SHORT-LIVED CLIMATE POLLUTANTS SPECIAL EDITION RESEARCH DIGEST

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TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

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

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SLCP

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 261 (2020): 113650.

Multiple Benefits/Impacts & Crosscutting

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

Using Satellites to Track Indicators of Global Air Pollution and Climate Change Impacts: Lessons Learned From a NASA-Supported Science-Stakeholder Collaborative

The 2018 NASA Health and Air Quality Applied Science Team (HAQAST) "Indicators" Tiger Team collaboration between NASA-supported scientists and civil society stakeholders aimed to develop satellite-derived global air pollution and climate indicators. This Commentary shares our experience and lessons learned. Together, the team developed methods to track wildfires, dust storms, pollen counts, urban green space, nitrogen dioxide concentrations and asthma burdens, tropospheric ozone concentrations, and urban particulate matter mortality. Participatory knowledge production can lead to more actionable information but requires time, flexibility, and continuous engagement. Ground measurements are still needed for ground truthing, and sustained collaboration over time remains a challenge.

Anenberg, Susan C., et al. "Using satellites to track indicators of global air pollution and climate change impacts: Lessons learned from a NASA-supported science-stakeholder collaborative." GeoHealth: e2020GH000270.

Do sustainable energy policies matter for reducing air pollution?

Yes, they matter. To reply to this question, we assess the impact of energy efficiency and renewable energy policies on six different air pollutants: carbon dioxide (CO), methane (CH), nitrous oxides (NO), non-methane volatile organic compounds (NMVOCs), nitrogen oxides (NO) and sulfur dioxide (SO) in Italian provinces in the

decade 2005–2015. The empirical analysis is performed in a panel data context by means of propensity score matching with multiple treatments, since our framework is characterized by the presence of two treatments, corresponding to the two different energy policies analyzed, i.e. energy efficiency policy and renewable policy. These two policies can be applied by each province as mutually exclusive strategies or as joint strategies. Our results show that renewable policies are the most effective in terms of climate goals especially when implemented on a local scale, while energy efficiency policies alone are ineffective. Moreover, the success of these policies depends on the type of pollutant to be reduced. Finally, we note that the effect of energy policies was reinforced by the counter-cyclical fiscal policies implemented to counter the Global Financial Crisis in 2008.

Baiardi, Donatella. "Do sustainable energy policies matter for reducing air pollution?." Energy Policy 140 (2020): 111364.

Health co-benefits of achieving sustainable net-zero greenhouse gas emissions in California

The achievement of net-zero greenhouse gas (GHG) emissions by 2100 is required to limit global temperature rise below 2 °C above preindustrial levels. Earlier accomplishments of net-zero GHG emissions in developed regions support this global target. Here, we develop a road map for California to achieve net-zero GHG emissions sustainably in 2050 by using detailed modelling of energy system transformation, cross-sectoral connectivity and technology penetration, as well as quantify the associated health co-benefits from reduced co-emitted air pollutants. We find that approximately 14,000 premature deaths can be avoided in California in 2050 and that these health co-benefits are disproportionately higher in disadvantaged communities (that is, 35% of avoided deaths will come from 25% of the state's population). The annualized monetary benefits (US$215 billion) exceed the GHG abatement cost (US$106 billion) by US$109 billion. This road map requires the use of bioenergy with carbon capture and sequestration technology to offset some GHG emissions. However, this technology comes at a price as it would emit a considerable amount of air pollutants and reduce health co-benefits by US$4 billion. Nevertheless, our analysis shows that ambitious GHG reduction efforts can provide substantial health co-benefits, especially for residents of disadvantaged communities.

Wang, Tianyang, et al. "Health co-benefits of achieving sustainable net-zero greenhouse gas emissions in California." Nature Sustainability (2020): 1-9.

Identifying common paths of CO2 and air pollutants emissions in China

China faces the dual challenge of mitigating climate change and preventing air pollution. The coordinated control of both problems has become an issue of widespread concern. This study combined environmentally extended input-output analysis and structural path analysis to analyze the CO2, SO2, NOx, black carbon, and PM2.5 emissions embodied in the production supply chain of China in 2012. The results showed that electricity and heat production, nonmetallic mineral products along with the smelting and pressing of metal were primary sources of environmental emissions from the production perspective, and construction contributed 20–38% relevant emissions from the consumption perspective. Among the 100 largest paths, 22 common critical paths accounted for 16–37% of relevant emissions, meaning that measures focusing on these shared paths will have obvious co-controlling effects. These 22 critical supply chains were mainly driven by fixed capital formation and exports. The dominant sectors included the construction, electricity and heat production, transportation and storage, and construction-materials production (nonmetallic mineral products, smelting and pressing of metal). Therefore, measures from the production-side and the consumption-side should be given equal attention to effectively co-control such emissions. Measures to decrease energy intensity, thus reducing end-of-pipe discharge in these sectors, rather than to remove specific pollutants, represent the most promising production-related measures. Moreover, slowing construction growth by guiding investments and encouraging the use or export of products with lower emissions using environmental information labels are essential consumption-related policies.

Liu, Yu-Sheng, et al. "Identifying common paths of CO2 and air pollutants emissions in China." Journal of Cleaner Production (2020): 120599.

Cost-effective approaches for reducing carbon and air pollution emissions in the power industry in China

The power industry of China plays an important role in reducing the carbon dioxide (CO2) and air pollutant emissions. This paper focuses on synergistic CO2 and air pollution emission reduction by implementing technical and structural measures, and explores the processes aimed at achieving the co-benefits of carbon reduction and air pollution control effectively in the power industry at a local level. The results of the analysis show that the structural measures achieve overall co-benefits, and the technical measures have a good effect in reducing the air pollution, but simultaneously increase CO2 emissions because of the additional electricity used for running air pollution control devices (APCDs). Based on the analysis of the power generation incremental cost and pollutant emission reduction cost, cost-effective approaches to attain different emission reduction targets are proposed to the power industry in four case regions. These approaches can provide policy makers and stakeholders useful and relevant policy and operation recommendations to reduce CO2 and air pollution emissions cost-effectively and promote low carbon sustainability in the power industry of China.

Jiang, Ping, et al. "Cost-effective approaches for reducing carbon and air pollution emissions in the power industry in China." Journal of Environmental Management 264 (2020): 110452.

Estimating transboundary economic damages from climate change and air pollution for subnational incentives for green on-road freight

Subnational incentives to adopt zero emission vehicles (ZEVs) are critical for reducing the external economic damages posed by transportation to air quality and the climate. Few studies estimate these damages for on-road freight, especially at scales relevant for subnational policies requiring cross-border cooperation. Here, we assess the damages to US receptors from emissions of air pollutants (PM2.5, NOx, SO2, NH3), and greenhouse gases (CO2, CH4, N2O) from medium and heavy duty freight trucking, and the benefits of ZEV adoption by census division in the Province of Ontario. We develop an integrated modelling framework connecting a travel demand model, a mobile emissions simulator, and a regression based marginal damages model of air pollutants and climate change. We estimate $1.9 billion (2010 USD) in annual cross-border damages, or $0.16/VKT, resulting from scaled up atmospheric emissions from a 'typical day' of medium and heavy duty truck traffic volume for Ontario in 2012. This implies approximately $8000 per truck per year in damages, which could inform an economic incentive for emission reduction. The provincial goal of 5% ZEV adoption would reduce GHG emissions in 2012 by 800 ktCO2e, yielding $89 Million (2010 USD) in cross-border benefits annually, with air quality co-benefits of $83/tCO2e. This result varies between −19% and 22% based on sensitivity analysis for travel and emissions models, though economic damages are likely the largest uncertainty source. Such advances in subnational scale integrated modeling of the environmental impacts of freight can offer insights into the sustainable design of clean freight policy and programs.

Wang, Wilson, et al. "Estimating transboundary economic damages from climate change and air pollution for subnational incentives for green on-road freight." Transportation Research Part D: Transport and Environment 82 (2020): 102325.

Methane

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

Quantifying CH4 concentration spikes above baseline and attributing CH4 sources to hydraulic fracturing activities by continuous monitoring at an off-site tower

Hydraulic fracturing (hydrofracking) for natural gas has increased rapidly in the area of the Marcellus Shale in the last thirty years and estimates of CH4 emissions from hydrofracking operations are still uncertain. Previous studies on CH4 emissions at hydrofracking operations have used bottom-up approaches collected at discrete timepoints or discrete aerial surveys covering a wide spatial area, constraining the temporal scale of inference

regarding these emissions. This project monitored atmospheric CH4 concentrations and stable carbon isotopes at a half-hourly temporal resolution from a 20-m tower downwind of a hydrofracking well pad in West Virginia for eighteen months. We collected four months of baseline observations prior to onsite well development to construct an empirical artificial neural-network model of baseline CH4 concentrations. We compared measured CH4 concentrations against the ANN-modeled CH4 baseline to identify CH4 concentration spikes that coincided with different stages of onsite well development, from the baseline period through fracking. CH4 concentration spikes were significantly more frequent than baseline conditions during the vertical drilling and fracking phases of operations. We found that the median magnitude of CH4 concentration spikes during the vertical drilling phase was 316% larger than that of the baseline phase, and the median magnitude of CH4 concentration spikes was 509% larger in the hydraulic stimulation (fracking) stage compared to the baseline phase. We also partitioned the sources of measured CH4 concentrations to biogenic ruminant and geologic shale gas isotopic signatures by measuring 13CH4 gas at high temporal resolution and using a source-partitioning 13CH4 model. The measured median value of half-hourly CH4 concentration spikes attributed to a geologic shale gas isotopic origin was 27% larger than the median CH4 concentration spikes attributed to ruminants, and the maximum half-hourly CH4 concentration spike attributed to shale gas was up to 179% higher than maximum CH4 concentration spike for ruminant-dominated half-hours. This study developed a framework for off-site, single tower measurements to identify CH4 concentration spikes associated with the phases of unconventional natural gas well development in a complex CH4 emissions airshed.

