Short-lived Climate Pollutant Research Digest

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Multiple Benefits/Impacts

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

Evaluation of mitigation measures for air quality in Italy in 2020 and 2030

A large portion of the Italian population is exposed to high air pollution levels exceeding both European and WHO standards. To face this serious environmental risk, several efforts have been undertaken at policy-administration level in Italy and a national-regional cooperation act (the Po Basin Agreement, PBA) was adopted in 2013 in Northern Italy. The signatory parties agreed to identify and implement concerted actions contrasting air pollution, in addition to measures already in place. In this paper, a first evaluation of the identified measures has been carried out using the MINNI model, an integrated assessment model that allows the impact evaluation of emission variations. Assuming that PBA measures are applied in the whole Italian territory and focusing on residential heating, road transport and agriculture, the consequent impact on air quality was assessed for the scenario years 2020 and 2030. The Current Legislation scenario for the year 2030 shows that neither the national emission ceilings (NEC) nor the European air quality standards would be reached with the measures already in place and that additional actions are needed. The PBA 2030 scenario shows the attainment of the NEC targets, but non-compliance for daily PM10, daily maxima of 8 h running means of O3 and annual PM2.5 concentrations still remains.

D'Elia, I., et al. "Evaluation of mitigation measures for air quality in Italy in 2020 and 2030." Atmospheric Pollution Research (2018).

Methane

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

Methane Feedbacks to the Global Climate System in a Warmer World

Methane (CH4) is produced in many natural systems that are vulnerable to change under a warming climate, yet current CH4 budgets, as well as future shifts in CH4 emissions, have high uncertainties. Climate change has the potential to increase CH4 emissions from critical systems such as wetlands, marine and freshwater systems, permafrost, and methane hydrates, through shifts in temperature, hydrology, vegetation, landscape disturbance, and sea level rise. Increased CH4 emissions from these systems would in turn induce further climate change, resulting in a positive climate feedback. Here we synthesize biological, geochemical, and physically focused CH4 climate feedback literature, bringing together the key findings of these disciplines. We discuss environment-specific feedback processes, including the microbial, physical, and geochemical interlinkages and the timescales on which they operate, and present the current state of knowledge of CH4 climate feedbacks in the immediate and distant future. The important linkages between microbial activity and climate warming are discussed with the aim to better constrain the sensitivity of the CH4 cycle to future climate predictions. We determine that wetlands will form the majority of the CH4 climate feedback up to 2100. Beyond this timescale, CH4 emissions from marine and freshwater systems and permafrost environments could become more important. Significant CH4 emissions to the atmosphere from the dissociation of methane hydrates are not expected in the near future. Our key findings highlight the importance of quantifying whether CH4 consumption can counterbalance CH4 production under future climate scenarios.

Dean, Joshua F., et al. "Methane feedbacks to the global climate system in a warmer world." Reviews of Geophysics (2018).

Symposium review: Uncertainties in enteric methane inventories, measurement techniques, and prediction models

Ruminant production systems are important contributors to anthropogenic methane (CH4) emissions, but there are large uncertainties in national and global livestock CH4 inventories. Sources of uncertainty in enteric CH4 emissions include animal inventories, feed dry matter intake (DMI), ingredient and chemical composition of the diets, and CH4 emission factors. There is also significant uncertainty associated with enteric CH4 measurements. The most widely used techniques are respiration chambers, the sulfur hexafluoride (SF6) tracer technique, and the automated head-chamber system (GreenFeed; C-Lock Inc., Rapid City, SD). All 3 methods have been successfully used in a large number of experiments with dairy or beef cattle in various environmental conditions, although studies that compare techniques have reported inconsistent results. Although different types of models have been developed to predict enteric CH4 emissions, relatively simple empirical (statistical) models have been commonly used for inventory purposes because of their broad applicability and ease of use compared with more detailed empirical and process-based mechanistic models. However, extant empirical models used to predict enteric CH4 emissions suffer from narrow spatial focus, limited observations, and limitations of the statistical technique used. Therefore, prediction models must be developed from robust data sets that can only be generated through collaboration of scientists across the world. To achieve high prediction accuracy, these data sets should encompass a wide range of diets and production systems within regions and globally. Overall, enteric CH4 prediction models are based on various animal or feed characteristic inputs but are dominated by DMI in one form or another. As a result, accurate prediction of DMI is essential for accurate prediction of livestock CH4 emissions. Analysis of a large data set of individual dairy cattle data showed that simplified enteric CH4 prediction models based on DMI alone or DMI and limited feed- or animal-related inputs can predict average CH4 emission with a similar accuracy to more complex empirical models. These simplified models can be reliably used for emission inventory purposes.

Hristov, A. N., et al. "Symposium review: Uncertainties in enteric methane inventories, measurement techniques, and prediction models." Journal of dairy science (2018).

A new approach for improving emission factors for enteric methane emissions of cattle in smallholder systems of East Africa – Results for Nyando, Western Kenya

In Africa, the agricultural sector is the largest sector of the domestic economy, and livestock, are a crucial component of agriculture, accounting for ~ 45% of the Kenyan agricultural GDP and > 70% of African agricultural greenhouse gas (GHG) emissions. Accurate estimates of GHG emissions from livestock are required for inventory purposes and to assess the efficacy of mitigation measures, but most estimates rely on TIER I (default) IPCC protocols with major uncertainties coming from the IPCC methodology itself. Tier II estimates represent a significant improvement over the default methodology, however in less developed economies the required information is lacking or of uncertain reliability. In this study we developed an alternative methodology based on animal energy requirements derived from field measurements of live weight, live weight change, milk production and locomotion to estimate intake. Using on-farm data, we analysed feed samples to produce estimates of digestibility by season and region, then and used these data to estimate daily methane production by season, area and class of animal to produce new emission factors (EF) for annual enteric CH4 production. Mean Dry Matter Digestibility of the feed basket was in the range of 58–64%, depending on region and season (around 10% greater than TIER I estimates). EFs were substantially lower for adolescent and adult male (30.1, 35.9 versus 49 kg CH4) and for adolescent and adult female (23.0, 28.3 versus 41 kg), but not calves (15.7 versus 16 kg) than those given for “other” African cattle in IPCC (Tier I) estimates. It is stressed that this study is the first of its kind for Sub-Sharan Africa relying on animal measurements, but should not automatically be extrapolated outside of its geographic range. It does however, point out the need for further measurements, and highlights the value of using a robust methodology which does not rely on the (often invalid) assumption of ad libitum intake in systems where intake is known or likely to be restricted.

Goopy, J. P., et al. "A new approach for improving emission factors for enteric methane emissions of cattle in smallholder systems of East Africa–Results for Nyando, Western Kenya." Agricultural Systems 161 (2018): 72-80.

Non-growing season methane emissions–a significant component of annual emissions across northern ecosystems

Wetlands are the single largest natural source of atmospheric methane (CH4), a greenhouse gas, and occur extensively in the northern hemisphere. Large discrepancies remain between "bottom-up" and "top-down" estimates of northern CH4 emissions. To explore whether these discrepancies are due to poor representation of nongrowing season CH4 emissions, we synthesized nongrowing season and annual CH4 flux measurements from temperate, boreal, and tundra wetlands and uplands. Median nongrowing season wetland emissions ranged from 0.9 g/m2 in bogs to 5.2 g/m2 in marshes and were dependent on moisture, vegetation, and permafrost. Annual wetland emissions ranged from 0.9 g m−2 year−1 in tundra bogs to 78 g m−2 year−1 in temperate marshes. Uplands varied from CH4 sinks to CH4 sources with a median annual flux of 0.0 ± 0.2 g m−2 year−1. The measured fraction of annual CH4 emissions during the nongrowing season (observed: 13% to 47%) was significantly larger than that was predicted by two process-based model ensembles, especially between 40° and 60°N (modeled: 4% to 17%). Constraining the model ensembles with the measured nongrowing fraction increased total nongrowing season and annual CH4 emissions. Using this constraint, the modeled nongrowing season wetland CH4 flux from >40° north was 6.1 ± 1.5 Tg/year, three times greater than the nongrowing season emissions of the unconstrained model ensemble. The annual wetland CH4 flux was 37 ± 7 Tg/year from the data-constrained model ensemble, 25% larger than the unconstrained ensemble. Considering nongrowing season processes is critical for accurately estimating CH4 emissions from high-latitude ecosystems, and necessary for constraining the role of wetland emissions in a warming climate.

Treat, Claire C., A. Anthony Bloom, and Maija E. Marushchak. "Non-growing season methane emissions are a significant component of annual emissions across northern ecosystems." Global change biology (2018).

