Short-Lived Climate Pollutants Research Digest

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TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

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Short-Lived Climate Pollutants (SLCPs)

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

Exploring effective short-lived climate pollutant mitigation scenarios by considering synergies and trade-offs of combinations of air pollutant measures and low carbon measures towards the level of the 2 °C target in Asia

This study analyzes emissions pathways and mitigation potentials of greenhouse gases (GHGs), air-pollution and short-lived climate pollutants (SLCPs), while taking mitigation actions for achieving a 2 °C global temperature change limit above pre-industrial levels, so-called "2 °C target." The study evaluates SLCPs (i.e. BC, CH4, tropospheric O3) mitigation scenarios by considering synergies and tradeoffs of various combinations of low-carbon measures and air pollutants control measures. It was found that, even if CO2 emissions pathways in this study are all similar to achieve the 2 °C target, reaching a carbon price at around 400 US$/tCO2eq. in 2050, SLCPs and air pollutants emissions pathways and mitigation potentials are largely influenced by combinations of some key mitigation measures. The maximum mitigation potential reductions of SLCPs (BC, CH4) and air pollutants (NOx, CO, NMVOC, which are precursors of tropospheric O3) in Asia are 89%, 22%, 67%, 37%, and 11% respectively by 2050 compared to the 2010 levels. After considering both direct SLCP reduction effects (i.e. mitigating BC, CH4) and indirect SLCP reduction effects (i.e. mitigating NOx, CO, NMVOC for reducing tropospheric O3 generation and atmospheric CH4 concentration), it can be adjudged that combinations of widespread promotion of renewable energies, drastic electrification in transport, residential and commercial sectors, high biofuel shares in the transport sector, and a certain level of deployment of removal devices would be effective SLCP mitigation scenarios.

Hanaoka, Tatsuya, and Toshihiko Masui. "Exploring effective short-lived climate pollutant mitigation scenarios by considering synergies and trade-offs of combinations of air pollutant measures and low carbon measures towards the level of the 2° C target in Asia." Environmental Pollution (2019): 113650.

Multiple Benefits/Impacts & Crosscutting

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

China's Non-CO2 Greenhouse Gas Emissions: Future Trajectories and Mitigation Options and Potential

Forecasts indicate that China's non-carbon dioxide (CO2) greenhouse gas (GHG) emissions will increase rapidly from the 2014 baseline of 2 billion metric tons of CO2 equivalent (CO2e). Previous studies of the potential for mitigating non-CO2 GHG emissions in China have focused on timeframes through only 2030, or only on certain sectors or gases. This study uses a novel bottom-up end-use model to estimate mitigation of China's non-CO2 GHGs under a Mitigation Scenario whereby today's cost-effective and technologically feasible CO2 and non-CO2 mitigation measures are deployed through 2050. The study determines that future non-CO2 GHG emissions are driven largely by industrial and agricultural sources and that China could reduce those emissions by 47% by 2050 while enabling total GHG emissions to peak by 2023. Except for F-gas mitigation, few national or sectoral policies have focused on reducing non-CO2 GHGs. Policy, market, and other institutional support are needed to realize the cost-effective mitigation potentials identified in this study.

Lin, Jiang, et al. "China's Non-CO 2 Greenhouse Gas Emissions: Future Trajectories and Mitigation Options and Potential." Scientific reports 9.1 (2019): 1-10.

Changes in Anthropogenic PM2.5 and the Resulting Global Climate Effects Under the RCP4.5 and RCP8.5 Scenarios by 2050

Using an aerosolclimate model, we studied the temporal and spatial variations of anthropogenic $PM_{2.5}$ (aerodynamic diameter $\leq$2.5 μm) and coarse particulate matter (CPM; aerodynamic diameter $>$2.5 μm) under Representative Concentration Pathway (RCP) 4.5 and RCP8.5 scenarios from 2014 to 2050. The corresponding radiative forcing and climate responses were also explored. The $PM_{2.5}$ burden decreases over most continents, especially East Asia. The CPM particles increase over northern Asia, North America, and central Africa, in contrast to decrease over most regions of East Asia and North Africa. Relative to 2014, the global annual mean effective radiative forcing due to changes in $PM_{2.5}$ and CPM burden are 1.17 (1.10) and −0.06 (−0.07) W m^{-2} under RCP4.5 (RCP8.5), respectively. The reduction in $PM_{2.5}$ burden leads to apparent warming, especially over high latitudes of the Northern Hemisphere, with global annual mean surface air temperature increasing by 1.25 K under RCP4.5, and 1.22 K under RCP8.5. In contrast, changes in CPM result in apparent cooling over North America and northern Asia, with global annual mean changes in surface air temperature of 0.10 K for both scenarios. The Northern Hemisphere Hadley cell weakens and moves northward due to changes in $PM_{2.5}$ after 2014, whereas the corresponding circulation in the Southern Hemisphere is strengthened, with the Intertropical Convergence Zone shifting to 10°N. Global annual mean precipitation increases by 0.10 mm day^{-1} under both scenarios. Generally, anthropogenic $PM_{2.5}$ contributes significantly to future changes in radiative forcing and climate.

Yang, Dongdong, Hua Zhang, and Jiangnan Li. "Changes in Anthropogenic PM2. 5 and the Resulting Global Climate Effects Under the RCP4. 5 and RCP8. 5 Scenarios by 2050." Earth's Future.

Numerical modeling of ozone damage to plants and its effects on atmospheric CO2 in China

Tropospheric ozone (O3) is known to damage plant cells and suppress leaf photosynthesis, which can further reduce terrestrial carbon uptake and leave more carbon dioxide (CO2) in the atmosphere. While recent studies have assessed the effects of O3 on terrestrial carbon fluxes, the potential impacts on atmospheric CO2 concentrations have not been quantified. Here, we use a regional climate model (RegCM-CHEM4) coupled with the Yale Interactive terrestrial Biosphere model YIBs to estimate the effects of O3 exposure on atmospheric CO2 over China. Compared to simulations without O3 effects, sensitivity experiments with O3 damage show a significant reduction (12.1 ± 4.4%) in the gross primary productivity (GPP), up to 35% in summer. Meanwhile, terrestrial carbon sink is suppressed by 112.2 ± 22.5 Tg C for 2013 at the national level. Strong inhibitions of O3 on carbon fluxes are found in North, Northeast and South Central China, where O3 levels are high. Consequently, we find a significant increase in atmospheric CO2 concentrations due to O3-induced terrestrial carbon sink reduction. The increases of CO2 are more evident in the growing season. The maximum CO2 enhancement reaches as high as 6 ppm in Yunnan and Guizhou provinces. Our assessments indicate that tropospheric O3 has a detrimental impact on plant carbon uptake and leads to more CO2 accumulating in the atmosphere. Such impacts of O3 should be taken into account in global carbon cycle and future climate change.

Xie, Xiaodong, et al. "Numerical modeling of ozone damage to plants and its effects on atmospheric CO2 in China." Atmospheric Environment 217 (2019): 116970.

