Short-lived Climate Pollutant Research Digest

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

Table of Contents

Short-Lived Climate Pollutants (SLCPs)

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

Impact on short-lived climate forcers increases projected warming due to deforestation

The climate impact of deforestation depends on the relative strength of several biogeochemical and biogeophysical effects. In addition to affecting the exchange of carbon dioxide (CO2) and moisture with the atmosphere and surface albedo, vegetation emits biogenic volatile organic compounds (BVOCs) that alter the formation of short-lived climate forcers (SLCFs), which include aerosol, ozone and methane. Here we show that a scenario of complete global deforestation results in a net positive radiative forcing (RF; 0.12 W m−2) from SLCFs, with the negative RF from decreases in ozone and methane concentrations partially offsetting the positive aerosol RF. Combining RFs due to CO2, surface albedo and SLCFs suggests that global deforestation could cause 0.8 K warming after 100 years, with SLCFs contributing 8% of the effect. However, deforestation as projected by the RCP8.5 scenario leads to zero net RF from SLCF, primarily due to nonlinearities in the aerosol indirect effect.

Scott, Catherine E., et al. "Impact on short-lived climate forcers increases projected warming due to deforestation." Nature communications 9.1 (2018): 157.

Multiple Benefits/Impacts & Crosscutting

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

Measuring the impact of global tropospheric ozone, carbon dioxide and sulfur dioxide concentrations on biodiversity loss

The aim of this study is to examine the impact of air pollutants, including mono-nitrogen oxides (NOx), nitrous oxide (N2O), sulfur dioxide (SO2), carbon dioxide emissions (CO2), and greenhouse gas (GHG) emissions on ecological footprint, habitat area, food supply, and biodiversity in a panel of thirty-four developed and developing countries, over the period of 1995–2014. The results reveal that NOx and SO2 emissions both have a negative relationship with ecological footprints, while N2O emission and real GDP per capita have a direct relationship with ecological footprints. NOx has a positive relationship with forest area, per capita food supply and biological diversity while CO2 emission and GHG emission have a negative impact on food production. N2O has a positive impact on forest area and biodiversity, while SO2 emissions have a negative relationship with them. SO2 emission has a direct relationship with per capita food production, while GDP per capita significantly affected per capita food production and food supply variability across countries. The overall results reveal that SO2, CO2, and GHG emissions affected potential habitat area, while SO2 and GHG emissions affected the biodiversity index. Trade liberalization policies considerably affected the potential habitat area and biological diversity in a panel of countries.

Bhuiyan, Miraj Ahmed, et al. "Measuring the impact of global tropospheric ozone, carbon dioxide and sulfur dioxide concentrations on biodiversity loss." Environmental research 160 (2018): 398-411.

Analysing the Co-Benefits of transport fleet and fuel policies in reducing PM2.5 and CO2 emissions

Previous research has highlighted the dangers of considering air pollution policy and climate change policy separately. Measures to reduce CO2 emissions have been adopted in several countries, and in some instances, these have resulted in increases in some air pollution emissions and vice versa. Research has also highlighted

the potential co-benefits of air pollution and climate change mitigation policy where these are considered together. This paper addresses the co-benefits of climate change mitigation policies to reduce the air pollution (PM2.5) and climate change (CO2) impacts of passenger cars, using a scenario-based approach in Ireland. Scenario-based approaches have previously been adopted for these pollutants in several co-benefit studies. However, a detailed disaggregation of non-exhaust PM2.5 by brake, tyre and road abrasion, and a disaggregation of both PM2.5 and CO2 by a number of current and future passenger car technologies have not been considered to date. The current study, therefore provides deeper insights into the impact of policy on exhaust and non-exhaust emissions. In order to derive detailed disaggregated emission, an add-on module was developed for a well-known emission modelling software (COPERT). The add-on module adopted concepts and parameters from previous research papers and analysis from the COPERT software to estimate fuel-based emissions e.g. exhaust and disaggregated non-exhaust PM2.5 and CO2 emissions. To analyse future scenarios (2015–2035), estimation was initially conducted using that software for the current Irish fleet data. This estimation was later replicated using the add-on module, as a baseline scenario considering a different disaggregation of the same passenger car fleet. Two additional estimations were conducted in the add-on module: An Electric Vehicle policy scenario, and a scenario to show the effects of a ban on the sale of conventional vehicles by 2030. The results revealed that CO2 emissions continuously decreased in the projection period, however, reductions of PM2.5 reversed from the year 2028 due to increases in the non-exhaust component of PM2.5 emissions. Under the two alternative scenarios, a 52–69% reduction of CO2 could be possible whereas only a 9–15% reduction in PM2.5 could be achieved by 2035. In conclusion, non-exhaust PM2.5 was found to have a larger share (as much as 34 times that of exhaust emissions) in 2035 where passenger cars with alternative technologies represented a major share in the fleet. The research also provided a methodology capable of detailing the CO2 and PM2.5 emissions in future scenarios for a range of vehicle technologies. This research also highlights an urgent need for investigation of emission factors for several emerging passenger car technologies.

Alam, Md Saniul, et al. "Analysing the Co-Benefits of transport fleet and fuel policies in reducing PM2. 5 and CO2 emissions." Journal of Cleaner Production 172 (2018): 623-634.

An overview of monitoring and reduction strategies for health and climate change related emissions in the Middle East and North Africa region

This review assesses the current state of air pollution in the Middle East and North Africa (MENA) region. Emission types and sources in the region are identified and quantified to understand the monitoring, legislative and reduction needs through a systematic review of available literature. It is found that both health (e.g., particulate matter, PM; and heavy metals) and climate change (e.g., carbon dioxide and methane) emissions are increasing with the time. Regarding health emissions, over 99% of the MENA population is exposed to PM levels that exceed the standards set by the World Health Organization (WHO). The dominant source of climate change emissions is the energy sector contributing ~38% of CO2 emissions, followed by the transport sector at ~25%. Numerous studies have been carried out on air pollution in the region, however, there is a lack of comprehensive regional studies that would provide a holistic assessment. Most countries have air quality monitoring systems in place, however, the data is not effectively evaluated to devise pollution reduction strategies. Moreover, comprehensive emission inventories for the individual countries in the region are also lacking. The legislative and regulatory systems in MENA region follow the standards set by international environmental entities such as the WHO and the U.S. Environmental Protection Agency but their effective reinforcement remains a concern. It is concluded that the opportunities for emission reduction and control could be best implemented in the road transportation sector using innovative technologies. One of the potential ways forward is to channel finance flows from fossil fuel subsidies to upgrade road transport with public transportation systems such as buses and trains, as suggested by a 'high shift' scenario for MENA region. Furthermore, emission control programs and technologies are more effective when sponsored and implemented by the private sector; the success of Saudi Aramco in supporting national emission monitoring is one such example. Finally, an energy-pollution-water nexus is assessed for the region as an integrated approach to address its urban issues. The assessment of topic areas covered clearly suggests a need to control the main sources of air pollution to limit its relatively high impact on the human health in the MENA region.

Abbass, Rana Alaa, Prashant Kumar, and Ahmed El-Gendy. "An overview of monitoring and reduction strategies

for health and climate change related emissions in the Middle East and North Africa region." Atmospheric Environment (2017).

Non-CO2 Greenhouse Gas Emissions in China 2012: Inventory and Supply Chain Analysis

Reliable inventory information is critical in informing emission mitigation efforts. Using the latest officially released emission data, which is production based, we take a consumption perspective to estimate the non-CO2 greenhouse gas (GHG) emissions for China in 2012. The non-CO2 GHG emissions, which cover CH4, N2O, HFCs, PFCs, and SF6, amounted to 2003.0 Mt. CO2-eq (including 1871.9 Mt. CO2-eq from economic activities), much larger than the total CO2 emissions in some developed countries. Urban consumption (30.1%), capital formation (28.2%), and exports (20.6%) derived approximately four fifths of the total embodied emissions in final demand. Furthermore, the results from structural path analysis help identify critical embodied emission paths and key economic sectors in supply chains for mitigating non-CO2 GHG emissions in Chinese economic systems. The top 20 paths were responsible for half of the national total embodied emissions. Several industrial sectors such as Construction, Production and Supply of Electricity and Steam, Manufacture of Food and Tobacco and Manufacture of Chemicals, and Chemical Products played as the important transmission channels. Examining both production- and consumption-based non-CO2 GHG emissions will enrich our understanding of the influences of industrial positions, final consumption demands, and trades on national non-CO2 GHG emissions by considering the comprehensive abatement potentials in the supply chains.

Zhang, Bo, et al. "Non‐CO2 Greenhouse Gas Emissions in China 2012: Inventory and Supply Chain Analysis." Earth's Future 6.1 (2018): 103-116.

Achieving China's Intended Nationally Determined Contribution and its co-benefits: Effects of the residential sector

In preparation for the 21st Conference of Parties (COP21) held in December 2015, the participating parties under the UN Framework Convention on Climate Change (UNFCCC) agreed to submit their own targets for national greenhouse gas emission reductions and mitigation, and adaptation actions that they intended to take under the post-2020 international framework for climate change. They were called Intended Nationally Determined Contributions (INDCs). One of the important actions by 2030 in China's INDC is to lower carbon dioxide (CO2) emissions per unit of GDP by 60%–65% from 2005 levels. The purpose of this study is 1) to examine the efforts on China's residential sector in achieving the CO2 reduction target stated in China's INDC, 2) to estimate the range of carbon prices and mitigation potential in the INDC targets, and 3) to analyze the co-benefits of low carbon measures to reduce emissions of major short-lived climate pollutants and air pollutants in the residential sector, such as black carbon (BC), fine particulate matter (PM2.5), and sulfur dioxide (SO2). To account for climate diversity and its impact on household energy service demands, our analysis divides China into 31 sub-national regions. It was found that the residential sector has significant reduction potential to succeed with “no-regret” CO2 reduction measures. To achieve the range of China's INDC targets, households in both rural and urban China must implement more efficient technologies and marginal abatement in the range of around $40–$60 US/tCO2. Compared to the FIX scenario, CO2, BC, PM2.5, and SO2 emissions from the residential sector in the whole China are respectively reduced by 38%, 21%, 16%, and 31% in 2030 in the lower boundary of the INDC targets. However, reduction rates vary across provinces due to climatic variations and economic disparities. For example, cold provinces contribute more to the total emission reductions than warm provinces, under a national carbon emission cap to achieve the INDC targets. It is also important to note that there are large co-benefits to reducing air pollutants due to low carbon measures, thus achieving the INDC targets will help improve indoor air quality in the residential sector, especially in rural areas.

