Short-lived Climate Pollutant Research Digest

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

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

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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

Linking fire and the United Nations Sustainable Development Goals

Fire is a ubiquitous natural disturbance that affects 3–4% of the Earth's surface each year. It is a tool used by humans for land clearing and burning of agricultural wastes. The United Nations Sustainable Development Goals (SDGs) do not explicitly mention fire, though many of the Goals are affected by the beneficial and adverse consequences of fires on ecosystem services. There are at least three compelling reasons to include a fire perspective in the implementation of the United Nations Sustainable Development Goals. The first reason relates to the stated vision of the United Nations 2030 Agenda to protect the environment. In order to achieve environmental protection during sustainable development activities, it is necessary to understand and plan for the effects of disturbances, in this case fire, on ecosystem services. The second reason is that fires produce emissions with regional and global impacts on air quality and rainfall patterns. Fires contribute to global warming though the release greenhouse gases, primarily CO2, and black carbon, identified as a SLCP (short-lived climate pollutant). The third reason is that fire is one of several complex processes that lead to land degradation across the globe. Opportunities exist to incorporate a fire perspective into sustainable development projects or approaches. Two examples are highlighted here. Transdisciplinary communication and collaboration are needed to address the complex issues related to fire, and to climate and land use change.

Martin, Deborah A. "Linking fire and the United Nations Sustainable Development Goals." Science of The Total Environment 662 (2019): 547-558.

Multiple Benefits/Impacts & Crosscutting

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

Air quality co-benefits for human health and agriculture counterbalance costs to meet Paris Agreement pledges

Local air quality co-benefits can provide complementary support for ambitious climate action and can enable progress on related Sustainable Development Goals. Here we show that the transformation of the energy system implied by the emission reduction pledges brought forward in the context of the Paris Agreement on climate change (Nationally Determined Contributions or NDCs) substantially reduces local air pollution across the globe. The NDCs could avoid between 71 and 99 thousand premature deaths annually in 2030 compared to a reference case, depending on the stringency of direct air pollution controls. A more ambitious 2 °C-compatible pathway raises the number of avoided premature deaths from air pollution to 178–346 thousand annually in 2030, and up to 0.7–1.5 million in the year 2050. Air quality co-benefits on morbidity, mortality, and agriculture could globally offset the costs of climate policy. An integrated policy perspective is needed to maximise benefits for climate and health.

Vandyck, Toon, et al. "Air quality co-benefits for human health and agriculture counterbalance costs to meet Paris Agreement pledges." Nature communications 9.1 (2018): 4939.

Managing China's coal power plants to address multiple environmental objectives

China needs to manage its coal-dominated power system to curb carbon emissions, as well as to address local environmental priorities such as air pollution and water stress. Here we examine three province-level scenarios for 2030 that represent various electricity demand and low-carbon infrastructure development

pathways. For each scenario, we optimize coal power generation strategies to minimize the sum of national total coal power generation cost, inter-regional transmission cost and air pollution and water costs. We consider existing environmental regulations on coal power plants, as well as varying prices for air pollutant emissions and water to monetize the environmental costs. Comparing 2030 to 2015, we find lower CO2 emissions only in the scenarios with substantial renewable generation or low projected electricity demand. Meanwhile, in all three 2030 scenarios, we observe lower air pollution and water impacts than were recorded in 2015 when current regulations and prices for air pollutant emissions and water are imposed on coal power plants. Increasing the price of air pollutant emissions or water alone can lead to a tradeoff between these two objectives, mainly driven by differences between air pollution-oriented and water-oriented transmission system designs that influence where coal power plants will be built and retired.

Peng, Wei, et al. "Managing China's coal power plants to address multiple environmental objectives." Nature Sustainability 1.11 (2018): 693.

Outlook for clean air in the context of sustainable development goals

Air pollution is linked with many of the United Nations Sustainable Development Goals. Strategies aiming at the improved air quality interact directly with climate mitigation targets, access to clean energy services, waste management, and other aspects of socio-economic development. Continuation of current policies in the key emitting sectors implies that a number of sustainability goals will likely not be met within the next two decades: emissions of air pollutants would cause 40% more premature deaths from outdoor air pollution than today, carbon emissions would rise globally by 0.4% per year, while nearly two billion people would not have access to clean cooking. This paper examines integrated policies to put the world on track towards three interlinked goals of achieving universal energy access, limiting climate change and reducing air pollution. Scenario analysis suggests that these goals can be attained simultaneously with substantial benefits. By 2040, emissions of main pollutants are projected to drop by 60–80% relative to today, and associated health impacts are quantified at two million avoided deaths from ambient and household air pollution combined. In comparison to costs needed for the decarbonization of global economy, additional investments in air pollution control and access to clean fuels are very modest against major societal gains. However, holistic and systemic policy assessment is required to avoid potential trade-offs.

Rafaj, Peter, et al. "Outlook for clean air in the context of sustainable development goals." Global Environmental Change 53 (2018): 1-11.

Would it be better to not talk about climate change? The impact of climate change and air pollution frames on support for regulating power plant emissions

This study examined how utilizing different frames to contextualize negative impacts of power plant emissions influenced belief in those impacts and support for policies to regulate emissions. Using a U.S. national YouGov sample (n = 1000), we examined how discussing emissions in terms of climate change or air pollution, and in terms of health or environmental impacts, influenced individuals with different partisan affiliations. The analysis utilized a moderated-mediation model, with belief in negative impacts of power plant emissions as the mediator, support for government action as the dependent variable, and political party as a moderator of the link from the message frame to belief. This analysis revealed that using a climate change frame relative to an air pollution frame lowered policy support both directly and indirectly via belief in negative impacts, with the strongest indirect effect observed for Republicans. There were no effects of discussing environmental versus health impacts. The results suggest that communicators may be more successful in increasing support for mitigating carbon pollution from power plants by focusing on non-climate change oriented risks that the pollution poses, rather than linking the pollution to climate change.

Hart, P. Sol, and Lauren Feldman. "Would it be better to not talk about climate change? The impact of climate change and air pollution frames on support for regulating power plant emissions." Journal of Environmental Psychology 60 (2018): 1-8.

