SHORT-LIVED CLIMATE POLLUTANTS SPECIAL EDITION RESEARCH DIGEST

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TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

All SLCP research digests are available on the CCAC website (http://ccacoalition.org/en/research-digest)

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Multiple Benefits/Impacts & Crosscutting

Description: This section includes articles addressing the multiple benefits of action to address SLCPs and implement SLCP measures.

Global climate and human health effects of the gasoline and diesel vehicle fleets

The global gasoline and diesel fuel vehicle fleets impose substantial impacts on air quality, human health, and climate change. Here we quantify the global radiative forcing and human health impacts of the global gasoline and diesel sectors using the NCAR CESM global chemistry-climate model for year 2015 emissions from the IIASA GAINS inventory. Net global radiative effects of short-lived climate forcers (including aerosols, ozone, and methane) from the gasoline and diesel sectors are +13.6 and +9.4 mW m−2, respectively. The annual mean net aerosol contributions to the net radiative effects of gasoline and diesel are −9.6 ± 2.0 and +8.8 ± 5.8 mW m−2. Aerosol indirect effects for the gasoline and diesel road vehicle sectors are −16.6 ± 2.1 and −40.6 ± 4.0 mW m−2. The fractional contributions of short-lived climate forcers to the total global climate impact including carbon dioxide on the 20-year time scale are similar, 14.9% and 14.4% for gasoline and diesel, respectively. Global annual total PM2.5- and ozone-induced premature deaths for gasoline and diesel sectors approach 115,000 (95% CI: 69,000–153,600) and 122,100 (95% CI: 78,500–157,500), with corresponding years of life lost of 2.10 (95% CI: 1.23–2.66) and 2.21 (95% CI: 1.47–2.85) million years. Substantial regional variability of premature death rates is found for the diesel sector when the regional health effects are normalized by the annual total regional vehicle distance traveled. Regional premature death rates for the gasoline and diesel sectors, respectively, vary by a factor of eight and two orders of magnitude, with India showing the highest for both gasoline and diesel sectors.

Huang, Yaoxian, et al. "Global climate and human health effects of the gasoline and diesel vehicle fleets." GeoHealth 4.3 (2020): e2019GH000240.

Quantifying the air quality, climate and equity implications of India's household energy transition

Economic growth, urbanization and changes in lifestyles are leading to a transition from traditional fuels to liquefied petroleum gas (LPG) and electricity in Indian households. We use National Sample Survey data – 43rd (1987–88) and 68th (2011–12) rounds – to show that contrary to concerns about rising greenhouse gas (GHG) emissions from fossil-fuel use, switching to LPG and electricity provides health and climate benefits, if non-Kyoto emissions are considered. Our modelled household energy transition scenarios (2011–2030) show that: one, adoption of LPG by 2030 in Business-As-Usual (BAU) projections results in 80% of urban India meeting the World Health Organization's (WHO) indoor PM 2.5 guidelines. In rural households, persistent use of firewood does not significantly improve indoor air quality across the income spectrum. Two, BAU scenario projects only a 3% rise in rural GHG emissions by 2030, driven by a transition away from kerosene lighting in spite of rising electricity consumption. Three, a complete transition to LPG and electricity by 2030 reduces PM 2.5 exposure to below WHO guidelines across all urban and rural households. This is not achieved in the other partial transition scenarios. Four, across scenarios improving coal-based power plant efficiency to 40% and increasing renewables' share to 40% lead to a decrease of 14–18% in GHG emissions by 2030 relative to 2011. Finally, improved biomass cookstoves can reduce indoor exposure by 75–86% but not below the WHO guideline, and result in higher GHG emissions compared to LPG replacement due to non-Kyoto emissions from burning firewood.

Maji, Poushali, and Milind Kandlikar. "Quantifying the air quality, climate and equity implications of India's household energy transition." Energy for Sustainable Development 55 (2020): 37-47.

Synergy and co-benefits of reducing CO2 and air pollutant emissions by promoting electric vehicles—A case of Shanghai

With the growing number of vehicles on the road, the transport sector has become the second largest consumer of energy, after the industrial sector, and has become the main source of air pollutants and greenhouse gas

emissions. To support low-carbon development, since 2009, electric vehicles have been used to replace traditional fuel vehicles in China. In 2016, electric vehicles, including buses, taxis and private vehicles, accounted for 26.41% of the total number of new-energy vehicles in Shanghai. In this study, the synergy and co-benefits of reducing CO2 and air pollutant emissions by using electric private cars, taxis, and buses in Shanghai are analyzed. The co-control coordinate system and pollutant reduction cross-elasticity (Elsa/b) are used to identify and evaluate the generated co-benefits. Based on the total driving life cost, the unit air pollutant equivalent (Apeq) abatement costs of achieving synergy in three types of vehicles are assessed. The co-benefits generated by using the three types of electric vehicles are discussed by combining environmental benefit and cost-effectiveness analyses. The results show that electric buses provide the highest co-benefits. Thus, replacing traditional fuel vehicles with electric buses can simultaneously reduce air pollution and CO2 emissions. If we consider subsidies to electric vehicles provided by the government, there are great environmental and economic benefits of implementing electric buses in Shanghai. In addition, private electric cars and taxis also provide the co-benefits of reducing CO, NOx, NMHC, and PM10 emissions. The economic benefits of using electric taxis in Shanghai are more notable, even without considering subsidies.

Alimujiang, Adila, and Ping Jiang. "Synergy and co-benefits of reducing CO2 and air pollutant emissions by promoting electric vehicles—A case of Shanghai." Energy for Sustainable Development 55 (2020): 181-189.

Air quality co-benefits from climate mitigation for human health in South Korea

Climate change mitigation efforts to reduce greenhouse gas (GHG) emissions have associated costs, but there are also potential benefits from improved air quality, such as public health improvements and the associated cost savings. A multidisciplinary modeling approach can better assess the co-benefits from climate mitigation for human health and provide a justifiable basis for establishment of adequate climate change mitigation policies and public health actions. An integrated research framework was adopted by combining a computable general equilibrium model, an air quality model, and a health impact assessment model, to explore the long-term economic impacts of climate change mitigation in South Korea through 2050. Mitigation costs were further compared with health-related economic benefits under different socioeconomic and climate change mitigation scenarios. Achieving ambitious targets (i.e., stabilization of the radiative forcing level at 3.4 W/m2) would cost 1.3–8.5 billion USD in 2050, depending on varying carbon prices from different integrated assessment models. By contrast, achieving these same targets would reduce costs by 23 billion USD from the valuation of avoided premature mortality, 0.14 billion USD from health expenditures, and 0.38 billion USD from reduced lost work hours, demonstrating that health benefits alone noticeably offset the costs of cutting GHG emissions in South Korea.

Kim, Satbyul Estella, et al. "Air quality co-benefits from climate mitigation for human health in South Korea." Environment International 136 (2020): 105507.

Integration of air quality and climate change policies in shipping: The case of sulphur emissions regulation

Ship air pollution has attracted much attention from the shipping community. Besides Greenhouse Gases (such as carbon dioxide) that contribute to Climate Change, shipping emits many other gases including sulphur and nitrous oxides. There is much scientific evidence that measures to reduce these pollutants do improve air quality but, at the same time, contribute to the acceleration of global warming, because they result in removing the cooling effect of these gases. Until now climate change and air quality regulations have been discussed independently. This work tries to assess the effect of policies to improve air quality on climate change, and vice versa. This paper discusses an approach to assess the impact of SOx reduction measures on global warming by presenting a way to place both emissions on a common scale to allow a comparison between them and to estimate their aggregate effect. Such integration can lead to better decisions by policymakers.

Kontovas, Christos A. "Integration of air quality and climate change policies in shipping: The case of sulphur emissions regulation." Marine Policy 113 (2020): 103815.