Xing, Rui, et al. "Achieving China's Intended Nationally Determined Contribution and its co-benefits: Effects of the residential sector." Journal of Cleaner Production 172 (2018): 2964-2977.

Unsustainability at the crossroads of climate change and air pollution sciences: implications for sustainable development and the scholarship of sustainability

Release of carbonaceous aerosols – comprising black carbon (BC) and organic carbon (OC) – from biomass

burning into the atmosphere is dependent on the burning conditions as to the resultant relative abundances of the emitted BC and OC. This provides a way of managing biomass burning in terms of manipulating the types of emitted aerosol. The carbonaceous aerosols are concerned in different ways in different scientific fields. The BC and OC exert complex implications for (a) radiative forcing in climate change science but (b) public health concern in air pollution science. Referring to these complex implications, a case of sustainability is constructed, which is being unsustainably dealt with at the crossroads of the sciences. This reveals an inadequacy of the reductionist mode of enquiry, necessitating a new mode with unique epistemological orientation for the scholarship of sustainability. The necessity of integration of perspectives that are currently segregated for this sustainability issue and the implications for sustainable development are elucidated.

Hossain, AMM Maruf. "Unsustainability at the crossroads of climate change and air pollution sciences: implications for sustainable development and the scholarship of sustainability." Sustainable Development (2018).

Methane

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

Source Partitioning of Methane Emissions and its Seasonality in the U.S. Midwest

The methane (CH4) budget and its source partitioning are poorly constrained in the Midwestern United States. We used tall tower (185 m) aerodynamic flux measurements and atmospheric scale factor Bayesian inversions to constrain the monthly budget and to partition the total budget into natural (e.g., wetlands) and anthropogenic (e.g., livestock, waste, and natural gas) sources for the period June 2016 to September 2017. Aerodynamic flux observations indicated that the landscape was a CH4 source with a mean annual CH4 flux of +13.7 ± 0.34 nmol m−2 s−1 and was rarely a net sink. The scale factor Bayesian inversion analyses revealed a mean annual source of +12.3 ± 2.1 nmol m−2 s−1. Flux partitioning revealed that the anthropogenic source (7.8 ± 1.6 Tg CH4 yr−1) was 1.5 times greater than the bottom-up gridded United States Environmental Protection Agency inventory, in which livestock and oil/gas sources were underestimated by 1.8-fold and 1.3-fold, respectively. Wetland emissions (4.0 ± 1.2 Tg CH4 yr−1) were the second largest source, accounting for 34% of the total budget. The temporal variability of total CH4 emissions was dominated by wetlands with peak emissions occurring in August. In contrast, emissions from oil/gas and other anthropogenic sources showed relatively weak seasonality.

Chen, Zichong, et al. "Source partitioning of methane emissions and its seasonality in the US Midwest." Journal of Geophysical Research: Biogeosciences 123.2 (2018): 646-659.

Methane emissions from storage of digestate at a dairy manure biogas facility

Conventional manure storages are an important source of methane (CH4), a potent greenhouse gas. Anaerobic digestion is an alternative manure management practice potentially able to provide environmental benefits, including the reduction of CH4 emissions from slurry storage. This study was conducted at a commercial farm in Ontario where a biodigester system became operational in May 2012. The purpose was to quantify year-round CH4 emissions from a digestate storage tank, examine the relationship between emissions and its driving factors, and compare these results to a similar emissions dataset from untreated manure measured during one year before the biodigester became operational. A micrometeorological mass balance approach was used to measure CH4 fluxes. Total annual CH4 emissions from digestate were 1.0 kg m−3 y−1, which was 85% lower compared to untreated manure. Monthly average volatile solids (VS) mass in the storage tank was 73 ± 24 Mg for digestate and 107 ± 30 Mg for manure, representing a 32% VS reduction in the tank, suggesting that lower emissions were not only due to VS mass reduction after biodigestion and solid-liquid separation. The annual CH4 emissions scaled by VS were 26 g kg−1 VS y−1 for digestate and 76 g kg−1 VS y−1 for manure, suggesting that VS in the digestate were less suitable for CH4 production (less digestible). This was also verified when investigating the relationship between fluxes and its driving factors: VS concentration did not correlate with CH4 emissions per volume for digestate ($r = 0.37$; $p = 0.29$), but did for untreated manure ($r = 0.95$; $p = 0.002$). However, the

correlation of temperature with emission was stronger for digestate than manure at all depths with no lag, especially at 2 m depth ($r = 0.98$, $p < 0.001$). At the same air temperature, digestate was warmer than manure, owing to the digestate leaving the digester at 38 °C. This study showed that co-digestion of dairy manure and off-farm materials (35% of loading volume) with a 60-day hydraulic retention time and subsequent solid liquid separation significantly reduced facility-scale CH4 emissions from the storage tank.

Maldaner, Lia, et al. "Methane emissions from storage of digestate at a dairy manure biogas facility." Agricultural and Forest Meteorology (2018).

Black Carbon

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

The theory-practice gap of black carbon mitigation technologies in rural China

Black carbon mitigation has received increasing attention for its potential contribution to both climate change mitigation and air pollution control. Although different bottom-up models concerned with unit mitigation costs of various technologies allow the assessment of alternative policies for optimized cost-effectiveness, the lack of adequate data often forced many reluctant explicit and implicit assumptions that deviate away from actual situations of rural residential energy consumption in developing countries, where most black carbon emissions occur. To gauge the theory-practice gap in black carbon mitigation – the unit cost differences that lie between what is estimated in the theory and what is practically achieved on the ground – this study conducted an extensive field survey and analysis of nine mitigation technologies in rural China, covering both northern and southern regions with different residential energy consumption patterns. With a special focus on two temporal characteristics of those technologies – lifetimes and annual utilization rates, this study quantitatively measured the unit cost gaps and explain the technical as well as sociopolitical mechanisms behind. Structural and behavioral barriers, which have affected the technologies' performance, are discussed together with policy implications to narrow those gaps.

Zhang, Weishi, et al. "The theory-practice gap of black carbon mitigation technologies in rural China." Atmospheric Environment 174 (2018): 122-131.

Tropospheric Ozone

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

Current surface ozone concentrations significantly decrease wheat growth, yield and quality

Tropospheric ozone is known to adversely affect crops and other vegetation. Most studies have focussed on the effects of elevated ozone levels vs. present ambient. We investigated the effect of present ambient surface ozone (O3) concentrations vs. preindustrial on a range of agronomically important response variables in field-grown wheat, using results from 33 experiments (representing 9 countries, 3 continents, 17 cultivars plus one set of 4 cultivars) having both charcoal filtered (CF) and non-filtered (NF) air treatments. Average filtration efficiency was 62%, reducing the O3 concentration from 35.6 ± 10.6 SD ppb in NF to 13.7 ± 8.8 SD ppb in CF. Average CF concentrations were in the range of levels believed to represent pre-industrial conditions, while NF concentrations were 7% lower than in the ambient air at plant height on the experimental sites. NF had significant ($p < 0.05$) negative effects compared to CF on grain yield (− 8.4%), grain mass (− 3.7%), harvest index

(− 2.4%), total above-ground biomass (− 5.4%), starch concentration (− 3.0%), starch yield (− 10.9%), and protein yield (− 6.2%). No significant effect was found for grain number and protein concentration. There was a significant relationship between the effect of filtration on grain yield and the difference in O3 concentration between NF and CF treatments. The average yield loss per ppb O3 removed was 0.38% and did not systematically vary with year of experiment (ranging from 1982 to 2010) or with the average O3 level in the experiments. Although there are many differences among the field experiments included in this meta-analysis (e.g. genotype, degree of O3 pollution of the site and year, nutrient and soil condition, filtration efficiency), our study clearly shows that there is a consistent and significant effect of present ambient O3 exposure on a range of important response variables in wheat, the most strongly affected being starch yield.

Pleijel, Håkan, et al. "Current surface ozone concentrations significantly decrease wheat growth, yield and quality." Science of The Total Environment 613 (2018): 687-692.

Hydrofluorocarbons (HFCs)

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

A corresponding state equation for the prediction of isobaric heat capacity of liquid HFC and HFO refrigerants

This work proposed a corresponding state equation for the prediction of isobaric heat capacity of liquid hydrofluorocarbon (HFC) and hydrofluoroolefin (HFO) refrigerants. The equation was derived from classic corresponding state principle and rigorous data analysis. With known acentric factor, critical point and ideal gas isobaric heat capacity, the equation could provide predictions for isobaric heat capacity of liquid refrigerants at a wide state range with satisfactory accuracy. By means of testing available experimental data, the overall prediction accuracy of the equation was confirmed to be 1.78%, which was much better than other prediction methods.

Gao, Neng, Guangming Chen, and Liming Tang. "A corresponding state equation for the prediction of isobaric heat capacity of liquid HFC and HFO refrigerants." Fluid Phase Equilibria 456 (2018): 1-6.