Methane

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

Methane emission from pan-Arctic natural wetlands estimated using a process-based model, 1901–2016

The vast pan-Arctic wetlands appear to be a large source of methane (CH4), a potent greenhouse gas. Here, I simulated CH4 emission from pan-Arctic wetlands (above 60°N) over the period 1901–2016 using a process-based biogeochemical model (VISIT), including two different schemes of wetland CH4 production, that was forced by historical atmospheric composition, climate, and land-use conditions. The two schemes simulated mean wetland CH4 emission rates of 10.9 and 11.4 Tg CH4 yr−1 in the 2000s with slightly different spatial source distributions. Both simulations showed clear seasonal cycles of CH4 emission, but the two schemes had different amplitudes and peak months. The schemes differed markedly in their simulated long-term patterns (i.e., a stationary trend and an increasing decadal trend), making it difficult to relate them to global atmospheric trends in a consistent manner. Linear regression analysis clarified the agreements and differences in environmental sensitivity and biological control of CH4 production simulated by the schemes. The time-series of CH4 emission in northern North America, northern Europe, and Siberia showed different patterns of correlation with two major meteorological teleconnection indices. This model-based study implied that the high-latitude CH4 emission accounts for 5–7% of global wetland emission and would play increasingly important roles (e.g., positive feedback) under changing climate. To reduce estimation uncertainties, as demonstrated by the comparison of two schemes, we need further studies for improving biogeochemical models in collaboration with field studies.

Ito, Akihiko. "Methane emission from pan-Arctic natural wetlands estimated using a process-based model, 1901–2016." Polar Science (2018).

A comparison of CH4 emissions from coastal and inland rice paddy soils in China

To achieve regional CH4 regulation, it is essential to understand the differences in methane (CH4) emissions from inland and coastal rice paddy soils. The aim of this study was to compare the CH4 emissions from coastal and inland rice paddy soils in China. A statistical analysis was conducted using a database compiled from published references, soil property datasets, and field experimental data. The results showed that during the growing seasons, the average CH4 emissions from inland rice paddy soils were significantly higher than those from coastal paddy soils ($p < 0.05$). For both inland and coastal zones, single and multiple drainage practices greatly decreased CH4 emissions from rice paddy soils ($p < 0.05$). Organic fertilizer application increased CH4 emissions from Chinese rice paddy soils ($p < 0.05$). Seasonal CH4 emissions decreased significantly with increases in longitude ($p < 0.001$) and latitude ($p < 0.05$). Total nitrogen, available P, soil organic matter, and some exchangeable cations (e.g., Al3+, Mg2+, and Ca2+) greatly affected the CH4 emissions from rice paddy soils. The results of this study can provide information useful to the development of assessment models for CH4 budgets and the best management practices for CH4 mitigation in rice paddy soils at the national scale.

Sun, Minmin, et al. "A comparison of CH4 emissions from coastal and inland rice paddy soils in China." Catena 170 (2018): 365-373.

Variability in Atmospheric Methane From Fossil Fuel and Microbial Sources Over the Last Three Decades

Atmospheric measurements show an increase in CH4 from the 1980s to 1998 followed by a period of near-zero growth until 2007. However, from 2007, CH4 has increased again. Understanding the variability in CH4 is critical for climate prediction and climate change mitigation. We examine the role of CH4 sources and the dominant CH4 sink, oxidation by the hydroxyl radical (OH), in atmospheric CH4 variability over the past three

decades using observations of CH4, C2H6, and δ13CCH4 in an inversion. From 2006 to 2014, microbial and fossil fuel emissions increased by 36 ± 12 and 15 ± 8 Tg y−1, respectively. Emission increases were partially offset by a decrease in biomass burning of 3 ± 2 Tg y−1 and increase in soil oxidation of 5 ± 6 Tg y−1. A change in the atmospheric sink did not appear to be a significant factor in the recent growth of CH4.

Thompson, Rona Louise, et al. "Variability in atmospheric methane from fossil fuel and microbial sources over the last three decades." Geophysical Research Letters 45.20 (2018): 11-499.

First observation of direct methane emission to the atmosphere from the subglacial domain of the Greenland Ice Sheet

During a 2016 field expedition to the West Greenland Ice Sheet, a striking observation of significantly elevated CH4 concentrations of up to 15 times the background atmospheric concentration were measured directly in the air expelled with meltwater at a subglacial discharge point from the Greenland Ice Sheet. The range of hourly subglacial CH4 flux rate through the discharge point was estimated to be 3.1 to 134 g CH4 hr−1. These measurements are the first observations of direct emissions of CH4 from the subglacial environment under the Greenlandic Ice Sheet to the atmosphere and indicate a novel emission pathway of CH4 that is currently a non-quantified component of the Arctic CH4 budget.

Christiansen, Jesper Riis, and Christian Juncher Jørgensen. "First observation of direct methane emission to the atmosphere from the subglacial domain of the Greenland Ice Sheet." Scientific reports 8.1 (2018): 16623.

Black Carbon

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

Source apportionment of trace elements and black carbon in an urban industrial area (Portland, Oregon)

This paper reports a current source apportionment study of trace elements and black carbon in particulate matter in industrial Southeast Portland, Oregon. The study aimed to determine whether metal pollution hotspots identified in the area in 2016 had been successfully mitigated by baghouse installation, or whether industrial sources continued to dominate local particulate matter. Particulate matter was filter-collected nearly continuously in 24-hour intervals between October 2017 and March 2018 (101 total filters). Filters were analyzed for 30 elements by x-ray fluorescence; black carbon was measured continuously during filter sampling using an aethalometer. EPA's Positive Matrix Factorization 5.0 was used for source apportionment modeling, yielding a 5-factor optimal solution. The source identities were resolved to be diesel and fuel emissions, sea salt, soil dust, secondary sulfates, and metals industry. The metals industry source was much less significant than expected, suggesting effective emissions reductions from the local factory. The source profiles' correlation with wind direction and speed using bivariate polar plots was examined to give further insight into the source identities and their locations. The NOAA HYSPLIT model was also used for air flow back-trajectory analysis. The results of the HYSPLIT and bivariate polar plots suggest that the coal power plant in eastern Oregon is a significant source of sulfates and mercury emissions. Using PMF on particulate matter data from a second industrial location in Southeast Portland (98 filters) revealed the same major sources except for the metals industry source, supporting the conclusion that regional sources dominate particulate matter metals composition, despite measurements made in an industrial urban location.

Miller, A. J., et al. "Source apportionment of trace elements and black carbon in an urban industrial area (Portland, Oregon)." Atmospheric Pollution Research (2018).