Impacts of ozone and climate change on yields of perennial crops in California

Changes in temperature and air pollution affect agricultural productivity, but most relevant research has focused on major annual crops (for example, wheat, maize, soy and rice). In contrast, relatively little is known about the effects of climate change and air quality on perennial crops such as fruits and nuts, which are important to dietary diversity and nutrition, and represent ~38% of California's agriculture by economic value. Moreover, the adaptive capacity of perennial crops may be limited by their long lifespans and sometimes large establishment costs. Here, on the basis of statistical modelling of historical data and downscaled climate model projections, we jointly assess the impacts of climate and ozone levels on historical and future yields of perennial crops in California. Although the effects of warming to date are not statistically significant for many perennial crops, the yields of most perennials show a significant negative response to ambient ozone, ranging from −2% for strawberries to −22% for table grapes, implying total losses of roughly US$1 billion per year. This suggests that historical improvements in California's air quality that reduced ozone exposures may have had large, unaccounted co-benefits for the state's perennial crop yields, and further pollution reduction could create additional gains. Indeed, the co-location of regions with high production and high ozone damage indicates that opportunities to improve crop yields through pollution mitigation are large.

Hong, Chaopeng, et al. "Impacts of ozone and climate change on yields of perennial crops in California." Nature Food 1.3 (2020): 166-172.

Methane

Description: This section includes articles addressing methane source apportionment, emissions factors, impacts and emissions trends.

Going beyond CO2: Strengthening action on global methane emissions under the UN climate regime

According to the 1.5°C Special Report of the Intergovernmental Panel on Climate Change, limiting global warming to 1.5 or 2°C, as specified in the Paris Agreement, will require significant reductions, both in cumulative carbon dioxide emissions and in short-lived climate pollutants, including methane. This article seeks to explore how action on global methane emissions could be strengthened under the United Nations climate regime, particularly through the Paris Agreement. To answer this question, the article begins by analysing the existing methane mitigation and reporting commitments under the United Nations Framework Convention on Climate Change, the Kyoto Protocol, the Paris Agreement and the Paris rulebook. The article then explores the possibilities to further strengthen these commitments through the Paris Agreement. Methane can be targeted in future rounds of nationally determined contributions through specified methane mitigation targets and strategies. The reporting of methane emissions will significantly improve through the enhanced transparency framework of the Paris Agreement and the reporting guidelines agreed under the Paris rulebook. In addition, the article identifies several further opportunities for strengthening action on methane under the Paris Agreement, including through its sustainable development mechanism, long-term low greenhouse gas emission development strategies, global stocktake, support and non-party action.

Pekkarinen, Veera. "Going beyond CO2: Strengthening action on global methane emissions under the UN climate regime." Review of European, Comparative & International Environmental Law (2020): 12329.

The methane footprint of nations: Stylized facts from a global panel dataset

We develop a global dataset of methane inventories derived from production, supply use (final production), and consumption activities for 1997–2014, disaggregated to 78 countries/regions. Our dataset extends existing data on methane emissions to 2014 and allows to trace emissions embodied in international trade in intermediates and in final goods. Anthropogenic emissions are quantitatively important for global warming and increased by about 18% from 1997 to 2014. The bulk of produced emissions is attributable to developing economies, though a considerable amount is exported mainly via manufactured goods to high income countries, which are net-

importers of methane. Trade-embodied emissions increased by 8% more than nationally produced emissions during 1997–2014, with the strongest increase experienced by China, India, and Indonesia. Decompositions of the growth rate of emissions over this period suggest that methane efficiency improved, but the effect of these efficiency gains on total emissions was outweighed by the effect of economic and population growth in low- and middle-income countries. In high-income countries, by contrast, methane efficiency gains were larger the effect of economic and population growth.

Fernández-Amador, Octavio, et al. "The methane footprint of nations: Stylized facts from a global panel dataset." Ecological Economics 170 (2020): 106528.

Polish underground coal mines as point sources of methane emission to the atmosphere

The Upper Silesian Coal Basin in Poland is one of the major European hotspots of CH4 release. Until now, no data concerning short-term CH4 emissions from coal mines have been accessible worldwide. They are available only on a yearly timescale. No values are provided on a higher temporal scale, that's why the measurements presented here are of great importance. This paper discusses short-term CH4 emissions from ventilation shafts of three mining fronts (Mf) divided into two periods. The concentrations of CH4 in shafts varied from 0.05 to 0.4 %. The highest levels occurred in Shaft IV (Mf I) and Shaft VI (Mf II): from 0.15 to 0.38 % (Period 1). These values correspond to emission levels ranging from 27 to 75 m3/min (Shaft IV) and from 18 to 40 m3/min (Shaft VI). In Period 2, the highest concentrations of CH4 occurred in Shaft VI (Mf II and III): from 0.2 to 0.4 %. The most significant CH4 emissions were recorded for Shaft VI (Mf II) and ranged from 29 to 54 m3/min. Presented data have been used to validate the measurements obtained in the CoMet campaign, which aimed at verifying the sensitivity of the test equipment operating from aircraft. During the test flights of HALO in 2015, the CoMet team achieved a remarkable consistency of measurements conducted with airborne equipment (26 ± 3m3/min) and the emission data (24.34 m3/min), for Shaft VI (Mf II). The analysed short-term data for individual shafts are more reliable and can improve CH4 flux estimates during the CoMet campaign in 2018.

Swolkień, Justyna. "Polish underground coal mines as point sources of methane emission to the atmosphere." International Journal of Greenhouse Gas Control 94 (2020): 102921.

Reduced net methane emissions due to microbial methane oxidation in a warmer Arctic

Methane emissions from organic-rich soils in the Arctic have been extensively studied due to their potential to increase the atmospheric methane burden as permafrost thaws. However, this methane source might have been overestimated without considering high-affinity methanotrophs (HAMs; methane-oxidizing bacteria) recently identified in Arctic mineral soils. Herein we find that integrating the dynamics of HAMs and methanogens into a biogeochemistry model that includes permafrost soil organic carbon dynamics3 leads to the upland methane sink doubling (~5.5 Tg CH4 yr−1) north of 50 °N in simulations from 2000–2016. The increase is equivalent to at least half of the difference in net methane emissions estimated between process-based models and observation-based inversions, and the revised estimates better match site-level and regional observations. The new model projects doubled wetland methane emissions between 2017–2100 due to more accessible permafrost carbon. However, most of the increase in wetland emissions is offset by a concordant increase in the upland sink, leading to only an 18% increase in net methane emission (from 29 to 35 Tg CH4 yr−1). The projected net methane emissions may decrease further due to different physiological responses between HAMs and methanogens in response to increasing temperature.

Oh, Youmi, et al. "Reduced net methane emissions due to microbial methane oxidation in a warmer Arctic." Nature Climate Change 10.4 (2020): 317-321.

Black Carbon

Description: This section includes articles addressing black carbon source apportionment, emissions factors, impacts and emissions trends.

Black carbon over an urban atmosphere in northern peninsular Southeast Asia: Characteristics, source apportionment, and associated health risks

Black carbon (BC) has been demonstrated to pose significant negative impacts on climate and human health. Equivalent BC (EBC) measurements were conducted using a 7-wavelength aethalometer, from March to May 2016, over an urban atmosphere, viz., Chiang Mai (98.957°E, 18.795°N, 373 m above sea level), Thailand in northern peninsular Southeast Asia. Daily variations in aerosol light absorption were mainly governed by open fire activities in the region. The mean mass-specific absorption cross-section (MAC) value of EBC at 880 nm was estimated to be 9.3 m2 g−1. The median EBC mass concentration was the highest in March (3.3 μg m−3) due to biomass-burning (comprised of forest fire and agricultural burning) emissions accompanied by urban air pollution within the planetary boundary layer under favorable meteorological conditions. Daily mean absorption Ångström exponent (AAE470/950) varied between 1.3 and 1.7 and could be due to variations in EBC emission sources and atmospheric mixing processes. EBC source apportionment results revealed that biomass-burning contributed significantly more to total EBC concentrations (34–92%) as compared to fossil-fuel (traffic emissions). Health risk estimates of EBC in relation to different health outcomes were assessed in terms of passive cigarette equivalence, highlighting the considerable health effects associated with exposure to EBC levels. As a necessary action, the reduction of EBC emissions would promote considerable climate and health co-benefits.

