SHORT-LIVED CLIMATE POLLUTANTS SPECIAL EDITION RESEARCH DIGEST

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CLIMATE & CLEAN AIR COALITION

TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

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SLCP

Description: This is a cross-cutting section which includes articles which specifically focus on SLCPs as a category of emissions and/or measures

Short-lived climate forcers have long-term climate impacts via the carbon–climate feedback

Short-lived climate forcers (SLCFs) like methane, ozone and aerosols have a shorter atmospheric lifetime than CO2 and are often assumed to have a short-term effect on the climate system: should their emissions cease, so would their radiative forcing (RF). However, via their climate impact, SLCFs can affect carbon sinks and atmospheric CO2, causing additional climate change. Here, we use a compact Earth system model to attribute CO2 RF to direct CO2 emissions and to climate–carbon feedbacks since the pre-industrial era. We estimate the climate–carbon feedback contributed 93 ± 50 mW m−2 (~5%) to total RF of CO2 in 2010. Of this, SLCF impacts were −13 ± 50 mW m−2, made up of cooling (−115 ± 43 mW m−2) and warming (102 ± 26 mW m−2) terms that largely cancel. This study illustrates the long-term impact that short-lived species have on climate and indicates that past (and future) change in atmospheric CO2 cannot be attributed only to CO2 emissions.

Fu, Bo, et al. "Short-lived climate forcers have long-term climate impacts via the carbon–climate feedback." Nature Climate Change (2020): 1-5.

Delayed emergence of a global temperature response after emission mitigation

A major step towards achieving the goals of the Paris agreement would be a measurable change in the evolution of global warming in response to mitigation of anthropogenic emissions. The inertia and internal variability of the climate system, however, will delay the emergence of a discernible response even to strong, sustained mitigation. Here, we investigate when we could expect a significant change in the evolution of global mean surface temperature after strong mitigation of individual climate forcers. Anthropogenic CO2 has the highest potential for a rapidly measurable influence, combined with long term benefits, but the required mitigation is very strong. Black Carbon (BC) mitigation could be rapidly discernible, but has a low net gain in the longer term. Methane mitigation combines rapid effects on surface temperature with long term effects. For other gases or aerosols, even fully removing anthropogenic emissions is unlikely to have a discernible impact before mid-century.

Samset, B. H., J. S. Fuglestvedt, and M. T. Lund. "Delayed emergence of a global temperature response after emission mitigation." Nature communications 11.1 (2020): 1-10.

Multiple Benefits/Impacts & Crosscutting

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

Co-benefit potential of urban CO2 and air quality monitoring: A study on the first mobile campaign and building monitoring experiments in Seoul during the winter

For the first time, mobile campaign and building monitoring experiments were conducted in downtown Seoul, Korea during the 2018/2019 winter period to assess the possibility of the co-benefit of CO2 emission reduction and air quality improvement. Given that CO2 and air pollutants in cities both originate from fossil fuel combustion, monitoring urban CO2 concentrations using a mobile vehicle and from the top of tall buildings can be a potentially effective approach for diagnosing the air quality. The local enhancement values (△species) related to urban emission sources were estimated by eliminating baseline concentrations. The results obtained showed high correlation coefficients between △CO2 and △air pollutants (i.e., 0.753, 0.505, and 0.525 for △CO, △NOX, and △NO2), confirming the applicability of CO2 as an indicator of air pollutant sources in downtown Seoul. The evaluation of the air quality in the study area using air pollutant ratios, including the ratios of CO and NOX/NO2, relative to CO2 showed that the ratios of △CO, △NOX, and △NO2 relative to △CO2 were 5.76, 1.89,

and 0.21 ppb ppm−1. The estimated △NO2/△NOX ratio (11%) and a comparison of the △NOX/△CO2 ratios obtained with those reported for other cities in different countries suggested the possibility of a relationship between the current air quality in downtown Seoul and the use of diesel vehicles. Results suggest that the development of municipal policies aimed at mitigating climate change should consider the co-benefit of air quality improvement so as to ensure the effective reduction of CO2 and air pollutant emissions.

Sim, Sojung, et al. "Co-benefit potential of urban CO2 and air quality monitoring: A study on the first mobile campaign and building monitoring experiments in Seoul during the winter." Atmospheric Pollution Research (2020).

Long-term variation in CO2 emissions with implications for the interannual trend in PM2.5 over the last decade in Beijing, China

Long-term CO2 and PM2.5 measurements in urban areas have important impacts on understanding the roles of urbanization in climate change and air pollution. From 2009 to 2017, CO2 fluxes were measured by the eddy covariance (EC) system at a height of 140 m on the Beijing Meteorological Tower. The CO2 fluxes followed a typical two-peak diurnal pattern all year round. The PM2.5 concentrations followed a similar diurnal pattern as the CO2 fluxes in summer but a different diurnal pattern in winter (low in the day and high at night). On a seasonal time scale, both the CO2 fluxes and the PM2.5 concentrations showed a pronounced seasonal variation (high in winter and low in summer). The spatial variations in CO2 fluxes were dominated by the prevailing land use types within the flux footprint, particularly dense residential areas and heavy traffic roads. On both diurnal and annual time scales, the urban underlying surface was a net source of CO2. The 9-year average annual total CO2 flux was 36.4 kg CO2·m−2 yr−1. Depending on the yearly prevailing wind direction, the effect of the heterogeneity correction on the annual total CO2 fluxes based on the gap-filled dataset could reach up to 3.5%. Over the 9-year period, both the CO2 fluxes and the PM2.5 concentrations exhibited a declining interannual trend, and CO2 fluxes could account for 64% of the interannual variability in PM2.5 concentrations. In summer, emissions were more likely to control the interannual variability in PM2.5 concentrations, whereas in winter, meteorological conditions had a greater impact on the interannual variability in PM2.5 concentrations.

Liu, Zan, et al. "Long-term variation in CO2 emissions with implications for the interannual trend in PM2. 5 over the last decade in Beijing, China." Environmental Pollution 266 (2020): 115014.

Public Health and Climate Benefits and Tradeoffs of U.S. Vehicle Electrification

Vehicle electrification is a common climate change mitigation strategy, with policymakers invoking co-beneficial reductions in carbon dioxide (CO2) and air pollutant emissions. However, while previous studies of U.S. electric vehicle (EV) adoption consistently predict CO2 mitigation benefits, air quality outcomes are equivocal and depend on policies assessed and experimental parameters. We analyze climate and health co-benefits and tradeoffs of six U.S. EV adoption scenarios: 25% or 75% replacement of conventional internal combustion engine (ICE) vehicles, each under three different EV-charging energy generation scenarios. We transfer emissions from tailpipe to power generation plant, simulate interactions of atmospheric chemistry and meteorology using the GFDL-AM4 chemistry climate model, and assess health consequences and uncertainties using the U.S. EPA Benefits Mapping Analysis Program Community Edition (BenMAP-CE). We find that 25% U.S. EV adoption, with added energy demand sourced from the present-day electric grid, annually results in a ~242M ton reduction in CO2 emissions, 437 deaths avoided due to PM2.5 reductions (95% CI: 295, 578), and 98 deaths avoided due to lesser ozone formation (95% CI: 33, 162). Despite some regions experiencing adverse health outcomes, ~$16.8B in damages avoided are predicted. Peak CO2 reductions and health benefits occur with 75% EV adoption and increased emission-free energy sources (~$70B in damages avoided). When charging-electricity from aggressive EV adoption is combustion-only, adverse health outcomes increase substantially, highlighting the importance of low-to-zero emission power generation for greater realization of health co-benefits. Our results provide a more nuanced understanding of the transportation sector's climate change mitigation-health impact relationship.