State-of-the-art integrated CO2 refrigeration system for supermarkets: A comparative analysis

This paper investigates the integrated and state-of-the art features of CO2 trans-critical booster systems. The main objective is to identify the most promising solutions in terms of energy efficiency impacts. First, the performance of modified features and integrated functions have been compared with the standard CO2 system and alternative heating and air conditioning solutions. Subsequently, the performance of the defined state-of-the-art CO2 system is compared to natural refrigerant-based cascade and HFC/HFO-based DX and indirect refrigeration solutions operating in cold and warm climates. The results indicate that two-stage heat recovery, flooded evaporation, parallel compression and integration of air conditioning are the most promising features of the state-of-the-art integrated CO2 system. This compact and environmentally friendly system is the most energy efficient solution in cold climates, and is also an efficient solution in warm climates, with comparable efficiency to cascade and HFC/HFO DX systems, but with no existing or potential limitations.

Karampour, Mazyar, and Samer Sawalha. "State-of-the-art integrated CO2 refrigeration system for supermarkets: A comparative analysis." International Journal of Refrigeration 86 (2018): 239-257.

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.

Occupational exposure to indoor air pollution among bakery workers in Ethiopia; A comparison of electric and biomass cookstove

The indoor air pollution (IAP) produced by the domestic combustion of solid fuels is responsible for up to 4 million deaths annually, especially among low and middle income countries. Occupational exposure within the food preparation industries of these nations remains underexplored. We investigated occupational exposure to the IAP produced during the commercial production of injera, a staple of the Ethiopian diet, from bakeries in Addis Ababa, Ethiopia. Measurements of PM2.5, black carbon (via the proxy measure PM2.5 absorbance) and CO were collected from 30 bakeries and their employees for an average of 4-h per working day. Measurements were compared between bakeries using biomass and electric cookstoves. Further, the respiratory health data of 35 bakery employees were collected by interview-based questionnaire. Personal exposure to PM2.5 from biomass cookstoves was double that of electric cookstoves (430 μg/m3 vs. 216 μg/m3), black carbon exposure was four times higher among biomass users (67 × 10-5m-1 vs. 15 × 10-5m-1), and CO exposure was twenty times higher among biomass users (22 ppm vs. 1 ppm). Mixed effect models indicated that the number of stoves in use and additional solid fuel usage (e.g. coffee brewing) also contributed to exposure levels. These findings indicate that the use of biomass powered cookstoves during commercial injera production significantly contributes to IAP and self-reported respiratory symptoms. As injera is the staple foodstuff of Ethiopia, a widespread conversion to electric cookstoves is likely to have a significant impact. However, as high levels of IAP were also observed within the electric bakeries, further identification of pollution sources is required.

Downward, George S., et al. "Occupational exposure to indoor air pollution among bakery workers in Ethiopia; a comparison of electric and biomass cookstoves." Environmental Pollution 233 (2018): 690-697.

Laboratory experiments regarding the use of filtration and retained heat to reduce particulate matter emissions from biomass cooking

There are a number of methods to help reduce the exposure to household air pollution associated with using biomass fuel for daily cooking and heating in nearly 40% of global households. These most commonly include use of cleaner fuels and cookstoves, increasing ventilation, and use of a chimney. This paper investigates two less-commonly considered methods, 1) reducing exposure through filtration and capture of PM2.5 and 2) avoiding emissions using retained heat for cooking. If cookstoves are operated inside an enclosure from which smoke is pulled by a fan through an inexpensive HEPA-type filter before exiting to the outside, the personal exposure levels, room concentrations, and external pollution might be reduced. To test this method, an enclosure was built from which a box fan pulled the air and PM2.5 through a filter, and four different filters were tested. The rate of PM2.5 production (mg/min) exiting the filter was monitored with gravimetric measurement under an emissions hood during the high and low power phases of the Water Boiling Test 4.2.3 conducted on a biomass rocket stove with forced draft. The average of seven baseline emissions tests with no filter was 7.5 mg/min of PM2.5. The average of seven tests using the highest quality furnace filter (3 M 2200) was reduced to 1.5 mg/min and the difference was significant at 95% confidence. The use of retained heat to simmer also reduced emissions of PM2.5 to zero by burning the boil-phase-made-charcoal while 5 l of water were simmered for 35 min.

Still, Dean K., et al. "Laboratory experiments regarding the use of filtration and retained heat to reduce particulate matter emissions from biomass cooking." Energy for Sustainable Development 42 (2018): 129-135.

Characterising the distribution of methane and carbon dioxide emissions from the natural gas supply chain

Methane and CO2 emissions from the natural gas supply chain have been shown to vary widely but there is little understanding about the distribution of emissions across supply chain routes, processes, regions and operational practises. This study defines the distribution of total methane and CO2 emissions from the natural gas supply chain, identifying the contribution from each stage and quantifying the effect of key parameters on emissions. The study uses recent high-resolution emissions measurements with estimates of parameter distributions to build a probabilistic emissions model for a variety of technological supply chain scenarios. The distribution of emissions resembles a log-log-logistic distribution for most supply chain scenarios, indicating an extremely heavy tailed skew: median estimates which represent typical facilities are modest at 18–24 g CO2 eq./MJ HHV, but mean estimates which account for the heavy tail are 22–107 g CO2 eq./MJ HHV. To place these values into context, emissions associated with natural gas combustion (e.g. for heat) are approximately 55 g CO2/MJ HHV. Thus, some supply chain scenarios are major contributors to total greenhouse gas emissions from natural gas. For methane-only emissions, median estimates are 0.8–2.2% of total methane production, with mean emissions of 1.6–5.5%. The heavy tail distribution is the signature of the disproportionately large emitting equipment known as super-emitters, which appear at all stages of the supply chain. The study analyses the impact of different technological options and identifies a set of best technological option (BTO) scenarios. This suggests that emissions-minimising technology can reduce supply chain emissions significantly, with this study estimating median emissions of 0.9% of production. However, even with the emissions-minimising technologies, evidence suggests that the influence of the super-emitters remains. Therefore, emissions-minimising technology is only part of the solution: reducing the impact of super emitters requires more effective detection and rectification, as well as pre-emptive maintenance processes.

Balcombe, P., N. P. Brandon, and A. D. Hawkes. "Characterising the distribution of methane and carbon dioxide emissions from the natural gas supply chain." Journal of Cleaner Production 172 (2018): 2019-2032.

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

Beneficial effect of compost utilization on reducing greenhouse gas emissions in a rice cultivation system through the overall management chain

Livestock manure application can stimulate greenhouse gas (GHG) emissions, especially methane (CH4) in rice paddy. The stabilized organic matter (OM) is recommended to suppress CH4 emission without counting the additional GHG emission during the composting process. To evaluate the effect of compost utilization on the net global warming potential (GWP) of a rice cropping system, the fluxes of GHGs from composting to land application were calculated by a life cycle assessment (LCA) method. The model framework was composed of GHG fluxes from industrial activities and biogenic GHG fluxes from the composting and rice cultivation processes. Fresh manure emitted 30 Mg CO2-eq. ha− 1, 90% and 10% of which were contributed by CH4 and nitrous oxide (N2O) fluxes, respectively, during rice cultivation. Compost utilization decreased net GWP by 25% over that of the fresh manure during the whole process. The composting process increased the GWP of the industrial processes by 35%, but the 60% reduction in CH4 emissions from the rice paddy mainly influenced the reduction of GWP during the overall process. Therefore, compost application could be a good management strategy to reduce GHG emissions from rice paddy systems.

Jeong, Seung Tak, et al. "Beneficial effect of compost utilization on reducing greenhouse gas emissions in a rice cultivation system through the overall management chain." Science of The Total Environment 613 (2018): 115-122.

Annual methane and nitrous oxide emissions from rice paddies and inland fish aquaculture wetlands in southeast China

Inland aquaculture ponds have been documented as important sources of atmospheric methane (CH4) and nitrous oxide (N2O), while their regional or global source strength remains unclear due to lack of direct flux measurements by covering more typical habitat-specific aquaculture environments. In this study, we compared the CH4 and N2O fluxes from rice paddies and nearby inland fish aquaculture wetlands that were converted from rice paddies in southeast China. Both CH4 and N2O fluxes were positively related to water temperature and sediment dissolved organic carbon, but negatively related to water dissolved oxygen concentration. More robust response of N2O fluxes to water mineral N was observed than to sediment mineral N. Annual CH4 and N2O fluxes from inland fish aquaculture averaged 0.51 mg m−2 h−1 and 54.78 μg m−2 h−1, amounting to 42.31 kg CH4 ha−1 and 2.99 kg N2O-N ha−1, respectively. The conversion of rice paddies to conventional fish aquaculture significantly reduced CH4 and N2O emissions by 23% and 66%, respectively. The emission factor for N2O was estimated to be 0.46% of total N input in the feed or 1.23 g N2O-N kg−1 aquaculture production. The estimate of sustained-flux global warming potential of annual CH4 and N2O emissions and the net economic profit suggested that such conversion of rice paddies to inland fish aquaculture would help to reconcile the dilemma for simultaneously achieving both low climatic impacts and high economic benefits in China. More solid direct field measurements from inland aquaculture are in urgent need to direct the overall budget of national or global CH4 and N2O fluxes.

Wu, Shuang, et al. "Annual methane and nitrous oxide emissions from rice paddies and inland fish aquaculture wetlands in southeast China." Atmospheric Environment 175 (2018): 135-144.