Pani, Shantanu Kumar, et al. "Black carbon over an urban atmosphere in northern peninsular Southeast Asia: Characteristics, source apportionment, and associated health risks." Environmental Pollution 259 (2020): 113871.

Temporal variations of atmospheric black carbon and its relation to other pollutants and meteorological factors at an urban traffic site in Istanbul

This study aimed to investigate the variability of Black Carbon (BC) at one traffic site in Istanbul as a function of other pollutants, traffic density and meteorological parameters in order to identify the source and determinants of concentration. This was carried out through the statistical analyses of data measured in the period of May 2016–December 2018. The mean concentration of BC was observed as 6.5 ± 3.5 μg m−3. Daytime BC was observed to be higher than nighttime during the weekdays but slightly lower at the weekend, similar to oxides of nitrogen (NOx). However, nighttime traffic during the weekend was found to be higher than the weekdays. The diurnal pattern showed two peaks of BC corresponding to the traffic rush hours in the morning and evening. Since the traffic density did not change during the day, the sharp decrease after the morning rush hour is attributed to enhanced atmospheric mixing, due to an increased wind speed and boundary layer depth. In addition, polar plots indicated that the only major source of BC is in the vicinity of the monitoring site, consistent with road traffic. Moreover, episodic north-easterly atmospheric transport events from the ship activity in the Bosphorus in summer can contribute to elevated BC concentrations. These results suggest that vehicular emissions heavily impact the environmental concentrations of BC and affect NOx concentrations more than other pollutants. BC concentrations are highly correlated with NOx, reflecting a common source in diesel vehicle emissions. Since the proportion of diesels in total vehicles in Istanbul is increasing every year, there may be future increases in BC and NOx unless exhaust after-treatment works effectively on newer vehicles entering the fleet.

Şahin, Ülkü Alver, et al. "Temporal variations of atmospheric black carbon and its relation to other pollutants and meteorological factors at an urban traffic site in Istanbul." Atmospheric Pollution Research (2020): https://doi.org/10.1016/j.apr.2020.03.009

Tropospheric Ozone

Description: This section includes articles addressing tropospheric ozone impacts and important trends in precursor emissions.

Evaluating the effects of surface O3 on three main food crops across China during 2015–2018

In order to tackle China's severe air pollution issue, the government has released the "Air Pollution Prevention and Control Action Plan" (known simply as the "Action Plan") since 2013. A recent study reported a decreased trend in PM2.5 concentrations over 2013–2017, but O3 pollution has become more serious. However, the effects of surface O3 on crops are unclear after the implementation of the "Action Plan". Here, we evaluated the potential negative effects of surface O3 on three main food crops (winter wheat, maize and rice) across China during 2015–2018 using nationwide O3 monitoring data and AOT40-yield response functions. Results suggested that mean O3 concentration, AOT40 and relative yield loss in China showed an overall upward trend from 2015 to 2018. During winter wheat, maize, single rice, double-early rice, and double-late rice growing seasons, mean O3 concentration in recent years ranged from 38.6 to 46.9 ppb, 40.2–43.9 ppb, 39.3–42.2 ppb, 33.8–40.0 ppb, and 35.9–39.1 ppb, respectively, and AOT40 mean values ranged from 8.5 to 14.3 ppm h, 10.5–13.4 ppm h, 9.8–11.9 ppm h, 5.2–9.2 ppm h, and 8.0–9.5 ppm h, respectively. O3-induced yield reductions were estimated to range from 20.1 to 33.3% for winter wheat, 5.0–6.3% for maize, 7.3–8.8% for single rice, 3.9–6.8% for double-early rice and 5.9–7.1% for double-late rice. O3-induced production losses for winter wheat, maize, single rice, double-early rice, and double-late rice totaled 39.5–88.2 million metric tons, 12.6–21.0 million metric tons, 9.5–11.3 million metric tons, 1.2–1.8 million metric tons, and 2.2–2.7 million metric tons, respectively, and the corresponding economic losses totaled 14.3–32.0 billion US$, 3.9–6.5 billion US$, 3.9–4.6 billion US$, 0.5–0.7 billion US$, and 0.9–1.1 billion US$, respectively. Our results suggested that the government should take effective measures to reduce O3 pollution and its effects on agricultural production.

Zhao, Hui, et al. "Evaluating the effects of surface O3 on three main food crops across China during 2015–2018." Environmental Pollution 258 (2020): 113794.

A Rossby wave breaking-induced enhancement in the tropospheric ozone over the Central Himalayan region

The high-altitude regions in the Himalayas are prone to high ozone concentrations frequently resulting from diverse dynamical and transport mechanisms. Here, we report an unusual enhancement in the surface and tropospheric ozone concentrations over the central Himalayan region from ground-based and space-borne measurements in the month of December 2010. The surface ozone levels (~80 ppbv) on 18–19 December 2010 is observed to be two-fold higher relative to the seasonal average (December-January-February) of about 40–50 ppbv in the central Himalayan region. The space-borne measurements from Tropospheric Emission Spectrometer and Ozone Monitoring Instrument onboard Aqua satellite also show higher values in the tropospheric column ozone over this region. The satellite observations indicate an increase in tropopause temperature of about 5 °C and decrease in tropopause altitude about 1 km during 18–19 December 2010 resulting in the occurrence of tropopause fold facilitating the stratospheric-tropospheric exchange processes over the study region. The plausible reason for the occurrence of tropopause fold and subsequent enhancement of tropospheric and surface ozone is found to be associated with the breaking Rossby waves in the upper troposphere. The wave breaking leads to the advection of high-PV (potential vorticity) air, with magnitudes of about 3–4 PVU, towards the central Himalayan region from high-latitudes. The vertical component of PV advection also shows a deep stratospheric intrusion of high-PV air into the troposphere. The isentropic transport of ozone across the folding tropopause due to the wave breaking is clearly depicted from the satellite and reanalysis datasets. Therefore, the present study has strong implications of upper tropospheric wave dynamics to the tropospheric and surface ozone over the Himalayan regions having complex topography.

Kumar, Kondapalli Niranjan, et al. "A Rossby wave breaking-induced enhancement in the tropospheric ozone over the Central Himalayan region." Atmospheric Environment 224 (2020): 117356.

Hydrofluorocarbons (HFCs)

Description: This section includes articles addressing hydrofluorocarbon emissions, relevant new information about use sectors, alternative refrigerants and relevant analysis of energy efficiency.

Overview of low GWP mixtures for the replacement of HFC refrigerants: R134a, R404A and R410A

The current European F-gas regulation establishes restrictions in the use of fluoride refrigerants with a high global warming potential (GWP) in applications of refrigeration and air conditioning (RAC) systems. Moreover, a gradual limitation on the GWP weight of the fluoride refrigerants placed on the market is ongoing and will end with approximately one-fifth of today's offer. In this context, many of the RAC systems operate with refrigerants R134a, R404A, and R410A that have GWP values of 1300, 3943 and 2088, respectively, are being forced to be replaced by environmentally friendly alternatives, like hydrofluoroolefin (HFO) refrigerants and their mixtures with hydrofluorocarbons (HFC), which can be designed to present intermediate characteristics and become the ideal candidate many RAC applications. This work presents the most recent HFC/HFO/HC/R744 refrigerant mixture options for an alternative to the refrigerants mentioned above and compares their energetic and performance with the early developed mixture prototypes.

Heredia-Aricapa, Y., et al. "Overview of low GWP mixtures for the replacement of HFC refrigerants: R134a, R404A and R410A." International Journal of Refrigeration 111 (2020): 113-123.