Assessment of biomass burning and fossil fuel contribution to black carbon concentrations in Delhi during winter

This study aims to assess the contribution of fossil-fuel combustion (BCff) and biomass (or wood) burning (BCwb) to wintertime black carbon (BC) concentrations in Delhi using the "Aethalometer model" approach. Continuous measurements using 7-wavelength Aethalometer (AE-33) were taken from December 2015 to February 2016 in Delhi downtown, as part of a multi-instrument research campaign, revealing high BC concentrations of 24.4 ± 12.2 µg m−3 (range from 3.2 to 59.9 µg m−3). The BCff contribution dominates with an average fraction of 72% at 880 nm, indicating an important contribution from biomass burning (28%). The daily-averaged Absorption Ångström Exponent (AAE370-880) varies between 1.08 and 1.46 due to changes in the BC emission rates, variations in the relative strength between fossil-fuel and wood-burning sources and mixing processes in the atmosphere. The average BCff/BCwb ratio is estimated as 2.90 ± 1.47 at 880 nm, while the BCwb contribution maximized in the evening hours due to enhanced wood burning for heating. The BC, BCff and BCwb concentrations exhibit remarkable diurnal variations with maximum values in the morning and evening/night hours and lower around noon, primarily driven by changes in the mixing-layer height. The highest BC, BCff and BCwb concentrations are associated with weak winds (<2 ms−1), revealing a dominance of local emission sources within the Delhi metropolitan area. A sensitivity analysis is performed by changing the wavelength pairs and the pre-assumed AAE values in order to evaluate the stability of the "Aethalometer model" in assessment of the BC source apportionment. The results reveal that the "Aethalometer model" is more sensitive in estimating the BCwb, while the changes in the BCff component are rather low.

Dumka, U. C., et al. "Assessment of biomass burning and fossil fuel contribution to black carbon concentrations in Delhi during winter." Atmospheric Environment 194 (2018): 93-109.

Exploratory assessment of outdoor and indoor airborne black carbon in different locations of Hanoi, Vietnam

Black carbon (BC) is a significant component of atmospheric particulate matter, especially in areas affected by combustion emissions. Despite the fact that air pollution is a great concern in Vietnam, there are no studies on the level of BC in the outdoor and indoor environment. In this exploratory study, an assessment of urban BC concentrations was conducted through monitoring of both outdoor and indoor BC concentrations in three households and one working office at different locations across Hanoi. PM2.5 and meteorology data were also obtained for this monitoring period to evaluate the association between them and the outdoor BC concentration. Overall, the mean indoor and mean outdoor BC concentrations by 30 second-logs for the monitoring period were 4.42 µg/m3 and 4.89 µg/m3, respectively. Time-series analysis of paired indoor and outdoor BC concentrations suggested that indoor BC level was usually influenced by outdoor BC level ($r = 0.78$, $p < 0.001$). In this study, we observed a significant positive association between outdoor BC and PM2.5 ($r = 0.39$, $p < 0.001$) while outdoor BC negatively correlated with wind speed ($r = -0.34$, $p < 0.001$). The level of outdoor BC in Hanoi measured in this study is relatively high and should be confirmed by further studies.

Tran, Long K., et al. "Exploratory assessment of outdoor and indoor airborne black carbon in different locations of Hanoi, Vietnam." Science of the total environment 642 (2018): 1233-1241.

Spatio-temporal trends and source apportionment of fossil fuel and biomass burning black carbon (BC) in the Los Angeles Basin

In this study, we evaluated the spatial and temporal trends of black carbon (BC) in the Los Angeles Basin between 2012–2013 and 2016–2017. BC concentrations were measured in seven wavelengths using Aethalometers (AE33) at four sites, including central Los Angeles (CELA), Anaheim, Fontana, and Riverside. Sources of BC were quantified using the equivalent black carbon (EBC) model. Results indicate that total BC concentrations nearly doubled in colder period compared to the warm period. Source apportionment results revealed that fossil fuel combustion has higher annual contributions (ranging from 82% in Riverside to 91% in CELA) than biomass burning (ranging from 9.3% in CELA to 18.7% in Riverside) to the total BC concentrations at all sites. This trend was more clearly observed at the sites closer to major freeways, such as CELA and Anaheim. The relative contribution of fossil fuel to total BC concentrations was higher in the warm period, whereas biomass burning had higher contributions in the colder period. The diurnal variation of fossil-fuel-originated BC (BCff) to the total BC concentrations revealed major rises during the traffic rush hours, especially

in the warm period. In contrast, the fraction of BC originating from biomass burning (BCbb) peaked at nighttime, particularly in the cold period, reaching values as high as 25–30% of total BC concentration. Moreover, we observed a clear decrease in both absolute BC concentrations as well as relative contributions of BCff to total BC concentrations from 2012–2013 to 2016–2017, which can be attributed to the implementation of strict regulations in California to reduce transportation-related PM emissions. Results from the present study suggest that as these regulations become increasingly stricter, the relative contributions of traffic sources to BC also decrease, thereby making the impact of non-fossil fuel combustion sources, such as biomass burning, to the overall BC levels more significant.

Mousavi, Amirhosein, et al. "Spatio-temporal trends and source apportionment of fossil fuel and biomass burning black carbon (BC) in the Los Angeles Basin." Science of the Total Environment 640 (2018): 1231-1240.

Tropospheric Ozone

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

Surface and tropospheric ozone trends in the Southern Hemisphere since 1990: possible linkages to poleward expansion of the Hadley circulation

Increases in free tropospheric ozone over the past two decades are mainly in the Northern Hemisphere that have been widely documented, while ozone trends in the Southern Hemisphere (SH) remain largely unexplained. Here we first show that in-situ and satellite observations document increases of tropospheric ozone in the SH over 1990–2015. We then use a global chemical transport model to diagnose drivers of these trends. We find that increases of anthropogenic emissions (including methane) are not the most significant contributors. Instead, we explain the trend as due to changes in meteorology, and particularly in transport patterns. We propose a possible linkage of the ozone increases to meridional transport pattern shifts driven by poleward expansion of the SH Hadley circulation (SHHC). The SHHC poleward expansion allows more downward transport of ozone from the stratosphere to the troposphere at higher latitudes, and also enhances tropospheric ozone production through stronger lifting of tropical ozone precursors to the upper troposphere. These together may lead to increasing tropospheric ozone in the extratropical SH, particularly in the middle/upper troposphere and in austral autumn. Poleward expansion of the Hadley circulation is partly driven by greenhouse warming, and the associated increase in tropospheric ozone potentially provides a positive climate feedback amplifying the warming that merits further quantification.

Lu, Xiao, et al. "Surface and tropospheric ozone trends in the Southern Hemisphere since 1990: possible linkages to poleward expansion of the Hadley circulation." Science Bulletin (2018).