The effective mitigation of greenhouse gas emissions from rice paddies without compromising yield by early-season drainage

Global rice production systems face two opposing challenges: the need to increase production to accommodate the world's growing population while simultaneously reducing greenhouse gas (GHG) emissions. Adaptations to drainage regimes are one of the most promising options for methane mitigation in rice production. Whereas several studies have focused on mid-season drainage (MD) to mitigate GHG emissions, early-season drainage (ED) varying in timing and duration has not been extensively studied. However, such ED periods could potentially be very effective since initial available C levels (and thereby the potential for methanogenesis) can be very high in paddy systems with rice straw incorporation. This study tested the effectiveness of seven drainage regimes varying in their timing and duration (combinations of ED and MD) to mitigate CH4 and N2O emissions in a 101-day growth chamber experiment. Emissions were considerably reduced by early-season drainage compared to both conventional continuous flooding (CF) and the MD drainage regime. The results suggest that ED + MD drainage may have the potential to reduce CH4 emissions and yield-scaled GWP by 85–90% compared to CF and by 75–77% compared to MD only. A combination of (short or long) ED drainage and one MD drainage episode was found to be the most effective in mitigating CH4 emissions without negatively affecting yield. In particular, compared with CF, the long early-season drainage treatments LE + SM and LE + LM significantly ($p < 0.01$) decreased yield-scaled GWP by 85% and 87% respectively. This was associated with carbon being stabilised early in the season, thereby reducing available C for methanogenesis. Overall N2O emissions were small and not significantly affected by ED. It is concluded that ED + MD drainage might be an effective low-tech option for small-scale farmers to reduce GHG emissions and save water while maintaining yield.

Islam, Syed Faiz-ul, et al. "The effective mitigation of greenhouse gas emissions from rice paddies without compromising yield by early-season drainage." Science of the Total Environment 612 (2018): 1329-1339.

Methane and nitrous oxide emissions from conventional and modified rice cultivation systems in South India

Rice (Oryza sativa L.) production is facing major challenges, including scarcity of irrigation water and ongoing climate change. Modifications of the current cropping techniques could increase yield, save water, and mitigate greenhouse gas emission. We investigated the effect of planting methods (young seedlings, wide spacing with alternate wetting and drying irrigation [YW-AWD], old seedlings, narrow spacing with continuous flooding [ON-

CF], and in-between the two planting methods [IB-AWD]) and rice varieties on methane (CH4) and (N2O) emissions during two crop seasons. The results show that CH4 emission, averaged over rice varieties, reduced for YW-AWD by 41% and 24%, compared with ON-CF, while the reduction in emission for the IB-AWD method was 48% and 26% in summer (dry) and monsoon (wet) season, respectively. However, an increase in N2O emission was observed for YW-AWD and IB-AWD methods in both seasons. There was no significant difference in CH4 and N2O emissions between the tested varieties. The total water saving under YW-AWD and IB-AWD was 47.5% and 49.3% in summer, and 79.4% and 79.8% in monsoon season, respectively, compared with ON-CF. The grain yields of YW-AWD and IB-AWD were comparable with the yield of ON-CF in both seasons. The CO2-eq emission and yield-scaled CO2-eq emission from YW-AWD and IB-AWD were significantly lower compared with ONCF due to low CH4 emission, while maintaining similar rice yields. This study showed that the YW-AWD and IB-AWD methods are effective in reducing CO2-eq emission and saving irrigation water, while maintaining the rice yield.

Oo, Aung Zaw, et al. "Methane and nitrous oxide emissions from conventional and modified rice cultivation systems in South India." Agriculture, Ecosystems & Environment 252 (2018): 148-158.

Methane and nitrous oxide emissions from paddy fields in Japan: An assessment of controlling factor using an intensive regional data set

Rice paddy fields, producing a major staple food to support growing world populations, represent a major source of greenhouse gases (GHGs) from agricultural ecosystems. The GHG emissions, mainly as CH4 and N2O from paddy ecosystems, are highly sensitive to both environmental and management factors. Yet the identification of specific factors, a fundamental step for GHG inventory and mitigation, is often limited by data availability. Here, we compiled 572 and 174 data on CH4 and N2O emissions, respectively, from paddy fields across Japan, which arguably represents the most intensive GHG data set from paddy fields per region. We hypothesized that statistical analyses of the intensive data set allow the identification of key factors and possible mechanisms that have not been fully appreciated in the previous studies. Important environmental factors newly identified for CH4 emission were soil type and precipitation pattern. The soil emitted CH4 the most was Histosols (172% higher) and the least was Andosols (32% lower) compared to the other soil types. Our analysis also revealed that the region of severe summer rainfall (southwestern Japan) tended to have higher CH4 emission. The most critical management-related factor was straw incorporation and its timing had significant impact as previously reported. Specifically, CH4 emission was 242% and 59% higher by pre-puddling and post-harvest incorporation, respectively. The CH4 response to straw incorporation had relatively large uncertainty, which partly resulted from the variation in straw mass and soil type (esp. Andosols). In addition, the soils having inherently low CH4 emission due presumably to more oxidized conditions had significantly higher response to straw incorporation. Organic amendment increased CH4 by 35%, while water management effect was unclear. We also found that N2O accounted only for 5.5% of total global warming potential from the paddy fields and was mainly emitted in fallow season (84% of annual emission). The amount of nitrogen fertilizer added, the commonly-used factor to estimate N2O emission (e.g., IPCC guideline) showed no significant relationship with the N2O emission in rice growing season, which may be explained by very low level of fertilizer application in Japanese paddy fields (typically < 100 kg ha−1 y−1) compared to other parts of the world. While some of the findings are unique to specific regions (e.g., Andosols), new findings on the factors and potential mechanisms controlling GHG emissions from rice paddy ecosystems would be useful to develop strategies for regional GHG estimate and for modeling biogeochemical cycle in rice paddy ecosystems.

Kajiura, Masako, et al. "Methane and nitrous oxide emissions from paddy fields in Japan: An assessment of controlling factor using an intensive regional data set." Agriculture, Ecosystems & Environment 252 (2018): 51-60.

Maintaining rice production while mitigating methane and nitrous oxide emissions from paddy fields in China: Evaluating tradeoffs by using coupled agricultural systems models

China is the largest rice producing and consuming country in the world, accounting for more than 25% of global production and consumption. Rice cultivation is also one of the main sources of anthropogenic methane (CH4) and nitrous oxide (N2O) emissions. The challenge of maintaining food security while reducing greenhouse gas

emissions is an important tradeoff issue for both scientists and policy makers. A systematical evaluation of tradeoffs requires attention across spatial scales and over time in order to characterize the complex interactions across agricultural systems components. We couple three well-known models that capture different key agricultural processes in order to improve the tradeoff analysis. These models are the DNDC biogeochemical model of soil denitrification-decomposition processes, the DSSAT crop growth and development model for decision support and agro-technology analysis, and the regional AEZ crop productivity assessment tool based on agro-ecological analysis. The calibration of eco-physiological parameters and model evaluation used the phenology and management records of 1981–2010 at nine agro-meteorological stations spanning the major rice producing regions of China. The eco-physiological parameters were calibrated with the GLUE optimization algorithms of DSSAT and then converted to the counterparts in DNDC. The upscaling of DNDC was carried out within each cropping zone as classified by AEZ. The emissions of CH4 and N2O associated with rice production under different management scenarios were simulated with the DNDC at each site and also each 10 × 10 km grid-cell across each cropping zone. Our results indicate that it is feasible to maintain rice yields while reducing CH4 and N2O emissions through careful management changes. Our simulations indicated that a reduction of fertilizer applications by 5–35% and the introduction of midseason drainage across the nine study sites resulted in reduced CH4 emission by 17–40% and N2O emission by 12–60%, without negative consequences on rice yield.

Tian, Zhan, et al. "Maintaining rice production while mitigating methane and nitrous oxide emissions from paddy fields in China: Evaluating tradeoffs by using coupled agricultural systems models." Agricultural Systems 159 (2018): 175-186.

Performance and methane emissions by beef heifer grazing in temperate pastures and in integrated crop-livestock systems: The effect of shade and nitrogen fertilization

Methane (CH4) emissions from enteric fermentation by cattle are the main source of greenhouse gases in livestock systems, but scarce information is available on the effect of production scenarios on CH4 emissions. The objective of this study was to assess animal performance and CH4 emissions by beef heifers grazing in a mixed Lolium multiflorum × Avena strigosa pasture in two different types of integrated systems, crop-livestock only (CL) or crop-livestock-tree (CLT), and with two nitrogen (N) supply levels (90 and 180 kg N ha−1, N90 and N180, respectively). The study was performed during the winter season (i.e., stocking season) over three years (2012–2014). Pasture shading by 6- to 8-year-old trees in the CLT system led to a reduction in the total annual herbage accumulation of approximately 2.6 Mg dry matter ha−1 (−51%) and a reduction in winter carrying capacity of 0.5 stock units ha−1 in comparison to the CL system. Average daily gain (ADG) was reduced by 32% in CLT compared to CL. Average CH4 emissions were 163 ± 9.12 g CH4 day−1 in heifers with an initial average live weight (LW) of approximately 250 kg. Emissions of CH4 per kg of LW did not differ between treatments ($P > 0.05$) with a mean of 0.58 ± 0.030 g kg−1. However, there were significant differences between treatments and among years when CH4 was expressed in g kg ADG−1 and kg ha−1 day−1. Per unit area, CH4 production ranged between 0.51 ± 0.05 (CLT N180) and 0.86 ± 0.12 kg ha−1 day−1 (CL N180). Possible strategies to reduce losses in animal production in the CLT systems are discussed, as well as the potential of C sequestration by woody biomass of eucalyptus trees to mitigate CH4 emissions.

da Silveira Pontes, Laíse, et al. "Performance and methane emissions by beef heifer grazing in temperate pastures and in integrated crop-livestock systems: The effect of shade and nitrogen fertilization." Agriculture, Ecosystems & Environment 253 (2018): 90-97.