Peters, D. R., et al. "Public Health and Climate Benefits and Tradeoffs of US Vehicle Electrification." GeoHealth:

e2020GH000275.

Methane

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

China's CH4 emissions from coal mining: A review of current bottom-up inventories

As the world's largest CH4 emitter, China's CH4 emissions contribute to climate change more than the amount emitted by many developed countries combined. The rapid growth of China's coal demand has important implications for CH4 emissions from coal mining or coal mine methane (CMM) emissions. This paper aims to present an overview of bottom-up estimation of China's CMM emissions, including the trend in the last four decades and the limitations of current understanding on CH4 emissions. Although characterized by significant differences in inventory compilation, statistically, the total CMM emissions rose from 4.64 to 16.41 Tg with a peak of 21.48 Tg from 1980 to 2016. Large discrepancies of inventory results existed in previous studies, which were affected by the coverage of emission sources, emission factors and activity-level data. The disagreements can be largely attributable to the emission factors of underground mining, which contain substantial variances in both spatial and temporal dimensions. To develop more reliable CMM inventories and make targeted mitigation measures, more attention should be paid to the transparency of the estimated results, coal statistics, on-site CMM emission factors, and the emissions from abandoned coal mines. As the leading CH4 emission source in China, the estimations of CMM emissions urgently need to overcome existing and emerging challenges for compiling a consistent and accurate inventory.

Gao, Junlian, ChengHe Guan, and Bo Zhang. "China's CH4 emissions from coal mining: A review of current bottom-up inventories." Science of The Total Environment (2020): 138295.

Marginal methane emission estimation from the natural gas system

A new cause-based approach was used to estimate the change in methane emissions from the natural gas system resulting from a change in throughput. The analysis builds upon prior work (Mac Kinnon et al., 2018) positing that a cause-based, marginal approach to estimating methane emission impacts of reducing or increasing natural gas use was more accurate than assuming that methane emission vary one-for-one with throughput. The goal of this work is to determine the relationship between methane emissions and changes in throughput both over short time horizons where the gas infrastructure is fixed and over time periods where system expansion (or retirement) and technological improvements via component replacement occur. The results show that methane emissions change with throughput but the relative change in emissions is less than the relative change in throughput. There are many components (emissions sources) in the natural gas system that emit the same amount of methane to the atmosphere regardless of their operational mode; meaning some emissions sources have no or only partial dependence on throughput. As a result, reducing natural gas consumption in the future will not yield a directly proportional reduction in the methane emissions. It is believed that the results of this study will help energy policymakers to understand better the effect of policies aimed at reducing natural gas use on greenhouse gas (GHG) emissions and where such policies should be applied (e.g. system operator or end user).

Heydarzadeh, Zahra, et al. "Marginal methane emission estimation from the natural gas system." Applied Energy 277 (2020): 115572.

Invited Review: Methane sources, quantification, and mitigation in grazing beef systems

The purpose of the review was to examine enteric methane emissions, quantification methods, and mitigation strategies in grazing beef systems. Peer-reviewed literature and conference abstracts were the main sources of information for this review. Methane emissions (CH4) can be reduced by improving forage quality by including more cool-season forages and legumes and rotationally grazing animals. Including forages with beneficial

secondary compounds such as condensed tannins and saponins also has CH4-mitigation potential. Providing nutritional supplements that improve the nutritional status of the animal and the efficiency of feed energy use has the potential to reduce CH4 emissions from grazing cattle. Genetic selection has shown some viability in reducing herd emissions, but heritability estimates are low for CH4 yield. More research is needed to understand the potential. Soil methanotrophy may partially offset CH4 emissions when animals are stocked moderately but soil CH4 uptake rates are relatively low in most grazing ecosystems. A new metric to quantify the global warming potential of CH4, GWP*, may allow future models to more appropriately consider the behavior and effects of CH4 in the atmosphere. Methane mitigation strategies in grazing environments are limited, but producer decisions that improve the nutritional status of animals, the quality of the forage base, and supplementation of known CH4-mitigation compounds can reduce CH4 production. Now that less expensive, easier to use quantification tools exist, researchers need to conduct more long-term monitoring experiments and focus on reducing CH4 production of grazing animals where potential for reduction is largest.

Thompson, L. R., and J. E. Rowntree. "Invited Review: Methane sources, quantification, and mitigation in grazing beef systems." Applied Animal Science 36.4 (2020): 556-573.

Black Carbon

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

Long-term (2008–2017) analysis of atmospheric composite aerosol and black carbon radiative forcing over a semi-arid region in southern India: Model results and ground measurement

To achieve an in-depth understanding of radiative forcing due to aerosols is a crucial challenge for climate change studies. The first-ever long-term measurement of direct shortwave composite and black carbon aerosol radiative properties over a semi-arid region, Anantapur, in southern India is presented. Long-term variations in Aerosol Optical Depth (AOD) and Black Carbon (BC) mass concentration from December 2007 to November 2017 are discussed with specific emphasis on intra-seasonal variation in aerosol optical properties, meteorology, transport pathways, and their implications for direct short wave radiative forcing over Anantapur. The intra-seasonal mean AOD showed strong seasonal dependence with the highest (0.47 ± 0.03) during summer and lowest (0.28 ± 0.03) during the monsoon. Meanwhile, the intra-seasonal mean (±) BC mass concentration was about 3.57 ± 0.45, 2.60 ± 0.58, 1.22 ± 0.18 and 2.24 ± 0.28 μg m−3 during winter, summer, monsoon and post-monsoon respectively. Furthermore, there is an obvious temporal variation in intra-seasonal BC mass concentration during the dry season (winter and summer). To be more specific, the intra-seasonal mean (±) BC mass concentration before 2012 (after 2012) during the dry season was about 3.37 ± 0.7 μg m−3 (2.80 ± 0.58 μg m−3), respectively. Concentration weighted trajectory analyses (CWT) revealed that the air masses originated from the continental and polluted environments located in the central and northern parts of India (except monsoon), in regulating BC mass concentration over measurement location. Further, Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) derived aerosol vertical extinction profiles (532 nm) showed that majority aerosols (>250 Mm−1) are confined within 2 km from the surface during winter while in summer particles are distributed throughout the profile (~6 km) with extinction coefficient varying between 200 and 250 Mm−1. The Santa Barbara Discrete Ordinate Radiative Transfer (SBDART) model estimated intra-seasonal mean direct shortwave composite aerosol radiative forcing (DARF) in the atmosphere (ATM) was about 31.13 ± 3.36, 34.82 ± 3.89, 17.10 ± 1.15, and 17.44 ± 1.81 Wm-2 during winter, summer, monsoon and post-monsoon, respectively. The positive signs of ATM forcing in all seasons indicate a warming of the atmosphere, and the corresponding heating rate was around a factor of two higher during the dry season (0.92 ± 0.12 Kday−1) than the wet season (monsoon and post-monsoon) (0.49 ± 0.04 Kday−1). The intra-seasonal mean BC forcing in ATM before 2012 (After 2012) during the dry season was about 24.14 ± 2.85Wm-2(20.09 ± 2.59Wm-2), respectively. The contribution of BC alone to the composite forcing during the study period over the station was ~68%. These findings would be helpful for regional climate studies and making air pollution control policy over the region.