Socio-Economic Impacts

Description: This section includes articles addressing the socio-economic impacts due to air pollutions and SLCP related climate changes

The effect of Economic Development on haze pollution (PM2.5) based on a spatial perspective: Urbanization as a mediating variable

With the development of the economy and urbanization, haze pollution in Chinese cities has become increasingly serious. This paper uses the spatial Durbin model (SDM) to explore the impact mechanism of economic development on haze pollution using panel data of 249 cities from 1998 to 2016. Urbanization is used as an intermediary variable to test whether it plays a mediating effect. The results show that 1) from the national and regional level, there are N-shaped relationships between economic development and haze pollution and a U-shaped relationship between urbanization and haze pollution; 2) urbanization plays a mediating role in the impact of the economy on haze pollution; that is, through the effect of urbanization, economic development causes more serious haze pollution; 3) convenient transportation, technological progress, and increased education levels can alleviate haze pollution while an increased opening-up level aggravates pollution; moreover, technological progress and an increased opening-up level alleviate haze pollution in the eastern region; and 4) an increase in the annual average humidity can alleviate haze pollution while an increase of the annual average wind speed will lead to the aggravation of haze pollution in adjacent areas. According to the research of this paper, some pertinent policies and suggestions are proposed.

Gan, Ting, et al. "The effect of Economic Development on haze pollution (PM2. 5) based on a spatial perspective: Urbanization as a mediating variable." Journal of Cleaner Production (2020): 121880.

Public health effect and its economics loss of PM2.5 pollution from coal consumption in China

China's energy structure is based on coal resource and it accounts for main proportion in the primary energy consumption. Coal consumption produces PM2.5 pollution, which seriously affects public health. Considering that there are few studies on the effect PM2.5 pollution produced by coal consumption, this paper uses the Poisson Regression model to estimate the impacts on public health and the economic loss of PM2.5 pollution produced by coal consumption using the data in 2015. Based on these results, the paper also predicts the impacts on public health effect and its economic loss caused by PM2.5 pollution from coal consumption under the baseline scenario and total coal consumption control scenario in 2020 and 2030. Finally, based on the research conclusions, suggestions are proposed to reduce the public health economic loss from PM2.5 pollution caused by coal consumption.

Chen, Hong, et al. "Public health effect and its economics loss of PM2. 5 pollution from coal consumption in China." Science of The Total Environment (2020): 138973.

Estimation of abatement potentials and costs of air pollution emissions in China

Understanding the air pollution emission abatement potential and associated control cost is a prerequisite to design cost efficient control policies. In this study, a linear programming algorithm model, International Control Cost Estimate Tool, was updated with cost data for applications of 56 types of end-of-pipe technologies and five types of renewable energy in 10 major sectors namely power generation, industry combustion, cement production, iron and steel production, other industry processes, domestic combustion, transportation, solvent use, livestock rearing, and fertilizer use. The updated model was implemented to estimate the abatement potential and marginal cost of multiple pollutants in China. The total maximum abatement potentials of sulfur dioxide (SO2), nitrogen oxides (NOx), primary particulate matter (PM2.5), non-volatile organic compounds (NMVOCs), and ammonia (NH3) in China were estimated to be 19.2, 20.8, 9.1, 17.2 and 8.6 Mt, respectively, which accounted for 89.7%, 89.9%, 94.6%, 74.0%, and 80.2% of their total emissions in 2014, respectively. The associated control cost of such reductions was estimated as 92.5, 469.7, 75.7, 449.0, and 361.8 billion CNY in SO2, NOx, primary PM2.5, NMVOCs and NH3, respectively. Shandong, Jiangsu, Henan, Zhejiang, and Guangdong provinces exhibited large abatement potentials for all pollutants. Provincial disparity analysis shows that high GDP regions tend to have higher reduction potential and total abatement costs. End-of-pipe technologies tended be a cost-efficient way to control pollution in industries processes (i.e., cement plants, iron and steel plants, lime production, building ceramic production, glass and brick production), whereas such technologies were less cost-effective in fossil fuel-related sectors (i.e., power plants, industry combustion, domestic combustion, and transportation) compared with renewable energy. The abatement potentials and marginal abatement cost curves developed in this study can further be used as a crucial component in an integrated model to design optimized cost-efficient control policies.

Zhang, Fenfen, et al. "Estimation of abatement potentials and costs of air pollution emissions in China." Journal of Environmental Management 260 (2020): 110069.

Production and consumption-based primary PM2.5 emissions: Empirical analysis from China's interprovincial trade

Cross-regional trade activities not only facilitate the exchange of products but trigger the transfer of pollutants. In this study, China's production-based PM2.5 emissions were estimated by compiling sectoral resolution PM2.5 emission inventories. Integrated with a multiregional input-output model, the consumption-based PM2.5 emissions from 30 provinces in 2012 were calculated. Only approximately 14% of the PM2.5 emissions were induced by consumers' direct usage, while 86% of the emissions were triggered by upstreaming production processes, as quantified by simulation in the structural path analysis model. For specific sectors, 'other services' play an important role in direct usage, while 'nonmetal products', 'petroleum refining', 'metallurgy', 'coal mining' and 'chemical industry' are the dominant PM2.5 emission sectors in subsequent supply chains, which has implications for optimization of the industrial structure as well as for improving energy utilization efficiency to a reasonable level for production processes. Furthermore, this study investigated consumption-based PM2.5 emissions transfer from original to destination provinces, which varied from 9%~84%. Most of the consumption PM2.5 emissions dominant provinces located in east coastal of China, outsourcing PM2.5 emissions to Central and Western China, such as Inner Mongolia, Shanxi, Guizhou and Hebei, each accounted for more than 50% of their total PM2.5 emissions. In addition, all provinces except Xinjiang present spatial connections with surrounding provinces through close trade cooperation. The findings of this research provide a solid foundation for identifying different provinces' responsibility for air pollutant control and proposing insightful observations to help policymakers to formulate associated cross-regional PM2.5 emissions reduction and control measures.

Zheng, Hanzhong, and Linyu Xu. "Production and consumption-based primary PM2. 5 emissions: Empirical analysis from China's interprovincial trade." Resources, Conservation and Recycling 155 (2020): 104661.

Biomass Burning & Household Energy

Description: This section includes articles primarily addressing SLCP measures and innovations related to the household energy initiative, open burning of agricultural residue, and SLCP emissions in relevant sectors. Solid waste burning is covered in the waste section.

Characterization of emissions from a pilot-scale combustor operating on coal blended with woody biomass

Emissions generated from the combustion of coal have been a subject of regulation by the United States Environmental Protection Agency (U.S. EPA) and State agencies for years, as they have been associated with adverse effects on human health and the environment. Over the past several decades, regulations on these facility emissions have become more stringent and have therefore caused industry to look toward new pre- and post-combustion control technologies. In more recent years, there has been a “push” toward renewable and cleaner burning alternative fuels as replacements for traditional fossil fuels. Part of this “push” has been accomplished by States and Regions offering incentives and options for renewable portfolios, which over half of the states now have in some form.

The current study investigates the potential changes in both gaseous and particulate emissions from the use of a variety of woody biomass materials as a drop-in replacement for coal as compared to use of 100% bituminous coal. Four different biomass materials are blended individually with coal at 20% and 40% by mass for testing on the U.S. EPA’s Multi-Pollutant Control Research Facility, a pilot-scale coal-fired facility located in Research Triangle Park, North Carolina. Emissions are calculated based on measurements from the flue gas to characterize gaseous species (CO, CO2, NOX, SO2, other acid gases, and several organic hazardous air pollutants) as well as fine and ultrafine particulate (mass, size distribution, number count, elemental carbon, organic carbon, and black carbon) and compared among each combination of fuels and 100% bituminous coal.

Yelverton, Tiffany LB, et al. "Characterization of emissions from a pilot-scale combustor operating on coal blended with woody biomass." Fuel 264 (2020): 116774.

Kitchen concentrations of fine particulate matter and particle number concentration in households using biomass cookstoves in rural Honduras

Cooking and heating with solid fuels results in high levels of household air pollutants, including particulate matter (PM); however, limited data exist for size fractions smaller than PM2.5 (diameter less than 2.5 µm). We collected 24-h time-resolved measurements of PM2.5 (n = 27) and particle number concentrations (PNC, average diameter 10–700 nm) (n = 44; 24 with paired PM2.5 and PNC) in homes with wood-burning traditional and Justa (i.e., with an engineered combustion chamber and chimney) cookstoves in rural Honduras.