Russell, Sarah J., et al. "Quantifying CH4 concentration spikes above baseline and attributing CH4 sources to hydraulic fracturing activities by continuous monitoring at an off-site tower." Atmospheric Environment (2020): 117452.

Increased methane emission from natural gas seepage at Katakolo Harbour (Western Greece)

Geological gas seepage in petroleum-bearing sedimentary basins is an important natural source of atmospheric methane. In methane budget models geological emissions are generally considered constant over time, not affecting decadal atmospheric methane changes. Here, we report the case of a considerable sub-decadal variation of methane seepage from one of the largest thermogenic gas seep sites in Europe, Katakolo Harbour (Western Peloponnese, Greece). Based on gas flux measurements by accumulation chamber performed in 2010 and 2018, methane emission from cracks and fissures throughout the asphalt and concrete pavement of the harbour increased about four times (from 57 to 225 kg d−1) with emission factor changing from ~4,000 to 15,000 t km−2 y−1. Multiple lines of evidence, including mechanical deformation and fissuring of concrete and asphalt pavement, increased exhalation with constant fissure conditions, and no significant cracking with operating corrosion from 2004 to 2010, suggest that the methane emission increase is mainly due to intensification of subsurface gas flow (seepage) after 2010. Deep gas pressure and fault permeability variations, likely induced by the numerous earthquakes of the region, might have played a role. We estimate that if similar short-term variations of emission factor occur in large seepage areas worldwide, the global geological methane emission can significantly change, contributing to decadal changes of atmospheric methane budget.

Kordella, Stavroula, et al. "Increased methane emission from natural gas seepage at Katakolo Harbour (Western Greece)." Applied Geochemistry (2020): 104578.

Global methane emissions from coal mining to continue growing even with declining coal production

This paper presents projections of global methane emissions from coal mining under different coal extraction scenarios and with increasing mining depth through 2100. The paper proposes an updated methodology for calculating fugitive emissions from coal mining, which accounts for coal extraction method, coal rank, and mining depth and uses evidence-based emissions factors. A detailed assessment shows that coal mining-related methane emissions in 2010 were higher than previous studies show. This study also uses a novel methodology for calculating methane emissions from abandoned coal mines and represents the first estimate of future global methane emissions from those mines. The results show that emissions from the growing population of abandoned mines increase faster than those from active ones. Using coal production data from six integrated assessment models, this study shows that by 2100 methane emissions from active underground mines increase by a factor of 4, while emissions from abandoned mines increase by a factor of 8. Abandoned mine methane

emissions continue through the century even with aggressive mitigation actions.

Kholod, Nazar, et al. "Global methane emissions from coal mining to continue growing even with declining coal production." Journal of Cleaner Production 256 (2020): 120489.

Black Carbon

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

Evaluation of spatial and temporal heterogeneity of black carbon aerosol mass concentration over India using three year measurements from IMD BC observation network

Extensive measurements of equivalent black carbon (EBC) aerosol mass concentration at fifteen stations of India Meteorological Department (IMD) BC observation network during the period 2016–2018 are used to study the spatial and temporal heterogeneity over India. The sampling sites represent different geographical region of India. Spatial distribution shows higher values of EBC over stations of north India and IGP. Highest annual mean EBC mass concentration during study period was reported at two mega cities New Delhi (13,575 ± 8401 ng/m3) followed by Kolkata (12,082 ± 6850 ng/m3) whereas lowest mean concentration was at Ranichauri (1737 ± 884 ng/m3) followed by Bhuj (2021 ± 1471 ng/m3). Stations located in coastal region of south India reported low concentration of EBC. In order to find out the quantitative contribution of biomass burning (EBCBB) and fossil fuel (EBCFF) in total mass concentration of EBC, source apportionment study has been carried out using Aethalometer model. The EBCFF is the dominant contributor to EBC mass concentration at all the sites in every season, while the highest seasonal biomass burning mass contribution (37%) was observed in the winter at a background site Ranichauri. Maximum concentration of EBCBB was observed at Srinagar (2671 ng/m3) where as EBCFF was maximum in Delhi (11,074 ng/m3). Seasonal and diurnal variation studies have also been carried out for all the stations. The EBC mass concentrations exhibited strong seasonality, with the highest values occurring in postmonsoon/winter and the lowest in monsoon season. The higher EBC concentration in postmonsoon/winter seasons was attributed to the increased use of fuel in seasonal emission sources, domestic heating and stagnant meteorological conditions, whereas the low levels in monsoon season were related to the precipitation scavenging. Maximum concentration of EBC (22,409 ± 10,510 ng/m3) was observed in winter season over Kolkata. Our study finds high spatial heterogeneity in EBC concentrations across the study area.

Kumar, Ravi Ranjan, Vijay Kumar Soni, and Manish Kumar Jain. "Evaluation of spatial and temporal heterogeneity of black carbon aerosol mass concentration over India using three year measurements from IMD BC observation network." Science of The Total Environment (2020): 138060.

Personal black carbon exposure and its determinants among elderly adults in urban China

Personal exposure to air pollution is affected by its concentration in the microenvironment and individual time-activity patterns. To investigate personal black carbon (BC) exposure levels and identify their potential determinants, we conducted a panel study among 67 elderly residents aged 60–69 years in Jinan, China. Personal BC exposure was measured using portable real-time monitors, while corresponding ambient BC concentrations and meteorological conditions were also collected from the local central site. Time-activity and household characteristics were recorded. A linear mixed-effects model was used to identify potential determinants of personal BC exposure. The daily average personal BC exposure concentration was 4.1 ± 2.0 μg/m3 (±standard deviation, SD), which was significantly lower than the ambient concentration (4.6 ± 2.5 μg/m3) ($p < 0.001$). Strong correlation (Spearman's $r = 0.63$, $p < 0.001$) was found between personal and ambient BC concentrations. The fixed-site monitoring ambient concentration cannot fully reflect the actual personal exposure concentration. Ambient BC concentration, ambient temperature, relative humidity, education level and air purifier use were significant determinants of personal BC exposure. Our findings highlight the need for detailed assessment of personal exposure on health risk assessment of BC and also help develop strategies for targeted risk reduction.

Zhou, Huichan, et al. "Personal black carbon exposure and its determinants among elderly adults in urban China."

Environment International 138 (2020): 105607.

Characterization of Equivalent Black Carbon at a regional background site in Central Europe: Variability and source apportionment

Characterizing Black Carbon (BC) at regional background areas is important for better understanding its impact on climate forcing and health effects. The variability and sources of Equivalent Black Carbon (EBC) in PM10 (atmospheric particles with aerodynamic diameter smaller than 10 µm) have been investigated during a 5-year measurement period at the National Atmospheric Observatory Košetice (NAOK), Czech Republic. Ground based measurements were performed from September 2012 to December 2017 with a 7-wavelength aethalometer (AE31, Magee Scientific). The contributions of fossil fuel (EBCff) and biomass burning (EBCbb) were estimated using the aethalometer model. Seasonal, diurnal and weekly variations of EBC were observed that can be related to the sources fluctuations and transport characteristic of pollutants predominantly associated with regional air masses recirculating over the Czech Republic and neighboring countries. The absorption Ångström exponent (α-value) estimated in summer (1.1 ± 0.2) was consistent with reported value for traffic, while the mean highest value (1.5 ± 0.2) was observed in winter due to increased EBCbb accounting for about 50% of the total EBC. This result is in agreement with the strong correlation between EBCbb and biomass burning tracers (levoglucosan and mannosan) in winter. During this season, the concentrations of EBCbb and Delta-C (proxy for biomass burning) reached a maximum in the evening when increasing emissions of wood burning in domestic heating devices (woodstoves/heating system) is expected, especially during the weekend. The diurnal profile of EBCff displays a typical morning peak during the morning traffic rush hour and shows a decreasing concentration during weekends due to lower the traffic emission.

Mbengue, Saliou, et al. "Characterization of Equivalent Black Carbon at a regional background site in Central Europe: Variability and source apportionment ☆." Environmental Pollution 260 (2020): 113771.

Tropospheric Ozone

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

An investigation into the role of VOCs in SOA and ozone production in Beijing, China

In recent years, PM2.5 and O3 pollutions are prevalent in the atmosphere in Beijing. The study on pollution characteristics of VOC, which are important precursors of O3 and secondary organic aerosols (SOA) contributing PM2.5, is of great significance for providing a reference to guide its reduction policy formulation. Herein, the seasonal variation of atmospheric VOCs and meteorological conditions at the sampling frequency of 1 time per hour were continuously measured from March 2016 to January 2017 in Beijing. Using the collected data combined with multiple models, the role of VOCs in SOA and O3 production was investigated. Alkanes were the most abundant species, contributing 54.1–64.7% of the total VOC concentration for four seasons, followed by aromatics, alkenes and acetylene. The SOA potential (SOAP) was highest in winter at 2885.1 µg m−3, followed by autumn, spring and summer. Aromatics were the main contributors to SOAP, accounting for ~98.2% of the total SOAP during the entire observation period. The empirical kinetic modeling approach results showed that O3 production featured the VOC-limited regime in Beijing. Alkenes and aromatics were major contributors to O3 formation potential (OFP), accounting for 33.1–45.6% and 27.2–45.2%, respectively, particularly ethylene and m,p-xylene. Positive matrix factorization results indicated that motor vehicle exhaust was still the largest local source of VOCs, but its proportion was considerably reduced. The potential source contribution function results revealed that regional transport sources of VOC pollution in Beijing mainly came from the northwest and southern areas. Thus, to control PM2.5 and O3 pollution in Beijing, the restriction of alkenes and aromatics emission, accompanied by regional cooperation combined with local control, is essential.