Quantifying impacts of crop residue burning in the North China Plain on summertime tropospheric ozone over East Asia

Crop residue burning has been proved to have negative impacts on regional atmospheric environment. In this study, an evidence-based statistical modeling framework was established to quantify potential impacts of crop residue burning in the North China Plain (NCP) on summertime tropospheric ozone increase over East Asia during 2004–2016. To assess the intensity of crop residue burning, fire occurrence counts derived from the MODerate-resolution Imaging Spectroradiometer onboard the Terra and Aqua satellites were used as a proxy. Additionally, another six factors were employed as potent explanatory variables. Maximum covariance analysis was first applied to decouple spatiotemporal interactions between tropospheric ozone and each explanatory variable. Based on the decoupled modes, multivariate linear regression (MLR) and artificial neural network (ANN) were used to establish statistical relationships between tropospheric ozone and contributing factors, respectively. The results indicate that the ANN-based modeling scheme enables to approximate the observed tropospheric ozone variations better than MLR. Further investigations reveal that the summertime

crop residue burning in the NCP is the predominant factor contributing to the observed additive tropospheric ozone increases over East Asia, yielding extra 8% tropospheric ozone elevation on average in June. Moreover, UV radiation and wind also played critical roles in modulating the observed tropospheric ozone variations therein. In general, the critical role of crop residue burning over the NCP in modulating summertime tropospheric ozone increase over East Asia have been well demonstrated based on the proposed evidenced-based modeling framework.

Ma, Mingliang, et al. "Quantifying impacts of crop residue burning in the North China Plain on summertime tropospheric ozone over East Asia." Atmospheric Environment 194 (2018): 14-30.

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.

Field-based emission measurements of biomass burning in typical Chinese built-in-place stoves

Residential combustion emission contributes significantly to ambient and indoor air pollution in China; however, this pollution source is poorly characterized and often overlooked in national pollution control policies. Few studies, and even fewer field-based investigations, have evaluated pollutant emissions from indoor biomass burning. One significant feature of Chinese household biofuel stoves is that many are built on site. In this study, 112 tests were conducted to investigate pollutant emission factors and variations for 11 fuel-stove combinations in actual use in the field. Results showed that, compared to those emission tests under controlled fuel burning conditions, EFs of methane, sulfur dioxide, particulate matter, and organic carbon from the field-based uncontrolled tests were higher, but carbon monoxide, nitrogen oxides, and elemental carbon were not significantly different. Controlled burning tests may be unrepresentative of real-world fuel burning. Pollutant emissions from uncontrolled burning tests had much higher variations compared with controlled tests. Most pollutant emissions from indoor straw burning are higher than that in open burning, except nitrogen oxides. The typical built-in-place home stoves in China had low efficiencies and high pollutant emissions that were rated as Tier 0 (the worst) or Tier 1 of a four-tier scale according to the International Organization for Standardization, International Workshop Agreement 11–2012. Effective interventions are expected to lower pollutant emissions from residential combustion to improve air quality and to protect human health.

Du, Wei, et al. "Field-based emission measurements of biomass burning in typical Chinese built-in-place stoves." Environmental pollution 242 (2018): 1587-1597.

Impact of biomass burning and its control on particulate matter over a city in mainland Southeast Asia during a smog episode

Cities in mainland Southeast Asia have long faced smog problems. Developing effective control strategies for smog reduction has been a challenge for academics and policy makers. In this study, emission control measures were assessed using both the Weather Research and Forecasting (WRF) and Community Multi-scale Air Quality (CMAQ) modeling systems during a smog episode between 1st and 31st of March 2012. The study found that there was a strong impact from biomass burning outside of the city on PM concentrations within the city, with contributions of approximately 85% and 89% for PM10 and PM2.5 respectively. Control of biomass burning in the city significantly affects local PM concentrations. This study investigated the success of biomass burning control inside the city when no biomass is burned outside of the city. The control scenarios focused on specific reduction levels in biomass burning emissions, which included 0%, 20%, 40%, 60%, 80% and 100%. The results yielded the following rates: the mean PM2.5 concentrations decreased by 0.70% per %decrease of biomass burning emission; the maximum daily average PM2.5 concentrations decreased by 0.84% per %decrease of biomass burning emission; and the average percentage of PM2.5 concentrations that exceeded the NAAQS

decreased by 1.05% per %decrease of biomass burning emission. This information provide good guidelines for successful decision-making at each control level to solve the problems related to of smog in cities. However, smog problems cannot only be solved by emission control measures in the city; biomass burning must also be reduced on a regional scale.

Pimonsree, Sittichai, and Patipat Vongruang. "Impact of biomass burning and its control on particulate matter over a city in mainland Southeast Asia during a smog episode." Atmospheric Environment 195 (2018): 196-209.

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

Paddy soil drainage influences residue carbon contribution to methane emissions

Water drainage is an important mitigation option for reducing CH4 (methane) emissions from residue-amended paddy soils. Several studies have indicated a long-term reduction in CH4 emissions, even after re-flooding, suggesting that the mechanism goes beyond creating temporary oxidized conditions in the soil. In this pot trial, the effects of different drainage patterns on straw-derived CH4 and CO2 (carbon dioxide) emissions were compared to identify the balance between straw-carbon CH4 and CO2 emissions influenced by soil aeration over different periods, including effects of drainage on emissions during re-flooding. The water treatments included were: continuous flooding [C] as the control and five drainage patterns (pre-planting drainage [P], early-season drainage [E], midseason drainage [M], pre-planting plus midseason drainage [PM], early-season-plus-midseason drainage [EM]). An equal amount of 13C-enriched rice straw was applied to all treatments to identify straw-derived 13C-gas emissions from soil carbon derived emissions.

The highest fluxes of CH4 and δ13C-CH4 were recorded from the control treatment in the first week after straw application. The CH4 flux and δ13C-CH4 were reduced the most (0.1–0.8 µg CH4 g−1 soil day−1 and -13 to −34‰) in the pre-planting and pre-planting plus midseason drainage treatments at day one after transplanting. Total and straw-derived CH4 emissions were reduced by 69% and 78% in pre-planting drainage and 77% and 87% in pre-planting plus midseason drainage respectively, compared to control. The early-season, midseason, pre-planting plus midseason and early-season-plus-midseason drainage treatments resulted in higher total and straw-derived CO2 emissions compared to the control and pre-planting drainage treatments. The pre-planting and pre-planting plus midseason drainage treatments lowered the global warming potential by 47–53%, and early-season and early-season-plus-midseason drainage treatments reduced it by 24–31% compared to control. By using labelled crop residues, this experiment demonstrates a direct link between early drainage and reduced CH4 emissions from incorporated crop residues, eventually leading to a reduction in total global warming potential. It is suggested that accelerated decomposition of the residues during early season drainage prolonged the reduction in CH4 emissions. Therefore, it is important to introduce the early drainage as an effective measure to mitigate CH4 emissions from crop residues.

Tariq, Azeem, et al. "Paddy soil drainage influences residue carbon contribution to methane emissions." Journal of environmental management 225 (2018): 168-176.