Enteric methane emissions and their response to agro-ecological and livestock production systems dynamics in Zimbabwe

Without disregarding its role as one of the key sources of sustainable livelihoods in Zimbabwe and other developing countries, livestock production contributes significantly to greenhouse gas (GHG) emissions through enteric fermentation. For the livestock sector to complement global efforts to mitigate climate change, accurate estimations of GHG emissions are required. Methane emissions from enteric fermentation in Zimbabwe were quantified over 35 years under four production systems and five agro-ecological regions. The Intergovernmental Panel on Climate Change emission factor methodology was used to derive CH4 emissions from seven livestock categories at national level. Emission intensities based on human population, domestic export of livestock meat and climate variables were used to assess emission drivers and predict future emission trends. Over the past 35 years, enteric fermentation CH4 emissions from all livestock categories ranged between 158.3 and 204.3 Gg year− 1. Communal lands, typified by indigenous livestock breeds, had the highest contribution of between 58% and 75% of the total annual emissions followed by livestock from large scale commercial (LSC) farms. The decreasing livestock population on LSC farms and consequent decline in production could explain the lack of a positive response of CH4 emissions to human population growth, and decreasing emissions per capita over time at − 0.3 kg CH4 capita− 1 year− 1. The emissions trend showed that even if Zimbabwe's national livestock population doubles in 2030 relative to the 2014 estimates, the country would still remain with similar magnitude of CH4 emission intensity as that of 1980. No significant correlations ($P > 0.05$) were found between emissions and domestic export of beef and pork. Further research on enhanced characterisation of livestock species, population and production systems, as well as direct measurements and modelling of emissions from indigenous and exotic livestock breeds were recommended.

Svinurai, Walter, et al. "Enteric methane emissions and their response to agro-ecological and livestock production systems dynamics in Zimbabwe." Science of The Total Environment 616 (2018): 710-719.

Black Carbon

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

Trends of atmospheric black carbon concentration over the United Kingdom

The continuous observations over a period of 7 years (2009–2016) available at 7 locations show declining trend of atmospheric BC in the UK. Among all the locations, the highest decrease of 8 ± 3 percent per year was observed at the Marylebone road in London. The detailed analysis performed at 21 locations during 2009–2011 shows that average annual mean atmospheric BC concentration were 0.45 ± 0.10, 1.47 ± 0.58, 1.34 ± 0.31, 1.83 ± 0.46 and 9.72 ± 0.78 μgm−3 at rural, suburban, urban background, urban centre and kerbside sites respectively. Around 1 μgm−3 of atmospheric BC could be attributed to urban emission, whereas traffic contributed up to 8 μg m−3 of atmospheric BC near busy roads. Seasonal pattern was also observed at all locations except rural and kerbside location, with maximum concentrations (1.2–4 μgm−3) in winter. Further, minimum concentrations (0.3–1.2 μgm−3) were observed in summer and similar concentrations in spring and fall. At suburban and urban background locations, similar diurnal pattern were observed with atmospheric BC concentration peaks (≈1.8 μg m−3) in the morning (around 9 a.m.) and evening (7–9 p.m.) rush hours, whereas minimum concentrations were during late night hours (peak at 5 a.m.) and the afternoon hours (peak at 2 p.m.). The urban centre values show a similar morning pattern (peak at 9 a.m.; concentration - 2.5 μgm−3) in relation to background locations but only a slight decrease in concentration in the afternoon which remained above 2 μgm−3 till midnight. It is concluded that the higher flow of traffic at urban centre locations results in higher atmospheric BC concentrations throughout the day. Comparison of weekday and weekend daily averaged atmospheric BC showed maximum concentrations on Friday, having minimum levels on Sunday. This study will help to refine the atmospheric BC emission inventories and provide data for air pollution and climate change models evaluation, which are used to formulate air pollution mitigation policies.

Singh, Vikas, et al. "Trends of atmospheric black carbon concentration over United Kingdom." Atmospheric Environment 178 (2018): 148-157.

Source apportionment of black carbon during winter in Beijing

Black carbon (BC) in PM2.5 was measured at an urban site in Beijing during winter 2015 using an aethalometer. The characteristics and sources of BC during pollution episodes and clean days were analyzed. The average hourly mass concentration of BC during the study period was 5.31 ± 6.27 μg/m3. BC was highly correlated with PM2.5 (R2 = 0.80), with its concentration ranging from 0.17 μg/m3 in clean days to 35.33 μg/m3 in haze days. Source apportionment results showed that the average contribution of liquid fuel source (e.g., vehicle emission) to BC was around 50% in clean days. While during the pollution episodes, solid fuel sources including coal combustion and biomass burning were the predominant sources, accounting for 61–83% of BC. Specific source tracers suggested that coal combustion and biomass burning dominated in different pollution episodes. Ratios of BC/PM2.5 and BC/CO as well as source tracers provided further supportive evidences for the source apportionment results. Our findings suggest that it is more important to control solid fuel sources such as coal combustion for BC abatement in Beijing during haze days, while liquid fuel source (e.g., vehicle emission) plays a relatively more important role in clean days compared to pollution episodes.

Liu, Yue, Caiqing Yan, and Mei Zheng. "Source apportionment of black carbon during winter in Beijing." Science of The Total Environment 618 (2018): 531-541.

Black carbon emissions from biomass and coal in rural China

Residential solid fuel combustion makes a major contribution to black carbon (BC) emissions in China. A new estimation of BC emissions from rural solid biomass and coal consumption has been derived from field survey data. The following new contributions are made: (1) emission factors are collected and reviewed; (2) household energy data are collected from field survey data and from the literature; (3) a new extrapolation method is developed to extend the field survey data to other locations; (4) the ownership and usage of two stove types are estimated and considered in the emission calculations; and (5) uncertainties associated with the estimation

results are quantified. It is shown that rural households with higher income will consume less biomass but more coal. Agricultural acreage and temperature also significantly influence the amount of solid fuel consumed in rural areas. It is estimated that 640 ± 245 Gg BC/y were emitted to the atmosphere due to residential solid fuel consumption in rural China in 2014. Emissions of BC from straw, wood, and coal contributed 42 ± 13%, 36 ± 15%, and 22 ± 10% of the total, respectively. We show that effective BC mitigation (a reduction of 47%) could be obtained through widespread introduction of improved stoves in rural households.

Zhang, Weishi, et al. "Black carbon emissions from biomass and coal in rural China." Atmospheric Environment (2017).

Ambient black carbon particulate matter in the coal region of Dhanbad, India

Light-absorbing, atmospheric particles have gained greater attention in recent years because of their direct and indirect impacts on regional and global climate. Atmospheric black carbon (BC) aerosol is a leading climate warming agent, yet uncertainties in the global direct aerosol radiative forcing remain large. Based on a year of aerosol absorption measurements at seven wavelengths, BC concentrations were investigated in Dhanbad, the coal capital of India. Coal is routinely burned for cooking and residential heat as well as in small industries. The mean daily concentrations of ultraviolet-absorbing black carbon measured at 370 nm (UVBC) and black carbon measured at 880 nm (BC) were 9.8 ± 5.7 and 6.5 ± 3.8 μg m− 3, respectively. The difference between UVBC and BC, Delta-C, is an indicator of biomass or residential coal burning and averaged 3.29 ± 4.61 μg m− 3. An alternative approach uses the Ångstrom Exponent (AE) to estimate the biomass/coal and traffic BC concentrations. Biomass/coal burning contributed ~ 87% and high temperature, fossil-fuel combustion contributed ~ 13% to the annual average BC concentration. The post-monsoon seasonal mean UVBC values were 10.9 μg m− 3 and BC of 7.2 μg m− 3. Potential source contribution function analysis showed that in the post-monsoon season, air masses came from the central and northwestern Indo-Gangetic Plains where there is extensive agricultural burning. The mean winter UVBC and BC concentrations were 15.0 and 10.1 μg m− 3, respectively. These higher values were largely produced by local sources under poor dispersion conditions. The direct radiative forcing (DRF) due to UVBC and BC at the surface (SUR) and the top of the atmosphere (TOA) were calculated. The mean atmospheric heating rates due to UVBC and BC were estimated to be 1.40 °K day− 1 and 1.18 °K day− 1, respectively. This high heating rate may affect the monsoon circulation in this region.

Singh, S., et al. "Ambient black carbon particulate matter in the coal region of Dhanbad, India." Science of the Total Environment 615 (2018): 955-963.

Tropospheric Ozone

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

High-resolution air quality modeling in a medium-sized city in the tropical Andes: Assessment of local and global emissions in understanding ozone and PM10 dynamics

Application of high-resolution air quality models in the Andes Region is scarce, especially in medium-sized cities of South America, which are undergoing a fast urban growth, increasing the risk associated with air pollution episodes. In this study, the WRF-Chem model was applied for analyzing the influence of local and global emission inventories (EI) in the representation of O3 and PM10 concentrations in the medium-sized Andean city of Manizales, Colombia. Furthermore, the relative impact of anthropogenic emissions on O3 and PM10 dynamics was evaluated. The use of local emission fluxes allowed significant improvements in O3 representation, characterized by better performance metrics (MGE, RMSE and r coefficient of 7.6 ppb, 8.8 ppb, and 0.81 respectively) than that obtained from the use of the EDGAR-HTAP global database (MGE = 11.6 ppb, RMSE = 13.9 ppb and r = 0.64). In terms of PM10 concentrations, better metrics were obtained using the local EI (MGE = 10 μg/m3 and RMSE = 11.5 μg/m3), compared with those from the global EI (MGE = 28 μg/m3 and

RMSE = 28.8 µg/m3). Analysis of the relative impact of anthropogenic emissions suggests that PM10 levels and ozone chemistry in the urban area of Manizales were controlled by emissions of its precursors from on-road vehicular sources and possible transport of O3 at a regional scale from near rural zones. Results obtained highlight the importance of estimating and improving local EIs in medium-sized cities, for a more realistic analysis of emission impacts.