Kalluri, Raja Obul Reddy, et al. "Long-term (2008–2017) analysis of atmospheric composite aerosol and black carbon radiative forcing over a semi-arid region in southern India: Model results and ground measurement."

Atmospheric Environment (2020): 117840.

Tropospheric Ozone

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

Examining the relationship of tropospheric ozone and climate change on crop productivity using the multivariate panel data techniques

Home to one-fourth of the world's population and ranked amongst the fastest growing economies, the South Asian countries are marred with the predicament of inexorable pollution. Amidst the growing pollutants, ground-level ozone has become an important component in understanding health, and productivity of agricultural crops. In this regard spatio-temporal analysis of tropospheric ozone for wheat, rice and cotton crops was carried out. Followed-up with a multivariate regression model; establishing a statistical relationship between tropospheric ozone (TO) and crop productivity. The results indicate that predominantly ozone is increasing, with a significant trend visible in all crop growing seasons. Observations indicate higher concentrations of TO in the rice & cotton growing seasons, with a seasonal average of 68 ppb, compared to wheat growing season (55 ppb). Regression results specify that with an increase of 1% in tropospheric ozone concentration within the study area; crop productivity decreases for cotton (−4.0%), rice (−2.3%), and wheat (−0.7%). Furthermore, with the presence of the dominant tropospheric ozone in the regression model, the temperature's impact on productivity becomes statistically inconsequential.

Mahmood, Fatimah, Muhammad Fahim Khokhar, and Zafar Mahmood. "Examining the relationship of tropospheric ozone and climate change on crop productivity using the multivariate panel data techniques." Journal of Environmental Management 272 (2020): 111024.

Historical total ozone radiative forcing derived from CMIP6 simulations

Radiative forcing (RF) time series for total ozone from 1850 up to the present day are calculated based on historical simulations of ozone from 10 climate models contributing to the Coupled Model Intercomparison Project Phase 6 (CMIP6). In addition, RF is calculated for ozone fields prepared as an input for CMIP6 models without chemistry schemes and from a chemical transport model simulation. A radiative kernel for ozone is constructed and used to derive the RF. The ozone RF in 2010 (2005–2014) relative to 1850 is 0.35 W m−2 [0.08–0.61] (5–95% uncertainty range) based on models with both tropospheric and stratospheric chemistry. One of these models has a negative present-day total ozone RF. Excluding this model, the present-day ozone RF increases to 0.39 W m−2 [0.27–0.51] (5–95% uncertainty range). The rest of the models have RF close to or stronger than the RF time series assessed by the Intergovernmental Panel on Climate Change in the fifth assessment report with the primary driver likely being the new precursor emissions used in CMIP6. The rapid adjustments beyond stratospheric temperature are estimated to be weak and thus the RF is a good measure of effective radiative forcing.

Skeie, Ragnhild Bieltvedt, et al. "Historical total ozone radiative forcing derived from CMIP6 simulations." npj Climate and Atmospheric Science 3.1 (2020): 1-10.

Hydrofluorocarbons (HFCs)

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

Updated Global Warming Potentials and Radiative Efficiencies of Halocarbons and Other Weak Atmospheric Absorbers

Human activity has led to increased atmospheric concentrations of many gases, including halocarbons, and may lead to emissions of many more gases. Many of these gases are, on a per molecule basis, powerful greenhouse gases, although at present-day concentrations their climate effect is in the so-called weak limit (i.e., their effect scales linearly with concentration). We published a comprehensive review of the radiative efficiencies (RE) and global warming potentials (GWP) for around 200 such compounds in 2013 (Hodnebrog et al., 2013, https://doi.org/10.1002/rog.20013). Here we present updated RE and GWP values for compounds where experimental infrared absorption spectra are available. Updated numbers are based on a revised "Pinnock curve", which gives RE as a function of wave number, and now also accounts for stratospheric temperature adjustment (Shine & Myhre, 2020, https://doi.org/10.1029/2019MS001951). Further updates include the implementation of around 500 absorption spectra additional to those in the 2013 review and new atmospheric lifetimes from the literature (mainly from WMO (2019)). In total, values for 60 of the compounds previously assessed are based on additional absorption spectra, and 42 compounds have REs which differ by >10% from our previous assessment. New RE calculations are presented for more than 400 compounds in addition to the previously assessed compounds, and GWP calculations are presented for a total of around 250 compounds. Present-day radiative forcing due to halocarbons and other weak absorbers is 0.38 [0.33–0.43] W m−2, compared to 0.36 [0.32–0.40] W m−2 in IPCC AR5 (Myhre et al., 2013, https://doi.org/10.1017/CBO9781107415324.018), which is about 18% of the current CO2 forcing.

Hodnebrog, Ø., et al. "Updated global warming potentials and radiative efficiencies of halocarbons and other weak atmospheric absorbers." Reviews of Geophysics (2020): e2019RG000691.

Electricity savings and greenhouse gas emission reductions from global phase-down of hydrofluorocarbons

Hydrofluorocarbons (HFCs) are widely used as cooling agents in refrigeration and air conditioning, as solvents in industrial processes, as fire extinguishing agents, for foam blowing and as aerosol propellants. They have been the primary substitutes for ozone-depleting substances regulated under the Montreal Protocol (MP). However, HFCs are potent greenhouse gases (GHGs) and as such subject to global phase-down under the Kigali Amendment (KA) to the MP. In this study, we develop a range of long-term scenarios for HFC emissions under varying degrees of stringency in climate policy and assess co-benefits in the form of electricity savings and associated reductions in GHG and air pollutant emissions. Due to technical opportunities to improve energy efficiency in cooling technologies during the phase-down of HFCs, there exist potentials for significant electricity savings under a well-managed phase-down of HFCs. Our results show that annual pre-KA baseline emissions of HFCs are expected to increase from almost 0.5 to about 4.3 Gt CO2eq between 2005 and 2050 and reach between 6.2 and 6.8 Gt CO2eq in 2100. The growth is driven by a strong increase in demand for refrigeration and air conditioning services, which in turn is driven by an expected increase in per capita wealth in developing countries and a warmer future climate. We estimate that full compliance with KA means cumulative global HFC emissions that are 87 % lower than in the pre-KA baseline between 2018 and 2100. Also, the opportunity to simultaneously improve energy efficiency in stationary cooling technologies during such a transition could bring about additional climate benefits of about the same magnitude as that attributed to the phase-down of HFCs. If technical energy efficiency improvements are fully implemented, the resulting electricity savings could exceed a fifth of future global electricity consumption. Together with an HFC phase-down, this means preventing between 390 and 640 Gt CO2 equivalent of GHG emissions between 2018 and 2100, thereby making a significant contribution towards keeping the global temperature rise below 2 °C. Reduced electricity consumption also means lower air pollution emissions in the power sector, estimated at about 10 % for SO2, 16 % for NOx and 9 % for PM2.5 emissions, compared with a pre-KA baseline.