Li, Qianqian, et al. "An investigation into the role of VOCs in SOA and ozone production in Beijing, China." Science of The Total Environment (2020): 137536.

Vegetation feedbacks during drought exacerbate ozone air pollution extremes in Europe

Reducing surface ozone to meet the European Union's target for human health has proven challenging despite stringent controls on ozone precursor emissions over recent decades. The most extreme ozone pollution episodes are linked to heatwaves and droughts, which are increasing in frequency and intensity over Europe, with severe impacts on natural and human systems. Here, we use observations and Earth system model simulations for the period 1960–2018 to show that ecosystem–atmosphere interactions, especially reduced ozone removal by water-stressed vegetation, exacerbate ozone air pollution over Europe. These vegetation feedbacks worsen peak ozone episodes during European mega-droughts, such as the 2003 event, offsetting much of the air quality improvements gained from regional emissions controls. As the frequency of hot and dry summers is expected to increase over the coming decades, this climate penalty could be severe and therefore needs to be considered when designing clean air policy in the European Union.

Lin, Meiyun, et al. "Vegetation feedbacks during drought exacerbate ozone air pollution extremes in Europe." Nature Climate Change 10.5 (2020): 444-451.

Hydrofluorocarbons (HFCs)

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

Comparative analysis of conventional and low-GWP refrigerants with ionic liquid used for compression-assisted absorption cooling cycles

To address the problems of conventional absorption technologies, various working pairs consisting of low-global-warming-potential hydrofluorocarbons/hydrofluoroolefins and ionic liquid were numerically investigated for two compression-assisted absorption cooling cycles driven by heat sources at lower temperatures. The property prediction model and thermodynamic performance model were established and verified. The performance improvements were evaluated and the compression ratio was optimized. With the compression-assisted absorption cycle, the coefficient of performance (COP) was enhanced from 0.191–0.463 to 0.366–0.670, while the minimum generation temperature was reduced by about 20 °C, reaching 45 °C. For both basic and compression-assisted absorption cycles, difluoromethane yielded the highest COP, followed by fluoroethane and 1,1-difluoroethane with slightly lower COPs; 2,3,3,3-tetrafluoropropene performed the worst in most conditions; 1,1,1,2-tetrafluoroethane performed worse than trans-1,3,3,3-tetrafluoropropene using the basic cycle but outperformed trans-1,3,3,3-tetrafluoropropene using the compression-assisted absorption cycle. The thermal COP varies similarly to but higher than the COP, while the mechanical COPs are much higher for all the working pairs, reaching 11–14 (R152a showing the highest) with a CR of 1.5. The mechanical COP decreases dramatically with the compression ratio. For the low-pressure compression-assisted absorption cycle with a generation temperature of 70 °C, the optimal compression ratios were 1.9–3.4 with the maximum COPs of 0.546–0.663 and were 1.3–2.2 with the maximum exergy COPs of 0.192–0.289. The low-pressure compression-assisted absorption cycle was better than the high-pressure compression-assisted absorption cycle due to the higher cycle efficiency and lower compressor discharge temperature. This study provides suggestions on the selection of compression-assisted absorption cycles, working pairs and optimal parameters for renewable/waste cooling.

Wu, Wei, et al. "Comparative analysis of conventional and low-GWP refrigerants with ionic liquid used for compression-assisted absorption cooling cycles." Applied Thermal Engineering (2020): 115145.

Socio-Economic Impacts

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

Health and economic consequences of applying the United States' PM2.5 automobile emission standards to other nations: a case study of France and Italy

The US has among the world's strictest automobile emission standards, but it is now loosening them. It is unclear where a nation should draw the line between the associated cost burden imposed by regulations and the broader societal benefits associated with having cleaner air. Our study examines the health benefits and cost-effectiveness of introducing stricter vehicle emission standards in France and Italy. Quasi-experimental study. We used cost-effectiveness modeling to measure the incremental quality-adjusted life years (QALYs) and cost (Euros) of adopting more stringent US vehicle emission standards for PM2.5 in France and Italy. Adopting Obama era US vehicle emission standards would likely save money and lives for both the French and Italian populations. In France, adopting US emission standards would save €1000 and increase QALYs by 0.04 per capita. In Italy, the stricter standards would save €3000 and increase QALYs by 0.31. The results remain robust in both the sensitivity analysis and probabilistic Monte Carlo simulation model. Adopting more stringent emission standards in France and Italy would save money and lives.

Kim, Sooyoung, et al. "Health and economic consequences of applying the United States' PM2. 5 automobile emissions standards to other nations: a case study of France and Italy." Public Health (2020).

Quantifying public health benefits of PM2.5 reduction and spatial distribution analysis in China

In recent years, particulate matter (PM) air pollution has become a significant and growing public health problem in China. In this study, the daily PM2.5 exposure level at a spatial resolution of 100 km2 was simulated based on the data of 1328 monitoring sites and the Voronoi Neighborhood Averaging (VNA) interpolation method. The results reveal that the daily mean PM2.5 concentration reduced from 47.82 μg/m3 (2016) to 40.87 μg/m3 (2018), a reduction of 14.53%. We first calculated the heath impacts and economic benefits of this reduction (Scenario 1) by using Environmental Benefits Mapping and Analysis Program (BenMAP). The estimated avoided premature mortalities for all-cause, cardiovascular diseases, respiratory diseases, and lung cancer were in the range of 7214 to 81,681 cases (total of 154,176 cases). The estimated economic benefits based on willingness to pay (WTP) ranged from 3.96 to 44.85 billion RMB (total of 84.66 billion RMB). Moreover, the PM2.5 concentration in the control scenario was rolled back to the Grade I standards (35 μg/m3, Scenario 2). The avoided deaths are in the range of 58,820 to 590,464 cases (total of 1,217,671 cases). The estimated monetary value of the avoided cases of all health endpoints range from 36.63 to 367.66 billion RMB based on WTP (total of 758.21 billion RMB). In addition, the spatial autocorrelation analysis reveals that the distribution of both avoided premature mortality and economic benefits exhibit a certain spatial aggregation.

Luo, Guiwen, et al. "Quantifying public health benefits of PM2. 5 reduction and spatial distribution analysis in China." Science of The Total Environment 719 (2020): 137445.

Effects of PM2.5 on health and economic loss: Evidence from Beijing-Tianjin-Hebei region of China

Rapid industrialization and urbanization have triggered severe PM2.5 pollution and induced serious health hazards and economic losses in densely populated regions. A substantial number of health-related economic loss assessment methods, which quantify economic losses caused by diverse health endpoints, have been applied. However, traditional models neglect pollutant distribution and optimization of distribution parameters, which may lead to poor estimation accuracy. In this study, a health-related economic loss evaluation system is proposed, which deals with PM2.5 distribution, optimization of distribution parameters, and evaluation of health-related economic losses. This assessment system efficiently simulated the characteristic of PM2.5 concentrations in three cities of the Beijing-Tianjin-Hebei region and addressed economic losses estimation problems. The results indicate that the system not only provides a novel perspective on health-related economic loss assessment, but also assists policymakers in its practical application.

Wang, Jianzhou, et al. "Effects of PM2. 5 on health and economic loss: Evidence from Beijing-Tianjin-Hebei region of China." Journal of Cleaner Production 257 (2020): 120605.

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.

Emission inventories of rice straw open burning in the Red River Delta of Vietnam: Evaluation of the potential of satellite data

Although rice straw open burning is one of the main sources of air pollution in Asian countries, problems remain in collecting the activity data needed to calculate emission inventories. In Vietnam, the results from traditional data collection methods, which are reported by the Vietnam General Statistics Office high levels of uncertainty. This is largely due to a lack of human and financial resources. To improve upon this, this study critically assessed the benefits of incorporating cultivation area data obtained by the Sentinel-1 Synthetic Aperture Radar (SAR) satellite in combination with crop production records during the period of 2015–2017. The results suggested that incorporating remote sensing data, especially satellite data, into a process-based crop model can improve the spatial distribution of yield estimates. Satellite data for 2018 were also applied to estimate emissions from rice straw open burning in the Red River Delta, Vietnam, for which official statistics are not otherwise yet available. The results show that a total of 3.24 Mt of burnt rice straw produced 3.82 Mt of CO2, 301 Gg of CO, 29.5 Gg of PM10, and 27 Gg of PM2.5. The estimated emission amounts for the common air pollutants SO2, NOx, and NH3 were 583 tonnes, 7.4 Gg, and 13.3 Gg, respectively. Hydrocarbon emissions were 31 Gg for CH4 and 22.7 Gg for NMVOC. The emission of BC, which is one of the main short-lived climate forcers, totalled 1.6 Gg. Based on these results, satellite data demonstrate great potential for estimating emissions from rice croplands, having the advantages of timely availability and cost competitiveness.

Le, Hoang Anh. "Emission inventories of rice straw open burning in the Red River Delta of Vietnam: Evaluation of the potential of satellite data." Environmental Pollution 260 (2020): 113972.