Ammonia and greenhouse gas emissions at beef cattle feedlots in Alberta Canada

This study was conducted at beef cattle feedlots, over two years in southern Alberta Canada, and focused on deriving the ammonia, methane, nitrous oxide and carbon dioxide emissions from two feedlots from June/July to October. Line-averaging sensors were used to measure ambient gas concentrations in the vicinity of the feedlots, and an inverse dispersion method was used to calculate emissions. Results show that ammonia and methane emissions were consistent with that measured from other studies. Both feedlots lost about 40% of the nitrogen feed intake as ammonia. The emission of nitrous oxide, when compared on a greenhouse gas bases, was similar to the methane emission. A diet difference between feedlots coincided with a slight difference in feedlot methane emission. There was good agreement between previously reported ammonia and methane

emission rates and those derived in our feedlot study. Further evaluation of the underlying relationships causing variation in emissions should follow. A key to understanding emissions at commercial feedlots is to fully engage the management data available.

McGinn, S. M., and T. K. Flesch. "Ammonia and greenhouse gas emissions at beef cattle feedlots in Alberta Canada." Agricultural and Forest Meteorology (2018).

Transportation

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

Contribution of ship emissions to the concentration of PM2.5: A comprehensive study using AIS data and WRF/Chem model in Bohai Rim Region, China

The differences in PM2.5 concentrations between two relatively close stations, one situated near a major highway and the other much more distant were used to develop a protocol for determining the impact of highway traffic on particulate matter concentrations at the roadside. The roadside station was <15 m away from the edge of a major highway while the other was located ~170 m away. The roadside station contains a suite of continuous instrumentation capable of near-real-time speciation of PM2.5. The particulate matter difference, formally termed the PM2.5 imbalance was arbitrarily defined as a case wherein |Near-road PM2.5 - Far from road PM2.5|/Near-road PM2.5 50%. Of interest was the variation of multi-time factors based on ME2 analyses of the speciation data from the roadside station during these imbalance events. Of the 7 mass-contributing ME2 factors, a black carbon factor was determined to be the major cause of the PM2.5 imbalance and was especially dominant for the case when PM2.5 concentrations at the roadside station were greater than the farther-station PM2.5. The black carbon concentrations observed during these specific events were further regressed against other traffic-related and meteorological parameters with two nonlinear optimization algorithms (generalized reduced gradient and rules ensemble) in our attempts to model any potential relationships. It was observed that the traffic counts of heavy duty vehicles (predominantly diesel-powered) dominated the relationship with black carbon while contributions from light duty vehicles were negligible during these [PM2.5]Roadside > [PM2.5]Farther events at the roadside station. This work details the most critical ways that highway traffic can contribute to local ambient PM2.5 concentrations that commuters are exposed to and will be important in informing policies and strategies for particulate matter pollution reduction.

Sofowote, U. M., et al. "Understanding the PM2. 5 imbalance between a far and near-road location: Results of high temporal frequency source apportionment and parameterization of black carbon." Atmospheric Environment 173 (2018): 277-288.

Quantifying decade-long effects of fuel and traffic regulations on urban ambient PM2.5 pollution in a mid-size South American city

Most of urban air quality studies focus on the megacities of North America, Europe and, recently, Asia. Meanwhile, the most polluted urban areas in the world are rapidly growing large, mid-size and small cities of Asia, Middle East, Africa and South America. This raises a question: why relatively smaller cities are more polluted than the megacities? This study presents the first comprehensive decade-long analysis of the effects of fuel and transport regulations on PM2.5 (particulate matter of aerodynamic diameter <2.5 µm) pollution in Quito, a medium-size city of South America. The effectiveness of a number of regulations is quantified through the elaboration of a high accuracy (98%) regression model. The model estimated that the PM2.5 concentrations were reduced by 67.6 µg/m3, combating the effect of city growth and intense motorization, reducing the annual PM2.5 concentrations to 17.4 µg/m3. This study is recommended as a guideline for thousands of other cities worldwide looking for optimal urban particulate pollution management.

Zalakeviciute, Rasa, et al. "Quantifying decade-long effects of fuel and traffic regulations on urban ambient PM2. 5 pollution in a mid-size South American city." Atmospheric Pollution Research (2017).

On-road assessment of light duty vehicles in Delhi city: Emission factors of CO, CO2 and NOX

This study presents the technology based emission factors of gaseous pollutants (CO, CO2, and NOX) measured during on-road operation of nine passenger cars of diesel, gasoline, and compressed natural gas (CNG). The emissions from two 3-wheelers, and three 2-wheelers were measured by putting the vehicles on jacks and operating them according to Modified Indian Driving Cycle (MIDC) at no load condition. The emission factors observed in the present work were significantly higher than values reported from dynamometer study by Automotive Research Association of India (ARAI). Low CO (0.34 ± 0.08 g km−1) and high NOX (1.0 ± 0.4 g km−1) emission factors were observed for diesel passenger cars, oppositely high CO (2.2 ± 2.6 g km−1) and low NOX (1.0 ± 1.6 g km−1) emission factors were seen for gasoline powered cars. The after-treatment technology in diesel vehicles was effective in CO reduction. While the use of turbocharger in diesel vehicles to generate high combustion temperature and pressure produces more NOx, probably which may not be effectively controlled by after-treatment device. The after-treatment devices in gasoline powered Post-2010, Post-2005 vehicles can be acclaimed for reduced CO emissions compared to Post-2000 vehicles. This work presents a limited data set of emission factors from on-road operations of light duty vehicles, this limitation can be improved by further measurements of emissions from similar vehicles.

Habib, Gazala. "On-road assessment of light duty vehicles in Delhi city: Emission factors of CO, CO 2 and NO X." Atmospheric Environment 174 (2018): 132-139.

An assessment of the real-world driving gaseous emissions from a Euro 6 light-duty diesel vehicle using a portable emissions measurement system (PEMS)

Recent investigations demonstrated that real-world emissions usually exceed the levels achieved in the laboratory based type approval processes. By means of on-board emissions measurements, it has been shown that nitrogen oxides emitted by diesel engines substantially exceed the limit imposed by the Euro 6 regulation. Thus, with the aim of complementing the worldwide harmonized light vehicles test cycle, the real driving emissions cycle will be introduced after 1 September 2017 to regulate the vehicle emissions in real-world driving situations. This paper presents on-board gaseous emissions measurements from a Euro 6 light-duty diesel vehicle in a real-world driving route using a portable emissions measurement system. The test route characteristics follow the requirements imposed by the RDE regulation. The analysis of the raw emissions results suggests that the greatest amount of nitrogen oxides and nitrogen dioxide are emitted during the urban section of the test route, confirming that lower speeds with more accelerations and decelerations lead to higher nitrogen oxides emissions levels than constant high speeds. Moreover, the comparison of the two calculation methods proposed by the real driving emissions regulation has revealed emissions rates differences ranging from 10% to 45% depending on the pollutant emission and the trip section considered (urban or total). Thus, the nitrogen oxides emissions conformity factor slightly varies from one method to the other.

Luján, José M., et al. "An assessment of the real-world driving gaseous emissions from a Euro 6 light-duty diesel vehicle using a portable emissions measurement system (PEMS)." Atmospheric Environment 174 (2018): 112-121.

Road vehicle emission inventory of a Brazilian metropolitan area and insights for other emerging economies

The vehicle fleet in the Ceará state has grown 180% over the last ten years. The growth of the resulting emissions is unknown in view of the expansion of this fleet in the greater Fortaleza Metropolitan Area (FMA). The largest fleet in the FMA is in the Fortaleza city itself, where flex fuel vehicles predominate (~30%). Flex fuel motorcycles increased significantly (greater than 800%) between 2010 and 2015. This paper aims to estimate the road vehicle emissions of carbon monoxide (CO), non-methane hydrocarbons (NMHC), aldehydes (RCHO), nitrogen oxides (NOx), and particulate matter (PM) from the main road vehicle fleets of Fortaleza and its metropolitan area using a macrosimulation, bottom-up method, between 2010 and 2015. The results showed that road vehicle emissions

of CO, NMHC and RCHO increased mainly by Otto cycle vehicles increase due to the introduction of flex fuel vehicles; however, the NOx and PM emissions noticeable reduction is also a result of emission policies that seed the introduction of new technologies. In 2015, more than 70,000 tons of CO (21.2 ton/1000person), 8000 tons of NMHC (2.5 ton/1000person), 290 tons of RCHO (0.09 ton/1000person), 15,000 tons of NOx (4.4 ton/1000person) and 600 tons of PM (0.2 ton/1000person) were emitted in the region under study. Comparing with other Brazilian regions, FMA emit higher levels of pollutants per inhabitant than the state of São Paulo and the state of Rio de Janeiro but lower levels than Porto Alegre city.

Policarpo, Nara Angélica, et al. "Road vehicle emission inventory of a Brazilian metropolitan area and insights for other emerging economies." Transportation Research Part D: Transport and Environment 58 (2018): 172-185.

Waste and Waste Management

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

Estimation of fugitive landfill methane emissions using surface emission monitoring and Genetic Algorithms optimization

As municipal solid waste (MSW) landfills can generate significant amounts of methane, there is considerable interest in quantifying fugitive methane emissions at such facilities. A variety of methods exist for the estimation of methane emissions from landfills. These methods are either based on analytical emission models or on measurements. This paper presents a method to estimate methane emissions using ambient air methane measurements obtained on the surface of a landfill. Genetic Algorithms based optimization combined with the standard Gaussian dispersion model is employed to identify locations as well as emission rates of potential emission sources throughout a municipal solid waste landfill. Four case studies are employed in order to evaluate the performance of the proposed methodology. It is shown that the proposed approach enables estimation of landfill methane emissions and localization of major emission hotspots in the studied landfills. The proposed source-locating-scheme could be seen as a cost effective method assisting landfill operators to reasonably estimate and locate major methane emissions.

Kormi, Tarek, et al. "Estimation of fugitive landfill methane emissions using surface emission monitoring and Genetic Algorithms optimization." Waste Management (2016).