Purohit, Pallav, et al. "Electricity savings and greenhouse gas emission reductions from global phase-down of hydrofluorocarbons." Atmospheric Chemistry and Physics Discussions (2020): 1-38.

Socio-Economic Impacts

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

The political economy of air pollution: Local development, sustainability, and political incentives in China

Political promotion can be seen as the most important career incentive for officials in China. With an emphasis on GDP, the Chinese central government made promoting economic growth the main performance evaluation criterion for Party secretaries. On the contrary, this kind of regional competition among Party secretaries raises the possibility that the central government can motivate Party secretaries to pay more attention to environmental issues. In late 2007, the central government advocated a scientific concept of green development, and the traditional performance evaluation criterion for Party secretaries has been gradually replaced by the Green GDP evaluation criterion. The paper aims to discuss the impact of promotion incentive on air pollution with a panel dataset of 152 Party secretaries across 30 Chinese provinces from 2000 to 2017. We present evidence that the Green GDP evaluation criterion has put Party secretaries under much more pressure to mitigate the side effect of economic growth after 2007. This finding further implies that the effect to constrain the air pollution by promoting or demoting Party secretaries on the basis of Green GDP evaluation criterion is likely to diminish on their second term. That is a perceived tendency of second terms called 'second-term' curse. Therefore, the government must strictly enforce environmental laws and regulations, explore the means to establish and implement a lifelong liability system for major decisions and a retrospective mechanism to hold people accountable for wrong decisions.

Zheng, Wei, and Pei Chen. "The political economy of air pollution: Local development, sustainability, and political incentives in China." Energy Research & Social Science 69 (2020): 101707.

PM2.5 pollution-related health effects and willingness to pay for improved air quality: Evidence from China's prefecture-level cities

The public health risks attributed to PM2.5 pollution exposure are far greater in China than in many other countries. Few studies have focused on the potential impact of PM2.5 pollution on respondents' self-rated health, physical health, and mental health. Using an instrumental variable model and constructing instrumental variables of ventilation coefficients, this study analyzes 2011, 2013, and 2015 data from the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative sample of adults over 45 years of age. By matching the health data with the PM2.5 data in 272 prefecture-level cities, this study examines the impact of PM2.5 pollution on public health and measures the marginal cost (MC) of PM2.5 reduction. Empirical results show that PM2.5 can significantly lower self-rated health and increase the probability of chronic diseases and mental depression. Using the marginal rate of transformation between income and PM2.5, the results show residents, on average, are willing to pay 869 Yuan for reduced PM2.5. Moreover, respondents' gender, age, education level, and locality significantly affect PM2.5 pollution-related health and the MC for clean air. Specifically, MC levels in males are higher than those in females; people aged over 60 show the highest MC levels; the respondents who are less educated are willing to pay more for pollution mitigation; and residents living in Eastern China have a greater MC for PM2.5 pollution control. We further propose several important recommendations for policy-makers based on our results, which offer new evidence to mitigate PM2.5 pollution in China.

Zhang, Bingbing, Beibei Wu, and Jing Liu. "PM2. 5 pollution-related Health Effects and Willingness to Pay for Improved Air Quality: Evidence from China's Prefecture-level Cities." Journal of Cleaner Production (2020): 122876.

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.

Household air pollution exposure and associations with household characteristics among biomass cookstove users in Puno, Peru

Household air pollution (HAP) from combustion of biomass fuel, such as wood and animal dung, is among the leading environmental risk factors for preventable disease. Close to half of the world's population relies on biomass cookstoves for their daily cooking needs. Understanding factors that affect HAP can inform measures to maximize the effectiveness of cookstove interventions in a cost-effective manner. However, the impact of kitchen and household characteristics, as well as the presence of secondary stoves, on HAP concentrations is poorly understood in Puno, Peru. To explore how household characteristics explain variability of kitchen area concentrations and personal exposures to CO, PM2.5 and BC from biomass cookstoves among women in rural Peru. Household characteristics (including kitchen materials and layout, wealth, and cooking behaviors) and HAP measurements were collected from 180 households in Puno, Peru, from baseline measurements of a randomized trial. Kitchen area concentrations and personal exposures to carbon monoxide (CO), fine particulate matter (PM2.5) and black carbon (BC) were sampled for 48 h. We implemented simple and multivariable linear regression models to determine the associations between household characteristics and both kitchen area concentration and personal exposure to each pollutant. Mean daily kitchen area concentrations and personal exposures to HAP were, on average, 48 times above World Health Organization indoor guidelines for PM2.5. We found that roof type explained the most variability in HAP and was strongly associated with both kitchen area concentrations and personal exposures for all pollutants after adjusting for other household variables. Personal exposures were 27%–36% lower for PM2.5, CO and BC, in households with corrugated metal roofs, compared to roofs made of natural materials (straw, totora or reed) after adjusting for other factors. Higher kitchen area concentrations were also associated with less wealth, owning more animals, or sampling during the dry season in multivariable models. Having a liquefied petroleum gas (LPG) stove and having a chimney were associated with lower personal exposures, but were not associated with kitchen area concentrations. Personal exposures were lower by 21% for PM2.5 and 28% for CO and BC concentrations among participants who had both LPG and biomass stoves compared to those with only biomass cookstoves adjusting for other household factors. Characterizing HAP within different settings can help identify effective and culturally-relevant solutions to reduce HAP exposures. We found that housing roof type is strongly related to kitchen area concentrations and personal exposures to HAP, perhaps because of greater ventilation in kitchens with metal roofs compared to those with thatch roofs. Although HAP concentrations remained above guidelines for all households, promoting use of metal roof materials and LPG stoves may be actionable interventions that can help reduce exposures to HAP in high-altitude rural Peru and similar settings.

Fandiño-Del-Rio, Magdalena, et al. "HOUSEHOLD AIR POLLUTION EXPOSURE AND ASSOCIATIONS WITH HOUSEHOLD CHARACTERISTICS AMONG BIOMASS COOKSTOVE USERS IN PUNO, PERU." Environmental Research (2020): 110028.