Characterisation of atmospheric pollution near an industrial site with a biogas production and combustion plant in southern Italy

Although biogas production can have some benefits, there is a research gap on potential influence of biogas plant emissions on local air quality, thus an accurate and comprehensive evaluation of impacts of this technology is needed. This study deals with this issue by means of a characterisation of air pollution near an industrial area including a biogas production (from biomass) and combustion plant located in South Italy. The methodology consists in advanced statistical analysis on concentration of gaseous pollutants, particles concentration and size distribution in number and mass, and PM2.5 chemical composition. High-temporal resolution measurements, supported by ancillary meteorological parameters, and source apportionment of PM2.5 using Positive Matrix Factorization (PMF) receptor model, are performed. The integrated approach provides the emissive picture consisting in different anthropogenic sources (i.e. traffic, biomass burning, and industrial facilities) with particular focus on biogas plant emissions. Results showed that CO and nitrogen oxides were influenced by vehicular traffic and biomass combustion, however, a contribution of the plant to NO was observed. SO2 was influenced mainly by transport from the industrial zone, but a second local contribution compatible with the emissions of the biogas plant was detected. Number particle concentrations were analysed in four size ranges: nanoparticles ($D < 0.05$ µm), ultrafine particles ($D < 0.3$ µm), accumulation ($0.3 < D < 1$ µm) and coarse particles ($D > 1$ µm). Nanoparticles and ultrafine particles were mainly influenced by vehicular traffic and biomass burning, instead, a contribution of the plant was individuated in the accumulation mode. PMF5 identified the contribution of six sources: crustal (14.7% ± 2.1% of measured PM2.5); marine aerosol (aged) (12.9% ± 2.3%); biomass burning (32.8% ± 1.4%); secondary sulphate (19.7% ± 2.4%); primary industrial emissions (5.4% ± 2.3%); traffic and secondary nitrate (17.0% ± 3.9%). The plant is likely to contribute to both sources, the industrial and the traffic plus secondary nitrate.

Merico, E., et al. "Characterisation of atmospheric pollution near an industrial site with a biogas production and combustion plant in southern Italy." Science of The Total Environment 717 (2020): 137220.

County-level emission inventory for rural residential combustion and emission reduction potential by technology optimization: A case study of Henan, China

In recent years, air pollution has been a serious problem in China, not only in the city but also in the countryside. Moreover, the statistics data of coal and solid biomass consumption for rural households are significantly underestimated, which has a negative impact on the air pollution control. In this study, Henan province, an agricultural province in China, is taken as a case to analyze the county-level emission characteristics and emission reduction potential of rural household combustion. Firstly, activity data at county-level are obtained through regression based on partial activity data from field survey in 2016, and a high-resolution emission inventory of multi-type air pollutants from rural residential combustion is established. Then, twelve abatement technologies are selected to replace coal and solid biomass used in heating and cooking. A new optimization model is established based on the rural household burden ratio to discuss the optimal emission reduction schemes at county-level under five substitution scenarios. The results show that the total emissions of SO2, NOx, PM2.5, PM10, CO, NH3 and VOCs from rural residential combustion in Henan province are estimated at about 108.6, 30.9, 72.7, 113.5, 1141.9, 19.6 and 110.0 kt, respectively. The inventory results of different counties vary greatly, with PM2.5 emissions ranging from 7.9 t to 1550.3 t. Counties with large emissions have more agricultural activities. Among the abatement technologies, air source heat pump (ASHP) and palisade structure (PS) are more suitable for promotion in rural areas. The PM2.5 emissions in the five substitution scenarios are 99.0%, 98.8%, 99.1%, 98.6% and 98.8% lower than BAU-scenario, and S1-scenario is more conducive to rural emission reduction with considering the costs. It is suggested that the government should pay more attention to the air pollution caused by rural household combustion and improve the existing energy statistics system, especially for solid biomass. Abatement technologies suitable for heating and cooking in rural areas should be actively promoted, such as air source heat pump.

Zhu, Mingyue, et al. "County-level emission inventory for rural residential combustion and emission reduction potential by technology optimization: A case study of Henan, China." Atmospheric Environment (2020): 117436.

Reduction in black carbon concentration and its exposure in rural settings of Northern India: An intervention analysis

The present study estimated the concentration of black carbon (BC10 and BC2.5) during cooking hours in three types of kitchen in ten households and two improved cookstoves (ICS) tested against traditional mud cookstoves (TCS) in the real field conditions. The study also used a community-engaged approach to involve the local public regarding the benefits of intervention. The results clearly revealed that personal BC concentration was highest in an enclosed kitchen (83 µg/m3) while using TCS compared to a semi-enclosed (25 µg/m3) and open kitchens (16 µg/m3), respectively. The results showed that deployment of ICS would help in reduction in personal BC concentration in all the households ranged from 36 to 84% and 33–89% in BC10 and BC2.5, respectively. The study measured the personal dose of BC concentration for women of all the selected households. The reduction in the exposure dose for personal BC10 and BC2.5 was 69% and 59%, respectively. The results showed that BC concentration during cooking greatly varies with time-activity pattern of users and which in turn affects the exposure levels of the participants. Thus, it is imperative to measure the exact time users spend near to the emission source to get actual exposure inhalation concentration. The results of the study also shared with the local communities to build their capacity for better understanding about the benefits of advanced cooking technologies, household design to improve the ventilation conditions in the kitchen areas and health benefits in terms of reduction in exposure levels especially for vulnerable group like women and children.

Sharma, Deepti, and Suresh Jain. "Reduction in black carbon concentration and its exposure in rural settings of Northern India: An intervention analysis." Chemosphere 247 (2020): 125838.

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

The influence of soil temperature, methanogens and methanotrophs on methane emissions from cold waterlogged paddy fields

Paddy fields are major sources of atmospheric methane (CH4). However, CH4 emissions from cold-waterlogged paddy fields, a major type of paddy soil in China, remain unclear. Here we investigated the CH4 emissions and associated influential factors in cold-waterlogged paddy fields at two sites (Yangxin County and Daye City) in Hubei Province, South China. Normal paddy fields matched with parental material and cropping system were used as the controls. The CH4 emissions from cold-waterlogged fields were significantly higher than those from normal fields with (3.0–4.4-fold) or without (3.5–8.6-fold) rice. Rice planting increased CH4 emissions by 59–78% in cold-waterlogged fields and by 85–247% in normal fields. CH4 instantaneous fluxes were positively correlated with soil temperature and methanogen mcrA (methyl coenzyme M reductase alpha subunit) and methanotroph pmoA (methane monooxygenase) copy numbers at the annual scale. Under rice planting, mcrA copy number was higher in cold-waterlogged fields than in normal fields at both sites, whereas pmoA copy number had the same trend at the Daye site only. Soil temperature and water content influenced mcrA and pmoA copy numbers in the normal paddy fields, whereas soil organic matter content was more influential in the cold-waterlogged paddy fields. These findings suggest that perennial waterlogging is a prerequisite for substantial CH4 emissions from cold-waterlogged paddy fields, and it promotes the proliferation of methanogens and methanotrophs under rice planting. Therefore, CH4 production-oxidation processes are more active in cold-waterlogged paddy fields than in normal paddy fields.

Xu, Xiangyu, et al. "The influence of soil temperature, methanogens and methanotrophs on methane emissions from cold waterlogged paddy fields." Journal of Environmental Management 264 (2020): 110421.

Meta-analysis of greenhouse gas and ammonia emissions from dairy manure composting

In order to minimise nutrient losses, comprehensive overviews of the magnitude of gaseous emissions from manure composting processes and the factors that influence these losses are urgently needed. This study presents a meta-analysis of greenhouse gases (GHGs) and ammonia (NH3) emissions from four main dairy manure composting methods (static, turning, windrow and silo) based on 41 scientific articles (153 treatments). Gaseous emissions and secondary variables such as average composting temperature, initial moisture content, initial total carbon (TC) and initial total nitrogen (TN) content from each compost treatment were extracted and normalised to enable inter-study comparison. Six mitigation measures for composting were selected and mitigation efficiency () of each measure on different gas emissions were calculated. Gaseous emissions from different composting methods showed large differences. Turning composting resulted in larger carbon and nitrogen losses compared to other composting methods. Although silo composting significantly promoted NH3 emission, it reduced GHG losses by 82.84% compared with turning composting. Principal component analysis showed that the initial TC and TN content of the composted material were crucial in mediating gaseous emissions. Low TC and TN content can simultaneously reduce CH4, CO2 and N2O emissions. Applying compost biofilters was the most effective way to reduce NH3 emission with ME value of −97%. Adding sawdust or straw could reduce CH4 and N2O emissions by 66.3% and 44.0% respectively. Gaseous emissions from dairy manure composting varied a lot and were affected by physical characteristics of composted material and management practices of composting.

Ba, Shidi, et al. "Meta-analysis of greenhouse gas and ammonia emissions from dairy manure composting." Biosystems Engineering 193 (2020): 126-137.