A simulation model for methane emissions from landfills with interaction of vegetation and cover soil

Global climate change and ecological problems brought about by greenhouse gas effect have become a severe threat to humanity in the 21st century. Vegetation plays an important role in methane (CH4) transport, oxidation and emissions from municipal solid waste (MSW) landfills as it modifies the physical and chemical properties of the cover soil, and transports CH4 to the atmosphere directly via their conduits, which are mainly aerenchymatous structures. In this study, a novel 2-D simulation CH4 emission model was established, based on an interactive mechanism of cover soil and vegetation, to model CH4 transport, oxidation and emissions in landfill cover soil. Results of the simulation model showed that the distribution of CH4 concentration and emission fluxes displayed a significant difference between vegetated and non-vegetated areas. CH4 emission flux was 1–2 orders of magnitude higher than bare areas in simulation conditions. Vegetation play a negative role in CH4 emissions from landfill cover soil due to the strong CH4 transport capacity even though vegetation also promotes CH4 oxidation via changing properties of cover soil and emitting O2 via root system. The model will be proposed to allow decision makers to reconsider the actual CH4 emission from vegetated and non-vegetated covered landfills.

Bian, Rongxing, Danhui Xin, and Xiaoli Chai. "A simulation model for methane emissions from landfills with interaction of vegetation and cover soil." Waste Management 71 (2018): 267-276.

Estimates and Predictions of Methane Emissions from Wastewater in China from 2000 to 2020

Methane accounts for 20% of the global warming caused by greenhouse gases, and wastewater is a major anthropogenic source of methane. Based on the Intergovernmental Panel on Climate Change greenhouse gas inventory guidelines and current research findings, we calculated the amount of methane emissions from 2000 to 2014 that originated from wastewater from different provinces in China. Methane emissions from wastewater increased from 1349.01 to 3430.03 Gg from 2000 to 2014, and the mean annual increase was 167.69 Gg. The methane emissions from industrial wastewater treated by wastewater treatment plants (EIt) accounted for the highest proportion of emissions. We also estimated the future trend of industrial wastewater methane emissions using the artificial neural network model. A comparison of the emissions for the years 2020, 2010, and 2000 showed an increasing trend in methane emissions in China and a spatial transition of industrial wastewater emissions from eastern and southern regions to central and southwestern regions and from coastal regions to inland regions. These changes were caused by changes in economics, demographics, and relevant policies.

Du, Mingxi, et al. "Estimates and Predictions of Methane Emissions from Wastewater in China from 2000 to 2020." Earth's Future 6.2 (2018): 252-263.

Quantitative analysis of the methane gas emissions from municipal solid waste in India

Increased emissions of greenhouse gases have altered the global ambient temperature and adversely affected global climatic conditions. The municipal solid waste (MSW) generated by households is considered the third largest anthropogenic source of methane (CH4) emissions, constituting 11% of all global CH4 emissions. The current study derived total MSW CH4 emission estimates using the IPCC default method (DM), modified triangular method (MTM) and first order decay method (FOD). The estimated CH4 emission was higher for the DM than the other methods, and was comparable to estimates from other studies. This study observed that the net annual emission of CH4 from landfills in India increased from 404 Gg in 1999–2000 to 990 Gg and 1084 Gg in 2011 and 2015, respectively. We also found that CH4 emissions were highly correlated (R2 = 0.8) with the gross state domestic product (GSDP) of states and the gross domestic product (GDP) of the country, which is an indicator of human well-being. The MSW management policy of India needs to be reviewed in a current policy context, as the management and efficient utilization of MSW technologies might help increase the use of CH4 as an energy source and thereby improve its sustainable and cost-effective management.

Singh, Chander Kumar, Anand Kumar, and Soumendu Shekhar Roy. "Quantitative analysis of the methane gas emissions from municipal solid waste in India." Scientific reports 8.1 (2018): 2913.

PM2.5 and Air Pollution

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

Long-term trends and spatial patterns of satellite-retrieved PM2.5 concentrations in South and Southeast Asia from 1999 to 2014

Fine particulate matter, or PM2.5, is a serious air pollutant and has significant effects on human health, including premature death. Based on a long-term series of satellite-retrieved PM2.5 concentrations, this study analyzed the spatial and temporal characteristics of PM2.5 in South and Southeast Asia (SSEA) from 1999 to 2014 using standard deviation ellipse and trend analyses. A health risk assessment of human exposure to PM2.5 between 1999 and 2014 was then undertaken. The results show that PM2.5 concentrations increased in most areas of SSEA from 1999 to 2014 and exceeded the World Health Organization average annual limit of primary PM2.5 standards. Bangladesh, Pakistan and India experienced average PM2.5 values higher than the total average for SSEA. From 1999 to 2014, the entirety of SSEA exhibited an increased rate of 0.02 μg/m3/year on average. Bangladesh and Myanmar witnessed greater incremental rates of PM2.5 than India. Correspondingly, the center of the average regional PM2.5 concentration gradually shifted to the southeast during the study period. The

proportion of areas with PM2.5 concentrations exceeding 35 µg/m3 increased consistently, and the areas with PM2.5 concentrations below 15 µg/m3 decreased continuously. The proportion of the population exposed to high PM2.5 (above 35 µg/m3) increased annually. The extent of high-health-risk areas in SSEA expanded in size and extent between 1999 and 2014, particularly in North India, Bangladesh and East Pakistan. Therefore, all of SSEA should receive special attention, and strict controls on PM2.5 concentrations in SSEA countries are urgently required.

Shi, Yusheng, et al. "Long-term trends and spatial patterns of satellite-retrieved PM 2.5 concentrations in South and Southeast Asia from 1999 to 2014." Science of The Total Environment 615 (2018): 177-186.

Temporal-spatial characteristics and source apportionment of PM2.5 as well as its associated chemical species in the Beijing-Tianjin-Hebei region of China

PM2.5 and its major chemical compositions were sampled and analyzed in January, April, July and October of 2014 at Beijing (BJ), Tianjin (TJ), Langfang (LF) and Baoding (BD) in order to probe the temporal and spatial characteristics as well as source apportionment of PM2.5 in the Beijing-Tianjin-Hebei (BTH) region. The results showed that PM2.5 pollution was severe in the BTH region. The average annual concentrations of PM2.5 at four sampling sites were in the range of 126–180 µg/m3, with more than 95% of sampling days exceeding 35 µg/m3, the limit ceiling of average annual concentration of PM2.5 regulated in the Chinese National Ambient Air Quality Standards (GB3095-2012). Additionally, concentrations of PM2.5 and its major chemical species were seasonally dependent and demonstrated spatially similar variation characteristics in the BTH region. Concentration of toxic heavy metals, such as As, Cd, Cr, Cu, Mn, Ni, Pb, Sb, Se, and Zn, were higher in winter and autumn. Secondary inorganic ions (SO42−, NO3−, and NH4+) were the three-major water-soluble inorganic ions (WSIIs) of PM2.5 and their mass ratios to PM2.5 were higher in summer and autumn. The organic carbon (OC) and elemental carbon (EC) concentrations were lower in spring and summer than in autumn and winter. Five factors were selected in Positive Matrix Factorization (PMF) model analysis, and the results showed that PM2.5 pollution was dominated by vehicle emissions in Beijing, combustion emissions including coal burning and biomass combustion in Langfang and Baoding, and soil and construction dust emissions in Tianjin, respectively. The air mass that were derived from the south and southeast local areas around BTH regions reflected the features of short-distant and small-scale air transport. Shandong, Henan, and Hebei were identified the major potential sources-areas of secondary aerosol emissions to PM2.5.

Gao, Jiajia, et al. "Temporal-spatial characteristics and source apportionment of PM 2.5 as well as its associated chemical species in the Beijing-Tianjin-Hebei region of China." Environmental Pollution 233 (2018): 714-724.

Temporal variation of fine and coarse particulate matter sources in Jeddah, Saudi Arabia

This study provides the first comprehensive analysis of the seasonal variations and weekday/weekend differences in fine (aerodynamic diameter <2.5 µm; PM2.5) and coarse (aerodynamic diameter 2.5–10 µm; PM2.5–10) particulate matter mass concentrations, elemental constituents, and potential source origins in Jeddah, Saudi Arabia. Air quality samples were collected over 1 yr, from June 2011 to May 2012 at a frequency of three times per week, and analyzed. The average mass concentrations of PM2.5 (21.9 µg/m3) and PM10 (107.8 µg/m3) during the sampling period exceeded the recommended annual average levels by the World Health Organization (WHO) for PM2.5 (10 µg/m3) and PM10 (20 µg/m3), respectively. Similar to other Middle Eastern locales, PM2.5–10 is the prevailing mass component of atmospheric particulate matter at Jeddah, accounting for approximately 80% of the PM10 mass. Considerations of enrichment factors, absolute principal component analysis (APCA), concentration roses, and backward trajectories identified the following source categories for both PM2.5 and PM2.5–10: (1) soil/road dust, (2) incineration, and (3) traffic; and for PM2.5 only, (4) residual oil burning. Soil/road dust accounted for a major portion of both the PM2.5 (27%) and PM2.5–10 (77%) mass, and the largest source contributor for PM2.5 was from residual oil burning (63%). Temporal variations of PM2.5–10 and PM2.5 were observed, with the elevated concentration levels observed for mass during the spring (due to increased dust storm frequency) and on weekdays (due to increased traffic). The predominant role of windblown soil and road dust in both the PM2.5 and PM2.5–10 masses in this city may have implications regarding the toxicity of these particles versus those in the Western world where most PM health assessments have been made in the past. These results support the need for region-specific epidemiological

investigations to be conducted and considered in future PM standard setting.