González, C. M., et al. "High-resolution air quality modeling in a medium-sized city in the tropical Andes: Assessment of local and global emissions in understanding ozone and PM10 dynamics." Atmospheric Pollution Research (2018).

The Impact of Stratospheric Ozone Feedbacks on Climate Sensitivity Estimates

A number of climate modeling studies have shown that differences between typical choices for representing ozone can affect climate change projections. Here we investigate potential climate impacts of a specific ozone representation used in simulations of the Hadley Centre Global Environment Model for the Coupled Model Intercomparison Project Phase 5. The method considers ozone changes only in the troposphere and lower stratosphere and prescribes stratospheric ozone elsewhere. For a standard climate sensitivity simulation, we find that this method leads to significantly increased global warming and specific patterns of regional surface warming compared with a fully interactive atmospheric chemistry setup. We explain this mainly by the suppressed part of the stratospheric ozone changes and the associated alteration of the stratospheric water vapor feedback. This combined effect is modulated by simultaneous cirrus cloud changes. We underline the need to understand better how representations of ozone can affect climate modeling results and, in particular, global and regional climate sensitivity estimates.

Nowack, Peer J., et al. "The impact of stratospheric ozone feedbacks on climate sensitivity estimates." Journal of Geophysical Research: Atmospheres (2018).

Hydrofluorocarbons (HFCs)

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

Low GWP Halocarbon refrigerants: a review of thermophysical properties

In the present work, a large number of compounds described in the publicly available literature have been reviewed with the aim to identify possible substitutes for high-GWP HFCs in HVAC&R and organic Rankine cycle (ORC) applications. Taking into account various criteria (particularly low toxicity, low flammability, low GWP, and high energy efficiency), only a few single-component compounds are suitable for many of the relevant applications. In particular, in addition to natural fluids, studies have shown that there are only a few HFCs and a dozen or so HFOs, i.e. halogenated olefins characterized by the presence of a C=C double bond in the molecule, that are potentially suitable for a number of relevant applications. Here, a review of the present state-of-the-art of experimentally-determined thermophysical properties of a number of HFOs working fluids and their mixtures also with other categories of refrigerants is presented, with particular emphasis placed on saturation and critical properties, vapor phase PVT data, liquid density, specific heat capacity, thermal conductivity, viscosity, and surface tension.

Bobbo, Sergio, et al. "LOW GWP HALOCARBON REFRIGERANTS: A REVIEW OF THERMOPHYSICAL PROPERTIES." International Journal of Refrigeration (2018).

A quantitative assessment of distributions and sources of tropospheric halocarbons measured in Singapore

This work reports the first ground-based atmospheric measurements of 26 halocarbons in Singapore, an urban-industrial city-state in Southeast (SE) Asia. A total of 166 whole air canister samples collected during two intensive 7 Southeast Asian Studies (7SEAS) campaigns (August–October 2011 and 2012) were analyzed for C1-C2 halocarbons using gas chromatography-electron capture/mass spectrometric detection. The halocarbon dataset was supplemented with measurements of selected non-methane hydrocarbons (NMHCs), C1-C5 alkyl nitrates, sulfur gases and carbon monoxide to better understand sources and atmospheric processes. The median observed atmospheric mixing ratios of CFCs, halons, CCl4 and CH3CCl3 were close to global tropospheric background levels, with enhancements in the 1–17% range. This provided the first measurement evidence from SE Asia of the effectiveness of Montreal Protocol and related national-scale regulations instituted in the 1990s to phase-out ozone depleting substances (ODS). First- and second-generation CFC replacements (HCFCs and HFCs) dominated the atmospheric halocarbon burden with HFC-134a, HCFC-22 and HCFC-141b exhibiting enhancements of 39–67%. By combining near-source measurements in Indonesia with receptor data in Singapore, regionally transported peat-forest burning smoke was found to impact levels of several NMHCs (ethane, ethyne, benzene, and propane) and short-lived halocarbons (CH3I, CH3Cl, and CH3Br) in a subset of the receptor samples. The strong signatures of these species near peat-forest fires were potentially affected by atmospheric dilution/mixing during transport and by mixing with substantial urban/regional backgrounds at the receptor. Quantitative source apportionment was carried out using positive matrix factorization (PMF), which identified industrial emissions related to refrigeration, foam blowing, and solvent use in chemical, pharmaceutical and electronics industries as the major source of halocarbons (34%) in Singapore. This was followed by marine and terrestrial biogenic activity (28%), residual levels of ODS from pre-Montreal Protocol operations (16%), seasonal incidences of peat-forest smoke (13%), and fumigation related to quarantine and pre-shipment (QPS) applications (7%).

Sarkar, Sayantan, et al. "A quantitative assessment of distributions and sources of tropospheric halocarbons measured in Singapore." Science of The Total Environment 619 (2018): 528-544.

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.

Indoor air pollution from biomass cookstoves in rural Senegal

Although indoor air pollution from the use of biomass fuels is a serious health problem in Senegal, little effort has been made in this country to evaluate indoor air quality impacts from biomass combustion with traditional stoves and indoor air quality improvements derived from the use of improved cookstoves. A cross-sectional study was conducted in a rural village of Senegal to determine indoor air pollution during cooking and non-cooking periods. PM2.5 and CO concentration levels were determined, along with two far less studied pollutants in cookstove studies, ultrafine particles and black carbon, using portable monitors. A total of 22 households were selected, 12 using the traditional stove and 10 using a locally produced rocket stove. Rocket stoves, the most extended type of improved stove used in sub-Saharan Africa, contributed to a significant reduction of total fine and ultrafine (UFP) particles and carbon monoxide (CO) (75,4%, 30,5% and 54,3%, respectively, $p < 0.05$) with regard to the traditional stoves, but increased black carbon (BC) concentrations (36,1%, $p < 0.05$). This proves that the climate and health-relevant properties of stoves do not always scale together and highlights that both dimensions should be always considered. Findings evidence that, in addition to a switch in the emission source (i.e. cookstove and/or fuel), successful strategies focused on the improvement of household air quality in Senegal should contemplate ventilation practices and construction materials.

de la Sota, Candela, et al. "Indoor air pollution from biomass cookstoves in rural Senegal." Energy for Sustainable Development 43 (2018): 224-234.

Differences between a deciduous and a conifer tree species in gaseous and particulate emissions from biomass burning

In the Mediterranean ecosystem, wildfires are very frequent and the predicted future with a probable increase of fires could drastically modify the vegetation scenarios. Vegetation fires are an important source of gases and primary emissions of fine carbonaceous particles in the atmosphere. In this paper, we present gaseous and particulate emissions data from the combustion of different plant tissues (needles/leaves, branches and needle/leaf litter), obtained from one conifer (Pinus halepensis) and one deciduous broadleaf tree (Quercus pubescens). Both species are commonly found throughout the Mediterranean area, often subject to wildfires. Experiments were carried out in a combustion chamber continuously sampling emissions throughout the different phases of a fire (pre-ignition, flaming and smoldering). We identified and quantified 83 volatile organic compounds including important carcinogens that can affect human health. CO and CO2 were the main gaseous species emitted, benzene and toluene were the dominant aromatic hydrocarbons, methyl-vinyl-ketone and methyl-ethyl-ketone were the most abundant measured oxygenated volatile organic compounds. CO2 and methane emissions peaked during the flaming phase, while the peak of CO emissions occurred during the smoldering phase. Overall, needle/leaf combustion released a greater amount of volatile organic compounds into the atmosphere than the combustion of branches and litter. There were few differences between emissions from the combustion of the two tree species, except for some compounds. The combustion of P. halepensis released a great amount of monoterpenes as α-pinene, β-pinene, p-cymene, sabinene, 3-carene, terpinolene and camphene that are not emitted from the combustion of Q. pubescens. The combustion of branches showed the longest duration of flaming and peak of temperature. Data presented appear crucial for modeling with the intent of understanding the loss of C during different phases of fire and how different typologies of biomass can affect wildfires and their speciation emissions profile.

Pallozzi, Emanuele, et al. "Differences between a deciduous and a conifer tree species in gaseous and particulate emissions from biomass burning." Environmental Pollution 234 (2018): 457-467.