Limited potential of harvest index improvement to reduce methane emissions from rice paddies

Rice is a staple food for nearly half of the world's population, but rice paddies constitute a major source of anthropogenic CH4 emissions. Root exudates from growing rice plants are an important substrate for methane-producing microorganisms. Therefore, breeding efforts optimizing rice plant photosynthate allocation to grains, i.e., increasing harvest index (HI), are widely expected to reduce CH4 emissions with higher yield. Here we show, by combining a series of experiments, meta-analyses and an expert survey, that the potential of CH4 mitigation from rice paddies through HI improvement is in fact small. Whereas HI improvement reduced CH4 emissions

under continuously flooded (CF) irrigation, it did not affect CH4 emissions in systems with intermittent irrigation (II). We estimate that future plant breeding efforts aimed at HI improvement to the theoretical maximum value will reduce CH4 emissions in CF systems by 4.4%. However, CF systems currently make up only a small fraction of the total rice growing area (i.e., 27% of the Chinese rice paddy area). Thus, to achieve substantial CH4 mitigation from rice agriculture, alternative plant breeding strategies may be needed, along with alternative management.

Jiang, Yu, et al. "Limited potential of harvest index improvement to reduce methane emissions from rice paddies." Global change biology (2019).

Agricultural non-CO2 emission reduction potential in the context of the 1.5 °C target

Agricultural methane and nitrous oxide emissions represent around 10–12% of total anthropogenic GHG emissions and have a key role to play in achieving a 1.5 °C (above pre-industrial) climate stabilization target. Using a multi-model assessment approach, we quantify the potential contribution of agriculture to the 1.5 °C target and decompose the mitigation potential by emission source, region and mitigation mechanism. The results show that the livestock sector will be vital to achieve emission reductions consistent with the 1.5 °C target mainly through emission-reducing technologies or structural changes. Agriculture may contribute emission reductions of 0.8–1.4 Gt of CO2-equivalent (CO2e) yr−1 at just US$20 per tCO2e in 2050. Combined with dietary changes, emission reductions can be increased to 1.7–1.8 GtCO2e yr−1. At carbon prices compatible with the 1.5 °C target, agriculture could even provide average emission savings of 3.9 GtCO2e yr−1 in 2050, which represents around 8% of current GHG emissions.

Frank, Stefan, et al. "Agricultural non-CO2 emission reduction potential in the context of the 1.5° C target." Nature Climate Change 9.1 (2019): 66.

Transportation

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

High-resolution vehicle emission inventory and emission control policy scenario analysis, a case in the Beijing-Tianjin-Hebei (BTH) region, China

Urban air pollution has become a major concern in China. In the heavily populated and developed Beijing-Tianjin-Hebei (BTH) region, vehicle emissions are major pollution contributors. This paper aims to establish 2014 vehicle emission inventories for five major air pollutants in the BTH region: CO, HC, NOx, PM10 and PM2.5 and carry out an emission control policy scenario analysis based on the newly developed inventories. Results showed that total emissions of CO, HC, NOx, PM10 and PM2.5 from vehicles in the BTH region were 1622.4 kt, 187.5 kt, 544.7 kt, 23.5 kt, and 26.1 kt, respectively. Based on the emission inventory, high-resolution emission distribution maps of the study area were created at a scale of 1 km × 1 km by incorporating local traffic flow data. The CO, HC and NOx emission levels were higher in the southeast, while the PM10 and PM2.5 levels were relatively evenly distributed throughout the BTH region. Based on the emission inventories, four policy scenarios were set to simulate the emission changes, and results showed that eliminating old vehicles and upgrading oil quality could reduce emission efficiently. A policy of eliminating old vehicles was selected to calculate the economic cost. Results showed that the emission reduction efficiencies of unit cost decreased from Hebei, Tianjin to Beijing. The results of this study could help policy makers identify pollution sources and design appropriate control measures.

Yang, Wen, et al. "High-resolution vehicle emission inventory and emission control policy scenario analysis, a case in the Beijing-Tianjin-Hebei (BTH) region, China." Journal of Cleaner Production 203 (2018): 530-539.

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

The effectiveness of passive gas ventilation on methane emission reduction in a semi-aerobic test cell operated in the tropics

Two landfill test cells, with and without gas vents, were used to investigate the effectiveness of passive aeration, through basal leachate pipes, in mitigating methane emissions from municipal solid waste disposal in the tropical climate of Thailand. Surface methane emission rate, as well as methane content in the landfill gas, were determined for a period of three years. The results indicate that the average methane emission rate from the test cell with passive gas vents (42.13 g/t dry wt./d) was about half of that from the test cell without gas vents (90.33 g/t dry wt./d). Methane emission rates from both test cells fluctuated and were influenced by precipitation. The emission rate during the wet period in the test cell with gas vents (61.67 g/t dry wt./d) was 3 times as much as that observed during the dry period (20.95 g/t dry wt./d). The emission rate during the wet period in the test cell without gas vents (120.33 g/t dry wt./d), was twice the value of that observed during the dry period (60.32 g/t dry wt./d). The measurements also revealed the formation of methane hotspots in the test cell with passive vents after rainfall events, leading to higher localized surface emissions. Introduction of gas vents helped reduce methane emissions from solid waste landfills in a tropical region. However, rainfall should be limited to avoid turning semi-aerobic conditions into anaerobic conditions.

Sutthasil, Noppharit, et al. "The effectiveness of passive gas ventilation on methane emission reduction in a semi-aerobic test cell operated in the tropics." Waste Management (2018).

Economic and environmental assessment of electricity generation using biogas from organic fraction of municipal solid waste for the city of Ibadan, Nigeria

In this paper, biogas recovery from organic fraction of municipal solid waste for the purpose of electricity generation is presented with the objective of determining its economic and environmental benefits for the city of Ibadan, Nigeria. Two methods of biogas recovery technologies (i.e., anaerobic digestion and landfill gas recovery technologies) were considered. The environmental impact was performed using life cycle assessment technique while the economic assessment was determined using total life cycle cost, levelised cost of energy, net present value, internal rate of return and payback period. Sensitivity analysis was conducted to investigate the influence electricity generation efficiency, capacity factor, per capita waste generation rate, discount rate, population growth rate and waste collection efficiency on the economic viability of the two technologies. Some of the results indicated that in a span of 20 years (i.e., 2017–2036), the waste generation potential of the city of Ibadan was estimated between 477,001 and 966,897 tons. The methane yield for anaerobic digestion and landfill gas recovery technologies were determined to be about (104.66–212.15) x 106 m3/yr and (22.65–127.65) x 106 m3/yr, respectively. Also, the electricity generation potential ranged between 321.73 and 652.15 Gigawatt-hour for anaerobic digestion and 63.25–436.18 Gigawatt-hour for landfill gas recovery technologies. The economic indicators showed that both technologies are economically viable as they presented positive net present values. The net present value for anaerobic digestion was 834.12 million US dollar while that of landfill gas recovery was 489.26 million US dollar. The levelised cost of electricity generation was between 0.0681 and 0.0336 US dollar per kilowatt-hour for anaerobic digestion technology while it ranged from 0.2411 to 0.0350 US dollar per kilowatt hour for landfill gas recovery technology. The payback period, internal return and the total life cycle cost were 5 years, 19.3% and 413.68 million US dollar for the anaerobic digestion and 7 years, 23.4% and 288.05 million US dollar for landfill gas recovery technology. This paper intends to serve as first-hand technical information to potential investors, government agencies, policy makers and potential non-governmental organisations to enhance optimal investment in biogas to energy technologies in Nigeria.