Lim, Chris C., et al. "Temporal variations of fine and coarse particulate matter sources in Jeddah, Saudi Arabia." Journal of the Air & Waste Management Association 68.2 (2018): 123-138.

Source apportionment of PM2.5 using hourly measurements of elemental tracers and major constituents in an urban environment: Investigation of time resolution influence

We demonstrate with field data the benefit of using high-time resolution chemical speciation data in achieving more robust source apportionment of fine particulate matter (PM2.5) using positive matrix factorization (PMF). Hourly composition data were collected over a month in Shanghai, including four inorganic ions, thirteen elements, organic and elemental carbon. PMF analysis of the hourly dataset (PMF1h) resolves eight factors: secondary nitrate/sulfate, vehicular/industrial emissions, coal combustion, secondary sulfate, tire wear, Cr and Ni point source, residual oil combustion, and dust, with the first three being the major ones and each contributing to >20% of PM2.5 mass. To characterize the benefit gained from time resolution, we carried out separate PMF analyses of 4-h and 6-h averaged data of the same dataset (PMF6h and PMF4h). PMF6h and PMF4h produce an eight-factor solution sharing similar factors to those by PMF1h, but show less stability and more mixing in source profiles. Profile mixing was especially noticeable for tire wear, coal combustion and Cr and Ni point source in PMF6h, as the 6-h averaging significantly decreased between-sample variability and increased rotational ambiguity. While the three sets of PMF solutions were similar in contributions for factors with major species as source markers (e.g., secondary nitrate/sulfate), larger variations existed for factors with trace species as markers due to mixing of major species in the profiles and higher rotational uncertainties in PMF4h and PMF6h. Our results indicate that hourly time series of elements and major components could achieve more robust source apportionment through better capturing of diurnal-scale dynamics in source activities.

Wang, Qiongqiong, et al. "Source apportionment of PM2. 5 using hourly measurements of elemental tracers and major constituents in an urban environment: Investigation of time resolution influence." Journal of Geophysical Research: Atmospheres (2018).

Air pollution & Health Impacts

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

Ambient PM2.5 exposure and expected premature mortality to 2100 in India under climate change scenarios

Premature mortality from current ambient fine particulate (PM2.5) exposure in India is large, but the trend under climate change is unclear. Here we estimate ambient PM2.5 exposure up to 2100 by applying the relative changes in PM2.5 from baseline period (2001–2005) derived from Coupled Model Inter-comparison Project 5 (CMIP5) models to the satellite-derived baseline PM2.5. We then project the mortality burden using socioeconomic and demographic projections in the Shared Socioeconomic Pathway (SSP) scenarios. Ambient PM2.5 exposure is expected to peak in 2030 under the RCP4.5 and in 2040 under the RCP8.5 scenario. Premature mortality burden is expected to be 2.4–4 and 28.5–38.8% higher under RCP8.5 scenario relative to the RCP4.5 scenario in 2031–2040 and 2091–2100, respectively. Improved health conditions due to economic growth are expected to compensate for the impact of changes in population and age distribution, leading to a reduction in per capita health burden from PM2.5 for all scenarios except the combination of RCP8.5 exposure and SSP3.

Chowdhury, Sourangsu, Sagnik Dey, and Kirk R. Smith. "Ambient PM 2.5 exposure and expected premature mortality to 2100 in India under climate change scenarios." Nature Communications 9.1 (2018): 318.

Exposures to fine particulate matter (PM2.5) and birthweight in a rural-urban, mother-child cohort in Tamil Nadu, India

Exposure to PM2.5 (fine particulate matter <less than 2.5 µm in aerodynamic diameter) related to ambient and household air pollution has been associated with low birthweight. Few of these studies, however, have been conducted in high exposure settings that are commonly encountered in low and middle income countries (LMICs). We examined whether PM2.5 exposures during pregnancy were associated with birthweight in an integrated rural-urban, mother-child cohort in the state of Tamil Nadu, India. We recruited 1285 pregnant women in the first trimester of pregnancy from primary health care centers and urban health posts and followed them until birth to collect antenatal care data and birthweight. We estimated pregnancy period PM 2.5 exposures through direct serial measurements of 24-h household PM2.5 concentrations, performed across each trimester. Mothers also completed detailed questionnaires to provide data on covariates related to household, socio-economic, demographic and maternal health characteristics. The association between PM2.5 exposures and birth weight was assessed using linear and logistic regression models that controlled for potential confounders. A 10-µg/m3 increase in pregnancy period PM2.5 exposures was associated with a 4 g (95% CI: 1.08 g, 6.76 g) decrease in birthweight and 2% increase in prevalence of low birthweight [odds ratio(OR) = 1.02; 95%CI:1.005,1.041] after adjusting for gestational age, infant sex, maternal BMI, maternal age, history of a previous low birth weight child, birth order and season of conception. The study provides some of the first quantitative effects estimates for linking rural-urban PM2.5 exposures and birthweight in India, adding important evidence for this association from high exposure settings in LMICs, that also experience dual health burdens from ambient and household air pollution. Study results also point to the need for considering maternal PM2.5 exposures alongside other risk factors for low birthweight in India

Balakrishnan, Kalpana, et al. "Exposures to fine particulate matter (PM 2.5) and birthweight in a rural-urban, mother-child cohort in Tamil Nadu, India." Environmental research 161 (2018): 524-531.

Estimating premature mortality attributable to PM2.5 exposure and benefit of air pollution control policies in China for 2020

In past decade of rapid industrial development and urbanization, China has witnessed increasingly persistent severe haze and smog episodes, posing serious health hazards to the Chinese population, especially in densely populated cities. Quantification of health impacts attributable to PM2.5 (particulates with aerodynamic diameter ≤ 2.5 µm) has important policy implications to tackle air pollution. The Chinese national monitoring network has recently included direct measurements of ground level PM2.5, providing a potentially more reliable source for exposure assessment. This study reports PM2.5-related long-term mortality of year 2015 in 161 cities of nine regions across China using integrated exposure risk (IER) model for PM2.5 exposure-response functions (ERF). It further provides an estimate of the potential health benefits by year 2020 with a realization of the goals of Air Pollution Prevention and Control Action Plan (APPCAP) and the three interim targets (ITs) and Air Quality Guidelines (AQG) for PM2.5 by the World Health Organization (WHO). PM2.5-related premature mortality in 161 cities was 652 thousand, about 6.92% of total deaths in China during year 2015. Among all premature deaths, contributions of cerebrovascular disease (stroke), ischemic heart disease (IHD), chronic obstructive pulmonary disease (COPD), lung cancer (LC) and acute lower respiratory infections (ALRIs) were 51.70, 26.26, 11.77, 9.45 and 0.82%, respectively. The premature mortality in densely populated cities is very high, such as Tianjin (12,533/year), Beijing (18,817/year), Baoding (10,932/year), Shanghai (18,679/year), Chongqing (23,561/year), Chengdu (11,809/year), Harbin (9037/year) and Linyi (9141/year). The potential health benefits will be 4.4, 16.2, 34.5, 63.6 and 81.5% of the total present premature mortality when PM2.5 concentrations in China meet the APPCAP, WHO IT-1, IT-2, IT-3 and AQG respectively, by the year 2020. In the current situation, by the end of year 2030, even if Chines government fulfills its own target to meet national ambient air quality standard of PM2.5 (35 µg/m3), total premature mortality attributable to PM2.5 will be 574 thousand across 161 cities. The present methodology will greatly help policy makers and pollution control authorities to further analyze cost and benefits of air pollution management programs in China.

Maji, Kamal Jyoti, et al. "Estimating premature mortality attributable to PM2. 5 exposure and benefit of air pollution control policies in China for 2020." Science of the Total Environment 612 (2018): 683-693.

Geospatial hot spot analysis of lung cancer patients correlated to fine particulate matter (PM2.5) and industrial wind in Eastern Thailand

Lung cancer is the most common type of cancer and is the major cause of death first among males and second among females in Thailand. Lung cancer is highly related to particulate matter (PM)—especially fine particulates with a diameter of 2.5 µm or less (PM2.5). Recent studies have indicated a strong correlation between fine particulate matter (PM2.5) and lung function diseases. Therefore, this study aims to investigate and explore the phenomenon of lung cancer and its spatial correlation to mortality and PM2.5 in Eastern Thailand from 2008 to 2012 using multidisciplinary techniques. The cancer registry was utilized as data inventory and geographical information system (GIS), Global Moran's I, Getis-Ord G statistics, Average Nearest Neighbor (ANN) tool, Inverse Distance Weighting (IDW), Local Indicators of Spatial Autocorrelation (LISA), and ordinary least square (OLS) methods to generate the PM2.5 maps to create hot spots in Eastern Thailand. The results visualize and analyze lung cancer hot spots and are adjusted for known factors such as sex and age of lung cancer patients. Choropleth maps of lung cancer incidence and mortality rates, generated for the first time, revealed that the number of male cancer patients is higher than that of females in Eastern Thailand. Global autocorrelation demonstrated considerable spatial clustering of lung cancer incidence and mortality. 91.56% of the lung cancer patients belonged to the age group of above 50 in both sexes. Significant relationships were found between the PM2.5 variable and the spatial patterns of lung cancer incidence and mortality. The Chonburi and Chanthaburi provinces were found to be the major hot spots for lung cancer incidence, which are close to industrial areas. These findings are useful in identifying the cancer registry information globally as well as locally. This study also provides a useful set of tools to identify and create hot spots in the developing countries where data and resources are major limitations.

Zhang, Haoran, and Nitin Kumar Tripathi. "Geospatial hot spot analysis of lung cancer patients correlated to fine particulate matter (PM2. 5) and industrial wind in Eastern Thailand." Journal of Cleaner Production 170 (2018): 407-424.