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

Combination of modified nitrogen fertilizers and water saving irrigation can reduce greenhouse gas emissions and increase rice yield

The combined impacts of modified nitrogen (N) fertilizers and water saving irrigation (WSI) on greenhouse gas (GHG) emissions and grain yield of rice paddies have not previously been documented. GHG emissions from rice paddies under modified N fertilizers and WSI deserve attention because water and N are being used extensively to attain higher grain yield. A field experiment was conducted to evaluate the influence of modified N fertilizers and WSI on methane (CH4) and nitrous oxide (N2O) emissions and grain yield in rice paddies. Four treatments were applied: urea with conventional irrigation (U + CI), urea with shallow water depth with alternate wetting-drying water saving irrigation (U + SWD), polymer-coated controlled release urea with SWD (CRU + SWD), and nitrapyrin-urea composition plus hydroquinone with SWD (NU + HQ + SWD). Compared to U + CI, CH4 emissions significantly decreased by 26% and 31%, and N2O emissions increased by 52% and 42% under U + SWD in the early and late rice growing seasons respectively ($p < 0.05$). Although SWD increased N2O emissions, total GHG emissions (TGHG) reduced by 20% and 25% in the two rice seasons under U + SWD, and GHG emission intensity (GHGI) decreased by 24% on average. Modified N fertilizer applications also affected grain yield and GHG emissions under SWD. Compared with U + SWD, CRU + SWD and NU + HQ + SWD reduced CH4, N2O emissions and TGHG by 28–49%, 12–44% and 26–45%, respectively, while grain yield increased by 6–35%. Reduction in CH4 emissions occurred because, compared to urea, CRU and NU + HQ can inhibit CH4 production and transport by controlling development of invalid tillers, while their nitrogen release patterns were more favorable for CH4

consumption. In summary, modified N fertilizers in combination with SWD are a win-win strategy to improve grain production while reducing GHG emissions in the rice cropping system.

Li, Jianling, et al. "Combination of modified nitrogen fertilizers and water saving irrigation can reduce greenhouse gas emissions and increase rice yield." Geoderma 315 (2018): 1-10.

A three-year experiment of annual methane and nitrous oxide emissions from the subtropical permanently flooded rice paddy fields of China: Emission factor, temperature

Annual CH4 and N2O emissions from these rice production systems that accounts for over 10% of national rice cultivation of China are rarely reported. To improve understanding of greenhouse gas emissions from croplands in China, we measured methane (CH4) and nitrous oxide (N2O) emissions from the subtropical permanently flooded rice paddy fields through a 3-year field experiment that utilized three nitrogen fertilizer application rates (0 [N0], 150 [N150] and 250 [N250] kg N ha−1) in southwestern China. Results showed that seasonal patterns of CH4 and N2O emissions were consistent with temporal weather patterns. The average annual cumulative CH4 fluxes were in the range of 794 to 883 kg CH4-C ha−1 yr−1 and N2O fluxes ranged from 1.61 to 3.10 kg N2O-N ha−1 yr−1 across the experimental treatments. The Q10 values (soil temperature sensitivity coefficient) of CH4 and N2O emissions were 2.72–3.67 and 3.32–6.05, respectively, for the three treatments. Inconsistent with our hypothesis, the nitrogen fertilizer application did not increase seasonal and annual N2O emissions over three years, compared to the control. Thus, the annual direct N2O emission factors (EFd) averaged 0.07%, which was substantially lower than the IPCC default value of 0.30% for rice paddy fields. Nitrogen fertilizer application significantly decreased the mean seasonal global warming potential (GWP) and yield-scaled GWP for the rice season, whereas this was not true on an annual basis if fallow season was also considered. Since CH4 emission was the major contributor to total GWP, it is necessary to propose mitigation options, which could include draining the floodwater layer and introducing upland crops during the fallow season. However, it will be challenging to reduce N2O emissions and retain soil organic carbon if the floodwater layer is drained and upland crops are introduced during the fallow season.

Zhou, Minghua, et al. "A three-year experiment of annual methane and nitrous oxide emissions from the subtropical permanently flooded rice paddy fields of China: Emission factor, temperature sensitivity and fertilizer nitrogen effect." Agricultural and Forest Meteorology 250 (2018): 299-307

Transportation

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

A review of the European passenger car regulations – Real driving emissions vs local air quality

Europe's regulation of passenger car emissions has been proven to have failed when it comes to nitrogen oxide emissions (NOx) by diesel engines. Due to historical decisions favouring diesel technology, Europe has become a diesel island with no equal worldwide. As a result, virtually every European citizen breathes in air which is deemed harmful to human health. Real driving emissions (RDE) testing by means of portable emissions measurement systems (PEMS) can potentially eliminate the discrepancy between lab and road tests, and will complement the dynamometer type-approval procedure from September 2017 onwards. Despite the significant potential of PEMS testing, the emission assessment has been watered down through politics to provide the automotive manufacturers with additional lead-time. In this way, the lab to road gap is not eliminated but only decreased. This means that diesel cars will continue to over-emit NOx until the 2020s at earliest. This has consequences for effectively bringing down local air quality issues, especially in low emission zones (LEZ). This paper presents a review of the European emission regulation history up to date and makes a comparison with the approach in the other important car markets globally. One can conclude that a substantial update of the European regulatory framework concerning automotive emissions is required, while ambitious post-2021

targets should be set if Europe does not want its automotive industry to lose its competitive position in the global market. In addition, an equilibrium should be sought for between sustainable personal transport in the form of zero-emission vehicles (ZEV), and a sustainable economic climate for the automotive industry. The former is needed if LEZs are to effectively bring down pollutant levels in cities.

Hooftman, Nils, et al. "A review of the European passenger car regulations–Real driving emissions vs local air quality." Renewable and Sustainable Energy Reviews 86 (2018): 1-21.

Experimental assessment of the potential to decrease diesel NOx emissions beyond minimum requirements for Euro 6 Real Drive Emissions (RDE) compliance

The objective of this study was to test the potential for NOx emissions improvements on a typical Euro 6 diesel vehicle, following modifications to its emissions control system, under Real Drive Emissions (RDE) testing conditions. A commercially available car was selected and was first measured in its original configuration according to RDE on the road and an initial conformity factor (CF) of 5.4 was determined. Subsequent engine calibration and installation of a Selective Catalytic Reduction (SCR) device were conducted and tested on a fully transient engine dyno setup, which precisely reproduced the engine operation under the on-road RDE test. The NOx reduction achieved with those upgrades was 90%, leading to a CF of 0.53, with no CO2 or fuel consumption penalty. These findings demonstrate that diesel vehicles can reach low NOx levels under real world driving conditions, when well-designed modern exhaust aftertreatment components are installed and properly calibrated.

Triantafyllopoulos, Georgios, et al. "Experimental assessment of the potential to decrease diesel NOx emissions beyond minimum requirements for Euro 6 Real Drive Emissions (RDE) compliance." Science of The Total Environment (2017).

On-road and laboratory emissions of NO, NO2, NH3, N2O and CH4 from late-model EU light utility vehicles: Comparison of diesel and CNG

Exhaust emissions of eight Euro 6 light duty vehicles – two station wagons and six vans – half powered by diesel fuel and half by compressed natural gas (CNG) were examined using both chassis dynamometer and on-road testing. A portable on-board FTIR analyzer was used to measure concentrations of reactive nitrogen compounds – NO, NO2 and ammonia, of CO, formaldehyde, acetaldehyde and greenhouse gases CO2, methane and N2O. Exhaust flow was inferred from engine control unit data. Total emissions per cycle were compared and found to be in good agreement with laboratory measurements of NOX, CO and CO2 during dynamometer tests. On diesel engines, mean NOX emissions were 136–1070 mg/km in the laboratory and 537–615 mg/km on the road, in many cases nearly an order of magnitude higher compared to the numerical value of the Euro 6 limit. Mean N2O emissions were 3–19 mg/km and were equivalent to several g/km CO2. The measurements suggest that NOX and N2O emissions from late-model European light utility vehicles with diesel engines are non-negligible and should be continuously assessed and scrutinized. High variances in NOX emissions among the tested diesel vehicles suggest that large number of vehicles should be tested to offer at least some insights about distribution of fleet emissions among vehicles. CNG engines exhibited relatively low emissions of NOX (12–186 mg/km) and NH3 (10–24 mg/km), while mean emissions of methane were 18–45 mg/km, under 1 g/km CO2 equivalent, and N2O, CO, formaldehyde and acetaldehyde were negligible. The combination of a relatively clean-burning fuel, modern engine technology and a three-way catalyst has resulted in relatively low emissions under the wide variety of operating conditions encountered during the tests. The on-board FTIR has proven to be a useful instrument capable of covering, with the exception of total hydrocarbons, essentially all gaseous pollutants of interest.

Vojtíšek-Lom, Michal, et al. "On-road and laboratory emissions of NO, NO2, NH3, N2O and CH4 from late-model EU light utility vehicles: Comparison of diesel and CNG." Science of The Total Environment 616 (2018): 774-784.