Ayodele, T. R., A. S. O. Ogunjuyigbe, and M. A. Alao. "Economic and environmental assessment of electricity generation using biogas from organic fraction of municipal solid waste for the city of Ibadan, Nigeria." Journal of Cleaner Production 203 (2018): 718-735.

Air pollution & Health Impacts

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

Underlying causes of PM2.5-induced premature mortality and potential health benefits of air pollution control in South and Southeast Asia from 1999 to 2014

Quantification of spatial and temporal variations in premature mortality attributable to PM2.5 has important implications for air quality control in South and Southeast Asia (SSEA). The number of PM2.5-induced premature deaths during 1999–2014 in SSEA was estimated using an integrated exposure-response model based on 0.01° × 0.01° satellite-retrieved PM2.5 data, population density, and spatially and temporally variable baseline mortality data. The results showed extremely high premature death rates in North India and Bangladesh. PM2.5-induced premature deaths in SSEA increased with small interannual variations from 1999 to 2014 owing to the interannual variations in PM2.5 concentrations. Moreover, four scenarios on the effects of premature deaths by PM2.5 mitigation efforts based on World Health Organization (WHO) air quality guidelines (AQG) and interim targets (ITs) were investigated for each disease and each country during 1999–2014. Four scenarios based on WHO AQG (10 μg/m3), IT-3 (15 μg/m3), IT-2 (25 μg/m3), and IT-1 (35 μg/m3) resulted in 69.3%, 49.1%, 25.4%, and 12.8% reductions compared to the total reference premature deaths (1256,300), which was calculated using the original PM2.5 datasets. Overall, stroke was the most serious disease associated with air pollution, causing 40% of total premature deaths. Ischemic heart disease was the largest contributor (58%) to the deaths in relatively cleaner air (Scenario 1). The annual rate of change in premature deaths in South Asian countries (India, Bangladesh, and Pakistan) was higher than that in Southeast Asian countries under all scenarios. The results for different scenarios provide insight into the largest health benefits of PM2.5 reduction efforts.

Shi, Yusheng, et al. "Underlying causes of PM2. 5-induced premature mortality and potential health benefits of air pollution control in South and Southeast Asia from 1999 to 2014." Environment international 121 (2018): 814-823.

Premature Mortality Due to PM2.5 Over India: Effect of Atmospheric Transport and Anthropogenic Emissions

The annual premature mortality in India attributed to exposure to ambient particulate matter (PM2.5) exceeds 1 million (Cohen et al., 2017, https://doi.org/10.1016/S0140-6736(17)30505-6). Studies have estimated sector-specific premature mortality from ambient PM2.5 exposure in India and shown residential energy use is the dominant contributing sector. In this study, we estimate the contribution of PM2.5 and premature mortality from six regions of India in 2012 using the global chemical-transport model. We calculate how premature mortality in India is determined by the transport of pollution from different regions. Of the estimated 1.1 million annual premature deaths from PM2.5 in India, about ~60% was from anthropogenic pollutants emitted from within the region in which premature mortality occurred, ~19% was from transport of anthropogenic pollutants between different regions within India, ~16% was due to anthropogenic pollutants emitted outside of India, and ~4% was associated with natural PM2.5 sources. The emissions from Indo Gangetic Plain contributed to ~46% of total premature mortality over India, followed by Southern India (13%). Indo Gangetic Plain also contributed (~8%) to the most premature mortalities in other regions of India through transport. More than 50% of the premature mortality in Northern, Eastern, Western, and Central India was due to transport of PM2.5 from regions outside of these individual regions. Our results indicate that reduction in

anthropogenic emissions over India, as well as its neighboring regions, will be required to reduce the health impact of ambient PM2.5 in India.

David, Liji M., et al. "Premature mortality due to PM2. 5 over India: Effect of atmospheric transport and anthropogenic emissions." GeoHealth (2019).

The estimated change in the level and distribution of PM2.5-attributable health impacts in the United States: 2005–2014

Photochemical modeling can predict the level and distribution of pollutant concentrations over time, but is resource-intensive. Partly for this reason, there are few studies exploring the multi-year trajectory of the historical change in fine particle (PM2.5) levels and associated health impacts in the U.S. We used a unique dataset of Community Multi-Scale Air Quality (CMAQ) model simulations performed for a subset of years over a decade-long period fused with observations to estimate the change in ambient levels of PM2.5 across the contiguous U.S. We also quantified the change in PM2.5-attributable health risks and characterized the level of risk inequality over this period. We estimated annual mean PM2.5 concentrations in 2005, 2011 and 2014. Using log-linear and logistic concentration-response coefficients we estimated changes in the numbers of deaths, hospital admissions and other morbidity outcomes. Calculating the Gini coefficient and Atkinson Index, we characterized the extent to which PM2.5 attributable risks were shared equally across the population or instead concentrated among certain subgroups. In 2005 the estimated fraction of deaths due to PM2.5 was 6.1%. This estimated value falls to 4.6% by 2014. Every portion of the contiguous U.S. experiences a decline in the risk of PM-related premature death over the 10-year period. As measured by the Gini coefficient and Atkinson index, the level of PM mortality risk is shared more equally in 2014 than in 2005 among all subgroups. Between 2005 and 2014, the level of PM2.5 concentrations fall, and the risk of premature death, declined and became more equitably distributed across the U.S. population.

Fann, Neal, et al. "The estimated change in the level and distribution of PM2. 5-attributable health impacts in the United States: 2005–2014." Environmental research 167 (2018): 506-514.

