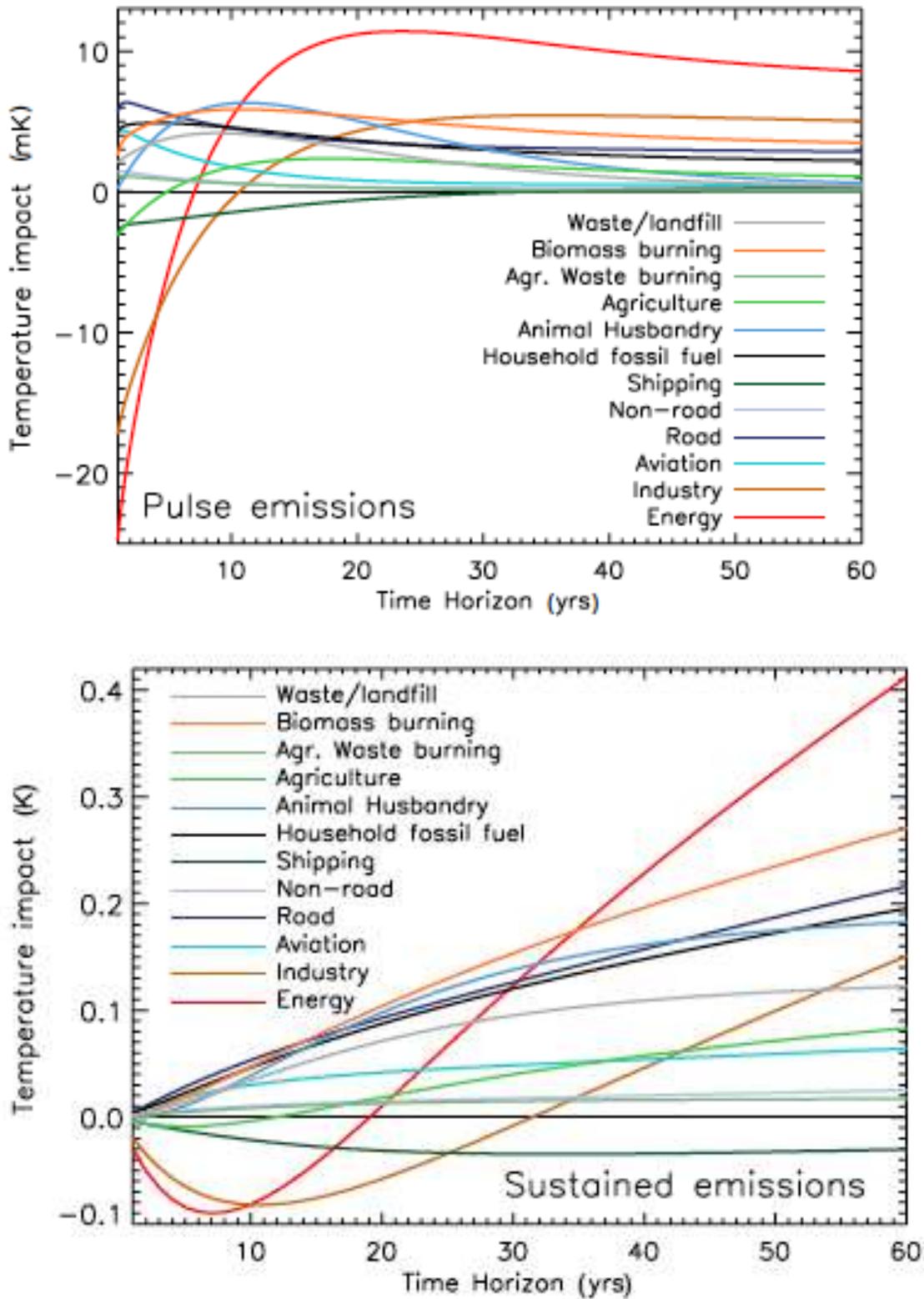


Figure 2, showing temperature impact of all current anthropogenic emissions in each sector in terms of the effect of a single year's worth of emissions (a pulse, upper panel) or continuous present-day emissions (sustained, lower panel). Reproduced from IPCC AR5, Figures 8.SM.9 and 8.SM.10.