Air quality impacts of implementing Emission reduction strategies at southern California airports

Reducing aviation emissions will be a major concern in the coming years, as the relative contribution of aviation

to overall emissions is projected to increase in the future. The South Coast Air Basin of California (SoCAB) is an extreme nonattainment area with many airports located upwind of the most polluted regions in the basin. Techniques to reduce aviation emissions have been studied in the past, and strategies that can be implemented at airports include taxi-out times reduction, ground support equipment electrification and aviation biofuel implementation. These strategies have been analyzed only at the national scale, their effectiveness to improve air quality within the SoCAB given the local meteorology and chemical regimes is unclear. This work studies how the adoption of the techniques at commercial SoCAB airports affect ozone (O3) and fine particulate matter (PM2.5) concentrations. In addition, potential impacts on public exposure to PM2.5 and O3 resulting from changes in the concentration of these pollutants are estimated. In addition, the work calculates aviation emissions for each scenario and simulate the transport and atmospheric chemistry of the pollutants using the Community Multiscale Air Quality (CMAQ) model. The simultaneous application of all reduction strategies is projected to reduce the aviation-attributable population weighted ground-level PM2.5 by 36% in summer and 32% in winter. On the other hand, O3 increases by 16% in winter. Occurring mostly in densely populated areas, the decrease in ground-level PM2.5 would have a positive health impact and help the region achieve attainment of national ambient air quality standards.

Benosa, Guillem, et al. "Air quality impacts of implementing Emission reduction strategies at southern California airports." Atmospheric Environment (2018).

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

A Simulation model for estimating methane oxidation and emission from landfill cover soils

Quantification of methane (CH4) oxidation and emission from landfill cover soils is important for evaluating measures to mitigate anthropogenic greenhouse gas emissions. In this study, a model that combines the multicomponent diffusive equation and Darcy's law, coupled with the dual Monod kinetic equation, was established to simulate CH4 transport, oxidation and emission in landfill cover soils. Sensitivity analysis was performed to illustrate the influence of model parameters on CH4 transport, oxidation and emission. The model was then applied to predict CH4 emissions from several column experiments. The results of the sensitivity analysis showed that a high CH4 oxidation rate can be obtained with a high Vmax of cover soil, even for a low cover soil thickness, and that oxidation efficiency is constant when the thickness of the cover soil becomes greater than a threshold value. The simulated results fitted well with the measured values, confirming that the new model provides a reliable method for estimating CH4 emissions from landfills.

Bian, Rongxing, Danhui Xin, and Xiaoli Chai. "A Simulation model for estimating methane oxidation and emission from landfill cover soils." Waste Management (2018).

Measuring methane emissions from a UK landfill using the tracer dispersion method and the influence of operational and environmental factors

The methane emissions from a landfill in south-east, UK were successfully quantified during a six-day measurement campaign using the tracer dispersion method. The fair weather conditions made it necessary to perform measurements in the late afternoon and in the evening when the lower solar flux resulted in a more stable troposphere with a lower inversion layer. This caused a slower mixing of the gasses, but allowed plume measurements up to 6700 m downwind from the landfill. The average methane emission varied between 217 ± 14 and 410 ± 18 kg h−1 within the individual measurement days, but the measured emission rates were higher on the first three days (333 ± 27, 371 ± 42 and 410 ± 18 kg h−1) compared to the last three days (217 ± 14, 249 ± 20 and 263 ± 22 kg h−1). It was not possible to completely isolate the extent to which these variations were a consequence of measuring artefacts, such as wind/measurement direction and measurement distance,

or from an actual change in the fugitive emission. Such emission change is known to occur with changes in the atmospheric pressure. The higher emissions measured during the first three days of the campaign were measured during a period with an overall decrease in atmospheric pressure (from approximately 1014 mbar on day 1 to 987 mbar on day 6). The lower emissions measured during the last three days of the campaign were carried out during a period with an initial pressure increase followed by a period of slowly reducing pressure. The average daily methane recovery flow varied between 633 and 679 kg h−1 at STP (1 atm, 0 °C). The methane emitted to the atmosphere accounted for approximately 31% of the total methane generated, assuming that the methane generated is the sum of the methane recovered and the methane emitted to the atmosphere, thus not including a potential methane oxidation in the landfill cover soil.

Rees-White, T. C., et al. "Measuring methane emissions from a UK landfill using the tracer dispersion method and the influence of operational and environmental factors." Waste Management (2018).

Development and implementation of a screening method to categorise the greenhouse gas mitigation potential of 91 landfills

A cost-effective screening method for assessing methane emissions was developed and employed to categorise 91 older Danish landfills into three categories defined by the magnitude of their emissions. The overall aim was to assess whether these landfills were relevant or irrelevant with respect to methane emission mitigation through the construction of biocovers. The method was based on downwind methane concentration measurements, using a van-mounted cavity ring-down spectrometer combined with inverse dispersion modelling to estimate whole-site methane emission rates. This method was found to be less accurate than the more labour-intensive tracer gas dispersion method, and therefore cannot be recommended if a high degree of accuracy is required. However, it is useful if a less accurate examination is sufficient. A sensitivity analysis showed the dispersion model used to be highly sensitive to variations in input parameters. Of the 91 landfills in the survey, 25 were found to be relevant for biocover construction when the methane emission threshold was set at 2 kg CH4 h−1.

Fredenslund, Anders M., et al. "Development and implementation of a screening method to categorise the greenhouse gas mitigation potential of 91 landfills." Waste Management (2018).

Methane emissions from a landfill in north-east India: Performance of various landfill gas emission models

Rapid urbanization and economic growth has led to significant increase in municipal solid waste generation in India during the last few decades and its management has become a major issue because of poor waste management practices. Solid waste generated is deposited into open dumping sites with hardly any segregation and processing. Carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) are the major greenhouse gases that are released from the landfill sites due to the biodegradation of organic matter. In this present study, CH4 and CO2 emissions from a landfill in north-east India are estimated using a flux chamber during September, 2015 to August, 2016. The average emission rates of CH4 and CO2 are 68 and 92 mg/min/m2, respectively. The emissions are highest in the summer whilst being lowest in winter. The diurnal variation of emissions indicated that the emissions follow a trend similar to temperature in all the seasons. Correlation coefficients of CH4 and temperature in summer, monsoon and winter are 0.99, 0.87 and 0.97, respectively. The measured CH4 in this study is in the range of other studies around the world. Modified Triangular Method (MTM), IPCC model and the USEPA Landfill gas emissions model (LandGEM) were used to predict the CH4 emissions during the study year. The consequent simulation results indicate that the MTM, LandGEM-Clean Air Act, LandGEM-Inventory and IPCC models predict 1.9, 3.3, 1.6 and 1.4 times of the measured CH4 emission flux in this study. Assuming that this higher prediction of CH4 levels observed in this study holds well for other landfills in this region, a new CH4 emission inventory (Units: Tonnes/year), with a resolution of 0.10 × 0.10 has been developed. This study stresses the importance of biodegradable composition of waste and meteorology, and also points out the drawbacks of the widely used landfill emission models.

Gollapalli, Muralidhar, and Sri Harsha Kota. "Methane emissions from a landfill in north-east India: Performance of various landfill gas emission models." Environmental Pollution 234 (2018): 174-180.

PM2.5 and Air Pollution

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

Chemical characteristics and source apportionment of PM2.5between heavily polluted days and other days in Zhengzhou, China

PM2.5 samples were collected in Zhengzhou during 3 years of observation, and chemical characteristics and source contribution were analyzed. Approximately 96% of the daily PM2.5 concentrations and annual average values exceeded the Chinese National Ambient Air Quality Daily and Annual Standards, indicating serious PM2.5 pollution. The average concentration of water-soluble inorganic ions was 2.4 times higher in heavily polluted days (daily PM2.5 concentrations > 250 μg/m3 and visibility < 3 km) than that in other days, with sulfate, nitrate, and ammonium as major ions. According to the ratio of NO3−/SO42−, stationary sources are still the dominant source of PM2.5 and vehicle emission could not be ignored. The ratio of secondary organic carbon to organic carbon indicated that photochemical reactivity in heavily polluted days was more intense than in other days. Crustal elements were the most abundant elements, accounting for more than 60% of 23 elements. Chemical Mass Balance results indicated that the contributions of major sources (i.e., nitrate, sulfate, biomass, carbon and refractory material, coal combustion, soil dust, vehicle, and industry) of PM2.5 were 13%, 16%, 12%, 2%, 14%, 8%, 7%, and 8% in heavily polluted days and 20%, 18%, 9%, 2%, 27%, 14%, 15%, and 9% in other days, respectively. Extensive combustion activities were the main sources of polycyclic aromatic hydrocarbons during the episode (Jan 1–9, 2015) and the total benzo[a]pyrene equivalency concentrations in heavily polluted days present significant health threat. Because of the effect of regional transport, the pollution level of PM2.5 in the study area was aggravated.