The median 24-h PM2.5 concentration (n = 27) was 79 µg/m3 (interquartile range [IQR]: 44–174 µg/m3); traditional (n = 15): 130 µg/m3 (IQR: 48–250 µg/m3); Justa (n = 12): 66 µg/m3 (IQR: 44–97 µg/m3). The median 24-h PNC (n = 44) was 8.5 × 104 particles (pt)/cm3 (IQR: 3.8 × 104–1.8 × 105 pt/cm3); traditional (n = 27): 1.3 × 105 pt/cm3 (IQR: 3.3 × 104–2.0 × 105 pt/cm3); Justa (n = 17): 6.3 × 104 pt/cm3 (IQR: 4.0 × 104–1.2 × 105 pt/cm3). The 24-h average PM2.5 and particle number concentrations were correlated for the full sample of cookstoves (n = 24, Spearman ρ: 0.83); correlations between PM2.5 and PNC were higher in traditional stove kitchens (n = 12, ρ: 0.93) than in Justa stove kitchens (n = 12, ρ: 0.67). The 24-h average concentrations of PM2.5 and PNC were also correlated with the maximum average concentrations during shorter-term averaging windows of one-, five-, 15-, and 60-min, respectively (Spearman ρ: PM2.5 [0.65, 0.85, 0.82, 0.71], PNC [0.74, 0.86, 0.88, 0.86]).

Given the moderate correlations observed between 24-h PM2.5 and PNC and between 24-h and the shorter-term averaging windows within size fractions, investigators may need to consider cost-effectiveness and information gained by measuring both size fractions for the study objective. Further evaluations of other stove and fuel combinations are needed.

Benka-Coker, Megan L., et al. "Kitchen concentrations of fine particulate matter and particle number

concentration in households using biomass cookstoves in rural Honduras." Environmental Pollution 258 (2020): 113697.

Agriculture and Livestock

Description: This section includes articles primarily addressing SLCP measures and innovations related to the Agriculture initiative and SLCP emissions in relevant sectors

Ericaceous species reduce methane emissions in sheep and red deer: Respiration chamber measurements and predictions at the scale of European heathlands

greenhouse gas and the significant contribution from ruminant enteric fermentation on methane emissions at a global scale, little effort has been made to consider the influence that different plant-based natural diets have on methane emissions in grazing systems. Heathland is an ericaceous dwarf-shrub-dominated habitat widespread across the northern hemisphere, in Europe, provides valuable ecosystem services in areas with poor soils, such as water flow regulation, land-based carbon skin, energy reservoir and habitat of key game species. We (i) measured methane emissions from red deer (Cervus elaphus) and sheep (Ovis aries) fed mixed diets of natural grass plus ericaceous species (either Calluna vulgaris or Vaccinium myrtillus) using open-circuit respiration chambers; and (ii) modelled the results to estimate methane emissions from red deer and sheep populations inhabiting heathland habitats across Europe under different scenarios of grass-based mixed diets with varying proportions of ericaceous species. Our results indicated that methane emissions per unit of digestible organic matter intake decreased as the proportion of ericaceous species in diet increased, but this relationship was complex because of the significant interaction between the proportion of ericaceous species in the diet and digestible organic matter intake. According to our estimates red deer and sheep populations across European heathlands produce 129.7 kt·y−1 methane (se = 1.79) based on a hypothetical grass-ericaceous species mixed diet containing 30% of ericaceous species; this is 0.5% of total methane emissions from human activity across Europe (24,755 kt·y−1), and a reduction in methane emissions of 63.8 kt·y−1 against the same deer and sheep populations, if assumed to consume a grass-only diet. We suggest the implementation of carbon credits as a measure to value the relevance of heathland systems to promote biodiversity and its potential contribution to reduce methane emissions in ruminant grazing systems.

Pérez-Barbería, Francisco Javier, et al. "Ericaceous species reduce methane emissions in sheep and red deer: Respiration chamber measurements and predictions at the scale of European heathlands." Science of The Total Environment 714 (2020): 136738.

Conversion of winter flooded rice paddy planting to rice-wheat rotation decreased methane emissions during the rice-growing seasons

To our knowledge, the conversion of winter flooded rice paddy (RF) to rice-wheat rotation (RW) has markedly decreased methane (CH4) emissions during the wheat-growing seasons. However, the effects of this conversion on CH4 emissions during the rice-growing seasons are unclear. To determine CH4 emissions during the rice-growing season and associated environmental factors under RF and RW systems, a split-plot design experiment was conducted in three RF fields in hilly areas of Sichuan province, China. One-half of each field was converted to RW, and the other half remained RF. Each plot of RW and RF was further divided into four subplots: three subplots for conventional nitrogen fertilization treatment (RW-CN and RF-CN) and one for unfertilized treatment (RW-NN and RF-NN). The study showed that the cumulative CH4 emissions from RW-CN during the rice-growing seasons were 192.77 ± 11.36 and 302.07 ± 28.34 kg C ha−1 in 2013 and 2014, respectively, which were decreased by 26.8% and 24.3% as compared to that from RF-CN. While for RW-NN, the cumulative CH4 emissions decreased by 54.1% and 24.0% as compared to that from RF-NN (372.49 ± 67.05 and 300.53 ± 13.49 kg C ha−1 in 2013 and 2014, respectively, $P < 0.05$). A higher Q10 (soil temperature sensitivity coefficient) of CH4 emissions during the whole experiment period was observed for RW-CN (6.69) than that for RF-CN (4.48). With rising soil temperature during the rice-growing seasons, the CH4 emissions for RW-CN escalated more rapidly

than that for RF-CN. As expected, a positive correlation between CH4 fluxes and soil dissolved organic carbon (DOC) for both RF-CN and RW-CN was observed and DOC in RF-CN during the rice-growing seasons were higher than RW-CN. The soil dissolved inorganic nitrogen (DIN) was negatively correlated to CH4 emissions as the soil temperature ranged 22℃– 28℃. Moreover, rice yields in the RF-CN and RW-CN treatments were similar in both years of 2013 and 2014. These findings suggested that CH4 emissions were primarily controlled by soil environment, which was affected by water and fertilizer managements. The implication of this study is that the decreased CH4 emissions and increased crop yields could be achieved by conversion management from RF to RW.

Xu, Peng, et al. "Conversion of winter flooded rice paddy planting to rice-wheat rotation decreased methane emissions during the rice-growing seasons." Soil and Tillage Research 198 (2020): 104490.

Methane production and estimation from livestock husbandry: A mechanistic understanding and emerging mitigation options

Globally, livestock is an important contributor to methane (CH4) emissions. This paper reviewed the various CH4 measurement and estimation techniques and mitigation approaches for the livestock sector. Two approaches for enteric livestock CH4 emission estimation are the top-down and bottom-up. The combination of both could further improve our understanding of enteric CH4 emission and possible mitigation measures. We discuss three mitigation approaches: reducing emissions, avoiding emissions, and enhancing the removal of emissions from livestock. Dietary management, livestock management, and breeding management are viable reducing emissions pathways. Dietary manipulation is easily applicable and can bring an immediate response. Economic incentive policies can help the livestock farmers to opt for diet, breeding, and livestock management mitigation approaches. Carbon pricing creates a better option to achieve reduction targets in a given period. A combination of carbon pricing, feeding management, breeding management, and livestock management is more feasible and sustainable CH4 emissions mitigation strategy rather than a single approach.

Kumari, Shilpi, et al. "Methane production and estimation from livestock husbandry: A mechanistic understanding and emerging mitigation options." Science of The Total Environment (2019): 136135.