Reconciling global sustainability targets and local action for food production and climate change mitigation

The Sustainable Development Goals (SDGs) imply country-led implementation. Yet, their achievement depends on sustainability targets compatible across different sectors and scales. Our study examines how the GHG emission intensity of agriculture (EIA) should evolve globally, regionally (Western Europe) and nationally (The Netherlands) under different socioeconomic pathways, so that two major aims of SDGs 2 and 13 (i.e. sufficient food production and climate change mitigation) are achieved simultaneously. Results show that, by 2050, relative to 2010 values, EIA should decrease at all three levels when measured on a product basis (GHG emissions per ton dry matter) and on a land basis (GHG emissions per ha). This indicates that, globally, agriculture should be intensified per unit area, while in Western Europe and even more so in the Netherlands additional emission

reductions require increased production efficiency and lower production volumes. Projected reductions in methane and nitrous oxide emissions from enteric fermentation, manure management and fertilizer application in Dutch agriculture are much higher than what would be achieved through the extrapolation of current trends. Given the high costs of increasing production efficiency further, our analysis indicates the need for significantly more ambitious policy targets and systemic changes, including reduced consumption of animal-sourced food. Besides shedding light on the interaction between climate and agricultural strategies, our analysis illustrates the application of cross-scale thinking in the operationalization of the SDG agenda and underscores the need for concerted action amongst countries.

Gil, Juliana DB, et al. "Reconciling global sustainability targets and local action for food production and climate change mitigation." Global Environmental Change 59 (2019): 101983.

Methane

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

Understanding atmospheric methane sub-seasonal variability over India

Atmospheric methane (CH4) is considered to be one of the most important greenhouse gases due to its increasing atmospheric concentrations and the fact that it has a warming potential 28 times that of atmospheric carbon dioxide (CO2). Over the Indian sub-continent, fluxes and transport both contribute towards CH4 seasonal variability. Its intra-seasonal variability however is more complex as it is additionally influenced by monsoonal activity during the Asian Summer Monsoon (ASM) period. In this study, the intra-seasonal variability of atmospheric CH4 is examined using ground-based observations at two sites located in the Southern Indian Peninsula, Sinhagad (SNG) and Cape Rama (CRI); and outputs from three different model simulations. Both, the ground based observations and multi-model simulations show that the dominant spectral variability of CH4 is coherent with 20–90 day oscillations in the dynamics of the monsoon (termed hereafter as Intra-Seasonal Oscillations, ISOs). The multi-model analysis revealed that CH4 is heavily influenced by advection due to this intra-seasonal variability. The simulations also display a clear northward propagation of CH4 anomalies over India. The co-evolution of CH4, outgoing long wave radiation (to represent convection) and OH radicals (proxy to CH4 sinks) is presented. The study quantifies CH4 variability at intra-seasonal timescales and also its spatial extent. The results suggest that the effect of ISOs on CH4 needs to be considered along with the corresponding observations for future inverse modeling.

Tiwari, Yogesh K., et al. "Understanding atmospheric methane sub-seasonal variability over India." Atmospheric Environment (2019): 117206.

Methane emissions from oil and gas production on the North Slope of Alaska

Recent warming of the Arctic has motivated assessments of methane (CH4) release from the North Slope Region of Alaska (NSRA). This study examines the contributions of thermogenic emissions from the Prudhoe Bay Oil Field (PBOF) to the elevated concentrations of atmospheric CH4 observed across the NSRA. We report high precision atmospheric measurements of CH4 and ethane (C2H6) within and downwind of the PBOF. Biogenic CH4 emissions, due to methanogenic processes within the Arctic tundra, are not co-emitted with C2H6. We show that the thermogenic gas emanating from oil and gas extraction point sources contains on average 1 mol of C2H6 for every 16 mol of CH4. We use a mass balance approach to estimate total emissions of thermogenic CH4 from two days in the summer of 2016 and find 2–5 times greater emissions than the sum of all sources in the PBOF reported to the EPA Greenhouse Gas Reporting Program in 2016. Although higher than reported, these emissions are much smaller than estimates of CH4 emissions from other oil and natural gas production areas in the US, and they make a very small contribution to total CH4 emissions from the North Slope.

Floerchinger, Cody, et al. "Methane emissions from oil and gas production on the North Slope of Alaska." Atmospheric Environment 218 (2019): 116985.

Black Carbon

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

Reducing black carbon emissions from Arctic shipping: Solutions and policy implications

As the most efficient atmospheric particulate matter to absorb visible light among shipping air pollutants, black carbon (BC) can significantly affect the Arctic climate because of its strong effect on reducing snow albedo. Thus, mitigation efforts to curb BC emissions from Arctic shipping have elicited considerable research interest. In this study, we revisit potential technical and operational solutions to reduce BC emission from shipping. Possible barriers to the main solutions that are applicable to Arctic shipping are discussed. We argue that Arctic shipping, which operates in a sensitive region with complicated navigational conditions, can affect the practical performance of BC abatement solutions. On the basis of a comprehensive analysis, this study mainly recommends that 1) combinations of technical and operational solutions are encouraged, but empirical studies are needed to test the effectiveness of those abatement technologies in the Arctic; 2) given the potential costs and average robust BC reduction performance, the switch from heavy fuel oil to distillate fuels should be prioritized for adoption by shipowners; 3) low impact and fuel efficient fishing needs to be introduced for fishing vessels, which are the largest fleet in the Arctic, to improve fishing practices and gears; and 4) regional actions and global cooperation are imperative for the governance of Arctic shipping.

Zhang, Qiang, et al. "Reducing black carbon emissions from Arctic shipping: Solutions and policy implications." Journal of Cleaner Production (2019): 118261.

Analysis of equivalent black carbon multi-year data at an oil pre-treatment plant: Integration with satellite data to identify black carbon transboundary sources

This study analyzes a multi-year dataset of equivalent black carbon (EBC) concentration collected in 2012–2015 by a 7-wavelengths Aethalometer at Centro Olio Val d'Agri (COVA) in southern Italy, which is the largest European oil pre-treatment plant. These data, together with the local air circulation analysis, were used to identify the black carbon (BC) sources in Agri valley, specifically the COVA plant and vehicular traffic. During a limited period of 2012–2013, simultaneous measurements of PM10 concentration were available for comparison with the EBC data, which revealed correlation values of 0.31–0.43 between PM10 and EBC indicating a relevant contribution of BC to particulate matter at the site. On average, EBC/PM10 ratio is 7%, a value equal to that found at an urban-background site in Rome measured during non-rush hours. Moreover, an ad hoc procedure combining EBC data, Hybrid Single-Particle Lagrangian Integrated Trajectory back-trajectories (HYSPLIT), and satellite fire data enabled detection of days affected by the transport of carbonaceous particles. Both Visible Infrared Imaging Radiometer Suite (VIIRS) and Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data were used as input for the algorithm, and the corresponding results were compared and discussed. VIIRS showed a better performance in detecting smaller/cooler hotspots especially in cases of flaring, as observed during flaring events at the COVA plant itself. Application of the procedure suggests that both regional and non-regional biomass burning episodes, which occur mainly during summer, could contribute to the BC load at the site. The approach applied to the case study of the present work can be useful for estimating the relative contributions of local and remote sources of BC.

Castagna, Jessica, et al. "Analysis of equivalent black carbon multi-year data at an oil pre-treatment plant: Integration with satellite data to identify black carbon transboundary sources." Remote Sensing of Environment 235 (2019): 111429.

Atmospheric black carbon concentrations in Mexico

Atmospheric black carbon concentrations were measured at two urban sites (Mexico City and Monterrey), one

suburban site (Juriquilla) and one high-altitude site (Altzomoni) in Mexico during 2015 and part of 2016. Black carbon concentrations were compared against other criteria gases finding a strong correlation with carbon monoxide at the urban sites. The carbon monoxide-black carbon correlation for the Mexico City site is 0.77. Urban sites had an average black carbon concentration of above 2.5 μg m−3, the suburban site 0.75 μg m−3, and the high-altitude site 0.27 μg m−3. Compared to other studies, the average levels are comparable, and the urban and suburban locations showed a trend towards increased atmospheric black carbon concentrations at year end. Other urban places (Guadalajara, Cuernavaca, and Iztapalapa) reported black carbon concentrations, but for less than a year. For the first time, a Latin-American country (Mexico) measured black carbon continuously at several sites for a year applying the same data quality assurance.