Jiang, Nan, et al. "Chemical characteristics and source apportionment of PM2. 5 between heavily polluted days and other days in Zhengzhou, China." Journal of Environmental Sciences (2017).

Source apportionment of PM2.5 at the Lin'an regional background site in China with three receptor models

Source apportionment of fine particulate matter (PM2.5) were conducted at the Lin'an Regional Atmospheric Background Station (LA) in the Yangtze River Delta (YRD) region in China from July 2014 to April 2015 with three receptor models including principal component analysis combining multiple linear regression (PCA-MLR), UNMIX and Positive Matrix Factorization (PMF). The model performance, source identification and source contribution of the three models were analyzed and inter-compared. Source apportionment of PM2.5 was also conducted with the receptor models. Good correlations between the reconstructed and measured concentrations of PM2.5 and its major chemical species were obtained for all models. PMF resolved almost all masses of PM2.5, while PCA-MLR and UNMIX explained about 80%. Five, four and seven sources were identified by PCA-MLR, UNMIX and PMF, respectively. Combustion, secondary source, marine source, dust and industrial activities were identified by all the three receptor models. Combustion source and secondary source were the major sources, and totally contributed over 60% to PM2.5. The PMF model had a better performance on separating the different combustion sources. These findings improve the understanding of PM2.5 sources in background region.

Deng, Junjun, et al. "Source apportionment of PM2. 5 at the Lin'an regional background site in China with three receptor models." Atmospheric Research 202 (2018): 23-32

Source Apportionment and Influencing Factor Analysis of Residential Indoor PM2.5 in Beijing

In order to identify the sources of indoor PM2.5 and to check which factors influence the concentration of indoor PM2.5 and chemical elements, indoor concentrations of PM2.5 and its related elements in residential houses in Beijing were explored. Indoor and outdoor PM2.5 samples that were monitored continuously for one week were collected. Indoor and outdoor concentrations of PM2.5 and 15 elements (Al, As, Ca, Cd, Cu, Fe, K, Mg, Mn, Na, Pb, Se, Tl, V, Zn) were calculated and compared. The median indoor concentration of PM2.5 was 57.64 μg/m3.

For elements in indoor PM2.5, Cd and As may be sensitive to indoor smoking, Zn, Ca and Al may be related to indoor sources other than smoking, Pb, V and Se may mainly come from outdoor. Five factors were extracted for indoor PM2.5 by factor analysis, explained 76.8% of total variance, outdoor sources contributed more than indoor sources. Multiple linear regression analysis for indoor PM2.5, Cd and Pb was performed. Indoor PM2.5 was influenced by factors including outdoor PM2.5, smoking during sampling, outdoor temperature and time of air conditioner use. Indoor Cd was affected by factors including smoking during sampling, outdoor Cd and building age. Indoor Pb concentration was associated with factors including outdoor Pb and time of window open per day, building age and RH. In conclusion, indoor PM2.5 mainly comes from outdoor sources, and the contributions of indoor sources also cannot be ignored. Factors associated indoor and outdoor air exchange can influence the concentrations of indoor PM2.5 and its constituents.

Yang, Yibing, et al. "Source Apportionment and Influencing Factor Analysis of Residential Indoor PM2. 5 in Beijing." International journal of environmental research and public health 15.4 (2018): 686.

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).

Chemical composition and source apportionment of PM2.5 and PM2.5–10 in Trombay (Mumbai, India), a coastal industrial area

PM2.5 and PM2.5–10 concentrations, elemental constituents, and sources in a densely populated coastal industrial area (Trombay, Mumbai) were investigated in 2010 and 2011. The PM2.5 and PM2.5–10 concentrations were 13.50–71.60 and 22.40–127.78 µg/m3, respectively. The daily PM2.5 concentrations exceeded the Indian Central Pollution Control Board limit (60 µg/m3) several days in winter. Of the elements analyzed, Si then Al had the highest concentrations in PM2.5–10, but black carbon then Si had the highest concentrations in PM2.5. The element concentrations varied widely by season. Al, Ca, Fe, Si, and Ti concentrations were highest in summer, Cl, Mg, and Na concentrations were highest in the monsoon season, and the other trace metal concentrations in both PM2.5 and PM2.5–10 were highest in winter. The PM2.5 and PM2.5–10 sources were apportioned by positive matrix factorization. PM2.5 and PM2.5–10 had six dominant sources, crustal material (8.7% and 25.3%, respectively), sea salt spray (6.1% and 15.0%, respectively), coal/biomass combustion (25.5% and 13.8%, respectively), fuel oil combustion (19.0% and 11.2%, respectively), road traffic (17.7% and 12.6%, respectively), and the metal industry (10.6% and 7.0%, respectively). Anthropogenic sources clearly contributed most to PM2.5 but natural sources contributed most to PM2.5–10.

Police, Sandeep, et al. "Chemical composition and source apportionment of PM 2.5 and PM 2.5–10 in Trombay (Mumbai, India), a coastal industrial area." Particuology (2018).

The impact of fine particulate matter (PM2.5) on China's agricultural production from 2001 to 2010

This study provides the first empirical analysis of the direct impact of PM2.5, one of the primary pollutants of haze, on China's agricultural output. An econometric model is estimated using panel data on three of the most commonly grown crops (wheat, rice, and corn) from 303 perfectural level administrative divisions in 25 provinces and autonomous regions in China from 2001 to 2010. The interaction effect between PM2.5 and climatic factors, the nonlinear effect of PM2.5 and climatic factors, and the possible endogeneity between PM2.5 and agricultural production are taken into account. PM2.5 concentrations have significant adverse effects on average yields of wheat and corn, suggesting that the reduction of PM2.5 can contribute to the yields of these two crops. Similar to climatic factors, such as temperature, precipitation, and the sunshine, PM2.5 has a quadratic effect on the average yields of wheat and corn. In the future, it remains a continuing challenge to develop effective long-term strategies in the face of air pollution represented by PM2.5 and the hazards of PM2.5 to agricultural production and food security.

Zhou, Li, Xiaohong Chen, and Xi Tian. "The Impact of Fine Particulate Matter (PM 2.5) on China's Agricultural Production from 2001 to 2010." Journal of Cleaner Production (2017).

Examining the effects of socioeconomic development on fine particulate matter (PM2.5) in China's cities using spatial regression and the geographical detector technique

The frequent occurrence of extreme smog episodes in recent years has begun to present a serious threat to human health. In addition to pollutant emissions and meteorological conditions, fine particulate matter (PM2.5) is also influenced by socioeconomic development. Thus, identifying the potential effects of socioeconomic development on PM2.5 variations can provide insights into particulate pollution control. This study applied spatial regression and the geographical detector technique for assessing the directions and strength of association between socioeconomic factors and PM2.5 concentrations, using data collected from 945 monitoring stations in 190 Chinese cities in 2014. The results indicated that the annual average PM2.5 concentrations is 61 ± 20 μg/m3, and cites with more than 75 μg/m3 were mainly located in North China, especially in Tianjin and Hebei province. We also identified a marked seasonal variation in concentrations levels, with the highest level in winter due to coal consumption, lower temperatures, and less rainfall than in summer. Monthly variations followed a “U-shaped” pattern, with a down trend from January and an inflection point in September and then an increasing trend from October. The results of spatial regression indicated that population density, industrial structure, industrial soot (dust) emissions, and road density have a significantly positive effect on PM2.5 concentrations, with a significantly negative influence exerted only by economic growth. In addition, trade openness and electricity consumption were found to have no significant impact on PM2.5 concentrations. Using the geographical detector technique, the strength of association between the five significant drivers and PM2.5 concentrations was further analyzed. We found notable differences among the variables, with industrial soot (dust) emissions playing a greater role in the PM2.5 concentrations than the other variables. These results will be helpful in understanding the dynamics and the underlying mechanisms at work in PM2.5 concentrations in China at the city level, and thereby assisting the Chinese government in employing effective strategies to tackle pollution.

Zhou, Chunshan, Jing Chen, and Shaojian Wang. "Examining the effects of socioeconomic development on fine particulate matter (PM 2.5) in China's cities using spatial regression and the geographical detector technique." Science of the Total Environment 619 (2018): 436-445.

Air pollution & Health Impacts

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

The Effect of PM2.5 from Household Combustion on Life Expectancy in Sub-Saharan Africa

Household fuel combustion, especially using solid combustibles (biomass and fossil fuels), for cooking and other activities produces emissions that contribute to concentrations of indoor as well as outdoor air pollutants such as particulate matter with diameter smaller than 2.5 μm (PM2.5) that deteriorate health and likely affect life expectancy (LEX). This study investigates the impact of PM2.5 from household combustion on LEX considering several covariates while controlling for ambient PM2.5 generated by other sectors. The generalized method of moments (GMM) model and the panel cointegration model were applied to a dataset of 43 Sub-Saharan Africa (SSA) countries over the time period of 1995–2010. Both approaches provide similar results indicating that household PM2.5 is significantly and negatively associated with higher aggregate LEX in the long-run, and, to a greater degree for female's. Also, among the control variables, PM2.5 from the transport sector has a greater influence on male's LEX. Thus, efforts should be combined to reduce household PM2.5 since lower levels are associated with increased LEX.