Effects of domestic sewage from different sources on greenhouse gas emission and related microorganisms in straw-returning paddy fields

Reusing domestic sewage for crop irrigation is a promising practice, particularly in developing countries, since it is a substitute for chemical fertilizer and reduces water contamination. More attention was paid to the effect of sewage irrigation on crop yield and soil nutrients, but little attention was paid to greenhouse gas (GHG) emission from straw-returning paddy fields. In this study, a soil column monitoring experiment was conducted to assess the effects of untreated domestic sewage (dominated with ammonia) and treated domestic sewage (dominated

with nitrate) irrigation on methane (CH4), nitrous oxide (N2O) emission, and related soil microorganisms in straw-returning paddy fields. Results showed that straw-returning dramatically promoted CH4 emission but had little effect on N2O emission. Both untreated and treated domestic sewage irrigation decreased CH4 emission of straw-returning paddy whether nitrogen fertilizer applied or not. The mitigating effect of treated sewage irrigation on CH4 emission was greater than untreated sewage irrigation. CH4 emission had a significant correlation with the abundance of soil methanogens and methanogens/methanotrophs. N2O emission increased with untreated or treated domestic sewage irrigation, although the total N input, including the N carried by sewage water, was the same for all treatments. No significant correlation between N2O and denitrification functional genes was found in this study. Treated domestic sewage irrigation reduced the global warming potential (GWP) by 66.7%, but untreated domestic sewage had no evident influence on the GWP. Results indicated that treated domestic sewage irrigation could significantly inhibit CH4 emission and the GWP by decreasing the ratio of methanogens to methanotrophs, and is promising in mitigating GWP from straw-returned paddy fields.

Li, Mengyao, et al. "Effects of domestic sewage from different sources on greenhouse gas emission and related microorganisms in straw-returning paddy fields." Science of The Total Environment 718 (2020): 137407.

Experimental harvesting of wetland plants to evaluate trade-offs between reducing methane emissions and removing nutrients accumulated to the biomass in constructed wetlands

Constructed wetlands built for water treatment often need biomass harvesting to remove nutrients from the system. Usually harvesting is done during the peak growing season to maximize the amount of nutrients removed from the system. This, however, can create huge methane fluxes that escape from plant tissues to the atmosphere. We used manual chambers and eddy covariance measurements to analyze the increase in methane emissions due to the harvesting of two common wetland species, Typha spp. and Schoenoplectus spp., in two climatically different constructed wetlands in Estonia and California. In addition, we determined the biomass nutrient and carbon concentrations from harvested biomass. We found that harvesting during the summer season, e.g. June and August, resulted in a significant release of methane at both sites. At the California site, baseline median methane emissions were 217.6 nmol m−2 s−1, and harvesting resulted in increases to 395.4 nmol m−2 s−1 that decreased to baseline emission within three days. Footprint modeling demonstrated that the emission increases measured by eddy covariance were dominated by contributions from the cut area to the total footprint signal. At the Estonian site, harvesting resulted in methane increases of 15.9 nmol m−2 s−1 to 110.4 nmol m−2 s−1 in August. However, in September and October the emission was significantly lower. Plant biomass analyses showed clear temporal dynamics in terms of nutrient concentration, being highest in summer and lowest in winter. Our experiments indicate that the optimal time for aboveground biomass harvesting is at the end of the growing season before nutrient translocation to belowground plant structures begins coinciding with lowest methane emissions. Therefore, strategic planning of the harvest timing may help reduce greenhouse gas emissions from managed wetlands and thus improve their multi-faceted ecological benefit.

Kasak, K., et al. "Experimental harvesting of wetland plants to evaluate trade-offs between reducing methane emissions and removing nutrients accumulated to the biomass in constructed wetlands." Science of The Total Environment 715 (2020): 136960.

Transportation

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

Quantifying aircraft emissions of Shanghai Pudong International Airport with aircraft ground operational data

The air traffic growth at Shanghai Pudong International Airport (PVG) has attracted much concern over the potential impacts on local air quality and human health; however, the emission contributions due to aircraft activities, impact on air quality and health effects remain unclear. In this study, the ground operational data

derived from the Aircraft Communication Addressing and Reporting System (ACARS) dataset are newly utilized to obtain the PVG-specific emission parameters of 10 distinct aircraft-engine combinations during the taxi-in and taxi-out phases of the landing and take-off (LTO) cycle. The resulting emission parameters, together with PVG-specific operational conditions, are applied to quantify the annual emissions in 2017 for main engines and auxiliary power units (APUs) at PVG, emission variations caused by mixing layer height, sensitivity of black carbon (BC) emissions to the estimation method and sensitivity of PM2.5 emissions to the fuel sulfur content (FSC). The results show noticeable discrepancies between the corrected fuel flows and NOx emission indices (EIs) and those certified by the International Civil Aviation Organization (ICAO). The annual emissions of hydrocarbons (HC), CO, NOx, NO, NO2, HONO, HNO3, NOy, SO2, SO42−, BC, organic carbon (OC) and PM2.5 with corrected emission parameters are 3.82 × 105 kg, 4.35 × 106 kg, 5.36 × 106 kg, 4.40 × 106 kg, 9.58 × 105 kg, 1.03 × 105 kg, 3.83 × 103 kg, 5.47 × 106 kg, 3.56 × 105 kg, 1.31 × 104 kg, 5.43 × 104 kg, 4.73 × 103 kg and 7.22 × 104 kg, respectively, while the application of the maximum height of the mixing layer contributes to emission increases as high as 16.9% (NOx). An alternative estimation of BC emissions leads to an increase of 50% compared with first-order approximation 3 (FOA3), while a reduction in PM2.5 emissions can be expected by minimizing the FSC.

Xu, Hao, et al. "Quantifying aircraft emissions of Shanghai Pudong International Airport with aircraft ground operational data." Environmental Pollution 261 (2020): 114115.

Pollutant measurements at near road and urban background sites in New York, USA

Due to the potential for heightened exposure to vehicle exhaust pollutants, air monitoring has been required at near roadway (NR) locations within large urban centers in the United States since 2010. In this paper pollutant measurements at two urban NR locations, Rochester and New York City, Queens are discussed. Pollutants measured at these sites include PM2.5 mass, nitrogen oxides (NO, NO2, NOx), ultrafine particles (UFP), black carbon (BC) and carbon monoxide (CO). Measurements at NR sites are made in conjunction with existing urban background (UB) sites. Although pollutant concentrations at Rochester and Queens are elevated at the NR sites compared to the UB sites particularly during the daytime hours, all pollutants are below the level of the National Ambient Air Quality Standards (NAAQS). At Rochester, BC at the NR site is elevated by a factor of 2–3 between 7 a.m. and 3 p.m. and drops to near uniform concentrations at both sites at night. The enhancement or increment in BC is highest in summer and lowest in winter. Other co-pollutants including NOx and CO are also elevated at the Rochester NR site by varying degrees during daytime hours. Similarly, enhanced pollutant concentrations are observed at the Queens NR site. At both locations small increments are observed for PM2.5 mass. For example, an annual increment of 0.27 µg/m3 and a daily increment of 0.80 µg/m3 was observed at the Rochester NR site. At Queens NR annual PM2.5 mass increments of 0.92 and 1.0 µg/m3 were observed in 2017 and 2018. In addition, a NR daily increment of 1.4 µg/m3 was observed at Queens in 2018. The data are analyzed for diurnal, weekday vs weekend and seasonal patterns. Nonparametric wind regression identified the roadways as the major source of traffic related air pollutants.

Rattigan, O. V., et al. "Pollutant measurements at near road and urban background sites in New York, USA." Atmospheric Pollution Research (2020).

Application of reduction scenarios on traffic-related NOx emissions in Trabzon, Turkey

Traffic-related emissions are the main sources of certain air pollutants that affect large number of people in many city centers. Because of this fact, quantification of traffic-related emissions and their dispersion modeling are required to determine human exposure to these pollutants. In this study, the most populated Ortahisar district of Trabzon, a city located in the Eastern Black Sea region of Turkey, was selected as the study area since high traffic density is known to be one of the major sources of air pollution in this district. Moreover, air quality measurement stations located close to major roads are available to provide experimental data for model validation. Traffic emission inventory for some pollutants (NOx, SO2, CO, PM and VOCs) was prepared. Considering that NOx is the most representative air pollutant of road traffic emissions, its inventory together with topographical properties and meteorological conditions were used in AERMOD dispersion model to calculate NOx concentrations at selected receptor points. For validation, model data were compared to measurement data by certain statistical tools. According to the model results, 10.1% of the population living in

Ortahisar district was exposed to traffic-related NOx concentrations higher than the regulatory limit value. In the study, five different emission reduction scenarios were tested to observe the effects on the exposure levels. Model results indicated that the measures represented by these scenarios are capable of reducing exposure levels between 2.4 and 99.5 percent.

Tezel-Oguz, Melike Nese, et al. "Application of reduction scenarios on traffic-related NOx emissions in Trabzon, Turkey." Atmospheric Pollution Research (2020).

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 sector

Climate change mitigation potential in sanitation via off-site composting of human waste

Approximately 4.5 billion people lack access to safely managed sanitation globally, and 1 billion live in slums, often relying on anaerobic waste containment in pit latrines. Providing access to safely managed sanitation may lead to reduced GHG emissions and thus simultaneously address both Sustainable Development Goals. Here we measure cumulative GHG emissions of carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) during the off-site composting of human waste to estimate scalable emission factors. We find that CH4 emission factors are one to two orders of magnitude smaller than IPCC values for other excreta collection, treatment and disposal processes. After accounting for GHG emissions throughout the sanitation cycle, including transport, urine and compost end-use, the climate change mitigation potential is 126 kg of CO2-equivalent per capita per year for slum inhabitants. If scaled to global slum populations, composting could mitigate 3.97 Tg CH4 yr−1, representing 13-44% of sanitation sector CH4 emissions.

McNicol, Gavin, et al. "Climate change mitigation potential in sanitation via off-site composting of human waste." Nature Climate Change (2020): 1-5.