Expected health benefits from mitigation of emissions from major anthropogenic PM2.5 sources in India: Statistics at state level

Exposure to fine particulate matter (PM2.5) is one of the leading risk factors for the mortality and morbidity burden in India. Health benefit expected from mitigation of emissions from individual sectors is the key policy information to address this issue. Here we quantify the relative shares of four major year-round anthropogenic sources to ambient PM2.5 in India using a chemical transport model and estimate premature deaths that could have been avoided due to complete mitigation of emissions from these sources at state level. Population-weighted all-India averaged (±1σ) annual ambient PM2.5 exposures due to residential, transport, industrial and energy sectors in 2010 are estimated to be 26.2 ± 12.5, 3.8 ± 4.3, 5.5 ± 2.7 and 2.2 ± 2.3 μg m−3, respectively. Complete mitigation of emissions from the transport, industrial and energy sectors combined would avoid 92,380 (95% uncertainty interval (UI), 40,918–140,741) premature deaths annually, primarily at the urban hotspots. For the residential sector, this would result in avoiding 378,295 (95% UI, 175,002–575,293) premature deaths due to a reduction in ambient PM2.5 exposure in addition to the benefit of avoiding all premature deaths from household exposure. Bihar and Goa are expected to have the largest (289) and smallest (48) premature mortality burden per 100,000 population due to anthropogenic PM2.5 exposure. From policy perspective, controlling residential sources should be prioritized in view of the effectiveness of implementing mitigation measures and the expected larger health benefit at a regional scale. However, additional mitigation measures are advised at the urban hotspots to curb emissions from the other sectors to get maximum possible health benefit.

Upadhyay, Abhishek, et al. "Expected health benefits from mitigation of emissions from major anthropogenic PM2. 5 sources in India: Statistics at state level." Environmental pollution 242 (2018): 1817-1826.

Air pollution and healthcare expenditure: Implication for the benefit of air pollution control in China

Quantitating the health effects of air pollution is important for understanding the benefits of environmental regulations. Using the China Urban Household Survey (UHS) Database, this paper estimated the effect of air pollution exposure on household healthcare expenditure. To address potential endogeneity concerns, we performed household healthcare expenditure regressions using an instrumental variables (IV) strategy based on spatial air pollution spillovers. Our research revealed that a 1% increase in yearly exposure to fine particulate matter (PM2.5) corresponds to a 2.942% (95% confidence interval: 1.084%, 4.799%) increase in household healthcare expenditure. The estimates suggest that the 13th Five-Year Plan for Ecological and Environmental Protection (the 13th FYP) would reduce annual national healthcare expenditure by 47.36 Billion Dollar (95% confidence interval: 17.45 Billion Dollar, 77.25 Billion Dollar), which accounts for 0.64% (95% confidence interval: 0.24%, 1.04%) of China's gross domestic product (GDP).

Yang, Jing, and Bing Zhang. "Air pollution and healthcare expenditure: Implication for the benefit of air pollution control in China." Environment international 120 (2018): 443-455.

Coal-fired power plant regulatory rollback in the United States: Implications for local and regional public health

President Trump wants to promote coal and weaken Clean Air Act regulations that affect coal-fired power plants. We analyze which US regions have benefited from air quality improvements realized since adoption of two Clean Air Act power plant rules, the transport and mercury rules, which have been targeted by lobbyists and national officials. For 20 coal states, we create a pre-regulatory emissions scenario for the current (2016) fleet of power plants. Using the US Environmental Protection Agency's CO-Benefits Risk Assessment screening model, we estimate the differences between the impacts of pre-regulatory emissions and current emissions on fine particulate matter (PM2.5) concentrations and on public health. We compare those impacts with voting patterns in the 2016 presidential election and with demographic data. Among the air quality and public health gains of the current situation relative to the pre-regulatory scenario are that: annual average PM2.5 concentrations are lower by 1–5 µg/m3; 17,176–39,291 premature mortalities are avoided for each year of lower emissions; coal mining counties and White, rural counties experience some of the best improvements in air quality; and, in several states, Trump counties benefit more than Clinton counties. We suggest refining these results with atmospheric dispersion models.

Thomson, Vivian E., Kelsey Huelsman, and Dominique Ong. "Coal-fired power plant regulatory rollback in the United States: Implications for local and regional public health." Energy Policy 123 (2018): 558-568.

PM2.5 and Air Pollution

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

Characteristics of Indoor PM2.5 Concentration in Gers Using Coal Stoves in Ulaanbaatar, Mongolia

Coal combustion in ger areas is the main source of ambient air pollution in Ulaanbaatar (Mongolia). This study determined the characteristics of indoor PM2.5 concentrations in gers using coal stoves during winter. The study population consisted of 60 gers in the Chingeltei district of Ulaanbaatar. The indoor particle number concentration (PNC) in each ger was measured using a Dylos DC1700 particle counter for 24 h in January and February 2016. The PNC by Dylos was converted into the mass concentration using a calibration equation developed using a collocated real-time light scattering monitor adjusted by gravimetric measurement. The average 24 h PM2.5 concentration was 203.9 ± 195.1 µg/m3 in gers with traditional stoves (n = 29) and 257.5 ± 204.4 µg/m3 in those with improved stoves (n = 31). In the daily profile, concentrations were lower at night, increased in the early morning, and peaked up to noon. The temperature in gers was slightly higher than that recommended in winter. Many development-assistance programs have supported the installation of improved

energy-efficient stoves. Better control measures are needed to improve the indoor air quality of gers.

Lim, Miyoung, et al. "Characteristics of Indoor PM2. 5 Concentration in Gers Using Coal Stoves in Ulaanbaatar, Mongolia." International journal of environmental research and public health 15.11 (2018): 2524.

Six sources mainly contributing to the haze episodes and health risk assessment of PM2.5 at Beijing suburb in winter 2016

Aiming to a better understanding sources contributions and regional sources of fine particles, a total of 273 filter samples (159 of PM2.5 and 114 of PM1.0) were collected per 8 h during the winter 2016 at a southwest suburb of Beijing. Chemical compositions, including water soluble ions, organic carbon (OC), and elemental carbon (EC), as well as secondary organic carbon (SOC), were systematically analyzed and estimated. The total ions concentrations (TIC), OC, and SOC of PM2.5 were with the following order: 16:00–24:00 > 08:00–16:00 > 00:00–08:00. Since primary OC and EC were mainly attributed to the residential combustion in the night time, their valley values were observed in the daytime (08:00–16:00). However, the highest ratio value of SOC/OC was observed in the daytime. It is because that SOC is easily formed under sunshine and relatively high temperature in the daytime. Positive matrix factorization (PMF), clustering, and potential source contribution function (PSCF) were employed for apportioning sources contributions and speculating potential sources spatial distributions. The average concentrations of each species and the source contributions to each species were calculated based on the data of species concentrations with an 8 h period simulated by PMF model. Six likely sources, including secondary inorganic aerosols, coal combustion, industrial and traffic emissions, road dust, soil and construction dust, and biomass burning, were contributed to PM2.5 accounting for 29%, 21%, 17%, 16%, 9%, 8%, respectively. The results of cluster analysis indicated that most of air masses were transported from West and Northwest directions to the sampling location during the observation campaign. Several seriously polluted areas that might affect the air quality of Beijing by long-range transport were identified. Most of air masses were transported from Western and Northwestern China. According to the results of PSCF analysis, Western Shandong, Southern Hebei, Northern Henan, Western Inner Mongolia, Northern Shaanxi, and the whole Shanxi provinces should be the key areas of air pollution control in China. The exposure-response function was used to estimate the health impact associated with PM2.5 pollution. The population affected by PM2.5 during haze episodes reached 0.31 million, the premature death cases associated with PM2.5 reached 2032. These results provided important implication for making environmental policies to improve air quality in China.