Aboubacar, Badamassi, et al. "The Effect of PM2. 5 from Household Combustion on Life Expectancy in Sub-Saharan Africa." International journal of environmental research and public health 15.4 (2018): 748.

Short-term exposure to traffic-related air pollution and ischemic stroke onset in Barcelona, Spain

To assess the relationship between short-term exposure to outdoor ambient air pollutants (fine particulate matter [PM2.5] and black carbon [BC]), ischemic stroke (IS) and its different subtypes, and the potential modifying effect of neighborhood greenspace and noise. This time-stratified case-crossover study was based on IS and transient ischemic attacks (TIA) recorded in a hospital-based prospective stroke register (BASICMAR 2005–2014) in Barcelona (Catalonia, Spain). Daily and hourly pollutant concentrations and meteorological data were obtained from monitoring stations in the city. Time-lags (from previous 72 h to acute stroke onset) were analyzed. Greenness and noise were determined from the Normalized Difference Vegetation Index (NDVI) and daily average noise level at the street nearest to residential address, respectively. The 2742 cases with known onset date and time, living in the study area, were analyzed. After adjusting for temperature, no statistically significant association between pollutants exposure and overall stroke risk was found. In subtype analysis, an association was detected between BC exposure at 24–47 h (odds ratio, 1.251; 95% confidence interval [CI], 1.001–1.552; P = 0.042) and 48–72 h (1.211; 95% CI, 0.988–1.484; P = 0.065) time-lag prior to stroke onset and large-artery atherosclerosis subtype. No clear modifying effect of greenness or noise was observed. Overall, no association was found between PM2.5 and BC exposure and acute IS risk. By stroke subtype, large-artery atherosclerotic stroke could be triggered by daily increases in BC, a diesel fuel-related pollutant in the study area.

Vivanco-Hidalgo, Rosa Maria, et al. "Short-term exposure to traffic-related air pollution and ischemic stroke onset in Barcelona, Spain." Environmental research 162 (2018): 160-165.

Personal exposure measurements of school-children to fine particulate matter (PM2.5) in winter of 2013, Shanghai, China

The aim of this study was to perform an exposure assessment of PM2.5 (particulate matter less than 2.5μm in aerodynamic diameter) among children and to explore the potential sources of exposure from both indoor and outdoor environments. In terms of real-time exposure measurements of PM2.5, we collected data from 57 children aged 8–12 years (9.64 ± 0.93 years) in two schools in Shanghai, China. Simultaneously, questionnaire surveys and time-activity diaries were used to estimate the environment at home and daily time-activity patterns in order to estimate the exposure dose of PM2.5 in these children. Principle component regression

analysis was used to explore the influence of potential sources of PM2.5 exposure. All the median personal exposure and microenvironment PM2.5 concentrations greatly exceeded the daily 24-h PM2.5 Ambient Air Quality Standards of China, the USA, and the World Health Organization (WHO). The median Etotal (the sum of the PM2.5 exposure levels in different microenvironment and fractional time) of all students was 3014.13 (μg.h)/m3. The concentration of time-weighted average (TWA) exposure of all students was 137.01 μg/m3. The median TWA exposure level during the on-campus period (135.81 μg/m3) was significantly higher than the off-campus period (115.50 μg/m3, P = 0.013 < 0.05). Besides ambient air pollution and meteorological conditions, storey height of the classroom and mode of transportation to school were significantly correlated with children's daily PM2.5 exposure. Children in the two selected schools were exposed to high concentrations of PM2.5 in winter of 2013 in Shanghai. Their personal PM2.5 exposure was mainly associated with ambient air conditions, storey height of the classroom, and children's transportation mode to school.

Zhang, Lijun, et al. "Personal exposure measurements of school-children to fine particulate matter (PM2. 5) in winter of 2013, Shanghai, China." PloS one 13.4 (2018): e0193586.

Exposure to fine particulate matter during pregnancy and risk of term low birth weight in Jinan, China, 2014–2016

Existing studies exploring the association between low birth weight (LBW) and maternal fine particulate matter (aerodynamic diameter < 2.5 μm, PM2.5) exposure have presented equivocal results, and one of the possible reasons for this finding might be due to relatively low maternal exposures. In addition, relatively narrow maternal exposure windows to PM2.5 have not been well established for LBW. We employed a nested matched case-control design among 43,855 term births in a large maternity and child care hospital in Jinan, China. A total of 369 cases were identified, and four controls per case matched by maternal age were randomly selected among those with normal birth weight (n = 1,476) from 2014 to 2016. Ambient air monitoring data on continuous measures of PM2.5, nitrogen dioxide (NO2), and sulfur dioxide (SO2) (24-h average concentrations) from 2013 to 2016 were collected from thirteen local monitoring stations. An inverse distance weighting method based on both home and work addresses was adopted to estimate the individual daily exposures to these air pollutants during pregnancy by weighting the average of the twelve nearest monitoring stations within 30 km of each 100 m × 100 m grid cell by an inverse squared distance, and then the average exposure concentrations for gestational months, trimesters and the entire pregnancy were calculated. Adjusted conditional logistic regression models were used to estimate the odds ratios (ORs) per 10 μg/m3 increment in PM2.5 and by PM2.5 quartiles during different gestational periods. In this study, the estimated mean values of PM2.5, NO2, and SO2 exposure during the entire pregnancy were 88.0, 54.6, and 63.1 μg/m3, respectively. Term low birth weight (TLBW) increased in association with per 10 μg/m3 increment in PM2.5 for the 8th month [OR = 1.13, 95% confidence interval (CI): 1.04, 1.22], the 9th month (OR = 1.06, 95% CI: 0.99, 1.15), the third trimester (OR = 1.17, 95% CI: 1.05, 1.29), and the entire pregnancy (OR = 1.38, 95% CI: 1.07, 1.77) in models adjusted for one pollutant (PM2.5). In models categorizing the PM2.5 exposure by quartiles, comparing the second, third, and highest with the lowest PM2.5 exposure quartile, the PM2.5 was positively associated with TLBW during the 8th month (OR: 1.77, 95% CI: 1.09, 2.88; OR: 1.77, 95% CI: 1.03, 3.04; OR: 1.92, 95% CI: 1.04, 3.55, respectively) and for the 9th month, only association for exposure in the third versus the lowest quartile was significant (OR: 1.91, 95% CI: 1.02, 3.58). The study provides evidence that exposure to PM2.5 during pregnancy might be associated with the risk of TLBW in the context of very high pollution level of PM2.5, and the 8th and 9th months were identified as potentially relevant exposure windows.

Wu, Han, et al. "Exposure to fine particulate matter during pregnancy and risk of term low birth weight in Jinan, China, 2014–2016." International journal of hygiene and environmental health (2017).

Other SLCP Source Sectors & Measures

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

Sources of nitrous oxide and other climate relevant gases on surface area in a dairy free stall barn with solid floor and outside slurry storage

Livestock production systems in agriculture are one of the major emitters of greenhouse gases. So far, the focus of research in the dairy farm sector was primarily on ruminal methane (CH4) emissions. Emissions of nitrous oxide (N2O) usually arise from solid manure or in deep litter free stall barns. Release of N2O occurs as a result of interactions between organic material, nitrogen and moisture. Data of N2O emissions from modern dairy barns and liquid manure management systems are rare. Thus, the goal of this research was to determine the main sources of trace gas emissions at the dairy farm level, including N2O. Areas such as the scraped surface area where dry and wet conditions alternate are interesting. Possible sources of trace gases within and outside the barn were localised by measuring trace gas concentration rates from different dairy farm areas (e.g., areas covered with urine and excrement or slurry storage system) via the closed chamber technique. The results indicate typical emission ratios of carbon dioxide (CO2), CH4 and N2O in the various areas to generate comparable equivalent values. Calculated on the basis of nitrogen excretion from dairy cows, total emissions of N2O were much lower from barns than typically measured in fields. However, there were also areas within the barn with individual events and unexpected release factors of N2O concentrations such as urine patches, polluted areas and cubicles. Emission factors of N2O ranged from 1.1 to 5.0 mg m−2 d−1, respectively, for cleaned areas and urine patches. By considering the release factors of these areas and their proportion of the entire barn, total emission rates of 371 CO2-eq. LU−1 a−1, 36 CO2-eq. LU−1 a−1, and 1.7 kg CO2-eq. LU−1 a−1 for CO2, CH4 and N2O, respectively, were measured for the whole barn surface area. The CH4 emissions from surface area were stronger climate relevant comparing to N2O emissions, but compared to CH4 emissions from slurry storage or ruminal fermentation (not measured) even insignificant.