Peralta, Oscar, et al. "Atmospheric black carbon concentrations in Mexico." Atmospheric Research 230 (2019): 104626.

Urban black carbon - source apportionment, emissions and long-range transport over the Brahmaputra River Valley

This research investigates whether the vehicular black carbon emissions originated in the North-Eastern city of Guwahati are transported over and in the Brahmaputra River Valley and the Himalayas. The total black carbon was apportioned between the fossil fuel and biomass burning by real-time measurements of black carbon concentrations at two distinct locations having different traffic volumes in 2016–17. The average observed BC concentrations were 20.58, 6.42, 3.50 and 5.29 μg/m3 at the low traffic location and 22.44, 17.14, 9.2 and 16.87 μg/m3 at the high traffic location in winter, pre-monsoon, monsoon and post-monsoon seasons, respectively. Temperature, wind speed, and solar radiation were found to have significant negative correlations with BC concentrations, while relative humidity had positive correlations. It was found that vehicles contributed over 85% of the ambient black carbon at both locations. Black carbon emission from this dominant source was estimated for 2018, which showed that from vehicles it increased to 0.44–0.55 Gg in 2018 from 0.29 to 0.33 Gg in 2011, which may result in the adverse impacts on the eco-sensitive Brahmaputra River Valley and the Himalayas. The transport and deposition of black carbon under different climatic seasons was modelled using HYSPLIT. The results showed that black carbon particulates are being transported and deposited all-round the year in the Himalayas and the surrounding region. Pre-monsoon and monsoon seasons contributed to the largest amounts of deposition, and a clear relation was found between deposition and rainfall. The total BC deposited in the Brahmaputra River Valley and the Himalayas during one year was 22,142.69 kg and 1566.53 kg with average deposition rates of 0.6452 μgm−2 day−1 and 0.0182 μgm−2 day−1, respectively.

Barman, Neeldip, and Sharad Gokhale. "Urban black carbon-source apportionment, emissions and long-range transport over the Brahmaputra River Valley." Science of The Total Environment 693 (2019): 133577.

Tropospheric Ozone

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

Tropospheric ozone over the Indian subcontinent from 2000 to 2015: Data set and simulation using GEOS-Chem chemical transport model

The Indian subcontinent (IS) is a region of increasing economic growth, urbanization, and consequently, anthropogenic emissions, altering tropospheric ozone (O3) over the region with impacts on the lives and health of 1.3 billion people. We have developed a comprehensive data set of the tropospheric O3 for 16 years (2000–2015) for the region between 50-115°E and 0–45°N, focusing on the IS. The data set included available balloon-borne, aircraft, and satellite-based measurements. We used a global three-dimensional chemical transport model, GEOS-Chem, at a 2° × 2.5° resolution to calculate daily tropospheric O3 over the region. The simulated O3 abundances in the boundary layer and lower, mid, and upper troposphere were compared with ozonesonde, aircraft, and satellite observations. The statistical analyses indicate that the model simulated boundary layer and

lower, mid, and upper tropospheric O3 column abundances reasonably well with a mean bias ~1–3 DU in comparison to observations, but within the uncertainties of the observations. The model reproduced the vertical profiles of O3 and CO with a bias of less than 20% over different regions in the IS. The simulated tropospheric column NO2 was higher by a factor of ~1.5 compared to satellite observations. The model reproduced the regional difference in seasonal variations of tropospheric column O3 as observed by the Ozone Monitoring Instrument. We conclude that the CO emissions from the IS are underestimated while those of NOx are overestimated, both by around 20–30%.

David, Liji M., et al. "Tropospheric ozone over the Indian subcontinent from 2000 to 2015: Data set and simulation using GEOS-Chem chemical transport model." Atmospheric Environment 219 (2019): 117039.

Tropospheric ozone pollution reduces the yield of African crops

Northern, Southern and Equatorial Africa have been identified as among the regions most at risk from very high ozone concentrations. Whereas we know that many crop cultivars from Europe, north America and Asia are sensitive to ozone, almost nothing is known about the sensitivity of staple food crops in Africa to the pollutant. In this study cultivars of the African staple food crops, Triticum aestivum (wheat), Eleusine coracana (finger millet), Pennisetum glaucum (pearl millet) and Phaseolus vulgaris (bean) were exposed to an episodic ozone regime in solardomes in order to assess whether African crops are sensitive to ozone pollution. Extensive visible leaf injury due to ozone was shown for many cultivars, indicating high sensitivity to ozone. Reductions in total yield and 1,000-grain weight were found for T. aestivum and P. vulgaris, whereas there was no effect on yield for E. coracana and P. glaucum. There were differences in sensitivity to ozone for different cultivars of an individual crop, indicating that there could be possibilities for either cultivar selection or selective crop breeding to reduce sensitivity of these crops to ozone.

Hayes, Felicity, et al. "Tropospheric ozone pollution reduces the yield of African crops." Journal of Agronomy and Crop Science (2019).

Hydrofluorocarbons (HFCs)

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

Trends in atmospheric HFC-23 (CHF3) and HFC-134a abundances

The Montreal Protocol banned the production of major ozone depleting substances such as chlorofluorocarbons (CFCs) to protect the Earth's ozone layer. The resulting increased production and emissions of CFC-replacement hydrofluorocarbons (HFCs) has caused a dramatic increase in their atmospheric abundances. Although these HFCs do not contribute directly to the depletion of the ozone layer because they contain no chlorine, they are powerful greenhouse gases with large global warming potentials. In January 2019, the Kigali Amendment to the Montreal Protocol came into force to phase out long-lived HFCs. The two most abundant HFCs in the atmosphere, HFC-134a (CF3CH2F) and HFC-23 (CHF3), are measured from orbit by the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS). These measurements will be useful for monitoring the Kigali Amendment to the Montreal Protocol. Analysis of the ACE-FTS measurements provides near-global distributions and confirms the rapid increase in HFC-134a (4.9 ± 0.1 ppt per year) and HFC-23 (0.75 ± 0.02 ppt per year) volume mixing ratios (VMRs).

Fernando, Anton M., Peter F. Bernath, and Christopher D. Boone. "Trends in atmospheric HFC-23 (CHF3) and HFC-134a abundances." Journal of Quantitative Spectroscopy and Radiative Transfer (2019).

Life cycle cost-benefit analysis of refrigerant replacement based on experience from a supermarket project

The Kigali Amendment to the Montreal protocol calls for the phase-down of hydrofluorocarbons (HFC). With natural refrigerant gaining momentum worldwide, it is important to ascertain if the use of natural refrigerant reduce greenhouse gas emissions from refrigeration when the broader energy system in a cost-effective manner is considered. This study employs a generic process chain analysis framework to examine the life cycle costs and benefits of refrigerant replacement. The case study data are collected from a supermarket in China which has recently changed from a R22 system to a R134A-R744 system. There are three key findings from this study. First, the values of the life cycle greenhouse gas abatement costs can be significantly influenced by the costs and emissions due to electricity usage. Under a 15% discount rate, the reference values of the greenhouse gas abatement cost are found to be 207.28 and 1.40 $/t-CO2e with and without the costs and emissions due to electricity use respectively. Next, under the current state of technology development, cost reductions should be prioritised for natural refrigerant based system to become commercially attractive. Last and most important, current natural refrigerant based systems can only be suitable replacement of aging systems and/or systems approaching obsolescence.