Xu, Xianmang, et al. "Six sources mainly contributing to the haze episodes and health risk assessment of PM2. 5 at Beijing suburb in winter 2016." Ecotoxicology and environmental safety 166 (2018): 146-156.

Estimation of the contributions of the sources driving PM2.5 levels in a Central Mediterranean coastal town

Receptor modelling techniques are widely used in order to identify the main natural and anthropogenic processes driving aerosol levels at a receptor. In this work, Positive Matrix Factorization (PMF) was used to apportion PM2.5 levels at a traffic site (Msida) located in a coastal town. 180 filters collected throughout a yearly sampling campaign conducted in 2016, were chemically characterized by light absorbance analysis, x-ray fluorescence and ion chromatography in order to determine the concentrations of black carbon, 17 elements and 5 ions, respectively. The resulting chemical data base was used in conjunction with PMF in order to identify the 7 components affecting the PM2.5 levels at the receptor site. Six of these sources are considered to be typical of the atmospheric composition of coastal traffic sites: traffic (27.3%), ammonium sulfate (23.6%), Saharan dust (15%), aged sea salt (12.7%), shipping (5%) and fresh sea salt (4.6%). This is the first time that such a study was carried out in Malta and helps in understanding the aerosol pollution climate of the Central Mediterranean, which is still relatively understudied when compared to the Eastern and Western Mediterranean. Furthermore, we have isolated a factor exclusive to Malta: the fireworks component, which is responsible for 2.9% of the PM2.5 and which has health implications due to its chemical composition. The results of this work should also serve to guide the policy makers in achieving the necessary emission reductions in order to achieve the WHO guideline for PM2.5 by 2020.

Scerri, Mark M., et al. "Estimation of the contributions of the sources driving PM2. 5 levels in a Central Mediterranean coastal town." Chemosphere 211 (2018): 465-481.

PM2.5-related health and economic loss assessment for 338 Chinese cities

China is in a critical stage of ambient air quality management after global attention on pollution in its cities. Industrial development and urbanization have led to alarming levels of air pollution with serious health hazards in densely populated cities. The quantification of cause-specific PM2.5-related health impacts and corresponding economic loss estimation is crucial for control policies on ambient PM2.5 levels. Based on ground-level direct measurements of PM2.5 concentrations in 338 Chinese cities for the year 2016, this study estimates cause-specific mortality using integrated exposure-response (IER) model, non-linear power law (NLP) model and log-linear (LL) model followed by morbidity assessment using log-linear model. The willingness to pay (WTP) and cost of illness (COI) methods have been used for PM2.5-attributed economic loss assessment. In 2016 in China, the annual PM2.5 concentration ranged between 10 and 157 µg/m3 and 78.79% of the total population was exposed to >35 µg/m3 PM2.5 concentration. Subsequently, the national PM2.5-attributable mortality was 0.964 (95% CI: 0.447, 1.355) million (LL: 1.258 million and NPL: 0.770 million), about 9.98% of total reported deaths in China. Additionally, the total respiratory disease and cardiovascular disease-specific hospital admission morbidity were 0.605 million and 0.364 million. Estimated chronic bronchitis, asthma and emergency hospital admission morbidity were 0.986, 1.0 and 0.117 million respectively. Simultaneously, the PM2.5 exposure caused the economic loss of 101.39 billion US$, which is 0.91% of the national GDP in 2016. This study, for the first time, highlights the discrepancies associated with the three commonly used methodologies applied for cause-specific mortality assessment. Mortality and morbidity results of this study would provide a measurable assessment of 338 cities to the provincial and national policymakers of China for intensifying their efforts on air quality improvement.

Maji, Kamal Jyoti, et al. "PM2. 5-related health and economic loss assessment for 338 Chinese cities." Environment international 121 (2018): 392-403.

SLCPs & Vulnerable Regions

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

Effect of biomass burning on black carbon (BC) in South Asia and Tibetan Plateau: The analysis of WRF-Chem modeling

The focus of this study is to evaluate the impact of biomass burning (BB) from South Asia and Southeast Asia on the glaciers over the Tibetan Plateau. The seasonality and long-term trend of biomass fires measured by Terra and Aqua satellite data from 2010 to 2016 are used in this study. The analysis shows that the biomass burnings were widely dispersed in the continental of Indian and Southeast Asia and existed a strong seasonal variation. The biomass burnings in winter (January) were relatively weak and scattered and were significantly enhanced in spring (April). The highest biomass burnings located in two regions. One was along the foothill of Himalayas, where is a dense population area, and the second located in Southeast Asia. Because these two high biomass burning regions are close to the Tibetan Plateau, they could have important effects on the BC deposition over the glaciers of the Tibetan Plateau. In order to study the effect of BB emissions on the deposition over the glaciers in the Tibetan Plateau, a regional chemical model (WRF-Chem; Weather Research and Forecasting Chemical model) was applied to simulate the BC distributions and the transport from BB emission regions to the glaciers in Tibetan Plateau. The result shows that in winter (January), due to the relatively weak BB emissions, the effect of BB emissions on BC concentrations was not significant. The BC concentrations resulted from BB emissions ranged from 0.1 to 2.0 µg/m3, with high concentrations distributed along the foothill of Himalayas and the southeastern Asia region. Due to the relative low BC concentrations, there was insignificant effect of BB emissions on the deposition over the glaciers in the Tibetan Plateau in winter.

However, the BB emissions were highest in spring (April), producing high BC concentrations. For example, along the Himalayas Mountain and in the southeastern Asia region, The BC concentrations ranged from 2.0 to 6.0 µg/m3. In addition to the high BC concentrations, there were also west and south prevailing winds in these regions. As a result, the BC particles were transported to the glaciers in the Tibetan Plateau, causing significant deposition of BC particles on the snow surface of the glaciers. This study suggests that the biomass burning emissions have important effects on the BC deposition over the glaciers in the Tibetan Plateau, and the contaminations of glaciers could have significant impact on the melting of snow in the Tibetan Plateau, causing some severe environmental problems, such as the water resources.

Xu, Ruiguang, et al. "Effect of biomass burning on black carbon (BC) in South Asia and Tibetan Plateau: The analysis of WRF-Chem modeling." Science of The Total Environment 645 (2018): 901-912.