Impacts globaux sur la santé et le climat de particules de différentes sources

Global health and climate impacts of particles from specific sources

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Introduction

Airborne fine particulate matter imposes a substantial global burden of disease [Cohen *et al.*, 2006]. Reducing that burden will require significant reductions in emissions of particles and related precursor gases from pollution sources that also influence climate. The combined benefits for climate and public health of emissions reductions in specific emissions sectors have not been previously examined comprehensively at the global scale, hindering prioritization of mitigation strategies. Public policies that target specific anthropogenic sectors have the potential, if chosen wisely, to mitigate both climate and health impacts.

While $PM_{2.5}$ levels have stabilized or improved in some places in recent decades, much of the developing world has seen levels increase along with economic development. Global average $PM_{2.5}$ concentration today is estimated at approximately 20 ± 6.7 µg/m^3, according to the satellite-based estimate of Van Donkelaar *et al.* [2010]. Concentrations in urban areas, where most of the world's population now lives, range as high as 100 to 200 ug/m^3.

$PM_{2.5}$ has been associated with a broad spectrum of acute and chronic health effects, most importantly with premature mortality due to cardiopulmonary disease and lung cancer [Krewski, Jerrett, & Burnett, 2009; Pope III *et al.*, 2002]. Cohen *et al.* estimated the global burden of disease due to $PM_{2.5}$ in urban areas larger than 100,000 persons to be 800,000 annual deaths and 6.4 million annual DALYs (Disability-adjusted life year) in the year 2000 [Cohen *et al.*, 2004].

Particles and associated gaseous emissions also impact climate in complex ways involving both net warming and cooling, depending on the component species [Forster *et al.*, 2007]. For example, black carbon leads to overall warming, whereas sulfate is estimated to have a net cooling effect. A recent multi-pollutant study quantified the net global and regional radiative forcing impacts of a range of emission sectors [Unger *et al.*, 2010]. In addition to affecting radiative balance, sector-specific emissions also alter ground level $PM_{2.5}$ concentrations, and thus population health [Susan C Anenberg, Horowitz, Tong, & West, 2010; Cohen *et al.*, 2004; Pope III *et al.*, 2002].

Our objective was to estimate global mortality attributable to a broad range of anthropogenic emissions sectors, and to weigh these impacts against medium – and long-term sector-specific climate warming impacts.

Methods

The contributions of 13 anthropogenic emission sectors to surface $PM_{2.5}$ concentrations across the globe for the year 2000 were calculated using a global atmospheric model. Global radiative forcing (RF) due to constant emissions at year 2000 levels were computed for two future time points, 2020 and 2100, as described in detail by Unger *et al.*, [2010]. RF of nine separate pollution species were partitioned into 13 anthropogenic emission sectors. Atmospheric concentrations and resultant RF were computed for short-lived atmospheric species (SLSs) (ozone, sulfate, nitrate, black carbon and organic carbon), methane, and the long-lived greenhouse gases (LLGHGs) CO_2 and N_2O. RF at the 2020 time point is mainly driven by SLSs whereas LLGHGs become dominant at the 2100 time point. The effects of sector-specific emissions on surface $PM_{2.5}$ concentrations were modeled with the NASA GISS ModelE general circulation model with embedded fully interactive photochemistry and aerosol modules [D. T. Shindell *et al.*, 2006]. The atmospheric composition-climate model includes full coupling between tropospheric gas-phase and aerosol chemistry and aerosols and cloud microphysics for liquid-phase stratus and cumulus clouds. Surface concentrations of $PM_{2.5}$ due to each emission sector were estimated in µg/m3 as the sum of sulfate, nitrate, black carbon and organic carbon aerosol deriving from that sector. In this way annual average concentrations were computed for the index year 2000.

These data were geographically linked to gridded population data and baseline cardiovascular mortality data, along with cardiovascular mortality concentration-response functions, to generate country level estimates of cardiovascular mortality based on the methodology of Cohen *et al.* [2004]. Global mortality and climate warming effects were compared for each emissions sector.

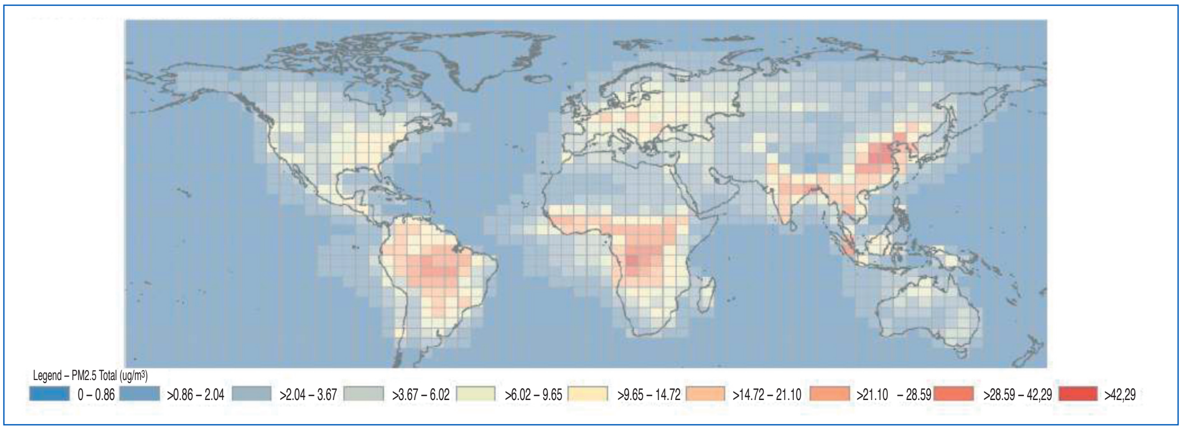

Figure 1.
Global distribution of $PM_{2.5}$ Concentration, combination of all emissions sectors; units are µg/m3.