Air pollution & Health Impacts

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

Exposure and mortality apportionment of PM2.5 between 2006 and 2015 over the Pearl River Delta region in southern China

In the early 2000s, the Pearl River Delta (PRD) became one of the earliest regions in China to implement a stringent control policy on air pollution emission. In particular, during the 11th Five Year Plan (FYP) and 12th FYP (i.e., 2006–2015), the emission control measures were executed intensively and efficiently under the supervision of law enforcement authorities. These measures helped substantially reduce the fine particulate matter (PM2.5) concentration over this region. Hence, it is now important to determine how the decrease in PM2.5 concentration influenced the exposure condition and health burdens in the PRD region during 2006–2015. In this study, the exposure and mortality apportionment of PM2.5 under both 2006 and 2015 emission scenarios were investigated. The simulated population-weighted PM2.5 concentration was found to be lower under the 2015 emission scenario compared with that under the 2006 scenario. The average reductions in simulated PM2.5 exposure concentrations (population-weighted average) for Guangzhou, Dongguan, Foshan, and Shenzhen were 32.7, 27.0, 25.3, and 24.1 μg/m3, respectively. After excluding the meteorological variations, a difference of approximately 16,400 (95% CI: 9,100, 22,800) in the number of simulated premature deaths was obtained after the 10-year efforts for emission control and industrial restructuring. Among the five major anthropogenic emissions (mobile, area, power plant, marine vessel, and industrial point emissions), the control of mobile emissions was found to be the most relevant to the estimated health benefits. The calculated economic benefits from controlling mobile emissions reached 30,300 (21,600, 37,100) million USD in 2015. In contrast, the mortality related to area emissions turned out to be higher under the 2015 emission scenario. The

difference between 2006 and 2015 meteorological scenarios could substantially influence the simulated exposure concentration in each month. However, the impact of the meteorological factors was found to be limited when the exposure concentrations of the 4 months were averaged. Further, 26,700 (18,500, 33,400) premature deaths difference was calculated after the PM2.5 concentration over the PRD region reached the Air Quality Guideline standard. Therefore, more efforts, including the control of area emissions and the enhancement of regional cooperation (e.g., reducing industrial emission consistently and systematically in southern China), are crucial further to reduce the PM2.5 concentrations in the PRD region and improve the living conditions for the residents.

Lu, Xingcheng, et al. "Exposure and mortality apportionment of PM2. 5 between 2006 and 2015 over the Pearl River Delta region in southern China." Atmospheric Environment (2020): 117512.

Hourly association between ambient PM2.5 and emergency ambulance dispatches in 11 cities in Japan

Numerous epidemiological studies have demonstrated that short-term exposure to ambient PM2.5 increases mortality and morbidity. Investigating the association using hourly ambient PM2.5 exposure may provide important insights, as current evidence is limited mostly to daily lag term. This study aimed to investigate the hourly association between ambient PM2.5 concentrations and all-cause emergency ambulance dispatches (EAD) in 11 cities in Japan. We used a time-stratified case-crossover design and examined the hourly lags of ambient PM2.5 up to 24 h (unconditional distributed lags and moving average lags) using a conditional Poisson regression model. A significant increase in all-cause EAD was observed at lag 0 h [relative risk (RR): 1.0037 (95% CI: 1.0000, 1.0074)] and all moving average lags. The highest RR was observed within the first 6 h (at lag 0–5 h) [RR: 1.0091 (95% CI: 1.0068, 1.0114)], with a slight ascending pattern. This was followed by a descending pattern at lags 0–11, 0–17, and 0–23 h, but significant positive RR was observed even at lag 0–23 h, when the lowest RR was observed [RR: 1.0072 (95% CI: 1.0044, 1.0100)]. Though similar pattern was observed among the elderly, a different pattern was observed among the children (gradually ascending pattern). We conclude that all-cause EAD could be triggered by ambient PM2.5 exposure with very short lags.

Hui, Phung Vera Ling, et al. "Hourly association between ambient PM2. 5 and emergency ambulance dispatches in 11 cities in Japan." Environmental Research (2020): 109448.

PM2.5 and ozone in office environments and their potential impact on human health

It is important to have good indoor air quality, especially in indoor office environments, in order to enhance productivity and maintain good work performance. This study investigated the effects of indoor office activities on particulate matter of less than 2.5 µm (PM2.5) and ozone (O3) concentrations, assessing their potential impact on human health. Measurements of indoor PM2.5 and O3 concentrations were taken every 24 h during the working days in five office environments located in a semi-urban area. As a comparison, the outdoor concentrations were derived from the nearest Continuous Air Quality Monitoring Station. The results showed that the average 24 h of indoor and outdoor PM2.5 concentrations were 3.24 ± 0.82 µg m−3 and 17.4 ± 3.58 µg m−3 respectively, while for O3 they were 4.75 ± 4.52 ppb and 21.5 ± 5.22 ppb respectively. During working hours, the range of PM2.5 concentrations were 1.00 µg m−3 to 6.10 µg m−3 while for O3 they were 0.10 ppb to 38.0 ppb. The indoor to outdoor ratio (I/O) for PM2.5 and O3 was <1, thus indicating a low infiltration of outdoor sources. The value of the hazard quotient (HQ) for all sampling buildings was <1 for both chronic and acute exposures, indicating that the non-carcinogenic risks are negligible. Higher total cancer risk (CR) value for outdoors (2.67E-03) was observed compared to indoors (4.95E-04) under chronic exposure while the CR value for acute exposure exceeded 1.0E-04, thus suggesting a carcinogenic PM2.5 risk for both the indoor and outdoor environments. The results of this study suggest that office activities, such as printing and photocopying, affect indoor O3 concentrations while PM2.5 concentrations are impacted by indoor-related contributions.

Othman, Murnira, et al. "PM2. 5 and ozone in office environments and their potential impact on human health." Ecotoxicology and Environmental Safety 194 (2020): 110432.

Long-term exposure to ambient PM2.5 and impacts on health in Rome, Italy

The aim of this study was to estimate the impact of long-term exposure to PM2.5 on residents of Rome, Italy in terms of ischemic heart diseases (IHD), chronic obstructive pulmonary diseases (COPD), lung cancer (LC), stroke and the number of working days lost (WDL). In this study, we estimated human health impacts from long-term exposure to ambient PM2.5 through application of linear RR and integrated exposure-response (IER) functions and the AirQ + software. In 2014, on average 1189, 348, 43, 301 and 387 cases of IHD, COPD, LC, stroke and WDL, respectively could be avoided in Rome if the annual mean PM2.5 concentration was reduced from 15.6 to 10.0 μg m−3. In 2014, 27.67% of IHD, 15.9% of COPD, 9.5% of LC, 19.9% of stroke as well as 2.5% of WDL are attributed to the long-term exposure to PM2.5 concentrations exceeding 10 μg m−3. This may be achieved through adoption of stringent air pollution regulations and sustainable city planning. Increase in urban green infrastructures and improving road transportation will reduce PM2.5 levels in urban environment, thereby safeguarding human health from air pollution and improving citizens' well-being.

Amoatey, Patrick, et al. "Long-term exposure to ambient PM2. 5 and impacts on health in Rome, Italy." Clinical Epidemiology and Global Health 8.2 (2020): 531-535.

Spatiotemporal and probability variations of surface PM2.5 over China between 2013 and 2019 and the associated changes in health risks: An integrative observation and model analysis

We used statistical methods and the GEOS-Chem model to interpret the observed spatiotemporal and probability variations of surface PM2.5 concentrations in China from December 2013 to November 2019, as well as to assess the drivers for the variations and the implications for health risks associated with long-term and short-term exposure to PM2.5. Annual and seasonal PM2.5 concentrations have decreased over most areas in China during the 6-year period. We decomposed the observed day-to-day variation of PM2.5 concentrations in eastern Chinese cities and found that it showed two distinct major spatial modes, which fluctuated in strength seasonally. The first mode, characterized by most of Eastern China being in the same phase, was mainly associated with the regional ventilation of pollutants. The second mode showed a dipolar pattern between the Beijing-Tianjin-Hebei area and the Yangtze River Delta area and was more prominent in summer. Using model simulations, we showed that this dipole mode was chemically driven by the secondary formation of sulfate in summer. We further used a gamma distribution to succinctly interpret the changes in the probability distributions of PM2.5. We found that the nationwide decline in seasonal mean PM2.5 concentrations mainly reflected decreased occurrences of extremely high PM2.5 concentrations, which was strongly driven by the interannual variation of meteorology. These changes in the annual means and probability distributions of PM2.5 since December 2013 has led to significant decline of the estimated mortality risks associated with long-term and short-term PM2.5-exposures. Regions that were less polluted saw the largest relative benefit per unit decrease in PM2.5 concentration, due to the steepness of the exposure-response curve at the low-concentration end. Our integrated methodology effectively diagnosed the drivers of PM2.5 variability and the associated health risks and can be used as part of the decision tool for PM2.5 pollution management over China.

Jiang, Zhongjing, et al. "Spatiotemporal and probability variations of surface PM2. 5 over China between 2013 and 2019 and the associated changes in health risks: An integrative observation and model analysis." Science of the Total Environment (2020): 137896.