Wang, Yabo, et al. "Life cycle cost-benefit analysis of refrigerant replacement based on experience from a supermarket project." Energy 187 (2019): 115918.

Socio-Economic Impacts

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

Socioeconomic factors and regional differences of PM2.5 health risks in China

China is a country with one of the highest concentrations of airborne particulate matter smaller than 2.5 μm (PM2.5) in the world, and it has obvious spatial-distribution characteristics. Areas of concentrated population tend to be regions with higher PM2.5 concentrations, which further aggravate the impact of PM2.5 pollution on population health. Using PM2.5-concentration and socioeconomic data for 225 cities in China in 2015, we adopted a PM2.5-health-risk-assessment method (with simplified calculation) and applied the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model to analyze the effects of socioeconomic factors on PM2.5 health risks. The results showed that: (1) At the national level, the order of contribution degree of each socioeconomic factor in the PM2.5-health-risk and PM2.5-concentration model is consistent. (2) From a regional perspective, in all three regions, the industrial structure is the decisive factor affecting PM2.5 health risks, and reduction of energy intensity increases PM2.5 health risks, but the impact of the total amount of urban central heating on PM2.5 health risks is very low. In the eastern region, the increased urbanization rate and length of highways significantly increase PM2.5 health risks, but the increasing effect of the extent of built-up area is the lowest. In the central region, the increasing effects of the extent of built-up area on PM2.5 health risks are significantly greater than the decreasing effects of the urbanization rate. In the western region, economic development has the least effect on reducing PM2.5 health risks. Our research enriches PM2.5-health-risk theory and provides some theoretical support for PM2.5-health-risk diversity management in China.

Zhang, Zheyu, et al. "Socioeconomic factors and regional differences of PM2. 5 health risks in China." Journal of environmental management 251 (2019): 109564.

Health impacts and cost-benefit analyses of surface O3 and PM2.5 over the U.S. under future climate and emission scenarios

Health impacts of surface ozone (O3) and fine particulate matter (PM2.5) are of major concern worldwide. In this work, the Environmental Benefits Mapping and Analysis Program tool is applied to estimate the health and

economic impacts of projected changes in O3 and PM2.5 in the U.S. in future (2046–2055) decade relative to current (2001–2010) decade under the Representative Concentration Pathway (RCP) 4.5 and 8.5 climate scenarios. Future annual-mean O3 reductions under RCP 4.5 prevent ~1,800 all-cause mortality, 761 respiratory hospital admissions (HA), and ~1.2 million school loss days annually, and result in economic benefits of ~16 billion, 29 million, and 132 million U.S. dollars (USD), respectively. By contrast, the projected future annual-mean O3 increases under RCP8.5 cause ~2,400 mortality, 941 respiratory HA, and ~1.6 million school loss days annually and result in economic disbenefits of ~21 billion, 36 million, and 175 million USD, respectively. Health benefits of reduced O3 double under RCP4.5 and health dis-benefits of increased O3 increase by 1.5 times under RCP8.5 in future with 2050 population and baseline incidence rate. Because of the reduction in projected future PM2.5 over CONUS under both scenarios, the annual avoided all-cause deaths, cardiovascular HA, respiratory HA, and work loss days are ~63,000 and ~83,000, ~5,300 and ~7,000, ~12,000 and ~15,000, and ~7.8 million and ~10 million, respectively, leading to economic benefits of ~560 and ~740 billion, ~240 and ~320 million, ~450 and ~590 million, and ~1,400 and ~1,900 million USD for RCP4.5 and 8.5, respectively. Health benefits of reduced PM2.5 for future almost double under both scenarios with the largest benefits in urban areas. RCP8.5 projects larger health and economic benefits due to a greater reduction in PM2.5 but with a warmer atmosphere and higher O3 pollution than RCP4.5. RCP4.5 leads to multiple-benefit goals including reduced O3 and PM2.5, reduced mortality and morbidity, and saved costs. Greater reduction in future PM2.5 under RCP4.5 should be considered to achieve larger multi-benefits.

Yang, Peilin, et al. "Health impacts and cost-benefit analyses of surface O3 and PM2. 5 over the US under future climate and emission scenarios." Environmental research 178 (2019): 108687.

Spatiotemporal variation in PM2.5 concentrations and their relationship with socioeconomic factors in China's major cities

The air quality issues caused by extreme haze episodes in China have become increasingly serious in recent years. In particular, fine particulate matter (PM2.5) has become the major component of haze with many adverse impacts and has therefore become of great concern to scientists, government, and the general public in China. This study investigates the spatiotemporal variation in PM2.5 in 269 Chinese cities from 2015 to 2016 and its associations with socioeconomic factors to identify the possible strategies for PM2.5 pollution mitigation. Specifically, we first quantified the spatial pattern of PM2.5 concentrations in both 2015 and 2016, and then changes between the two years. Next, we examined the relationship between socioeconomic factors and PM2.5 concentrations and changes. The results showed that most cities in eastern China experienced decreases in PM2.5 concentration, although most of these cities already had high PM2.5 pollution level. Cities with low PM2.5 concentrations experienced increases in PM2.5 concentrations and were mostly located in southern and southwestern China. The PM2.5 concentration was the highest in winter, followed by in spring, autumn and summer; for changes in PM2.5 concentrations, the highest magnitude of decrease occurred in summer, followed by the decreases in winter, autumn and spring. Cities with high PM2.5 concentrations tended to be clustered, but the clustered characteristics were not clearly related to the changes in PM2.5 concentrations. The relationship between PM2.5 concentration and urban size was an inverse U-shaped curve, suggesting the existence of the Environmental Kuznets Curve for air quality in China. Population density and secondary industry share are the keys factors relating to air pollution control. In comparison to other cities, most moderately developed cities had a greater magnitude of decrease in PM2.5 concentrations and the key factor for pollution improvement was industrial structure; however, smaller cities tended to have a greater increase in PM2.5 concentrations and population density was the most important influencing factor. As a result, for air pollution control in China, specific regulations should be carried out according to different regions and different developmental stages based on the locations of cities.

Zhao, Xiuling, et al. "Spatiotemporal variation in PM2. 5 concentrations and their relationship with socioeconomic factors in China's major cities." Environment international 133 (2019): 105145.

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.

The role of biomass burning agricultural emissions in the Indo-Gangetic Plains on the air quality in New Delhi, India

Agricultural residue burning in the Indo-Gangetic Plains (IGP) releases large amounts of reactive nitrogen, among other pollutants, into the atmosphere each year. This study focuses on rice paddy residue burning and wheat residue burning during October–November and April–May, respectively, in 2016 and 2017. Emissions of reactive nitrogen species (ammonia (NH3), nitrous oxide (N2O) and oxides of nitrogen (NOx = NO + NO2)) were estimated for the study period using a suite of satellite products from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on the National Aeronautics and Space Administration (NASA) Aqua and Terra satellites. Emissions were compared against ambient concentrations of fine particulate matter (PM2.5) in New Delhi, India, to help determine the impact that these agricultural burns have on PM2.5, which is known to have numerous health and environmental impacts associated with prolonged exposure to elevated concentrations. Daily average measured concentrations of PM2.5 in New Delhi range from 22.43 μg m−3 to 718.94 μg m−3 (average 127.15 μg m−3 ± 95.23 μg m−3), with the daily average PM2.5 concentration exceeding the national ambient air quality standard of 60 μg m−3 approximately 75% of the time. Concentrations of PM2.5 were found to peak during October–November, which corresponds with rice paddy residue burning in the IGP. In addition to this, statistical regression models were created to predict average daily PM2.5 concentrations in New Delhi, India, based on emissions of NH3 and organic carbon (OC) in the IGP as well as meteorological conditions. The regression model predicted ambient PM2.5 concentrations ranging from 35 to 719 μg m−3. The average modeled concentrations of PM2.5 in New Delhi, India, were 111 μg m−3 (standard deviation: ± 23 μg m−3) during April/May and 207 ± 87 μg m−3 during October/November. Both regression models (for wheat residue burning and for rice paddy residue burning) were comparable to the average observations (normalized mean bias less than 0.1%).