Assessing the role of advanced cooking technologies to mitigate household air pollution in rural areas of Solan, Himachal Pradesh, India

The problem of household air pollution (HAP) due to the use of inefficient cooking devices continues to affect the rural population of India. With the ongoing efforts to improve indoor air quality (IAQ) through intervention of clean cooking options it is imperative to assess these interventions in real world conditions before large scale rollouts. The present study is an attempt to assess the impact of three clean cooking solutions - induction stove (IS), forced draft cookstove (FDC) and a traditional cookstove with hood (TCH) in rural area of Solan, Himachal Pradesh in India. Using a cross-sectional study design mean 24 h kitchen area concentration of PM2.5 and PM1, carbon monoxide (CO) along with cooking time black carbon (BC) were measured. A significant ($p<0.05$) reduction of >70% in mean 24 h and cooking time concentrations of all the pollutants was observed in all three

clean cooking interventions compared to the traditional cookstove. However, in case of IS the reduction in mean 24 h PM2.5 and PM1 concentrations were 72% and 74% respectively which were much lower than nearly 100% reduction in CO and BC. Low cost interventions such as TCH were also found to improve IAQ significantly. However, higher BC fraction in PM in FDC indicated a scope for technological improvement in design of such stoves and a need for integrating BC as a stove performance indicator was also realized. Additionally, a comparative analysis using IAQ data from related studies highlighted the role of kitchen geometry and ambient air quality in causing variation in IAQ. So, for large scale community programs and initiatives that aim to mitigate HAP it is important to have multi-pronged approach that takes into cognizance factors other than cookstove which impact IAQ.

Arora, Pooja, et al. "Assessing the role of advanced cooking technologies to mitigate household air pollution in rural areas of Solan, Himachal Pradesh, India." Environmental Technology & Innovation (2020): 101084.

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

Does grazing management provide opportunities to mitigate methane emissions by ruminants in pastoral ecosystems?

Agriculture, and livestock production in particular, is criticized for being a contributor to global environmental change, including emissions of greenhouse gases (GHG). Methane (CH4) from grazing ruminants accounts for most of livestock's carbon footprint because a large share of them are reared under suboptimal grazing conditions, usually resulting in both low herbage intake and animal performance. Consequently, the CH4 quota attributed to animal maintenance is spread across few or no animal outputs, increasing the CH4 intensity [g CH4/kg live weight (LW) gain or g CH4/kg milk yield]. In this review, the generalized idea relating tropical pastures with low quality and intrinsically higher CH4 intensity is challenged by showing evidence that emissions from animals grazing tropical pastures can equal those of temperate grasses. We demonstrate the medium-to-high mitigation potential of some grazing management strategies to mitigate CH4 emissions from grazing ruminants and stress the predominant role that sward canopy structure (e.g., height) has over animal behavioral responses (e.g., intake rate), daily forage intake and resulting CH4 emissions. From this ecological perspective, we identify a grazing management concept aiming to offer the best sward structure that allows animals to optimize their daily herbage intake, creating opportunities to reduce CH4 intensity. We show the trade-off between animal performance and CH4 intensity, stressing that mitigation is substantial when grazing management is conducted under light-to-moderate intensities and optimize herbage intake and animal performance. We conclude that optimizing LW gain of grazing sheep and cattle to a threshold of 0.14 and 0.7 kg/day, respectively, would dramatically reduce CH4 intensity to approximately 0.2 kg CH4/kg LW gain, as observed in some intensive feeding systems. This could represent a mitigation potential of around 55% for livestock commodities in pasture-based systems. Our results offer new insights to the debate concerning mitigation of environmental impacts of pastoral ecosystems.

Zubieta, Ángel Sánchez, et al. "Does grazing management provide opportunities to mitigate methane emissions by ruminants in pastoral ecosystems?." Science of The Total Environment (2020): 142029.

Dietary mitigation of enteric methane emissions from ruminants: A review of plant tannin mitigation options

Methane gas from livestock production activities is a significant source of greenhouse gas (GHG) emissions which have been shown to influence climate change. New technologies offer a potential to manipulate the rumen biome through genetic selection reducing CH4 production. Methane production may also be mitigated to varying degrees by various dietary intervention strategies. Strategies to reduce GHG emissions need to be developed which increase ruminant production efficiency whereas reducing production of CH4 from cattle, sheep, and goats. Methane emissions may be efficiently mitigated by manipulation of natural ruminal microbiota with

various dietary interventions and animal production efficiency improved. Although some CH4 abatement strategies have shown efficacy in vivo, more research is required to make any of these approaches pertinent to modern animal production systems. The objective of this review is to explain how anti-methanogenic compounds (e.g., plant tannins) affect ruminal microbiota, reduce CH4 emission, and the effects on host responses. Thus, this review provides information relevant to understanding the impact of tannins on methanogenesis, which may provide a cost-effective means to reduce enteric CH4 production and the influence of ruminant animals on global GHG emissions.

Min, Byeng R., et al. "Dietary mitigation of enteric methane emissions from ruminants: A review of plant tannins mitigation options ☆." Animal Nutrition (2020).

Biochar amendment pyrolysed with rice straw increases rice production and mitigates methane emission over successive three years

A sustainable biochar strategies on increasing crop yield and mitigating CH4 emissions over successive years is unknown. Thus, on-site equivalent rice straw biochar-returning (ERSC, biochar at 2.8 t ha−1 annual) were compared with on-site equivalent rice straw- returning (RS, rice straw at 8 t ha−1 annual) and high application rate biochar-returning (RSCH, biochar at 22.5 t ha−1 only in the first year). The RS and RSCH treatments increased rice production by 10.1% and 11.8% on average, respectively. The ERSC treatment continually increased rice production by 8.0%, 1.6% and 7.3% in three successive years. The ERSC treatment had a cumulative effect on the soil nutrients phosphorus (P), potassium (K), and magnesium (Mg), as well as increasing total carbon (TC) and total nitrogen (TN) and continuously reducing the effect of soil available aluminum (Al). The RS treatment significantly promoted CH4 emissions while the ERSC treatment reduced methane emissions by 43%, 31% and 30% and the RSCH treatment reduced methane emissions by 52%, 22% and14% in three successive years. Compared with RSCH, ERSC showed the best long-term stable effect on methane emission mitigation in three successive years. This might result from the fact that fresh biochar promoted anaerobic oxidation of methane. This research gives us scientific evidence that an on-site equivalent rice straw biochar-returning strategy may be a promising method for sustaining rice production and mitigating methane emissions.

Nan, Qiong, et al. "Biochar amendment pyrolysed with rice straw increases rice production and mitigates methane emission over successive three years." Waste Management 118 (2020): 1-8.

Quantifying greenhouse gas emissions from global aquaculture

Global aquaculture makes an important contribution to food security directly (by increasing food availability and accessibility) and indirectly (as a driver of economic development). In order to enable sustainable expansion of aquaculture, we need to understand aquaculture's contribution to global greenhouse gas (GHG) emissions and how it can be mitigated. This study quantifies the global GHG emissions from aquaculture (excluding the farming of aquatic plants), with a focus on using modern, commercial feed formulations for the main species groups and geographic regions. Here we show that global aquaculture accounted for approximately 0.49% of anthropogenic GHG emissions in 2017, which is similar in magnitude to the emissions from sheep production. The modest emissions reflect the low emissions intensity of aquaculture, compared to terrestrial livestock (in particular cattle, sheep and goats), which is due largely to the absence of enteric CH4 in aquaculture, combined with the high fertility and low feed conversion ratios of finfish and shellfish.

MacLeod, Michael J., et al. "Quantifying greenhouse gas emissions from global aquaculture." Scientific reports 10.1 (2020): 1-8.