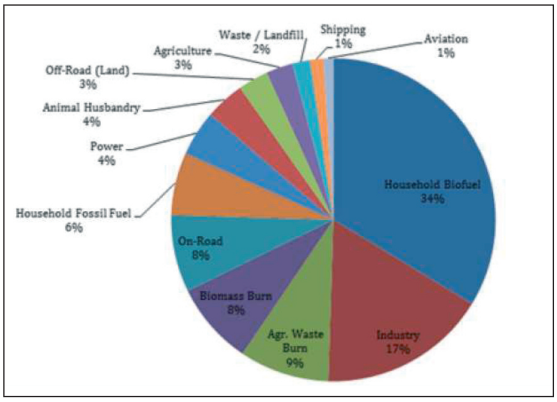

Figure 2.
Percentage Breakdown of $PM_{2.5}$ Attributable Mortality, by Sector

Results

Figure 1 displays the overall global distribution of $PM_{2.5}$ concentrations due to all emission sectors combined. Concentrations were greatest in China and south Asia, sub-Saharan Africa, and South America.

Figure 2 shows a pie chart of sector-specific mortality effects, and Figure 3 plots sector-specific global mortality impacts against global temperature impacts due to RF in 2020 and 2100. $PM_{2.5}$-attributed deaths are plotted on the Y axis and temperature change on the X axis. The vertical black line on each graph indicates net global temperature influence of zero. Sectors to the right of this line exert a net warming influence on the climate, while sectors to the left of this line currently exert a net cooling influence on the

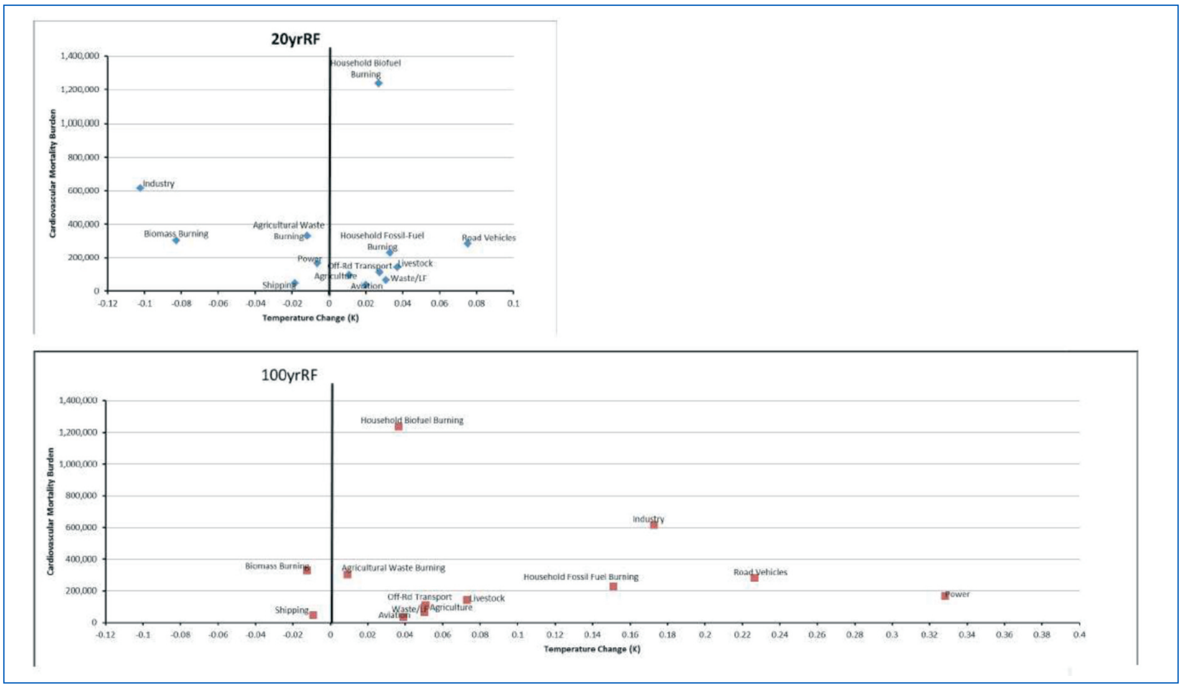

Figure 3.
Plot of Cardiovascular Mortality Burden versus Temperature Change, for 20 year and 100 year RF.

climate. Sectors closer to the top of the graph have higher mortality impacts. Thus, sectors on the upper right are those which contribute most to both mortality and global warming, and could provide the greatest opportunities for health and climate co-benefits if emissions were to be reduced.

Conclusion

Our results suggest that the household biofuel burning and on-road transportation sectors present opportunities to reduce overall positive climate forcing on short timescales, and at the same time make significant progress in reducing particle-related cardiovascular mortality.

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