Bray, Casey D., William H. Battye, and Viney P. Aneja. "The role of biomass burning agricultural emissions in the Indo-Gangetic Plains on the air quality in New Delhi, India." Atmospheric Environment 218 (2019): 116983.

Connecting Crop Productivity, Residue Fires, and Air Quality over Northern India

Northwestern India is known as the “breadbasket” of the country producing two-thirds of food grains, with wheat and rice as the principal crops grown under the crop rotation system. Agricultural data from India indicates a 25% increase in the post-monsoon rice crop production in Punjab during 2002–2016. NASA’s A-train satellite sensors detect a consistent increase in the vegetation index (net 21%) and post-harvest agricultural fire activity (net ~60%) leading to nearly 43% increase in aerosol loading over the populous Indo-Gangetic Plain in northern India. The ground-level particulate matter (PM2.5) downwind over New Delhi shows a concurrent uptrend of net 60%. The effectiveness of a robust satellite-based relationship between vegetation index—a proxy for crop amounts, and post-harvest fires—a precursor of extreme air pollution events, has been further demonstrated in predicting the seasonal agricultural burning. An efficient crop residue management system is critically needed towards eliminating open field burning to mitigate episodic hazardous air quality over northern India.

Jethva, Hiren, et al. "connecting crop productivity, Residue fires, and Air Quality over northern india." Scientific reports 9.1 (2019): 1-11.

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

Enhanced efficiency nitrogen fertilizers maintain yields and mitigate global warming potential in an intensified spring wheat system

Enhanced efficiency nitrogen fertilizers (EENFs), including nitrification inhibitors (NIs) and slow-release fertilizers (SRFs), are considered a feasible pathway for improving grain yield and mitigating greenhouse gas (GHG) emissions. However, the usage of EENFs in an intensified spring wheat system has not been well documented. The combined application of EENFs with water and fertilizer management (EENFs-WFM) was investigated in an irrigated spring wheat cropping system over two years. Measurements of soil nitrous oxide (N2O), methane (CH4) and carbon dioxide (CO2) fluxes were taken across five treatments: no N fertilizer as a control (CK), conventional N fertilization and irrigation (Con), optimum N fertilization and irrigation (Opt), optimum N fertilization and irrigation plus nitrification inhibitor (Opt + NI), and optimum N fertilization as slow-release fertilizer and irrigation (Opt-SRF). The cumulative N2O emissions in both growing seasons were significantly ($P < 0.05$) higher than the fallow seasons and accounted for 56–83% of total emissions. The Opt, Opt-SRF, and Opt + NI treatments significantly reduced the cumulative N2O emissions by 25%, 34%, and 45%, respectively, relative to the Con treatment, while the fertilizer N input decreased by 36%. The soil acted as a tiny sink for atmospheric CH4, with no significant effect in any treatment. Moreover, global warming potential (GWP) and greenhouse gas intensity (GHGI) declined by ~45% and ~33%, respectively, in the Opt + NI treatment and ~46% and ~34%, respectively, in the Opt-SRF treatment, relative to the Con treatment, with almost no effect on grain yield. Our results highlight that EENFs-WFM is a promising management system for maintaining yield while minimizing GWP and GHGI.

Lyu, Xiaodong, et al. "Enhanced efficiency nitrogen fertilizers maintain yields and mitigate global warming potential in an intensified spring wheat system." Field Crops Research 244 (2019): 107624.

Unexpected high reduction of methane emission via short-term aerobic pre-digestion of green manured soils before flooding in rice paddy

Soil organic matter (SOM) is used as an important indicator of soil quality and a countermeasure to mitigate global warming. To increase SOM stock, cover cropping and its biomass incorporation as green manure are strongly recommended in mono-rice paddy soils. However, green manure application significantly increased greenhouse gas emission, in particular, methane (CH4) during rice cultivation, and then its simultaneous positive and negative outcome has become a serious issue. We hypothesized that the short-term aerobic pre-digestion of green manured soil under dry soil condition before flooding might degrade labile organic C into carbon dioxide (CO2) and then reduce CH4 production during the flooded rice cultivation period. In order to evaluate the feasibility of the short-term aerobic pre-digestion of green manured soil on reducing CH4 emission in rice paddy, cover crop biomass was incorporated in the inner dry soil at different time intervals from 0 to 30 days before flooding, and then CH4 and CO2 emission rates were monitored. Over 10 days of aerobic pre-digestion significantly decreased CH4 flux by 88–98% over the control (flooded soil without aerobic pre-digestion) during the two month's incubation test. Similar results were observed during the field test, in which only at 10 days' aerobic pre-digestion under dry soil condition, total CH4 flux decreased by approximately 60% over the control. This reduction effect was slightly increased when aerobic pre-digestion period was extended. In contrast, rice productivities were not significantly different from 0 to 30 days of aerobic pre-digestion. As a result, more than 10 days of aerobic pre-digestion of green manured soil before flooding decreased CH4 flux intensity (kg CH4 kg−1 grain) by 60% over the control. In conclusion, the short-term aerobic pre-digestion of green manured soil before flooding can be a good soil management strategy to mitigate CH4 emission without productivity decrease in rice field.

Lee, Jin Ho, et al. "Unexpected high reduction of methane emission via short-term aerobic pre-digestion of green manured soils before flooding in rice paddy." Science of The Total Environment (2019): 134641.

Value and impact of publicly funded climate change agricultural mitigation research: Insights from New Zealand

In this paper we discuss a framework to evaluate the benefits of publicly-funded research that includes scientific impact, impacts on stakeholders (next and end users of research outputs), and economic and environmental values. We apply this framework to evaluate two agricultural greenhouse gas (GHG) mitigation research science projects funded in New Zealand: research looking at mitigation options given by genetic markers for low methane animals, and the identification of emission-reducing management practices. From this analysis we achieve two main findings. First, the prominence of the research combined with the low likelihood of research occurring on this scale without public support suggests strongly that the results would not have been obtained in absence of public funding. Second, the advances reached in some areas have the potential for GHG emission reductions that would be significant in environmental terms, and whose value at likely carbon pricing levels would be in the hundreds of millions of dollars. The results discussed are conditional on several factors such as future domestic and international policy settings and implementation, adoption rates and the practical availability of mitigation options and practices for different farm landscapes. However, the impacts and economic and environmental values attached to these research projects, and mitigation research more generally, cannot be overlooked. The case studies evaluated clearly demonstrate the potential benefits that public investments can make to the development of more sustainable agricultural systems.

Fleming-Muñoz, David A., Kate Preston, and Andrea Arratia-Solar. "Value and impact of publicly funded climate change agricultural mitigation research: Insights from New Zealand." Journal of Cleaner Production (2019): 119249.