Transportation

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

Comprehensive analysis of the air quality impacts of switching a marine vessel from diesel fuel to natural gas

New environmental regulations are mandating cleaner fuels and lower emissions from all maritime operations. Natural gas (NG) is a fuel that enables mariners to meet regulations; however, emissions data from maritime operations with natural gas is limited. We measured emissions of criteria, toxic and greenhouse pollutants from a dual-fuel marine engine running either on diesel fuel or NG as well as engine activity and analyzed the impacts on pollutants, health, and climate change. Results showed that particulate matter (PM), black carbon (BC), nitric oxides (NOx), and carbon dioxide (CO2) were reduced by about 93%, 97%, 92%, and 18%, respectively when switching from diesel to NG. Reductions of this magnitude provide a valuable tool for the many port communities struggling with meeting air quality standards. While these pollutants were reduced, formaldehyde (HCHO), carbon monoxide (CO) and methane (CH4) increased several-fold. A health risk assessment of exhaust plume focused on when the vessel was stationary, and at-berth showed the diesel plume increased long-term health risk and the NG plume increased short-term health risk. An analysis of greenhouse gases (GHGs) and BC was performed and revealed that, on a hundred year basis, the whole fuel cycle global warming potential (GWP) per kWh including well-to-tank and exhaust was 50% to few times higher than that of diesel at lower engine loads, but that it was similar at 75% load and lower at higher loads. Mitigation strategies for further reducing pollutants from NG exhaust are discussed and showed potential for reducing short-term health risks and climate impacts.

Peng, Weihan, et al. "Comprehensive Analysis of the Air Quality Impacts of Switching a Marine Vessel from Diesel Fuel to Natural Gas." Environmental Pollution (2020): 115404.

Traffic related PM2.5 air quality: Policy options for developing Pacific Island countries

Traffic related PM2.5 air pollution data remain largely absent in the Pacific Island Countries (PICs). Increased use of second hand cars and inadequate emission control policies may result in harmful levels of roadside PM2.5 concentrations. To bridge the data gap, we monitored roadside PM2.5 concentrations in two of the largest cities in the PIC's, Suva and Lautoka, both of Fiji using high volume air sampler. Daily mean roadside PM2.5 concentrations in Suva and Lautoka cities were reported to be 21.6 ± 13.3 µg/m3 and 67.2 ± 35.2 µg/m3 respectively. In comparison, mean PM2.5 concentration determined at the roadside site in Lautoka city was more than twice the World Health Organisation 24 h mean guideline concentration of 25 µg/m3. Elevated PM2.5 in Lautoka may have serious public health implications. This work investigates existing vehicle emission and importation related polices and approaches in reducing land transport based emissions in the PICs.

Mani, S. A., et al. "Traffic related PM2. 5 air quality: Policy options for developing Pacific Island countries." Transportation Research Part D: Transport and Environment 87 (2020): 102519.

The inharmonious mechanism of CO2, NOx, SO2, and PM2.5 electric vehicle emission reductions in Northern China

Beijing benefits from the promotion of electric vehicles (EVs) in the improvement of road tailpipe emissions; these emissions are caused by internal combustion engine vehicles (ICEVs) and reduce the surrounding environmental quality. When analyzing the electricity grid, upstream emissions of EVs in Beijing can be tracked back to Shanxi and Inner Mongolia. This study investigates the inharmonious mechanism of emission reduction to promote EVs in Beijing and Northern China based on 6 scenarios and 42 real EVs. Because there is a neighbor effect, Beijing only accounts for 34%, 34%, 41%, and 35% of the total CO2, NOx, SO2 and PM2.5 emissions, respectively. Although the local CO2, NOx, and PM2.5 emissions can be easily reduced (as long as the conversion of "coal to gas" plan is realized), it is difficult to achieve emission reductions of NOx and SO2 without increasing the clean electricity generation mix in Shanxi and Inner Mongolia at the total emission level. However, there is still a large reduction potential of EVs themselves due to an increasingly clean electricity mix in Beijing, Shanxi and Inner Mongolia. Beijing local CO2, NOx, SO2 and PM2.5 emissions can be reduced by 86.92%, 98.79%, 99.98% and 99.94%, respectively, and a total reduction of 78.43% of CO2, 93.83% of NOx, 97.85% of SO2 and 99.26% of PM2.5 emissions is possible. Compared with the corresponding ICEV, an EV of 18 kWh/100 km starts to reduce

Beijing local CO2, NOx and PM2.5 emissions in scenario 1, 3 and 1, respectively, while the SO2 emissions cannot be reduced. However, the total CO2, NOx, SO2 and PM2.5 emissions can be reduced in scenario 2, 5, 5, and 1, respectively. A sensitivity analysis shows that the promotion of EVs can reduce Beijing local CO2, NOx, SO2 and PM2.5 emissions by 125.568–238.960 g/km, 0.059–0.113 g/km, −0.00003 - - 0.00007 g/km and 0.034–0.065 g/km, respectively. In addition, the total CO2, NOx, SO2 and PM2.5 reduction in emissions can be 132.883–253.757 g/km, 0.189–0.361 g/km, 0.299–0.569 g/km and 0.053–0.101 g/km, respectively.

Wang, Lei, et al. "The inharmonious mechanism of CO2, NOx, SO2, and PM2. 5 electric vehicle emission reductions in Northern China." Journal of Environmental Management 274 (2020): 111236.

Air pollution & Health Impacts

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

Air quality mitigation in European cities: Status and challenges ahead

Cities are currently at the core of air quality (AQ) improvement. The present work provides an overview of AQ management strategies and outcomes in 10 European cities (Antwerp, Berlin, Dublin, Madrid, Malmö, Milan, Paris, Plovdiv, Prague, Vienna) in 2018, and their evolution since 2013 (same cities, plus Ploiesti and Vilnius), based on first-hand input from AQ managers. The status of AQ mitigation in 2018, and its evolution since 2013, were assessed. While results evidenced that the majority of mitigation strategies targeted road traffic, emerging sources such as inland shipping, construction/demolition and recreational wood burning were identified. Several cities had in 2018 the ambition to continue decreasing air pollution concentrations to meet WHO guidelines, an ambition which had not yet been identified in 2013. Specific needs identified by all of the cities assessed were tools to quantify the effectiveness of mitigation strategies and for cost-benefit analysis, as well as specific and up to date technical guidance on real-world road vehicle emissions. The cities also requested guidance to identify mitigation measures promoting co-benefits, e.g., in terms of AQ, climate change, and noise. Support from administrations at local-regional-national-EU scales, and especially involving local policy-makers early on in the air quality management process, was considered essential. This work provides insight into the drivers of successful/unsuccessful AQ policies as well as on the challenges faced during their implementation. We identify knowledge gaps and provide input to the research and policy-making communities as to specific needs of cities.

Viana, Mar, et al. "Air quality mitigation in European cities: Status and challenges ahead." Environment International 143 (2020): 105907.