Other SLCP Source Sectors & Measures

Description: This section includes articles relating to SLCP emissions and measures from sources not currently addressed by the CCAC

The reduction of summer sulfate and switch from summertime to wintertime PM2.5 concentration maxima in the United States

Exposure to particulate matter air pollution with a nominal mean aerodynamic diameter less than or equal to 2.5 µm (PM2.5) has been associated with health effects including cardiovascular disease and death. Here, we add to the understanding of urban and rural PM2.5 concentrations over large spatial and temporal scales in recent years. We used high-quality, publicly-available air quality monitoring data to evaluate PM2.5 concentration patterns and changes during the years 2000–2015. Compiling and averaging measurements collected across the U.S. revealed that PM2.5 concentrations from urban sites experienced seasonal maxima in both winter and summer. Within each year from 2000 to 2008, the maxima of urban summer peaks were greater than winter peaks. However, from 2012 to 2015, the maxima of urban summertime PM2.5 peaks were smaller than the urban wintertime PM2.5 maxima, due to a decrease in the magnitude of summertime maxima with no corresponding decrease in the magnitude of winter maxima. PM2.5 measurements at rural sites displayed summer peaks with magnitudes relatively similar to those of urban sites, and negligible to no winter peaks through the time period analyzed. Seasonal variations of urban and rural PM2.5 sulfate, PM2.5 nitrate, and PM2.5 organic carbon (OC) were also assessed. Summer peaks in PM2.5 sulfate decreased dramatically between 2000 and 2015, whereas seasonal PM2.5 OC and winter PM2.5 nitrate concentration maxima remained fairly consistent. These findings demonstrate that PM2.5 concentrations, especially those occurring in the summertime, have declined in the U.S. from 2000 to 2015. In addition, reduction strategies targeting sulfate have been successful and the decrease in PM2.5 sulfate contributed to the decline in total PM2.5.

Chan, Elizabeth AW, Brett Gantt, and Stephen McDow. "The reduction of summer sulfate and switch from

summertime to wintertime PM 2.5 concentration maxima in the United States." Atmospheric Environment 175 (2018): 25-32.

Air pollution at Rochester, NY: Long-term trends and multivariate analysis of upwind SO2 source impacts

There have been many changes in the air pollutant sources in the northeastern United States since 2001. To assess the effect of these changes, trend analyses of the monthly average values were performed on PM2.5 and its components including major ions, elemental carbon (EC), organic carbon (OC), and gaseous pollutant concentrations measured between 2001 (in some cases 1999) and 2015 at the NYS Department of Environmental Conservation sites in Rochester, NY. Mann-Kendall regression with Sen's slope was applied to estimate the trends and seasonality. Using piecewise regression, significant reductions in the air pollution of Rochester area were observed between 2008 and 2010 when a 260 MW coal-fired power plant was decommissioned, new heavy-duty diesel trucks had to be equipped with catalytic regenerator traps, and the economic recession that began in 2008 reduced traffic and other activities. The monthly average PM2.5 mass showed a downward trend (− 5 μg/m3; − 41%) in Rochester between 2001 and 2015. This change is largely due to reductions in particulate sulfate that showed a 65% decrease. The sulfate concentrations were compared to changes in SO2 emissions in seventeen upwind source domains, and other systematic changes by multivariate linear regression. Selectivity ratio obtained from target projection discriminated the most important source domains that are SO2 emissions from Georgia for winter, North Carolina for transition (spring and fall) and Ohio along with other influences for summer. North Carolina and Michigan were identified as the main sources for entire period. These observations suggest that any further reductions in the specified regional SO2 emissions would result in a proportional decrease in sulfate in Rochester.

Emami, Fereshteh, Mauro Masiol, and Philip K. Hopke. "Air pollution at Rochester, NY: Long-term trends and multivariate analysis of upwind SO2 source impacts." Science of The Total Environment 612 (2018): 1506-1515.

Maritime NOx Emissions Over Chinese Seas Derived From Satellite Observations

By applying an inversion algorithm to NOx satellite observations from Ozone Monitoring Instrument, monthly NOx emissions for a 10 year period (2007 to 2016) over Chinese seas are presented for the first time. No effective regulations on NOx emissions have been implemented for ships in China, which is reflected in the trend analysis of maritime emissions. The maritime emissions display a continuous increase rate of about 20% per year until 2012 and slow down to 3% after that. The seasonal cycle of shipping emissions has regional variations, but all regions show lower emissions during winter. Simulations by an atmospheric chemistry transport model show a notable influence of maritime emissions on air pollution over coastal areas, especially in summer. The satellite-derived spatial distribution and the magnitude of maritime emissions over Chinese seas are in good agreement with bottom-up studies based on the Automatic Identification System of ships.

Ding, J., et al. "Maritime NOx Emissions Over Chinese Seas Derived From Satellite Observations." Geophysical Research Letters 45.4 (2018): 2031-2037.

Urban SLCPs

Description: This section includes articles addressing SLCP emissions, trends, and measures specifically in urban environments

Investigation of black carbon aerosols and their characteristics over tropical urban and semi-arid rural environments in peninsular India

We conducted the campaign studies on Black Carbon (BC) aerosol measured at two different locations such as semi-arid rural, Anantapur (ATP) and tropical wet and dry urban, Tirupati (TPTY) of Andhra Pradesh. The campaign took place from June 1 to June 30, 2015. We studied diurnal variations and weekdays/weekends differences of BC mass Concentration and its correlations with meteorological parameters for two sites. BC

exhibits a strong weekly cycle in which weekend concentrations are significantly lower than weekday concentrations by ~14 and 31% for ATP and TPTY due to the decrease in the local traffic volumes during weekends due to a well-known 'weekend effect'. An estimation of percentage of contribution of BC indicates the main sources of BC as fossil fuel combustion and which is dominantly observed at TPTY than at ATP. Finally, the influence of the transported air masses has also been discussed with the help of HYSPLIT air mass backward trajectories.

Hussain, S. Nazeer, et al. "Investigation of black carbon aerosols and their characteristics over tropical urban and semi-arid rural environments in peninsular India." Journal of Atmospheric and Solar-Terrestrial Physics (2017).

Sulfate Aerosol in the Arctic: Source Attribution and Radiative Forcing

Source attribution of Arctic sulfate and its radiative forcing due to aerosol-radiation interactions (RFari) for 2010–2014 are quantified in this study using the Community Earth System Model equipped with an explicit sulfur source-tagging technique. The model roughly reproduces the seasonal pattern of sulfate but has biases in simulating the magnitude of near-surface concentrations and vertical distribution. Regions that have high emissions and/or are near/within the Arctic present relatively large contributions to Arctic sulfate burden, with the largest contribution from sources in East Asia (27%). Seasonal variations of the contribution to Arctic sulfate burden from remote sources are strongly influenced by meteorology. The mean RFari of anthropogenic sulfate offsets one third of the positive top of the atmosphere (TOA) RFari from black carbon. A 20% global reduction in anthropogenic SO2 emissions leads to a net Arctic TOA forcing increase of +0.019 W m−2. These results indicate that a joint reduction in BC and SO2 emissions could prevent at least some of the Arctic warming from any future SO2 emission reductions. Sulfate RFari efficiency calculations suggest that source regions with short transport pathways and meteorology favoring longer lifetimes are more efficient in influencing the Arctic sulfate RFari. Based on Arctic climate sensitivity factors, about −0.19 K of the Arctic surface temperature cooling is attributed to anthropogenic sulfate, with −0.05 K of that from sources in East Asia, relative to preindustrial conditions.

Yang, Yang, et al. "Sulfate aerosol in the Arctic: Source attribution and radiative forcing." Journal of Geophysical Research: Atmospheres 123.3 (2018): 1899-1918.

SLCPs & Vulnerable Regions

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

Near-Surface Refractory Black Carbon Observations in the Atmosphere and Snow in the McMurdo Dry Valleys, Antarctica, and Potential Impacts of Foehn Winds

Measurements of light-absorbing particles in the boundary layer of the high southern latitudes are scarce, particularly in the McMurdo Dry Valleys (MDV), Antarctica. During the 2013–2014 austral summer near-surface boundary layer refractory black carbon (rBC) aerosols were measured in air by a single-particle soot photometer (SP2) at multiple locations in the MDV. Near-continuous rBC atmospheric measurements were collected at Lake Hoare Camp (LH) over 2 months and for several hours at more remote locations away from established field camps. We investigated periods dominated by both upvalley and downvalley winds to explore the causes of differences in rBC concentrations and size distributions. Snow samples were also collected in a 1 m pit on a glacier near the camp. The range of concentrations rBC in snow was 0.3–1.2 ± 0.3 µg-rBC/L-H2O, and total organic carbon was 0.3–1.4 ± 0.3 mg/L. The rBC concentrations measured in this snow pit are not sufficient to reduce surface albedo; however, there is potential for accumulation of rBC on snow and ice surfaces at low elevation throughout the MDV, which were not measured as part of this study. At LH, the average background rBC mass aerosol concentrations were 1.3 ng/m3. rBC aerosol mass concentrations were slightly lower, 0.09–1.3 ng/m3, at the most remote sites in the MDV. Concentration spikes as high as 200 ng/m3 were observed at LH, associated with local activities. During a foehn wind event, the average rBC mass concentration increased to 30–

50 ng/m3. Here we show that the rBC increase could be due to resuspension of locally produced BC from generators, rocket toilets, and helicopters, which may remain on the soil surface until redistributed during high wind events. Quantification of local production and long-range atmospheric transport of rBC to the MDV is necessary for understanding the impacts of this species on regional climate.

Khan, Alia L., et al. "Near-Surface Refractory Black Carbon Observations in the Atmosphere and Snow in the McMurdo Dry Valleys, Antarctica, and Potential Impacts of Foehn Winds." Journal of Geophysical Research: Atmospheres 123.5 (2018): 2877-2887.