Mitigation of ammonia and greenhouse gas emissions from stored cattle slurry using acidifiers and chemical amendments

Cattle and cow slurry storage is a significant source of agricultural greenhouse gas (GHG) and ammonia (NH3) emissions. While acidification has been demonstrated to significantly reduce these emissions, a knowledge gap exists to identify a range of chemical amendments that are safe, suitable and cost effective to mitigate both GHG and NH3 gases simultaneously. The current study showed that ferric chloride, sulphuric acid, alum and acetic acid were extremely effective at abating emissions, with NH3 reduced by 96%, 85%, 82% and 73%, respectively. In terms of methane (CH4), ferric chloride, alum, sulphuric acid and acetic acid reduced emissions by 98%, 96%, 95% and 94%, respectively. Previous studies have found that the reduction of >pH 6 can inhibit the release of these gases; however, the effectiveness can vary depending on each amendment's composition. The cost benefit analysis, assessed the amendments in terms of both gaseous emissions reduction and net cost. Sulphuric acid, acetic acid, ferric chloride and alum ranked best, respectively. Currently, the cost of implementing these amendments is, at best, cost neutral. Therefore, incentivising chemical amendments for the abatement of GHG and NH3 gases from slurry storage is needed. This incubation experiment is an effective means of pre-screening amendments before they are explored at pilot or full scale with subsequent field application. Future research should consider the assessment of cheaper on- and off-farm alternative waste streams as slurry amendment.

Kavanagh, I., et al. "Mitigation of ammonia and greenhouse gas emissions from stored cattle slurry using acidifiers and chemical amendments." Journal of Cleaner Production 237 (2019): 117822.

Transportation

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

Impacts of China's national vehicle fuel standards and subway development on air pollution

To reduce air pollution, China gradually upgrades the fuel for vehicles while building the subway system in some major cities. Using panel data covering 16 major cities in China during the period between 2014 and 2017, this

paper investigates the impacts of China Fuel Standard V for petrol and diesel and subway operation on Air Quality Index (AQI) and four pollutants, namely PM2.5, SO2, NO2 and CO. Empirical results find the positive impacts of Fuel Standard V on the reduction in SO2, PM2.5 and CO. The impact is strongest in the context of SO2, with Fuel Standard V Diesel having a larger impact compared to Fuel Standard V Petrol. In addition, the operation of subway systems leads to a decrease in CO. Furthermore, this paper explores not only separate but also the joint effects of fuel standards and subway. Interestingly, the results indicate that while the operation of the subway system itself cannot affect PM2.5 concentrations, it contributes to the reduction in PM2.5 when Fuel Standard V is implemented. These results emphasise the importance of policy coordination to reduce air pollution in China.

Wei, Honghong. "Impacts of China's national vehicle fuel standards and subway development on air pollution." Journal of Cleaner Production 241 (2019): 118399.

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).

Waste and Waste Management

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

Estimating greenhouse gas emissions from Iran's domestic wastewater sector and modeling the emission scenarios by 2030

Domestic and industrial wastewaters are categorized as anthropogenic greenhouse gas emission sources. Wastewater collection systems, wastewater treatment plants and discharging wastewater to the environment lead to direct greenhouse gas (carbon dioxide, nitrous oxide, and methane) emission from biological processes and indirect emissions due to energy consumption. In this study, the current status of greenhouse gas emissions from the domestic wastewater sector in Iran and emission scenarios up to the horizon of 2030 were estimated. According to the developed estimations based on the calculation method presented by Intergovernmental Panel on Climate Change (IPCC) for greenhouse gas emissions, methane (144.94 kt/yr) and nitrous oxide (1.47 kt/yr) are emitted directly in the domestic wastewater sector. Thus, wastewater treatment plants are releasing methane (8.542 kt/yr) and nitrous oxide (0.0273 kt/yr) directly along with carbon dioxide (901.77 kt/yr) indirectly. In the next phase of this study, different scenarios of greenhouse gas emissions from the domestic wastewater sector were developed. According to the calculations, the highest emission will occur in 2030, when the people access to wastewater treatment systems increases, while the performance of the wastewater

treatment plants has not been improved (6,024.46 ktCO2e/yr). Also, the lowest emission will occur when people's access to wastewater treatment systems has increased and the performance of these wastewater treatment plants has been improved at the same time (2,739.31 ktCO2e/yr). According to the result of this study, the best outline will be achieved if the primary focus is on the improvement of wastewater treatment operation by 2025, and since then the focus shifts forward to increasing population coverage and upgrading performance.

Nayeb, Hossein, et al. "Estimating greenhouse gas emissions from Iran's domestic wastewater sector and modeling the emission scenarios by 2030." Journal of Cleaner Production 236 (2019): 117673.

Reduction potential of GHG emissions from municipal solid waste incineration for power generation in Beijing

With rapid economic growth and massive urbanization, China faces the problem of municipal solid waste (MSW) disposal and the pressing need for development of alternative energy. MSW incineration for power generation is playing an increasingly important role in MSW management in China. In order to study the reduction of GHG emissions caused by MSW incineration for power generation, the GHG emissions under the baseline level is calculated by using Clean Development Mechanism (CDM) methodology. Then, the GHG emission reduction is estimated based on the improved upstream-operation-downstream (UOD) framework. Finally, the GHG emission reduction in Beijing is studied and forecasted through grey prediction model and scenario analysis, and the main factors affecting the reduction potential are identified. The results show that the GHG emission reduction target can be achieved through MSW incineration for power generation. Direct and alternative GHG emissions from MSW incineration are the main sources of emissions, while indirect emissions account for a small proportion. The MSW disposal volume, the moisture content of MSW, the installed capacity of biomass energy, the average line loss of power generation and the quantity of fossil fuels consumed by power generation are five important factors that affecting GHG emission reduction potential. It is recommended that the dominant form of waste disposal in China should be replaced by MSW incineration for power generation, and the full classification of MSW needs to be promoted. Furthermore, the installed capacity of biomass energy should be increased and the average line loss of power generation should be reduced.

Yao, Xilong, et al. "Reduction potential of GHG emissions from municipal solid waste incineration for power generation in Beijing." Journal of Cleaner Production 241 (2019): 118283.

Air pollution & Health Impacts

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

Transition in source contributions of PM2.5 exposure and associated premature mortality in China during 2005–2015

The serious fine particle (PM2.5) pollution in China causes millions of premature deaths. Driven by swift economic growth and stringent control policies, air pollutant emissions in China have changed significantly in the last decade, but the change in the source contribution of PM2.5-related health impacts remains unclear. In this study, we develop a multi-pollutant emission inventory in China for 2005–2015, and combine chemical transport modeling, ambient/household exposure evaluation and health impact assessment to quantify the contribution of eight emission sectors to PM2.5 exposure and associated health risk. From 2005 to 2015, the mortality due to PM2.5 from ambient air pollution (AAP) decreases from 1.04 (95% confidence interval, 0.84–1.25) million to 0.87 (0.70–1.04) million. The agricultural sector contributes 25% and 32% to ambient PM2.5-attributed mortality in 2005 and 2015, respectively, representing the largest contributor during this period. The contribution of power plants drops monotonously from 13% to 6%. The percentage contribution of industrial process drops significantly while the contribution of industrial combustion stays the same level. The overall contribution of industry is still as large as 26% in 2015 in spite of strict control measures. For transportation, despite strict emission standards, its contribution increases remarkably due to the rapid growth of vehicle

population. When both ambient and household PM2.5 exposures are taken into account, the mortality due to integrated population-weighted exposure to PM2.5 (IPWE) drops from 1.78 (1.46–2.09) million in 2005 to 1.28 (1.05–1.52) million in 2015. Most of the IPWE reduction comes from domestic combustion as a result of urbanization and improved income, whereas this sector remains the largest contributor (58%) to IPWE-related health risk in 2015. Our results suggest that the government should dynamically adjust the air pollution control strategy according to the change in source contributions. Domestic combustion and agriculture should be prioritized considering their predominant contributions to mortality and the lack of effective control policies. More stringent control measures for industry and transportation are necessary since the existing policies have not adequately reduced their health impacts. Electricity production is no longer the top priority of air pollution control policies given its lower health impact compared with that of other sources.