Schmithausen, Alexander J., Manfred Trimborn, and Wolfgang Büscher. "Sources of nitrous oxide and other climate relevant gases on surface area in a dairy free stall barn with solid floor and outside slurry storage." Atmospheric Environment 178 (2018): 41-48.

First Top‐Down Estimates of Anthropogenic NOx Emissions Using High‐Resolution Airborne Remote Sensing Observations

A number of satellite-based instruments have become an essential part of monitoring emissions. Despite sound theoretical inversion techniques, the insufficient samples and the footprint size of current observations have introduced an obstacle to narrow the inversion window for regional models. These key limitations can be partially resolved by a set of modest high-quality measurements from airborne remote sensing. This study illustrates the feasibility of nitrogen dioxide (NO2) columns from the Geostationary Coastal and Air Pollution Events Airborne Simulator (GCAS) to constrain anthropogenic NOx emissions in the Houston-Galveston-Brazoria area. We convert slant column densities to vertical columns using a radiative transfer model with (i) NO2 profiles from a high-resolution regional model (1 × 1 km2) constrained by P-3B aircraft measurements, (ii) the consideration of aerosol optical thickness impacts on radiance at NO2 absorption line, and (iii) high-resolution surface albedo constrained by ground-based spectrometers. We characterize errors in the GCAS NO2 columns by comparing them to Pandora measurements and find a striking correlation ($r > 0.74$) with an uncertainty of 3.5 × 1015 molecules cm−2. On 9 of 10 total days, the constrained anthropogenic emissions by a Kalman filter yield an overall 2–50% reduction in polluted areas, partly counterbalancing the well-documented positive bias of the model. The inversion, however, boosts emissions by 94% in the same areas on a day when an unprecedented local emissions event potentially occurred, significantly mitigating the bias of the model. The capability of GCAS at detecting such an event ensures the significance of forthcoming geostationary satellites for timely estimates of top-down emissions.

Souri, Amir H., et al. "First Top‐Down Estimates of Anthropogenic NOx Emissions Using High‐Resolution Airborne

Remote Sensing Observations." Journal of Geophysical Research: Atmospheres (2018).

Statistical analysis of dispersal and deposition patterns of volcanic emissions from Mt. Sakurajima, Japan

With the eruption of Eyjafjallajökull (Iceland) in 2010, interest in the transport of volcanic ash after moderate to major eruptions has increased with regards to both the physical and the emergency hazard management aspects. However, there remain significant gaps in the understanding of the long-term behaviour of emissions from volcanoes with long periods of activity. Mt. Sakurajima (Japan) provides us with a rare opportunity to study such activity, due to its eruptive behaviour and dense observation network. In the 6-year period from 2009 to 2015, the volcano was erupting at an almost constant rate introducing approximately 500 kt of ash per month to the atmosphere. The long-term characteristics of the transport and deposition of ash and SO2 in the area surrounding the volcano are studied here using daily surface observations of suspended particulate matter (SPM) and SO2 and monthly ashfall values. Results reveal different dispersal patterns for SO2 and volcanic ash, suggesting volcanic emissions' separation in the long-term. Peak SO2 concentrations at different locations on the volcano vary up to 2 orders of magnitude and decrease steeply with distance. Airborne volcanic ash increases SPM concentrations uniformly across the area surrounding the volcano, with distance from the vent having a secondary effect. During the period studied here, the influence of volcanic emissions was identifiable both in SO2 and SPM concentrations which were, at times, over the recommended exposure limits defined by the Japanese government, European Union and the World Health Organisation. Depositional patterns of volcanic ash exhibit elements of seasonality, consistent with previous studies. Climatological and topographic effects are suspected to impact the deposition of volcanic ash away from the vent: for sampling stations located close to complex topographical elements, sharp changes in the deposition patterns were observed, with ash deposits for neighbouring stations as close as 5 km differing as much as an order of magnitude. Despite these effects, deposition was sufficiently approximated by an inverse power law relationship, the fidelity of which depended on the distance from the vent: for proximal to intermediate areas (<20 km), errors decrease with longer accumulation periods (tested here for 1–72 months), while the opposite was seen for deposition in distal areas (>20 km).

Poulidis, Alexandros P., et al. "Statistical analysis of dispersal and deposition patterns of volcanic emissions from Mt. Sakurajima, Japan." Atmospheric Environment 179 (2018): 305-320.

Urban SLCPs

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

Characteristics of mass concentration, chemical composition, source apportionment of PM2.5 and PM10 and health risk assessment in the emerging megacity in China

In this study, 228 daily Particulate matter (PM) filters (57 Quartz and 57 Teflon samples for both PM2.5 and PM10, respectively) were collected from an urban site in Zhengzhou in typical months from 2014 autumn to 2015 summer representing the four seasons. PM concentrations, water-soluble inorganic ions, organic carbon, elemental carbon, and elements were determined, and positive matrix factorization was used for source apportionments. Health risks of toxic elements in PM2.5 and PM10 were also evaluated. The annual mean values of PM2.5 and PM10 were higher than the standards in China, and the highest seasonal concentrations of PM2.5 and PM10 were in winter. Secondary inorganic aerosols (SIAs) were the major component, with the ratio of SIAs/PM highest in summer. The seasonal concentrations of SO42− were high in winter and summer. Crustal elements mainly existed in PM2.5–10; however, elements from anthropogenic sources (i.e., Zn, Pb, Cu, As, Cd, and Mo) were more abundant in fine particles than in the coarse fraction. The main pollution sources were dust, SIAs, coal combustion, vehicle and road dust, and industry, accounting for 10%, 26%, 25%, 20% and 15% in PM2.5 and 32%, 14%, 24%, 18% and 8% in PM10, respectively. Dust source has the highest contribution in PM10; however, SIAs source has the highest content in fine particles. The carcinogenic risks of As to children through

the daily intake pathway in PM2.5 and PM10 exceeded the acceptable level. Noncarcinogenic risks of As and Cd in PM2.5 and PM10 to children via the daily intake pathway were significant. Moreover, the sum of noncarcinogenic risks in PM10 via inhalation exposure for local residents and that via dermal absorption for children were significant. The details of the pollution characteristics and the results of source apportionments and health risks assessment of PM2.5 and PM10 in this study can play an important role for the government to formulate reasonable and effective policy to mitigate the atmospheric pollution of PM. To our knowledge, this systematic study is the first to investigate the chemical characterizations, source apportionments, and health effects of PM2.5 and PM10 in Zhengzhou.

Jiang, Nan, et al. "Characteristics of mass concentration, chemical composition, source apportionment of PM2. 5 and PM10 and health risk assessment in the emerging megacity in China." Atmospheric Pollution Research (2017).

SLCPs & Vulnerable Regions

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

Resolving Size Distribution of Black Carbon Internally Mixed With Snow: Impact on Snow Optical Properties and Albedo

We develop a stochastic aerosol-snow albedo model that explicitly resolves size distribution of aerosols internally mixed with various snow grains. We use the model to quantify black carbon (BC) size effects on snow albedo and optical properties for BC-snow internal mixing. Results show that BC-induced snow single-scattering coalbedo enhancement and albedo reduction decrease by a factor of 2–3 with increasing BC effective radii from 0.05 to 0.25 μm, while polydisperse BC results in up to 40% smaller visible single-scattering coalbedo enhancement and albedo reduction compared to monodisperse BC with equivalent effective radii. We further develop parameterizations for BC size effects for application to climate models. Compared with a realistic polydisperse assumption and observed shifts to larger BC sizes in snow, respectively, assuming monodisperse BC and typical atmospheric BC effective radii could lead to overestimates of ~24% and ~40% in BC-snow albedo forcing averaged over different BC and snow conditions.

He, Cenlin, Kuo‐Nan Liou, and Yoshi Takano. "Resolving size distribution of black carbon internally mixed with snow: Impact on snow optical properties and albedo." Geophysical Research Letters 45.6 (2018): 2697-2705.

Black carbon and the Arctic: Global problem‐solving through the nexus of science, law and s pace

Black carbon pollution is an important driver of climate change in the Arctic region. Most black carbon emissions entering the Arctic originate from non‐Arctic sources, and hence mitigating black carbon pollution in the Arctic region requires not only regional, but global engagement. Attempts to regulate borderless climate pollutants such as black carbon force us to think about law's effectiveness from the perspective of its relationship to science as well as its engagement with space. This article argues that for effective legal problem‐solving, black carbon pollution must be addressed from the point of view of science, law and space. Scientific, social and spatial landscapes reveal different legal narratives embedded in climate governance that have traditionally fallen outside the State‐led discourse of environmental legal negotiation and yet are central to developing a meaningful understanding of global climate 'law', realities and outcomes.

Khan, Sabaa Ahmad, and Kati Kulovesi. "Black carbon and the Arctic: Global problem‐solving through the nexus of science, law and space." Review of European, Comparative & International Environmental Law 27.1 (2018): 5-14.