Cable bacteria reduce methane emissions from rice-vegetated soils

Methane is the second most important greenhouse gas after carbon dioxide and approximately 11% of the global anthropogenic methane emissions originate from rice fields. Sulfate amendment is a mitigation strategy to reduce methane emissions from rice fields because sulfate reducers and methanogens compete for the same substrates. Cable bacteria are filamentous bacteria known to increase sulfate levels via electrogenic sulfide oxidation. Here we show that one-time inoculation of rice-vegetated soil pots with cable bacteria increases the sulfate inventory 5-fold, which leads to the reduction of methane emissions by 93%, compared to control pots lacking cable bacteria. Promoting cable bacteria in rice fields by enrichment or sensible management may thus become a strategy to reduce anthropogenic methane emissions.

Scholz, Vincent V., et al. "Cable bacteria reduce methane emissions from rice-vegetated soils." Nature communications 11.1 (2020): 1-5.

Transportation

Description: This section includes articles primarily addressing SLCP measures and innovations related to the Diesel initiative and SLCP emissions in relevant sectors

Emission inventory for on-road traffic fleets in Greater Yangon, Myanmar

On-road traffic emissions of Greater Yangon in 2015 were estimated using IVE model. Local surveys revealed the engine technology distributions, driving activities and flows for the fleets of bus, personal car (PC), pickup (PU),

taxi, van and light duty truck. Vehicles in Greater Yangon were relatively new but recent use of leaded gasoline caused deactivation of catalytic converters that bring about high emission factors (EFs) of CO, VOC and NOx from gasoline-powered vehicles. Pre-Euro diesel-powered buses and trucks were high PM emitters while pre-Euro and Euro1 gasoline vehicles were high emitters of CO and VOC. Composite EFs of CO and VOC were the highest for PU (45.1 and 3.2 g/km, respectively) followed by taxi (34.2 and 2.6 g/km, respectively). CNG vehicles with their small number and low EFs contributed the least to total on-road traffic emissions. The bus fleet, despite being diesel-powered at only 28%, still had the highest EFs of PM and NOx, 1.6 and 2.7 g/km, respectively. Total emissions for 2015 (base case) in Greater Yangon from six surveyed fleets and the motorcycle fleet of CO; VOC; NOx; PM; BC; OC; CO2; CH4 and air toxics, in Gg/year, were 358; 41; 24; 3.8; 1.6; 0.9; 5358, 6.8 and 3.1, respectively. If all vehicles in this domain at least comply with Euro3 standard, the collective emission reduction from the base case of the air pollutants would be 71% while that of GWP (GHGs and short-lived climate pollutants) 43%, hence showing significant potential co-benefits.

Huy, Lai Nguyen, et al. "Emission Inventory for On-road Traffic Fleets in Greater Yangon, Myanmar." Atmospheric Pollution Research (2019): https://doi.org/10.1016/j.apr.2019.12.021

Quantifying the air quality and health benefits of greening freight movements

Commercial vehicle movements have a large effect on traffic-related air pollution in metropolitan areas. In the Greater Toronto and Hamilton Area (GTHA), commercial vehicles include large and medium diesel trucks as well as light-duty gasoline-fuelled trucks. In this study, the emissions of various air pollutants associated with diesel commercial vehicles were estimated and their impacts on urban air quality, population exposure, and public health were quantified. Using data on diesel trucks in the GTHA and a chemical transport model at a spatial resolution of 1 km2, the contribution of commercial diesel movements to air quality was estimated. This contribution amounts to about 6–22% of the mean population exposure to nitrogen dioxide (NO2) and black carbon (BC), depending on the municipality, but is systematically lower than 3% for fine particulate matter (PM2.5) and ozone (O3). Using a comparative risk assessment approach, we estimated that the emissions of all diesel commercial vehicles within the GTHA are responsible for an annual total of at least 9810 Years of Life Lost (YLL), corresponding to $3.2 billion of annual social costs. We also assessed the impact of decreasing freeway-sourced diesel emissions along Highway 401, one of the busiest highways in North America. This is comparable with a removal of 250 to 1000 diesel trucks per day along that corridor, which could be replaced by alternative technologies. The mean NO2 and BC exposures of the population living within 500 m of the highway would decrease by 9% and 11%, respectively, with reductions as high as 22%. Such a measure would save 1310 YLL annually, equivalent to $428 million in social benefits.

Minet, Laura, et al. "Quantifying the air quality and health benefits of greening freight movements." Environmental Research 183 (2020): 109193.

Air pollution & Health Impacts

Description: This section includes articles primarily addressing linkages between air pollution exposure and health impacts

The association between long-term fine particulate air pollution and life expectancy in China, 2013 to 2017

China is experiencing one of the worst air quality problems in the world. China implemented the Air Pollution Prevention and Control Action Plan (APPCAP) and the air quality has recently achieved remarkable improvement.

To evaluate the associations of variations in annual fine particulate matter (PM2.5) levels and changes in life expectancy in Chinese urban populations from 2013 to 2017.

We collected annual-average concentrations of PM2.5 and average life expectancy of urban residents in 214 cities from 2013 to 2017. We conducted a longitudinal panel analysis applying linear mixed-effect models to

evaluate the association between PM2.5 reduction and life expectancy increase with and without adjustment for socioeconomic and medical-care confounders.

The nationwide-average annual PM2.5 concentrations decreased from 67.78 μg/m3 in 2013 to 45.25 μg/m3 in 2017; meanwhile, the average life expectancy of urban residents increased from 78.53 to 79.86 years. A decrease of 10 μg/m3 in PM2.5 was associated with an increment of 0.18 (95% confidence interval: 0.06, 0.30) year in life expectancy. After simultaneously adjusting for GDP per capita, smoking prevalence, urbanization rate and maternal mortality, the association turned to be insignificant at the national level, but remained significant in the eastern region with life expectancy gained 0.16 (95% CI: 0.04, 0.27) year per 10 μg/m3 reduction of PM2.5.

Lower PM2.5 air pollution might be associated with extended life expectancy in east of China. The implementation of APPCAP during 2013 to 2017 might have resulted in benefits on life expectancy, especially in east of China.

Wu, Yihan, et al. "The association between long-term fine particulate air pollution and life expectancy in China, 2013 to 2017. "Science of The Total Environment (2020): 136507.

Cause and Age-specific premature mortality attributable to PM2.5 Exposure: An analysis for Million-Plus Indian cities

In India, a majority population is exposed to high levels of ambient PM2.5 resulting in adverse health outcomes. Epidemiological studies have associated diseases such as Ischemic Heart Disease (IHD), Cerebrovascular Disease (Stroke), Chronic Obstructive Pulmonary Disease (COPD), Lower Respiratory Infection (LRI), and Lung Cancer (LNC) to long-term PM2.5 exposure resulting in premature mortality. In the present work, the Integrated Exposure Response (IER) model is used to estimate such premature deaths for the year 2016 in 29 million-plus Indian cities. The city-specific registered deaths data along with information of percent share of cause-specific deaths in the total deaths and measured ambient PM2.5 concentrations are used to estimate cause-specific baseline mortality in a city. The premature mortality attributable to PM2.5 exposure is estimated from this baseline mortality. The premature mortality burden attributable to PM2.5 exposure in these cities is 114,700 (104,100–125,500) deaths from the five causes (IHD, Stroke, COPD, LRI, and LNC). IHD is the leading cause of death accounting for 58% of PM2.5 related premature deaths, followed by Stroke (22%), COPD (14%), LRI (4%), and LNC (2%) in these 29 cities. The estimated number of PM2.5 related deaths in productive age group (25 – 50 years) is quite low compared to older people, but the percentage share of these deaths in the cumulative cause-specific baseline deaths is higher for productive age group. Thus, the productive population is considerably at a higher risk of mortality due to PM2.5 exposure. There is approximately 18% and 70% reduction in premature mortality if these cities can attain National Ambient Air Quality Standards (NAAQS) (40 μg/m3) and the World Health Organization (WHO) guidelines (10 μg/m3) of annual PM2.5, respectively. The estimates of air pollution related mortality at the city level could assist in city-specific policy formulation for better air pollution control.

Saini, Prateek, and Mukesh Sharma. "Cause and Age-specific premature mortality attributable to PM2. 5 Exposure: An analysis for Million-Plus Indian cities." Science of The Total Environment 710 (2020): 135230.