Zheng, Haotian, et al. "Transition in source contributions of PM2. 5 exposure and associated premature mortality in China during 2005–2015." Environment international 132 (2019): 105111.

Long-term residential exposure to PM2.5 constituents and mortality in a Danish cohort

Studies on health effects of long-term exposure to specific PM2.5 constituents are few. Previous studies have reported an association between black carbon (BC) exposure and cardiovascular diseases (CVD) and a few studies have found an association between sulfate exposure and mortality. These studies, however, relied mainly on exposure data from centrally located air-monitoring stations, which is a crude approximation of personal exposure.

We focused on specific chemical constituents of PM2.5, i.e. elemental and primary organic carbonaceous particles (BC/OC), sea salt, secondary inorganic aerosols (SIA, i.e. NO3–, NH4+, and SO42-), and secondary organic aerosols (SOA), in relation to all-cause, CVD and respiratory disease mortality.

We followed a Danish cohort of 49,564 individuals from enrollment in 1993–1997 through 2015. We combined residential address history from 1979 onwards with mean annual air pollution concentrations obtained by the AirGIS air pollution modelling system, lifestyle information from baseline questionnaires and socio-demography obtained by register linkage.

During 895,897 person-years of follow-up, 10,193 deaths from all causes occurred – of which 2319 were CVD-related and 870 were related to respiratory disease. The 15-year time-weighted average concentrations of PM2.5, BC/OC, sea salt, SIA and SOA were 13.8, 2.8, 3.4, 4.9, and 0.3 µg/m3, respectively. For all-cause mortality, a higher risk was observed with higher exposure to PM2.5, BC/OC and SOA with adjusted hazard ratios of 1.03 (95% confidence intervals: 1.01, 1.05), 1.06 (1.03, 1.09), and 1.08 (1.03, 1.13) per interquartile range, respectively. The associations for BC/OC and SOA remained after adjustment for PM2.5 in two-pollutant models. For CVD mortality, we observed elevated risks with higher exposure to PM2.5, BC/OC and SIA. The results showed no clear relationship between sea salt and mortality.

In this study, we observed a relationship between long-term exposure to PM2.5, BC/OC, and SOA and all-cause mortality and between PM2.5, BC/OC, and SIA and CVD mortality.

Hvidtfeldt, Ulla Arthur, et al. "Long-term residential exposure to PM2. 5 constituents and mortality in a Danish cohort." Environment international 133 (2019): 105268.

Health impact assessment by the implementation of Madrid City air-quality plan in 2020

Air pollutant concentrations in many urban areas are still above the legal and recommended limits that are set to protect the citizens' health. Madrid is one of the cities where traffic causes high NO2 levels. In this context, Madrid City Council launched the Air Quality and Climate Change Plan for the city of Madrid (Plan A), a local strategy approved by the previous government in 2017. The aim of this study was to conduct a quantitative health impact assessment to evaluate the number of premature deaths that could potentially be prevented by the implementation of Plan A in Madrid in 2020, at both citywide and within-city level. The main purpose was to support decision-making processes in order to maximize the positive health impacts from the implementation of Plan A measures.

The Regional Statistical Office provided information on population and daily mortality in Madrid. For exposure assessment, we estimated PM2.5, NO2 and O3 concentration levels for Madrid city in 2012 (baseline air-quality scenario) and 2020 (projected air-quality scenario based on the implementation of Plan A), by means of an Eulerian chemical-transport model with a spatial resolution of 1 km × 1 km and 30 vertical levels. We used the concentration-response functions proposed by two relevant WHO projects to calculate the number of attributable annual deaths corresponding to all non-accidental causes (ICD-10: A00-R99) among all-ages and the adult population (>30 years old) for each district and for Madrid city overall. This health impact assessment was conducted dependant on health-data availability.

In 2020, the implementation of Plan A would imply a reduction in the Madrid citywide annual mean PM2.5 concentration of 0.6 μg/m3 and 4.0 μg/m3 for NO2. In contrast, an increase of 1 μg/m3 for O3 would be expected. The annual number of all-cause deaths from long-term exposure (95% CI) that could be postponed in the adult population by the expected air-pollutant concentration reduction was 88 (57–117) for PM2.5 and 519 (295–750) for NO2; short-term exposure accounted for 20 (7–32) for PM2.5 and 79 (47–111) for NO2 in the total population. According to the spatial distribution of air pollutants, the highest mortality change estimations were for the city centre – including Madrid Central and mainly within the M-30 ring road –, as compared to peripheral districts. The positive health impacts from the reductions in PM2.5 and NO2 far exceeded the adverse mortality effects expected from the increase in O3.

Effective implementation of Plan A measures in Madrid city would bring about an appreciable decline in traffic-related air-pollutant concentrations and, in turn, would lead to significant health-related benefits.

Izquierdo, Rebeca, et al. "Health impact assessment by the implementation of Madrid City air-quality plan in 2020." Environmental Research (2019): 109021.

$PM_{2.5}$ and Air Pollution

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

PM2.5 in Abuja, Nigeria: Chemical characterization, source apportionment, temporal variations, transport pathways and the health risks assessment

Due to rapid industrial development and urbanization, Abuja is characterized with poor and deteriorated air quality. The level of PM2.5 concentrations in Abuja is very high and above the statutory limits; however, the high levels of pollution in Lugbe do not seem to be consistent with local emission sources. This study analyzed the chemical composition of PM2.5 to perform source identification and contributions in Lugbe, Abuja, Nigeria. Sampling in 2016 provided 246 PM2.5 samples at 2 sites across all the four months of sampling. The highest ambient PM2.5 concentration (142 μg m−3) was recorded in winter while the lowest (84 μg m−3) was observed in summer. Chemical mass closure suggested that dust (40.5%) contributed most of the PM2.5 mass. Source apportionment of PM2.5 was performed using positive matrix factorization (PMF) model and six sources were identified. They include mineral dust, crustal dust, vehicle exhaust, secondary nitrate, secondary sulfate, and industrial sources. Crustal dust, vehicle exhaust, and secondary sulfate were the major sources of ambient PM2.5 in Lugbe, contributing 33.3, 29.8, and 18.0%, respectively. The results of 120-h backward trajectories showed that external northeastern region was more dominant in January, while during the remaining three months, southwesterly winds prevailed. The results of bivariate polar plots for most of the factors showed the influence of the southern areas of Lugbe. The study found that there was long-range regional transport of PM2.5 into Lugbe area throughout the four months. Risk assessments revealed that ingestion route was the major exposure pathway for both children and adults. Non-carcinogenic and carcinogenic risk levels were below the acceptable threshold limits. Finally, the results of this study have shown that ambient air quality in Lugbe can be substantially improved by reducing the emissions from crustal dust, vehicle exhaust, and secondary sulfate sources in the external southern regions.

Sulaymon, Ishaq Dimeji, et al. "PM2. 5 in Abuja, Nigeria: Chemical characterization, source apportionment,

temporal variations, transport pathways and the health risks assessment." Atmospheric Research (2019): 104833.

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 (2019): 134577.