Understanding global PM2.5 concentrations and their drivers in recent decades (1998–2016)

The threat of fine particulate matter (PM2.5) is increasing globally. Tackling this issue requires an accurate understanding of its trends and drivers. In this study, global risk regions of PM2.5 concentrations during 1998–2016 were spatiotemporally derived. Time series analysis was conducted in the spatial relationship between PM2.5 and three socio-environmental drivers: population, urban ratio, and vegetation greenness that can cause changes in the concentration of PM2.5. “High Risk” areas were widely distributed in India and China. In India and sub-Saharan Africa, the increased overall population was strongly correlated with PM2.5 concentrations. Urban ratio increased in both developed and developing countries. A “decoupling” phenomenon occurred in developed countries, where urban expansion continued while PM2.5 concentrations decreased. Vegetation greenness and PM2.5 were strongly correlated in High Risk zones. Although urban expansion and population growth generally reduce vegetation greenness, developed countries reduced PM2.5 while maintaining greenness, whereas developing countries increased PM2.5 with decreasing greenness significantly in High Risk regions. Ultimately, economic and national growth should occur without increasing PM2.5 concentrations. Recent cases from Europe and the eastern United States demonstrate that this is possible, depending on the development pathway.

Lim, Chul-Hee, et al. "Understanding global PM2. 5 concentrations and their drivers in recent decades (1998–2016)." Environment International 144 (2020): 106011.

Thirty years of the Clean Air Act Amendments: Impacts on haze in remote regions of the United States (1990–2018)

The Clean Air Act Amendments of 1990 were aimed at reducing major environmental threats in the United States, such as acid rain, urban air pollution, toxic air emissions, and regional haze. To this end, there have been major reductions in anthropogenic gaseous emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx). SO2 and NOx are also major contributors to particulate haze, which affects visibility in both urban and rural environments. The Interagency Monitoring of Protected Visual Environments (IMPROVE) network has tracked trends in haze in remote regions of the United States since the late 1980s by reconstructing total light extinction (bext) from speciated particulate concentrations. Regional trends in bext were examined using aggregated data from individual sites. Regional, annual mean short-term trends analyses (2002–2018) indicated strong reductions in bext associated with reduced SO2 and NOx emissions, especially in the eastern United States (−4.3% yr−1, $p < 0.001$) where haze historically was dominated by sulfate particles. Less improvement occurred in the Intermountain West/Southwest (−0.9% yr−1, $p = 0.03$) and trends were negative but insignificant along the West Coast (−1.5% yr−1, $p = 0.19$). On average, across the continental remote United States, bext has decreased at a rate of −2.8% yr−1 ($p < 0.001$) from 2002 through 2018 and -1.8% yr−1 ($p < 0.001$) from 1992 through 2018. The composition of haze has shifted away from being sulfate-dominated to having higher contributions from carbonaceous and crustal aerosols. This shift points to the success of combined regulatory activities aimed at reducing anthropogenic emissions over the last three decades. As emissions from regulated sources of SO2 and NOx continue to decline, the contributions to haze from unregulated sources, both anthropogenic and natural, such as oil and gas extraction, international sources, biomass burning, and dust, have increased in importance. Reducing haze from these sources would require additional mitigation strategies and resource management plans.

Hand, J. L., et al. "Thirty years of the Clean Air Act Amendments: Impacts on haze in remote regions of the United States (1990–2018)." Atmospheric Environment (2020): 117865.

Thirty years of the Clean Air Act Amendments: Impacts on haze in remote regions of the United States (1990–2018)

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de Jesus, Alma Lorelei, et al. "Two decades of trends in urban particulate matter concentrations across Australia." Environmental Research (2020): 110021.

Ambient particulate matter source apportionment using receptor modelling in European and Central Asia urban areas

This work presents the results of a PM2.5 source apportionment study conducted in urban background sites from 16 European and Asian countries. For some Eastern Europe and Central Asia cities this was the first time that quantitative information on pollution source contributions to ambient particulate matter (PM) has been performed. More than 2200 filters were sampled and analyzed by X-Ray Fluorescence (XRF), Particle-Induced X-Ray Emission (PIXE), and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) to measure the concentrations of chemical elements in fine particles. Samples were also analyzed for the contents of black carbon, elemental carbon, organic carbon, and water-soluble ions. The Positive Matrix Factorization receptor model (EPA PMF 5.0) was used to characterize similarities and heterogeneities in PM2.5 sources and respective contributions in the cities that the number of collected samples exceeded 75. At the end source apportionment was performed in 11 out of the 16 participating cities. Nine major sources were identified to have contributed to PM2.5: biomass burning, secondary sulfates, traffic, fuel oil combustion, industry, coal combustion, soil, salt and "other sources". From the averages of sources contributions, considering 11 cities 16% of PM2.5 was attributed to biomass burning, 15% to secondary sulfates, 13% to traffic, 12% to soil, 8.0% to fuel oil combustion, 5.5% to coal combustion, 1.9% to salt, 0.8% to industry emissions, 5.1% to "other sources" and 23% to unaccounted mass. Characteristic seasonal patterns were identified for each PM2.5 source. Biomass burning in all cities, coal combustion in Krakow/POL, and oil combustion in Belgrade/SRB and Banja Luka/BIH increased in Winter due to the impact of domestic heating, whereas in most cities secondary sulfates reached higher levels in Summer as a consequence of the enhanced photochemical activity. During high pollution days the largest sources of fine particles were biomass burning, traffic and secondary sulfates.

Almeida, S. M., et al. "Ambient particulate matter source apportionment using receptor modelling in European and Central Asia urban areas." Environmental Pollution 266 (2020): 115199.

Effects of atmospheric particulate matter pollution on sleep disorders and sleep duration: a cross-sectional study in the UK biobank

Sleep disorder prevalence exhibited a six-fold relative increase from 2000 to 2010 in the United States. Sleep problems could increase the risk of stroke, cardiovascular disease, diabetes and cancer. Objective short sleep duration is associated with increased mortality. Obesity, smoking and sex differences could influence sleep disorders and sleep duration. The health effects of atmospheric particulate matter (PM) pollution are of great concern. However, a large general population-based study with abundant demographic and lifestyle information is needed to confirm the effect of PM pollution on sleep disorders and sleep duration. Information on PM air pollution, demographics and other related factors was obtained from the UK Biobank. Subjects' characteristics were described as the means and 95% confidence intervals (95% CIs) for continuous variables and counts (percentages) for categorical variables. In the case–control study of sleep disorders, univariate analysis, single-pollutant models and a four-pollutant model with logistic regression were performed to estimate the odds ratio (OR) of the risk factors. For sleep duration, univariate analysis, single-pollutant models and a four-pollutant model with linear regressions were carried out to assess the effect of the factors. Sensitivity analysis was performed by data imputation and study population change. There were 5976 cases and 97,160 controls included in the case–control study of sleep disorders. For sleep duration analysis, most of the participants had environmental PM data, and 457,358 participants were selected. The single-pollutant models showed that the OR of PM2.5 for sleep disorders was 2.39 (95% CI: 1.64–3.48) for every 10 μg/m3 increase. PM2.5 and PM10 reduced sleep duration by 0.14 (95% CI: 0.10–0.18) and 0.12 (95% CI: 0.10–0.14) hours for every 10 μg/m3 increase, respectively. Four-pollutant models showed that the OR of PM2.5 for sleep disorders was 4.42 (95% CI: 2.36–8.26) for every 10 μg/m3 increase. PM10 appeared to reduce sleep duration by 0.09 (95% CI: 0.06–0.12) hours for every 10 μg/m3 increase. The main results showed good robustness after sensitivity analysis. PM2.5 was a risk factor for sleep disorders. PM2.5 and PM10 reduced sleep duration. A reduction in particulate matter exposure may decrease the risk of sleep disorders and improve sleep duration.