Source country-specific burden on health due to high concentrations of PM2.5

Asian countries face frequent spikes in concentrations of particulate matter smaller than 2.5 μm (PM2.5), which may consist of domestic emissions, transported pollutants from neighboring countries, and secondary aerosol formation (SAF). We aimed to estimate the burden on health in South Korea due to PM2.5 exposure from source countries. We computed the health benefits of meeting air quality guidelines during high pollution periods or spike periods. We used daily mortality counts, PM2.5 concentrations, and primary and secondary contributions to pollutant levels in seven cities and nine provinces in South Korea during 2006–2016. Generalized additive mixed modeling with a Poisson distribution and random effects in 16 regions was used to examine the short-term effects of PM2.5 on mortality. We computed attributable burden due to PM2.5 exposure and the potential benefits of meeting the air quality guidelines set by the World Health Organization (WHO, 25 μg/m3) and the Korea Ministry of Environment (50 and 35 μg/m3 before and after 2015, respectively). A concentration–

response curve showed a non-linear relationship between daily mortality counts and PM2.5 levels. The short-term health impacts of PM2.5 were suggested to be 1638 non-accidental deaths in 2016 in South Korea due to daily domestic emissions and pollutants transported from neighboring countries. Of these, 1509, 995, or 238 deaths could have been prevented if the daily mean PM2.5 concentration had been kept below 25, 35, or 50 µg/m3. After accounting for the contribution of SAF to PM2.5, primary sources of PM2.5 resulted in 258–860 and 26–88 deaths due to pollution transported from China and North Korea, respectively, and 162–538 deaths were due to domestic emissions. Meeting the air quality guidelines of the WHO could have prevented most of these deaths.

Lim, Youn-Hee, et al. "Source country-specific burden on health due to high concentrations of PM2. 5." Environmental Research 182 (2020): 109085.

Health effects of PM2.5 sources on children's allergic and respiratory symptoms in Fukuoka, Japan

Exposure to fine particulate matter (PM2.5) is a potential aggravating factor for respiratory and allergic diseases. However, which PM2.5 sources are associated with such diseases remains unclear. This study aimed to investigate the association of PM2.5 sources with allergic and respiratory symptoms in schoolchildren. PM2.5 samples were collected in Fukuoka during the spring in 2014 and 2015. Asian dust was observed in 2014. Ion components, elemental components, and organic components were analyzed. Positive matrix factorization (PMF) was conducted to calculate PM2.5 concentrations from each source. Mixed logistic regression analysis with a random intercept for each schoolchild was performed to evaluate the association of components and sources with symptoms. Among 2317 schoolchildren, the mean prevalence was 28.9%, 23.6%, 11.2%, and 11.4% for lower respiratory, nasal, ocular, and skin symptoms, respectively. PMF identified the following six PM2.5 sources “Secondary sulfate and coal combustion”, “Secondary nitrate”, “Heavy oil combustion”, “Sea salt”, “Soil” and “Traffic emission”. An interquartile range of PM2.5 mass was associated with nasal (Odds ratios 1.08, 95% confidence interval [1.03, 1.13]), ocular (1.10, [1.04, 1.16]), and skin symptoms (1.13, [1.06, 1.20]). Among the source factors, “Heavy oil combustion” was significantly associated with nasal symptom (1.11, [1.05, 1.18]) while “Sea salt” was associated with nasal (1.06, [1.02, 1.11]) and skin (1.073, [1.01, 1.14]) symptoms. We found “Soil”, which might be affected by Asian dust, was associated with ocular (1.07, [1.03, 1.10]) and skin (1.05, [1.01, 1.08]) symptoms. Further studies in other seasons or places are needed to clarify the influence of PM2.5 sources on children's health.

Sugiyama, Taichi, et al. "Health effects of PM2. 5 sources on children's allergic and respiratory symptoms in Fukuoka, Japan." Science of The Total Environment 709 (2020): 136023.

Evaluating the impact of PM2.5 atmospheric pollution on population mortality in an urbanized valley in the American tropics

There is enough scientific evidence indicating a relationship between particulate matter in ambient air and health. Since at a global scale there is an important number of people exposed to this pollutant, studies have focused on evaluating its possible effects on human population. Aburrá Valley Metropolitan Area (AMVA), in Antioquia-Colombia, is a region with about 3,909,729 inhabitants (2018), where 79% of PM2.5 present in the atmosphere is emitted by motor vehicles, with 1534 ton/year (AMVA, 2018). In the last decade, monitoring stations have reached daily mean concentrations of 113 µg/m3, which is 226% in excess of the maximum permissible daily level established at 50 µg/m3 by Colombian regulations (AMVA 2016; MinAmbiente, 2017). The object of the study was to evaluate the impact of PM2.5 concentrations in cases of premature mortality of urban population. To this end, the BenMap-CE v.1.1 model was used, together with Krewski et al. (2009) Health Impact functions to evaluate associations with adult mortality (>30 years of age) due to All Causes (AC)—including natural and non-natural—(ICD-10: A00-Y98), Ischemic Heart Disease (IHD) (ICD-10: I20–I25) and LungCancer (LC) (ICD-10: C34); and Woodruff et al. (2006) functions to explore associations with child mortality (population 0–1 year of age) due to All Causes (AC)—including natural and non-natural. Health impact was evaluated for year 2016 (baseline) and estimated for 2020 and 2030, from annual mean concentrations reported and projected by the environmental authority. The study was carried out based on annual mean mortality rates reported for the period 2007–2016. Among the most relevant results, it was found that for 2016 the areas with

the highest annual concentrations of PM2.5 were Medellín (downtown area), Caldas, and Medellín (northern area) (39.4 µg/m3, 33.7 µg/m3, and 33.2 µg/m3, respectively). Consequently, health impact estimations (mortality due to all causes in adults) showed the highest associations: 15.70% (676 cases; CI: 470.29–873.06), 12.90% (32 cases; CI: 22.04–41.34) and 12.63% (736 cases; CI: 508.65–954.76), respectively.

Aguiar-Gil, David, et al. "Evaluating the impact of PM2. 5 atmospheric pollution on population mortality in an urbanized valley in the American tropics." Atmospheric Environment 224 (2020): 117343.

Diabetes Minimally Mediated the Association Between PM2.5 Air Pollution and Kidney Outcomes

Epidemiologic observations suggest that exposure to ambient fine particulate matter (PM2.5) is associated with increased risk of chronic kidney disease (CKD) and diabetes, a causal driver of CKD. We evaluated whether diabetes mediates the association between PM2.5 and CKD. A cohort of 2,444,157 United States veterans were followed over a median 8.5 years. Environmental Protection Agency data provided PM2.5 exposure levels. Regression models assessed associations and their proportion mediated. A 10 µg/m3 increase in PM2.5 was associated with increased odds of having a diabetes diagnosis (odds ratio: 1.18, 95% CI: 1.06–1.32), use of diabetes medication (1.22, 1.07–1.39), and increased risk of incident eGFR <60 ml/min/1.73 m2 (hazard ratio:1.20, 95% CI: 1.13–1.29), incident CKD (1.28, 1.18–1.39), ⩾30% decline in eGFR (1.23, 1.15–1.33), and end-stage renal disease (ESRD) or ⩾50% decline in eGFR (1.17, 1.05–1.30). Diabetes mediated 4.7% (4.3–5.7%) of the association of PM2.5 with incident eGFR <60 ml/min/1.73 m2, 4.8% (4.2–5.8%) with incident CKD, 5.8% (5.0–7.0%) with ⩾30% decline in eGFR, and 17.0% (13.1–20.4%) with ESRD or ⩾50% decline in eGFR. Diabetes minimally mediated the association between PM2.5 and kidney outcomes. The findings will help inform more accurate estimates of the burden of diabetes and burden of kidney disease attributable to PM2.5 pollution.

Bowe, Benjamin, et al. "Diabetes Minimally Mediated the Association Between PM 2.5 Air Pollution and Kidney Outcomes." Scientific reports 10.1 (2020): 1-9.