Defending blue sky in China: Effectiveness of the “Air Pollution Prevention and Control Action Plan” on air quality improvements from 2013 to 2017

Air pollution control has become one of the top priorities of China's “Ecological Civilization” development. As a quick response to the 2013 PM2.5 episodes, the Chinese Government issued the “Air Pollution Prevention and Control Action Plan” as the national strategy and roadmap for air quality improvements consisting of phased quantitative targets and concrete measures. Taking this into account, this study explores the spatiotemporal variations of the five conventional pollutants—PM2.5, PM10, SO2, NO2, and O3—as well as the Air Quality Index and primary pollutants in 338 Chinese cities from 2013 to 2017 in order to comprehensively understand China's current air pollution situation and evaluate the effectiveness of the Action Plan. The results indicate that: (1) the overall air quality has been significantly improved, with the concentrations of PM2.5, PM10, and SO2 decreasing noticeably, although the still high PM level, the dramatically increasing O3 concentration, and the stagnant amounts of NO2 present further challenges, along with the intensification of regional compound air pollution problems; (2) in contrast to the three key regions under the Action Plan exhibiting significant decreases in PM and SO2, the Fen-Wei Plain (FWP) is suffering from serious compound pollution, suggesting that there is an urgent need for the development of a regional joint prevention and control mechanism in the FWP and similar areas; (3) with the exception of the common pollution hot spots mainly concentrated in the FWP as well as Beijing-Tianjin-Hebei (BTH) and its surrounding regions, the distribution of each pollutant exhibited remarkable spatial heterogeneity due to their distinctive emission sources, a finding that strongly indicates the need for regionally differentiated management; and (4) the most frequent primary pollutant at the national level was O3, followed by PM2.5 and PM10. In the Wuhan Metropolitan Area (WHM), Changsha-Zhuzhou-Xiangtan Metropolitan Area (CZT), and Sichuan-Chongqing Region (CY), PM2.5 pollution is playing the dominant role, while in the FWP, BTH, Yangtze River Delta region (YRD), and Pearl River Delta region (PRD), the synergistic control of PM2.5 and O3 pollutants is urgently needed as soon as possible, which will require that more attention be paid to emission mitigation in the transportation sector, as well as the synergistic control of NOx and VOC emissions.

Feng, Yueyi, et al. "Defending blue sky in China: Effectiveness of the "Air Pollution Prevention and Control Action Plan" on air quality improvements from 2013 to 2017." Journal of environmental management 252 (2019): 109603.

SLCPs & Vulnerable Regions

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

Investigation of potential source regions of atmospheric Black Carbon in the data deficit region of the western Himalayas and its foothills

In the present study, BC was measured at three western Himalayan sites (Site-A≈650 m, Site-B≈2050m and Site-C≈2600 m a.s.l.) during summer and winter seasons of 2014–2016. The objective of this study is to investigate the variability of BC as a function of meteorological conditions and identify potential combustion sources (biomass vs fossil fuel). Furthermore, boundary layer (ABL) height and wind patterns, MODIS fire maps and Concentrated Weightage Trajectory (CWT) analysis were utilized to study potential BC source regions. The average BC concentration at Site-A, B and C were observed to be 4.98 ± 2.79, 4.57 ± 3.54 and 3.01 ± 2.95 μgm−3, respectively. At Site-B, daytime BC was observed to be higher than nighttime, indicating that ABL development and consequent upward transport of pollution from IGP contributed to high BC concentrations in lesser Himalayas. Nevertheless, variable fraction of BC attributable to biomass vs fossil fuel at three stations indicates the effect of transport from IGP overlapped with the effect of mixing with different combustion sources, including local biomass burning practices which modulated BC levels especially at a high-altitude site in winter. On the basis of CWT analysis and MODIS fire counts, emissions from agriculture residue burning in northwestern-IGP impacted the BC aerosols at all monitoring locations, although, based on our in-situ aethalometer measurements, biomass burning fraction of BC remained below 25–30% at Site-A and B. Episodic westerly long-range transport events (from Middle-East, Europe and Central-Asia) can contribute to background BC concentrations especially in wintertime which were, however, in range of sub-μgm−3 levels based on our observations at Site-C.

Soni, Ashish, et al. "Investigation of potential source regions of atmospheric Black Carbon in the data deficit region of the western Himalayas and its foothills." Atmospheric Pollution Research 10.6 (2019): 1832-1842.

Amazonian Biomass Burning Enhances Tropical Andean Glaciers Melting

The melting of tropical glaciers provides water resources to millions of people, involving social, ecological and economic demands. At present, these water reservoirs are threatened by the accelerating rates of mass loss associated with modern climate changes related to greenhouse gas emissions and ultimately land use/cover change. Until now, the effects of land use/cover change on the tropical Andean glaciers of South America through biomass burning activities have not been investigated. In this study, we quantitatively examine the hypothesis that regional land use/cover change is a contributor to the observed glacier mass loss, taking into account the role of Amazonian biomass burning. We demonstrated here, for the first time, that for tropical Andean glaciers, a massive contribution of black carbon emitted from biomass burning in the Amazon Basin does exist. This is favorable due to its positioning with respect to Amazon Basin fire hot spots and the predominant wind direction during the transition from the dry to wet seasons (Aug-Sep-Oct), when most fire events occur. We investigated changes in Bolivian Zongo Glacier albedo due to impurities on snow, including black carbon surface deposition and its potential for increasing annual glacier melting. We showed that the magnitude of the impact of Amazonian biomass burning depends on the dust content in snow. When high concentration of dust is present (e.g. 100 ppm of dust), the dust absorbs most of the radiation that otherwise would be absorbed by the BC. Our estimations point to a melting factor of 3.3 ± 0.8% for black carbon, and 5.0 ± 1.0% for black carbon in the presence of low dust content (e.g. 10 ppm of dust). For the 2010 hydrological year, we reported an increase in runoff corresponding to 4.5% of the annual discharge during the seasonal peak

fire season, which is consistent with our predictions.

de Magalhães, Newton, et al. "Amazonian Biomass Burning Enhances Tropical Andean Glaciers Melting." Scientific reports 9.1 (2019): 1-12.

Sources of black carbon in the atmosphere and in snow in the Arctic

We systematically identify sources of black carbon (BC) in the Arctic, including BC in the troposphere, at surface and in snow, using tagged tracer technique implemented in a 3D global chemical transport model GEOS-Chem. We validate modeled BC sources (fossil fuel combustion versus biomass burning) against carbon isotope measurements at Barrow (Alaska), Zeppelin (Norway), Abisko (Sweden), Alert (Canada) and Tiksi (Russia) in the Arctic. The model reproduces the observed annual mean fraction of biomass burning (fbb, %) at the five sites within 20% and the observed and modeled monthly fbb values agree within a factor of two. Model results suggest that fossil fuel combustion is the major source of BC in the troposphere (50–94%, vary with sub-regions), at surface (55–68%) and in snow (58–69%) in the Arctic as annual mean, but biomass burning dominates at certain altitudes (600–800 hPa) and during periods of time between April to September. The model shows that BC in the troposphere, in deposition and in snow in different Arctic sub-regions have distinctively different sources and source regions. We find that long-range transport of Asian emissions has a stronger influence on BC in the atmosphere than on BC deposition. In contrast, contributions from Russian and European emissions are larger for BC deposition than for BC in the atmosphere. Specifically, Asian fossil fuel combustion emissions dominate BC loading in all Arctic sub-regions in both winter (Oct.–Mar., 35–54%) and summer (Apr.–Sep., 34–56%). For BC deposition, Siberian fossil fuel emissions are the largest contributors in Russia both in winter (62%) and summer (44%), and European fossil fuel emissions dominate in Ny-Ålesund (44% in winter) and Tromsø (71% in winter and 46% in summer). For BC deposition in the North American sector, Asian fossil fuel emissions are the largest contributors in winter (25–38%) and North American biomass burning emissions (38–72%) dominate in summer.

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