Li, Lei, et al. "Effects of atmospheric particulate matter pollution on sleep disorders and sleep duration: a cross-

sectional study in the UK biobank." Sleep Medicine (2020).

Exposure to ambient air pollutants and the onset of dementia in Québec, Canada

Effects of air pollutants are related to oxidative stress which is also linked to the pathogenesis of dementia including Alzheimer's and related diseases. We assessed associations between exposure to air pollutants and the onset of dementia; the association with the distance between residence and major roads was also assessed for the island of Montreal. We created an open cohort of adults aged 65 years and older starting in 2000 and ending in 2012 in the province of Québec, Canada using linked medico-administrative databases. New cases of dementia were defined based on a validated algorithm. Annual residential levels of nitrogen dioxide (NO2) and fine particles (PM2.5) at residential levels were estimated for each year of follow up using estimates based on satellite images and ground air monitoring data. Hazard ratios (HRs) were assessed with Extended (time dependent exposure) Cox models with age as the time axis and stratified for sex, for the annual exposure level at each residential address. Models were adjusted for the calendar year, area-wide social and material deprivation indexes and for NO2 or PM2.5; they were also indirectly adjusted for smoking. 1,807,133 persons (13,242,270 person-years) were followed and 199,826 developed dementia. From models (adjusted for calendar year, social and material deprivation indexes), HRs for an interquartile range (IQR) increase in time-varying exposure to NO2 (IQR 13.26 ppb), PM2.5 (IQR 3.90 µg/m^3), and distance to major roads (IQR 150 m, in Montreal only), were 1.005 (CI 95% 0.994–1.017), 1.016 (CI 95% 1.003–1.028) and 0.969 (CI 95% 0.958–0.980), respectively. Results suggest that the onset of dementia may be related to residential exposure to PM2.5, NO2, and distance to major roads.

Smargiassi, Audrey, et al. "Exposure to ambient air pollutants and the onset of dementia in Québec, Canada." Environmental Research (2020): 109870.

Premature Deaths in Brazil Associated With Long-Term Exposure to PM2.5 From Amazon Fires Between 2016 and 2019

Amazonian deforestation from slash-and-burn practices is a significant contributor to biomass burning within Brazil. Fires emit carbonaceous aerosols that negatively impact human health by increasing fine particulate matter (PM2.5) exposure. These negative effects on health compound the already detrimental climatological and ecological impacts. Despite high biomass burning emissions in Brazil and the international attention drawn by the relaxation of Amazon protections in 2019, little is known about the health impacts from PM2.5 exposure attributable to these fires. We estimate PM2.5-related premature deaths in Brazil associated with biomass burning, focusing on temporal, interannual, and spatial trends. We find that during the fire season of 2019, 4,966 (2,427, 8,340) premature deaths were attributable to fire emissions making up 10% (5, 17) of all PM2.5-related premature deaths in Brazil. Between the 2019 and 2018 seasons, fire emissions increased by 1.37 Tg (1.00, 2.18) or 115% (60, 201), which was responsible for an increase in health impacts of 2,109 (965, 3,623) premature deaths or 74% (54, 98). Biomass burning emissions throughout Brazil contribute significantly to premature deaths, with the largest burning events occurring in northwestern Brazil. The impact of fires on PM2.5-related premature deaths is highest in heavily populated regions despite their fires being 1 to 2 orders of magnitude smaller than the largest burning events. Results from this study characterize the extent to which elevated PM2.5 exposure levels owing to fires affect public health in Brazil and present an additional, public health-focused, support for increased Amazon protections.

Nawaz, M. O., and D. K. Henze. "Premature deaths in Brazil associated with long-term exposure to PM2. 5 from Amazon fires between 2016-2019." GeoHealth (2020): e2020GH000268.

SLCPs & Vulnerable Regions

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

Mass concentration and origin of black carbon in spring snow on glaciers in the Alaska Range

Black carbon (BC) is one of the light-absorbing particles that reduce the albedo of snow surfaces. Snow samples were taken from the surface of three glaciers in the Alaska Range in mid-April 2017. The BC size distribution and concentration were analyzed with a laser-induced incandescence (LII) method. The BC concentration of the snow samples was 1–6 μg L−1 and 0.5–3.1 μg L−1 at a depth of 0–2 cm (surface) and 2–10 cm (subsurface), respectively. These values are comparable to other Arctic areas and are considered to be the Alaskan background level. The BC concentrations are 0.5% of those of insoluble solid particles (ISPs) measured using an electrical sensing zone method. The surface albedo change due to BC and other ISPs concentrations was estimated to be 0.004–0.007 for the snow surface in April. The ablation at the observation sites on Gulkana Glacier would be 1.2% larger in the ablation season due to black carbon deposition. The chemical transport model revealed that 17%–34% of BC originates from biomass burning in Asia and Siberia, and 60% of BC originates from China in this study.

Konya, Keiko, et al. "Mass concentration and origin of black carbon in spring snow on glaciers in the Alaska Range." Polar Science (2020): 100572.

Black carbon pollution in snow and its impact on albedo near the Chilean stations on the Antarctic peninsula: First results

BC can be transported through the atmosphere from low and mid-latitudes to Antarctica, or it can be emitted in the Antarctica in situ. To establish a possible relationship between BC and the human activities in Antarctica, shallow snow samples were taken in four sites from Antarctic peninsula during summer periods (2014–2019): Chilean Base O'Higgins (BO), La Paloma Glacier (LP) (6 km away from BO); Chilean Base Yelcho (BY) and P4 (5 km away from BY). BC concentration in snow samples was determined by using a novel methodology recently developed, published and patented by the authors. The methodology consisted in a filter-based optical transmission method at a wavelength of 880 nm. Results showed that snow from BO presented the highest BC concentration (3395.7 μg kg−1), followed by BY (1309.2 μg kg−1), LP 2016 (745.9 μg kg−1), LP 2015 (233.6 μg kg−1) and finally P4 (179.4 μg kg−1). BC values observed in Antarctic snow were higher than others previously reported in the literature and showed the influence of anthropic activities in the study area, considering that the two highest values of BC concentration in snow were found at sites near the bases. To evaluate the impact of the BC concentrations found in the snow of the study area, snow albedo modeling was performed, using the on-line version of the “Snow, Ice, and Aerosol Radiative” (SNICAR) Model. Modeling outputs exposed that the measured variations in BC content caused large differences in the modeled albedo in the visible range of the spectra, which showed to be more sensitive at lower BC concentrations. These data could help to understand the role of BC in the actual scenario of climate change, in which Antarctica is presented as a very fragile environment that needs to be protected, starting with the management of the activities developed in-situ.

Cereceda-Balic, Francisco, et al. "Black carbon pollution in snow and its impact on albedo near the Chilean stations on the Antarctic peninsula: First results." Science of The Total Environment 743 (2020): 140801.