Stroke burden and mortality attributable to ambient fine particulate matter pollution in 195 countries and territories and trend analysis from 1990 to 2017

Background

Fine particulate matter (PM2.5) exposure is associated with stroke incidence and mortality. However, the global distribution and trends of stroke burden and mortality attributable to PM2.5 are rarely studied. We estimated the spatial patterns and temporal trends of PM2.5-attributable stroke burden in 195 countries and territories from 1990 to 2017. Detailed data on stroke burden attributable to PM2.5 were extracted from the Global Burden of Disease Study (GBD) 2017. The numbers and age-standardized rates of stroke disability-adjusted life years (DALYs) and mortality (ASDR and ASMR) were estimated by age, sex, subtype, region, and country. Temporal

trends in ASDR and ASMR were analyzed using estimated annual percentage change (EAPC). Globally, in 2017, 10.5 million DALYs and 0.4 million deaths related to stroke were attributable to PM2.5. The corresponding ASDR and ASMR increased with age, were highest in males and for intracerebral hemorrhage, and varied greatly across countries, with the largest burden in high-middle sociodemographic index (SDI) regions and East Asia. The global ASDR and ASMR decreased by 7.2% and 12.2% from 1990 to 2017, with EAPCs of −0.42 (95% confidence interval [CI]: -0.55, −0.28) and −0.57 (95% CI: -0.72, −0.42), respectively. Age-specific stroke burden rates declined significantly, except in the middle-aged population. The decrease was more pronounced in women and for subarachnoid hemorrhage, while proportions of ischemic stroke burden increased globally and in all SDI regions. Most geographic regions achieved significant declines in ASDR and ASMR since 1990; however, Asia and approximately 30% of countries and territories, especially in low-income countries, showed undesirable increasing trends. The patterns and trends were heterogeneous across countries. Strengthened and tailored approaches for stroke prevention and air pollution management are still needed to reduce the disease burden associated with PM2.5, particularly in males, middle-age populations, and low-income countries and for ischemic stroke.

Jiang, Yanfeng, et al. "Stroke burden and mortality attributable to ambient fine particulate matter pollution in 195 countries and territories and trend analysis from 1990 to 2017." Environmental Research (2020): 109327.

Urban Air Pollution & Megacities

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

Evaluating the effectiveness of a stove exchange programme on PM2.5 emission reduction

Residential wood combustion (RWC) is one of the most important sources of particulate matter (PM) in urban areas. As a consequence, different types of regulatory instruments are being implemented to reduce emissions. In this study, we evaluate both the potential and actual effect of a subsidy programme for stove exchange, which has been in place for over 20 years in Oslo (Norway). The subsidy programme provides economic support to the inhabitants for substituting old stoves for RWC with new and cleaner stoves as a measure to reduce emissions. Different approaches were selected to assess the potential effect of the Oslo subsidy programme. First, we evaluate the potential for reductions in emissions and pollution levels through the use of emission and dispersion modelling under different scenarios. We then assess the actual reductions associated with the stoves already replaced with the subsidy. We conclude the study by evaluating the time variation (2005 to 2018) in emissions, wood consumption and emission factors in Oslo in comparison with other municipalities with and without subsidy programmes in place. Results from emission and dispersion modelling show that the replacement of old wood stoves for new ones could have a significant effect on the reduction of emissions (up to 46%) and levels (up to 21%). Despite that, with near 8% of the total existing stoves in Oslo being exchanged with subsidy, the potential for reduction based on improved emission factors was estimated to be smaller by an order of magnitude. We find no evidence that municipalities with subsidy reduce emissions faster than those without subsidy. We therefore conclude that there is no evidence from our modelling results, supported by available observation data, that indicate that the emissions or concentrations in Oslo have been reduced as a result of the subsidy programme.

Lopez-Aparicio, Susana, and Henrik Grythe. "Evaluating the effectiveness of a stove exchange programme on PM2. 5 emission reduction." Atmospheric Environment (2020): 117529.

Estimating ground-level PM2.5 using micro-satellite images by a convolutional neural network and random forest approach

PM2.5 poses a serious threat to public health, however its spatial concentrations are not well characterized due to the sparseness of regulatory air quality monitoring (AQM) stations. This motivates novel low-cost methods to estimate ground-level PM2.5 at a fine spatial resolution so that PM2.5 exposure in epidemiological research can be better quantified. Satellite-retrieved aerosol products are widely used to estimate the spatial distribution of

ground-level PM2.5. However, these aerosol products can be subject to large uncertainties due to many approximations and assumptions made in multiple stages of their retrieval algorithms. Therefore, estimating ground-level PM2.5 directly from satellites (e.g. satellite images) by skipping the intermediate step of aerosol retrieval can potentially yield lower errors because it avoids retrieval error propagating into PM2.5 estimation and is desirable compared to current ground-level PM2.5 retrieval methods. Additionally, the spatial resolutions of estimated PM2.5 are usually constrained by those of the aerosol products and are currently largely at a comparatively coarse 1 km or greater resolution. Such coarse spatial resolutions are unable to support scientific studies that thrive on highly spatially-resolved PM2.5. These limitations have motivated us to devise a computer vision algorithm for estimating ground-level PM2.5 at a high spatiotemporal resolution by directly processing the global-coverage, daily, near real-time updated, 3 m/pixel resolution, three-band micro-satellite imagery of spatial coverages significantly smaller than 1 1 km (e.g., 200 200 m) available from Planet Labs. In this study, we employ a deep convolutional neural network (CNN) to process the imagery by extracting image features that characterize the day-to-day dynamic changes in the built environment and more importantly the image colors related to aerosol loading, and a random forest (RF) regressor to estimate PM2.5 based on the extracted image features along with meteorological conditions. We conducted the experiment on 35 AQM stations in Beijing over a period of ~3 years from 2017 to 2019. We trained our CNN-RF model on 10,400 available daily images of the AQM stations labeled with the corresponding ground-truth PM2.5 and evaluated the model performance on 2622 holdout images. Our model estimates ground-level PM2.5 accurately at a 200 m spatial resolution with a mean absolute error (MAE) as low as 10.1 μg m−3 (equivalent to 23.7% error) and Pearson and Spearman r scores up to 0.91 and 0.90, respectively. Our trained CNN from Beijing is then applied to Shanghai, a similar urban area. By quickly retraining only RF but not CNN on the new Shanghai imagery dataset, our model estimates Shanghai 10 AQM stations' PM2.5 accurately with a MAE and both Pearson and Spearman r scores of 7.7 μg m−3 (18.6% error) and 0.85, respectively. The finest 200 m spatial resolution of ground-level PM2.5 estimates from our model in this study is higher than the vast majority of existing state-of-the-art satellite-based PM2.5 retrieval methods. And our 200 m model's estimation performance is also at the high end of these state-of-the-art methods. Our results highlight the potential of augmenting existing spatial predictors of PM2.5 with high-resolution satellite imagery to enhance the spatial resolution of PM2.5 estimates for a wide range of applications, including pollutant emission hotspot determination, PM2.5 exposure assessment, and fusion of satellite remote sensing and low-cost air quality sensor network information.

Zheng, Tongshu, et al. "Estimating ground-level PM2. 5 using micro-satellite images by a convolutional neural network and random forest approach." Atmospheric Environment (2020): 117451.

Spatial-temporal variability of PM2.5 air quality in Beijing, China during 2013–2018

This study investigates spatial-temporal variability and trends of ambient PM2.5 in Beijing, China, using data collected from eight urban and four suburban stations. During 2013–2018, the city-wide annual PM2.5 concentrations decreased significantly by 40% (84 μg/m3 in 2013 vs. 50 μg/m3 in 2018). The decreasing PM2.5 trend is more pronounced in winter and during the heating season (November–March), in urban areas, and at the median and upper percentiles of PM2.5 concentrations. The 95th percentile PM2.5 concentrations had decreased by 20 μg/m3/yr in the heating season and 16 μg/m3/yr in the non-heating season. During the six-year study period, there was a significant increase in excellent air quality days (PM2.5 concentration < 35 μg/m3) and a significant decrease in heavy pollution days (PM2.5 concentration > 150 μg/m3). PM2.5 concentrations were strongly correlated across the 12 stations. Urban areas in south Beijing experienced higher PM2.5 levels than suburban sites at every hour-of-day, day-of-week, and month-of-year. PM2.5 levels were higher during winter and the heating season, when PM2.5 emission was high due to space heating and mixing layer heights were low. PM2.5 was higher at weekends than during weekdays, when 20% of private passenger vehicles are prohibited, and higher at night than during the day, when heavy duty delivery vehicles are not permitted. These temporal and spatial trends suggest that Beijing's PM2.5 is strongly impacted by local emissions. Our results indicate, control strategies implemented were successful in Beijing's air quality improvement, but further reduction of PM2.5 concentrations in Beijing could be challenging due to significant contribution from its neighboring cities, calling for comprehensive and collaborative efforts in regional/national scale.

Xu, Xiaohong, and Tianchu Zhang. "Spatial-temporal variability of PM2. 5 air quality in Beijing, China during 2013–2018." Journal of Environmental Management 262 (2020): 110263.