Urban Air Pollution & Megacities

Description: This section includes articles addressing PM2.5 and air pollution source apportionment, impacts and emissions trends.

Investigating the impacts of coal-fired power plants on ambient PM2.5 by a combination of a chemical transport model and receptor model

Aimed at evaluating the impacts of coal-fired power plants on urban air quality and human health, a one-month intensive observation campaign was conducted in a typical polluted city located in the 2 + 26 city cluster (Beijing, Tianjin and 26 other cities) of the North China Plain in December 2017. The observation results illustrated that the coal-fired power plant in this city increased the monthly average fine particulate matter (PM2.5) concentration by ~5% at the city scale. The impacts differed under various diffusion conditions. A three-dimensional nested air quality condition model (the Nested Air Quality Perdition Model System or NAQPMS) with source apportionment was employed to analyze the impacts. The results indicated that power plants had the largest effect on regional air quality during the severe-pollution period, while any influence could be ignored during periods with excellent dissipation under robust winds. PM2.5 contributed by the power plant mainly occurred below 150 m, diffused 100 km away, and reached a level of approximately 5 µg m−3 during the light-pollution period. During the accumulation period, the plume reached a height of 500 m, diffused to the downwind area approximately 100 km away within half a day, and contributed at most 40 µg m−3 to PM2.5. The affected area expanded to 250 km during the severe-pollution period, and the contribution to PM2.5 was at least 10 µg m−3 at different distances. The affected height reached approximately 500 m, with PM2.5 exceeding 10 µg m−3, mainly constrained below 150 m. Overall, regional integrated control strategies should be implemented for the power plants in the 2 + 26 city cluster during pollution episodes to further improve air quality.

Chen, Xi, et al. "Investigating the impacts of coal-fired power plants on ambient PM2. 5 by a combination of a chemical transport model and receptor model." Science of The Total Environment (2020): 138407.

Monitoring history and change trends of ambient air quality in China during the past four decades

This study summarized the history of ambient air quality monitoring and air pollution prevention and control, and it analyzed the spatiotemporal patterns of ambient air pollutants during 1981–2017 in China. The results showed that monitoring of ambient air quality has changed dramatically in terms of determinants, sampling methods, monitoring extent, and evaluation basis during the previous four decades. Annual average concentrations of total suspended particulates, PM10 and SO2 have shown obvious decreasing trends during the studied period. These improvements have been closely related to the considerable efforts and various approaches undertaken to prevent and control air pollution. However, although policy implementation has been decisive and, at least in part, it has been enforced effectively, significant challenges remain. Air pollution control cannot be accomplished without a long-term strategy designed to achieve clean air in all parts of China.

Zhang, Fengying, et al. "Monitoring history and change trends of ambient air quality in China during the past four decades." Journal of Environmental Management 260 (2020): 110031.

Satellite-derived spatiotemporal PM2.5 concentrations and variations from 2006 to 2017 in China

The PM2.5 concentration is an important evaluation index for the global Sustainable Development Goals (SDGs) for its negative impacts on human health. Last decade, several fine particulate pollution episodes occurred in the vast area of China. In response to this, the Chinese government has stepped up efforts to tackle air pollution. In this paper, the temporal trends of PM2.5 and the quantitative potential impact of environmental governance on PM2.5 are analyzed for China. Due to the lack of historical records, a two-stage model was used to estimate the historical PM2.5 concentrations, combined with the newly released satellite-based aerosol optical depth (AOD) product (MODIS Collection 6.1) and other data. The estimated PM2.5 concentrations showed strong consistency with the surface observations. Furthermore, significant seasonal variations existed in the PM2.5 concentrations and the temporal trends were captured, especially in city clusters. Then eight major city clusters were selected as typical samples. All the city clusters showed decrease trends in recent years, with PM2.5 concentrations in these regions decreased by 0.269–1.604 μg m−3 year−1. From 2006 to 2017, the annual PM2.5 concentrations decreased by 7.83%–26.35% in the major city clusters among China. Technological innovation and environmental governance play an important role in the decrease of PM2.5. In order to quantify the influence of governance, environmental regulation intensity and synergy were applied as the indicators of the internal governance and co-governance in each city cluster. In most city clusters, PM2.5 concentrations were significantly negatively correlated with regional internal governance and co-governance ($R = -0.596$ to -0.930, $p < 0.05$), and the effect on PM2.5 lasted for several years. However, 1- to 2-year lagged effect was found for governance, which means that the regulatory measures should be enhanced to decrease PM2.5 in the future to achieve the SDGs in China.

Xue, Wenhao, et al. "Satellite-derived spatiotemporal PM2. 5 concentrations and variations from 2006 to 2017 in China." Science of The Total Environment 712 (2020): 134577.

SLCPs & Vulnerable Regions

Description: This section includes articles addressing SLCP impacts on vulnerable regions or studies discussing the specific vulnerabilities of regions to SLCPs.

Critical contribution of south Asian residential emissions to atmospheric black carbon over the Tibetan plateau

Black carbon (BC) over the Tibetan Plateau (TP), both in the air and deposited on the surface of snow and ice, has been shown to accelerate the retreat of mountain glaciers. Previous study indicated that South Asian

anthropogenic emissions primarily contributed to atmospheric loading of BC over the TP, it is essential to further identify the major sector in South Asia and provide guidance for potential mitigation strategies. In this study, the regional atmospheric chemistry model WRF-Chem was run for an entire year. The results suggested that residential BC emissions from South Asia contributed the largest (25.8% in summer and 44.8% in winter) to BC concentrations over the TP compared to other anthropogenic emission sectors in the region. Furthermore, significant seasonal variability existed in the transport process of residential BC from South Asia to the TP. The South Asia monsoon during summer and the mountain-valley wind system during spring could transport South Asian residential BC across the Himalayas to the TP. However, the higher transportation flux along 30°N indicated that the transport was mainly influenced by westerly winds, implying that residential emissions from northern India were the critical source of BC aerosols over the TP. A further assessment of emission control strategies suggested that reducing emissions from South Asian residential sources can effectively reduce BC concentrations over the TP, which may potentially alleviate the TP's accelerating glacier melting.

Yang, Junhua, Shichang Kang, and Zhenming Ji. "Critical contribution of south Asian residential emissions to atmospheric black carbon over the Tibetan plateau." Science of The Total Environment 709 (2020): 135923.

Yearlong first measurements of black carbon in the western Indian Himalaya: Influences of meteorology and fire emissions

Measurements of equivalent black carbon (EBC) aerosols are presented for the first time from a high-altitude station Ranichauri (30°18′ N, 78°24′ E; 2200 m amsl) in the lesser Himalaya during January-December 2016. The influences of meteorology, fire emissions and transport, on [EBC] variations have been investigated here. The daily mean values of [EBC] are observed to vary from 0.04 ± 0.03 µgm−3 to 7.83 ± 2.66 µgm−3 with peak during April. A significant enhancement in [EBC] is observed towards the end of April, reaching the levels as high as 23.95 µgm−3 and attributed to fire emissions. Diurnal variations are suppressed with typically lower [EBC] levels during the summer monsoon (0.42 ± 0.25 µg m−3 in July) due to the transport of marine air mass and scavenging. On a seasonal basis, the average [EBC] levels are found to be higher during winter (2.72 ± 1.86 µgm−3) and pre-monsoon (2.56 ± 1.80 µg m−3), and lowest during the summer monsoon (0.89 ± 01.03 µg m−3).Our measurements in conjunction with the analysis of model meteorology (Era Interim reanalysis) show profound effects of boundary layer dynamics on EBC concentrations. Wintertime [EBC] maximum is suggested to be due to confinement of regional anthropogenic emissions in shallow boundary layer. In addition, transport from the North-West, and Western regions, characterized by wood-burning and fossil fuel combustion, also affected [EBC] the variations here, except during the summer monsoon.

Pandey, Chhavi P., et al. "Yearlong first measurements of black carbon in the western Indian Himalaya: Influences of meteorology and fire emissions." Atmospheric Pollution Research (2020): https://doi.org/10.1016/j.apr.2020.04.015