Source apportionment of fine particulate matter over a National Park in Central India

PM2.5 mass and chemical constituents were measured over Van Vihar National Park (VVNP), a forested location within Bhopal. Positive Matrix Factorization (USEPA PMF5) was applied to two-year long (2012 and 2013) measurements of PM2.5 chemical species including water-soluble inorganic ions, organic, pyrolitic, and elemental carbon, and trace elements for the quantitative apportionment of PM2.5 mass. The model resolved seven factors. A combination of source profiles, temporal evolution, and potential source locations were used to identify these factors as secondary sulfate, combustion aerosol, re-suspended crustal dust, pyrolysis carbon-rich aerosol, biomass burning aerosol, secondary nitrate, and sea salt with mean contributions of 24.8%, 23.6%, 17.3%, 15.7%, 11%, 4.1%, 0.8%, respectively, to the PM2.5 mass during the study period. Rest of the mass was unapportioned. Inter-annual and seasonal variability of sources contributing to PM2.5 mass were also assessed. Combustion aerosol and pyrolysis carbon-rich aerosol were responsible for several high PM2.5 mass concentration episodes at the sampling location. Re-suspended crustal dust was also found to be contributing to episodic highs in PM2.5 mass. Biomass burning aerosol contribution to PM2.5 mass increased during stubble burning months in central and northern India. Conditional Bivariate Probability Function (CBPF) and Potential Source Contribution Function (PSCF) analyses were used to identify local and regional source locations (and/or preferred transport pathways) of aerosol sources, respectively. It was found that PM2.5 at the study was mostly regionally transported and that the predominant regional source locations were Chhattisgarh, northern and south-eastern parts of Madhya Pradesh, western Uttar Pradesh, Delhi, Haryana, Rajasthan, and the Arabian Sea. The outcomes of this study are expected to strengthen the air quality management plans for both VVNP and the city. Further, it is hoped that the results of this study will provide inputs to validate emissions inventories as well as climate model outputs over the region.

Kumar, Samresh, and Ramya Sunder Raman. "Source apportionment of fine particulate matter over a National Park in Central India." Science of The Total Environment (2020): 137511.

Analysis of the atmospheric dust in Africa: The breathable dust's fine particulate matter PM2.5 in correlation with carbon monoxide

The dust has direct effects on people's health and climate change; so, this research studied the remotely sensed dust deposition in Africa from 1980 to 2018, and the dust's particulate matter of 2.5 µm size (or PM2.5), in particular, which pollutes the breathable air. PM2.5 is studied in comparison with multispectral carbon monoxide (CO), an abundant atmospheric air pollutant in central Africa. CO is an atmospheric gaseous pollutant for which the smoke, a gaseous aerosol from incomplete combustion processes, is the biggest source. The literature clarifies that both the particulate matter and the CO endanger human health while breathed in. The dust from the desert of Sahara is windblown all over the world. CO, in Africa, is from the anthropogenic fire and volcanic eruptions' smoke; these are two good reasons to have focused on Africa. Due to the big size of Africa, five sub-regions are set; these are the western, central, northern, eastern and southern sub-regions. The Goddard interactive online visualization and analysis infrastructure (GIOVANNI) has been a bridge to the collected remote sensing data, in this research. The data was collected online, from the measurement of pollution in the troposphere (MOPITT) as well as a second version of the modern era retrospective analysis for research and applications (MERRA-2); the analysis was done by a joint of the software tools, worth noting is the Arc GIS. As the amount of African dust dramatically increased by 2000; the heaviest in 2004, results are based on the selected dust deposition over 2000–2018: time-averaged maps, correlations, and quantitative estimations are reported in this research. The heaviest annual dust deposition reached 25.3 t/km2 over the year 2004, in Liberia, a focal point of study for the western sub-region. An important finding: the dust's PM2.5 positively correlated with multispectral CO from November to May; the positively high correlation coefficient was 0.86 in April 2018. The negative correlation between the two measurements started from June to October; the negatively high correlation was −0.68 in October 2015; this research discussed the possible reasons. This research recommends some onsite studies about the real figures and facts about the dust's effects on health, in all the seasons; thus, an alert to policymakers who would set some strategies to mitigate the dust hazards on the health of African inhabitants, neighbors, and visitors.

Rushingabigwi, Gerard, et al. "Analysis of the atmospheric dust in Africa: The breathable dust's fine particulate matter PM2. 5 in correlation with carbon monoxide." Atmospheric Environment 224 (2020): 117319.

Impacts of post-harvest open biomass burning and burning ban policy on severe haze in the Northeastern China

Open filed biomass burning is a major contributor to airborne particulate matter and reactive trace gases during the post-harvest season in the Northeastern China. Due to prevailing weather conditions and high emission density, this region is prone to the accumulation of air pollutants that often leads to severe haze events. In this study, we combined satellite and ground observations, and a regional air quality modeling system to quantify the contribution of open biomass burning to surface PM2.5 (particulate matter with diameter less than 2.5 μm) concentrations during a severe haze episode. During this period (November 1st - 4th, 2015), the average PM2.5 concentrations in Heilongjiang, Jilin, and Liaoning provinces reached 116.98 μg/m3, 98.60 μg/m3, and 70.17 μg/m3 respectively. Model simulations showed that open biomass burning contributed to 52.7% of PM2.5 concentrations over Northeast China. Using the differences in active fire spots as detected by the Visible Infrared Imaging Radiometer Suites (VIIRS) aboard the Suomi-NPP, we estimated that the burning ban enforced in 2018 have caused the PM2.5 concentrations to decrease from the 2015 level by 67.10%, 53.23%, and 10.06% in the Heilongjiang, Jilin, and Liaoning provinces respectively. Over the region, the burning ban proved to be effective in reducing fire emissions and lowering region-wide PM2.5 concentration by 48.1% during the post-harvest season.

Yang, Guangyi, et al. "Impacts of post-harvest open biomass burning and burning ban policy on severe haze in the Northeastern China." Science of The Total Environment 716 (2020): 136517.

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 237 (2020): 104833.

Amplified transboundary transport of haze by aerosol–boundary layer interaction in China

Although air quality in China has substantially improved since 2013 as a consequence of the clean air action,

severe haze events still frequently strike megacities despite strict local emissions reduction efforts. Long-range transport and local accumulation as well as chemical transformation have been deemed as key factors of heavy haze pollution; however, the formation mechanisms of regional long-lasting haze and the physical and chemical connections between different megacities clusters are still poorly understood. Here we present that long-range transport and aerosol–boundary layer feedback may interact rather than act as two isolated processes as traditionally thought by investigating typical regional haze events in northern and eastern China. This interaction can then amplify transboundary air pollution transport over a distance of 1,000 km and boost long-lasting secondary haze from the North China Plain to the Yangtze River delta. Earlier emission reduction before the pollution episodes would provide better air pollution mitigation in both regions. Our results show an amplified transboundary transport of haze by aerosol–boundary layer interaction in China and suggest the importance of coordinated cross-regional emission reduction with a focus on radiatively active species like black carbon.

Huang, Xin, et al. "Amplified transboundary transport of haze by aerosol–boundary layer interaction in China." Nature Geoscience (2020): 1-7.

SLCPs & Vulnerable Regions

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

Estimating Arctic Temperature Impacts from Select European Residential Heating Appliances and Mitigation Strategies

The use of residential heating devices is a key source of black carbon and other short-lived climate forcer emissions in Arctic and other high latitude regions, with important impacts to the Arctic climate and human health. The types of combustion technologies and fuels used varies by region, which impacts the emission profiles of these pollutants and thus the magnitude of Arctic climate responses. Using emission inventory data from 14 European countries, we derive wood-fueled residential heating emissions of black carbon, organic carbon, and sulfate from six appliance types in 2016. Using previously derived equilibrium Arctic temperature responses, we estimate Arctic temperature influences from each appliance type. Using the 2016 appliance emission data as a baseline, we compute the emission mass and Arctic temperature mitigation potential from hypothetical stove conversion scenarios. A total of 43.2 gigagrams (Gg) of black carbon, 175.7 Gg of organic carbon, and 10.3 Gg of sulfate were emitted in 2016 from the six appliance types in the 14 countries. The combined emissions increased Arctic surface temperatures by +2.8 millikelvin. If each country converted its appliance fleet to the technologically advanced pellet stoves and boilers, the combined black carbon, organic carbon, and sulfate emissions from heating appliances could be reduced by 94% and the Arctic temperature response reduced by 85%. The specific source and originating region of emissions are important factors in resolving the magnitude of their impacts. Improved country-level accounting of specific appliances and their emission characteristics can lead to a better understanding of potential mitigation options.

Seay, Brannon, et al. "Estimating Arctic Temperature Impacts from Select European Residential Heating Appliances and Mitigation Strategies." Earth's Future: e2020EF001493.

Impacts of Two East Asian Atmospheric Circulation Modes on Black Carbon Aerosol Over the Tibetan Plateau in Winter

Light-absorbing particles over the Tibetan Plateau (TP) can accelerate glacial retreat, thus causing a series of serious environmental and social problems. Previous studies mainly focus on seasonal transport of aerosols over the TP, while the potential factors influencing the subseasonal variation in airborne black carbon (BC) are almost ignored. In this study, the Weather Research and Forecasting coupled with chemistry (WRF-Chem) model and multiple observations are used to investigate the impacts of East Asian atmospheric circulation on BC aerosol over the TP in winter. Results show that the weakness of westerly wind over northern TP, acceleration of westerly wind over southern TP, and eastward shift of East Asia major trough are responsible for the high BC

concentration over east slope of the TP. In this circumstance, more BC from northern India can be transported to eastern TP and the south slopes of the TP by the enhanced westerly wind. The intensified southwesterly wind over eastern TP brings more BC from the Sichuan Basin to northeastern TP. The BC can also penetrate to eastern TP in planetary boundary layer. Subsequently, the weakened westerly wind over northern TP and positive anomalous updrafts over east slope of the TP support the accumulation and uplift of BC. Another circulation mode is opposite to the pattern above and results in low BC concentration over the TP. These two circulation modes are possibly associated with the low-level meridional temperature anomaly over East Asia, which modulates the upper level atmospheric circulation through the transient eddy feedback.

Yuan, Tiangang, et al. "Impacts of two East Asian atmospheric circulation modes on Black Carbon aerosol over the Tibetan Plateau in winter." Journal of Geophysical Research: Atmospheres: e2020JD032458.